EBC

Energy in Buildings and Communities Programme

EBC NEWS

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

Energy Technology Network

ECBCS Transformed to EBC

It is my pleasure to announce that our international research and development programme has adopted a new name and a new logo. We are now known as the IEA 'Energy in Buildings and Communities' Programme, or EBC for short. Alongside these changes, the EBC Executive Committee has approved new designs for the newsletter, the Annual Report and the website, which have been created by a talented young Swiss designer. This renewal of our identity has been one of my first initiatives as the Committee Chair and is certainly the most visible.
Since the EBC Programme was founded in 1977, the logo had remained substantially unchanged. The Committee felt that this now symbolized out-of-date technologies and did not capture the full scope of our work. So, it was decided the new logo should represent not only small houses, but also larger buildings and community scale technologies. We believe the new logo meets these requirements, in which the circle enclosing the buildings symbolizes communities. In addition, the logo’s style fits well with that of the IEA R&D Network, enhancing communication and the shared identity.
Beyond the Executive Committee’s wish to create a new logo, it was considered to be important to simplify both our full name and our acronym to help to increase the prominence of the Programme. 'Energy in Buildings and Communities' was selected, because it retains the main keywords of the Programme and concisely explains our focus.
As a consequence, these enhancements in communications naturally led to a redesign of our reports and website to present a coherent identity. With the help of my Executive Committee colleagues and the strong support of our secretariat. I am therefore pleased this task is now complete. What you are holding in your hands (or reading on your screen) is the result - I hope you like it.
Our commitment to high impact technology research and development for energy conservation in integrated building and community systems remains unchanged.

Andreas Eckmanns
EBC Executive Committee Chair

Cover pictures - Top: application and testing of aerogel based high performing rendering. Bottom: historical building renovated with aerogel based rendering. Source: Empa, Switzerland

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EBC Executive Committee Support Services Unit (ESSU), c/o AECOM Ltd
Colmore Plaza
Colmore Circus Queensway
Birmingham B4 6AT
United Kingdom
Tel: +44 (0)121 262 1920
Email: newsletter@iea-ebc.org

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Living and Working in the Future

Buildings Energy Research in Switzerland

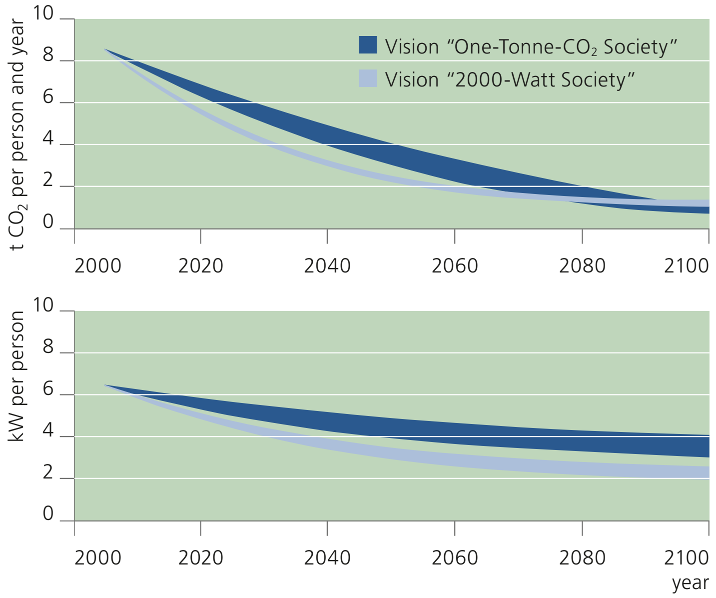
Andreas Eckmanns

Double vision usually needs correction, but not for Switzerland. They have created two ambitious yet convergent visions for their future energy system and have challenged their buildings research community to respond.

While buildings account for about 45% of total primary energy consumption and 40% of all energy-related carbon dioxide (CO_2) emissions in Switzerland, existing research findings show there is huge room for improvement in these areas. Indeed, various national and international strategies are already calling for our building stock to undergo a thorough makeover according to sustainable development criteria.

At a national level, two rather different visions have emerged about the long term goal for reductions, both of which were developed in the ETH Domain. Energy efficiency is central to the first idea, the '2000-Watt Society'. This concept requires global primary energy use to be reduced by 2100 to a level equivalent to a continuous consumption of 2000 Watts per person. To place this in context, in 2010 average energy consumption in Switzerland was 6500 Watts per person. The second idea, the 'One-Tonne-CO_2 Society', allows for less extreme energy demand reductions, as long as the differences can be offset by renewable sources of energy supply. The main aim would be to reduce long-term total CO_2 emissions per person to below one tonne per year.

Different ways of reducing primary energy requirements and CO_2 emissions: visions of a 2000-Watt Society and of a One-Tonne-CO_2 Society



Reduction patterns in these two models will be similar in the immediate future. At the end of the century both strategies would lead to emissions of one tonne CO_2 per person, albeit with differing energy requirements.
Source: Swiss Federal Energy Research Commission CORE

Renovation of an apartment block with prefabricated elements. Source: Empa
The EBC project 'Annex 50: Prefabricated Systems for Low Energy Renovation of Residential Buildings', led by Switzerland, developed innovative solutions for the efficient renovation of apartment blocks.

National energy policy

In 2008, the climate change policy for Switzerland was set with the goal of reducing domestic CO_2 emissions to 80% of 1990 levels by 2020. In 2011, the Federal Council decided to continue to maintain Switzerland's high level of electricity supply security even with the phasing out of nuclear energy in the medium term. To guarantee supply security in the future, the Federal Council is focusing on increased energy efficiency, the expansion of hydropower and use of new renewable energy supplies, and, where necessary, on fossil fuel based electricity production (combined heat and power plants, gas-fired combined cycle power plants) and imports. Furthermore, expansion of Switzerland's electricity networks to accommodate these changes is underway and energy research is to be intensified. To address these key areas in terms of research and development (R&D), the Federal Energy Research Masterplan has been established. This Masterplan defines four focus areas which essentially cover all aspects of energy research. They reflect everyday life and our everyday energy requirements. The four focus areas are also recognised in other countries as the main ways of improving efficiency and reducing CO_2 emissions. These are:

- 'Living and Working in the Future'
- 'Mobility of the Future'
- 'Energy Systems of the Future'
- 'Processes of the Future'

The buildings-related R&D priorities are defined within the focus area 'Living and Working in the Future'.

Living and Working in the Future

The vision of the research focus area 'Living and Working in the Future' points towards energy efficient and near emissions free ways of living and working: It states that in the future the majority of the Swiss building stock should no longer produce pollutants and greenhouse gases. In fact, buildings should be important contributors to distributed energy generation and should collectively produce approximately the amount of energy required to meet heating and electricity needs in our daily lives. To achieve this vision, this focus area has initiated research into technologies and concepts involving energy requirements, energy conversion, energy use and local generation of renewable energy in individual buildings, groups of buildings, neighbourhoods, towns and whole cities. Because cost-benefit analyses highlight the need for different solutions where old and new buildings are concerned, Switzerland is faced with a number of different challenges: For existing buildings, energy consumption should be considerably reduced and at the same time converted to 'carbon-neutral' operation, in which CO_2 emissions are avoided by local generation of renewable energy. New buildings should not generate any polluting emissions. In future, emissions generated during building construction and the subsequent disposal of construction materials should be considerably less than at present.

To achieve this, the research community needs to develop technologies and concepts by which energy can be generated, converted and used intelligently in buildings. This includes both technological and socio-economic research. The findings must then be translated into products, planning and implementing instruments, and subsequently transferred to the market.

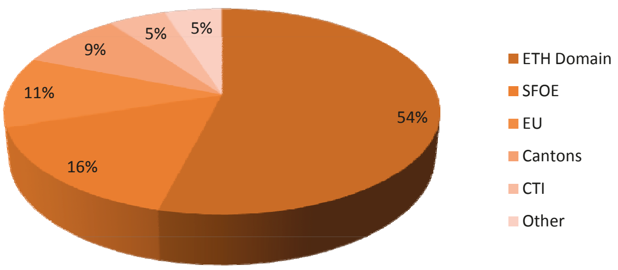
Public funding of energy related R&D

In Switzerland public funds for energy-related R&D cover a total amount of 220 million Francs per year (around 180 million Euros per year). More than half of this is allocated to the ETH Domain including ETH Zurich, EPFL Lausanne, Empa and other federal institutes. As the second important funding entity, the Swiss Federal Office of Energy (SFOE) provides 16%, followed by EU funds with 11%, the Cantons 9% and the Commission for Technology and Innovation with 5%. The SFOE sponsors applied research projects, including national contributions to the collaborative R&D programmes of the International Energy Agency (IEA).

The SFOE R&D programme 'Energy in Buildings' aligns with the IEA Energy in Buildings and Communities (EBC) programme. In its plan for the period 2013 - 2016, SFOE has defined five research areas:

- Building renovation has priority over new buildings: The challenge for the future lies in the refurbishment of the existing stock.
- Optimal use of technology: Technical improvements to buildings service systems and envelopes are able to contribute to energy demand reduction, but it is crucial to design and operate building technologies in an optimal way.
- From a single building to urban areas: The 'system boundary' should be expanded from buildings up to building clusters, settlements or whole cities.
- The building as a 'storage power station': Every building has the potential to produce energy through the use of energy from underground, from the environment or from the roof. More than this, they offer a variety of possibilities for energy storage.
- Indirect energy consumption: Embodied energy of the construction materials and occupant travel, as well as occupant behaviour, all contribute to the energy 'footprint' of buildings.

Energy research is facing the major challenge to develop technologies and approaches to create a sustainable energy sector over the coming years. The buildings sector must bear the burden for a large part of this task.



Shares of public funding of energy-related R&D in Switzerland.
Total annual funds are 214 million Francs (about 180 million Euro).

Further information

Energy Strategy 2050, Federal Council, 2012, www.bfe.admin.ch

Key areas of the Swiss federal energy policy

- Energy efficiency: Reduction of energy consumption, predominately in the buildings sector.
- Renewable energy: Hydropower should be the main source of domestic renewable energy. The proportion of other renewable energy sources in the energy mix should be increased.
- Large power stations: From 2020 some major power stations will be disconnected from the grid. Switzerland needs either to build new conventional large power stations, import more power, or create a large number of smaller combined heat and power (CHP) installations.
- Foreign energy policy: One of the key focuses of the energy strategy is to improve international co-operation, in particular with the EU.

Financing Energy Renovation of Existing Buildings in Italy

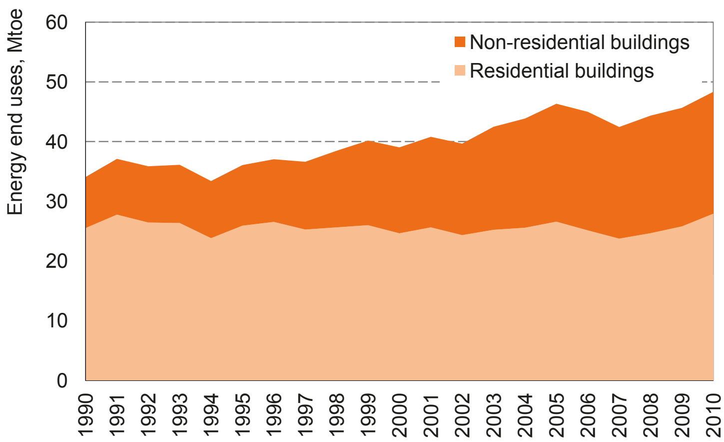
Michele Zinzi and Gaetano Fasano

Funding energy efficiency improvements to existing buildings by making them tax deductible has helped Italy to achieve their energy saving plans. Energy renovation is not taxing.

Energy efficiency is a national political priority in Italy, as in many other countries worldwide. To help to stimulate achieving this goal, the Energy Efficiency Action Plan has been agreed in 2007, which sets ambitious targets for energy savings.

The existing building stock in Italy is generally energy inefficient and much of it requires renovation. However, experience with this sector is already demonstrating that financial mechanisms to support energy efficiency policies are useful instruments at several levels. These include mobilising funding for construction, providing economic support to end users, recognising changing energy end uses mixes, supporting market penetration of new technologies, and helping to achieve targets through refurbishment.

Evolution of energy end use in the buildings sector



Progress

As required by EU Directives, an objective for a 10% saving has been fixed compared with average energy end use between 2001 and 2005. Actual energy end use was 135 Mtoe (1570 TWh) in 2011, which is in accordance with the Energy Efficiency Action Plan. This represents a 3% reduction in primary energy consumption relative to 2010. This reduction is believed to arise from the combined effect of the economic crisis and of energy policies.

The success of energy efficiency policies is strongly related to the buildings sector, which uses most energy. In this sector, the share of total energy use decreased from 36% in 2010 to 34% in 2011. The national implementation of the EU Energy Performance of Building Directive (EPBD) 2002 set high energy efficiency standards for new buildings and for building renovation, but these have not yet had a significant impact on the sector. This is mainly due to the characteristics of the building stock in Italy and to a lack of exploitation of energy saving potential during building renovation.

The building stock

The Italian residential building stock consists of 29.6 million dwellings contained within 11.6 million individual buildings. Single and two family houses account for more than 40% of this stock. Large blocks with more than 15 apartments account for the 10% of the buildings and for the 23% of the dwellings. There are approximately 150,000 non-residential buildings, with offices and schools accounting for the 80% of the total. Around 30% of residential buildings and 20% of office and school buildings were built before 1945. 70% of the national stock was built before the introduction of the first law on the energy efficiency of buildings in the mid-1970s. Only 10% was constructed during the last 20 years, when improved energy performance was legally required. In this regard, two crucial issues have emerged:

- Much of the stock is obsolete and characterised by poor energy performance, often coupled to other safety aspects, such as static and environmental hazards. As an example, more than 40,000 school buildings have severe structural problems. A national plan for retrofitting them is being developed, so providing an important opportunity to include energy retrofit measures.
- The rate of new building completion has been very low during the last twenty years. This means that even if energy standards for new buildings are very strict, the impact on the whole sector would not be significant for many years ahead. This implies the energy performance of the existing stock also has to be upgraded.

Energy end use in the buildings sector

The implementation of energy efficiency policies has had a positive impact for residential buildings. As a consequence, while electricity use by space cooling equipment and other appliances in the residential sub-sector went up significantly between 1990 and 2010, overall energy use in this sub-sector did not change appreciably over the same period.

In contrast, energy use increased by 140% in the non-residential sub-sector, in which there has been a significant growth both of stock size and of energy use. While residential buildings accounted for 75% of energy end use of the buildings sector in 1990, this had decreased to 58% by 2010. The trend shows that the two sub-sectors are likely to account for similar total energy use in the next few years. A number of further issues should be addressed by successful energy policies:

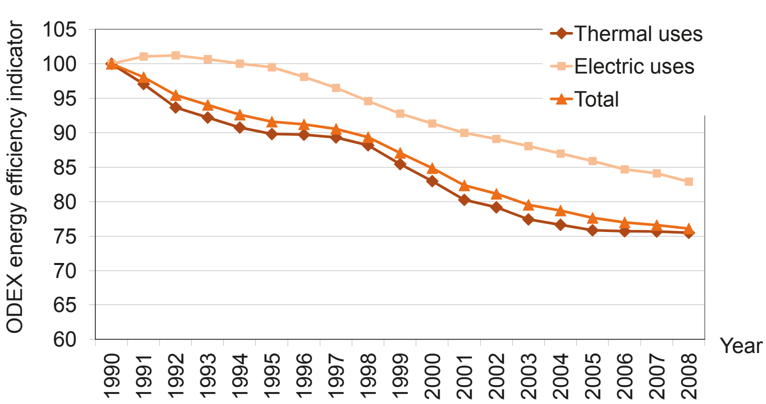
- As a priority, heating energy use is critical for residential buildings, accounting for close to 70% of overall use.
- As in many other industrialised countries, the economy is increasingly service oriented. This transformation impacts the building stock and its related energy use.
- The non-residential sector and some specific building categories are experiencing a noticeable increase in electricity use for air conditioning.

Measures for energy retrofit of existing buildings

The first law on the energy performance of buildings was issued in 1976 and several others have been produced since then. Since this time attention has been focused on heating energy use, as the most demanding service. High heating energy use is a common characteristic of the residential stock built before the 1970s, with improved performance in later construction.

Taking these factors into account, policy makers decided to develop funding schemes to support the energy renovation of buildings. An important financial scheme was launched in 2007, with a 55% tax deduction offered for energy saving measures in existing buildings. The scheme is applicable to both individuals and companies. The measures are focused on heating performance including the building envelope,

Evolution of the ODEX energy efficiency indicators in the residential sector (1990 = 100)



The ODEX energy efficiency indicators are defined in various ways appropriate to end use and are expressed here relative to 1990 levels.

heat generators and renewable energy supplies. The minimum requirements depend on the climatic zone, with a fixed maximum cost for each measure.

In the latest Annual Energy Efficiency Report, it is estimated the energy saving associated with the tax deduction scheme is 7.6 TWh. Particularly during the current financial crisis, the scheme is now considered a necessity for end users, as well as for the industry that it benefits. In fact, industry association studies have estimated it has generated a turnover of 11 billion Euros between 2007 and 2010, with an additional 4.5 billion Euros expected from 2011 to 2012.

The success of the 55% tax deduction scheme and a separate PV funding scheme led to the implementation of another financial mechanism commencing in 2013. The scheme, called Conto Termico Energia, is focused on the production of thermal energy by renewable energy systems and on energy efficiency improvements. Private entities are permitted access to the financial mechanism relating to energy production from renewable energy supply systems, which includes heat pumps. In addition, solar cooling, an emerging technology, is included. Relating to such schemes, Italy is also involved in the EBC project, 'Annex 56: Cost Effective Energy and CO_2 Emissions Optimization in Building Renovation' to help to ensure they have a sound technical and financial basis.

Based on a public incentive of 7.9 billion Euros, a gross turnover of 20 billion Euros is expected from the scheme from 2012 to 2020. Moreover, it should increase renewable thermal energy production from 7 ktoe per year in 2013 up to around 10 ktoe per year by 2020. If successfully implemented, annual energy savings from the scheme are expected to reach 1.6 Mtoe (19 TWh) per year by 2020.

Conclusions

The national Energy Efficiency Action Plan for Italy has set ambitious targets for energy savings in the buildings sector. To this end, financial mechanisms to underpin energy efficiency policies are useful because:

- They mobilise investments even during severe recessions, often providing the breadline for many small and medium-sized companies operating in the construction sector.
- They provide economic support to upgrade the quality of their buildings for end users, who would otherwise often be forced to occupy poorly performing buildings.
- They recognise the increase in cooling demand.
- They support the market penetration of new technologies.
- They support the achievement of the national energy saving targets through the refurbishment of the existing building stock.

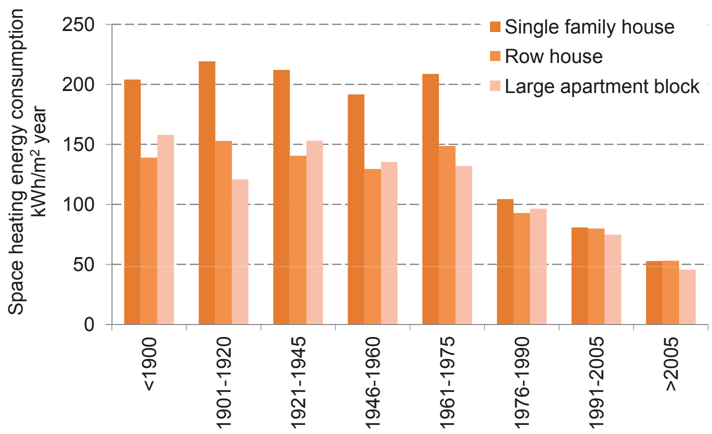
Further information

Italian Action Plan for Energy Efficiency, 2007, Ministry of Economic Development

Energy Efficiency Annual Report, 2011, ENEA

www.efficienzaenergetica.enea.it

Estimated energy consumption for space heating in residential buildings by construction period



The evolution of energy demand over time is shown for space heating according to building typology. High energy use for the stock built before the 1970s is evident, as are the good standards achievable through legislation for dwellings constructed after 1976.

Total Energy Use in Buildings

Completed Project: Annex 53

Prof Hiroshi Yoshino

Set your mind at rest, better models for occupant behaviour may lead to improved strategies and policies for energy savings in buildings.

One of the most significant barriers to reducing building energy use is insufficient knowledge about the full range of factors that determine it. The well-known factors that have a direct influence include climate, the building envelope, building services, indoor environmental conditions and equipment. But, energy use also depends on operation and maintenance and occupant behaviour, the latter of which has not been well understood. The recently completed international EBC project, 'Annex 53: Total Energy Use in Buildings: Analysis and Evaluation Methods' was therefore established, with emphasis on improving knowledge about occupant behaviour. The project objectives were to:

- Define terminology, indicators and quantify influencing factors for energy use for two building types (offices and residential buildings), particularly to characterise occupant behaviour.
- Improve methodologies and techniques to monitor total building energy use.
- Create new methodologies to analyse total building energy use and then investigate the factors that influence this, including modelling of occupant behaviour.
- Create methodologies to predict total energy use in buildings and to assess the impacts of energy saving policies and techniques, including the influence of occupant behaviour.

As a key contributor to total building energy use, the role of occupant behaviour modelling within energy performance evaluation has had close attention in the project. This, in turn, has increased confidence in the application of energy performance evaluation for individual buildings and for stock analysis.

Modelling occupant behaviour and energy performance evaluation

Energy use both in residential and in office buildings is influenced by the behaviour of occupants in various ways. Such behaviour is related to actions controlling building operation, as well as to household or other activities. These actions and activities may be driven by various factors. Occupants experience their physical environments due to their locations, biological and psychological states, and by interactions with those environments.

Concerning residential buildings, behaviour is affected by the presence of an occupant at a specific time and location with access to specific building controls. Beyond these, their building and appliance usage profiles, attitude to energy costs, and attention to maintenance may each contribute to overall energy use. For residential buildings, particular aspects of behaviour relate to use of:

- heating,
- cooling,
- ventilation and windows,
- domestic hot water,
- appliances and electric lighting, and
- cooking.

The classification of energy-related occupant behaviour in office buildings requires three different levels, namely:

1. individual occupant / manager level,
2. zone / office level, and
3. building level.

At each level, occupant and management behaviour needs to be considered with respect to electric lighting, equipment, natural or mechanical ventilation, and heating and domestic hot water systems.
As for modelling occupant behaviour, in general there are two kinds that can help to:

- understand stimuli for the behaviour itself, and
- reveal its relationships with energy demand, usage profiles and the underlying stimuli.

Energy performance evaluation carefully taking into account occupant behaviour is intended to make predictions based on building simulation tools more robust. A systematic approach to this was developed in the project based upon 'sensitivity analysis' of simulation results with respect to the influencing parameters. This can take place at two different points in the building life-cycle, either at new build stage or in operation.
At new build stage during the design phase, propagation of input parameter uncertainties is quantified by finding sensitivity coefficients from simulation results. Based upon this systematic procedure, a 'regression model' (linear or non-linear) is identified, which can be used to estimate the performance of a given design.
For an existing building in operation, the same type of regression model may be used. In this case, certain parameters may already be known accurately and these should be fixed during the analysis. The performance of a number of 'energy conservation measures' can then be assessed.

Individual building and stock analysis

A highly structured database has been defined in the project, which has been used to collate information about the influencing factors for building energy use. This has been applied along with the terminology and indicators developed to 12 office and 12 residential building case studies. Based on the collated information, the analyses performed can be divided into three consecutive steps that require the use of: statistical analysis to produce a clear description of the study building; statistically based tools to identify the most relevant factors influencing the building energy use; statistically based methods to define and apply a suitable model to predict the building energy use.

The investigations have been focused at three different scales, these being for:

- individual buildings,
- large building stocks, and
- regional or national level analyses.

When the study focuses on very large building stocks (for regional or national analysis), useful evaluations can be performed even if little information is available for each individual building. But, for a study focusing on an individual building, the amount of required information increases, not least because data about energy use and the corresponding influencing factors have to be collected at monthly or shorter time intervals.

Project outcomes

By combining expertise from organisations in 15 participating countries, the project has generated new knowledge about total building energy use that will enable the development of new strategies and policies for energy savings. The project outcomes include:

- guidance on how to apply statistical and analytical methods as predictive models for total energy use, and
- documented building case studies, measurement methods and total energy use data.

The project has improved understanding about modelling occupant behaviour, and so has increased confidence in the use of simulation for assessing total energy use for individual buildings and for large building stocks.

Further information

www.iea-ebc.org

Micro-Generation in Buildings

Completed Project: Annex 54

Peter Tzscheutschler and Evgueniy Entchev

Small systems may have a big future. Micro-cogeneration used with energy storage and other technologies can help to balance supply and demand.

To achieve ambitious targets for non-renewable energy savings in the buildings sector in industrialised countries, innovative energy supply technologies must be applied. These should be highly efficient and able to integrate renewable supply systems. For this purpose, micro-generation offers good possibilities to contribute to more sustainable energy supply systems. This has been the focus of the international EBC research project 'Annex 54: Micro-Generation and Related Technologies in Buildings'.

A 1 kW (electricity) µCHP system including thermal storage.

What is micro-generation?

Micro-generation comprises of technologies for generating useable energy with small-scale systems of up to around ten kilowatts capacity, such as photovoltaic systems or micro-wind turbines. The combined production of heat and electrical power (CHP) in a single small-scale process is called micro-cogeneration (µCHP). This can be extended to a micro tri-generation system if cooling is produced in addition. A micro-cogeneration system consists of a high efficiency unit to produce heat and power and typically several of the following components:

- a thermally or electrically driven cooling system if required,
- a thermal storage buffer, used to decouple heat and power and to increase µCHP runtime,
- an auxiliary burner for thermal peak load coverage,
- a supplementary electrical power generation system, for example photovoltaics or a micro wind turbine,
- a battery storage system to save surplus electricity and cover peak loads (for example using a 'second life' battery previously installed in an electric vehicle),
- an electrical grid connection for surplus feed-in and peak load coverage, or
- an advanced control system for optimal operation of the components.

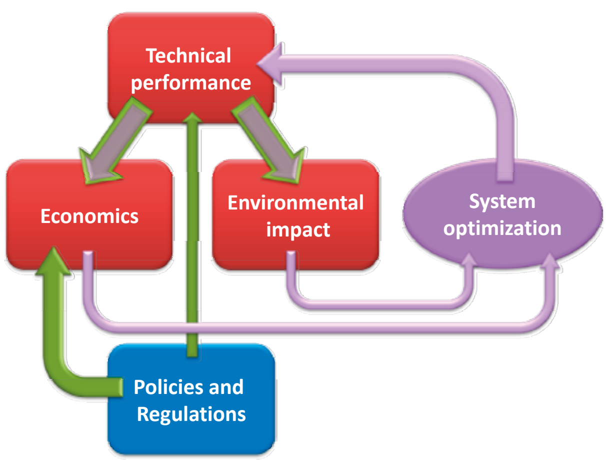
Technical developments

State of the art µCHP systems are highly efficient due to the use of otherwise waste heat from electricity generation. The integration of thermal storage allows temporal decoupling of electricity generation from heat demand. Currently, µCHP systems are mainly fuelled with natural gas, but LPG and fuel oil systems are also available. Small-scale systems running on renewable resources such as vegetable oil, biogas or wood pellets are not yet commercially available.

Co-generators using conventional internal combustion engines (ICE) at the scale of several hundred kilowatts are widely deployed. In the range of µCHP, ICE co-generators with 1 kW to 5 kW electrical and up to about 12 kW thermal output have been on the market for about a decade. Small Stirling engine systems with about 1 kW electrical output are new to the market and are suitable for single family houses.
Fuel cell based µCHP systems have high electrical efficiency with no moving parts and thereby low maintenance requirements. The high power to heat ratio of fuel cells fits well with the requirements of low energy buildings with low heat demand, but still with significant electricity use. Much development work on fuel cell µCHP has been carried out, for instance in Japan, where this technology is already on the market. Meanwhile, these systems are also now available in Europe and North America.
Besides the development of micro-generation components, it is essential to focus on advanced control systems. These would enable micro-generation technologies to act as active components in future smart grids.

Smart local generation

The management of energy flows within buildings and the ability to store thermal and electrical energy will be of great importance in the future, when fluctuating generation patterns including major renewable energy sources will be expected to align with energy demand profiles. Together with a building energy management system, thermal and electrical storage capacities, micro-generation offers possibilities to locally match electrical power generation with energy demands, but in an interconnected smart grid environment.



A schematic representation of the technology assessment process that can be used for system optimization.

Technology assessment

To evaluate and optimize a system, technical performance has to be determined and improved. For micro-generation one key performance parameter is therefore the system efficiency. This is broadly defined as the output of useful energy in terms of heat and electricity in relation to the input of delivered energy, in this case generally natural gas. Typically at the moment, the electrical efficiency for µCHP lies in the region of 25% for ICE systems, 15% for Stirling engine systems and up to 50% for systems using fuel cells. Also taking into account the generation of useful heat can result in a total efficiency from 85% to 95%.
To determine its environmental impact in terms of primary energy demand and greenhouse gas emissions, a micro-generation system should be compared with a conventional reference system. So, the characteristics of the existing energy supply system have to be taken into account, including large scale electrical power generation and the relevant policy and regulatory framework. As these vary widely between different countries, such an assessment can only be made on a national basis. Nonetheless, recent results show that depending on national circumstances, µCHP systems are able to save up to 20% in terms of primary energy and CO_2-emissions compared to conventional reference systems.

Further information

www.iea-ebc.org

Embodied Energy and CO_2

New Project: Annex 57

Prof Tatsuo Oka

Fossil fuel use needed to make construction products and deliver them to site is rapidly gaining attention. Embodied energy is material.

The 'embodied' energy and carbon dioxide (CO_2) of construction products are defined as the fossil fuel energy use and the related CO_2 emissions respectively, arising during the entire process of:

- extracting and processing of raw materials,
- manufacture, and
- transportation.

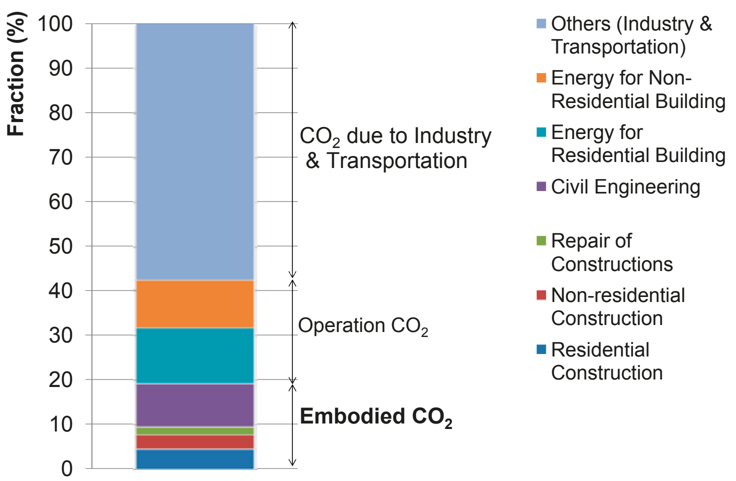
Because building operational energy use is now being reduced in many industrialised countries, embodied energy (and similarly embodied CO_2) is becoming increasingly significant. Particularly for 'low carbon' building design, the embodied CO_2 may constitute a large proportion of the whole life emissions encompassing the construction, operation and demolition phases. Further to this, fractions of embodied energy are already generally higher in developing than in industrialised countries, where they often exceed the building operational energy.

At present, a generally accepted methodology is lacking for calculating embodied energy and CO_2 for building construction. For this reason, the new international EBC project, 'Annex 57: Evaluation of Embodied Energy and Carbon Dioxide Emissions for Building Construction' has been initiated. The project was launched in 2012 and for benefit of building designers is now developing:

- evaluation methods for embodied energy and CO_2 emissions, and
- design and construction methods for buildings with low embodied energy and CO_2 emissions.

To date, efforts have been made to approximately evaluate embodied energy and CO_2 using information from existing databases.

Annual fraction of embodied CO_2 of total emission in Japan (1.29 Billion tonnes CO_2 in 2005)



The corresponding fractions of embodied CO_2 due to building construction and public works were estimated using an input-output analysis. Embodied CO_2 was 19.2% of the total, while the operation of buildings was 23.2%.

Database selection

Two alternative types of database of embodied energy and CO_2 for building construction materials have previously been compiled. These are both widely used and are based on either:

- the International Organization for Standardization (ISO) methodology, or
- 'input-output' (IO) analysis.

It is considered that ISO-based databases tend to reflect manufacturing efficiencies rather than the embodied energy and CO_2 due to building construction. Although databases compiled using IO analysis would seem to be more relevant, from a practical standpoint fewer building components are contained within them than in the ISO-based databases.

Building materials and components

Key materials and components used in building construction may include: concrete, steel, wood, brick, external surface materials, glazing and framing materials, insulation, floor surfaces, ceiling and inner surfaces of the exterior walls, or fixed building services systems (electrical systems including distribution, building management, IT and security, electric lighting; HVAC; hot and cold water supply and foul drainage; indoor transportation).

Since a building typically consists of several hundred components, reducing the number of components, if possible, would decrease embodied energy and CO_2. Moreover, since the total embodied energy used in the building is equal to the value of the embodied energy intensity multiplied by the quantity of materials, the latter is an important factor.

Achieving designs with low embodied energy and CO_2 emissions

Thus far in the project, approximate estimations have been made to find the significant factors for reducing embodied energy and CO_2.

At an early design stage, building designers need to compare the embodied energy and CO_2 with benchmarks for the proposed construction to examine the impact of its form and features. Since approximately 90% of the building performance is determined in the initial design stages, designers can benefit from case studies that show how embodied energy and CO_2 can be reduced. Therefore, these will be produced by the participating countries in the project.

Design and construction methods for buildings with low embodied energy and CO_2 are being improved by the use of recycled materials, prolongation of building life, retrofitting, and also reduction of non-CO_2 greenhouse gas emissions. In fact, 60% of global warming overall has been calculated to be due to CO_2 emission, but with a further 14% attributed to Freon gases, which in some countries still are used in insulation materials and in electric refrigerators.

Further information

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Fraction of embodied energy of building components at the gate factory

	Energy consumption in industrial sector (%)			
Industrial Sector	Cement product	Hot rolled steel	Air con	Non wooden building
Cement	32.4	0.0	0.1	5.5
Cement products	18.7	0.0	0.0	0.4
Pigiron	11.4	78.9	21.6	27.4
Hot rolled steel	0.9	5.9	1.2	2.0
Cast and forged materials	0.0	0.0	3.0	0.2
Air conditioning equipment	0.0	0.0	5.9	0.0
Non wooden building	0.0	0.0	0.0	6.4
Electricity supply	15.4	6.2	33.8	16.0
Total	**78.8**	**91.1**	**65.5**	**57.9**

The 'gate factory' is the final factory in the supply chain for a construction product. The energy use in the gate factory is small compared with the total embodied energy, and therefore shows that the embodied energy of input materials into each gate factory should be estimated accurately.

EBC International Projects

Current Projects

Annex 5 Air Infiltration and Ventilation Centre
The AIVC carries out integrated, high impact dissemination activities with an in depth review process, such as delivering webinars, workshops and technical papers.
Contact: Dr Peter Wouters
E: aivc@bbri.be

Annex 51 Energy Efficient Communities
The project is specifically targeting local decision makers and stakeholders, who are not experts in energy planning. Guidance, case studies and a decision making tool are being produced to assist in implementing robust based approaches.
Contact: Reinhard Jank
E: reinhard.jank@Volkswohnung.com

Annex 52 Towards Net Zero Energy Solar Buildings (NZEBs)
The project is achieving a common understanding of net-zero, near net-zero and very low energy buildings concepts and is delivering a harmonized international definitions framework, tools, innovative solutions and industry guidelines.
Contact: Josef Ayoub
E: Josef.Ayoub@RNCan-NRCan.gc.ca

Annex 53 Total Energy Use in Buildings: Analysis and Evaluation Methods
Improved knowledge of the influence of different factors on energy use in buildings, particularly occupant behaviour, is essential to accurately assess short- and long-term energy saving measures, policies and technologies. The beneficiaries of the work are policy makers, energy services contracting companies, manufacturers and designers.
Contact: Prof Hiroshi Yoshino
E: yoshino@sabine.pln.archi.tohoku.ac.jp

Annex 54 Integration of Micro-generation and Related Energy Technologies in Buildings
A sound foundation for modelling small scale co-generation systems underpinned by extensive experimental validation has been established to explore how such systems may be optimally applied.
Contact: Dr Evgueniy Entchev
E: eentchev@nrcan.gc.ca

Annex 55 Reliability of Energy Efficient Building Retrofitting - Probability Assessment of Performance and Cost
The project is providing decision support data and tools concerning energy retrofitting measures for software developers, engineers, consultants and construction product developers.
Contact: Dr Carl-Eric Hagentoft
E: carl-eric.hagentoft@chalmers.se

Annex 56 Cost-Effective Energy and CO_2 Emission Optimization in Building Renovation
The project is delivering accurate, understandable information and tools targeted to non-expert decision makers and real estate professionals.
Contact: Dr Manuela Almeida
E: malmeida@civil.uminho.pt

Annex 57 Evaluation of Embodied Energy and CO_2 Emissions for Building Construction
The project is developing guidelines to improve understanding of evaluation methods, with the goal of finding better design and construction solutions with reduced embodied energy and related CO_2 emissions.
Contact: Prof Tatsuo Oka
E: okatatsuo@e-mail.jp

Annex 58 Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurements
The project is developing the necessary knowledge, tools and networks to achieve reliable in-situ dynamic testing and data analysis methods that can be used to characterise the actual energy performance of building components and whole buildings.
Contact: Prof Staf Roels
E: staf.roels@bwk.kuleuven.be

Annex 59 High Temperature Cooling and Low Temperature Heating in Buildings
The project aim is to improve current HVAC systems, by examining how to achieve high temperature cooling and low temperature heating by reducing temperature differences in heat transfer and energy transport processes.
Contact: Prof Yi Jiang
E: jiangyi@tsinghua.edu.cn

Annex 60 New Generation Computational Tools for Building and Community Energy Systems Based on the Modelica and Functional Mockup Interface Standards
The project is developing and demonstrating new generation computational tools for building and community energy systems based on the non-proprietary Modelica modelling language and Functional Mockup Interface standards.
Contact: Michael Wetter, Christoph van Treeck
E: mwetter@lbl.gov, treeck@e3d.rwth-aachen.de

Annex 61 Development and Demonstration of Financial and Technical Concepts for Deep Energy Retrofits of Government / Public Buildings and Building Clusters
The project aims to develop and demonstrate innovative bundles of measures for deep retrofit of typical public buildings to and achieve energy savings of at least 50%.
Contact: Dr Alexander M. Zhivov, Rüdiger Lohse
E: Alexander.M.Zhivov@erdc.usace.army.mil, ruediger.lohse@kea-bw.de

Annex 62 Ventilative Cooling
This project is addressing the challenges and making recommendations through development of design methods and tools related to cooling demand and risk of overheating in buildings and through the development of new energy efficient ventilative cooling solutions.
Contact: Per Heiselberg
E: ph@civil.aau.dk

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EBC

Energy in Buildings and Communities Programme

EBC Executive Committee Members

CHAIR
Andreas Eckmanns (Switzerland)

VICE CHAIR
Dr Takao Sawachi (Japan)

AUSTRALIA
Stefan Preuss
E:
Stefan.Preuss@sustainability.vic.gov.au

AUSTRIA
Isabella Zwerger
E: Isabella.Zwerger@bmvit.gv.at

BELGIUM
Dr Peter Wouters
E: peter.wouters@bbri.be

CANADA
Dr Morad R Atif
E: Morad.Atif@nrc-cnrc.gc.ca

P.R. CHINA
Prof Yi Jiang
E: jiangyi@tsinghua.edu.cn

CZECH REPUBLIC
To be confirmed

DENMARK
Rikke Marie Hald
E: rmh@ens.dk

FINLAND
Dr Markku J. Virtanen
E: markku.virtanen@vtt.fi

FRANCE
Pierre Hérant
E: pierre.herant@ademe.fr

GERMANY
Markus Kratz
E: m.kratz@fz-juelich.de

GREECE
To be confirmed

IRELAND
Prof J. Owen Lewis
E: j.owen.lewis@gmail.com

ITALY
Dr Marco Citterio
E: marco.citterio@enea.it

JAPAN
Dr Takao Sawachi (Vice Chair)
E: tsawachi@kenken.go.jp

REPUBLIC OF KOREA
Dr Seung-eon Lee
E: selee2@kict.re.kr

NETHERLANDS
Piet Heijnen
E: piet.heijnen@agentschapnl.nl

NEW ZEALAND
Michael Donn
E: michael.donn@vuw.ac.nz

NORWAY
Eline Skard
E: eska@rcn.no

POLAND
Dr Beata Majerska-Palubicka
E: beata.majerska-palubicka@polsl.pl

PORTUGAL
Prof Eduardo Maldonado
E: ebm@fe.up.pt

SPAIN
José María Campos
E: josem.campos@tecnalia.com

SWEDEN
Conny Rolén
E: conny.rolen@formas.se

SWITZERLAND
Andreas Eckmanns (Chair)
E: andreas.eckmanns@bfe.admin.ch

UK
Clare Hanmer
E: Clare.Hanmer@carbontrust.co.uk

USA
Richard Karney
E: richard.karney@ee.doe.gov

IEA Secretariat
Mark LaFrance
E: Marc.LAFRANCE@iea.org

EBC Secretariat
Malcolm Orme
E: essu@iea-ebc.org