ENERGY EFFICIENT BUILDINGS EUROPEAN INITIATIVE (E2B EI) AND THE ROLE OF THE CERAMIC INDUSTRY

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Mr. Juan Manuel Mieres has an experience of more than 18 years in the research field applied to the construction sector, and since 1994 he has been the R&D Director of Acciona. As a result, Mr. Mieres has been quite active in the performing of national, European and international RTD projects, and has developed a portfolio of professional skills focused on project management and development, as well as, real applications on site.

Mr. Mieres holds a Civil Engineer Degree by the Polytechnic University of Madrid (Spain) specialized in structures, having reached an specialist level on the design of structures in composites materials.

Education activities have also been a key element in the professional career of Mr Mieres, through his participation in several congresses, lectures and publications.

Since the very beginning of his professional career, Mr Mieres has collaborated as a technology consultant in more than 150 international and national projects applying his knowledge on project management, constructive procedures and material technologies. Some of the most relevant ones are:

"TING-KAU BRIDGE" (Hong Kong).

"SIDI KRIK POWER STATION" (Alejandria).

Mr Mieres presence at national and international level has been strengthened through its membership to a variety of associations and platforms like:

President of the E2B A (Energy Efficient Buildings Association).

PTEC – National Construction Technology Platform.

ECTP – European Construction Technology Platform.

ENCORD - The European Network of Construction Companies for Research and Development.

FIEC – Federation of the European Industry of Construction.

ECCREDI - European Council for Construction Research, Development and Innovation.

EUROACE - European Alliance for Companies for Energy Efficiency.

European Group in charge of Eurocode 10 & 11 elaboration.

1. EUROPEAN CONSTRUCTION SECTOR: STRATEGIC IMPORTANCE ON ECONOMY, ENVIRONMENT AND SOCIETY

Construction is one of Europe's biggest sectors, including the building, civil engineering, demolition and maintenance industries. It is also by far the largest employer in EU with 25 million jobs, contributing to about 10.4% of the Gross Domestic Product, with 2.7 million enterprises, most of them being SMEs. In fact, 95 % of these enterprises are SMEs with fewer than 20 employees and 93% are SMEs with fewer than 10 employees.

Within the construction market, the buildings industrial sector (residential and non residential) is the first economic sector, as their construction and refurbishment account for the 80% (1,200 billion €) of the total construction sector output (1,519 billion €), while civil engineering accounts for only 20%.

The construction sector also has a major impact on the environment being the highest energy consumer in EU (about 40%) and main contributor to GHG emissions (about 36% of the EU's total CO_2 emissions and for about half of the CO_2 emissions which are not covered by the Emission Trading System).

2. EUROPE'S BIG CHALLENGE. KEY ROLE OF THE CONSTRUCTION SECTOR IN FULFILLING THE ENVIRONMENTAL TARGETS SET BY THE EUROPEAN COUNCIL

2.1. Europe's energy goals.

In March 2007, the European Council set clear goals:

- Reduction of 20% of total energy consumption (below 2005 consumption).
- 20% of total contribution of Renewable energies to total energy consumption (11.5% above 2005 contribution).

- 20% reduction of Greenhouse gases (GHG) below 1990 emissions (14% below 2005 emissions).

The energy consumption has to be reduced by 20% compared with 2005 levels of total energy consumption (1,750 Mtoe), that means a 350 Mtoe reduction of energy consumption. Buildings are responsible of 40% of the total Energy Consumption, 700 Mtoe in 2005.

In this context, the building sector must assume very ambitious objectives of 165 Mtoe (millions of tons of oil equivalent) in energy reduction and contribute with 50 Mtoe from Renewable energies in 2020. To understand the nature of the challenge, these figures are equivalent to the total joint energy consumption of Spain, Portugal, Greece and Ireland in 2006[1].

Therefore, as it is stated in the recent communication of the President of the European Commission José Manuel Durão Barroso "An European Recovery Plan", Construction Sector will have to face significant challenges in the transition to the green economy. Moreover, during the last years these challenges *have become* increasingly *difficult* for the Construction Sector as it is one of the sectors that have recently seen demand plummet as a result of the crisis.

However, according to the same communication, the smart investment in this sector, boosting the innovation within it and improving the energy efficiency of its final products (buildings, infrastructures,..) will be part of the actions that Europe in general and especially the European Construction sector will have to take in order to tackle the current economic crisis and reinforce its competitiveness.

2.2. Research and Innovation in construction: Existence of a market failure.

In front of the challenges raised by climate change and energy dependence, the construction industry has until now exhibited several significant weaknesses.

2.2.1. Slow implementation.

Going rapidly from successful experiment to large scale, satisfactory application of new materials or systems is always a difficult task in the construction sector.

Basically, implementation of new products is slow for several reasons:

- A very fragmented market.
- Based on the work of very small companies.
- Small margins.
- Complex assembly of very different techniques.
- An industry that conveys images of the past, slowing the innovation process.

1. *DG TREN- EU Energy and transport in Figures- Statistical Pocketbook 2009.*

2.2.2. Concentrating on new buildings.

a) New Buildings.

Research and innovation are focused on new buildings: It is easier to start from scratch than to act on a "fixed design". Some difficulties:

- Working on an existing building or district fixes design parameters and will prohibit certain solutions.
- Some actors are less interested to work on renovation projects simply because work done is not immediately perceptible from outside.
- Working on existing buildings is more difficult because the building is in use and occupied.

And if we compare this with other industries, who would try to implement modern, up-to-date techniques in a fifteen years old car? But buildings should be made to last, because of the size of the needed investment (it is also a matter of sustainability), and energy savings should be made on the existing stock in order to have a real action as previously explained in this document.

All these reasons bring in a second market failure: until now prototypes, experiments have been made but with very limited replication and dissemination.

b) Retrofitting is key.

There is a current stock of around 160 million buildings in the EU. The present rate of construction of new buildings is below 2% per year in all major European countries, and recession could further inhibit growth. These figures push the horizon for a truly energy-efficient built environment far beyond one century and probably closer to two centuries if action is limited to new buildings.

Focus is therefore needed on the renovation of existing buildings, including historic ones. Reducing energy consumption during the whole life-cycle would be an effective action against climate change, while also contributing to a decrease in the EU's dependence on energy imports. In order to make a substantial impact, there is a need to act at a Europe-wide level, with public buildings representing a prime target.

2.2.3. Lack of training and expertise.

The fragmented market, the very small companies, the complexity of interaction between techniques brings in a third type of market failure: the lack of training and expertise.

Implementing new techniques needs to permeate deeply a tangled web of actors. Most of these actors run their jobs on very small margins and long hours. In these conditions it is not surprising to see that proper training and dissemination of expertise are difficult. The end result is generally that expected performances are not reached, in particular when implementing new techniques.

2.2.4. Insufficient R&D efforts.

While the pharmaceutical industry claims a figure of 15.3% of R&D effort versus turnover, the automotive industry 3.6%, the construction remains at a very modest 0.3%.

Until recently, construction activities were not very "R&D oriented". Research was made for exceptional works like very large civil engineering works, particular high performance structural materials, or very specific topics like seismic behaviour. It remained in the hands of universities, laboratories and of a few large companies.

As a result, the construction industry often exhibits a poor, non-attractive image. ECTP has been leading a strong action and construction leaders are aware and conscious that significant progress should now be made urgently.

2.2.5. Energy efficiency in construction: a forgotten field.

Energy was cheap, awareness was low, so why care for energy efficiency? Saving has never been an attractive business; at first level it does not bring profit. Awareness that some energy sources will disappear is also quite recent.

And the construction industry started to care for energy in the second half of the nineties, when new regulations appeared in several EU countries. This is obviously a significant market failure.

2.2.6. Limitations of existing regulatory framework and associated instruments.

Limitations of the existing regulatory framework, in particular EPBD and the national/regional measures that implement it, are also preventing the higher reductions of energy consumption.

These originate, firstly, from lack of clarity and the complexity of certain provisions of the EPBD and, secondly, from the low level of ambition in its implantation. At the moment, the EC is working in the recast of the EPBD in which the scope of the current Directive will be broadened.

2.2.7. Summary of the problems for energy efficient buildings RTD.

Until recently, although significant EU public funds have already been directed to research, and energy efficiency in buildings is already included in the FP7 themes as NMP, Energy, ICTs and Environment research portfolio as a component of the RTD strategy, the technologies needed to boost energy efficient buildings are unlikely to be commercially available as quickly as it is desirable specially for buildings renovation. The danger that energy efficient buildings development does not meet with the energy and environmental mandates exists, due to the lack of both standardised cost effective technologies and solutions, and business models, while facing the still unsolved market failures and lagging behind global competitors. The main reasons for that are:

- The research needed is often so complex that no single company or public research institution can perform it alone;

- The absence of an agreed long-term budget plan and strategic technical and market objectives to encourage industry and the research community to commit more of their own resources;

- The sub-optimal application of funds leaving gaps and producing overlaps with a fragmented research coverage;

- The insufficient volume of funds for an integrated and continuous programme covering fundamental research, applied research and large-scale EU-level demonstrations;

- The European energy efficient buildings sector is dispersed across different countries and activity areas (public and private promoters, designers and architects, construction companies, technology developers and providers, SMEs, research organisations) which restricts the exchange and pooling of knowledge and experience;
- The expectations of potential customers request technical breakthroughs in order to improve cost effectiveness, performance, reliability and durability of materials, components and systems for Energy Efficient Buildings and Districts.

3. ENERGY EFFICIENT BUILDINGS EUROPEAN INITIATIVE (E2B EI)

3.1. Introduction: E2B EI and E2B Association.

a) E2B EI.

The European Construction Technology Platform (ECTP) approved, on December 23rd 2005, the vision for 2030 and the Strategic Research Agenda. Its Implementation Action Plan, discussed with the European Commission along 2006, was definitely adopted in June 20th 2007 by the High Level Group. The main deliverable was a proposal for the creation of a Joint Technology Initiative on Energy Efficient Buildings - E2B JTI (now called, E2B EI).

"The overall objective of the E2B EI is to deliver, implement and optimize building and district concepts that have the technical, economic and societal potential to drastically decrease the energy consumption and reduce CO_2 emissions produced by existing and new buildings at the overall scale of the EU.

The E2B EI will speed up research on key technologies and develop a competitive industry in the fields of energy efficiency processes, products and

services, with the main purpose to reach the goals set forth for 2020 and 2050 to address climate change issues and contribute to improve EU energy independence thereby transforming this challenge into a business opportunity".

A PPP Initiative has a number of clear advantages over the Business-as-Usual FP7 alternative:

- A long-term commitment (10 years) and a stable and clear increase in European RTD and demonstration funds, encouraging confidence in public and private investors in providing affordable results,
- Propitiating new business models for the whole value chain and solve market failures,
- Using the co-financing principle, that will leverage at least 700 M€ more than BAU (Business as Usual) for the remaining FP7 period, corresponding to almost two and a half times as much private research investment, strengthening the financial and resource commitment from industry,
- Resulting in a clear deliverable: Energy Efficient buildings that permit integrate dispersed funds and efforts for RTD and demonstration,
- Boosting research and demonstration at European level of energy-efficient systems and materials in new and renovated buildings,
- Reducing radically their energy consumption and CO_2 emissions and increasing the share of RES while improving the security of supply,
- Facilitating potential associated investments, sustainable growth and job creation,
- Contributing to the objectives of the SET Plan.
- Shortening time to penetrate in the market by about 5 years;

b) E2B Association.

In order to address towards the creation of the E2B EI a group of industrial stakeholders have joined their forces to pave the way for the launch of a Public Private Partnership.

As a first step, an International "Non Profit Industrial Association" has been created, the E2B Association that will compose the private part of the future Joint Undertaking (PPP for Energy Efficient Buildings) and that it is already operative since November 20th 2008, under the Belgian law.

The nine Founding Members cover the Energy Efficient Buildings supply chain: Acciona (ES), Arup (UK), Bouygues (FR), D'Appolonia (IT), EDF (FR), Mostostal (PL), Philips (NL), Saint-Gobain (SE) and Stiebel-Eltron (DE). Currently, 132 companies, covering the whole European construction sector's supply chain (see figure 1 below), belong to the E2B Association.

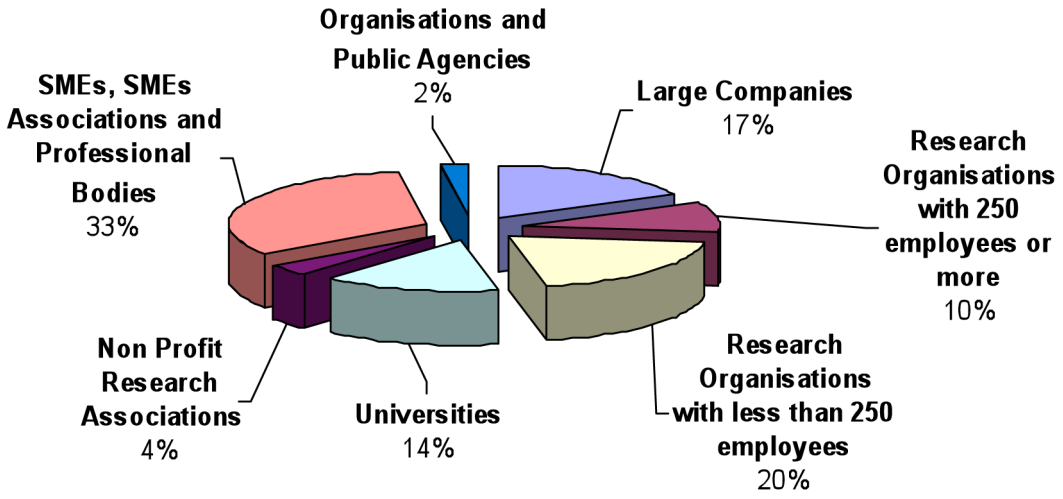

Figure 1. E2B members by Type of organisation.

Regarding the large European manufacturing companies and buildings' materials suppliers, the following companies are already members of the E2B Association:

- **Glass:** Saint Gobain.
- **Cement:** Lafarge, Heidelberg.
- **Steel:** Corus.

(More information in www.e2b-ei.eu).

3.2. Launching of the Public Private Partnerships (PPPs), including E2B.

The 26 of November of 2008, the European Commission announced the launch of the three PPPs in the framework of the plan for the economic recovery of Europe - **COM (2008) 800-"A European Economic Recovery Plan**." Brussels, 26.11.2008.

The Commission proposes to launch **3 major partnerships between the public and private sectors:**

- In the automobile sector, a "European green cars initiative"
- ***"In the construction sector, a "European energy-efficient buildings' initiative".***
- To increase the use of technology in manufacturing, "a factories of the future initiative"

3.2.1. 'European energy-efficient buildings' initiative.

'***European energy-efficient buildings' initiative:***" *to promote green technologies and the development of energy-efficient systems and materials in new and renovated buildings with a view to reducing radically their energy consumption*

*and CO_2 emissions. The initiative should have an important regulatory and standardisation component and would involve a procurement network of regional and local authorities. The estimated envelope for this partnership is € **1bn.**"*

a. Implementation of the E2B calls.

In the short term the E2B calls will be managed by the EC following the rules of FP7. During this period, the E2B A will be asked to set up an industrial advisory group. The role of the E2B Association will be the definition of the Research and Demonstration programme and priorities.

The EC funding distribution in the period 2010-13 for each of the different areas will be the following:

EC Funding distribution period 2010-2013:

M€	NMP	TREN	INFSO	ENV	Total
2010	30	15	15	5	**65**
2011	40	20	20	5	**85**
2012	70	35	25	7	**137**
2013	110	55	40	8	**213**
Total	250	125	100	25	**500**

Figure 2. EC Funding Distribution Period 2010-2013.

First call Topics → WP 2010 Energy-efficient Buildings PPP:

- New nanotechnology-based high performance insulation systems for energy efficiency - **NMP**.
- New technologies for energy efficiency at district level - **NMP**.
- ICT for energy-efficient buildings and spaces of public use - **INFSO**.
- Compatible solutions for improving the energy efficiency of historic buildings in urban areas - **ENV**.
- Demonstration of Energy Efficiency through Retrofitting of Buildings – **TREN**.

b. Industrial Advisory Group.

The EC has asked the E2B A to provide them with priorities for 2010-2013. The E2B A has set up an Ad Hoc Advisory group to accomplish this task during this period. As the private part of the PPP, E2B A has been considered as a preferential interlocutor by the EC. Among its main roles are the following:

- Seek and demonstrate industry engagement.
- Represent and coordinate members' research interests within the PPP.
- Keep close links with relevant international initiatives and research programmes.
- Collect information on national research priorities and initiatives and integrate them at EU level.

The Ad-Hoc Advisory group set up within the framework of the E2B Association is responsible for defining the RTD roadmap based in a strategic research agenda influenced by six working groups. It has set up six different technical working groups with the following role:

- To define the RTD priorities for 2010, 2011, 2012, 2013.
- To mobilise specific projects to answer to the EC Calls.
- To gather the inputs of E2B A members.
- To define a strategic Roadmap for the period 2010-2013.

The following figures give a global view of the composition, structure and communication flows of the Ad Hoc Advisory Group and its Working groups.

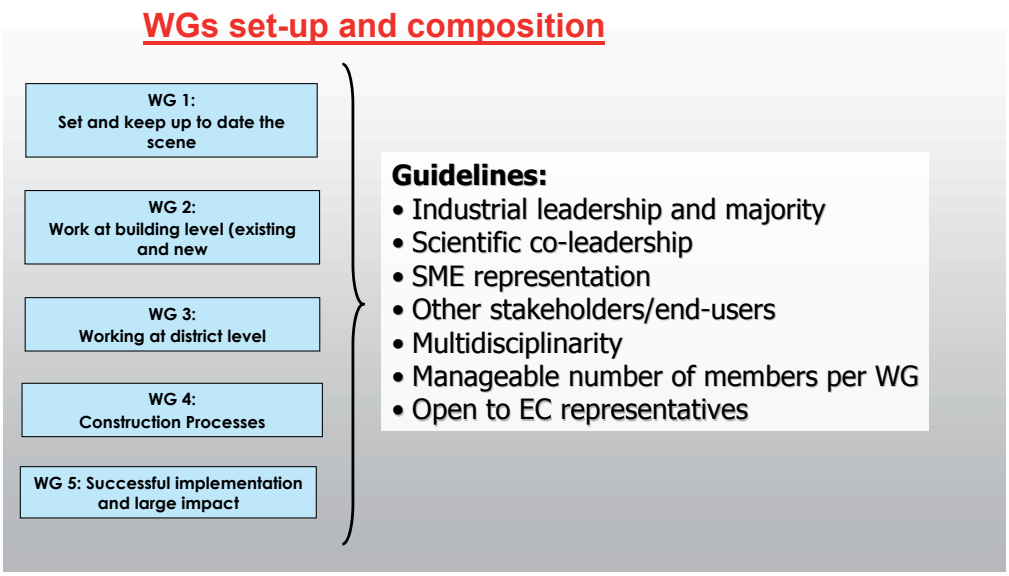

Figure 3. WGs set-up and composition.

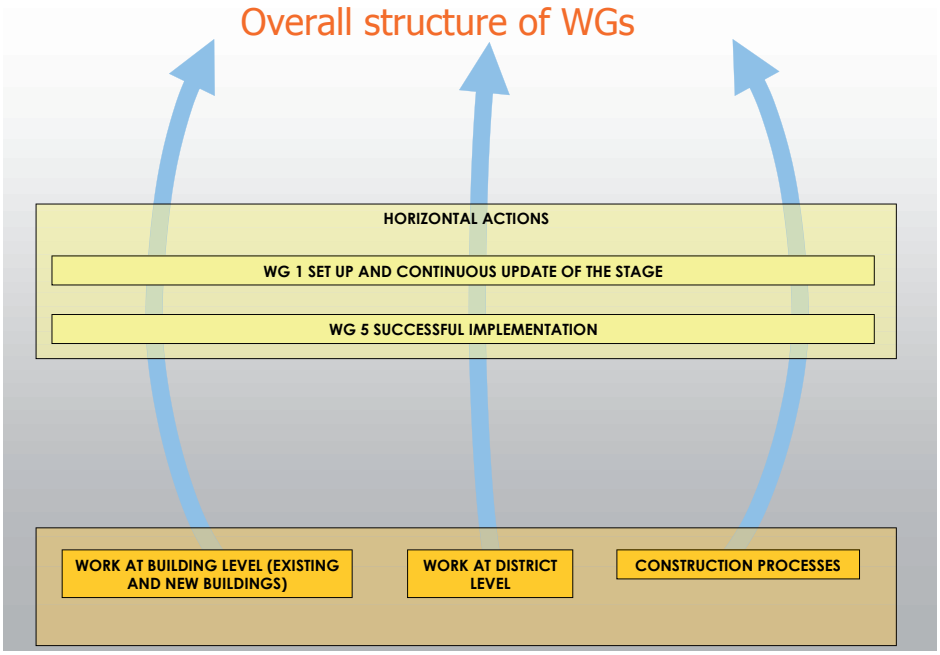

Figure 4. Overall structure of WGs.

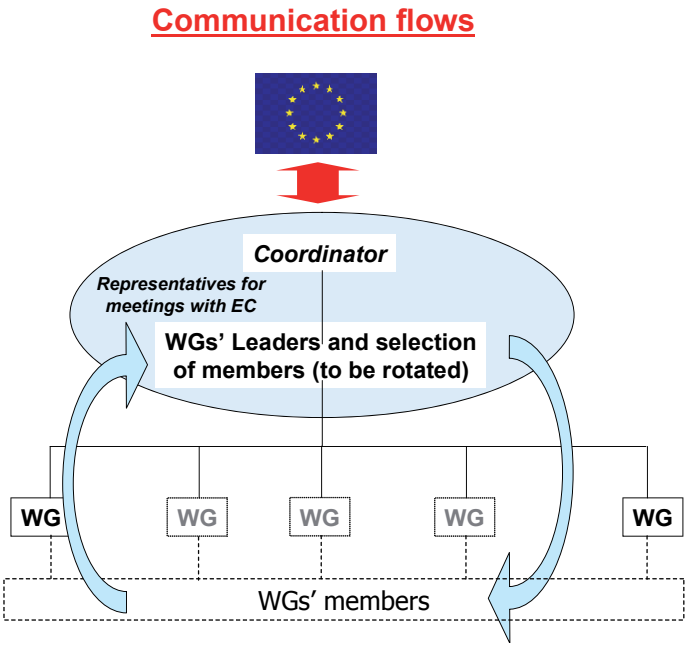

Figure 5. Communication Flows.

4. E2B PPP RESEARCH PRIORITIES: MULTI-ANNUAL ROADMAP AND LONG TERM STRATEGY[2]

4.1. Proposed scenario.

The difficult question is how to reach the 165 Mtoe (23.6%) reduction from the existing (in 2005) buildings and the contribution of 50 Mtoe from renewable energies during the period from now until 2020.

2. The last version of the Multiannual Roadmap can be downloaded from the E2B A website www.e2b-ei.eu.

The proposers of the initiative have established a scenario to understand the different challenges. The scenario assumes that:

a) There is a stock of around 160 million buildings in Europe; which cannot be approached in the same way due to their use (e.g. Industrial).

b) Buildings are divided into four groups - three groups of existing buildings and one of new buildings, according to their average possibility of energy savings and integration of RES.

Group 1: Existing buildings consuming, in 2005, a fraction of 40% (280 Mtoe) of the total energy consumption in buildings.

- They offer low possibilities for reduction. The maximum average saving possibilities is considered to be 12% of 280 Mtoe, equivalent to 33.6 Mtoe.
- They offer low possibilities for renewable energies. The maximum average contribution is considered to be 3.3% of their final energy consumption (246 Mtoe) equivalent to 8.1 Mtoe of renewable energies.

These targets would be achieved through the following main actions:

- Low improvements in efficiency of equipments.
- Low improvements in windows, air flows…
- Certain improvements in user's behaviour.
- Other minor interventions.

Group 2: Existing buildings consuming, in 2005, a fraction of 30% (210 Mtoe) of the total energy consumption in buildings.

- They offer medium possibilities for reduction. The maximum average saving possibilities is considered to be 25% of 210 Mtoe, equivalent to 52.5 Mtoe.
- They offer medium possibilities for renewable energies. The maximum average contribution is considered to be 8% of their final energy consumption (157.5 Mtoe) equivalent to 12.6 Mtoe of renewable energies.
- These targets would be achieved through the following main actions:

  - Important improvements in efficiency of equipments.
  - Important retrofitting, in line with the EPBD's mandate.
  - Medium improvements in user's behaviour.
  - Other medium level interventions.

Group 3: Existing buildings consuming, in 2005, a fraction of 30% (210 Mtoe) of the total energy consumption in buildings

- They offer high possibilities for reduction. The maximum average saving possibilities is considered to 40% of 210 Mtoe, equivalent to 84 Mtoe.
- They offer medium possibilities for renewable energies. The maximum average contribution is considered to be 15% of their final energy consumption (126 Mtoe) equivalent to 18.9 Mtoe of renewable energies.
- These targets would be achieved through the following main actions:
  - Replacement of equipments by other of much higher efficiency.
  - High energy level retrofitting going further than the EPBD's mandate.
  - Important improvements in user's behaviour.
  - Other high level interventions.

Group 4: New buildings built in the period 2005/2020.

- They would represent an increase of around 60 Mtoe if they were built according to the actual national regulations.
- It is considered to be possible to reduce a maximum of around 60% of this consumption, equivalent to around 36 Mtoe. So, the final energy consumption of new buildings built in the period would be around 25 Mtoe.
- The maximum contribution of renewable energies in the new buildings, built in the period, is considered to be 40% of their final total energy consumption: 10 Mtoe.

The following table shows a summary of the contribution from the different building groups in order to achieve the energy consumption needed.

	Existing Buildings (700 Mtoe)			New Buildings*	Total
	GROUP 1	GROUP 2	GROUP 3	GROUP 4	
Initial energy consumption	40% of thel total = 280 Mtoe	30% of the total = 210 Mtoe	30% of the total = 210 Mtoe	25 Mtoe	725 Mtoe
Average Energy Saving Potential	Low: 12% = 33.6 Mtoe	Medium 25% = 52.5 Mtoe	High 40% = 82 Mtoe	-	Aprox. 168.1 Mtoe
Average RES Integration Potential	Low 3.3% = 8.1 Mtoe	Medium 8% = 12.6 Mtoe	High 15% = 18.9 Mtoe	10 Mtoe	Aprox. 50 Mtoe

Figure 6. Expected reduction in energy consumption and the integration of associated renewable technologies. (New Buildings: Built under energy efficient measures).*

4.2. Key pillars of the roadmap.

The challenges the sector faces are too complex to be solved by a uniform, single-oriented action. Furthermore the EU's buildings sector is a true example of the EU's diverse nature. For example, looking just at the integration of renewable energies in the built environment will not in itself be sufficient to decrease Europe's energy dependence. In a similar way, retrofitting buildings one by one will never solve climate change problems. These are some of the reasons why we need to also adopt two **holistic approaches**, both on a **technical point of view** and on the **urban scale level**.

Working at district level, or on large groups of buildings is certainly the true scale identified within the long term strategy by the E2B Association and it is fully reflected in the design of a long term roadmap. Only district scale intervention will permit the achievement of the much higher energy efficiency targets required by optimizing the use of energy at different levels:

- Whole district (networks and grids, street lighting and signalisation, urban heat production..);
- Groups of dwellings (sharing and managing energy production, social attitudes, involving public owners…);
- Residential and non-residential building level (insulation, building energy management systems, high performance energy systems, integration of renewable energies, etc.).

One of the fundamentals of the long term strategy is that energy efficiency will respond to climate change and energy issues, providing we are able to trigger large scale actions concerning all Member States. Different climates, building traditions and cultural, historic and economic factors have resulted in significant variations between the EU Member States and even between their regions.

In order to generate impact, the E2B roadmap therefore addresses the **concept of "Geo-clusters"**, conceived as virtual trans-national areas/markets where strong similarities are found, for instance, in terms of climate, culture and behaviour, construction typologies, economy and energy/resources price policies, Gross Domestic Product, but also types of technological solutions (because of local demand-supply aspects) or building materials applied etc.

Our roadmap is therefore based on a holistic approach, contributing to a proper integration of specific solutions developed in the various technical fields to form a coherent, global solution. In this framework, the roadmap has been built on the following **pillars**, namely: 1) **systemic approach**; 2) **exploitation of the potential at district level**; 3) **geo-clusters**. As a result, the roadmap will fully leverage on the GOLD rule: Globally Optimised, Locally Designed.

Fast implementation and performance feedback represent a fourth major pillar in building up the long term strategy and the Multiannual Roadmap within the

E2B PPP. Monitoring and proper reactive actions are then major components. Both are included in what industry has called a "wave action". In this "**wave action**" plan, continuous, ongoing research feeds successive waves of projects as stated here below. The knowledge gained in the first "wave" feeds in the second at the design stage, realising a continuous implementation process. The roadmap is based therefore on the following logic:

- Continuous, ongoing research feeding successive "waves" of projects (Design & Building "D&B" followed by Operation "O") as stated in the figure 7 below;
- Knowledge gained in the first "wave" feeding also the second at the design stage, realising a continuous implementation process;

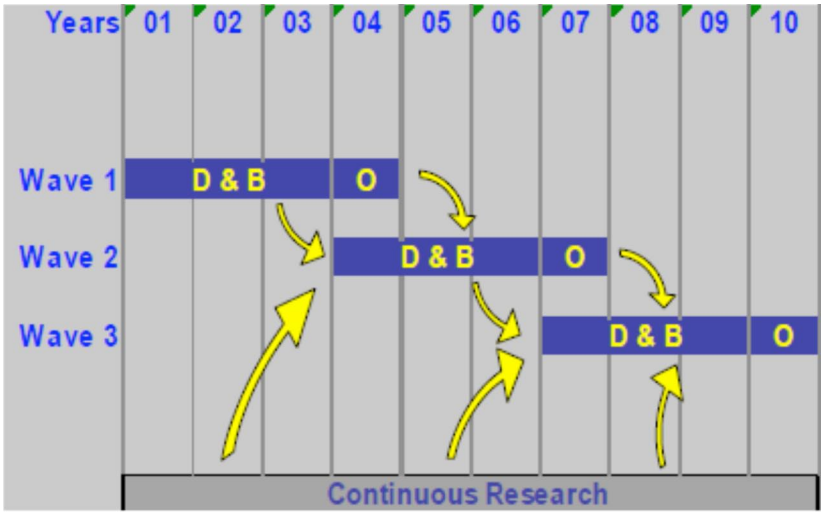

Figure 7. Multiannual Roadmap Wave actions.

Within a ten year time perspective, three waves will have been completed. A movement will have been started and other waves of implementation will follow. Clearly in our vision and ambition the work will not stop after ten years. As a result of this "wave action" it is expected to reach impact following a stepped approach, namely:

- **Step 1**: Reducing the energy use of buildings and its negative impacts on environment through integration of existing technologies:
- **Step 2**: Buildings cover their own energy needs;
- **Step 3**: Transformation of buildings into energy providers, preferably at district level.

The implementation of the Multiannual Roadmap will have a direct impact on the Energy Technologies which have their application domain in buildings, as showed in the Technology Map of the SET-Plan (see figure 8 below).

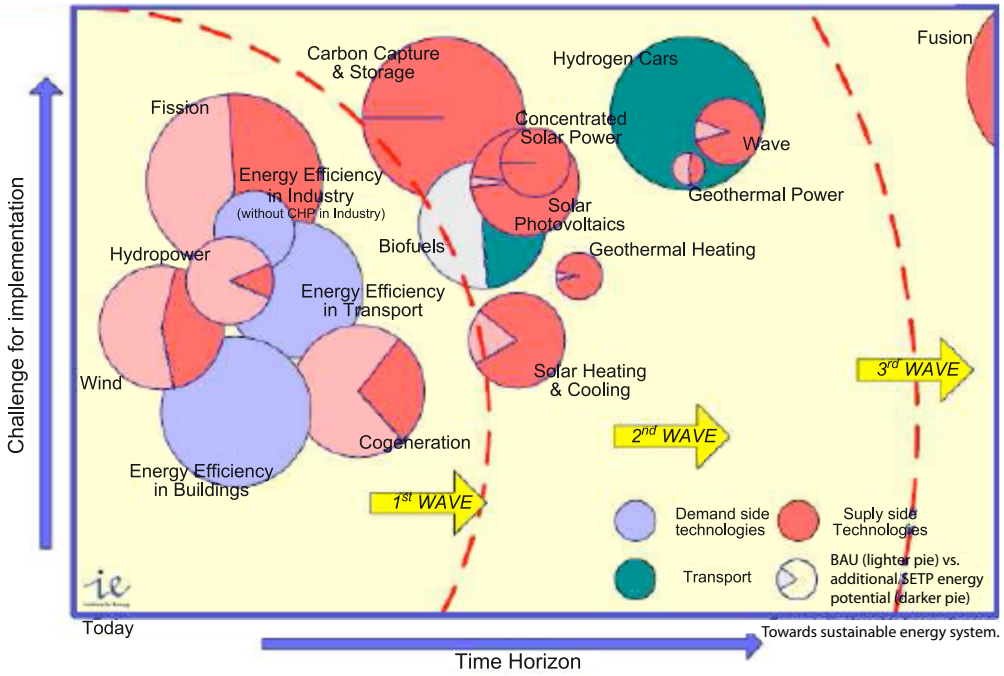

Figure 8. Technology Map of the SET-Plan, 2007.

The focused effort put in Energy Efficiency in Buildings (Low-Left corner of the figure 8) through the proposed Roadmap will reduce the time horizon of other technologies involved also in buildings, such as Cogeneration, Solar Heating and Cooling, Solar Photovoltaic and Geothermal Heating, to name a few, due to a demand driven approach. The long term strategy would involve a collaboration with the industrial initiatives (Smart grids, Solar, Wind,…) identified within the SET Plan in order to ensure collaboration and avoid overlapping of activities. This is particularly relevant considering the synergies and coherence with the "Smart Cities" initiative.

4.3. Research challenges at the basis of a Multiannual Roadmap

In order to address the challenges ahead and accomplish the strategic vision highlighted, a number of research areas have been identified, as detailed in the following figure 9:

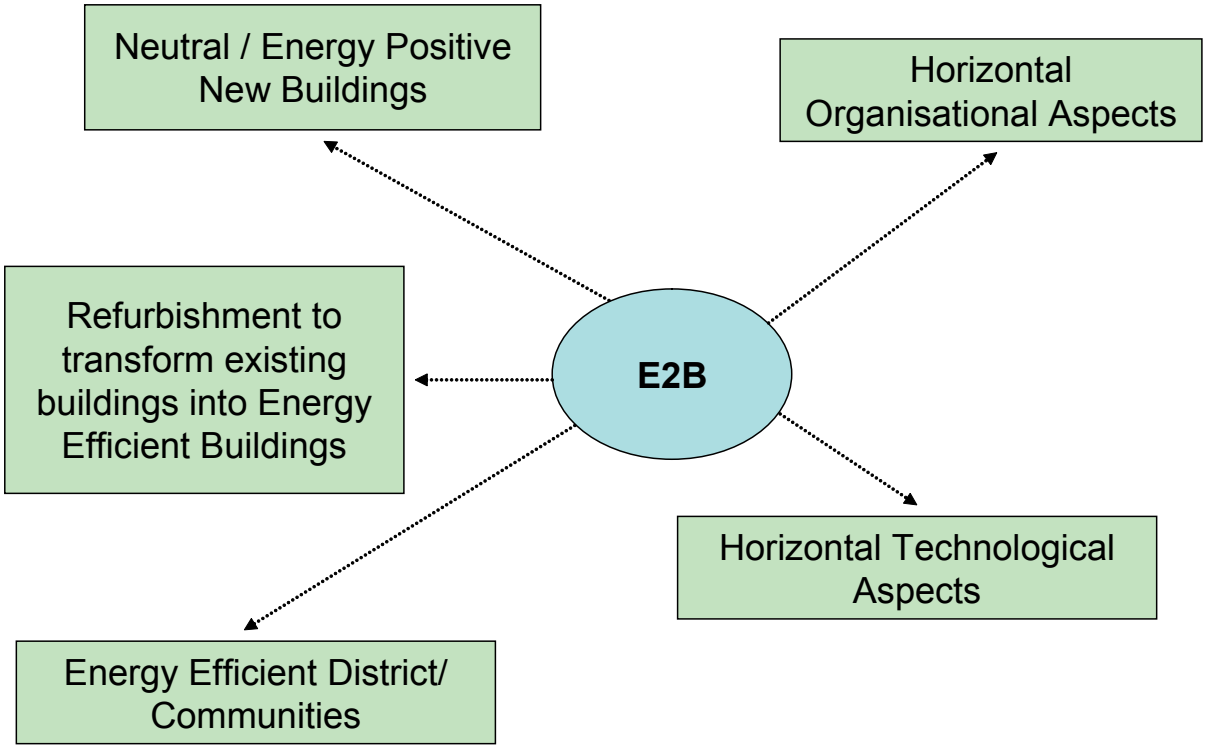

Figure 9. Key Research areas targeting the challenges at the basis of the long term strategy.

The following diagram in the figure 10 in the next page shows the inter-relationship among research challenges for each of the three application areas.

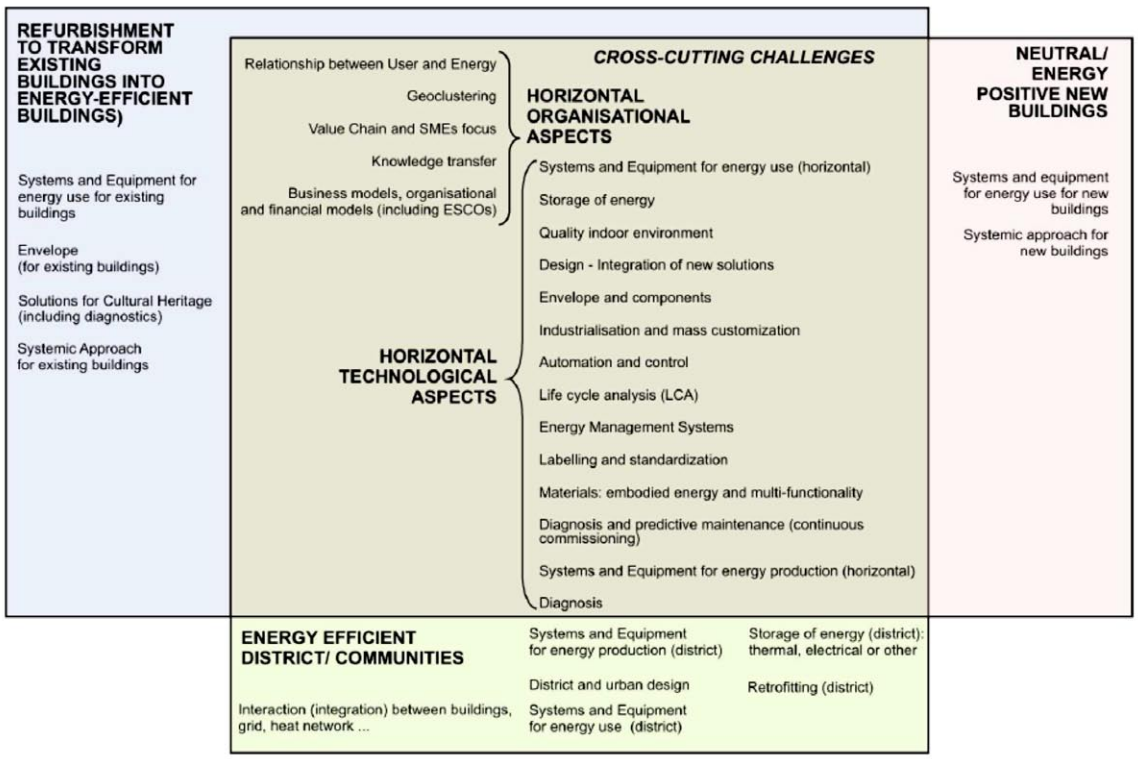

Figure 10. VENN diagram- Interrelationship among research challenges.

4.3.1. Refurbishment to transform Existing Buildings into energy-efficient buildings.

- **Envelope (for existing buildings)**: new materials, products and components to address energy efficiency with fault tolerant procedures and building techniques. Development of insulation systems specifically designed for the energy efficient retrofitting of existing and occupied buildings.
- **Solutions for cultural heritage (including diagnostic)**: Novel sustainable strategies, concepts, methodologies and techniques to improve the energy efficiency of cultural heritage buildings; accurate evaluation of the prerequisites and definition of different solutions for the control and maintenance of historical buildings. Development of innovative methodologies to improve the planned maintenance and conservation policies at EU level; Breakthroughs for new simulation tools for an open 4D GEODbase accessible to all stakeholders to allow the definition of common EU standard and common approaches.
- **Systems and equipment for energy use (for existing buildings)**: new methodologies to integrate comfort systems, energy management systems and local energy generation; new flexible and efficient equipment to be operated in existing buildings; Improved heat pump technology targeting higher efficiency heating solution (and of low cost, small size) specific for retrofit buildings; new concepts of heating and/or cooling sources, higher efficiency as well as connection to existing thermal distribution systems; passive systems enabling replacement of conventional ventilation and cooling systems, used both in office and residential buildings.
- **Systemic approach (for existing buildings)**: integral concepts consisting of building and system technologies making up energy efficient refurbishment packages with improved comfort, indoor air quality as well as high reproduction potential, making optimal use of local energy opportunities and boundary conditions; energy efficient "kits" to retrofit buildings at affordable prices.

4.3.2. Neutral/Energy Positive new buildings.

- **Systems and equipment for energy use (for new buildings)**: in line with the need in existing buildings, energy efficient technologies, as heat pumps, need further development to target higher efficiency heating solution for new buildings; Energy efficiency by applying new concepts of heating and/or cooling sources; Passive systems enabling replacement of conventional ventilation and cooling systems; New design and technologies to provide higher heat transfer efficiency; Application of new materials and designs for more efficient heat transfer areas.
- **Systemic Approach (for new buildings)**: integral concepts, consisting of building and system technologies (e.g. roofing and facade systems for high

envelope/plants integration) making up neutral/energy positive buildings are needed, with good indoor air quality and high reproduction potential, making optimal use of local energy opportunities and boundary conditions.

4.3.3. Energy Efficient District/Communities.

- **District and Urban Design**: there is a need for the development of new decision support tools for eco-district design choices in line with the GOLD paradigm (Globally Optimized Locally Designed). In this framework, innovative approaches in district design are needed to study and to introduce climate adaptation and mitigation. Breakthroughs are searched for in the development of innovative methodologies, tools and solutions for continuous district commissioning.
- **Systems and equipment for energy production (at district level)**: solutions are needed for achieving 20% coverage of built environment energy demand by RES production at district level; New methods of assessment of day ahead accurate prediction of RES production up to 15 min level; new methodologies to link district systems and smart grids. New and more efficient Cooling, heating and Power systems that are RES based (i.e. Solar district heating and cooling) and Combined Heat and power systems applied at district level.
- **Systems and equipment for energy use (at district level)**: energy-conversion hub/router concepts enabling maximum RES usage from de-central (electrical, thermal) production by combination of storage and energy-conversion techniques in one district demand-supply station; Efficient water pumps for global energy reduction in water supply and distribution; Integration of advanced efficient urban lighting, including new preventive maintenance procedures, efficient transportation infrastructures at district and urban level to minimise energy use and fuel consumption, (hybrid and full electric vehicles, future hydrogen-based mobility systems,..).
- **Storage of energy**: thermal, electrical or other (chemical, hydrogen, mechanical, others): innovative solutions for storage of renewable thermal energy at district level; novel approaches for the development of innovative methodologies for using bio-gas as storage medium, combined with effective waste management strategies at district level;
- **Interaction (integration) between buildings, grid, heat networks…**: innovative methodologies for the bi-directional connection between storage systems, smart grids, buildings and vehicles/mobility systems and between heat, power and CO_2 grids; New methods for real-time energy demand-supply management jointly with innovative approaches for building-to-grid integration without power quality pollution; New technologies and approaches enabling effective Building to Building interaction as energy market; Methodologies and tools for CO_2 as well as certification procedures at district level.

- **Retrofitting**: specific solutions for the use of green areas in the urban retrofitting planning; solutions for energy efficient retrofitting of historical districts; Cost-effective integration of emerging technologies to improve the return of investment within a holistic life cycle perspective.

4.3.4. Horizontal Technological Aspects.

- **Envelope and components (for new or existing buildings)**: new integrated approaches to fill the gap between theory and practice in the training process of workmanship, including emerging technologies like virtual or augmented reality; New modelling and simulation approaches for the overall physics and behaviour of the envelope when planning its refurbishment (e.g. air-tightness, insulation, shading); New thermal insulation materials with improved properties (i.e. For internal insulation: thinner and with higher insulation capacities): coatings, ceramics, nanotechnologies; New or adapted products and techniques to increase energy efficiency of transparent envelope parts; Multi-functional façade panels, Active panels and windows collecting and/or capable of storing energy, highly efficient and smart windows, local solutions to reduce thermal bridges,..
- **Systems and Equipment for energy use (for new or existing buildings)**: new flexible and efficient equipment with advanced technologies for heating, cooling, lighting, ventilation…Integration of advanced lighting like (O) LEDs with sensors and actuators; suitable intelligent power electronics and control systems interfacing with energy management systems and local energy generation by RES; Passive systems enabling replacement of conventional ventilation and cooling systems; Power electronics needs further development for its cost-effective integration in systems and equipment.
- **Systems and Equipment for energy production (for new or existing buildings)**: improvements in the integration of PV in the external covering (e.g. Building Integrated Photovoltaic Panels (BIPV) made of ceramic substrates); New and more efficient Cooling heating and Power systems that are RES based (i.e. Solar Cooling and heating systems) and Combined Heat and power systems applied in buildings; New concepts for ventilated facades (e.g. Ceramic ventilated facades) with integrated systems for energy production; Innovative integration of solar thermal systems for building heating and cooling (i.e. absorption technologies); Small wind turbines; Innovative Geothermal solutions with free-heating and cooling integration for residential/ commercial sectors; Efficient integration of hydrogen and RES technologies in buildings (i.e. fuel cells); New intelligent power electronics (PV inverters or converters/generators for wind turbines) and integrated in complex energy production systems at building and district scale.
- **Storage of energy, thermal or electrical**: new flexible systems for energy storage considering different working conditions (e.g. different

climate and seasons) and storage methods (e.g. ground storage); Innovative energy storage enabling a higher thermal energy density; new solutions for seasonal storage of renewable thermal energy integrated at building level and for decreasing energy loss during storage to less than 10% (current thermal losses are around 50%); solutions enabling storage of renewable electric energy produced at building level locally (e.g. into plug-in hybrids).

- **Quality indoor environment (including comfort and health)**: effective mechanical ventilation combined with air cleaning and air control techniques; exchange of indoor air with fresh air from outside, based on counter-current thermal exchangers to reduce the heating power; New solutions considering energy efficiency, indoor air quality, comfort as well as the reproduction potential simultaneously: breakthroughs addressing the potential of energy efficiency to realize healthy and comfortable indoor environments with high reproducibility.
- **Design - Integration of new solutions**: development of a European-wide database with optimal technical interventions (i.e. Best practices database) to facilitate the energy retrofitting of buildings and the design of new buildings considering energy performance criteria; Assessment, simulation and visualization techniques for supporting decision making, removing gaps between prediction and reality; Reliable LCC calculation methodologies and benchmarks, including investment, maintenance and energy aspects. New methods and tools for smooth information-sharing among different stakeholders on projects (i.e. Building Information Model, BIM); Methodologies and support tools for a simplified building monitoring and building performance analysis; A standardised methodology for European countries for a more comprehensive approach to building assessment.
- **Automation and control**: new methods and procedures to integrate ICT tools (e.g. low-cost vision systems, building information models, embedded wireless devices, new user interfaces, new processing algorithms, etc) into construction processes and maintenance operations, essential for energy efficiency, productivity and security; Service oriented architectures to introduce building and district automation and control systems; Web based control platforms allowing the user to monitor and immediately act on the installation from a remote location (through cell phones, laptops); Interoperability standards, protocols and interfaces for wired and wireless communication; Integration of real-time with design/operation information (static information),…
- **Industrialisation and mass customisation**: cost effective industrialised solutions and products, capable of being adapted to the final conditions of the building (size, finishing, etc). Configuration design, intelligent E-catalogues, logistics, templates, etc.

- **Life Cycle Analysis (LCA)**: whole LCA Approach methodologies, acceptation of the LCA approach "from design to reconstruction" as the only one by evaluation of long term complex quality of buildings and its urban neighbourhood; Building up environmental databases for the development of materials, products and processes as well as development and verification of EPDs (Environmental Product Declarations); Solutions to provide verified environmental information and tools for architects and engineers when designing new or existing buildings; Reduction of embedded energy; embodied CO_2; waste generated; A Europe-wide common standard in order to ensure the development of a common basis of understanding for all architects and producers of new sustainable products.
- **Energy Management Systems**: Building Energy Management Systems (BEMS) intelligent and self-adaptive to the different operation's conditions of the buildings, including building/grid energy balancing. BEMS for holistic approaches by integrating and managing all energy-related systems; New Smart Metering systems (i.e. user friendly awareness tools: providing intuitive feedback to users on real time consumption in order to change behaviour on energy-intensive systems usage); New strategies for monitoring, protocols, service platforms, standards as well as user interfaces.
- **Labelling and Standardisation**: a holistic approach for an efficient labelling system of sustainable buildings is needed, in order to give reliable measurement and comparable results. There is a need for integration and definition of standard protocols to make possible to analyze energy behaviour at the same terms all along EU countries and better understanding of energy aspects from building experts to end-users. The standardisation is strongly focusing on energy performance of buildings, but products and systems on physical characterisation. Between both there is a gap which must be covered with research activities to develop accurate standardisation methodologies.
- **Materials: Embodied energy and Multi-functionality**: embodied energy in materials represents a very high percentage (in some cases up to 25%) of the energy spent in the whole life cycle of a building. New approaches combining novel processes, sensors and material science are needed to minimize the embodied energy of main construction materials such as cement, concrete, glass, steel, ceramics…; New multifunctional materials with higher thermal and acoustic properties. New technology routes to integrate waste in the production cycle (recycling) of materials.
- **Diagnosis and predictive maintenance (continuous commissioning)**: in order to guarantee energy efficiency performance throughout the life cycle, new solutions are needed for automated or continuous commissioning including diagnosing faulty economic operation, un-calibrated or malfunctioning sensors, valves, actuators..; diagnosing faulty or improper

ventilation control strategies…For new buildings solutions performing checkout and functional tests, collect data used for performance verification and retain completed functional test sheets. For existing buildings new solutions to perform functional tests, collect monitored data and retain functional test and monitoring data results to confirm initial findings; Solutions should also operate within districts for the maintenance of district energy infrastructure.

4.3.5. Horizontal Organisational Aspects.

- **Relationship between user and energy**: Reliable knowledge of the relationship of energy efficiency versus wellbeing (e.g. comfort,) needs to be created (and quantified through specific indicators), taking into account the behaviour of the users; Different dissemination levels for experts, students, end-users; New technologies (e.g. user-adaptive controls) to enable provision of wellbeing rather than temperature or light, for instance; Demonstration houses for both new (plus-energy) and existing buildings (refurbishment); Effective user awareness generation for (district) energy systems.
- **Value Chain and SMEs focus:** There is a need to build up a seamless value chain which makes use of latest ICT solutions and is "SME-friendly". This requires a fully EU wide approach to develop tools and approaches that will not be restricted by any particular workflow and collaboration pattern; New concepts and tools for process integration along the construction value chain, with a special consideration of energy issues, by engaging actors in energy supply, storage, and use; To provide the SMEs with tools that would assist them in developing a clear view, in differentiating and optimising the value they deliver along the full value chain.
- **Geoclustering**: Modelling largely differing regional profiles across the EU, as regards processes, materials and technologies in use to create a solid horizontal data infrastructure, to the use of other EU wide services and tools in energy and construction, including national key performance indicators (KPI) and best practices/available technologies ready to use; Structured information at EU level on typology, volume energy status, etc of the existing building stock; Buildings vs. Districts data modelling (i.e. Multi Spatial Geographic Design tool); Semantic 4D model to support energy efficiency analysis of traditional materials/techniques and sustainable analysis of innovative one's.
- **Knowledge transfer**: encouraging the transfer of good practices, technologies and methodologies, including cross-sectorial cooperation, the set up of a communication infrastructure and the organization of a number of coaching events; New cost effective, fast and easy to use tools have to be developed to overcome actual barriers (cultural, linguistic,..); To spread the information, training and providing an infrastructure of Experimental

Buildings that incorporate cutting-edge technologies in the field of Energy in buildings to achieve coordination between the EU and national/regional levels; The integration of new solutions and existing networks at EU level is the key.

- **Business models, organisational and financial models (including ESCOs)**: development of innovative business models and organizational paradigms (dedicated particularly to SMEs) is needed, including the marketing of energy positive buildings and their demonstration; Common energy tool set at the EU level taking into account country specific issues: energy, best available technologies (BATs), structured information on typology,... of the existing building stock; New business models using life cycle costing and/or total cost of ownership at building or even district level; Synergies with ongoing initiatives should be established by mapping the relationship between relevant programmes and actions at national and regional level among Member States; Innovative financing and business models and private and public incentive schemes to encourage main-streaming of solutions at district scale or greater (Policy approaches: Voluntary Codes, regulations).

5. ROLE OF THE EUROPEAN CERAMIC INDUSTRY IN THE FRAMEWORK OF THE PPP

During the last years, the European research and development of innovative ceramic materials with new functionalities for their use in outdoors, buildings and urban applications have lead to important achievements and promising results.

The use of nanotechnology for the development of advanced ceramics materials has led to high-performance ceramic materials with improved and innovative properties such as: low thermal conductivity (higher levels of insulation), high mechanical strength, low thickness, ceramic layers for photovoltaic energy generation (see figure 11 below). These characteristics have made possible that, nowadays, ceramic-based materials are been increasingly considered as a key means for improving the energy efficiency of buildings in Europe.

Figure 11. Photovoltaic tiles installed alongside traditional clay tiles. Source: SRS Energy[3] Fuente: SRS Energía[4].

Implementing advanced ceramic-based materials in the envelope of buildings has several advantages compared with other traditional insulation materials as these ceramic materials can contribute to keep the building cool in the summer, warm in the winter; to allow moisture to escape, to protect against the elements,..

E2B EI represents a unique opportunity for the Ceramic industry, as it will support the research, development and validation of innovative ceramic materials addressed to improve the buildings' energy efficiency. Therefore, it is encouraged that more Ceramic-related companies join the E2B Association[4] as they will be able to propose their own key research priorities within the E2B A's overall approach.

The Ceramic industry can and must play a key role in the development of high added value products achieving the following targets:

- To reduce the energy consumption and CO_2 emissions in both new and existing buildings → new ceramic materials with higher thermal and acoustic insulation properties, ceramic ventilated facades.
- Development of new ceramic elements through the use of the nanotechnology with high mechanical properties, lightweight and aesthetic added value.
- Contribution to local renewable energy generation → Integration of photovoltaic ceramic tiles in building facades and roofs for photovoltaic energy generation.
- To improve the building's indoor environmental quality (including indoor air quality) and comfort by developing innovative ceramic-based materials with new functionalities → multifunctional ceramic coverings capable of controlling humidity and with anti-pollutant, self-cleaning and antibacterial properties.

3. *www.srsenergy.com.*

4. *The information about the procedure to join the E2B Association can be found at www.e2b-ei.eu.*

- To develop new construction techniques and systems for an efficient an low-impact integration of these materials in both new and existing buildings → new ceramic portable units.
- To develop new industrialisation processes and techniques for reducing the commercial cost of these new ceramic materials and reducing the energy required for their manufacturing (embodied energy).