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# 1 Introduction

This document was prepared in the early stage of REEB WP4 as background information about relevant related activities for developing the Vision and the Roadmap. Only minor updates have been done during the preparation of WP4 deliverables.

## 2 European policies

The European institutions, and especially the European Commission (EC), have acknowledged that Construction industry is a key industrial sector both in terms of employment and societal impact, and in terms of energy efficiency targets:

- The construction industry comprising construction, renovation, maintenance and demolition of buildings and infrastructures directly employs around 13.6 million persons and supports about 26 million jobs in Europe<sup>1</sup>. It represents 6.2% of GDP. Demand in Europe is coming from private households, the business society and the public sector alike, the latter dominating demand for infrastructure building. Even if economic projections anticipate a reduction of 4.3% of the total activity in 2009 (with differentiations to be made between EU-15 and EU-12, and between the various countries all over Europe), a slow and gradual recovery is already expected in 2010-2011.
- In terms of energy efficiency, Europe has recognised “Energy Efficient Buildings” as a key industrial target – together with “Green Cars” and “Factories of the Future” – for improving the use of energy and decreasing GHG emissions: Buildings (residential, public, commercial and industrial) account for approximately 40% of energy end-use in the EU, of which more than 50% is electrical power. The sector has significant untapped potential for cost-effective energy savings which, if realised, would mean an 11% reduction in total energy consumption in the EU by 2020.
- The Action Plan for Energy Efficiency [6] estimates that the largest cost-effective energy savings potential lies in the residential (around 27%) and commercial buildings (around 30%, see also ECTP [39]). Considering electricity only, about one fifth of the world’s electricity consumption is for lighting, presenting a major potential for savings. The adoption of high-efficiency light-emitting diode (LED) technology, already available on the market, could save 30% of today’s consumption by 2015 and up to 50% by 2025. By adding sensing and actuation capabilities to energy-efficient bulbs, so that they automatically adjust to the environment (e.g. to natural light, people’s presence) another 20% can be saved [19].
- Under the Directive on ecodesign of energy-using products (EuP) [9], implementing measures laying down requirements for energy and environmental performance, are being enacted for ICT products used in the buildings and construction sector [8]. There is scope for ICT to contribute to further realising this potential, through the application of building and energy management systems, smart metering technologies, solid-state lighting and lighting control systems, intelligent sensors and optimisation software. In view of the contribution to energy performance of many different factors, including materials and

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<sup>1</sup> Automotive industry is much smaller: directly employs 2.3 million people and supports around 12 million jobs in Europe

technologies, and the various potential trade-offs among them, developing a systemic understanding of the energy performance of a building is highly desirable.

- As part of the European Economic Recovery Plan [7], the Commission proposes to launch partnerships between the public and private sectors to further develop and demonstrate green technologies and energy-efficient systems and materials in buildings with a view to reducing radically their energy consumption and carbon emissions
- The estimated envelope for the proposed Energy Efficiency Buildings Private-Public Partnership (EEB PPP) is €1bn. It is worth noticing that ICT is referred to as follows: “Research on ICT for energy efficiency in buildings, such as design and simulation tools, interoperability/standards, building management systems, smart metering and user-awareness tools”.
- The proposed recast of the Directive on the Energy Performance of Buildings (EPBD) [10] introduces a general framework for a methodology to calculate the energy performance of buildings. Implementation of EPBD will yield a large amount of information on the make-up of building stock across Europe. Such information provides a useful baseline for the buildings and construction sector, as well as policy-makers. It also opens up opportunities for a collaboration framework between the ICT and buildings and construction sectors that is to be established with a view to exploiting opportunities for the development of software applications for the purpose of compliance with the EPBD.
- It is therefore a strategy acknowledged by the EC that the ICT sector is to be invited to work together with the buildings and construction sector to identify areas where the impact and cost-effectiveness of ICTs can be maximised, and to specify requirements. They should also promote interoperability between auditing tools, and building and energy management systems, with a view to developing a systemic understanding of a building's energy performance. There is scope to go beyond the general methodological framework introduced in the Directive and agree on common methodologies for presenting data. Then ICTs could be applied for EU-wide collection, aggregation and comparative analyses to support benchmarking and policy evaluation.

All in all, ICT have an important role to play in reducing the energy intensity and therefore increasing the energy efficiency of the economy, in other words, in reducing emissions and contributing to sustainable growth. ICT will also stimulate the development of a large leading-edge market for ICT enabled energy-efficiency technologies that will foster the competitiveness of European industry and create new business opportunities. As ICT is today pervasive to all industrial and business domains, it is expected to generate a deep impact in the energy efficiency of buildings of tomorrow.

### 3 DG ISM, Unit H4: ICT for Sustainable Growth

The Commission's Directorate General Information Society & Media (DG ISM) has launched Flagship Initiatives under the Commission's i2010 initiative to underline the full potential of ICT to improve quality of life in Europe. This has been done in four critical areas that are European Digital Library, Intelligent Car, ICT for Independent Living in an Ageing Society, and ICT for sustainable development. In this context, one of the focus areas of the Unit H4 of the DG ISM is: Energy efficiency – Harnessing the power of ICTs to ensure we waste less energy, from all sources, and make better use of energy sources which cause least damage to the environment.

Recent calls for proposals supported this policy with the topics (in chronological order):

- ICT-2007-6.3 (Call 2): ICT for Environmental Management and Energy Efficiency: New and affordable ICT for Energy-intensive Systems.
- CIP-ICTPSP-2008-2.1: ICT for energy efficiency in public building and spaces, including lighting.
- ICT-2009-6.3 (Call 4): ICT for energy efficiency: ICT support to energy-positive buildings and neighbourhoods.
- CIP-ICTPSP-2009-4.1: ICT for energy efficiency in social housing.

During summer 2008, Unit H4 launched among others a Smart Buildings Consultation Group to identify and investigate ways in which ICT can contribute to energy efficiency in the Building and Construction sector, and to identify actions that the Commission can take to reinforce this contribution and accelerate its impact. The conclusions drawn by this Concertation Group [17] indeed fed the outcomes of a (high level) advisory group aiming at providing information on potential as well as recommendations to the EC in terms of ICT for Energy Efficiency. This Concertation group was also to be seen, from the “Construction ICT” side, as the channel for involving DG ISM in the activities the Construction sector needs.

The Recovery Plan [7] proposed by the Commission in November 2008 includes public-private partnerships for research and development in three areas: (1) Factories of the Future, (2) Energy-Efficient Buildings and (3) Green Cars. The initiatives will be implemented in 2009 through a series of coordinated calls between the relevant FP7 themes: NMP, Energy, ICT and Environment. ICT plays an important role in the three initiatives. In “Energy-Efficient Buildings” ICT helps improve energy efficiency in buildings through, for example, better monitoring and control of energy consumption, advanced lighting systems, and smarter and optimised interconnections with the power grids.

All these ongoing efforts from Unit H4 are oriented towards support to projects for take-up of ICT systems to enable future Construction to become energy neutral, intelligent energy-efficient building management systems.

## 4 Energy performance of buildings directive (EPBD)

The EPBD directive [10] covers a wide range of requirements in 5 so-called themes:

- Certification procedures.
- Inspection of boilers and air conditioning systems.
- Requirements for experts and inspectors.
- Calculation procedures.
- Minimum Energy Performance requirements.

The theme "Calculation procedures" deals with the adoption of methodology. This theme includes the assessment of the relevant EN (CEN) and EN ISO standards, in particular the way they are or will be implemented at national level, options for quality assurance of calculation methods, differences between methods or data input for new versus existing buildings, legal aspects (e.g. national versus CEN options), practicability (as "simple" as possible and yet sufficiently accurate and distinctive, methodologies for innovative technologies, further needs and possibilities for further harmonisation and more.

Member States shall apply a methodology, at national or regional level, of calculation of the energy performance of buildings on the basis of the general framework. The energy performance of a building shall be expressed in a transparent manner and may include a CO<sub>2</sub> emission indicator.

A mandate has been given to the CEN committee to develop appropriate calculation procedures to support Member States in the national implementation of a calculation methodology of energy performance.

The methodology of calculation of energy performances of buildings shall include at least the following aspects: thermal characteristics of the building (shell and internal partitions, airtightness etc.); heating installation and hot water supply, including their insulation characteristics; air-conditioning installation; ventilation; built-in lighting installation (mainly the non-residential sector); position and orientation of buildings, including outdoor climate; passive solar systems and solar protection; natural ventilation; indoor climatic conditions, including the designed indoor climate.

The positive influence of the following aspects shall, where relevant in this calculation, be taken into account: active solar systems and other heating and electricity systems based on renewable energy sources; electricity produced by CHP; district or block heating and cooling systems; natural lighting.

For the purpose of this calculation, different types of buildings should be adequately classified into categories.

## 5 ARTEMIS JTI - Advanced Research & Technology for EMbedded Intelligence and Systems Joint Technology Initiative

Since 2008, the ARTEMIS JTI is implemented as a Joint Undertaking (JU) which is a public-private partnership between The European Commission, Member States and Artemisia, a non-profit industrial association.

The vision is that our environment will be widely supported by intelligent Embedded Systems [1]. All systems, machines, and objects will become digital, self-managed, interconnected resources. Embedded Systems will make real the dream of Ambient Intelligence in which intelligent support for people will be embedded in everyday objects, such as furniture, clothes, vehicles, buildings, roads and smart materials. Embedded Systems will increase our quality of life, alleviating the pressure on our environment by reducing pollution and increasing energy savings. They will help to make life healthier and more secure. And they will provide more comfort for Europe's ageing population. This "embedded everywhere" revolution is fuelled by device miniaturisation, where more and more functionality is available for less and less cost; by cheap and pervasive networking technologies; and by digital convergence between formerly distinct technology families and industrial sectors.

Artemis objective is to define and implement a Research Agenda for Embedded Computing Systems. The ARTEMIS JU is managing and co-ordinating research activities through open calls for proposals through a 10-year €2.5 billion research programme on Embedded Computing Systems. The programme is open to organisations in European Union Member States and Associated Countries. Selected projects are co-financed by the JU and the Member States that have joined ARTEMIS.

Despite technology convergence, markets for Embedded Systems are mostly fragmented. This has led to fragmentation of the supply industry and fragmentation of RTD investment. It is an ambition of ARTEMIS to overcome this fragmentation, cutting barriers between application sectors so as to "de-verticalize" the industry, sharing across sectors tools and technology that are today quite separate, provided by a new embedded system industry. Therefore a set of eight "ARTEMIS Sub-Programmes" (ASP) are identified. Among them, "ASP7 Embedded technology for sustainable urban life" [2] focuses on the development and application of embedded technologies for sustainable buildings and urban environments. It covers the domains of both private spaces and public infrastructures including residential and non-residential areas, offices, schools, hospitals, etc. and the optimisation of transportation in urban areas. Embedded technology in this domain is aimed at introducing comfort, security, and intelligent resource management capabilities (energy, water, waste ...) in buildings and districts.

Specific attention is devoted to the management of massive distribution of renewable energy resources in the electric power grid. Three main market sectors are identified from the applications viewpoint:

- Public infrastructures and utilities.
- Residential and non-residential buildings.
- Domestic electronics and appliances.

A key objective is to develop the embedded technology needed to resolve issues such as the interoperability of massively distributed devices that are integrated in buildings and (public) infrastructures. Additionally, these devices must be mass produced and highly customisable, and exhibit high reliability features while offering an accessible interface for users and operators.

## 6 BuildingSmart, International Alliance for Interoperability

BuildingSMART - formerly the International Alliance for Interoperability, IAI - is an alliance of organisations developing and promoting Industry Foundation Classes (IFC), a standard specification for interoperability and sharing of building information models (BIM) [3]. In parallel, two complementary standards are being developed: Information Delivery Manual (IDM) and Model View Definition (MVD) specify which information is to be exchanged in each scenario. International Framework for Dictionaries (IFD) is a standard for terminology libraries or ontologies.. It allows information to be found and understood by humans using natural language. It also supports globally unique identification of objects [20].

Vision: Open interoperability and full life cycle implementation of BIM-based methods and tools. Information is sharable between various ICT tools of different stakeholders without re-entry and loss of semantics. Virtual buildings, based on BIM, support all information needs about a building before it is constructed and throughout its entire life cycle, quickly, reliably and efficiently. By using BIM-based methods stakeholders take more and better informed decisions earlier in the life cycle of a built facility thereby reducing costs, delivery time and environmental impact as well as improving communication, productivity and quality.

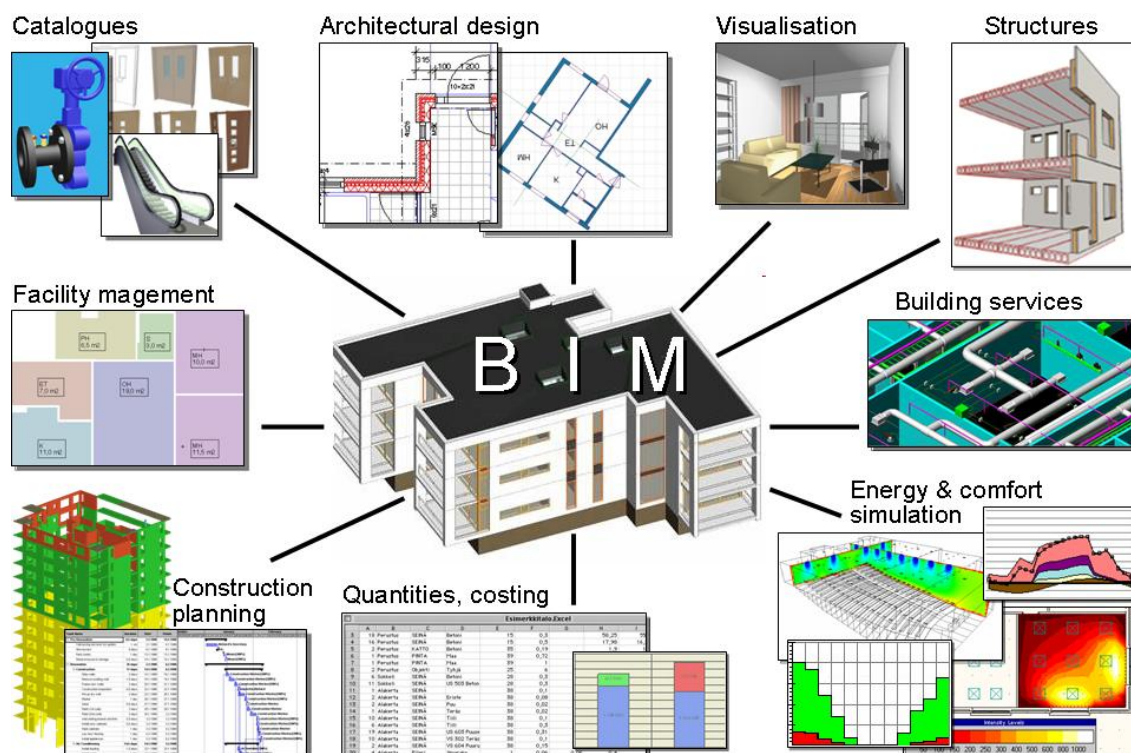


Figure 1. Examples of various engineering applications supported by BIM [16], [26]

An increasing number of software tools used by the building sector are already compliant with the IFC standard. Current implementations support data exchange via file transfer.

Future challenges include e.g.: (a) Model servers for (near) real time information sharing and cross-disciplinary collaborative work enabling truly integrated design. (b) Integration of BIM with real time operational information to support facility management and operation as well as various life-cycle support services. (c) Catalogues of re-usable knowledge, such as materials and components, with built-in parametrics and constraints to support configuration of customised design solutions.

## 7 High-performance commercial buildings technology roadmap

The U.S. Department of Energy's Office of Building Technology, State and Community Programs has facilitated a number of industry-led developments of technology roadmaps. The "high-performance commercial buildings technology roadmap" emphasizes the "whole buildings" approach [18]. Component-level technologies - such as lighting, windows, building envelopes, and heating, ventilation, and air conditioning systems - are the subject of other technology roadmaps.

Through a whole-buildings approach - sometimes referred to as "systems engineering" - all of the building components and subsystems are considered together, along with their potential interactions and impact on occupants, to achieve synergies. The fundamental goal is to optimize the building's performance - in terms of comfort, functionality, energy efficiency, resource efficiency, economic return, and lifecycle value. The whole-buildings approach crosses disciplines - requiring the integration of planning, siting, design, equipment and material selection, financing, construction, commissioning, and long-term operation and maintenance. Implementing a whole-buildings approach has been shown to enhance air quality, lighting, and other key aspects of the building indoor environment. The natural environment benefits as well - through energy and waste reduction and more effective land use.

### Vision 2020

- Successful public/private partnerships will deliver highly adaptable, sustainable, cost-effective commercial buildings.
- Advances in building design and operation will provide simple solutions to address the complex interactions of systems and equipment.
- Commercial buildings will be valued by occupants, owners, builders, and communities as healthy, productive, and desirable places to learn, work, and play.

### Strategies

- Performance metrics: Establish key definitions and metrics for high performance commercial buildings. Establish methods for evaluating total life-cycle costs and benefits for owners and communities.
- Technology development: Develop systems integration, monitoring, and other technologies that enable commercial buildings to optimally achieve targeted performance levels over their life cycles. Whole-building design tools, smart integrated building controls and methods to improve interoperability.
- Process change: Create models of collaborative commercial whole-buildings design and development, and establish the tools and professional education programs needed to support these processes. Tools and methodologies for collaborative communication, problem solving and integrated decision making in design, construction, operation and renovation.. Restructuring compensation and incentives.
- Market transformation: Stimulate market demand for high-performance commercial buildings by demonstrating and communicating compelling economic advantages. Integration of processes in the fragmented industry. Define and promote tax and financing incentives that would support commercial whole-building approaches. Develop and promote a "brand name" and identity for high-performance buildings.

In addition to technology development, ICT is a key enabler also in the other strategies.

## 8 ECTP - European Construction Technology Platform

In its Vision 2030 document the ECTP recommends that the design and construction sector actively engages with a sustainable and competitive Europe. It presents a construction industry that is increasingly client/user-driven, sustainable and knowledge-based, and proposes key goals to achieving these goals:

- **Meeting Clients/User Requirements:** providing a healthy and comfortable habitat for all, promoting a new image of European cities, developing underground transport to free surface space, developing mobility and supply through efficient networks ;
- **Becoming Sustainable:** reducing resources consumption (energy, materials, water), reducing the environmental impact of human activities, maintaining efficient transport and utility networks, enhancing our cultural heritage, improving safety and security;
- **Transforming the Construction Sector:** developing a knowledge-based, client driven construction process, supported by ICT, automation, high added value construction materials and making construction workplaces attractive.

The Implementation Action Plan (IAP) of the ECTP defines 55 RTD priorities. Many of them are applications that are enabled by common technologies such as ICT. The below figure shows a suggestion by FA Processes & ICT (PICT) for 8 consolidated technology oriented RTD priorities across various application domains. The ECTP is in the process of updating its SRA and IAP in 2009.

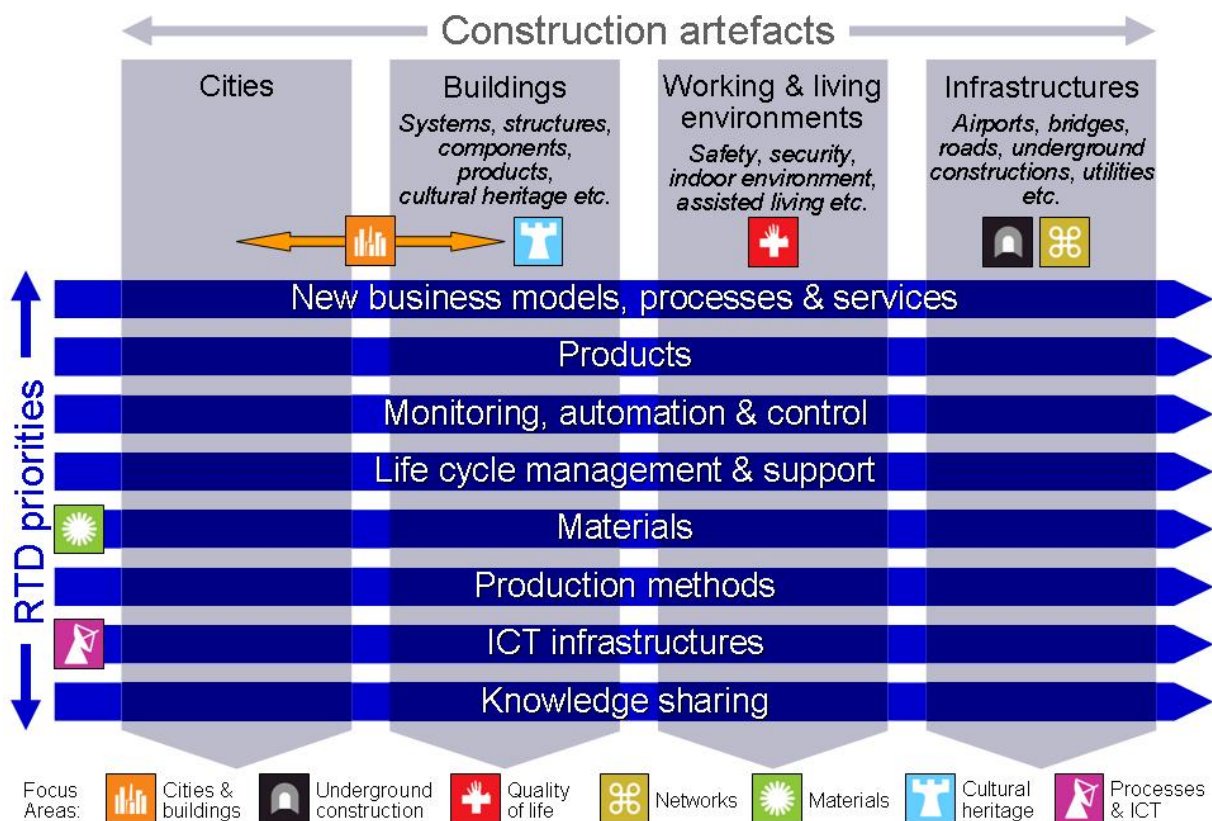


Figure 2. RTD priorities of the ECTP grouped into 8 technology categories

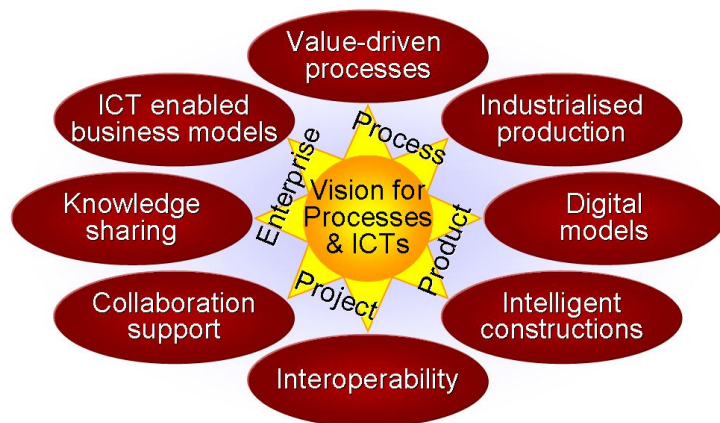
## 9 ECTP FA7 – Focus Area Processes & ICT

Focus Area 7 of the ECTP, Processes & ICT (FA PICT), analysed the SRAs of all other ECTP FAs and suggested 8 consolidated RTD priorities to meet their requirements for ICT support. Energy efficiency was considered by all FA SRAs but was not the main issue [38].

The overall vision of FA PICT is that the construction sector:

- Achieves sustainability in products and processes.
- Considers whole life cycle of its products and services.
- Applies value / performance driven business processes.
- Meets users' and clients' requirements and aspirations.
- Uses innovation, knowledge and ICTs as key assets.
- Operates competitively in the European wide open market.
- Provides products that offer comfortable and healthy working and living environment.
- Is attractive as a working place.

*Figure 3. RTD priorities of ECTP FA PICT*



The main challenge for the construction sector is to achieve holistic and integrated ICT support covering the complete project life cycle from conception to demolition. PICT defined the following RTD priorities:

- Value-driven business processes: ICT for customer centric product & service definition, requirement management & compliance assessment. Performance based contracting.
- Industrialised production: ICT for modular provision of customised constructions, logistics, assembly & services. Digital sites.
- Digital models: nD models. Access to life time information for all stakeholders anywhere anytime. ICT for design, configuration, analysis, simulation, visualisation.
- Intelligent constructions: Smart embedded systems & devices for monitoring and control. Embedded learning & user support.
- Interoperability: Ontologies & open ICT standards for semantic communication. ICT infrastructures.
- Collaboration support: ICT tools for information sharing, project steering, negotiations, decision support, risk mitigation, etc.
- Knowledge sharing: ICT for transforming project experiences into corporate assets. Object repositories. IPR protection of complex shared data. Context aware applications.
- ICT enabled business models: New ways for sustainable exploitation of ICT as a key part of business strategy in the open European / global construction marketplace.

The vision, roadmap and implementation recommendations of REEB will form the update of the PICT strategy in 2009-2010.

## 10 European Technology Platforms

Energy efficient buildings is a broad and multidisciplinary domain. It is addressed by almost half of all – about 42 – European Technology Platforms (ETP) [13]. The following list of 19 ETPs includes excerpts of their contributions, based mainly on their SRAs:

- ARTEMIS: Embedded intelligence and systems: Energy savings in buildings. Home ambient intelligence. Digital home. Intelligent infrastructures e.g. buildings. ARTEMIS has evolved into a Joint Undertaking that issues calls for proposals on topics [section 5], [1].
- EBFTP: European Biofuels Technology Platform [28].
- ECTP: European Construction Technology Platform. Updating the SRA is ongoing in 2009 [40].
- EMOBILITY: Mobile and wireless communications: Home networks [44].
- EPOSS: Smart systems integration: Safe home management. Assisted living for the elderly. Home care. Smart homes. Energy management [34].
- ESTEP: Steel Technology Platform: Recyclability of materials and components. Suitability for refurbishment and industrialised production [30].
- ESTTP: Solar Thermal Technology Platform: Solar thermal systems for heating and cooling of buildings [42]. (*ESTTP is being transformed into RHC-ETP, see below*).
- EUMAT: Advanced engineering materials and technologies: Optoelectronics for sensing in smart buildings. Materials for energy conservation and storage [27].
- FOREST: Forestbased sector: Wood as construction material reduces energy consumption, binds carbon and is recyclable as bio-fuel [35].
- HFP: European Hydrogen & Fuel Cell Technology Platform: Fuel cell systems for provision of heat and electricity in buildings [41].
- MANUFUTURE: Manufacturing: Virtual representation of (factory) buildings. Reduction of energy consumption by manufacturing processes and products over their whole life cycles [43], [48].
- NEM: Networked and Electronic Media: Home networks [36].
- NESSI: Networked software and service: Service oriented business models (in all sectors). ICT platforms from embedded systems to distributed environments [45].
- PHOTONICS21: Lighting. Sensors for air quality control [37].
- PVTP: Photovoltaics: PV modules mounted on roofs or integrated in building components. Functional integration with shading, thermal systems, ventilation etc. [29].
- RHC: Renewable Heating & Cooling: Residential and district heating & cooling [25].
- SMARTGRIDS: Electricity networks: Customer-side energy management, demand forecasting & balancing. Response to price signals. End-user behaviour. Smart metering & customer interfaces. Multiple energy carrier systems in cities and buildings [31].
- SUSCHEM: Sustainable Chemistry: Smart energy homes. Insulation materials. Coatings for windows. Electrochromatic smart windows. Phase changing materials. Organic light emitting diodes. Energy-generating components [32].
- TPWIND: European Technology Platform for Wind Energy: Local electricity marketplaces [33].

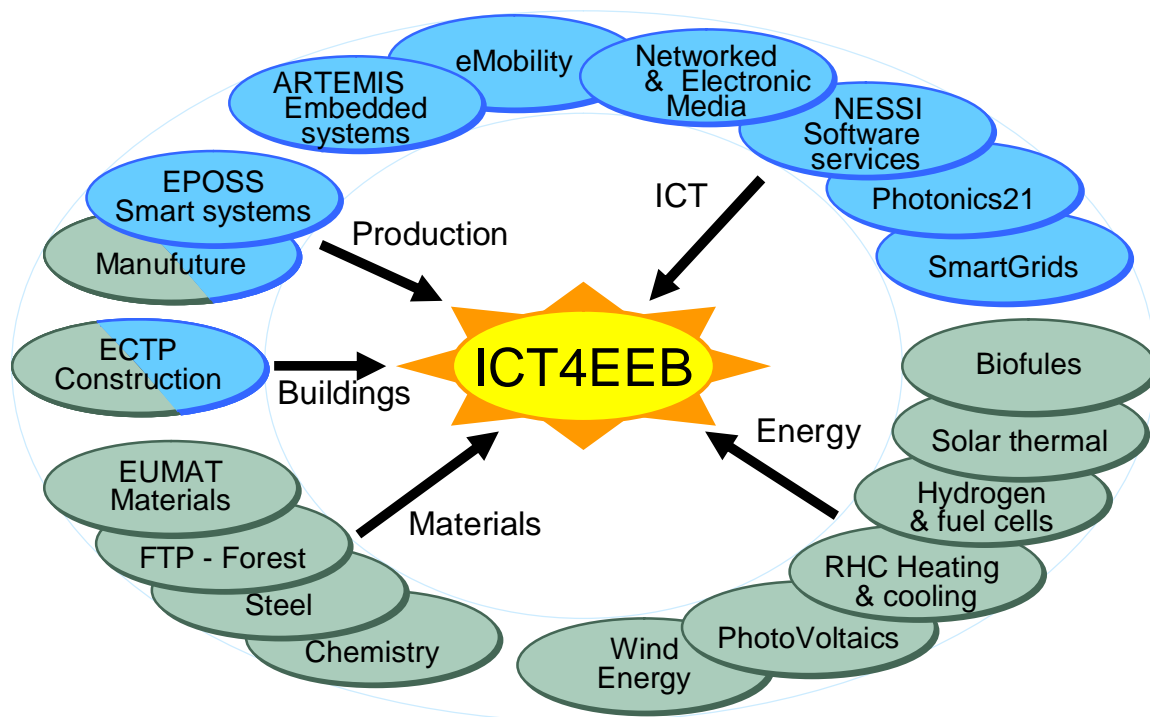


Figure 4. Related European Technology Platforms (blue: ICT-related)

The following 23 ETPs are not deemed as relevant for REEB:

- ACARE: Aeronautics and Air Transport
- EIRAC: European Intermodal Research Advisory Council (on transport)
- ENIAC: Nanoelectronics
- ERRAC: Rail
- ERTRAC: Road transport
- ESTP: Space Technology
- ETPIS: Industrial safety
- EUROP: Robotics
- FABRE: Farm Animals
- Food for Life
- FTC: Future Textiles & Clothing
- GAH: Global Animal Health
- Gas Cooled Reactors
- GMES: Global Monitoring for Environment and Security
- IMI: Innovative Medicines for Europe
- ISI: Integral Satcom Initiative
- Nanomedicine
- PLANTS for the future
- SMR: Sustainable Mineral Resources
- SNETP: Sustainable Nuclear Energy
- WATERBORNE: Advisory Council on Maritime R&D in Europe, ACMARE
- WSSTP: Water supply & sanitation
- ZEP - Zero Emission Fossil Fuel Power Plants

## 11 E2B EI - Energy Efficient Buildings - European Initiative

E2B EI is currently under elaboration, which objective is to deliver and implement building and district concepts that have the technical, economic and societal potential to cut the energy consumption in existing and new buildings by 50 % within 2030, thereby contributing to improve the energy independence of EU. To reach this goal implies a holistic combination of technologies that are needed to realise the building concepts. These technologies include ICT as a key element for improving energy efficiency in buildings and districts.

E2B EI will be implemented as a E2B Joint Technology Initiative (JTI) or other kind of Public Private Partnership (PPP). The private part will be represented by E2B Association (E2BA) and the public part will be represented by the European Commission (EC) [12].

The overall objective of E2B European Initiative (E2B EI) is to deliver, implement and optimise building and district concepts that have the technical, economic and societal potential to drastically decrease the energy consumption and reduce CO<sub>2</sub> emissions due to existing and new buildings at the overall scale of the European Union [11]. The E2B EI will speed up research on key technologies in the fields of energy efficient construction processes, products and services, with the main purpose of reaching the goals set forth for 2020 and 2050 to address climate change issues and contribute to improve EU energy independence thereby transforming these challenges into a business opportunity.

The scientific and technological agenda of E2B EI will be managed by an Ad-hoc Industrial Advisory Group set up between the E2BA and the EC. This group will coordinate the inputs from 5 Working Groups. As a generic technology, ICT enables many applications across the various WGs. The WGs are listed below with indications of potential ICT contributions. REEB contributes mainly to the “vertical” WGs 2, 3 & 4 (application-driven RTD) but also to the “horizontal” WGs 1 & 5 (support activities).

- WG1 Set the scene: Networking/liasons with national & European programs; Reference databases (to support RTD): best practices, existing methods & tools, glossaries, state-of-the-art, RTD activities & strategies; Benchmarking, technology/market analysis/foresights/roadmaps/scenarios; Impact models, methods & assessment.
- WG2 Work at the building level: Tools and technologies to improve the energy efficiency and use of renewables in existing and new buildings; Integration of materials, spaces, products, systems, energy generation and networks/grids; Embedded intelligence: sensors, smart components, smart buildings, smart metering, smart spaces / virtual environments, user interfaces and awareness tools; Automation, monitoring and control. Sensor networks. Building energy management systems, demand management.
- WG3 Work at district level: District/city design and urban planning tools; Energy & resource management systems to control local generation, and matching between buildings, facilities, networks and grids.
- WG4 Construction processes: Whole life cycle approach & supporting tools for assessment/evaluation, configuration management, decision support, design, modelling, optimisation, planning, simulation, visualisation etc.; New business models, branding, financing, incentivisation, operation & maintenance, organisation, performance metrics & management, services, user involvement, value propositions; Industrialisation: logistics, on- and off-site production, manufacturing control & management, supply management, renovation. ICT infrastructures: adaptive & learning systems, databases, collaboration/communication/service platforms, gateways, guidelines, information models, inter-

operability, protocols, system architectures, standards; Knowledge sharing: education, catalogues of reusable solutions, regulations, standards, training.

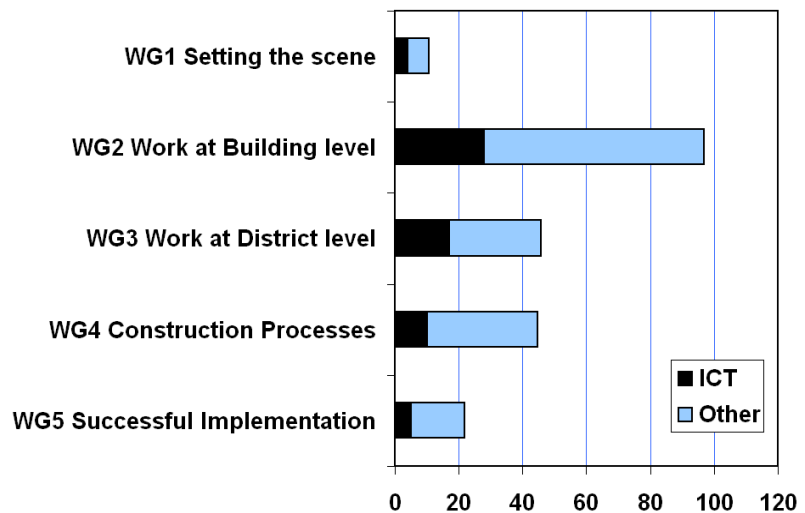
- **WG5 Successful implementation:** Demonstrations & dissemination; Promotion of labelling, regulations, standards and new business & financing models; Validation and certification of ICT based methods.

The Multi-annual Implementation Plan for E2B is in preparation. Tentatively it will be structured as follows:

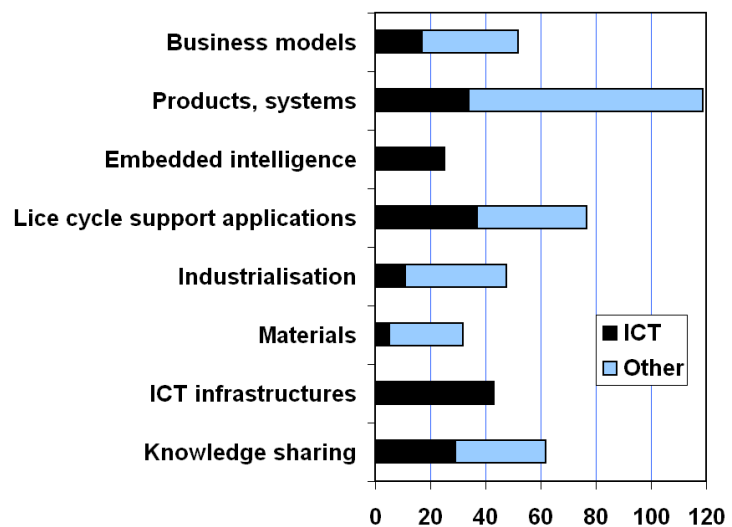
- Short term (until 2013): Reducing the energy consumption of buildings and its negative impacts on the environment through integration of existing technologies.
- Medium term: Buildings cover their own energy needs.
- Long term: Transformation of buildings into energy provider preferably at district level

As a first step E2BA launched a call for suggestions for RTD topics among its members in May 2009. The figures below are based on a first assessment of the received 221 proposals.

*Figure 5. RTD topic proposals to E2BA roadmap in May 2009 – about 30% of all proposals address ICT issues.*



*Figure 6. RTD topic proposals mapped to technologies – about 44% of all proposed technologies include use of ICT.*



## 12 FIATECH - Fully Integrated and Automated Technologies for capital projects

The closest activity related to the ECTP outside of EU is FIATECH: The Capital Projects Technology Roadmapping Initiative [15] brings together key players in the USA and Canada. While the ECTP is mainly driven by public funding opportunities, FIATECH aims at defining and executing industry-funded RTD and take-up projects. Thus the FIATECH roadmap is also an implementation plan. FIATECH's vision is:

The vision of the future for the capital projects industry is of a highly automated project and facility management environment integrated across all phases of the facility lifecycle. Information is available on demand, wherever and whenever it is needed to all interested stakeholders.

This integrated environment will enable all project partners and project functions to instantly and securely "plug together" their operations and systems. Interconnected, automated systems, processes, and equipment will drastically reduce the time and cost of planning, design, and construction. Scenario-based planning systems and modeling tools will enable rapid, accurate evaluation of all options, resulting in the selection of the best balance of capability and cost-effectiveness. New materials and methods will reduce the time and cost of construction and greatly extend facility performance, functionality, aesthetics, affordability, sustainability, and responsiveness to changing business demands.

Building Information Model (BIM) is seen as the key enabler [22]:

A digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle from inception onward.

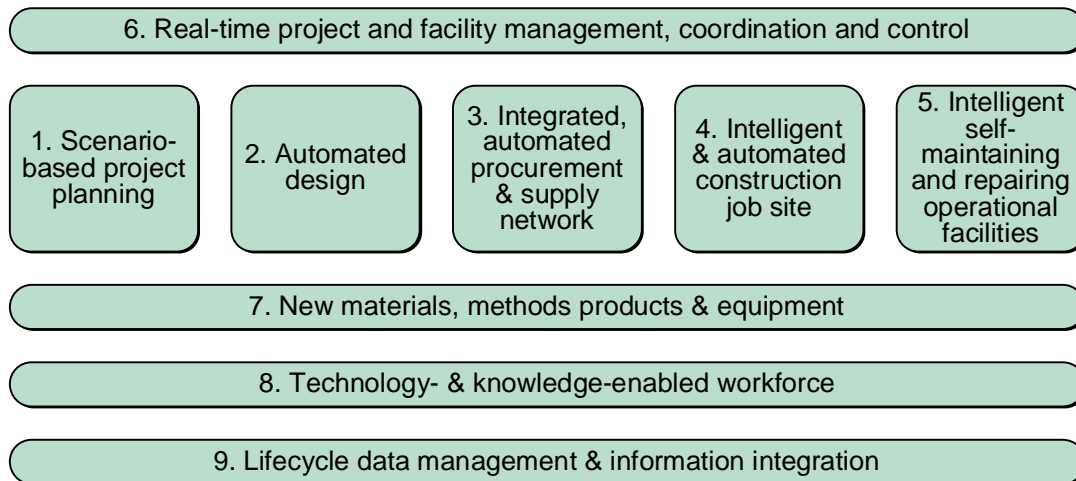


Figure 7. Nine critical elements of the FIATECH Capital Projects Technology Roadmap

The FIATECH roadmap addresses similar topics as this REEB rapport and the ECTP FA PICT SRA with two exceptions:

- FIATECH does not address new business models. This can be explained by somewhat shorter term thinking in FIATECH.
- FIATECH addresses materials. In the ECTP they are addressed by FA Materials.

## 13 UK National Platform for the Built Environment

The UK National Platform for the Built Environment [46] defines 4 high level priorities:

- Reduced resource consumption,
- Client-orientation.
- Knowledge-based process.
- ICT and automation.

In the area of ICT the following **5 priorities** were defined:

- Collaborative prototyping to define & deliver client requirements.
- Efficient, seamless sharing of information across the built environment stakeholders.
- Ability to interact with real-time information regardless of physical location and timezone.
- Mass adoption & application of off-site manufacturing, automation & mechanisation processes & systems.
- Well trained, well qualified workforce, able to use the latest, best practice technologies.

### Targets for ICT:

- Fully interoperable and integrated ICT systems must be developed to encourage the free flow of knowledge throughout all elements of the industry.
- Advances in information and communications technology (ICT) can produce 'intelligent products' capable of communicating location, orientation and condition.
- The continued reduction in the cost of communications and data processing enable construction processes to be fully monitored, incorporating all actors on the construction site into in the same chain of information.
- ICT can provide the means to enable the new era of a knowledge-based built environment sector.

**Detailed research** topics will include:

- Development of industry standards and effective de-facto standards for data exchange, object definitions, and integrated model servers.
- ICT tools for the efficient connection of all those involved in mobile sites to corporate information networks, incorporating readily available health and safety knowledge throughout.
- Development of new visualization, virtual reality and communication tools, based on advanced ICT systems and using shared integrated data models to enable a value assessment of the built environment.
- The development of new off-site manufacturing systems, automation and mechanisation.

## 14 CIB

CIB, International Council for Research and Innovation in Building and Construction (previously “Conseil International du Bâtiment”) has a large number of focused groups that organise events and compile publications [4].

The CIB groups are relevant to REEB mainly as focused target groups for dissemination and validation of RTD roadmap in specific areas.

In the context of REEB the at least the following groups seem relevant:

### Task Groups

- TG061 Benchmarking Construction Performance Data
- TG066 Energy and the Built Environment
- TG069 Green Buildings and the Law
- TG074 New Production and Business Models in Construction

### Working Commissions

- W070 Facilities Management and Maintenance
- W077 Indoor Climate
- W078 Information Technology for Construction.
- W084 Building Comfortable Environments for All
- W092 Procurement Systems
- W098 Intelligent and Responsive Buildings
- W102 Information and Knowledge Management in Building
- W108 Climate Change and the Built Environment
- W111 Usability of Workplaces
- W116 Smart and Sustainable Built Environments

### Priority themes

- Sustainable construction
- Clients & users
- Revaluing construction
- Integrated design solutions

## 15 Major standardisation bodies and standards

### BIM

- BuildingSmart: IFC Industry Foundation Classes; IDM Information Delivery Manual; MVD Model View Definition; IFD International Framework for Dictionaries.
- CityGML: Common information model for the representation of 3D urban objects. [5]
- ISO TC/184 SC4 Industrial data: WG2 Standard for the neutral representation of standard parts; WG3 Product modeling.
- ISO TC/59 SC 13 Building construction - Organization of information about construction works.

### Building and home automation

- CLC TC/205: Standards for all aspects of home and building electronic systems in relation to the Information Society.
- BACnet: Data communication protocol for building automation and control networks.
- Bluetooth: Open wireless protocol for exchanging data over short distances using short length radio waves [49].
- Lonmark: Standard for control systems in buildings, based on ISO/IEC 14908-1 and related standards.
- Konnex: Standard for all applications in home and building control, based on European standards (CENELEC EN 50090 and CEN EN 13321-1) and international ones (ISO/IEC 14543-3).
- CEN TC/247: Building automation, controls and building management systems.
- CENELEC TC/205: Home and building electronic systems.
- ISO TC/205: Building environment design, WG3 Building control system design.
- ISO/IEC 14543-3: Standard for home and building control (KNX).
- ISO/IEC 14908: Open data communication in building automation, controls and building management (LonWorks control networking technology).
- ISO/IEC JTC 1/SC 25: Interconnection of information technology equipment.
- IEC 61850: This standard was originally defined for the design of electrical substation automation, but some organizations, as EPRI (Electric Power Research Institute), are working in its evolution to support the integration of buildings in the smart grid.
- DLMS-COSEM: It is the common language for Automatic Meter Reading, or more general - Demand Side Management.
- HomePlug / Broadband PLC: Networking over power lines [49].
- Modbus: Serial communications protocol. De facto standard communications protocol for connecting industrial electronic devices. [23]
- IPv6, Internet Protocol Version 6, “next generation internet” [21], [47].
- OPC: Previously “OLE for Process Control”, now “Open Connectivity”, emerging: “OPC Unified Architecture”. Open connectivity via open standards in industrial automation and the enterprise systems. [24]
- Wifi: Trademark of the Wi-Fi Alliance that may be used with certified products that belong to a class of wireless local area network (WLAN) devices based on the IEEE 802.11 standards. Because of the close relationship with its underlying standard, the term Wi-Fi is often used as a synonym for IEEE 802.11 technology [49].

**Sensor networks**

- ZigBee Standard for home automation.
- 6LowPAN: Acronym of IPv6 over Low power Wireless Personal Area Networks, or IPv6 over LoW Power wireless Area Networks.

**Web services**

- OASIS Organization for the Advancement of Structured Information Standards: oBIX Open building information Xchange, DPWS Devices Profile for Web Services.

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