Cities are the most desirable places to live in
Foreword

This document is the first version of the Vision 2030 & Strategic Research Agenda (SRA) established by the Focus Area Cities & Buildings of the European Construction Technology Platform (ECTP). It addresses the research needs of Europe in the field of the urban area over the next 25 years, and sets out the likely directions of technological and organisational changes that will need to be converted into specific research programmes over the coming years.

The working document stresses the importance of cities and buildings and identified four important areas of attention:

− Urban Issues,
− Buildings,
− Energy,
− Materials.

This SRA is based on the preparatory elements of the Vision 2030. Purpose is to guide and stimulate all those interested with the relevant research programmes, whether from a governmental, industrial, social, funding, policy or regulatory perspective. It is not to list specific research programmes or collaborating actors, it is to pave the way for future research by clear sets of directions and priorities.

This SRA proposes Research Priorities organised along the four main areas of attention of the Focus Area as mentioned before. Under each area, detailed research topics derived from research domains presented in the Vision have been sorted out according to major strategic research priorities agreed by the Working Groups of the Focus Areas.

This Agenda is the first of a series of agenda documents aimed at delivering and updating a long-term view of research priorities and needs. It is a document under constant development, but already makes an important contribution towards organisation and optimisation of research efforts in the area of Cities and Buildings.
Executive Summary

The importance of Cities and Buildings is without doubt. They perform many functions for those that use them and have a big influence on the quality of life of the European citizen. However, currently Cities and Buildings are also related with important problems regarding the well-being of its inhabitants. Important potential for improvements has been identified that are related with the design, construction, renovation and demolition of the buildings and the built environment.

The Focus Area Cities & Buildings has identified four major areas of attention:
- Urban Issues,
- Buildings,
- Energy,
- Materials.

An analysis of the background, present situation and challenges of these four areas lead to an important number of challenges that have to be addressed. These challenges range for example from the empowerment of all sections of society or reduction of GHG emissions to erection and assembly processes or the inclusion of nano-technologies in construction materials.

This understanding of the present situation and its challenges has enabled the Focus Area to define an overall vision accompanied by 4 partial visions for the areas of attention. The overall vision for Cities and Buildings is:

**Cities are the most desirable places to live in.**

To be able to reach this vision, a Strategic Research Agenda, including key performance parameters and targets to evaluate its progress, has been prepared around 4 Strategic Research Priorities:
1. Cities are developed through sustainable urban policies that ensure the holistic development with significant involvement of citizens in decision-making.
2. New business processes for healthy, safe, attractive and accessible buildings for all.
3. Highly efficient energy buildings and urban areas.
4. Changed materials and construction technologies in order to provide buildings and cities that meet users’ and society's needs better.

The organisation of the Focus Area and the members of it are mentioned in a special chapter as well as the implementation plan for the FA.
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1. Introduction

1.1. Cities and Buildings – The importance

Urban areas perform many functions for their inhabitants and those that use them. These include housing, employment, access to goods and services, cultural activities and social interaction. To provide and support these functions, urban areas have many different static elements such as buildings, infrastructure, green space, abandoned and derelict land, as well as dynamic elements such as transport, water, air, energy and waste.

Buildings and the built environment are the defining elements of the urban environment. They give a town and city its character and landmarks that create a sense of place and identity, and can make towns and cities attractive places where people like to live and work. The quality of the built environment therefore has a strong influence on the quality of the urban environment but this influence is much deeper than purely aesthetic considerations.

Some 80% of Europe’s citizens live in urban areas and it is here that the effects of many environmental problems are felt most strongly. Noise, poor air quality, heavy traffic, neglect of the built environment, poor environmental management and a lack of strategic planning lead to health problems and a lower quality of life. If we want to tackle the major environment-related health problems in Europe, it follows that we have to bring about a marked improvement in the urban environment and quality of life. In many areas citizens are turning their back on their towns and cities, preferring to live on the edges instead because they rightly feel that their well-being is affected by urban pollution. This urban sprawl generates higher levels of traffic and the problems then reinforce each other with the focus of activity being on the periphery rather than on the weakening heart of the city. An ever-increasing number of urban areas show these symptoms of excess strain. It is therefore not surprising that “pollution in towns and cities” is the image Europeans most frequently associate with the environment.

Changing the ways that buildings and the built environment are designed, constructed, renovated and demolished therefore has the potential to make significant improvements in the environmental and economic performance of towns and cities and the quality of life of urban citizens.

1.2. Cities and Buildings – Areas of attention

To be able to achieve the environmental, economic and quality of life improvements so much desired for the towns and cities of Europe, this Focus Area will concentrate on four areas of attention. The following figure shows the interdependency of the four areas.

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1.2.1. Urban Issues

The area of attention on ‘Urban Issues’ covers a range of matters like; land use, territorial planning, development policy, design, lifestyle, participation and governance. This area takes into account the interactions between policy makers, professionals and users and explores the relationship of the built environment to legislation and policies.

1.2.2. Buildings

The area of attention on ‘Buildings’ covers as well new buildings as existing buildings. Attention will be given to the life-cycle of buildings, construction technologies, renovation techniques and service oriented business and systems.

1.2.3. Energy

The area of attention on ‘Energy’ deals with energy efficiency of existing and new buildings (energy systems of buildings and/or small group of buildings). Efficient retrofitting of existing buildings and construction of new very efficient ones are the two main fields. That needs to cover a wide range of matters: technical solutions, industrial organisation, diagnostic and design-optimisation tools, continuous sociology survey, practices dissemination, codes and regulations, PPP and collaborative schemes.

1.2.4. Materials

The area of attention on ‘Materials’, works in close cooperation with the Focus Area on ‘Materials’. Within ‘Cities and Buildings’ a focus on the materials concerning the urban environment is taken, where possible.
2. Background, present situation and challenges

2.1. Urban Issues

2.1.1. Urban Issues - A Working Definition

In order to assure the development of a coherent and well-understood set of objectives in the subject of Urban Issues, the Working Group of the Focus Area has set down a definition that establishes the limits of the subject area. Urban Issues, for cities and urbanised areas, covers a range of matters that include:

- Land use, territorial planning, regeneration and development policy
- Design of urban areas including buildings, streets, underground spaces, external spaces, squares and parks
- The lifestyle needs and requirements of the citizen, which vary depending on factors such as age, social group, ability and economic circumstances
- Participation in the process of making, modifying and maintaining the built environment
- The incubation function of cities for new businesses, technologies, innovation and processes
- The function of cities as repositories of knowledge and learning
- The connectivity of cities - their potential to act as both hubs and networks at one time
- Governance and inclusion at all levels in the process

The definition encompasses all of the interactions between professionals, policy makers and users that result in the formulation and creation of the urban environments in which approximately 80% of EU citizens live. Notably Urban Issues must be considered in relation to legislation and policies currently being defined or implemented at EU, National, Regional or Local level. These include a number of significant items such as:

- The architectural policies of many EU Countries inspired by Council Resolution 2001/C73/04 on architectural quality in urban and rural environments and the follow-up to be given by Ministers of Culture at their meetings under the Luxembourg Presidency
- The EU directive on Strategic Environmental Assessment (of development plans)
- The 7th Framework Programme for Research that is due to be presented to the Parliament in the Spring of 2005
- The Sixth Environmental Action Programme of the EU, which is developing a number of Thematic Strategies, several of which are relevant to Urban Issues. These include the Thematic Strategies on the Urban Environment, on the Sustainable Use of Natural Resources, on Clean Air for Europe and on Waste Prevention and Recycling
- The implementation of the conclusions of the Ministerial Meeting in Rotterdam (November 2004) on the topic of territorial cohesion and urban policy
- The expected outputs from the Inter-group of the European Parliament “Urban Housing” over the life of the current Parliament (2004-2009)
“2010 – Europe Accessible for All” the report of the expert group set up by the European Commission in 2003, the European Year of People with Disabilities

UN Standard Rules on Equalisation of Opportunities for Persons with Disabilities

If we are to provide the urban environments in which our society and culture can flourish in the coming decades, then there are a significant number of challenges that must be faced. These challenges can become the inspiration for the setting of a Strategic Research Agenda (SRA) that should be undertaken in order to deliver the Vision for Urban Issues set out above. That agenda must include technological, policy, sociological, cultural, economical and environmental research themes that are set within an action-oriented perspective.

Crucial to the success of the SRA to be established is the need to break with the path-dependent thinking that currently retards the development of new approaches to these issues. Mechanisms for the widespread and early uptake of the outcomes of the work to be undertaken in this and previous research must be written into project programmes and the means to ensure their transfer to useful implementation must be assured.

This follow-up and monitoring could become a function of the ECTP itself, at a time after the SRA is the implementation phase. It could be an observatory of progress towards the achievement of the Vision 2030 and a catalyst to the uptake of the expected outcomes of the vast array of research projects that will arise from its recommendations. Such a function would ensure that there is one, central location where reliable and validated information can be sourced into the future.

2.1.2. Urban Issues - The Challenges

1. Cities are dynamic entities, constantly changing in physical and perceptual ways. There is a need to further examine and understand the underlying forces that shape them. The challenge is to unravel the inter-linked influences that go into the making, maintenance and management of the city in such a way that future policies and approaches to these issues can intelligently incorporate them and thus ensure a cogent, widely accepted and appropriate future for our cities.

2. Cities encapsulate the aspirations of those who build them and through those actions cities develop an identity. There is a need to understand how the identity of a city is developed and how its inhabitants, its visitors and outsiders, perceive this identity. From this understanding the challenge will be to use this information to form and shape the identity of existing and new cities in such a way that they can capitalise on that identity to the benefit of their citizens.

3. Cities occupy space and they have a significant impact on both the land they occupy and on the land that surrounds them (the hinterland). There is a need to study land use patterns so as to devise sustainable strategies for future land use. Such studies must take account of all major factors including economic, social, environmental and cultural ones. The challenge will be to devise recommendations for future land use that respects each of these factors and that, at the same time, respects the rights of the individual.
4. Cities are made up of buildings, streets, squares, parks and the spaces between them and they are supported by services and transport infrastructures. The inter-relationship, or architecture, of these various elements give character to a city. The quality of this architecture has a fundamental impact on the well-being of those who live and work in cities. There is a need to better understand these interrelationships and the various ways in which their impacts are felt in urban situations. The challenge will then be to integrate the resulting conclusions into development policies, planning decisions and the design of cities and their components.

5. The lifeblood of cities is mobility and transport. It is the nature and design of the built environment that determines the need for mobility and for transport infrastructures. There is a crucial relationship between locations and types of facilities and the means of gaining access to them. For the creation of an all-inclusive urban society such mobility and transport must be easy, reliable, safe, reasonably quick and accessible to all persons and sections of society. There is a need to undertake holistic studies of how these factors operate in current cities and thereby to devise approaches for better systems. The challenge will then be to bring these new approaches into operation in a short timeframe so as to open our cities and their facilities to all.

6. The design of a city has a crucial impact on the realisation of an equitable society. In order to permit all citizens to live in autonomy and therefore to pursue active social and economic lives, the design of cities must ensure safety, accessibility and adaptability. The challenge will be to find ways to make new and existing urban areas accessible and useable for all citizens regardless of ability, social group or age.

7. Cities and urban areas exert a strong pull on people. As centres of economic, social and educational life many people are drawn to move to cities and to establish their lives in an urban environment. Significant migration from surrounding areas and other countries has occurred in recent decades. This phenomenon is set to become, in the EU, more marked in future decades as the demographic profile changes and the demands for skilled workers continues to rise. The challenge will be to devise policies and means by which these new groups can be welcomed and accommodated whilst maintaining social cohesion and prosperity in all urbanised areas.

8. Cities are arguably best known by those who use them. We are all users of cities in one way or another, but not all sections of society are able to express their views about the place in which they live. There is a need to examine this phenomenon and to gain an insight into how to empower all sections of society so that their inputs to the planning, building and maintenance of cities are harnessed. The challenge will be to devise new modes of governance that allows for this widespread, holistic involvement in a manner that will enrich and strengthen the decision making processes, ensuring that they are timely to the achievement of the overall objective of creating the most desirable places to live and work. This will contribute to an overall improvement of the organising capacity of cities, which is necessary in a dynamic multi-actor policy situation that deals with opposing interests.

9. Cities consume resources of all types with noticeable impacts on the environment, on quality of life and on physical infrastructure. There is a need to examine this consumption in detail in order to identify how best to manage and reduce it. The challenge will be to find ways in which cities and urban areas can sit lightly on the earth,
maintaining their vitality and viability without depletion of the resources on which they depend and without cumulative negative effects on the wider environment.

10. The cities of tomorrow are with us today as approximately 80% of the buildings and structures of the future city are already constructed. This presents a major challenge in relation to the aspirations set out in the paragraphs above. It will be essential to ensure that as innovations and breakthroughs come on stream, they are equally applicable to the existing buildings, spaces and infrastructures that make up our cities.

11. The cities of tomorrow will be cities with a large creative class and strong incubation functions for innovation, new small companies and new job opportunities. The challenge will be to find an approach to city design that matches this new situation in terms such as density, mixture of functions and diversity.

12. The outcome of the research work that is being recommended by the European Construction Technology Platform will have to be implemented by people. Many of these people are already employed on the issues raised, but have received their education and training at a time when a clear statement of the challenges to be faced and an agreed vision for the future were not set out. There is a need to develop training courses that will address this lacuna and to ensure that the curricula taught to the future generations of people to be charged with the responsibility of achieving the vision are properly conceived. The challenge will be to win acceptance for these innovative curricula among the schools and professions involved. It will also be necessary to win acceptance for the innovative products, projects and processes that will result from this work among the professionals involved in decision-making, administration, designing, city planning, engineering and construction through conferences, workshops, training courses and demonstration projects.

13. Cities are the centres of excellence of our society in which the universities, schools and research centres are generally based. Their populations are the resources on which progress, in all domains, rests. The challenge will be to ensure that this remains the case and that the means of providing ongoing training and education for all sections of society is maintained during the anticipated period of great change that lies ahead.

14. Cities, through the optimum use of resources and the maximisation of quality of life can act as hubs for the development of new preservation, regeneration and total management models. As such they can accommodate new generation infrastructures and services in both the utilities and communications fields. On the other hand, by networking, cities can stimulate equitable distribution of economic activity and sustainable territorial development aimed at increasing territorial cohesion and regional competitiveness. The challenge is to devise ways in which cities can act as both hubs and networks simultaneously so as to create true economic value, social integration and cultural sustainability.
2.2. Buildings

The quality of the built environment has a major influence on the quality of the urban environment; not only are the buildings and the build environment the ‘face’ of the city, as well are they the mayor energy consumer in a city, use 50% of the resources and produce 25% of the waste. Further the citizen of Europe spends 90% of its time inside buildings and therefore buildings have a major impact on the health of our citizens. Special attention is needed for the existing building stock, where 40% of our citizens live. Sustainable construction of new buildings and built environment and the sustainable renovation of existing ones will improve the environment and quality of life of the European citizen significant.

Important factors within the life-cycle of buildings that require improvement to be able to improve the quality of life of the European citizens are:
− The building process,
− The construction technologies,
− Renovation techniques,
− Business processes and systems.

The building process

The current building process has various characteristics that require improvement:
− The whole process, from design to management, is very fragmented,
− The logistics of the process (during construction phase) are far from optimal,
− The buildings are designed and built for a specific use, there is hardly any flexibility to adapt it to changes in requirements due to a change of use.

Traditionally, the process in which a building is realised is fragmented in clearly separated stages in which a different group of professionals is responsible for a special end-product.

The logistics management of the average work site is done by phone and fax. During the construction phase it is impossible to adapt logistics to changes in the planning. Another important problem is the necessity to move materials around the site due to the lack of space, leading to dangerous situations for the workforce and loss of material due to rough handling.

The automation of processes and management techniques has not kept pace with those of other industries, such as the car industry, where they have been used with all their full potential and efficiency. As far as equipment is concerned, no efforts have been made to develop tools that address their management from start to finish (selection-location-operation control-recording of operation time in the different areas of the site), and suitable to be integrated into a system that manages the other resources too.

Wireless and display technologies are in their infancy. Automated logistics management would benefit in an important way from these technologies.
**Flexibility of the buildings to adapt to the office and dwelling changes** hardly exists. In general housing and offices are built following the requirements of the developer and clients requirements, respectively, offering the final owners/users very little options to adapt their house to their wishes and those of later owners.

**Construction technologies**

The current construction technologies that require improvement are:

− Erection and assembly processes,
− Traditional trades,
− Equipment and materials,
− Resource based processes and products,
− Human Science principles are not included.

The current construction technologies are based on on-site **erection** and the **assembly** of elements that in general require heavy equipment. Both processes often require important quantities of temporary structures. This results in general in lower productivity and quality of the building and increased risks for the workforce on-site.

Current construction technologies still rely in a great content on **traditional trades**. This leads to variety in quality, longer critical paths in the process, increased production of waste and increased risks for the tradesman.

As indicated before in the part on assembly, often heavy **equipment** is needed for the assembly of the few (often heavy) **materials** that are fabricated of-site and for the erection on site. The costs and energy use of this equipment together with the risk of having it together with the workforce on the same building site are important drawbacks of their use.

The current construction technologies are **resources based** in stead of knowledge based. In general the knowledge available within a company is hardly shared and new technologies hardly find their way to the construction site.

**Human science principles** are hardly present in current construction technologies, where end-user participation in the design and feedback from these end-users are practically non-existing.

**Renovation techniques**

To be able to come to renovation techniques that convert existing buildings again in buildings that meet the (changing) requirements of their end-users, the following needs improvement:

− Management of existing buildings,
− Design tools,
− Materials and technologies for renovation,

The current **management of existing buildings** does not have diagnosis methods, quality basis for the diagnosis and procedures that are sufficient to come to a high quality renovation.
There are hardly any specialised design tools available that can assist engineers and architects in the renovation of existing building and especially our cultural heritage.

The current materials and technologies for renovation are still quite limited. They are often intrusive, require considerable business interruption and ignore the benefits of the existing building.

**Business processes and systems**

To provide its clients with a better service, the construction sector has to improve its:

− Customer and supplier networks,
− Business models.

To be able to deal with the increasing number of tasks within construction services, the construction sector has to improve the functioning of its customer and supplier networks.

The construction sector is more and more involved in providing service to its clients during the whole life-cycle of the facilities it builds, this requires new business models.
2.3. Energy

Energy is not “visible”, but everybody knows that it provides vital services and well-being ones, especially in buildings. European way of life is not achievable without energy. On another hand, energy consumption have deep impacts on environment and European economy. It is the reason why European policy includes a large chapter about energy.

Two main concerns dominate political thinking on European energy policy:

− reducing Europe’s reliance on imported energy,
− reducing GHG (Green House Gas) emissions in order to reduce global warming and the damaging economic and ecological consequences that it implies.

Reduction by 4 of CO2 emissions of European countries by 2050 is one of the strongest challenges of European energy policy.

European buildings are deeply affected by these two main objectives:

− they represent the first (40%) final energy consumer sector of European Union (E.U. 15, fig.1),
− households and services are the third largest source of CO2 emissions in EU-15 if electric power generation is not included (Electric Power : 31%, Transport : 29%, Buildings : 18% in 2001). It becomes the first emitter if electricity is included in final sectors (fig. 2 : buildings : 36%, industry : 33%, transport : 27% in 2001).

In today’s context, the embodied energy in construction materials and components is still much (about 10 times) smaller than the energy use during operation of the building over its lifetime. Life-cycle analysis shows that 80% of a building energy consumption (close rate for CO2 emissions) is achieved during its service life (only 20% for materials, construction and demolition). Priority is given to energy savings in new and existing buildings during their lifetime.

![Fig. 1: Building sector is the largest energy consumer in the E.U.15 (ADEME)](image-url)
In order to achieve these two main targets, building sector have to win two challenges before mid-century:

− **reduce drastically energy consumption of buildings** (existing and new ones),
− **reduce CO2 content of energy consumed in buildings**.

Buildings of tomorrow have to be high energy efficient buildings able to became “renewable and net CO2-free energy” providers”.

![Graph showing CO2 emissions in EU-15](image)

**Fig. 2: CO2 emissions in EU-15 (Buildings = Households and services) with electricity related emissions allocated to end-use sectors (IDDRI)**
Understanding which R&D actions have to be driven in order to beat these challenges, some specificities of European buildings have to be pointed:

- European building stock keeps slowly increasing (about 1%/year for dwellings, and a little bit higher for services buildings, about 1.5%/year).
- Renewal of building stock is even slower. More than 2/3 of 2030 European building stock is existing today.
- European building stock is aged. About 2/3 of residential buildings were built before 1971, before first oil shock and without any energy efficiency codes (fig. 3).
- “average energy performance” of European building stock is poor: energy consumption of existing buildings is about twice more than new ones, and very much higher than “passive” or “low energy” buildings (fig. 4).

![Fig. 3: Composition of European dwelling stock (EU 15) (Eurostat - 2001)](image)

![Fig. 4: Difference of energy demand between existing and new buildings in Germany and Sweden (European project Cepheus - 1999)](image)

In 2050, and in a “Business As Usual way”, this part of the stock is still important with more than 50% of the total. Existing dwellings of today are 75% of dwelling stock of 2050. Only 25% of the 2050 stock is built between 2000 and 2050.
This situation leads us to conclude that:

- Targets for energy savings can be higher in new buildings. It is technically possible to drastically decrease energy consumption of new buildings and make them very “low energy consumer” and “CO2-free energy providers”. This solution is not yet affordable. This point have to be improved in order to promote largely this solution. Energy policies have to help this goal.

- but it is also obvious that very efficient new buildings are not a sufficient solution in order to really decrease energy consumption and GHG emissions of the sector by 2030. Retrofitting of existing buildings with high rates of energy efficiency is another key solution that cannot be ignored (fig. 5). Some technical solutions are existing, but possibilities are poorer compared to new buildings. Some specific solutions, adapted to existing buildings have to be developed. Existing techniques have to be inventoried and implemented.

![Fig. 5: Total energy consumption of french dwellings (space heating - main houses) from 2000 to 2050 with 4 scenarios](CNRS - 2004)

Fig. 5 shows that in France, even with all new dwellings built from 2000 to 2050 completely self sufficient regarding energy consumption for space heating, total energy consumption for space heating of dwellings would only be decreasing of 13% by 2050, compared to a “BAU way” (Business As Usual) action plan on new dwellings. Very efficient new buildings and high rates of retrofitting (possibly 2% of stock every year, so, largely higher rates than BAU) are necessary to decrease drastically (50%) total consumption by 2050.

Very high amounts of energy savings are technically achievable if it possible to detect which buildings have to be retrofitted (buildings characteristics) and take benefit in retrofitting actions (diagnosis tools). Main economies relay on space heating. It is technically possible to divide by 2 this part of dwellings energy consumption with thermal insulation actions and replacement of heating systems with heat pumps and efficient boilers. Nevertheless retrofitting of existing buildings with high standards of energy efficiency is much more difficult than design and building of new ones with same high standards level. Some technical solutions are existing but are not adapted to all kinds of buildings. They have to be cheaper than today in order to have a large diffusion. Innovative technical solutions, specific to existing buildings, have to be developed.
Same conclusion for “CO2-free energy production from existing buildings”: it is not always possible to integrate solar panels (problems of roof and efficiency regarding roof orientation); and the use of biomass at large scale with CHP systems is not likely to be able to cover all the needs.

It is not possible to succeed without breaks. Innovations in various fields (not only technical ones) are needed to adapt high efficient solutions to existing buildings and to develop construction of efficient and affordable new building on a large scale.

Ambitious targets have to be proposed to solve the problem:
– 50% decrease in energy consumption and CO2 emissions from new buildings by 2015,
– 50% decrease of existing buildings by 2030.

Targets like these provide opportunities for innovation, adapted energy policies have to support them.

**Europe has therefore to address two main research fields:**
- retrofitting of existing buildings with low energy consumption able to produce net CO2-free energy.
- designing and building of affordable new energy efficient buildings (very low energy consumption) able to produce net CO2-free energy from renewable resources, with the target of self sufficient buildings and net CO2-free energy producers.

These two targets seem similar, but problems and solutions are not always the same and need different programs:
- many technical solutions already exist for new efficient buildings. Difficulties are more about affordability of such buildings and construction organizations able to implement efficiently a large amount of these new concepts. On the other hand, human behaviour in very efficient buildings and impact on health are not very well known.
- for existing buildings, situation is different: technical possibilities are poorer, most have to be invented, ways to retrofit with low intrusive activities need innovations. Affordability problems are very important, social demand and acceptance of very efficient buildings are not very well known.

Ambitious research programs are needed, but expected benefits does not only concern energy aspects. Improvement of services provided by buildings to occupants are expected (thermal comfort and reliability, reduced health problems, better convenience, value, and aesthetics).

The European building sector must have the ambition to become a leader in design, construction and retrofitting of high efficient energy buildings. The proposed research program gives knowledge weapons in order to achieve this challenge.
2.4. Materials

For any kind of construction building materials are needed. The total amount of materials required for construction purposes in Europe exceeds 2 billion tonnes per year, making it the largest raw material consuming industry. The materials form an essential part of the buildings and cities we live and work in. Materials, and their combinations, create the aesthetic expression, provide structural strength and durability to buildings and cities, and participate to the eco-efficiency of each building.

Construction materials have an important role to play in a sustainable development through their energy performance and durability, as this determines the energy demand of buildings through the lifetime. By developing the use of materials and their combinations, significant improvements of the environment and quality of life can be achieved. Together with the energy and the raw materials used during their manufacturing it becomes obvious that the production of building materials has a significant environmental impact due to the sheer quantities involved. Decreasing waste and recycling is also certainly an important item.

In the present situation, only a small part of buildings and building components are industrialised in plants. Most of the integration work is done on site, with all consequences on all the impacts mentioned before. Development of new materials and improvement of traditional materials is one of the key aspects to achieve new developments in the construction sector.

A wide variety of materials are used in buildings and cities: cement, ceramics, concrete, composites, glass, gypsum, insulation materials, natural stone, polymers, steel, wood...

All material are different but they require improvements to be able to give an answer to the challenges of tomorrow:
- Production of building materials
- Application of building materials
- Use phase
- Demolition, re-use & recycling
- New advanced functionalities

**Production of building materials**

The production process of most building materials requires high amounts of energy and, together with that, gives rise to CO2 and other emissions. The reduction of raw material consumption, energy demand and emissions in the production of building materials is thus of primary importance. Simultaneously, the product performance and economic efficiency of the production process needs to be improved.

Even slight progress in production processes means significant steps in improving environmental impact. There is a big potential for further enhancing the environmentally beneficial properties of many innovations envisaged over the coming years stem from a very strong focus on even lower production costs coupled with product and system innovations, so creating greater value for our customers in the construction sector. New processes will be required that offer greater integration and flexibility than existing methods. Process lines that are more compact with short response times and extended capability are currently being
investigated. The new EU REACH regulation is also considered to have an impact on the innovation in the production of building materials.

Innovations are also foreseen in the preparation of a site for building. When succeeding in adapting the properties of the local soil, and to fit them with the requirements of the construction, then no removal of soil and replenishment with other material is needed. Recent advances in nano-technology, bio-technology, modelling, analytical techniques and other technologies have shown the potential of creating such a breakthrough.

Strengthening a close cooperation between the equipment supplier industry and the materials producers presents also an opportunity of maintaining and further developing Europe's leading role in the production technology of building materials.

**Application of building materials**

Many of the traditional building materials currently used are not optimal in terms of applicability in that specific design, manufacturing, installation, and recycling criteria limit the wider use of these materials. Efficiency of the construction process is of major concern to the industry. Indeed significant improvements in this area are necessary before many new, innovative technologies can be taken up and implemented within construction in a cost effective way. One of the root causes for not fully exploiting the potential of building materials is that the design process is not focused enough on such aspects as multiple use, ease of use, ergonomics, safety, and the dismantling or demolition processes. Standards and building codes in many cases hamper innovation and the introduction of new materials and construction processes. A change towards a performance-based concept is expected to overcome these barriers.

New materials developed should simplify application and use in such a way that they simplify the life of the end user who will live, work and travel in buildings made with such materials.

**Use phase**

Many challenges are still to be faced to optimise the structural performances, the cost effectiveness, the aesthetic function, the resource efficiency, the health, hygiene and safety in the use phase.

**Demolition, re-use & recycling**

The amount of construction and demolition waste (C&DW) is of great importance. It is estimated that roughly 180 million tonnes C&DW are produced annually in Europe according to the European Commission.

Increased knowledge on materials properties in regard to re-use and recycling of building materials is needed to facilitate the development of decision systems regarding materials choice and new systems for waste recycling, including required technology and logistic systems. The ultimate final goal will be a closed-loop system valorising the materials at maximum value.
**New advanced functionalities**

Materials for construction are usually considered and classified as having traditional functionalities (structural, covering, etc.) and, as a consequence, they are used by builders only in a traditional way.

The possibility of having materials with new and improved functionalities opens up new opportunities in the way constructions are conceived from the design stage up to the final use.

Successful technological solutions have to be sought increasingly further upstream in the design and production processes; new materials and **nano-technologies** have a crucial role to play as drivers of innovation.
3. Cities and Building 2030: A vision for the Future of the Cities and Buildings of Europe

3.1. The overall vision for Cities and Buildings

The overall vision for the future of the Cities and Buildings of Europe is:

| Cities are the most desirable places to live in |

3.2. The main areas of attention of the Focus Area Cities and Buildings

4 Main areas of attention have been identified:

1. Urban Issues,
2. Buildings,
3. Energy,

3.3. Partial visions

A companion document describes with more detail the response proposed by the Focus Area Cities and Buildings: European Construction Technology Platform - Focus Area 1: Cities and Buildings of the European Union.

The 4 areas of attention have defined the following visions:

| Urban Issues |
| Cities are the Most Desirable Places to Live |

| Buildings |
| The buildings of Europe are healthy, safe, attractive and accessible places to live and work in, built and maintained in a sustainable and smart way, through new forms of alliances between the end-users and the construction industry in its broadest sense |

| Energy |
| Ambitious retrofitting programs and construction of new very efficient buildings allowed drastic reduction of energy consumption of buildings and urban areas. New concepts of buildings make them able to supply their remaining energy needs by producing renewable energies. Cities are designed in such a way as to reduce energy demand of their buildings |

| Materials |
| Materials and construction technologies will change, through research and through the adoption of new concepts from other sectors, in order to provide buildings and cities that meet users’ and society’s needs better. |
4. Strategic Research Priorities

<table>
<thead>
<tr>
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| Table 1 List of Strategic Research Priorities |
4.1. Cities are developed through sustainable urban policies that ensure the holistic development with significant involvement of citizens in decision-making

New understanding of the city as a system and a systematic adoption of holistic approaches together with mechanisms for engagement with all actors and dealing with different interests to build consensus lead to cities as the most desirable place to live and work.

4.1.1. Introduction

The area of attention on ‘Urban Issues’ covers a range of matters like; land use, territorial planning, development policy, design, lifestyle, participation and governance. It encompasses all of the interactions between professionals, policy makers and users that result in the formulation and creation of the urban environments in which approximately 80% of EU citizens live. Notably Urban Issues must be considered in relation to legislation and policies currently being defined or implemented at EU, National, Regional or Local level.

If we are to provide the urban environments in which our society and culture can flourish in the coming decades, then there are a significant number of challenges that must be faced. Crucial to the success of the SRA to be established is the need to break with the path-dependent thinking that currently retards the development of new approaches to these issues. Mechanisms for the widespread and early uptake of the outcomes of the work to be undertaken in this and previous research must be written into project programmes and the means to ensure their transfer to useful implementation must be assured.

4.1.2. Research Areas

For this priority the following areas have to be researched:

For the Nearby Future:

1. Mechanisms for Engagement with all Actors
   a. What is the state of the art - what models for participation exist?
   b. How can e-governance improve participation? What type of knowledge infrastructure is needed to guarantee equal access to knowledge resources?
   c. How have projects benefited through participation?
   d. How can new approaches be devised that better match the evolution of society?
   e. How can we integrate the actions of professionals at all stages (decision-making, city planning, design, building, maintenance) and at all levels (European, National, Regional and Local)?
   f. How can we bring together various disciplines (roads, utilities, street furniture, green space planning etc.) into integral design and management of public space?
2. Designing Cities Accessible and Useable for All Regardless of Age, Ability or Social Group
   a. What strategies should be used to achieve a city designed for all?
   b. How can the process towards a society for all be accelerated?
   c. How should a city, accessible and useable for all be designed?
   d. How can urban issues, infrastructure and the design of dwellings support the possibility for the ageing population to live an independent life for as long as possible?

3. Policy Development to Ensure that Capacities are Harnessed and Organised
   a. How is land use policy affected by ownership and tenure?
   b. What models of tenure exist and what are the effects of each on spatial planning?
   c. How can path dependency and “lock-in” in planning and policy making be recognised at an early stage and prevented?
   d. How do we best organise capacities so as to achieve development objectives?
   e. How can a holistic approach to service provision ensure a high level of quality for the elderly and (other) minorities?
   f. How can urban research inform policy decisions?
   g. How to evaluate existing policy choices – what is the role of indicators and benchmarking?

   a. What attracts people to cities and why do they stay? How can cities invest in their attraction capacity and what implications does this have for the private citizen and the business sector?
   b. What is the role of attractiveness within the context of competition with other cities in the EU and worldwide?
   c. How is a city provided with its needs – food, materials and energy?
   d. How are the cycles managed? How should they be managed? How can they be better managed?
   e. How can sustainable urban design reduce the city energy consumption (buildings, transport, ...)?
   f. How can sustainable urban design support the process of regeneration of old industrial urban areas and infrastructure?
   g. What is the role of sustainable mobility in improving the quality of the urban environment?
   h. How can green and social public procurement criteria improve the competitiveness of the industry sector?

For the Future:

5. Path Dependency in Planning Policy and new Models to Address Urban Sprawl
   a. To what extent are new planning policies based on historical models?
   b. To what extent do the problems of the moment hinder the development of innovative approaches to integrated urban planning?
   c. Which models of urban sprawl contribute most to a sustainable and creative city for all? What densities, functional mixes and architecture are used in successful models?
   d. What is the functional and policy relationship between the parent city and its suburbs and other nearby towns?
6. Governance Models – their Successes and Failures
   a. What are the existing Governance models that are applied across the cities of the EU?
   b. To what extent can the quality of policy development be linked to governance?
   c. What are the emerging models of governance that hold the most promise for the future?

7. State of the Art Techniques and Their Applicability
   a. How can the state of the art in research and new developments into urban issues be uncovered and disseminated?
   b. What are the techniques and technologies that need to be harnessed for use in the achievement of the Vision 2030 in Urban Issues?
   c. How can such techniques be applied to Urban Issues?

8. Barriers to the Uptake and Transfer of Knowledge and Research Outputs
   a. Why do research results remain on the shelf?
   b. What forms of demonstration projects, exchange meetings between professionals, data storage, drawing on the results of research, are most appropriate for encouraging and facilitating the dissemination of results to all actors in the chain?
   c. How should research projects be structured in order to ensure quick adoption of results?
   d. What are the essential characteristics of action-oriented research?
   e. How can the availability and exchange of data improve the performance of city administrations and the private sector?

9. Territorial Regeneration and Cohesion
   a. How can territorial infrastructures and services be optimised?
   b. How can city complementarities, within territories and regions, be articulated and harnessed?
   c. Is it possible to develop 3-d geographical information systems (GIS) in order to improve public management, private investments, citizen’s integration and participation?

For the Far Future:

10. Integration Techniques for Technological, Process and Governance Innovations
    a. How can the various divergent aspects of research be brought together to form truly holistic approaches to the creation and maintenance of our cities and urban areas?

4.1.3. Key Performance Indicators and Targets for 2030

The key performance indicators to be used will be the same one as published in the Urban Audit².

² http://www.urbanaudit.org/
4.2. New business processes for healthy, safe, attractive and accessible buildings for all

Buildings built and maintained in a sustainable and smart way, through new forms of alliances between the end-users and the construction industry in its broadest sense.

4.2.1. Introduction

The quality of the built environment has a major influence on the quality of the urban environment; not only are the buildings and the build environment the ‘face’ of the city, as well are they the mayor energy consumer in a city, use 50% of the resources and produce 25% of the waste. Further the citizen of Europe spends 90% of its time inside buildings and therefore buildings have a major impact on the health of our citizens. Special attention is needed for the existing building stock, where 40% of our citizens live. Sustainable construction of new buildings and built environment and the sustainable renovation of existing ones will improve the environment and quality of life of the European citizen significant.

4.2.2. Research Areas

To be able to build and maintain the buildings of Europe in a sustainable and smart way and make them healthy, safe, attractive and accessible places, it is necessary to act on:

For the Nearby Future:

1. Integrated life-cycle process for buildings
   a. New logistics management systems. The research in this area should focus on a fully integrated (visual 4D) logistics management system, integrating the management and control of resources into an evolutionary environment such as the construction site areas, using automatic and real-time techniques to dynamically optimise the production process. Research in the following areas is needed:
      i. Application of (RFID-)tags in the whole life-cycle of materials/components
      ii. Develop progress monitoring with a graphic display on an integrated site monitor. It could show the model of the work being completed.
      iii. The resource management optimisation process in a holistic manner
      iv. To study the introduction of materials management systems in environments so different to that of an ordinary warehouse, such as those found in construction sites.
      v. To study the extension of material control and management techniques to non-discrete items.
2. Construction technologies
   a. Erection and assembly processes. The lifespan, performance, flexibility, and cost-effectiveness of future capital facilities will be greatly enhanced by enable rapid, high-quality erection, using:
      i. New, lightweight, high-strength and high-performance components,
      ii. Innovative assembly and joining methods applied by new generations of automated, smart tools, equipment and systems.
   b. Industrial production to replace traditional trades,
   c. Lighter equipment and materials,
   d. New models based on Human Science principles. The goal of human engineering is to optimize systems performance by taking human physical and cognitive capabilities and limitations into consideration during all life-cycle building. Themes of the workspace design to be studied are:
      i. Sustainability,
      ii. flexibility,
      iii. usability, and
      iv. participation and empowerment

3. Low-intrusive renovation techniques with minor impact on public, directed to groups with special needs
   a. Management of existing buildings,
      i. diagnosis methods,
      ii. quality basis for the diagnosis,
      iii. procedures that are sufficient to come to a high quality,
   b. Design tools,
   c. Materials and technologies for renovation,
      i. not intrusive,
      ii. no considerable business interruption,
      iii. take advantage of the benefits of the existing building,
      iv. reversible,
      v. less disruptive,
      vi. implemented without the need for heavy equipments,

For the Future:

4. Service oriented business and systems: from “design for the customer” to “design by the customer”
   a. Change in business models
      i. Information and communication technology will make it possible to develop new products and service concepts for the entire life span of the real estate and for its various functions.
      ii. Overall solutions that take account of the needs of various users are developed by combining cross-technological collaboration and competence with business models of new value networks.
      iii. Workplaces, homes and hotels constitute a service platform where innovative combination of new technology with the working and living environment and infrastructure creates new service markets.
      iv. New Business models based on long term contractor-supplier alliances.
5. Integrated life-cycle process for buildings
   a. An integration of the processes of design, planning, procurement, construction management and management during use. Accurate and flexible simulation tools for the construction process, in all its dimensions, are central to solving the problem of performance of the constructed facility over the entire life cycle. To be able to create a truly integrated and automated life-cycle process environment for buildings, the following items have to be part of the research agenda:
      i. Current and emerging capabilities in 3-D design,
      ii. Analytical modelling and simulation,
      iii. Intelligent systems,
      iv. Distributed information management,
      v. Virtual reality and related technologies.
      vi. Procurement methods which allow contractors to be involved earlier in the process,
      vii. Lean manufacturing,
      viii. Demand-based product pull.

6. Construction technologies
   a. Knowledge based construction processes and products. In order to improve constructability, knowledge-based systems to incorporate construction knowledge into the design process are needed. These knowledge-based systems require research in:
      i. Knowledge management tools,
      ii. Management of the workforce.

For the Far Future:

7. Integrated life-cycle process for buildings
   a. Flexibility of buildings. We must emphasize eliminating unintentional barriers and employing designs and features usable by persons with a broad range of needs. Universal design increases accessibility for persons with physical limitations and provides flexibility necessary to add features if desired at a later date. This flexibility can increase a home's marketability, particularly to elderly persons and those with physical limitations. To decrease the costs associated with future changes in building use:
      i. Facile removal of building systems, e.g., partitions, has to be addressed so that alternative use can be accommodated,
      ii. Building interiors, furnishings, and ventilation systems have to be made more modular and flexible,
      iii. Design features that facilitate the installation and re-configuration of communications wiring have to be developed.

8. Construction technologies
   a. Radically advanced construction concepts. Breakthrough technologies that support the ultimate vision of entirely self-constructing facilities and structures should be developed, such as:
      i. Programmable nano-materials and nanoconstructors
      ii. Biomimetic materials, structures and facility systems
9. Service oriented business and systems: from “design for the customer” to “design by the customer”

   a. New managing relationships to establish world-class customer and supplier networks,
      i. Virtual 4D design/construction programmes allow participation of end-users, government bodies, etc. integrating efficiently knowledge demand and supply networks.
      ii. Increasingly, construction services include financial deal structuring, planning and design, supply-chain coordination and risk management, as well as the management of coalitions of interests concerned with project operations, including legal, environmental and regulatory authorities.
      iii. Working from a Computer Supported Cooperative Work (CSCW) perspective means to get to know the users, as well how the users interact and are organised.

4.2.3. Key Performance Indicators and Targets for 2030

<table>
<thead>
<tr>
<th>Key Performance Indicator</th>
<th>Target 2030</th>
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<tbody>
<tr>
<td>Delivery time of new buildings</td>
<td>Reduction of 80%</td>
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<tr>
<td>Life Cycle Costs of new buildings</td>
<td>Reduction of 75%</td>
</tr>
<tr>
<td>Functional life time of buildings</td>
<td>200 years</td>
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<tr>
<td>Renovation techniques existing buildings</td>
<td>60% low – or non-intrusive</td>
</tr>
<tr>
<td>Businesses and systems</td>
<td>50% “design by the customer”</td>
</tr>
<tr>
<td>Accessibility of buildings</td>
<td>Access for all</td>
</tr>
<tr>
<td>Self construction</td>
<td>Nano – and biometric technologies completely developed</td>
</tr>
</tbody>
</table>
4.3. Highly efficient energy buildings and urban areas

Drastic reduction of energy consumption of existing built environment through retrofitting, construction of new buildings respecting energy-efficient principles, integration of renewable energy technologies in the built environment.

4.3.1. Introduction

Energy consumption of urban areas and buildings must be drastically reduced. First requirement is to develop a new generation of “high efficient buildings” (reduced energy demand and net CO2 free energy producers). But the existing stock has a long lifetime, and solutions for retrofitting of existing buildings are lacking regarding solutions for new ones: it is even more necessary to upgrade to high level the existing built environment to comply with Kyoto’s protocol.

In today’s context, life-cycle analysis show that 80% of a building energy consumption (close rate for CO2 emissions) is achieved during its service life (only 20% for materials, construction and demolition). The priority is to reduce energy consumption of buildings during their lifetime.

4.3.2. Research Areas

Technical innovations are necessary - but not sufficient - to reach proposed vision. Consequently, research areas are defined for efficient existing and new buildings regarding 4 items: tools, technical solutions, economy and building sector organization, social sciences.

For the Nearby Future:

1. Existing buildings: identification of existing solutions for building renovation:
   a. Specific design tools:
      i. Categorise various existing European buildings according to their ability to be retrofitted (function, structure, materials used in their construction, geographic location (incl. solar gain));
      ii. Map existing technical solutions and classification from simplest to most sophisticated to implement;
   b. Incorporate efficient technologies into retrofitted buildings:
      i. Advanced insulation products and windows adapted to retrofitting specifications,
      ii. Efficient and renewable energy equipments integrated in existing buildings: compact/integrated HVAC (dedicated ventilation systems including heat recovery, specific heat pumps (i.e. small geothermal heat pumps)), biomass heating, combined photovoltaic/ solar thermal panels and collectors, more efficient boilers,

Solutions have to be developed and implemented without health impact for inhabitants (moulds, moisture).
2. **Existing buildings**: development of products specific to retrofitting market:
   
a. Specific design tools:
   i. Adapt design tools to retrofitting contexts;
   ii. Perform multi-criteria analysis for optimised choices (promote energy efficiency and exergy optimisations model codes);

b. Incorporate efficient technologies into retrofitted buildings:
   i. Adapted ventilation systems (i.e ventilation units including small exhaust air heat pumps),
   ii. Development of retrofitting actions that minimize disruption to the occupiers of buildings (see social sciences),

Solutions have to be developed and implemented without health impact for inhabitants (moulds, moisture).

3. **New buildings**: First demonstrations of feasibility of concept are achieved for new buildings (60% reduction compared to 2005 new buildings, major part covered with CO2 free emissions energies).
   
a. Tools for design:
   i. Continuous mapping of existing solutions in European countries, analysis of best practices, and study of ways to adapt to specific contexts,
   ii. Adapted guidelines for specific national situations,
   iii. ICT tools for bio-climatic design,

b. Technical solutions for new efficient buildings:
   i. High efficient materials for advanced thermal insulation techniques (high resistance of insulation, phase changes, heat storage, variable level of insulation),
   ii. High efficient air heating and cooling systems: heat pumps, integrated heat exchangers,
   iii. High efficient ventilation systems including heat recovering and avoiding health impacts,
   iv. Renewable energy production implemented during construction.

Compatibility of these solutions with inhabitants health have to studied: solutions have to be developed and implemented without health impact for inhabitants (high insulation levels, controlled air renewal, new insulation materials).

4. **Economy and building sector business**:
   
a. Analysis of the economic and structural barriers for the development of a cost-effective and eco-efficient built environment,

b. Cost reduction and financial solutions for new “low energy consumption buildings” and “energy self sufficient buildings”: 2010: over cost less than 15%,

c. Development of data bases proposing typical solutions for a large variety of refurbishment situations at all levels, small work or overall renovation,

d. Identification and organisation of technical transfers from western countries to new members states and candidate countries,
e. Take account experience and various situations of European countries by developing an ambitious pan-European vision:
   i. to develop synergy between national plans, codes and regulations, begin a convergence,
   ii. and adapt methods to national contexts of all EU member states in order to reach high standards of energy efficiency in various situations,
   iii. to accelerate technologies, best practices dissemination, and changes in building industry in a large variety of cultures and situations.

5. Social sciences:
   a. Identify retrofitting situations and decision making which could include energy efficiency improvement,
   b. Analyse social demand and compatibility for very efficient buildings,
   c. Understand keys of success in order to lower disturbance caused by retrofitting actions, simultaneously develop campaigns that explain why intrusive retrofitting actions are needed.

For the future:

6. Existing buildings: 30% of existing buildings are renovated with high standards of energy efficiency. Average decrease of consumption is about 50%:
   a. Specific design tools:
      i. Bring out adapted guidelines for specific buildings situations.
      ii. Optimise interfaces between buildings and local energy production:
         − sizing of renewable energy production components able to be integrated during retrofitting operation (PV, solar thermal, biomass),
         − sizing of efficient distributed energy production systems regarding building energy load and demand after retrofitting (micro-CHP: Stirling engines, fuel cells).
   b. Incorporate efficient technologies into retrofitted buildings:
      i. energy production (especially renewable ones) included in existing buildings and adapted to retrofitting actions,
      ii. energy management at building scale (ICT) using general public communication infrastructure (mass audiovisual and computer equipments).

7. New buildings: New concepts for new high efficient buildings are affordable and they represent a significant part of this market.
   a. Tools for design:
      i. Multi-criteria analysis for optimised design based on Energy Efficiency and Exergy optimisations model codes,
      ii. Interfaces between buildings design and local net CO2-free energy production:
         − sizing of renewable energy production components integrated to the building regarding the building and energy load,
         − sizing of distributed energy production systems regarding each king of building (load and demand).
      iii. ICT based design of local energy management systems.
b. Technical solutions for construction of new efficient buildings:
   i. Pre-designed, modular multi-functional building components that combine a building function (are part of the wall, roof, foundations, windows...) with an energy function (thermal (variable) insulation, heat storage, energy production (heat, and electricity)),
   ii. Specific solutions for space heating with very low energy demand (high performance of thermal insulation),
   iii. Low energy supply systems that match the low energy buildings based on individual or central systems.
   iv. Energy management of space heating with low load,
   v. Energy management at building scale (ICT) using general public communication infrastructure (mass audiovisual and computer equipments),
   vi. Energy supply to buildings for heating purposes to be based on use of non-fossil energies i.e. energy from incineration plants, waste heat from industrial processes and conversion of energy, solar thermal plants and geothermal plants,

8. Economy and building sector business:
   a. Cost reduction and financial solutions for new “low energy consumption buildings” and “energy self sufficient buildings”: 2020: less than 5% over-costs,
   b. Analysis of savings in resources, pollution reduction, effects on security of energy efficient buildings and their energy supply,
   c. Industrialisation of construction (manufactured envelope components),
   d. Promotion of PPP and cooperative schemes in a local context, including various forms of ESCOs (Energy Service COmpanies) services.
   e. Innovations in industrial organisations in order to be able to retrofit larger amount of existing buildings per year,
   f. New business models and collaborative schemes between majors and SMEs,
   g. Identify and organise technical transfers from EU-15 countries to the New Members States and Candidate Countries.
   h. Cost reduction of adapted solutions and financial solutions for implementation of these solutions even in poorest contexts,
   i. Support should be given to legislations that encourage energy savings goals:
      i. stronger legislation for CO2 emissions decrease in building sector,
      ii. products and equipments must respect minimum standards of energy efficiency,
      iii. retrofitting actions have to be framed and public helps have to be submitted to minimum level of energy efficiency goals and quality of actions,
      iv. appliances and multi media equipments have to give information when selling (energy consumption, electricity leaks) and respect minimum standards of energy efficiency and clearly indicate their energy consumption.
9. **Social sciences:**
   a. understand keys of success in order to lower disturbance of retrofitting actions,
   b. organize a continuous sociology survey and adequate communication help managing acceptance of energy efficient solutions,
   c. study rebound effects (relaxed attention of users) in order to adverse it.
   d. Analysis of breaks for acceptance of very efficient buildings,
   e. Analysis of acceptability and time scales for construction firms, including craftsmen, appropriation on new technologies.

**For the fare future:**

10. **New buildings:** Major part of new buildings in the EC have nearly zero CO2 emissions.
   a. Technical solutions:
      i. Solutions for maintaining indoor comfort during the summer (solutions for drastic reduction of heating energy demand could generate health and summer comfort problems),
      ii. Energy supply systems that have high flexibility with respect to the overall energy system due to distribution and storage possibilities.
   b. Economy: Cost reduction and financial solutions for new “low energy consumption buildings” and “energy self sufficient buildings”: 2030: no over cost compared to today.

11. **Existing buildings:** 100% of 2005 building stock are retrofitted.
   a. Technical solutions:
      i. thermal (heat/cold) and electricity storage units embodied in the building envelope and foundations,
      ii. efficient systems for summer indoor comfort in renovated buildings,
   b. Economy: industrialisation of retrofitting business.

At every time scale, 2 points have to be included:

1. **Education and training, dissemination are a key factor:**
   a. video-games-like soft-wares and low cost internet services help developing better information, better education and training of professionals and users,
   b. to build on ICT for virtual performance evaluation of projects, of new materials and equipments, and develop large share of best practices for new and existing buildings,
   c. to develop integrated, compatible, plug and play soft-wares largely used by professionals, including small craft-men firms.
2. **Forecasting and road mapping are necessary:**
   a. Acceptability of constraining life habits have to be evaluated;
   b. Realistic time scales for large implementation of advanced and rapidly changing new technologies by building community, including craftsmen firms, have to be evaluated;
   c. Efficient training practices need to be tested and planed;
   d. Financial scenarios have to be built, tested and implemented,
   e. Codes and regulations improving energy efficiency for new and existing buildings have to be implemented with adapted speeds to specific contexts,
   f. Technical solutions have not same level of technical feasibility and affordability; scenarios have to be developed and evaluated;
   g. Different levels of energy efficiency have to be proposed for various kinds of buildings,

4.3.3. **Key Performance Indicators and Targets for 2030**

Proposed vision is not reachable without breaks. Ambitious targets have to be proposed in order to promote research programs on these necessary breaks.

Key performance indicators:

- By 2010, first demonstrations of feasibility of concept are achieved for new buildings (60% reduction compared to 2005 new buildings, major part covered with CO2 free emissions energies). Existing solutions for building renovation are identified and development of products specific to retrofitting market begins.
- By 2020, 30% of existing buildings are renovated with high standards of energy efficiency. Average decrease of consumption is about 50%. New concepts for new high efficient buildings are affordable and they represent a significant part of this market.
- By 2050, major part of new buildings in the EC has nearly zero CO2 emissions (new buildings production of renewable energies is able to cover the main part of their energy demand). 100% of 2005 building stock are retrofitted. Decrease of sector energy consumption is about 50%, decrease of sector CO2 emissions is about 75%. Most of energy consumption of buildings are CO2 free and major part of it is produced by buildings themselves.

Targets for 2030:

- 50% decrease in energy consumption and CO2 emissions from new buildings by 2015,
- new buildings without use of fossil fuels in 2030,
- 50% decrease of existing buildings by 2030.

Targets like these provide opportunities for innovation, adapted energy policies have to support them.
4.4. Changed materials and construction technologies in order to provide buildings and cities that meet users’ and society’s needs better

New technologies and knowledge-based materials ready for tomorrow’s needs of the buildings and cities.

4.4.1. Introduction

In the present chapter the strategic research agenda is presented in seven different themes. The research areas are to a large extent general and valid for all building materials. However, attention has to be paid to the fact that the situation/relevance for the various aspects might differ from material to material and so do the research needs.

4.4.2. Research Areas

To live up to the vision for materials the following main objectives need to be accomplished:

1. Reduce the environmental impact of construction and demolition (energy, material consumption, waste)
   a. Strong reduction of use of natural raw materials,
   b. Strong reduction of energy usage in building material production and logistic,
   c. Zero-waste construction / integrated materials re-use,
2. Improve predictability and efficiency of building material production processes
   a. New manufacturing processes of building materials with high performance
   b. Cost-effective industrial processes for functionally graded and multi-functional materials
3. Improve resource efficiency of buildings and infrastructure in use through improved materials:
   a. Expanding the limits of existing materials
   b. Significant reduction of energy demand of old buildings,
   c. New buildings are energy self-sufficient and save 50 % of water,
4. Reduce lifecycle costs of building materials
   a. New “high value and multifunctional” materials manufacturing technologies and processes,
   b. Cost-effective materials with improved functions and guaranteed long service life,
   c. Construction materials are friendly to be inspected, maintained and / or renovated,
5. Improve comfort of living (safety, health, hygiene) through materials adapted to:
   a. High safety / protection level of structures,
   b. High indoor comfort and health/hygiene level,
   c. No environmental impact during life cycle,
   d. Aesthetic appearance is a changeable parameter,
6. Improve working conditions (site management, safety, ease of applicability)
   a. Building materials optimized for industrial prefabrication, increase the
      modularity and assembly of the different products,
   b. Materials easy to apply,
   c. Materials light to be managed,
7. Develop new, functional materials and construction systems adjusted to the customer
   needs
   a. Develop new, multi-functional, knowledge-based materials adjusted for the
      construction of new buildings and adjusted for the renovation of existing
      buildings,
   b. Develop new equipments adapted to the new materials and to the customer
      needs,

4.4.3. Key Performance Indicators and Targets for 2030

1. Reduce the environmental impact of construction and demolition (energy, material
   consumption, waste)
   − 30 % specific reduction of the natural raw materials need of building materials
     production
   − 100 % re-utilization of construction and demolition waste
   − 30 % specific reduction in CO$_2$ emission of building materials production

2. Improve predictability and efficiency of building material production processes
   − Production time and costs reduced by 50 % through innovative, efficient and
     predictable manufacturing processes
   − Improvement of production quality to 100 % of 1$^{st}$ choice products with high
     flexibility and reduced production batches tailor-made to the markets demands
   − Materials suppliers are fully integrated in the construction processes
   − New manufacturing processes are able to sustain the production of materials with
     new functionalities
   − Industrialised production which at the same time allows for individual design

3. Improve resource efficiency of buildings and infrastructure in use through improved
   materials:
   − Insulation and storage (thermal, acoustic, electro-magnetic) capabilities increased
     by 20 % with respect to current building materials
   − Cost-effective materials for energy-positive new buildings
   − Energy consumption for transport reduced by 30 % by optimised use of pavement
     materials
   − Total energy consumption and emissions reduced by 50 % during the life cycle of
     new buildings

4. Reduce lifecycle costs of building materials
   − Knowledge-based control of properties of building materials (such as porosity,
     microstructure and behaviour at nano-metric scale) to allow total architectural
     freedom in selection and combination of building materials, structural design and
     design of surface appearance
   − Total life-cycle costs for buildings and structures are reduced by 30 %
   − Building materials can be 100 % inspected and maintained in-situ with no impact
     on building functionality
5. **Improve comfort of living (safety, health, hygiene)**
   - Tailor-made materials which can fulfil any demand on active response and aesthetics
   - Building materials capable to adapt 100% indoor environmental conditions depending on changing use requirements
   - Full understanding of aesthetic durability is used in the design and maintenance strategy of structures
   - Improved general well-being of people by creating an “easy-to-use” environment

6. **Improve working conditions (site management, safety, ease of applicability)**
   - Number of days lost through sickness reduced by 50%
   - Number of lost-time injuries in construction industry reduced by 50%
   - Building materials are optimised for industrialised prefabrication

7. **Develop new, functional materials and construction systems adjusted to the customer needs**
   - New advanced functionality materials are ready, accepted and widely utilized
   - New and innovative building materials and production technologies are compatible with the application of IST technologies in the building, e.g. sensing, monitoring
   - New, integrated concepts and networks from material producers to facilitate management suppliers and clients exploiting the full benefit of multi-functional materials
   - Tailor-made materials, which can fulfil any demands on durability, strength, active responses etc.
5. Organisation

5.1. Organisation Chart

5.2. Leadership

The Focus Area is industry lead and has a shared leadership between Saint-Gobain and NECSO Entrecanales Cubiertas.

The persons from these companies that lead the Focus Area are:
- NECSO – Chair of Focus Area
- Saint-Gobain

The Secretary of the Focus Area is:
- NECSO

5.3. Task Force

The Task Force of the Focus Area is formed by the leaders of the 4 Working Groups that have been formed within the Focus Area. This Task Force is in charge of the day to day management of the Focus Area and through this group the coordination of the work done in the different Working Groups takes place. The Task Force is responsible for the final documents and other output of the Focus Area

Members of the Task Force are:
- Architects Council of Europe, Leader of Working Group 1
- NECSO, Leader of Working Group 2
- CSTB, Co-Leader of Working Group 3
- Electricité de France, Co-Leader of Working Group 3
- Saint-Gobain, Leader of Working Group 4
5.4. Working Groups

Only one overall Working Group was formed. This limited group was formed by experts of various organisations and was responsible for the creation and co-ordination of the first draft documents and the initial content and organisation of the Focus Area. After the second meeting of this Working Group, it was decided to continue the work of the Focus Area through 4 working groups that were formed around the 4 central themes that were selected for the Focus Area; Urban Issues, Buildings, Energy and Materials, Products/Systems and Services Technologies.

Working Group 1 - Urban Issues

Leader of this Working Group is:
– Architects Council of Europe

Working Group 2 - Buildings

Leader of this Working Group is:
– NECSO

Working Group 3 - Energy

Leaders of this Working Group are:
– CSTB
– Electricité de France

Working Group 4 - Materials

Leader of this Working Group is:
– Saint-Gobain

5.5. Membership

Membership of the Focus Area is open to all European interested organisations, and will be accepted after a written request to the Focus Area leaders, with the nomination of a liaison person and with the express commitment to participate in the working group activities and with a clause to support the level of dissemination of the information received accordingly with the rules established in the group. The members will come from:
– Research community - public and private; technical and socio-economic;
– Industry (incl. SMEs) - embracing the whole production and supply chain;
– Public authorities - European, national, regional, local;
– Financial community - banks, venture capital, insurance;
– Users and consumers - to ensure markets for products;
– Civil society - to enhance public awareness.

The Focus Area will encourage the participation of SME’s and organizations from the 10 countries recently incorporated to the European Union, as well as it will encourage the participation of women in the group’s activities.
Members of the Consortium organized around the Integrated Project MANUBUILD will be invited to join this working Group. Also members of the Consortia included in the research projects developed under Fifth Framework Program of the European Union will be invited.

On 1 October 2005 the 103 members of 79 organisations represented in the Focus Area are:

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<th>Name</th>
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6. Implementation plan

6.1. Actions

Actions for the FA Cities & Buildings are:

- Development of Vision 2030 12/2004
- Development of Strategic Research Agenda 06/2005
- Initiation of Integrated Projects / Joint Technology Initiatives 09/2005
- Presentation of Vision 2030 & Strategic Research Agenda 10/2005

6.2. Calendar

27 July 2004 – The first meeting of the Focus Area was one of the Working Group and was held in Brussels.

9 and 10 September 2004 – The second meeting of the Focus Area was a combined Working Group meeting and General Meeting and was held in Madrid.

14 October 2004 – A presentation on the Focus Area was held during the B4E Conference in Maastricht. During the conference a poster was exposed about the Focus Area.

7 December 2004 – A meeting of the Working Group 1 – Urban Issues was held in Brussels.

3 December 2004 – A meeting between the Focus Area Leadership and the coordinator of the IP ManuBuild was held in Madrid.

20 January 2005 – A meeting of the Working Group was held in the City Council of Paris.

21 September 2005 – A General Meeting was held in Brussels.

6.3. Financial aspects

The resources to be used for the implementation of work will come initially from the organisations present in the Focus Area. It is the intention of this initial group to mobilize public and private funds to achieve the objectives of this Focus Area.

A mix of National and European research funds will be requested to collaborate in the expenses of this working group, and the research initiatives will be submitted in the relevant call of proposals with the collaboration of the members of the Consortium, other interested parties will be called to participate in the research proposals and the funds allocated for research in this field either in public or private organisations will be welcomed to support the working group objectives.

Through a close cooperation with the IP ManuBuild, various members of the Focus Area are expected to save costs on travelling.
Annex I: Detailed Strategic Research Agenda ‘Buildings’
To be able to build and maintain the buildings of Europe in a sustainable and smart way, it is necessary to create an integrated life-cycle process for buildings, develop new construction technologies and to make this process sustainable.

1. Integrated life-cycle process for buildings

An integrated life-cycle process for buildings requires an integration of the processes of design, planning, procurement, construction management and management during use, that currently are very often separated processes. This includes logistics, erection and assembly processes.

a. Integration of design, planning, procurement, construction management, and management during use:

Traditionally, the process in which a building is realised is clearly defined in separated stages in which a different group of professionals is responsible for a special end-product:

- In the design phase the building is designed following the wishes of the owner and the results are drawings and specifications of what is to be built.
- In the planning phase the drawings and specifications are used to come to a (preliminary) planning of the construction of the building.
- In the procurement phase the contractor uses the design, specifications and planning to come to an offer for the construction of the building.
- In the construction management phase:
  * The construction plans describe the activities required to construct the building, the human resources (including subcontracting), the materials and equipment needed, what has to be finished before the next step begins and what can be done after each step is completed.
  * The quantity surveyor produces a bill of quantities - an itemised description of the components in the building, used as a basis for pricing the project and measuring progress during construction.
- Once the building is finished it is handed over to the owner, who then comes up with a plan to manage the building.

Integration of current and emerging capabilities in 3-D design, analytical modelling and simulation, intelligent systems and distributed information management on one hand and virtual reality and related technologies on the other, offer the opportunity to create a truly integrated and automated life-cycle process environment for buildings. This environment can take advantage of the recent innovations in procurement methods which allow contractors to be involved earlier in the process and in the principles of lean manufacturing and demand-based product pull.

In this 4-D (three dimensions plus time) environment, all tools will work together as an interconnected system that provides all of the functionality needed to develop and validate detailed designs for every aspect of a project, based on the design criteria. This will enable important improvements for the whole life-cycle of the building:

- In the design phase:
- information of the construction plan can be used to find designs that are ‘almost impossible to construct’;
- different options for construction and management can be used to find optimisations in the design;
- reduce the time and cost in moving from concept to construction execution and management during use through automation of complex design engineering tasks;
- reduce errors and liability through comprehensive, automated design optimization and verification

• In the planning phase one can:
  - assess visually whether the generated construction plan ‘looks right’,
  - identify when two different trades are scheduled to work in the same area (clashes);
  - assess alternative construction sequences;
  - suggest speed-ups in the construction process;
  - identify when one dangerous activity may be under way above another activity and suggest methods of resolving these safety issues (Occupational Health and Safety implications);
  - visually assess the location of key plant such as cranes and site sheds;
  - present complex planning information to others who are not expert at reading construction plans and schedules;

• In the procurement phase:
  - 

• In the construction management phase:
  - to accelerate and optimize supply chain response and status feedback based on initial design requirements or changes;
  - optimize both materials and services sourcing and logistics activities, and construction planning and control through the automated delivery of design data to procurement systems;
  - planning and scheduling of construction activities based on procurement actions and supply chain status;
  - real time reporting and decision support on cost, schedule, progress and trends and/or plan variances based on consumption of procured goods and services and site capacities or other production constraints.
  - The global electronic procurement network (including 3-D product definitions, product specifications and supporting analytical models) will automatically identify and solicit qualified bidders and support evaluation of source capabilities and assured ability to deliver. Similarly, the system will enable rapid creation of new delivery schedules validated against supplier capabilities should there be changes to site construction schedules.

b. New logistic management technologies
The work performed in pursuit of innovative techniques in the construction industry has focused on the achievement of better construction procedures or on the development of advanced equipment. The automation of processes and management techniques has not kept pace with those of other industries, such as the car industry, where they have been used with all their full potential and efficiency.

The research in this area should focus on a fully integrated (visual 3D) logistics management system, that starts with the production of materials/components for the construction site, goes through the transport of them and their reception on site to the assembly of them on site (using e.g. RIF-tags or bar-codes). Also, the control of the workforce is also an important goal. In short, the key is the integration of the management and control of resources into an evolutionary environment such as the construction site areas, using automatic and real-time techniques to optimise the production process. Apart from incorporating an automatic system of data collection, we must incorporate the concept of dynamism.

Basically, the automatic management of resources in real time shall result in: increases in productivity, quality improvements, optimisation of resources, the ability to meet prevailing needs and a virtual zero-waste level of materials and power.

The start of the management system would lie at the factories where the materials/components are produced. The tags should be incorporated into the off-site manufactured materials/components, as an integral part of the production system, and can then be used by most asset management systems. Where appropriate, the information on the tag can be updated throughout the life of an asset. Once the materials/components are equipped with the tags, they can be followed during the whole logistic cycle from production line, through storage in factory, transport, storage on site to assembly. In a further development, progress monitoring would come to life with a graphic display on an integrated site monitor. It could show the model of the work being completed.

As far as equipment is concerned, no efforts have been made to develop a tool that address management from start to finish (selection-location-operation control-recording of operation time in the different areas of the site), and capable of being integrated into a system that manages the other resources too.

To be able to use the gathered information in a correct way, it is important to overcome the problem that the technological advances in Construction Management that have taken place in recent years do not address the resource management optimisation process in a holistic manner. Construction has an important need for a theory on process control and resource optimisation. As far as the implementation of materials management systems is concerned, it shall be quite a challenge to introduce them in environments so different to that of an ordinary warehouse, such as those found in construction sites. The space available for the receiving and storage of materials varies with time as work progresses and materials become more complex. Another major innovation consists in the extension of material control and management techniques to non-discrete items, that is to say, go beyond the scope of prefabricated parts and include even the management and control of bulk materials such as concrete, which is a major component of the construction industry.
Wireless and display technologies are in their infancy. While research into construction applications and problems has begun in academia, technology suppliers have not begun actual prototype development and testing in field application environments. In order for RFID to be widely adopted within the building industry, it must be thought of as part of an overall system, working alongside existing methods and technologies. New systems must be integrated smoothly within existing practices, making it important for barcode and RFID technology to become partners within single systems. Once RFID technology becomes more widely adopted, the benefits could be seen right across the construction industry. The tags with an internet-enabled scanner could provide additional information in real time, so that the basic health and safety requirements, maintenance inspection notes etc, can be downloaded from the internet and records all linked with specific building components.

c. Flexibility of the buildings to adapt to the office and dwelling changes

We must emphasize eliminating unintentional barriers and employing designs and features usable by persons with a broad range of needs. Universal design increases accessibility for persons with physical limitations and provides flexibility necessary to add features if desired at a later date. This flexibility can increase a home’s marketability, particularly to elderly persons and those with physical limitations. This market will become increasingly important over the next 30 years.

Designed for movable walls, convertible rooms, and flexible systems are needed to accommodate the changing needs of occupants (e.g., newborns to seniors) and future technological innovations.

Flexibility will be affected principally by design to limit barriers to alternative uses. It is very difficult to make a rational investment in flexibility when the nature of alternative use is unknown. An alternative is to allow facile removal of building systems, e.g., partitions, so that alternative use can be accommodated. Additionally, building interiors, furnishings, and ventilation systems can be made more modular and flexible, to decrease the costs associated with future changes in building use. Also, design features that facilitate the installation and re-configuration of communications wiring can decrease future costs.

Adaptable workplace interiors are integrated with all the building systems to provide the high-performance capabilities required by accelerating workplace demands. But merely satisfying those demands is not enough. The workplace must be synchronized with specific performance criteria related to building operating efficiency. To do that, the designer must look at the workplace as a network of six integrated performance systems.

The key lesson is that individual interior spaces, if they are to support an adaptable work environment, can no longer be considered in isolation. Companies should look beyond conventional “office building” thinking and consider the workplace as a network of systems. Within that network, the key elements of an adaptable workplace deliver the optimal

• Air quality (filtration, ventilation and humidity control).
• Thermal comfort (enhanced individualized control at a reasonable cost)
• Connectivity (wireless and wired options with access to the infrastructure that is no disruptive to ongoing workplace operations).
• **Lighting** (a system of affordable and cost-effective zonal distribution and controls that when feasible, takes advantage of natural light and integrates it with the general ambient lighting)

• **Interior spaces** (increased integration of previously isolated systems)

• **Building shell** (an adaptable workplace interior must still consider the impact of the building shell)

Achieving an adaptable workplace requires a strategy. Synchronized interior systems can deliver adaptable HVAC, voice, data, power, and lighting from above the ceiling, at the desktop, or from below a raised floor. Acoustical control poses one of the greatest challenges to adaptable interiors. Demountable walls that block noise must integrate with acoustical ceilings that absorb sound. Sound-masking systems require behavioral protocols to enhance effectiveness.

“Renovation rate” provides a key criterion for measuring adaptability, depending on how often a company demolishes and rebuilds interior spaces. It is different from “churn,” which typically is little more than a “box move.” Ascertaining the impact that frequent renovation will have upon a facility requires a comprehensive evaluation of integrated building systems.

Accurate and flexible simulation tools for the construction process, in all its dimensions, are central to solving the problem of performance of the constructed facility over the entire life cycle. In the design stage, simulations maintenance or renovation activities (changes in the requirements of the user) are as essential to design as they are to selection of optimal alternative construction processes.

Products: Simulations and simulation tools will be developed for the performance of individual pieces of construction equipment. These simulations and software tools will permit users to determine key characteristics of construction equipment and processes. Manufacturers and commercial software companies will develop the "commercial" simulation capabilities, but will make use of common standards for data exchange, thus facilitating inter-operability and flexibility.

2. **Construction technologies**

   a. **Erection, new assembly processes**

   New, lightweight, high-strength materials and components, combined with innovative assembly and joining methods applied by new generations of automated, smart tools and equipment will speed all aspects of the fabrication and radically reduce the primary elements of cost.

   Modularity, at the largest and smallest elements of a structure, will enable rapid build as well as affordable reconfigurability to maximize lifecycle utility. There is significant opportunity for new materials, joining technologies, and automated processes to reduce traditional build times to a fraction of today's norms, reduce the direct labour content required to manufacture and assemble, and eliminate a significant amount of non-value-added indirect labour content.
These new resources will also greatly extend the life span, performance, and flexibility of both facilities and structures including resiliency to accidents and catastrophic events. Flexible and "programmable" properties will enable materials to be easily transported, placed, formed, and attached with little or no cure times or temporary support structures. Improved strength-to-weight ratios, thermal properties, and other properties will enable the design and construction of facilities that radically extend the envelope of what is possible to build. These improvements will greatly expand capacity, performance architectural creativity, and functionality for all types of facilities.

The benefits from better materials and methods are pervasive. New materials will open the door for new building methods that eliminate many labour-intensive and hazardous tasks. Drastic reduction of cure times and temporary structures will shorten build times and enable far more concurrent operations. New methods will enable the production of attractive, functional structures at greatly reduced cost.

**Improved Joining** - Develop new materials and methodologies that allow faster assembly of components, require fewer on-site craft skills and equipment during assembly, and support highly engineered and automated rapid-erection designs and methods such as automated laser activated joining of steel structural members.

**Zero Temporary Structures** - Develop highly engineered erection methods that eliminate the need for the fabrication and handling of temporary systems such as scaffolding, material lifting and placement, and support. Develop materials that do not require temporary construction systems (e.g., forming or packing materials).

**Intelligent, Interactive Construction Equipment and Systems** - Develop new classes of construction equipment and systems (e.g., cranes, lifts, earth movers, pipe fitters, auto welders, material handlers) with the onboard intelligence and flexibility to autonomously place and install materials and components, working in collaboration with different items of equipment and under human guidance and control.

The lifespan, performance, flexibility, and cost-effectiveness of future capital facilities will be greatly enhanced by new and improved materials of construction that are fabricated and applied by intelligent construction systems to enable rapid, high-quality erection. Ultra-lightweight, high-modulus materials that do not require temporary systems for placement will reduce construction time and cost. Materials that provide high performance using only thin layers, have rapid cure and immediate functionality, and are self-configuring will drastically reduce the time and cost of construction.

b. **Industrial production to replace traditional trades**

Concepts and solutions for new manufacturing technologies having a potential applicability for manufactured buildings must be identified, assessed and developed. This includes the introduction of the production cell concept for on-site and off-site factories, mobile factories as well as on-site assembly.

The development of materials and elements should focus on:
- Building components and structural systems composed entirely of 2- and 3-dimensional composite panel and structural element technology.
- Automated manufacturing techniques to mass-produce wall, partition, floors of new or non-traditional raw materials.
• Pre-manufactured building enclosure panels. Panels might be designed with an underlying modular dimensioning approach to minimize waste of materials while allowing for easy handling by two workers.

• Enclosure assembly techniques that go beyond conventional systems interfacing to true integration. For example, wall assemblies that also serve as HVAC system supply or return ducts; foundations that can be part of an on-site rainwater collection and storage system.

• Window, door, and other envelope-penetration systems that are leak proof and reduce envelope's discontinuities.

Support for projects that eliminate the proliferation of discrete building components and minimize complexity while maximizing the variation and flexibility, durability, and cost-effectiveness of building systems utilizing composite panel technology.

Research the downstream costs of call-backs, warranties, repair, and upkeep resulting from excessive dependence on on-site labour for installation of separate parts, in contrast to prefabrication at off-site plants.

Develop control systems and robotic mechanisms for the viable implementation of on-site automated material handling, sorting, assembly, and finishing of entire building systems.

c. Use lighter equipment in combination with lighter materials

Lightweight, high-strength, high-modulus materials and fabrication methods that enable low-cost assembly, maintenance, and ownership can greatly improve productivity. Understanding of long-term life and failure modes and mechanisms of high-modulus materials and material systems such as woven fibres, textured materials, and their anisotropic behaviour characteristics is needed, as well as manufacturing and on-site assembly methods for lightweight materials.

Construction and Transportation costs are also reduced with the use of lower density components based in lighter materials as FRP composites. Charges for freight are usually based on weight - the low densities of FRP composites reduce shipping costs for a given volume. There is less need for heavy construction handling equipment at construction/installation sites. Hire charges for this type of equipment are reduced. The ease of handling of components requires fewer personnel to manoeuvre or assemble components in the field. Significantly faster construction times are accomplished. Pre-assembly of certain components can reduce field assembly costs and times.

d. Radically Advanced Construction Concepts

Breakthrough technologies that support the ultimate vision of entirely self-constructing facilities and structures should be developed, such as:

• Programmable Nanomaterials and Nanoconstructors - Develop the technological basis for nanodevices that can be programmed with the complete design for a facility or structure and which will process raw material feed stocks to systematically build the facility and communicate real-time progress to the Asset Lifecycle Information System
• Biomimetic Materials, Structures, and Facility Systems - Develop the technological basis for materials, structures, and facility systems that monitor ambient conditions, loads, stresses, and requirements and autonomously "morph" - in a manner similar to a biological system - within specified control limits to optimize performance under changing conditions, including proactive response to fire, chemical/biological contamination, and other safety-critical events.

e. Knowledge based building construction processes and products

In order to improve constructability, knowledge-based systems to incorporate construction knowledge into the design process are needed. Computer programs based on knowledge developed from consultation with experts on a problem, and the processing and/or formalizing of this knowledge using these programs in such a manner that the problems may be solved. This transformation will be achieved over time through a combination of training, technology implementation, and evolution of business processes to incentives productivity and efficiency. Lifelong learning and ready acceptance of new technology will be the norm across the industry. Workers at all levels will benefit from technologies that assist them in doing their jobs more effectively. The technological transition will drive a gradual transformation of the industry work culture. Committed workers who serve the total interests of the capital project enterprise will replace trades-based, transient workers.

Management of the workforce will shift from mandated practices to embedded practices. Health, safety, and environmental awareness will be engineered into methods, processes, systems, and equipment. Training and education will make proactive use of emerging technologies, providing, interactive multimedia instruction and monitoring to assure compliant practice.

The demand for the new generation of workers will be met by a knowledge supply network. The present system of supply and demand will be augmented by a proactive system that focuses on projected needs by region, company, or skill, and specifically prepares workers to fill those needs. Government, industry, labour unions, and other stakeholders will work together to assure the ready supply of workers with the right skills and cultural mindset.

Knowledge capture and application is an integral part of the vision. Knowledge management tools will help assure that lessons are truly learned and that well-defined, meaningful best practices are used in all applications. Knowledge-based advisors will assist workers in all segments of the industry in performing their jobs to the optimum.

Successes in using expert systems technology to develop practical applications for the building industry are relatively few, compared with advances in computer aided design, real-time control, and data analysis. Expert systems are also referred to as knowledge based systems or decision support systems. The definition of an expert system that is often given, states that there is a heuristic component that can operate on or use knowledge to make recommendations, draw conclusions, and/or propose a hypothesis. It is also stated that it can act as an expert, and possess the ability to learn. In reality, systems at present do not possess this learning component. An accurate definition of how an expert thinks has yet to
be developed. This does not mean that expert systems technology cannot be used successfully to aid in decision making for many applications in the experts.

A successful expert system is one that mimics the way an expert(s) would apply his problem-solving abilities in making a recommendation or drawing a conclusion, with a high degree of accuracy. Expert systems differ significantly from other computer program architectures because they separate what is known about an application, called domain knowledge, from the logic that controls how the knowledge is used, known as inference procedures. Fuzzy set theory and Bayesian logic may help in this regard as well as in selecting the best expert system.

f. New models based on Human Science principles.

The goal of human engineering is to optimize systems performance by taking human physical and cognitive capabilities and limitations into consideration during all life-cycle building. Sustainability, flexibility, usability, and participation and empowerment are new variables of the workspace design, and they are not at all as well studied as others properties of workspace. These studies employ the latest knowledge of human engineering, usability and the new "soft" approach to the economy and the organisational factors (cf. e.g. Himanen M. 2003a, 83-85.). The meaning of such issues as the tacit knowledge, ethics and the human or intellectual capital are included in the common business practises. The human aspects are covered not only on the behalf of psychology and social behaviour but they are also embracing human mental or spiritual capacities.

Despite the focus in human engineering so far has been in the commercial buildings, such human aspects as senses, intelligence, feelings, moods and emotions, and mental skills are not excluded in building design and construction either. In contrary, housing is provided for home, which does not mean only the physical environment, but the sense and feeling of home, a place for close relationships and caring. The whole spectrum of humanity is allowed to show and act at home rather than in the outside world of it. There is challenge enough in housing design in taking the human factor into account.

The end-user participation to design and the need for feedback is inevitable in any science, but in housing in particular. Several methods have been on their way for permanent applications. It have been used such methods as monitoring either manually or by video, interviews and posted questionnaires mainly for post-occupancy studies or for need analysis, laboratory tests of users' response to various environmental settings, and in special cases benchmarking has been employed. However, it has not been easy to cope the different end-user needs, or are there so many of them after all - nevertheless, it has not been easy to clarify the multidisciplinary subject of housing design requirements, despite the multitude of valuable knowledge of technical housing solution for various user groups.

3. Low-intrusive renovation techniques with minor impact on public, directed to groups with special needs

Because the financial resources for the maintenance of buildings and infrastructures are always limited, there is a need to find ways to allocate them among the various projects suggested for rehabilitation, renovation, and upgrading of existing buildings. New models to solve the problem of resource allocation taking into account: (1) maximization of benefits
while adhering to a fixed budget or (2) minimization of costs while putting the emphasis on the performance of the buildings.

Methods to improve diagnosis of the deterioration / damage observed are needed; such as tools to assist in gathering and processing the required information from inspections, sampling, NDT, analysis etc. Also needed is a basis for indicating the quality of the diagnosis undertaken; with indication such as “qualified guess”, “previous experience” through to a detailed explanation of all findings drawing together all aspects of the investigation and available information without leaving any loose ends.

Procedures are needed for the selection of repair methods for particular circumstances and damage situations, linked to the owner’s strategy for the future management of the structure. These would need to be linked to the reliability of the diagnosis & assessment carried out, as well as the owner’s other obligations that influenced the chosen approach.

Implementing retrofit solutions can be intrusive and require considerable business interruption. Standard approaches often ignore the benefits of the existing building because it is difficult to evaluate. We must therefore develop design tools that allow us to take full advantage of the existing structure, whilst sensitively integrating appropriate strengthening solutions. The need for cost-effective technologies is particularly acute in the retrofit/renovation market. There is an important need of research in new FRP lighter materials, less intrusive than the alternative in traditional building materials. They must offer easier handling, adapt readily to shape irregularity and resistant to the corrosion. Unlike traditional methods, the new approach must be reversible, less disruptive process, and must be implemented without the need for heavy equipments. Security specialists are well aware that while there might be little that can be done to defend a building against these scenarios, much can be done to reduce their impacts in the building stability.

Provide extensions to emerging construction and O and M technologies to support the unique needs of facility upgrades and major renovations.

- **Non-intrusive Autonomous Effectors** - Develop small-scale autonomous devices able to operate inside existing structures (e.g., walls and piping) to perform common tasks such as rewiring and removal/replacement of insulation.

- **Legacy Integration and Emulation Technologies** - Develop techniques, materials, systems, and practices that support the renovation of legacy facilities/structures without compromising desirable features, such as in the case of historical preservation, and which enable "minimum change" renovation of legacy materials and structures, resulting in low-cost refurbishment instead of large-scale renovation.

- **Advanced Materials for Reinforcement and Resurfacing** - Develop new materials (and supporting application techniques) capable of being applied to/integrated with existing facility materials to provide reinforcement and resurfacing to like-new condition or to accommodate changes in requirements, such as higher throughput, greater loads, new safety/security/environmental compliance features, or more extreme environmental conditions.

Lack of or improper commissioning, the inability of the building operators to grasp the complexity controls, and lack of proper maintenance lead to inefficient operations and
reduced lifetimes of equipment. If regularly scheduled, manual maintenance or re-commissioning practices are adopted, they can be expensive and time consuming. Automated proactive commissioning and diagnostic technologies applied to parts of the commissioning process address two of the main barriers to commissioning: cost and schedules. Automated proactive commissioning and diagnostic tools can reduce both the cost and time associated with commissioning, as well as enhance the persistence of commissioning fixes. In the long run, automation even offers the potential for automatically correcting problems by reconfiguring controls or changing control algorithms dynamically.

Internet can improve communications and service. Environmental Property Services Plc is developing a new WEB based service to enable their clients to access contract information over the World Wide Web. The system allows any PC user with access to the Web, access to job and contract data via the EPS website. In addition, using hand held terminal technology; the EPS operatives will update job progress from the site. This will be relayed to the EPS web servers providing clients with up to date job and contract information. Benefits include no software investment for the client (apart from enabling access to the internet) and provision of immediate access to job and contract information from anywhere in the world. Residents can play an important role in focusing the project or service to the customers needs. Resident participation can take many forms for example:

- Selection of contractors
- Contract performance reviews
- Customer satisfaction surveys
- Consultation on contract specifications
- Consultation on overall polices for stock

4. Service oriented business and systems: from “design for the customer” to “design by the customer”

New forms of alliances between the end-users and the construction industry in its broadest sense have been formed.

a. New managing relationships to establish world-class customer and supplier networks

Virtual 3D design/construction programmes allow participation of end-users, government bodies, etc. Efficient integration of knowledge demand and supply networks ON

Construction often involves a number of long- and short-term business-to-business interactions. Firms compete in dynamic environments in which they need to manage production and innovation across organisation boundaries, within networks of interdependent suppliers, customers and regulatory bodies. Increasingly, construction services include financial deal structuring, planning and design, supply-chain coordination and risk management, as well as the management of coalitions of interests concerned with project operations, including legal, environmental and regulatory authorities.

Buildings are long-lasting and impact, sometimes dramatically, not only on the immediate clients who commissioned the works but also on end users and bystanders. For the construction firms such shifts have meant that they need to find ways to deal with
community relations – in the past these were the province very largely of the public sector – and to involve the community in early negotiations about proposals. In this way lead firms are coming closer not only to the commissioners of their works but also to end users broadly considered.

Working from a Computer Supported Cooperative Work (CSCW) perspective means to get to know the users, as well how the users interact and are organised. This can be accomplished in several ways. CSCW is influenced from many different fields. It uses terms from organisation theory, cognitive psychology, linguistics and computer science and therefore also borrows various methods from these fields. The methods here are the most commonly used and talked about. These methods aim to not only to study the users but also how the users are organised and how they cooperate.

**b. Change in business models**

The real estate and building industry is switching to service business, where physical facilities are only part of the service concept. The facilities and traffic channels in the built environment will form a significant business platform. Customer and network management will become a renewing force in the service business sector, one that is based on competence and whose technological development is based on information and communication technology.

Materials, construction products and construction and building technology systems that contain intelligent product and life span information will be developed by means of cross-technological competence. The tangible presence of information and communication technology in the planning and construction process as well as in the use of real estate has made it possible to develop new products and service concepts for the entire life span of the real estate and for its various functions.

The planning processes will be based on product models, and the planning information connected with the construction process management systems.

Interactive, virtual environments will be developed for assessing the functionality of buildings and the built environment, and to support decision-making by customers. Important applications that support well-being include solutions for a healthy, safe, comfortable and efficient living environment. Overall solutions that take account of the needs of various users are developed by combining cross-technological collaboration and competence with business models of new value networks. An example of this is the living at home of the elderly and the human technology that supports it. Ecologically managed remote work, remote presence and remote management are on their way.

Workplaces, homes and hotels constitute a service platform where innovative combination of new technology with the working and living environment and infrastructure creates new service markets. In this development, services are an integral part of the products and their important components include learning information and communication technologies and a serving person. Genuine and rapid conversion flexibility with its services can be developed so that it is optimised for both the life span of the building and the needs of the user.
New Business models based on long term contractor-supplier alliances. They will be adopted where there is a need to develop mutually complementary services (or skills) over a period of time. For example, contractors may enter into business alliances with frequently used specialist suppliers. Business alliances are most appropriate where the parties have a regular need for each other’s services, for example between main contractors and their regular suppliers or specialist subcontractors.