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Cross-ETP Research and Innovation Roadmap for the Energy Efficiency in Building

BUILDING UP

SEVENTH FRAMEWORK PROGRAMME

Steinbeis-Edition

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Foreword

Building Up Research and Innovation Roadmap is intended to provide a thorough overview on targets up to 2020 and beyond related to nanotechnologies, materials and processes, necessary to be achieved in order to improve the energy efficiency in the built environment.

The document has been produced as part of the Coordination and Support Activities being carried out in the European project Building Up ("Multi-stakeholder, cross-sectorial, collaborative long term Research & Innovation Roadmap to overcome technological and non-technological barriers towards more energy-efficient buildings & districts"), that was co-financed under the European Commission's 7th Framework Programme, more specifically within the nanosciences, nanotechnologies, materials and new production technologies (NMP) thematic priority.

One of the aims of the project was the development of this roadmap, through a fruitful collaboration among European Technology Platforms (ETPs) from different sectors and industrial and research stakeholders from various Member States all gathered around a common topic: energy efficiency in the built environment.

The background for developing the roadmap was a broad review of foresight studies and other relevant sources (EU-funded work and reports, research agendas from ETPs, and other national and multinational initiatives), which take into consideration climate change, resource scarcity and demographic change as well as global changes that will affect the building sector.
Discussion, revision and validation of the roadmap were performed through several working group meetings, surveys and participation to conferences and public events.

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About the Building Up project

The strategic objective of the project is to create an effective coordination of European Technology Platforms and major initiatives whose Strategic Research Agendas (SRAs) and activities address energy efficiency in the built environment from an NMP perspective, to identify and review their needs in terms of long term research and innovation, thus accelerating the implementation of sustainable solutions by addressing non-technological barriers and gaps at programme level.

Building Up consortium, coordinated by the "Centre Scientifique et Technique du Bâtiment", (chair of the European Construction Technology Platform - ECTP), ensured an active involvement of a wide spectrum of stakeholders working in the energy efficiency of the built environment, yet coming from different technology sectors (e.g. steel, chemistry, textiles, materials development, forest-based products, water treatments, renewable energy, etc.).

Indeed, Building Up brought together the know-how and expertise from its eleven partners, covering various technology sectors. Six European Technology Platforms (ETPs), namely:

- *European Construction Technology Platform* (ECTP),
- *European Technology Platform for Sustainable Chemistry* (Suschem),
- *European Technology Platform for Advanced Engineering Materials and Technologies* (EUMAT),
- *European Technology Platform for the Future of Textiles and Clothing* (TEXTILE ETP),
- *European Steel Technology Platform* (ESTEP),
- *Forest-based Sector Technology Platform* (FTP),

including their national platforms, as well partners specialised in supporting innovation and technology transfer issues (Austrian Society for Environment and Technology, D´Appolonia and Steinbeis-Europa-Zentrum) joined forces with other relevant initiatives such as the ERANET ERACOBUILD in order to perform all project activities including the development of this Building Up roadmap. The project started in May 2011 and ended in October 2012, with a final public event disseminating the roadmap.

In addition to this roadmap the project website offers a good source of information on the main project activities and provides the contact details of the project coordinator and consortium partners.

http://www.buildingup-e2b.eu/

Executive Summary

This document aims at presenting the Building Up Research and Innovation Roadmap, detailing targets up to 2020 and beyond related to nanotechnology, materials and processes, in order to improve the energy efficiency in built environment.

This roadmap has been developed by E2BA and DAPP, supervised by the Coordinator and with the collaboration of the involved European Technology Platforms (ETPs) and Building Up project partners and stakeholders.

Moreover, other initiatives linked to project partners such as ENBRI (The European Network of Building Research Institutes) and Eracobuild (Strategic Networking of RDI Programmes in Construction and Operation of Buildings) were invited in meetings for discussion and dissemination of the roadmap.
Finally, a community of Building Up stakeholders contributed to the Roadmap through the Building Up Website (online surveys, posts, etc.).

The overall objectives of the Building Up Industrial and Research Roadmap are:

- To outline and detail cross-sectorial research and innovation targets up to 2020 and beyond related to nanotechnology, materials and processes, in order to improve the energy efficiency in built environment;
- To obtain such goal with a cross-ETP roadmapping activity, involving the Building Up network through large public consultations and debates.

Building Up long term vision is well aligned with the E2BA “2020 Research & Innovation Roadmap” which aims at driving the creation of an innovative high tech energy efficiency industry where the entire value chain will produce advanced systems, solutions and high value services for intelligent and sustainable buildings and districts.

This vision meets the 2020 targets with the overarching goal to support both Climate and Energy policies set at European level for the full decarbonization by 2050 of the European economy. This requires preparing new market conditions where building owners are ready to invest into an affordable built environment having lower energy demand and lower GHG emission footprints over their whole life cycle, while improving optimal indoor air-quality and comfort.

Mandatory energy-saving measures, including renovating public buildings, energy-saving schemes for utilities, and energy audits for all large firms mentioned in the new recently approved “Energy Efficiency Directive” will further boost the creation and development of an Energy Efficiency and new built market. In this framework Building Up project will contribute to transforming the current market into an Energy Efficiency one.

Whilst it is based on a long term vision (up to 2050), the Building Up Roadmap focuses its main targets in the short-medium term (up to 2020), with some suggested actions for longer terms (beyond 2020). In this framework, the Building Up Roadmap includes:

- 8 Cross-Platform (CP) collaboration areas in research and innovation in the NMP field, i.e. areas considered (1) of interest by several ETPs involved in the roadmapping, (2) with high impact for the energy efficiency in the built environment. These are:
    - CP1. Performance Based Approach for building components, including
    - sustainable design, Life Cycle Analysis;
    - CP2. Multi-materials and composites;
    - CP3. Healthy and comfortable indoor environment (including air quality,

- ventilation, lighting, acoustic performance);
- CP4. Electricity generation and storage materials and systems (e.g. storage
- systems including building integrated energy technologies);
- CP5. Thermal generation and storage materials and systems (e.g. storage
- systems including building integrated energy technologies);
- CP6. Advanced thermal insulation construction materials for new buildings
- and existing buildings (e.g. aerogel, nanofoams, vacuum insulation panels);
- CP7. Building materials recyclability and re-use of components;
- CP8. Renewable resource-based products.

- A set of cross-cutting targets with considerations on broad non technological issues.

- The overall social, environmental and economic impact, adding specific examples on target markets and expected benefits of the proposed actions for each cross-platform areas. These are the following:

The background for developing the roadmap was a broad review of foresight studies and other relevant sources (EU-funded work and reports, research agendas from ETPs, and other national and multinational initiatives), which take into consideration climate change, resource scarcity and demographic change as well as global changes that will affect the building sector.

The Building Up Roadmap aims to contribute addressing the 138 barriers identified by the project team and divided in two main groups: technological and non-technological.
Both groups have two categories each as shown in the following figure.

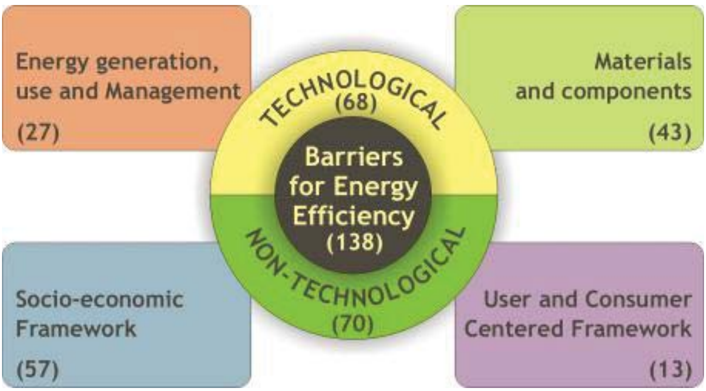

Figure 1 – Barriers for energy efficiency in buildings – main categories

Furthermore there were defined six major sub-categories where barriers for energy efficiency in buildings occurred:

- costs / economic aspects (technological and non-technological barriers),
- innovation / communication (technological barriers),
- education / training (technological and non-technological barriers),
- technology (technological barriers),
- public and municipal steering mechanisms (non-technological barriers),
- culture, behaviour, lifestyle and the rebound effect (non-technological barriers).

The 8 cross-platform collaboration areas correspond to the major groups of identified barriers as shown in the following figure.

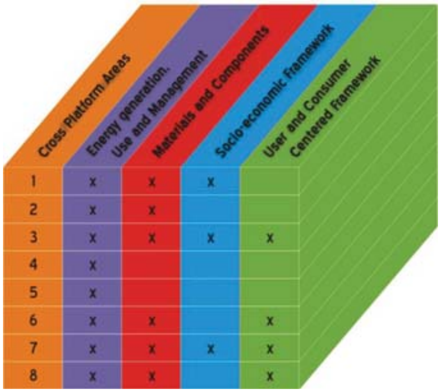

Figure 2 – Relation between cross platform areas and barriers

A summary of targets and priorities for each of the Cross-Platform Areas is provided in the next table:

Table 1 – Summary of targets and priorities for each of the Cross-Platform Areas

TARGETS	PRIORITIES
CP1 Performance Based Approach for building components, including sustainable design, Life Cycle Analysis	
1) All building components meet an ecodesign approach (including LCA) covering the whole chain of the building life (material production, construction, use, recycling); 2) To assure higher energy efficiency and advanced building performance (e.g. acoustic, seismic, etc.).	• Agreement on common understanding (boundaries) and handing back to national standards; • Common methodology based on existing Life Cycle Analysis /LCA studies (CEN TC 350 based); • Systemic approach for all energy usages (energy, water…) taking into account their mutual interaction; • Link with future modifications of Ecodesign EU directive; • Design tools for optimization of buildings and building components; • Building design tools for architects allowing for real time building eco-design; • Development of new devices for reduction of water consumption.
CP2 Multi material and composites	
1) To provide multifunctional materials from: • Assembling of materials and/or components having different functions to obtain new elements enabling the exploitation of these different functionalities; • Producing composite materials enabling to exploit new functionalities; 2) To increase the use of building waste into recycled composites; 3) To develop composites consisting of renewable source matrix and fiber materials.	• Low-cost processing technologies for composite materials production and for components assembling; • New production processes for fibres - easy application methods; • Bio-mimetic technologies: need for better understanding of surface interaction on nano scale; Multi-scale modelling from atom to system; development of Chemical coupling agents and binders.
CP3 Healthy and comfortable indoor environment (including air quality, ventilation, lighting, acoustic, etc.)	
1) Availability of validated planning and measuring tools for Indoor Environmental Quality; 2) To improve comfort levels in buildings and houses, including historical buildings through highly energy-efficient and financially affordable internal components; 3) Active functions are integrated into the building; 4) All used materials have near zero harmful emissions (e.g. Reducing the Volatile Organic Compound (VOC) content of building materials).	• New and accurate IEQ assessment and planning tools; • Better understanding of VOC emittance. Better control over acoustics. Better control over moisture; • Empirical and reliable epidemiological data on correlation between buildings and human health; • Improved aesthetic room concept • Low-E insulating glazing, coatings, vacuum glazings and aerogel for reduced U value. Electrochromic, thermochromic or photochromic properties for G value control; • Multifuntional glazing; • Improvement of building material properties in order to maximize human comfort; • Establishing a methodological guide for the energetic rehabilitation of historic buildings; • Efficient, comfortable indoor lighting (Flexible Lighting based on LEDs – Development of

TARGETS	PRIORITIES
	LED integrated coated textiles); • Materials/systems with integrated failure warning; • Reducing the Volatile Organic Compound (VOC) content of building materials
CP4 Electric generation and storage materials and systems (e.g. storage systems including building integrated energy technologies)	
1) System and components need to be optimized (cost and energy) and their performance evaluated correctly. Tools for modeling new energy generating system performances need to be designed and developed; 2) Availability of new technologies and systems for electric energy storage and electric generation.	• New testing procedures, identification of new performances for new existing materials (e.g. with reference also to adaptive performances); • Holistic, intelligent & predictive energy control systems; • Fuel cells for static applications; • Smart grid solutions to fully enable distributed energy generation. Demand response solutions to fully exploit energy production at local level; • Building Integrated PV, producing energy to be stored in either batteries or hydrogen through electrolysis.
CP5 Thermal generation and storage materials and systems (e.g. storage systems including building integrated energy technologies)	
1) Advancement for total building integration (e.g. in plaster, windows, tiles, etc.): to increase aesthetics and integration flexibility, efficiency, cost, quality insurance, plug and play development. Market implementation 2) Availability of new technologies, systems and processes for energy storage and heating and cooling management 3) Further development of advanced nanotechnology	• Need for modeling behavior and properties of building integrated thermal technology (e.g. Development of flexible high efficiency solar thermal collectors); • Validation of thermal energy generation through advanced modeling tools; • To explore the potential for demand side management opportunities associated with the storage of energy in the thermal mass of buildings; • Research on new technologies for chemical composition of storage materials and efficient integration of existing ones.
CP6 Advanced thermal insulation construction materials for new buildings and existing buildings	
1) Availability of insulation materials with highly enhanced properties ($\lambda < 0.03$ W/m*k, fire safety, improved durability, low cost, recyclability) especially for retrofitting; 2) Availability of components with very high insulated materials, eco innovative, easy to install.	• Development of new cost-effective energy-efficient insulating materials from renewable sources or waste materials; • Development of materials that enable to create insulation materials with active properties; • Evolution of materials with $\lambda < 0.03$ W/m*k (e.g. nanofoams or silica aerogels); • Cost-effective large volume manufacturing • Cost-effective analysis on pilot test demonstration in public / administrative buildings • To determine the environmental tradeoffs between using insulation and sophisticated building techniques to control indoor climate in buildings with energy using heating / cooling and ventilation systems; • Integration of insulated materials in traditional products for large application;

TARGETS	PRIORITIES
	innovative solution for retrofit; thermal insulation, with good vapor permeability; • Improved material combinations in a layered and structured facade construction, IR absorption and reflection on demand in combination with insulation and switchable U-values.
CP7 Building materials recyclability and re-use of components	
1) Reduction of the amount of down cycling, considering cost and energy issues; 2) Design implementation of recycling and re-use of materials and techniques in construction; 3) Establishment of deconstruction processes and guidelines for existing buildings.	• Development of solutions to recycle and re-use the light part of construction materials, including thermal recycling; Increase the uptake by the manufacturing chain; • Research about the recyclability of different types of demolition products; • Better adhesives and other methods allowing disassembly of boded structures / assemblies; • Optimization of recyclability properties of materials for new buildings; • Building concepts with high fraction of material replacement where needed; clear separation of functionality layers in buildings; • Building concepts with very low resource input: low emissions recycling options; • Specific trainings to companies and end-users in order to improve recycling and re-using skills and techniques; • Information management and traceability.
CP8 Renewable resource-based products	
1) Availability of renewable (bio-based) construction materials and systems as alternatives to fossil and mineral based products for sheathings as well as advanced insulation products with improved performance and cost-effectiveness; 2) Availability of bio-based treatments such as paints, adhesives and modification for high performance renewable products.	• Creation of new value chains considering the complete life cycle (possibility of re-using, etc.); • Optimization of natural fibers for insulations in order to ensure durability; • Advanced research on biotechnology and new bio-based materials such as plastics for barriers, pipes, etc. and foams for insulation; • Creation of new value chains.

The next two figures summarise the Roadmap cross platform collaboration areas and the Building Up Roadmap structure for each CP.
The latter figure includes logos of ETPs and EU initiatives that are mainly involved in Building Up roadmapping activities.

Figure 3 – Overview of the Building Up Roadmap

Figure 4 – Structure of the Cross-Platform areas & involvement of ETPs and associations

In the following table, **the expected outcome in terms of products and services as well as the main field of application** are listed for each cross-platform area.

Table 2 – Outcome and field of application for each CP area

CP AREA	OUTCOME	FIELD OF APPLICATION
CP1 - Performance Based Approach for building components, including sustainable design, Life Cycle Analysis	Eco-construction techniques(including methodologies for assessing the energy efficiency of water supply systems)	Any scale of Construction: - Residential; - Non-residential (e.g. offices); - Public facilities (e.g. schools, hospitals); - Commercial (e.g. shops); - Industrial (light and heavy) - Infrastructures (e.g. bridge).
CP2 - Multi-materials and composites	Multi-materials and composites	**Composites for exterior design include:** - columns - pediments - domes - cornices - formworks **Interior Composite applications include:** - walls - floors - building envelop - panels - blinds - sanitary-ware - functional items (letter boxes, meter boxes) - decorative items - window profiles
CP3 - Healthy and comfortable indoor environment (including air quality, ventilation, lighting, acoustic performance)	Healthy, comfortable and quality indoor environment: - Energy Efficient Equipments (including HVAC, lighting, acoustic performance, integrated systems, energy efficient glazing, etc.) - Planning, metering and monitoring tools and services.	The following buildings and construction sites: - Residential; - Non-residential (e.g. offices); - Public facilities (e.g. schools, hospitals); - Commercial (e.g. shops); - Industrial (light and heavy); - Outdoor sites; - Cultural/historical buildings
CP4 - Electric generation and storage materials and systems	Electric generation materials	Entire skin of the building, including building envelop (e.g. roofing, sun-shading, glazing, architectural fabrics).

CP AREA	OUTCOME	FIELD OF APPLICATION
	Storage solutions technologies	Various types of existing or potential storage technologies are adapted for different uses. All storage technologies are designed to respond to changes in the demand for electricity, but on varying timescales. Demand fluctuations on shorter timescales—sub-hourly, from a few minutes down to fractions of a second—require rapidly-responding technologies like flywheels, super-capacitors, or a variety of batteries, which are often of smaller capacity.[1]
CP5 – Thermal generation and storage materials and systems	Solar Thermal Energy	**Domestic hot water & space heating** - One/two/multi-family homes - Hotels, hospitals, residential homes, etc. - District heating systems - Multifunctional façades - PV-Thermal (PV-T) hybrid collectors **Process heat** - Low up to 100C - Medium up to 250C - Solar assisted cooling and refrigeration
	Biomass (Solid biomass, bio fuels / bio gas)	**Small burners** - Pellets stove - Wood chip boiler - Log wood stove/boiler **District heating & cooling and process heat** *Heat only or combined heat and power* - Pellets boiler - Wood chips boiler - Waste & agricultural feedstock boiler
	Geothermal: Shallow GT (Geothermal HP, Underground thermal storage)	- DHW, space heating & cooling - process heat
	Geothermal: Deep GT (>400m) (Direct heat use, Comb heat & power)	- District heating - Agriculture and industrial processes - Balneology Cooling

[1] http://205.254.135.7/todayinenergy/detail.cfm?id=4310

CP AREA	OUTCOME	FIELD OF APPLICATION
	Cross Cutting Technologies - District heating and cooling (DHC)	- District heating - District cooling - DH&C with seasonal storage
	Cross Cutting Technologies - Thermal energy storage	- Water storage - PCM - Thermo chemical - Underground storage (UTES)
	Cross Cutting Technologies - Hybrid systems and heat pumps	- Innovative system design - Ground, water and air heat pumps
	Cross Cutting Technologies - Energy Distribution	The entire building skin could be used for capture and the building elements – such as floors – could be used for storage.

CP6 - Advanced thermal insulation construction materials for new buildings and existing buildings	Insulation construction materials:
	• Wool
	    ○ Rockwool
	    ○ Glasswool
	• Plastic foams
	    ○ Expanded polystyrene
	    ○ Extruded polystyrene
	    ○ Polyurethane foams
	    ○ Other plastic foams
	• Mineral foams with low lambda, low carbon footprint and good fire resistance
	• Fiberglass and foamglass
	• Highly insulating glass
	• Other insulation materials
		• Wall insulation:
		    ○ External walls
		    ○ Internal walls (including curtain walls)
		    ○ Cavity walls
		• Roof insulation:
		    ○ Flat roofs
		    ○ Pitched roofs
		• Floor insulation

CP7 - Building materials recyclability and re-use of components	Re-used or recycled construction materials and components	All kind of load bearing structures, such for example: - bridges and major infrastructures; - houses and buildings; Moreover, traditionally waste may be re-used in:

CP AREA	OUTCOME	FIELD OF APPLICATION
		- construction of roads and road foundations; - sports grounds; - noise protection walls; - earth banks ; - landscape construction; - as aggregates in the concrete and stone production. Finally, steel can be re-used in building components and also recycled
CP8 - Renewable resource-based products	Renewable resource-based products	- All kind of wood products: walls, roofs, etc.; - All kind of clay products: bricks, etc. - Insulating products in general.

Regarding the **expected impact, Building Up** project will **promote the European knowledge in the built environment** and **boost the industrial competiveness** of the construction sector (in particular SMEs) and the inter-connected sectors.

The project is well **aligned with E2BA Roadmap priorities** to complement the EU pathways in supporting energy savings in buildings and districts and preparing the all value chain of the building sector (designers, technology manufacturers, construction companies, energy utilities, etc.) to be in line with the **2050 decarbonisation goals**[2] **of the European Economy**.

Moreover, Building Up will contribute to tackle crucial challenges Europe is facing today of insufficient innovation, and several environmental and societal challenges. **All the eight Cross-Platform Areas identified in the project will focus and provide support particularly to the key priorities "Industrial leadership" and "Societal Challenges" in the upcoming "*Horizon 2020*"[3].**

- **Industrial leadership** in particular by developing technologies enabling Energy-efficient buildings which will increase the technological competitiveness of EU industry and the involvement of a wide range of SMEs;

- **Societal Challenges** focusing on *"Secure, clean and efficient energy" as well as on "Health, demographic change and wellbeing" and "Climate action, resource efficiency and raw materials"* with the overarching objective of sustainable development.

Each Cross-Platform areas will have an impact on several markets which were identified with the help of ETPs experts. The table below summarizes **markets and expected benefit** identified for each of the Cross-Platform areas.

[2] http://ec.europa.eu/energy/energy2020/roadmap/doc/com_2011_8852_en.pdf
[3] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0808:FIN:en:PDF

Table 3 – Markets, Expected Benefit and reference Cross-Platform Areas

MARKET	REFERENCE CROSS-PLATFORM AREAS	EXPECTED BENEFIT
Energy Efficiency and new built market (including construction industry, eco-construction, green, recycled building materials and renewable source-based building materials)	**CP1** – Performance Based Approach for building components, including sustainable design, Life Cycle Analysis **CP2** - Multi-materials and composites **CP6** - Advanced thermal insulation construction materials for new buildings and existing buildings **CP7** - Building materials recyclability and re-use of components **CP8** - Renewable resource-based products	The development and release of target, products/applications/services described in CP1, CP2, CP6, CP7 and CP8 will increase the technological competitiveness of EU industry and the involvement of a wide range of SMEs from different sectors (including Steel, Wood & Paper and Chemical sectors) as suppliers of materials and components. In particular CP7 and CP8 materials and products will help towards addressing the Societal Challenges *"Climate action, resource efficiency and raw materials"* by re-using the construction and demolition waste (components and materials), increasing the usage of recyclable and sustainable products, and the use of renewable raw materials, such as natural fibers, which do not form any residues, and soy-based resins, which are cheaper, lighter and potentially bio-degradable. However, sensible efforts in research and innovation should be made in order to improve the cost-effectiveness and good quality of such solutions. Specific design for deconstruction will enable easier dismantling of the building and further increase the recycling and reuse of the materials. This "eco" added value including economic and social benefit will increase with time and give European companies a quality advantage to other countries. The percentage of ecological products will depend on the market situation but as seen in Germany with the passive house standard it can increase in short time from some percentages to 30%. All the CPs, in particular CP2 and CP6, will further contribute to the scarcity of raw materials issue by developing new sharpen and synthetic materials and products. Resource consumption will be significantly reduced thanks to more efficient solutions and products. The sustainable design in CP1 will also help the reduction and optimization of global energy consumption through an energy efficiency assessment of the water systems. Moreover, the environmental footprint of all different solutions should be taken into account with a life cycle approach.

MARKET	REFERENCE CROSS-PLATFORM AREAS	EXPECTED BENEFIT
		A particular emphasis will be given on opportunities for the supply chain and the value chain (including consumers).
Composite materials and multi-material components market	**CP2** - Multi-materials and composites	CP2 target, technologies and products will allow constructing buildings with low embodied energy and resources, thanks to multi-material solutions such as load bearing functions, insulation, vapour barrier and integrated exterior solar energy generation. Thus highly contributing to address both the Social challenge *"Climate action, resource efficiency"* and the Industrial leadership priorities.
The "Comfort" market: - **IEQ tools and services: planning, analytical equipments and human physiological diagnostics;** - **Conservation of historical materials and works of art;** - **Acoustic and Thermal comfort, including HVAC;** - **Lighting (including day lighting).**	**CP3** - Healthy and comfortable indoor environment (including air quality, ventilation, lighting, acoustic performance)	CP3 approach and its developed technology and solutions will give feedback of the indoor air quality and its implications to human health, not just by using theoretical estimations which do not give true feedback of their relevance. The integration of different indoor environment components/systems as HVAC and lighting systems will bring to a totally new insight and performance characteristics. With respect to the energy efficient glazing, indoor environment will be improved thus contributing to the nearly "zero energy" 2020 goal in buildings. Public and private organisations and companies in the construction sector, including organisation responsible for the custody, conservation and management of cultural and historical assets and materials will benefit from CP3.
Combined power generation and storage for buildings	**CP4** - Electric generation and storage materials and systems **CP5** - Thermal generation and storage materials and systems	CP4 and CP5 targets, technologies and products will develop standardized solutions for a more efficient and sustainable electric and thermal power generation, storage systems fully integrated in buildings as well services and solution for easy management, performance monitoring and energy, and distribution systems for both buildings and districts having a particular impact on the local supply. Such solutions will enhance the competitiveness of EU SMEs and large companies active in building equipment and process engineering, in cooperation with construction industries. Additionally, there will be an increase

MARKET	REFERENCE CROSS-PLATFORM AREAS	EXPECTED BENEFIT
		of development and manufacturing cooperation of building industry and energy suppliers. These CPs will highly contribute to the Societal Challenge *"Secure, clean and efficient energy"* by tremendously decreasing the use of fossil fuels and decreasing GHG emissions footprint. Furthermore, they will bring economic benefit for the users through better management and power generation.
Insulation construction materials	**CP6** - Advanced thermal insulation construction materials for new buildings and existing buildings	Future advantages of improved insulation materials will bring to: 1. Better insulation at same or less thickness: important for space restricted applications like cavity wall, refrigerated transport, etc. 2. Thinner insulation layers at same or less U-value: this is important for architectural aesthetics, less material (energy) bound in the insulation, reduced transport volume. Durable and well performing new insulation materials will replace existing insulation solutions facilitating the fading of the market share; today construction market is conservative and can create difficulty to accept new materials (adoption times of >8yrs have to be expected). This will have an impact on other markets too, directly or in-directly connected to the construction sector. This area is strictly linked with CP1 and CP8. CP6 target, technologies and products will greatly contribute to the Societal Challenge *"Climate action, resource efficiency and raw materials"* and *"Secure, clean and efficient energy"*. Moreover, it will improve the cost-benefits (e.g. manufacturing and transport), decrease the environmental footprint, and enlarge retrofitting opportunities. This will get to an increase of the involvement in the construction sectors of industries and SMEs from different sectors (including Steel, Wood & Paper and Chemical sectors) as suppliers of materials and components. A direct benefit on CP3, CP4 and CP5 is estimated.

Finally the involved ETPs agreed on an estimated distribution of private and public funding among the cross-platform areas, which would be required to implement the proposed actions. The figure below shows such estimation, considering 100% as the whole budget foreseen to cover the implementation of Building Up Roadmap.

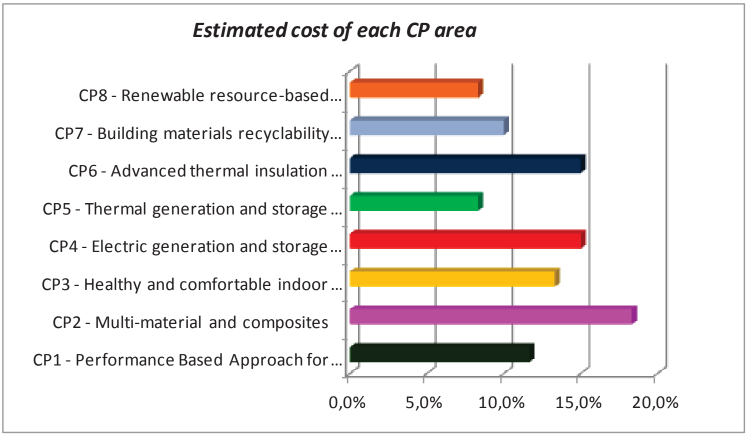

Figure 5 – Distribution of estimated cost in terms of needed private and public funding for each CP area

The Roadmap was validated through a validation meeting where the Advisory Board and the ETP experts gave the latest inputs as well as through an open consultation launched in the Building Up website (Deliverable D4.4).

The Roadmap is available online on http://www.buildingup-e2b.eu/.

List of Acronyms and Abbreviations

CA	Coordination Action
CP Area	Cross-Platform Area
CSA	Coordination and Support Action
DAPP	D'Appolonia SpA
DoW	Description of Work
ECTP	European Construction Technology Platform
ESTEP	European Steel Technology Platform
ETP	European Technology Platform
EU	European Union
EUMAT	European Technology Platform for Advanced Engineering Materials and Technologies
E2BA	Energy Efficient Buildings Association
FOREST-BASED PLATFORM	Forest Based Sector Technology Platform
HVAC	Heating, ventilation, and air conditioning (system)
LED	Light Emitting Diode
LOW-E	Low emissivity
NMP	Nanotechnology, Materials and Processes
OLED	Organic Light Emitting Diode
PPP	Public Private Partnership
PV	Photovoltaics
RHC	Renewable Heating and Cooling Platform;
SUSCHEM	Sustainable Chemistry ETP
TEXTILES ETP	European Technology Platform for the Future of Textiles and Clothing
TRL	Technology Readiness Level
WP	Work Package
WssTP	Water Supply and Sanitation Technology Platform

Definitions

Building sector
In the context of this document, "building sector" encompasses activities along the whole building value chain from design to end-of-life, which includes architects and engineering services, manufacturers of construction materials and technologies, onsite construction companies, property developers and facilities managers, energy companies as well as building users (households, offices, …).

Construction sector
According to the statistical classification of economic activities in the EU (NACE Rev 1.1), this sector covers five different NACE groups which correspond to different chronological stages of the construction process:
- demolition and site preparation (NACE Group 45.1);
- general construction activities (NACE Group 45.2);
- installation work (NACE Group 45.3);
- completion work (NACE Group 45.4);
- renting of construction equipment (NACE Group 45.5).

Cross-Platform Research and Innovation Area
In this document, a Cross-Platform Research and Innovation Area is a large research and innovation domain, in the field of energy efficiency for the built environment, which receives the interest of several ETPs involved in the roadmapping activities.

District
A set of connected buildings, public spaces, transport infrastructure, and networks (e.g. electricity, heating, cooling, water and wastewater, etc.), including inhabitants, building users and managers.

Embodied energy
Total of all energy consumed in the processes associated with the production (and transport) of the materials and components that go into a building or structure. For construction materials such as steel and concrete, 'embodied carbon' will be used instead of 'embodied energy'.

Roadmap Priorities
In this document, Building Up Roadmap Priorities are the priorities agreed among the ETPs involved in roadmapping on common research and innovation actions needed to reach the agreed targets for 2020.

Roadmap Targets
In this document, Building Up Roadmap Targets are the general goals agreed among the ETPs and related to a particular cross-platform area.

1 Scope, objective and methodology of the roadmap

1.1 Overall scope and objectives

The Building Up project aims to create an effective coordination of ETPs and major initiatives whose Strategic Research Agendas and activities address energy efficiency in the built environment considering research on nanotechnology, materials and processes.

In this framework, the overall objectives of the Building Up **Industrial and Research Road-map** are:

- To outline and detail cross-sectorial research and innovation targets up to 2020 and beyond related to nanotechnology, materials and processes, in order to improve the energy efficiency in built environment;
- To obtain such goal through a cross-ETP roadmapping activity, involving the Building Up network and **large public consultations and debates**.

1.2 Roadmapping methodology

The Building Up roadmapping process is described in the image below.

Figure 6 – The Building Up Roadmapping Process

The roadmapping process may be divided in the following steps:

1. **PLANNING and DESK RESEARCH:** The first step was aimed at organise the roadmapping activity and the flow of information as well as the definition of the background knowledge. This step was performed based on:

a. Careful planning of aims, methods and deadlines;
b. Integration and further development of available desk research (ETP Strategic Research Agendas, National and European policy documents, research reports, etc.) with contributions from supporting ETPs and associations.
c. Identification of ETP experts to be involved into workshops and of a large network of stakeholders to be invited to online surveys.

2. **ROADMAP DEVELOPMENT:**
   a. Identification of cross-platform research and innovation areas, i.e. areas considered (1) of interest by several ETPs involved in the roadmapping, (2) with high impact for the energy efficiency in the built environment;
   b. Development of each cross-platform area, through expert workshop and web surveys.

3. **PLAN PREPARATION:**
   a. *ROADMAP RELEASE* (shown in this deliverable D3.2): integration of all cross-platform areas in a overall roadmap scheme. Identification of non-technological cross-cutting actions.
   b. *WIDE VALIDATION of the ROADMAP*: the roadmap is validated through consultation with Advisory Board and other stakeholders.

4. **DISSEMINATION & FOLLOW-UP:**
   a. *DISSEMINATION:* The Roadmap is disseminated through ETP large networks. Particular care is taken that the main results of the roadmap will be integrated into the E2BA roadmap, to be publicly presented in July during the PPP-Info day. The Building Up Roadmap is also disseminated through a final meeting.
   b. *FOLLOW-UP:* In order to keep the Building Up Roadmap live and effective, periodic revisions of the roadmaps are needed after the final release, beyond the completion of the funded project. Continuous incorporation of changes in roadmap, taking into account latest developments in research and innovation, are suggested.

1.3 ETPs and Stakeholders involved in Building Up Roadmap

The Deliverable has been developed by E2BA and DAPP, supervised by the Coordinator and with the collaboration of the involved European Technology Platforms (ETPs) and Building Up Stakeholders.
The involved ETPs are:

- **ECTP:** European Construction Technology Platform;
  E2BA: Energy Efficient Buildings Association;
- **ESTEP:** European Steel Technology Platform;
- **EUMAT:** European Technology Platform for Advanced Engineering Materials and Technologies;
- **FOREST-BASED PLATFORM:** Forest Based Sector Technology Platform;
- **RHC:** Renewable Heating and Cooling Platform;
- **SUSCHEM:** Sustainable Chemistry ETP;
- **TEXTILES ETP:** European Technology Platform for future of Textile and Clothings;
- **WssTP:** Water Supply and Sanitation Technology Platform.

Moreover, other initiatives linked to project partners such as ENBRI (The European Network of Building Research Institutes) and Eracobuild (Strategic Networking of RDI Programmes in Construction and Operation of Buildings) were invited in meetings for discussion and dissemination of the roadmap.
Finally, a community of Building Up stakeholders contributed to the Roadmap through the Building Up Website (online surveys, posts, etc.). More information is available at www.buildingup-e2b.eu.

2 Building Up vision

Building Up will pave the way towards the development of radically new products and services enabled by NMP technologies while ensuring that all the necessary bottlenecks and gaps at technological, non-technological and programme level are properly addressed. Enhanced sustainability, competitiveness and employment are key socio-economic challenges for a knowledge based and “eco-innovative” society in the 21st century.

The collaboration framework pioneered in Building Up will be an effective demonstrator to draw guidelines and policy recommendations for the engagement of the public and private sectors in the area of Energy Efficient Buildings and districts. This will allow preparing the ground for any future implementation beyond 2013 through relevant European and National public and private (industrial) research initiatives, fully in line with the long term programme defined in 2009[4] around a **“wave action”.** The following figure shows how continuous, on-going research feeds successive waves of projects.

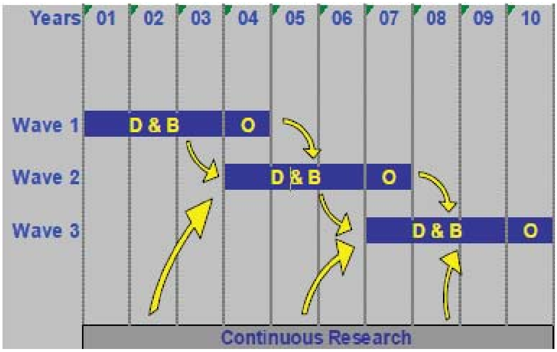

Figure 7 – Wave action along the E2BA roadmap
(D&B: Design&Building; O: Operation)[5]

Building Up long term vision is well aligned with the E2BA “2020 Research & Innovation Roadmap” which aims at driving the creation of an innovative high-tech energy efficiency industry where the **entire value chain** will produce advanced systems, solutions and high value services for intelligent and sustainable buildings and districts. This vision meets the 2020 targets with the overarching goal to support both Climate and Energy policies set at European level for the full decarbonization by 2050 of the European economy. This requires preparing new market conditions where building owners are ready to invest into an affordable built environment having lower energy demand and lower GHG emission footprints over their whole life cycle, while improving optimal indoor air-quality and comfort.

The commercialisation of sustainable and safe innovative technologies (including nanotechnology, etc.) for the built environment should consider also **safety aspects**.

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[4] EeB PPP “Research priorities for the definition of a multi-annual roadmap and longer term strategy”, July 2009

[5] Energy-Efficient Buildings PPP. Beyond 2013 – Research and Innovation Roadmap (draft)

In this framework, several EU and national initiatives (e.g. the Nanosafety cluster, the European Technology Platform on Industrial Safety, Suschem ETP, etc.) are taking care of roadmapping on safety aspects, taking actions or suggesting standards & best practice guidelines for handling materials (e.g. nanoparticles, nanopowders), risk assessment and risk management, environmentally friendly and sustainable production and processes.
Therefore, when implementing Building Up targets and priorities, links between technological research and demonstration projects and such cross-sectorial safety initiatives should be guaranteed in order to promote effective reduction and management of any possible risk arising from the developed materials and processes.

Building Up’s roadmap aim is to overcome technological and non-technological barriers towards more **energy-efficient** buildings and districts: the **human being** will be taken into account as a central element within the building and systems improvement, in order to maximize comfort, usability and safety.
The final user (building owner, school user, office user) covers the role of primary element within building environment: the comfort is considered a main concern by Building Up Roadmap, and its development is functional for a better improvement of human conditions.

3 Roadmap overview: focus on cross-platform (CP) research and innovation areas

3.1 Roadmap overview

Whilst is based on a long term vision (up to 2050), the Building Up Roadmap focuses their main targets in the short-medium term (up to 2020), with some suggested actions for longer term (beyond 2020).

In this framework, the Building Up Roadmap includes:

- ***8 Cross-Platform (CP) collaboration areas*** in research and innovation, i.e. areas considered (1) of interest by several ETPs involved in the roadmapping, (2) with high impact for the energy efficiency in the built environment. These are the following:

    - *CP1. Performance Based Approach for building components, including sustainable design, Life Cycle Analysis;*
    - *CP2. Multi-materials and composites;*
    - *CP3. Healthy and comfortable indoor environment (including air quality, ventilation, lighting, acoustic performance);*
    - *CP4. Electricity generation and storage materials and systems (e.g. storage systems including building integrated energy technologies);*
    - *CP5. Thermal generation and storage materials and systems (e.g. storage systems including building integrated energy technologies);*
    - *CP6. Advanced thermal insulation construction materials for new buildings and existing buildings (e.g. aerogel, nanofoams, vacuum insulation panels);*
    - *CP7. Building materials recyclability and re-use of components;*
    - *CP8. Renewable resource-based products*

- ***A set of cross-cutting targets*** with consideration on broad non technological issues.

- The **overall social, environmental and economic impact**, adding specific examples on **target markets** and **expected benefits** of the proposed actions for each cross-platform areas.

The background for developing the roadmap was a broad review of foresight studies and other relevant sources (EU-funded work and reports, research agendas from ETPs, and other national and multinational initiatives), which takes into consideration climate change, resource scarcity and demographic change as global changes that will affect the building sector.

The Building Up Roadmap aims to contribute addressing the 138 barriers identified by the project team and divided in two main groups: technological (68) and non-technological (70). Both groups have two categories each as shown in the following figure.

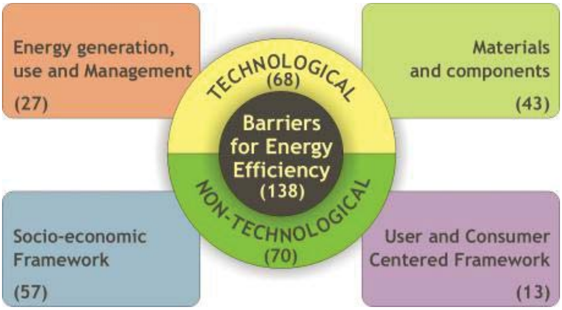

Figure 8 – Barriers for energy efficiency in buildings – main categories

Furthermore there were defined six major sub-categories where barriers for energy efficiency in buildings occurred:

- costs / economic aspects (technological and non-technological barriers),
- innovation / communication (technological barriers),
- education / training (technological and non-technological barriers),
- technology (technological barriers),
- public and municipal steering mechanisms (non-technological barriers),
- culture, behaviour, lifestyle and the rebound effect (non-technological barriers).

The 8 cross-platform collaboration areas correspond to the major groups of identified barriers as shown in the following figure.

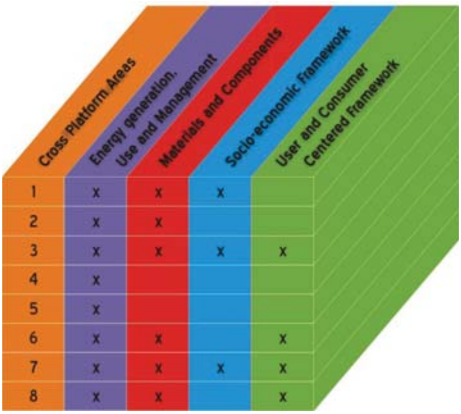

Figure 9 – Relation between cross platform areas and barriers

The figure below reports an overview of the Building Up Roadmap.

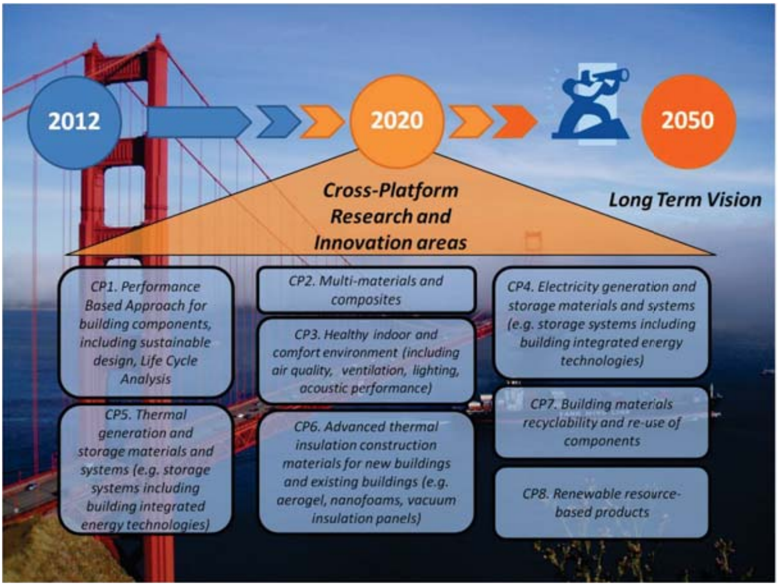

Figure 10 – Overview of the Building Up Roadmap

For each cross Platform area, the following items are detailed:

- **State of the art** in terms of technological and non technological aspects;
- **Detailed Targets for 2020** and corresponding **Priorities**, highlighting the interests of different ETPs;
- **Target applications and end-users**;
- **Considerations beyond 2020** including draft long term targets.

The following figure shows the structure of each platform area, including logos of ETPs and EU initiatives that showed interest in them and in Building Up roadmapping activities during experts' workshops, ETP meetings, Advisory Board meetings and through online consultations.

Figure 11 – Structure of the Cross-Platform areas & involvement of ETPs and associations

4 CP1 - Performance Based Approach for building components, including sustainable design, Life Cycle Analysis

The cross-platform area CP1, entitled "Performance Based Approach for building components, including sustainable design, Life Cycle Analysis" contains different targets and priorities towards 2020. A scheme of this cross-ETP research and innovation area is described in the figure below.

Figure 12 – Scheme of CP1 targets and priorities

4.1 Current situation (State of the Art)

It is known that improving the energy performance of buildings is critical for achieving 2050 decarbonisation goals. Therefore, major efforts are needed in order to contribute to rethink the approach about the main activities that concern a building: materials manufacturing, construction, use and maintenance, and end of life.

The Life-Cycle Stages of a building are described below:

- ✓ ***Materials Manufacturing stage***: Extraction of raw materials from earth, transportation of materials to the manufacturing locations, manufacture of finished or intermediate materials, building product fabrication, and packaging and distribution of building products;

- ✓ ***Construction stage***: All activities relating to the actual building project construction;

- ✓ ***Use and Maintenance stage***: Building operation including energy consumption, water usage, waste generation, repair and replacement of building assemblies and systems, and use and transport of equipment for repair and replacement;

- ✓ ***End of Life stage***: Includes energy consumed and waste produced due to building demolition and disposal of materials to landfills, and transport of waste materials. Recycling and reuse activities related to demolition waste also can be included. [6]

All these phases need to be checked and designed with specific tools which must take into account the sustainability of the building and the energy consumption, in order to reduce the environmental impacts.

State of the Art in Technology/Research: Public funding facilitated several projects focusing on the individual and holistic performance. However, the sustainability in the whole life cycle of the product (including the construction process) is still less in focus modern building, this is increasingly important since the production phase today can account for equal emissions of e.g. CO2 as the usage phase. The European government worked a lot towards a more sustainable building industry, developing several guidelines and directive:
CEN/TC 350 "Sustainability of construction works" is responsible for the development of voluntary horizontal standardized methods for the assessment of the sustainability aspects of new and existing construction works and for standards for the environmental product declaration of construction products.
Today Life Cycle Assessment (LCA) tools analyze the environmental impact of buildings and support decisions to reduce these impacts: there are many disparate rating system and certification about energy efficiency (LEED, Energy Star, etc.) that have started to incorporate Life Cycle Assessment.
Nowadays the Construction Product Regulation (CPR) is replacing the old Construction Product Directive (CPD), while regulations are directly binding (no national implementation like for Directives required); this CPR introduces sustainability especially with new 7thbasic work requirement (BR7): “sustainable use of natural resources” and add minor changes in BR3 (environment, health).

4.2 Targets by 2020

The following targets were considered:

1) All building components have to meet an eco-design approach (including LCA) covering the whole chain of the building life: material production, construction, use, recycling;
2) In order to control every loss of energy and monitor energy consumptions, it will be necessary to guarantee higher building physics performance (e.g. acoustic, vibration, etc.).

[6] AIA Guide to Building life cycle assessment in practice; Georgia Institute of Technology 2010

4.3 Research and Innovation Priorities

The targets previously mentioned need to be strongly linked with specific priorities, in order to fill the gap between the current situation and the desired future condition.

A scheme of those connections is described in the following sub-chapter.

4.3.1 Research and Innovation Priorities by Target

Target 1 includes the following priorities:

- ✓ Agreement on common understanding (boundaries) and handing back to national standards;
- ✓ Common methodology based on existing Life Cycle Analysis/LCA studies and standards (CEN TC 350 based);
- ✓ Systemic approach for all energy usages (energy, water, …) taking into account their mutual interaction;
- ✓ Link with future modifications of Ecodesign UE directive;
- ✓ Design tools for optimization of sustainability of buildings and building components (embedding LCA, etc.);
- ✓ Building design tools for architects allowing for real time building eco-design.
- ✓ Development of advanced devices for the reduction of the water consumption and for the recycling of water, such as an overall water efficiency indicator WSEE (Water Supply Energy Efficiency), defining further indicators for buildings and districts linked to distribution networks, water losses and pumping systems.

In order to reach the implementation of a common eco design approach and energy-saving oriented standard (Target 1) the following platform suggestions are explained in the tables below.

ESTEP	
	• Adoption of designing innovation processes, including all aspects of life-cycle design.
	• Environment Product Declaration (E.P.D.)'s of all components and solutions should be considered as a mandatory requirement for buildings. It can be an added value information for designers: it would be good to have a tool that once you pick a product in the design phase, the tool will tell you its E.P.D. value and contribution.
	• Modeling and simulation, evaluating the performance of nano-enabled materials.
	• Service-life design methods for multi-material and composites; interaction of various materials to degradations and ageing models in various environmental and loading conditions.

SUSCHEM	
	• Raising public awareness and dissemination of Life Cycle Analysis techniques for the building sector, paying attention in not to disclose intellectual property during LCA processes.
	• The combination of different building materials to obtain a cost-optimum solution and the measurement of actual building performance will be important versus just only data from the material suppliers.

EUMAT	
	• Deep analysis of the mechanisms that influence the durability of the different properties of construction materials, products and components, including improved Life Cycle Analysis (LCA) tools and reliable, fast and robust ageing models.
	• Development of processes to generate improved durability, including reliable test methods and inspection procedures.
	• Focus on emerging market of bio based materials, or resources that are renewable in less than 10 years, low in embodied energy, carbon neutral and/or biodegradable. Research is needed on potential gains in terms of embodied energy compared to conventional materials and on LCA of bio-based materials.
	• Development of prototypes of new products and systems, and identification of more transparent and dedicated LCA methodology .

4.4 CP Expected outcome

CP expected outcome in terms of products/services/methods and field of applications are listed in the following table.

Table 4 – Outcomes and field of application for CP1

OUTCOME	FIELD OF APPLICATION
Eco-construction techniques (including methodologies for assessing the energy efficiency of water supply systems)	Any scale of Construction: - Residential; - Non-residential (e.g. offices); - Public facilities (e.g. schools, hospitals); - Commercial (e.g. shops); - Industrial (light and heavy) - Infrastructures (e.g. bridge).

4.5 Considerations beyond 2020

It is necessary to consider buildings as complete systems rather than sums of components: performance-based approach must be a recognized as driving factor all over Europe, assuming that existing best practices become the standard (both in new construction and renovation) after a certain transition time.

It has been estimated by the Consortium that the large majority (>85%) of building products should obtain EPD (Environmental Product Declarations) compliant with CEN TC 350 (Sustainability of Construction Works) by 2030, at the same time increasing the use of embodied energy calculations and LCA in product manufacturing.

It would be desirable to have a sort of “speaking” components: those elements must have indicators built into them to point out their status, their effective functioning and the availability to modify several parameters.

5 CP2 - Multi-materials and composites

The cross-platform area CP2, entitled “Multi-material and composites” contains several targets and priorities towards 2020. A scheme of this cross-ETP research and innovation area is described in the figure below.

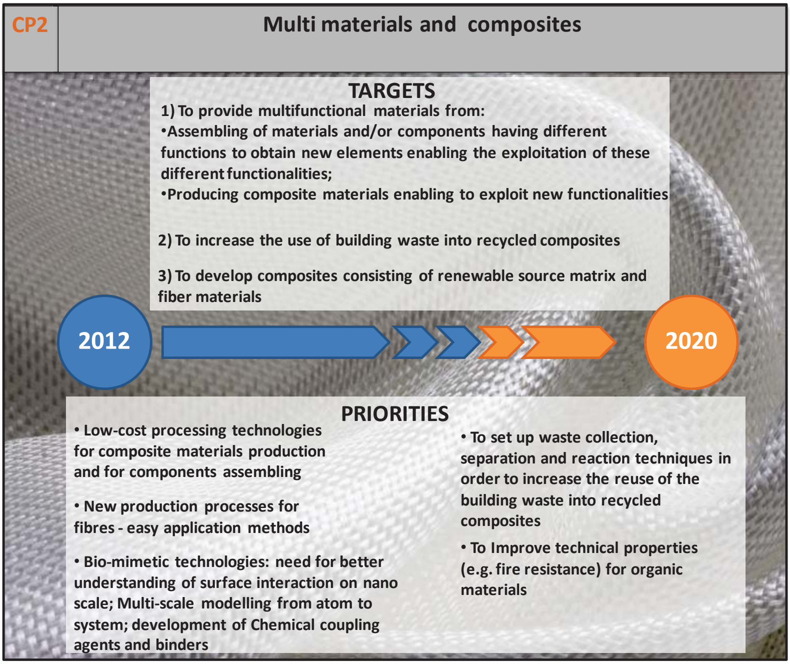

Figure 13 – Scheme of CP2 targets and priorities

5.1 Current situation (State of the Art)

State of the Art in Technology/Research: Almost all construction materials are nowadays multi-material composites. We use concrete with admixtures and additives. We use plastics with different additions of other materials for performance enhancement. Plasters and renders are likewise stabilized, plasticized and strengthened by organic, inorganic and metallic additions. The steel-based solutions comprise steel-concrete composite structures (beams, columns, floors, heavy walls) and sandwich panels with cores made of various materials. The basic design methods are standardized based on intensive research. New applications need usually experimental involvement. Nano-technologies used for improved coatings. Therefore we can state that there are no construction materials existent that are not multimaterial mixtures. Even semi natural products like cellulose fibres, used for heat insulation, have anti bacteria additions in order to increase their durability. However, if we talk about multimaterial composites we should separate the meaning into two categories: formulations and "combination". In formulations you can find a dominant phase, e.g.

aggregates in concrete, while two or materials coexist in comparable fractions in combinations/composites. These combinations/composites have normally a different scale than formulations and clearly separated functions for each "partner" material.

State of the Art in non technical aspects (standards, commercialization, regulation): There is a need of services to support recycling of building components & materials (link with CP7).

5.2 Targets by 2020

Energy savings can be achieved through several leading actions regarding materials, waste processes and advanced composites, summarised in the following targets:

1) To provide multifunctional materials from:
   - Assembling of materials and/or components having different functions to obtain new elements enabling the exploitation of these different functionalities;
   - Producing composite materials enabling to exploit new functionalities;
2) Increasing the reuse of the building waste into recycled composites;
3) Developing composites consisting of renewable source matrix and fibre materials.

5.3 Research and Innovation Priorities

Targets previously mentioned need to be closely related to specific priorities, in order to fill the gap between the current situation and the desired future condition.
It is important to remark that nano and other chemical based technologies should go through technology assessment before used in big scale
A scheme of those connections is described in the following sub-chapter.

5.3.1 Research and Innovation Priorities by Target

In order to reach Target 1 is necessary to advance towards different main concerns, both technological and process-related issues:

- ✓ Low-cost processing technologies for composite materials production and for components assembling;
- ✓ New production processes for fibres - easy application methods;
- ✓ Bio-mimetic technologies: need for better understanding of surface interaction on nano-scale; Multi-scale modelling from atom to system; development of Chemical coupling agents and binders.

The platforms proposed several actions to reach Target 1, which are described in the table below:

ESTEP	
	• Combinations of high-strength materials and multifunctional materials, contribution to light weight solutions: e.g. sandwich panels with improved long-term performance.

SUSCHEM	
	• Nanocomposite materials with competitive mechanical properties (mainly structural) compared to steel.
	• Formulation of thermoplastics for composites used in construction & performance evaluation with respect to concrete.
	• Low embedded energy concrete with high mechanical properties and obtained at low temperature.
	• Performance-oriented development.
	• Self-healing materials (plastic composites, concrete and coatings for integrated mechanical and insulating performance), that will reduce maintenance costs, producing measurable benefits for the building owner.

TEXTILES	
	• Use of advanced textiles as reinforcement materials for next generation building composites.
	• Advanced (top)coatings for building composites.

EUMAT	
	• Renewable biotic materials are low in embodied energy, and have a favourable carbon footprint. These are particularly applicable to insulation materials.
	• Bio-based polymers, in particular bio-based resins, allow wood composites, hybrid composites and fibre insulations.

In order to reach Target 2 it would be valuable to go towards the following priority:

- ✓ Set up waste collection, separation and reaction techniques in order to increase the reuse of the building waste into recycled composites

The platforms suggested several actions to hit Target 2 which are described in the table below:

SUSCHEM	
	• Development of new coupling agents and binders as well as a process to cost-effectively combine different waste streams into composite materials; • Bio-degradation / enzymatic degradation of binders

TEXTILES	
	• Advanced bio-based building composites.

FOREST TECHNOLOGY Platform	
	• The potential for and benefits from energy recyclability of renewable resources should be considered.

Target 3 could be achievable through advancing in research and development activities about the next priority:

- ✓ To Improve technical properties (e.g. fire resistance) for organic materials

The platforms proposed several actions to reach Target 3 which are described in the table below:

SUSCHEM	
	• Bio-based non-toxic flame retardants.

FOREST TECHNOLOGY Platform	
	• There is a strong interest in increasing the amount of renewable materials in multi-material composites. Also highly interesting to increase the amount of renewable biomass in all other construction materials. In both cases this will contribute to lower energy use and CO2 emissions.

5.4 CP Expected outcomes

CP expected outcome in terms of products/services/methods and field of applications are listed in the following table.

Table 5 – Outcomes and field of application for CP2

OUTCOME	FIELD OF APPLICATION
Multi-material composites	**Composites for exterior design include:** - columns - pediments - domes - cornices - formworks **Interior Composite applications include:** - walls - floors - building envelop - panels - blinds - sanitary-ware - functional items (letter boxes, meter boxes) - decorative items - window profiles

5.5 Considerations beyond 2020

The results from implementing those technologies and processes will be buildings that cost less to operate and are worth more to their occupants: so it would be good if construction companies and industrial partner could be able to reuse all building waste into recycled composite materials; ***FOREST TECHNOLOGY PLATFORM*** suggest to set up waste collection, separation and reaction innovative techniques in order to support the overall recyclability of construction & demolition materials.

Another crucial target would be to provide intelligent materials that can be connected and disconnected by needs, that react on their environment according to different situations, materials that "know" each other and organize accordingly (e.g. nano glues for different types of molecular surfaces, etc): this goal can be achieved through the development of advanced technologies such as molecular construction, that could support the spread of those intelligent materials.

6 CP3 - Healthy and comfortable indoor environment (including air quality, ventilation, lighting, acoustics, etc.)

The cross-platform area CP3, entitled “Healthy and comfortable indoor environment” includes different targets and priorities towards 2020. A scheme of this cross-ETP research and innovation area is described in the figure below.

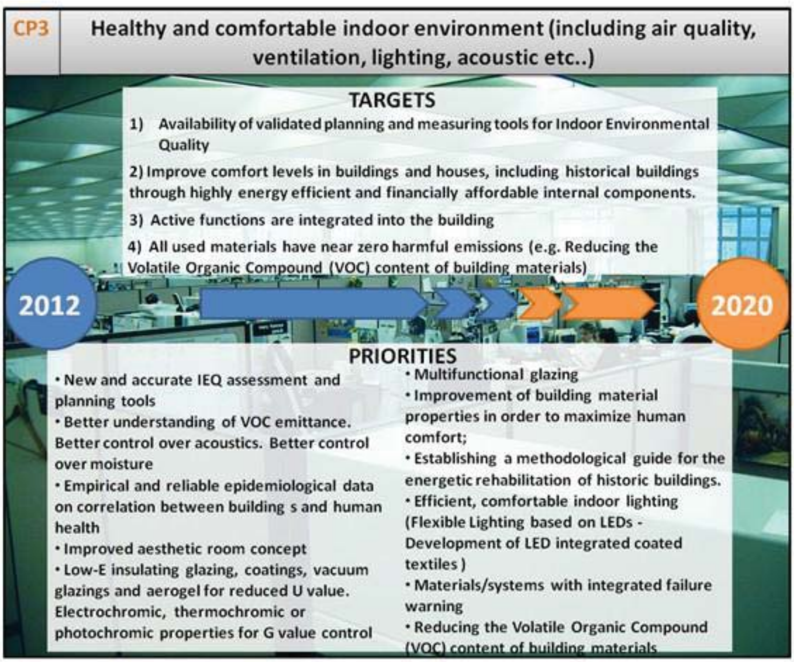

Figure 14 – Scheme of CP3 targets and priorities

6.1 Current situation (State of the Art)

State of the Art in Technology/Research: "Indoor Environmental Quality" refers to the quality of the air in an office or other building environments. While research has shown that some respiratory symptoms and illnesses can be associated with damp buildings, it is still unclear what measurements of indoor contaminants show that workers are at risk for disease[7]. Despite uncertainty about what to measure and how to interpret what is measured, research shows that building-related symptoms are associated with building characteristics, including dampness, cleanliness, and ventilation characteristics.

[7] The National Institute for Occupational Safety and Health (NIOSH), http://www.cdc.gov/niosh/topics/indoorenv/

But indoor environments are highly complex and building occupants may be exposed to a variety of contaminants (in the form of gases and particles):

- Professional activities (ex. office machines, cleaning products, hospitals, paints, dried washing shops, hair-cut shops, cooking, carpets and furnishings, cigarette smoke, …);
- Outdoor pollutants (road traffic, professional activities vectorization, unfavourable weather, …);
- Construction materials pollution release (paints, coating, wood treatment, plastic equipments, carpets, curtains, …);

Other factors such as indoor temperatures, relative humidity, and ventilation levels can also affect how individuals respond to the indoor environment.

The topic "indoor environment" was reinvented recently. After years of discussions about limitation of certain compounds it was realized that an added value is based on the actual "feeling" of people working and living in spaces. The feeling issue is not strictly related to these limits. It is rather dependent on soft criteria like artificial lighting, architectural design, heating and ventilation concepts. For example, steel product manufacturers and suppliers of whole-building solutions have a range of tools to model and simulate indoor air quality including technologies and materials that influence on the human health. However, the current practices focus mainly almost solely on individual building materials and their emissions, which is mandatory to ensure product safety. As the emissions from building materials represent only a part, and sometimes even an insignificant part, the scope of research needs to be extended to overall performance of buildings. Needs for major reductions in the energy consumption of buildings create other needs to ensure the healthy and comfortable indoor environment quality (IEQ).

High-tech products to reduce energy consumption from heating and air-conditioning in buildings have been developed by the glass industry, in order to improve also the general indoor environment. Three of the most famous glazing solutions are Low-Emissivity, highly insulating glass and solar control glass.

State of the Art in non technical aspects (standards, commercialization, regulation): Since Ecolabel is being released at the end of 2012, regulations for indoor/outdoor air environment have to be studied in order to adapt with the technology evolution. Indeed the EC Joint Research Centre's Institute for Prospective Technological Studies (JRC-IPTS) in cooperation with the Circe consortium for the European Commission's Directorate General for the Environment is currently carrying out a pilot study on developing an EU Ecolabel and Green Public Procurement (GPP) criteria for buildings[8]. Among the documents released by this study it is worth mentioning the minutes[9] from “Second meeting on development of GPP criteria for Office building” in which a set of criteria for indoor quality and well-being are identified,

namely: Visual comfort, Separate rooms for printers and office equipment, Exclusion of certain materials and Minimum ventilation rates. Even if discussions about these criteria are focused only on office buildings and development are still ongoing, it is important to notice that CEN is now developing the TC351 standard for IAQ based on emissions from construction materials that will be mandatory in future.

[8] http://susproc.jrc.ec.europa.eu/buildings/

[9] http://susproc.jrc.ec.europa.eu/buildings/docs/GPP%20draft%20minutes%2024022012.pdf

6.2 Targets by 2020

To achieve a healthy and comfortable indoor environment, the following targets have been identified:

1) Tools for planning and instruments for measuring Indoor Environmental Quality are available and well validated;
2) Highly energy efficient and financially affordable glazing and general components are available to reduce air-conditioning use and CO2 production, to improve safety and security, to improve fire resistance. These achievements will lead to an overall improvement of comfort levels in buildings and houses, including historical buildings
3) Active functions are integrated into the building;
4) Acoustics materials/systems;
5) Energy Monitoring and Controlling (EMC) systems;
6) Lighting systems;
7) All used materials have limited emissions of indoor air pollutants and ventilation rates are in accordance with European standards.

6.3 Research and Innovation Priorities

The targets previously mentioned need to be strongly linked with specific priorities, in order to fill the gap between the current situation and the desired future condition.
A scheme of those connections is described in the following sub-chapter.

6.3.1 Research and Innovation Priorities by Target

In order to reach Target 1 is necessary to advance and work on different main concerns, both technological and process-related issues:

- ✓ To create and validate new and accurate Indoor Environmental Quality (IEQ) assessment and planning tools for building structures and materials in Energy Efficient buildings (e.g. sustainable labels). Example: New quality control procedure of Indoor Air Quality (IAQ) during the manufacture and use of buildings.

- ✓ Better understanding of volatile organic compounds (VOC) emission and control of harmful components. Better control over acoustics; Better control over moisture. Example: Multifunctional measurements for evaluating indoor environment.

- ✓ Provide empirical and reliable epidemiological data on correlation between building structures, materials, indoor environment quality and human health, desirable level of microorganisms, etc. This may include User behaviour studies about inhabitants feeling comfortable.

- ✓ Improved aesthetic/functional room concepts.

The platforms proposed several actions to reach Target 1 which are described in the table below:

ESTEP	
	• Controlling indoor-environment by design (e.g. removal of thermal bridges; promotion of dry technologies to reduce moisture and water from structures). Smart building technologies and continuous monitoring in use.

SUSCHEM	
	• Buildings materials and building performance analysis. Evaluation of factors with respect to health and toxicology of compounds for which information is lacking but are commonly emitted from materials • Materials allowing control over key parameters of comfort and health inside buildings: acoustics control, humidity control, temperature control, perhaps even electromagnetic field shielding and light control. Ideally these should be building-integrated and where attractive available as layers on the interior building surface (e.g. allowing lighting surfaces, humidity control surfaces, sound deadening surfaces). • Building energy rating certification could be a lever to improve energy efficiency and economical targets, generating a set of shared standard UE regulations in term of definitions and environmental specifications, which each national system must comply with could be a great help.

RHC Platform	
	• Creating and validating a risk assessment and planning tool for HVAC systems, materials and structures in EE buildings in terms of their impact on IAQ&IEQ

EUMAT	
	• Advanced multi-functional ceramic surfaces (e.g. with natural indoor air quality or moisture control)

In order to reach Target 2 is necessary to advance and work on different main concerns, both technological and process-related issues:

- ✓ Improvement of Low-E (low-emissivity) insulating glazing, low-E coatings, vacuum glazings and aerogel for reduced U value. Improvement of electrochromic, thermo-chromic or photochromic properties for G value control;

- ✓ Combination with many other features for multifunctional glazing, such as thermal insulation, self-cleaning, noise reduction, decorative glass, enhanced safety and security, solar control, low-maintenance;

- ✓ Improvement of building material properties in order to maximize human comfort;

- ✓ Establishing a methodological guide for the energetic rehabilitation of historic and artistic interesting buildings.

The platforms proposed several actions to reach Target 2 which are described in the table below.

SUSCHEM	
	• Lambda 0,03 W/m^2K insulative performance of windows including their window frames at economically viable cost levels. • Promote this technology to manage UV radiation window cutoff (photochromism) to avoid/limit air conditioning running to compensate. Photochromism versus Electrochromism takes the advantage to work without any power supply. To control the cost, promote not only windows replacement but smart films technologies (plastic films) to add on the windows on existing buildings. • PHOTOCATALYTIC windows with self-cleaning and air-purification properties, including improvement in efficiency in visible light range • Strong focus on system development: panel, frame and sealant.

In order to reach Target 3 is necessary to advance and work on different main concerns, both technological and process-related issues:

- ✓ Efficient, comfortable indoor lighting (Flexible Lighting based on LEDs - Development of LED integrated coated textiles)

- ✓ Materials/systems with integrated failure warning

The platforms proposed several actions to reach Target 3 which are described in the table below:

SUSCHEM	
	• Air filters consisting of advanced (non-woven?) textiles combined with active coatings such as microbe-killing Ag or TiO_2 nanoparticles; offering high air flow at low mechanical ventilation power consumption, reduced cleaning or replacement intervals of such filters.

TEXTILE	
	• Catalytic materials have to be promoted to be also integrated in air conditioning system or in stand-alone application (as air cleaner device). Some setups are under development in startup companies but still suffer of many drawbacks: Catalytic performance

In order to reach Target 4 is necessary to advance and work on different main concerns, both technological and process-related issues:

- ✓ Reducing the Volatile Organic Compound (VOC) content of building materials (in the production phase).

6.4 CP Expected outcomes

CP expected outcome in terms of products/services/methods and field of applications are listed in the following table.

Table 6 – Outcomes and field of application for CP3

OUTCOME	FIELD OF APPLICATION
Healthy, comfortable and quality indoor environment: - Energy Efficient Equipments (including HVAC, lighting, acoustic performance, integrated systems, energy efficient glazing, etc.) - Planning, metering and monitoring tools and services	The following buildings and construction sites: - Residential; - Non-residential (e.g. offices); - Public facilities (e.g. schools, hospitals); - Commercial (e.g. shops); - Industrial (light and heavy); - Outdoor sites; - Cultural/historical buildings.

6.5 Considerations beyond 2020

Indoor Environmental Quality represents one of the most critical issues for the development of more energy efficient buildings and districts, because it consists of many parameters representing the interface between users and buildings. The complexity of elements related with IEQ is also apparent when considering the different initiatives related with parameters, standards and rules aiming at regulating this area. Therefore among longer term targets it has been highlighted the need for providing more stable and constant conditions for the indoor environment of a building. This may be achieved through:

- Optimum balance between HVAC and insulation;
- Implementation of Phase Change Materials to buffer variation in external conditions;
- Bringing more natural light inside the buildings.

Moreover there will be the need of a wider application of new glazing materials in public and private buildings including historical buildings, in order to improve day lighting, that measuring smart windows to redirect light around within rooms in order to reduce the need for artificial lighting.
Another example of future improvement could be the use of advanced chemical products, like thermoplastic polymethyl methacrylate, that makes a valuable contribution to energy saving. PMMA transmits more light than conventional glass and the use of multi-skin sheets in greenhouses offer an ideal energy balance. Their good heat insulation means that less energy is required than with conventional glazing, thus cutting costs and CO_2 emissions.

7 CP4 - Electric generation and storage materials and systems

7.1 Current situation (State of the Art)

The cross-platform area CP4, entitled "Electric generation and storage materials and systems" contains several targets and priorities towards 2020. A scheme of this cross-ETP research and innovation area is described in the figure below.

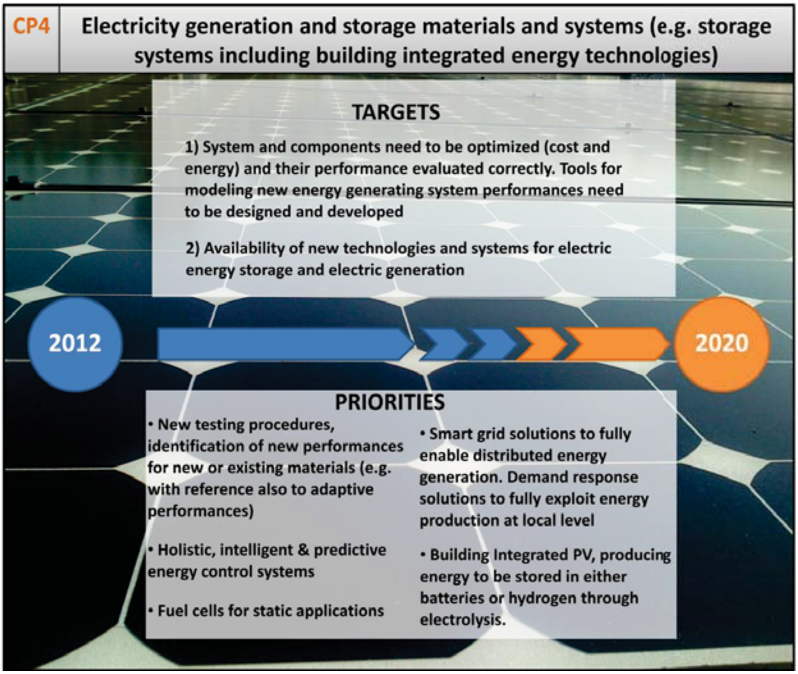

Figure 15 – Scheme of CP4 targets and priorities

State of the Art in Technology/Research:

Electricity generation could be implemented through several devices: photovoltaic systems and small wind turbine are current technologies for building installation.

Photovoltaic systems use solar panels to convert sunlight into electricity: their effectiveness changes over the year with a certain regularity, because generating power from renewable energy sources is subject to extreme fluctuations and cannot be controlled since the period during which power is generated (when the sun is shining) only coincides by chance with power consumption. Already, today, not all the green energy generated can be fed into the grid all the time.

In order to overcome this physical and technological barrier it is necessary to improve in storage systems and innovative batteries, also because increased electricity consumptions and reduced availability of fossil fuels will lead in next years to a global increased energy needs.[10]

Small wind turbines could be one of the most adaptable, flexible and easy to use technologies for generating sustainable and cheap electricity. Currently Small Wind Turbine (SWT) is still an unsafe technology, because their efficiency is strictly correlated to wind conditions and altitude installation.
Those devices consume more electricity than they deliver[11] when they are installed in urban environments at sub-optimal heights (<15mt) and do not provide sufficient payback, in contrast with previous assumption AWEA stated that SWT are a valuable solution if installed minimum 15 meters above buildings[12].

Materials are key enablers in all PhotoVoltaic systems. The materials supply chain needs to be able to supply sufficient quantities of the required elements, and thus, cost effective recycling solutions should be developed along with standardised performance testing. Reliability/ageing test protocols needs to be developed to provide confidence (and so bankability) for PV devices employing newly developed materials in a wide range of operating conditions (from Europe to Sunbelt environments).

Electricity storage
Electricity energy storage technologies are important for improving the efficiency of electrical energy utilisation. The primary aims of developing and deploying electricity storage technologies is their potential to generate an "electricity reserve", the benefits of which include:

- Stabilisation of the energy market: Areas that could see improvement with the wider application of energy storage are increased diversification and security of supply;

- Stabilisation of the transmission and distribution grid: A consequence of this is that energy management can potentially reduce the need for reserve fossil fuel plants. Power quality applications can assist in smoothing out faults and other short term disruptions and perturbations, reducing the requirement for 'spinning reserve' in the system.

- Optimisation of intermittent renewable energy resources, particularly wind: Linkage between intermittent sources of energy and associated storage - for example during the night or other periods of low demand - could reduce the vulnerability to supply shortages by providing a means to store excess energy, and then release it during periods of high demand. Improvements in this field will enable intermittent sources to command a higher price for the energy produced by making it more dispatchable.[13]

Today, most storage technologies are too costly and exhibit inadequate technical performances for a wide-spread deployment and integration at system scale.

[10] State-of-the-art electricity storage systems, Deutsche Bank Research, 2012
[11] http://www.theoildrum.com/node/6954
[12] http://www.awea.org/learnabout/smallwind/upload/awea_smallwind_gms2011report_final.pdf
[13] Outlook Of Energy Storage Technologies; UE Parliament - Policy Department Economic and Scientific Policy; 2007

7.2 Targets by 2020

The construction of low-energy 'passive' or even 'zero-energy' houses promises to cut energy use dramatically: in this framework the following targets were identified:

1) building system and components need to be optimized (cost and energy) and their performance evaluated correctly. Tools for modeling new energy generating system performances need to be designed and developed.

2) Energy savings could be achieved only through the availability of new technologies and systems for electric energy storage and electric generation.

7.3 Research and Innovation Priorities

Targets previously mentioned need to be strictly linked with specific priorities, with the aim of associating detailed matters required for filling the gap between actual situation and future condition. A scheme of those connections is described in the following sub-chapter.

7.3.1 Research and Innovation Priorities by Target

In order to reach Target 1 it will be necessary to adopt new testing procedures, identification of new performances for new or existing materials (e.g. with reference also to adaptive performances);it would be useful to provide holistic, intelligent & predictive energy control systems that could manage a sustainable building.

The following platforms suggest reaching those targets through the actions described in the tables below.

ESTEP	
	• Building components that are capable to capture & store energy
	• Smart control system that can balance the three activities (capture, storage and distribution)

TEXTILES	
	• Incorporation of electronic/sensor functions into building composites materials
	• Integration of energy storage systems into building composites materials

EUMAT	
	• **Energy generation**- 1. Layer CdTe <1,5µm / CIGS <1,0 µm; Wider total layer band gaps than current (e.g. TFPV 1,7-1,8 eV; multi junction 2,2 eV); Elimination of all toxic substances in PV devices; Non indium containing TCOs with adequate performance; Low Silver / silver free metallisation. The combined effect of all improvements should lead to a reduction by 50% of the LCOE by 2020 and >65% by 2030 compared with 2011;
	• 2. Typical PV module efficiencies (crystaline Si- 18-23%; thin film Si- 13-14%; other thin films- 10-18%; HCPV 40-50%);
	• 3. Glass thickness reduction - <1mm by 2020.
	• **Electricity storage**- Li-ion battery performance improvements to 180-350 Wh/kg -350-800 Wh/L

The widespread availability of new technologies and systems (e.g. building integrated PV) is strictly needed (Target 2), in order to produce energy to be stored in either batteries or hydrogen through electrolysis. The stored electricity can be used in household appliances or for electric vehicles. Stored hydrogen can also be transformed back to electricity or used directly in fuel cell electric vehicles.
An integration of electricity generation in holistic supply systems, demand driven generation and storage is strongly needed to ensure a well developed structure:
the system involves integration of PV (also in the infrastructures at large), smart meters/grids, battery technology, electrolysis and fuel cells, transparent electric active windows; also smart grid solutions could be necessary to fully enable distributed energy generation. Demand response solutions will be crucial to fully exploit energy production at local level; also with the wide market distribution of fuel cells devices for static applications.

The following platforms suggest reaching those targets through the actions described in the tables below.

ESTEP	
	• Implementation of Sandwich panels & entire building envelope; Pilot and demonstration buildings
	• Smart components that work intelligently and remotely with the smart grid

SUSCHEM	
	• **Energy generation:** support the introduction and optimization of cost/performance of PV techno generation 2 (thin films) and generation 3 (Organic photovoltaic) in building environment. According to the light weight module and functioning under scattered or low light, indoor and outdoor applications can be investigated without “perfect” PV panel orientation. A semi-transparent PV panel has also to be considered to use surface windows (smart windows…). Combination with or replacement of glass with optically active layers based on acrylic polymers. Further develop photovoltaic steel (e.g. binding, sticking) • Support market development (mass production materials, technology dissemination...). • Sensors for building integration have to be anticipated regarding domotic approach for long term development: robust and low cost sensors ; sensors can monitor different kind of parameters (weather, sun level, energy storage and production systems and energy use) • BIPV (Building Integrated PhotoVoltaics) will be developed in the near future through integration in building materials and surfaces: it will be necessary to validate regarding life time of devices and Building Regulations compliance. • **Energy storage**: New polymeric materials and membranes for stationary batteries; also BIPV will require a further development of batteries on site for standalone use (off grid), or to be integrated on grid.

7.4 CP Expected outcomes

CP expected outcome in terms of products/services/methods and field of applications are listed in the following table.

Table 7 – Outcomes and field of application for CP4

OUTCOME	FIELD OF APPLICATION
Electric generation materials	Entire skin of the building, including building envelop (e.g. roofing, sun-shading, glazing, architectural fabrics).
Storage solution technologies	Various types of existing or potential storage technologies are adapted for different uses. All storage technologies are designed to respond to changes in the demand for electricity, but on varying timescales. Demand fluctuations on shorter timescales—sub-hourly, from a few minutes down to fractions of a second—require rapidly-responding technologies like flywheels, super-capacitors, or a variety of batteries, which are often of smaller capacity.[14]

7.5 Considerations beyond 2020

Buildings could play an active role in energy saving with the possibility to produce electricity with PV systems. Buildings will also have the capability to store energy (batteries, fuel cell, etc.) in time periods with low energy demand, and to release this energy again in periods with a high energy need and thereby lead to a reduction of the total energy demand.
A further development and a wider application of new energy generating and storage system will be highly recommended, specifically a integration on urban scale.
A driving priority could be the expansion of smart building envelops capable of adapting their energy generation and storage to external condition, with automatic weather stations that provide inputs in order to self-regulate several parameters.

ESTEP suggests investing in solution & tools capable to transform buildings into mini power stations capable of producing energy and consider whole urban areas, i.e. urban planning level.

EUMAT suggests the development of technologies with the following improved characteristics:

- *Electricity generation* - Typical module efficiencies (crystalline Si- >30%; thin film Si- >16%; other thin films- 16->21%; HCPV 50-60%;
- *Electricity storage* - Li-ion improvement to >350 Wh/kg and >800 Wh/L.

[14] http://205.254.135.7/todayinenergy/detail.cfm?id=4310

8 CP5 - Thermal generation and storage materials and systems

The cross-platform area CP5, entitled “Thermal generation and storage materials and systems” includes different targets and priorities towards 2020. A scheme of this cross-ETP research and innovation area is described in the figure below.

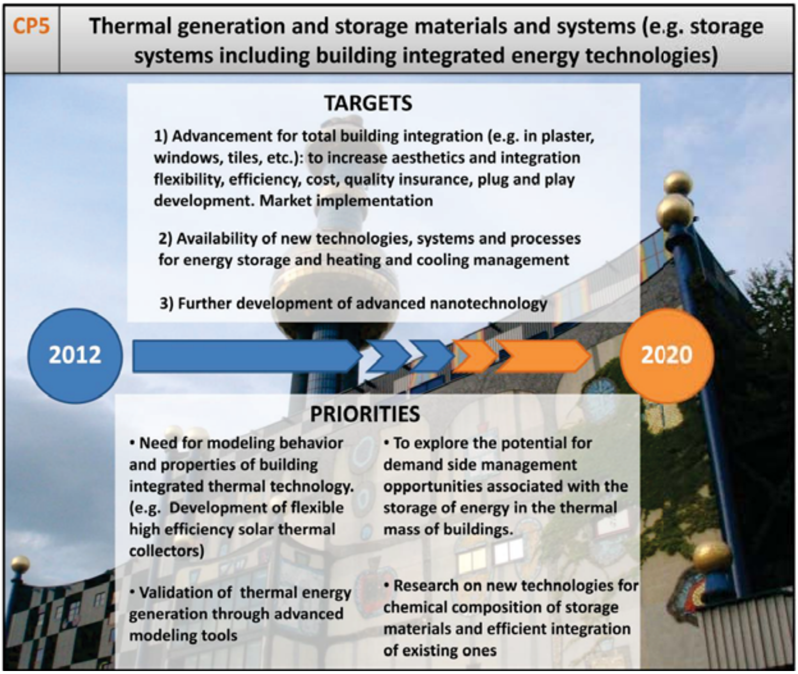

Figure 16 – Scheme of CP5 targets and priorities

8.1 Current situation (State of the Art)

Thermal generation became a main concern in order to save energy: many innovative devices like cogeneration and trigeneration systems are entering step by step into the mass market.

The storage of energy efficiently converted into the required form is also a current day challenge for scientists.

Energy storage not only reduces the difference between supply and demand but also improves the performance and reliability of energy systems, playing a valuable role in conserving the energy. It leads to saving fuels and makes systems more cost effective by reducing the waste of energy and capital costs. Thermal energy storage can be collected as a change in internal energy of a material as sensible heat, latent heat and thermochemical or a combination of these ones.[15]

State of the Art in Technology/Research: The vast majority of the thermal energy used in buildings is currently produced through the combustion of fossil fuels such as oil, gas and coal, with an impressive environmental impact in terms of greenhouse gas emissions. A variety of renewable heating and cooling technologies exist which can be integrated into the built environment.

Directive 2009/28/EC on the promotion of the use of energy generation from renewable sources classifies the following technologies:

- Solar Thermal;
- Biomass;
- Geothermal and Aerothermal Heat Pumps.

These technologies can be combined in highly efficient hybrid heating (and/or cooling) systems.

Thermal energy storage solutions can be classified according the temperature level of stored thermal energy (heat storage; cool storage), the time length of stored thermal energy (short term; long term), and the status of energy storage material (sensible heat storage; latent heat storage; thermochemical heat storage).

Sensible heat storage systems (e.g. hot and chilled water) and some latent heat stores (e.g. ice storage) are mature technologies. However, developments in advanced PCM and thermochemical materials are opening up possibilities for new applications, such as PCMs embedded in building materials used for bricks, wall boards or flooring. Phase Change Materials (PCMs) respond to slight changes in temperature meaning that they are good at buffering changes in temperature close to the temperature at which they change phase. Using ice storage, chiller capacity can be generally reduced by 50% or more thanks to the reduction in the electrical peak loads. Hybrid systems are also possible, for instance plastic PCM modules can be put into a tank where the heat-transfer fluid (usually water) melts or solidifies the PCM. This hybrid system has a higher storage density than that of water, but less than a pure PCM system. The development of thermochemical materials and technologies is still at an early stage.[16]

State of the art of solar thermal technology

Current key applications of solar thermal technologies:

- Domestic hot water preparation for single- and multi-family houses with typical solar fractions between 40 – 80% (meaning the energy of sunlight meets these shares of demand for this use);
- Space heating of single and multiple family houses with typical solar fractions between 15 – 30%;
- Hot water preparation in the hotel and tertiary sector.

In some European countries, such as Austria, Denmark, Germany and Sweden, solar-assisted district heating systems are already well established. In recent years the number of solar thermal systems for cooling and air conditioning and industrial process heat has

[15] Garg HP, Mullick SC, Bhargava AK. Solar thermal energy storage. D. Reidel Publishing Co; 1985.
[16] Atul Sharma , V.V. Tyagi , C.R. Chen , D. Buddhi; Review on thermal energy storage with phase change materials and applications; Devi Ahilya University 2010

increased considerably, while there is a big untapped potential in new applications such as sea water desalination and water treatment.
***The increase in the installations of solar thermal combined-systems, providing both domestic hot water and space-heating, is a very promising development enabling greater use of the solar resource**.* 100% solar-heated buildings (Active Solar Buildings) have already been demonstrated in Central European climates (both detached houses and multi-family buildings). These buildings need very good thermal insulation, space for a large collector area and for a heat store.

State of the art of biomass technology

Technology for providing bioheat to households, commerce and industry is available, reliable and efficient but has to compete against well-established systems based on fossil fuels. Bioenergy can provide both low-temperature heat and steam, and high temperature heat suitable for industrial processes.
Small-scale heating systems fired with wood logs, chips or pellets offer good ease of use, low operating costs and are replacing oil heating in many European regions. Biomass district heating is of growing importance in Scandinavia, Austria, and other countries where demand for heat by the residential / service sector is high.
Methane production by fermentation is an alternative route suitable for wet raw materials. Biogas can be burned directly in a boiler for heat or in an engine for cogeneration, while upgraded biogas (methane) can additionally be injected into the natural gas grid or as vehicle fuel.

State of the art of geothermal technology

By definition, geothermal energy is the energy stored as heat beneath the earth's surface. Currently, besides electricity production, geothermal energy is used for district heating and cooling, and to heat and cool single buildings or groups of buildings (offices, shops, houses, schools, greenhouses, swimming pools). At low temperature (up to 25°C) a number of innovative applications of geothermal energy have been developed based on the relatively stable groundwater and ground temperatures found at depths of up to 400 m. Typically, but not necessarily, heat pumps are used to raise the temperature to the level required by the hot water, heating or cooling end-use. In certain conditions and configurations, this system can be used to change ground temperatures artificially, in order to use the ground as heat or cold storage. ***UTES (Underground Thermal Energy Storage) represents a growing market for combined heating and cooling systems mainly for commercial and institutional buildings.***
In new construction, shallow geothermal energy (geothermal heat pumps) has already achieved a market share of about 20% in some countries. Most low-temperature energy demand is found in existing houses, and these can be supplied by geothermal district heating systems

State of the Art in non technical aspects (standards, commercialization, regulation):

The RES Directive (28/2009/EC) is not yet effectively and fully implemented in all Member States. Binding energy efficiency targets and renewable energy obligations in both new and existing buildings are essential. In addition, "electricity-only" generation from biomass should be discouraged, with regulation providing an incentive for cogeneration.

Measures to enforce EU-wide CEN standards, certification and quality labels for renewable heating and cooling equipment and systems are therefore required.
A comprehensive framework for the certification and accreditation of installers should be put in place in order to ensure quality standards are met and customers are kept satisfied. This will in turn spur further market deployment.

Specifically for bio-energy, an increased focus is needed on the sustainability of the whole chain from biomass production and supply to conversion and use, leading to a unified, transparent EU bio-energy market.
New business models for daily and seasonal storage need to be developed. The expected growth of UTES in Europe requires a clear legal status and policy. Although improvements are still desirable, in general the legal framework for borehole thermal energy storage is fairly well developed in Europe. The use of groundwater for energy storage is generally poorly regulated and in some countries there are significant barriers to it. Labelling or certification standards for thermal energy storage have not been developed yet. They are necessary to evaluate and compare new storage materials, products, and systems as they will become available on the market.[17]

8.2 Targets by 2020

The following targets to be achieved by 2020 were identified:

1) Research, development and demonstration activities should proceed in order to obtain a total building integration (e.g. in plaster, windows, tiles, etc.) of energy generation and storage systems. A maximization of the use of thermal energy as a source for comfort and energy savings is strongly recommended. It is also essential for a high mass market implementation to increase aesthetics and integration flexibility, efficiency, cost, quality insurance, plug and play development, and support market implementation of plug and play hybrid solutions for sustainable heating and cooling systems;
2) It is critical to make available new technologies, systems and processes for thermal energy storage and heating & cooling management, including enhanced control and automation (Target 2). Finally a further development of advanced nanotechnology application for total building integration will be needed.

8.3 Research and Innovation Priorities

Targets previously mentioned need to be strictly linked with specific priorities, with the aim of associating detailed matters required for filling the gap between actual situation and future condition.
A scheme of those connections is described in the following sub-chapter.

8.3.1 Research and Innovation Priorities by Target

In order to reach <u>Target 1</u> is necessary to advance and working on different main concerns, both technological and modelling topics:

- ✓ Need for modeling behavior and properties of building integrated thermal technology. (e.g. Development of flexible high efficiency solar thermal collectors; modeling of thermal inertia of buildings, etc.);
- ✓ Validation of thermal energy generation through advanced modeling tools.

The following platforms suggest reaching those targets through the actions described in the tables below.

[17] ftp://ftp.cordis.europa.eu/pub/etp/docs/rhc-vision_en.pdf

ESTEP	
	• Adoption of energy efficiency tools, in order to fully validate solar thermal (and not only) technologies
	• District heating system may be a solution for thermal needs: utility companies could sells directly thermal energy like a commodity

SUSCHEM	
	• To concentrate on the development of smart sensors for building integration: those sensors should be resilient, low cost and should monitor different kind of parameters (energy storage, production systems and energy use) • Storage materials should be able to generate long term profit for building owners.

RHC	
	• **Biomass technology**: to increase system efficiency and reduce emissions (e.g. particulate emissions) from stoves, boilers and Combined Heat & Power (CHP) plants from micro to large scale
	• Development of high efficient biomass conversion systems to trigeneration (heating, cooling and power) and the advancements in material sciences that will allow the reduction of costs for condensing biomass boiler technologies whilst maintaining the reliability of operation and life time of the condensation heat exchangers.
	• **Geothermal technology** : to integrate geothermal energy in standard housing systems
	• To develop Heating & Cooling networks integrating ground source heat pumps and Underground Thermal Energy Storage (UTES)
	• Geothermal Heat Pumps: Decreasing installation cost , increasing of Seasonal Performance Factor (SPF), optimisation of the system integration (ground heat source / heat pump/ distribution), and support of activities towards a decrease of overall energy demand in buildings.
	• Geothermal Heat Pumps: Decreasing installation cost , increasing of Seasonal Performance Factor (SPF), optimisation of the system integration (ground heat source / heat pump/ distribution), and support of activities towards a decrease of overall energy demand in buildings.
	• **Solar thermal technology:** to adopt more efficient ways to use conventional collector materials (metals, glass, insulation), especially with a view to developing multifunctional building components, which also act as an element of the building envelope and a solar collector.
	• Evolution in the optical properties of collector components, in particular, a more systematic use of optical films to enhance heat/light transmission in glass covers and to reduce this transmission during excessive exposure; and the use of colours in absorbers or covers to achieve more flexible integration concepts

New technologies deployment is a key passage to make thermal storage a more efficient solution: to meet Target 2 it is necessary to work on another priority regarding the exploration of the potential demand side management opportunities associated with the storage of energy in the thermal mass of buildings or in the ground surrounding the buildings in district heating systems.

The idea here is that there may be possibilities to store heat in some building types (e.g. public big facility) during periods of low energy demand which can then be used in other areas of the system during periods of high energy demand.
An integration in holistic supply systems of demand driven generation, storage and conversion of energy devices will be an enabling factor to reach those targets.
The following platforms suggest reaching the goal through the actions showed in the tables below.

ESTEP	
	• To work towards different solutions for various energy-sources, e.g. soil heat through eco-pile and uptake in advanced components and systems

SUSCHEM	
	• To support and promote projects which wants to integrate Phase Change Materials (PCMs) within heating infrastructure setup (classical heating and solar heating to smooth the need of consumers).

PCMs are substances with a high heat of fusion which, melting and solidifying at a certain temperature, are capable of storing and releasing large amounts of energy. Heat is absorbed or released when the material changes from solid to liquid and vice versa; thus, PCMs are classified as latent heat storage elements.[18]
Two kinds of heat storage systems have to be supported in the short-medium term:

- daily storage (to capture heat for the day and release the night);
- seasonal storage (capture heat summer times and control the release in winter).

Fundamental R&D activities needs to be performed into ultra-high enthalpy transition materials, that can be used to replace present Phase Change Materials which shave off the peaks of day-to-night temperature cycles. Similar R&D should be performed on materials that allow for ultra-high efficiency of heat-to-cold processes of heat energy storage. Evolution of the Regulations and certification level will push and promote material discovery for heat storage (batteries, heat, …) to fix next step of challenges (in analogy with automotive environmental cleanup evolution).

RHC	
	• **Thermal energy storage:** to reduce costs and improve the ability to efficiently shift energy demand over days, weeks or seasons
	• R &D on advanced sensible heat storage, PCM, sorption and thermochemical
	• Improving the properties of TES materials is important, in particular concerning their stability and the number of charging and discharging cycles they can withstand. The durability of new systems and their constituent parts must also be accurately quantified in order to estimate their long-term performance
	• Research focused on the integration and optimisation of heat/cold stores with renewable energy technologies. A “system-level perspective” is needed, taking into account the heat demand patterns of all consumers connected to the system, as well as the interaction with the building envelope and the energy networks.

[18] http://www.colorado.edu/engineering/ASEN/asen5519/1999-Files/presentations/ben-mottinger.pdf

EUMAT	
	• To promote R&D actions on solid ceramic particles, high temperature Phase Change Materials, graphite, high temperature concrete; furthermore it should be developed studies on thermo-chemical energy storage materials and on high temperature materials.
	• Enabling of smart technologies to be easily integrated with the building envelope: driven for the need for better insulated zero-carbon buildings, a new generation of actively controlled components should replace conventional materials. These smart devices must respond to seasonal variations in temperature and solar radiation, in order to continuously provide a healthy environment for occupants.

8.4 CP expected outcomes

CP expected outcome in terms of products/services/methods and field of applications are listed in the following table.

Table 8 – Outcomes and field of application for CP5

OUTCOME	FIELD OF APPLICATION
Solar Thermal Energy	**Domestic hot water & space heating** - One/two/multi-family homes - Hotels, hospitals, residential homes, etc. - District heating systems - Multifunctional façades - PV-Thermal (PV-T) hybrid collectors **Process heat** - Low up to 100C - Medium up to 250C - Solar assisted cooling and refrigeration
Biomass (Solid biomass, Bio fuels / bio gas)	**Small burners** - Pellets stove - Wood chip boiler - Log wood stove/boiler **District heating & cooling and process heat** *Heat only or combined heat and power* - Pellets boiler - Wood chips boiler - Waste & agricultural feedstock boiler
Geothermal: Shallow GT (Geothermal HP, Underground thermal storage)	- DHW, space heating & cooling - process heat

OUTCOME	FIELD OF APPLICATION
Geothermal: Deep GT (>400m) (Direct heat use, Comb heat & power)	- District heating - Agriculture and industrial processes - Balneology Cooling
Cross Cutting Technologies - District heating and cooling (DHC)	- District heating - District cooling - DH&C with seasonal storage
Cross Cutting Technologies - Thermal energy storage	- Water storage - PCM - Thermo chemical - Underground storage (UTES)
Cross Cutting Technologies - Hybrid systems and heat pumps	- Innovative system design - Ground, water and air heat pumps
Cross Cutting Technologies – Energy Distribution	The entire building skin could be used for capture and the building elements – such as floors – could be used for storage

8.5 Considerations beyond 2020

Wider applications of new cost efficient and durable solutions (applicable also on urban scale) for thermal energy generation and storage will be achieved, enhancing the ability to efficiently shift energy demand and facilitating the integration of Renewable Energy Sources.
Renewable energy technologies for heating and cooling should be designed on the assumption that buildings and industrial processes will be more energy efficient. Solar thermal, biomass and heat pump technologies will achieve a significant costs reduction and relative performance improvement.

Wider application of advanced solar thermal technology in buildings will help to spread also hydrogen technology, helping an innovative implementation of grid integration; hydrogen will be produced with renewable sources, stored, and with air taken from the atmosphere will produce the heat needed to warm the building, through a catalyser that allows hydrogen and oxygen to combine in a molecule of water, simultaneously releasing heat.[19]

[19] www.solaritaly.enea.it/Documentazione/Calore%20ad%20alta%20temperatura%20dal%20sole.pdf

9 CP6 - Advanced thermal insulation construction materials for new buildings and existing buildings

The cross-platform area CP6, entitled "Advanced thermal insulation construction materials for new buildings and existing buildings" includes several targets and priorities towards 2020. A scheme of this cross-ETP research and innovation area is described in the figure below.

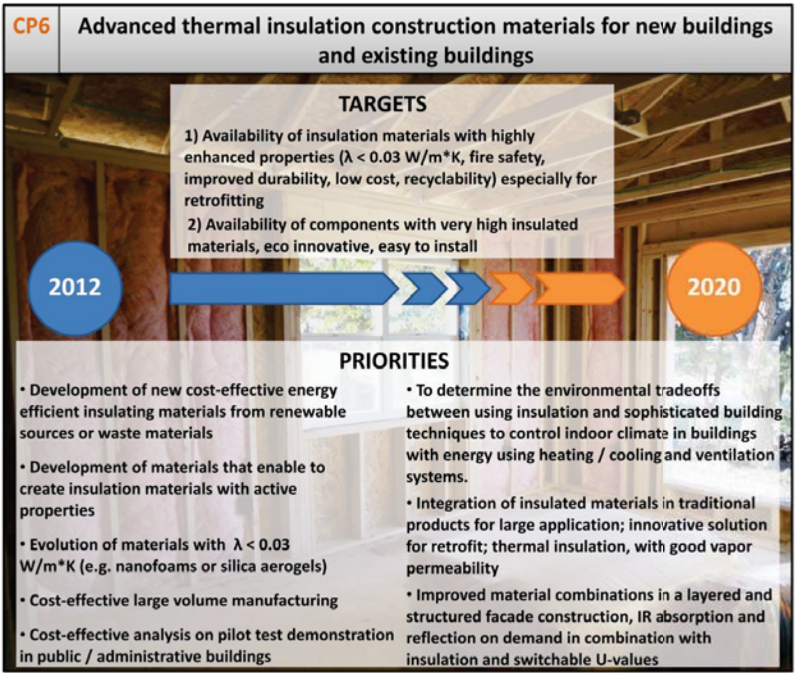

Figure 17 – Scheme of CP6 targets and priorities

9.1 Current situation (State of the Art)

Measures to improve insulation materials, in order to reduce the heating/cooling demand in buildings, represent a significant part of the potential of the Construction Sector to highly contribute to meet EU objectives in terms of energy efficiency and reduction of CO_2 emissions.
Currently available methods are largely based on non-renewable resources as well as consuming a large amount of energy and causing air pollution during production and disposal. A less resource-consuming substitute is needed which is both more ecological and provides other positive aspects of sustainability

State of the Art in Technology/Research: New technologies were developed, (e.g. organic nano-structured materials), older technologies improved (e.g. aerogels and vacuum insulations), and new material combinations placed successfully in the demanding markets.

However, the increasing insulation demands caused also new problems, such as algae growth on north orientated facades, increased fire loads and significantly increased difficulties on construction sites.

State of the Art in non technical aspects (standards, commercialization, regulation): Increased stricter national regulations led to a significant improvement in research and performance of new insulation materials.

9.2 Targets by 2020

The reduction of the overall energy consumption in the building sector requires a significant decrease in energy consumption in buildings, particularly in existing ones.
As energy-efficiency standards for buildings become further severe, using a traditional insulation material often means having to accept gradually more thick layers of insulation in walls, floors, and roofs. This matter consumes valuable floor space in new construction. In refurbishment project, valuable aesthetic and functional compromises are often required to retrofit more insulation on the inside or outside of the building envelope.
In this framework, the following targets to be reached by 2020 were identified:

1) availability of insulation materials with innovative characteristics e.g. highly enhanced properties (λ < 0.03 W/m2K, fire safety, improved durability, low cost, recyclability) especially for retrofitting;
2) availability of components with very high insulated materials, eco innovative, easy to install (used especially in retrofitting operations).

9.3 Research and Innovation Priorities

As read in previous paragraph a better improvement in insulation material goes through several steps: a continuous technology development, an economic analysis of cost/benefits of the new material and integration with existent structures and work methods.
So it is necessary to consider several priorities to reach goals: in the following subchapter a scheme of the links between targets and priorities is described.

9.3.1 Research and Innovation Priorities by Target

A cost-effective improved material with prominent properties (Target 1) can be obtained through working on the following topics:

- ✓ Development of new cost-effective energy efficient insulating materials from renewable sources or waste materials;
- ✓ Optimization of materials with active properties (e.g. Semi permeable insulation membranes, pigments with a certain absorption reflection spectrum that changes at different conditions);
- ✓ Evolution of materials with λ < 0.03 W/m2K based on nanofoams or silica aerogels, capable to both retain and reflect heat from inside or outside, integrate other functions (e.g. fire safety) with solutions for both new buildings and for energetic improvement of existing ones.

The following platforms suggest reaching those targets through the actions described in the tables below.

SUSCHEM	
	• Further advance of suitable processes for nanofoams manufacturing and application
	• The improvement of processes to produce modular, easy to assemble/disassemble and fully recyclable insulating systems may be useful for new buildings, while the improvement of thin layer insulating coatings and paintings could be functional for the refurbishment of existing buildings

TEXTILES	
	• to develop advanced insulation materials (i.e. ecological, lightweight, cost-efficient, multifunctional
	• To be detailed

FOREST TECHNOLOGY PLATFORM	
	• Developing new insulation products based on cellulose and nanocellulose fibres: they are a green, efficient, non-toxic, affordable thermal alternative to be considered in future refurbishment for existing buildings and for the construction of new buildings.

The availability of components with advanced insulation properties, such as prefab materials (Target 2) is a driving factor that can be pursued by:

- ✓ Identification of the environmental tradeoffs between using insulation and sophisticated building techniques to control indoor climate in buildings with energy using heating / cooling and ventilation systems;
- ✓ Integration of insulated materials in traditional products for large application (plaster, bricks, etc.); innovative solution for retrofit, e.g. internal insulation; thermal insulation, with good vapour permeability;
- ✓ Improved material combinations in a layered and structured facade construction, IR absorption and reflection on demand in combination with insulation and switchable U-values;
- ✓ Cost-effective analysis on pilot test demonstration in public / administrative buildings;
- ✓ Cost-effective large volume manufacturing.

The following platforms propose to reach those targets through the actions described in the tables below.

ESTEP	
	• To develop self insulating components, i.e. without need for insulation layer/material, in order to save money and installation costs

SUSCHEM	
	• To integrate additional breakthrough advantages (e.g. fire safety, self cleaning, reduced time for construction), in parallel with demonstrating cost effectiveness and performance (feasibility of zero emission potential) in public / administrative buildings
	• To create conditions for a quick and quantifiable recovery of invested capital through energetic gains

TEXTILES	
	• Development of advanced, multifunctional insulation materials based on non-woven
	• Integration of insulation and energy harvesting/storage systems

EUMAT	
	• Analyzing and developing new materials combining structural properties and/or thermal resistance/inertia and/or lightweight structures
	• Foamglass, nano-foams, foam insulation with addition of storage capacity: basic research for material optimization and applied research to investigate material integration in new constructive solutions (e.g. breaking cold bridges, combination between reinforcement and insulating material, constructive strength for heavy and pulling loads). Also thermal properties (mainly resistance and inertia) of structural/lightweight materials should increase of 30% with respect to current best performers: a 20 % specific reduction of embodied energy in production should be pursued.

FOREST TECHNOLOGY PLATFORM	
	• To concentrate major efforts on promoting industrially manufactured prefab components for building envelope retrofitting: for example prefabricated light-weight systems for envelope energy efficiency retrofitting with integration of insulation and technical installation of retrofit systems.
	• The use of prefabricated systems and sustainable raw materials can help in drastically reducing energy demand, performing a reduction of heat loss in a building, and at the same time lowering the embodied energy.

9.4 CP expected outcomes

CP expected outcome in terms of products/services/methods and field of applications are listed in the following table.

Table 9 – Outcomes and field of application for CP6

OUTCOME	FIELD OF APPLICATION

Insulation construction materials:
• Wool
  ○ Rockwool
  ○ Glasswool
• Plastic foams
  ○ Expanded polystyrene
  ○ Extruded polystyrene
  ○ Polyurethane foams
  ○ Other plastic foams
• Mineral foams with low lambda, low carbon footprint and good fire resistance
• Fiberglass(and foam glass)
• Highly insulating glass
• Other insulation materials
	• Wall insulation:
	  ○ External walls
	  ○ Internal walls (including curtain walls)
	  ○ Cavity walls
	• Roof insulation:
	  ○ Flat roofs
	  ○ Pitched roofs
	• Floor insulation

9.5 Considerations beyond 2020

The possible introduction of new housing models & spaces for next standard design in Europe is quite desirable: the improvement of the energy efficiency of buildings, through an advanced thermal insulation, could be a major benefit to the energy saving potential as well as a valuable action to the reduction of the total CO_2 emissions from buildings.
ESTEP hopes for the implementation of active insulation material that is capable to work in both directions - cold & heat barrier – in order to achieve the aim of new efficient buildings;

EUMAT propose to make an effort in developing super insulation properties of cost-effective materials to minimize building Operational Energy/Carbon. Maximization of insulation/storage properties by at least 60 % with respect to current best-performer building materials (e.g. thermal conductivity < 0.001 W m-1K-1) with 50 % cost reduction (including installation and maintenance cost) by 2050.

10 CP7 - Building materials recyclability and re-use of components

The cross-platform area CP7, named “Building materials recyclability and re-use of components” includes several targets and priorities towards 2020. A scheme of this cross-ETP research and innovation area is showed in the figure below.

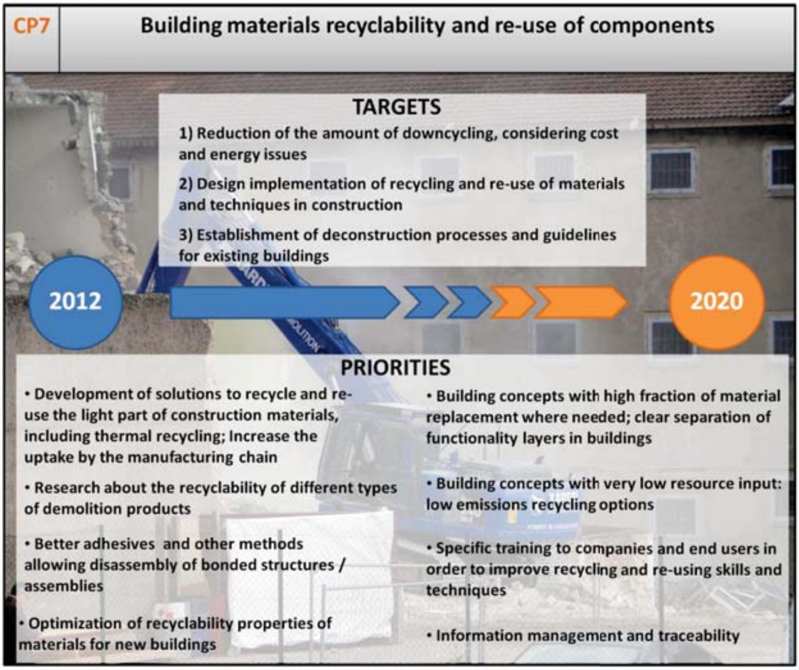

Figure 18 – Scheme of CP7 targets and priorities

10.1 Current situation (State of the Art)

Existing building practices focuses mainly on the act of construction: at this time a little thought is given to the full life cycle of a building, both in a functional and environmental sense. Nowadays there’s fortunately a big interest in improving the sustainability of structures: reuse and recycling of the main components of residential and commercial buildings appear to be making continuous progress. The benefits of reuse and recycling of waste streams from building construction and demolition include diversion of waste materials from land fill sites and reduced depletion of natural resources. Both of these benefits contribute to sustainable development within building industry.

Anyway there several barriers, both economical and technical, which are difficult to overcome: one of the main barrier to deconstruction process is that buildings are not designed to facilitate it. Most of them are constructed in a manner that does not allow for disassembly as a simple reversal process.[20]
Otherwise economic barriers include the need for rapid demolition and clearing of the site, the cost of separating the material to be recycled from contaminating materials and the relative economic advantage of disposal versus recycling. These issues and the role of the market are a driver for increased reuse and recycling of construction and demolition waste.

State of the Art in Technology/Research: The heavy fraction of demolition and construction waste streams is today 98% recyclable into granulates that can be applied in road construction and even to some extent in concrete. Overall, there is 95% recycling technologically possible but this should be cost-effective. For some materials a recycling approach seems to be impossible and ecological not suitable, e.g. plasticizers in concrete. The cradle to cradle approach seems to be possible but difficult, e.g. for plastics. Deconstruction is also not an art but rather a more complex job. Documentation of building materials components is not sufficient.

State of the Art in non technical aspects (standards, commercialization, regulation): The current situation is different among European countries. National codes and regulations try to push the subject but the quotas of recycling materials of individual materials and products differ a lot. There is a need for services to support recycling and re-use of building components & materials.

10.2 Targets by 2020

The following targets to be achieved by 2020 were identified:

1) *A reduction of the amount of down-cycling, considering cost and energy issues is required*. In fact, the quality of materials changes in a relevant way when it is recycled: not all products can be made into qualitatively equal products when they are recycled. It is important to investigate in recyclability over the full lifecycle, and combining research on degradability and recycling at the same level. Down-cycling process also reduces the number of times a product can be recycled: this is a particular problem with elements, like building components that are obliged to maintain high structural and high quality properties;
2) *Further implementation of recycling and re-use of materials and techniques in construction is needed*. In fact, minimizing the use of energy is a central task in a sustainable building, also reducing the use of natural resources and maximizing the recycling potential are other important tasks to take into consideration into the design phase;
3) *It is necessary to establish a standardized deconstruction processes and guidelines for existing buildings in order to provide useful tools for stakeholders*. Demolition of building structures produces enormous amounts of materials that in most countries results in a significant waste stream.

[20] Developing Guidelines For Designing For Deconstruction – Crowther – Queensland University of Technology, Brisbane Australia – 2000

10.3 Research and Innovation Priorities

Improved recycling practices that utilize reused materials instead of virgin materials would significantly improve the environmental performance of the building sector, but it will be essential to follow several priorities to achieve those targets.
In the following sub-chapter a scheme of the link between targets and priorities is illustrated.

10.3.1 Research and Innovation Priorities by Target

An improvement in reducing the amount of down-cycling can be done (Target 1) through putting efforts on the following topics:

- ✓ Development of solutions to recycle and re-use the light part of construction materials, including thermal recycling; Increase the uptake by the manufacturing chain;
- ✓ Research about the recyclability and durability of different types of demolition products;
- ✓ Adoption of a clear description and documentation of materials used in buildings, comparable to automotive industry.

The following platforms propose to reach those targets through the actions described in the tables below.

ESTEP	
	• To put a lot of effort in analyzing and understanding the business model for re-use, in order to clarify the economical sustainability and technical feasibility of a different approach.
	• To make a deep analysis on demolishing technologies for multi-material solutions and the development of modular systems and their connections for easy demolishing.
	• To develop tool that can measure the amount of recycling/reuse and give us an LCA value. The tool should be smart enough to account and credit the content of re-use in a design

SUSCHEM	
	• Need for studying high added value, sustainable solutions to recycle or otherwise process the light fraction of demolition and construction waste streams;
	• Switchable adhesives allowing disassembly of adhesive bonded structures / assemblies
	• Added-value construction products by using recyclable construction and demolition (RCD) materials: stony and other fractions
	• Green cement/concrete development with less energy waste and less production costs

TEXTILES	
	• Mono-component approach for building materials, Ecodesign methodology for recyclable building materials

EUMAT	
	• Further consideration of Design for Destruction (DfD) (see LCA targets). The Waste Framework Directive specifies a 70% target by 2020. A 90% target by 2030 is considered achievable.

FOREST TECHNOLOGY PLATFORM	
	• The potential for and benefits from energy recyclability of renewable resources should be considered;
	• Bio-based renewable building materials and components;
	• Light-weight volumetric modular construction for improved reusability of buildings

The adoption of suited guidelines and processes for deconstruction and recycling/reusing materials (Target 2) are achievable through the following enabling factor:

- ✓ Improved adhesives and other methods allowing disassembly of bonded structures / assemblies ;
- ✓ Optimization of recyclability properties of materials for new buildings ;
- ✓ Building concepts with high fraction of material replacement where needed; clear separation of functionality layers in buildings ;
- ✓ Building concepts with very low resource input: low emissions recycling options.

The following platforms propose to reach those targets through the actions described in the tables below.

ESTEP	
	• To work for the implementation of unique deconstruction guidelines that could help in improving deconstruction processes according standardized practices;

SUSCHEM	
	• To use more often switchable adhesives , that allow to disassembly of adhesive bonded structures
	• Introduction of added-value construction products by using recyclable construction and demolition (RCD) materials, like stony and other fractions would be valuable

TEXTILES	
	• to promote recycling instead of downcycling, because the resulting product of downcycling is often of lesser quality

FOREST TECHNOLOGY PLATFORM	
	• A further development of biobased renewable building materials and components: some of the major factors that could influence the demand for bio-based products will be a limited availability and increased cost of fossil resources vs. renewable bio-based resources,

	also the policy development, in particular climate change mitigation, sustainable production and consumption
	• A changing consumer demand based on the awareness of the need to ensure sustainable production and consumption.

There is a shared need to perform a wide adoption of deconstruction guidelines for existing buildings, because there's a lack of knowledge among construction companies and designers, and also the structures itself often presents a lack of information about constituent materials (Target 3):

- ✓ Specific training to companies and end users in order to improve recycling and re-using skills and techniques;
- ✓ Information management and traceability (e.g. database of recyclable components and materials).

The following platforms propose to reach those targets through the actions described in the tables below.

ESTEP	
	• The implementation of demolishing technologies for multimaterial solutions, and the development of modular systems and their connections for an easy demolishing process;

FOREST TECHNOLOGY PLATFORM	
	• To raise the use of light-weight volumetric modular constructions in order to facilitate a better improved reusability of buildings.

10.4 CP expected outcomes

CP expected outcome in terms of products/services/methods and field of applications are listed in the following table.

Table 10 – Outcomes and field of application for CP7

OUTCOME	FIELD OF APPLICATION
Re-used or recycled construction materials and components	All kind of load bearing structures, such for example: - bridges and major infrastructures; - houses and buildings; Moreover, traditionally waste may be re-used in: - construction of roads and road foundations; - sports grounds; - noise protection walls; - earth banks ; - landscape construction; - as aggregates in the concrete and stone production. Finally, steel can be re-used in building components and also recycled.

10.5 Considerations beyond 2020

Less use of natural resources would be a wide adopted solution: a reduced use of imported goods will make home grown materials more valued. Timber and other plants such as hemp, flax and reeds will become increasingly important for use as building materials and in textile manufacture. The economic and environmental benefits derived from ecosystems, for example in water retention and purification, will be recognised, and opportunities for re-naturalising land to capitalise on this should be sought.

EUMAT believes that a possible mandatory requirement of 90% recycling of demolition wastes could be a leading factor to reduce the usage of natural resources.

11 CP8 - Renewable resource-based products

The cross-platform area CP8, entitled “Renewable resource-based products” takes into account several targets and priorities towards 2020 and a consideration about long term actions. A scheme of this cross-ETP research and innovation area is described in the figure below.

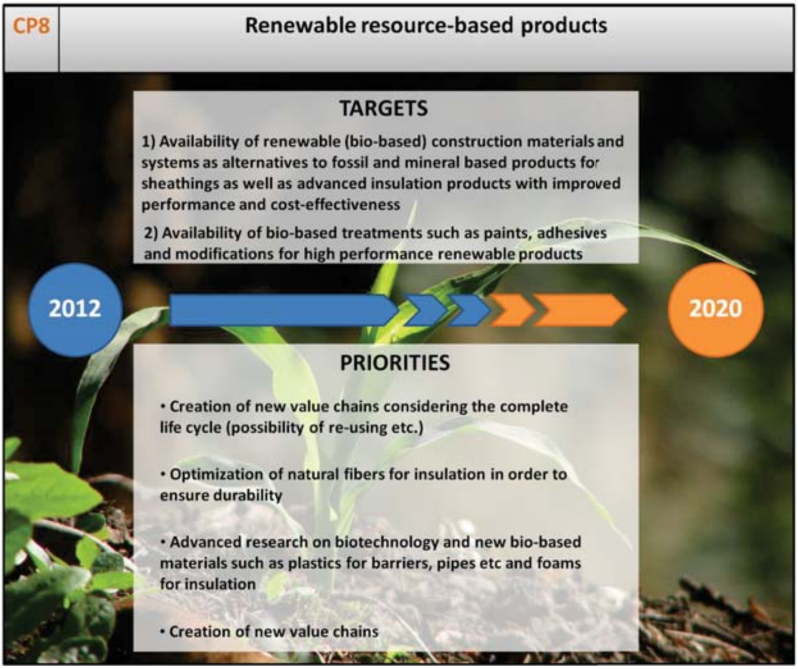

Figure 19 – Scheme of CP8 targets and priorities

11.1 Current situation (State of the Art)

A renewable resource is something “that is grown, naturally replenished, or cleansed, at a rate which exceeds depletion of the usable supply of that resource.” The length of time needed to replace a renewable resource can vary greatly depending upon the resource: for example, it can take 30-100 years for a tree to mature while bamboo can be harvested in as little as 7 years. Rapidly renewable resources are defined as those that can be replaced within 10 years. Bamboo, linoleum, and cork are just a few of the more common examples of rapidly renewable resources.

The key point for building’s sustainability is based on a more efficient and responsible use of resources. It is necessary to start including renewable and recyclable materials instead of petroleum based products in the construction value chain. The development of biomaterials is crucial to support industries in closing material loops.

Advances have been made in developing biodegradable foams, resins from vegetable oils, and biopolymers for making plastics.[21]

State of the Art in Technology/Research: Non-renewable construction materials such as mineral or fossil based materials today dominate the market. Materials based on renewable resources are primarily wood or natural fibre based, the use of which are currently slowly increasing. The increasing interest can be attributed to the renewability as such but also to the fact that they act as carbon sinks and reduce the CO2 in the atmosphere. An additional benefit is also the fact that at the end-of-life of the building or product, energy recycling is an efficient alternative for renewable resources. The potential in the building industry for further renewable resource-based materials is huge, as construction and sheathing materials and insulation, but also as bio-based adhesives and surface treatments and as bio-energy.

State of the Art in non technical aspects (standards, commercialization and regulation): Up to date, there are no economic incentives for choosing materials that result in lower CO2 emissions in the production phase of a building.
There is also a lack of suitable standards (covering such areas as the determination of bio-based content and environmental impact) was identified as a factor hindering market uptake both by consumers and in public procurement. Two standardisation mandates were issued: in 2008 as a direct result of the LMI action plan:

- Mandate 52/2008 for the programming of standards for all types of bio-based products
- Mandate 53/2008 for the rapid elaboration of pre-standards for bio-lubricants and Biopolymers.

The LMI aim was to develop Technical Specifications as an interim measure and convert these into full European Standards (ENs) subsequently.

11.2 Targets by 2020

The following targets were identified:

1) Availability of renewable (bio-based) construction materials and systems as alternatives to fossil and mineral based products for sheathings as well as advanced insulation products with improved performance and cost-effectiveness;
2) Accessibility of bio-based treatments such as paints, adhesives and modifications for high performance renewable products.

11.3 Research and Innovation Priorities

Targets previously mentioned need to be strictly linked with specific priorities, with the aim of associating detailed matters required for filling the gap between actual situation and future condition.
Those new technologies should go through "technology assessment" before being used in big scale and commercial level.
A scheme of those connections is described in the following sub-chapter.

[21] Bio-Materials in the Construction Industry - B.Van der Heyden - University of Florida

11.3.1 Research and Innovation Priorities by Target

A cost-effective improved material with advanced properties (Target 1) can be implemented through working on the following issues:

- ✓ Creation of new value chains considering the complete life cycle (possibility of re-using, etc.);
- ✓ Optimization of natural fibres for insulation in order to ensure durability;
- ✓ Advanced research on biotechnology and new bio-based materials such as plastics for barriers, pipes, etc. and foams for insulation.

It should be also reached an uniform requirement and verification of the cleanliness of re-used materials and products when it comes to emissions, mould growth, pollutants, etc.

The following platforms propose to reach those targets through the actions described in the tables below.

SUSCHEM	
	• To invest on bioplastics based on wood as renewable feedstock, combined with possible breeding of optimal tree species to offer optimum feedstock for such processes. For example 'liquid cellulose' is today used to produce viscose
	• Use of materials reinforced by wood based renewable fibres delivering a 100% renewable feedstock composite
	• Improvement of sandwich structures combining steel sheet with bioplastic core materials could be helpful, also with the introduction of a wood combined with bioplastics as sandwich structures or using the bio-based resin for coating of such wooden structures
	• R&D activities should be performed to acquire information on several topics: about the disassembly of multimaterial structures allowing their high-end recycling or reuse, about surface chemistry R&D on interfaces between the different materials (steelbioplastic, wood-bioplastic); about bio-based flame retardants for use as additives in polymeric materials; about eco-friendly Biocides for the protection of bio-based products.

EUMAT	
	• To lower the use of non-renewable resources (e.g. fossil energy carriers) by increasing recycled content (e.g. use of paper fibres) up to 90 % (currently quite high), shifting towards renewable resources (e.g. bio-based materials, being low in embodied energy, renewable and/or biodegradable).
	• To increase recycling potential for products with non renewable elements could be useful to achieve the target.
	• To increase efficiency and lowering environmental impacts of production processes

FOREST TECHNOLOGY PLATFORM	• To insert in the building value chain forest (and agriculture) based industries as suppliers of raw materials and products for the construction materials industry
	• Need to agree on methodology and system boundaries so the benefits of the renewable resources will be included

11.4 CP expected outcomes

CP expected outcome in terms of products/services/methods and field of applications are listed in the following table.

Table 11 – Outcomes and field of application for CP8

OUTCOME	FIELD OF APPLICATION
Renewable resource-based products	- All kind of wood products: walls, roofs, etc.; - All kind of clay products: bricks, etc.; - Insulating products in general.

11.5 Considerations beyond 2020

Design feasibility of economically and competitive buildings made of renewable resources are needed: in fact, in next year non-renewable resources will gradually substitute renewable resources up in order to achieve a zero-emission status for new buildings.
Wood-based construction materials will be widely used, helping the built environment to highly contribute to reduction of 80% of CO_2 by 2050, extending the carbon storage role of forests by providing a further storage period in products and at the same time replacing other (energy or carbon intensive) construction materials. For example, replacing cement or steel with a cubic meter of wood would result in saving about 1.1 tonnes of CO2 emissions. New wood construction techniques allow for solutions not seen before. At the end of their service life, wood products are reused or recycled, before being used as a carbon neutral fuel.[22]

[22] The Forest Fibre Industry; 2050 Roadmap to a low-carbon bio-economy; CEPI

12 Expected Impact

12.1 Overall Economic, Social and Environmental Impact

The construction market accounts for 6 to 10% of EU's GDP (depending on the source) and with at least 2.9 million companies (around 15 million operatives or 7% of EU workforce), it is the biggest industrial employer in the EU.

The built environment is responsible for **42% of total EU final energy consumption** and produces about **35% of all greenhouse gas emissions**. More than 50% of all materials extracted from earth are transformed into construction materials and products.[23]
Moreover, the world population is over 6 billion people and is projected to increase by 50% to 9 billion people by 2050. As the population grows, so will our energy requirements. Finally, the expected improvement in the standard of living in the emerging economies will again lead to a higher energy demand[24].

Key Figures of the construction in Europe[25]:

- Estimated construction investment (EU 27 - 2009): 1.173 billion €
- 9,9 % of GDP
- 51,4 % of Gross fixed Capital Formation
- 3 million enterprises (EU 27), of which
    - 95% are SMEs with fewer than 20 and
    - 93% with fewer than 10 operatives
- 14,9 million operatives:
    - 7,1 % of Europe`s total employment
    - 29,1 % of industrial employment
- 44,6 million workers in the EU depend, directly or indirectly, on the construction sector

The figures above show how construction activities are of major importance for the European economy and the environment in general. Meeting the environmental sustainability criteria and contributing to the competitiveness of the EU economy by making it more energy and resource efficient are the key challenges the sector has to face today and in the future.

The construction market focusing on the building sector is divided into two big market segments: <u>residential</u> and <u>non-residential</u>. Besides, an important distinction exists between the construction of new buildings and the refurbishment of existing ones. The latter representing a huge market potential both domestically and internationally. Furthermore SMEs are at the core of this two market segments, representing the majority of enterprises mainly working at national and local level.

Developments in the construction sector, further than bringing positive outcomes to the all value chain, including both basic manufacturing and supply of construction materials and several knowledge-intensive private/public services, also have a significant indirect impact on the growth in other sectors of the economy.
The figure below shows the number of people employed in the construction sector (including infrastructure) by MS in 2006.

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[23] http://ec.europa.eu/enterprise/newsroom/cf/_getdocument.cfm?doc_id=5417
[24] Energy technology perspective - Scenarios & Strategies to 2050; IEA 2008
[25] http://www.fiec.eu/

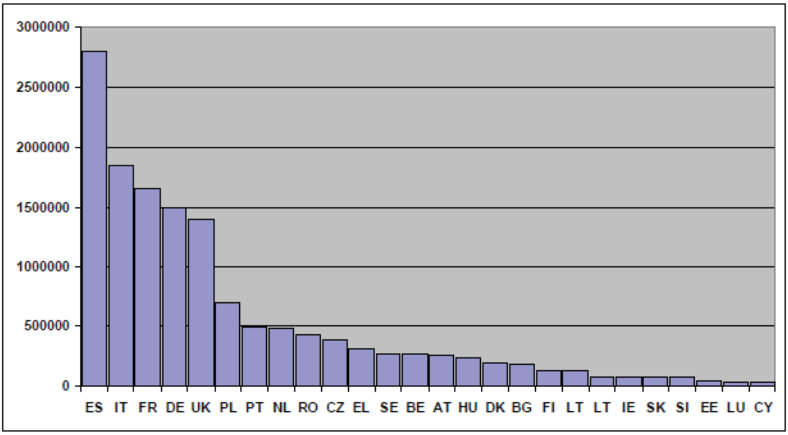

Figure 20 − Total number of people employed in the construction sector by Member State in 2006 *(Source: Eurostat)*

Having a particular focus on a **user centric approach**, Bulding Up will further contribute to direct and indirect benefit to the society at large. **Education and training activities will receive a special attention in order to provide affordable building and districts in the coming future.**

Building Up project will **promote the European knowledge in the built environment** and **boost the industrial competiveness** of the construction sector (in particular SMEs) and the inter-connected sectors.

The project is well **aligned with E2BA Roadmap priorities** to complement the EU pathways in supporting energy savings in buildings and districts and preparing the building sector (technology manufacturers, construction companies and energy utilities) to be in line with the **2050 decarbonisation goals**[26] **of the European Economy**.

Moreover, Building Up will contribute to tackle crucial challenges Europe is facing today of insufficient innovation, and several environmental and societal challenges. **All the eight Cross-Platform Areas identified in the project will focus and provide support particularly to the key priorities "Industrial leadership" and "Societal Challenges" in the upcoming "*Horizon 2020*"**[27]**.**

- **Industrial leadership** in particular by developing technologies enabling Energy-efficient buildings which will increase the technological competitiveness of EU industry and the involvement of a wide range of SMEs;

- **Societal Challenges** focusing on *"Secure, clean and efficient energy" as well as on "Health, demographic change and wellbeing" and "Climate action, resource efficiency and raw materials"* with the overarching objective of sustainable development.

[26] http://ec.europa.eu/energy/energy2020/roadmap/doc/com_2011_8852_en.pdf
[27] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0808:FIN:en:PDF

A strong point for successful exploitation of energy efficiency innovation is **standardization**. The adoption of common best practices and the validation of innovative products/processes will increase the potential uptake of new solutions by the market, thus reducing the initial investment risk taken by industries. The existence of a set of standard/rules/laws will be particularly beneficial for SMEs, which work with limited resources and personnel and will have guidelines to improve their proficiency in managing processes, projects and people. Building Up Roadmap will help to address crucial solutions towards **energy efficiency**, identifying suitable and standardised choices in order to facilitate a sustainable development of energy efficient buildings and districts.

Furthermore, the development of **business models** for new technologies, materials and processes is another key point for the effective exploitation of energy efficiency innovation. Building Up Roadmap will have a closer look into new business models and will certainly contribute in their development.

12.2 Example of target stakeholders and end-users

The target stakeholders and end-users of the technologies and products to be developed through Building Up roadmap may be summarized as follows:

- Civil Society at large;
- Users and inhabitants. Occupants of residential, public, commercial and industrial buildings in urban and rural areas;
- Civil engineers, architects and designers, including interior designers;
- Building contractors, dealers, wholesalers and building workforce;
- Builders and managers;
- Wood & paper industries, chemical industry, ceramics manufacturers, steel industry and suppliers of raw and advanced materials and components;
- Integrators of building components and systems;
- Public Authorities, building inspectors and consultants (e.g. for air quality testing systems);
- Building owners, tenants;
- Energy suppliers, buildings cooperatives;
- Energy managers;
- SMEs and large companies.

12.3 Example of markets addressed by the CPs

Each Cross-Platform areas will have an impact on several markets which have been identified with the help of ETPs experts.

The table below summarizes the markets and expected benefit identified for each of the Cross-Platform areas.

Table 12 – Markets, Expected Benefit and reference Cross-Platform Areas

MARKET	REFERENCE CROSS-PLATFORM AREAS	EXPECTED BENEFIT
Energy Efficiency and new built market (including construction industry, eco-construction, green, recycled building materials and renewable source-based building materials)	**CP1** – Performance Based Approach for building components, including sustainable design, Life Cycle Analysis **CP2** - Multi-material composites **CP6** - Advanced thermal insulation construction materials for new buildings and existing buildings **CP7** - Building materials recyclability and re-use of components **CP8** - Renewable resource-based products to substitute non-renewable based products	The development and release of target, products/applications/services described in CP1, CP2, CP6, CP7 and CP8 will increase the technological competitiveness of EU industry and the involvement of a wide range of SMEs from different sectors (including Steel, Wood & Paper and Chemical sectors) as suppliers of materials and components. In particular CP7 and CP8 materials and products will help towards addressing the Societal Challenges *“Climate action, resource efficiency and raw materials”* by re-using the construction and demolition waste (components and materials), increasing the usage of recyclable and sustainable products, and the use of renewable raw materials, such as natural fibres, which do not form any residues, and soy-based resins, which are cheaper, lighter and potentially bio-degradable. However, sensible efforts in research and innovation should be made in order to improve the cost-effectiveness and good quality of such solutions. Specific design for deconstruction will enable easier dismantling of the building and further increase the recycling and reuse of the materials. This “eco” added value including economic and social benefit will increase with time and give European companies a quality advantage to other countries. The percentage of ecological products will depend on the market situation but as seen in Germany with the passive house standard it can increase in short time from some percentages to 30%. All the CPs, in particular CP2 and CP6, will further contribute to the scarcity of raw materials issue by developing new sharpen and synthetic materials and products. Resource consumption will be significantly reduced thanks to more efficient solutions and products. The sustainable design in CP1 will also help the reduction and optimization of global energy consumption by for instance reducing the embodied energy of materials and through an energy efficiency assessment of the water systems. Moreover, the environmental footprint of all different solutions should be taken

MARKET	REFERENCE CROSS-PLATFORM AREAS	EXPECTED BENEFIT
		into account with a life cycle approach. A particular emphasis will be given on opportunities for the supply chain and the value chain (including consumers).
Composite materials and multi-material components market	**CP2** - Multi-material composites	CP2 target, technologies and products will allow constructing buildings with low embodied energy and resources, thanks to multi-material solutions such as load bearing functions, insulation, vapour barrier and integrated exterior solar energy generation. Thus highly contributing to address both the Social challenge *"Climate action, resource efficiency"* and the Industrial leadership priorities.
The "Comfort" market: - **IEQ tools and services: planning, analytical equipments and human physiological diagnostics;** - **Conservation of historical materials and works of art;** - **Acoustic and Thermal comfort, including HVAC;** - **Lighting (including day lighting).**	**CP3** - Healthy indoor environment (including air quality, ventilation, lighting, acoustic performance, energy efficient glazing)	CP3 approach and its developed technology and solutions will give feedback of the indoor air quality and its implications to human health, not just by using theoretical estimations which do not give true feedback of their relevance. The integration of different indoor environment components/systems as HVAC and lighting systems will bring to a totally new insight and performance characteristics. With respect to the energy efficient glazing, indoor environment will be improved thus contributing to the nearly "zero energy" 2020 goal in buildings. Public and private organisations and companies in the construction sector, including organisation responsible for the custody, conservation and management of cultural and historical assets and materials will benefit from CP3.
Combined power generation and storage for buildings	**CP4** - Electric generation and storage materials and systems **CP5** - Thermal generation and storage materials and systems	CP4and CP5 targets, technologies and products will develop standardized solutions for a more efficient and sustainable electric and thermal power generation, storage systems fully integrated in buildings as well services and solution for easy management, performance monitoring and energy, and distribution systems for both buildings and districts having a particular impact on the local supply. Such solutions will enhance the competitiveness of EU SMEs and large companies active in building equipment and process engineering, in cooperation with construction industries. Additionally, there will be an increase of development and manufacturing cooperation of building industry and energy suppliers.

MARKET	REFERENCE CROSS-PLATFORM AREAS	EXPECTED BENEFIT
		These CPs will highly contribute to the Societal Challenge *"Secure, clean and efficient energy"* by tremendously decreasing the use of fossil fuels and decreasing GHG emissions footprint. Furthermore, they will bring economic benefit for the users through better management and power generation.
Insulation construction materials	**CP6** - Advanced thermal insulation construction materials for new buildings and existing buildings	Future advantages of improved insulation materials will bring to: 3. Better insulation at same or less thickness: important for space restricted applications like cavity wall, refrigerated transport, etc. 4. Thinner insulation layers at same or less U-value: this is important for architectural aesthetics, less material (energy) bound in the insulation, reduced transport volume. Durable and well performing new insulation materials will replace existing insulation solutions facilitating the fading of the market share; today construction market is conservative and can create difficulty to accept new materials (adoption times of >8yrs have to be expected). This will have an impact on other markets too, directly or indirectly connected to the construction sector. This area is strictly linked with CP1 and CP8. CP6 target, technologies and products will greatly contribute to the Societal Challenge *"Climate action, resource efficiency and raw materials"* and *"Secure, clean and efficient energy"*. Moreover, it will improve the cost-benefits (e.g. manufacturing and transport), decrease the environmental footprint, and enlarge retrofitting opportunities. This will get to an increase of the involvement in the construction sectors of industries and SMEs from different sectors (including Steel, Wood & Paper and Chemical sectors) as suppliers of materials and components. A direct benefit on CP3, CP4 and CP5 is estimated.

A brief overview is given for each of the market identified.

12.3.1 Energy Efficiency and new built market (including construction industry, eco-construction, green building materials and renewable source-based building materials)

The construction sector is the largest raw material consuming industry. More than 50% of all materials extracted from earth are transformed into construction materials and products. In Europe, the volume of buildings materials used exceeds 2 billion tons per year[28]. Given the size of the market and its prospects for further expansion, the construction industry represents an attractive opportunity for OEMs, material suppliers and component suppliers.

Raw and refined materials include:

- Stone
- Wood
- Steel
- Cement
- Glass
- Ceramic
- Bricks
- Bio material

European industries have leading positions in the world market in the production of the most important building materials, as ceramics, steel, glass, cement, bricks, natural stones, wood, plaster/gypsum boards, paints, insulation materials, cool roofs, etc.

The refining and development of raw materials into products for the construction sector (e.g. concrete, composites, blocks, windows and doors, façade material, roof coverings, insulation, infrastructure (system) in the building for ventilation, heating, cooling, water supply, electricity, gas, etc.) need a tremendous quantity of energy thus emitting a great amount of GHG in the atmosphere. Moreover, some specific raw materials (e.g. rare hearth) are critical and their use has to be reduced and carefully recycled.

Eco-construction focuses specifically on the sustainable dimension by reducing the natural resource requirements (energy, but also water and land) and the overall environmental impact of buildings. In principle, eco-construction starts with the design phase, and it ends with demolition and recycling. Life-cycle assessment encompasses the assessment of raw material production, manufacture, distribution, use and disposal including all transportation. Eco-construction also requires a high degree of integration in architecture, design, construction, and building systems and materials. **Potentially huge market potential lies in retrofitting the existing building stock according to modern standards.**[29]

One of the new growing industries is production of bioplastics. Annual growth of the European bioplastics market reached 48% in 2003-2007. The world-wide production is projected to increase from its current about 360 000 tons to 2.33 million tons in 2013 and to 3.45 million tons in 2020. This is equivalent to average annual growth rates of 37% by 2013, and 6% between 2013 and 2020. The long term growth potential for bio-based products will depend on their capacity to substitute fossil-based products and to satisfy various end-use requirements at a competitive cost, to create product cycles that are neutral in terms of greenhouse gas and to leave a smaller ecological footprint, i.e. generating less waste, using less energy and less water (EU 2007 LMI action plan). The total maximum technical

[28] SET Plan _ Energy efficient materials for buildings_ JRC 2011
[29] http://ec.europa.eu/enterprise/newsroom/cf/_getdocument.cfm?doc_id=5417

substitution potential of bio-based polymers replacing their petrochemical counterparts is estimated up to 90% but due to various types of barriers, this is a long term target.

Bio-based polymers use carbon from renewable sources such as sugar, starch, vegetable oils, and replace materials that are made using petroleum products. Polylactic acid or PLA, for example, is a relatively new biodegradable plastic made from corn, wheat or sugarcane. There are strong long-term hopes to replace even energy-intensive construction materials like steel and concrete. Biobased resins and natural fibers allow wood composites, hybrid composites and fiber insulations. Combination of various polymers and nanoparticles is one line of research. Biomaterials are manufactured from plants and trees (agricultural or forestry feedstock's). Fibers can be made from crops like hemp, flax, sisal, jute or straw. The manufacturing of films and polymers from starch is also in development, as is the production of adhesive systems based on tannins. There are also examples of getting the fibers from recycled paper for thermal insulation. Several big companies are developing or have already launched new products based on improved share of recycled and bio-based materials.[30]

The market for building information modeling (BIM) software and services is still nascent, but evolving rapidly. Some EU governments are taking steps to implement BIM: for example, in the UK, the government has a dedicated minister pushing BIM in public projects.
In fact, BIM software and processes have evolved to allow new ways of collaboration, work sharing, and virtual design capabilities that serve to reduce costs for building owners and add visibility to the overall design and construction process. With this added visibility and upfront understanding of a project's detailed characteristics, building owners and operators are realizing that the lifecycle costs of a building can be significantly reduced.[31]

The recycling quota for construction and demolition waste is on average to be increased significantly: for example a 70% increase in recycling of mineral waste is targeted for 2020 in the 25 EU. In construction the readiness to recycle differs remarkably in Europe and depending on the materials (mineral waste, polymer, composite or metal-based waste). Altogether approximately two thirds of the waste is produced in the fields of construction, demolition, mining and extraction of stones and earths. This waste consists predominantly of mineral waste. Thus it is the aim to produce high-quality construction products of construction waste in the sense of a closed cycle.[32]

12.3.2 Composite materials and multi-material components market

The global composites market has been growing steadily over the past decade. Estimates of the current size of the industry vary considerably, but suggest that the current market size is somewhere between £12 billion33 and £53 billion34 (or an average estimate of £33 billion). According to the report "*Growth Opportunities in Global Composites Industry 2011-2016"*, Composite materials industry is expected to reach $ 27.4 B in 2016 at a CAGR of 5.3%. In the European construction market specifically, the report predicts a **market size of $2 billion by 2016 for composites in construction.** According to market experts, the global industry for composites materials is estimated to grow in the mid-single digits in the next five years. The two sectors that will drive this growth are aerospace and wind energy, expected to grow by 15.6% and 13.3% each year respectively. Japan and USA are the

[30] SET Plan _ Energy efficient materials for buildings_ JRC 2011
[31] http://www.reportlinker.com/p0849206-summary/Building-Information-Modeling.html
[32] http://www.eqar.info/en/info-center/european-market-of-recycled-building-materials.html
[33] Global Composites Market 2009-2014: Opportunities, Markets and Technologies (Lucintel, July 2009)
[34] Advanced Manufacturing Package (BIS, July 2009)

leading global investors in carbon fibre. Japan is home to the world's top three suppliers of carbon fibre, representing over 70% of global production with its main application sectors being aerospace, automotive, wind energy and industrial equipment.[35] The following figure shows the average annual global growth composite material forecasts by market segment.

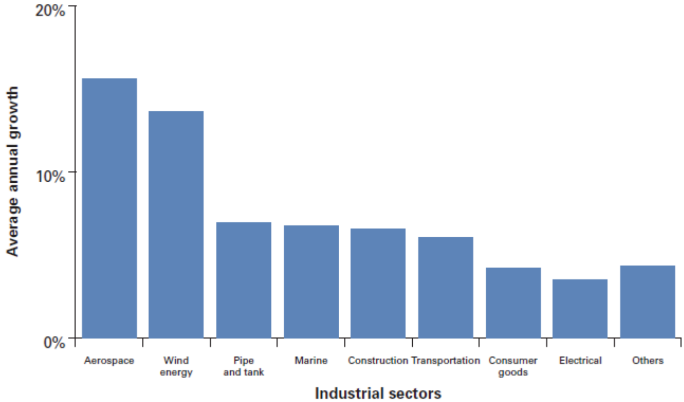

Figure 21 − Average annual global growth composite material forecasts by market segment, 2009-2014[36]

In construction, opportunities also exist in residential and non-residential buildings, and other structures such as bridges. Opportunities for increased use of composites have arisen due to their durability, insulating and high load bearing qualities. The reduced weight of composites relative to many other engineering materials allows composite structures to be fabricated offsite and installed quickly with minimal overall environmental impact, shown by bridges. These qualities also make them attractive as a repair material.

The major obstacles for the continued expansion of the use of composites in the construction sector are the lack of design data coupled with inexperience and unfamiliarity with the materials from the construction sector as a whole. The construction industry is also notoriously conservative, extremely price sensitive and safety critical. In addition, the industry is very large, which could present logistical problems for the composite industry (i.e. demands exceeding supply). However, the use of composites is likely to increase gradually within the industry.[37]

12.3.3 "The Comfort" Market

The Comfort market is here considered as a set of several markets related to comfort and IEQ aspects including: (1) IEQ tools and services: planning, analytical equipments and human physiological diagnostics (2) conservation of historical materials and works of art; (3) acoustics and thermal comfort, including HVAC systems and (4) lighting systems.

[35] The UK composites strategy, Department for Business Innovation & Skills, 2009 http://www.compositesuk.co.uk/

[36] Global Composite Market 2009–2014; Materials, Markets and Technologies, Lucintel 2009.

[37] Composites, Centre for Urban and Regional Development Studies, 2009 http://www.compositesuk.co.uk/

12.3.3.1 IEQ tools and services: planning, analytical equipments and human physiological diagnostics

One of the main challenges in indoor air today is the very limited building indoor air "testing" system: currently we rely mainly on theoretical estimation of indoor air quality based on individual product testing, performed just after products came from the production line. However, the indoor air harmful and healthy components arise from diverse sources outside the original construction materials throughout the lifetime of the building. Consequently, to ensure truly healthy and comfortable indoor air and environment it is mandatory to start developing meaningful testing and measurements of actual in-situ indoor air and its implications to human health.

Air quality consulting and testing services were estimated to be around $2.7 billion in 2011 in US, with an estimated 10% AAGR over the next 5-year period.

Environmental services, including mold remediation, asbestos abatement, and radon mitigation reached around $2.9 billion in US in 2011.

Currently, the end-use markets with the biggest potential for applications of IAQ (indoor air quality) equipment and services include residential dwellings, commercial buildings, historical and cultural buildings, schools and health care facilities. The commercial segment was the largest market for IAQ equipment and services, accounting for 26% of the market in 2005, followed by schools (22%), residences (19%), and health care facilities (17%).[38]

12.3.3.2 Conservation of historical materials and works of art

The market of historical preservation and monitoring services requires ***advanced careful planning as well as advanced technologies to monitor and maintain suitable environment for historical buildings, materials and works of art***.
For example, optimal conservation of historical materials and works of art requires deep architectural and environmental investigation, which may include probing beneath surfaces using <u>non-destructive methods</u>, which provide minimal damage to historic fabric (x-rays to penetrate surfaces in order to see nail types and joining details; boroscopes, fiber optics, ultra violet or infra-red lights to observe differences in materials and finishes, etc.).
Another example can be cleaning technologies as inappropriate <u>cleaning methods</u> and coating treatments are a major cause of damage to historic masonry buildings. Masonry cleaning methods generally are divided into three major groups: water, chemical, and abrasive. Water methods soften the dirt or soiling material and rinse the deposits from the masonry surface. Chemical cleaners react with dirt, soiling material or paint to effect their removal, after which the cleaning effluent is rinsed off the masonry surface with water. Abrasive methods include blasting with grit, and the use of grinders and sanding discs, all of which mechanically remove the dirt, soiling material or paint (and, usually, some of the masonry surface). Laser cleaning is another technique that is used sometimes by conservators to clean small areas of historic masonry. It can be quite effective for cleaning limited areas, but it is expensive and generally not practical for most historic masonry cleaning projects.
Finally, certain fine works of arts (e.g. ancient books, frescos) require specific environments (controlled humidity light and temperature and ventilation) that need a careful IEQ monitoring and planning, with some ad hoc HVAC system design.

[38] http://www.bccresearch.com/report/ENV003B.html

12.3.3.3 *Acoustic and Thermal Comfort, including HVAC*

In today's competitive economy, worker productivity is critical to success. A great deal of new technology is devoted to improving productivity, but one of the simplest and most obvious factors is often overlooked – noise. According to the American Society of Interior Designers (ASID), Washington, D.C., an industry-sponsored study showed that more than 80 per cent of the workers surveyed believed they would be more productive if their workspaces were quieter. Their belief was confirmed: When noise was reduced, productivity measurably improved. Moreover, **acoustic comfort** is fundamental also in residential buildings and public facilities such as schools, hospitals, hotels, where a quiet environment is required for the comfort and health of the inhabitants, clients, children or patients. Governments are tightening up legislation on noise pollution and local residents are being more vociferous in seeking a quieter environment.

Wiring, telecommunications, traffic patterns, even air delivery routes are all clearly visible on blueprints or engineering plans. Acoustical issues and potential problem areas are not that easy to see. The planning stage is the best time to consider these problems and address them cost-effectively. For example, it is fairly economical to design an air-handling system to minimize unwanted noise, but once the space is built, options are much more limited and solutions more costly.

No clear economic data were found on the market related to noise control and acoustic comfort management but it is clear that this activity relates to different applications, that goes beyond HVAC systems. Examples of applications of markets for acoustic comfort management within the building industry are: buildings in general (from design to construction, use and demolition), acoustic ceilings and wall absorber systems, flooring.

Regarding the **thermal comfort**, for decades, surveys of building occupants have shown their biggest complaint about their workplace is the lack of a comfortable thermal environment. More recent surveys of office building occupants confirm that this long-standing complaint is unchanging. A recent survey shows occupants consider the two most important elements in a workspace to be **thermal comfort and air quality**. The same survey shows that lack of occupant control and lack of adequate comfort constitute the two largest complaints occupants have about their buildings.[39]. The market of thermal comfort includes smart design of buildings and building components, efficient insulation and ventilation systems. One of the main pillars of thermal comfort is an efficient HVAC system.

The worldwide HVAC equipment market is estimated to be 150 billion€ per year, with Europe accounting for more than 50 billion€ per year, including HVAC cleaning services. Global demand for HVAC equipment is projected to rise over 6% a year through 2014 to more than US$88 billion, according to the latest 'World HVAC Equipment' report from Bharat Book Bureau. Approximately 40% of the global market is covered by HVAC for commercial buildings, where cooling equipments will continue to outpace heating equipments. Demand will benefit from recovery in the key US market, which will rebound from dismal levels in 2009. Demand in the Asia/Pacific region will also outpace the global average, increasing 6.6% a year through 2014. China will be the fastest-growing national market, and comprise the largest share of global demand growth through 2014.
Above-average growth will also occur in India due to solid gains in the number of households and rising per capita incomes.[40]
Heating, Ventilation, and Air Conditioning (HVAC) systems represent almost 33% of the energy use in commercial facilities (14% space heating, 10% space cooling and 9% ventilation). In this framework, the European Multi-Annual Roadmap and Longer Term

[39] http://automatedbuildings.com/news/jul00/articles/hartman/hrtmn.htm
[40] http://www.constructionweekonline.com/article-8564-global-hvac-market-to-hit-us88bn-in-2014/

Strategy, released in the framework of the Energy-Efficient Buildings Public Private Partnership initiative, set as a priority target to reduce the primary energy usage for heating and cooling by a factor 2 from 2020 onwards.

12.3.3.4 Lighting

The global lighting market is expected to have revenues of around EUR 110 billion in 2020, with 6 percent and 3 percent p.a. growth from 2010 - 16 and 2016 - 20, respectively, based on McKinsey's Global Lighting Market Model.

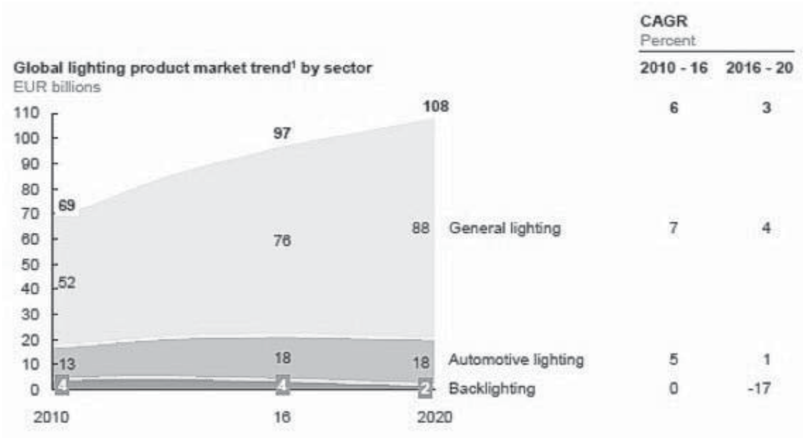

Figure 22 − Worldwide market for lighting
(Source: McKinsey's Global Lighting Market Model)

General lighting is the dominant market, with total market revenues of approxi-mately EUR 52 billion in 2010, which represents close to a 75 percent share of the total lighting market. This is expected to rise to some EUR 88 billion by 2020 – approximately 80 percent of the total lighting market. The general lighting market has two key drivers. The strong growth in construction investment in emerging countries is one. The second is the greater penetration of higher priced light source technology, including LED, which raises the average price of lighting products.[41]
The next generation of technology, OLED (Organic Light Emitting Diode), could be a really technological breakthrough in this business area with two main features: very low energy consumption and a great adaptability (flexible display, etc.). One of the main issues of this emerging technology is to reinvent the lighting management into building because this device can be used also for flexible and flat surface. Therefore, new ways of integration of such solutions should be found, in order to improve the energy efficient of the building.

[41] Lighting the way: Perspectives on the global lighting market. McKinsey & Company http://img.ledsmagazine.com/pdf/LightingtheWay.pdf

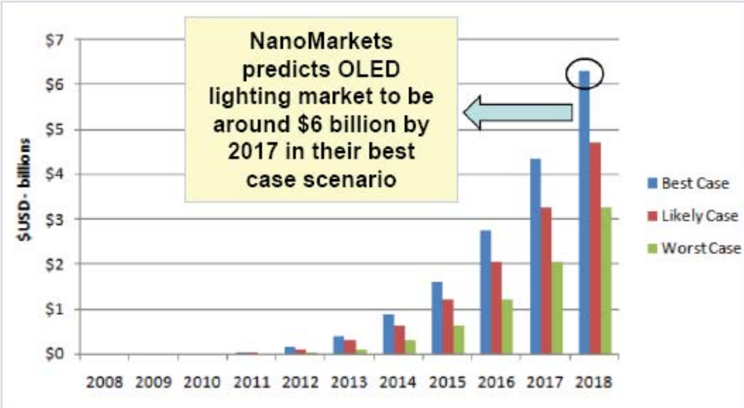

Figure 23 − OLED lighting market forecast
(Source: Nanomarket OLED Lighting Market Forecast Q2 2012)

12.3.4 Combined power generation and storage for buildings

Combined power generation and storage for buildings is a growing market which may include (1) electric generation and electricity storage for buildings and (2) thermal generation and storage material and systems.

The building stock will impact energy systems. Buildings will increasingly have the capacity to produce and store energy, both electrical and thermal. In order to optimise the energy systems, the conditions for further interaction and integration of buildings, that have thermal storage capacity and have intermittent surplus thermal energy, and the thermal district energy systems need to be further studied. Combined Heat and Power (CHP) as cross cutting issue between electric and thermal generation will play a key role in this market. As a matter of fact, 75% of district heat in Europe comes from Combined Heat and Power (CHP) units, sometimes running on RES.

12.3.4.1 Electric generation and electricity storage for buildings

With almost 22 GW of grid connected PV installations in 2011, Europe has in-creased its cumulative capacity base by over 50% compared to 2010. Figure below shows how the 2011 market was shaped, distinguishing among mounted on ground, commercial and industrial rooftop, and residential applications. Overall a very large share of the market in Europe is concentrated in the commercial rooftop segment; this trend will continue, based on the foreseen evolution of the legal framework.[42]

[42] http://files.epia.org/files/Global-Market-Outlook-2016.pdf

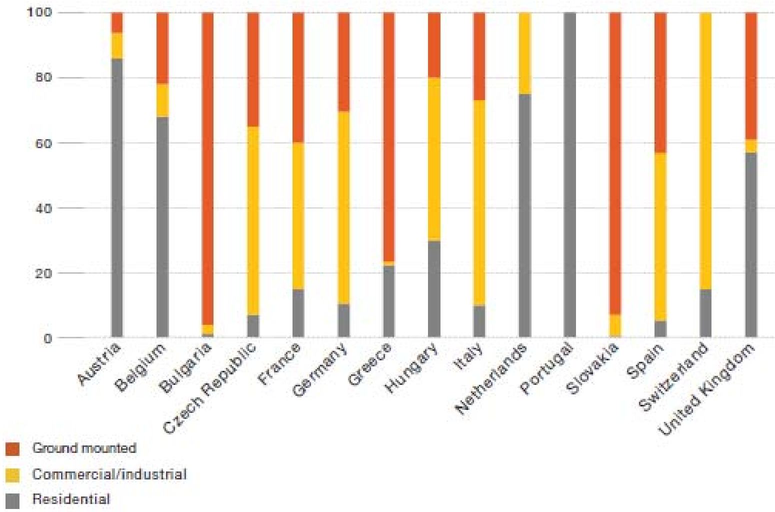

Figure 24 − European PV market segmentation 2011 (%)
(Source: Global Market Outlook for Photovoltaics until 2016_EPIA)

Building-integrated photovoltaics (BIPV) currently make up a small but noticeable part of the world PV market. **The global market was valued at 1,201 megawatts in 2010 and is expected to increase at a 56% compound annual growth rate (CAGR) to reach a capacity of 11,392 megawatts in 2015.** BIPV roofing is the largest near- and mid-term market segment. The global market for BIPV capacity in the roofing sector was 404 megawatts in 2010 and is expected to reach 3,197 megawatts in 2015, a compound annual growth rate (CAGR) of 51%. The market for architectural fabrics may be very large and expanding, but the rate of adoption of BIPV elements will be slow for a period of time. This sector had a capacity of .2 megawatts in 2010 but is expected to increase at a 670% compound annual growth rate (CAGR) to reach a capacity of 5,439 megawatts in 2015.[43]

[43] http://www.bccresearch.com/report/building-photovoltaics-tech-egy072a.html

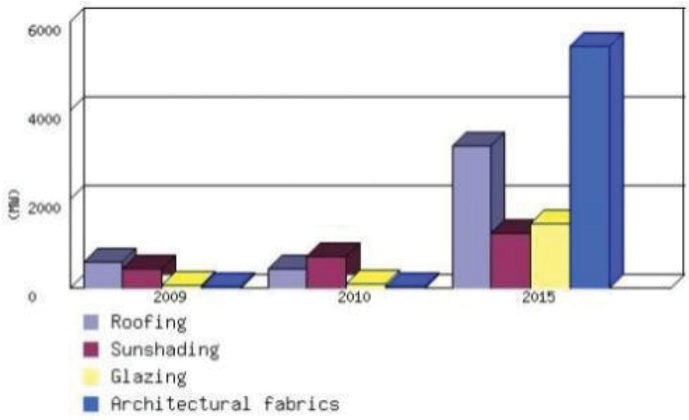

Figure 25 − Global Building Integrated PV annual market segment (in MW), years 2009-2015 *(Source: BCC Research)*

The following figure shows a forecast on the prices of utility-scale PV systems up to 2020.

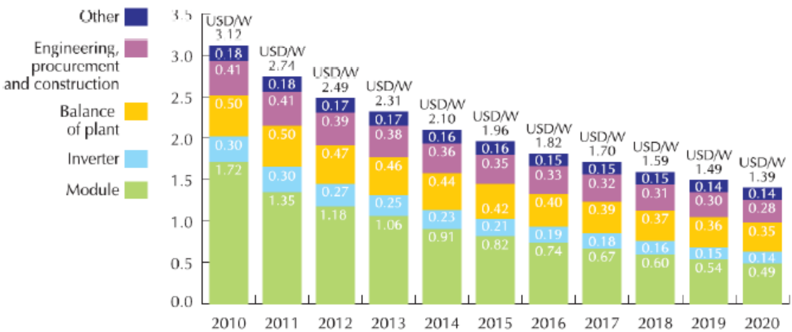

Figure 26 − Utility-scale PV system price forecast[44]
(*Source: Bloomberg New Energy Finance*)

The total global utility-scale electricity storage (UES) market is valued at nearly $4 billion in 2010 and is expected to reach $18.5 billion by 2015, at a 5-year compound annual growth rate (CAGR) of 36.6%. Total UES market volume is led by the Asian/Australian market, which will surpass $7 billion annually by 2015, an increase over the 2010 value of $2.7 billion, reflecting a 5-year compound annual growth rate (CAGR) of 21.7%. The most significant jump in UES markets is expected in the North American market,

[44] Module price derives from experience curve + margin; system price in markets with cost-based, rather than value-based pricing (such as Germany).

which is anticipated to leap from a 2010 market size of $272 million to more than $6 billion by 2015, at a compound annual growth rate (CAGR) of 86.2%.[45]

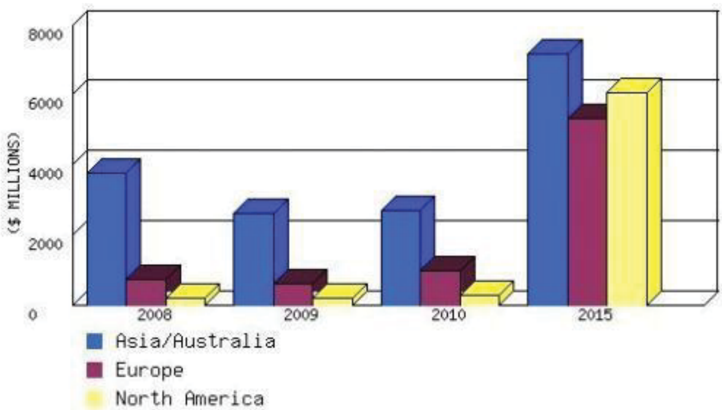

Figure 27 − Utility-Scale Electricity Storage Technology Sales, 2008-2015 ($ MILLIONS) ***(Source: BCC Research)***

12.3.4.2 Thermal generation and storage material and systems

Every year, almost **50% of the total energy consumed in Europe is used for the generation of thermal energy** for either domestic or industrial purposes. In residential buildings, approximately 80% of the energy used is required for space heating & cooling and sanitary hot water. In this context thermal generation and storage systems based on renewable sources appear promising to address energy needs while overcoming current resource challenges. From a commercial point of view, in a global market, the main competitive strength of the European Renewable Heating & Cooling industry is the high quality of its products.

In 2010, the European solar thermal market totalled 2 586 MWth (3 694 940 m²) of newly installed capacity, decreasing by an estimated 13% in comparison with 2009. Although it is the first time in over 10 years that the market has declined in two successive years, it still remains above the 2007 level. The effects of the 2008/2009 financial crisis are still being felt with very low renovation rates and collapse of new build developments, preventing the solar thermal sector from taking full advantage of the European trend towards more demanding standards for the energy performance of buildings.[46]

Key facts:
MARKET 2010 (EU-27 + Switzerland):
- Newly Installed: 3.7 Mio m2 / 2.6 GWth;
- Total installed: 34 Mio m2 / 24 GWth;
- Heat produced: 1.5 Mtoe / 17 TWh.

[45] http://www.bccresearch.com/report/utility-scale-electricty-storage-egy056b.html
[46] Solar Thermal Markets in Europe_Trends and Market Statistics 2010 June 2011, ESTIF

The biomass heat market share in Europe should rise from 11% in 2007 to about 25% in 2020, even considering the reduction in heat demand. In 2007, about 35 Mtoe of biomass have been used for grid independent supply of energy to households and services within EU-27, which make it the dominant application for bioenergy, and more largely for renewable energy in general in Europe.[47]

Key facts:
MARKET 2010 (EU-27):

- Newly Installed: 16.9 GWth;
- Total installed: 393 GWth;
- Heat produced: 61 Mtoe / 712 TWh.

Currently geothermal energy sources provide about 24 GWhth for heating and cooling in the EU, equivalent to 2.1 Mtoe per year, whereby geothermal Heat Pump systems contribute to the largest part. In the EU 27, the installed capacity in 2020 will amount to around 50 GWth installed corresponding to a contribution of more than 10 Mtoe.[48]

Key facts:
MARKET 2010 (EU-27):

- Newly Installed: 2.7 GWth;
- Total installed (with GSHP): 15 GWth;
- Heat produced: 2.8 Mtoe / 33 TWh.

12.3.5 Insulation construction materials

Insulation materials are an integral part of the overall design of buildings and are of great importance for the energy efficiency in use. Insulation materials include:

- Mineral wool
- Glass fibre
- Foamed plastic material such as polyethyle, polystyrene, polyurethane
- Foamed glass
- Glass insulation
- Organic materials such as cellulose fibre, cork, hemp, linen, straw, wool.

Today fossil fuel based (e.g. EPS, PUS) and mineral based (e.g. glass wool, stone wool, etc.) are the most used. Nanotechnology applications leading to high thermal insulation performance, e.g. vacuum insulation panels, nano-cellular foams, aerogels (with thermal conductivity up to ten times lower than conventional insulation materials) are still in need of further research.

Global demand for insulation materials as a whole is expected to expand by 3.8% annually to reach €29 billion by 2012: the demand may be segmented in foamed plastics, mineral wool, fibreglass and other types of materials (see figure below)[49].

[47] Strategic Research Priorities for Biomass Technology, RHC Platform
[48] Strategic Research Priorities for Geothermal Technology, RHC Platform
[49] Observatory NANO briefing number 3 on Construction, August 2010, available at www.observatorynano.eu.

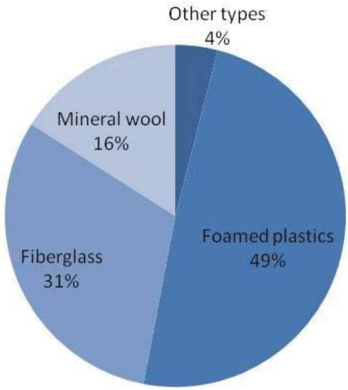

Figure 28 − Global market segmentation for insulation construction materials ***(Source: ObservatoryNANO)***

Coherently, recent studies report that the worldwide demand for building insulation is expected to increase an average of 5% per year through 2014 to nearly 23 billion square meters of R-1 value. In this framework more than 40% of all new global insulation demand between 2009 and 2014 will occur in the Asia/Pacific region. Insulation consumption in the region is forecast to increase almost 6% annually due to advances in process manufacturing, appliance shipments, and residential and non-residential building construction. China alone will account for 29% of all new global insulation demand between 2009 and 2014 [50].

[50] http://www.reportlinker.com/p0109778-summary/World-Insulation-Market.html

13 Funding of the CP areas: expected cost

In order to assign approximate funds to the several cross-platform roadmaps a detailed consultation was performed among ETPs representatives.
An activity was performed during the 4rth Expert Panel Workshop with the aim of estimating the distribution of needed private and public fundings to develop the actions up to 2020 of the different Cross-Platform Areas.

Every ETPs representative assigned a percentage of its budget to each CP considering several criteria:

- Readiness to market: some of the ETPs experts assigned a lower budget to some of the CP Area because they considered that targets were more ready to be achieved, with easier solutions to be implemented in the market and with less economical effort;

- CP Area's resources demanding: some of the ETPs experts assigned an higher budget to CP Area which they believed were more economically and resource demanding than others;

- Commitment: some of the ETPs expert showed more interest in some platforms instead of others, due to the higher affinity of platform content with ETPs activities, and consequently they assigned an higher percentage of their available budget.

Figure 29 − Picture of "How much do you want to spend for each CP" activity performed during the 4th inventive meeting of Building Up project

The following figure presents the results of the activity in terms of % budget estimation for each CP area, considering 100% as the whole budget foreseen to cover the implementation of Building Up Roadmap.

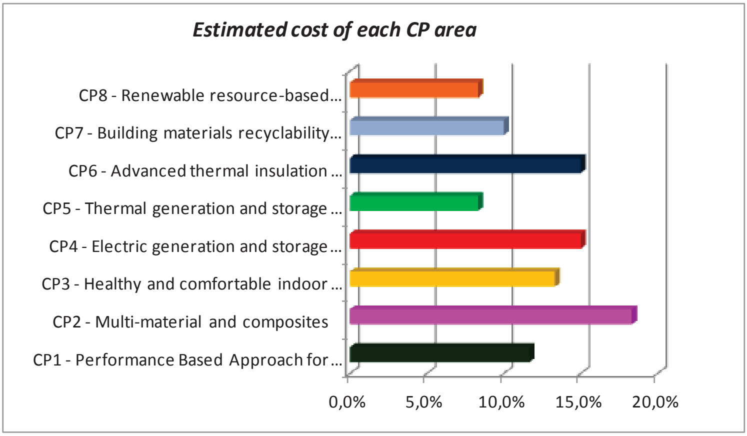

Figure 30 – Distribution of estimated cost in terms of needed private and public funding for each CP area

14 Conclusion

The Roadmap was successfully developed through a wide consultation approach, involving different experts and stakeholders from various ETPs and sectors.
8 Cross-Platform collaboration areas were detailed, developing targets and priorities for short-medium terms (up to 2020) as well as considerations for long term. The overall impact of the roadmap and an estimation of cost distribution were also provided.

The Roadmap was validated through a validation meeting where the Advisory Board and the ETP experts gave the latest inputs as well as through an open consultation launched in the Building Up website.

The Roadmap is available online on http://www.buildingup-e2b.eu/.

Already published in Steinbeis-Edition

Collaboration in Research, Development and Innovation in the Construction Sector

Success Factors and Barriers for Cooperation & Identification of Priority Research Topics for SMEs

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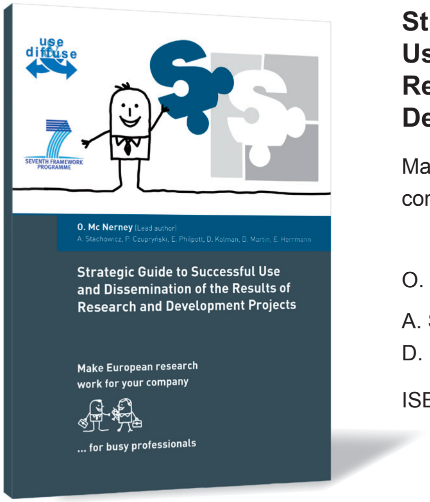
The construction sector is of crucial relevance to the European economy. It accounts for around 2.3 million enterprises – predominantly small and medium-sized enterprises (SMEs) – which generate an annual turnover of almost € 1 billion, contributing an estimated 10% of the EU's GDP. Thus, improving the collaboration among different actors in such a key industrial sector in order to improve the uptake of new technologies and innovations is of strategic importance to Europe. PRESTO finds its reasoning precisely in that background. PRESTO is a project aimed at facilitating the identification of priority research topics for associations of small and medium-sized enterprises (SMEsAs) by establishing a close and sustainable dialogue with European Technology Platforms (ETPs). As part of PRESTO activities a series of analyses, studies, surveys and consultation panels with construction experts, ETPs and SMEsAs representatives were conducted. The present publication is enshrined within the above mentioned context and summarises some of the most relevant findings of the project.



Strategic Guide to Successful Use and Dissemination of the Results of Research and Development Projects

Make European research work for your company... for busy professionals

O. Mc Nerney (Lead author)

A. Stachowicz, P. Czuprynski, E. Philpott, D. Kolman, D. Martin, E. Herrmann

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This Guide is intended to provide Small and Medium Sized Enterprises (SMEs), as well as Universities, Institutes and other Research Technology Development organisations (RTDs) with practical, useful and easy to follow advice on how to maximise the impact of Research and Development projects involving SMEs by ensuring that the results are effectively used and disseminated. The information and advice contained in this Guide is relevant not only for projects that are funded under the Cooperation Programme of the European Commission's 7th Framework Programme (FP7), but the Capacities Programme as well (Research for SME/ Research for SME Associations projects).