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Collaborative Project (ii) Large-scale integrating project

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This report consists of 32 pages.
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Freiburg, Thursday, 28 February 2013

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1 Executive summary

Recent studies by Fraunhofer ISE[1] reliably prove that electricity and heat supply systems for Germany based completely on renewable energy sources would cause lower macroeconomic costs than the current energy system relying mainly on nuclear and fossil fuels. The total costs for the construction, operation & maintenance and financing of a German electricity and heating supply system based on 100 % renewable energy sources would thus be lower than the costs which are incurred today (comprising construction, operation & maintenance, fuel costs and financing) to supply electricity and heat. This scenario was calculated using current global market prices, and does not take any projected price increase for fossil fuels into account, although this can be anticipated. In the study, it is assumed that the required photovoltaic (PV) and solar thermal systems can be installed exclusively on roofs and building façades, i.e. that building envelopes offer a sufficiently large potential surface area. It is of course rational to use the available roof surfaces of a building first, as they usually receive more solar radiation than the façades. Particularly for taller buildings, however, the roof area is often relatively small compared to the entire building envelope. Furthermore, the roof area of high-rise buildings is often completely occupied by equipment for technical building services such as cooling towers, chillers and similar installations. In these cases, it is also sensible to use the façades for PV and solar thermal purposes. Recognition of these facts, combined with the national and European goal of CO_2 neutrality for the building stock by 2050, means that a strong increase can be expected in the number of solar energy components mounted on buildings or integrated into the building envelope. Such building integrated facade components have to be customized so that they meet the individual requirements of the building under consideration (sizes, wind load, safety barrier function, …). Such customized components will be manufactured in most cases by local manufacturers on demand. This means that such locally produced innovative components are a big chance for European manufacturers on the European market. Within this project we

- developed a set of 5 of new façade components and systems:
  - a glazing integrated transparent solar thermal collector
  - air-heating vacuum tube collectors for façade application
  - an angle-selective transmittance BIPV-component
  - a facade integrated natural ventilation system with heat recovery
  - a solar assisted decentralized heat pump system using unglazed solar thermal collectors with plaster covering.
- developed integrated (techno-economic) concepts consisting of technical concepts and corresponding business-models for the most important categories of existing high-rise buildings in Europe (EU25). This includes also the identification of the most important categories of existing high-rise buildings.
- demonstrated the practical feasibility in two pilot buildings in Spain and Slovenia. The Slovenian pilot building has been added to the project within the within the project lifetime in order to be able to demonstrate more of the new technologies.

[1] http://www.ise.fraunhofer.de/de/veroeffentlichungen/veroeffentlichungen-pdf-dateien/studien-und-konzeptpapiere/studie-100-erneuerbare-energien-in-deutschland.pdf

2 Summary description of project context and objectives

The main objective of the EU Cost Effective project is to convert facades of existing high-rise buildings into multifunctional, energy gaining components.

This project wants to contribute to the development of a competitive industry in the fields of energy-efficient construction processes, products and services, with the main purpose of reaching the goals of the EC set forth for 2020 and 2050 to address climate change issues and to contribute to improve EU energy independence. In 2009 the regulatory framework and the business environment for the construction sector has changed significantly in order to reduce the CO2-emissions of existing and new buildings. It is now officially agreed within Europe that Net-Zero-Energy buildings are the goal for the future. New buildings have to be net-zero after 2020, some public buildings already after 2018. Several national Governments (e.g. Germany) try to achieve a net-zero primary energy balance for the complete building stock until 2050 which is truly a grand challenge. In order to reach these goals two things have to be done:

- increase the efficiency, especially in case of existing buildings
- cover the remaining energy demand with renewable sources.

The two most challenging aspects resulting from these goals are:

- the number of buildings which have to renovated is really huge, which means that a lot of investments are to be done and which also means that much more labour for construction works is needed than currently available.
- in many cases, current processes and building components are not ready for a widespread and cost-effective implementation of energy-harvesting functionalities in the building skin.

Therefore a fundamental transformation of the construction sector is necessary in order to streamline the fragmented responsibilities and to develop business models which are attractive for third-party financing. This "great transition" implies the necessity of dramatic changes in the near future (see also "World in Transition – A Social Contract for Sustainability" Flagship Report 2011 of the Advisory Council of the German government on Global Change [http://www.wbgu.de/en/publications/flagship-reports/flagship-report-2011]). We are sure that these changes cannot be avoided. But we also expect a strongly increased activity in the building sector, especially in case of existing buildings.

The main project objectives include new façade components, business models, technical concepts and the demonstration in two pilot buildings. In more detail, the following items had to be reached:

- a set of 5 of new façade components and systems
  - a glazing integrated transparent solar thermal collector
  - air-heating vacuum tube collectors for façade application
  - an angle-selective transmittance BIPV-component
  - a facade integrated natural ventilation system with heat recovery
  - a solar assisted decentralized heat pump system using unglazed solar thermal collectors with plaster covering.
- integrated (techno-economic) concepts consisting of technical concepts and corresponding business-models for the most important categories of existing high-rise buildings in Europe (EU25). This includes also the identification of the most important categories of existing high-rise buildings.
- demonstrate the practical feasibility in two pilot buildings in Spain and Slovenia. The Slovenian pilot building has been added to the project within the within the project lifetime in order to be able to demonstrate more of the new technologies.

In order to reach this goals, a project plan was defined which is shown in the next figure (Figure 1).

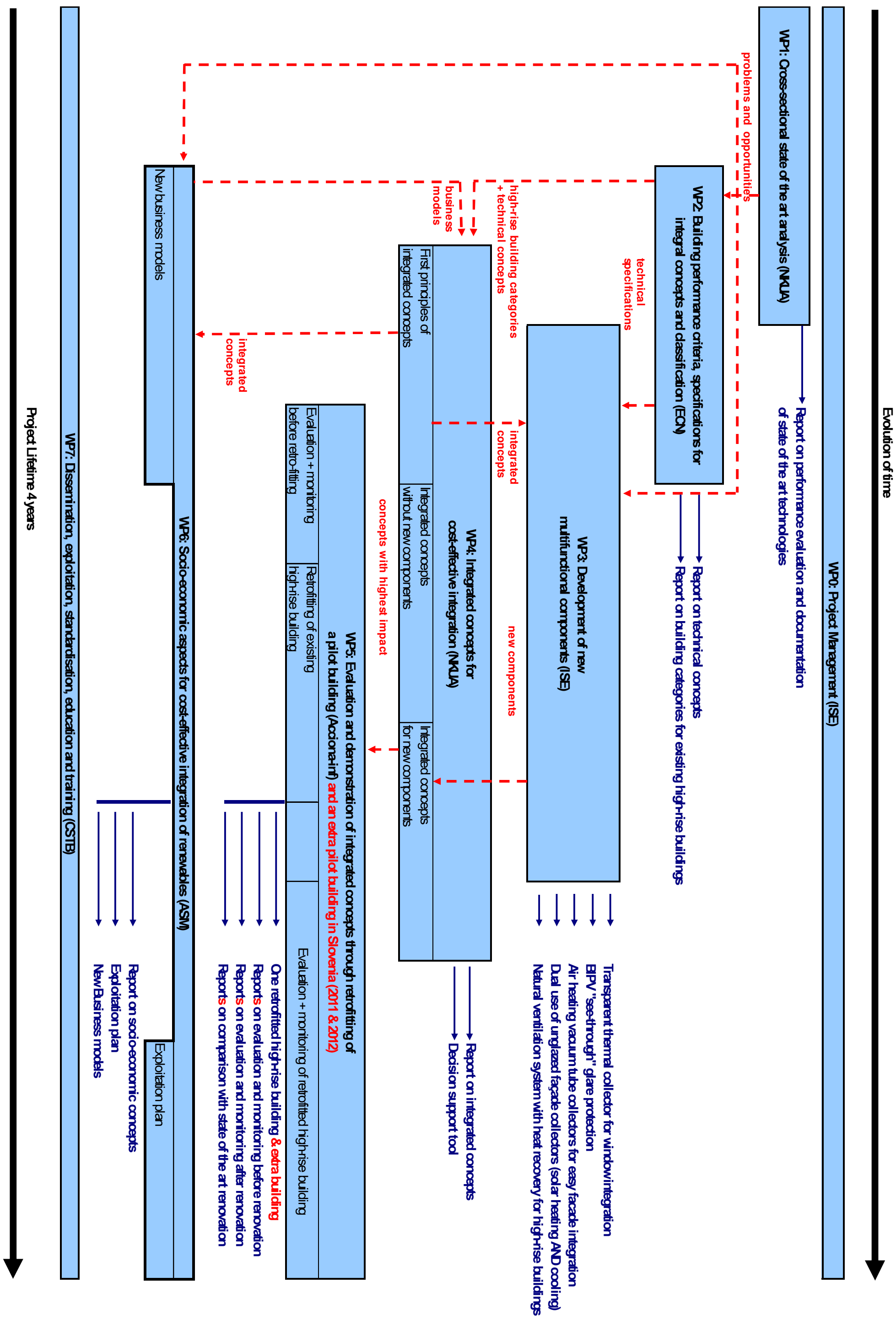


Figure 1 project plan – overview – including the additional SL pilot-building (amendment 2011&2012)

3 Description of the main S&T results/foregrounds

The primary task of the project is to develop and implement new and highly advanced integrated cost-effective façade concepts, based on new multi-functional components and/or new combinations of (improved) existing building envelope technologies in order to improve the primary energy balance of the building. Thus the project contributes (1) to convert renewable energy into useful forms for specific applications and (2) to significantly "improve the building energy performance through cladding and ventilation technologies and utilisation of embedded renewable energy sources" as addressed by the Call NMP- II.4.4.0-5

3.0 main results of WP0 (project management)

All meetings of project-steering bodies have been held regularly as planned. General decisions (like acceptance of new Partner Signet Solar etc.) have been taken in the General Assembly (GA) meetings. The project management board (PMB) met every 6 months in order to monitor the progress of the project. Fraunhofer ISE with the administrational help of PSE dealt with the day-to-day management of the project. The project management website for the internal communication is up and running since the start of the project. The project advisory committee provides very helpful comments for the steering of the project. The periodic reports have been submitted to and accepted by the EC. The same is true for the interim technical reports.

Within the project, the following publications have been produced:

- deliverable report: D0.1.4 »final publishable summary report« (this document)

3.1 main results of WP1 (cross-sectional state of the art analysis)

WP1 collected information necessary information and identified problems and opportunities in existing high-rise buildings in EU25, USA and China. Main results per task:

- **Task 1.1:** statistical information on existing and new high-rise buildings has been collected in order to determine the geographical distribution and the corresponding characteristics of high-rise buildings. We successfully completed the task. Nevertheless we recognised, that – especially in Italy and Spain – it was sometimes very difficult to get the necessary data.

- **Task 1.2:** problems and opportunities have been identified regarding the use of innovative systems in existing high-rise buildings. All existing information has been gathered and classified with respect to the identified technologies for high-rise buildings. For an analysis of Greek buildings see also (Karlessi, Santamouris et al. 2010).
- **Task 1.3:** a cross-sectional analysis of the performance of the various state-of-the-art energy and environmental technologies for high-rise buildings has been done. The results are presented in the public deliverable D1.4.1.

Within the project, the following publications have been produced:

- deliverable report: D1.4.1 » Report on performance evaluation and documentation of state-of-the-art technologies in EU25, USA and China (Synthesis of all the results of WP1)« (see http://www.cost-effective-renewables.eu/publications.php?type=brochure)
- a conference paper with the title » Analyzing the profile of High Rise Buildings in Greece: actions and recommendations for improving their performance« has been presented in 2010 at the PALENC conference in Greece (Karlessi, Santamouris et al. 2010)

3.2 main results of WP2 (Building performance criteria, specifications for integrated concepts and classification)

Within WP2 the specifications of the various building components with regard to energy consumption reduction goals and user comfort (performance-based) have been defined. In addition to that various new technical concepts for whole buildings have been developed, the potential performance of the new concepts has been assessed. And finally high-rise building categories together with typical buildings for each category have been established. The results of this work package are an important part of the basis for the work in WP4. The identified typical buildings where used as reference cases in WP3.

Within the project, the following publications have been produced:

- deliverable report: D2.1.1 »Report on categorisation of high-rise buildings« (see http://www.cost-effective-renewables.eu/publications.php?type=brochure)
- deliverable report: D2.1.2 » Report on identification of representative buildings per building category (set of representative buildings) « (see http://www.cost-effective-renewables.eu/publications.php?type=brochure)
- deliverable report: D2.1.3 »Set of four categories of buildings that have the highest impact on the energy conservation potential for

EU25. « (see http://www.cost-effective-renewables.eu/publications.php?type=brochure)

- deliverable report: D2.2.1 » Report on specified energy performance requirements for the buildings described in D2.1.3« (see http://www.cost-effective-renewables.eu/publications.php?type=brochure)
- deliverable report: D2.2.2 » Report on unambiguous technical/physical specifications for the building elements, components and constructions described in D2.1.3 « (see http://www.cost-effective-renewables.eu/publications.php?type=brochure)
- deliverable report: D2.3.1 » Report on optimisation and energy performance of the building elements, components and constructions described in D2.2.2.« (see http://www.cost-effective-renewables.eu/publications.php?type=brochure)
- deliverable report: D2.3.2 » Sketches of technical composition of building elements, components and constructions as described in D2.2.2. « (see http://www.cost-effective-renewables.eu/publications.php?type=brochure)

Building categories	Post-war, reinforced concrete structure with massive facade	Reinforced concrete with (precast) concrete façade	Skeleton construction with precast concrete panels (strip windows)	Skeleton construction with curtain-wall façade	Tall buildings, Skeleton construction with curtain-wall facade, air-conditioned
Image					
category	1	2	3	4	5
time line	1945-1965	1960-1980	1975-1990	1975-1995	1980-2005
main construction	reinforced concrete	reinforced concrete	reinforced concrete	reinforced concrete	reinforced concrete / steel
precast	no	possible	possible	no	no
facade	load bearing	load bearing	non bearing	non bearing	non bearing
stability	facade	facade/core	core	core	core
material facade	massive brick, brick cavity wall	brick, natural stone, stucco, ceramic tiles, glass cladding	concrete, metal cladding	metal profiles, metal cladding	metal profiles, metal cladding
glazing	single	single/double	double	double	double coated
windows	openable	openable	openable	openable/closed	closed
floor plan	lineair cell structure	lineair cell structure	core cell structure	cell/open structure	cell/open structure
air-conditioning	no	no	no	no	yes

Figure 2 high-rise building categories

3.3 main results of WP3 (Development of new multifunctional components)

WP3 is the biggest work package of the project (37% of the total budget). Its results are important input for WP2, WP4, WP5 and WP7. In particular, the following S&T results have been achieved:

- **Task 3.1:** two generations of prototypes of new transparent solar thermal façade collectors (TSTC) have been developed. The first generation is integrated in a sealed glazing unit, the second generation is integrated in a closed cavity façade. They have been characterised with detailed measurements and concepts for their integration in whole high-rise building heating, ventilation and cooling (HVAC) concepts have been developed. In WP5 he TSTCs have been installed in a pilot building in Slovenia. The installation in Slovenia is the first/one of the first applications where solar thermal facade collectors are used for solar cooling applications. Within the project, the following publications have been produced:
  - deliverable report: D3.1.2 »Prototype for transparent thermal collector for window integration« (see http://www.cost-effective-renewables.eu/publications.php?type=brochure)
  - a PHD-thesis with the title »theoretical and experimental analysis of semi-transparent solar thermal façade collectors« (Hauser, Michl et al. 2012) has been successfully finalised.
  - a paper has been published in the well-known journal "energy and buildings" (Maurer and Kuhn 2012).
  - the general ideas have been presented at EUROSUN 2008 (Hermann, Kuhn et al. 2008)
  - a conference paper has been published at the 12th Conference of International Building Performance Simulation Association (Maurer, Baumann et al. 2011)
  - a conference paper has been published at the Otti Thermie 2011 conference (Maurer et. al. 2011)
  - a conference paper has been published at the Solar Heating and Cooling Conference 2012 in San Francisco, USA (Maurer and Kuhn 2012).

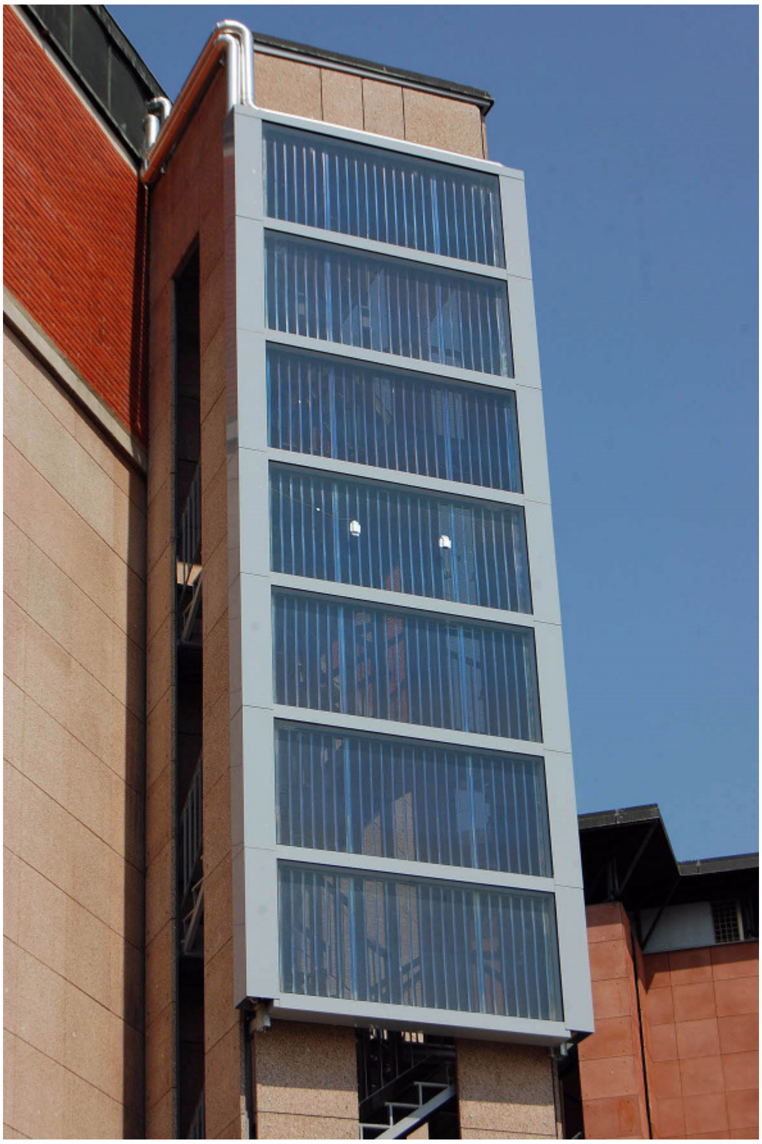


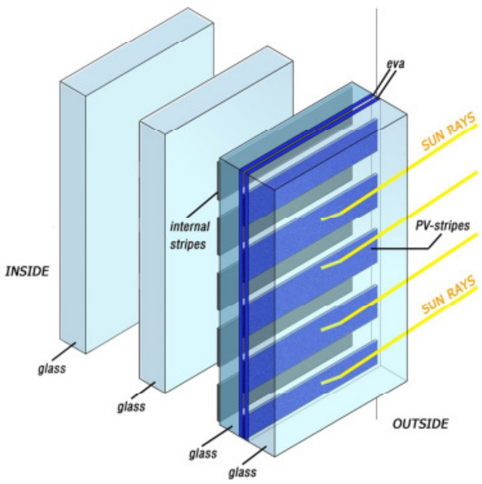
Figure 3 prototype transparent solar thermal façade collectors, installed at the pilot building in Slovenia.

- **Task 3.2:** prototypes of façade-integrated **solar-thermal vacuum tube collectors will be used to heat air directly** have been developed successfully. The heated air can be used directly for room heating in winter or in combination with solar heating and cooling systems. Because air is used as the heat transfer medium (simple handling of stagnation situations), easy façade integration is possible. In WP5 we successfully installed the new collectors in a pilot building in Slovenia. The fundamentals of the new collectors where the basis for the further development of the collector test standards in WP7. Within the project, the following publications have been produced:

- deliverable report: D3.2.2 »Prototype of an air heating vacuum tube collector for façade integration.« (see http://www.cost-effective-renewables.eu/publications.php?type=brochure)
- a conference paper has been published at the 22th Symposium Thermische Solarenergie, Bad Staffelstein (Germany) from 9 to 11 May 2012 (Welz, Di Lauro et al. 2012)

Figure 4 air-heating vacuum tube collectors (tubes in the middle) at the international trade fair Bau 2011 in Munich.

- **Task 3.3:** prototypes of a **glazing unit with integrated PV, which generates electricity and simultaneously provides solar control and glare protection** have been developed successfully. In WP5 we successfully installed the new PV-glazing in a pilot building in Cacéres, Spain. The solar control functionality significantly reduces the energy consumption of buildings because of lower cooling loads. The generated electricity helps to cover the primary energy demand of the building itself. Within the project, the following publications have been produced:
  - deliverable report: D3.3.2 »Description of prototype for BIPV component« (see http://www.cost-effective-renewables.eu/publications.php?type=brochure)
  - a PHD-thesis with the title » Daylight and solar control in buildings: general evaluation and optimization of a new angle selective glazing façade« (Frontini 2009) has been successfully finalised.
  - a conference paper has been published at the important conference PV-Sec 2011 (Sprenger, Solntsev et al. 2011)
  - a conference paper has been published at Eurosun 2010 (Frontini and Kuhn 2010).
  - a conference paper has been published at Plea 2011 (Frontini 2011)
  - a conference paper has been presented at the Otti BIPV conference in 2012
  - Fraunhofer ISE has initiated the process to protect the trademark PVShade®



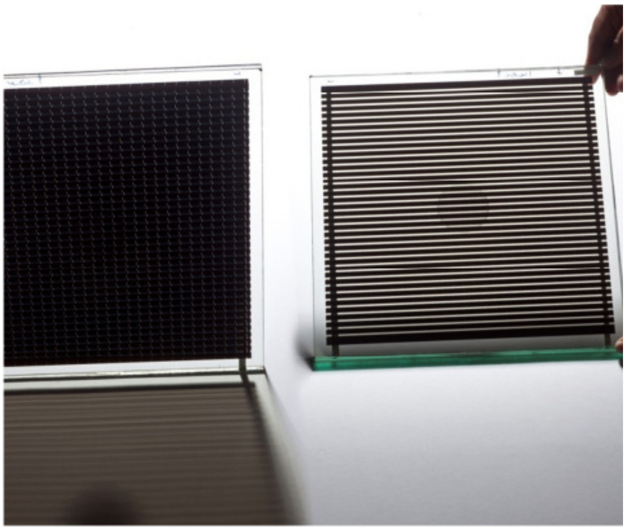


Figure 5 PVShade®

- **Task 3.4: A Façade-integrated natural ventilation concept with heat recovery** has been developed and demonstrated successfully. The cost effectiveness has been improved by eliminating the supply air ducting by using decentralized supply. The concept consists of local HVAC units placed in the façade which, without air ducting or fans (no noise!), supply preheated or cooled outside air to users. The unit can be driven by low-temperature energy sources, e.g. originating from exhaust air (twin coil) or from renewable energy sources. Within the project, the following publication **and patent** have been produced:
  - deliverable report: D3.4.2 »natural ventilation system with heat recovery – prototype report« (see http://www.cost-effective-renewables.eu/publications.php?type=brochure)
  - Alusta patent NL 2005006 for optimal integration of room heating in natural ventilation unit.

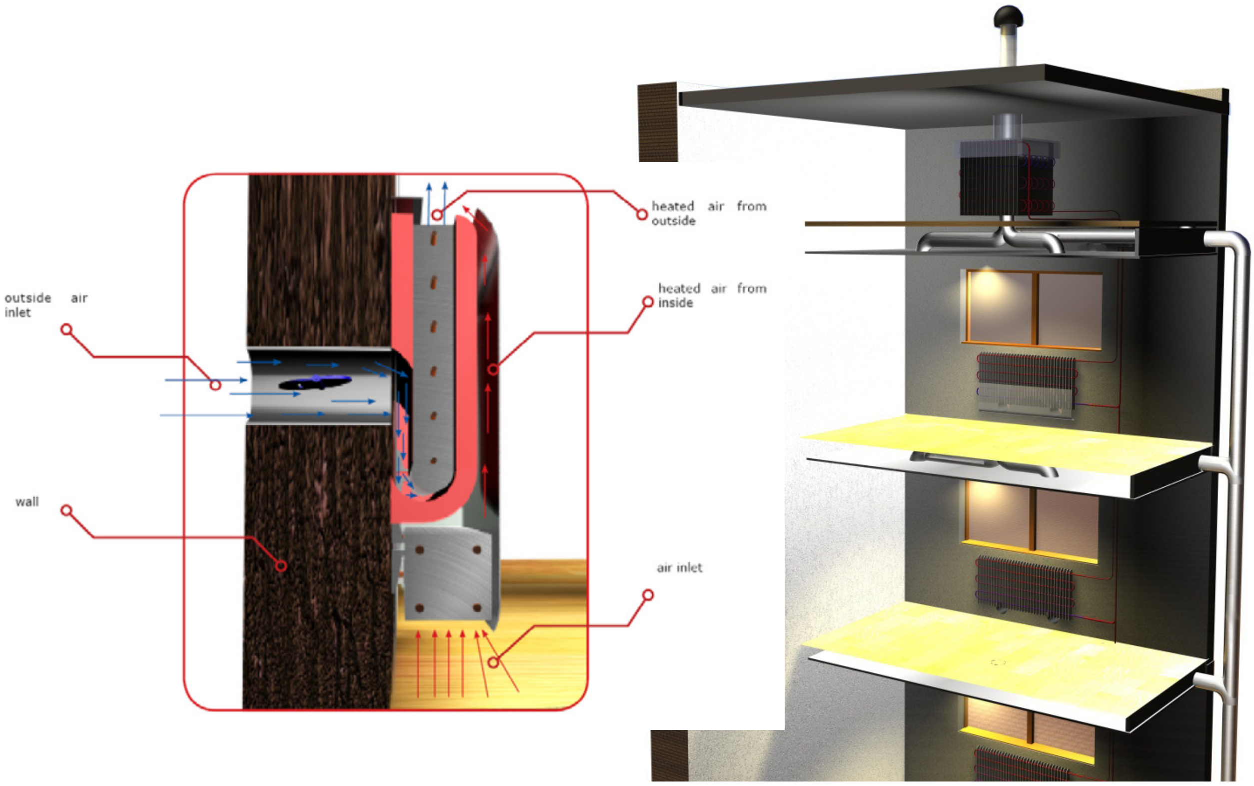


Figure 6 natural ventilation with heat recovery. The left side shows a sill area integrated device. On the right hand side the device is integrated in the suspended floor.

- **Task 3.5** developed successfully a heating/cooling system for high-rise buildings using active solar façade elements to take advantage of the available unglazed vertical surface. The system is composed of a cost effective active solar façade coupled to a reversible heat pump. The active façade works as a low temperature solar collector as well as an atmospheric heat exchanger and a nighttime heat-dissipater in order to boost the heating/cooling efficiency of the system. The first work exchanges have pointed out the technical issues and limitation such as condensation or frost formation on the façade and the need for heat storage means. Following, a number of concepts have been proposed, analysed and discussed, sometimes with the help of simulation. At this stage two main choices were maid: 100% thermodynamic: no use of direct electric heat as a back-up, even during coldest conditions, individual systems sized for one office. This preliminary work resulted in the general definition of a few retained concepts, then, EDF, ISE and Tecnalia have carried out detailed modelling and simulations of these concepts. Based on the results, several system modifications were proposed, analysed and discussed to reach a detailed system definition with sizing indications. As a conclusion, an additional air heat-exchanger for the heat pump has to be used in order to avoid condensation and frost formation on the façade in wintertime. Furthermore, an additional heat storage is needed since the times with heating demand and the times with solar gains are too disjoint. The heat storage capacity is a way to optimise the thermal transfers between them.

  In addition, a state of the art survey showed no existing heat-pump suitable for the application.
  STO manufactured a first façade collector and NIBE assembled a first heat pump prototype, both components were individually tested at ISE and showed the expected capability, furthermore, based on the test results, some improvements were identified to increase the performances. The complete system coupling both components was assembled at ISE in order to analyse the interactions.
  Meanwhile, EDF and NIBE worked on improved specifications for the heat pump and a second improved heat pump prototype was assembled and tested with the improved expected results. ISE and STO improved the façade collector based on the initial test results and manufactured a second façade collector prototype, tested at ISE.
  In parallel, the advanced control and regulation strategy of the system has been developed by EDF on the basis of simulations and with the help of the first test results. This control/regulation strategy allows the system to take the most benefit of the active façade. Finally, the complete system with the improved heat pump has been assembled and functionally tested .at EDF R&D Les Renardières.
  Within the project, the following publications have been produced:

- deliverable report: D3.5.2 »Dual use of unglazed façade collectors (solar heating and cooling)« (see http://www.cost-effective-renewables.eu/publications.php?type=brochure)
- the results have been presented at the 10th IEA Heat Pump Conference, Tokyo, Japan (Ruschenburg, Baisch et al. 2011)

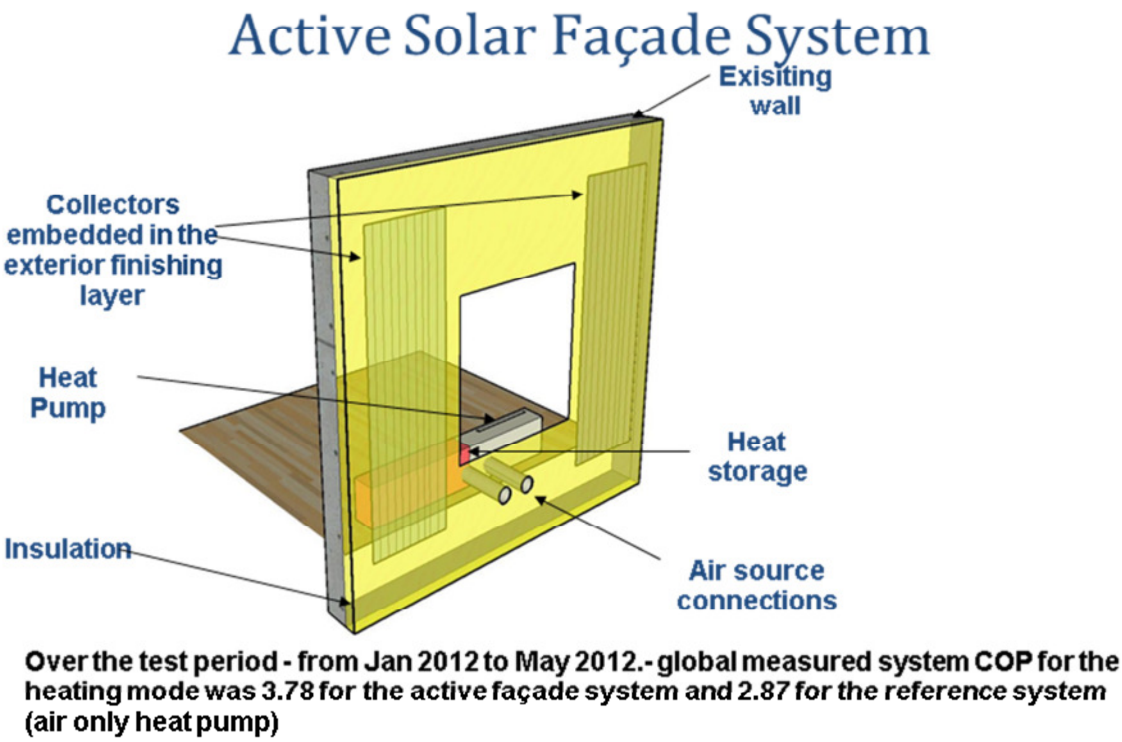


Figure 7 unglazed collector & heat-pump

3.4 main results of WP4 (integrated concepts for cost-effective integration of renewables)

New integrated techno-economic concepts (business models + technical concepts) including new and existing façade-integrated, energy-generating components based on renewable energy sources have been developed based on the technical concepts from WP2 and economic input from WP6. All concepts have been developed and fine-tuned with respect to:

- constructional aspects. A catalogue of solutions has been produced that helps the planners to integrate the new components. It contains ideas for the integration (deliverable 4.1.2).
- environmental aspects have been taken into account through LCA (life-cycle-assessment). See deliverable 4.1.3.
- a catalogue with ideas for the architectural and aesthetic integration has been produced (deliverable 4.1.4)
- the socio-economic aspects have been assessed with user assessments (deliverable 4.1.5)
- different possibilities for the integration in building management systems (BMS) have been described and analysed (deliverable 4.1.6).

The efficiency of the following concepts and components has been assessed in **long-term laboratory tests under pseudo-real conditions** (task 4.7):

- The new natural ventilation system with heat recovery has been tested in newly designed test facilities at the premises of TNO, NL.
- heat storage systems including model validation at the CSTB Sophia Antipolis test site. One of the Cost effective concepts for HVAC system uses three heat storage vessels. It has been experimentally assessed. Two real water vessels, one of 400L (HHS), one of 1000L (LHS) have been emulated in the semi-virtual laboratory. This experimentation showed that a global renewable energy source ratio of 46.0% for the HVAC system can be obtained, with a heating renewable energy source part of 63.5% and a cooling renewable energy source part of 36.7%.
- an active solar façade system using unglazed façade collectors and a reversible heat pump. Both components, façade collector and heat pump have been newly developed within the project and tested at the test facility ETNA (Les Renardières EDF R&D - France)
- The transparent BIPV-system PVShade® has been tested in a test facility on the roof of the Fraunhofer ISE building in Germany.

- the other tests which have been planned originally in task 4.7 have been moved to task 5.2, the Slovenian pilot building. This task has been added during the lifetime of the project and it allows to perform not only lab-tests but also pilot integration in a real building.

A decision support tool (DST) has be developed. The public version is dedicated to help to disseminate the results of WP4 to architects, planners, owners and tenants (see D4.1.8). The internal version of the decision support tool will help the industrial project partners to further optimise or newly develop cost-effective multifunctional energy-harvesting façade components.

Within WP4, the following publications have been produced:

- demonstration and practice on the public version of the DST in the framework of an educational seminar at the NKUA to post-graduate students of building physics
- D4.1.1 Report on the developed techno-economic integrated concepts. The re-port will focus on the four building cate-gories with the highest impact (delivered from WP2) and will describe all the de-tected practical difficulties.
- D4.1.2 Report including a catalogue of exam-ples on how to integrate the new con-cepts from a constructive point of view. The report will offer advice to façade consultants on how to integrate the new concepts in the construction.
- D4.1.4 A report in the form of a catalogue accessible through the web, describing design examples. The catalogue aims to offer the architects good aesthetical so-lutions for the integration of the new concepts and components.
- D4.1.5. A report on the detailed analysis of the socio-economic aspects of the inte-grated concepts for the four building categories with the highest impact.
- D4.1.6 A report including guidelines on how to implement the new concepts and com-ponents in building management sys-tems (BMS). For each of the concepts an implementation strategy will be developed.
- D4.1.7 A report describing the results of each of the laboratory tests. The report will in-clude and describe the common moni-toring protocol and the results of the cross-sectional analysis of all the test.
- deliverable power-point-tool: D4.1.8 »A DST tool including Case studies with examples and pictures of virtual and real buildings, support for planners on how to integrate the new concepts in building manage-

ment systems, Best practice catalogues, Examples of business models, test results for components, Support for design and commissioning of building management systems« This DST disseminates somehow the results of the whole WP4 in a user friendly way. (see http://www.cost-effective-renewables.eu/)

- a conference paper with the title »Determining the environmental influence of energy generating components for façade integration within existing high-rise buildings by means of LCA« at the LCM 2011 – Berlin – 28th to 31st of August 2011 (Lenz, Held et al. 2011)

Figure 8 Front-end of the decision support tool.

3.5 main results of WP5 (experimental evaluation and demonstration of integrated concepts in a pilot building)

The goal of this work package was to demonstrate new integrated concepts and some of the new components in one pilot building. Within the course of the project we added a second pilot building in order to be able to show more of the new components in pilot installations. We also assessed the performance of the installed concepts. As planned from the beginning of the project the assessment did not cover a full year but it provides insight in the performance of the new concepts and it delivers experiences from first pilot installations in real buildings.

Within the project, the following publications have been produced:

- deliverable report: D5.3.1 »Retrofitted high-rise building in Mediterranean climate« (see http://www.cost-effective-renewables.eu/publications.php?type=brochure)
- deliverable report: D5.3.2 »Retrofitted high-rise building in Slovenian climate« (see http://www.cost-effective-renewables.eu/publications.php?type=brochure)
  This is a voluntary extra deliverable, not mandatory!

Figure 9 pilot installation in the Spanish pilot building in Cacéres. Upper picture: New BIPV panel on the left part of the window. Lower pictures: Installation of the additional internal thermal insulation.

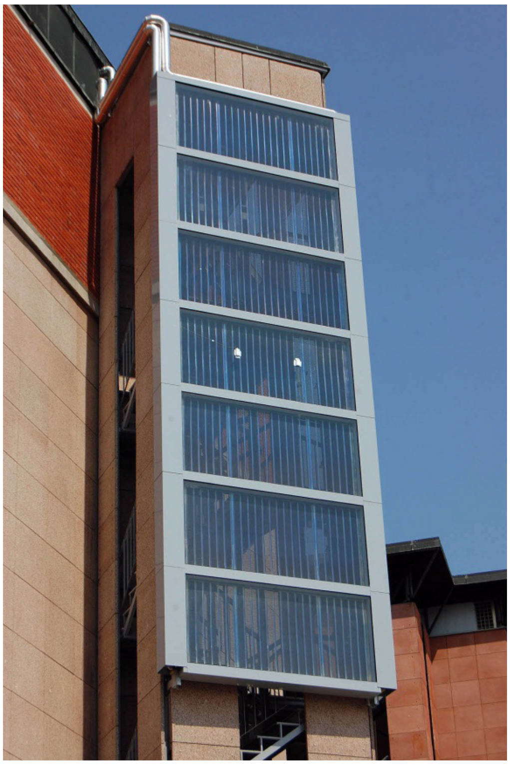



Figure 10 pilot installation in the Slovenian pilot building in Ljubljana. Air heating vacuum tube collectors (right) and transparent solar thermal collectors (left) are used for solar heating and cooling.

3.6 main results of WP6 (socio-economic & market aspects for cost-effective integra-tion of re-newables)

The main goal achieved within WP6 was to set up the basis for development and verification of business models allowing successful implementation of new technology developed in the project into the market.

At the beginning of the project market analysis for business models – with an overview of different renewable energy technologies was prepared. In this task also customers knowledge, perception, attitude towards multifunctional façade components as well as barriers towards renewables, expected added values and key success factors were identified.

Second step included identification of elements of new business models and the Most Important Customers. MIC included building owner/investor, building user/tenant and the ESCO (Energy Saving Company). Three business models types for retrofitting of high-rise buildings with renewable energy applications based on traditional assumptions were proposed: **product based business model** (transfer of the ownership at purchase**)**, **service based business**

model (no ownership transfer, value is delivered via access to the energy) and **product & service based business model** (partly transferred ownership, part of the value is delivered via access to the energy). An existing background and possibilities in particular the relations with traditional building process organisation model, innovative concepts, ideas, assessment tools, philosophies, etc. as an **approach towards innovative business models** development were analysed. The socio-economic justification of the business models was discussed through the field research in WP4. The economic feasibility of proposed business models is presented in a calculation (.xls) tool developed in task T.4.1 which allows a customer to co-design the Cost-Effective offer to meet his needs with regard to product or service features offered.

In order to verify the concepts with the market in-depth interviews with Most Important Customers - experts (ESCO) and potential clients group (investors/owners) were performed. As a result best solutions and business models were identified.

Within the project, the following publications have been produced:

- Report: D.6.1.1 »Report on market analysis (desk research)«
- Report: D.6.1.2 »Report on market analysis (field research) «
- Report: D 6.3.1 »Verification of business models«

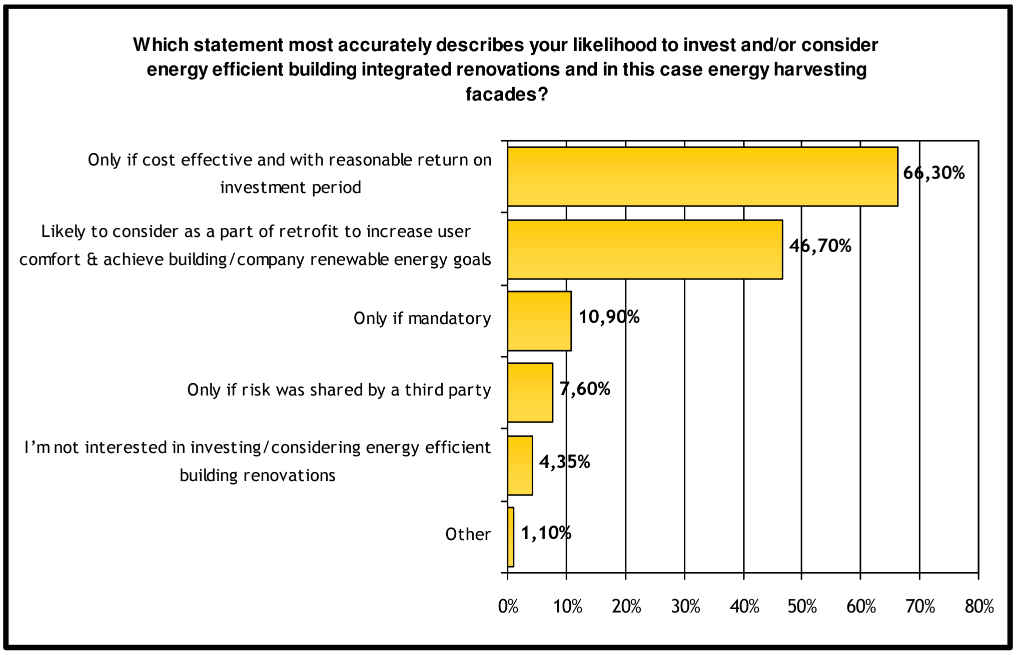


Figure 11 Likelihood to invest/consider energy efficient building integrated renovations (N=92)

3.7 main results of WP7 (Dissemination, Exploitation, Standardisation, Education and Training)

The goal of this work package was to disseminate project results (through European technology platforms, web-sites, news-letters, conferences, etc), to streamline national and European legislation through an active participation in standardisation committees and to elaborate material/guidelines for the training of professionals

Within WP7, the following publications have been produced:

- a public website www.cost-effective-renewables.eu providing access to the project results for the public.
- A set of 8 Newsletters (D7.2.1 to D7.2.8, to be downloaded on the public website) providing to the targeted audience regular information on project achievement.
- deliverable report: D7.3.1: Reports on meetings with NTPs. The project has been presented to the European Construction Technology Platform (ECTP), the Renewable Heating and Cooling Technology Platform (RHC) and the European PV Platform. We put the focus on ECTP since the project goals are in the focus of the E2B initiative of the E2B.
- deliverable report: D7.4.1: Brochure. A high-quality brochure was edited to promote the results of the project.
- deliverable report: D7.7.1: Proceeding of the Cost Effective Workshop held in Bressanone, Italy on 5th December 2011 in liaison with the 6th International ENERGY FORUM on solar building skins.
- deliverable report: D7.8.1: Report describing work performed within CEN/TC 312 concerning the integration of air heating solar collectors (requirements and test methods) in European standards.
- deliverable report: D7.9.1: Report on trade fair & University exhibitions. A video, presenting the project and the solar assisted decentralized heat pump system (available only in French) was prepared for the BATIMAT trade fair. This video can be downloaded at: http://stream.cstb.fr/batiment_durable/COSTEFECTIVE.wmv
- various articles edited in order to enhance the audience of the Cost effective project (EeB Project Review 2011 and 2012 for instance).

- a conference paper gave a general overview on the new façade technologies at the PALENC2010 conference in Greece (Kuhn, Herkel et al. 2010)

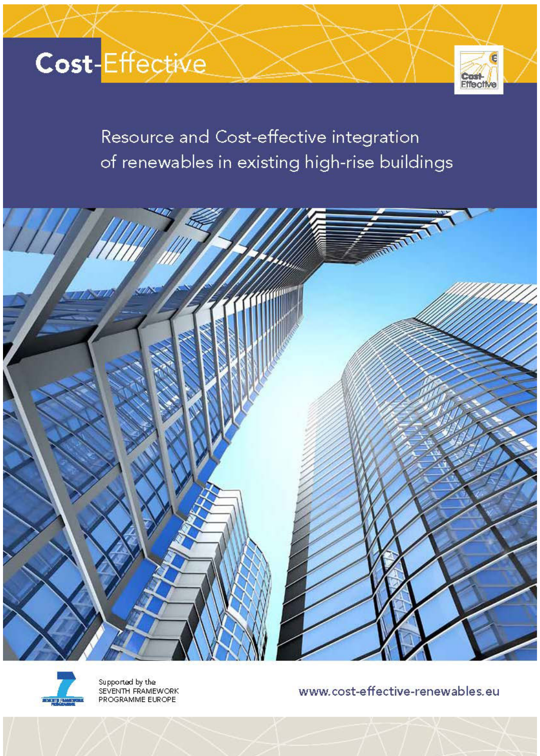


Figure 12 Cost Effective brochure

4 Potential impact

Recent studies by Fraunhofer ISE[2] reliably prove that electricity and heat supply systems for Germany based completely on renewable energy sources would cause lower macroeconomic costs than the current energy system relying mainly on nuclear and fossil fuels. The total costs for the construction, operation & maintenance and financing of a German electricity and heating supply system based on 100 % renewable energy sources would thus be lower than the costs

[2] http://www.ise.fraunhofer.de/de/veroeffentlichungen/veroeffentlichungen-pdf-dateien/studien-und-konzeptpapiere/studie-100-erneuerbare-energien-in-deutschland.pdf

which are incurred today (comprising construction, operation & maintenance, fuel costs and financing) to supply electricity and heat. This scenario was calculated using current global market prices, and does not take any projected price increase for fossil fuels into account, although this can be anticipated. In the study, it is assumed that the required photovoltaic (PV) and solar thermal systems can be installed exclusively on roofs and building façades, i.e. that building envelopes offer a sufficiently large potential surface area. It is of course rational to use the available roof surfaces of a building first, as they usually receive more solar radiation than the façades. Particularly for taller buildings, however, the roof area is often relatively small compared to the entire building envelope. Furthermore, the roof area of high-rise buildings is often completely occupied by equipment for technical building services such as cooling towers, chillers and similar installations. In these cases, it is also sensible to use the façades for PV and solar thermal purposes. Recognition of these facts, combined with the national and European goal of CO_2 neutrality for the building stock by 2050, means that a strong increase can be expected in the number of solar energy components mounted on buildings or integrated into the building envelope. Such building integrated facade components have to be customized so that they meet the individual requirements of the building under consideration (sizes, wind load, safety barrier function, …). Such customized components will be manufactured in most cases by local manufacturers on demand. This means that such locally produced innovative components are a big chance for European manufacturers on the European market. Components for the European market will mostly be produced in Europe since it would be too slow and too costly to produce such individual components in e.g. far east and to ship them to Europe. The new components developed in this project are therefore an important starting point for the participating industrial partners in this important upcoming market.

5 Project public website

The public project web site is up and running and can be found at:
www.cost-effective-renewables.eu
It contains all publications, newsletters and public scientific reports.

In addition to the public project web-site an internal project website has been installed for the exchange of documents, the documentation of the progress and for the tracking of action items from the regular PMB and GA project meetings.

Figure 13 public project web-site »www.cost-effective-renewables.eu«

6 Project logo

Figure 14 Logo of the FP7 Project Cost-Effective

7 List of all beneficiaries with the corresponding contact names

1 Fraunhofer Institute for Solar Energy Systems ISE (coordinating) / T. E. Kuhn
2 PSE AG / W. Warmuth
3 Acciona energia Solar (terminated after month 3) / Julio Carabe Lopez
4 Acciona Infraestructuras / Jesus Garcia Dominguez
5 Electricité de France – SA / Alain Marti
6 Acciona Instalaciones (replaced Acciona energia solar in month 3) / Silvio Vitali-Nari
7 Permasteelisa S.p.a. / Stefano Pavan
8 Bundesverband Solarwirtschaft e.V. (German Solar Industry Association) / Thomas Chrometzka
9 NIBE AB / Holger Svensson
10 Interpane Entwicklungs-und Beratungsgesellschaft mbH & Co KG / Lars Michel
11 Sto AG / Markus Zwerger
12 IPB GmbH Ingenieurgesellschaft für Energie- & Gebäudetechnik / Thomas Baumann
13 ASM - Centrum Badań i Analiz Rynku Sp. z o.o. / Aleksandra Oleksik
14 D'Appolonia S.p.A./ VIktorija Nvaikaité
15 Emmer Pfenninger Partner AG / Kurt Pfenninger
16 Kollektorfabrik GmbH & Co. KG / Kurt Schüle
17 Centre Scientifique et Technique du Bâtiment / Dominique Caccavelli
18 ECN Energy research Centre of the Netherlands (terminated in 2011) / Frans Koene
19 National and Kapodistrian University of Athens / Mattheos Santamouris
20 Labein Tecnalia / Jose Maseda
21 TNO Netherlands Organisation for Applied Scientific Research / Frans Koene & Piet Jacob
22 Universität Stuttgart (LBP) / Katrin Lenz
23 Slovenian National Building and Civil Engineering Institute / Sabina Jordan
24 Alusta natuurlijke ventilatietechniek BV / Andre W. J. Mester
25 Hidria IMP Klima d.o.o. / Erik Pavlovic
26 KOW Architectuur B.V. (terminated 2011) / Tjerk Rijenga
27 Signet Solar (signed CA and contributed, but never got a contract because of insecure financial status) / K.-H. Stegemann

Disclaimer

Cost-Effective is a Collaborative Project (CP) funded by the European Commission under FP7 COOPERATION - THEME 4 – 'NMP-2007-4.0-5 Resource efficient and clean buildings';
Contract: 212206 Start date of Contract: October 1st 2008; Duration: 4 years

8 Annex

8.1 List of newsletters and public project reports

WP0

- deliverable report: D0.1.4 »final publishable summary report«

WP1

- deliverable report: D1.4.1 » Report on performance evaluation and documentation of state-of-the-art technologies in EU25, USA and China (Synthesis of all the results of WP1)«

WP2

- deliv. report: D2.1.1 »Report on categorisation of high-rise buildings«
- deliverable report: D2.1.2 »Report on identification of representative buildings per building category (set of representative buildings)«
- deliverable report: D2.1.3 »Set of four categories of buildings that have the highest impact on the energy conservation potential for EU25.«
- deliverable report: D2.2.1 »Report on specified energy performance requirements for the buildings described in D2.1.3«
- deliverable report: D2.2.2 »Report on unambiguous technical/physical specifications for the building elements, components and constructions described in D2.1.3«
- deliverable report: D2.3.1 »Report on optimisation and energy performance of the building elements, components and constructions described in D2.2.2.«
- deliverable report: D2.3.2 »Sketches of technical composition of building elements, components and constructions as described in D2.2.2.«

WP3

- deliverable report: D3.1.2 »Prototype for transparent thermal col-lector for window integration«
- deliverable report: D3.2.2 »Prototype of an air heating vacuum tube collector for façade integration.«
- deliverable report: D3.3.2 »Description of prototype for BIPV component«
- deliverable report: D3.4.2 »natural ventilation system with heat recovery – prototype report«

- deliverable report: D3.5.2 »Dual use of unglazed façade collectors (solar heating and cooling)«

WP4

- D4.1.1 Report on the developed techno-economic integrated concepts. The re-port will focus on the four building cate-gories with the highest impact (delivered from WP2) and will describe all the de-tected practical difficulties.
- D4.1.2 Report including a catalogue of exam-ples on how to integrate the new con-cepts from a constructive point of view. The report will offer advice to façade consultants on how to integrate the new con-cepts in the construction.
- D4.1.4 A report in the form of a catalogue accessible through the web, describing design examples. The catalogue aims to offer the architects good aesthetical so-lutions for the integration of the new concepts and components.
- D4.1.5. A report on the detailed analysis of the socio-economic aspects of the inte-grated concepts for the four building categories with the highest impact.
- D4.1.6 A report including guidelines on how to implement the new concepts and com-ponents in building management sys-tems (BMS). For each of the concepts an implementation strategy will be de-veloped.
- D4.1.7 A report describing the results of each of the laboratory tests. The report will in-clude and describe the common moni-toring protocol and the results of the cross-sectional analysis of all the test.
- deliverable power-point-tool: D4.1.8 »A DST tool including Case stud-ies with examples and pictures of virtual and real buildings, support for planners on how to integrate the new concepts in building manage-ment systems, Best practice catalogues, Examples of business models, test results for components, Support for design and commissioning of building management systems« This DST disseminates somehow the re-sults of the whole WP4 in a user friendly way.

WP5

- deliverable report: D5.3.1 »Retrofitted high-rise building in Mediterra-nean climate«
- deliverable report: D5.3.2 »Retrofitted high-rise building in Slovenian climate« **This is a voluntary extra deliverable, not mandatory!**

WP6

- deliverable report: D.6.1.1 »Report on market analysis (desk research)«
- deliverable report: D.6.1.2 »Report on market analysis (field research) «
- deliverable report: D 6.3.1 »Verification of business models«

WP7

- A set of 8 Newsletters (D7.2.1 to D7.2.8, to be downloaded on the public website) providing to the targeted audience regular information on project achievement.
- deliverable report: D7.3.1: Reports on meetings with NTPs. The project has been presented to the European Construction Technology Platform (ECTP), the Renewable Heating and Cooling Technology Platform (RHC) and the European PV Platform. We put the focus on ECTP since the project goals are in the focus of the E2B initiative of the E2B.
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8.2 List of publications

Frontini, F. (2009). Daylight and solar control in buildings: general evaluation and optimization of a new angle selective glazing façade. Ph.D. dissertation, Politecnico di Milano

Frontini, F. (2011). Daylight and solar control in building: a new angle selective see-thorough PV-facade for solar control. 27th International Conference on Passive and Low Energy Architecture, July 13-15, Louvain-la-Neuve, Belgium.

Frontini, F. and T. E. Kuhn (2010). A new angle-selective, see-through BIPV façade for solar control. EuroSun 2010, International Conference on Solar Heating, Cooling and Buildings, September 28 - October 1. E. International Solar Energy Society. Graz, Austria, International Solar Energy Society (ISES).

Hauser, H., B. Michl, et al. (2012). "Honeycomb texturing of Silicon via nanoimprint lithography for solar cell applications." IEEE Journal of Photovoltaics **2**(2): 114-122.

Hermann, M., T. E. Kuhn, et al. (2008). Development of a multifunctional semi-transparent façade collector. EuroSun 2008, International Conference on Solar Heating, Cooling and Buildings, October 7-10, Lisbon, Portugal, International Solar Energy Society (ISES).

Karlessi, T., M. Santamouris, et al. (2010). Analyzing the profile of High Rise Buildings in Greece: actions and recommendations for improving their performance. 3rd International Conference on Passive and Low Energy Cooling for the Built Environment (PALENC), 5th European Conference on Energy Performance & Indoor Climate in Buildings (EPIC), 1st Cool Roofs Conference, September 29 - October 1. Rhodes Island, Greece.

Kuhn, T. E., S. Herkel, et al. (2010). Active solar facades (PV and solar thermal). 3rd International Conference on Passive and Low Energy Cooling for the Built Environment (PALENC), 5th European Conference on Energy Performance & Indoor Climate in Buildings (EPIC), 1st Cool Roofs Conference, September 29 - October 1, Rhodes Island, USA.

Lenz, K., M. Held, et al. (2011). Determining the environmental influence of energy generating components for façade integration within existing high-rise buildings by means of LCA. Life Cycle Management Conference LCM 2011, August 28-31, Berlin, Germany.

Maurer, C., T. Baumann, et al. (2011). Heating and cooling in high-rise buildings using façade-integrated transparent solar thermal collector systems. 12th Conference of International Building Performance Simulation Association, November 14 - 16, Sydney, Australia.

Maurer, C. and T. E. Kuhn (2012). SHC with transparent façade collectors in a demo building. 1st International Solar Heating & Cooling Conference, July 10 - 12. San Francisco, USA.

Maurer, C. and T. E. Kuhn (2012). "Variable g value of transparent façade collectors." Energy and Buildings **51**: 177-184.

Ruschenburg, J., K. Baisch, et al. (2011). Experimental and simulation results on a solar assisted heat pump prototype for decentral applications. 10th International Heat Pump Conference, June 27 - August 31. Tokyo, Japan.

Sprenger, W., S. Solntsev, et al. (2011). A new approach to simulation the electricity yield of complex BIPV structures. 26th European Photovoltaic Solar Energy Conference and Exhibition, September 5-8, Hamburg, Germany.

Welz, C., P. Di Lauro, et al. (2012). Physikalische Modellierung und Simulation sowie detaillierte Vermessung von Luftkollektoren. Thermische Solarenergie / 22. Symposium, May 9-11, Kloster Banz, Bad Staffelstein, Germany, OTTI e.V.