SMART ENERGY REGIONS
SKILLS, KNOWLEDGE, TRAINING AND SUPPLY CHAINS

Editors: Jaume Roset Calzada, Ingrid Kaltenegger, Jo Patterson and Fabrizio Varriale.
Contents

Introduction to skills, knowledge, training and supply chains  

SKILLS, KNOWLEDGE AND TRAINING

Introduction and analysis of skills, knowledge and training  
Higher Education
An overview of the role of higher education in the implementation of low carbon technologies  
Interdisciplinary Master’s programme – Energy-efficient and Sustainable Building (MSc) at TUM, Munich  
Master of Architecture and Urbanism II “Green” architecture  
Development of training network for improving education in energy efficiency (ENERGy)  
MSc programme in Sustainable Architecture at NTNU  
Master’s programme: Sustainable Building (MSc) at Rzeszow University of Technology, Poland  
Education on energy efficiency in the building sector  
ZHAW Bachelor’s degree programme Energy and Environmental Engineering  
Welsh Energy Sector Training (WEST)  

Lifelong Learning
Introduction to Lifelong Learning  
PassiveHouse crafts(wo)men Courses – PHCC and PHCC PLUS  
Cap2020  
REGAIN  
The MODEL (Management of Domains related to Energy in Local Authorities) project in Bulgaria  
Sustainability assessment technical training ‘Whole life management of sustainable construction programme’  
Energy advice and promotion supports to community groups  
Expert in sustainable building  
ARCA Academy for Designers  
Building capacities in the construction sector – BUILDUP Skills  
Energy efficiency in buildings: The BUILDUP Skills project Malta  

Others
Introduction to the other case studies  
DELTHER  

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Buildings are responsible for 40% of energy consumption and 36% of CO2 emission in the EU. The construction sector in Europe represents 7.5% of total European employment (EFBWW, 2016). The application of low carbon technologies across Europe provides the opportunity to:

- reduce energy use and associated emissions in line with targets;
- increase stable employment markets through the employment in the manufacture, installation and manufacture of such technologies;
- improved living conditions and quality of life through investment in existing stock;
- increased energy security through local energy generation and storage.

Europe has well-developed Regions that, following EU definition, have varying levels of political power and have the potential to influence national government in a positive way. It is therefore important that tools that allow feedback between Regional and National government are developed to support change.

Figure 1 - Illustration of the Regions involved in the Smart Energy Regions COST Action (source: http://ec.europa.eu/eurostat/web/regions/statistics-illustrated)

In March 2012, the COST Action Smart Energy Regions (COST TU1104) began. The Smart Energy Regions COST Action involves 27 countries with specialists from disciplines including architects, engineers, planners and scientists covering a broad range of Regions across Europe. The Action takes a regional perspective on energy and the low carbon agenda, including the drivers that are being used to promote and encourage low carbon regions and also the barriers that are blocking progress.
This publication is part of a suite of outputs from the Smart Energy Regions COST Action investigating different aspects associated with implementation of the low carbon agenda at a regional scale.

An initial book produced in 2014 ‘Smart Energy Regions’ demonstrated how different policies are being implemented in European countries to provide an understanding of how low carbon technologies can be made appropriate and transferable within and between regions. The role of ‘cost and value’ is also being considered by Action members and looks at the role of cost and value in Environmental Design, Sustainable Retrofitting, Energy Systems and Technologies as well as Smart Energy Regions, touching on strategies for a top-down versus a bottom-up approach.

A task from the Smart Energy Regions COST Action has been to investigate good practice that have been used to enhance skills, knowledge, training and supply chains associated with energy and low carbon agenda at a Regional scale. 70 people from 27 countries have contributed to this investigation including researchers not directly involved in the Action.

**Low carbon technologies**

At product scale, a low carbon technology can be intended as any building material or component that delivers carbon savings by:

- having a lower embodied carbon than its conventional substitute (e.g. a timber beam instead of steel), and/or
- contributing to reduce the carbon emissions due to operational energy use, either by reducing the energy demand (e.g. double glazed windows) or by de-carbonising the energy supply (e.g. photovoltaic panels).

At building level, single LCTs are combined and integrate into a system to maximise carbon savings (e.g. a Passivhaus). The building can be connected and integrated at the urban level, allowing the delivery of additional carbon savings (e.g. district heating). Thus the concept of LCT can be extended from the building to urban scales to indicate components and systems which are able to reduce the carbon emission of the built environment.

**Skills, knowledge and training**

There is a large skills, knowledge and training shortage related to implementing low carbon technologies in the built environment. These include both generic and specific skills, from installing and maintaining technologies together with the management of long term planning and large-scale application. The decision to implement low carbon technologies is often made by an individual or group of senior managers on a design team without involving stakeholders who will be involved in installation, and long term operation and maintenance to ensure low carbon performance which can result in critical issues being overlooked.

Case studies have been collected from Regions involved in the Smart Energy Regions COST Action to demonstrate how the development of the expertise of stakeholders involved in the process of selection, installation and operation of low carbon technologies has taken place, and to what extent.

Three levels of skills and training have been investigated:

- Higher Education – University level training;
- Life-long learning – active workers upgrading skills, knowledge and training;
- other – for example, promotion of citizen’s participation, using bikes, etc.

Commitment and knowledge from management to technical levels have been evaluated, together with involvement of expertise from outside the traditional construction sector to develop skills necessary for the successful implementation of low carbon technologies.

Investigations into the training and education sector have been made to qualify and quantify existing skill requirements and to confirm provisions currently in place. This has helped to identify additional skills and training requirements and at what levels would be required to upgrade the necessary sectors to enable a large scale roll out of low carbon technologies. These could be stimulated particularly through Regional policy.

25 skills, knowledge and training case studies are presented. Ingrid Kaltenecker provides an overall overview and analysis of the skills, training and knowledge case studies. Elena Dimitrova and Aleksandar Krstic-Furundzic provide an overview and brief analysis the topics of Life-Long Learning (10 cases), Higher Education (8 cases), and ‘Others’ cases (7 cases).

**Supply chains**

The availability of components and materials are necessary to ensure large-scale roll out of low carbon technologies which is particularly relevant at a regional level to encourage a strong economy. Case studies have been selected to demonstrate supply chains involved in the implementation of low carbon technologies. These case studies take a range of different perspectives – low carbon materials, technologies, and the role of the supply chain in projects that combine technologies in both retrofit and new build projects.

Supply chain case study investigations have looked at material and component selection, detail of design, timescales involved with provision and installation, source of manufacture and raw materials, embodied energy, quality, maintenance and cost. The case studies illustrate how businesses within the low carbon technology supply chain can be strengthened and supported further. Flexibility and adaptability of the process has been considered to identify how much design can be modified to accommodate technologies and at what stage this can occur.

The Introduction to 23 supply chains case studies is presented by Jo Patterson and Fabrizio Varriale who also provide an analysis and discussion on the supply chain case studies.

The case study material has been collated between 2013 and 2015. The case studies present ‘common features’ whilst explaining logical and contextual differences. The skills and training investigations dealt with people, and for the supply chains the focus has been on materials. The important factor is that knowledge links the two and the need for interaction and understanding between the different stakeholders groups involved in the application of low carbon technologies. The potential for low carbon technologies to be implemented at a regional scale is significant and policy relating to skills, training and supply chains can be used to stimulate this at the regional scale. There are benefits of working a regional scale, and these should be enhanced. Regions allow for contextual factors to be considered and therefore provide a beneficial geographical scale to work at. Regions should generate strong links to stimulate exchange of knowledge and good practice to encourage the uptake of low carbon technologies further.

**References**


Introduction and analysis of skills, knowledge and training

Author
Ingrid Kaltenegger
Ingrid.kaltenegger@joanneum.at
Joanneum Research, Austria

Introduction

Already many low carbon technologies exist and are being implemented at all different scales – from small individual buildings to large-scale dwellings – in new buildings as well as in retrofitting. Nevertheless barriers still exist and more projects and programmes could be implemented if there wasn’t a certain shortage of skills, knowledge and training in a broader sense, from installation and maintenance of technologies to the management of long-term planning and large-scale application. The aim of this overview is to provide a summary of different types of education and training opportunities, which are already in place in countries that are participating in this COST Action and to identify gaps where and at what levels more education and training would be required to upgrade the necessary sectors to enable a large scale roll out for low carbon technologies.

All members of the COST Action were asked to provide case studies and 22 countries are represented in this section of this book, 2 cases each coming from Belgium, Greece and Italy, being 25 cases in total. This collection of case studies is more about dissemination and sharing of examples, as the countries vary significantly in culture, politics, history and other parameters, which does not make a strict comparison meaningful and useful.

A template was designed and sent out to all members to unify the information and make the content of the cases as consistent as possible. Within the case studies the following topics were addressed:

- for which stakeholders was the training delivered;
- which knowledge/tools were used (e.g. meetings, training – courses, etc.);
- at which scale was the training delivered (e.g. regional, national, etc.);
- in which area (building, transport)?;
- comments and conclusions.

The findings of the case analysis are presented in the following sections in more detail.

Overview of the case studies

When analysing the cases in a first round, it became obvious that it was necessary to further classify the cases to cope with the different parameters of each case. The three categories that were chosen are:
- Higher Education (HE);
- Life Long Learning (LLL); and
- Others.

More detailed information on these three categories and case studies are provided in the introductions to the categories. Table 1 provides an overview on all of the case studies on skills, knowledge and training, listing only the main stakeholders and tools used. More detailed information can be gained from the case studies themselves. All content has been provided by the members of the COST Action and their associates named in each case study.

This collection of case studies does by no means reflect the whole spectrum of different kinds of education and training programmes and initiatives available throughout Europe and Israel but gives a good cross-section of the portfolio. The collection also shows that most cases are, as a matter of fact, on buildings, often closely related to energy management and energy efficiency. Fewer cases are on mobility and transport, which also include behaviour change. The case studies are quite diverse in terms of stakeholders. The following chapters provide an overview of the characteristics of the skills, knowledge and training case studies.

Table 1 - Overview of case studies

<table>
<thead>
<tr>
<th>Country</th>
<th>Cat.</th>
<th>Name of case study</th>
<th>Main stakeholders</th>
<th>Main tools</th>
<th>Scale</th>
<th>Main topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>LLL</td>
<td>Passive House craftsmen course (PHCC)</td>
<td>Craftsmen</td>
<td>Exercises, training workshops, on-site trainings, e-learning, handbook</td>
<td>Regional &amp; cross-border</td>
<td>Buildings (envelope and systems)</td>
</tr>
<tr>
<td>Belgium</td>
<td>LLL</td>
<td>CAP2020</td>
<td>Companies, research units, training institutions, public authorities</td>
<td>Newsletter, social media, website, events, site visits, decision-maker lunch, conferences and seminars, internal working groups, database</td>
<td>Regional</td>
<td>Buildings</td>
</tr>
<tr>
<td>Bosnia and Herzegovina</td>
<td>OTH</td>
<td>DELTER</td>
<td>Ministries</td>
<td>Demonstration projects, newsletter, webpage, TV, reports</td>
<td>Regional, national</td>
<td>Buildings (mainly energy efficiency)</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>LLL</td>
<td>MODEL (management of Domains related to Energy in Local Authorities)</td>
<td>Local authorities</td>
<td>Training courses, events (e.g. energy days for public)</td>
<td>International, national and local</td>
<td>Energy planning and management</td>
</tr>
<tr>
<td>Cyprus</td>
<td>LLL</td>
<td>Sustainability assessment technical training</td>
<td>Consultants, developers, contractors, teachers, students, government officers</td>
<td>Half-day sessions, special software, presentations, break-out sessions, manuals, e-learning tool</td>
<td>National</td>
<td>Holistic approach in sustainable construction</td>
</tr>
<tr>
<td>Denmark</td>
<td>OTH</td>
<td>Copenhagen biking</td>
<td>Citizens</td>
<td>Trainings, campaigns, course materials, online education</td>
<td>Local, regional, national</td>
<td>Behaviour, Mobility</td>
</tr>
<tr>
<td>Finland</td>
<td>OTH</td>
<td>ILMANKOS (Working together for the climate)</td>
<td>Citizens</td>
<td>Thematic workshops, local actions, trips, projects, leaflets, forums for participation</td>
<td>Local and regional</td>
<td>Every day living, travelling, food, shopping, waste</td>
</tr>
<tr>
<td>Germany</td>
<td>HE</td>
<td>Interdisciplinary Master’s programme “Energy-efficient and Sustainable Building”</td>
<td>Graduates in architecture, civil and environmental engineering</td>
<td>Interdisciplinary, lectures, exercises, excursions, work placements, seminars, and projects</td>
<td>National, international</td>
<td>Buildings</td>
</tr>
<tr>
<td>Country</td>
<td>Cat.</td>
<td>Name of case study</td>
<td>Main stakeholders</td>
<td>Main tools</td>
<td>Scale</td>
<td>Main topic</td>
</tr>
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</tr>
<tr>
<td>Greece</td>
<td>OTH</td>
<td>Bike to Work</td>
<td>Citizens, resp. employees</td>
<td>Contest, competition</td>
<td>Regional</td>
<td>Behaviour (Mobility)</td>
</tr>
<tr>
<td></td>
<td>OTH</td>
<td>Integrated Waste Management</td>
<td>Companies, residents</td>
<td>Information material, website, social media, school visits, trainings</td>
<td>Regional</td>
<td>Behaviour (Waste)</td>
</tr>
<tr>
<td>Hungary</td>
<td>OTH</td>
<td>Energy efficient and environmental friendly villages</td>
<td>All inhabitants</td>
<td>Traditional technologies refreshed and extended with new technologies</td>
<td>Local and regional</td>
<td>Buildings (mainly energy efficiency)</td>
</tr>
<tr>
<td>Ireland</td>
<td>LLL</td>
<td>Energy Advice &amp; Promotion Supports to Community Groups</td>
<td>Community groups, citizens and enterprises</td>
<td>Information evenings for citizens, certificates, mentoring of enterprises, studies</td>
<td>Regional</td>
<td>Energy sector</td>
</tr>
<tr>
<td>Israel</td>
<td>HE</td>
<td>Master of Architecture and Urbanism III - Green Architecture</td>
<td>Undergraduate students in architecture or town planning from the TECHNION or with equivalent degree</td>
<td>Research-based design studio courses, study trips, field visits, lectures, seminars, tools</td>
<td>National and international</td>
<td>Buildings</td>
</tr>
<tr>
<td>Italy</td>
<td>LLL</td>
<td>Expert in sustainable building</td>
<td>Artisans in the building sector</td>
<td>Complex training courses, lectures, exercises, practical examples software, workshops, discussions</td>
<td>Regional (province of Trento), further developed during the European project ENERBUILD</td>
<td>Buildings - energy efficiency</td>
</tr>
<tr>
<td></td>
<td>LLL</td>
<td>ARCA Academy for Designers</td>
<td>Main operators of the timber construction chain: designers</td>
<td>Lectures, practical applications, workshops, problem-based learning, software, real case studies</td>
<td>National</td>
<td>Buildings (architecture, materials, systems, etc.)</td>
</tr>
<tr>
<td>Latvia</td>
<td>HE</td>
<td>Development of Training Network for Improving Education in Energy Efficiency* (ENERGY)</td>
<td>Students, academics and teaching staff at 7 universities in Non-EU countries</td>
<td>Management meetings, workshops, IT platform under development, experience exchange among partners, development of course material;</td>
<td>International (transfer of knowledge from EU to Belarus, Kosovo, Azerbaijan</td>
<td>Energy efficiency</td>
</tr>
<tr>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Former Yugoslavian Republic (FYR) of Macedonia</td>
<td>LLL</td>
<td>BUILDUP Skills – Macedonia</td>
<td>Ministries, the Energy Agency of Macedonia, University Educational institutions, Economic Chamber of Macedonia, etc.</td>
<td>State-of-the-art analysis of laws and qualifications needed, certification scheme for workers consists of theory and practice classes and an exam, courses and seminars, work in construction companies</td>
<td>National (also in other countries in Europe)</td>
<td>Building Industry</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Country</th>
<th>Cat.</th>
<th>Name of case study</th>
<th>Main stakeholders</th>
<th>Main tools</th>
<th>Scale</th>
<th>Main topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malta</td>
<td>LLL</td>
<td>BUILDUP Skills – Malta</td>
<td>Public and private stakeholders, Building Industry Consultative Council</td>
<td>Analysis of EU policy documents, identify competences needed, evaluation, recommendations</td>
<td>National (also in other countries in Europe)</td>
<td>Building Industry</td>
</tr>
<tr>
<td>Norway</td>
<td>HE</td>
<td>MSC programme in Sustainable Architecture</td>
<td>Bachelor Students in Architecture, Engineering or Urban Planning.</td>
<td>University lectures and courses, design projects, research projects, laboratory analysis at a research centre, one semester abroad is advised</td>
<td>National and international</td>
<td>Buildings</td>
</tr>
<tr>
<td>Poland</td>
<td>HE</td>
<td>Master’s programme on Sustainable Buildings</td>
<td>Master students</td>
<td>Mandatory and elective courses, lectures, exercises, excursions, seminars and projects, software</td>
<td>National, as the program is only in Polish</td>
<td>Buildings</td>
</tr>
<tr>
<td>Serbia</td>
<td>HE</td>
<td>Education on energy efficiency in the building sector</td>
<td>Architects and master students – 2 different courses</td>
<td>Lectures, discussions, workshops, meetings, round tables, studio design projects</td>
<td>National, regional and local</td>
<td>Buildings (mainly energy efficiency)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>OTH</td>
<td>Energy education and awareness raising for different target groups</td>
<td>Local population (pupils, teachers, municipality staff, employees of private companies)</td>
<td>Workshops and lectures for smaller target groups, broader campaigns and conferences for wider targeted groups, practical work (learning by doing)</td>
<td>Local and regional</td>
<td>Behaviour, energy efficiency and sustainable mobility</td>
</tr>
<tr>
<td>Switzerland</td>
<td>HE</td>
<td>ZHAW Bachelor’s degree “Energy and Environment Engineering”</td>
<td>Bachelor students</td>
<td>Lectures, group teaching, exercises, laboratory work</td>
<td>National and international</td>
<td>Energy, environment engineering</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>HE</td>
<td>The WEST Programme</td>
<td>Everyone who is looking to update their skills and obtain training on a new technology</td>
<td>Traditional face-to-face learning. E-learning, accreditation, experience exchange</td>
<td>Regional</td>
<td>Energy sector</td>
</tr>
</tbody>
</table>
Stakeholders

Most cases comprise more than one stakeholder group; the biggest groups that are addressed are students and craftsmen, followed by citizens. This is due to the fact that most emphasis was laid on the building sector, where planning and implementation are very important. Citizens are the biggest stakeholder group in all cases where the main issues are information distribution and behaviour change.

Knowledge and tools

The different kinds of tools that are used to transfer knowledge and educate and train people were analysed and by far most commonly used tool are training courses in different forms (modular, standard and advanced courses), followed by e-learning platforms and information distribution, including websites and leaflets. Other tools like events and campaigns were used in the case studies, mainly in the those categorised as “Others”, which are aimed at citizens, including wide ranges of population, from children to older people as well.

Scale and topic

Most of the cases are on a regional basis, especially the ones that were considered as Life Long Learning cases. One of these cases was classified as national but at the same time was a cross-border case between Austria and Hungary. National and International cases were not always easy to distinguish for example, master programmes at universities are based in a country, therefore being national but by accepting foreign students also being international. Two “truly” international cases were the ones from Malta and Macedonia, the BUILDUP Skill cases, an EU project running in several European countries, but also the case of Latvia, that even goes beyond EU.

Cases aimed at all citizens or special groups therein (e.g. children) are mostly based on a regional or even local level, bringing together people from one city or district.

One case in Italy was started as a regional initiative but got international recognition and in the case in Bulgaria, the activities were set at three levels: the exchange of experience, training and events took place at the European level, the support for the pilot cities by training and information was done on a national level and various practical activities were organised at the local level in pilot municipalities.

Most of the cases are placed in the building sector, followed by a few cases in the mobility and transport sector. The area energy use/saving was foreseen in the template as separate option but in most cases this topic is closely related to the building sector and was quite hard to distinguish from that. Behaviour (change) was the aim in more or less all cases classified as “Others”.

The following graphs try to illustrate the clusters and also gaps of education and training activities by showing the relationship between the different topics.

Figure 1 shows that most cases in the building area are on a national basis, followed by a more regional approach. Mobility and energy topics are more dealt on a regional basis, and training and events to change people’s behaviour take place mostly on a national and regional level. From the selection of cases in this book, all areas can be found on the regional level, whereas on EU level, only one case on energy could be detected.

Figure 2 shows that the education and training offered for craftsmen are mostly at a national or regional level, those citizens are also in most cases on a regional level. Universities/student programmes are mostly at an international level, meaning that students from other countries are accepted. For citizens as well as for teachers and children, the main scale on which education and training is provided is the regional or local level.

Training courses and analysis are mostly used on a national level, whereas information distribution is done mostly on a regional level, together with training days and seminars. The graph shows that the different tools are quite widespread throughout all scales, from local to EU level.
that in some areas or scales programmes and project are missing but maybe that the means to educate and train people are different in many ways, depending on the country, culture, politics, etc.

A collection of good practice is presented, illustrating how skills, knowledge and training are successfully transferred in different countries but they are also meant to give incentives to find different ways and try something new. The cases studies provided by the partner countries of this COST Action foster an exchange of know-how and ideas with the purpose to enable a large scale roll out for low carbon technologies in the (near) future.

Figure 5 - Which tools for which stakeholders?

Figure 4 shows that in the building area training courses are most often used but they also seem to be a quite appropriate tool in all other areas to pass on skills and knowledge. Workshops are also a good tool to educate people in the building sector. Information distribution, provided by different means like webpages, etc. is also quite often used. In general, it can be noted that for the building sector all different means of knowledge transfer are used.

In Figure 5 it can be see that in the building area training courses are offered for many stakeholder groups, for craftsmen, student, authorities but also for citizens. Information distribution via different channels is the most appropriate tool to reach citizens.

Conclusions

All the case studies collected relating to skills, knowledge and training show that learning is manifold and taking place on different levels. Case studies were meant to help identify the clusters and gaps of education and training programmes. But gaps don’t necessarily mean

An overview of the role of higher education in the implementation of low carbon technologies

Characteristics of Higher Education on energy efficiency in the building sector

This overview of the role of higher education in the implementation of low carbon technologies in the building sector is based on the case studies of the following European countries participating in COST Action Smart Energy Regions: Germany, Israel, Latvia, Norway, Poland, Serbia, Switzerland and United Kingdom. Participation of countries from the Western, Central, Northern and South-eastern Europe, and the Middle East, can be noted.

Through the analysis of the case studies it can be noticed a serious approach to higher education in energy efficiency that is present at different levels of the education process, which indicates that it is treated as a continuous educational process.

The sample of the case studies gives good insight into the strategies of the educational processes in the energy efficiency field in Europe. The case from Latvia demonstrates a multi-national approach.

The project aims to develop mutually recognised curricula in the directions of enhancement of energy efficiency, energy saving, energy effective materials and use of renewable sources, as well as to enhance networking among higher education institutions across the EU member states and non-EU countries for improving education in the field of the energy efficiency.

The necessity to transfer technical knowledge from higher education and research institutions to practitioners has resulted in practice-oriented training programmes, like The Welsh Energy Sector Training (WEST) programme which is based on a partnership between six Welsh universities. The training programme was aimed to deliver knowledge and skills on the five themes: Low Carbon Built Environment; Hydrogen; Marine; Solar Photovoltaic; Large
Designing energy efficient buildings and applying low carbon technologies and advanced building concepts requires an integrative approach supporting the design of integral concepts for energy-efficiency and sustainability, taking into account the aesthetic, social, economic, ecological, functional, technical, and climatic requirements. In this respect it should be mentioned that the Master’s Programme “Energy-Efficient and Sustainable Building” at TUM, Munich, involves the joint project in which the interdisciplinary team of students, coming from the field of architecture, civil and environmental engineering as well as building technology and services, study current problems in science and industry.

### Professional opportunities

Possible fields of professional work depend on the scope and content of specific programmes, but mainly include design and engineering offices, construction companies and research institutions, as well as governmental, regional and municipal administrations on a national and international level.

In the case of the Tempus project “Development of Training Network for Improving Education in Energy Efficiency”, which is coordinated by Riga Technical University, Latvia, the main stakeholders are the project partners from universities from EU and non-EU countries, who modernise academic programmes in the topic of energy efficiency.

Industry stakeholders have been observed as interested in training programmes, but flexible training to adapt to the targeted professionals and their requirements in terms of location and time are of crucial relevance. In that sense WEST staff conducted inquiries to education and industry stakeholders in Wales in order to identify the gaps in education and practical skills which hinder the progress of the low carbon agenda.

### Programmes context

Titles of programmes are similar and usually refer to energy-efficient architecture, sustainable building, sustainable architecture or green architecture. The majority of programmes are open to national and international students. For international students lectures are usually in English. The programmes are divided into mandatory and elective modules, which combine lectures, exercises, excursions, work placements, seminars, and projects. Continuous assessment is a feature of all the programmes, modules and courses.

The study programmes are based on a combination of theoretical and practical courses. Of particular significance practical courses include advanced research-based design studios. The advantage of such programmes is that students gain theoretical and practical background required to design buildings according to the proper norms and regulations. The lecturers are usually professors, experienced practitioners and consultants in companies. Different tools are in use for different courses. For education at universities it is usually ex-cathedra lectures, discussions, project based education and workshops. Laboratory packages and workshops let the students train and develop their abilities in computer-based energy modelling.

Scale Power Generation. The next step was the development of a Masters in Research (MRes) programme at the Welsh School of Architecture in Cardiff University intended to enable a more efficient transfer of knowledge from research to practice, thus contributing to the progress of the low carbon agenda in Wales.

Generally, it can be noticed that bachelor, masters and PhD degrees are available where most programmes promote interdisciplinary studies in the area of energy efficiency and sustainability in the built environment. Some programmes include a few categories of specialisation. The bachelor’s degree programme “Energy and Environmental Engineering” at ZHAW Zurich University of Applied Sciences enables students to select one of three specialisations in the third year of studies:
- Renewable Thermal Energies;
- Renewable Electric Energies;
- Environment and Sustainability.

The interdisciplinary master’s programme “Energy-Efficient and Sustainable Building” at TUM, Munich, offers five options for specialisation:
- architecture, City, and Landscape;
- building Services Engineering and Renewable Energy;
- building Physics and Energy-Efficiency;
- building Technology and Life Cycle Engineering;

This reflects the convergence and interaction of the different disciplines. The interdisciplinarity is the characteristic of the majority of programmes because energy efficiency in building sector involves knowledge and skills from different technical disciplines, but also including ecological, economic and social aspects.

When considering the process of creating the programme, cooperation with relevant institutions can be noticed, as in the case of the MSc programme in Sustainable Architecture at Norwegian University of Science and Technology-NTNU in Norway, which is developed in collaboration with the interdisciplinary Research Centre on Zero Emission Buildings-ZEB, ensuring contact with state-of-the-art research and practice in Norway. During the two years students at NTNU are involved in research projects and laboratory analyses at the ZEB research centre as part of their curriculum.

The skills, knowledge and training received through bachelor’s and master’s degree enable students to upgrade their knowledge through the specific specialist or PhD studies. In some countries, such as Serbia, in addition to academic programmes, education in the field of energy efficiency is organised by the chamber of engineers giving the opportunity to different professionals to get licensed as experts in this field.

With regard to the specific features, similarities and differences, the Higher Educational programmes have been summarised for each region:

- **The Faculty of Civil Engineering and Surveying and the Faculty of Architecture at the Technische Universität München (TUM), Germany, has offered an interdisciplinary Master’s Programme in Energy-Efficient and Sustainable Building since October 2011. This programme promotes interdisciplinary studies in the area of energy-efficiency and sustainability in the built environment. It focuses on designing with ecology and energy in mind, as well as on economic, social, technical, and process-oriented aspects of construction. Five options for specialisation are offered.**
- **The Faculty of Architecture and Town Planning at the Technion, Israel, offers Master of Architecture and Urbanism II – “Green Architecture”. The objective of the programme, which started in 2010, is to expand and enrich the professional knowledge base of architects and their role in the design process, or in other professional positions related to the topic of sustainable design, green architecture, and low carbon technologies.**
- **Riga Technical University, Latvia, since 2012 coordinates the Tempus project “Development of Training Network for Improving Education in Energy Efficiency” initiated by 14 partners from 9 EU and non-EU countries. The project aims are modernisation of curricula in the field of energy efficiency and enhancement of networking among higher education institutions participating in the project. The project is still running and each day brings new experience.**
- **The MSc programme in Sustainable Architecture at NTNU, Norway, aims at educating and training students in the use and development of competitive technologies.**
methods and solutions for lowering greenhouse gas emissions from the built environment. The programme was initiated in 2010 and developed in connection to the interdisciplinary Research Centre on Zero Emission Buildings-ZEB. Students are directed towards the development of integrated design strategies in order to solve environmental, functional and construction issues in a holistic way.

- The Faculty of Civil and Environmental Engineering and Architecture at the Rzeszow University of Technology, **Poland**, offers a Master’s Programme in Sustainable Building since October 2010. The interdisciplinary character of the course, joining housing construction, architecture and environmental engineering, allows the students to easily approach the subjects of eco-building and urban housing.

- At the Faculty of Architecture, University of Belgrade, **Serbia**, since 2006 at the level of Master studies, Master module Architectural Technologies – Architectural constructions, materials and building physics, students interested in the area of energy efficiency in building sector may choose several elective modules, seminars and studio design projects. The specialist studies “Energy-efficient and green architecture” was organised by the Faculty of Architecture, University of Belgrade in October 2012. Also, education in the field of energy efficiency is organised by the Serbian chamber of engineers.

- ZHAW Zurich University of Applied Sciences, **Switzerland**, offers the Bachelor’s degree programme Energy and Environmental Engineering since 2012. It is offered as a practice-integrated course. The study programme provides fundamental knowledge ranging from industrial thermal processes to electrical systems. A basic understanding of economic processes and sustainable development is equally important. In the third year of studies students focus on one of three specialisations they can select.

- The Welsh Energy Sector Training (WEST), a pilot training programme, was led by a **UK** team of researchers based at the Welsh School of Architecture in Cardiff University. WEST programme is aimed at the transfer of knowledge from the Higher Education sector to the industry and to help the uptake of new technologies developed through the Low Carbon Research Institute (LCRI). The programme was available only in the Convergence areas of Wales and run from September 2011 to February 2015. Both the LCRI and WEST are based on partnerships between six Welsh universities: The School of Engineering at Cardiff University, the University of South Wales, Glyndŵr University, Swansea University, and Swansea Metropolitan University. The majority of training focused on Low Carbon Built Environment (LCBE). Development of the pilot WEST – Low Carbon Built Environment (LCBE) training included the establishment of the Master in Research (MRes) programme at the Welsh School of Architecture (WSA) in Cardiff University. Currently the WSA offers five programmes of Masters in Science (MSc) related to LCBE research themes-modules: Low carbon building design; Building envelope; Energy generation and storage; Building monitoring and Low carbon urban scale design.

**Conclusions**

Most programmes associated with the implementation of low carbon technologies in the higher education sector started in the last 5 years, with continuous improvement taking place. Orientation to interdisciplinary studies and programmes with multi-disciplinary approach can be seen. This approach promotes the understanding that sustainable building as an interdisciplinary intersection between architecture, city and landscape, environment and infrastructure, and resources and energy in a national and international context. It closes the gap between traditional building engineers/architects and environmental engineers. The driving force of the development of education on energy efficiency in the building sector is that students are challenged to combine artistic and technical skills in their work, while concern for the environment is becoming a creative inspiration for the design of new architectural achievements. Such education increases the opportunities in a dynamically developing business field, both on a national and on an international level.

To enhance the quality and relevance of higher education it is important to bring together education excellence and best practice in the field of the energy efficiency enhancement, energy saving and use of renewable energy sources. Higher education will develop sustainable educational and human links between target groups. According to this, it is necessary to enhance networking among higher education institutions across the EU member states and non-EU countries.
Interdisciplinary Master’s programme – Energy-efficient and Sustainable Building (MSc) at TUM, Munich

Author
Werner Lang
w.lang@tum.de
Technische Universität München, Germany

Energy-Efficient and Sustainable Building

The Faculty of Civil Engineering and Surveying and the Faculty of Architecture at the Technische Universität München, Germany (TUM) offers an interdisciplinary Master’s Programme in Energy-Efficient and Sustainable Building since October 2011 for graduates of a 3-years BA or BSc study in architecture, civil engineering, environmental engineering, mechanical engineering or supply engineering. The master’s Programme is open to all national as well as international students. The language used in teaching at the moment is in most cases German, in some special courses also English. From 2017 onwards, all courses will be taught in English.

The aim of this programme is to promote interdisciplinary studies in the area of energy-efficiency and sustainability in the built environment. It focuses on designing with ecology and energy in mind, as well as on economic, social, technical, and process-oriented aspects of construction.

The interdisciplinary Master’s Programme is intended for graduates from the fields of Architecture, Civil Engineering and Environmental Engineering, as well as suitably qualified graduates from comparable programmes, who are instructed in the specific subject areas according to their prior knowledge.

The programme is characterised by interdisciplinary instruction of required skills in the area of energy-efficient and sustainable building. The content is taught in an integrative manner highlighting the relationships and synergy effects which are required for an effective implementation of energy-efficient and sustainable building.

In view of the scope of the topics, five options for specialisation are offered, which reflect the convergence and interaction of the different disciplines:

- Architecture, City, and Landscape;
- Building Services Engineering and Renewable Energy;
- Building Physics and Energy-Efficiency;
- Building Technology and Life Cycle Engineering;

Upon successful graduation from this Master’s Programme at the Technische Universität München, the students are awarded the title “Master of Science (M.Sc.) in Energy-Efficient and Sustainable Building”.

Programme content

Proceeding in an interdisciplinary manner, the programme imparts knowledge and skills related to engineering while factoring in ecological, economical, and social aspects. Integral building with a focus on energy-efficiency and sustainability is at the heart of the programme.

Networked and system-oriented thinking is called for, particularly due to the complexity of mutually influential and interacting factors. This includes fundamental principles in specific fields, such as resource scarcity, energy-efficiency, regenerative energy, new construction materials, material efficiency, life cycle analysis, and costs, etc. Drawing on existing knowledge, methodical skills are developed in order for students to be able to develop independent, project-specific solutions in the area of energy and sustainability in the built environment and to apply common assessment procedures.

The content is taught in an integrative manner highlighting relationships and synergy effects, which are required for the effective implementation of energy-efficient and sustainable planning, building, operation, and demolition.

Professional opportunities

The possible fields of professional work include design and engineering offices, construction companies and research institutions as well as governmental, regional and municipal administrations on a national and international level, for example:

- consulting and planning services for energy-efficient and sustainable building, design, operation, and demolition;
- life cycle oriented assessment of construction processes and structures in consideration of ecological and economic aspects;
- coordination of projects and specialised designers/expert consultants during sustainability processes and integral planning of cities and infrastructure;
- provision of spatial-structural solutions in consideration of architectural, climatic, and energetic aspects;
- provision of new technical and constructive solutions for energy-efficient and sustainable settlements and buildings with regard to the necessary infrastructure for energy supply, water supply and disposal, and means of transport;
- application of design instruments to establish and assess energetic and ecological footprints, life cycle costs, and quality of sustainable settlements and buildings;
- design services for new buildings and renovation of energetically, ecologically and economically optimised settlements and buildings in consideration of social aspects;
- design services to maintain and renew structures, focusing on subjects such as environmental, building energy, management of material and resources (e.g. recycling and disposal of construction material), as well as revitalisation and renewal of cities;
- consulting services for the optimisation of operational procedures of sustainable real estate development and management.

Students select four of the five areas of specialisation before embarking on their studies. This individual selection will determine the combination of compulsory modules to be taken. The mentors advise students on their choice of specialisations and elective modules, thereby striving to ensure the quality of each schedule.

The Master’s Programme is designed to offer a maximum degree of choice and freedom to pursue personal interests and ambitions during the studies. Regardless of the module combination chosen, the quality of the education offered is guaranteed.

Interdisciplinary project

In the joint project, the interdisciplinary team of students, coming from the field of architecture, civil – and environmental engineering as well as building technology and services will study...
current problems in science and industry. The project deals with subjects that reflect the complexity of sustainable and energy-efficient planning and development of independent and project-specific solutions in the built environment. Particular emphasis is placed on exploring the intersection between ways of thinking and approaching the subject in different disciplines. The understanding gained and the discussions form the basis for sustainable planning. This project straddles the five specialisations and will be treated as an integral subject. At the same time, it will contribute to the development of individual interests through in-depth work on particular aspects.

The project definition is announced at the beginning of the second semester. Each team works on particular aspects. The individually investigated areas are embedded in the overarching context of the subject through joint meetings with the mentor, and also through interim presentations.

Just as the Master’s Programme as a whole, the project is based on an interdisciplinary approach, supporting the design of integral concepts for energy-efficiency and sustainability, taking into account the aesthetic, social, economic, ecological, functional, technical, and climatic requirements.

The project clearly identifies the criteria, indicator systems and planning tools of sustainable building, and allows for the application of technical knowledge as well as the assessment tools in the area of an integral building assessment. Students must recognise the ecological, but also the often crucial economic need for considering a building from a perspective which encompasses the entire life cycle, from the extraction of raw materials to the demolition, recycling and re-use. This involves understanding, controlling, and integrating all project stakeholders, implementing the strategies of sustainable building in the integral planning, and also assessing aspects which are relevant in particular local, regional, or national frameworks and defining feasible results.

What is gained from this degree?

The interdisciplinary Master’s Programme promotes a targeted building of the student’s profile and offers a wide range of qualifications and skills:
- designing architecture which meets aesthetic, social, economic, ecological, technical, energy-related, and climatic requirements;
- understanding regional and urban planning, and landscape design and understanding infrastructural planning;
- analysing general sustainability criteria such as population density and settlement structures, and the resulting use of resources such as energy, water, and air;
- assessing the relationship between humans, buildings, the environment, and infrastructure at different scales;
- evaluating structural, constructive, physical, and scientific relationships in the built environment;
- planning physical relationships and technologies while considering comfort requirements, indoor climate, and climate impact, as well as the necessary air conditioning systems and technologies;
- distinguishing between the fundamental terms of building aerodynamics and flow simulations, as well as different simulation models and their impact variables;
- monitoring rights and regulations, procedures for practical realisation and implementation;
- leading and integrating the project stakeholders and implementing the potential roles in integrated planning;
- evaluating built environment heritage and the issue of preservation, renovation, valuation, and integration of the building stock as a resource;
- characterising the impact of cultural, social, political, and economic developments and their interaction;
- recognising the criteria and indicator systems, and planning instruments of sustainable building, and implementing the assessment tools for an integral evaluation of buildings;
- understanding energy-efficiency and sustainability requirements in the construction industry;
- understanding relevant content from philosophy, political science, and ethics;
- determining ecological sustainability for designs and concepts to reduce the energy and resource consumption and the environmental impact;
- modifying typical and energy-efficient concepts for buildings using renewable energy and basics for ecological and economic assessment;
- coordinating engineering and technology implications, innovative developments, and the results of the latest research;
- assessing knowledge about building construction, materials, provision and disposal, as well as building and fire protection technology;
- evaluating life cycle rating, risk assessment score and structural reliability;
- assessing life cycle costs and the basics of life cycle assessment and material cycles;
- life cycle oriented assessment of building processes, from design and realisation to demolition and recycling, taking the aspects of ecology, economy, and social acceptability into consideration;
- understanding materials, use, properties, and construction;
- demonstrating building cost planning and control;
- organising the operation of the real estate economy, financial relationships of investments in real estate and facility management;
- coordinating property valuation and development;
- understanding the market mechanisms and their impact on the built environment;
- monitoring project control, project development, and project management.

The Master’s Programme in Energy-Efficient and Sustainable Building strives to provide students with many skills and qualifications which will serve to grasp far-reaching integrated relationships and knowledge of all aspects of sustainable building, which control the sustainability processes as an interdisciplinary intersection between architecture, city and landscape, environment and infrastructure, and resources and energy in a national and international context.

Besides academic qualifications and technical skills, so-called soft skills are promoted and challenged in order to advance personal development:
- conducting independent scientific work;
- applying autonomous, problem-oriented, and structured methods and ideas;
- grasping integral relationships;
- developing project specific solutions;
- ability to work in a team, social and communicative competence, and leadership qualities;
- implementing time and stress management;
- presentation techniques and the accompanying body language;
- ability to clearly present and convey complex facts orally, in writing, in graphics, and in digital form in both German and English;
- formulating a judgment and your own opinion and perception.

New opportunities

The knowledge and skills taught enable the graduates of the Master’s Programme to apply their acquired technical knowledge in a leading position as integrated members in an established field of engineering in order to develop and realise especially energy-efficient and sustainable settlements, infrastructure systems, or construction projects.

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**Figure 1 - Structure of the programme**

| Master in energy and efficient and sustainable buildings | | | | | |
| --- | --- | --- | --- | --- | |
| Architecture, city and landscape | Building, services engineering and renewable energies | Building physics and energy efficiency | Building technology and life cycles engineering | Real Estate development, value assessment and life cycle costs | 72 1. -3 |
| Interdisciplinary project | 9 2/3. | | | | |
| Elective course | 9 1. -3 | | | | |
| Master’s thesis | 30 4. | | | |
With this programme, a new, independent occupational field is created which closes the gap between the traditional civil engineer/architect and the environmental engineer, and increases the opportunities in a dynamically developing business field, both on a national and on an international level.

**Participating institutes**

- Institute of Energy-Efficient and Sustainable Design and Building, Prof. Dr.-Ing. Werner Lang
- Institute of Building Climatology and Building Services, Prof. Dipl.-Ing. Thomas Auer
- Institute of Building Physics, Prof. Dr.-Ing. Klaus Sedlbauer
- Chair of Timber Construction and Structural Design, Prof. Dr.-Ing. Stefan Winter
- Chair of Construction and Real Estate Management, Prof. Dr.-Ing. Josef Zimmermann

**Academic counselling**

Director of the Institute of Energy-Efficient and Sustainable Design and Building: Prof. Dr.-Ing. Werner Lang

**Contacts**

Dipl.-Ing. Katja Schwering
master.enb'tum.de
www.enpb.bv.tum.de/master-enb

**Author**

Guedi Capeluto
arguedi@technion.ac.il
Technion – Israel Institute of Technology, Israel

**Introduction: areas of training**

All aspects of architectural planning, from urban planning, the building, building systems, and building details and materials, could change conditions prevailing in open areas in the city and inside buildings. Some of these changes are irreversible and could significantly affect the continued sustainability of humans and other life forms. In recent years, this involvement has raised social and ethical issues and dilemmas, requiring the adoption of behaviours that require bearing responsibility for the environment and for future generations. Today, it is agreed that action must be taken to reduce environmental damage and to ensure the preservation of built and natural environments, alongside the necessary development according to needs and taking conditions into account (sustainable development). Architecture that takes the environment into consideration, on the one hand, and creates a quality physical environmental in the building and in the city, on the other hand, is called “green architecture.”

Buildings are responsible for about 40% of the total primary energy consumption and contribute approximately to one third of the total GHG emissions. In recent years there is an increasing awareness about green buildings and energy rating systems, both from designers and consumers. Green and Sustainable building standards and certification systems include requirements for both new and existing buildings. An essential element of sustainable planning and “green architecture” involves the topic of energy efficiency in buildings and the utilisation of environmentally friendly renewable natural energy resources and low carbon technologies. The benefits of this are two-fold: on the one hand, a reduction occurs in the utilisation of non-renewable resources, and on the other hand, a reduction occurs in the emissions of contaminants. In “green architecture”, beyond the emphasis placed on architectural qualities, reference is made to other consumable resources, such as land, water and materials, whereby the topic of materials recycling, water recycling and their subsequent efficient utilisation, as well as a reduction in waste production and pollution caused by private transportation, are being introduced into planning considerations during the different stages of a building’s life.

**Green design and green standards**

One of the major contributions of the introduction and dissemination of building rating systems as the American LEED (USGBC 2005; USGBC 2009), the British BREEAM (BRE 2013), the Israeli SI 5281 (The Standards Institution of Israel 2005; The Standards Institution of Israel 2011), EPBD in Europe (Concerted Action EPBD 2013, EU Directive 2009/12/ec) and others, is their holistic approach raising awareness of designers and the general public regarding the importance of environmental issues as a whole. Terms such as green architecture, green and sustainable buildings, and climatic design are widely used today in architecture. However, the use of these terms do not always reflect the implementation of knowledge or green techniques in projects, but is often done for advertising or promoting the image of the developer involved in the project. Therefore it is important that green standards include a description of the objective of each of its sections and clear criteria for assessment and documentation.

Israeli Standard SI 5281 (The Standards Institution of Israel, 2005; The Standards Institution of Israel, 2011) also provides a multi-disciplinary approach for assessment of buildings. The standard is a set of criteria and requirements, for examining new and thoroughly renovated buildings, by scoring
points and compliance thresholds. Besides being a means to implement environmentally friendly construction targets, SI 5281 can be seen, as well as similar standards and rating systems around the world, as a comparative tool for the analysis and ranking of the performance of buildings in various environmental areas.

Programme objectives

There are several graduate studies tracks in Architecture offered by the Faculty of Architecture and Town Planning at the Technion:
- "Master of Science in Architecture": Research track with a research thesis or thesis project, in various fields of architecture including architectural design, sustainable design and green buildings, technology, theory, history and criticism of architecture and urbanism, digital architecture, preservation of buildings and sites.
- "Doctor of Philosophy" in Architecture.

Master Of Architecture And Urbanism II: “Green Architecture”: The objective of the programme is to expand and enrich the professional knowledge base of architects and their role in the design process, or in other professional positions related to the topic of sustainable design, green architecture, and low carbon technologies. The programme will provide architects with a broad view of all relevant aspects of activity in areas of “sustainable and green architecture” (Climate and Energy Lab 2010).

Admission requirements

The programme is open to national and international students. Candidates who have completed their BArch undergraduate studies in architecture or in architecture and town planning from the Technion – Israel Institute of Technology, or those who have an equivalent professional degree, will be accepted to the programme. Candidates will be accepted based on their undergraduate degree grades and professional achievements, if any, and in any case will be subject to the admission requirements of the Technion Graduate School according to the following criteria:
- eligible to apply to the programme are university graduates who completed their studies with an average grade of at least 80;
- admissions Committee: In special cases, it will be at the discretion of the Admissions Committee to accept candidates having considerable relevant experience (~five years) whose average grade is below 80, or an architecture graduate after four years of study who will be required to complete an additional 10 credit points.

Upon completion of studies in the programme, graduates will be awarded a Master of Architecture and Urbanism II – “Green Architecture”

Study programme format

Studies in the programme are over a period of about two years.

The studies will require completing 40 credit points, which are divided as follows:
- 30 credit points for compulsory courses according to the following division;
- 2 points – basic course: Preparation for the Research Process;
- 3 points – extended project or course work;
- 8 points – specific design-studio projects;
- 17 points – general subjects on topics of technology and the environment.

The study programme is based on a combination of theoretical and advanced research-based design studio courses, including study trips and field visits according to the needs. The theoretical courses cover a wide range of topics (detailed in the next section), and include lectures and seminars providing state of the art knowledge and tools. These tools are mainly software tools (but not only) for the analysis of the microclimate around the project (PASYS, Climate Consultant, ENVI-met, etc.), solar and daylight rights (SustArc, SunTools), energy performance of buildings (Energy Plus, Design Builder, EnergyUI, the last for compliance with the Israeli Standard for Energy Rating of Buildings). The research studio courses are taught by leading professionals and researchers and expose students to different approaches to sustainable design.

Core course:
- climate, Energy and Architecture, 3.0 credit points. Students who studied this course during their undergraduate studies will be exempt from taking this course. Other students must study this core course, which will not be included within the framework of accumulating 40 credit points to complete the degree.

Compulsory courses:
General (5 credit points):
- preparation for the Research Process (basic course), 2.0 credit points;
- extended Project or Course Work, 3.0 credit points.
Projects (8 credit points):
- climate and Energy-Conscious Design, Studio Project, 4.0 credit points;
- “Green Architecture”, Studio Project, 4.0 credit points.

Technology (11 credit points):
- lighting in Architecture, 3.0 credit points;
- innovations in Environmental Control Systems, 3.0 credit points;
- seminar in Designing Passive Solar Buildings, 3.0 credit points;
- recycling in Construction, 2.0 credit points;
- environment (6 credit points);
- seminar in Sustainable Architectural Planning Assessment, 3.0 credit points;
- computerised Models for Sustainable Architectural Planning, 3.0 credit points;
- Total compulsory courses: 30 credit points.

Elective courses (10 credit points):
A student can choose 10 credit points from the list of courses below: at least one course must be from the Technology list and one from the Environment list (not including seminars or selected topics).

Technology:
- Advanced Acoustics, 2.0 credit points;
- Climatic Aspects in Building Design, 3.0 credit points;
- Micro-Climate in the City Using Vegetation, 3.0 credit points;
- Fundamentals of Building Climatology, 3.0 credit points;
- Wind Turbines and Energy Production, 3.0 credit points;
- Energy-Rich Electro-Chemical Systems, 2.0 credit points.

Environment:
- Seminar in Environmental Assessment, 3.0 credit points;
- Selected Topics in Architecture 3, 3.0 credit points;
- Selected Topics in Architecture 4, 2.0 credit points;
- ecological Principles in Urban and Regional Planning, 3.0 credit points;
- seminar in Environmental Policy Planning and Management, 3.0 credit points;
- environmental Impact Surveys, 3.0 credit points;
- Environmental Laws, 3.0 credit points;
- Environmental Planning, 2.0 credit points;
- Environmental Economics, 2.0 credit points;
- Air Pollution, 2.5 credit points;
accordingly.

Programmes should be revised and adapted.

The relation between these specialisations, among them Sustainable Architecture and Town Planning at the Technion – Israel Institute of Technology, from courses in another faculty or from other universities, with the approval of the Study Track Committee.

Free Elective:

- Seminar in Mathematic Models in Environmental Impacts Assessment, 2.0 credit points.
- Air Pollution Control, 2.0 credit points.


The Standards Institution of Israel 2011, Israel Standard SI 5281, Sustainable Building (Green Building).


Contacts

- Master of Architecture and Urbanism II – “Green Architecture”, programme coordinators:
  - Associate Prof. Guedi Capeluto
  - Assistant Prof. Abraham Yezioro

- Prof. Guedi Capeluto
  arrguedi@technion.ac.il

- Ms. Irit Gertzwolf, Graduate Studies Secretary
  iritg@ar.technion.ac.il

Technion website: http://www.technion.ac.il

References


Energy efficiency, providing the basis for the development and normal operation of all the branches of economy, plays an increasingly important part in prosperity of every country. The finite and inhomogeneous distribution of natural fuel and power resources (FPR) contribute towards what is known as a power problem which is one of the greatest challenges for humanity, in all countries and regions of the world.

In particular, many of EU and non-EU States of Europe do not have sufficient amounts of their own energy resources and, very often, are linked to a practically single FPR source. Therefore, these countries need to organise a search for new forms of FPR, expanding the use of modern energy-efficient technologies for the production, transmission, accumulation and utilisation of energy, looking for the potentials provided by renewable and non-traditional energy sources, and improvement of the energy-saving techniques. Because of this, training of specialists in such fields as energy-effective technologies, renewable/ non-traditional energy sources, energy saving methods, enhancement of the energy efficiency as a whole, management of energy resources are of particular importance for these countries.

In order to modernise academic programmes in the topic of energy efficiency 14 partners from 9 EU and non-EU countries initiated the project “Development of Training Network for Improving Education in Energy Efficiency” (the project acronym: ENERGY). The project number: 530379-TEMPUS-1-2012, the duration time: October 2012 – October 2015 (36 months), its budget: EUR 1 440 050. Riga Technical University (Latvia) is a coordinator of the project. The project involves higher education institutions from Latvia, Estonia, Lithuania, Poland, Belgium and from the non-EU countries of Belarus, Kosovo, and Azerbaijan.

This project contributes to the sharing of European universities’ expertise among higher education institutions in non-EU countries. The long-term outcomes of the project are the application of energy savings technologies, energy effective materials and use of renewable resources in the electrical engineering, constructions transport and other industries. The project pursues modernisation of curricula in three directions: introduction of European Credit Transfer System (ECTS), degrees recognition in the teachers training and modernisation of education science (physical sciences in Belarus and engineering professions in Azerbaijan, Belarus and Kosovo).

The project aims to develop mutually recognised curricula in the directions of enhancement of energy efficiency, energy saving, energy effective materials and use of renewable sources.

Energy efficiency, providing the basis for the development and normal operation of all the branches of economy, plays an increasingly important part in prosperity of every country. The finite and inhomogeneous distribution of natural fuel and power resources (FPR) contribute towards what is known as a power problem which is one of the greatest challenges for humanity, in all countries and regions of the world.

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The project aims to develop mutually recognised curricula in the directions of enhancement of energy efficiency, energy saving, energy effective materials and use of renewable sources.

Conclusions

The programme which started in 2010, is ongoing. About 15 – 20 architects in total have studied in the programme in order to broaden their expertise in the area of green architecture, and the number of students per year is growing gradually.

As of 2015, students of architecture study a six-year course leading to a professionally accredited Master’s of Architecture and Town Planning degree, offering different specialisations, among them Sustainable Architecture.

In Israel, a green building standard and a rating system of buildings according to their energy consumption have been developed in recent years, to provide practical tools for designers aimed to achieve high-quality architectural solutions on the one hand, and provide consumers with a simple means for identifying and understanding the product quality encouraging the demand and application of green construction, on the other. The programme’s graduates help introducing the Green Standard principles in the common architectural practice in Israel. Since the Faculty of Architecture and Town Planning at the Technion is moving nowadays to a 4+2 MArch professional degree, the relation between these programmes should be revised and adapted accordingly.

Development of training network for improving education in energy efficiency (ENERGY)

Authors

Anatolijs Zabasta
anatolijs.zabasta@rtu.lv

Nadezda Kunicina
nadezda.kunicina@rtu.lv

Leonids Ribickis
leonids.ribickis@rtu.lv

Riga Technical University, Latvia

Introduction

Project ‘ENERGY’ targets

The main objective of the project is to enhance networking among higher education institutions across EU member states and non-EU countries for improving education in the field of the energy efficiency enhancement, energy saving and use of renewable sources of energy.

The project pursues specific objectives:

- to enhance the quality and relevance of higher education in the non-EU countries by bringing together education excellence and best practice in the field of the energy efficiency enhancement, energy saving and use
of renewable sources of energy on the base of creation and modernisation study programmes;
- to make compatible or unified curricula for improving education and expertise of target groups: undergraduate and master students, academic and teacher staff;
- to confirm teaching and learning approaches (lectures, practice classes, didactic materials, etc.) and tools (equipment, hardware and software, methodological guides, manuals, etc.);
- to create electronic libraries to enhance knowledge of energy efficiency, energy saving, energy effective materials, use of renewable sources.

The implementation of the project allows the creation of a joint educational platform as a system of improved compatible education tools and didactic materials needed to transfer experience of EU universities to non-EU countries universities. All non-EU partners highlighted the curricular reform in the engineering professions as a main priority.

Project materials are being developed in topics:
- power electronics;
- effective lightening;
- gas – and Hydrodynamics;
- heat pumps;
- distribution of power energy;
- energy saving technologies;
- energy effective materials;
- solar energy and photovoltaics;
- hydrogen energy;
- wind energy.

The accomplishment of the project goal allow (a) modernisation of study programmes, knowledge, equipment and training level, (b) development of sustainable educational and human links between target groups and (c) dissemination of the achievements, deliverables and experience related to renewable energy sources and energy saving.

To achieve these objectives, an experience and expertise of EU universities is applied in order to make closer the educational programmes and teaching/learning instruments in educational institutions of non-EU countries to EU universities. Therefore, the project partners implement such activities:
- the development of compatible curricula and study programmes for partners;
- the development of compatible and complementary laboratory classes;
- the development/improvement lecture synopsis and other compatible teaching (didactic) materials;
- the delivering and upgrade of equipment, software for laboratory classes (classical and virtual);
- creation of a single electronic library for synopses and teaching (didactic) materials with shared possibilities to use them by all partners.

The project activities are focused on main target groups: students, academic and teaching staff of seven universities in Belarus, Azerbaijan and Kosovo.

Project ‘ENERGY’ main activities

Since the beginning of the project, the partners held five Management Committee meetings, which enable smooth coordination between partners and driving project activities (Figure 1).

At the first Management meeting in Riga the partners committed to develop 10 common training courses according to the project task. By now, all 10 English version of the courses have been completed, therefore the course materials are available on the website http://e-energy.rtu.lv. It was a challenging task, because the university, responsible for elaboration of particular course, has to achieve a commitment among partners with very divergent expertise and very high ambitions. For example, the course “Energy saving technologies” is a result of contribution of academic staff of eight universities (see Figure 2). Furthermore, partners shared experience at eight workshops devoted to each training course (Figure 3).

The accomplishment of the project goal allow a) modernisation of study programmes, b) development of sustainable educational (didactic) materials, c) creation of a joint educational platform as a system of improved compatible education tools and didactic materials needed to transfer experience of EU universities to non-EU countries universities. All non-EU partners highlighted the curricular reform in the engineering professions as a main priority.

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Figure 1 - Participants of a Management Committee meeting held in KHAZAR University in Baku, Azerbaijan, April 2014

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Figure 2 - Example of cooperation between eight universities for elaboration of a training course

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Scale and topic

It is an international scale project, which focuses on knowledge transfer from EU countries and Belarus, Kosovo and Azerbaijan universities. The project consortium comprises EU countries universities: Riga Technical University, Tallinn University of Technology, Vilnius University, Lublin University of Technology, Politechnika Koszalińska, KU Leuven University, UD”G “Dunarea de Jos” University of Galati, Khazar University, Qafqaz University and National Aviation Academy of Azerbaijan represent Azerbaijan, Belarus is represented by Belarusian State University, Belarusian National Technical University and Belarusian State Agrarian Technical University. The participant from Kosovo is the University of Pristina in Kosovska Mitrovica.

The energy saving area in wider understanding includes basic physics, and its application in different engineering fields (transport, construction, power production etc.).

Conclusions

The project is still running, only some of deliverables have been fulfilled, and each day brings new experiences.

At the time of this case study, only preliminary figures of new training course testing were available. Seven non-EU universities arranged new curricular testing during autumn semester of 2014 and spring semester of 2015. Each university arranged students training in 2 by 17 courses (e.g., Belarus State University, the largest university of Belarus) groups from 10 by 30 students. It is envisaged that new courses on energy efficiency will be implemented in the existing training programmes, or will be used as modules of the new training programmes after accreditation process completion.

Furthermore, the project partners created a collaborative network, which includes more than 50 high-qualified persons: professors and PhD from 14 universities of different European and neighbour EU regions. 12 creative workshops with around 216 participants are held in the project. Despite different background, diverging experience and cultural awareness the project team members achieved a commitment related the approach for creating common compatible curricula in the universities of non-EU countries. As a result, the project team achieved the first planned results.

RTU has an excellent experience in multidisciplinary application of Electromagnetic compatibility (EMC) phenomena. RTU Electromagnetic Compatibility Centre researches are focused on development and research of electromagnetically compatible matrix-type converter. The EMC phenomena is investigated under ongoing researches such as Energy Saving Multifunctional AC Converters, Performance Optimisation Services for Electric, Semiconductor Converters for Electrical Technologies, Industrial Automation, etc. In a frame of the project, RTU in May of 2014 organised a training course on EMC for the students of two partners’ Azerbaijan universities (see Figure 5 and Figure 6). The students of non-EU universities obtained experience during a study “Training in electromagnetic compatibility”, which was timed to an annual scientific student conference.

Contact

TEMPUS project “Development of Training Network for Improving Education in Energy Efficiency” (http://energy.rtu.lv)
Anatolijs Zabasta
Anatolijs.zabasta@rtu.lv
T: +371 29232872
Riga Technical University, Kalku Str., Riga, Latvia, LV 1658

References

MSc programme in Sustainable Architecture at NTNU

Authors
Luca Finocchiaro
luca.finocchiaro@ntnu.no
Aoife Houlihan Wiberg
aoife.houlihan.wiberg@ntnu.no
Annemie Wyckmans
annemie.wyckmans@ntnu.no
Norwegian University of Science and Technology, Norway

Introduction
In a global perspective, buildings are responsible for about 40% of greenhouse gas emissions. IPCC reports point to measures in the building sector as being the most economical, when compared to other significant sectors.

The MSc programme in Sustainable Architecture at NTNU aims at educating and training students in the use and development of competitive methods and solutions for lowering greenhouse gas emissions of the built environment. Throughout the two years of the MSc programme, technologies and solutions for carbon neutrality becomes the source for inspiring the design of new architectural paradigms. In each semester students are required to address different issues in their designs, coherently with the courses content and profile: Bioclimatic design (I semester), life cycle assessment and environmentally friendly materials and energy systems design and integration (II semester) and integrated energy design (III semester). In each semester, thus, a design project is developed over a different scientific platform and focus. In designing their projects high demands are made towards the development of integrated design strategies that would be able to solve environmental, functional and construction issues in a holistic perspective. Students with different backgrounds train in interdisciplinary cooperation throughout the semesters. Engineers and architects from other departments are also invited to join the courses and a balance of engineering and architecture skills is always aimed for in the design team.

Curriculum
The two year curriculum has been structured around a set of three concerns related to environmental impact of the built environment: environmental performance (I semester), environmental impact of materials and energy systems design and integration plus integrated energy design (II semester). In each semester, thus, a design project is developed over a different scientific platform and focus. In designing their projects high demands are made towards the development of integrated design strategies that would be able to solve environmental, functional and construction issues in a holistic perspective. Students with different backgrounds train in interdisciplinary cooperation throughout the semesters. Engineers and architects from other departments are also invited to join the courses and a balance of engineering and architecture skills is always aimed for in the design team.

Semester 1 – Climate and built + light and lighting
Inside this course students are trained, through both theory and practice, in understanding the architectural design of climate adapted buildings as a meaningful process based on the understanding of the external environment. Theory lectures provide knowledge of climate analysis, architectural design of bioclimatic buildings, energy modelling and building tectonics (up to passive house standards). Each lecture has a corresponding laboratory session allowing students to develop their abilities in computer aided energy modelling. Students also join a theory course in light and lighting systems held by the Light and Colour group at the Faculty of Architecture.

The main focus of the semester is the environmental performance of climate adapted buildings and their ability to passively create comfortable internal conditions. Both the

Figure 1 - Project developed by students at the first semester of the MSc programme. Focus: Environmental performance

Figure 2 - Project developed by students at the second semester of the MSc programme. Focus: materials accounting and environmental impact
combined project – theory and design – on “Climate and built form” and the “Light and lighting” theory course stress the potential of passive design for architectural quality and energy efficiency. Energy demand is seen as a direct feedback of the more or less successful passive design of the building.

During the first semester students are also introduced to different green buildings concepts from passive house to Zero Emission buildings. Students will also train and develop competence in the use of advanced simulation tools for climate analysis and dynamic energy modelling.

Semester 2 – Emission as design drivers

The aim of the combined courses in “emissions as design drivers” is to enable students to develop knowledge and provide an overview of the architectural strategies relevant for energy positive and potentially net Zero Emission buildings (nZEBs). The students will learn how to integrate energy and emission calculations in the exploration of their architectural concepts and strategies. The students learn methods to analyse the key drivers that contribute to lowering energy and CO₂eq emissions in order to achieve the net zero emission ambition set in both courses. The students use their design project to investigate whether it is possible to achieve a net Zero Emission Building (nZEB) by balancing emissions from the energy used for operation and embodied emissions from materials with those from on-site renewables in the cold climate of Norway.

During the second semester students will also develop specific competences related to accounting energy and emissions embodied in materials and perform a life cycle analysis of their design. Students are also introduced to environmentally friendly materials developing a critical attitude towards an indiscriminate use of commercially available and ready made solutions.

Beside the combined course in “Emissions as design drivers” students join, as part of their second semester activities, an EiT – Experts in Teamwork course at NTNU. Experts in Teamwork is a course in which students apply their academic competence in interdisciplinary project work to learn teamwork skills to prepare them for working life. (more information can be found in the following link: http://www.ntnu.edu/eit)

Semester 3 – Integrated energy design

During the third semester students are trained, through laboratories and theory modules, in developing integrated architectural design concepts able to synthesise functional, energy systems, and structure into a one. This is only possible through a proper integrated energy design process where people of different competence join their forces in a multidisciplinary team. Structural and mechanical engineers from other faculties, beside regular architecture students, are thus invited to join the third semester courses in integrated energy design.

Theory lectures provide knowledge of building energy systems, advanced envelopes, and parametric modelling for energy efficiency. Theory modules introduce laboratory packages and workshops specifically developed to let the students train and develop their abilities in computer based energy modelling (dynamic SIM, BIM accounting and parametric modelling through Rhino and Grasshopper).

The main focus of the course is the development of integrated architectural systems able to minimise energy use through their entire life cycle, combining both passive and active means for energy efficiency.

In the third semester students develop further competences in managing dynamic simulation tools and model building form and technical equipment as a one machine.

Semester 4 – Master thesis

During the third semester students are invited to join ZEB research projects as part of the “Integrated Energy Design” theory course. Their work often becomes the starting point for their thesis developed in the fourth semester. During this last semester students are asked to give evidence of a more mature and holistic understanding of the content of the three semesters. Research by design is often chosen as an option for those interested in developing architectural design project, while academic oriented people often choose to develop or take part into research project going on at the faculty during that period.

Stakeholders

The MSc programme in Sustainable Architecture at NTNU was initiated in 2010, two years after the establishment of the Zero Emission Buildings Research Centre. Its development in connection with the ZEB centre contributed to ensure close contact with state-of-the-art research and practice in Norway and abroad.

The MSc programme is open to both international and Norwegian students in possession of a 3-year Bachelor Degree in Architecture, Engineering or Urban Planning. Students with a background in other relevant fields are considered for admission as well, after discussion with the Master coordinator and Advisory Board. In selecting participants to the MSc programme a balance between architecture and engineering students is pursued. Every second year between 15 and 20 new students are selected from almost 200 applicants. Applicants mostly come from abroad and are often in possession of a different Master degree but would like to deeper their interest towards sustainability in the built environment.

In June 2015 the third cycle of the Master of Science programme was completed with 11 new students getting their diploma. Since it was initiated over fifty students have graduated as Master of Science in Sustainable Architecture at NTNU.

Architecture and engineering

The MSc in Sustainable Architecture act as a boundary between architecture and engineering, often questioning the artificial borders created between these two disciplines.
Students are challenged into combining artistic and technical skills in their work, where environmental concerns and research questions become the creative sparkle for imagining new architectural scenarios.

The dual nature of the master programme is often translated into an increased complexity of the teaching activities, but represents an essential requirement for shaping practitioners able to take the charge of effectively reduce environmental impact of the future built environment. Another recurrent difficulty is that engineers focus on the use and development of technical solutions while architects improve the architectural quality of their sketches. During the MSc programme the aim is shifting the students’ attitude towards the development of integrated solutions.

The Faculty of architecture is working on increasing capacity and robustness of the teaching team in order to give access to a larger number of students every year instead of every other starting from August 2015. For the moment the main effort is given into further developing the connection of the programme with the ZEB research centre and its partners while stressing the different focus of each semester in terms of lectures’ content, methodology and learning outcomes.

Contacts
More information regarding the programme can be found on the NTNU website: www.ntnu.edu/studies/mssusarc
Programme coordinator and students advisor: Luca Finocchiaro
luca.finocchiaro@ntnu.no
Academic advisor: Erik Sigvaldsen
erik.sigvaldsen@ntnu.no

Sustainability is a topic of central relevance to the construction industry. This is not only true of the planning and production stages of buildings, but is also especially relevant in the operation of buildings, their maintenance, and their final demolition and recycling.

Stricter political and legal requirements aiming to improve energy and material efficiency, decreasing primary energy consumption, boosting the use of renewable energy, and reducing the resources spent, underscore the relevance of these topics. In this context, the use of fossil fuels is especially the subject of political and social debate.

This dynamic process requires occupational profiles that stand apart from the traditional profiles of civil engineers. These specialists in energy-efficiency and sustainability, whose expertise is increasingly in demand due to the stricter legal requirements, soaring energy prices, and growing public awareness, will be able to face challenges in a more targeted manner and open up the major globally significant markets of the future. Programme content ranges from renewable energy in buildings, ecological technologies and construction principles, across traditional areas, such as design principles, building technology, helio-energetic building, and mechanical engineering and all the way through to materials science.

The Faculty of Civil and Environmental Engineering and Architecture at the Rzeszow University of Technology, Poland has offered a Master’s Programme in Sustainable Building since October 2010. Since then 118 students began the programme, 93 of them graduated until 2014. Each year about 30 students apply. The aim of this programme is to promote studies in the area of sustainability and energy-efficiency in the built environment. It focuses on designing with ecology and energy in mind, as well as on economic, social, technical, and process-oriented aspects of construction.

Sustainable Building
The Master’s Programme is intended for graduates from the fields Civil Engineering. Currently the programme is taught only in Polish, but within the next two years studies will be introduced in English.

The programme is characterised by instruction of required skills in the area of sustainable building. The content is taught in an integrative manner highlighting the relationships and synergy effects which are required for an effective implementation of sustainable building.

Upon successful graduation from this Master’s Programme at the Rzeszow University of Technology, the students are awarded the title Master of Science (M.Sc.) in Sustainable Building.

Programme content
The programme imparts knowledge and skills related to engineering while factoring in ecological and economic aspects. Integral
building with a focus on sustainability is at the heart of the programme.

Networked and system-oriented thinking is called for, particularly due to the complexity of mutually influential and interacting factors. This includes fundamental principles in specific fields, such as resource scarcity, energy-efficiency, renewable energy, new construction materials, material efficiency, life cycle analysis, and costs, etc. Drawing on existing knowledge, methodical skills are developed in order for students to be able to develop independent, project-specific solutions in the area of energy and sustainability in the built environment and to apply common assessment procedures.

### Professional opportunities

The possible fields of professional work include design and engineering offices, construction companies and, research institutions as well as governmental, regional and municipal administrations on a national and international level, for example:

- consulting and planning services for sustainable building, design, operation, and demolition;
- life cycle oriented assessment of construction processes and structures in consideration of ecological and economic aspects;
- provision of new technical and constructive solutions for energy-efficient and sustainable settlements and buildings;
- application of design instruments to establish and assess energetic and ecological footprints, life cycle costs, and quality of sustainable settlements and buildings.

### Programme structure

The programme comprises three semesters, during which 104 ECTS must be obtained. In the first two semesters, the students have traditional building subject and of course subjects focused on sustainable, ecological building (68 ECTS).

The third semester serves to write and present the final Master’s Thesis (22 ECTS) apart of that students have to take four subjects (14 ECTS).

The study programme is divided into mandatory and elective modules, which combine lectures, exercises, excursions, work placements, seminars, and projects. Continuous assessment takes place in each module.

### Sustainable building

The sustainable building is one of the five specialisations of the Master’s programme in civil engineering. The most general course modules are: energy performance certification, renewable energy in building, solar heating in building, eco-friendly technologies in building.

During the first semester, the energy performance certification module introduces postgraduate students to the concept of green building. During this part of the course students learn about the most essential legislation relating to the energy performance of buildings. They are also taught the energy performance certification methodological requirements.

Students not only gain the theoretical knowledge, but they are also obliged to put it into practice during their own individual projects. The projects focus on creating an energy performance certificate for a chosen building. During the project-related classes students learn how to calculate the heat transfer coefficient and thermal bridges. They also learn how to calculate the amount of through-wall heat transfer and how to assess the building heat balance. Other very important skills taught during the projects are the ability to read technical documentation, the ability to gain information from the user of the building and the ability to correctly recognise building materials during an on-site visit.

On the second semester, students deepen their knowledge of green building going through other two modules. The first one covers the problem of renewable energy in buildings. The main objective of this module is to transfer the information concerning the contemporary renewable energy sources and their application in building. During the lectures students deeply analyse the renewable energy sector development and the influence of renewable energy on building investment projects and the environment. During the classes students learn how to use renewable energy sources and also how to optimise them according to the energy performance of given buildings. They also get to know the most modern software and tools which help to calibrate energy management systems.

The second module, which is taught at the same time, is focused on solar heating in building. In this module students are given the broad knowledge of solar power systems used in buildings, their division and estimated energy efficiency. The classes in this module improve the skills required for designing solar systems. Students also deepen their knowledge of estimating the potential advantages of using mentioned systems.

On the third semester students consolidate the knowledge from previous semesters and analyse the information in the context of modern sustainable building technologies, their features and the possible applications in energy saving buildings and passive buildings.

### What is gained from this degree?

The programme is organised to allow the students to gain specialist knowledge related to the sustainable building field. It is important nowadays as sustainable development is essential when planning building investments and projects. The interdisciplinary character of the course, joining housing construction, architecture and environmental engineering, allows the students to easily approach the subjects of sustainable building and urban design. The training also provides the students with more confidence to implement energy-saving technologies and renewable energy sources when satisfying the environmentally-aware, modern clients’ needs.

At the end of the course students gain the theoretical and practical background required to design buildings according to norms and regulations. Students’ knowledge is extended in terms of new green building technologies. The programme of the course successfully becomes the part of the “Green professions” trend in education and it is one of the key elements of the Europe 2020 strategy. It helps to increase the employment rate among the graduates, who are able to find jobs even in the highly competitive global market sectors. The course enables students to work for:

- planning, design and construction companies;
- local or central administration, in building, environment, development or new technology departments;
- planning firms, preparing investment documentation for construction companies, with the emphasis on eco friendly building;
- consulting companies;
- real estate development companies;
- non-government organisations, regional organisations, environment foundations;
- EU institutions responsible for the energy saving building area;
- research units specialising in building.

### Master’s thesis example

Study project

Theme: Eco-village in straw bale technology.

Author: Anna Pomykała

Supervisor: Adam Rybka

**Target of the project:** the purpose of the project was to verify whether small group housing with central unit is able to create intentional community developing in direction of social, economic and environmental sustainability. The proposed complex is intended to show the advantages of sustainable building.

**Figure 1 - The concept of sustainable development**

**Idea:** the project refers to the idea of intelligent cities, in particular to the field of intelligent environment. In order to reduce the consumption of mass goods the project envisages to achieve a certain degree of energy self – sufficiency of people by construction of smart grids. The straw bale is considered a replacement of natural building materials based on the principle of sustainability.
Solutions guided by the principles of sustainable development are provided within the building complex including cultivation of energetic willow, photovoltaic panels, ground heat exchangers, straw bale as the main building material, together with cultivation of fruit and vegetables.

Description of the concept: the complex consists of a central unit (red), twelve family houses (yellow) and the recreation and sports services (blue).

The architecture of objects is restrained and friendly. Traditional elements of the urban layout are connected with natural, simple finishes. Passages between houses physically merge groups of houses. To prevent the phenomenon of limitation, segments are not absolutely tight in their ranks.

Technical solutions: straw-bale construction is a building method that uses bales of straw as structural element and building insulation.

The advantages of this system include the renewable natural straw, cost, easy availability, naturally fire-retardant and high insulation value. The applied technology allows reducing the construction costs of building a fully functional home, while also meeting functional and aesthetic expectations of modern society.

Each family living in the village has at disposal cultivated field (brown). Cultivation of energetic willow (green) provides self-sufficiency in terms of thermal energy. Roofs of central unit are equipped with solar cells. Slope inclination (60 and 30 degrees) from the south-east, optimises solar gains throughout the year.

Globalisation, dynamic flow of industry, capital and services have a very significant impact on urban development. The continuity of the urbanisation process is the reason of increasing the number of population living in urban areas. Migration of people from rural to urban areas is increasing rapidly especially in developing countries. Residents are surrender to dynamic influences demographic processes, migration, environmental pollution and social structural changes. Quality of life is decreasing, as a result of deteriorating living conditions and urban sprawl.
In the face of rapid change, local governments need to look at their actions from a completely different perspective. The study of the changes in the spatial structure and economic performance of cities reduced to develop ideas for development mechanisms and tools that can be used by local authorities to stimulate and control the processes taking place in the cities. An answer to the problems of modern cities can be the ‘eco village’.

Nowadays, when the needs of society are increasing in the face of the need to reduce natural resources, the redefinition of the notion of sustainable building should be the major challenge for architects. This project tries to answer the question concerning how a small eco-community at the edge of a medium-sized city might function and how it might look like. The main challenge was to combine sustainable building and fulfilling lifestyle to create an optimal environment for the community. Looking for an answer to the question ‘how to reduce the consumption of mass goods without decreasing quality of life’ presents the advantages of low-tech architecture which is made by their owners with local materials with local skills and techniques, as energy-efficiently and self-sufficiently as possible.

This project illustrates reflection on ecology and its relationship to architecture. The main purpose was to contribute to getting a better and fuller understanding of architecture in the context of its impact on the environmental sustainability, prices, and access to a broad audience. The project is an attempt to show the general trend of the possible development and popularisation of ecological architecture in the city.

Conclusions
The course of Sustainable Building (MSc) is specifically tailored towards graduates in disciplines of building and construction. The course is structured to accommodate the interests and skills of those who are interested in building design, building energy and environmental performance. The emphasis is on the integration of renewable and sustainable energy technologies into buildings. The increasing drive towards low carbon and sustainable solutions in the built environment has introduced a need for building constructors professionals who can take a holistic view of the sustainability debate. The course combines the design and engineering issues associated with the delivery of sustainable built environments. The course considers building fabric and renewable energy technologies, setting out which approaches may be taken when considering new buildings or the existing building stock. The goals of the course are to develop skills and understanding around the principles of sustainable building with a view to delivering healthy, comfortable, efficient and environmentally friendly new and existing buildings.

Contact
Arch Adam Rybka
Rzeszow University of Technology
Warszawy 12 35-959 Rzeszow Poland
akbyr@prz.edu.pl
T: +48 178651624
Website: https://portal.prz.edu.pl/

Education on energy efficiency in the building sector

By supporting research and demonstration programmes, governments stimulate the energy efficiency in the building sector. Programmes that inform citizens about the importance of building energy efficiency lead to public support. Once people are informed of the possibilities to improve their quality of life by investing in renewable energy sources, combined with economically sound projects, there is no limit for the citizens’ enthusiasm and involvement (Christiansen, 2006). Of great significance is the development of programmes for education on energy efficiency in building sector.

Experts are trained in the field of energy efficiency in buildings at several levels. At the Faculty of Architecture, University of Belgrade, on the level of Master studies, students interested in this area may choose several elective modules, seminars and studio design projects that are dedicated to energy efficiency in building sector. They get the basic information which enables them easily to upgrade their knowledge through the specialist studies “Energy-efficient and green architecture”, organised by the Faculty of Architecture, University of Belgrade. Also, education in the field of energy efficiency is organised by the Serbian chamber of engineers giving the opportunity to different professionals – engineers to get license as experts in this field.

Since 2006, the Masters module “Architectural Technologies – Architectural constructions, materials and building physics” introduces students to principles of design and construction of energy efficient buildings. Learning is organised through studio design projects associated with certain seminars which give students the specific theoretical knowledge and practical skills in the following fields: building physics, bioclimatic design, energy saving, use of renewable energy sources,
advanced façade and roof technologies, building refurbishment techniques.

The idea is for students to become familiar with low carbon technologies in architecture and the decision-making approaches encouraged by government regarding building materials and components selection as well as building design and construction solutions.

The course Studio design project on the Masters level includes practical work (Figure 1), concrete design of a building taking into consideration location and climatic characteristics, optimal orientation in respect to sun exposure limitations which requires an overshadowing analysis to be conducted, as well as building function and capacity and issues related to design of energy efficient buildings. The methodological approach usually entails the creation of different scenarios of building envelope design, numerical simulations of building energy performances and CO₂ emissions, and selection of optimal design solution which results from comparative analyses (Krstić-Furundaic and Kosic, 2012; Krstić-Furundaic and Kosic, 2014). The students model in scale the typical unit of the façade in order to check the visual and aesthetic performances (see Figure 2).

Sometimes free software available on the internet is used for numerical analyses, but complex numerical analyses are supported by companies involved in building energy efficiency calculation and estimation (BDSP (YU) d.o.o., Belgrade; Passive House Center, Novi Sad; ENERGO, Mrs. Marija Golubovic). The collaboration between education and economic sectors is welcomed from the both sides, the Faculty and companies, giving opportunity for students to be informed about real projects, methodology and calculation procedures in certain software packages (PHPP’2007; TAS).

The specialist studies “Energy-efficient and green architecture” and “Urban Renovation – city in the new millennium” are one-year courses with 60 ECTS. The requirements for admission to the programme are: completed graduate studies in architecture or other related fields, and the achievement of a minimum of 300 ECTS credits. The first study programme is in the field of sustainable, energy-efficient and green architecture and the second one in the field of urban design.

The main objectives of the energy-efficient and green architecture course are:
- deepening the knowledge necessary for the design, construction and evaluation of energy efficient and green buildings;
- the acquisition of professional qualifications (input basis for the license) to work in the field of development studies of energy efficiency and energy certification of buildings;
- the acquisition of professional qualifications as input a basis for the examination and obtaining the title of LEED-G(reen) A(ssocicate).

The outcome of the learning process is the acquisition of appropriate knowledge, skills and competences, as well as the professional qualification, which allows independently and responsibly dealing with the architectural and engineering professions in the field of design, construction and evaluation-certification of energy efficient and green buildings, in accordance with current national and relevant international regulations.

The main objectives of the specialist studies in the field of urbanism are:
- deepening and developing the professional knowledge and skills in the field of urban renovation of traditional towns with aspects of urban design, urban planning and urban management toward the concept of sustainable and smart city;
- implementation of the principles of sustainable development, followed by ecological, economic and social parameters for planning the city of the future.

The learning process is accompanied by workshops (see Figure 3).

The Serbian Energy Efficiency Institute (SEEI) together with the consultant company YU Build also organise a two-day course about energy efficiency and green buildings for getting the TÜV certificate.

There are also other courses, but not on a higher level, organised by NGO’s or companies involved in building construction and free on-line courses (three days advance course for local managers in energy efficiency and Sustainable Energy Action Plan for reduction CO₂ emissions for 4 Municipalities in Serbia, Schneider electric on-line course about energy efficiency). Some of the courses are organised by education centres or consulting companies, such as: Thermography course organised by Infrared Training Centre, SGS Education Centre, Ving consulting etc.

**Stakeholders**

The training of architects and other experts in the field of energy efficiency (specialisation and education) is mostly organised by, Serbian Chamber of Engineers (SCE). They are partly funded by and partly by participants or their companies.

Since May 2005, the Serbian Chamber of Engineers has been conducting a cycle of one-day lectures and courses related to the engineering theory and practice, within its project of the permanent professional development intended for its members. The topics include different fields in design, construction, urban planning, spatial planning, management, information technology, and the issues in connection with the legal procedures. The attendance is free of charge for the Chamber members.

The Serbian Energy Efficiency Institute (SEEI) facilitates practice. It supports changes in industry sector and from green building experts. It offers training programmes for professionals (LEED continuing education, thematic lectures and workshops on creating and managing greener workplaces/schools, financial consideration for green buildings, envelopes for green buildings, and so on).

**Knowledge and tools**

The lecturers are usually professors, experienced practitioners and consultants in companies.
The knowledge is both theoretical and practical. The different tools were used for different courses. For education at universities it is usually ex-cathedra lectures and discussions, for short courses (one day or two days courses) lectures, workshops and for courses organised by NGO, meetings, workshops, excursions and round tables.

**Scale and topic**

The scale depends on the type of the course. Formal knowledge at Universities cover national level as well as courses organised by Serbian Chambers of Engineers and Serbian Energy Efficiency Institute, while other courses are more oriented toward the regional and local level.

The level of Master studies covers energy efficiency in the building sector, use of renewable energy in architecture and development of low carbon built environment, smart cities and mobility; it is dedicated to architects, urban planners and spatial planners.

The level of specialisation covers the same area but is dedicated to architects, civil engineers, mechanical engineers, landscape architects, economics, spatial planners, traffic engineers. The course organised by Serbian chamber of engineers covers large scale of themes and it is dedicated to different professionals – mostly engineers.

**Conclusions**

In Serbia the education on energy efficiency in the building sector is in continuous development. The activities are focused on main target groups: students and academics, as well as teaching staff of the universities.

Non-formal education in the field of energy efficiency is also present in Serbia. It is not widespread but more concentrated in its capital city – Belgrade. Some courses are organised for local authorities and officials in Municipalities.

The specialist studies “Energy-efficient and green architecture” at the Faculty of Architecture, University of Belgrade, started in 2012, and so far enrolled 73 students, of which 59 completed the specialisation. There is need to extend this course in the future.

The Serbian Chamber of Engineers has issued about 2,000 licenses for responsible engineers for the energy efficiency of buildings. Through education at various levels, responsible design and construction have been introduced in accordance with the new standards. There has been a good experience and increasing responsibility in terms of energy consumption and environmental protection.

To enhance the quality and relevance of higher education it is important to bring together education excellence and best practice in the field of the energy efficiency enhancement, energy saving and use of renewable energy sources. It will develop sustainable educational and human links between target groups. According to this, it is necessary to enhance networking among higher education institutions across the EU member states and non-EU countries and be part of it.

It is also important to enhance and widespread permanent professional development for engineers in practice as well as education of officials in Municipalities and local government who have a responsibility with urban design and construction sector.

**References**


ZHAW Bachelor's degree programme Energy and Environmental Engineering

Author

Vicente Carabias
cahu@zhaw.ch
ZHAW Zurich University of Applied Sciences, Switzerland

Stakeholders

The study programme is designed for interested, future-oriented Bachelor students from Switzerland as well as from abroad. It is also offered as a practice-integrated Bachelor degree course for students who have the school-leaving certificate. A Bachelor degree in Energy and Environmental Engineering will open up a wide range of interesting professional assignments to them in industrial, service and power companies, as well as in consulting agencies and public administration. The next generation will be prepared to develop and leverage low carbon technologies.

The energy sector, together with society as a whole requires, more than ever, people with creative drive and expertise in the fields of energy and the environment. The major topics of the future directly affect these sectors. The Energy and Environmental Engineering study programme therefore provides its graduates with the optimal tools for a diverse and interesting job with the best prospects for the future supporting the energy and mobility transition.

Knowledge and tools

The study programme comprises six semesters, each including 14 weeks of classroom teaching. The teaching is primarily conducted in the form of lectures, group teaching, exercises and laboratory training. The study programme is divided into modules which form a complete learning unit of one semester in length. The programme includes compulsory and elective modules. Individual modules are combined into module groups which form the basis for the granting of ECTS credits.

The first year of the Bachelor study is an assessment level. It comprises basic modules such as mathematics and physics, mechanics, fluid and thermodynamics, electrical and solar engineering, informatics, national and energy economics, environmental law, efficiency, energy and stock flows, technology assessment, measurement techniques, project management and languages such as English for Engineers. Passing this assessment is the requirement for admission into the main study programme.

In the second year most of these modules are continued. Business economics completes the economic education. Efficiency is followed by modules on consistency and sufficiency (in the sense of achieving a higher quality of life with less consumption of resources and energy). Electrical engineering is focused on the power supply system (grid, a.c./d.c. power conversion), electrical drives and generators, control and regulation technologies. In addition, chemistry, power plant technologies, smart grids and electro mobility are taught to best prepare the students for the upcoming energy transition.

The three-year study programme is concluded in the final year with a Bachelor thesis. In the project work and Bachelor thesis, students deal independently with current topics and problems, usually in close collaboration with a company or in the frame of an ongoing research project. In the third year of studies students focus on one of three specialisations. In the Renewable Thermal Energies specialisation, students are involved with thermal machines, equipment components and entire systems, such as energy-related systems, solar and geothermal energies, industrial energy efficiency, wind and water power, heat pumps and refrigeration technologies, exhaust gas and waste water treatment, fuel cells and combustion. In the Renewable Electric Energies specialisation, students are involved with energy-related components, equipment components and entire systems, fundamentals of power electronics (for the supply of wind and solar power), photovoltaics, electrical storage systems, smart and power grids. In the Environment and Sustainability specialisation, students are involved in the development of long-term prospects for the creation of sustainable energy systems. The training programme focuses on innovation management, business dynamics, business models in energy and environmental engineering, foresight as well as energy and environmental scenarios, biogenic energy sources and usage.

To meet future societal challenges and advance low carbon technologies as well as smart energy regions, the Energy and Environmental Engineering study programme provides fundamental knowledge ranging from industrial thermal processes to electrical systems. A basic understanding of economic processes and sustainable development is equally important.

Materials and technologies

The power generation industry is facing a radical upheaval. The consumption of conventional energy sources must be reduced to protect the environment. At the same time, the need for renewable energies is greatly increasing. The global conversion to regenerative energies such as solar energy, wind power or geothermal energy increases the need for qualified engineers with an interdisciplinary background. The future fields of application in industry are just as diverse as the challenges. Exciting tasks are emerging for dedicated professionals. Besides understanding the transformation of regional energy systems, energy efficiency and sufficiency as well as the relevant framework conditions are also prerequisites to contribute to the energy transition.

Graduates are awarded the protected and internationally recognised title of Bachelor of Science UAS Zurich in Energy and Environmental Engineering. The Bachelor programme comprises a total of 180 ECTS credits.
Scale and topics

The course is focused at the national scale, but open also to international students. Currently approx. 50 students are annually enrolled. In the third year, students focus on one of three specialisations. In the “Environment and Sustainability” specialisation, they will be involved in the development of long-term prospects for the creation of innovative energy systems. In the “Renewable Electric Energies” specialisation, students get involved with energy-related components, equipment components and entire systems and in particular focus on power electronics for the supply of wind and solar power, such as photovoltaics, electrical storage systems and smart grids. In the “Renewable Thermal Energies” specialisation, students will be involved with thermal machines, energy-related systems, equipment components and entire systems, such as solar and geothermal energies, fuel cells, and energy efficiency. To sum up, several areas are addressed: energy saving, renewable energies, energy efficiency.

Conclusions

To meet the energy challenges, the ZHAW Energy and Environmental Engineering study programme provides fundamental knowledge ranging from industrial thermal processes to electrical systems. A basic understanding of economic processes, future-orientation and sustainable development is equally important. The Bachelor’s degree programme is now in its third year and students have just started with their study focus. By end of 2015 first experiences can be expected. Excellent graduates have then the opportunity to continue with the Master of Science in Engineering at ZHAW.

Lecturers work on interdisciplinary research and development projects in collaboration with industrial and economic partners. Results of this collaboration are continually incorporated into the teaching. International profiles are still to be developed, but first a consolidation of the teaching experiences and stronger ties to relevant industries and administrative units are envisaged.

Contacts

More information is available from:

• the head of the study programme on Energy and Environmental Engineering, Dr Joachim Borth, bthj@zhaw.ch;

• or from the Swiss COST TU1104 MC member Vicente Carabias, cahu@zhaw.ch;


Welsh Energy Sector Training (WEST)

The Welsh Energy Sector Training (WEST) is a pilot training programme aimed at the transfer of knowledge from the High Education sector to industry. The programme was available only in the Convergence areas of Wales (Figure 1) and ran from September 2011 to February 2015. The main objective of WEST was to foster skills among professionals to aid the uptake of new technologies developed through the Low Carbon Research Institute (LCRI). The LCRI works with companies, particularly Small and Medium Enterprises (SMEs), to develop new industry-relevant technologies that will provide business opportunities and help Wales deliver its low carbon agenda. Both the LCRI and WEST are based on partnerships between six Welsh universities. The LCRI funded the WEST project through the Convergence Energy Programme, which brings together resources from Welsh Universities and companies (£15 million) and from the European Regional Development Fund (ERDF) (WEST, 2011).

The training opportunities offered by WEST were relevant to relevant professionals and practitioners looking to update their skills, obtain training on a new technology or transfer across areas within the energy sector. Participation was fully funded for those living or working in Convergence areas of Wales (Figure 1) and not employed in the public sector. Due to the pilot nature and the limited resources of the WEST project, the target number of trainees was set to 70 people (Stevenson V., personal communication, 1/10/2014). The training programme was structured to deliver knowledge and skills on the five themes which have been the focus of research in the LCRI:

• low Carbon Built Environment (LCBE);
• hydrogen;
• marine;
• solar Photovoltaic (SPV);
• large Scale Power Generation (LSPG).

Research within these themes is technology focused and encompasses cross-cutting topics such as power electronics and environmental assessment. This case study focuses only on the preparation and delivery of the WEST training modules related to the Low Carbon Built Environment (LCBE) research.

Figure 1 - Convergence areas in Wales

WEST team structure

The WEST programme was led by Dr Julie Gwilliam and Management Team of researchers based at the Welsh School of Architecture in Cardiff University. The School of Engineering at Cardiff University and Swansea University were partners of the programme. The training courses in each of the five LCRI research theme were delivered by specialised staff members.
An additional research team at Swansea Metropolitan University and Glyndwr University focused on the strategy for Further Education (FE).

Identification of training needs

At the start of the project in September 2011, WEST staff conducted inquiries on education and industry stakeholders in Wales to identify the gaps in education and practical skills which were hindering the progress of the low carbon agenda. Investigations were made to assess the needs of industry and the gaps in delivery in both the Higher Education (HE) and FE sectors (Stevenson and Gwilliam, 2014).

Among HE Institutions in Wales and just across the border with England, it was found that there some relevant training opportunities existed, such as through MSc programmes, which covered the 5 relevant research themes. However, the majority of training focuses on LCBE and SPV, leaving the other topics almost uncovered. Moreover, it was found that long courses such as MSc are not easily undertaken by professionals, who need opportunities for Continuing Professional Development (CPD) to be compatible with their full-time professional activity (Banteli et al, 2014). Regarding FE opportunities in Wales, WEST researchers noted that although there are programmes covering design and installation of low-carbon technologies, there remained a general lack of knowledge on low carbon energy issues and the “low-carbon economy” of the UK (Rudd et al, 2014).

In order to identify the needs of industry, Skills and Training Needs Analyses (STNA) were conducted by WEST staff reviewing the latest literature and engaging with stakeholders through events and a questionnaire (Ruiz del Portal et al, 2014). The analysis concluded that:

- regulation requirements were the most important factor driving the demand for upskilling in industry;
- although the industry showed a certain awareness of the low carbon agenda, understanding and technical expertise needed to act were still largely missing;
- high cost and time constraints were identified as the most relevant obstacles for the up take of training programmes;
- the existing training opportunities were focused on future professionals, while it is necessary to address current professionals;
- the current offer of training opportunities on low carbon technologies also need to be increased to match the growing demand (Ruiz del Portal et al, 2014).

Engagement with industry stakeholders was delivered through events across Wales in December 2012 and a questionnaire survey. During these consultations, stakeholders were surveyed regarding their interest for training in the LCRI-LCBE array of topics (Figure 2). Additional training interest was identified through desk-based research. The WEST researchers concluded that the expertise of the LCRI – LCBE group was adequate for the delivery of training in the following areas:

- low carbon building design;
- building envelope;
- energy generation and storage;
- building monitoring;
- low carbon urban scale design.

Although high interest was received from industry stakeholders for training opportunities, the following topics were not developed into training modules as they did not fall within the scope of the LCRI – LCBE research:

- energy retrofit;
- sustainable alternative materials;
- software tools for design and assessment;
- legislation;

The delivery phase

The delivery phase of the WEST – LCBE modules ran from April 2014 to February 2015. The courses were delivered through a blended learning approach, with a mixture of traditional face-to-face learning and e-learning, where core content was delivered during the face-to-face sessions this was integrated with additional material on the Moodle Platform. The whole package was required in order for the trainee to obtain the CPD qualification.

The courses were delivered in three phases:

1. Online material was development that intended to enable professionals to adapt their learning activity to their personal time schedules. However, it was found that participants had a tendency to lose touch with the online aspects of the course and to extend the time taken for completion.

2. The face-to-face sessions took place in locations across Wales in order to address the issue of uneven distribution of existing training opportunities (Banteli and Gwilliam, 2014). These sessions had half-day duration and were delivered in the morning, as it was found that this schedule would allow professionals to ensure dedicated time to the training. The face-to-face sessions were also particularly appreciated by the participants as opportunities for professionals to exchange experience. Since the WEST researchers had restricted their target audience to a specific category of building professionals, an interesting mix of expertise was observed among the trainees, though the majority were either architects or consultants (Stevenson V., personal communication, 5/2/2015).

WEST – LCBE delivered the following training modules:

- Welsh timber in building construction: myths and facts – This module was delivered to a total of 12 online participants, of which 10 attended the face-to-face sessions. The latter were delivered in 3 different locations of Wales by WEST researchers and representatives from Coed Cymru and WoodKnowledge Wales, two regional initiatives for the promotion of Welsh timber, and Fforest Timber Engineering;
- low carbon building principles – This module was delivered to a total of 10 attendees and 13 online participants, of which 12 attended the face-to-face sessions delivered in 2 Welsh locations by WEST researchers;
- energy Simulation: Building & Urban Scale – This module was delivered only in two face-to-face sessions for a total of 4 participants.

Figure 2 - Interest expressed by Welsh industry stakeholders in receiving training on LCBE themes
(source: Ruiz del Portal et al, 2014b, p.73)

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Figure 3 - WEST event in Swansea

Each training module corresponded to 1 credit unit (10 hours) valid as Continuing Professional Development (CPD). Typically, annual CPD requirements for professions relating to the building sector range between 30 – 50 hours.

The modules delivered by WEST fitted into this range, as they were small units of 10 hours (1 credit). Currently, the smallest qualification available from HE in Wales is the Post Graduate Certificate of 60 credits (600 hours). For this reason, the Welsh awarding organisation ‘Agored Cymru’, was chosen to accredit the WEST training units under the Quality Assured Lifelong Learning (QALL) pillar of the Credit and Qualification Framework for Wales (CQFW) (Stevenson V., personal communication, 1/10/2014).
However, many trainees did not consider the CPD accreditation to be an essential motivation for their participation, but were interested in the content of the modules itself. In fact it is possible that the small “weight” of each module (only one credit) and the limited reputation of the awarding body did not present sufficient drivers to pursue the WEST training as CPD. An accreditation through a more well-known organisation such as RIBA (the Royal Institute of British Architects) might have constituted a stronger driver (Stevenson V., personal communication, 5/2/2015). The route for accreditation was a requirement of the WEFO funding.

The WEST researchers had envisioned the continuation strategy of the pilot WEST – LCBE training to be the establishment of a Master in Research (MRes) programme at the Welsh School of Architecture (WSA) in Cardiff University (Banteli and Gwilliam, 2014). Currently the WSA offers three programmes of Masters in Science (MSc) related to LCBE research themes, which are based on 120 “taught” credits and 60 dissertation credits. All Masters can be attended on a full-time or part-time basis, for a correspondent duration of 1 and 2 years, which the exception of the MSc in Environmental Design of Buildings, available also for distance-learning for a 3 years duration (WSA, 2014).

Since the analysis of the HE opportunities concluded that these programmes have limited accessibility for professionals engaged in full-time work due to time constraints and the prevalence of taught material, a potential future MRes programme at the WSA is planned to be delivered in 2 years on a part-time basis, and structured on 60 taught credits and 120 research credits. This format is intended to allow professionals to integrate the theoretical content of the programme into their practice and be flexible in regards to their time schedules, whilst ensuring the high academic standard of education (Stevenson V., personal communication, 1/10/2014).

### Conclusions

This case study showed how the WEST pilot project addressed the necessity to transfer technical knowledge from research institutions to professionals and practitioners of Wales, in a country where significant research on low carbon technologies is conducted but the uptake by industry is still limited, often due to a lack of training accessible to working professionals and practitioners.

An extensive investigation of the opportunities and needs in Wales for training was conducted by the WEST researchers. This preliminary activity identified the issues of the current system for knowledge transfer trough FE and HE existing in Wales, and reported the rising interest of industry towards practice-oriented training programmes. As a result, the innovative delivery of the WEST modules through flexible training was designed to adapt to the targeted professionals and their requirements in terms of flexibility in terms of location and time of delivery. In the future, the development of the WEST – LCBE experience into a bespoke MRes programme at WSA is intended to enable a more efficient transfer of knowledge from research to practice, thus contributing to the progression of the low carbon agenda in Wales.

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### Contacts

- **WEST Programme Director:**
  - Dr Julie Gwilliam
gwilliamja@cardiff.ac.uk
- **WEST Project Manager:**
  - Dr Vicky Stevenson
  stevenonv@cardiff.ac.uk
- **WEST website:**
  - [www.westproject.org.uk](http://www.westproject.org.uk)
- **Low Carbon Research Institute website:**
  - [www.lcri.org.uk](http://www.lcri.org.uk)
Introduction to Lifelong Learning

Author
Elena Dimitrova
University of Architecture, Civil Engineering and Geodesy (UACEG), Bulgaria

As already broadly acknowledged, scientific and technological innovations and resulting societal changes continually occurring for over 50 years all over the world have had a profound effect on learning needs and styles. Acquiring relevant knowledge and skills in time and space has been increasingly re-conceptualised and understood as an ongoing process throughout the whole lifespan of individuals – thus resulting into the newly coined term ‘lifelong learning’ (LLL). The concept of lifelong learning has proved to be of vital importance with the emergence of new technologies that change how we receive and gather information, collaborate and communicate with others, and strive for personal and professional realisation. This has also posed considerable challenges to national education and training systems.

The lifelong learning concept is not entirely new, it emerged in the early 1970s in different formats all over the world. It stemmed from the pioneering work of the Canadian scholar Allen Tough on adult learning, self-directed growth, and personal change (Tough, 1971). It gained popularity in the USA in 1990s and it was adopted in 2000 as a governing principle needed in the society based on lifelong learning as a key lever and means of survival. The Memorandum on Lifelong learning adopted in 2000 states that LLL is designed to provide the people of Europe with the essential tools they require for self-development and in order to play an active part in modern society, including the skills needed in the field of new technologies (CEC, 2000).

Lifelong learning is defined in official EU policy documents as “all learning activity undertaken throughout life, with the aim of improving non-formal education and informal learning to be recognised, and enabled the emergence of a ‘learning society’, which would enhance “the quality of life of both individuals and their communities in a fast changing, increasingly technologised, world” (Wain, 2001).

The emerging concept of ‘lifelong learning’ was embraced by the European Commission and the Organisation for Economic Co-operation and Development (OECD). The First Global Conference on Lifelong Learning, organised by the Brussels-based European Lifelong Learning Initiative (ELLi) in Rome in 1994 stressed the multilevel importance of lifelong learning as a survival concept for the 21st Century (Milana and Holford, 2014).

Following this the concept gained explicit support from numerous policy documents at the EU level over the last 20 years. By establishing 1996 as a European Year of Lifelong Learning EC set the objective “to make the European public aware of the importance of lifelong learning, to foster better cooperation between education and training structures and the business community, particularly small and medium-sized enterprises, to help to establish a European area of education and training through the academic and vocational recognition of qualifications within the European Union, and to stress the contribution made by education and training to the equality of opportunities” (EC, 1995). From 1996 a series of crucial documents was adopted by various European bodies, paving the way to a ‘learning society’ based on lifelong learning as a key lever and means of survival. The Memorandum on Lifelong learning adopted in 2000 states that LLL is designed to provide the people of Europe with the essential tools they require for self-development and in order to play an active part in modern society, including the skills needed in the field of new technologies (CEC, 2000).

The LLL concept builds upon the centrality of the learner, the importance of equal opportunities and the quality and relevance of learning. It sets the objective of creating “a culture of learning”, which is linked to increasing personal competitiveness and employability but also to enhancing personal self-sustainability and providing for social inclusion, active citizenship and better quality of life. Lifelong learning is thus further promoting the striving of European countries “to become more inclusive, tolerant and democratic”.

Related EC policy publications on adult learning argue that concentrating on quality, efficiency and equity would reap benefits for both society and the economy (EC, 2006).

The process of lifelong learning for the needs of smart energy regions in Europe responds to two of the seven flagship initiatives of the European Commission, within the ‘Europe 2020’ strategy – the Agenda for new skills and jobs: A European contribution towards full employment (EC, 2008), officially launched in November 2010, and A Resource-efficient Europe (EC, 2011).

Overview of case studies

The ten case studies developed within the COST Action that deal with lifelong education/training in the area of low carbon technologies present practical training experience from eight European countries:
- Austria – Passive House Craftsmen Course (PHCC / PHCC+ project, Austria);
- Belgium – CAP 2020 project and REGAIN project;
- Bulgaria – MODEL project;
- Cyprus – Whole Life Management of Sustainable Construction Programme;
- Ireland – Energy Advice and Promotion Support for Community Groups project;
- Italy – Expert in Sustainable Building project and ARCA Academy for designers;
- FYR of Macedonia – BUILDUP Skills project;
- Malta – BUILDUP Skills project.

They cover diverse regions in Europe with regard to their geographic as well as socioeconomic and cultural characteristics.

The case studies address a major current challenge in all the participating countries – continually enriching knowledge on energy-related issues, their interdependence and the resulting need for developing smart approaches and integrated management tools to tackle energy issues in organising the built environment of today.

Because of the continually enhancing knowledge and the on-going re-conceptualisation of competences needed for putting smart energy approaches into practical action, a continual learning process is vital to providing professional competence responding to the peculiarities of the energy management process. A broad range of knowledge and skills – technical, spatial, social, behavioral, etc., should be recognised and communication undertaken with diverse target groups with different training demands and learning capacity.

The comparative analysis of the COST Action case studies sought for responding to five key research questions related to the training and education process:
- what are the education/ training objectives and what outcomes are aimed at?
- what are the target groups addressed?
- what training and education approaches are considered relevant and applied?
- who provides funding sources for that kind of education and training?
- what are the main challenges identified in the LLL process?

A considerable variety of education/ training objectives could be traced throughout the case studies. Some of them are focused on introducing a common language and awareness (Expert in Sustainable Building, Italy), easing relations among actors of the construction sector (CAP 2020, Belgium) or introducing common evaluation methods (REGAIN project, Belgium).
Others are explicitly aimed at developing and implementing integrated management methods at the local level (MODEL project, Bulgaria). Many projects and activities strive for providing knowledge and skills related to specific building topics, e.g. timber construction (ARCA Academy project, Italy), semi-industrial buildings (REGAIN project, Belgium or passive house projects (PHCC / PHCC² project, Austria). The choice of the training focus is strongly context sensitive and pragmatic; projects address priority issues identified well in advance (Expert in sustainable building project, Italy; Build-Up Skills projects in Macedonia and Malta; etc.).

The target groups addressed by the various projects were relevant to the objectives set and understandably a broad variety of actors were regarded. Logically, a major set of target groups belongs to the building sector. Some projects address groups at the low expertise level (Expert in Sustainable building project, Italy), while others are aimed at promoting highly specialised international tools in the construction process (REGAIN project, Belgium – SB tool; Construction and Engineering Systems project; ARCA Academy, Italy – advanced training in timber constructions).

The second major set of target groups covers local authorities, citizens, and business people. The specific requirements of each group have been considered there, yet in many cases different groups are involved in a number of joint activities in order to develop a shared understanding and common language on smart energy issues and policy (MODEL project, Bulgaria; Whole Life Management of Sustainable Construction Programme, Cyprus; Energy Advice and Promotion Support for Community Groups project, Ireland). Children are included in the Bulgarian case study as a particularly important target group in line with the long-term objective of creating broad public awareness about the importance of energy related issues and of promoting relevant behavioural models.

Diverse training methods are discussed in the case studies and a continuous search for the most effective ones is claimed. Although methods vary depending on the training objective and the target group, some general tendencies are clearly outlined – the courses are predominantly short-term and intensive; a combination of theoretical and practical aspects is usually preferred, with a strong focus on practice related issues raised by participants themselves. The two Belgian case studies demonstrate how traditional methods as on-site visits and progressive workshops (REGAIN project) are complemented by innovative ICT-based ones (a virtual platform for knowledge exchange and networking developed within CAP 2020 project).

Education and training courses are usually organised at different levels – local, regional or national, with an increasingly visible EU support (financial as well as methodological) for developing systematic approaches (BuildUp Skills Project) and a strong focus on continuity and synergies (Austria, Bulgaria, etc.).

The training institutions involved in the process usually come from specialised professional institutions (ARCA Academy, Italy) and networks (EcoEnergy, Bulgaria), universities and vocational schools. International expert support is also provided through networking and experience exchange (REGAIN project, MODEL project). An impressively large scale of the cooperation is presented by the Austrian case study where the partnership includes the Passivhaus-Institut Darmstadt, (in the initial stage of the project) four Secondary Colleges of Engineering, two Austrian “construction academies” and one vocational training school). The validation of training is in most cases considered important and provided through certificates issued by the training authorities.

The implemented funding schemes in the case studies vary considerably depending on available resources and policy priorities. Some of the programmes are self-sustained and rely on membership fee (CAP 2020, Belgium) as professional associations meet the estimated needs of their own members; others are paid as they provide training services where the need for higher expertise is already broadly acknowledged by relevant professionals (ARCA Academy, Italy).

A major funding source comes into the field from the EU level through already established programmes such as Intelligent Europe (MODEL project, Bulgaria; BUILDUP Skills, Macedonia), INTERREG IV (REGAIN project, Belgium), European Social Fund (ESF) (Expert in Sustainable Building project, Italy), Lifelong Learning Programme - Leonardo Da Vinci - Transfer of Innovation (PHCCplus project, Austria) This funding is explicitly focused on integral capacity building at the local level and very sensitive to the urgent need for covering existing knowledge and management gaps that have resulted in greater vulnerability of some regions across Europe. EU funding is often combined with local and regional funding (Expert in Sustainable Building, Italy – Province of Trento; MODEL project, Bulgaria – participating seven pilot municipalities).

The challenges related to lifelong training and education in the smart energy field are not quite visibly outlined in the case studies. They seem not to be fully conceptualised yet, but many of them have recently implemented and middle- and long-term consequences could not be currently identified and fully estimated. Yet, an important observation was mentioned in one of the case studies (Expert in Sustainable Building, Italy) with regard to the ‘training-market’ relationship, where the authors claim that “the market seems not to be ready’ for the higher expertise provided by the training courses. The difficulties identified in the case study from Malta – the lack of data about the green construction industry and the composition of the construction sector (prevaling micro-companies), might be expected to prove relevant to other places in Europe as well.

Several general conclusions could be drawn from the international comparative analysis: Lifelong education and training in the smart energy field is a very complex and multi-faceted process as it comprises a broad variety of aspects that are to be considered in an integrated manner – it requires a common understanding about a broader process and mastering of integral approaches; needed knowledge and skills comprise specific technical aspects as well as social, economic, managerial skills. Building a common language is a major prerequisite for the fruitful implementation of effective measures at all levels. Lifelong education and training for all the actors involved in the development of smart energy regions is an ongoing innovative process in itself. Providing the education and training services needed goes in parallel with studying and better understanding a continually changing societal and technical context, estimating the effectiveness of the measures undertaken and re-inventing the technical approaches and policy instruments previously implemented.

Lifelong education and training provides an excellent chance for being responsive to the diversity of dynamic changes in the smart energy field and for guaranteeing relevant flexibility of the training process – issues addressed and target groups approached, based on continually estimated dynamic needs. It is therefore important to keep a special focus on some important recommendations about needed further development with regard to lifelong education and training in the smart energy field:

- There is a need for re-conceptualising the urban process with regard to its energy aspects by introducing a stronger sensitivity to the social aspects of energy performance and on the interaction of different actors in the energy management process at the urban and regional level;
- The relation between the demand for smart energy based services and the demand for providing relevant education and training in the field, is a twofold one – lifelong education and training should be sensitive to market demands but also increasingly proactive in order to counteract a potentially delaying sensitivity of the market to smart energy requirements and development opportunities.

- A process of mutual learning through clustering and networking of all the actors involved in LLL and smart energy processes – policy makers, research institutions, professional bodies, providers and potential beneficiaries of LLL education and training services at multiple levels, could provide additional opportunities for successfully integrating innovative approaches and tools in
the lifelong education/training process.

• The Lifelong Learning concept and approach is particularly relevant and helpful in the low carbon technology field where the complexity and dynamics related to all the technological aspects of innovation related to energy production, distribution and management are combined with a deepening understanding about the nature and mechanisms of social interaction aimed at democratic urban governance and participatory urban development.

References


Available at http://files.eric.ed.gov/fulltext/ED471201.pdf


The innovative training concept contributes to a great extent to quality assurance in the passive and plus energy houses sector.

In addition to that, the increase of career opportunities, especially for Hungarian crafts(wo)men, the promotion of transnational mobility of work force through ECVET-Credits (European Credit System for Vocational Education and Training) and the personnel certificate according to ISO 17024 for the international recognition of the training were important. The training of certified instructors, who will be situated at local training centres for further trainings in the local language, created an opportunity for education, which will massively support the dissemination of energy efficient building even above the border area of Austria and Hungary and foster life-long learning.

The first course within the project was designed with its focus on "new buildings in small and large domestic architecture", as in new buildings, the principles of highly energy efficient building can be demonstrated most clearly. The courses within the PHCC project were free of charge for the crafts(wo)men.

The training course was designed for all crafts(wo)men in the passive house sector, as well as developers and housing cooperatives. The concept was designed to be applied as in-service training, building upon the corresponding apprentice training as well as a first education and in Secondary Colleges of Engineering.

Further important aspects in the development as well as in the implementation of this course concept were the cooperation with Austrian and Hungarian Secondary Colleges of Engineering, two Austrian "construction academies" and one vocational training school in the design and implementation of the course. In the four Secondary Colleges of Engineering relevant contents of the PHCC shall be implemented in the primary education in the near future, whereas the network of the construction academies and vocational training school shall build the basis of the establishment of the course in further professional trainings.

The following elements are seen as the success factors of the PHCC / PHCCPLUS training course:
- development of a modular training concept, tailor-made for crafts(wo)men in different areas, according to their former training and education (construction manager, foreman, etc.);
- special focus on practical units at special training locations and construction sites;
- 170 / 250 pages textbook especially for passive house crafts(wo)men in "crafts(wo)men language" available in German and English.

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Figure 1 - PHI certified one-family passive house in Graz

Figure 2 - Passive house student home in Graz

Knowledge and tools
Whereas the PHCC’s 72 teaching units have been implemented "en bloc" in the winter period, the newly developed PHCCPLUS has already been tested and will be bookable modular from 2016 via four 24 teaching units thus enabling more craft(wo)men especially from SMEs to take part not only in the winter time but all over the year.

The second, very important further development of the PHCC during the CertCraft project is the new focus on the interface optimisation between the different crafts. Therefore the PHCC’s specialisation in building envelope and HVACR crafts(wo)men has been abandoned in favour of an integrated approach where both crafts get knowledge, skills and competences of the "foreign" crafts too in order to better communicate on the building site thus avoiding lots of structural damage in the future. Therefore according to the needs of the practice the new specialisations are on new buildings and refurbishment.

The learning outcomes orientated curriculum of the PHCCPLUS is structured along the four main modules "basics", "new buildings", "HVACR" and "refurbishment" comprising all together 17 learning modules, the main contents of which displayed in a knowledge-skills-competences – matrix to foster the ECVET process in the fields of energy efficient building.

The PHCCs Blended Learning Concept, the ECVET implementation and the ISO 17024 personnel certification are pursued in the PHCCPLUS too.

The basis of the course development in both projects was the translation of international training materials – which were until then only available for passive house planners – into "crafts(wo)men-language" and the adaptation to the situation of the partner countries, providing for the first time a more than 170 pages handbook for passive house crafts(wo)men. This handbook is available as loose-leaf so that it can be amended, updated and extended at any time, if needed.

Within the CertCraft project this "famous" passive house crafts(wo)men handbook, unique in whole Europe, has been updated and extended from 170 to more than 270 pages, comprising new example buildings and the new refurbishment module.

The material is focusses on the "real world – construction site knowledge". Besides numerous detailed chapters on outer walls, windows, roofs and chimneys, by means of seven mostly PHI – or klima:aktiv certified family houses, apartment buildings and offices (in massive, light and mixed construction method), the passive or nearly zero energy building process is explained from the basement to the roof top. Another important part is the module "HVACR in passive / nearly zero energy houses" providing a sound overview on all systems for heating, cooling and water heating, including plenty of up-to-date information. In addition to that, an e-learning platform has been installed where for two of the seven passive houses precise construction schedules, including explanation of the crafts interfaces and a complete photo documentation of the construction progress is available.

In the course itself, 20 units are exercises in training workshops (training units with experienced practitioners using 1:1 demo walls crucial PH details practically being installed by the participants themselves), 20 units take place on building sites (practical teaching units on-site at different passive house construction sites), 32 are theory (in the classroom) and 20 units are e-learning units for individual studies. In the senior coaching module graduates may call their instructors for 18 months after finishing the course for solving current problems i.e. on the construction site.

Stakeholders

The training course was designed for all crafts(wo)men in the passive house sector, as well as developers and housing cooperatives. The concept was designed to be applied as in-service training, building upon the corresponding apprentice training as well as a first education and in Secondary Colleges of Engineering.

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Hungarian (PHCC) and additionally in Romanian and English (PHCCPLUS);
- development of an e-learning platform, so that participants can learn location and time independently, on an individual basis (Blended Learning);
- Senior Coaching / Mentoring-model for follow-up coaching of the participants;
- cooperation with all relevant sector-specific education and training organisations (Secondary Colleges of Engineering, “construction academies”) in the design as well as in the implementation of the course;
- setup of an Advisory Board with well-known experts in the different areas;
- build-up of a pool of trainers, available as multipliers for a broad dissemination of the course;
- personnel certification according to latest ISO 17024 and ECVET – preparation.

| Passivehousecraftsmen Handbook (= 270 pages) |
| eLearning Platform |
| Workshop 30 TU Lecture Room 32 TU |
| Construction Site 10 TU |
| Mentoring/Senior Coaching System |
| ISO 17024, ECVET, klima:aktiv certification |

Further development of the project

As mentioned above the multiple rewarded PHCC is being further developed and enlarged to the “PHCCPLUS” within the project “CertCraft – Passivehouse Craftswomen Course for new buildings and refurbishment / PHCCPLUS”, Programme Leonardo Da Vinci, Transfer of Innovation between December 2013 and December 2015. Participating countries are, besides Austria and Hungary as former projects partners, also Switzerland and Romania.

In this project, the main goals have been:
- update and further development of the PHCC;
- adaptation to the actual state of national and European frameworks;
- development of a training module for thermal renovation of existing buildings.

At the end of the project CertCraft, 230 participants have finished the course and 69 trainers have been trained.

Since all outputs are available in German, Hungarian and Romanian as well as in English, the widest dissemination and further development of the course concept seems to be within reach thus significantly fostering the EC goals on energy efficiency in buildings. For more information please see the following websites:

- Passivhaus Crafts(wo)men Course
  - http://phcc.info
- CertCraft ISO & ECVET
  - http://certcraft.eu
- ECVET projects
  - http://www.ecvet-projects.eu

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Plate et al.: Marktpotenzial und Bekantheitsgrad des Passivhauses in Österreich, Wien, April 2010


Cap2020

CAP2020 is a regional cluster created under the impulsion of Wallonia. It gathers a group of enterprises active in the building industry, who adopt and pursue the 2020 European objective of massive energy consumption reduction applied to buildings and build a common attitude related to sustainability stakes.

More precisely, the declared objectives of the cluster are as follows:
- to reach a level of building energy performance that is 20 % more efficient than the regulatory prescription for 15 % of buildings (new or renovated) in 2020;
- to develop the production of energy from renewable sources, in a sustainable prospect;
- to improve the energy performance of the whole Walloon building stock by 1 %, each year.

In June 2014, the cluster was composed of 174 different effective members, coming from the three main roles involved in the Walloon building chain of the construction/renovation of buildings, which constitute the three statutory pillars of the cluster, i.e.:
- conception, design: architects, engineers, etc.
- contractors, all kind of construction companies (small, average and big companies: 36 members);
- producers and suppliers of building materials (42 members).

The 19 other members come from federations, research units and training institutions.

The cluster, financed by membership fees (which depends on the size of the “company”) and by (paying) attendance to activities, works thanks to three vital organs:
- the Administration Board, the strategic organ defining the guidelines, composed of 16 members from every professional groups; the presidency shifts every 2 years from one pillar to another;
- the Directorial Committee, the operational organ putting the strategies defined by the Administration Council into operation and managing day-to-day business. 9 of the 16 members of the Administration Council sit at this Committee;
- the Operational Team, composed of three official representatives and a communication responsible.

Cap2020 tries to ease relations between the main actors of the construction sector – who are most often alone in their office or company – so that they can meet, develop and share knowledge, exchange on experience, opportunities, good practices and (low-carbon) technologies (as far as sustainable building is concerned) and use networks of privileged professional partners created by the cluster.

But the philosophy of this cluster is also to make information available to construction actors (architects, contractors and material producers), for construction workers (not only members, but everyone who is interested in the information given by the action).

As the dissemination of skills and knowledge is delivered to the widest public, the stakeholders are multiple and various: they are the members of the cluster, architects, engineers and designers, contractors of all sizes, material producers and suppliers; private offices and companies or public authorities who consider Cap2020 cluster as a credible association to be consulted concerning evolution of performance and energy regulations at the Regional scale.
Different tools are available to this purpose; the interest is big, as 98 % of members participated in an activity organised by the cluster between June 2013 and May 2014.

The newsletter is a common communication used by all associations to get in touch with their members in a safe and regular way. In its monthly edition, the cluster keeps interested people in touch with events, actions, meetings, relevant result. As a modern association, which aims at a wider public, the cluster also studies and uses social media to diffuse information. The cap2020 website (http://clusters.wallonie.be/cap2020-fr/) is also an information platform on sustainable construction for private people, gathering information on basic principles, incentives, standards and innovation. 76 new articles have been posted on this website between June 2013 and May 2014.

Events are organised by the cluster under different forms, to give opportunities to b-2-b visits and:• “Noon of Cap2020”, which are small meetings, at lunchtime, during which the presentation of a company or of a product, or a debate on a specific topic can be organised. They are also a means of extending the members network, by making new contacts among non-members who are welcome to these events. 3 of these meetings have been organised between June 2013 and May 2014, gathering 60 people;• visits of innovative construction works on site, where general and particular solutions might be discussed, as well as innovative product implementation demonstration. For example, high quality projects that have been visited in steel structure buildings in Enghis, Belgium (20 participants) and in the region of Dunkerque, France (35 participants), or a visit of the REGAIN semi-industrial building (13 participants). 18 people also took part in a “day of sustainable construction” event in the Grand Duchy of Luxembourg;
• the “decision-maker lunches”, organised in a restaurant, aiming at reinforcing competitiveness and commercial links between cluster members and at easing access to innovative capacity. Other institutions, like local economic development (public) companies, or regional social housing organisation are also invited to present their activities, needs, projects or results. The interventions do not only revolve around sustainable buildings, but also other aspects of the sector, like training, communication (e.g. social media) or marketing. Between June 2013 and May 2014, five of these lunches have been organised, gathering 126 participants;
• conferences and seminars are regularly organised, on different subjects related to sustainable construction. They can take place in global “sustainable building fairs” or in separate events. For example, an evening dedicated to smart cities, called “Meetings around the cities of tomorrow” gathered 124 participants in May 2014. The September 2014 conference focused on Smart Buildings, during the Passive House Salon;
• techniques, knowledge, know-how and production process evolutions impose building professionals to continuously train if they want to stay on top of things. Needs in exchanging share of used between members; contacts are taken with Greenwal to organise training on sustainability-related themes like air tightness, ventilation, thermal bridges or LED lighting, etc. Greenwal (www.greenwal.be) is a “pole of excellence” which aims at boosting the construction and renovation sectors by building bridges between training, research and innovation. Members include confederations of actors, or large companies in the construction sector, training organisations, clusters (like Cap2020), and research units. They propose training of different importance (in length and attendance) for actors of sustainable construction, master classes and conferences on innovative topics. In 2016, an innovation demonstration platform (a place to diffuse innovation) should be established. Development of new training programmes, and coordination of the training offer in Wallonia is one of their missions.

Internally, different working groups have been created (members only) to reflect on topics and communicate the products of these reflections to the members as well as to external public, in different events organised by the cluster. Amongst the different topics studied by the 26 % of members who attended these working groups between June 2013 and May 2014, we can point to:
• innovation products and systems solutions, techniques, materials, equipment and services allowing more energy efficient buildings;
• labelling of buildings and companies;
• relations and visibility of the cluster;
• finance and construction economy;
• renovation (and ventilation);
• renewable energy sources, in relation with buildings, whether public, private, individual, collective, residential, tertiary or industrial ones.

Cap2020 also aims at promoting the conception and realisation of high quality projects, anticipating evolution of standards and environmental requirements and/or meeting the sustainable construction criteria. These cover, among others, the global energy performance of buildings, the controlled use of natural resources, water cycle management, waste management, comfort, health and the security of buildings and infrastructure users. Cluster Cap2020 is also a vector for introducing collaborative research projects to the Walloon research administration, such as:
• the ECOFFICE, a BREEAM certified passive office building built for a “small construction price” (under 1,000 €/m²); the originality and interest of this project also lies in the unusual early involvement of contractors, university research units and future tenant in the conception process, in addition to the architects. This inspiring example has already led to the construction of a similar (nearly zero energy) office building in Wierde, Belgium;
• CIMEDE (which stands for “Industrial Construction of Evolving, Sustainable and Economic Houses”, in French), a new building concept, based on industrialised prefabricated wood-framed panels, used to produce sustainable, evolving, low-energy and low-cost single family houses;
• the cluster also helped to give life to the “Reno2020” project, which aimed at studying the possibilities of inserting prefabricated and industrialised solutions into the renovation of the Walloon dwelling stock. One of the outcomes is the creation of software helping decision-makers in the renovation process of a building. This particular project and its results are used in another research programme about ventilation in renovation;
• it can be noted that, for the period of June 2013 to May 2014, 25 % of members were involved in a collaborative project (with at least one other cluster member).

Finally, the cluster insures a regular presence (in order to give information, advice or contacts) to different trade shows and fairs, like the “PassiveHouse”, “ECOBAT”, “Batibouw”, “Energie+” or “Energie et Habitat”.

The whole cluster which has been developed in Europe for 20 years, has proved its worth. In Wallonia, other clusters and competitiveness poles deal with “transport and mobility” issues (Logistics in Wallonia and SkyWin), Environment and Sustainable Development (EcoConstruction, GreenWin and Tweed, in addition to Cap2020), nutrition and health (BioWin and Wagralim) or transversal technologies (Infopole Cluster TIC, Mecatech, Cluster Photonique, PlastiWin and Twist). Quite similar to clusters, competitiveness poles are defined as the combination, on a given geographical region (Wallonia), of companies, training centres and research units, public or private, engaged in a partnership destined to clear synergies around common innovating projects. This partnership is organised around a market and a technological and scientific domain, and is seeking international visibility and competitiveness.

The Cap2020 cluster has been growing constantly in recent years, allowing anyone to reach a wide network of professionals that are committed in efficient design, materials and buildings construction. The number of members is foreseen to grow to 300 members in three years.

The cluster also inspires other organisations like “business clubs”, local gatherings of private companies, social economy enterprises, architects and material suppliers, creating platforms of 10 –15 enterprises which can therefore collaborate, inform and stimulate each other in order to reach better economical, ecological and technical performance.

Those clubs become places of exchange on various topics, such as innovation, services and partnership offers, employment, construction...
site organisation, communication, energy performance, environmental performance, marketing performance

It has become a new economic development tool, an indispensable and unique exchange platform regrouping energy construction stakeholders, implemented to stimulate the high potential of the sustainable building sector. It is a place of exchanges, of value creation and innovation incentives.

Up to now, the cluster works as an exchange platform of knowledge (about low-carbon materials, solutions and technologies), used mainly by the members. With only one training organised in the last year, when the construction sector is evolving so fast, the cluster knows the importance of developing the training service, to stimulate the diffusion of low-carbon skills. Other activities will be continued and developed, in order to raise the public attendance and complete the contact list. New collaborative projects are (and will be) developed, as well as working groups.

Contact

Deborah Depauw
deborah.depauw@cap2020.be
CAP2020 website:
www.clusters.wallonie.be/cap2020-fr/

Authors

Jean-Marie Hauglustaine
jmhauglustaine@ulg.ac.be
Stéphane Monfils
stephane.monfils@ulg.ac.be
University of Liege, Belgium

“REGAIN” is the acronym for “Reducing the Greenhouse Effect Through Alternative Industrial Estate Management in North-West Europe”, an INTERREG IV research project designed to develop a transnational method for the conception of semi-industrial buildings integrating industrial process (or craft industry) and offices, with very low energy consumption and very high environmental quality. Four countries, were associated in this project, represented by managers of business parks or of local communities and builders of pilot buildings: Belgium (represented by the Economy Bureau of the Province of Namur), France (SIZIAF), Wales (Blaenau-Gwent) and Scotland (SETIC). Two more partners participated as support: Italy (Envipark) and France (PALME).

The project realised the construction of four pilot buildings, on the four main investment partners' sites. These buildings had to be business incubators (welcoming and helping start-ups with their business, at a reasonable rent cost) with high energy and environmental performances. Reproducibility, as the main goal, makes cost optimisation another important objective. In this sense, the project itself is on an international scale but the construction techniques and solutions used are more regional.

The site chosen to build the Belgian prototype is the Scientific Park Crealys, close to Namur, recently ISO 14001 certified.

One of the specificities of the project was the early involvement of various construction sector actors, in order to guarantee results from an early conception stage. In the Belgian case, the technical team was composed of the REGAIN project managers and contracting authority (the Economy Bureau of the Province of Namur), the architect (Alain Stevens), HVAC engineers, construction site security coordinators, and the EnergySuD research unit of the University of Liege, expert in energy and environmental performances assessment.

This integrated working method, a key aspect of the building’s conception, is not yet usual in the building industry. Often, exchange between specialists is minimal, due to the separation of tasks, the inertia of the building sector and the weight of tradition in project management. But a strong will to get the best skills and knowledge when needed led to a warm welcome of every actor, from the early conception stages, to attend regular meetings, share views and knowledge, and to participate in technical assistance studies.

This method allowed early and direct confrontation of various expertise and views on the project. Economically speaking, the choice was to develop a concept and a design which cost would be as much as possible comparable to a “traditional” building, yet with the highest Belgian energy efficiency possible level. The resulting building, inaugurated in February 2011, is composed of a passive office wing and a “very low energy” industrial (workshops) wing.

Figure 1 - REGAIN Belgian office building

Figure 2 - CAP2020 events.
Ventilation has been carefully conceived, by solar and internal gains have been studied, so obviously, a very efficient envelope, the building displays interesting solutions: the entrance of the building is therefore needed to heat up and cool down in summer, the natural light use has been maximised, and the use of artificial light reduced and optimised; there is no air condition system, but a free cooling system. The comfort for the users has been taken into consideration: a passive building keeps more easily a constant temperature; the building materials that have been used were chosen taking into account the embodied energy; the industrial hall “only” reaches the low energy standard; it has been proved that better performance is unnecessary (given the use these spaces will be put to, higher insulation and air tightness would only increase overheating risks, even in winter).

Regular meeting were organised to gather national teams, in order to stimulate the dissemination of skills, knowledge, research results and chosen solutions. Another objective of the project was the stimulating comparison of the environmental performances between projects, with a common evaluation method. Each participating country, therefore, built a similar project, and the European funded project allowed share of experience and performance results. In order to get past the “only” (and often main) criterion of sustainability when applied to buildings – energy – an agreement on the environmental performance evaluation was necessary. There exists many frames of reference that include crucial criteria (such as water consumption, materials selection and integration into the landscape), but most of them are calibrated on national context, so that it soon appeared necessary to find common ground as far as criteria selection, weighting and benchmarking are concerned. Therefore, the chosen method for the REGAIN initiative was the SB-Tool (free International Sustainable Building Tool, www.isibe.org), devised under the framework of the International Green Building Challenge, which saw the participation of international organisations and institutions from 25 countries. Its methodology can be applied to any type of building and adapted to every geographical and regulatory context, no matter what the local construction practices are. It allows inclusion of energy analysis, but also evaluation of the wider social and environmental aspects, e.g. materials, construction techniques and users’ comfort. It considers the entire lifespan of the building: design, construction, occupancy, potential adaptation to future use, until demolition.

More meetings were organised, where the REGAIN committee (members from each participating country) gathered to reach an accord for common criteria. For example, the choice of the building site, with regards to its natural environment is to be evaluated identically in each country. Then each country team set their own national benchmark for offices and workshops for other criteria, for example, the evaluation of the acoustic performance within primary occupancy areas depends on national laws and standards.

Furthermore, a correct assessment of the project requires a reliable database for all the materials used. The project witnessed the lack of accessible and transparent information from material producers, as far as the environmental and sanitary characteristics of the materials are concerned, so that great difficulty came from the collection of data from architects and engineers. It is believed that, in the future, environmental certification could grow in importance (at least for “big” projects), so that products databases could be built up; in REGAIN project however, only the information needed for the assessment of these buildings were gathered.

A first assessment of the environmental performance of the Belgian building was done during the design phase, with regards to the weight allocated to each category, and values estimation which had to be checked after the occupation of the building. The global result during the conception of the Belgian building was 3.4 out of 5; a score of 0 represents a building conform to the good practice or the national (or regional) laws, while a score of 5

Figure 2 - Ground floor plan of the REGAIN Belgian building

Figure 3 - “Passive certified Offices by the Passive House Platform” and Regain logo on the entrance of the building

The building displays interesting solutions: obviously, a very efficient envelope, characterised by an average office wing U-value of 0.2W/m²K, and blower door test result (n50) of 0.5vol%; solar and internal gains have been studied, so that the annual heating and cooling demands, calculated with the passive house software, should both stay below 15kWh/m²•yr; only 10W/m² (or around 5kW in total) of power is therefore needed to heat up and cool down the building. Such low powers are hard to come by on the market, so that it has been decided by the technical team to heat and cool through ventilation air flows; ventilation has been carefully conceived, by constantly regulating the flows to the actual needs, and by using a heat exchanger to recover the calories. Given what has been said before, air flows can be increased when needed, whether to heat up in winter, or to cool down in summer; the natural light use has been maximised, and the use of artificial light reduced and optimised; there is no air condition system, but a free cooling system. The comfort for the users has been taken into consideration: a passive building keeps more easily a constant temperature; the building materials that have been used were chosen taking into account the embodied energy; the industrial hall “only” reaches the low energy standard; it has been proved that better performance is unnecessary (given the use these spaces will be put to, higher insulation and air tightness would only increase overheating risks, even in winter).

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corresponds to technically accessible perfection. The following graph illustrates the average result for each category. The “G” category (culture), has been considered inapplicable to the 4 projects.

Figure 5 - Star graph of the environmental performance assessment of the Belgian case building, on SB-Tool

Dissemination of knowledge is at the heart of this project, through:
- skilled actors and research teams from the early conception stages, with the objective to get the knowledge when needed and therefore reduce delays and costs.
- the design of a framework document about clean building sites;
- user sensitisation for a better experience from users; in a low energy or passive building, it is necessary to guide the users through the best way to use it, in order to reach maximum comfort, which is also visible through the quality and performance of services. Given that one of REGAIN objectives is to educate and train people, a users’ guide has been written and edited to accomplish this role as common base for any tenant to ensure the building’s best operation;
- technical training for the building sector and for students, learning on green worksite, specific techniques. All 4 buildings, on all 4 members’ sites, serve as examples through on-site visits of professionals or technical explanation of the chosen solutions, systems and materials. In 2014, 787 people came to the Belgian building, and were given different levels of information, depending on their interests. Among these people, 96 pupils came from primary schools, and 400 from secondary schools (building oriented); 45 were job seekers who underwent building training (searching for additional knowledge), others were stakeholders from green building clusters or companies involved in the sustainable building or management of semi-industrial buildings, etc. It has been recently visited by the members of the Cap2020 cluster, a group of Walloon companies active in the building industry, who adopt and pursue the 2020 European objective of massive energy consumption reduction applied to buildings;
- the dissemination of results: the project being financed by INTERREG IVB NEW, a financial instrument of the European Union’s Cohesion Policy, whose one objective was the exchange and comparison of results of four experiments in European construction and make them available for local, national and European communities.

The continuous environmental performance evaluation accompanying the project has provided more powerful projects: the Belgian Regain building received the best score of all building cases used to calibrate the Belgian referential of sustainable buildings, common to the three Belgian Regions. This project has therefore enabled to advance in the theoretical aspects of the environmental certification by setting benchmarks for each country, but also to see the difficulties in implementing a method of certification in practice.

Contact
REGAIN general secretary:
Olivier Granville
ogr@bep.be
REGAIN website:
www.programme-regain.eu

The continuous environmental performance evaluation accompanying the project has provided more powerful projects: the Belgian Regain building received the best score of all building cases used to calibrate the Belgian referential of sustainable buildings, common to the three Belgian Regions. This project has therefore enabled to advance in the theoretical aspects of the environmental certification by setting benchmarks for each country, but also to see the difficulties in implementing a method of certification in practice.
The MODEL (Management of Domains related to Energy in Local Authorities) project in Bulgaria

**Author**

Elena Dimitrova  
edim_far@uacg.bg  
University of Architecture, Civil Engineering and Geodesy (UACEG)

**Stakeholders**

The MODEL project (September 2007 – February 2010) started with the support of the Intelligent Energy Europe Programme and was aimed at helping local authorities in EU new member states and candidate countries to become models for their citizens and other municipalities in the field of energy planning and management. The project had two main objectives: (a) assisting its pilot cities to plan, implement and evaluate a full set of activities meant to improve local energy efficiency, focusing on their overall process management; (b) improving the practical capacities of the participating municipalities in the field of energy efficiency but also in communicating with their citizens and raising public awareness on energy efficiency issues. It applied a case study based approach in order to disseminate comprehensive information about particularly convincing good practices and the lessons learned through their analysis. Overall 43 pilot cities from eleven partner countries representing over 2 millions of citizens and almost 123,000 (and different experience in the energy efficiency field adopted the political decision for joining in the MODEL project and become ‘models for sustainable energy management’ (as the project objective was formulated). The Bulgarian Municipal Energy Efficiency Network EcoEnergy was the national project coordinator. One of the projects major goals was to upgrade expertise for energy planning and management at the municipal level through providing methodological training for the local experts from existing or newly established municipal energy management units.

The general framework methodology for the elaboration, implementation and assessment of Municipal Energy Plans (Figure 1) was developed by EnEffect, the Bulgarian Centre for Energy Efficiency and a MODE3 technical expert, and in cooperation with all MODE3 partners. It has been reviewed by the project participants within several joint workshops and tested under real conditions in the MODEL pilot municipalities.

The estimated major MODEL impacts in Bulgaria comprised results for five major areas:  
- **local capacity building through the establishment or strengthening of local energy management units**;  
- **promotion and instruments through the development of a municipal energy management methodology to be replicated in all the municipalities**;  
- **dissemination of good practices through a 10 % reduction of energy use in the municipality-owned buildings and facilities as a model for all the other participants**;  
- **community involvement through the encouragement of events promoting energy-efficient activities among all interested actors**; and  
- **networking through information and coordination support for municipal projects, training of energy managers, etc.**

A MODEL Awards Competition was announced with two categories: (a) The Best Energy Manager/Unit, and (b) The Best Municipal Intelligent Energy Days. First prizes were twice awarded to Bulgarian municipalities – the city of Dobrich (2009, for the Best Energy Management Unit) and the city of Lom (2008, for the Best Municipal Intelligent Energy Day). A special award category for the “Best Pilot City 2008” was moreover established in order to reward the overall excellent work in both categories of the city of Gabrovo.

**Knowledge and tools**

Diverse tools for capacity building and dissemination of knowledge and skills were applied within the project. Initial two-day training courses were organised for 21 energy managers and other technical and/or economic experts and decision makers from the seven Bulgarian pilot municipalities. The training of energy managers (EM) and officers went in parallel with setting up the Energy Management Units (EMUs) in Bulgarian pilot municipalities. The establishment of specialised EMUs in the municipalities (with the mayors’ political support) is expected to guarantee a consistent implementation of the Municipal Energy Programmes (MEP) and a sustainable energy management processes. EMUs are responsible to initiate, develop, organise and coordinate the programme, and to report implementation results to municipal authorities. Reports are provided regularly (at least twice a year) and at any time the local authorities would consider that necessary. After the training courses the trainees started developing MEP and annual energy action plans for their own municipalities with the methodological support of the project experts. The MEPs were later on adopted by the municipal councils in the pilot municipalities and put into real-life operation. Municipal Intelligent Energy Days (MIED) were organised in all the municipalities in order to disseminate information, raise awareness and promote action aimed at energy efficiency among citizens and institutions. They became a regular practice, from once a year to twice a month, and increasingly supported by local people – up to 5,000 people in Dobrich joined in the MIED in 2009. The involvement of children in various events (exhibitions, bicycle competitions, etc.) also proved to be very effective in attracting public attention and generating community commitment (Figure 2).
activities were organised at the local level in the pilot municipalities. They all resulted in developing human skills, technical capacities and communication skills as well as raising awareness among citizens. Information about the project activities and results was disseminated throughout all the municipalities in the country by the e-bulletin of EcoEnergy.

The results from the MODEL project implementation covered a broad range of activities: (a) the development and implementation of Municipal Energy Programmes and annual Action Plans in the pilot municipalities (aimed at minimum 10% energy consumption reduction in the municipal sites), so that they could provide a policy model for other municipalities; (b) the promotion of activities for strengthening knowledge and skills and for drawing public attention to possible action in the energy efficiency field; (c) the establishment and strengthening the Energy Management Units (EMUs) in the pilot municipalities; (d) the establishment of common methodology to be replicated and continually implemented throughout the country; and (e) the empowerment of a country-wide sustainable network, capable for initiating, coordinating and supporting the implementation of municipal energy policies aimed at saving energy and reducing CO₂ emissions.

The training provided within the project covered the area of municipal energy planning and management. It addressed in an integral manner a broad variety of aspects – technical, social and financial, all of them crucially important to the practical implementation of the planning methodology and the continuity of the local process towards energy efficiency.

The reported project results varied in the seven Bulgarian pilot municipalities as their priorities depended on the local context peculiarities and on estimated needs (Table 1).

Conclusions
The MODEL training built upon an ongoing process in the municipalities, which have already accomplished various energy efficiency projects focused on street lighting, rehabilitation of urban infrastructure, heating and thermal insulation of buildings. The training upgraded existing expert capacity and directly influenced municipal practical action in the field of sustainable energy. In parallel with the training process, the direct communication with local experts enabled the collection, processing and dissemination of information on real-life energy efficiency needs and barriers at the municipal level. The information would be extremely useful in supporting energy efficiency investment and demonstration projects to apply for EU funding. Local individual consultations aimed at clarifying legal requirements with regard to renewable energy sources (RES) implementation were also organised in some places.

The MODEL project was a next step towards building energy independent municipalities – Smolyan municipality became the first in the country with 100% of digitally controlled street and park lighting. The organisation of Municipal days of intelligent energy and the promotion of the full energy management tools (programmes and action plans) for their own municipalities. A broad range of local actors were addressed applying a variety of training tools and methods, specific for each group. A strong sense of community-shared values and to energy efficiency priorities was developed. Technical training went in parallel with enhancing political commitment in the municipality. Many of the activities were easy to observe and attractive to join in public space – mutual learning was thus taking place; the strong focus on children and learning by playing through various dissemination activities was aimed at guaranteeing the long-term effectiveness of the process towards energy efficiency in Bulgarian municipalities.

The methodology developed by EnEffect and later on applied at the municipal level in Bulgaria was estimated as the best working methodology among analysed eleven European methodologies and recommended by EU Joint Research Centre as the basis for developing the next guidelines on the elaboration of local Sustainable Energy Action Plans (SEAP):

“The MODEL (“Management of Domains Related to Energy in Local Authorities”) project has developed guidelines and recommendations which cover the main aspects of the SEAP elaboration process. A detailed, well-structured approach is proposed, with a lot of useful recommendations. An elaborated communication strategy is provided. A separate quite detailed inventory of available funds at European level is available” (JRC, 2010).

The training and dissemination results of the MODE3 project achieved in the pilot municipalities in Bulgaria were practically replicated in a broad number of municipalities in the country and in the SEE region by creatively applying the general methodology framework and building upon existing local experience/capacity. The MODE3 project was later on upgraded as MODEL-CIUDAD project with 6 new pilot cities from Armenia, Georgia, Moldova and the Ukraine. The EcoEnergy network, which has been the Bulgarian MODEL partner, is nowadays a supporting structure of the Covenant of Mayors project. It has continued its work on improving the methodology – the GHG emissions inventory was complemented and new guidelines were developed within the Covenant Capacity project. EcoEnergy is persistently providing methodological support to the development of municipal sustainable energy action plans (SEAP), training for municipal experts and disseminating good practices. The continuity of the process is thus guaranteed.

Practical experience has confirmed that closer attention should be paid to the initial stage of building up the common vision of a local community (still missing in the methodology) in order to outline specific priorities and existing potentials. Supporting the process methodologically at the national level through
the training activities of the EcoEnergy Municipal Energy Efficiency Network has proved to be a major factor for its sustainability. Building horizontal links and clustering among neighbouring municipalities needs further consideration and development. The commitment and expert support of national higher education institutions to local capacity building is still to be enhanced.

References

Sustainability assessment technical training
‘Whole life management of sustainable construction programme’

Author
Lora Nicolaou
loranicolaou@gmail.com
Frederick University, Cyprus

Stakeholders
The issue of sustainable construction and the minimisation of its impact (environmental, social and economic) has been central for the European research agenda during the last 10 – 15 years. The construction sector is slowly becoming aware of the need to minimise its impact on resources and the on-going cost of management of real estate. There is also a growing recognition that there is a lack of knowledge in management of sustainable construction throughout the life cycle of buildings and infrastructure.

A team of partners from the private and public sector including (Whole Life Consultants Ltd, FOR SAS di Paolo Tubino & C., PPP Centar d.o.o, Societatea Romanapentru Educatie Permanenta, DOCTUM and Frederick University) were awarded an EU funding with a key aim to transfer knowledge and provide training in respective countries on the specific aspects of sustainable construction. The “Whole Life Management of Sustainable Construction” project is part of European Programme Leonardo Da Vinci (Transfer of Innovation) and is co-funded by the European Union and the Lifelong Learning Programme. The project was led by Whole Life Consultations Limited, a spin-out company for the University of Dundee, UK (www.whole-life-construction.eu).

The five participants involve universities, training organisations and private sector companies who have a strong interest in the development of vocational skills on the management of sustainable built environments in their own countries.

Frederick – School of Engineering – were one of these contributing partners with Dr. C. Anastasiou, Dr. D. Nicolaides, Dr. A. Michael, Mr. A. Kalli and Mr. P. Grafias as the main team which ran and assessed two training programmes in Cyprus. The seminars took place in June and November 2013 during which stakeholders in the construction industry were invited for a series of 3 half-day seminars on the issue of the Management of life Cycle of Sustainable Construction.

The particular training events in Cyprus – a place with relatively limited opportunities for life long learning events – were very interesting in a number of ways; the training was highly technical in nature with a multi-skills and multi-disciplinary audience. Topics were introduced from the basic level of principles appropriate for the knowledge base of a multi-disciplinary group of specialists in the field, consultants, government officers, teachers and students, to the technicalities of leading edge software.

Scale
The seminars were hosted at a national level and were advertised through universities, technical and professional institutes, government departments and national press. The first event attracted 59 professionals and students, which was supported during the 3 days by 8 trainers, all coming from different sectors and specialties.

Participants came from the private sector developers, consultants, contractors including, public sector (technical staff of various relevant departments such as planning, environment agencies etc.), universities teachers and students mainly from engineering, environmental sciences, surveying and architecture. An interesting factor which surprised the training team was the percentage participation of women at 49% in a disciplinary context where women are by far the minority in both the profession as well as in their participation in higher education courses (with the exception of architecture).

The charts below (Figures 1, 2 and 3) present in more details the participant composition to the first training event.

Knowledge and tools
The training session was structured around three half day sessions covering 5 topic areas.

The first session began with an introductory overview of principals, themes and issues of sustainable development, issues and challenges of sustainable construction and an overview of energy design software (an overview of LEED). The second session focused on sustainability processes, drivers, indicators of good practice and assessment tools (BREEAM/LEED/CCEEQUAL). The third session address issues and processes of Environmental Impact Assessment (EIA) and whole life costing and value methods including principles for sustainable procurement.

Whilst there has been a focus in the past on training in technology and technical issues regarding training on issues of sustainability, this project addresses the need to enhance vocational skills in whole life management issues and in sustainable construction which have not been previously, addressed in detail. This includes procurement, innovation, assessment, stakeholder engagement and more. The project highlights the importance of the need to shift the mind-set to the management of sustainable construction and transfer knowledge to develop fully life-cycle approaches in delivering sustainability issues in a simple and clearly defined manner.

Figure 4 indicates in more detail the participant’s preferences to the five topic areas which form the structure of the seminar. Five main subject areas are:
1. sustainable development – Principals, Themes & issues;
2. energy Design software sustainable design, a view through LEED;
3. sustainability assessment tools;
4. environmental impact assessment;
5. sustainable procurement principles, drivers and process.

Figures 1, 2 and 3 – Composition of the participants to the training seminars (source: 1st training event report – Cyprus, Whole Life Management of Sustainable Construction Frederick University 2013)
The second seminar event was also very successful in attracting interest nationally and was very well attended and organised. The seminar participants were awarded attendance certificates.

The context of the training was holistic in its approach by demonstrating how the same principles of sustainable construction apply at a number of different scales of the design and delivery of buildings, large engineering installations, infrastructure or masterplanning, therefore covering a very wide range of scales of the built environment.

The sustainability and impact assessment software were presented through case studies and were taught through training sessions which covered building, urban and national scales infrastructure projects.

Materials and technologies

The seminars were delivered through conventional teaching tools such as presentations by experts in each field, demonstrations of energy design software with the use a real life examples, break out sessions for discussion of specific topics and testing of software applications in smaller groups, Q&A sessions, informal discussions during extensive breaks etc..

All background material, presentations and selective software and manuals where attached to an electronic database to which participants had access. The relevant material was circulated through the e-learning tool after the completion of the training with each participant given direct access to this tool. The material presented during the sessions was also made available.

Conclusions – Measuring the level of success

The evaluation of the relevance and quality of the programme were conducted through questionnaires completed at the end of each seminar.

The questionnaire was extensive and it attempted to assess the impact of training courses on different groups of participants (disciplinary/professional basis) in their understanding of the issues but also more importantly the impact on respective practice applications they could foresee. Other than a view on each module (see chart below) the questionnaire covered satisfaction levels on how well the seminars were structured, quality of presentations, appropriateness of place facilities and infrastructure etc..

The chart below indicates the success rate of the training in relation to knowledge generation and improvement of specialist skill of participant during the particular seminar session. It was obvious that in all module areas there was a significant shift of understanding on issue by almost all participants.

The overall feedback about the training event beyond the knowledge content was in general very positive. Attendees found the training sessions “very useful” and comments were made about the varied mixture of participants which has been characterised also as a good opportunity for networking and idea sharing.

Although the overall feedback of the first seminar was very positive, the time management and group activities were two areas, which could have benefited from an improved performance. This was taken into account when designing and running the follow-up training event. Additionally, more emphasis was given on course material relating to sustainable procurement content. Nevertheless, so far, no follow up has taken place yet.

Contact

Head of Civil Engineering at Frederick University
Christos Anastasiou
eng.ac@frederick.ac.cy

Whole Life Construction website: http://whole-life-construction.eu/ (WhLMSC, project number: 2012-1-GB2-LEO05-07807)
Energy advice and promotion supports to community groups

Authors
Derek Sinnott ¹
dsinott@wit.ie
Paddy Phelan ²
pphelan@ckea.ie
Oliver Kinnane ³
o.kinnane@qub.ac.uk

1) Waterford Institute of Technology, Ireland
2) Kilkenny Research and Innovation Centre, Ireland

Under the Rural Development Plan 2007 – 2013, Kilkenny Leader Partnership (KLP) supported the development of renewable energy and energy efficiency within county Kilkenny. This was done through providing technical support to community facilities to incorporate renewable energy and energy efficiency upgrade measures to improve the economic, social and cultural quality of life of the people / communities and through providing business development support of small enterprises (SMEs) in the area of renewable energy / energy efficiency (RE / EE). The Carlow Kilkenny Energy Agency was awarded the contract set out in two defined work packages:

- Work package A: Provide Energy Advice & Promotion supports to Community Groups;
- Work package B: Project development / monitoring & technical support.

Carlow Kilkenny Energy Agency (www.ckea.ie)

The Carlow Kilkenny Energy Agency (CKEA) is a non-profit for public good energy consultancy. It is limited by guarantor by its board of directors. It was established under the EU SAVE programme in 2002 to provide sustainable energy information and services to the people of Carlow and Kilkenny, to local businesses and community groups and to the relevant Local Authorities.

The Mission of the CKEA is to ‘lead and support Co. Kilkenny & Co. Carlow to reduce its CO₂ emissions by stimulating and contributing to the implementation of best practise in the field of sustainable energy’. CKEA works with its clients to reduce energy (kilowatt-hours), CO₂ emissions, cost while increasing sustainability.

CKEAs income stream is primarily consultancy through public and private clients to whom Energy Services are provided. CKEA has extensive knowledge and experience in energy auditing, integration of renewable energies, feasibility studies, training, business development, finance etc. for all its clients. The CKEA has supported a number of projects to achieve significant energy savings through a structured energy management approach.

In 2013 CKEA applied to the European Research Development Fund (RDF) through Kilkenny leader partnership to complete energy community preparation for the upcoming community grant programme in April 2013. This project was structured as follows resulting in co funding to deliver the services to the community sector with an aim to promote sustainable retrofit and create an economic stimulus to the region in terms of jobs and comfort. The Quality Assurance programme operated by the CKEA also led to a demand for contractor training and linking to programme such as the BUILDUP Skills initiative.

Objectives of the RDF Leader Programme

Work package A: Engage and educate community groups about the benefits and adoption of energy efficiency and renewable energy technologies:

- Task 1: Engage with rural community groups through information evenings:
  - identify what level of energy information is required by community groups in County Kilkenny;
  - organising up to 10 information evenings in the community.
- Task 2: Perform energy audits and recommendations for new community facility applications:
  - having identified above deliver the energy audits for community groups in Co. Kilkenny. It is proposed to contact these groups to follow up on their status of project development;
  - provide technical support / information to individuals.

Task 3: Provide Building Energy Rating certificates for community owned buildings.

Task 4: Ensuring the successful adaptation of renewable energy technologies in community settings:

- provide assistance and support on renewable energy projects in the county of 10 projects.

Work package B: Engage and educate enterprises in the adoption energy efficiency & renewable energy technologies:

- Task 1: Mentor micro rural enterprises – including reviews of initial business proposals and applications submitted under Rural Development Plan;
- Task 2: Electsic KLP development officers on energy related projects;
- Task 3: Engage and advise on the development of capital projects with RE technologies. This would lead CKEA to identify potential community renewable energy projects (biomass, wind & hydro) in County Kilkenny which would be eligible under RDF:
- Task 4: Mentor Community groups in the development of capital projects with RE component:
  - identify 3 potential community renewable energy projects (biomass, wind & hydro) in County Kilkenny which would be eligible under RDF;
  - undertake 3 feasibility studies into these projects;
  - provide guidance on procurement of 3 capital projects;
  - provide technical support to community groups while developing projects.

Main outcomes

- Information evening in 4 locations in county Kilkenny targeted at community groups / business wishing to improve their energy usage.
- CKEA completed 10 audits for community facilities. A number of these facilities were brought through the Sustainable Energy Authority – Better Energy Communities Grant Aid 2014. Measures included the upgrade of insulation, heating, lighting, boiler replacement and more options.
- Technical support to community groups / businesses wishing to adopt renewable energy technologies.
- Support to energy efficiency / renewable

Review of the RDF Programme

This was a valuable programme to be rolled out in County Kilkenny as it led to the implementation of energy efficiency / renewable energy upgrades at a number of facilities in County Kilkenny. It also provided technical support to development officers / community groups / SMEs and other people seeking information in the whole energy sector.

It was found that there was a lack of acknowledgement and awareness on how to improve energy efficiency within community facilities. However, once support was provided and where finance was available, there was an uptake in the installation of EE / RE technologies. This would lead CKEA to believe that if this type of support was available at a local level then this would improve the efficiency of local energy usage leading to an overall decrease in nationwide energy.

LIFELONG LEARNING | 83

¹ 82 SMART ENERGY REGIONS – SKILLS, KNOWLEDGE, TRAINING AND SUPPLY CHAINS
energy projects wishing to develop through the Rural Development Plan with Kilkenny Leader Partnership. Some projects which did not develop though this programme went onto be completed through the Better Energy Communities so this programme had a knock on effect.

It was found that one of the main barriers is independent technical support which was provided through this programme. This programme could be replicated in other counties in Ireland which would have the same positive experience of increase use and awareness of EE/RE at a local level.

Project outcomes culminating from the RDF Programme:

Projects contribution towards local sustainable energy include:

- The Carlow Kilkenny Energy Agency under the various phases of its development have consistently made progress in energy efficiency and renewable energy for the counties of Carlow and Kilkenny (Ireland).
- The most recent phase under the stewardship of its manager Mr. Paddy Phelan has seen its achievements ramp up to a significant level including 2014 Better Energy Communities award winner for best national energy project 2013. Taking a key role in empowering communities and organisations to be more energy efficient facilitating access to information, grants available and cost efficient improvements.

Diversity of contributions, political, economic include:

In 2015 both Carlow and Kilkenny County Councils have signed up to the covenant of Mayors. This follows CKEAs signing the supporting role agreement in December 2014. CKEA does not place the Energy Agency as the champion but the public and private communities that it serves. This has contributed in the increased collaboration and motivation of these communities, organisations and local business to actively improve their role in sustainable energy.

- Politically the CKEA has successfully negotiated at local, national and EU commission level for the betterment of its region. Its local elected representative is now EU Commissioner for Agriculture and Community.

Socio-economics aspects of the contributions include:

- The project was a key driver in achieving in excess of 8GWh of energy savings in social housing, public, private SME and community buildings. And €5m capital works and €856,000 energy white credits traded in 2014. This is not only improving the energy costs and consumptions, but also increasing the levels of comfort of under privilege members of the community.
- In 2013 a €3.6m capital energy retrofit also resulted in 5.2GWh of savings sustained. Achieving a significant reduction in fuel spend and made homes and businesses more sustainable into the future. Larger projects have been collated and submitted for 2015 at the moment.
- Current program under 2015 Better energy communities of circa €4.8m capital with approximately 5GWh to be evaluated post project implementation phase.

EU geographical outreach & territories impact includes:

- The Carlow Kilkenny Energy Agency has been actively working in the sustainable energy of County Carlow and Kilkenny. CKEA have also partner in a number of European Projects, Biomass (BioEnArea), Energy Saving (Interreg), Street Lighting (IEE) and Data4Action (IEE)

Summary

Resulting from the programme the CKEA have developed several community energy projects in Carlow, Kilkenny and Wexford since 2014. Ranging from SME, residential, public buildings and community groups.

This project is the first of its kind to be implemented by Kilkenny Local Authorities and Carlow Kilkenny Energy Agency the project illustrates the importance of strong community groups within the county. Kilkenny Local Authorities and Carlow Kilkenny Energy Agency are keen to integrate communities and re-invigorate the community spirit and the element of pride in one’s community. In 2013 this was done through the Better Energy Community project by bringing together a large community with one specific goal to reduce energy consumption and CO2 emissions.

The innovative approach was in getting different sections of the community together with a varying degree of energy usage and energy requirement. The community included hotels, GAA club, two community centres, City Hall and the housing project. The housing project implemented by Kilkenny Local Authorities included social housing in both the voluntary sector and Kilkenny County Council’s Housing stock. Areas with a high level of fuel-poor households throughout the community were identified (82% of houses for upgrade are Fuel Poor). The voluntary bodies identified under the scheme held discussions over the last number of years about ways of improving the energy efficiency of their stock. Kilkenny County Council’s proposal included some of the older schemes within the county with established communities that were willing to work with the local authority & CKEA to bring the scheme together.

The works carried out also created 75 jobs in the retrofit, delivering sustainable energy saving sector. 178 houses including, 140 local authority owned houses and 38 voluntary houses were renovated. Local Authorities managed the procurement of housing and CKEA coordinated the application and procurement for community bodies. The projects were delivered in less than 12 weeks from grants. Contractor training days ran in 2014 and 2015.

Figure 5 – Logos and acknowledgement of the project partners

“This project was part funded by Kilkenny LEADER Partnership through the European Agricultural Fund for Rural Development: Europe investing in Rural Areas”
Expert in sustainable building

Authors

Rossano Albatici 
rossano.albatici@unitn.it

Elisa Armeni 
e.armeni@artigiani.tn.it

1) University of Trento, Italy
2) Association of Craftsmen and Small Enterprises of the Province of Trento, Italy

This case study refers to the course “Expert in sustainable building” organised by the Association of Craftsmen and Small Enterprises of the Province of Trento from 2007 to present and financed through the European Social Fund and the Autonomous Province of Trento. The main aim is to develop skills in the field of energy efficiency and sustainability and to establish a new way to think, design and realise buildings towards a greater integration of different competences in the construction sector. Moreover, the basic idea is to introduce a new ‘language’ and new awareness to those workers, as craftsmen, that usually have less opposition to come in contact with the most advanced trends and technological innovations of building industry but that very often represents the first level of the “construction chain” with which customers and users get in contact. Therefore, artisans will be able to interact with their clients explaining the needs coming from the new paradigm of sustainability, thus being not only simple performers but also active actors in new building processes, even by using proper terms, changing their thinking and their way of working.

Stakeholders

The training course is designed for artisans in the building sector including builders, carpenters, electricians, hydrothermal systems installer and maintainers, window makers and installers members of the Association. The course is free, financed by the Autonomous Province of Trento and by the European Social Fund.

Knowledge and tools

In the framework of building sustainability, the Association of Craftsmen and Small Enterprises has organised and developed a complex training offer based on three main pillars:

• Development of technical and specialist knowledge: aimed at giving participants the opportunity to face the most advanced experiences, even not exclusively on theoretical basis, concerning the different specialisation:

• Integration between the different competences: to enhance the capabilities of the individual but even to increase the possibilities to work in team. This process has been tackled in two different ways: Horizontal, that means integration between craftsmen with different specialisation; Vertical, which means integration between craftsmen and designers (architects, engineers etc.) with different specialisations. The latter has been considered of high importance to allow a strong relationship between the different actors of the design and construction process and to guarantee the best results with no loss of information between the “rings” of the same chain.

• Communication: a great potential for action towards sustainability has been often lost because of the incapability of professionals to easily explain to people new concepts and advanced solutions. This section was grounded on a double path: Communication towards the final user: craftsman been seen as a “sensitisers”, able to use simple/effective terms and to promote energy-environmental sustainability; Communication between experts (craftsmen and designers), that is to have a common language and so common understanding of problems/actions to be done, in order to facilitate the integration and to produce a better final result.

The complete training consists of three different courses preferably organised between autumn and spring:

• Basic course: for a total amount of 26 hours. The main contents are politics and standards, opportunities for new markets, rating systems between sustainability and energy efficiency, specialist in-depth analysis, integrated solutions with little workshops in mixed groups. Until now, there have been 15 editions with 216 participants;

• Communicating energy saving: for a total amount of 24 hours. The main contents are communication principles, communicating environmental-energy concepts, communicating economic advantages. There have been 9 editions with 105 participants;

• Expert in sustainable building: for a total amount of 120 hours. Main contents are current politics, standard and opportunities for new markets, the concept of energy and environmental sustainability, comparison between rating systems (LEED, KlimaHaus, Arca), integrated approach to the buildings (connection envelope-systems-thermal envelope and energy requirements; systems sizing and their performance, integration between different specialisation to reach the expected energy and environmental targets), integrated approach to the building design (renovation and re-qualification, energy efficiency in historical buildings, building extension – timber, hints for new buildings – traditional and timber ones).

Usually, lectures are given in blocks of 12 – 16 hours every two weeks (for example, Friday 8 hours plus Saturday 4/8 hours). For what concerns the ‘Basic course’ and the ‘Expert in sustainable building’, participants usually share the 60 % of lessons so to promote an integrated vision and to build-up a common language on the issues of energy and environmental sustainability. Moreover, it is easier to conduct the final workshops where the different specialisations are mixed in different groups.
‘Communicating energy saving’ consists only of joint teaching. The main aim is to define a new figure whose main competences are:
- to identify the sustainable aspects of the project with particular reference to materials characteristics and qualities of indoor environment;
- to be familiar with components and necessary procedures for a sustainable management of the working site.

There have been 7 editions with 112 participants. The courses are promoted by notices in the Association newsletter, through e-mailing, web sites, specific meeting in the different Association headquarters in the area. They are open to all the members of the Association without an entrance test.

‘Expert in sustainable building’ is primarily based on lectures and simple numerical exercises: 80 hours as common part, 40 hours in small groups (up to 8 persons) per each working typology. So, participants are given a strong common background together with a deep view concerning their own expertise. At the end of each argument, participants must take and pass a written test (15 questions). As a conclusion, a final practical workshop is made (2 full days) where the participants, divided into 2 (or more) teams, must approach the design of a building, partially new and partially renovated, in small groups (up to 8 persons) per each working typology. The participants and the teachers, as well as during workshops. They were able to share their practical experience of everyday working life both with the teachers and with their colleagues. Organisers have been always present who acted as filter between the participants and the teachers, as well as between the participants themselves; this role has been fundamental in order to guarantee the positive run of the project. Before each course, meetings were organised with the teachers/experts and the organisers, so that the contents of the modules and the difficulties of the arguments were previously agreed on a common basis.

Surely the experience of the courses has been very good, and during the training all the participants have always been active and proactive both in theoretical sessions as well as during workshops. They were able to identify possible thermal bridges, acoustic bridges and areas of air/water infiltrations by properly reading the design layouts, even with particular attention to energy and environmental characteristics of the building components and their influence on inner comfort and air quality;
- to build ventilated continuous windows façades with attention to waterproofing, winter and summer ventilation, reduction of possible thermal bridges;
- to properly install windows in new buildings as well as in renovated ones, tackling the energy saving objectives defined in the project and established by law;
- to install shutters, to optimise indoor natural lighting and solving solar systems ensuring inner comfort conditions, air quality and energy efficiency.

The most important results of the training initiative are:
- the integration between artisans with different specialists to grow the capability of working together and solving problems as a team;
- the introduction of new ‘languages’ and new sensibilities in facing every day problems (e.g., putting attention to thermal bridges or to the use of proper materials) at the very first level of the building sector chain in the field of energy efficiency and sustainability;
- increased depth of knowledge (even technical) for artisans in an area where they may be not appropriately structured.

Scale

The training offered is managed on a regional scale, being the course destined for the members of the Association of Craftsmen and Small Enterprises of the Province of Trento. This experience has been further developed during the European project ENERBUILD (ENERgy Efficiency and Renewable Energies in the BUILDING Sector in the Alpine Space, 2009 – 11) addressing a better professional integration for the design and planning of high energy efficient buildings.

Conclusions

Although in 2011 a total of 27 artisans have been assigned the certification of “Habitech expert in sustainable design”, the market does not seem to be ready for this particular professional figure yet. Participants said that they have improved their knowledge and, in some occasion, even changed the way of work, but there was no specific monetary return, considering the overall amount or quality of works in which they have invested. Probably a better connection with other national bodies (building material retailers, construction companies, etc.) could be necessary to establish a virtuous system where each component recognises the qualities and the peculiarities of the others.

Until now the courses were offered also depend on the possibility of finding financial support. In the future, the idea is to guarantee the delivery of at least one course per year, in order to establish a permanent training offer.

Contacts

Training officer:
Elisa Armeni
e.armeni@artigiani.tn.it
Artisans’ Association website: www.artigiani.tn.it/

The Organising team was composed by Anita Da Col, Elisa Armeni and Debora Vichi. The competence validation system has been designed by Anita da Col.

Teacher and experts during courses were Rossano Albatici, Paolo Baggio, Giacomo Carlino, Cesare De Oliva, Peter Erlacher and Laurent Socal. Workshop tutorship by Matteo Agostini and Massimiliano Vanelia.
ARCA Academy for Designers

Authors
Rossano Albatici  
rossano.albatici@unitn.it
Anita da Col  
anita.dacol@dttu.it
1) University of Trento, Italy
2) Habitech: Trentino Energy and Environment Network, Italy

This case study refers to the course “ARCA Academy” organised from 2012 by ARCA Casa Legno Srl, the brand-owner company of the Italian certification system for timber constructions, based in Rovereto (Trento). ARCA Certification promotes quality and sustainability. It deals with the evaluation of seismic and fire resistance, acoustic, and energy-environmental performances. The main aim of ARCA Academy is to establish a continuous training centre in the field of timber construction and architecture, giving people working in the building industry the possibility of being part of a professional community aiming at enhancing and promoting quality in timber construction. The main three code words are: qualities, best practice and identity.

ARCA (www.arcacert.com) is the first certification system conceived and created exclusively for buildings with timber bearing structure. It covers also single wooden components such as door and window frames, and X-Lam components. ARCA was born in order to guarantee safety, energy efficiency, comfort and sustainability of timber buildings. It has been created in the Trentino Region with the aim to exploit an innovative and technologically highly developed product, the timber building, able to compete in the fast-growing and expanding sustainable building market.

Knowledge and tools

ARCA Academy training programme for Designers lasts approximately for six months and presents three parts: Base course, Design Principles, Final workshop. The last one is reserved to participants that have passed the test required at the end of the previous two modules. The ‘Base course’ does not have a maximum number of participants; ‘Design Principles’ is opened to a maximum of 15 participants; ‘Final workshop’ needs from 6 to 9 persons per specialisation (minimum 18, maximum 27 participants).

The first one (Base course) gives a general overview of ARCA certification protocol and its functioning and lasts for 24 hours (3 days in a row) with lectures and some practical application of the protocol, by means of Power point presentation and specific software. The aim is to train technicians to be able to consult and apply ARCA Technical Regulations, the checklists and to properly manage the certification process.

The second part (Design Principles) aims at giving an integrated design approach, based on ARCA principles and best practices, on timber technology and culture, on technical concepts and standards, for the construction of new buildings as well as for super-elevations and extensions.

The course is divided into three modules:
- timber structures and building systems: seismic resistance and safety, fire resistance and safety, rules for constructive quality, slabs vibration, maintenance plan;
- envelope efficiency: energy efficiency, acoustic insulation, air leakage, controlled mechanical ventilation, rules for constructive quality, maintenance plan;
- sustainable building: bioclimatic architecture and building orientation, certified timber and timber products, indoor quality and low emitting materials, local production.

This module lasts for 96 hours (12 days spread over two months) with both lectures and workshops. The last day deals with integration planning, project management and coordination skills: participating this integration workshops different designers can practice decision making process and define the construction detail drawings which grant high performances in timber building systems.

During the third part (Final Workshop), participants follow two different modules:
- in the first one they are divided into homogeneous groups based on their competences (structure, efficient envelope, sustainable building). They are given advanced knowledge on design and built timber constructions experiencing through a practical approach (together with the most relevant innovation factors), facing complexity, exchanging views with national and internationally renowned experts, enhancing the characteristics and possibilities of timber buildings. The module consists of mono-themed lectures (32 hours, 4 days) and a final written test must be taken and passed;
- in the second module, participants are divided into three groups, basically following individual choice, where all the different competences are represented. In this workshop each group has to focus on design strategies and technical details granting the high-quality performances required for a ARCA-Platinum timber building, applying concepts and innovations learned during the previous modules and implementing the integrated design principles, the heart of the ARCA certification system (24 hours, 3 days).

Participants present and discuss the project with their teachers and with external experts in a final exam session (0.5 day).

The title of “Arca Designer” is given that identify an expert in timber building and architecture in one of the three ARCA specialisation: Structure, Envelope Efficiency, and Sustainable Construction.

Training methods refer to problem-based learning. The main tools used during lectures are power point presentation and, most of all, practical examples/exercises solved using appropriate software. Drawings are produced with CAD but also by hand. During the lectures, participants are asked to share their competence and to solve/discuss together over some real case study so to develop flexible knowledge, self-directed learning and to collaborate effectively with the others team members.

Scale and topics

ARCA Academy for Designers is promoted by the Autonomous Province of Trento together with Trentino Sviluppo (a public agency born to foster the sustainable development of the Trentino system by taking action and providing services aimed at supporting the growth of business skills and the capacity for innovation) and Habitech (Trentino Energy and Environment Network). Even if the course is managed on a territorial basis, it is offered on a national scale with the attempt to spread the culture of timber buildings out of the Alpine region.

The most relevant area is the building, considering all the related topics:
- architecture (bioclimatic, passive solar elements, typologies and relationship with the environment);
- materials (low emitting materials, local resources, LCA, Environmental product declaration);
- structure (elements design and resistance, fire and seismic safety), envelope (energy balance, thermal bridges, natural ventilation, insulation, windows) systems (mechanical ventilation, solar and PV panels, heat pumps, Building and Automation Control Systems, smart devices).
Conclusions
The ARCA Academy is a valuable tool to spread the culture of timber buildings, paying attention to the quality of design, construction and maintenance, in a period where all over Europe (and in the Mediterranean countries as well) there is a “renaissance” of wooden architecture. Participants are given advanced knowledge in order to propose design and constructive solutions for the exploitation of the main timber building characteristics (by a technical and architectural point of view) avoiding the most common mistakes and taking also care of indoor comfort conditions. Participants are well motivated and consider the Academy as a good occasion of professional growth to face new challenges in the increasing market of timber buildings, super-elevations, extensions, and renovation works.

Therefore, the ARCA Academy enhances knowledge and skill integration in timber building construction throughout the professional and technical chain, beyond its training programmes. It designs and carries out initiatives and opportunities for all the ARCA Network, hosting and supporting problem-solving activities and best-practice exchange with experts, and organising workshops and professional visits of the ARCA Network Members to the major clusters for timber construction in the European context. Moreover, the ARCA Network of professionals and technicians aims to become the community of practices for timber construction:
• sharing always higher quality principles, standards, and performances;
• researching innovations in design, sustainability, implementation methods, products, and tools to test and measure results;
• increasing and sharing knowledge, involving in its working groups internationally wide-known experts;
• integrating contributions of different technicians and professionals in problem solving-based working groups.

Until now, there have been 2 editions of ARCA Academy for a total of 46 trained ARCA Designers. Training courses offered by the Academy are developing and improving over time, even through feedbacks gathered from participants, teachers and ARCA staff as well. Specific questionnaires are given to participants laying to both quantitative and qualitative data. Each comment rising during lessons and/or workshops, where ARCA staff is always present, is received and discussed.

Usually, suggestions regard possible improvements to a better definition (contents and duration) of the final design requirements in order to better guide participants towards the expected results, and to a more specific links to the contents of the different phases in which the course is divided.

Contacts
ARCA Training Manager:
Anita da Col
anita.dacol@dttn.it
ARCA Training Officer:
Micol Mattedi
micol.mattedi@dttn.it
ARCA officer responsible for certification:
Nicola Carlin
nicola.carlin@dttn.it
ARCA website:
www.arcacert.com

Figure 1 - Participants of the last course of ARCA Academy during the final workshop session

Building capacities in the construction sector – BUILDUP Skills

Authors
Todorka Samardzioska
samardzioska@gf.ukim.edu.mk
Robert Apostolska
bet@pluto.izis.ukim.edu.mk

University “Ss. Cyril and Methodius”, Former Yugoslavian Republic of Macedonia

The project BUILDUP Skills (Building capacities in the construction sector), supported by Intelligent Energy Europe, defines the path that needs to be followed in the country in the next seven years for the upgrade of skills and qualifications of the building workers in the practical application of energy efficiency (EE) and renewable energy sources (RES) measures, so the national energy targets for 2020 can be met.

Its main objective is to provide competent and qualified Macedonian workforce in the building sector, necessary for achievement of national energy efficiency targets. A national roadmap on quantified needs, measures and priorities, etc., a national platform including main stakeholders in the process, mapping of the foundation: relevant existing vocational qualifications of the building workers in the influence in the field of energy efficiency (EE) and renewable sources and how they meet EU requirements. It will provide data about the gap between the EU practice and the national legislation;
• analysis of all the qualifications and professions in the construction sector needed to be taken into consideration in the project actions since they have significant influence in the field of energy efficiency (EE) and renewable sources and they had to be selected for further training. Special focus should have been given to skills gap analysis as main pillar in prioritising of BUILDUP skills activities and roadmap preparation;
• establishment of a national platform with institutions interested in achieving national strategic goals and a roadmap for qualifications and targets groups that had to be included in the process of knowledge transfer;
• preparation of the roadmap according to the template provided by EU authority, devised by the project team composed of partners’ representatives. The endorsement of roadmap by Institutions joining the National platform, is organised in two steps: roadmap endorsement by non-governmental institutions (private sector
The following figures represent possible fields that could be improved.
The goal of the project was the creation of a workforce with sufficient knowledge or specialisation in the construction of nearly zero-energy buildings; legislative and policy measures need to be developed in turn to trigger the market evaluation of the qualified workforce. The Macedonian building sector can contribute significantly towards the achievement of ambitious national energy efficiency targets which are defined and quantified. Knowledge obtained through the project will ensure quality of energy efficiency of the buildings in Macedonia.

Energy efficiency in buildings: The BUILDUP Skills project Malta

Introduction

The BUILDUP Skills project was a strategic initiative launched under the Intelligent Energy Europe (IEE) programme through the calls for proposals 2011 – 2013, intended to boost, continuing or further education and training of craftsmen, other on-site construction workers and systems installers in the building sector (IEE). The final objective of the project was to increase the number of qualified workers across Europe to deliver renovations offering a high energy performance as well as new, nearly zero-energy buildings. The initiative addressed skills in relation to energy efficiency and renewables in all types of buildings. (BUILDUP Skills – EU 2015)

The project Building Up Skills has set the ground work for the establishment of a vocational training programme in Malta, which addresses the needs of workers and intended to enhance the quality of work in relation to energy efficiency and renewable energy sources. This includes curriculum development which caters for green building technology in Malta. A planned programme which is prepared in consultation with relevant stakeholders shall maximise benefits for workers and for society.

BUILDUP Skills project phases

The BUILDUP Skills initiative was organised in two Phases;

• Phase (Pillar I), the objective was to set up national qualification platforms and roadmaps to successfully train the building workforce in order to meet the targets for 2020 and beyond. Phase I was conducted between November 2011 and the end of 2013.

• On the basis of the Road Maps developed, the second Phase (Pillar II) was intended to facilitate the introduction of new and/or the upgrading of existing qualification and training schemes.

The European dimension of the initiative was emphasised during the whole duration of the project through regular exchange activities organised at EU level which were intended also to foster learning among countries. Thirty EU countries worked towards national roadmaps for qualifying their building workforce for the 2020 challenges.

The BUILDUP Skills Initiative was expected to contribute to the objectives of two flagship initiatives of the Commission’s ‘Europe 2020’ strategy; Resource-efficient Europe and An Agenda for new skills and jobs. The initiative forms part of the European Commission’s Energy Efficiency Action Plan 2011. It was also intended to enhance interactions with the existing structures and funding instruments like the European Social Fund (ESF) and the Lifelong Learning Programme and was based on the European Qualification Framework (EQF) and its learning outcome approach (BUILDUP Skills – EU).

National projects

National teams were formed in all participating countries and their first activity consisted in a detailed analysis of the national status quo. The aim was to assess and quantify supply and demand in the building sector towards 2020 and beyond. In addition the objective was to identify shortages in specific skills as well as key barriers. The National teams in each country set up a platform for discussion with stakeholders. This analysis formed the basis for broad discussions about current gaps, future needs and priorities, with public and private stakeholders. It led to the preparation and endorsement of a national roadmap of priority measures intended to improve skills and qualifications of craftsmen, on-site workers and system installers of buildings. The measures identified had the objective of addressing the 2020 targets in the building sector.
EU exchange meetings: representatives of the national teams constituted within phase I of the initiative had the opportunity to exchange on the challenges they face as well as on findings, best practices, common ways forward, etc. Flexible working group formats allowed for an in-depth exchange and learning; peer review activities: Groups of four countries were formed to support each other throughout the whole 18 months of activities on the roadmaps; publications: Key results including the national status quo reports and the national roadmaps were published and disseminated in the EU (BUILDUP Skills – EU 2015).

BUILDUP Skills Malta

The efficient use of energy in Malta is a main concern in view of the 2020 energy targets. A more efficient use of energy is amongst the top three priorities of the Maltese public as a means of overcoming the economic crisis. In addition there has been an increase in awareness of energy consumption in buildings and more importance has been given to the building’s energy performance by architects and engineers. An improved energy efficiency in buildings can be achieved through effective design and through the effective use of materials and systems in buildings. Sufficient knowledge on the performance of new materials and systems is necessary for the designers to advise the building owners on the right solution to be adopted. In addition contractors and workers need to have adequate knowledge of the new materials and systems installed. The efficient use of energy refers also to an improved energy efficiency in buildings and renewable energy. These require careful design of buildings and building services as well as the appropriate installations of services and finishes. The right skills of professional and technical practitioners in the industry are required to derive the best results from energy efficiency measures and from renewable energy sources.

There are few certified training schemes in the construction industry with workers normally learning the required skills on the job. The only certification required according to law in Malta is a mason’s license for construction and an electrical system installation license. Training courses commenced during 2011 at MCAST (Malta College for Arts Science and Technology) and at the University of Malta for the certification of installers of photovoltaic installations and solar water heaters. The BUILDUP Skills project had the objective to address these challenges through the development of a national qualifications platform leading to a roadmap to upgrade relevant skills for the building industry in Malta. The overall objective of the national roadmap was to embed training on intelligent energy solutions for buildings in the mainstream curricula and practice of building professionals, taking into account the expected contribution of the building sector to the national 2020 targets and the requirements for ‘nearly zero energy buildings’ (BUILDUP Skills – Malta).

In the first stage, a status quo report for Malta was prepared to enable the project Partners understand the weaknesses and strengths of the industry in relation to energy efficiency as well as skill deficiencies. The project brought together many stakeholders with an interest in energy efficient buildings who could contribute to ensure that skills deficiencies are adequately addressed. The stakeholders in the project included all main contributors of the construction industry, including policy makers, education institutions, building contractors and all relevant partners. The project enabled the setting up of a national platform and stakeholders were brought together through the organisation of regular meetings. The process included the involvement of public and private stakeholders, in the organisation of meetings, seminars and also through the Building Industry Consultative Council.

The stakeholders were also consulted in particular for the drafting of the National Status Quo report. The main deliverable of the Project consisted in a Roadmap addressing the needs of vocational training to upgrade building industry skills improved energy efficiency in buildings and renewable energy sources.

National status quo: Malta

The National Status Quo report for Malta presents a snapshot of the current situation in the building industry with a focus on matters related to energy efficiency and renewable energy sources in the Maltese Islands. This report was considered an important and fundamental step as it enabled the partners as well as the stakeholders to better understand how the building industry operates. It also helped define the barriers which prevent the industry from giving a greater importance to training and to energy efficiency.

The Malta College of Arts, Science and Technology (MCAST) in Malta has been entrusted with implementation of the national vocational education and training (MCAST, 2015). Various training programmes already exist in Malta. The aim of the report was to map the vocational education and training (VET) provisions available locally as well as the skill gaps in the workforce for the green construction industry. The strategies intended to increase awareness of the cost benefit an investment in renewable energy sources and energy efficient practices have been analysed. The report was based on the collection of primary data which consisted of interviews with a variety of industry professionals. The secondary data was collected through academic research, reports commissioned by the European Union, governmental departments and other institutions.

Results have shown a lack of data about the green construction industry and low levels of awareness about energy efficiency systems and renewable energy sources and the advantages of their use. Although the benefits of energy efficiency in buildings and renewable energy.
sources were found to be widely understood, the lack of awareness has caused companies to be cautious in investing in the relevant training. The sector which is composed of micro-companies further aggravates this issue, as training would cause considerable strain on the human resources and financial capacities of the companies. The other significant observation is related to inadequate enforcement of existing legislation. If enforced effectively, particularly the implementation of Energy Performance certificates for buildings, this system could have a pronounced positive impact on the industry, with a reduction in the energy demand of buildings. It could further lead to an increase in both employment and economic activity in this sector in Malta. Accreditation of the current workforce and the creation of a licensing system to easily regulate training of tradesmen could also be very beneficial to the industry. These would simplify the employment process, could also be very beneficial to the industry. These would simplify the employment process, and training. The project recommendations are drawn up and for each a rationale and specific actions measures are proposed.

The needed skills, identified from the content analysis exercise, analysed against existing IVET (Initial Vocational Education and Training) programmes. The extent of the skill gaps was then classified. This analysis was conducted by reviewing existing IVET courses related to construction and the built environment. The CVET (Continuous Vocational Education and Training) courses have not been reviewed for the scope of this exercise, since the latter focus on short training periods, and curriculum development can be developed ‘ad hoc’ as required (BUILDUP Skills RM, 2013).

The project identified gaps in skills, knowledge and training. The project recommendations include the following:

- management of data concerning the green construction industry. Improved awareness about Renewable energy systems and Energy efficiency systems and the advantages of using them.
- incentives for training of tradesmen in the sector;
- enforcement of existing legislation, particularly concerning the Energy Performance of buildings to address a reduction in the energy demand of buildings, employment opportunities including green jobs and economic activity;  
- accreditation of the current workforce and the creation of a licensing system to easily regulate training of tradesmen;
- a system for Continuous Vocational Education and Training programmes.

The BUILDUP Skills Malta project has led to an increased appreciation of the importance of energy efficient buildings. The project also results in an increase in awareness amongst stakeholders on the need for training programmes and that these should be carefully planned to maximise their effect. The project supported a better understanding by policy makers and the building industry that energy target objectives will be compromised if workers are not properly trained. It also led to more networking between policy makers, vocational training institutions and building contractors.

The project addressed the National qualification platform and stakeholder engagement. A consultation mechanism amongst the building industry already exists with the Building Industry Consultative Council of the Government of Malta bringing together some twenty three private and public agencies in the Building Industry. In addition, the Roadmap proposes the setting up of two permanent working groups within BICC:

- Building Energy Consultation Network: This will ensure that matters relating to energy efficiency in buildings are addressed appropriately. Subjects for discussion could include EU Directives, local legislation, new technologies, incentives and training needs;
- Construction Skills Unit: This will monitor the situation in relation to skills in the construction industry, relevant training programmes and accreditation systems such as skill cards.

The project helped identified the number of workers involved. The number of workers requiring training per year is between 523 and 698, with the number of workers trained per year reaching 386 (BUILDUP Skills Factsheet, 2013). The professions identified as having the highest needs are:

- Builder/Mason/Heritage Restorer (level 3)
- HVAC Technician (level 4)
- Construction Technician (level 4)
- Building Services Technician (level 4)

The project identified the following gaps in skills, knowledge and training. The project recommendations include the following:

- investigation of EU policy documents, legislation and directives focusing on low carbon buildings and associated VET skills;
- identify the knowledge, skills and competences needed for low carbon buildings;
- evaluate critically the low carbon skill gaps that exist within the local VET scenario;
- for the first three objectives, the outcome is a skill gap analysis for six specific occupational profiles;
- analyse the barriers that might hinder local VET provision towards low carbon buildings. These have been structured into five main themes;
- formulate recommendations of how VET may be carried out to achieve low carbon buildings. Nine main recommendations are drawn up and for each a rationale and specific actions measures are proposed.

The Roadmap for Energy Training set out the strategy and action plan for bringing the knowledge, skills and competences of construction workers to the level that will allow them to produce low energy buildings, meeting the latest requirements and, therefore, contribute significantly to Malta’s energy reduction targets. The Roadmap addresses not only the training and qualification issues, but proposes the associated measures required for successful implementation of the training. The Roadmap for energy training has six main objectives (BUILDUP Skills RM, 2013):
A number of organisations in Malta were identified as being key to the implementation of the roadmap. These include the Ministry for Energy and Conservation of Water, Malta Resources Authority, Faculty for the Built Environment University of Malta and the Employment and Training Corporation. In general it was concluded that vocational training cannot be discussed in isolation but is linked to accreditation and recognition for the training. Recognition provides a good motivation for workers to attend training and for companies to send their workers to training. Enforcement of legislation is also linked to training in that, where there is a legal requirement for skill card, effective enforcement will be a strong motivation for workers to improve their skills. The proper identification of skill gaps is needed to ensure that the training offered truly addresses requirements in relation to energy efficiency and RES. The training for energy efficiency has to be seen within the general context of the overall skill competence of the existing workforce since the lack of competence in the core skills of a particular occupational profile makes it more difficult to address lack of skill competence on energy efficiency. (BUILDUP Skills Factsheet, 2013).
DELTER

Author

Jovan Todorovic
joavan.todorovic@elprenos.ba
Elektroprivreda BiH, Bosnia & Herzegovina

Introduction

DELTER is an EU financed project dedicated to “Support Bosnia and Herzegovina to meet the requirements of the EU Energy Community Treaty (EnCT) for South East Europe (SEE) focusing on Energy Efficiency and Renewable Energy”. The overall objective of the project is to assist in the reform of the energy sector in Bosnia and Herzegovina (BiH) and to create a country wide energy market which is regulated and integrated into SEE and the EU in line with commitments to the EnCT, Energy Charter Treaty, Kyoto Protocol and all aspects of the Acquis Communautaire relating to EE, renewables and energy sustainability. The project started in late October 2010 with a project office in Sarajevo and a budget of €2,429,500 for two years. This project is predominantly taking place for municipal buildings, with demonstration projects in some of these municipalities.

The main goal of DELTER is the work on text preparation of future laws in energy efficiency. One of the activities was to help entities in the preparation of work materials for energy efficiency law. This activity assumes taking into account all European requirements, moving BiH closer to obligations originating from EU Energy Community Treaty for South East Europe. Information from these working materials had been used to present ideas how to establish an energy efficiency system in BiH. Special attention had been paid to local communities according to ideas of working text authors, thus involving local communities.

Stakeholders

The beneficiaries, and herewith partners in this project, were the:
- Ministry of Foreign Trade and Economic Relations (MoFTER) at State level, Ministry of Energy, Mining and Industry (MEMI) of Federation of Bosnia and Herzegovina (FBiH)
- Ministry of Industry, Energy and Mining (MEED) of Republic of Srpska (RS).

Additionally 2 Ministries of Spatial Planning of the entities were involved in the project. Excerpt experts from DELTER project, both entities had delegated their representatives in working groups for the preparation of law text working materials, so the final result was an agreed text of foreign experts from the project consortium and domestic representatives. Stakeholders are also local municipalities.

In parallel with these working groups, DELTER provided training, public education and communication called “Energy management in municipalities” throughout BiH and with demonstration projects in some of these municipalities.

Knowledge and tools

The DELTER project consists of four components.

Component 1: Implementation of demonstration projects in the area of energy efficiency. Component 1 is the most practical part of this project. With the help of nine demonstration projects throughout BiH, with equal distribution amongst the Entities the project has shown how energy efficiency can be turned into practice. Applications were received from 25 municipalities. Energy saving potentials were examined by energy specialists and the projects were ranked based on energy efficiency, feasibility and environmental impact. A Selection Committee made the final selection of the projects, which will receive EU funding for a supply contract. In return, municipalities agreed to contribute in the form of installation and civil works. The public institutions from nine cities from across BiH were selected for demonstration projects: Neum, Jajce, Tesanj, Zenica, Prijedor, Trebinje, Zvornik, Visegrad and Brcko.

Detailed energy audits were conducted at all nine locations and DELTER prepared detailed designs and procurement documents for the nine projects. Mayors from each beneficiary municipality and the EU Ambassador signed a Memorandum of Understanding specifying the conditions for participation and cooperation. Tendering was performed by the EU Delegation in Sarajevo in an open tendering procedure. The deadline for tender submission and the date of tender opening was the 7th of May 2012.

The selected municipal buildings were administration buildings, schools, kinder gardens etc., and were mainly focused on window replacements and energy efficient illumination. Figure 1 shows works for the replacement of old PVC windows with new ones. There are no exact figures of energy savings achieved in these buildings so far, but experiences from similar projects/actions in region show that it could be about 15–20% energy saving with proper wall insulation.

Component 2: Capacity building in energy efficiency, comprised training in the area of energy efficiency (EE) and renewable energy (RE), essential for the projects target groups. These training courses were attended by Entities and municipality experts concerned by energy efficiency issues. These experts are supposed to be authority representatives responsible for the energy efficiency law implementation either on state, regional or municipal level. The capacity building measures were predominantly taking place for municipal and canton staff of both Entities.

Component 3: This is a very important part of the DELTER project and involves public education and communication. Different target groups were selected: Municipality representatives and other civil servants, media, teaching personnel at universities and high schools, students, NGOs and other civil society movements, business people, general population of BiH, etc. Due to very low awareness of energy efficiency DELTER paid special attention to this project component.

There were many activities under this component which included regular information on DELTER development and news, by newspapers, web portals, TV, accompanying all DELTER components and report on the outcomes, organisation of a study tour, etc. The website (www.delter.eu) established was supposed to be a main communication tool and herewith to become a platform as a website containing different information on energy efficiency and renewable energy related mainly to BiH and the Western Balkan countries.

Component 4: assumes elaboration of a legal framework in the area of energy efficiency and renewable energy the final and primary goal of this project.

BiH is a country with very low energy efficiency awareness and is weak legal framework in this sector. A large amount of is energy needed for $1,000 GDP causes significant concern for responsible authorities in BiH to make first activities to mitigate this situation.

Finally, responsible Ministries in both Entities enacted Energy efficiency laws, the Ministry of Industry, Energy and Mining (MEMI) of the Republic of Srpska (RS) in 2013 and the Ministry of Energy, Mining and Industry (MEMI) of the Federation of Bosnia and Herzegovina (FBiH) in 2014.

Scale and topics

The scale at which the project operated at a national scale, since the main goal of DELTER is the work on text preparation of future laws in energy efficiency, but also the regional level, since it was concerned for local implementation of energy efficiency law and through activities in municipalities.

Figure 1 - The windows replacement in Zenica ambulance reception
Most buildings in Bosnia and Herzegovina were constructed 30–40 years ago. At that time, wall thermal insulation was not considered as it is treated today. Average energy consumption for the building heating in Federation of Bosnia and Herzegovina is about 180 kWh/m². According to European Eco-Management and Audit Scheme – EMAS, it is treated as an energy inefficient building. Over 85% of buildings do not satisfy thermal insulation requirements in B&H. Consequently, the heat dissipation from buildings is enormous, so there is great potential in energy savings in building retrofit. This fact was recognised from the project consortium and suggested demonstration projects were dealing with window replacements and energy efficient illumination.

Conclusions

This project has already achieved significant results by increasing public awareness of energy efficiency importance. Training and seminars for Entities and municipalities experts emphasised on very low level of energy efficiency in many sectors in Bosnia and Herzegovina. Special attention has been paid to building energy efficiency and there had been proposed suggestions and actions necessary to improve this situation.

DELETHER had strong communication with local communities and had suggested some pre-activities before the law of energy efficiency was done: monitoring of energy consumption of public buildings, engagement of one employee in each municipality to promote energy efficiency importance to local industry stakeholders, allocate part of the budget for energy efficiency project, prepare a priority list for energy efficiency projects, etc. Also, the importance of local communities was recognised and emphasised both as user of the public buildings eligible for energy efficiency project and as being responsible to implement and support energy efficiency projects/plans in local communities. Nine small demonstration projects successfully reached the final phase in nine public buildings in nine different cities all around Bosnia and Herzegovina.

The most important results of DETEHER are:

- the most valuable result of this project is supposed to be the laws in energy efficiency in both Entities. Working text on this law was being prepared and it was supposed to be accepted from both Entities in most parts of the proposed material. As the final result, the energy efficiency laws were enacted in the Republic of Srpska in 2013 and in the Federation of Bosnia and Herzegovina in 2014. These laws are being proposed as a legal framework for the financing of energy efficiency projects in the future, as the one of the most important issue;
- discussions with local authorities were carried out with special attention. Local communities recognised the obligation to adapt local laws in line with upper energy efficiency laws (state or entity laws);
- public education, training and demonstration projects had been started at the beginning of this process. Nine small demonstration projects were completed successfully.

These demonstration projects are good examples for local communities how to save energy, spare some budget money and give opportunities for similar projects on public buildings.

Originally, the DETEHER project was supposed to be finished in 2012, but it was extended until 2013.

Contacts

DELETHER website: www.delter.eu
EPTISASEE website: www.eptisasee.com/bosnia-and-herzegovina/

Biking Copenhagen

Author

Jonna Majgaard Krarup
jonna.krarup@kadk.dk
The Royal Danish Academy of Fine Arts, Schools of Architecture, Design and Conservation, Denmark

This case study refers to the established culture of cycling in Denmark, which is now part of an ambition and strategy of the city of Copenhagen to bring down CO₂ emissions from transportation. The bicycle is an everyday means of transportation in Denmark, and especially in Copenhagen where 36% of all those travelling to a workplace or an educational institution in Copenhagen use the bike. Out of these 36% Copenhageners, approximately 75% use the bike throughout the year. In 2012 Copenhageners owned approximately 650,000 bicycles and 125,000 cars, corresponding to 5.2 bicycles for each car (Copenhagen Technical and Environmental Administration, 2012a).

Even before the car use breakthrough in the inter-war period, cycling culture and the bike was already the dominating means of transportation in Copenhagen (Thelle, 2013). This established cycling culture has now become an integrated part of the official strategy of turning Copenhagen into a CO₂ neutral capital in 2025 (Copenhagen Technical and Environmental Administration, 2012b). The strategy is supported by and coordinated with the ambition to transform Copenhagen into the most bicycle friendly city in the world in 2015 (Copenhagen Technical and Environmental Administration, 2012a).

In order to encourage the citizens to go by bike and to bike even more, different initiatives are taken locally by the City of Copenhagen, and nationally by the traffic and bicycle training program for school children. On the national scale immigrants to Denmark are offered bicycle training as part of the integration program.

Stakeholders

Even though cycling levels in Copenhagen today are much higher than just some years ago, other forms of transport like car, bus, train and metro are also popular. In order to achieve the goal of a modal share of 50% cycling to work or education, an intensified effort is necessary to encourage users of other means of transport to start cycling.

Cycling training organised in corporation between the police and the schools is offered in fully funded courses for school children on a national scale. The courses offered to immigrants (adults and children) are either part of the official integration process, or organised and conducted by NGOs (for further information, see for example: http://frvillhuset.net/aktiviteter/cykling/, or http://www.rodekors.dk/det-goer-visocialt/)

The cycling training program for school children consists of two courses:

Course 1:
Target group: 2nd and 3rd grade pupils
Recommended: 6–8 lessons
The small Cyclists test consists of:
- “On the bike ride with Albert and Rose” – an interactive narrative theory;
- “The Great City” – additional tasks for the pupils;
- parents Module incl. parents letter;
a small driving test in a gated area – incl. tasks to the pupils; diplomas and Small Bicycle Licenses; an online teacher’s guide and a brief printable “Step by Step” Guide

Course 2:
Online educational material and a theory test and a final practical test in traffic.
Target group: 5th and 6th grade pupils
Recommended: 8 – 12 lessons

Cyclists test consists of:
- safe Cyclist – digital teaching;
- digital theory test and two tests;
- driving in traffic – incl. scoreboard and controller scheme;
- local ties with Google Street View;
- online teacher’s guide and a brief printable “Step-by-Step” guide;
- parent Letter and parents side with the bike check and advice for training;
- scoring and diplomas.

Conclusions
The training courses developed to encourage and to train school children and immigrants and to behave properly in the traffic are in several ways very successful.

The more the Copenhageners bike, the more they support and contribute to fulfil the ambition to bring down CO₂ emissions from transportation in the Copenhagen Region, and thus create a more human friendly urban environment, and increase the citizens’ well-being.

Hence the Copenhageners contribute to the realisation of the Climate 2025 Strategy for Copenhagen and the ambition of turning Copenhagen into the most cycling friendly city in the world.

Additionally the health benefits of the extra cycling are realised, as people who cycle daily are expected to have a longer life expectancy on average. In addition, the increase in the number of people engaged in a more active form of transportation is expected to result in 34,000 less sick days per year.

It is further estimated that the mortality rate for adults who cycle to and from work every day is reduced by 30 % equivalent to 1.7 billion Danish Kroner of annual health benefits from cycling in Copenhagen (Copenhagen Technical and Environmental Administration, 2012a). In doing that the city of Copenhagen benefits from a well-established cycling culture and tradition in Copenhagen, and a well-established cycling training program for children and immigrants on a national level.

One lesson that can be learned is that very simple and low-technology means as the bike can actually contribute to lower CO₂ emission from transportation, and that everybody despite age, gender, professional background can contribute to fulfilling this ambition. However it should also be noted that only 5 % of Copenhageners state that they use the bicycle for environmental reasons and out of concerns for the climate, 56 % states that the bike because it is faster than driving the car, walking or using public transportation in Copenhagen (Copenhagen Technical and Environmental Administration, 2012a). It should also be noted that the increase of citizens biking creates bicycle parking problems in urban spaces, especially at larger traffic nodes, and that some bikers tend to forget to behave properly towards other bikers and pedestrians.

Further that the percentage of people using the bike as the dominant means of transportation decreases significantly outside the Region of Copenhagen and outside the other main Danish cities such as Aarhus and Odense, meaning that the positive effects of bringing down CO₂ emissions from transportation by encouraging biking obtained in the Region of Copenhagen, are not supported on a national scale.

Campaigns, locally and nationally
From 2009 to 2012, the ‘Safe Road to School’ program in the Copenhagen Region focused on making transport to school safe and secure for children and their parents. Between 2010 and 2012, 87 schools and institutions established physical facilities to promote cycling and walking. 5,500 children took part in various cycling activities as part of the program safe roads to school in 2012.

Furthermore, courses and events to increase children’s traffic skills and bicycle behaviour have been held, including the local campaign ‘Young Copenhagen – walks, skates, cycles’ (Copenhagen Technical and Environmental Administration 2012a). On a national scale the ‘Back to School Campaigns’ are running annually.

Materials and technologies
The course material consists both of online education, digital and printed material, and of concrete lessons on bikes in school yards, in the streets and parks.

In order to encourage citizens to cycle and to cycle more, different planning initiatives are taken by the City of Copenhagen. Among these is better maintenance of the city’s cycle tracks, where they already exist. But also new cycle tracks are being planned and constructed. This means that planning and urban design thinking and methodologies are important and supportive ‘technology’.

Copenhagen’s bicycle strategy 2011 – 2015

<table>
<thead>
<tr>
<th>Percentage</th>
<th>’06</th>
<th>’08</th>
<th>’00</th>
<th>’02</th>
<th>’04</th>
<th>’06</th>
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<th>’12</th>
<th>’15</th>
<th>’20</th>
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<tbody>
<tr>
<td>Cycle to work or education*</td>
<td>30</td>
<td>30</td>
<td>34</td>
<td>32</td>
<td>36</td>
<td>36</td>
<td>37</td>
<td>35</td>
<td>36</td>
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<tr>
<td>Cyclists that feel safe*</td>
<td>60</td>
<td>58</td>
<td>57</td>
<td>56</td>
<td>58</td>
<td>53</td>
<td>51</td>
<td>67</td>
<td>76</td>
<td>80</td>
<td>85</td>
<td>90</td>
</tr>
<tr>
<td>Seriously injured cyclists (number per year)*</td>
<td>252</td>
<td>173</td>
<td>146</td>
<td>152</td>
<td>124</td>
<td>97</td>
<td>121</td>
<td>92</td>
<td>102</td>
<td>56</td>
<td>45</td>
<td>34</td>
</tr>
<tr>
<td>Share of the PLUS net that has three lanes*</td>
<td>17</td>
<td>40</td>
<td>60</td>
<td>80</td>
<td></td>
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<td></td>
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<tr>
<td>Reduction in cyclists’ travel time**</td>
<td>0</td>
<td>5</td>
<td>10</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Satisfaction with the condition of cycle tracks</td>
<td>48</td>
<td>51</td>
<td>40</td>
<td>45</td>
<td>50</td>
<td>48</td>
<td>54</td>
<td>50</td>
<td>61</td>
<td>70</td>
<td>75</td>
<td>80</td>
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<tr>
<td>Satisfaction with bicycle cultures' benefits to city life</td>
<td>67</td>
<td>73</td>
<td>70</td>
<td>75</td>
<td>80</td>
<td></td>
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</table>

* These goals appear in the City of Copenhagen’s ‘Eco-metropolis – Our Vision for Copenhagen 2015’
** New methodology starting in 2012

Figure 1 - Cyclists in Copenhagen
It can be concluded, that there are still...
technical, spatial and behaviour related problems to be solved in relation to encourage biking as a dominant means of transportation, in order to meet the ambitions on both transforming Copenhagen into a CO₂-neutral city in 2025 and turning Copenhagen into the world’s most cycling friendly city.

For further online information on bike cycle programs, courses, strategies, etc. in Copenhagen/Denmark, please see the following websites:

www.cyklistforbundet.dk/Alt-om-cykling/
Cykling/Laeer-at-cykle-som-voeksen/Kurser-
Sjaelland hovedstaden.drk.dk/sw106661.asp
www.sikkertraek.dk/Raad-og-viden/Paa-cykel/
Boern-paa-cykel.aspx
www.visitcopenhagen.dk/dakobenhavn/
sightseeing/cykelture
www.dac.dk/dac-life/ture/paa-egen-haand/
cykelruter-paa-egen-haand/

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Copenhagen Technical and Environmental Administration, 2012b. KBH 2015 KLIMAPLANEN. En grøn, smart og CO₂-neutral by.

ILMANKOS – Working together for the climate

Authors

Markku Norvasuo markku.norvasuo@aalto.fi
Janne Roininen janne.roininen@aalto.fi
Aalto University, Finland

Introduction

This case study describes a public climate campaign, entitled ILMANKOS, and a related research and development project, which followed and studied the campaign. These two parts had different goals, key actors and stakeholders. The region concerned in the project was Tampere and the surrounding municipalities, the second-largest urban area in Finland.

ILMANKOS, or ‘Working together for the climate’ was a public campaign of the City of Tampere between September 2008 and June 2009. The campaign was funded by the European Regional Development Fund (ERDF) and by the Finnish Innovation Fund Sitra (www.sitra.fo/en) and the Council of Tampere Region (www.pirkannmaa.fi/en/) on a national level. It was also sponsored by municipalities and public institutions of the region.

This was the actual training part, directed at individual citizens and families as stakeholders. Concerning low carbon technologies, the ILMANKOS campaign promoted ways to reduce greenhouse gas emissions in everyday living.

The ILMANKOS campaign was related to the Tampere Central Region climate strategy, which was prepared during the years 2008 – 2010. This regional scale strategy covered six municipalities around Tampere Central Region, including Tampere, Kangasala, Lempäälä, Nokia, Pirkkala and Ylöjärvi (www.tampereenseutu.fi/in_english/). These municipalities also had representatives in the ILMANKOS steering group.

As one part of the campaign there was a two-year research and development project, Climate change and citizen participation. It was carried out by an independent research party, the Centre for Urban and Regional Studies (currently the YTK Land Use Planning and Urban Studies Group) at Aalto University in 2008 – 2010. The parties that were in the research were partly those that were monitored in the campaign itself, but included also the organisational part of the campaign, like municipal actors, and the methods used in the campaign. An important goal was also to study the reception of the campaign among the citizens and the municipal actors.

The research project aimed at gaining knowledge of the involvement of citizens in climate change policy at local and regional level and analysing and developing participation tools for municipalities. The project report (Peltonen et al, 2011) points out some observations about the efficiency and reception of the campaign, mainly among citizens participation on the local and regional level. Conclusions presented in this text are primarily based on the report. Hence, they reflect the views of the research and development project.

The objectives of the campaign

The background of the ILMANKOS campaign resides in the Tampere Central Region climate strategy (Schmidt-Thomé and Klein, 2013). Its purpose was to assess the amount of greenhouse gas emissions until the year 2030, compared to year 2005, and the influence of different scenarios of land use and development, residential building, transport and economic activity (Peltonen et al, 2011).

The goals of the ILMANKOS campaign were parallel to the strategy and strived for the implementation of climate objectives.

The five specific climate topics of the ILMANKOS campaign were everyday living (especially dwelling issues), travelling and commuting, food, shopping, and waste, all
considered from the residents’ perspective. The campaign promoted knowledge participation and participation in the implementation of climate objectives. It encouraged citizens to reduce greenhouse gas emissions and get involved with the joint action to reach common climate policy objectives. There were also so-called “climate families”, whose carbon footprints and environmental impacts were assessed and monitored. The participants were found by using internet or announcements in local newspapers, or by direct contacts. Finding voluntary participants proved relatively easy.

According to the study report, the campaign “encouraged citizens to reduce greenhouse gas emissions and get involved with the joint action to reach common climate policy objectives. By engaging citizens in implementation of strategic goals and attaining common objectives the municipal administration sought to make the citizens feel as part of a bigger and shared climate change mitigation effort and to make them commit to the shared climate policy.” (Peltonen et al, 2011).

**Main activities and tools of the campaign**

The ILMANKOS campaign used several practical forms of knowledge and tools. In addition to the supporting and monitoring of climate families, they included events, thematic workshops, common forums for citizen participation and municipal actors, and cooperation with regional media. Participation was seen as policy implementation. A specific climate fund supported local action.

The campaign also produced guidance material (www.ilmankos.fi/materiaalit). Among the publications were an environmental guide for families with children, concise leaflets and a seminar presentation. Some of the published advice is also available in English. Dedicated leaflets were produced for all the main issues of the campaign (living, transportation, food, shopping and waste).

One of the leaflets (in Finnish) is presented in Figure 1. The main sections of the leaflet are (translated):

- for the reader,
- what is climate change mitigation about?
- why should municipal residents be involved?
- what can the residents do for the mitigation?
- how to promote climate democracy?
- case Tampere: What was done?
- recommendations.

![Figure 1 - A leaflet included in the ILMANKOS campaign material](image)

### Evaluation of the campaign

This part was executed by an independent research party. According to the summary of the research and development project, the research and evaluation project particularly:

- documented and evaluated the city-regional climate strategy process and the local ILMANKOS campaign in Tampere from the perspective of participation;
- introduced theoretical and conceptual tools for understanding modes of citizen involvement;
- conducted a literature review on the links between public participation and climate change;
- developed evaluator participation as a specific mode of participation, carrying out an experimental citizen-focused evaluation process on local climate policy measures;
- “studied housing corporations as a concrete context for climate policy participation.” (Peltonen et al, 2011);
- the research project also indirectly aimed at supporting the climate goals of the campaign by developing an independent citizen participation concept (issue 4 in the list: “what can the residents do for the mitigation?”).

In an evaluation study the project collected citizens’ views on climate policy. It also used a local workshop (on 27 December 2009) to find out evaluation criteria that could be used in the evaluation of local climate mitigation. A partial result of this task was an evaluation questionnaire. It had three levels, targeted at individual housing companies, municipalities, and regional organisations, respectively. The questionnaire was composed of individual claims about climate change mitigation, and the respondent has to assess their validity on a five-step scale, and also explain their choices. (Peltonen et al, 2011). This evaluation was made by using scientific standards and consisted of relatively elaborate methods, which are not further discussed here.

The fifth issue in the list above (“How to promote climate democracy?”) was targeted at housing companies. Finland has a specific system of limited liability housing companies, which is a common form of private ownership. Each share of the limited liability housing company provides the right of possession to the apartment or other part of the building or real estate, but the company is responsible for the upkeep of its possessions. Usually all shares shall carry the same rights in the housing company, and the shareholders exercise their power of decision at a general meeting, customarily held once in a year. Three such companies from Tampere were studied anonymously, in order to understand the influence of climate change questions in their practices. Another task was to evaluate how well the ILMANKOS campaign was able to reach the corporations. (Nupponen, 2010).

### Conclusions from the research and development project

In the final report (Peltonen et al, 2011) it was concluded that citizen participation is crucial in the implementation of a climate policy. Developing and promoting public participation and climate democracy makes the climate policy more transparent, legitimate and intelligible to lay persons, and thus enhances the process of implementation. The examples from the Tampere case provide the initial practical steps for the development of local climate democracy.

Participation was seen as a channel for local knowledge, and it contributed to trust, transparency and commitment. It therefore supported the implementation of climate-related decisions. Mutual learning was seen as a key function of participation. The climate family concept was also found useful in the evaluation of the campaign. Everyday living was a good approach to the climate mitigation issue. (Peltonen et al, 2011). The research and development project formulated a set of recommendation for future climate campaigns. They included the following principles:

- the role of participation should be decided from the beginning;
- it should be planned in advance, how to permanently establish the results;
- the campaign should be well embedded in the more general mitigation policy;
- a coordinated schedule between various regional and municipal actors is important;
- existing municipal information channels can be efficiently used in campaigns.

The choices concerning methods of participation include:

- interactive method (like workshop) vs. individual method (questionnaire);
- singular event vs. long participation;
- the type of participation (information, planning, decision making, implementation, evaluation) and the grade of influence;
- what is promised in the method;
- what is expected of the intended group of participants;
- the feasibility of the method for the group;
- the feasibility of the method for the issues in case;
- the resources and workload needed (Peltonen et al, 2011, 83–84).

The key recommendation was that citizen participation should be integrated consciouly and systematically in all local and regional climate change strategy initiatives. Municipalities or regions can promote climate democracy e.g. in the following ways:
• the municipality can show good example in climate change mitigation;
• the municipality educates citizens and shares information about mitigation opportunities;
• the municipality makes mitigation possible or easier;
• the municipality provides citizens with several participation opportunities in all phases of political processes.

References


Schmidt-Thomé, Philip, & Klein, Johannes (Eds.). (2013). Climate change adaptation in practice: from strategy development to implementation. Chichester: Wiley.

Bike to work

Authors

Yiannis Freris
yiannisfreris@gmail.com

Evanthia Nanaki
evananaki@gmail.com

1) University of Western Macedonia, Greece

Introduction

Sustainable urban mobility is the field that serves community needs for moving freely, having access to all infrastructures, being able to communicate and interact with fellow citizens, without "sacrificing" basic human or environmental requirements and prospects today or in the future (Papaioannou, 2012). Its basic principles are environmental protection, safety, protection and promotion of human health, serving of population needs for mobility, support of socially just economic activity, reduction of mobility costs, deterioration of infrastructure costs, etc.. In summary, it is the way of planning cities so that they are friendly to all users and the urban environment. The European Committee has issued in 2007 the Green Paper: ‘Towards a new culture for urban mobility’, aiming at the development of international and national sustainable urban mobility action plans and strategies. Greece, as a member of the EU, has signed many European Directives and laws that require the reduction of greenhouse gas emissions by 2020, the circulation of only green vehicles in city centres by 2050 and others. The above requires integrated strategies on the national level as well as the formulation of acts and plans in the local level, in order to ensure the creation of a low carbon city.

In this direction and given that the transportation sector accounts for one third of the CO2 emissions (Nazelle and Rodriguez, 2009), there is a demand for the development of new strategies able to mitigate air pollution stemming from vehicles, especially concerning urban environment (Nazelle et al, 2010).

Cycling in Athens

The general level of cycling in Greece is low. In the year 2000, the total bicycle passenger-km (800 million p’km) represented just 0.63 % of the total passenger-km by all land transport modes. Before the year 2000 there were only few efforts to promote cycling, usually in cities with significant cycling levels. These efforts increased, after 2000, as a number of papers appeared (i.e. Vlastos and Birbilli, 2000; Vlastos and Birbilli, 2001) in conjunction with the support of EU programs and the Greek government.

Regarding the metropolitan area of Athens it is noted that it consists of 30 municipalities and is inhabited by almost five million people, with the Municipality of Athens being the most dense and compact. Athens is a highly car-dependent city with 53 % of car share (TEMS, 2006); with car been used even for 5 – 15 min of walking distances, especially in less dense areas. During the past 5 years and due to Greece’s economic recession, the bicycle is gaining ground as an inexpensive, fast, healthy, and enjoyable mode of transport. More specifically, the bicycle use in Athens was steadily increasing during the last 4 years, to 20 % – 25 %. People have replaced car trips with bicycle trips for work, school and shopping related routes. Data indicate that almost 10,000 people cycle in Athens at least once a week. In 2010, the increase in bicycle sales reached 10 % (compared to 2009) and in the first trimester of 2011 the increase was 12 % (compared to the first trimester of 2010). Those sales refer to mostly cheap bicycles (up to €400) purchased by students and workers.
aged 20 – 35 years old (Foskolos, 2014). In 2011, about eleven new bicycle stores have launched and today more than 80 cycling groups have been founded in Athens. Rough estimations show a number of 5,000 active cyclists in Athens. Public Issue survey (Public Issue, 2012) for 2012 showed that 3.1% of Greeks cycle daily to and from work, school and for leisure purposes. In 2012, Greece was the European country with the second highest proportion in bicycle sales over cars and 320,000 new models of bicycles were developed compared to only 58,000 new car models (lefimerida, 2012). Moreover in 2013, five new bike-sharing systems have been launched in Athenian municipalities.

Daily travel to work is about unavoidable routine trips and commuting is detrimentally affecting both the environment and society as a whole. “Bike to work” is a project, which urges all employees to start going to work by bicycle, presenting the benefits of cycling to work to employers and also advertises the employers that promote cycling to work. The campaign is run for the second time by the bicycle advocacy collective “Podilatisses” which runs the website www.podilatisses.gr and has bi-weekly or monthly open meetings in Athens. Each year a contest is held, so as to see who can make the most trips commuting to work by bicycle. In Greece the contest took place from 15th of May till 14th of June 2014. It is a fun way to initiate commuting to work by bicycle. “Bike to work” is taking place at a regional level and is aiming at a low carbon culture at workplaces and gives the chance for experienced cyclists to give useful information and advice to their co-workers. It is a fun way to inspire employees to begin to commute to work by bicycle. The goal of this campaign is to encourage residents to develop new and lasting commuting habits that will result in healthy transportation choices. It is noted that the group of www.podilates.gr organises biking lessons each month.

More cycling means less traffic, cleaner air, and fewer accidents. Not only does biking to work have the potential to improve individuals’ health, wealth and standard of living, but the combination of more cyclists and fewer cars on the road could lead to the creation of a low carbon city.

It is noted that despite the fact that the data provided above can be considered encouraging for bicycle use in Athens, numbers are extremely small compared to other European cities (Amsterdam, Vienna, Stuttgart, etc.). The lack of bicycle infrastructure and mobility management schemes is the reason for the limited cycling in Athens (Vlastos, 2009). During the last 15 years, several measures have been implemented to upgrade the transportation service level in Athens, such as the development of the metro and tram network and suburban railway, the renewal of the bus fleet with many green buses and many more. Nonetheless, mobility and accessibility issues received little attention and a few fragmented actions have been considered towards integrated sustainable urban mobility strategic plans. Unfortunately, too many of Athens’s streets are designed solely for cars. Bicyclists and pedestrians struggle to travel safely along important roadways. In this direction, new infrastructure projects should be developed, so as to create roadways that will accommodate all users, including bicyclists, pedestrians, automobiles, and public transit.

![Figure 1 - Biking in the city of Athens](image)

### Conclusions

The campaign “Bike to work” creates a bicycle culture at workplaces and gives the chance for experienced cyclists to give useful information and advice to their co-workers. It is a fun way to inspire employees to begin to commute to work by bicycle. The goal of this campaign is to encourage residents to develop new and lasting commuting habits that will result in healthy transportation choices. It is noted that the group of www.podilates.gr organises biking lessons each month.

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For more information please see the following websites of organisations promoting the use of bicycle:
- [www.facebook.com/freedayride](http://www.facebook.com/freedayride)
- [www.filoi-podilatou.gr](http://www.filoi-podilatou.gr)
- [www.planetbike.gr](http://www.planetbike.gr)
- [www.podilatis.com](http://www.podilatis.com)
- [www.mbike.gr](http://www.mbike.gr)
- [www.biketowork.gr](http://www.biketowork.gr)

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25 % Increase in bicycle sales. One new bike-store opens every month (Online), IEKIMERIDA Web, 2012, [http://goo.gl/ecAl8v](http://goo.gl/ecAl8v)


A. Vlastos and E. Bakogiannis, Research on the Development of Long Cycling Routes in Athens, The Case of Faliron-Kifissia Route, National Technical University of Athens, Sustainable Mobility Unit: A research programme report, SMU (Sustainable Mobility Unit), 2009.


P. Papaioannou, Sustainable Mobility in Thessaloniki: Current and Future Role of
Introduction

The Athens-Biowaste project with the title: “Integrated Management of biowaste in Greece – The case study of Athens” implemented the first pilot source separation of biowaste in two Municipalities of the Attica Region, the Municipality of Athens and the Municipality of Kifissia. The biowaste collected is forwarded for composting to the Mechanical Recycling and Composting Facility (MBT) where it is separately treated for the production of high quality compost. The goals of this project are:

• implementation of biowaste separate collection in Greece for the very first time;
• composting of the collected biowaste and production of high quality compost;
• dissemination of best practices in other Municipal authorities wishing to develop similar waste management systems.

Greece produces 5 million tons of residential and commercial urban solid waste annually, equivalent to an average of 450 kilograms per person. Athens (Figure 1) and the wider Attica region produce 39 % of the country’s urban waste (Ministry for the Environment, Energy & Climate Change 2009). Figure 2 indicates that the majority of urban waste consists of organic (40 %), paper (29 %) and plastic (14 %). Greece is among the European countries maintaining high rates of land filling. The amount of Municipal Solid Waste (MSW) landfilled in 2010 was 4.2 million tons, equivalent to 81 % of the total generated MSW. Although the quantity of MSW going to landfill has remained relatively stable over the last 10 years, amounting to around 4 to 4.3 million tons, the share of landfilling has decreased by 10 % between 2001 and 2010, from 91 % to 81 %. This trend can be attributed to advancements in recycling which acquired increased importance in Greek waste management in recent years, especially after 2007, when recycling peaked at 20 % of the total generated MSW (HERCO – Hellenic Recovery Recycling Corporation, 2012). 212 wastewater treatment plants are currently in operation throughout Greece serving the needs of almost 90 % of the population. 80 % of the operating plants follow aerobic stabilisation, which is the most common method for sludge treatment. The largest installations (Athens and Thessaloniki) use anaerobic digestion and produce energy from biogas combustion.

Figure 1 - Athens and the wider Attica region

In Athens and across Greece, MSW is collected in two streams: mixed waste (plastic, glass, metals and others) and packaging waste (paper). The latter is collected by local authorities in cooperation with the Greek Recovery & Recycling Corporation (EEAA) and ends up in Recycling Materials Sorting Centres (KDAY) while the remaining mixed waste is...
The management of biowaste

European policies on waste management (Directive 2008/98/EC and the “Green Paper”) focus on the management of biowaste in two directions: composting (produced compost is used mainly as soil improver and fertilizer) and energy recovery (produced biogas is considered as “green fuel”). On this basis, the Directive 2008/98/EC sets quantitative goals concerning the biowaste management. In specific, by 2020 EU member states have to reduce the volume of biowaste directed to land filling to 35% of the total quantity produced at 1995. In addition, by 2020 the 10% of the total mass of biowaste has to be managed under a separate collection stream. The production of “biogas” through the biological treatment of biowaste contributes to one of the key targets of the “EU 2020” policy, the 20% share of renewable energy in final energy consumption by 2020. The European Environment Agency (European Environment Agency, 2009) estimated that in the EU approximately 7% of the total renewable energy could be generated by the biowaste management. Today, very different policies apply to municipal biowaste management across European cities. The rapid technology evolution has introduced a “slew” of options regarding the management of municipal biowaste. Particularly, integrated management systems have been suggested, concerning domestic biowaste management (home compost, drainage), collection (special bins, automatic collection systems), transfer (use of GPS, modified garbage trucks) and biological treatment (composting, green energy generation, mechanical-biological treatment). In addition, under the sixth Action Plan for Environment of the EU entitled “Environment 2010: Our Future, Our Choice” the thematic strategy on waste prevention and recycling (COM/2005/666 final) is put forward with the main objective to reduce the negative environmental impact of waste by converting the European Community into a “recycling society”. Regarding the management of solid waste, including the flow of biowaste, the policy of the EU, and thus that of member states, is based on the following hierarchy of management options in order of priority: • preventing and reducing the amount of waste; • recovering materials for reuse, and if that is not possible, for recycling; • energy recovery; and • safe disposal of waste in residue landfills.

However, no infrastructure for the separation and collection at the source of biowaste exists in Greece, although separate collection of organic waste is promoted in all Regional Waste Management Plans and numerous biological treatment projects are at the planning stage. In Greece, the separation of biowaste at the source has never been organised, as there is no adequate infrastructure to allow appropriate management yet. The Regional Solid Waste Management Plan (PESDA) of Attica and the action plan of the Association of Municipalities and Communities of Attica (ESDKNA) set out the construction of three new composting facilities in the greater Athens area (Fyli, Gramatiko and Keratea), which will treat pre-sorted organic waste. Therefore, the separation of biowaste at the source is of great significance.

This case study examines the implementation of biowaste separation at source in selected areas of the Municipalities of Athens and Kifissia and the treatment of the collected biowaste in the Mechanical and Biological Treatment Facility of EDSNA in order to produce high quality compost. A guide will be developed to promote and foster the market for compost and create awareness of the general public, the competent authorities and other stakeholders. The stakeholders of this project are citizens, catering authorities as well as other interested stakeholders on the management of biowaste. The scale of this project is regional as the pilot program applies to the collection of domestic food waste from the areas of Athens and Kifissia. The area of Athens is 3,795 ha, with population of 789,166 people, a density of 207 inhabitants per hectare and housing price ranging between 1000 - 8500 €/m². The area of Kifissia on the other hand is 3,403 ha, with population of 64,558 people, a density of 19 inh/ha and housing price ranging between 1250 – 4550 €/m².

The separate waste collection scheme of the Municipality of Athens (Figure 3) was based on the design of a dense network of waste bins, provided for each household. The citizens transferred the pre-sorted biowaste to the bins, which were collected by the Municipality services (Figure 4), starting in October 2013.
bins for the collection domestic food waste, and biodegradable bags were circulated. Special brown containers were installed in the streets in the vicinity of existing bins, where people drop the biodegradable bags with food waste. If included in the waste mix by accident, plastic does not decompose during the composting and contaminates the final product. Figure 7 indicates that the largest amount of household biowaste of Kifissia is ‘fruit’ waste (40.66 %) followed by waste from ‘vegetables and salads’ (26.26 %). Percentages of ‘rest biowaste’ recorded high values (21.57 %). The figures for ‘meat and fish’ and ‘bread and bakery’ food waste categories remained constant at around 2 %. Low enough were the percentages of ‘paper’ and ‘garden waste’ in Kifissia. As far as the Municipality of Athens is concerned ‘fruits’, vegetable and salads’ (26.26 %). Percentages of ‘rest biowaste’ represented the greatest amounts of solid waste. The figures for ‘meat and fish’ are slightly higher (26.02 %) than those recorded for Kifissia: albeit the increase is rather small. Remarkable differentiations comparing to those of Kifissia were recorded for the categories of ‘bread and bakery’ and ‘paper’ reaching a percentage of 15 %. The latter can be attributed to the fact that during this campaign biowaste originated from the Gazi area was also sorted. Gazi is a place in Athens where numerous bars, cafeterias and restaurants are located. Finally, low enough is the contribution of ‘green waste’ to overall waste composition, which is in line with the fact that the Municipality of Athens is more urbanised than the Municipality of Kifissia.

The composting tunnel requires more feedstock to operate at its maximum capacity and to fully optimise the composting process. The compost produced from the pre-sorted biowaste is of very high quality and value which is illustrated in Table 1. Good quality source separated compost, which satisfies most of biowaste End of Waste Criteria (EoWC): • heavy metals (lower than mixed compost which is currently produced at the MBT); • pathogen free; • sufficient organic matter content. As a result the compost can be used as soil conditioner, reducing the need for fertilizer imports. It is noted that the impurities level is an issue of concern in areas where biowaste container system is used (i.e Athens Municipality) and appropriate mechanical or manual sorting is required prior to composting; whereas this is not an issue in areas where door to door biowaste selection system is set up (i.e Kifissia Municipality).

The communication of the program was made through websites and social media, school visits, information leaflets, communication from the vice-mayor of Kifissia, press releases, distribution of the bins and biowaste separation training. The implementation of the program included the involvement of citizens in the areas of application of the separation at source program, the distribution of biowaste collection bins in the pilot areas, the recovery of 720 tons of biowaste through the implementation of the separation at source program in the application areas as well as the laboratory analysis of materials (e.g. waste composition, moisture content) collected from areas of the separation at source system, in order to evaluate the success of the separation. Moreover, the goal of this program was also to provide a guide for local authorities on sustainable management of biowaste through separation at the source. Among other things, the guide includes information on the capacity of biowaste collection, the types of collection separation at source program, the distribution of the biowaste collection bins in the pilot areas, the recovery of 720 tons of biowaste through the implementation of the separation at source program in the application areas as well as the laboratory analysis of materials (e.g. waste composition, moisture content) collected from areas of the separation at source system, in order to evaluate the success of the separation.

Moreover, the goal of this program was also to provide a guide for local authorities on sustainable management of biowaste through separation at the source. Among other things, the guide includes information on the capacity of biowaste collection, the types of collection bins in relation to the characteristics of the region, the shaping of the awareness campaign, the frequency of collection of biowaste, the management costs, the distribution of the final product, etc.

**Table 1 - Composition of produced compost compared to the European criteria for maximum values**

<table>
<thead>
<tr>
<th>Compost</th>
<th>Cd</th>
<th>Cr</th>
<th>Cu</th>
<th>Hg</th>
<th>Ni</th>
<th>Pb</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Athens biowaste compost</td>
<td>0.23</td>
<td>+0.19</td>
<td>17.07</td>
<td>+11.90</td>
<td>126.15</td>
<td>+42.40</td>
<td>0.07</td>
</tr>
<tr>
<td>compost from sorted biowaste</td>
<td>0.07</td>
<td>+0.05</td>
<td>126.15</td>
<td>+42.40</td>
<td>20.05</td>
<td>+9.51</td>
<td>103.99</td>
</tr>
<tr>
<td>mixed waste</td>
<td>0.94</td>
<td>33.02</td>
<td>214.36</td>
<td>1.08</td>
<td>47.63</td>
<td>182.90</td>
<td>433.81</td>
</tr>
<tr>
<td>EDSNA compost</td>
<td>1.5</td>
<td>100</td>
<td>200</td>
<td>1</td>
<td>50</td>
<td>120</td>
<td>600</td>
</tr>
<tr>
<td>European criteria end of Waste</td>
<td>1.5</td>
<td>100</td>
<td>200</td>
<td>1</td>
<td>50</td>
<td>120</td>
<td>600</td>
</tr>
<tr>
<td>Criteria (EoWC)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**Conclusions**

By developing this biowaste program, the benefits of sustainable methods for managing biowaste are implemented at a regional and local level. The development of integrated management of biowaste in Greece is being promoted, in conjunction with the evaluation of alternative management options for biowaste.
based on its whole life-cycle. In addition, this program provides guidance to local waste management authorities for the management of biowaste, while at the same time the environmental awareness and knowledge of citizens, authorities, and other interested stakeholders on the management of biowaste is significantly increased.

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Energy efficient and environmentally friendly villages

Authors
Ákos Nemcsics ¹
nemcsics.akos@kkv.uni-obuda.hu
Idikó Molnár ¹
molnar.idikol@bgk.uni-obuda.hu
Antal Ürmös
1) Óbuda University, Hungary

Introduction
In this case study, two exemplary initiatives are introduced in two villages where energy efficient and environmentally conscious developments have been carried out. One of them is in the Middle-East part of Hungary (Újszilvás) and the other is in the Western part of the country (Oszkó) (Figure 1). These two villages are located in regions with economic disadvantages. The economic environment is unfavourable and agriculture cannot provide for the local population. There are no large industrial towns nearby that can offer jobs to the people. This area has no impressive natural features, nor any significant tourist attractions.

Újszilvás is in lowland in the region of Tápióság and the settlements of this area are relatively far from one another. The size of the village is bigger than typical villages. Újszilvás is a quiet and peaceful settlement with a population of 2,600 people. It is surrounded by a dense forest and has the possibility to take advantage of geothermal energy. In the case of Újszilvás, the agile management of the village tries to find the opportunities in the disadvantages. Making use of the isolated location, they have strived to become self-sufficient and attract tourists who want to get away from society. The power supply is generated by a solar cell plant, built next to the village. Wastewater cleaning, composting and thermal pump energy extraction have also been implemented (Figure 2). These investments are primarily initiated by the pro-active major of the settlement and sponsored party by EU and Hungarian tenders.

Oszkó rests on a hilly area in the region of Hegyhát. Oszkó has a population of 652 people. This region is partially covered by forests and open agricultural areas. A very active civil organisation called Oszkói Hegypásztor Kör is associated with the settlement. A renovation of the ruined cellars and press houses of the village has taken place as part of a grass-root initiative. A tourist centre has been established providing accommodation. The power supply of the centre is provided through photovoltaic panels (Figure 3). These investments have been financed partly by EU and Hungarian tenders. New jobs have also been generated with the help of these investments.

Figure 1 - Újszilvás and Oszkó are in Tápióság and Hegyhát regions respectively

Stakeholders
In both of these cases, the aim of the interventions was to reduce the economic disadvantages of the settlements. The latter have not only become more developed and more comfortable, but some of the inhabitants obtained jobs during and after the investments. During the developments, both of these two settlements became exemplary in their region and later on for other regions as well. The local population benefited from these developments. Not only did they create job opportunities but they also changed the local population’s way of thinking.
As for Újszilvás, eco-tourism and related horse riding tourism became popular due to the peaceful environment. Another initiative was the organisation of motorcycle gatherings, which has become popular nationwide. Tourism and these gatherings attract many people to the settlement. The required developments were partially sponsored by a tender, in which one of the conditions was to hold seminars to other villages struggling with similar disadvantages. In case of Oszkó, the aim was to develop a focus on eco-tourism. A so-called “Kneipp route” was created based on traditional therapy, which led to the appearance of fitness tourism in addition to the eco-tourism. Not only were old wine press houses renovated but ‘eco-hotels’ were built in the vineyard. It was necessary to use traditional construction techniques during the renovation of old buildings. Consequently, there was a demand for training the workforce in these traditional construction techniques. In order to promote traditional professions, courses have been organised which attracted many visitors as well. Many artists have moved to live in these areas who have also been inspired by the beautiful landscape. In Oszkó, many creative workshops have been organised where a large number of artists from Hungary and elsewhere have taken part in the events.

Knowledge and tools

In the case of Újszilvás, the adaptation of new technologies has undeniably been the priority. Thanks to the funding, the installation of low carbon technologies such as photovoltaic plant, cycling paths, house compost, community wastewater handling, the geothermal heating of public institutions (the mayor’s office, the culture house, the school and kindergarden) have become possible.

In case of Oszkó, the goal was to restore the wine press house using traditional techniques making use of the skills of the older residents of the village. This traditional knowledge has been refreshed and extended with new technological possibilities. The revived techniques were used in the construction of harrow walls and thatched roofs. The Kneipp-cure also uses a traditional therapeutic method, connected to the region. The photovoltaic plant has been hidden behind the edge of the vineyard.

Scale

In the introduced projects, building scale, urban scale and the regional scale can be found. In Oszkó, the building scale appears in the application of old technologies. Here the conservation of the cultural heritage occurred. Buildings with harrow walls, adobe plasters and thatched roofs have been renovated. In Újszilvás, the building scale appeared in the increase of the energy efficiency of buildings (electrical and heating services renovations). The urban scale also appears in these two projects. The development of the vineyard followed the traditional settlement structure in Oszkó. The infrastructure developments of Újszilvás (electrical supply, community waste water cleaning) are also at this scale.

The effect at the regional scale can be observed in these two cases because the effect of the developments is observable beyond the borders of the village, especially in regards to job creation.

Contacts

Contact person at Oszkó: Ákos Zágorhidi Czigány
Manager of the Hegypásztorkőr Oszkó
akos@oszko.hu,
Oszkó website (in Hungarian):
www.oszko.hu

Contact person at Újszilvás: Dr. Csaba Petrányi
Mayor of the town
ujzsilvaspolghiv@gmail.com,
Újszilvás website (in Hungarian):
www.ujzsilvas.hu
Energy education and awareness arising for different target groups

The successful implementation of sustainable energy measures is based on the local understanding of all stakeholders regarding the local capacity building. If users are unaware of the root of the problem, they often ignore it and they are unwilling to do anything, as they believe that they are not decisive participants capable of introducing positive changes. In regard to that, it is extremely important to discover which tools and forms to choose for delivering information and overall messages for specific target groups. Subsequently, Energap organised a wide range of different events, from workshops and lectures for smaller target groups to broader campaigns and conferences for wider targeted groups, and paid special attention to the choices of the appropriate themes and tools for specific groups of people.

Knowledge and tools

During the first phase, in September 2008, when Energap installed the Central Energy Measurement System (CEMS) in primary schools and kindergartens, the implementation of measures and tools was accompanied by information and education campaigns for employees within different municipal sectors, school teachers and headmasters, and financial officers on energy efficiency, costs, living conditions, GHG reduction, and other environmental benefits. Special education about electronic energy bookkeeping and CEMS use was organised for them. Energap acts as focal point for all the buildings' energy data, by providing analyses, results and benchmarking issues to the users and owners. The system is upgraded by the possibilities of calculating economic analyses regarding different investments towards energy saving potentials as a basis for financial agreements.

Stakeholders

In current practice there is an ever-increasing need to adapt the ways in which energy is used in a more efficient and rational ways in general. In regard to this, it is necessary not only for all sectors of the economy but also for each individual of whatever age to contribute in the reduction of energy consumption and its use in a more sustainable manner. In order to achieve these goals, a certain degree of knowledge is necessary in order to be aware and act responsibly. With the intent of reaching a higher level of understanding of issues related to energy usages, Energap organised a series of informational and educational events for different target groups at local levels, comprising pupils and teachers from primary and secondary schools, members of the municipality staff, employees of private companies, and the public generally.

Authors

Metka Sitar 1
metka.sitar@um.si

Vlasta Krmelj 2
vlasta.krmelj@energap.si

1) University of Maribor, Slovenia
2) Energap – Energy Agency of Podravje, Slovenia

Regional and local bodies, as municipalities, can effectively contribute to promoting and implementing the use of renewable energy sources (RES), and improving energy efficiency. Recently, in regard to the EU energy policy, the roles of regional and local stakeholders have been emphasised.

In the case of the city of Maribor and the surrounding Upper Podravje Region, the Energy Agency of Podravje (Energap), Institute for Sustainable Energy Use, was established, regarding activities for introducing and improving the skills, knowledge and training about energy issues, as well as for the organisation of training courses. The idea was to mobilise citizens through special awareness raising campaigns supported financially by the Municipality of Maribor and several companies from the Podravje Region.

From the very beginning, Energap activities were focused on organising education and information activities aimed at different target groups of all ages, promoting awareness of energy issues, inspiring behaviour in favour of the reduction of CO2 emissions, fostering of use of renewable energy sources and more sustainable means of transport.

The ‘Energy days’

In parallel, the second target of Energap activities is oriented toward the educational field. Since 2007, Energap has been organising ‘Energy days’ for primary schools in the forms of several energy-related workshops where the experience of the CEMS are also included. It represents the idea on mobilising citizens of all the ages through special awareness-raising campaigns. The programme is performed based on practical examples of RES and efficient use of energy, as presented during 2 to 4 hours lectures, culminating in educational and informational activities. The pupils work in smaller groups and circulate between different workshops in order to learn about energy issues in an interactive way. The practical experience portfolio comprises attractive cases such as the building of wind turbine, examination of the IR thermos-camera, producing electricity with the use of a special bicycle, calculating CO2 emissions, etc.

Energap also adopts the approach “…to see, to touch and to try…” for communication with other target groups when implementing promotional and educational campaigns for the public. The two main projects, “The Icy Challenge project” from 2012 and “The one ton of CO2 project” from 2013 were exceptionally successful, causing significant activities to develop amongst professionals and civil societies in Slovenia and abroad. The first project on “mobilising citizens within the field of RUE through special awareness raising campaigns and Energy day” was the winner of the Manage Energy Award 2013 by the European Commission. The second one,
The 'Icy Challenge' project

This project was developed in order to show the significant benefits of thermal insulation in the case of improving domestic energy efficiency. The idea was presented as a large wooden cube, filled with 3 m$^3$ of ice, as a challenge for citizens to predict what quantity of the ice would melt during one month. In cooperation with the LUMAR, a Maribor-based company producing prefabricated houses, a model of high-insulated building with the very best characteristics of a passive house was erected for one month from May to June, 2012 in Trg Svobode, a square which is one of the central locations in Maribor. During this period, visitors were invited to make their prediction about the amount of melted ice. A grand prize of € 500 and gifts were awarded to the winners.

Figure 4 - “The Icy Challenge Project”, Maribor, 2012

The ‘1 ton of CO$_2$’ project

The second project, “The 1 ton of CO$_2$” was a challenge for Energap in cooperation with the Municipality of Maribor and the LUMAR Maribor by searching for a way of estimating correct numbers on a scale regarding CO$_2$ emissions, for visitors by considering their experiences in daily lives. On the 27th of May 2013, an 8.22m high cube was erected in the central square of Maribor, representing the volume of 1 ton of CO$_2$. Following the statistics, Slovenian residents produce 17 of such cubes every minute. The purpose was to emphasise how much humankind is affecting the atmosphere of the planet by their behaviour and, in this regard, to become aware of the need for changing our ways of thinking that “…what we cannot see, smell or hear, it does not exist…”. However, this experience showed that such concrete visualisation can provide better understanding than abstract figures.

After an extremely positive response, including international interest by the Intelligent Energy Europe project LEAP and the MED project Green partnerships Energap is planning to also place similar cubes in certain other Slovenian cities in order to promote the idea that everyone is co-responsible for the reduction of CO$_2$ emissions by more efficient energy usages.

Figures 5 and 6 - “The 1 Ton of the CO$_2$ Project” at the location of the Leon Štukelj Square in the centre of Maribor, 2013; the interior of the cube

Scale and topics

The training and the projects, combined with special events, were organised at regional level within the Upper Podravje Region and at a local level in the Municipality of Maribor, which played a central role in the achievements of raising of awareness, education, and the training activities, as implemented within the organisation of Energap. The topics of the activities were quite general, as awareness-raising and education initiatives on sustainable energy usages with special attention on energy efficiency and sustainable mobility.

Conclusions

In order to achieve long lasting behavioural changes, the population needs to be encouraged to enter into practical experiences by certain steps through individually successful phases of implementation in order to reach a point where new methods of behaviour are accepted and maintained. Therefore, in order to ensure the appropriate procedures, it is firstly necessary to ascertain at what certain stages the majority of target users’ groups are aware and have knowledge of energy efficiency issues, and secondly to develop appropriate methods and the communication strategies for implementing defined measures.

Raising awareness is not only about theories and oral communication. These cases, when people have the possibility to see, touch and perhaps also act, will have the biggest effect on their decisions. When promoting sustainable energy issues it is important to have in mind general messages devoted to positive emotions such as excitement, fun, moving, etc..

Improving energy behaviour does not mean that people do not take care about energy savings. In view of energy usages, appropriate behaviour would actually provide citizens with the possibilities of acting efficiently in such a way, which would improve their living quality rather than reduce its comfort. Additionally, energy efficiency measures are not just about implementing tools for cost reductions and general improvement of sustainability indicators, but they also present opportunities for fostering economic growth and creating a range of new jobs within this sector.

To conclude, it is worth mentioning that the awareness raising campaigns were estimated to have reached more than 100,000 people within the area of the City of Maribor. Additionally, 35,000 people come into Maribor for work daily, thus passing the central locations of promotional projects was of extreme importance. In parallel, Energap concentrated on numerous visitors to its web page (www.energap.si) and related links. Furthermore, the important media such as national, regional and local Radio – and TV-Stations, newspapers and professional magazines, covered Energap’s events and distributed messages in an attractive way. Finally active collaboration with the representatives of neighbouring municipalities and regions will be of special concern for future success.

For more information please see the following websites:
- University of Maribor: www.um.si/en/
- University of Maribor, Faculty of Civil Engineering, Transportation Engineering and Architecture: www.tg.um.si/en/nergap (In English) www.energap.si/
Introduction and analysis of supply chains

Authors

Jo Patterson
patterson@cardiff.ac.uk
Fabrizio Varriale
varrialef@cardiff.ac.uk
Cardiff University, Wales UK

The existing built environment and construction supply chains are based on fossil fuel as an energy source, this needs to change to achieve policy goals of decarbonisation, energy security and affordability (Hoggett, 2014).

Co-operation across the low carbon industry and along the supply chain has the potential to drive innovation (BIS, 2013; Montalvo, 2008).

However, ‘there is no single technological solution that can deliver a low carbon future’ (Ekins, P., et al., 2011), therefore the process of implementing Low Carbon Technology (LCT) needs to be flexible and adaptable and be supported by a reliable and resilient supply chain. The decision to implement LCT should be taken as early as possible in the development process, i.e. at the planning stage, and commitment should be maintained through design, procurement, construction, operation and management.

Kemp and Volpi (2007) and Rogers (2003) have argued that the penetration of new technologies into the market is not instantaneous and tends to follow a s-shaped curve as technology improves and becomes more accepted and technologically feasible. Adopters of LCTs increase as the effect of economies of scale lowers the cost of the technology and potential risks reduce with expensive and complex technologies diffusing more slowly. When different innovations compete for the same function and therefore within the same market, technology diffusion is more unpredictable (Kemp and Volpi, 2007).

Looking specifically at LCTs, Iyer et al. (2015) have found that diffusion is hindered by a series of factors which need to be overcome for real progress towards energy targets to be made, including:

- public adversity;
- uncertainty associated with the direction of climate change policy and unclear regulatory context;
- inadequate existing infrastructure;
- cultural inertia of the existing technological regimes - technological ‘lock-in’, (Foxon, 2007);
- inadequate or lack of financial support at business and household level;
- lack of technological expertise;
- limited capacity to adopt new technologies, typical of Small and Medium Enterprise (SMEs) (Iyer et al. 2015).

Hoggett (2014) suggests that supply chains associated with smaller scale technologies are more likely to support and enable the implementation of LCTs as they are less complex, illustrate a higher degree of flexibility and resilience in a rapidly changing energy system, despite there being an element of risk involved. If the LCT supply chain functions well at all levels from suppliers to installers and maintenance, then all stakeholders benefit. However, if one of component of the chain, be it a technology or a stakeholder underperforms, the whole supply chain could suffer. Construction supply chains often involve a large number of SMEs which, when implementing LCT, require a higher level of project management which can increase costs if contractor arrangements are not clearly established at the outset (Montalvo, 2008). As the direction of the energy system is uncertain, flexibility and adaptability is essential which is dependent on a high level of communication, trust and understanding.

Working collaboratively can enable other stakeholders within the supply chain to identify areas where cost savings, value creation and efficiencies can be achieved (Carbon Trust, 2016). By providing higher visibility to the rest of the supply chain innovative solutions may be identified. This is more achievable on a regional scale, particularly where SMEs are involved as higher levels of communication through face to face contact are possible.

Carris et al. (2011) have surveyed businesses within the supply chain of the Olympic Park project in London and found that the most significant drivers for the uptake of innovative LCT were:

- new requirements posed by regulation;
- technology developments for efficiency in construction;
- the promise of commercial gain as a consequence of the competitive advantage of the business;
- requirements from the client and the end-users, often related to design trends;
- an increase in reputation and the pursuit of corporate sustainability objectives (Carris et al. 2011).

The same businesses identified that the following barriers prevented uptake of innovative LCT:

- a lack of client demand for sustainable solutions;
- a lack of client engagement with the supply chain;
- poor communication and knowledge-sharing across the supply chain, leading to a lack of awareness amongst designers and contractors about new materials and products;
- client, designer and contractor concerns about the risks associated with using new products;
- cost of research and development against poor returns on investment due to low or slow adoption of innovative products;
- procurement rules which do not acknowledge sustainability and quality requirements;
- unwillingness of the industry to change its habits;
- lack of time to innovate for specific projects and one-off clients;
- lack of clarity from Government about future changes to policy, standards and building regulations (Carris et al. 2011).

Regulation can be used to stimulate the uptake of LCT within the supply chain, examples include:

- EU Energy Efficiency Directive;
- National building regulations;
- Public procurement policy.

Jaffe at al. (2005) found that the necessity for policy intervention aimed at increasing the implementation of LCT emerges from two factors, an increase in environmental pollution and the slow uptake of innovations technologies. The typical policy response to issues of this nature include environmental policy, setting a cap or a tax on pollution and technological policy, offering incentives to increase the technology uptake. The two measures should be integrated over the long term rather than selecting one measure (Jaffe at al. 2005).

Establishing and supporting local supply chains can provide a very sustainable market at a regional scale, particularly if supported by regional government whilst utilising regionally available resources. Taking the regional approach, the Welsh Government (WG), in their recent report, ‘Green Growth Wales: Local Energy’ (Welsh Government, 2015) have stated that there is a huge opportunity for the people of Wales to take control of their own energy needs. The WG, by stimulating locally generated electricity and heat markets through the implementation of LCTs, will support a stronger supply chain that will encourage further investment and support jobs in production, installation and maintenance of LCTs which has also stimulates further action to push LCT integration further.

Supply chains for Smart Energy Regions

The aim of the Smart Energy Regions COST Action is to investigate drivers and barriers of regional scale roll out of LCT. This section of this book enables the identification of some of the drivers and barriers associated with supply chains at a regional scale, using good practice case studies to demonstrate the use of drivers to encourage the establishment and continuation of successful supply chains. The case studies also illustrate where potential barriers in supply chains exist and solutions for how these can be overcome to enable large scale roll out of LCTs.

19 projects from different countries involved in the Action are presented. The case studies are varied and are contextually based within distinct regions, with each region and country having a different political, cultural, economic, environmental and social history. Therefore a direct comparison of the case studies is not
appropriate, although common factors are considered.

The following topic areas were addressed for each case study:
- description of the low carbon technology;
- potential impact of the low carbon technology;
- description of the supply chain involved;
- lessons learnt from the experience.

Information requested included:
- availability of materials and components for large scale implementation of low carbon technologies;
- reasons for selecting products;
- design requirements;
- timescale provision;
- sourcing and embodied energy;
- quality and maintenance;
- costs;
- support mechanisms to strengthen low carbon supply chains;
- flexibility and adaptability for integration;
- innovation/transition studies;
- technology development and commercialisation.

Factors that influence successful producers and suppliers of LCTs were considered and how these can be stimulated or hindered at a regional scale together with the role of existing supply chains within a region and how these have had an impact on the choice and/or delivery of low carbon technologies.

### Analytical overview

The 19 case studies consider three positions within the supply chain:
- low carbon materials/products;
- individual technologies;
- low carbon retrofit and new build projects.

Table 1 provides an overview of the case studies. All content has been provided by the members of the COST Action and their associates named in each case study, and are summarised below:
- Low carbon materials – 7 case studies (Bulgaria, Greece, Latvia, Macedonia, Malta, Portugal and Romania);
- Low carbon technologies – 5 cases studies (Austria, Denmark, Poland, Slovenia and Spain);
- Low carbon retrofits - 4 case studies (Belgium, Bosnia, Cyprus and Ireland);
- Low carbon new build - 3 case studies (Italy, Norway and UK).

The case studies illustrate a range of drivers involved in the large scale implementation of LCT within the supply chain which fall within three main categories:
- Regulatory:
  - adoption of EU regulations - Bosnia;
  - demand for energy efficiency in buildings - Belgium;
- Financial:
  - potential low cost of the LCT in comparison to other products - Bulgaria, Romania, Portugal;
  - economic savings delivered by the LCT against high energy prices - UK, Cyprus;
- Technological:
  - existence of an established LCT capable of delivering benefits - Poland, Belgium;
  - regional presence of a cluster of businesses capable of manufacturing, distributing and installing the LCT - Austria, Greece;
  - regional presence of resources - Bulgaria, Greece, Slovenia;

The barriers involved in the large scale implementation of LCT within the supply chain fall within three categories:
- Financial:
  - higher cost of the LCT compared to existing costs of a comparative product/material, technology, renovation or structure - Portugal, UK, Belgium, Ireland, Italy, Poland, Romania;
- Social:
  - low public and professional awareness of LCT and associated supply chains - Bulgaria;
  - socio-technical 'lock-in' (reluctance to change) - Denmark;
- Technological:
  - limitations of the existing infrastructure – Cyprus, Slovenia;
  - socio-technical 'lock-in' - Denmark, Latvia,

### Table 1 - Summary of the supply chain case studies

<table>
<thead>
<tr>
<th>Title of case study</th>
<th>Main topic</th>
<th>Scale of case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria Cluster of low carbon technologies for biomass heating in the district of Upper Austria</td>
<td>Biomass boiler</td>
<td>Technology</td>
</tr>
<tr>
<td>Belgium Development of an industrialised system for quick and easy retrofit of urban modest house facades</td>
<td>Façade retrofit system</td>
<td>Building - retrofit</td>
</tr>
<tr>
<td>Bosnia DELTER</td>
<td>basic energy efficiency measures</td>
<td>Building - retrofit</td>
</tr>
<tr>
<td>Bulgaria Textile Waste Based Materials (TWBM) for Thermal Insulation for the Construction Industry in Bulgaria</td>
<td>Recycled insulation</td>
<td>Materials</td>
</tr>
<tr>
<td>Cyprus Photovoltaic power generation for Domestic use (Net Metering); Impact of policy on supply chain.</td>
<td>Domestic PV</td>
<td>Building - retrofit</td>
</tr>
<tr>
<td>Denmark Energy efficient windows through supply chain pressure</td>
<td>High insulated windows</td>
<td>Materials</td>
</tr>
<tr>
<td>Greece- From bauxite to low-carbon building products</td>
<td>Aluminium</td>
<td>Materials</td>
</tr>
<tr>
<td>Ireland Low carbon adaptable home</td>
<td>Low carbon prototype</td>
<td>Building - retrofit</td>
</tr>
<tr>
<td>Italy The ZEFIRe building</td>
<td>Low carbon prototype</td>
<td>Building – new build</td>
</tr>
<tr>
<td>Latvia Latvian plywood</td>
<td>innovative plywood panels</td>
<td>Materials</td>
</tr>
<tr>
<td>Macedonia Woodchip concrete blocks</td>
<td>low carbon concrete blocks</td>
<td>Materials</td>
</tr>
<tr>
<td>Malta The EVG 3D sandwich panel</td>
<td>wall construction system</td>
<td>Materials</td>
</tr>
<tr>
<td>Norway Living Lab NTNU</td>
<td>Low carbon prototype</td>
<td>Building - new build</td>
</tr>
<tr>
<td>Poland Modern and efficient residential wood stoves-firesplaces</td>
<td>Wood stoves</td>
<td>Technology</td>
</tr>
<tr>
<td>Portugal The example of cork as a sustainable construction material</td>
<td>Cork insulation</td>
<td>Materials</td>
</tr>
<tr>
<td>Romania Supply chains for the construction of recycled asphalt pavement for roads and streets in Iasi County of Romania</td>
<td>Recycled road aggregates</td>
<td>Materials</td>
</tr>
<tr>
<td>Slovenia The market development for the CNG driven vehicles</td>
<td>CNG fuel for transport</td>
<td>Technology</td>
</tr>
<tr>
<td>Spain Electrically Heated Glass in Mediterranean Climate</td>
<td>Heated glass</td>
<td>Technology</td>
</tr>
<tr>
<td>UK Systems based approach to replicable low cost housing</td>
<td>Low carbon prototype</td>
<td>Building – new build</td>
</tr>
</tbody>
</table>
Macedonia, Malta, Norway, Portugal, Spain, UK.

The case studies illustrate that a range of stakeholders have an impact on the implementation of LCT:
- Government - through regulation and incentives;
- Funding streams and research initiatives;
- Client - specific request for LCT;
- Building designer (architect) and service designer (engineer);
- Contractor and sub-contractors – whose knowledge and experience provide support;
- End-user - through public awareness and demand for LCT;
- Suppliers – who encourage the uptake of technologies and can provide support.

All of the case studies were funded by European initiatives or through industry-research partnerships, which aim to stimulate regional supply chains and increase the uptake of LCTs, particularly through demonstration. Market-based mechanisms can be used to stimulate the supply chain within the LCT sector, such as tax discounts, Feed in tariff (FIT) and the Green Deal (UK). None of the case studies focussed on direct business support as a funding mechanism mainly due to the difficulty of combining these initiatives with other funding mechanisms.

Considering the existing literature and the case studies presented it can be argued that, for LCT to be successfully implemented at a larger scale, the following conditions are required:
- a policy context which provides rules and standards to regulate LCT installation and support businesses and households in the uptake of LCT. The cases show that the pressure of EU regulation has had positive effects on pushing local government and businesses towards LCT. However, the Cypriot case illustrates that when policy is uncertain, there is a reluctance to invest in LCT.
- an industrial infrastructure which can help develop, produce and distribute LCT in the regions. The case studies for Austria, Latvia and Romania show that industry clusters can grow around innovative technologies and that existing industries can change their practices to include new technologies. A pool of skilled designers and installers, capable to adapt and integrate the various LCTs is demonstrated in the case studies of Ireland, Italy and the UK. Close cooperation and collaboration between government, particularly regional, industry and academia can help to establish and stimulate relationships and the conditions necessary to enable continuity and growth of the supply chains.

Despite targets being set at an international government level, there is significant opportunity for action to be taken at regional and community scale, utilising more of a bottom up approach to enable communication between supply chains to stimulate confidence in markets. This approach could use the skills of professionals who have the knowledge and skills to develop and add value to existing supply chains by suggesting and adopting integrated approaches.

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Cluster of low carbon technologies for biomass heating in upper Austria

This case study presents a cluster of low carbon technologies related to biomass heating systems and the relative supply chain of biomass in the region of Upper Austria, and how this cluster helps transforming the region in respect to the use of innovative building components. Aspects of technological innovation and the uptake in the market leading to a cluster of biomass boilers producers are presented. Furthermore, factors for success are discussed.

**Introduction**

Regional governments, energy suppliers, brokers and low carbon industry companies, such as suppliers and producers of local or sustainable building material and technical equipment, are working in a common interest to become a smart energy region. Factors for success depend on geography, political and economical conditions of a region and its ability to adapt and enable transition. One important factor for the success is the establishment of new building products and components in the region. The case study presents a new development of a biomass burning central heating system with condensing boilers. The advantage of the innovation is the hybrid use of two different biomass sources within one system.

**Biomass heating technology**

The demand for a low carbon central heating system that is not dependent on fossil fuel is constantly increasing. The technological components discussed here are central heating systems fuelled by wood pellets. A central heating system is unit that is able to deliver heat to a single family house or a whole building block, often delivering domestic hot water as well. The heat is transmitted by circulating water in pipes and the system is regulated by a central steering unit attached to the boiler. This case study presents a new development of a biomass burning central heating system with condensing boilers. Such hybrid units can be fuelled by wood pellets or whole logs simultaneously, thus providing even more options to choose the most convenient supply chain between different types of biomass.

This case study presents a new development of a biomass burning central heating system with condensing boilers. The automated heating system starts burning pellets and then subsequently switches to the boiler unit that is fuelled by logs. As long as the logs are available (approximately up to 24 hours) the unit will use the stored wood, and then switch back to the reservoir of pellets. This hybrid heating system operates fully automated and with equal comfort as a conventional gas-fired heating system. To allow refilling of wood logs at any stage of the combustion phase, a special system of de-carbonisation takes care of the smoke during the opening of the boiler chamber. The advantage of the innovation is the hybrid use of two different biomass sources within one system.

**Impact of the technology**

The environmental impact results in short cycles of biomass from ecological controlled production to consumption. Given the condition, that biomass is from certified sources such as sustainable managed forests. Especially in rural areas there is quite a reasonable availability of local forests and wood-related industries to provide wood logs and pellets. These resources are properly stored and dried before being distributed to the market. In addition, there is potential for greater independency from international markets and suppliers of pellets.

Overall, in Upper Austria there are more than 50,500 automated biomass boilers in operation with a total power of 2,250 MW, producing more than 3,400,000 MWh each year. This equates to an annual fuel consumption of 1,150,000 tons of solid biomass and results an emission reduction of 1 million tons of CO₂ per year compared to conventional fossil fuels.

A driving factor was the strict emission and efficiency standards by the state government in Upper Austria together with an overall awareness campaign. This has supported the development of highly innovative and emission effective technologies.

**Supply chain development**

The supply chains are established and provide an example of good practice.

The market in relation to pellets has developed in a very promising way in general all over Europe (Egger et al., 2012). There is, however, a considerable difference in the use in European countries. Where in Scandinavian countries pellets are used for large scale systems such as district heating, the use of small facilities for single family houses up to now is mostly related to Germany, Switzerland and Austria.

The Upper-Austrian producers of biomass-heaters were very successful in selling their products on the domestic market (see Figure 4). A supporting supply chain of SMES have clustered around these producers. The regional availability of components is considered to be quite good. More than 30 different boiler-producers have been clustered and are active in the market as well as 20 pellets manufacturers establishing a leading position in that domain. More than
25% (as of 2012) of the installed biomass heating boilers in Europe are produced in that state (Egger et al., 2012).

This is supported by figures of employment and investments in biomass heating of the Biomass boiler and stove industry in Upper Austria:
- annual revenue (from production, sales, installation): 530 million Euro;
- employment (only from production, sales, installation): 3,600 jobs;
- annual investment in new biomass heating installations: 110 million Euro.

Data 2009 From: Biomass heating in Upper Austria, Green energy, green jobs. Egger, Öhlinger, Auinger, Brandstätter, Richler and Dell.

More than a quarter of all Austrian automated biomass central heating systems (below 100 kW) are located in the region of Upper Austria (Egger et al., 2012). This is due to the fact that the supply chain has been well established.

Furthermore, the regional marketing activities have been very successful to promote a technology that was invented in the area.

The average installed power is 25 kW. There are approx. 23,100 wood chip systems and more than 27,200 pellets burning units installed, suggesting that the region is leading in respect to biomass heating systems in Austria. The total installed power per year is shown in Figure 4.

In the last 10 years there has been also a considerable growth in large scale biomass heating facilities above 100 MW (approx. 2,200) in the region of upper Austria. Furthermore, the number of district heating projects is currently at 345 units.

The total of renewable energy currently supplies more than 30% of the total primary energy production in the Upper Austria. As shown in Figure 9, 10% results from hydro power, 15% from wood biomass and about 6% from solar and other renewable energy sources.

Biomass energy supply is considered to have a significant growth potential as it is forecasted that 28,000-0. biomass heating system will be potentially installed before 2030.

Lessons learned
This case study illustrates an important aspect of how constant technical improvement was able to influence the supply chain and vice versa via an existing cluster.

The supply chains of biomass boilers as well as of certified biomass production have developed due to various factors such as energy prices, superior technology, good marketing, from local to European market, and good research capacity at the local level of the manufacturers and demanding emission and efficiency standards by the state.

An important factor in the case of boiler manufacturing was a strong family-business oriented approach in the beginning, with no financial constrains from the stock market or bank dependencies to deliver early profit.

The ability to continually improve the product technologically as well in respect to design (won several red–dot design (3) awards) while constantly selling products is considered to be a success factor.

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Development of an industrialised system for quick and easy replacement of urban modest houses façades

The Reno2020 project engaged all construction actors, from stock owners to local material producers, to imagine efficient refurbishment solutions of dwellings in the suburbs of Liege (BE), according to their typology. This industrialised solution has been developed to replace the street façades of old, often insalubrious urban modest “blue-collar” houses. Among its strengths: set-up rapidity, high energy performance without loss of private or public space, locally-sourced materials and urban-scale retrofit potential.

Authors
Stephane Monfils, stephane.monfils@ulg.ac.be
Jean-Marie Hauglustaine jmhauglustaine@ulg.ac.be
Department of Science and Environmental Management, University of Liege, Belgium

Introduction
For more than a decade, the Walloon government has developed plans of economic redeployment; among these, the “Marshall Plan” financed (from 2009 to 2013) the “Reno2020” project, with the objective to demonstrate that the existing Walloon residential stock provides a vast potential for improvement, especially as far as energy and environmental performances are concerned. Furthermore, Reno2020 gathered together different actors of the construction sector social microcosm:
- the client, private or public owners of dwellings to be renovated;
- the architect, author of the renovation project;
- the contractors, transferring the projected renovation into reality;
- the product manufacturers, developing ad hoc solutions to particular problems;
- the scientific committee, composed by the Belgian Building Research Institute (BBRI, Sustainable Renovation Department), the Technical Control Bureau for Construction (SECO) and the University of Liege, Energy and Sustainable Development (EnergySuD) research unit.

This gathering finds its reason in the principle that all the actors in the construction industry are needed in order to develop new, global and coherent strategies for dwellings rehabilitation, solutions that would reduce costs (to ensure economic feasibility), reduce time for production, delivery and completion and ensure technical performance. Local industrial partners were therefore often consulted to help find or develop solutions to particular or general problems in retrofitting.

In the first part of the project, the University of Liege investigated the urban, typological, energy and technical characteristics of the existing residential building stock of Wallonia, categorising it in order to identify priority typologies and the improvement potential, as far as energy and sustainable renovation is concerned. In its conclusions, the study highlighted the need to renovate working-class neighbourhoods in urban contexts. Although recent decades have seen an increase in the construction of suburban detached houses, the majority of the priority stock comprises urban dwellings built before 1945, categorised as:
- “Blue-collar” houses: typically small, simple brick row houses, with a more recent and insalubrious annex, built for blue collar workers involved in the steel industry;
- “Master” houses, built during the same period by wealthier citizens, with larger dimensions, better design, details, materials and healthiness.

Together this two typologies represent a third of the Walloon residential stock.

Figure 1 - Examples of “blue collar” homes (top) and “master” homes (middle). At the bottom, a common example of such a building, divided in several apartments

The “façade-replacement” solution that is described in this case study has been developed for the “blue collar” building chosen to be renovated in the Reno2020 project. Historically, these houses were built by industry owners for their blue collar workers, in close proximity with the plant. They were generally built simply and quickly, in rows, with small dimensions – small volume, narrow front façade, low ceilings – and local materials (stones, bricks and wood). Whole neighbourhoods appeared, mainly composed of low-income families; obviously these districts evolved during the years, as their dwellers did; small houses were extended by unregulated constructions of annexes in the back (to shelter kitchens, sometimes bathrooms).

Half a century later, these houses often show general insalubrity, translating in humidity and cold air infiltrations, patches of mould and structural weaknesses. In the particular case of the Reno2020 project, the poor condition of front façade of the house made the necessity of its replacement an opportunity to develop a solution potentially applicable to similar units and even whole rows of dwellings.

Figure 2 - Front façade of the renovated building, before (top) and after (bottom) renovation
During the renovation, props were installed to support the loads that otherwise would rest on the façade. The original façade (30 to 40 cm of bricks), windows and door were then removed with care for the neighbouring façade, the roof eave and the zinc works. Other preparation works included cement patching and the application of a layer of foam glass on a sealing coat to ensure the junction between façade and floor insulations.

The company Arcelor Mittal, historically present in the Walloon Region for decades, developed several years ago in its branch that focuses on developing and improving building solutions a light metal structure (called Styltech, indicated in pink on Figure 3), for several wall applications (structural or non-structural). Though a prefabricated light structure can be easily erected for small buildings façade, the assembly plan had to be carefully prepared, with respect to the architects design and local constraints (such as the upholding of the existing roof and zinc works, the slope of the street and the connections to neighbouring façade). Once in place, the structure has been completely enveloped in mineral wool insulation.

The worldwide well-known producer of insulation and plaster-based materials Knauf, based in the region of Liege for several years, was also a big part of the development of this solution, which thus comprises mineral wool insulation (using the "Ecose" technology for a binder that reduces its environmental impact), an external fibre-cement panel (developed for external façade applications, fixed on the vertical metal structure through wooden battens for to avoid thermal bridging), external cement finishing and internal plaster boards.

Steel, plaster and mineral wool may not appear as "environment-friendly" materials, but it has to be pointed out that many improvements have been made to reduce their environmental impacts. First and foremost, Arcelor and Knauf have deep roots in the Walloon Region: raw materials are extracted nearby, so that the location of the industries near Liege reduces the impacts of transport. Also, if steel and mineral wool can be regarded as rather energy-consuming products, it must be noted that both companies have increased significantly the percentage of recycled materials in their processes. Knauf also improved the whole mineral wool production process by developing the new 'Ecose' technology that replaces hazardous binding components with natural sugar-based ones.

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The initial objectives of the project were to develop solutions impacting positively on:
- the technical performance: both companies have worked together to master materials associations, define assembly systems that would respect the required performances in terms of energy losses, acoustic insulation and speed of assembly. As a result, the façade was completely built in two days, and its performance assessed by the EnergySuD Research unit of the University of Liege, the Research and Development team of Arcelor-Mittal Construction and the BBRI;
- the duration of the on-site intervention: intensive prefabrication of the solutions also eases the on-site working process, increases workforce safety and decreases the inhabitant discomfort during the retrofitting process;
- the healthiness of old working-class neighbourhoods that lack of architectural interest: quite obviously, the renovation changes significantly the aesthetical aspect of the building, which means that this solution cannot be applied extensively on any urban building. The study of the different typologies and sizes defined some application potential, mainly in small row residential buildings;
- the cost of the applicable solutions: this particular solution has been developed for this building renovation, but every renovation case is different and needs to be studied carefully. Prefabrication and "easy" reproducibility of the solution are therefore difficult. The involved companies have nevertheless adapted this solution for new buildings, allowing for cost reduction through prefabrication and reproducibility;
- the environment: with reference to Life-Cycle Assessments (LCA) of the solutions and energy performance evaluation, before and after renovation.

The research teams from ArcelorMittal and BBRI published, as part of the Reno2020 project, an LCA of the renovation, and compared it with the LCA analysis of two other wall solutions, designed to present equal thermal transmittance (U= 0,3W/m²K), following three scenarios:
- the "BASE" scenario represent the "as-built" solution, where the main façade is replaced by the new construction, with other improvements including:
  - the insulation of the roof (15 cm of mineral wool in the existing structure), the floor (8 cm
of polyurethane under new concrete slab) and the back façade (8 cm of polystyrene under plaster covering);
• The replacement of all windows (Ug = 0.8 W/m²K);
• The placement of a ventilation system;
• The replacement of the boiler;
• “ALT1” describes a more traditional refurbishment solution, where the front façade is replaced by a wall composed of terracotta structural blocks, expanded polystyrene insulation and plaster covering; all other works are identical (see above);
• “ALT2” describes a more extreme solution, where the whole house is demolished and rebuilt using only the StyloTech structural solution. The systems in this scenario are identical to the previous two above. The comparison aims to evaluate the environmental impact of the different envelope renovation solutions, therefore the boundary of the LCA did not consider the energy consumption of the building in use (assumed as equal for all three solutions) but mainly the production, transport, replacement and end of life of materials, over a 60 years timespan.

According to the LCA results, expressed in the ReCiPe method used by BBRI, the overall environmental impact of 1m² of the new façade system (ALT2 scenario, see Figure 6) is almost double the impact of a more traditional brick wall (ALT1 scenario, see Figure 6). The high impact can mainly be attributed to the production phase of the galvanised steel elements used for the load bearing structure. Even if part of the material is recycled, it still has to be treated at high temperature to be re-shaped and used again. The double gypsum fibre boards, used on the inside of the system wall and considered replaced within the building’s service life of 60 years, also generate a significant environmental impact.

It would be easy to conclude that the use of a system wall in the current configuration does not perform well from an environmental point of view. In order to generalise these conclusions, however, it would be good to consider that comparison should also be made with other façade construction techniques and materials, and that the difference between steel and brick solutions is hidden in the overall results and only clear where the whole house is fully demolished and reconstructed using steel structure.

of more than 20 % (as shown in Figure 6) is nevertheless a solid base on which to found a comparison; the “extreme” alternative of whole reconstruction, using only “StyloTech” structural solution (ALT1 scenario), is less “environmental-friendly” than others.

The “traditional” construction system (terracotta blocks) seems to absorb the difference in both GWP and PED impacts between “BASE” and “ALT1”, so that the whole building performance is somewhat comparable. In other words, the relatively equivalent environmental impacts of the front façade in both “BASE” and “ALT1” configurations, bring negligible differences in the overall building environmental impact.

These results should also be moderated considering the local sourcing and transport of material. Belgium is struggling to obtain real data from its local material producers, so that average data is used in most LCA studies. Choosing a producer that uses locally-sourced raw materials, therefore, does not show in the results and this particular context is furthermore enlightening: Seraing, where this study took place, is located in the Meuse valley, a historical place for steelwork industry, with the presence of Arcelor Mittal industries and research centre. Knauf industries, providing locally-sourced cements, plasters and mineral wool insulation, are also located less than 50 km away from the renovation site. Unfortunately, the environmental performance data related to Ecose technology is for the moment unavailable and “regular” mineral wool data had to be used. AGC Flat Glass Europe, partner of the Reno2020 project and provider of new double glazing (with an U-value of 0.8 W/m²K), is also based in Wallonia.

Another study, led by the University of Liège assessed the performance of the system (U-value of 0.3 W/m²K), the efficiency of the insulation enveloping the structure and the performance of the thermal breaks in the plasterboard fixings. No superficial condensation is to be expected in the technical space, nor is internal condensation in the façade system, if a vapour barrier is added on the internal side of the insulation.
Using the regulatory and standardised method for the calculation of the energy performance of buildings in Belgium, the energy consumption of the house has been evaluated at 396 kWh/m².yr before renovation, and 151 kWh/m².yr after. The overall renovation of the building seem to allow a 73 % reduction of its theoretical primary energy consumption; the new façade alone is responsible for 12 % of the overall energy consumption reduction. If this solution could be applied to 200,000 similar houses in Wallonia, a reduction of around 1000 GWh per year in the regional primary energy consumption would be possible.

On the economic side, the life-cycle costing study realised by BBRI states that there is no significant difference in the economic performances of the two examined alternatives, namely the system wall façade and a brick wall façade. The values for investment, maintenance and operation costs are close to each other and within the margin error, thus both alternatives are considered performing equally.

These are, somewhat, good results; it has been proven that steel solutions are competitive when it comes to renovation, when cooperation and product development are encouraged in the upstream supply chain. In this case, replacing the front façade with the new solution or with traditional masonry seems to be comparable in terms of energy and environmental performances. However, the “Styltech” solution outdistances the traditional one when it comes to reducing renovation costs and duration. Steel hardly makes it to the top of environment-friendly materials list and will not easily replace wood and bricks among Walloon households’ cultural choices and habits. The inertia of the residential construction sector and the dynamics of the steel market make it more difficult for this solution to be fully accepted within the current conditions. However, the potential for economies of scale, low transportation impact (due to regionally sourced materials) and fast technical assembly (requiring skills that construction workers already possess, as proven by the “regular” team that erected this wall on site) could display the full advantage of this product, with the opportunity to renovate complete rows of front façade at once, if projects are well organised and financed. The supply chain is well established and provides an example of good practice. Its development has been made possible by the Reno2020 Research Project, supported by the Sustainable Building Department of the Walloon Administration and the Cap2020 Cluster. It is the meeting of two different industrial partners, the ULG and BBRI research units, the architects and the owners’ renovation case study that led to the development of this solution and the analysis of its performances. It is possible to see the potential at a higher scale: Europe has announced important renovation policies in the years to come, in order to reach its targets of energy consumption and GHG emissions reductions; large scale renovation projects will be necessary in order to improve the building stock, and smart, easy and fast solutions will be needed.

References

### DELTER – in support of energy efficiency in Bosnia and Herzegovina

DELTER is a European project especially dedicated to “Support Bosnia and Herzegovina to meet the requirements of the EU Energy Community Treaty (EnCT) for South East Europe (SEE) focusing on Energy Efficiency and Renewable Energy. The overall objective of the project is to assist in the reform of the energy sector in Bosnia and Herzegovina (B&H) and to create a country-wide energy market regulated and integrated into SEE and the EU (Eptisa, 2012). The main goal of DELTER is to develop the details of future energy-efficiency regulation in B&H. In parallel to this main activity, the project delivered energy efficiency demonstrations, capacity building including trainings in the area of energy-efficiency and renewable energy generation, and raised the public awareness through educational and informative activities.

The expected savings in energy consumption is about 15 – 20 %; • capacity building for energy-efficiency. This component comprised training in the area of energy-efficiency (EE) and renewable energy (RE). The trainees were experts administrators selected from the Entities and municipalities, responsible for the implementation of energy-efficiency regulation either at the national, regional or municipal level. Also, this project component was developed to educate those professionals expected to enact legal framework of energy-efficiency; • public education and communication. Due to very low public awareness on energy issues, special attention was paid to this project component. A variety of social groups were targeted, such as municipality representatives , civil servants, media, teaching staff in universities and high schools, students, non-governmental organisations, civil society movements, private companies, etc. Many activities were conducted under this component: regular information on DELTER development and news, by newspapers, web portals, TV, accompanying all DELTER components and report on the outcomes, organisation of a study tour, etc. A web site was established (www.delter.eu) as main platform for information and dissemination; • elaboration of a legal framework in the area of energy-efficiency and renewable energy. The primary and final goal of DELTER is to work on future regulation for energy-efficiency. This task included taking into account all European requirements, moving

**Author**
Jovan Todorovic
jovan.todorovic@elprenosbih.ba

**Elektroprenos BiH, Bosnia and Herzegovina**

**Introduction**

The DELTER project was financed by EU funding and started in late October 2010 with the opening of a project office in Sarajevo. The project consisted of 4 components. Funding was available for nine demonstration projects throughout B&H, with equal distribution amongst the Entities (Federation of Bosnia and Herzegovina (FBiH) and Republic of Srpska (RS)). The projects showed how energy-efficiency principles can be put into practice in the anticipation of future market stimulus.

The components of the DELTER project are:

- the implementation of demonstration projects in the area of energy-efficiency. This is the most practical part of the project. Nine demonstration projects throughout B&H were conducted with the purpose to show how energy-efficiency in buildings can be improved significantly with relatively simple measures. The emphasis was on the replacement of obsolete windows and lighting appliances with new and more efficient ones. Municipal buildings with public purpose were selected, such as administration buildings, schools, kinder gardens etc., in order to share the benefits of energy-efficiency improvements with the population and allow local people to witness the effects of the improvements.
B&H closer to the obligations set by the European Energy Community Treaty for South East Europe, B&H is a country with very low energy-efficiency awareness and a weak legal framework in this sector. It is recognised that a systematic approach is needed to remedy this situation. Finally, also thanks to the DELTER project the respective Ministries in the B&H Entities enacted energy-efficiency regulations, the Ministry of Industry, Energy and Mining (MEED) of Republic of Srpska (RS) in 2013 and the Ministry of Energy, Mining and Industry (MEMi) of Federation of Bosnia and Herzegovina (FBiH) in 2014 (Delter, 2012).

Nine demonstration projects have been implemented across B&H which are used to illustrate the installation of energy efficiency in practice. These nine projects were selected from 25 applications that were received. Energy saving potentials were examined by professionals and the projects were ranked on the basis of energy-efficiency, feasibility and environmental impact. A Committee made the final selection of the projects, which received EU funding for a supply contract. In return, municipalities agreed to contribute towards the costs for installation and civil works. Public institutions from nine cities were selected for demonstration projects: Neum, Jajce, Tesanj, Zenica, Prijedor, Trebinje, Zvornik, Visegrad and Brcko. Detailed energy audits were conducted at all nine locations and the DELTER staff prepared detailed designs and procurement documents for the nine projects. The mayors from each beneficiary municipality and the EU representative signed a Memorandum of Understanding specifying the conditions for participation and cooperation.

Figure 1 shows the replacement of old PVC windows with new ones in the hospital in the city of Zenica. All the windows across two floors of the hospital were replaced which included 18 windows 120x150 cm, 11 windows 100x120 cm and 7 windows 90x100 cm. The new windows were produced by the domestic company “SUMA plasti”. This company was founded in 1989 thanks to domestic and foreign investments. From its beginning the enterprise was focused on the use of modern materials and technologies aiming to manufacture product comparable with western European quality. The windows are made of PVC frames encasing double pane glass and are combined with aluminium shutters. The replacement works took only 6 days and was carried out by local construction firms. It is expected that the installation of the windows can deliver an energy saving up to 20 %.

Impact of the project

Besides the technical assistance provided by the DELTER project, the EU Delegation in Bosnia and Herzegovina allocated € 400,000 for the demonstration projects on energy efficiency, which has been distributed between the nine projects. The budget only covered the supply of materials, and the beneficiaries had to finance finishing works at their own expense. In figures, the municipalities were supposed to provide up to 5 % of investments, i.e. up to €20,000 for installation works. These demonstration projects are good examples for local communities to understand how energy and money can be saved.

Construction companies in B&H have started to recognise and adopt simple energy-efficient measures in building construction such as thermal insulation and efficient lighting equipment. Trained personnel is available for such measures, but due to the lack of investment and support from local and national authorities, these measures are seldom undertaken on old and obsolete buildings.

Supply chain development

Tendering for the demonstration projects was performed by the EU Delegation in Sarajevo in an open call procedure, and the selection was made based on criteria of costs and technical performance.

Most of buildings in Bosnia and Herzegovina, either private or public, are of poor quality and are very energy-inefficient. The most critical issues are the lack of wall and roof insulation, obsolete doors and windows and inefficient lighting. The installation of roof and wall insulation are the most expensive measures in most cases, but doors and windows replacement is a first steps toward more energy-efficient buildings.

Generally, the problem of energy-inefficiency in the buildings is acknowledged but the low financial returns are the main barrier to improvements. The solution to such a situation could be the provision of a strong initiative from local and government authorities in order to support and motivate people to start with these works on a larger scale. Furthermore, local industry could take advantage to start the production of low carbon technologies and satisfy the domestic needs which would stimulate the job market and encourage appropriate training. So far, the domestic industry can provide thermal insulation and energy-efficient doors and windows as the low carbon technologies, but not energy-efficient lighting equipment. Such situation should be acknowledged by the responsible authorities, and measures taken to provide support of production and installation. As a consequence, the construction supply chains would be stimulated and the energy-efficiency of buildings increased.

**References**


**Lessons learned**

Most of buildings in Bosnia and Herzegovina
An innovative insulation product is being developed in Bulgaria and expected to contribute to turning textile waste into a valuable resource for the construction industry, which would increase the economic efficiency and reduce the negative impact of the construction process on the environment. The production technology will utilise both ‘pre-consumption waste’ (from the textile industry) and ‘post-consumer waste’ (from already used textile products) in the construction of modest and financially affordable homes for socially vulnerable families with the lowest possible investment required, yet keeping good quality standards and ease of maintenance.

The process of implementation of municipal waste as insulation material which had previously been experimented in the Netherlands proved to be impossible in Bulgaria where this type of waste is usually mixed with decaying food waste. Therefore, another source of waste had to be considered. The interdisciplinary research team gathered by HHI comprised of experts from the fields of textile production technologies, construction materials, energy efficiency of buildings, economics and waste management.

The main aim of the project was to develop an innovative building product – insulation material based on textile waste – and the relative production technology. The resulting product would be an inexpensive material applicable in new buildings and refurbishments of social houses, of which the region is in great need (Figure 1). Thus the project was expected to contribute to turning textile waste into a valuable resource for the construction industry, increasing economic efficiency and reducing the negative impact on the environment.

The main project activities comprised composition design and the simulation of production technologies, at first in laboratory conditions and then in industrial ones. Ten insulation products out of 100 studied ones were selected, on the basis of feasibility criteria and the technical properties of the products. Product tests were performed by commonly accepted methods specified in EC standards for thermal insulation products. A Life Cycle Assessment (LCA) was applied as a further evaluation tool, and two types of insulation products with low environmental impact were selected for prototyping. Although the LCA was based on the main standards and recommendations in the field of construction products (EN 15804:2012+A1:2013, EN 15634-2:2011, ISO 21930:2007, ISO 14025:2006, Annex 5, ISO/TS 21929-1:2006 and ISO 14040:2006), several problems were encountered, due to the lack of data on Bulgarian conditions (the product was not in production) and to the peculiarities of the new products. The contribution of each production input to the overall environmental effect was evaluated and thus the main factors of impact were identified. Significant trade-off between environmental impact and technical performance were also investigated. For example, the use of flame-retardants would slightly improve the product fire behaviour – from class F for untreated products (acceptable for one-family houses, which are the main project target group) to class E for the treated ones; it would however increase the environmental impacts and the price of products. A market analysis was performed alongside economic and financial assessments of the ten insulation products. Two development scenarios were explored – the first related to the purchase of new equipment for the production of the insulating material, and the second for upgrading the existing ones in the country, which are used for non-woven textile. The quantity of material needed for the thermal insulation of two single family houses was produced and the optimal installation process was defined through the study of the insulated walls by a thermal camera. The improved energy efficiency of the buildings with the new thermal insulation was estimated by applying licensed software (EAB Software HC1.0). All the technical documentation required by the Construction Products Regulation 305/2011 was developed. A detailed description of the manufacturing process and a business plan for the realisation of the product in Bulgaria were prepared. A patent protection procedure (still ongoing) and a promotion among interested stakeholders were also included in the project activities.

Recycled material from textile waste (processed and non-processed textile waste, and textile packaging) was identified as the most appropriate for the purposes of the project in terms of the insulating characteristics of the material. Moreover, according to available statistical data at the national level, only 5 % of the total generated amount of textile waste is utilised and 16.6 % is exported, suggesting that this is an inexpensive resource still under-used in the country (Figure 2).

Waste produced from old clothing can also be considered as a reliable resource in the long-term perspective because, according to official data, the textile waste generated by the Bulgarian population in the period 2002 – 2006 varied between 3.2 % and 4.7 % of the overall quantity of municipal waste (MoEW, 2008). The percentage is comparable with other EU countries, for example, Austria at 3.2 %, the UK at 7.0 % and France at 3.0 %.

Taking into consideration the estimated tendency for a reduction of the generated solid municipal waste, the municipal textile waste generated annually could be expected to be 10 – 15 kg per capita (EAA, 2013). Expert evaluation has pointed out that at least 70 % of this quantity (overall 15,000 to 21,000 tons) would be recyclable.

**Introduction**

The project for the development of thermal insulation product from textile waste based materials and for its introduction in the construction industry in Bulgaria was initiated in 2011 by the ‘Habitat Social Business Solutions Company Ltd’, privately owned by the Bulgarian branch of the Habitat for Humanity International (HHI) Foundation. The project was funded by the European Regional Development Fund (ERDF) under the Operational Programme “Development of a Competitive Economy in Bulgaria, 2007 – 2013”, BG161PO003-1.1.05 “Development of Innovations for starting enterprises, Priority axis 1: “Development of knowledge and innovation based economy”, ref. no BG161PO003-1.1.05-0270-C0001 (EC, Structural Funds in Bulgaria).

The main activities of HHI have been aimed at providing modest and financially affordable homes for socially vulnerable families with the lowest possible investment required, ensuring good quality standards and ease of maintenance. This is the reason why the applied research of HHI is focused on the development of innovative insulation materials and production technologies for the construction industry.
The newly developed product will utilise ‘pre-consumption waste’ from the textile industry together with ‘post-consumer waste’ from already used textile products. The recycling of such waste for the purposes of producing insulation products needed by the building industry can be considered very effective in terms of environmental protection – it reduces not only the consumption of natural resources but also the labour and energy needed in the manufacture process. CO₂ emissions resulting from the decay of textile waste will be also avoided.

**Impact of the technology:**

**Environmental impact:**
The Textile Waste Based Insulation will have a low environmental impact as only up to 15 % primary materials (polymeric fibres as a binder or flame-retardants) will be needed in the production process; lower temperatures are required in the production process (about 1200°C) compared to those in the production of mineral insulation (690 – 9500°C). This will result in much lower energy consumption in comparison to conventional materials and technologies in the field of thermal insulation. The implementation of textile waste in the construction process will make a better use of a material, the production of which is among the most water-consuming in the world (10 tons of water is needed for the production of 1 kg of cotton thread). Moreover the utilisation of textile waste will result in decreased waste quantities for landfill (as in Bulgaria there is no energy recovery from waste neither the simple incineration of waste).

**Economic impact:**
Comparatively low costs of the product and the technology are expected, but this is still to be proven under real market conditions in the country.

**Social impact:**
The production of Textile Waste Based Insulation Materials (TWBIM) for the Construction Industry is to be undertaken by small size companies across the country. It will provide thermal insulation which would be accessible for vulnerable social groups. Reducing the cost of construction of new buildings and of residential retrofits in the country will provide an opportunity for a broader number of people, even those with lower income, to guarantee thermal comfort in their homes whilst meeting the growing legislative requirements for energy savings. It will also contribute to maintaining better thermal comfort in the numerous buildings providing important social services as schools, kindergartens, etc.

**Supply chain development**
The supply chain is just developing. The main materials involved in the supply chain can be locally sourced and are easily available. There are many enterprises involved in the textile and clothing industry throughout the country, from small to large ones. Production sites and facilities associated with the insulation product could be located close to the main sources of textile production and textile waste generation so that the transportation costs could be minimised. Sorting and pre-treatment of the textile waste does not require specific qualification and could provide additional working places in the factories (Figure 3).

**Lessons learned**
The project has been chosen for funding through the Operational programme because of its focus on an innovative product and its technology addressing the environmental, social and economic requirements of European and national policies towards sustainable development. Thermal insulation based on textile waste is a low-energy and resource-efficient product with a low environmental impact and is economically accessible to large social groups in the country. It could be also produced by small enterprises in the country, which would support local economic development and employment.

The comparison between the newly developed insulation, conventional products and the other existing waste-based or organic thread-based products has proved a series of environmental advantages of the proposed product:
- It could contain up to 100 % recycled material;
- it makes use of waste which would otherwise be landfilled, with all the potential impacts related to methane generation;
- the manufacture requires only low-temperature processing of the materials;
- products based on recycled textile waste are characterised by low levels of embodied energy (about 16 MJ/kg), much lower than foamed polyurethane (135 MJ/kg), mineral and glass wool (35 MJ/kg) and products of wood chips (30 – 40 MJ/kg) (Berge. 2009);
- at the end of the building life-cycle, the insulation product can be recycled through a low temperature process.

The current low price for land filling in Bulgaria could be considered a major barrier for the implementation of the product, as it is currently relatively cheap to dispose of waste at land fill. Yet it is expected that the price for land filling will increase more than 4.5 times by 2020, which will make the recycling of waste materials more economically favourable. There are also numerous illegal practices in textile waste management due to missing effective control and the general lack of collection points for textile waste. The identified lasting tendency of reducing the quantity of generated waste (textile waste included) is related to the general decrease in goods consumption registered in the country (EEA, 2013).

Although thermal insulation products based on natural organic fibres (straw, wool, cotton, etc.) have excellent insulating properties, they are still modestly applied in most of the developed countries, mainly because of lacking industrial production technologies and related testing procedures and standards. There are also some unfavourable properties of such materials that hamper the application, such as organic decay, which require additional processing. Adequate architectural systems and details are also to be still developed and tested.

The Bulgarian building industry is currently facing the challenge of integrating resource and energy efficiency requirements into a broader set of environmental, social and economic requirements, all related to the need for guaranteeing the long-term sustainability of the urban process.

The project has definitely confirmed the feasibility of the new environmentally friendly product for thermal insulation of buildings, as its technical characteristics meet the main requirements of EC Regulation 305/2011 for construction products, especially for thermal insulation ones. In order to be introduced in Bulgarian construction industry, the product should be issued a Bulgarian or EU technical Assessment. The production is also economically viable if an effective system for textile waste collection is established in the country. The expected social benefits of the project comprise the creation of new jobs and the affordability of the insulation product, which allows improving the energy efficiency of residential buildings.

**Environmental impact:**
Textile waste is currently transported to landfill at distances of 20 – 60 km or even further for being transported and recycled abroad (Italy). The transportation to a local collection point would not be more expensive or environmentally harmful.

**Economic impact:**
Comparatively low costs of the product and the technology are expected, but this is still to be proven under real market conditions in the country.

**Social impact:**
The production of Textile Waste Based Insulation Materials (TWBIM) for the Construction Industry is to be undertaken by small size companies across the country. It will provide thermal insulation which would be accessible for vulnerable social groups. Reducing the cost of construction of new buildings and of residential retrofits in the country will provide an opportunity for a broader number of people, even those with lower income, to guarantee thermal comfort in their homes whilst meeting the growing legislative requirements for energy savings. It will also contribute to maintaining better thermal comfort in the numerous buildings providing important social services as schools, kindergartens, etc.

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The potential or harvesting solar energy for electricity generation in Cyprus is obvious. While solar panels are widely used for the supply of hot water, policy delayed in facilitating the use of photovoltaics for electricity production. The Cypriot Energy Regulatory Authority (CERA) launched in 2012 an initiative for the application of ‘net metering’ to a limited number of government buildings and geographical areas which aims to reduce electricity prices for the households and to gain significant experience and knowledge on how to run the electricity grid using net metering.

Author

Lora Nicolaou
loranicolaou@gmail.com
Department of Architecture, Frederick University, Cyprus

Overview of the project and strategic policy context

This case study presents the government policy, formalised in 2010 in Cyprus, to initiate the establishment of Renewable Energy (RE) programmes and more specifically the use of photovoltaic (PV) for the generation of electricity for domestic use. The results of the policy indicate a significant shift of electricity generation towards renewables. What is not yet obvious or formally recorded is the impact this PV energy market had on the local industry which ‘exploded’ in order to cope with increased demand in system installations. The emphasis given to the policy context is particularly relevant to the way the supply chain has developed and continues to transform in a rapidly changing market. The economic context which policy creates seems to impact directly on how processes and industries respond to the challenges of RE applications.

The data presented, particularly where referring to the supply chain aspect of the ‘Net Metering programme’, are empirical and based mainly on the assessment of organisations and professionals involved in the industry. The lack of published data on the performance of this rapidly growing sector is indicative of the lack of effective monitoring of both policy and the industry involved in the supply chain. RE policy in Cyprus was a response to Article 4 of the European Directive 2009/28 which required the establishment of a strategic plan in each member state on how to achieve a shift from fossil fuel to RE. Each plan needed to state its targets for the market share of renewables relating to transport, electricity generation, and heat and cooling to 2020. The policy in Cyprus was formalised in 2010 in a ‘National Renewable Energies Action Plan’ (NREAP) by the Ministry of Commerce, Industry and Tourism in consultation with a number of relevant institutions, organisations and ministries. The plan sets a target for an increase in the supply of electricity from renewable sources to 7 % of electricity from RE by 2020, one of the highest increase in Europe. The high target for RE generation balances out the very poor performance of the transport sector and the lack of public transport in the Island.

In 2015, according to the (yet unpublished) assessment of the Energy Service (Department of the Ministry of Commerce, Industry and Tourism) the share of electricity production from renewables in Cyprus is at 34 % from wind, 12 % from photovoltaic and 4% from biomass. This is considered by the policy makers and the industry a success in achieving these quantitative policy targets. Although achieving qualitative targets, this paper will suggest that policy neglected key aspects which can support the long term growth of the RE industry and PV energy production in particular.

Specific policy programmes, mechanisms and technology

The feed-in tariff (FIT) was the first policy mechanism introduced in 2004 designed to accelerate the investment in RE technologies.
The FIT offers long-term contracts to RE producers, based on the generation capabilities of each technology and the cost of electricity currently sold on the market. The FIT often included “tariff derogation”, a mechanism according to which the price (or tariff) is varied in order to support the feasibility of production. As the market (suppliers/installers) increased and the technology costs decreased, the FIT subsidised pricing was adjusted to reflect such changes. When the cost of PVs energy became competitive with conventional energy production, the system (FIT) became redundant.

In 2012 the Cypriot Energy Regulating Authority (CERA) – an independent government organisation tasked to advice on strategic policy relevant to RE – suggested the need for further policy initiatives. On the basis of that assessment, in the same year Energy Services (ES) introduced ‘Net Metering’ (NM) as a pilot programme. The initial programme included the installation of PVs on selected governmental buildings by the public sector and to only a relatively limited number of applications by private house owners in specific geographic locations. The goal was to gain significant experience and knowledge on how to run the electricity grid in the context of the ‘net metering’ programme, meaning a distributed production of electricity by individual housing units.

The NM programme opened to applications in 2013 initially with a target for 3,000 households (with installation fully funded by applicants) and additional 1,500 applications by disadvantaged households which were subsidised for approximately 50% of the cost of installation (900 euro/kW). This increase in interest by the private sector at this stage was due to the reduced cost of the technology in relation to high electricity bills.

The programme was oversubscribed and more recent figures suggest an acceptance of some 5,500 applications and approx. 1,800 for subsidised installations (close to a 3 million euro total budget). The latest assessment of CERA was that the majority of approvals were implemented; some 6,760 out of 7,400 were approved by March 2015 with a small number still pending. Delays in implementation relate to the economic crisis and the inability of applicants to borrow in order to contribute to their share of the PV system installation cost. The programme was administered jointly by CERA and AHK (Cyprus Electricity Authority). The programme was considered a success with obvious consumer interest and good rate of installations. New programmes are under consideration for the acceleration of the Net Metering programme but with no date yet set.

Criticism towards the government was raised in regard to the pace of progress in initiating additional programmes which will facilitate the share of RE in the electricity market. A key barrier to the expansion of PV generation is the inability of the grid (the distribution system) to cope with the periodical increase in supply. Being an island, the electricity distribution system of Cyprus is autonomous with no connections to other countries, which could have assisted with the management of supply fluctuations. More recently the government has commissioned a study on ‘Grid Stability’ in order to evaluate this condition and propose updates to the system. There is no evidence either of any strategic plan for connecting the Cypriot grid with the neighbouring regions (i.e. Lebanon, Israel etc.) which could re-position management issues.

### Description and analysis of the supply chain

The call for applications for the NM pilot programme was launched in January 2014 and was characterised by the following conditions:

- total available capacity : 15 MW (13.5 MW for all private households, 1.2 MW for households in need of subsidy and 0.3 MW for local government buildings);
- total capacity per system at 3 KW which corresponded to 20 – 24 m² of PV panels for the production of electricity;
- costs and payment billing to consumers to be made every two months with any excess production to be forwarded to the following month and with final accounts in May of every year;
- cost of the installation varied in 2014 between € 4,000 – 6,000, depending on the quality of the components and country of origin (the import of technology is mainly from Germany and China). The payback period in this context is calculated to be from 5 to 7 years, which is considered a particular good investment.

Conventional and well-tested technologies are used and relatively easy and cost-effective to install.

The system consists of:

- A DC/AC inverter;
- the electronic service panel and the meter;
- PV panels of 20 – 25 m² per domestic unit;
- Wiring.

There is no need for batteries in the system, since the electricity produced is channelled directly into the grid through a bidirectional meter. The preparation of relevant application and the installation of PV panels and system are provided by private sector installation companies, whilst AHK is responsible for the assessment of applications, the installation of the bi-directional meters and the connection to the main grid. Most systems have close to 20 year guarantee (varies by different manufacturer of components) and with an annual maintenance fee of up to 200 euros.

There are no formally recorded data concerning the performance of the PV technology importers/installers industry in the island. Some information was gathered (but not verified or published) by two independent, non-profit agencies which were set up in order to ‘fill the gap’ in the monitoring of these programmes by the public sector: the Cyprus Energy Agency (CEA), was set up five years ago through EU grants in order to promote RE in Cyprus, and the Energy Professional Association (SEAPEK), an organisation set up initially by the large companies operating in the PV sector initially (importers of technology and installers) in an attempt to regulate the profession and provide relevant information to the consumers and public.

According to these organisations, the importer/installers industry is home-grown (no multi-national firms interest in such a small market) and gained enormous experience during the last 10 years of practice. Early RE programmes were delivered by only two firms offering installation services for mostly electricity production for large industrial/commercial buildings or parks. The local energy professional association (SEAPEK) has at present 40 members. CERA (regulating authority) puts that number of new companies to 65. Only 5 – 7 of those are large enough to service big projects employing several engineers. The rest are very small companies of 1 or 2 practitioners which sprang out of diversification of small electrical and plumbing firms. SEAPEK suggests that there are dozens of other small firms which provide substandard services and guarantees of systems which cannot honour, in a totally unregulated market. With no official government regulation, SEAPEK estimates that only 15 – 20 % of installations is of a high quality.

A significant reduction of the cost of electricity during the last year and the completion of the initial NM pilot programme with no further programmes running have a serious impact on the state of this industry. Small firms are beginning to close down leaving consumers exposed with no support for the system maintenance or way of claiming guarantees in the future and the ‘know-how’ of the industry developed during the last few years is disappearing.

Hardware is imported directly from Europe (mainly Germany) and more recently from China by the bigger installation firms, whilst smaller firms rely on two main importers for the various components. In 2003, the company ‘EN Photon’ was set up locally in order to assemble PV panels from components imported from Europe and Asia, primarily to
be exported again mainly to the Middle East. The company was very successful initially and won numerous awards for best practice and best export company in Cyprus. It did less well and became less competitive in relation to imported technology during the last two years and is now inactive. While one would expect that the simple increase of the PV installation market would have supported companies such as ‘EN Photon’, changes to the local and EU tax regulations on non-EU imports, made the particular industry economically unsustainable. The relaxation of regulation on non-EU imports (such as China) of technology components makes imports much cheaper to ones assembled locally.

Issues arising from the Net Metering 2013 pilot The fact that the Net Metering programme was initiated and launched even at a pilot scale is very significant, with impact not only on the actual production of energy but the changes to systems and cultural shift of all those involved toward RE.

This programme:
• set an initial government administrative and regulatory framework;
• promoted and ‘advertised’ new RE technologies as a valid alternative including raising awareness of the parallel issue of energy conservation/efficiency;
• Initiated a private sector service PV industry (importers/installers).

On the downside Cyprus failed to act earlier and to capitalise in establishing a more extensive infrastructure to support such programmes despite the significant potential for solar energy.

It is far too early to assess the full success of the programme and its long-term viability of the supply chain industry through statistically relevant and accurate data, particularly in the context of changing circumstances in the country (economic recession, potential for natural gas extraction etc.) which will change the framework governing energy production in Cyprus. This new economic landscape will need constant re-adjustments by effective policy which will to consider feasibility issues, in order to insure that programmes are attractive for the private sector in the future.

Conclusions
In summary, the experience of the implementation of the 2013 Net Metering programme suggests the following:
• potential of wider application: the wider application of PV as a major power generator for domestic use is feasible and can be as popular as solar panels for hot water. The installation of systems relies on well-established and simple technologies which became recently economically competitive. Technical concerns are only relevant to installations of large plants and commercial production and the ability of the grid to manage excess production;
• drivers: the reason for the relative success of the current pilot Net Metering programme, compared to previous ones was the high electricity prices and the parallel reduction of the cost of PV technologies. The role of policy therefore will need to continue to regulate the sensitive economic balance between the two production modes and insure the economic competitiveness of RE technology applications;
• advantages of the local context: In Cyprus a large proportion of the population live in single housing units in suburban settings were the installation and management of PV systems is easy to implement. Other European regions within the same climatic zone have developed higher density urban morphologies which imply less potential to accommodate PV installations without major refurbishments of buildings (considering added complexities of retrofitting/refurbishment);
• shortcomings: there is clearly the necessity for better regulation of the market and the establishment of minimum standards and control mechanism which will protect consumers from sub-standard practice. This will be particularly necessary as systems come to age with the need for maintenance and renewal become critical;
• barriers: challenges to the expansion of the policy is the management of the grid and distribution system the inevitable fluctuations of RE sources in comparison with the conventional electricity production. Only recently the government began to look at the re-design of systems and technology solutions which might overcome this difficulty.

One other barrier relates to the need of restructuring of AHK (the local, publicly owned electricity company) from an electricity supplier to a distribution company in order to service what would essentially be ‘the privatisation’ of the electricity production market;
• lessons to be learned: the application of well-established and simple technologies which could play a major role in the reduction of CO₂ emission appear marginal because of the delay of policy to consider decisively a shift in production from conventional to RE sources, currently economically viable, technologically possible and with the potential of becoming a ‘standard element’ of the local building construction practice.
Energy efficient windows through supply chain pressure

User demands can change entire supply chains and thus contribute to the development of energy efficient technologies. The residents’ design of their own single family house in a suburban development pushed the building company to pressure their Danish window supplier to develop energy-efficient windows, which are now available for the Danish market.

Authors
Morten Elle
elle@plan.aau.dk
Maj-Britt Quitzau
quitzau@plan.aau.dk
Department of Planning and Development, Aalborg University, Denmark

Introduction
This case describes how a local intervention pushed the existing supply chain in one of Denmark’s largest window producing industries to deliver more energy-efficient windows.

The case emphasises process innovation in terms of destabilising lock-in dynamics in a mainstream supply chain, rather than focusing on technology innovation related to a single low-carbon technology.

Most of the buildings are owner-occupied single family houses. The energy-efficient buildings are aimed at ordinary citizens, not at a special ‘green’ segment of the population, as a part of making low energy housing become the ‘new normal’.

Figure 2 - A typical house in Stenloese South – looking like an ordinary owner occupied single family house

The houses look quite ordinary in a Danish suburban context – it is the basic idea that they should look like any ‘normal’ building, but be more energy-efficient (several architects have been quite disappointed when the visited the area – they had expected buildings with a special visual appearance). Some houses are small, semi-detached houses (120 m²), but many are rather large detached houses, typically around 200 m². Many of the houses were built between 2006 and 2007. Recently a 117 m² semi-detached house was sold for approx. 310,000 € (Boliga, 2015), and a 226 m² house is set for sale for approx. € 850,000 (Home, 2015).

The Municipality of Egedal adjusted the existing planning and building procedures in order to promote energy-efficient building. Among other things, they used easements to set a specific maximum for energy performance per square meter of floor-space per year. They also developed a thorough information material including whole life costing. For more information about the municipal role see (Quitzau et al. 2013).

Energy efficient windows

The required level of energy performance generated important changes in the building structure and systems. Windows represent one of the important building elements to address in order to comply with the energy performance requirements. Windows are still one of the weak spots in energy-efficient buildings, resulting in substantial heat losses. One way of dealing with the heat loss from windows is to have fewer surfaces with windows. Another way of dealing with it is to increase the energy efficiency of the windows.

In the case of Stenloese South the supply chain development is interesting in relation to the increased energy efficiency of windows. Over the last couple of years, window manufacturers in Denmark have improved the energy efficiency of windows substantially. National Danish building legislation has been an important driver for this development, since functional requirements regarding heat loss from windows have been implemented. Our case, however, shows that local interventions can also represent an important way to push the existing supply chain to incrementally improve the energy efficiency of their products.

Impact of the technology

Narrowly seen, the increased energy efficiency of windows installed in Stenloese South has merely contributed to an improvement in the building envelopes at the development site, and not on a regional or national scale. This has resulted in an energy consumption 50 % lower than the existing energy regulations at that time (Merck, Thomsen and Rose, 2012). It is difficult to say exactly what share of the reduced consumption can be ascribed to the improvements in windows, because the combination of energy saving strategies varies for each building project. Although this impact may seem insignificant if only the direct impact in the development area is considered, the improvement in the efficiency of the windows has had a larger indirect impact. The new standards from the area were adopted in the entire industry. The window company in question, called Rational Windows & Doors, has now developed an international market as a result of the programme of works. This represents an important process innovation, because it illustrates a very difficult break with prevailing lock-in dynamics in the existing supply chain.

Improvements in the performance of windows are hindered by socio-technical lock-in dynamics, since there are many norms and expectations that make energy-efficient innovations difficult to develop. One important dynamic is that windows are expected to fit to the local building tradition. In most of Denmark, windows open out of the building making the window sill a usable place for flower-pots, souvenirs etc.. In many other countries, as for instance Germany, windows typically opens into the building – making it possible to have shutters. There are also specific expectations with regards to building materials in Denmark, since windows containing PVC are normally not considered an option in Denmark. Wooden windows (with aluminium core) are – like façades with bricks – considered a sign of good building quality.

Supply chain development

The supply chain development relating to windows was framed by the municipal initiative to set up local energy performance requirements. In addition, the design and construction process related to a specific single family house project in the area became decisive in challenging the production of windows in Rational Windows and Doors (Andersen, pers. comm.). The family in question had bought a piece of land in Stenloese South and were in discussion with the chosen standard house building firm, Lind & Risoe, about the construction of their house. Lind & Risoe is a large company specialising in building standardised single family houses delivered on a turn-key basis. The company was a sceptical concerning the
necessary changes to building more energy efficient buildings:

“When you need to go in and change the insulation, sectional views, and change your supplier of windows. And just changing the windows in a house has great implications, for how you lay bricks at the rabbot of the house. The measurements, the delivery of the windows, the sequence of work, surface treatment, etc. There is a whole lot of stuff. And being as big (company, red.) as we are, there are many of these things that run — and when things start running, then they run, and it is difficult to change these things on the way.” (Hansen, pers. comm.)

When the family bought the land, they had no special interest in energy efficient buildings – but they respected the local energy performance requirements. They wished to have a modern house with a lot of natural day-light, and would not accept that it could not be done due to the energy performance requirements. They actively engaged in the design process of the house by challenging the technical solutions set up by their building company based on the attitude that this was not ‘rocket science’:

Bo: “No. It’s probably just as much, because we have pulled them (the building company, ed.). And said that we wanted to be involved. And have also pushed them. We have acquainted ourselves with really many of these things and have studied it much, even though none of us work within the building profession.”

Katrine: “You see, we are not civil engineers, but we are used to acquaint ourselves with new technology. And be on top of how things function and function, and doing modelling ourselves. We both do product development, just in relation to other businesses. So we are not afraid of handling something, which is new.” (Andersen, pers. comm.)

In Bo and Katrine’s studies of energy efficient building they contacted a professor at the Technical University of Denmark, consulting him with their problems. He provided them with different options for their search. During their search of the market for energy efficient windows, they identified a newly developed window (called “Seven”) by the Danish company PRO TEC Windows. This represents one of the first examples of composite windows in Denmark, having an U-value of 0.76 W/m²K. According to Bo and Katrine, this newly developed window was the only highly energy efficient window on the market that fitted with modern architecture. They felt that the German alternativa house was inadequate. With the energy efficient window from PRO TEC Windows they could make a design for the building as a whole with fewer constraints in order to reach the required level of energy performance.

They approached Lind & Riscoer with their knowledge of energy efficient windows and requested that their house should be built with PRO TEC Windows.

The proactive initiative from Bo and Katrine was to some extent characteristic for first future-house-owners building in the area. Many of them were unsure about what energy-efficient technologies they should choose. An internet-based forum was used to discuss different aspects of buying. Besides discussions about windows, the forum had also contributed to challenging installation of heating systems from being predominantly based on air-to-air heat pumps to a water-based system. The network of future house-owners made it likely that others alongside Bo and Katrine would demand to have PRO TEC Windows in their houses in order to achieve the targets set by the authorities.

Lind & Riscoer however, had a long lasting relationship with their usual window-supplier: Rational Windows and Doors. Rational Windows and Doors was a supplier, which Lind & Riscoer trusted and was quite reluctant to replace with another supplier such as PRO TEC Windows. The distance to PRO TEC Window’s production site played no significant role in the discussion, since it was the trust that was decisive. Lind & Riscoer had a strong service agreement with Rational Windows and Doors that they were reluctant to give up.

As a result, Lind & Riscoer asked Rational Windows and Doors to develop windows that could match those from PRO TEC Windows. Rational Windows and Doors did not want to risk to losing Lind & Riscoer as one of their large customers. Rational Windows and Doors ended up developing a window that matched – and could be used in the Stenloese South development. The U-value of the windows in Bo and Katrine’s house went from a value above 1 to a value of 0.87 W/m²K. The product, produced in Denmark, is now fully available and further developed as a standard low-energy product with an even lower U-value (Rational, 2015)

Lessons learned

This case study illustrates an important process innovation, where dynamics of lock-in within an existing supply chain were challenged by a local intervention. This led to important incremental improvements in the energy efficiency of windows in Denmark. The prevailing lock-in was mainly a result of the conservative attitude of the building company, Lind & Riscoer, and their window supplier. They did not have motivation to design buildings that are more energy efficient than what is required by the regulation. Although they represent a large player in the Danish building sector, they adopted a conservative approach to comply with the energy performance requirements set up in Stenloese South.

The basis for challenging this lock-in was formed by the Municipality of Egedal that provided a legislative framework for development of energy efficient buildings through the implementation of local energy performance requirements. This pushed the families in the area to address and investigate different forms of energy efficient solutions. In relation to the window innovation, the building project of Bo and Katrine played an important role, because they actively pushed their building company to widen their scope of technological solutions. This pressure was mainly driven by the demand of the family to ensure that their new energy efficient house would not compromise with the amount of daylight expected in a modern house. The network of future house-owners made the influence of the single family stronger.

The result of this process was that Rational Windows and Doors, an important actor in the window producing industry, had to compete on energy efficiency by matching the U-value of the PRO TEC Windows company. This innovation process is rather untypical in the sense that the involved family is a quite special type of users. They did not take the building company’s solution as the only option, but researched technical details, considering existing solutions in other regions. They sparked the change in the supply chain. The success of their engagement, however, illustrates that lack of willingness or motivation for innovation in the building sector represents an important explanation for the prevailing lock-in.

The case shows how the smallest of interventions can lead to destabilisation and displacement of mainstream product development. The case is especially inspirational, because the innovations were carried through in the existing supply chain. This implies that the developed window is now on the market, not only in Denmark, but also in other European countries in which the company operates. An important dynamic that made this possible was the strong relationship between the building company and their window supplier. Without this relationship, the window producer would probably not have entered into the innovation of an energy efficient window.

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For the past 40 years, the bauxite reserves of Greece have been a driver for the development of
industrial activity that includes mining, aluminium production, extrusion and product development.
Extruded aluminium profiles are currently used in low-carbon applications such as thermal break
door and window frames and mounting structures for photovoltaic and solar thermal installations.
The whole supply chain is at a national level and has stimulated economic growth and social
benefits from a regional industrial activity that also accounts for almost 5 % of the country’s exports.

The aluminium sector in Greece encompasses
over 8,000 companies and is the 2nd largest
exporting sector with € 1.3 bin exports (4.7 %
of the country’s total), and provides roughly
30,000 jobs (AAG 2015).

Introduction
Greece ranks 9th in the world in terms
of bauxite reserves and 12th for bauxite
production while it is 1st in both activities
among the EU27 and EU33 countries (USGS
2014). The bauxite reserves are located mainly
in central Greece (Figure 1) and only three
companies are involved in their mining. For
alumina and primary aluminium production,
Greece is 16th and 30th in the world and 4th
and 12th in EE33, respectively (USGS 2013).
There is only one company in Greece that
produces alumina from bauxite (800,000 tons)
and the same company produces all of the
primary aluminium (160,000 tons). 60,000 tons
of the primary aluminium is sold to the Greek
market and the rest is exported (AAG 2015;
AL 2015).

The extrusion of aluminium profiles is one of
the later links of a supply chain that begins
with the mining of bauxite ore, proceeds to the
production of alumina (Al2O3) and then primary
aluminium, ready for extrusion. Extruded
aluminium profiles are used in a variety of
applications in buildings, machines and others.
Specific low-carbon application of aluminium
are thermal break frames for low energy doors
and windows, cladding and shading systems
for buildings and mounting structures for PV
and solar thermal installations.

Author
Demetri Bouris
dbouris@fluid.mech.ntua.gr
School of Mechanical Engineering, National
Technical University of Athens, Greece

Figure 1 - Location of bauxite reserves and
industrial extrusion facilities of Alumil S.A
(modified from L. Congress Cat. # 96686356)

Scope of the case study
There are several companies in Greece
that are based on the domestic production
of aluminium. One of the intermediate
stages for a number of final products is the
production of extruded aluminium profiles,
which is the primary activity for a number
of nationally based companies, and the
supply chain of these profiles is of interest
from an environmental, social and economic
perspective. The company ALUMIL S.A. is an
indicative example, being a privately-owned
aluminium extrusion group based in South-
East Europe with industrial facilities in Greece (location ‘A’ in Figure 1), Romania, Bulgaria, Albania, Serbia and Bosnia and an international sales network that includes 45 countries worldwide and 27 subsidiary companies in Europe, Africa, the Middle East, Russia and the United States of America (Alumil SA 2015). Architectural systems are the company’s dominating product group but extruded aluminium has also been used in other products, whose applications are relevant to energy conservation or energy production from renewable energy sources. Examples from the range of products based on extruded aluminium are aluminium profiles for non-thermal and thermal insulation window and door systems – including systems for passive buildings – façades including curtain walls, shutters, J-Bond composite panels and exterior covering systems (Cladding). In the past 12 years PV mounting structures for field and roof installations have also been developed.

Figure 2 - Extruded Aluminium Profiles, (Alumil S.A. 2015)

Materials

As concerns ALUMIL’s facilities located in Greece, the main material – aluminium – is produced from alumina, which derives from bauxite ore extracted and processed roughly 400 km from the company’s manufacturing site (Figure 1). While the distance is significant, the environmental impact is lower than the ones when the materials were imported, due to savings in energy and emissions from transport. The company runs a private foundry/smelting plant thus achieving a regional supply chain that runs from raw material to final product.

Aluminium is 100 % recyclable and the energy required for its recycling is drastically lower than that which is needed to produce it from bauxite (AAG 2015). The process is sustainable with the quality of the resulting recycled product of the same standard as that coming from bauxite. ALUMIL uses a significant amount (about 35 %) of recycled aluminium billets in the manufacturing process. Roughly 50 % of this is in the form of scrap while the rest is from primary aluminium T bars (Voulgarakis 2015).

Environmental, social and economic impacts

Mainly due to the economic crisis of the past years but also because of the virtual collapse of the domestic market for photovoltaic installations, the company has been facing falling sales and negative output. However, this trend is showing signs of deceleration, mostly due to the efforts of the management to reduce costs and increase efficiency.

In terms of Alumil’s energy consumption and carbon dioxide production, a recent (2008) replacement of LP3 with natural gas in the process’ energy mix (electricity/natural gas = 50:50 %), combined with other energy efficiency measures, has lead to a significant (14 – 23 %) improvement in the overall energy intensity indices for primary aluminium production. Detailed intensity indices on a per product unit basis are not available as the cost contribution of energy varies significantly, depending on the processing required for each final product. In general, it is within the range of 2 – 10 % of the final cost, which makes the processing of materials a major contributor and a major target for efficiency measures (Voulgarakis 2015).

Direct social impact is positive since the company has almost 2,000 employees and is one of the two largest employers in the region. Furthermore, as the commercial path of products includes retailers, exhibitors, fabricators and installers, there is an indirect positive social and economic impact. The company has earned a number of distinctions in this area: Great Places To Work, EUROPE TOP 500 and others. Direct economic impact is difficult to assess given the country’s general economic trend but a number of factors are positive (such as the fact that 80 % of the products are exported) and indicate a potentially positive outlook.

Degree of development of the supply chain

Considering that the supply chain starts with the domestic mining of bauxite, this began over 40 years ago with the first steps in bauxite mining in central Greece. Based on the presence of this raw material, a large and sustainable industrial sector has developed with deposits allowing viability for at least the next 30 years. Companies at the end of the supply chain have shown flexibility and adaptability to the needs of industry and society. In fact, the effects of this sector on regional development have been significant providing jobs, revenue, knowledge and skills.

For ALUMIL S.A., the supply chain is established and has been directed towards the building sector for many years while the PV sector has recently attracted focus due to recent demand for installations. Particularly within the past decade, the company has focused on a transition of production processes and the supply chain itself towards a higher sustainability performance. In addition to reducing the energy intensity of the production process, a number of measures have been taken:

- reduction in water consumption has led to a total savings of 80,000 m³/year. Specifically, one subsidiary company dealing with anodised aluminium has a water recycling system at a rate of 75 %;
- interventions in the painting and powder coating processes have led to a 38 % reduction in chemicals and a 60 % reduction in un-recyclable fine powder;
- the amount of timber used in the packaging has been reduced by 23 %;
- scrap has been reduced to marginal levels in all production departments;
- reorganisation of the fleet of trucks has led to a reduction of fuel consumption;
- a recycling system of waste and packaging materials has been introduced, implemented and improved while recycling and further processing is continuously being promoted (e.g. lathe aluminium, steel strap, paper, lumber, extrusion matrices enriched stainless steel etc.).

Lessons learned

The aluminium profile supply chain in Greece has obviously developed because of the domestic availability of bauxite as a raw material. The related mining industry developed locally in central Greece, around the mineral deposits. Close by, production of alumina and aluminium also developed and these three industrial activities have contributed to both regional and national development for many years.

A number of opportunities for final products based on primary aluminium have arisen and the industry has proven adaptable to market demands, producing a large range of products. Recent economic factors have proven to be a significant setback to the sector both through the recession in new building construction and retrofit, as well as the short lived demand for PV installations. Even so, in 2014, exports from the aluminium sector were valued at 1.29 billion €, accounting for 4.7 % of the Greek total (2nd among the 99 sectors considered) and an increase of 8.4 % compared to 2013 while total exports fell by 0.4 % in the same period (AAG 2015). Furthermore, the sector accomplished a 600 million € positive trade balance, corresponding to an 8.3 % increase compared to 2013 while Greece’s negative trade balance increased by 9.6 % in the same period (AAG 2015).

Although the aluminium profile supply chain is constrained by the location of the bauxite reserves, it has proven to be viable and sustainable in the Greek case. At the bauxite mining stage, a number of measures have been taken in order to reduce and even eliminate environmental impact. An example is the installation of filter presses (for a 9.5 million € expenditure) for the management of bauxite residues, which can then be utilised in other industrial applications cement or brick production, road construction and sanitary landfills (AL 2015). At the end of the aluminium supply chain there are a number of products associated to low-carbon technologies that also contribute to regional development as mentioned previously in the section on social and economic impacts.
The exploitation of bauxite in Greece has led to mining of a total of 100 million tons in the past 55 years (1/6th of current reserves) at a continued rate of extraction of about 2 million tons per year. However, only 9 – 15 million m² of ground surface have been accessed to extract the bauxite and these have been or are being restored corresponding to only about 1 % of the forest coverage of the region.

The aluminium supply chain may be considered a successful example for the development of supply chains of low carbon products based on the sustainable exploitation of existing regional natural resources.

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### Low carbon adaptable home

The LCAH housing prototype is designed and built for adaptation to today’s environmental and societal drivers, in the age of climate change. The house is designed with aims of sustainable low carbon operation and building adaptability, now and in future climates. It is designed to enable change in response to aging and occupant change and is founded in Lifetime Homes and Universal Design principles.

#### Author

- Oliver Kinnane 1,2
  - o.kinnane@qub.ac.uk
- Tom Grey 1
  - tom.grey@tcd.ie
- Derek Sinnott 1,3
  - sinnott@wit.ie

1) TrinityHaus Research Centre, Trinity College Dublin, Ireland
2) Architecture at SPACE, Queens University Belfast, Northern Ireland
3) Waterford Institute of Technology, Ireland

#### Introduction

The Low Carbon Adaptable Home (LCAH) is a full building prototype incorporating a prefabricated modular wall system. It is the prefabricated wall system that constitutes the primary low-carbon technology being presented, however the house prototype is itself marketed as a low-carbon product. The LCAH constitutes a new adaptable housing prototype that enables low energy operation and adaptation through its life cycle so that it can meet the changing needs of the occupants and be flexible to projected changes in climate. The performance of the house is assessed using an installed extensive bespoke monitoring system (Kinnane et al., 2013) that enables post occupancy evaluation, and modelling studies of the home now (Reynolds et al., 2013), and in the context of climate change (Kinnane et al., 2015). The core house is designed so that it can be stacked for use as multiple unit housing or enlarged with added pods for example in the case of a growing family unit (Figure 1).

The operational efficiency of the home makes it a low carbon technology with exceptional ability to retain heat via a highly insulated, airtight, envelope.

Design and development of this LCAH was supported by the governmental agency Enterprise Ireland through an Innovation Partnership scheme which supported collaboration between TrinityHaus Research Centre, Trinity College Dublin and the private company Glenbeigh Off-site Construction (GOS). The latter has developed a wide range of prefabricated units, primarily for buildings such as prisons, hospitals and schools. This product will enable GOS gain a firm footing in the residential market, and provide to pertinent housing product that can respond to the current housing shortage in Ireland and the UK. As a real-life design and built project it involved the construction of the house to a strict budget and for a client (Figure 1). The house was then rented on the open market and the occupant’s usage and response to the house are monitored.

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**Figure 1 - The case study building - the Low Carbon Adaptable Home (LCAH)**
The primary material is light gauge steel; a material with high embodied energy but appropriate durability for adaptability and reuse. Also included in the wall build-up are large quantities of polyisocyanurate (PIR) insulation, manufactured in Ireland by Kingspan, oriented strand board developed in Ireland using Irish wood products, and wall render imported from Europe.

**Description of the building**

The external envelope of the LCAH is constructed using light gauge steel and the entire building envelope is prefabricated into wall components before delivery to site.

The structure is clad in 140 mm of external polyisocyanurate (PIR) rigid insulation forming a continuous thermal envelope integrated with the insulated passive house foundation and slab system. The elevations are clad with either a directly applied render system or a fibre cement rainscreen cladding system in the designated expansion zones. In these zones the rainscreen cladding boards, the timber substructure, and the underlying PIR insulation boards are all screw fixed and therefore easily demountable to allow for their removal for the possible upgrade, or replacement, of the envelope as required or due to the addition of an extension. The glazing consisted of triple glazed low emissivity glass with argon-filled layers. The manufacturers’ specified U-value is 0.76 W/m²K. The LCAH has a glazing percentage of 39 % on the southerly facing façade (33 % west, 15 % north, 0 % east). The ground floor of the LCAH is of thick concrete construction and is composed of 300mm EPS, 200mm reinforced concrete (with 80 % GGBS), and 12mm tile. The roof of the LCAH is composed of: 4mm PVC, 150mm PIR insulation, 22mm plywood and 12.5mm plasterboard.

An air-source heat pump with Mechanical Heat Recovery Ventilation (MHRV) supplies ventilation and space heating. The system is set for constant operation but can be set in bypass mode allowing for natural ventilation operation as required, and particularly in summer. Air-source heat pumps are less efficient than ground source heat pumps due to variability in air temperature, however the air-source heat pump has advantages for adaptation as no ground collector is required. They are also appropriate for restricted spaces, e.g. urban areas and in retrofit situations. The MHRV installed can supply cooling through forced ventilation. This is generally used in a night cooling context when air temperature are lower. It can supply ‘cool’ air in the range 20 – 30°C with an outdoor to exhaust air temperature difference of 3 – 10°C.

The LCAH relies predominantly on electricity (as opposed to gas or oil) in line with renewable energy sources and smart grid developments. The house is future-proofed for greater on-site PV and wind generation with in place wiring on the roof and garden. Solar thermal panels situated on the roof are incorporated. On the request of the client a ‘top-up’ heating system is installed. The under floor heating piping system is embedded in the screed above the insulation in the floor.

Steel is a material with high environmental impact however, it is one of the world’s most recycled materials, with a recycling rate of over 60 % globally. Timber is an obvious sustainable alternative and one commonly used in prefabricated construction, however the inherent durability of steel gives an inherent benefit from the perspective of adaptation and reuse. A typical lightweight steel framed house typically uses only 40 – 45 kg of steel per m² floor area. Lightweight steel construction reduces material use by up to 70 % when using lightweight cladding relative to traditional housing (Lawson, 2009).

**Performance**

The LCAH has been occupied by a family since February 2013. The research team have been in contact with them on a regular basis and the response to the house has generally been positive.

The yearly energy consumption based on monitored data is 10,480 kWh (69kWh/ m²yr). The LCAH has 33 % higher energy consumption than what was forecasted by the simplified building assessment calculation procedure (SAP) and 15 % compared to the modelling analysis undertaken using detailed building energy software. This is in keeping with the commonly observed, and disappointing consistent, phenomenon of low energy buildings exhibiting higher energy consumption in operation than at evaluation design stage. Significant contrast is observed between summer (1,658 kWh) and winter (4,692 kWh) periods of operation.

The combined annual impact accounts for 52 % (5,477 kWh) of the total electricity consumption of the house. As monitored, the heating and ventilation load is 36 kWh/ m²yr. Maintaining background ventilation levels accounts for as little as 6.5 % of the energy load of the MHRV system. The space conditioning system exhibits a higher than expected energy consumption during the heating season, primarily due to high temperature settings. Occupant’s reaction to the system was somewhat negative with complaints focused on a lack of understanding of the system and controls, and background noise from fans in bedrooms. The system has since been serviced, settings updated, and occupants briefed on proper operation. When modelled for climate change significant increases in overheating are observed in the progression towards the end of century.

**Supply chain development**

The supply chain can be considered as highly developed for the core technology but underdeveloped with regard to its application as a housing product. Although the core technology is available for purchase, the holistic housing product is still in the later research phase. The supply chain for the production of prefabricated construction elements, including envelope panel modules is well-established and forms the basis of Glenbeigh’s Construction core product line. These panels are used for commercial and industrial buildings, developed for different energy and comfort performance. The prefabricated panels are available locally in Ireland and abroad, particularly in the UK. Glenbeigh have constructed a wide range of buildings in Ireland, particularly prisons, healthcare and educational building using the prefabricated light-gauge steel panel.

The majority of manufacture of the LCAH is undertaken in Ireland. The walls are prefabricated off-site at Glenbeigh Offsite Construction which can be assembled into pods in the factory and transported to site, for easy installation. The light gauge steel elements are cold formed and are manufactured in Ireland however, the rolls of raw steel are imported from varied locations abroad based on the cost of steel at any given time. The prefabricated panels can very efficiently be packed side by side in articulated trucks for transportation to site, allowing for more efficient transportation relative to movement of individual materials. The steel panels are durable for transport and on site erection.
41% of the 21 million homes in England have undergone at least one major alteration in their lifetime with up to 25% of these having three or more modifications (DCLG, 2004). However the majority of buildings continue to be designed and constructed for specific use with little consideration of future needs (Beadle et al., 2008), or changing conditions. Societal changes are many and dramatic in recent decades including: technological advances, changes in work practices, changes to family structure, increasingly multi-cultural societies, and the evolution of moral and societal values now require a radical shift to a more dynamic, diverse and adaptable design paradigm. New housing should be designed for adaptability to allow the home grow with the changing needs of the family and society. Adaptability should also aim to limit the environmental impact of inevitable extension.

Many lessons can be learned from the LCAH with regard to the development of efficient housing for now and into the future. The LCAH is presented as a contemporary typology necessitating evaluation, particularly as it contains a range of features commonly proposed as solutions in future residential buildings; rainscreen cladding, render systems, airtightness wrapping, external insulation, light gauge steel framing etc.

Today climate change is a reality and real concern. Lightweight, highly insulated buildings are much criticised. They run the risk of heating quickly and retaining heat for long periods and hence resulting in overheating in hot summer conditions. Designing for adaptability allows buildings transform and respond to changing climate and resulting occupant needs into a future of rapid climate change. This case study housing projects presents possible solutions and issues with adaptability decisions made. The LCAH exhibits overheating in projected 2030, 2050 and 2080 climates, but designed adaptability features allow it respond to these pressures.

The current housing stock is inflexible to change, resulting in high embodied energy during adaptation. All buildings grow through a process of continual change and evolution and a successful building should facilitate this evolution through adaptability (Brand, 1995).

Homes are particularly prone to change-over 41% of the 21 million homes in England have

**References**


The ZEFiRe building

The ZEFiRe building has been designed in order to propose a modular and repeatable construction according to sustainable criteria and using suitable tailored technical choices for assuring optimum indoor conditions even with the help of a building automation control system. The LCA and C2C analysis confirmed the design choice, also suggesting some possible improvement concerning building elements and materials.

Author
Rossano Albatici 1 rossano.albatici@unitn.it
Stefano Gialanella 2 stefano.gialanella@unitn.it
1) Department of Civil, Environmental and Mechanical Engineering, University of Trento, Italy
2) Department of Industrial Engineering, University of Trento, Italy

Introduction

This case study will present a small scale building module developed during a research project funded by the Autonomous Province of Trento within a programme concerning incentives to local enterprises. The research aimed to develop a productive building module that could be used for aquaculture and that included a clever and holistic design of the envelope together with a control system based on building automation. Aquaculture activity was focused on the joint farming of a local species, Salmo Carpio, living in fresh water at an average temperature of 13°C and a tropical one, Pterophyllum scalare. The latter is a popular ornamental species, used to live at an average water temperature of 26°C. This was a deliberate choice to create a virtuous heat exchange between the two parts of the building module (Faccenda et al 2013). Innovative materials and technical solutions including photovoltaic panels and phytoremediation as well as a careful evaluation of costs (realisation, management, running and disposal) have allowed substantial reductions in costs and environmental impact of the entire production cycle. This regards both the overall building structure and the fish-farming activity.

Figure 1 - ZEFiRE module: south-west view (the weather station close up)
(source ZEFiRE research group)

The main objectives of the projects were:
- to perform an integrated design procedure of the systems and the architectonic structure, taking into account green building design criteria coming from the most acknowledged international rating systems, such as LEED and BREAM;
- to adopt advanced technologies to control and regulate the system operation;
- to critically select the most technically appropriate materials to face the request of high energy efficiency of the building and its plants;
- to use renewables sources for electric energy production.

The multidisciplinary aspect of the research was tackled by setting up a team of experts consisting of technicians from different bodies other than the proposers (Edmund Mach Foundation); the Istituto Agrario di S. Michele all’Adige (FEM-IASMA) and the Department of Industrial Engineering of the University of Trento (DII-UNITN).

Description of the project

ZEFiRe is a small scale building module for aquaculture which contains a fish-farming plant. The dimensions of the building module are as follows: base 4.6 m x 10.6 m, maximum height 5.1 m. It consists of prefabricated elements assembled on site together with a steel structure and insulating synthetic materials for the roof and wall panels. In particular, the main bearing structure is made of metal profiles type HEA120 (with L 40 x 40 x 4 mm wind brace elements), with steel frame walls interposed. Panels of polyester and polyurethane act as thermal insulation layers (together with stone-wool for acoustic comfort) while finishings are made of plasterboard panels on the inside and corrugated aluminium on the outside. An array of silicon solar photovoltaic panels (PV), with an installed power of 6.9 kW peak, is located on the top face of the roof cover. Up to the 60 % of energy needs of the building (both electric and thermal) are covered by the PV panels. Windows and doors have an aluminium frame and are double-glazed.

Figure 2 - the module during the construction phase
(source: Federica Scavazza – Cogi srl)

All the building components have environmental certificates released by international institutions. The steel structure has a high percentage of recycled material, as well as the polyester panels (certified by the Environmental Product Declaration (EPD). The latter are produced by recycling plants ensuring a 50 % reduction of CO2 emissions into the atmosphere (with respect to the use of virgin fibre), stone-wool panels are completely recyclable and the plasterboard panels are certified with the Danish Indoor Climate Labelling, meaning that they do not contain harmful materials or potential allergens. The envelope is highly insulated, with a thermal transmittance (U-value) lower than 0.18 W/m2K and a periodic thermal transmittance YIE < 0.067 W/m2K. Thermal bridges are reduced through a careful design of the building details and a standardised assembling procedure on site. During winter 2011 a complete monitoring of the envelope was performed by the Department of Civil Environmental and Mechanical Engineering of the University of Trento, through thermal flux metering (continuous monitoring of thermal flux and wall surfaces temperatures every 10 minutes interval) and infrared thermography. The results of the monitoring confirm the design hypothesis both for the envelope and for the building energy demand. The building is equipped with a building automation system that records the main inner and outer environmental parameters as well as the system operation, consumption and production (for PV panels) with 5 second intervals. The overall situation can be visualised online on a restricted-access website.

Impact of the building

The ZEFiRe building module project has several impacts in environmental, economic and social terms.

Environmental Impact:
A Life-Cycle Assessment (LCA) has been performed, showing that the chosen materials have excellent environmental performances (Albatici et al 2013) while compared to other materials traditionally used or often considered more sustainable. The software Ecosoft by IBO “Österreichisches Institut für Bauen und Ökologie GmbH” based on the Microsoft Excel platform has been used to produce environmental indicators for the analysis of the different phases of construction and use of a building, following the recommendations
The main results of these changes are:

- the replacement of the steel structure with laminated timber elements allows a considerable reduction of environmental impact, as the O3Kon index of the walls goes from 280 to 111 and the O3Kon index of the roof goes from 468 to 346, even if not as much as one could expect;
- replacing polyester panels with wood fibre panels does not have any significant positive effect, O3Kon of the walls going from 280 to 277 and of the roof going from 468 to 479;
- replacing the external corrugated aluminium sheet with wood panels has a minor impact on the outer walls, with the O3Kon index going from 280 to 238.

Almost 95% of the operations on site are with ‘dry technology’ (meaning that water use is not necessary for the assembling) and completely reversible, and as such fully compatible with the Cradle-to-Cradle (C2C) approach. As all elements are standardised, simple and fast assembling is enabled. Although in its current form the building module is not fully stand-alone as concerns energy supply, it may be easily turned into a fully independent structure with a few modifications in the present layout. In this view, the module is very flexible and suitable to be built in an adaptive way and used in different climatic and geographic contexts. Construction and maintenance need skilled workers but simple operations are usually required.

**Economic impact**

Two main positive economic outcomes have been identified that relate to future positive impact on the construction industry:

- with the development of innovative and specialised sensors, it is possible to enter new markets, such as the one for smart devices dedicated to green buildings;
- the building demonstrates the advantages of dry construction, in particular steel framing, illustrating of the strength of existing technologies and the development of new ones. It will be possible to reduce construction time simplifying a great number of operations, saving energy and diminishing waste disposal.

The project has also enabled designing and testing a new steel cold form profile (called SteelMAX) whose innovative characteristics are lightness, high structural efficiency, durability, speed and simplicity of assembly.

It is especially appropriate for low rise buildings and/or elevations and extensions on existing structures.

**Social impact**

The project has enhanced a new way to design and build for the industry, which will be accessible to students (high school and universities) and experts/professionals of the building sector to increase their knowledge of new methodologies; craftsmen, building industries, materials manufacturers can get new ideas and, if the case, help in the development of the building module itself. The two project private partners intend to recruit new staff not only locally but also abroad, establishing joint ventures with international partners to produce more of the building modules for aquaculture. The research team members, including the University of Trento and the Edmund Mach Foundation, have introduced the findings of the research and the new methodological aspects within the suitable existing curricular courses, both MSc and PhD, and have disseminated the results within the international scientific community.

**Supply chain development**

The supply chain for the products used in the ZEFIRe module is now established and provides an example of good practice, even if the building module is highly innovative. Contact with industrial partners overseas (South America) have been made in order to produce ZEFIRe modules abroad. Moreover, it must be stressed that the research has been a good example of cooperation between industry and research, where each partner gave a contribution on its specific area of expertise. The two private partners (Cogi srl and Optoi srl) are well established firms in the Italian construction market. Cogi has been active from 1986 in the field of dry building components. Optoi was established in 1995 as a spin-off from the Bruno Kessler Foundation (the former Scientific and Technological Research Institute in Trento) with core business in smart electronic and microelectronic systems, sensors and packaging. All partners are based in the Trentino region, however, they have many international contacts and activities that can guarantee an adequate future diffusion and development of the building module. Most of the building components of the ZEFIRe module are manufactured in Italy and the structure, roofing and walls are mainly done with local materials. The materials and design methods support easy maintenance. A deep analysis of the construction phase has been made. An assembling and disassembling manual have been produced (with text and drawings) so that period of construction and number of elements used (consumables included) are properly considered. This allows fast and easy erection and dismantling of the building, with a minimum use of energy. In fact the whole structure and relevant services have been assembled in situ with no need of special equipment if not small tools. The easiness of construction is one of the guidelines that will be followed to improve the modularity of the structure, in order to make it attractive for a larger variety of applications and building contexts. Small volumes and light packaging allow low transport costs (and less carbon emissions) due to the optimised packing size.

**Lessons learned**

The results of the project show the benefits of a close relationship between industry and research in pushing forward the sustainable construction industry. This may occur even on local basis, considering that the technologies involved in the project are usually available in industrial contexts. This aspect is of course interesting since guarantees a sustainable management of materials production, acquisition and transportation. The importance of a deep energy analysis together with an LCA approach (integrated design) has been highlighted. The relationship between the building and the environment is not only passive (thermal mass, solar gain, free cooling, etc.) but even active (low energy plants, building automation, smart devices for the management of the building). The C2C analysis (performed in a second stage) reveals the importance of dry and reversible building technology, as planned at the beginning.

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*Figure 3 - Systems layout (source: Marco Facchini – Optoi srl)*

In order to understand the results of the LCA, a parametric comparison was carried out by repeating the LCA of the module, but after changing the specifications of the following elements:

- building structure, replacing the steel elements with profiles of laminated timber;
- thermal insulation, replacing the polyester and polyurethane insulation pads with wood fibre panels;
- external cladding, replacing the corrugated aluminium profile with timber boards.
Together with the choice of sustainable materials and technology, the design procedure too plays an important role towards environmental friendly buildings. To this aspect, an important contribution has come from the choice of reliable providers of all structural and functional components. In addition to the above specific results and outcomes of the project, we envisage an important novelty element in the deliberate attempt to design a building structure and relevant productive activity in an integrated way in order to achieve the highest possible energy efficiency and environmental sustainability. This approach can be applied also to buildings possibly with mixed residential and productive functions that can be selected on the basis of specific local needs. Eventually, with particular reference to urban areas, we believe that the proposed design methodology may provide important results also in refurbishing already existing structures.

References


Latvian timber supply and innovative plywood applications

The Latvian Plywood (LP) group focusses on technology with high added value products, essential to establish a successful supply chain. The LP group connects local resource managers with regional manufactures, allowing energy and monetary savings in logistics and production. Close cooperation between industry and researchers enabled the development of innovative products.

Authors
Nadezda Kunicina
Nadezda.Kunicina@rtu.lv
Anatolij Zabasta
Anatolij.Zabasta@rtu.lv
Kalnins Kalnins
Kaspars.Kalnins@rtu.lv
Gundars Asmanis
Gundars.Asmanis@rtu.lv
Edgars Labans
Edgars.Labans@rtu.lv
Riga Technical University, Latvia

Overview of the technology
This case study presents the Latvian Plywood supply chain, focusing on the development of low carbon processes for the plywood production technology and how this innovation impacts on the supply chain.

Increased demand for timber resources have raised concerns about the long-term sustainability of the forest industry. Taking into account the need for the rational use and conservation of timber stocks, the development of new timber-based products is encouraged. One of the novel solutions are ‘plywood sandwich panels’ (see Figure 1) with different core types, such as corrugated sheets or vertical ribs. This type of panel has a competitive advantage regarding specific bending stiffness and significant material savings compared to a typical plywood panel (Labans, Kalnins, Zudrags, 2013).

Figure 1 - Plywood sandwich panel with corrugated core

The sandwich structure allows integrating thermally and acoustically insulating layers within the panel at a low production cost, thus making these solutions more attractive to the market (Laban et al 2013).

Figure 2 - Honeycomb sandwich panel structure

Moreover, the ability to change core configuration allows flexibly suiting the requirements of customers. For example, metallic layer or honeycomb core (Figure 2) can be added to reduce electromagnetic influence. The honeycomb core helps to mitigate electromagnetic waves propagation, so the sandwich structure has dielectric material properties.

Similar sandwich-type panels are currently being widely utilised in the construction industry. The new material allows individual sandwich panels to be designed as self-supporting structures with chipboard or sawdust surfaces and mineral wool core.
Due to the sandwich structure, the construction of the panels becomes lighter and requires less timber for manufacturing, therefore also reducing the volume of waste to be recycled at the end of the life cycle. A renewable material – the Latvian wood – is used as basis for the panels.

The Latvian Plywood (LP) Joint Stock Company was founded in 1992. Its main activities are plywood production, product marketing, new product development, synthetic resin and impregnated paper production, and forestry management. The company’s turnover in 2011 was 169 million euro. LP group includes seven production factories (five of them in Riga), 19 Subsidiaries (eight Latvian, eleven non-Latvian). The company’s group exports comprises 95 % of the total sales volume, and sales volume shows that 90 % of sales is targeted to EU countries (Latvijas Finieris, 2014). The largest LP market is located in more technologically developed countries such as France, UK and Germany (see Figure 4).

LP is a market driven companies group that produces and supplies plywood. LP factories are certified according to "Program for the Endorsement of Forest Certification schemes". The LP Quality Management System complies with ISO 9001 and other standards requirements (Declaration 2014).

The twelve sales offices in the European and global markets provide exchange of information between customers and producers / suppliers and help to find the most adequate technological solutions.

The LP group supply chain (see Figure 6) starts with forestry management as raw materials extraction and replenishment, which enables a long-term sustainable supply. The main source of raw material is the Latvian forest, therefore the cost of timber transportation mostly depends on production volume and deviation in fuel prices. The forestry branch is operating in a self-regenerating cycle, enabling the sustainability of the business (see Figure 5) (Latvian Forest, 2014).

The twelve sales offices in the European and global markets provide exchange of information between customers and producers / suppliers and help to find the most adequate technological solutions.

The research team in Riga Technical University (RTU), who developed the plywood structural panels, contributed significantly to innovating the LP supply chain through the MAPICC 3D work programme. MAPICC 3D, “One-shot Manufacturing on Large Scale of 3D up Graded Panels and Stiffeners for Lightweight Thermoplastic Textile Composite Structures”, is a large-scale integrating collaborative project funded under the Seventh Framework Programme in 2011 – 2015.

The general concept of the project pursues developing manufacturing system for 3D shaped, multi-layered products based on flexible materials. The speed of production and the cost of manufacturing the 3D preform will be in accordance with requirements of transport, building and energy industries thanks to (Mappicc, 2013):

The sales branches are located in 16 countries worldwide and ensure market diversification and adjustments to variable conditions and growing competition. According to (Latforin, 2014), the LP market share of European birch plywood remained stable within 14 % during last years. The development of new products and services for clients and a prudent policy in skill development helps to be in a line with main competitors from Russia, Finland, Belarus and Poland. Proximity to Latvian academic and research centres (production is concentrated mostly in Riga) also encourages cooperation between the company and local researchers.

The research team in Riga Technical University (RTU), who developed the plywood structural panels, contributed significantly to innovating the LP supply chain through the MAPICC 3D work programme. MAPICC 3D, “One-shot Manufacturing on Large Scale of 3D up Graded Panels and Stiffeners for Lightweight Thermoplastic Textile Composite Structures”, is a large-scale integrating collaborative project funded under the Seventh Framework Programme in 2011 – 2015.

The goal of the project is to develop innovative products for composite materials. The project consortium uniting 18 partners from 10 European countries was coordinated by Ecole Nationale Superieure des Arts et Industries Textiles, Roubaix, France. Project partners have been chosen based on complementarity and high level of expertise in the field of textiles, mechanics, modelling and characterisation of final products. Latvian project partners Riga Technical University (RTU) and Latvian plywood manufacturer (LP) are involved in the development of the plywood structural panels for building and transport application.

The general concept of the project pursues developing manufacturing system for 3D shaped, multi-layered products based on flexible materials. The speed of production and the cost of manufacturing the 3D preform will be in accordance with requirements of transport, building and energy industries thanks to (Mappicc, 2013):

- The use of low-cost raw materials, based on thermoplastic hybrid yarns comprising various fibres (glass, polymeric reinforcing fibres).
- A decrease in production time. The polluting, labour-intensive and expensive steps of cutting, forming and joining which are necessary for the current composites production could be avoided.
- A dynamic quality control during the production to improve the process robustness.
- A decrease in the quantity of waste in comparison to the current 2D preform-based composite structures manufacturing.
This is a project driven by industry’s needs, as the project consortium pursues integrating the entire process chain and involves the industrial stakeholders from machine tools, automation and modelling processing of flexible materials, yarn and textiles, composites and end users for transport.

The industrial partner LP is responsible for the development of 3D panels for building and public transport application (in wall panels or flooring, or as insulation in combination with another material), to be achieved by the combination of new technologies and long-standing experience in plywood manufacturing.

The coupling of technologies and new processes (see Figure 7) allows producing improved panels, with higher resistance to cracking, shrinkage, twisting and warping (see Figure 8). An industrial prototype was successfully implemented in the laboratories of Riga Technical University (see Figure 9).

Industrial partners are going to achieve greater competitiveness in different sectors due to development of innovative composites, processes, simulation tools, procedures and modernisation of equipment.

Reduction in manufacturing costs in comparison with the current products will be achieved by improving the productivity by 38% due to two factors. The first factor is the performance improvement of the final composite parts thanks to the controlled fibre distribution. Second factor is the decreasing of manufacturing cost through the use of automated textile processes.

The availability of laboratory resources creates the opportunity to improve the manufacturing process and to adjust the parameters of the panels according to the requirements of partners and clients.

The major innovation developed by MAPICC 3D consists in the one-shot manufacturing of 3D preforms, this way avoiding all joining steps dealing with the weight reduction of structures. This new technology might induce a higher investment costs but the depression will be faster than current technologies and particularly 2D technologies and guarantees a rapid recovery of the initial investment. The MAPICC3D concept will develop a new composite industry based on low cost technology with high speed production. For Latvian Plywood and the Latvian timber supply chain the new technology, developed in the MAPICC project, discovers new opportunities. First of all, lower production cost and better quality can help not only to secure existing market share in the plywood market, but to get competitive advantage against main competitors. The other opportunity can be penetration in the metal industry market, since Latvian timber industry will become competitive in terms of productivity and cost.

For establishing a successful supply chain, MAPICC 3D integration of all process steps, from raw materials to 3D shaped end product, including simulations steps to select fibre combination and 3D structure, will contribute to provide OEM’s and SME’s with high competitive edge solutions. By over-passing the nowadays technological boundaries encountered with 2D technologies, MAPICC 3D brings the composite industry at the level of metal industry in terms of productivity and costs.

The References section includes:


Woodchip-concrete technology

Wall construction systems based on hollow woodchip-concrete blocks and reinforced concrete core are techniques which employ conventional materials in innovative form offering several benefits. This case study presents the state-of-the-art of these products in the FYR of Macedonia.

Authors

Todorka Samardzioska ¹
samaradzioska@gf.ukim.edu.mk

Roberta Apostolska ²
beti@pluto.izis.ukim.edu.mk

1) Civil Engineering Faculty, University “Ss. Cyril and Methodius”, FYR Macedonia
2) Institute of Earthquake Engineering and Engineering Seismology-IZIIS, University “Ss. Cyril and Methodius”, FYR Macedonia

Introduction

Buildings, in the way that they are currently designed and used, contribute to environmental problems due to the excessive consumption of energy and natural resources. There is a close connection between the use of energy in buildings and the environmental damage that arises as a consequence of the energy required in the construction of a building and to meet the demand for heating, cooling, ventilation and lighting.

However, buildings can be designed to meet occupant’s need for thermal and visual comfort with reduced levels of energy and resource consumption. Energy and resource efficiency in new buildings can be implemented by adopting an integrated approach to the design. The primary steps in this approach would be to:

• incorporate solar passive techniques in a building design to minimise loads on conventional systems (heating, cooling, ventilation and lighting);
• design energy-efficient lighting and HVAC systems;
• use renewable energy systems (solar photovoltaic systems/ solar water heating systems) to meet a part of the energy demand;
• use low-energy materials and methods of construction, and reduce energy for transportation.

Architects should also aim for efficient structural design, to reduce use of building materials with high embodied energy such as steel and glass.

Building ecologically with hollow woodchip-concrete blocks

Hollow woodchip-concrete blocks are a construction product used to various extent in Europe, however in Macedonia their use is in the initial phase. Hollow woodchip-concrete blocks demonstrate properties that favour noise insulation, heat storage, acoustic insulation and vapour diffusion along with fire resistance and earthquake safety. Wood is considered a typical natural building material. Concrete has many advantages, being a moldable material made of cement, sand and gravel. Cement is used as a binding agent for the woodchip in the woodchip-concrete block production process.

The wood contained in the woodchip, when growing, actively draws CO₂ from the atmosphere, thus assisting with reducing greenhouse gas concentration.

The formula for woodchip-concrete blocks

Hollow woodchip-concrete blocks combine the natural building materials of wood and stone in a modern form. This technology is ideal for building houses and facilities (such as barns) in urban and rural communities. The elements are made in a factory using standard procedures. Since the manufacture process is very simple and low cost, the blocks can be produced on site as well, if appropriate moulds are available.

The raw materials for the production of woodchip-concrete blocks are woodchips and wood-processing waste. Using minimum energy input the woodchips are reduced to the appropriate size. Cement, water and minerals are added and then cast into hollow blocks.

The main aim of this innovative technology is to cause as little damage to the environment as possible, in particular to protect air and water purity. CO₂ emissions are limited during the production process.

Figure 1 - Hollow woodchip-concrete block with integrated insulation, (source: http://www.isospan.eu/en/products.html)

Figure 2 - Vapour diffusion, (source: http://www.tritan.biz/ISOSPAN/1oved.html)

Figure 3 - The effect of thermal insulation, (source: http://www.tritan.biz/ISOSPAN/1oved.html)

Characteristics of the hollow woodchips – concrete blocks

Hollow woodchip-concrete blocks are characterised by reduced environmental impact during their manufacture. The construction of the walls requires low energy input, particularly if manufactured on-site. Thermal insulation of the external wall construction is such that, in case of fire, the damage is limited. The waste material is recyclable, and the environmental impact is reduced through minimal packaging. Performance characteristics associated with hollow woodchip-concrete blocks include:

• thermal insulation: Low U-values are ensured thanks to woodchip-concrete qualities with or without integrated polystyrene insulation. Load bearing exterior walls without insulation, with thickness of 25 cm provide U=0.93 W/ m²K. With integrated thermal insulation, the U-value is significantly lower, depending on the thickness of the insulation layer. For example, for an exterior wall with 10 cm integrated polystyrene and total thickness of 36 cm, the U-value is 0.26 W/ m²K;
• easy construction: The range of products offers a homogeneous and complete wall construction system which can be built without the use of mortar. This lack of mortar provides a surface without thermal bridges. By using the woodchip-concrete blocks there is no need for additional insulation measures. Neither adhesive nor binding materials are required. Therefore, there is a substantial reduction in the materials used during construction to provide quality indoor environment;
• vapour diffusion: Moisture absorption and diffusion qualities are good due to the open-pore structure of wood-concrete (water absorption 0.7 kg/m², water diffusion 2.1 kg/ m² – per hour). Thus constant ventilation of internal humidity towards the outside is possible through the uninterrupted elements. Therefore, dry walls are provided throughout the year, improving comfort and ensuring better conditions when the building is exposed to excessive rain. Moreover, this means that a new building can be occupied sooner than a traditional brick-wall building;
• thermal inertia: in winter, solar energy is accumulated in the concrete core during the day and released into the rooms later in the afternoon and evening, reducing energy demands. In summer, peak temperatures in hot afternoons are reduced and rooms are more pleasant for living as the thermal energy stored in the walls is released during the cooler evening and night.

SUPPLY CHAINS
acoustic insulation: Due to the concrete core, the construction system results in a density higher than average and achieve, even with thin wall constructions, excellent acoustic insulation. The concrete core also provides high load-carrying capacity. Generally, the heavier the wall, the better the acoustic insulation properties. By reducing stress caused by noise, a pleasant living atmosphere is created. Measurements in European countries state $R_w = 56\, \text{dB}$ for an exterior load-bearing wall without integrated insulation, and with 25 cm thickness. In Macedonia obligatory measurements on sound insulation in the buildings are not required yet.

### Construction technology

Prefabricated wall elements are easy to work with at the building site, following four simple steps:

1. **Delivery:** The prefabricated wall elements may be delivered in transport containers, or they may be produced on site. The containers are lifted from the lorry directly onto site, using a crane. This reduces unnecessary fetching and carrying, which in turn saves time when mounting the individual elements.

2. **Lift and place:** The elements are lifted and placed in the right position. Because the elements are very light, they are easy to position.

3. **Installing and adjusting:** When installing smaller elements wedges are used. When installing elements that are higher, mounting supports are used. A remote control crane makes the correct installation of the individual elements easier. After installing the elements, the reinforcement is added and the elements are filled with concrete.

4. **Wall joints:** Wall joints are achieved by pushing the elements together tightly. A concrete filling is only possible when there are no cracks between the joined elements. Joints on walls that are importantly positioned for acoustic insulation should be counter sunk from top to bottom.

In conclusion the advantages of the hollow woodchip-concrete blocks in respect to traditional masonry construction are:

- lower embodied emissions
- good thermal and acoustic insulation
- quick and low-cost construction
- 'breathing walls' due to high vapour diffusion
- high earthquake safety due to the compact structural core, particularly important for Macedonia as a seismic prone country.

### References


http://www.tritan.biz/ISOSPAN1/Voved.html

http://www.build.mk/?p=5122

**Insulated Panel Construction System: EVG-3D**

The insulated panel construction system EVG-3D was introduced in Malta as a new alternative construction. It consists in a modular panel system with three dimensional welded wire space frame fitted with an expanded polystyrene insulation core. Concrete layers are applied on site to either side of the panel. The system is intended to address building sustainability, resource efficiency, energy efficiency, economic and efficient construction and health and safety issues in construction. The system presents various advantages with regards construction time, labour and cost efficiency. The system also allows for flexibility in design and adaptation to the specific needs; it has been used effectively in new buildings and also in extensions to existing structures.

**Authors**

Ruben Paul Borg 1  
ruben.p.borg@um.edu.mt  
Andrew Psaila 2  
Mark Vassallo 2  
1) Faculty for the Built Environment, University of Malta, Malta  
Chairman, Research & Innovation, Building Industry Consultative Council, Malta  
2) J.M.Vassallo Vibro Blocks Ltd, Malta

**Description of the technology**

The construction system EVG-3D consists of panels made up of an Expanded Polystyrene (EPS) core of varying thickness, sandwiched between two plane-parallel welded wire mesh sheets. These sheets are positioned by uniformly distributed inclined diagonal cross wires that penetrate through the EPS core and are welded at both mesh interfaces. This results in a lightweight, three-dimensional truss system with high inherent stiffness. Strength and rigidity of the panels are achieved through the diagonal truss wires in combination with the concrete layers applied on either side. Full composite behaviour is achieved through the transfer of shear forces. The system offers an innovative building system providing high strength load bearing modular panels for the entire construction site where they are connected and assembled easily as wall and slab structural elements. Splice mesh is used to seal the joints between panels resulting in a continuous mesh reinforcement over the entire construction.

The panels are quickly and easily erected on site without the need of cranes since these are lightweight. The assembly of the system on site does not require specialised labour but training is required for specific tasks as in the case with ‘shotcrete’ operations. The panels can be trimmed and cut easily to size and to any specific shape to suit architectural design requirements. The concrete is applied to the structure after the building structure has been erected, contrary to other prefabricated panel systems. No formwork is required during the construction process. The resulting system consists of two concrete layers applied to either side of the EPS core which serves as a shutter in between. The panels are rigid and stiff and no buckling or bending of the panel occurs. Simple bracing is applied to hold the panels in the required position. Frames for windows and doors can be easily fixed in place and utilities and be quickly installed. The EPS panel is secured precisely in place and does not shift under the high pressure caused by the sprayed concrete, ensuring quality in construction including a uniform concrete thickness. Once the panels are installed, utilities places and aperture frames fixed, concrete is applied to each side of the panel either manually or using ‘shotcrete’ wet or dry systems. The concrete thickness varies according to the design requirements and a quality system can be applied to check the concrete thickness achieved.

The weight of a panel before the concrete application is about 7 kg/m² and can be easily transported and assembled on site. EVG-3D floor slab panels are designed mainly as reinforced concrete one-way spanning slab systems. The cover mesh serves as bottom or top reinforcement.

**Figure 1 - The EVG-3D construction system**

The panels are joined together on site to the desired configuration, forming a sandwich type construction. The concrete layers are general applied using a ‘shotcrete’ pump. The concrete layers have the function to transmit compressive forces and protect the reinforcement against corrosion with minimum concrete cover designed according to EN 1992 (Eurocode 2).

**Table 1 - Concrete thickness for each applied layer**

<table>
<thead>
<tr>
<th>Component type</th>
<th>Minimum concrete thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non load-bearing wall</td>
<td>40</td>
</tr>
<tr>
<td>Load-bearing wall</td>
<td>60</td>
</tr>
<tr>
<td>Slab (top layer)</td>
<td>60</td>
</tr>
<tr>
<td>Slab (bottom layer)</td>
<td>50</td>
</tr>
</tbody>
</table>

The advantages presented by the panel system include:  
- fast and simple erection of panels without the need of skilled labour;  
- no formwork is required;  
- no additional beams and columns are required;  
- easy installation of services and utilities;  
- high strength load bearing panels as vertical and horizontal structural elements;  
- thermal insulation properties achieved through the core with varying parameters;  
- monolithic construction system with continuous reinforcement;  
- earthquake resistance;  
- economical use of construction materials;  
- design flexibility;  
- long-life cycle of the building.

The conventional construction system in Malta consist of load bearing masonry block elements for vertical wall construction (including hollow concrete blocks) supporting reinforced concrete slabs. The EVG-3D panel system presents significant advantages over these traditional masonry block construction systems. The installation process of the EVG-3D system can be implemented with reference to an installation manual provided by the supplier.

**Figure 2 - Assembly of the prefabricated panels on-site**
Figure 4 - Production of the EVG-3D panels

The manufacturing process

The manufacturing process consists in the production of EPS panels and the production of the cover and splice mesh. The automatic plant with electronic process controls developed by EVG allows for the production of 3D panels of varying thickness and length. The manufacturing equipment and production process developed by EVG is protected by patents and allows for high volume production of panels at low cost. The system was developed in the early 1980s by EVG. The company provides support in the setting up and installation of new plants for the panel production and knowledge transfer and field assistance (EVG-3D, 2011). The system started being produced in Malta in 2013, by J M Vassallo Vibro Blocks Ltd, as a cost-effective construction system based on high strength, load bearing modular panels.

Figure 5 - Transport of the prefabricated panels to the construction site

Structural characteristics

Structural design of the EVG-3D construction system refers to European standards and codes. The design of the EVG-3D construction system is carried out using Eurocode 3 (EN1993-1-1) for the diagonal trusses and Eurocode 2 (EN1992-1-1) for the design of reinforced concrete. In addition the system allows designing for earthquake resistance. EVG-3D slabs are normally designed as one way simply supported, but can also be designed as continuous slabs. The limiting factors for the design of EVG-3D slabs are deflection, maximum additional reinforcement and shear resistance.

Energy efficiency

The building regulations in Malta refer to a holistic design solution (LN261/08) and minimum requirements on the energy performance of building elements are specified. The Technical Guidance: Conservation of Fuel, Energy and Natural Resources, stipulates limit values for building elements (Document F, 2006). An energy performance certificate is also necessary for new buildings (LN376/12). The EVG-3D panels offer continuous insulation and the EPS central core results in a system which has virtually no thermal bridges. The thermal transmittance (U-value) of the finished panels depends on the thickness of the EPS core and the configuration of the diagonal wires. The U-values obtained for different configurations are presented in Table 2. Installations including utilities are primarily located on the internal side of the panel resulting in fewer wall penetrations. The systems thickness for the same thermal performance is lower than that required for traditional masonry block and insulation construction systems therefore saving up to 10% on the internal floor area (EVG-3D, 2013). The system provides improved energy efficiency as a result of low U values, 0.7 W/m²K for load-bearing wall construction and 0.4 W/m²K for roof construction. This provides for a significant improvement with respect to conventional load bearing wall construction systems in Malta. In addition the requirements of the building regulations are adequately and effectively met.

Sound insulation

In view of the double shell construction of the EVG-3D system, sound transmission is minimised. Therefore sound insulation requirements of buildings are achieved, through screening from exterior sound and also through the dampening of interior sound propagation within buildings. Traditional walls with a single shell have a large mass compared to their surface. The large mass is reduced using the EVG-3D double shell wall system.

Fire resistance

The fire resistance of the standard panel construction depends on the S grade fire retardant EPS core, the concrete layer thickness, the quality of the concrete and the quality of the aggregate. The fire rating can be increased by additional treatments applied to the materials, coatings and finishing layers.

Table 2 - EVG-3D Construction System, Energy Efficiency

<table>
<thead>
<tr>
<th>Type of construction</th>
<th>U-Value (W/m²K)</th>
<th>R-Value (m²K/W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non Load-bearing</td>
<td>1.3</td>
<td>0.8</td>
</tr>
<tr>
<td>Load-bearing</td>
<td>0.7</td>
<td>1.4</td>
</tr>
<tr>
<td>Floor Slab</td>
<td>1.1</td>
<td>0.9</td>
</tr>
<tr>
<td>Roof Slab</td>
<td>0.4</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Impact of the technology

The EVG-3D system addresses environmental and economic considerations. The system is presented as an innovative solution for construction taking into account of resource and material efficiency, energy efficiency in buildings, cost effectiveness and health and safety in construction.

The system addresses the following key principles:
- lean construction process;
- resource efficiency;
- energy efficiency;
- environmental sustainability;
- cost and affordability;
- structural integrity;
- durability and maintenance;
- design flexibility and adaptability;
- safety.

The system has the potential for improved resource efficiency, with a reduction in material requirements of the EVG-3D system when compared to a conventional load-bearing masonry, for the same structural and thermal performance. The system has also the potential for improved energy efficiency when considering the whole system. This can be determined through a comprehensive performance assessment of the system taking into account assessment of resources and energy throughout the whole life cycle. The resource efficiency and energy efficiency of the system can be considered to contribute to environmental sustainability with a reduction in demand leading to a reduction in the environmental impact. A comparative analysis of the EVG-3D system with other construction systems is also necessary to evaluate the
actual performance over the whole life cycle (JMV Research, 2014).

General aspects of resource and energy efficiency for the EVG-3D system can be considered. The system makes use of local available material and other imported products, can be erected quickly and easily and requires training for specific tasks. The use of heavy equipment on site is reduced. The system also promotes improved health and safety on the construction site. The system has improved thermal properties resulting in improved energy efficiency and improved sound insulating properties when compared to traditional construction systems. The system provides for flexibility in use and architectural design. The system can be adapted easily to different forms of construction including curved elements. Services can be easily installed and routed without reducing the thermal and sound insulation. It also allows for structural integrity. The EVG-3D system is cost effective with regards to construction costs, and life cycle and maintenance costs. The system encourages efficient use of materials and conservation of resources, with reduced production of waste and recycling of waste materials. A more lightweight construction system results also in lower foundation costs. The system allows for practical maintenance and offers a durable solution in building construction. EVG-3D presents an alternative practical construction technology to the traditional load bearing masonry block construction, but the final building appearance does not look different from traditional ones. The continuous reinforcement provides additional strength to the system and earthquake resistance.

The system requires specific production equipment for panel manufacturing plants. In addition engineering support may be required for the planning stage and for the implementation of construction projects. Specific skills are required for the manufacture in the factory and assembly, and for ‘shotcrete’ operations on site.

### Applications

The system is used in the construction of structural and non-structural walls, roofing systems, perimeter walls, prefabricated floor slabs, infill walls ad in complex architectural designs. The panel construction system has been used in a variety of applications including residential, commercial and industrial buildings. The system has also been used in conjunction with traditional construction systems.

### Case study: extension of a hotel – Phase 1

The project included the renovation of the San Antonio Hotel, Malta (Phase 1). The project included also an extension to the existing hotel with the addition of 3 floors over the existing 5 floors. Each additional floor included a setback at the rear. This extension consisted in the addition of circa160 new hotel rooms, a roof garden, and infinity pool at roof level, restaurants, bars, lounges. The objective of this project was to increase the capacity of the hotel and re-branding. The project consisted in a significant investment and had to be completed within short timeframes, a maximum of 3 month. The structural design presented significant challenges. Geotechnical investigations were carried out together with a condition assessment of the structure.

The hotels extension was proposed to be built over the existing 20 year old structure. The hotels foundations were not adequate to withstand the additional 3 floors using traditional load-bearing masonry block construction. This issue was addressed using the EVG-3D Construction System. All internal and external walls, together with respective slabs and roof slab, were constructed using this system.

The construction works using the EVG-3D system were completed in 60 working days with approx. 40 workmen on site. It was estimated that the conventional traditional method based on load-bearing masonry units and reinforced concrete slabs would have taken double the time. The EVG-3D Construction System led to about 45% overall reduction in weight when compared to traditional methods of construction.

### Case study: extension of a hotel – Phase 2

This extension was carried out during 2015 and consisted in the construction of circa 30 additional hotel rooms over a relatively new structure. Considering the performance of the EVG-3D construction system in the first phase including weight reductions, construction time, energy performance and structural performance, the management and engineers opted once again to make use this system instead of the traditional system. A significant challenge during this phase was that the hotel was in operation during construction.

### Case study: construction of a detached house

This project consists in the construction of a detached house on two floors in Malta, covering an area of 150 m². The house is constructed using the EVG-3D system and is located on top of a reinforced concrete transfer slab with underlying basement garage and domestic floor. The EVG-3D system was applied for the first time to a domestic construction in Malta and was analysed to assess the performance of the system for this building typology.

The EVG-3D Construction system was set up in 20 working days with circa 5 workmen on site, saving considerable time when compared to traditional load bearing masonry construction. The system resulted in c. 35 % reduction in the overall weight of the structure over traditional construction.

### Supply Chain Development

Transportation: The system includes EPS which is manufactured in other separate factories in Malta. The EPS is transported to the EVG-3D production plant using road transport. However the company is investing in EPS production within its EVG-3D production facilities.

Materials Sourcing: Crushed aggregates are sourced locally in Malta, produced through the extraction from open pit quarries. Alternatively they are imported mostly from other Mediterranean regions. In the case of Malta, cement is also imported. The EPS raw material (the expandable polystyrene beads) is imported and shipped to Malta. The materials is expanded and moulded for the production of the EPS boards in Malta. The steel wire is also imported, mainly from Italy via sea transport. However the mesh reinforcement is manufactured and assembled within the factory, in the steel manufacture department. The panels are manufactured and then transported to the construction site through the arterial road network.

Waste: The panels are produced to size, and waste is in general limited to the formation of openings. The EPS is in general recycled. The steel waste is sold for recycling.

### Discussion

Various alternative construction systems and building envelope systems are available in Malta. The traditional construction system consists of load-bearing masonry structures with walls constructed using stone blocks or hollow concrete blocks and reinforced concrete
slabs. Prefabricated insulated concrete panel systems have been used in industrial buildings. Insulation of the building envelope can be provided using external or internal insulation applied to the walls.

Structural insulated panels (SIPs) are a high performance building system used in residential and light commercial construction in various countries. The panels consist of an insulating foam core sandwiched between two structural facings, typically oriented strand board (OSB). SIPs are manufactured under factory production control and can be fabricated to address different building design requirements. The system is considered to provide for the required strength and efficient and is also cost effective. However the system is not been used in general for the building envelope in Malta.

The EVG-3D system based on an EPS core in between concrete layers applied on site, presents significant advantages with drivers supporting the system. It also presents limitations and barriers in the Maltese construction industry.

Drivers: The product offers specific advantages namely monolithic load-bearing structures, with continuous insulation. The system can also be considered for extensions on existing buildings, offering a light solution when compared to the traditional load-bearing masonry construction system. The system provides for flexibility, reduced construction time and reduced effort, reduced costs and economic solutions and improved structural integrity. The system allows for the pre-installation of fixtures, service pipes and formation of openings. The system also allows for improved seismic performance.

When compared to the traditional construction system consisting of load-bearing masonry and reinforced concrete roof structures, the EVG-3D system leads to improved energy efficiency in view of the continuous EPS insulation. The system offers improved sound insulation and adequate fire performance. The panels can be easily handled and assembled without the need of skilled labour. The factory production lead to improved quality of the panel components in the construction system.

Barriers: The traditional construction system in Malta is based primarily on load-bearing masonry construction with reinforced concrete roofs. The EVG-3D system is based on a new methodology for planning and construction of buildings in Malta. It provides for load-bearing characteristics as for traditional load-bearing masonry construction. The construction system presents new techniques in the factory production of the panels, in the assembly of panels on site and in shotcrete operations. The training of workmen who are normally used to alternative construction system, is required to address the basic skills necessary for the effective implementation of the system. Construction detailing can present various challenges in specific cases, particularly in connections with adjacent structures, in the case of party walls and when additional floors need to be constructed over existing buildings. Dismantling of buildings using the EVG-3D system also offers specific challenges and demolition can be ineffective with regards recycling at the end of life of the structure, due to difficulties in separation of the EPS from the concrete. However it has been noted that the best and most effective option is not demolition but dismantling of the system, by cutting and saving the panels. This is effective also in view of possible re-use of panels, reduction in waste and therefore resource conservation in the construction industry.

**Conclusion**

The EVG-3D system presents an alternative construction technology, based on a modular panel system. The system presents various advantages with regards construction time, labour and cost efficiency. The factory production of the panels leads to improved quality. The system allows for flexibility in design and adaptation to the specific needs. The system can be adapted to different requirements to address improved durability and strength. It offers robustness and can be designed to withstand lateral loads. The continuous EPS insulation is intended to improve the energy efficiency of buildings. The system also offers effective sound insulation and fire resistance.

A number of case studies where the system has been used effectively, have been assessed, in order to identify the merits and limitations of the system. The main challenge in the effective use of the system concerns the shift from traditional load-bearing masonry construction techniques, as the predominant form of construction technology in the construction industry in Malta. In general the EVG-3D system presents significant advantages over traditional construction systems for various applications including both new constructions and extensions to existing buildings.

In comparison the traditional load-bearing construction, the system leads to a reduction in the materials used and a reduction in waste generated during construction, resulting in resource conservation. This is an important consideration in the case of Malta as an Island State with limited natural resources and as a Country which relies heavily on the import of construction materials and products. The reduced weight of the system also results in reduction in the size of supporting structural elements, further addressing the concept of resource conservation. It can be considered as an effective solution when additional floors need to be constructed on existing buildings which were not intended to take the excessive loads of the traditional load-bearing system. The system provides for insulation through the EPS core, contributing towards energy conservation of buildings in a Mediterranean climate and in line with regulations and the requirements for energy efficient design.

A life cycle analysis can also address the different phases of the system’s life cycle, from manufacture to its end of life, in comparison to traditional and alternative construction systems.

**Acknowledgement**

The authors would like to acknowledge the support of JM Vassallo Vibroblocks Ltd. The assessment of the EVG-3D Construction System forms part of the University of Malta – JM Vassallo Vibro Blocks Ltd. Research Project in Sustainable Construction Materials.
Architectural design of Zero Emission Buildings – The case of the Living Lab at the ZEB research centre

Within the activity program of the Zero Emission Buildings (ZEB) research centre in Trondheim, two new laboratories are under construction at the NTNU campus of Gløshaugen in Trondheim. Both Living-LAB and Test Cell have been designed through the collaboration between researchers, material suppliers both local and international, and local building contractors involved in the construction process. The LivingLAB was designed in order to be representative, for dimension and construction, of a regular size Norwegian detached house. Specific solutions adopted in the renewable energy system integration, HVAC and detailing could be replicated in Norwegian detached houses, representing 29% of the total building stock.

The Living LAB is representing for construction and dimension of detached houses representing the most energy demanding typology in Norway (Sartori and Wachenfeldt, 2007, p. 6).

Project ‘environmental’ targets

In order to reach the carbon-neutrality target significant effort was required in the simulation and optimisation of the building construction in the climatic context of Trondheim (Haase and Finocchiaro, 2011). The final goal of carbon neutrality is denoted ZEB-COM, where the ‘C’ is related to the construction process of the building, ‘O’ the operation of the building, and ‘M’ the emission related to the material use of the building – including demolition (Dokka et al., 2013).

Four different ambition levels of “being ZEB” have been identified at the Zero Emission Building research centre in Trondheim. Each level aims, with increasing ambition, at balancing, through a positive energy budget, emissions due to:

• O/Eq – zero emission in operation, excluding energy use from appliances and other equipment
• O – Zero emission in operation, including appliances and equipment
• O+M – ZEB taking into account operation and materials but excluding the construction phase.
• O+M+C – zero emission accounting operation, environmental impact of materials, construction process and demolition.

Authors

Luca Finocchiaro  
luca.finocchiaro@ntnu.no

Aoife Houlihan Wiberg  
aoife.houlihan.wiberg@ntnu.no

Annemie Wyckmans  
anemie.wyckmans@ntnu.no

Arild Gustavsen  
arild.gustavsen@ntnu.no

Department of Architectural Design, History and Technology, Norwegian University of Science and Technology, Norway

Introduction

Within the activity program of the Zero Emission Buildings (ZEB) research centre in Trondheim, two new laboratories are under construction at the NTNU campus of Gløshaugen in Trondheim. Both ‘Living-LAB’ and ‘Test Cell’ have been designed through the collaboration between the ZEB research centre and the faculty of Architecture at NTNU, where the centre is located. In the Living-LAB, materials and components that have been developed to aim for a low carbon built environment will be tested in relation to users and behaviours. In the Test-Cell it will be possible to conduct comparative analyses between different components or relate the same technology to different kinds of technical equipment.

The preliminary concept of the building was developed by students at the MSc in Sustainable Architecture under the guidance of the teaching team leading the whole design process towards ZEB targets’ accomplishment. Students were organised in teams collecting results and effective energy demand and production. The building’s capacity to provide comfortable internal environmental conditions will also be monitored.
Researchers and experts in building environmental performance, materials environmental impact and energy systems design and integration have been collaborating throughout the design process. In the diagrams represented in Figure 6 it has been summarised the supply chain of people involved in the project from concept, in the upper part, until construction, in the lower part. The ZEB research centre had a key role in the project development administrating both the project finance (indicated with a $ in the diagram) and being directly involved into the design of both architectural system and technological content of the house. ZEB partners have been involved both as material suppliers and researchers throughout the design process. Local companies have been also involved when materials were not available among ZEB partners. After building contractors have been identified (in green in the diagrams) architects and engineers from ZEB have been directly involved into the design of both envelope characterised by a glass ratio of 45 cm (and a U-value of 0.11, 0.10 and 0.11 W/m²K, respectively). Ninety squared meters windows have been provided by three different research partners in AEB: Adena, 2008 – to 35.7 gCO₂eqKWh by 2050 in Norway (European Commissions, 2011). This requires a reduction of CO₂ emissions by 2050 in Norway (Grabaak and Feilberg, 2011). This is “verified” by the EU program “A roadmap for moving to a competitive low carbon economy by 2050” (European Commissions, 2011). This requires a reduction from the 357 gCO₂eq/KWh in 2004 – European OECD nations factor (Selvig and Zdena, 2008) – to 35.7 gCO₂eq/KWh by 2050. This is equivalent to 132 gkWh over a 60 years lifetime of the building (assuming stationary factor commonly used in ZEB at NTNU).

**Table 2 - Model optimisation**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
</tr>
</thead>
<tbody>
<tr>
<td>U-value walls</td>
<td>W/m²K</td>
<td>.12</td>
<td>.11</td>
<td>.11</td>
</tr>
<tr>
<td>Windows u-value</td>
<td>W/m²K</td>
<td>.72</td>
<td>.65</td>
<td>.65</td>
</tr>
<tr>
<td>Air tightness</td>
<td>ach</td>
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<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>North window height</td>
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<td>90</td>
<td>90</td>
<td>45</td>
</tr>
<tr>
<td>Heating D.</td>
<td>KWh/y</td>
<td>3232</td>
<td>2998</td>
<td>2918</td>
</tr>
<tr>
<td>Heating D.</td>
<td>KWh/m²</td>
<td>30.4</td>
<td>28.2</td>
<td>27.4</td>
</tr>
</tbody>
</table>

**Building environmental footprint**

Norway is an integral part of the European electricity grid network. Simulations conducted by Grabaak and Feilberg (2011) in the document “CO₂ Emissions in different scenarios of electricity generation in Europe” showed that it is possible to achieve a 90 % reduction of CO₂ emissions by 2050 in Norway (Grabaak and Feilberg, 2011). This is “verified” by the EU program “A roadmap for moving to a competitive low carbon economy by 2050” (European Commissions, 2011). This requires a reduction from the 357 gCO₂eq/KWh in 2004 – European OECD nations factor (Selvig and Zdena, 2008) – to 35.7 gCO₂eq/KWh by 2050. This is equivalent to 132 gkWh over a 60 years lifetime of the building (assuming stationary factor commonly used in ZEB at NTNU).

**Modelling building performance**

Simulations have been run using different software aimed at optimising the environmental behaviour of the building and its PV Energy production. Preliminary energy calculations have been conducted in order to identify the most effective and robust energy efficiency measures to use in the Norwegian climatic context. On the basis of these preliminary calculations an adaptation strategy aimed at optimising the building towards maximum efficiency was defined.

Optimisation process aimed at reducing transmission losses through the building envelope while maximising solar heat gains.
m² – the operational CO₂ footprint of the house, on a 60 years lifetime basis could be quantified as 522.1 kgCO₂(eq).

On the basis of preliminary calculations conducted at the ZEB centre on a virtual residential building – titled shoebox model – embodied emissions in materials would account for around 5.0 kgCO₂(eq)/m² if we assume a 60 year lifetime of the building (Wiberg et al. 2014). Environmental footprint of the shoebox model was calculated assuming construction and energy systems that would commonly be used in any conventional residential building respecting Norwegian passive house standards. This was assumed as one of the criteria in the design of the LivingLAB in order to be sure that the building would have been representative of residential building stock for dimension and construction. Emissions related to the renewable energy system integrated in the house – PV and solar thermal – necessarily larger than those eventually used in conventional buildings, have been instead calculated assuming the specific components dimensioned for reaching the ZEB target. Under these conditions emissions related to the use of PV accounted for almost 40 % of the total building footprint. Calculations have been conducted taking into account environmental impact parameters extracted from to the ECOINVENT (Wiberg et al., 201). Environmental footprint of a residential building – titled shoebox model was calculated assuming the specific components dimensioned for reaching the ZEB target. Under this condition operational and embodied emissions would account both for around 500 kgCO₂(eq). The total footprint of the LivingLAB would be thus 1,054.1 kgCO₂(eq) per year. The annual PV production of electricity required to balance this quantity is calculated to be 8,109.4 kWh, based on the premise that a kilowatt-hour of energy exported to the grid reduces the central production of a kilowatt-hour and associated CO₂ emissions (Finocchio et al. 2012).

Calculations have been performed in PVSyst considering the efficiency of commercially available panels used in the project (260 W/ module of standard dimension 165x99 cm, equivalent to 140Wp/m²). Results, collected in table 3, show that reaching the target of 8,109.4 kWh per year would be possible by adopting two arrays of 24 panels inclined 30 degrees towards south. This 11 kWp system would be sufficient for making the Living-LAB a carbon neutral building assuming a life span of 60 years.

A monthly analysis over an entire year was conducted in order to estimate the mismatch between electricity use and generation (Figure 8) and explore the possibility of dimensioning a battery deck to buffer the energy on a seasonal basis. Since it resulted it would have been extremely difficult to balance the environmental impact of such a system, this possibilities was not further explored.

### Lessons learned

The design of the LivingLAB has provided evidence, that even in the northern countries the target of carbon-neutrality is theoretically achievable.

Architectural design of the building resulted being particularly time demanding in order to run all the simulations required while balancing energy demand and produced energy in order to aim for ZEB target.

It is expected that the replication of any of the three energy systems in a conventional building would require much less effort in terms of working hours. Components adopted in each of the three alternative energy systems are commercially available in the Norwegian territory and could be easily replicated in any conventional detached house.

Specific solutions such as the integration of the vacuum insulation panels in the windows construction have been specifically conceived for the LivingLAB collecting materials coming from two different partners. Although this did not become yet a commercially available solution, it increased awareness of the window industry towards the potential of implementing such materials in their future products. Beside a relatively high embodied energy, according to simulation the use of VIP would reduce significantly heat losses towards energy efficiency, justifying a limited use in specific solutions where the use of thick insulation layers would be difficult.

Phase changing materials panels, characterised instead by low embodied energy, have been integrated in the whole ceiling construction. Their use was unknown to local contractors that were particularly interested into its heat storage potential. This was easy to install and...
could be easily replicated into passive houses often characterised by light construction and thus exposed to overheating problems. Its potential for energy efficiency reducing the building environmental footprint is today under monitoring.

Minor difficulties were experienced by local contractors in integrating the solar thermal system in the building façade, instead of the roof, and in combining several components related to different systems into a one in connection with a advanced monitoring system. Collaboration between researchers and local stakeholders, beyond the ZEB research centre partnerships, resulted into an increased awareness of solutions for a low carbon built environment.

The biggest limit of the design and construction process has been that of involving builders and contractors only in a later stage of the design process. A supply chain involving all the stakeholders throughout the whole process would have most likely resulted into an even more complex architectural design process but would have also facilitated and potentially made faster the construction process.

Behind the morphological solution adopted in the LivingLAB, coming from the original design based on a prefabricated system, low carbon solutions adopted into the living lab project are easily replicable in most conventional detached houses in Norway. All the three energy systems adopted into the house are made by commercially available components, rather diffused in the whole national territory. Large Renewable energy systems such as solar thermal and large photovoltaic systems are still not diffused at the building scale. There is still a quite high scepticism towards the use of solar systems in high latitude climatic contexts. Reduced price of PV together with increased performance have anyway attracted the interest of providers in the national territory. Pilot projects from ZEB are aiming at increasing social awareness towards the potential of those technologies in high-latitude climatic contexts.

References


Supply chains for clean and efficient wood burning stoves-firesplaces in the Lesser Poland region

Growth of the energy demands and fuel prices significantly affects the entire supply chains and hereby contribute to the development of cleaner and energy efficient technologies. This study provides some important initiatives in the Cracow and Lesser region associated with the efficient individual heating systems, including the biomass and wood-burning stoves and firesplaces.

Authors

Mariusz Filipowicz 
filipowicz@agh.edu.pl

Jan Górski 
 jagorski@agh.edu.pl

Leszek Kurcz 
kurcz@agh.edu.pl

Adam Rybka 
akbyr@prz.edu.pl

1) Faculty of Energy and Fuels, AGH University of Science & Technology, Poland
2) Faculty of Civil & Environmental Engineering, Rzeszow University of Technology, Poland

Introduction

The air pollution harms human health and the environment. Rapid economic and urban population growths have triggered a series of challenges to the endeavours of maintaining the good air quality. There is natural inclination towards alternative energy sources throughout the world considering the diminishing resources and the environmental problems associated with coal combustion. Focus on the abatement of air pollutants, and the increase of air quality in urban and industrial areas are common trend nowadays.

Many countries using coal and biomass as major sources of domestic heating have serious air pollution problems, such as for example Austria and Poland. In Poland, the Particulate Matter (PM) emissions from small combustion sources accounts for 35% of the national total emissions, and up to 90% of the total PM emissions from combustion activities (Olendrzynski, 2002). Today, Krakow is one of the most polluted cities in Europe. The daily limit value for PM10 is exceeded up to 250 times a year. During peak pollution days over the winter, levels of PM10 can reach up to 400 µg/m2 – eight times over the limit. This has an impact not only on human health but also on the works of art and historical buildings that this Polish city is famous for. Emissions from domestic heating account for 42% of PM10, 34% of PM2.5 and 68% of BaP – the most harmful pollutants to health which are associated with asthma, cancer and heart disease. Figure 1 presents the annual exposure levels of PM10, PM2.5, benzo(a)pyrene (BaP), sulphur dioxide and nitrogen oxides relating to the number of residents in the ‘Lesser Poland’ province (Malopolska). The main culprit is the coal used for domestic heating.

Figure 1 - Rate of population exposure to concentrations of harmful ambient air compounds within the Lesser Province in 2013 (source: www.malopolskie.pl/Plik/2013/)

Appendix A: Evaluation of the energy efficiency of the Passive House for the Lesser Poland region

The Passive House or ZEB (Zero Energy Buildings) are one of the most promising solutions in the building sector. The idea of Passive House builds on the principles of passive system and low energy consumption. Passive House is based on the idea that the heat loss from the building should be equal to the heat energy generated or produced by renewable energy sources during the particular period of the year. The aim of Passive House is to achieve a high energy efficiency and minimum energy consumption in the building. The Passive House is designed to achieve a high energy efficiency and minimum energy consumption in the building. The Passive House is designed to achieve a high energy efficiency and minimum energy consumption in the building. The Passive House is designed to achieve a high energy efficiency and minimum energy consumption in the building. The Passive House is designed to achieve a high energy efficiency and minimum energy consumption in the building. The Passive House is designed to achieve a high energy efficiency and minimum energy consumption in the building. The Passive House is designed to achieve a high energy efficiency and minimum energy consumption in the building. The Passive House is designed to achieve a high energy efficiency and minimum energy consumption in the building. The Passive House is designed to achieve a high energy efficiency and minimum energy consumption in the building. The Passive House is designed to achieve a high energy efficiency and minimum energy consumption in the building.
The estimated number of coal furnaces in the private dwellings in Krakow is 30,000 and over 40,000 in the neighbouring communities. In 2013, the city government and the province have introduced a total ban on coal burning in Krakow from 2018. However, the introduction of a local ban on coal must be consistent with the law throughout the country. Under the new EPA rules signed this year by the Polish president Andrzej Duda, local authorities can now prohibit its use. Prohibition on the use of coal in household heating installations in Krakow requires a considerable investment of €5.5 million. The three main sources of funding are:

- EU funding, i.e. Regional Operational Programme for the Malopolska 2014 – 2020;
- National Fund for Water Management and Environmental Protection (NFONJi.W) – Programme ‘KAWKA’ for the removal of low-efficient energy sources supporting the growth and deployment of decentralised renewable energy sources;
- Regional Fund for Water Management and Environmental Protection (FOSiGW).

Also, in the municipal budget sufficient resources should be allocated to create supporting programmes for the poorest people who will receive subsidies for bills up to 100% after switching from coal to an alternative heating systems (BIP Newsletter, 2015). This case study presents some components of equipment and materials supply chain for energy efficient and cleaner residential heating systems in the context of the city of Krakow and its surrounding.

**Description of the technology**

Because the ‘fixed bed technologies’ are mainly used in small combustion installations (in particular for residential heating) under very poor conditions and far from an optimum combustion process, the emissions of pollutants are higher in comparison to more advanced combustion technologies applied at the industrial scale. Small combustion installations – fireplaces, stoves, old design chamber boilers (capacity below 50 kW) operate as residential heating systems, without regulation and control of the fuel and air supply to the combustion chamber, with an annual average efficiency that is about 50% (Kubica et al 2007). There is renewed interest in burning biomass to help save money on domestic heating bills, and reduce dependence on hard coal and fuel imports. Of particular interest recently have been the masonry heaters, which differ from fireplaces due to their ability to store large amounts of heat in a thermal mass. The stoves-fireplace is a modern type of masonry heater, constructed mostly of masonry and ceramic materials. Hot gases generated during fast and clean combustion pass through series of channels saturating the masonry mass with heat (Chernov, 2008). The mass then radiates heat into the surrounding area for the next 12 to 24 hours (Krok, 2014). As high thermal mass storage devices, masonry heaters offer steady heat output with typically one to two full loads of fuel per day.

The process of burning timber loads, depending on the heating demand of the building, may require a total amount of 15 – 18 kg per day. Example solution of a stoves fireplace in contemporary architecture is shown in the Figure 2. The usually used fuel is a natural gas, LNG, wood, briquettes or pellets.

![Figure 2 - Modern stoves-fireplace (CEBUD Co., 2015)](image2)

These modern units are characterised by multiple air inlets and pre-heating of secondary combustion air by heat exchange with hot flue gases. A stoves-fireplace includes a firebox, a large masonry mass and long twisting smoke channel that runs through the heat accumulating mass (Figure 3). The main purpose of stoves-fireplaces is to provide heat in a high efficient way – its efficiency ranges from 75 to 85%. Many test results (Filipowicz et al, 2014) indicate that, in contrast to typical ornamental fireplaces, these systems could be the main source of heat for heating and domestic hot water production in the residential house.

**Figure 3 - Stoves-fireplace with ACM system (CEBUD); a) – burning chamber, b) – ACM elements, c) – chimney, d – CMA modules**

The amount of heat received and accumulated in a stoves-fireplace is determined by the refractory core, i.e. the number of the internal Accumulation Ceramic Modules (ACMs) and the furnace space. Therefore this heaters are heavy (3-7 Mg) and require independent foundation system, located at the lowest level. Depending on the particular design, stove-fireplace can be ventilated either through a separate free-standing masonry chimney or through an insulated stainless-steel chimney. Stoves-fireplace should also match the projected heat loss of the building. A simple rule of thumb for rough estimation of stoves-fireplace heater output says that the heater’s surface will emit 550-600 W/m² in two cycles per day.

![Figure 4 - Stoves-fireplace with water HEX (OGW, CEBUD)](image4)

**Impact of the technology**

From 2013, Krakow authorities addressed air pollution issues by co-financing the replacement of old coal stoves with new heating systems. So far more than 1200 applications to have old stoves replaced were submitted from local companies and households, for a total cost of €2.1 million. The city council has enough funding to co-finance the replacement of about 25,000 old coal-fired stoves in Krakow.

In comparison to old wood and coal stoves, the 3rd generation stoves-fireplaces are highly efficient (over 80% efficiency) and low-emission heating units. The performance parameters of modern stoves-fireplaces have been confirmed by Filipowicz et al (2014) in the laboratory of Dept. of Energy and Fuels at the AGH University in Krakow. The complete study included over 2 months measurement period in which 8 kg/cycle of wood logs were burned by loading them in three cycles per day. A proper number of heat-accumulation elements (CMA – Akubet™) was between 70-100 kg mass per 1 kg of fuel (wood-logs, briquettes). These ceramic components are produced and patented by the CEBUD Co.

It should be noted that the combustion of dry wood (<20% RH) or briquettes, herein results in a low emission of PM and gaseous pollutants. The results of measurements of NOx, SO2, and CO emissions from the tested stoves-fireplace are shown in the Figure 5. The
measured concentration of NOx was close to 45 ppm at the initial part of the combustion cycle but after two hours was less than 10 ppm. The similar behaviour was observed for concentration of SO2 (from 25 ppm to ~5 ppm) and CO (from ~1000 ppm, below 400 ppm), and after two hours are acceptable.

Unfortunately, in our country there are no limits and regulations on air pollution from small biomass combustion, such as those that are applied in Germany and Austria.

![Figure 5 - NOx, SO2 and CO concentration of in the flue gas (Filipowicz, et al, 2014)](image)

**Supply chain development**

Wood burning has the great potential to be a sustainable technology, but it must be done with high efficiency and low emissions. These demands can be met through the development of advanced fuel burning stoves-firesplaces. As was mentioned, the 3rd generation of stoves-firesplaces can easily replace many old coal-fuel heating systems in detached homes and rural dwellings. Currently, many efforts are expected to develop an appropriate supply chain for the delivery and production of major components and better resistant materials for heat accumulation.

Since 1990 many new small and medium-sized enterprises in Malopolska have been producing and installing stoves and stoves-firesplaces. The supply chain includes more than 110 companies involved in selling items (including tile, brick chamotte, inserts accumulating, housing, etc.). Many of these companies also lead the production and sale of processed wood and agro-biomass (pellets and briquettes). The fuels are produced from forestry, maintenance of gardens and sawmills. An important issue that must be considered is the need to develop a low-cost production process for fuel pellets that could improve the calorific content and reduce the level of harmful emissions into the atmosphere.

Wood is subject to necessary seasonal drying and/or conversion (up to six months). Wood pellets are produced primarily from sawdust, wood shavings and mixed with agricultural waste. Pellets are compressed under high pressure, without glue or other additives. Particle size and moisture content are controlled before the raw material can enter the pellet mill. Small size pellets packed in bags (10, 15, 20 kg) are very popular among individual consumers in the market. On the wholesale market also distribute standard-size solid briquettes (like a cylinder or cube) in pallets of 960 kg. Production of wood-briquettes in the region involves about 15 companies, which also provide transportation to the fuel recipient. The main sources of supply of wood include local and national reserve forests and imports from abroad (Ukraine, Russia).

Manufacturing activities of ceramic clay, tiles and other elements in the Malopolska region is well developed. The extraction of raw materials for production does not constitute a barrier because of the long tradition and the good availability throughout the region. Currently, more than 12 companies produce ceramics and structural elements for stoves and stoves-firesplaces, also in the vicinity of Krakow (AccelorMittal Refractories, VITCAS S.A. and ALCOR S.A.). Recently in the Malopolska region 18 private SME’s have been involved in construction of stoves-firesplaces and the renovation of old furnaces. Clay used in the manufacturing of refractory ceramic is opencast mined and delivered from the neighbouring provinces (Lower Silesia and Swietokrzyskie, about 150 km from Krakow).

Among the specialised companies in the Malopolska region, many are members of OSKP (Polish branch of European Associations of the stove-fitter’s trade VEUKO). An important source of information is the quarterly ‘Kominek’ (‘Fireplace’) issued for practitioners in the field of design and operation of stoves. The aim of OSKP is to represent the common interests of particular groups: manufacturers and importers, service providers, protect their professional and economic interests, support for small and medium-sized centres of industry, as well as taking care of the highest level of service. Mr. Jacek Ręka (MSC), the owner of CEBUD Co. and board member of VEUKO, cooperates with the AGH University in the research of new heat accumulation materials, and testing of advanced stoves-firesplaces.

**Lessons learned**

Small-scale domestic combustion in firesplaces, wood and coal-fired stoves as well as boilers are significant contributors to air pollution. They emit fine particulate matter (PM2.5), sulphur and nitrogen oxides, carbon monoxide, poly-aromatic hydrocarbons (PAHs) and dioxins which form ground level ozone. The technical potential for cutting emissions from the burning of solid fuels in small-scale combustion appliances is huge. Currently, space heating and cooling as well as hot water are estimated to account for roughly half of global energy consumption in buildings.

There is a growing awareness of the urgent need to turn political statements and analytical work into more realistic action. Finally, in the JCR Report (Kubica et al, 2007) has been pointed: Small combustion installations are not small emitters which is why is necessary to establish new policy, new control and monitoring systems on regional, national and European levels. But it is necessary to introduce economy systems for applying primary and secondary measures to reduce emissions from these sources’.

High efficiency and low emissions make stoves-firesplaces an ideal choice for heating low-energy houses using renewable fuels such as wood. Stoves-firesplaces technology should therefore be further promoted. It should not rely entirely on research and development, but other forms of stimulus are needed to bring new products to market. Industry and market actors have a key role in developing and putting innovations on the market.

<table>
<thead>
<tr>
<th>System</th>
<th>Energy source</th>
<th>Unit cost PLN/a</th>
<th>€*/a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condensing boiler (15 kW; 104% efficiency.)</td>
<td>Nat. Gas (31 MJ/m³)</td>
<td>0.24 PLN/kWh</td>
<td>3700 880</td>
</tr>
<tr>
<td>Oil Boiler (17 kW; 88%)</td>
<td>Fuel oil (35.4 MJ/dm³)</td>
<td>0.39 PLN/kWh</td>
<td>6410 1530</td>
</tr>
<tr>
<td>Accumulation electric heaters and electric boiler</td>
<td>Electricity (3.6 MJ/kWh)</td>
<td>0.35 PLN/kWh</td>
<td>5460 1300</td>
</tr>
<tr>
<td>Condensing boiler and solar collect. (104%)</td>
<td>LPG (45.6 MJ/kg)</td>
<td>0.45 PLN kWh</td>
<td>4750 1130</td>
</tr>
<tr>
<td>Air/Water heat pump (16 kW; EER = 3.5)</td>
<td>Air/Electr. (3.6MJ/kWh)</td>
<td>0.18 PLN/kWh</td>
<td>2730 650</td>
</tr>
<tr>
<td>Coal boiler (19 kW; 82%)</td>
<td>Coal (24 MJ/kg)</td>
<td>0.18 PLN/kWh</td>
<td>2880 686</td>
</tr>
<tr>
<td>Stoves-firesplace (18 kW / HEX; 84 %)</td>
<td>Wood logs (15 MJ/kg)</td>
<td>0.12 PLN/kWh</td>
<td>1850 440</td>
</tr>
</tbody>
</table>

Table 1 - Annual costs of heating and hot water at 160 m² area house (70 kWh/m²y) in Poland (11.2 + 4.1 kW (*Assuming the exchange rate: 100 € = 420 PLN*))
Additional measures should be considered if the natural change out of older equipment is not expected to be sufficient to achieve the desired goal. This could for example be done by setting deadlines for using particular kinds or models of stoves. Effective mechanisms for the promotion and introduction of new products in this branch requires diverse taxes and other economic instruments. The operating costs of stoves-fireplaces are very advantageous compared to other heating systems in the individual house. The comparison presented in Table 1 for home heating with an area of 160 m² in Poland. The assumed conditions refer to the fuel prices and heating technology ‘state of art’ in Poland at the middle of 2014 (E0 = 70 kW/h/m², and hot water demand 200 l/day). An annual energy demand equals to 15.3 kW (11.2 kW for heating and 4.1 kW for hot water preparation). Obtained results indicate very low energy expenses of exploitation the stoves-fireplace unit comparing to other individual heating systems.

References


The example of cork as a sustainable construction material

As the world largest cork producer Portugal has a long and rich experience in managing cork oak forest in an environmentally conscious way. Cork oak forest is a top biodiversity hotspot, playing also a key role in ecological processes such as water retention, soil conservation, and carbon storage. Cork is one of the most versatile natural raw materials known. The cork industry produces a wide variety of products, including those for construction applications, which are durable, reusable and recyclable.

Table 1 - Geographical distribution of world cork oak forest areas Sources: Portugal – AFN (2010); Espanha-MARM (2007); Itália – FAO (2005); França – IM Liège (2005); Marrocos – HCEF Marroc (2011); Argélia – EFI (2009); Tunísia – Ben Jamaa (2011).

Author
Helena Corvacho
corvacho@fe.up.pt.
Faculty of Engineering, University of Porto, Portugal

Introduction

Cork is a well-known material which has been used by mankind for thousands of years and for which there are multiple possibilities of application, from wine stoppers to aeronautics and aerospace. Cork is the suberous covering (or bark) of the species Quercus Suber L., commonly known as the cork oak. It can be extracted from cork oaks every nine years without any harm to the trees.

Cork oaks grow mostly in Western Mediterranean area, where they can reach heights of 25 m and live up to 200 years. Table 1 and Figure 1 show the geographical distribution of cork oak forest areas.

The cork oak forests represent around 23 % of the whole area of Portuguese forest. They are referred to as montados and they have such an important role for nature and people that they are protected by law. In Portugal, the cork oak is the National Tree and it has been protected by law since the 13th century. A growing awareness of the value of the ecosystem of the cork oak forest has led to important initiatives in reforestation and the systematisation of good practices, with the current rate of reforestation being estimated at 10,000 hectares per year. Cork forests rank among the top biodiversity hotspots. They are home to 135 plant species and over 200 animal species, many of who are endangered or critically endangered.

Figure 1 - Cork oak forest (APCOR)
According to the World Wildlife Fund, “Cork oak landscapes are one of the best examples of balanced conservation and development anywhere in the world. They also play a key role in ecological processes such as water retention, soil conservation, and carbon storage.” Cork oak trees play also a role in fire protection, their thick bark acts as a protective barrier against fire and heat. This protection extends to the forest itself and the animals within it. In fact, the scientific name for these species of tree is pyrophytes – which literally mean ‘fire plants’.

Cork is one of the most versatile natural raw materials known. It is a very lightweight material, elastic and flexible and almost impermeable to gases or liquids, imperishable and a good electric and thermal insulator, as well as sound and mechanical absorbent. As a cellular material its unique properties arises from its closed cell structure.

**Cork production**

Cork production consists in the cultivation and rational management of the cork oak forest, including the periodical stripping of the cork bark. Table 2 presents the annual production of cork in 2010 (in tonnes).

**Table 2 - Annual cork production in the world**

<table>
<thead>
<tr>
<th>Country</th>
<th>Annual cork production (tonnes)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portugal</td>
<td>100,000</td>
<td>49.6</td>
</tr>
<tr>
<td>Spain</td>
<td>61,504</td>
<td>30.5</td>
</tr>
<tr>
<td>Morocco</td>
<td>11,686</td>
<td>5.8</td>
</tr>
<tr>
<td>Algeria</td>
<td>9,915</td>
<td>4.9</td>
</tr>
<tr>
<td>Tunisia</td>
<td>6,962</td>
<td>3.5</td>
</tr>
<tr>
<td>France</td>
<td>6,161</td>
<td>3.1</td>
</tr>
<tr>
<td>Italy</td>
<td>5,200</td>
<td>2.6</td>
</tr>
<tr>
<td>Total</td>
<td>201,428</td>
<td>100</td>
</tr>
</tbody>
</table>

Cork sales and recycling

Portugal exports 90 % of the cork produced in the country, which means that only 10 % supplies the national market. Figure 6 shows the distribution of exports per type of product. Cork stoppers lead Portuguese cork exports, followed by cork building materials.

In 2008 the Green Cork project was launched, a partnership between the largest Portuguese cork company and the main national environmental association ‘Quercus’. Subsequently, the project has spread to other countries, such as Spain, the USA and Canada, France, Italy, the United Kingdom, South Africa and Australia. The cork stoppers gathered within Europe are treated and grinded in the first licensed cork recycling unit of Portugal, which has been in operation since 2009. Cork waste can thus be transformed into granules and be utilised as raw material. Although it can never be used in stoppers, the recycled cork can be used in coverings, insulation, memo boards, high competition kayaks, badminton rackets, tennis and cricket balls, car and aircraft components, design and fashion items and a multitude of other uses.

Social Impact

Cork is a vital source of regional rural employment. Cork oak woodlands provide employment and guarantee the survival of local communities. It has been estimated that more than 100,000 people in the seven Mediterranean cork-producing countries depend directly and indirectly on cork economies. In Portugal, besides the 9000 cork industry employees, cork exploitation generates thousands of indirect jobs (catering, tourism, etc.).

The current use of cork in construction

The applications of cork related to building underwent an enormous market expansion in the first part of the 20th century, namely due to the development of different cork-based agglomerates. What started in some cases as a solution to use the leftovers generated by the production of cork stoppers, has resulted in the current diversified portfolio of efficient construction solutions.

The most common cork products used in buildings are: thermal, acoustic and vibration insulators (in various shapes); suspended ceilings; coverings for walls, floors and ceilings; baseboards; linoleums; granules as fillers for insulating, expansion or compression joints and mortar mixtures; and for industrial purposes: anti-vibration for machinery and insulation for industrial cold storage. The main manufactured cork products can be described as follows (Gil, 2007):

**Granulated cork**: Granules are obtained by the operation of various mill types, depending on the product to be ground and the desired granule type. Usually a drying process through hot air is necessary in order to give the granules the desired level of moisture.

**Composition cork**: Composition cork (agglomerated) is manufactured using granules and is the result of an agglutination process. Cork granules with a specific granulometry and volumetric mass are treated through a combination of compression, high temperature and chemical binding, depending on the type of final product and the desired performance. In order to manufacture cork agglomerate for decorative purposes synthetic resins of polyurethane, phenolics and melamines are used, and less often resins of vegetable origin. However it is also possible to manufacture cork agglomerate without an agglutinant agent, as in the case of expanded agglomerated cork.

**Expanded agglomerated cork (ICB)**: Expanded agglomerated cork is 100 % natural. The agglutination is obtained entirely through the cork natural resin. The agglutination is carried out by an autoclave process that also acts as mold. The granules are unloaded and...
slightly compressed. The boiling process is delivered by steam, superheated to a temperature of around 300 – 370°C. The superheated steam passes through the granule mass resulting in the secretion of the cork resin to the granule surface and an increase in its volume which, being confined in the autoclave, determines its agglutination. The manufactured blocks can be cut into boards of varying thicknesses, normally using a band saw, followed by corrections in size and squareness, usually using a disk saw. The slabs may be treated with sanding on one or both sides. Blocks which are rejected due to irregularities on the upper or lower sides, defective boards and those obtained from demolitions, can be used to produce re-granulated expanded cork by means of pulverisation.

Regarding environmental concerns, there is evidence of very good achievements. As an example, the expanded insulation corkboard produced by the largest cork Portuguese company was included in the Building Green Top-10 Products for 2013, the largest North American directory of sustainable construction products. It can be mentioned that biomass (cork dust) also constitutes the main source of the energy used in the Portuguese cork company.

Floating floor panels: The so-called ‘floating floors’ are usually made of an intermediate layer of medium – or high-density fibre boards with an agglomerated cork sheet on the lower side and a decorative agglomerated high-density cork sheet on the upper side. The joining of the different layers is carried out by applying glue on both sides of the intermediate layer and thereafter on the upper and lower cork layers.

Linoleum: For the manufacture of linoleum the finest and densest cork granules are used in addition to oxidised linseed oil, resin, jute, saw, metal oxides and colouring, to produce a compact material, very resistant to wear and tear and easy to clean. In Figures 7, 8 and 9 some examples of the use of cork for coverings are shown.

Figure 7 - External cork covering of Portuguese Pavillion at Shanghai 2010
When it is not possible to recover the panels due to damages or contamination with other products, granulation is possible, thus the cleaned re-granulated cork, can be destined for new applications such as thermal insulation or as an inert substance in the manufacture of concrete and light mortars. Natural non-expanded granulated cork, when it is not mixed with other products can also be re-used as a filler or in the manufacture of agglomerated cork and mortars. Composition cork products for construction can incorporate various types of recycled cork (for example, used cork wine stoppers, remains of agglomerated cork, etc.), thus contributing to global recycling rates.

In recent years several studies have been carried out in order to evaluate the environmental impact of cork products across their life cycle and allow comparisons with alternative materials. Expanded polystyrene (EPS) was compared with expanded agglomerated cork as an insulation material (Lopes, 2011). The products were compared on the basis of their capacity to provide thermal insulation, thus a greater mass of cork was considered (4.8 kg of cork against 1.2 kg of EPS), as the thermal resistance of cork is lower than EPS. The study was made at European and world level, which resulted in a longer transport distance for cork due to its concentration in the Mediterranean region. As the positive effect of carbon sequestration was not considered in this study, the overall environmental impact of the agglomerated cork in these conditions was similar to that of the EPS, except in the aquatic toxicity category where the impact of cork was much higher.

Another comparative LCA study of different insulation materials (Pargana, 2014) identified the environmental advantages of agglomerated cork as well as its major drawbacks when used as a building insulation material in Portugal. The different materials are compared on the basis of their capacity to provide thermal insulation, and the results are summarised in Table 4.

Table 4 - Comparative LCA results (cradle to gate) per functional unit (adapted from (Pargana, 2014))

<table>
<thead>
<tr>
<th>Material</th>
<th>PE-NRe (MJ)</th>
<th>PE – Re (MJ)</th>
<th>ADP (kg Sb eq)</th>
<th>AP (kg SO2 eq)</th>
<th>EP (kg PO4 eq)</th>
<th>GWP (kg CO2 eq)</th>
<th>ODP (kg R-11 eq)</th>
<th>POCP (kg C2H4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPS</td>
<td>73.8</td>
<td>0.63</td>
<td>0.035</td>
<td>0.011</td>
<td>1.35E-03</td>
<td>3.25</td>
<td>9.25E-03</td>
<td>5.83E-03</td>
</tr>
<tr>
<td>ICB</td>
<td>32.8</td>
<td>307</td>
<td>0.013</td>
<td>0.036</td>
<td>0.016</td>
<td>1.61</td>
<td>1.11E-07</td>
<td>2.55E-03</td>
</tr>
<tr>
<td>PUR</td>
<td>82.6</td>
<td>3.37</td>
<td>0.035</td>
<td>0.013</td>
<td>1.56E-03</td>
<td>3.33</td>
<td>8.23E-08</td>
<td>1.17E-03</td>
</tr>
<tr>
<td>XPS (thick. ≤ 80 mm)</td>
<td>96.8</td>
<td>1.31</td>
<td>0.047</td>
<td>0.017</td>
<td>1.83E-03</td>
<td>5.21</td>
<td>4.30E-08</td>
<td>0.013</td>
</tr>
</tbody>
</table>

It can be noticed that the impact of agglomerated cork (ICB) is significantly lower than the considered alternatives in the categories of non-renewable primary energy use (PE-NRe), global warming (GWP) and abiotic depletion (ADP) potential, but higher in others, notably acidification potential (AP) and ozone depletion potential (ODP). Given the obvious impact of the cork mass needed for a certain thermal insulation resistance (see Table 3), a different approach must be used in the application of cork in construction when lighter materials with equivalent performances, in terms of thermal insulation, are available. Innovative cork applications, alone or in combination with other materials, able to take full advantage of the eco-friendliness of cork when compared with alternatives, focusing not only on thermal insulation capability but also on other kind of performance indicators, call for research and creativity.

Innovative uses of cork in construction

A new generation of vacuum insulation panels using cork are being developed in the scope of the FP7 project VIP4ALL which was planned to be concluded in 2015. A significant investment is made on research and development of new products by Portuguese cork companies. New wall coatings incorporating cork are being studied namely in what concerns their thermal and acoustic characteristics and their durability.

With architects and designers, construction solutions combining cork with other materials are a recent trend. The use of cork in other elements such as urban furniture pieces and temporary constructions in public facilities is also developing.
Supply Chain Development

The supply chain has been well established for many years, but in the construction sector it still has issues competing in the global market. Specific innovative uses and ways of lowering prices must be addressed in order to satisfy the increasing interest of the construction sector on cork products.

Lessons learned

The cork industry exists in symbiosis with the local resources it relies on, but despite this achievement the cork industry must be able to compete in the global market. The main barrier for the full development of cork products in the construction sector is the high cost. It should be considered that the price of cork which is paid to producers actually supports the viability of the cork forest exploitation, as well as the services provided by its ecosystem. On the contrary, the price of conventional products does not always take into account their negative impacts on the environment. Even in the case of Portugal, the local abundance of cork and the limited transport distances are often not enough to lower the price enough to compete with conventional products.

In the domain of thermal insulation materials, for instance, cork must compete with the low price of synthetic materials based on fossil sources, such as EPS. Considering global markets, since cork has a low thermal resistance and is produced in a narrow geographic area in comparison to conventional products, cork insulation can present a high environmental impact. Moreover, cork products must also compete with cheaper alternatives coming from countries less strict on environmental and social issues. Therefore the environmental advantages of cork products must be stressed out as a marketing argument, but a smart approach is needed to focus on specific issues such as lowering the costs of cork. A strong investment in R&D searching for innovative and better solutions will possibly address this barrier.

References


Supply chains for the construction of recycled asphalt pavement for roads and streets in Iasi County of Romania

The present study conducted on a regional basis highlights the environmental indicators and technologies associated with recycling supply chains. The environmental performance of new and recycled asphalt pavements have been evaluated in a Life Cycle Assessment (LCA) perspective in order to evaluate the benefits of recycling as compared to a conventional engineering approach. These benefits consist mainly in reducing CO₂ emissions up to 50 % and stimulating the sector of construction materials (aggregates, bitumen, etc.) with significant decrease of costs. The impact of the construction process, expressed in terms of CO₂ emissions has been assessed using TRL asPECT software.

The object of this case study is a new asphalt pavement product which is obtained by recycling existing deteriorated pavements of roads and streets (streets are in fact roads in towns having similar structural and geometric design adapted to the local town condition). The technology can be used mainly for:
• in situ recycling – for roads;
• in plant recycling – for streets.

Both recycling supply chains have a low carbon footprint in comparison with more conventional technologies.

The stakeholders involved in this project are:
• in situ recycling of pavements – the Research Centre of our University (CCEGEFIMIT, 2005), the Regional Road Department of Iasi, the City Council of Iasi and two road construction enterprises, Bitunova Romania (Bitunova Romania, 2014) and SC VIAROM S.A IASI (S.C. Viacom S.A. Iasi, 2014);
• in plant recycling of pavements – the local company SC VIAROM S.A IASI.

The widespread use of Reclaimed Asphalt Pavement (RAP) has been supported by the technological development of asphalt mixtures equipment and plants, which enable operating in situ or in fixed plant (technical process detailed in Figures 1, 2 and 4) (FHWA, 2011).

Introduction

The present study conducted on a regional basis highlights the environmental indicators and technologies associated with recycling supply chains. The environmental performance of new and recycled asphalt pavements have been evaluated in a Life Cycle Assessment (LCA) perspective in order to evaluate the benefits of recycling as compared to a conventional engineering approach. These benefits consist mainly in reducing CO₂ emissions up to 50 % and stimulating the sector of construction materials (aggregates, bitumen, etc.) with significant decrease of costs. The impact of the construction process, expressed in terms of CO₂ emissions has been assessed using TRL asPECT software.

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• in situ recycling of pavements – the Research Centre of our University (CCEGEFIMIT, 2005), the Regional Road Department of Iasi, the City Council of Iasi and two road construction enterprises, Bitunova Romania (Bitunova Romania, 2014) and SC VIAROM S.A IASI (S.C. Viacom S.A. Iasi, 2014);
• in plant recycling of pavements – the local company SC VIAROM S.A IASI.

The widespread use of Reclaimed Asphalt Pavement (RAP) has been supported by the technological development of asphalt mixtures equipment and plants, which enable operating in situ or in fixed plant (technical process detailed in Figures 1, 2 and 4) (FHWA, 2011).
The technological process of recycling asphalt mixtures consists in the use of material derived by milling, grinding and mixing with correspondent amounts of binder and natural aggregates. The obtained mixture is then properly bedded and compacted. The asphalt course obtained using this procedure must meet the quality requirements of new asphalt course obtained using this procedure. For laying the binder course in small roads or as additive pavement which includes reclaimed asphalt materials into its mix.

The dosages of materials incorporated in the recycled mixtures are established through laboratory studies for asphalt pavements design, with the dosage of embedded RAP varying between 20 % (Europe) and 70 % (USA) (FHWA, 2011). Although the physical and mechanical characteristics of the recycled product are similar to those of new materials, in Romania the recycling of asphalt pavements is not commonly practiced despite the need for economic, environmental and social benefits. Usually, the RAP is stored in landfills, and used for laying the binder course in small roads or as filler material, but recently some construction enterprises have began to incorporate this practice in their renovation works.

**Materials and technologies used**

60 – 70 % of materials used in preparation of the asphalt mixes are extracted directly from the existing road pavements, usually by cutting the surface layer (wearing course and binder course), and processing the material either in situ (alternative A/in situ recycling) or transporting it to the specific asphalt plants (alternative B/plant recycling) as shown in Figure 2.

The raw materials and energy used in these activities are sourced mainly within the country, as follows:

- the bitumen binder is produced and supplied by the crude oil refineries of Romania ROMPETROL VEGA PLOIESTI (ROMPETROL VEGA PLOIESTI, 2014);
- the lime or limestone filler is produced and supplied by the Romanian filler factory CARPACMENT HOLDING SA BICAZ (Heidelberg Cement, 2014);
- the crushed aggregates of various sizes are produced and supplied by the Romanian company CARPAT AGREGATE SA (Heidelberg Cement, 2014);
- various adhesives or modifiers (used to improve the bond between bitumen and aggregates) are produced and supplied by the Italian company INTERCHIMICA SRL ROMA ITALY (INTERCHIMICA SRL ROMA ITALY, 2014);
- the electric energy is supplied by the local company E.ON Moldova (E.ON MOLDOVA, 2014).

The raw and non-renewable materials used in the recycling process are bitumen binder, lime or limestone filler, crushed aggregates and adhesives or modifiers which constitute the remaining 30 – 40 % of the asphalt mix. The manufacture location. The recycling asphalt plants are located in the county of Iasi (North-East Romania) as shown in Figure 3.

A comparative evaluation of the carbon footprint (kg of CO2 equivalent emissions) embodied in the recycled asphalt and conventional new road asphalt was performed for a particular case of the application of the technology. The assessment has been conducted by using the TRL asPect software (TRL, 2014) (see Figure 4), for a road sector of 1km length.

In order to assess the impact of the recycled asphalt, the whole processing chain from cradle (resource extraction) to manufacture and layering the mix on site has been considered and is presented in Figure 4, showing the technological stages of the construction of a flexible pavement which includes reclaimed asphalt materials into its mix.

The first step is milling the surface layers of the existing road and transporting the material to the asphalt plant. In order to prepare an asphalt mixture that meets the technical quality requirements it is necessary to add a certain amounts of natural aggregates, bituminous binders, adhesives and fillers. These amounts are determined through laboratory studies conducted on the reclaimed asphalt. The additional materials are supplied by the companies mentioned above, transported to the asphalt plant and then incorporated in the asphalt mixtures along with the reclaimed material. The last stage of the process includes transporting the resulting product at the working place and laying and compacting the new asphalt.

The environmental impacts of transportation are likely to be minimal, since the large part of transportation happens within county of Iasi. However, the specific distance of road transport might play a larger role, thus increasing the GHG emissions.
The two different scenarios investigated are:
- Alternative 1: Conventional road: construction of a complete new pavement structure (Table 1);
- Alternative 2: Recycled mixture: renovation of an existing road, having the same pavement structure as that of alternative 1, but where all the top asphalt layers BA 16, BAD 25 and AB2 are replaced with plant recycled asphalt (Table 2).

Table 3 shows the results of the quantitative assessment of the environmental impact associated with each technological stage of the production and execution of asphalt mixtures for the two alternatives considered. The calculation was carried out for two boundaries, namely Cradle to Site, (steps 1 – 7), and Cradle to Grave (steps 1 – 10), taking into account the quantity of asphalt mixture necessary for the construction of one kilometer pavement as in Tables 1 and 2. The total quantity of CO₂e is summed in order to make a comparative analysis between the two alternatives. As it may be observed, because the recycled asphalt mixture features a smaller quantity of new materials and energy consumption, the total emissions are much less in comparison to a conventional pavement.

As shown in Table 3, the difference between the emissions embodied in a 1 km of conventional pavement and a recycled one under a Cradle to Grave perspective is more than 60,000 total kg CO₂e, showing that a reduction of emissions of over 25 % can be achieved through the use of recycled asphalt. The long term benefits related to the recycling process of pavements can be identified in the reduction of:
- the non-renewable resources used as primary materials;
- the environmental impacts and energy use associated with the asphalt life cycle;
- the material consumption and construction waste;
- the associated costs.

**Supply chain development**

The supply chain of road asphalt is undergoing a transition towards a higher sustainability performance increasing the percentage of the recycling materials in the asphalt mix, especially in regard to in situ applications. As it may be observed, because the recycled asphalt mixture features a smaller quantity of new materials and energy consumption, the total emissions are much less in comparison to a conventional pavement.

![Diagram of asphalt production and placement process](image)

**Figure 5 - Schematic supply chain of the recycled asphalt from resource extraction to on site construction**

<table>
<thead>
<tr>
<th>Layer</th>
<th>Layer thickness</th>
<th>Quantity of mixture (t)</th>
<th>kg CO₂e/t</th>
<th>kg CO₂e/km road (7000 m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>644 t</td>
<td>194.8</td>
<td>125,437.7</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>1008 t</td>
<td>214.8</td>
<td>216,517.5</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>2520 t</td>
<td>213.3</td>
<td>537,440.1</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>4172 t</td>
<td>207.6</td>
<td>879,395.3</td>
</tr>
</tbody>
</table>

**Table 1 - Environmental impact (kg of CO₂e per ton of asphalt mix) of Alternative 1/Conventional road, broken down for each road layer**

<table>
<thead>
<tr>
<th>Layer</th>
<th>Layer thickness</th>
<th>Quantity of mixture (t)</th>
<th>kg CO₂e/t</th>
<th>kg CO₂e/km road (7000 m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2</td>
<td>644 t</td>
<td>143.8</td>
<td>92,592.2</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>1008 t</td>
<td>132.8</td>
<td>133,836.8</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>2520 t</td>
<td>124.2</td>
<td>313,096.8</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>4172 t</td>
<td>133.6</td>
<td>539,525.8</td>
</tr>
</tbody>
</table>

**Table 2 – Environmental impact (kg of CO₂e per ton of asphalt mix) of Alternative 2/Recycled mixture, broken down for each road layer. Note: BA 16 – asphalt concrete with the maximum size of the aggregate of 16 mm; BAD 25 - asphalt concrete with the maximum size of the aggregate of 25mm; AB – asphalt base; BA 16 – recycled asphalt concrete with the maximum size of the aggregate of 16 mm; BAD 25 – recycled asphalt concrete with the maximum size of the aggregate of 25mm; AB – recycled asphalt base**

<table>
<thead>
<tr>
<th>Layer</th>
<th>Layer thickness</th>
<th>Quantity of mixture (t)</th>
<th>kg CO₂e/t</th>
<th>kg CO₂e/km road (7000 m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>644 t</td>
<td>194.8</td>
<td>125,437.7</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>1008 t</td>
<td>214.8</td>
<td>216,517.5</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>2520 t</td>
<td>213.3</td>
<td>537,440.1</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>4172 t</td>
<td>207.6</td>
<td>879,395.3</td>
</tr>
</tbody>
</table>

alternatives.

Table 3 - Life Cycle Stage summary of the environmental impact for the investigated pavements

<table>
<thead>
<tr>
<th>No.</th>
<th>Life Cycle Phase</th>
<th>Conventional asphalt mixture</th>
<th>Recycled asphalt mixture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>kg CO₂e/t</td>
<td>Total kg CO₂e</td>
</tr>
<tr>
<td>1</td>
<td>Material extraction and processing</td>
<td>42.29</td>
<td>27,235.64</td>
</tr>
<tr>
<td>2</td>
<td>Transport to plant</td>
<td>40.92</td>
<td>26,353.70</td>
</tr>
<tr>
<td>3</td>
<td>Asphalt production</td>
<td>26.02</td>
<td>16,754.62</td>
</tr>
<tr>
<td>4</td>
<td>Transport to site</td>
<td>9.39</td>
<td>6,049.79</td>
</tr>
<tr>
<td>5</td>
<td>Laying and Compacting</td>
<td>4.00</td>
<td>2,576.00</td>
</tr>
<tr>
<td>6</td>
<td>Project works</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>7</td>
<td>Maintenance</td>
<td>208.65</td>
<td>108,500.00</td>
</tr>
<tr>
<td>8</td>
<td>End of life</td>
<td>63.72</td>
<td>41,037.57</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Perspective</th>
<th>Cradle to site</th>
<th>Cradle to grave</th>
<th>Cradle to site</th>
<th>Cradle to grave</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total kg CO₂e</td>
<td>78,968.75</td>
<td>228,507.32</td>
<td>64,366.29</td>
<td>167,210.93</td>
</tr>
<tr>
<td>Tonnage</td>
<td>644.00</td>
<td>1164.00</td>
<td>644.00</td>
<td>1164.00</td>
</tr>
<tr>
<td>kg CO₂e/ton</td>
<td>122.62</td>
<td>196.31</td>
<td>99.95</td>
<td>143.65</td>
</tr>
</tbody>
</table>

There are several companies which deal specifically with novel technologies for pavement recycling in the county of Iasi. For example Bitunova Romania SA has undertaken several construction works using the recycling procedure across the North-East Region, namely on DJ 282 Flamanzi-Prajeni and DJ 292 Corlateni – Podeni – Vorniceni in Botosani County (see Figure 6).

Within the region, there are several manufacturers and distributors of materials for recycled pavements, such as the asphalt plant, located in the county of Iasi and the filler and aggregates factories from the county of Neamț. These enterprises are willing to change their practices in order to further increase the use of recycling process, but there are some barriers related to Romanian regulations. The national Road Agencies have reported the absence of technical regulations for the use of recycled materials in asphalt mixes, as well as the lack of information on the behaviour of such structures in time. Hence it is necessary, at national level, to develop technical regulations regarding the use of RAP in asphalt pavements and to monitor their long-term performance. Currently there are several ongoing studies regarding the recycling process at Technical University “Gh. Asachi” Iasi, undertaken in order to facilitate the implementation of these procedure in the current practice.

The supply chain and the execution of the works are monitored by the recycling companies for roads, and by the Regional Road Department of Iasi and the City Hall of County Iasi for streets through two types of preliminary analysis: in situ studies, surveys carried out on executed layer; or laboratory studies, consisting of specimen sampling and testing. Additionally, periodical site verifications are performed to test the accomplishment of technical and quality conditions of the layers.

Although at its beginning, the supply chain can be considered successful due to the close cooperation between infrastructure administration, industry and research. Also, the demand pressure from road users who are expecting to use better roads is an important factor. Competition with larger businesses producing technologies already developed and accepted on the market is a potential barrier for the further development of the recycling technology. A limited knowledge of the new products among the stakeholders could represent significant obstacles for the companies.

The novel recycling technologies (see Figure 6) and related good practices, such as in situ recycling of all types of pavement layers using specific adhesives, implemented during the last year by prestigious European Contractors and the experience of the North-East Region of Romania could inspire other regions to adopt the recycling technology.

For the further development of the supply chain of recycled pavements it is envisaged the potential extension of this technology to cover the entire public road network of Romania. Taking into consideration the actual national road rehabilitation program involving 15,000 km of national roads and over 150,000 km of county and local roads and streets, the implementation of the described supply chain involving the recycling technology may lead to significant reduction of greenhouse gas emissions, estimated to overpass the figure of ten million tons CO₂e during the next 20 – 30 years.

This case study demonstrates that an improved road policy, creating incentives for close cooperation between infrastructure managers, industry and research centres in a concerted effort for developing and implementation of sustainable technologies such as those involving recycled asphalt would enhance the environmental, social and economical benefits for the whole society, contributing to the establishment of a sustainable economic progress and regional development.

References


Figure 6 – Asphalt recycling process performed on DJ 282 Road (source: authors)
Market perspectives for the compressed natural gas (CNG) driven vehicles in Slovenia

To increase the attractiveness of public transport, the endeavours for more environmentally friendly vehicles in urban regions include the establishment of compressed natural gas (CNG) supply chain for the Slovenian market. In comparison with other alternative fuel vehicles, the CNG solutions deliver sustainable benefits like the reduction of environmental burdens, as well as the general decline of import of fuel. Initiated by the Energy Agency of Podravje (EnergaP), the recent campaign should promote sustainable transport in economic and environmental terms for Slovenian cities and regions.

Introduction

In Slovenia, for several decades the volume of public transport has been declining, mainly on the account of the growing transport by personal car, and after 2002, also by air transport. After the economic crisis in 2008, the enormous growth of number of personal cars stopped. In parallel, the percentage of transportation by more sustainable modes has also declined. Over the last decade, the share of bus passenger transport has started to decline (Figure 1).

Numerous factors, such as the development of motorisation, investments in national motorway system and road infrastructure, changing patterns of settlements, and the lack of competitiveness of public transport, support the continuing slight increase of personal car transport in Slovenia. Nevertheless, negative effects of transport on the environment heavily burden the living quality of urban areas. Consequently, they are forcing the governments’ administration to act in different directions. The first endeavours for sustainable passenger transport at local and regional level are evident by the activities in two biggest Slovenian cities, Maribor and Ljubljana and their city regions. They include the introduction of less environmentally burdened fuels, as well as the establishment of reliable supply chains for alternative fuel markets, based on cleaner energy sources and demonstrating cost and logistics advantages.

Figure 1 - The volume and the structure of public passenger transport (km/mio). Blue: transport by personal cars. Dark green: bus public transport. Light green: city public transport. Brown: railway internal transport

In the Slovenian road transport system, the majority of vehicles runs on gasoline. Statistical data from 2013 shows that the largest share of private cars runs on gasoline, followed by diesel and petroleum gas, gas, and the rest by other fuels, as electricity etc. (Figure 2).
registered in 2013 in Slovenia

Figure 2: The share of private cars by fuel, first registered in 2013 in Slovenia

One of the main characteristics of the fuel market in Slovenia is the extremely high dependency on the import of all kinds of fuel. In 2012, in case of liquid fuels and natural gas the share of imported fuels reached 100 % (Figure 3).

Figure 3 - The share of imported fuels in total energy supply in Slovenia. Blue: coal; Orange: oil; Grey: oil products; Yellow: natural gas
(source: Statistical Office of the Republic of Slovenia, 2013
Jozef Stefan Institute, 2013)

Natural gas as an environmental friendly fuel

The key factors shaping the future of transport systems are the initiatives that address the environmental challenges toward the transition to a greener transport fleet. Sustainability initiatives are focusing on natural gas vehicles, in particular. In Slovenia, in order to achieve the carbon reduction goals while maintaining economic viability, the endeavours support the upgrading of the maintenance facilities and the constructing of natural gas fuelling stations. In the logistics and supply chain management, several providers have opened new markets enhancing new services for developing a safer, smarter and simpler vehicles fleet. Alternative natural gas stations in different locations should assist the promotion of the converting of existing passengers system based on public and private vehicles to more environmentally friendly transport system.

Compared to more conventional fuels like gasoline and diesel natural gas offers variety of benefits, especially in view of a long-term sustainable clean technology. Namely, natural gas is one of the cleanest, safest and the most effective energy sources by decreasing negative impacts, as different kinds of environmental burdens and the economic dependency on importing fuel. Compressed natural gas (CNG) is natural gas that is compressed at the fuel station. Since the technology for production of CNG is almost the same as for biomethane, the endeavours for the development of the new transport system are devoted to the production of the 100 % biomethane which is directly injected in the natural gas grid. In this regard, the CNG pipelines for transporting biomethane that are installed recently will be fully exploited. In this regard, the production of biomethane can be provided also by recycling of the waste of used vehicles etc. When blended with the renewable counterpart of biomethane, which is nearly CO₂ neutral CNG can reduce the CO₂ emissions up to 25 %. For example, the CNG vehicles, blended with of 20 % of biomethane, decrease the emissions by 40 % (ERDGAS, 2014). From strategic point of view, Slovenia aims at the introduction of natural gas as an alternative fuel, which is one of the cleanest, safest and the most effective energy sources by decreasing negative impacts, as different kinds of environmental burdens and the economic dependency on importing fuel. Compressed natural gas (CNG) is natural gas that is compressed at the fuel station. Since the technology for production of CNG is almost the same as for biomethane, the endeavours for the development of the new transport system are devoted to the production of the 100 % biomethane which is directly injected in the natural gas grid. In this regard, the CNG pipelines for transporting biomethane that are installed recently will be fully exploited. In this regard, the production of biomethane can be provided also by recycling of the waste of used vehicles etc. When blended with the renewable counterpart of biomethane, which is nearly CO₂ neutral CNG can reduce the CO₂ emissions up to 25 %. For example, the CNG vehicles, blended with of 20 % of biomethane, decrease the emissions by 40 % (ERDGAS, 2014). From strategic point of view, Slovenia aims at the production of biomethane and has no plans for production of natural gas.

The establishment of an efficient CNG market system, linked to the alternative fuel vehicles, provides a list of benefits as, (i) reduction of total CO₂ emissions up to 25 %, (ii) elimination of smog-producing particulates to avoid air pollution, (iii) reduction of fuel costs by app. 42 %, and (iv) the development of advanced technologies to optimise the transport fleet. (NGVA Europe, 2014)

Table: Number of private cars on December, 31st, 2013

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Number of private cars on December, 31st, 2013</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>gasoline</td>
<td>633,646</td>
<td>59,56 %</td>
</tr>
<tr>
<td>Diesel, oil, petroleum</td>
<td>429,303</td>
<td>40,36 %</td>
</tr>
<tr>
<td>Gas</td>
<td>780</td>
<td>0,07 %</td>
</tr>
<tr>
<td>Other</td>
<td>66</td>
<td>0,01 %</td>
</tr>
<tr>
<td>total</td>
<td>1,063,795</td>
<td>100,00 %</td>
</tr>
</tbody>
</table>

Figure 2: The share of private cars by fuel, first registered in 2013 in Slovenia

Figure 4 - Greenhouse gas emissions in the overall balance of different fuels in g CO₂eq/km
(source: ERDGAS MOBILE, 2008)

Supply chain of compressed natural gas (CNG)

The availability of alternative fuels such as natural gas is becoming increasingly important for Slovenian attempts in strengthening sustainable energy policies. The activities toward cleaner energy will diminish the country’s dependence on import of oil products. On the other hand, the bad air quality in urban areas is a growing environmental problem, and, therefore, the transition to a cleaner energy source in transport system is of special importance. The case study is presenting the activities for establishing the supply chains of CNG for personal cars, public buses, and freight transport for vans and trucks in the cities and regions of Slovenia, based on the positive experience in Maribor.

CNG offers the possibilities to decline costs, and is an attractive alternative in favour of energy production security for domestic market. CNG represents an economically sustainable energy source that can be produced and used locally. Recently, European and world producers offer a variety of the CNG vehicles. Unfortunately, there is a lack of this specific market in Slovenia. From this perspective, the introduction of natural gas as an alternative fuel means a challenge for developing the new CNG market for vehicles, particularly for CNG buses as the main public transport system in Slovenia.

Activities of Energy Agency of Podravje (EnergaP) for the establishment of the CNG market in Slovenia

In order to decrease the environmental damages caused by vehicles, EnergaP started the campaign by promoting the CNG technology with the ambition to intervene in the transport sector at regional and local level. In 2007, EnergaP joined the EU research project Madagascar – Market Development for Gas Driven Cars that was conducted at regional level and integrated 10 EU countries: Sweden, Austria, United Kingdom, Germany, Spain, Slovenia, Czech Republic, Lithuania, Poland, and Bulgaria. Based on information, knowledge and best practice experience, the main goal of the project was to develop the general strategy for the CNG driven vehicles for Slovenian market. As a starting point, EnergaP established the cooperation on energy technology with the Slovenian National Association of Gas Supply Companies (SNAGSC) with 16 companies as members. Within the frame of the Madagascar project,
the best practices of CNG system experienced in the EU countries were presented first to the main stakeholders – the representatives of the Slovenian Ministry of Traffic, the Slovenian Chamber of Commerce, and the Slovenian Chamber of Crafts. The promotion and information campaign included also the organisation of the high profile national conference that was attended by all important Slovenian market players of fuel providers. On behalf of SNAGSC, EnergaP prepared the study on the development strategy for the future implementation of natural gas in Slovenia, based on the best practice showcases (Madagascar Project, 2007).

As the next step, EnergaP started to prepare the initiative for installing the first CNG fuelling station. The biggest problem was the lack of finances. Finally, the project was co-financed by support of several research programmes including the national subsidies scheme in frame of the National Eco Fund. In 2010, the first small CNG fuelling station in Slovenia was constructed in Maribor which is the centre of the Podravje Region (Picture 1). Parallely, EnergaP purchased the first CNG car in cooperation with public company Energetika, which is the heat provider in the Municipality of Maribor. Since then, EnergaP has been continuously actively involved in the development of the CNG market in terms of promotion of the CNG vehicles for all transportation modes.

In 2014, financed by the public energy company Energetika Maribor, the second public fuelling station in Maribor was established (Picture 2). Currently, there are 11 CNG buses operating in the Maribor Municipal public transport system. In two biggest cities in Slovenia, Maribor and Ljubljana, and their city regions the idea to replace the complete public bus fleet by CNG vehicles is a part of future action plans concerning the development of sustainable public transport. Over the last few years, also the Municipality of Ljubljana, which is the Slovenian capital, has been very active in this field. In 2011, the second CNG fuelling station in Slovenia was constructed on the site of the company Public Passenger Transport of Ljubljana (PPTL). This fuelling station supplies buses, service vehicles of public companies, as well as personal cars. Since then, within the EU-project Civitas Elan, 20 new CNG buses for PPTL public transportation network were co-financed, aiming at gradually conversion of the existing fleet to the CNG (Civitas Elan, 2012). Since 2014, based on positive environmental impacts, the PPTL has been gradually replacing the municipal public transport fleet with the new CNG buses, planning to purchase 10 additional buses by the end of 2015.

Figure 5 - The first CNG car and the first small CNG filling station in Maribor, 2010 (source: EnergaP, 2010)

Figure 6 - Opening of the first public CNG filling station in Podravje Region in Maribor (source: EnergaP, 2014)

The advantages of CNG in terms of energy efficiency and environmental protection

Compared to conventional fuels, CNG offers a range of environmentally and economically friendly benefits. As one of the cleanest fuels, it reduces greenhouse gas emissions and particulate matters. The vehicles engines that run on CNG meet strict consumption requirements in accordance with the Enhanced Environmentally Friendly Vehicle standards (EEV standards) set by the EU. These standards define the limits that are acceptable for exhaust emissions caused by the new vehicles sold in EU member states. Currently, the % for gas emissions and particulate matters are regulated by differentiating standards for most vehicle types as personal cars, trucks, trains, tractors and similar machinery, excluding the seagoing ships and aeroplanes.

Based on the international expertise, regional and local benefits of establishing CNG vehicles market system in Slovenia are estimated as follows (ERDGAS, 2013):

- zero emissions of particulate matter;
- up to 95 % less emissions of nitrogen oxides in comparison with diesel;
- up to 25 % less CO₂ emissions in comparison with gasoline;
- low emissions levels;
- high security standards;
- lower fuel consumption;
- lower fuel prices;
- lower maintenance costs etc.

The EEV standards are performed in a series of EU directives that have progressively introduced more and more strict regulations concerning the % of emissions. In this view, the CNG market will tremendously increase the public awareness of renewable energy sources and more rational use of energy.

Lessons learned

The EnergaP experienced the establishment of the CNG market in Slovenia as a long procedure starting from the initial idea to the final implementation. The first steps were dedicated to the introduction of the knowledge base that enabled the implementation of the idea on CNG vehicles in practice. As a next step, the market for public CNG bus transport was successfully developed and the fleet of buses started to expand in the two most densely populated Slovenian urban areas – the city regions of Maribor and of Ljubljana. Currently, both cities are offering public CNG filling stations for all kind of vehicles. However, there is still very little interest for purchasing CNG personal cars by private persons.

In order to increase the development of the CNG market, the newest initiative is based on the investment in the development of CNG infrastructure system of fuelling stations along the national motorways as essential to support the alternative CNG transport mode. The development of the CNG market in Slovenia presents a successful model to enhance the introduction of alternative energy sources and cleaner technology as a long-term strategy for smart cities and regions. Additionally, the strategy integrates the benefits to economic growth in terms of creating new profiles of jobs in transport sector at local and regional level.

References


Ryder, (online).
Electrically heated glass in Mediterranean climate

The study of Electrically Heated Glass (EHG) is important due to the increasing use of highly-glazed façades in commercial buildings. The use of this technology can be considered a different approach to the growing interest in contemporary design of transparent buildings, which does not neglect the occupants’ comfort and the sustainability aspects associated with natural daylighting and energy savings. Commercial buildings located in the Mediterranean Regions consume significant amounts of energy for cooling, but require limited heat in winter due the high internal gains from appliances and the mild weather. At the same time, the significant role of radiant temperature in ensuring thermal comfort makes it especially convenient to use EHG during winter season in glazed façades.

Authors

Giuseppe La Ferla ¹
  g.laferla.licitra@gmail.com

Jaume Roset Calzada ²
  jaime.roset@upc.edu

Petra Amparo Lopez Jiménez ¹
  palopez@upv.es

1) Construction and Architectural Technology Department, Universidad Politécnica de Madrid / Chapman Taylor, Spain
2) ETS Arquitectura Barcelona, Universitat Politècnica de Catalunya, Spain
3) Hydraulic and Environmental Engineering Department, Universitat Politècnica de València, Spain

Description of the technology

There is a growing interest in the use of highly-glazed façades in commercial buildings. With origins in Europe the trend is expanding to all over the world, linked with the concept of hi-tech, modern design, daylighting and energy savings (Lee et al., 2002). Commercial buildings usually have high internal loads, due to information system equipment and the number of occupants (Duska et al., 2007), and short daily use of eight hours per day.

The heat gained or lost through the glazed façade depends on the physical properties of the material (conductivity, absorption, reflection, and transmittance) and on the environmental conditions. These factors determine the glass surface temperature and the amount of heat transferred between the occupants and the building through convection and radiation (Anderson et al., 2011). Thermal comfort conditions are also influenced by the distance between the glass surface and the occupants, the size of the glazing, the occupants’ clothing and the activities undertaken within the building. In Mediterranean climates (Cs, with mild to cool wet winters, Chazara et al. 2011) these buildings have a limited heating demand for most of the cold season.

Where Electrically Heated Glass (EHG) has been integrated into the façade, the exchange area between the environment and the heat source is across the whole extension of the glazing. Thus the total radiant energy emitted by the EHG to satisfy the heat demand is the result of the EHG unitary power multiplied for the whole façade area, which achieves a low increase between the mean radiant surface temperature and the internal temperature, with a consequent reduction of the energy consumption. With the temperature of the glazing near to the comfort range, the low radiant asymmetry temperature (less than 10°C) (Lyons and Arasteh, 2000) ensures thermal comfort and PMV (Predicted Percentage of Dissatisfied) and PPD (Predicted Mean Vote) decrease rapidly (figure 1) (ASHRAE, 2001) (Olesen and Parsons, 2002). This means an improvement with respect to a normal double glazing.

In addition, operating at similar comfort levels, the internal air is kept at a lower temperature than what is necessary with traditional heating systems (around 4 – 5°C) IQ Glass (2014), with consequently energy saving. This means that...
by maintaining the temperature of the glass surface near or slightly higher than the comfort level (usually 30°C), the indoor air temperature can be maintained to a lower level, saving around 8% of energy consumption per year for each air degree lowered in the room (Amunaz, 2013).

In summer, when the heated layer is turned off, the low Solar Heat Gain Coefficient (SHGC) of a low-emissivity glass pane can reduce the heat gains from solar radiation thus decreasing the cooling demand, especially in hot regions where the solar radiation is high, and achieving more energy savings in the year balance of the building. The value of this effect depends on the orientation of the façade, and it is more important in the South.

The EHG can be considered as part of the building envelope as well as part of the service system (La Ferla et al., 2004). The main component of this technology is the low-emissivity glass, which is used in common reflective glazing for its high optical transmission at visible wavelengths and effective reflection near infrared and infrared (i.e., heat) wavelengths. It is also known as Transparent Conductive Oxide (TCO), and its impact on the orientation of the façade, and it is more important in the South.

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The efficiency of the electrical energy use of heated windows is defined as the proportion of the electrical heat output which is used to cover the heat losses from the window and from the heating of the room, and it is inversely proportional to the U-value of an unheated window. Also it is practically independent of the inner surface temperature of windows, and can be expressed by a simple linear equation of U-value (Kurnitski, 2004).

According to IQ Glass (a commercial brand system) and tests by Laborelec in Belgium in 1990, EHG can produce energy savings of 25%, compared to a convection heating system (IQ Glass, 2014). Another study by CEBTP in 1997 for IQ Glass asserts that in a room where the glazed area is more than 1/3 of the total floor area, EHG is recommended. This study confirms that with traditional heating, air has to be heated to 25°C for the occupant to experience a sensation of approximating 20°C; with EHG, air temperatures of only 17.8°C provide a sensation of warmth of 22°C. The difference of 12.8°C to have same sensations can be expressed by a simple linear equation of U-value (IQ Glass, 2014).

Impact of the technology

The embodied environmental impact of EHG is equal to a low-e double glazing because it is using a standard product of building technology (low-e float glass), although glass material has significant environmental impacts due to the high energy intensity of its production process.

In the EU the total CO₂ emission for the float glass production was around 6,500 kton with average emissions of 697 kgCO₂ per ton of packed product (Standing Committee Of The European Glass Industries, 2010). According to the National Glass Association of Spain, in 2011 the domestic emission for the production of float glass was 520 kgCO₂/ton (Pejenaute, 2013).

The supply chain for the production and installation of EHG technology is very similar to conventional insulating glass for the building sector. The production of low-e coating float glass and installation of bar of the edge of the panes is undertaken by large companies such as AGC, Guardian, Pilkington and Saint-Gobain Glass. The assembly and electification is done by national manufacturers. Onsite installation of the glass curtain wall (for large scale glass façades) or in case of small scale buildings it is usually done by regional contractors.

Secondary industries are involved in the supply chain such as electrical manufacturers (for electric power transformer) and domestic home systems (for thermal regulation by thermostat or microprocessor equipment). Thus the economic impact of the EHG technology can be positive at a national and regional scale as several manufacturers and local companies are involved in the process of producing, assembling and installing the technology. Social impacts could be positive due to the potential for local employment, and the use of skilled workers. High qualified workers are needed in large companies for industrial production, as well as in the medium sized companies for the assembly. Low skilled workers are needed in local companies for the installation in the buildings.

Supply chain development

The adoption of EHG in the building sector will use existing industries and local contractors, therefore enhancing existing supply chains. The type of glass required is available in Spain because large companies can provide the main material (float glass), and local manufacturers can provide the coating layers, the electrode bus bars, and assemble the system.
Despite the fact that it could be generally available, the use of EHG is not yet widespread among stakeholders because of lack of demand. In 2008 there were four companies trying to introduce EHG in the building sector (Cytherm, Power-e, Termocristales and Eglass) but due to the economic crisis only one company (Control Glass) exists. These are collaborating with the Universidad Politécnica de Madrid to test the EHG performance in Madrid Region.

The Spanish national industry of float glass has 1,200 icons capacity of production per year with 7 plants belonging to 3 companies (AGC, Guardians and Sant-Gobain), € 500 million of turnover per year and 3,500 employees (Ministerio de Medio Ambiente, 2007). These figures show the relevant impact on the glass industry in the building manufacture and construction sector, particularly in the Spanish economy which depends significantly on construction activity. The importance of this technology lies in the novel approach, using normal products in a different way to solve problems emerging with the increase use of glazed façades.

The impact of transportation could be significant because the supply of main material and the localisation of glass industries are established by international large companies. This part of the supply chain cannot be modified because it depends on other industrial factors. However the impact of transportation could be reduced in the others stages as several regional manufacturers are producing glass for industry components and applications in the building sector.

### Lessons learned

This case study shows that EHG is an innovative technology of the building sector even though the components can be found in conventional products. The technologies can be employed in a different way, with a small change, to increase energy savings in buildings. Regarding the supply chain, it can be considered established as necessary glass factories and local manufacturers of the technological components are present within the Spanish building sector.

Despite this, further research is needed to demonstrate the efficiency of the EHG for commercial buildings in the Mediterranean climate, and more dissemination in order to improve the market acceptance.

A barrier for the large scale adoption of EHG may be the initial higher cost for the installation in comparison to conventional windows. Another barrier could be the commercial building market itself, because this sector is usually seeking low cost technology. At the moment there is no research or publication that shows if the energy savings in Mediterranean Regions can provide pay off the initial higher cost of implementation. Other barriers include mistrust due the limited knowledge of the new products among the stakeholders, especially when they are small local companies which lack experimentation on a large scale for different buildings. This barrier could be overcome with close collaborations between the glass industry and the research sector, evaluating the energy saving of EHG in different climate areas and considering the side effects and real impact on the energy demand of commercial buildings.

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Systems based approach to replicable low cost housing: renewable energy supply, storage and demand reduction

Staff at the Welsh School of Architecture at Cardiff University have recently designed and constructed the Solcer House to demonstrate how a systems based approach, combining renewable energy supply, energy storage and reduced demand technologies, can be integrated into the design of a typical house whilst significantly reducing energy use and carbon emissions. The Solcer House is capable, over an annual period, of generating more energy than it requires whilst the construction costs of the house are within the limits of typical affordable home. Regional manufacturers, suppliers and installers of low carbon technologies have been used wherever possible to maintain competitive costs and stimulate local supply chains.

Authors

Jo Patterson
patterson@cardiff.ac.uk
Ester Coma-Bassas
combe@cardiff.ac.uk
Fabrizio Varriale
varrialef@cardiff.ac.uk
Welsh School of Architecture, Cardiff University, Wales UK

Introduction

Staff at the Welsh School of Architecture at Cardiff University in the UK have designed and built Wales’ first low carbon ‘energy-positive’ house. The Solcer House (Figure 1) is capable, over an annual period, of exporting more energy to the national electricity grid than its uses. The overall aim of the Solcer House is to optimise a whole building energy system by combining building integrated renewable energy supply, energy storage and reduced energy demand for both thermal and electrical energy. This case study focuses on the design and construction of the affordable and replicable Solcer House.

Building low carbon dwellings is generally perceived to be costly and difficult in the current economic climate. However, the Solcer House has been built with market technologies that are affordable, available ‘off the shelf’ and from local suppliers. The innovation is the combination of the components into a system and into the architectural design, to demonstrate how future houses can be built. The selected low carbon technologies are already available on the market but have been integrated into the building design rather than added using the conventional ‘bolt on’ approach. The project team hope to provide social and private housing sector with evidence that similar low carbon houses could be replicated at a regional scale at an affordable cost whilst stimulating the regional economy. Significant benefits for home occupants can be realised by delivering lower energy bills and a good quality indoor environment at a price that housing providers can afford.

Figure 1 – View of the Solcer House south elevation

The Solcer House has been built as part of the SOLCER (Smart Operation for a Low Carbon Energy Region) research project.
The project was funded through the Wales European Regional Development Fund (ERDF) Programme and is part of the Low Carbon Research Institute (LCRI) WEFO Programme (LCRI 2015), launched in September 2009 with funding of more than £15 million from ERDF through the Welsh Government and matched with £19 million from Welsh Universities and industry. The Solcer project ran from September 2012 to February 2015 and received £3 million pounds of funding. The project team were located across Wales at Cardiff University, Swansea University, Glyndŵr University and the University of South Wales who, working with a broad range of stakeholders, investigated a broad systems-based approach combining renewable energy supply, storage and reduced demand at a range of scales from component to building to regional scale.

The Solcer House is sited near Bridgend in South Wales, UK. It is located on an industrial site owned by Cenin Cement Ltd, a company producing low carbon cement through a manufacturing process powered by renewable energy, which is generated on site by a 735 KW photovoltaic farm. A 1.5 MW wind turbine is planned to be installed on site in November 2015 together with an anaerobic digestion plant which will generate up to 3 MWh of electricity.

**Description of the project**

The Solcer House is a three-bedroom, four-person unit, designed in accordance with affordable housing requirements. Its 100 m² of habitable space is slightly more generous than affordable housing standards (Nominal Floor Area: 90 m², WG 2015) and has been designed with the potential to be constructed in a terrace, as a semi-detached or detached dwelling.

The Solcer House has been designed to meet social housing standards (WG 2005) with the layout and specifications of a typical UK dwelling. However, the building cannot be actually used as a residence due to funding and planning restrictions, and is therefore being used as office space and a demonstration and training centre. The design complies with UK Building Regulations, Lifetime Homes (Habinteg 2010., Development Quality Requirements (WG 2005), and the construction was conducted under the Considerate Constructors Scheme (CCS 2015) and the NICEIC standard for electrical works (NICEIC 2015). The building has been certified as BREEAM Excellent and not under the Code for Sustainable Homes, as it is legally considered a commercial/office building. The construction of the house lasted 16 weeks and involved local contractors and manufacturers wherever practically feasible. The stages of the construction process can be seen in Figure 2.

The energy systems combine solar PV generation and battery storage to power the houses combined heating, ventilation and hot water system, as well as its electrical systems, which include low energy appliances and LED lighting, as illustrated in Figure 3.

The integrative approach to construction uses renewable energy supply systems as building elements. The south façade incorporates a Transpired Solar Collector (TSC) and the south facing roof comprises a glazed 4.3 kWp photovoltaic (PV) panel system. This approach reduces costs and improves the aesthetics of the building, avoiding the ‘bolt-on’ approach often associated with renewable energy systems in buildings.

The energy storage comprises a Victron Energy lithium ion system containing six lightweight batteries with a total 6.9 kWh capacity, located in the roof space. The distance between the PV roof and the battery system is as short as possible to minimise losses. Energy from the PV to the battery is via DC.

In order to minimise energy demand, the Solcer house was built with high levels of thermal insulation and airtightness. The innovative and energy efficient design features include low carbon cement, Structural Insulated Panels (SIPS), external insulated render and low emissivity double glazed windows and doors. The objective of the design was to reduce the operational energy needed over the lifetime of the house, as well as reducing the energy embodied in its construction. The house uses grid electricity supply when the PV – battery system is exhausted. The installation of the different components is illustrated in Figure 4.
In winter, space heating demand is met by pre-heating the external air through the south-facing TSC and through the mechanical ventilation heat recovery unit (MVHR). In case the pre-heating is not sufficient to reach the required temperature, a heat pump is used to supply the necessary heat to the air. The exhaust air is extracted from the kitchen and bathrooms and passed through the MVHR to recover the remaining heat before the air is extracted. The heat pump, also used to heat the Domestic Hot Water (DHW), is powered by the PV and battery storage system.

Impact of the project

Energy positive: by combining suitably sized renewable energy sources and storage together with demand reduction technologies and energy efficient design, a house could completely energy independent. However, in the current market conditions this stand-alone option is prohibitively expensive for large scale regional applications. The aim of the Solcer House was to demonstrate that an energy-positive dwelling can be cost effective if the optimum level of autonomy is achieved, so that over a year the house generates more energy than it needs.

Energy used in the house is taken directly from the PV. If supply exceeds direct demand at any time, excess energy is stored in the batteries. Once the batteries are fully charged the excess energy is then exported to the grid. Modelling the energy behaviour of the system suggests that the supply from the renewable supply or from the battery storage. In winter, it is expected that there will be times when the supply from the PV and the storage will not be sufficient, and therefore the house will use electricity from the grid. However, over the course of a year the house energy export-to-import ratio is 1.75, so for every kWh the house imports from the grid it exports 1.75 kWh to the grid. The modelled energy demand and supply is shown in Figure 5.

Figure 5 - Energy supply and surplus (kWh) in the Solcer house over a year, as modelled by the Welsh School of Architecture

Low cost: the final construction cost of the house is being analysed but the project team believes that a £120,000 budget is deliverable for a single unit (135 m² of floor space), with reductions of 10 – 15 % achievable when building several units together as a result of economies of scale. Therefore, the estimated cost of the house is around £1,000 /m², compared with a typical UK social housing benchmark of £800 – £1,000 /m².

Figure 6 compares the costs for building components for the Solcer house with those for a typical UK housing unit. Costs for structural works and systems in the Solcer House are higher than a typical unit explained by structural function of the SIPS and the larger quantity of ‘technology’ installed in the Solcer house in comparison to conventional heating and electrical systems. However, external and internal works are less due to the role of the SIPS panels. Further cost savings could be achieved such as future reductions in battery prices as a result of market developments and faster installation times as contractors become more familiar with technological components.

Low Carbon: the Solcer team has performed an estimation of CO2 emissions embodied in the house materials and products, from the extraction to the manufacturing phase ('cradle-to-gate' boundary). This is illustrated in Figure 7. The estimated result of 340 kgCO2/m² (Kg of equivalent CO2 per m² of habitable area). Considering that energy systems are included in the estimate, this figure compares quite well with benchmarks that can be found in embodied carbon studies for UK buildings. For example, the BedZed housing project included in the estimate, this figure compares quite well with benchmarks that can be found in embodied carbon studies for UK buildings.

The components of the Solcer House have been sourced, as far as reasonably practicable, from Welsh manufacturers and installers, and the house will be used as a demonstration of advanced Welsh construction technologies.
BSI standard PAS 2050:2011 Specification for the assessment of the life cycle greenhouse gas emissions of goods. The considerable reduction of CO₂ emissions from the production of cement at Cenin is achieved by:

- increasing the percentage of recycled material in the cement, which reduces the overall embodied carbon of the input material;
- generating the energy used in the factory through renewable energy sources, which reduces the carbon emissions associated with the manufacture phase.

Structure/walls: The structural function in the Solcer house is delivered by Structural Insulated Panels (SIPS), which are vertical or horizontal elements made of two layers of oriented strand board containing a thermally insulating core of expanded polystyrene (EPS). SIPS are prefabricated at the plant and assembled on-site through a relatively fast process. This technology was chosen to enable a short construction time. 194 mm SIPS, rather than the standard thickness of 150 mm, have been used to provide a U-value of 0.14 W/m²K. The insulated render covering the external walls minimises the risk of thermal bridging and brings the overall wall U-value to 0.13 W/m²K. The SIPS were supplied by SIPS Eco Panels located in Scotland, transported to site by lorry in one trip and installed by a local company, SIPS Wales.

Roof: The asymmetrical design with a larger south-facing roof, was manufactured and installed by Central Roofing South Wales, based in Bridgend near the site.

PV panels: The south-facing roof accommodates 40 m² of PV integrated into clear cladding. The panels, designed and manufactured by the Welsh manufacturer GB-Sol, provides 4.3 Kwp of power. Integrating renewable sources into the structure helps not only to bring daylight into the building but also to bring cost down by not requiring any roof tiles.

Battery: At the start of the project the research team planned to use a lead acid battery, but a reinforced structure was designed to support its weight. Through research within the broader Solcer project the team switched to a lighter weight lithium ion alternative produced by Victron Energy, located in The Netherlands. The unit comprises six batteries with a total 6.9 kWh capacity. These can discharge up to 80% of capacity, while a lead acid battery can only discharge up to 50% of its capacity. Despite being a more expensive option, the discharge capacity and the lifetime of the battery together with reliability and the ability to remote monitor the performance proved to make this a more favourable option. All the electrics and battery system was installed by the local company Ecolek, based in Ebbw Vale, South Wales.

Transpired solar collector (TSC): The upper level of the south facing elevation incorporates a 17 m² TSC. This consists of a thin metal layer with small perforations that allow the air to pass through. During the day the metal layer is heated by solar radiation, and a fraction of this heat is passed to the air that is drawn inside the cavity behind the metal layer. The air is then drawn into the ventilation system and distributed into the building. The TSC, the standing seam roof and the rainfall water hardware were manufactured and installed by Central Roofing South Wales, a local company.

heating, ventilation and hot water system: The house is equipped with a Mechanical Ventilation with Heat Recovery (MVHR) system. The house is so well thermally insulated that the hot water requirement significantly exceeds the demand for space heating. The 450 W heat pump is run by the PV/battery system or from the grid if necessary. The heat from the exhaust air is also recovered to warm the domestic hot water supply. This system is unusual and was manufactured by Genvex, located in Denmark, and installed by a specialist supplier, located on the Wales/England boarder (Total Home Environment).

Lighting: LED lightings are fitted throughout the building, ensuring an energy-efficient lighting system.

Windows: All windows have aluminium clad timber frames incorporating Pilkington energiKareTM glazing, and were manufactured and installed by the Cardiff-based company Vel lace.

A key aspect of the systems based approach used in the Solcer house is taking a flexible approach to supply and installation. Two of the key stakeholder’s of the project, the construction manager – Roman Projects – and the electrical installers – Ecollek – displayed a strong commitment to the project, acting in a flexible way and suggesting improvements based on experience, skills and a desire for the market to move forward. This enhanced the project, contributing significantly to its success.

Lessons learned

Now that the Solcer house has been built the key task is to ensure that all of the installed technologies are monitored to assess the operation and measure the actual energy use of the building. This information will be used to inform future projects and industry partners to ensure that Wales remains at the heart of the development of a zero carbon housing future. The building demonstrates leading edge low carbon supply, storage and demand technologies at the domestic scale, which the Solcer team hopes will be replicated in other areas of Wales and the UK in the future.

The Solcer project has shown successful collaboration between academia, industry and government which has taken place as a result of the LCR’s HEFCW Reconfiguration and WEFO Convergence Programmes (2008 to 2015). The project has been a learning opportunity for all stakeholders involved. For some of the installers it was the first time experience of the components, so a significant learning experience was gained from the project. They are already applying the systems based approach into other buildings as a result of working on the project.

For more information on the Solcer House, see @LowCarbon_House; for information on the Solcer Project, see www.solcer.org

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### Contact details

#### Austria

<table>
<thead>
<tr>
<th>Name</th>
<th>Email</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ingrid Kaltenegger</td>
<td><a href="mailto:ingrid.kaltenegger@joanneum.at">ingrid.kaltenegger@joanneum.at</a></td>
<td>Joanneum Research, Elisabethstrasse 18/I, A-8010 Graz, Austria</td>
</tr>
<tr>
<td>Herwig Hengsberger</td>
<td><a href="mailto:herwig.hengsberger@passivhausplus.at">herwig.hengsberger@passivhausplus.at</a></td>
<td>IG PASSIVHAUS PLUS, Reinhagassstrasse 5, A-8020 Graz, Austria</td>
</tr>
<tr>
<td>Gerald Leindecker</td>
<td><a href="mailto:office@iap.eu">office@iap.eu</a></td>
<td>Institute of Analytical Structure Development Planning (IAP3), Austria</td>
</tr>
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#### Belgium

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<thead>
<tr>
<th>Name</th>
<th>Email</th>
<th>Institution</th>
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<tbody>
<tr>
<td>Jean-Marie Hauglustaine</td>
<td><a href="mailto:jmhauglustaine@ulg.ac.be">jmhauglustaine@ulg.ac.be</a></td>
<td>Department of Sciences and Environmental Management, University of Liege</td>
</tr>
<tr>
<td>Stéphane Monfils</td>
<td><a href="mailto:stephane.monfils@ulg.ac.be">stephane.monfils@ulg.ac.be</a></td>
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#### Bulgaria

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<th>Name</th>
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<tbody>
<tr>
<td>Elena Dimitrova</td>
<td><a href="mailto:eldim_far@uacg.bg">eldim_far@uacg.bg</a></td>
<td>University of Architecture, Civil Engineering and Geodesy (UACEG), 1 Hristo Smirnenski Blvd, Sofia 1046, Bulgaria</td>
</tr>
<tr>
<td>Roumiana Zaharieva</td>
<td><a href="mailto:roumiana.zaharieva@gmail.com">roumiana.zaharieva@gmail.com</a></td>
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#### Bosnia & Herzegovina

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<tr>
<th>Name</th>
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<tr>
<td>Jovan Todorovic</td>
<td><a href="mailto:jovan.todorovic@elprenosbih.ba">jovan.todorovic@elprenosbih.ba</a></td>
<td>Elektroprenos BiH, 78000 Banja Luka, Marije Bursač 7a, Bosnia &amp; Herzegovina</td>
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#### Cyprus

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<tr>
<th>Name</th>
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<tbody>
<tr>
<td>Lora Nicolaou</td>
<td><a href="mailto:loranicolau@gmail.com">loranicolau@gmail.com</a></td>
<td>Frederick University, Cyprus</td>
</tr>
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#### Denmark

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<th>Name</th>
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<tr>
<td>Jonna Maigaard Krarup</td>
<td><a href="mailto:jonna.krarup@kadk.dk">jonna.krarup@kadk.dk</a></td>
<td>Institute of Architecture, City and Landscape, The Royal Danish Academy of Fine Arts, Schools of Architecture, Design and Conservation, Philip de Langes Allé 10, 1435 Copenhagen, Denmark</td>
</tr>
<tr>
<td>Morten Elle</td>
<td><a href="mailto:elle@plan.aau.dk">elle@plan.aau.dk</a></td>
<td>Center for Design, Innovation and Sustainable Transition (DIST), Department of Planning and Development, Aalborg University – Copenhagen,</td>
</tr>
<tr>
<td>Maj-Britt Quitzau</td>
<td><a href="mailto:quitzau@plan.aau.dk">quitzau@plan.aau.dk</a></td>
<td>A. C. Meyers Vaene 15, DK-2450 Copenhagen SV, Denmark</td>
</tr>
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#### Finland

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<tr>
<th>Name</th>
<th>Email</th>
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<tbody>
<tr>
<td>Markku Norvasuo</td>
<td><a href="mailto:markku.norvasuo@aalto.fi">markku.norvasuo@aalto.fi</a></td>
<td>Aalto University, YTK Land Use Planning and Urban Studies Group, P.O. Box 12200, FI-00076 Aalto, Finland</td>
</tr>
<tr>
<td>Janne Roininen</td>
<td><a href="mailto:janne.roininen@aalto.fi">janne.roininen@aalto.fi</a></td>
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#### Germany

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<tr>
<th>Name</th>
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</thead>
<tbody>
<tr>
<td>Werner Lang</td>
<td><a href="mailto:w.lang@tum.de">w.lang@tum.de</a></td>
<td>Institute of Energy-Efficient and Sustainable Design and Building, Room 2221, Arcisstr. 21, 80333 München, Germany</td>
</tr>
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#### Greece

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<th>Name</th>
<th>Email</th>
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<tbody>
<tr>
<td>Evanthia Nanaki</td>
<td><a href="mailto:evananaki@gmail.com">evananaki@gmail.com</a></td>
<td>University of Western Macedonia, Bákola and Sialvera, 50100 Kozani, Greece</td>
</tr>
<tr>
<td>Christopher J. Koroneos</td>
<td><a href="mailto:koroneos@aix.meng.auth.gr">koroneos@aix.meng.auth.gr</a></td>
<td>Aristotle University of Thessaloniki - Laboratory of Heat Transfer and Environmental Engineering PO Box 483, 54124 Thessaloniki Greece</td>
</tr>
<tr>
<td>Demetri Bouris</td>
<td><a href="mailto:dbouris@fluid.mech.ntua.gr">dbouris@fluid.mech.ntua.gr</a></td>
<td>School of Mechanical Engineering, National Technical University of Athens</td>
</tr>
<tr>
<td>Country</td>
<td>Contact Person</td>
<td>Email</td>
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</tr>
<tr>
<td>Hungary</td>
<td>Ákos Nemcsics</td>
<td><a href="mailto:nemcsics.akos@kvk.uni-obuda.hu">nemcsics.akos@kvk.uni-obuda.hu</a></td>
</tr>
<tr>
<td></td>
<td>Ildikó Molnár</td>
<td><a href="mailto:molnar.ildiko@bgk.uni-obuda.hu">molnar.ildiko@bgk.uni-obuda.hu</a></td>
</tr>
<tr>
<td></td>
<td>Antal Úrmos</td>
<td></td>
</tr>
<tr>
<td>Ireland</td>
<td>Derek Sinnott</td>
<td><a href="mailto:dsinnott@wit.ie">dsinnott@wit.ie</a></td>
</tr>
<tr>
<td></td>
<td>Oliver Kinnane</td>
<td><a href="mailto:o.kinnane@qub.ac.uk">o.kinnane@qub.ac.uk</a></td>
</tr>
<tr>
<td></td>
<td>Tom Grey</td>
<td><a href="mailto:tom.grey@tcd.ie">tom.grey@tcd.ie</a></td>
</tr>
<tr>
<td></td>
<td>Paddy Phelan</td>
<td><a href="mailto:pphelan@ckea.ie">pphelan@ckea.ie</a></td>
</tr>
<tr>
<td>Israel</td>
<td>Guedi Capeluto</td>
<td><a href="mailto:arguedi@technion.ac.il">arguedi@technion.ac.il</a></td>
</tr>
<tr>
<td>Italy</td>
<td>Rossano Albatici</td>
<td><a href="mailto:rossano.albatici@unitn.it">rossano.albatici@unitn.it</a></td>
</tr>
<tr>
<td></td>
<td>Stefano Gialanella</td>
<td><a href="mailto:stefano.gialanella@unitn.it">stefano.gialanella@unitn.it</a></td>
</tr>
<tr>
<td></td>
<td>Elisa Armeni</td>
<td><a href="mailto:e.armeni@artigiani.tn.it">e.armeni@artigiani.tn.it</a></td>
</tr>
<tr>
<td>Latvia</td>
<td>Anatolijs Zabasta</td>
<td><a href="mailto:anatolijs.zabasta@rtu.lv">anatolijs.zabasta@rtu.lv</a></td>
</tr>
<tr>
<td></td>
<td>Nadezda Kunicina</td>
<td><a href="mailto:nadezda.kunicina@rtu.lv">nadezda.kunicina@rtu.lv</a></td>
</tr>
<tr>
<td></td>
<td>Leonids Ribickis</td>
<td><a href="mailto:leonids.ribickis@rtu.lv">leonids.ribickis@rtu.lv</a></td>
</tr>
<tr>
<td></td>
<td>Kaspar Kalnins</td>
<td><a href="mailto:kaspars.kalnins@rtu.lv">kaspars.kalnins@rtu.lv</a></td>
</tr>
<tr>
<td></td>
<td>Gundards Asmanis</td>
<td><a href="mailto:gundars.asmanis@rtu.lv">gundars.asmanis@rtu.lv</a></td>
</tr>
<tr>
<td></td>
<td>Edgars Labans</td>
<td><a href="mailto:edgars.labans@rtu.lv">edgars.labans@rtu.lv</a></td>
</tr>
<tr>
<td>FYR Macedonia</td>
<td>Todorka Samardziska</td>
<td><a href="mailto:samardziosa@gf.ukim.edu.mk">samardziosa@gf.ukim.edu.mk</a></td>
</tr>
<tr>
<td></td>
<td>Roberta Apostolska</td>
<td><a href="mailto:beti@pluto.iziis.ukim.edu.mk">beti@pluto.iziis.ukim.edu.mk</a></td>
</tr>
<tr>
<td>Malta</td>
<td>Ruben Paul Borg</td>
<td><a href="mailto:ruben.p.borg@um.edu.mt">ruben.p.borg@um.edu.mt</a></td>
</tr>
<tr>
<td>Norway</td>
<td>Luca Finocchiaro</td>
<td><a href="mailto:luca.finocchiaro@ntnu.no">luca.finocchiaro@ntnu.no</a></td>
</tr>
<tr>
<td></td>
<td>Aoife Houlihan Wiberg</td>
<td><a href="mailto:aoife.houlihan.wiberg@ntnu.no">aoife.houlihan.wiberg@ntnu.no</a></td>
</tr>
<tr>
<td></td>
<td>Annemie Wyckmans</td>
<td><a href="mailto:annemie.wyckmans@ntnu.no">annemie.wyckmans@ntnu.no</a></td>
</tr>
<tr>
<td></td>
<td>Arild Gustavsen</td>
<td><a href="mailto:arild.gustavsen@ntnu.no">arild.gustavsen@ntnu.no</a></td>
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### Poland

<table>
<thead>
<tr>
<th>Name</th>
<th>Email</th>
<th>Institution</th>
</tr>
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<tbody>
<tr>
<td>Jan Górski</td>
<td><a href="mailto:jagorsi@agh.edu.pl">jagorsi@agh.edu.pl</a></td>
<td>Faculty of Energy and Fuels, AGH University of Science and Technology, al. Mickiewicza 30, 30-059 Krakow, Poland</td>
</tr>
<tr>
<td>Mariusz Filipowicz</td>
<td><a href="mailto:filipow@agh.edu.pl">filipow@agh.edu.pl</a></td>
<td></td>
</tr>
<tr>
<td>Leszek Kurcz</td>
<td><a href="mailto:kurcz@agh.edu.pl">kurcz@agh.edu.pl</a></td>
<td></td>
</tr>
<tr>
<td>Adam Rybka</td>
<td><a href="mailto:akbyr@prz.edu.pl">akbyr@prz.edu.pl</a></td>
<td>Rzeszow University of Technology, Warszawy 12 35-959, Rzeszow, Poland</td>
</tr>
<tr>
<td>Karolina Kozłowska</td>
<td><a href="mailto:kkozloowska@prz.edu.pl">kkozloowska@prz.edu.pl</a></td>
<td></td>
</tr>
<tr>
<td>Magdalena Sęp</td>
<td><a href="mailto:sep@prz.edu.pl">sep@prz.edu.pl</a></td>
<td></td>
</tr>
<tr>
<td>Anna Pomykala</td>
<td><a href="mailto:pomykalcia@gmail.com">pomykalcia@gmail.com</a></td>
<td></td>
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### Portugal

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<thead>
<tr>
<th>Name</th>
<th>Email</th>
<th>Institution</th>
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<tbody>
<tr>
<td>Helena Corvacho</td>
<td><a href="mailto:corvacho@fe.up.pt">corvacho@fe.up.pt</a></td>
<td>Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, s/n, 4200-465 Porto</td>
</tr>
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### Romania

<table>
<thead>
<tr>
<th>Name</th>
<th>Email</th>
<th>Institution</th>
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<tbody>
<tr>
<td>Radu Andrei</td>
<td><a href="mailto:radu.andrei.d@gmail.com">radu.andrei.d@gmail.com</a></td>
<td>Technical University Gheorghe Asachi, 43 Prof. Dimitrie Mangeron Str., Code 700050, Iasi, Romania</td>
</tr>
<tr>
<td>Vasile Boboc</td>
<td><a href="mailto:vboboc1956@yahoo.com">vboboc1956@yahoo.com</a></td>
<td></td>
</tr>
<tr>
<td>Alina Mihaela Nicuta</td>
<td><a href="mailto:alinanicuta@yahoo.com">alinanicuta@yahoo.com</a></td>
<td></td>
</tr>
<tr>
<td>Ionela Botezatu</td>
<td><a href="mailto:ella_scanteianu@yahoo.com">ella_scanteianu@yahoo.com</a></td>
<td></td>
</tr>
<tr>
<td>Mihaela Condurat</td>
<td><a href="mailto:conduratmihaela@yahoo.com">conduratmihaela@yahoo.com</a></td>
<td></td>
</tr>
<tr>
<td>Diana Nicoleta Dragoslav</td>
<td><a href="mailto:dianadima3006@yahoo.com">dianadima3006@yahoo.com</a></td>
<td></td>
</tr>
<tr>
<td>Gheorghe Lucaci</td>
<td><a href="mailto:gheorghe.lucaci@ct.upt.ro">gheorghe.lucaci@ct.upt.ro</a></td>
<td>Polytechnic University of Timisoara, Romania</td>
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### Serbia

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<thead>
<tr>
<th>Name</th>
<th>Email</th>
<th>Institution</th>
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<tbody>
<tr>
<td>Aleksandra Krstic-Furundzic</td>
<td><a href="mailto:akrstic@arh.bg.ac.rs">akrstic@arh.bg.ac.rs</a></td>
<td>University of Belgrade, Faculty of Architecture Bulevar kralja Aleksandra 73/I, Belgrade, Serbia</td>
</tr>
<tr>
<td>Aleksandra Djukic</td>
<td><a href="mailto:adjukic@afrodita.rcub.bg.ac.rs">adjukic@afrodita.rcub.bg.ac.rs</a></td>
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### Slovenia

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<tr>
<th>Name</th>
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<tbody>
<tr>
<td>Metka Sitar</td>
<td><a href="mailto:metka.sitar@um.si">metka.sitar@um.si</a></td>
<td>Faculty of Civil Engineering, Transportation Engineering and Architecture, University of Maribor</td>
</tr>
<tr>
<td>Vlasta Krmelj</td>
<td><a href="mailto:vlasta.krmelj@energap.si">vlasta.krmelj@energap.si</a></td>
<td>EnergaP - Energy Agency of Podravje, Institution for Sustainable Energy Use</td>
</tr>
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### Spain

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<tr>
<th>Name</th>
<th>Email</th>
<th>Institution</th>
</tr>
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<tbody>
<tr>
<td>Jaume Roset Calzada</td>
<td><a href="mailto:jaime.roset@upc.edu">jaime.roset@upc.edu</a></td>
<td>Universitat Politecnica de Catalunya, Barcelona, Spain</td>
</tr>
<tr>
<td>Petra Amparo Lopez Jiménez</td>
<td><a href="mailto:palopez@upv.es">palopez@upv.es</a></td>
<td>Hydraulic and Environmental Engineering Department, Universitat Politécnica de València</td>
</tr>
<tr>
<td>Giuseppe La Ferla</td>
<td><a href="mailto:g.laferla.licitra@gmail.com">g.laferla.licitra@gmail.com</a></td>
<td>Construction and Architectural Technology Department, Universidad Politécnica de Madrid/ Chapman Taylor, Spain</td>
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### Switzerland

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<thead>
<tr>
<th>Name</th>
<th>Email</th>
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</thead>
<tbody>
<tr>
<td>Vicente Carabias</td>
<td><a href="mailto:cahu@zhaw.ch">cahu@zhaw.ch</a></td>
<td>ZHAW Zurich University of Applied Sciences, Institute of Sustainable Development, Switzerland P.O. Box 8401 Winterthur, Switzerland</td>
</tr>
</tbody>
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### United Kingdom

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<thead>
<tr>
<th>Name</th>
<th>Email</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jo Patterson</td>
<td><a href="mailto:patterson@cardiff.ac.uk">patterson@cardiff.ac.uk</a></td>
<td>Welsh School of Architecture, Cardiff University, Bute Building, King Edward VII Avenue, Cardiff, CF10 3NB, Wales U.K.</td>
</tr>
<tr>
<td>Fabrizio Varriale</td>
<td><a href="mailto:varrialef@cardiff.ac.uk">varrialef@cardiff.ac.uk</a></td>
<td></td>
</tr>
<tr>
<td>Ester Coma Bassas</td>
<td><a href="mailto:comae@cardiff.ac.uk">comae@cardiff.ac.uk</a></td>
<td></td>
</tr>
</tbody>
</table>
COST (European Cooperation in Science and Technology) is a pan-European intergovernmental framework. Its mission is to enable break-through scientific and technological developments leading to new concepts and products and thereby contribute to strengthening Europe’s research and innovation capacities. It allows researchers, engineers and scholars to jointly develop their own ideas and take new initiatives across all fields of science and technology, while promoting multi- and interdisciplinary approaches. COST aims at fostering a better integration of less research intensive countries to the knowledge hubs of the European Research Area. The COST Association, an International not-for-profit Association under Belgian Law, integrates all management, governing and administrative functions necessary for the operation of the framework. The COST Association has currently 36 Member Countries.

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This book presents work undertaken as part of the COST Action Smart Energy Regions (SMARTER). Case studies are presented illustrating good practice being used to enhance skills, knowledge, training and supply chains associated with energy and low carbon agenda at a regional scale across the 27 European countries participating in the Action.

The skills, knowledge and training section provides a summary of different types of education and training opportunities available, helping to identify gaps where further education and training are required to enable a large scale roll out for low carbon technologies. The investigation into supply chains illustrates how businesses within the low carbon technology sector can be strengthened and supported further.

This work supports the broader aims and objectives of the Smart Energy Regions COST Action to investigate the drivers and barriers that may impact on the large scale implementation of low carbon technologies in the built environment essential to meet the targets for sustainable development set by the EU and national governments. This publication is part of suite of outputs from the Smart Energy Regions COST Action investigating different aspects associated with implementation of the low carbon agenda at a region scale.

This publication is supported by COST.