Deliverable 3.1
Vision for multi-disciplinary ICT-enabled Energy Efficiency

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SEVENTH FRAMEWORK PROGRAMME

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EXECUTIVE SUMMARY

This deliverable presents the REViSITE vision for multi-disciplinary ICT-enabled Energy Efficiency. The baseline for the development of the REViSITE vision is made by the current visions (sector and non sector specific) supplemented by expert views, analysis of state-of-the-art RTDs, ICTs and the potential of their application on a cross sectoral basis. The REViSITE vision builds on the interpretation of current visions and the envisioned implications of the full uptake of ICTs as an enabler for ICT4EE across various sectors. The REViSITE vision is broken down into components as per the SMARTT taxonomy (as described in Deliverable D2.1) and will lead to identifying the ICTs which maximise the impact of ICT on EE without necessarily being related to a specific sector. This vision will lay down the basis for the development of the future Europe's ICT4EE roadmap and its associated Strategic Research Agenda (SRA) and Implementation Action Plan (IAP).

Three steps were employed to produce the REViSITE vision: (i) Review and analysis of general and sector specific ICT visions under SMARTT taxonomy categories; (ii) Validation through statistical content analysis of existing ICT visions; and (iii) Qualitative survey of domain experts' vision views within the REViSITE Expert Group (REG). To extract useful ICT related components from the reviewed visions a comparative analysis has been conducted to determine the apparent and potential commonalities; this used a mapping table summarising all the components which are relevant to the ICT4EE vision across the four sectors. The main extracted components were clustered using the SMARTT taxonomy.

Content analysis of the text in the reviewed visions' documents was carried out based on a number of codes in order to extract the commonalities in various documents inherent to the vision on ICT4EE in Europe. Sections of text which referred to these codes were extracted as they appeared in the various visions documents, then were analysed separately in their original context to help the development process of the REViSITE vision after being classified using the SMARTT taxonomy.

A questionnaire was sent to the REG members regarding their views on the vision for ICT4EE and their corresponding feedback was also used in the formulation process of the vision.

As a result REViSITE suggests that Europe has to focus on a stronger role of ICT as an enabler of energy efficiency requiring more embedded intelligent computing systems, and to transform EU into more knowledge driven economy based on competitive R&D system and networked enterprises to rationalise processes and resources to improve energy efficiency. All will be heavily supported by efficient knowledge sharing and the pooling of research and technological development resources of all disciplines. This ensures a wide availability of new services at reasonable costs to the providers and the users, with a sector of consumers shifting to be 'prosumers'. Management, monitoring, data analysis and decision making will become a service that is provided via a networked system similarly to the internet.

The alignment of the REViSITE vision with the SMARTT taxonomy leads to identifying ICT enablers for Specification & design, Materialisation, Automation & operation support, Resource & process management, Technical integration and Trading and transactional management. REViSITE can more clearly identify 'what' ICTs should be adopted or developed, 'where' they should be applied and 'how' they are likely to impact on sustainability. These ICTs are foreseen to contribute to the realisation of the vision where new services for EE are widely available; processes and systems are integrated; design and automation systems are interoperable with the availability of cross sectoral data exchange standards; knowledge sharing related to energy consumption and grids loads are enhanced and facilitated; Infrastructures for distributed collaborative engineering are available; Open platforms for monitoring, automation and control are widely used; embedded intelligent systems are in operation; and new business models geared to EE are implemented with a shift from 'consumer culture' to 'prosumer culture'.

ACRONYMS AND TERMS

BAU ....Business As Usual

CAD ....Computer Aided Design

DEFRA...............Department of Environment, Food and Rural Affairs (UK)

DG ....Distributed Generation

DSM ....Demand Side Management

ECTP ....European Construction Technology Platform

ECTP FA PICT ..ECTP Focus Area Processes and ICTs

EE ....Energy Efficiency

ICT ....Information and Communication Technology

ICT4EE...............ICT for Energy Efficiency

REEB..................European strategic research Roadmap to ICT enabled Energy-Efficiency in Buildings and constructions

REG ....REViSITE Expert Group

RES……………....Renewable Energy Sources

RTD ....Research and Technology Development

Prosumer............Energy client who sell energy to the grid as they generate more than they require

SOGE ....Sustainable Operations on the Government Estates

SRA ....Strategic Research Agenda

Taxonomy...........Division into ordered groups or categories (refer to free dictionary). In this report “Taxonomy” refers to categories of RTD topics that are common between at least 2 of the 4 target domains.

1. INTRODUCTION

1.1 Project Background

It is envisaged that REViSITE will contribute to the formation of a European multidisciplinary 'ICT for energy-efficiency' research community by bringing together the ICT community and four important and complementary application sectors: Grids, Buildings, Manufacturing and Lighting. The REViSITE work package structure is outlined below:

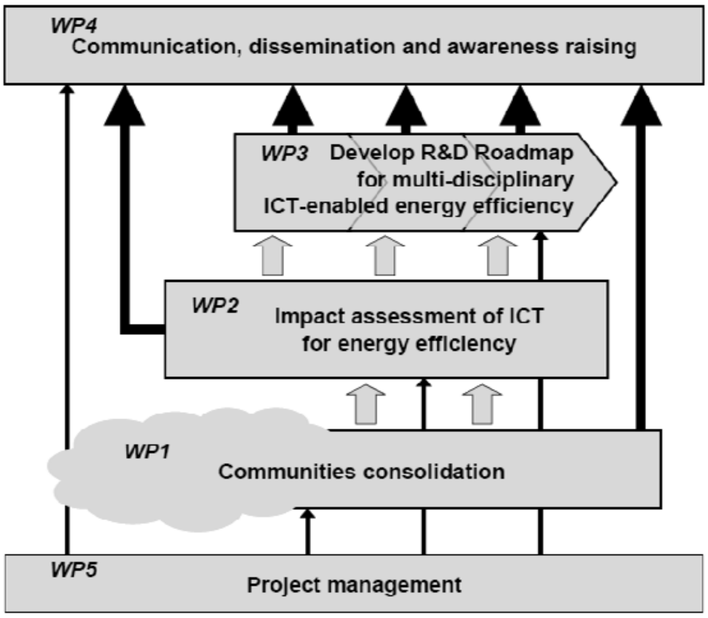

Figure 1 REViSITE work package structure

The REViSITE project will co-ordinate co-operation and communication within the ICT4EE research community in Europe. The core of this community will be formed from the European Technologies Platforms (ETPs) that represent RTD in these sectors: ARTEMIS, ECTP, MANUFUTURE, PHOTONICS21, SMARTGRIDS.

WP1 - REViSITE will identify complementarities between the four target sectors: grids, buildings, lighting and manufacturing in the area of ICT for energy efficiency (ICT4EE), harmonising common RTD priorities for ICT4EE in the four sectors, and establishing a cross-sectoral "community" with links to different industry sectors and related ETPs.

WP2 - REViSITE will compile a state-of-current-practice review and develop a causal model of how ICT can impact on energy consumption in 4 key sectors. Based on available statistical data and, where such data is not available, estimations by experts, the project aims to identify RTD priorities for ICT4EE.

WP3 - The project will engage key stakeholders from the 4 sectors via a 'focus group' and a dedicated concise 'expert group' to compare and analyse sector specific RTD agendas such as Strategic Research Agendas (SRAs) of the relevant European Technology Platforms (ETPs), European and national RTD initiatives etc. A consolidated roadmap will be derived as a synthesis. This will catalyse synergetic RTD and innovation in multiple sectors by pointing to cross-sectoral RTD opportunities in common areas of interest that have the highest potential impact.

1.2 Purpose

The purpose of this deliverable is to present the REVISTE vision based on the review of sector specific visions and visions developed through other initiatives supplemented by expert views. This deliverable will:

Summarise available ICT4EE related visions in the four sectors and other initiatives.

- Identify a common vision shared across several sectors.
- Set up baseline for D3.2 and D3.3.

The ultimate goal of WP3 is to produce the REViSITE roadmap, where:

- T3.1 – will identify key vision requirements, to be clustered and aligned with the REViSITE SMARTT taxonomy (developed in WP2)
- T3.2 – will generate the SRA based on a harmonised vision tailored for the four sectors.
- T3.3 – will develop a proposal for an implementation plan of the resulting recommendations and the SRA.

The applied approach to fulfilling T3.1 is summarised in the following activities:

- Identification of all target requirements within existing visions mapped in a matrix and aligning to the four sectors.
- Classification of these requirements under each sector so that findings can be compared and common ICT-related RTD requirements supporting the vision can be aligned to the REViSITE taxonomy categories. Finally consolidate the harmonised common vision under the taxonomy categories as pillars for future vision of the ICT4EE serving the four sectors.

1.3 Contributions of partners

Loughborough University (LOU) has compiled the whole document and generated the executive summary and the following sections: 1-introduction; 2- Summary of existing visions; 4- The REViSITE cross sectoral vision and section 5- which is conclusion.
KEMA has contributed by section 3.1- Vision for Grids and ICT as the Enabler
FHG has contributed by section 3.2- Vision for Manufacturing and ICT as the Enabler
CSTB has contributed by section 3.3- Vision for Buildings and ICT as the Enabler
VTT has contributed by section 3.4- Vision for Lighting and ICT as the Enabler
INN has contributed to section 4.2 by conducting a content analysis of the visions documents.
INTEL as the developers of the REViSITE impact assessment methodology and SMARTT taxonomy contributed to the vision development strategy and has acted as content reviewers.

Table 1 Contribution of partners

Partner	Section or Chapter
LOU	1, 2, 3.5, 4, 5, 6 and 7
KEMA	3.1 and 7
FHG	3.2 and 7
CSTB	3.3 and 7
VTT	3.4 and 7
INN	4.2

1.4 Overview of the REViSITE SMARTT Taxonomy

The REViSITE taxonomy (see Appendix 1) utilises six high level categories, which are aligned with life cycle thinking and is and following the SMARTT acroynom. Each category is further broken down into secondary and tertiary level as follows:

a. **Sub-category** allowing for more granular categorisation

   i. **RTDs & ICTs** detailing the specfic areas of research and possible devleopment giving existing or envisaged ICT exemplars

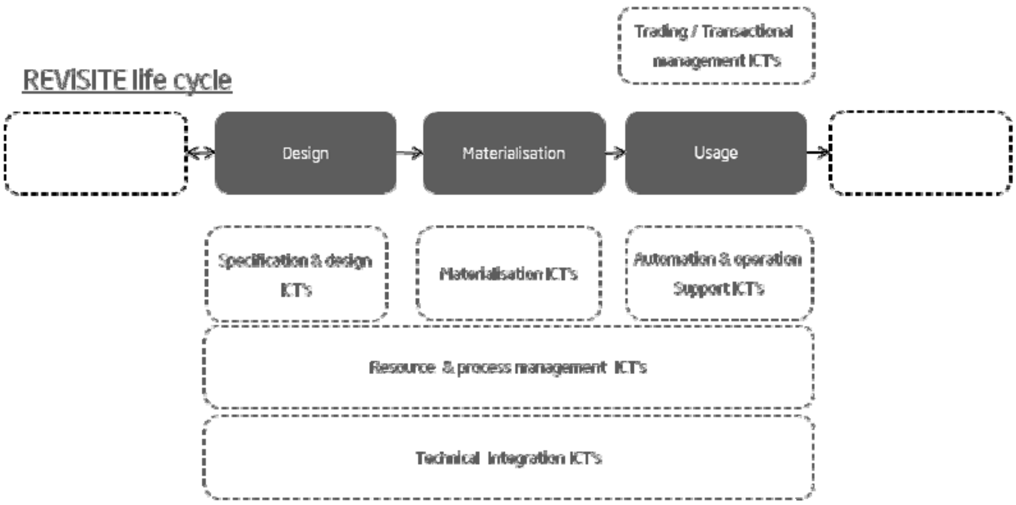

Figure 2 SMARTT Taxonomy mapped to Life Cycle phases

SMARTT is posited as a generic and useful taxonomy for any sector, including transport. In the example of transport it may well be the case that those categories and sub-categories which align to the materialisation life cycle phase would not be particularly applicable. Nevertheless, those that apply to the design and usage phases would be pertinent. What follows lists the taxonomy, main categories and sub-categories:

1. **<u>S</u>pecification & design ICTs**
   a- Design conceptualisation; b- Detailed design; c- Modelling; d- Performance estimation; e- Simulation; and f- Specification & Product / component selection
2. **<u>M</u>aterialisation ICTs**
   a- Decision support & visualisation; b- Management & control; and c- Real-time communication
3. **<u>A</u>utomation & operational decision support ICTs**
   a- Automated monitoring & control; b- Operational decision support & visualisation; c- Quality of service; and e- Wired/Wireless sensor networks
4. **<u>R</u>esource & process management ICTs**
   a- Inter-enterprise coordination; and b- Process integration: Knowledge sharing
5. **<u>T</u>echnical Integration ICTs**
   a- Technical integration & interoperability
6. **<u>T</u>rading / transactional management ICTs**
   a- District energy management; b- Facility energy management; and c- Citizen (personnel) energy management

1.5 Terminology used – Smart / Energy Efficient

The Term ”Smart” sector (Grid, Manufacturing, Building or Lighting) will be understood in this document as “Energy Efficient” combined with “intelligent” in the way it uses and processes information received and then reacts adequately. Therefore the scope will be here on ICT enabled energy efficiency of the specific sector. This topic is in the intersection of 3 disciplines: building/infrastructure/equipment/tools, ICT and energy, where ICT plays the enabling role to achieving energy efficiency.

The term “Smart” which is used throughout REViSITE documents was used in the following two contexts:

- “to be understood as the higher level of energy performance
- As an intelligent way of processing the data received and responded to by making the optimal decision and by taking action when needed.

2. Summary of Existing Visions

A review of the documents reporting on the visions which were developed through other initiatives in the four sectors (Grids, Buildings, Manufacturing and Lighting), was conducted, and the corresponding synthesis of these documents are given in Appendix 2. The text provided in table 2 is extracted from the corresponding visions documents which are publicly available, and in some cases are summarised with special focus on ICT related requirements. The following table is a concise summary of some of the main existing visions:

Visions	Requirements /Targets
Europe 2020	Flagship Initiative: "A Digital Agenda for Europe": To create a true single market for online content and services; To reform the research and innovation funds and increase support for ICTs; To promote internet access and take-up by all citizens.
GeSI Smart 2020	Accessible opportunities for ICT to enable significant reductions of emissions and savings are: Smart motor systems, Smart logistics, Smart buildings and Smart grids. And also potential energy savings from dematerialisation or substitution – replacing high carbon physical products and activities with virtual low carbon equivalents. The key actions needed can be summarised as the SMART transformation (standardise (S), monitor (M), accountability (A), rethink (R) and transformation (T)).
Digital Europe Vision	Europe 2020 strategy is focused on competitiveness as the essential condition for economic growth and job-creation in the global 21st century economy. Europe must be both host and home to a dynamic ICT sector that is tightly interwoven with the manufacturing, environmental, cultural, and political fabric.
Green ICT Vision	In line with the existing Sustainable development On Governmental Estate (SOGE) targets and definition for Carbon Neutrality, the energy consumption of Government ICT on the office estate will be Carbon Neutral by 2012; By 2020 Government ICT will be carbon neutral across its lifecycle.
UK-ICT-Enabled Environmentally Smart Buildings: by 2015	EU set of integrated standards for the 'Smart Home will be in place by 2015', it includes: Low cost technologies to be available for operation in homes; Development of UK expertise in software for optimisation and control of networks of multiple buildings; The availability of an energy service offering, enabled by integrate technology offering and changes in OFGEM regulations; Building regulations improve to trigger the need for increased EE; A strong UK body exists for 'Smart Buildings' which drives standards, provides an effective forum and competence centre; Emergence of major Energy Service Providers in the UK; Government investment in UK software sector for development of network monitoring and optimisation software

Table 2 Summary of some of the main existing visions

3. Summary of Existing Sector Specific Visions

3.1 Vision for Grids

The Overall vision for Grids is based on the publications by the European Technology Forum Grids, and on several European FP7 financed projects.

The vision within the European SmartGrids Technology Platform [4]: for energy transport and distribution networks of the future that are presented here by the Advisory Council of the technology platform ”SmartGrids” proposes that Europe should move forward in different ways in these important fields. This vision focuses on electricity networks, and would lead to new products, processes and services, improving industrial efficiency and use of cleaner energy resources while providing a competitive edge for Europe in the global market place. At the same time, it would ensure the security of the infrastructure, helping to improve the daily lives of ordinary citizens. All this makes the grid an important element for achieving the largest knowledge-based economy in the world. In this highly regulated sector, efficient knowledge sharing and the pooling of research and technological development resources of all disciplines are now critical. Through co-operative RTD actions, both within and outside the Union, Europe creating a critical mass of ideas and solutions strengthening European excellence. The setting up of this Technology Platform for the “Electricity Networks of the Future” is one way of responding to these objectives. It will hopefully bring together all parties involved in the future grids to develop a Strategic Research Agenda”. By Janez Potocnik, the Commissioner for Science and Research.

3.1.1 Grids holistic vision

Summarised, the vision for the Grids in the near future will include a programme that will lead to electricity transport and distribution networks which support the energy generation and consumption patterns as foreseen in 2030 and later.

Minimum requirements to these networks are:

- **Flexible**: fulfilling customers’ needs whilst responding to the changes and challenges ahead;
- **Accessible**: granting connection access to all network users, particularly for renewable power sources and high efficiency local generation with zero or low carbon emissions;
- **Reliable**: assuring and improving security and quality of supply, consistent with the demands of the digital age with resilience to hazards and uncertainties;
- **Economic**: providing best value through innovation, efficient energy management and ‘level playing field’ competition and regulation.

3.1.1.1 Grid Detailed requirements

The plans for CO_2 reduction, for renewable energy, and for decrease of fossil energy sources, impose more requirements:

- Large scale integration of Distributed Generation (DG) and Renewable Energy Sources (RES)
- Renewal of the existing power-plants, development of efficiency improvements, increased flexibility towards the system services, integration with RES and DG;

- Demand response and demand side management (DSM): developing strategies for local demand modulation and load control by electronic metering and automatic meter management systems.

European policies impose requirements:

- Liberalised markets: responding to the requirements and opportunities of liberalisation by developing and enabling both new products and new services; high demand flexibility and controlled price volatility, flexible and predictable tariffs; liquid markets for trading of energy and grid services;
- Continuing development and harmonisation of policies and regulatory frameworks in the European Union (EU) context.

Reliability, availability of electrical energy and resilience of networks set the following:

- Pursuing efficient asset management, increasing the degree of automation for better quality of service; using system wide remote control; applying efficient investments to solve infrastructure ageing;
- Interoperability of European electricity networks: supporting the implementation of the internal market; efficient management of cross border and transit network congestion; improving the long-distance transport and integration of renewable energy sources; strengthening European security of supply through enhanced transfer capabilities.

3.1.1.2 Distributed generation and Renewable Energy sources

There are several ways to implement distributed generation resources. A basic division is:

1. Local, relatively small scale, electricity generation, e.g. wind turbines, CHP units, solar panels;
2. Switching off electricity consumption, e.g. unnecessary air-conditioning;
3. Delaying, or shifting, energy consumption in time, e.g. production process rescheduling or schedule the washing machine.

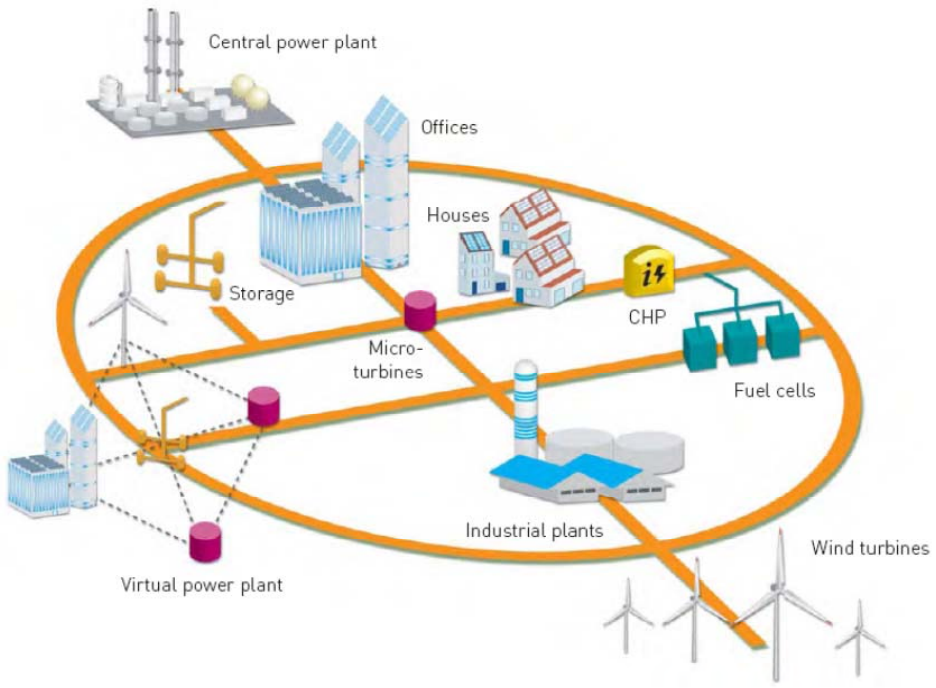

Figure 3 Central and distributed generators

Local control of these resources is strictly known technology. Calculating the appropriate set points for each one of the controls however can be complicated. Changing the load in distribution networks will in all cases influence stability of the distribution process, and instabilities in the distribution process will have influence on the transport process.

The electricity generation for the entire grid will be shared between central and distributed generators. Control of several relatively small distributed generators could be aggregated to form “microgrids” or “virtual power plants” (VPP). Such virtual power plants should have sufficient capacity to manage their production as a unit, and integrate them into the energy markets.

Distributed Generators allow small scale consumers to supply energy to the grid. This allows bi-directional energy flows throughout the distribution grid, whereas in the traditional distribution grid the flow is in a single direction towards the consumers.

3.1.1.3 Internet-style grids

One possible model for the electricity network of the future would be analogous to the internet, in the sense that decision-making is distributed and that flows are bi-directional. Applying this concept to the electricity networks would lead to control is being distributed across nodes spread throughout the system. Not only could the supplier of power for a given consumer vary from one time period to the next but also the network use could vary as the network self-determines its configuration.

Such a system would require advanced hardware and management protocols for connections, whether for suppliers of power, for consumers or for network operators. The market structures and regulatory mechanisms need to be in place to provide the necessary incentives.

This type of network would ease the participation of DG, RES, DSM and flexible energy storage and would also create opportunities for novel types of equipment and services, all of which would need to respect the protocols and standards adopted. New business and trading opportunities can be envisaged- based on new power sources, new power consumption habits and new regulation, all of which favour cleaner and more efficient generation and consumption as well as the development of a flexible, multi-user connected network which establishes power and communication transfer possibilities among all players.

3.1.2 ICT as an enabler of Grids vision

It is important to emphasise the role of ICT – in particular telecommunications – in adapting electricity networks to the real time actions and managing control distributed in the network, which may not be fully supported by the present internet generation.

Even if the internet protocol is universal, a serious effort is needed to use communications equipment effectively for a distributed real-time control of electricity networks. The real time performance of the internet as communication means is known to be very difficult to assess and it is critical given the power balance needed at any instant in time.

It is possible to conceive such a network but the real hardware, protocols, standards and markets at all levels are more difficult to realise. The question of international regulation must be addressed, not only at the technical but also at the political level.

3.1.2.1 Topics for further development

The following topics require specific ICT related developments.

Monitoring and control of transmission and distribution networks

The high voltage transport grids are mostly completely monitored and controlled throughout the whole of Europe. Medium voltage grids, with voltages between 110 and 50 kV, are not always entirely monitored, and seldom remotely controlled. Low voltage (below 10kV) distribution grids are seldom monitored and hardly ever controlled.

Monitoring and controlling the entire transport and distribution grid is bases on existing technology, however the size of the entire grid, and the amount of data to be processed, complicates this issue.

Research and development is needed to:

1. Complete the existing data models (Common Information Model) and data definitions for transport grids, include definitions for distribution grids (this activity is now 90% complete), and introduce DG, RES as well as DSM functionalities into the data models.
2. Design and build systems to process the monitoring data generated by relatively large distribution grids.

Control Mechanisms

The centralised control, whereby key generators and the high voltage transport grid are controlled from a central control centre, must be replaced by a distributed control architecture which will be coordinated and integrated into existing control methodologies in order to take advantage of the intelligence that will enhance the networks of the future.

Such control mechanisms should be fully automated, and should optimise the following:

1. Generation of electricity for large central generators as well as for relatively small scale DG, RES. Aggregation into VPP should be supported. Optimisation can be one of the following:
    a. Optimise financial result of all generators, based on a market model
    b. Optimise environmental parameters, e.g. set preference to renewable energy sources
    c. Optimise the stability of the grids, and security of energy supply to consumers.
2. Transport and distribution; always to minimise (technical) transport losses.

Research and development is required to define control functionalities and test them.

Energy Markets

The energy markets that are operational at this time are based on purely financial parameters. This could possibly lead to a preference for large scale, high efficiency, generators. If environmental aspects are to be taken into account in the choice for energy generators, then the market model should be changed.

Extensive research and development is required to achieve this. Market structures should allow for intermittent generators (wind and solar energy), and should not penalise intermittent schedule deviations.

Prosumer User Interface

For optimal results DG, or RES, may be controlled by a combination of the following groups:

- Energy traders, with direct access to the electricity market;
- Local installation owners, controlling their own electricity consumption profile;
- Transport or distribution companies, mainly focused on stability of supply.

Each one of the control interfaces must allow for complex decision-support functions. These decision-support functions may also vary in time, or depending on market or grid status.

Decision support functions for the local installation owner should e.g. take into consideration the financial implications of control actions that can be forecast based on market structure, but should also take into consideration the possibility of instability in the distribution or transmission grids.

Prosumer Installation Interface

Besides the basic control of (local) generators, prosumers may also let electricity consumption patterns (profiles) be controlled. This would mean in case of a small scale industry, the control of a production line, with the ability (e.g.) consuming the bulk of the energy for a production cycle in off-peak hours. In case of households (or groups of households), this could mean (e.g.) delaying washing machine cycles until after midnight.

Besides, infrastructural modifications (i.e. installation of metering equipment within production processes or in washing machines), it would also mean an advanced data communication mechanism to acquire measured data and to control instruments.

3.2 Vision for Manufacturing

3.2.1 Manufacturing holistic vision

The ManuFuture Technology Platform (launched in December 2004) is an industry-led initiative [5], which aspires to promote a research oriented strategy that will ensure the future of European manufacturing in a knowledge-based economy. It represents a planning and implementation initiative that defines, prioritizes and coordinates the necessary scientific, technical and economic actions. Manufuture developed a vision for the future of European Manufacturing, which is published in the document “Manufuture –a Vision for 2020”. This document was the basis for the development of a Strategic Research Agenda (SRA).

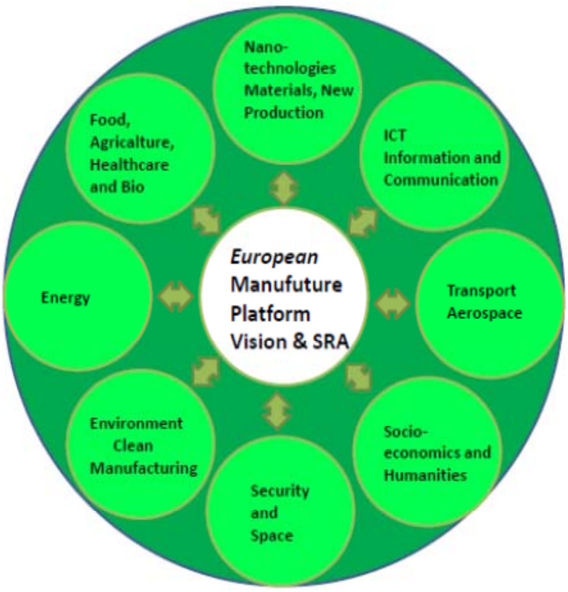

Figure 4 ManuFuture and European Thematic Priorities [6]

As a framework for the vision, the ManuFuture initiative identified main principal drivers of change for the future European Manufacturing sector, these are [5]:

- **Increasingly competitive global economic climate**
  "The industrial context … will depend even more on flexibility and speed, as well as on localised production. Manufacturing is also likely to become increasingly service intensive. This service orientation of manufacturing and the increased customer demand will have consequences for the organisation of production, supply-chain management and customer relations. Furthermore, there is a continuous increase in foreign direct investment in manufacturing outside Europe"
- **Rapid advances in science and technology**
  "Especially in the fields of nanotechnology, materials science, electronics, mechatronics, ICT and biotechnology there will be rapid renewal. The development of new production processes based on research outcomes, and the integration of separate technologies exploiting the converging nature of scientific and technological developments, may radically change both the scope and scale of manufacturing."
- **Environmental challenges and sustainability requirements**
  "The manufacturing sector will also have to comply with stricter environmental regulations in the future, which should further stimulate the adoption of energy- and resource- saving technologies."
- **Socio-democratic aspects**
  "New societal needs and the demands of an increasingly ageing public, having an impact on mobility, the size of the labour force, and on customer requirements. At the level of the labour supply, the manufacturing and research sectors will be confronted with the retirement of the currently large age groups, while innovation might require completely new sets of skills – the availability of which, in both manufacturing and research, could become a critical factor"
- **Regulations and standards**
  "Stricter environmental and safety regulation will lead to changes in manufacturing. The intellectual property rights (IPR) system might have to respond to changes in an innovation process that is increasingly based on knowledge sharing and networking."
- **Values – public acceptability**
  Ethical concerns need urgently to be taken into account, when science and new technology are being adopted and exploited

These global drivers lead to ManuFuture's vision, the so-called "**Knowledge based Competitive and Sustainable Manufacturing (CSM)".** In detail the vision aims a holistic approach towards transforming the European manufacturing industry into a knowledge based sector, capable of competing successfully in the globalised marketplace and considering the following 4 main strategic objectives:

- competitiveness of sustainable European manufacturing industries,
- leadership in manufacturing technologies,
- European leadership in cultural, ethical and social values and
- environment-friendly products and manufacturing, which is broken down into
  - reducing the adverse environmental impact;
  - cutting the consumption of limited resources;
  - boosting the use of renewable resources
  - maximising the benefits of each product throughout its life cycle

The required transformation process of manufacturing industry to achieve these objectives is mainly addresses in two ways: On the one hand there is an urgent need for ***new added-value***

products and services. On the other hand a fundamental concept of the ManuFuture vision is that of ***innovating production***, which includes new business models, new modes of industrial manufacturing engineering and the ability to profit from ground-breaking manufacturing sciences and technologies. In this case the factories in which these new forms of innovating production take place are regarded as complex, long-life products themselves, operating permanently on the highest level of effectiveness (economic, ecological and social) using the latest technologies and adapting continuously to quickly changing requirements of customers and markets.

But the initiative fosters not only the transformation of the industry sector itself, but also the transformation of R&D and Education infrastructure for high value manufacturing and for a more and more "efficient" generation, distribution and use of knowledge in Europe.

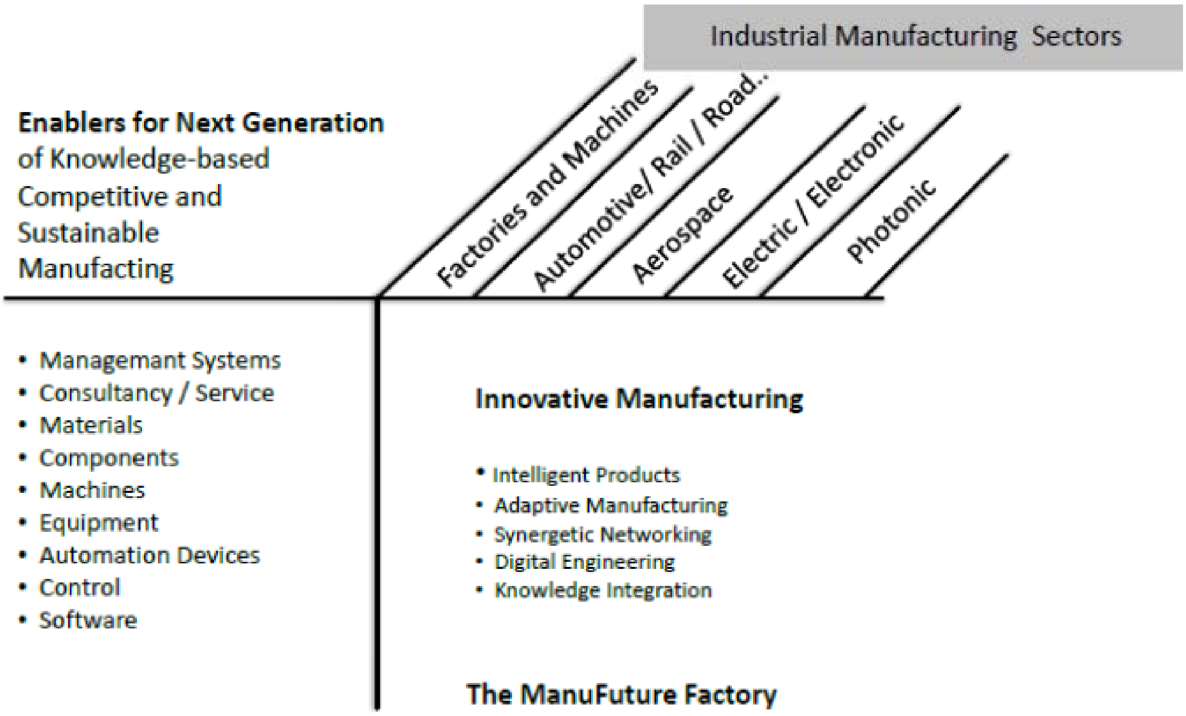

Figure 5 The ManuFuture Factory as European High-Value Product [6]

The key conclusions of the vision are summarized by ManuFuture as followed *[5]*:

- *"There is a need for the development and implementation of a European manufacturing strategy, based on research and innovation, following the ManuFuture approach.*
- *An economy based on service industries alone will not survive in the longer term. As each job in Manufacturing is linked to two jobs in services, the reliance on services cannot continue in the long-term without a competitive EU Manufacturing.*
- *Industrial transformation is a must. In order to meet the competitive, environmental and social challenges, a concerted effort will be needed to transform European manufacturing from a resource intensive to a knowledge intensive, innovative sector capable of achieving and maintaining technological and production leadership in the global market place.*
- *New approach to manufacturing is required – innovating production. The traditional structure of manufacturing industries is constructed upon the three pillars of land, labour and capital. The challenge is to move towards a new structure, which can be described as 'innovating production', founded on knowledge and capital. The*

transition will depend on adoption of new attitudes towards the continued acquisition, deployment, protection and funding of new knowledge.

- *The knowledge-driven economy demands: a competitive and sustainable E&I&RTD system; a new approach to knowledge generation and innovation; adaptation of education and training schemes".*

3.2.1.1 Factories of the Future PPP

The Factories of the Future Public-Private Partnership (FoF PPP) [7], launched under the European Economic Recovery Plan, addresses the development of the next generation of production technologies that will be applied from 2015 onwards. From the manufacturing R&D perspective its vision bases on the Competitive and Sustainable Manufacturing (CSM) vision, and is more or less identical with Manufuture vision. ICT as an enabler of Smart Manufacturing vision

"Information and communication technologies (ICT) are driving the way to knowledge-based and intelligent manufacturing."[6]

The stakeholders of the ManuFuture initiative defined five action fields for competitive and sustainable Manufacturing, whereby the field of Information and Communication Technologies (ICT) received an enabling position in the strategic development.

On a very high level ManuFuture formulates it's vision for ICT enabled the manufacturing as followed: "*research must focus on ICT, mainly involving the use of a wide range of planning tools, software and ICT to integrate new technologies into the design and operation of production systems*".[5]

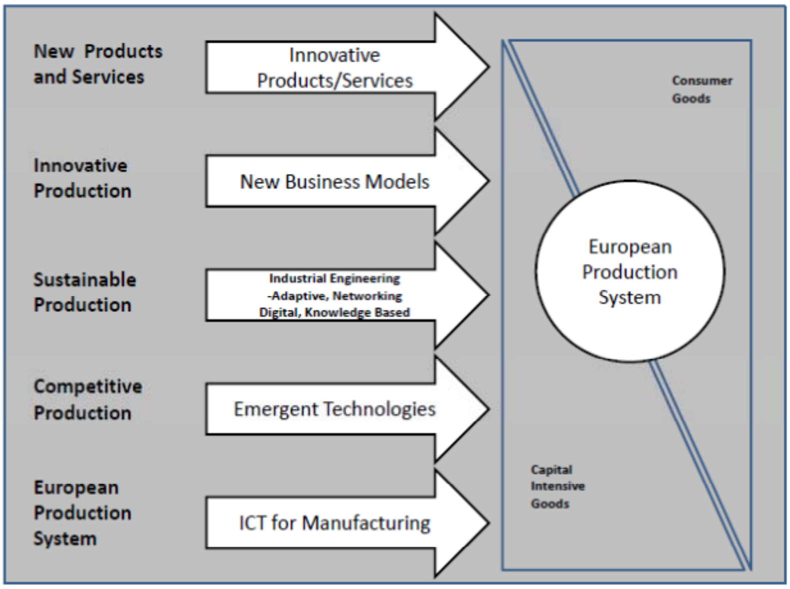

Figure 6 Action Fields for Boosting Manufacturing in Leading Positions [6]

In detail the role of this research will be to [6]:

- *"integrate new technologies with currently applied standards and methodologies (non-disruptive approach),*
- *adapt new technologies according to users' needs, based on modeling at different levels,*

- *develop engineering methodologies for the ubiquitous computer environment in product/process design, control and simulation".*

Concretely the strategic goal in the field of ICT for Manufacturing is defined as followed: *"Manufacturing needs efficient tools for Management, Engineering and Operations with high integration in internal and external ICT architectures and applications. Open systems and embedding electronics enable the realization of high integrated knowledge-based manufacturing. Standards, Modularisation and System Engineering will contribute to the changeability and transformability of manufacturing. In the field of operations, adaptable manufacturing systems and robots support the targets of high efficiency and capability of processes. The enablers of high-performance are intelligent components with embedded electronics and sensors."* [6]

"The vision of long term development is the realisation of real time support with information and a distributed and open network including innovative technologies like wireless, ubiquitous computing, sensor integration, intelligent monitoring etc. The development of future ICT for manufacturing has to take care of the specific requirements of all these processes and specificities of companies." [6]

In fact ICT plays a very important role in all five action fields; however the following two points are significantly driven by ICT:

Action field ICT for Manufacturing refers to transferring next generations of ICT technologies and applications (often driven from home or business sectors) into the manufacturing sector. However the following requirements need to be taken into account for sector specific developments [6]:

- *open systems and architectures of IT systems for manufacturing,*
- *global platforms and standard interfaces for distributed engineering and network management,*
- *a global platform for life cycle management of technical products, vision technologies,*
- *efficient interaction of humans and machines,*
- *solutions for technical intelligence, process monitoring, diagnostics, navigation,*
- *real-time operations from process to networking ,*
- *knowledge management based on data collection, analysis of history and experiences in the life cycle of products,*
- *reliability of systems in high efficient manufacturing execution,*
- *grid technologies for manufacturing engineering.*

ManuFuture indentifies Manufacturing industries as one of the strongest markets of ICT. A detailed Roadmap for the ManuFuture action field "ICT for Manufacturing" is given in Appendix 1 - SMARTT taxonomy

Taxonomy of ICT applications in the 4 sectors as identified in D2.1

The Taxonomy has three levels –

1. Main category aligned to the Life cycle phases and following the SMARTT acronym.
    a. Sub-category allowing for more granular categorisation
        i. RTD's & ICT's detailing the specific areas of research and possible development giving existing or envisaged ICT exemplar's

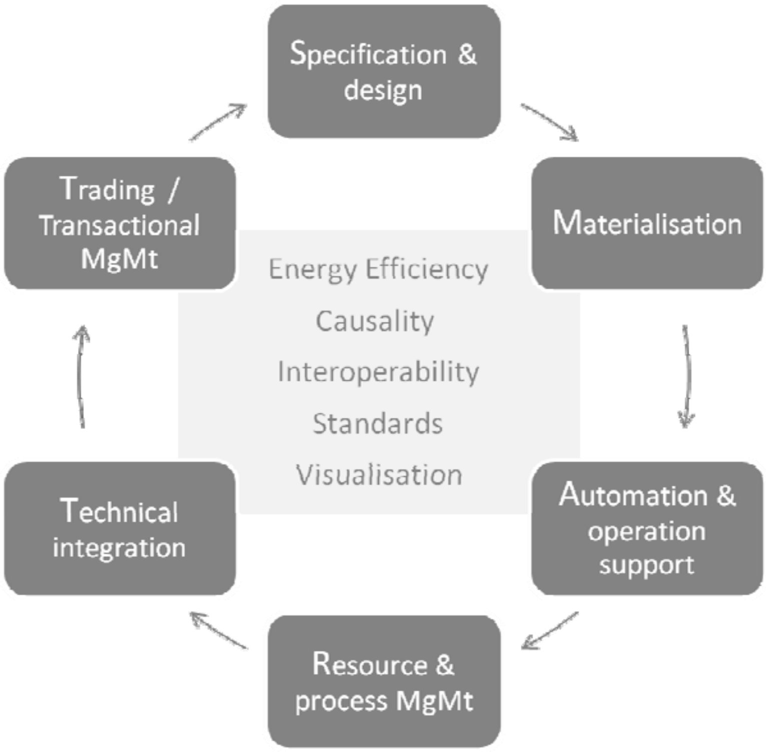

Figure 14 REViSITE SMARTT Taxonomy

2. Specification & design ICT's
    a. Design conceptualisation: requirement engineering/mgmt tools such as Quality Function Deployment tools, concept modelling for design ideation. Building and urban planning applications.
    b. Detailed design: Software design tools, CAD (e.g. Autodesk, 3D studio max), Multimedia (e.g. Flash, Silverlight), Graphics (e.g. Photoshop, Illustrator).
    c. Modelling: all types of technologies that are utilised to systematically describe the physical reality, Life cycle modelling, computer-aided diagramming (e.g. Sankey, Response flow, Cause and effect, influence diagrams etc) some Excel and some CAD applications. Also include are models for the rationalisation of decisions for example computer-interpretable representation and exchange of product/material manufacturing information for materials to be used in construction.
    d. Performance estimation: classical financial based IT applications, ROI, NPV, TCO. Various technologies used to analyse the performance of the target system e.g. Life Cycle Analysis, Finite Element Mode analysis and a wide variety of engineering analysis tools that could also be applied in both the design and materialisation phases.
    e. Simulation: Analysis of the dynamic behaviour of a system as part of the design function. All simulation requires modelling but not all modelling leads to simulation. Example technologies include - CFD, power system simulation, thermal simulation, Wide Area Network simulators etc
    f. Specification & Product / component selection: technologies for design & specification realisation, component selection e.g. material characteristic database & retrieval. (bridge note)

3. Materialisation ICT's

    g. Decision support & visualisation: technologies for visual representation of work flows focused on energy efficient task completion. What if - scenario simulation, & modelling to support real-time decisions in the field. May incorporate automated processing coupled with visual aids or alert mechanisms. Basically, any dynamic technologies that assist with the materialisation of the physical, whether that be a grid, building, factory or lighting infrastructure.

    h. Management & control: adherence to performance requirements, conformance validation, commissioning and phase specific task management in terms of efficient materialisation of the physical building, grid, factory process or lighting infrastructure.

    i. Real-time communication: Any real-time communications that facilitate decision making. E.G. sensor information regarding integrity of building materials during construction integrated into an alert mechanism such as a text or on-screen display.

4. Automation & operational decision support ICT's

    j. Automated monitoring & control: intelligent HVAC, smart (new generation) lighting, automated backend control with little or no human decision interaction. Smart (intelligent) monitoring (metering). Smart (intelligent) metering linked with machine self-actuation adjustment. E.G. energy consumption managed via intelligent control which responds automatically to say gradual electrical load consumption shifting, wastage of energy due to simultaneous heating and cooling, drifting or malfunctioning equipment operation.
    k. Operational decision support & visualisation: Performance management in the usage phase as in the occupancy of a building or in the manufacturing of products or in dynamic load provisioning within the grid. Visualisation and cognitive decision support in terms of energy dashboards and real-time communications regarding usage. What if - simulations to support operational changes for optimal running of manufacturing lines, heating systems or micro-power generation.
    l. Quality of service: backend service provisioning & rightsizing of communication networks. Quality assurance of applications in the field and self-healing of networks, SLA protocols.
    m. Wired/Wireless sensor networks: secure backend wired/wireless communications, dedicated high speed wired/wireless networks, sensor hardware/software so essential to sub-metering strategies, 6LoWPAN, ZigBee PLC etc

5. Resource & process management ICT's

    n. Inter-enterprise coordination: contract & supply network management, process planning & scheduling, procurement, Intra-logistics, elements of Enterprise Resource Planning systems etc

    o. Process integration: collaboration support, groupware tools, electronic conferencing, distributed systems, social-media, business work flows, ERP (front end) systems

p. Knowledge sharing: access to knowledge, knowledge management, knowledge repositories, knowledge mining and semantic search, long-term data archival and recovery. Technologies here are involved in moving data up the up the DIKW (Data, Information, Knowledge, Wisdom) chain in order to add value.

6. Technical Integration ICT's
   q. Technical integration & interoperability: Context and semantic interoperability is as important as technical integration, for example agreement on business processes is as important as data exchange protocols. But the main focus here will be on technical integration. - Technical protocols, formats and standards for say data exchange. Technologies such as middleware, gateways, interfaces, complex-event processing (CEP) with automated response, service orientated architectures and platforms, BMS/FMS backend infrastructure. Backend infrastructure of BIM or ERP systems etc.

7. Trading / transactional management ICT's
   a) District energy management: Distributed 'cloud' based networks for the holistic and sustainable management, trading and brokering of energy resources beyond the limits of one enterprise. Demand response capabilities, real-time self-assessment, load balancing technologies, energy network and integration management, secure, smart (intelligent) interfaces with smart (the new generation) grids. Market Management Systems (MMS), Distribution Management Systems (DMS), transactional aspects of Energy Management Systems etc
   b) Facility energy management: energy specific management systems, energy specific integration platforms and middleware. Smart (intelligent) metering infrastructure and protocols, Context Event Processing, on-demand energy management and optimisation, load and distributed energy resources forecast algorithms, smart (Intteligent) appliances.
   c) Citizen (personnel) energy management: Personal CO2 quota system with interpersonal trade of pollution rights (scope is beyond the buildings category and includes activities like car refuelling). However we may want to include interaction of various agents within a district, those agents could be Buildings, Citizens, vehicles etc.

Appendix 2 - Major European vision on adoption of ICT

<u>Europe 2020</u>

It is worth commencing this section with the initial proposal given by José Manuel Barroso, President of the European Commission: "What I propose is to bring the different strategies and instruments together, adapting them where necessary. In particular, we need to revise the current Lisbon strategy to fit the post 2010 period, turning it into a strategy for an integrated vision of "EU 2020". This strategy for the "EU 2020" will comprise a more convergent and coordinated approach for the reform of Europe's economies through investment in new sources of growth." As a result three mutually reinforcing priorities were identified: (i) EU to become a smart (which uses more ICT for intelligence across all sectors), (ii) sustainable and (iii) inclusive economy should help the EU and the Member States deliver high levels of employment, productivity and social cohesion.

Concretely, the Union has set five ambitious objectives - on employment, innovation, education, social inclusion and climate/energy - to be reached by 2020. The 5 targets for the EU in 2020 are:

- Employment - 75% of the 20-64 year-olds to be employed
- R&D / innovation - 3% of the EU's GDP (public and private combined) to be invested in R&D/innovation
- Climate change / energy greenhouse gas emissions - 20% (or even 30%, if a satisfactory international agreement can be achieved to follow Kyoto) lower than 1990, 20% of energy from renewables and 20% increase in energy efficiency
- Education - reduce school drop-out rates below 10% at least 40% of 30-34–year-olds completing third level education (or equivalent)
- Poverty / social exclusion - at least 20 million fewer people in or at risk of poverty and social exclusion

From Europe 2020 report we can recall to major flagship initiatives;

Flagship Initiative: "A Digital Agenda for Europe"

The aim is to deliver sustainable economic and social benefits from a Digital Single Market based on fast and ultra fast internet and interoperable applications, with broadband access for all by 2013, access for all to much higher internet speeds (30 Mbps or above) by 2020, and 50% or more of European households subscribing to internet connections above 100 Mbps. Some areas that the EU commission has committed to work on at EU level are:

- To create a true single market for online content and services (i.e. borderless and safe EU web services and digital content markets
- To reform the research and innovation funds and increase support in the field of ICTs
- To promote internet access and take-up by all European citizens.

At national level, Member States will need:

- To draw up operational high speed internet strategies, and target public funding;
- To establish a legal framework for coordinating public works to reduce costs of network rollout;
- To promote deployment and usage of modern accessible online services (e.g. e-government, online health, smart home, digital skills, security)

Sustainable growth means building a resource efficient, sustainable and competitive economy, exploiting Europe's leadership in the race to develop new processes and technologies, to prosper in a low-carbon, resource constrained world while preventing environmental degradation, biodiversity loss and unsustainable use of resources. Europe must act for Clean and efficient energy: Meeting our energy goals could result in € 60 billion less in oil and gas imports by 2020. This is not only financial savings; this is essential for our energy security. Further progress with the integration of the European energy market can add an extra 0.6% to 0.8% GDP. Meeting the EU's objective of 20% of renewable sources of energy alone has the potential to create more than 600 000 jobs in the EU. Adding the 20% target on energy efficiency, it is well over 1 million new jobs that are at stake.

Flagship Initiative: "Resource efficient Europe"

The aim is to support the shift towards a resource efficient and low-carbon economy that is efficient in the way it uses all resources. At EU level, the Commission will work:

- To mobilise EU financial instruments as part of a consistent funding strategy, that pulls together EU and national public and private funding;

- To enhance a framework for the use of market-based instruments (e.g. emissions trading, revision of energy taxation, state-aid framework);
- To present proposals to modernise and decarbonise the transport sector thereby contributing to increased competitiveness. This can be done through a mix of measures e.g. infrastructure measures such as early deployment of grid infrastructures of electrical mobility, intelligent traffic management, better logistics, pursuing the reduction of CO2 emissions for road vehicles , for the aviation and maritime sectors including the launch of a major European "green" car initiative;
- To accelerate the implementation of strategic projects with high European added value, in particular cross border sections and inter modal nodes (cities, ports, logistic platforms);
- To complete the internal energy market and implement the strategic energy technologies (SET) plan, promoting renewable sources of energy in the single market;
- To present an initiative to upgrade Europe's networks, including Trans European Energy Networks, towards a European supergrid, smart (new Generation) grid;
- To adopt and implement a revised Energy Efficiency Action Plan and promote a substantial programme in resource efficiency;
- To establish a vision of structural and technological changes required to move to a low carbon, resource efficient and climate resilient economy by 2050, this will also contribute to improving global food security.

At national level, Member States will need:

- To phase out environmentally harmful subsidies, limiting exceptions to people with social needs;
- To deploy market-based instruments such as fiscal incentives and procurement to adapt production and consumption methods;
- To develop smart (intelligent), upgraded and fully interconnected transport and energy infrastructures and make full use of ICT;
- To ensure a coordinated implementation of infrastructure projects, within the EU Core network, that critically contributes to the effectiveness of the overall EU transport system;
- To focus on the urban dimension of transport where much of the congestion and emissions are generated;
- To use regulation, building performance standards and market-based instruments such as taxation subsidies and procurement to reduce energy and resource use and use structural funds to invest in energy efficiency in public buildings and in more efficient recycling
- To incentivise energy saving instruments that could raise efficiency in energy-intensive sectors, such as based on the use of ICTs.

Transformational Agenda from Digital Europe Vision

The Transformational Power of Digital Technologies

The Europe 2020 strategy is rightly focused on competitiveness as the essential condition for economic growth and job-creation in the global 21st century economy.

Competitiveness depends on permanent productivity growth and permanent innovation in products, services, business processes and business models. The priority of any Europe 2020 policy objective should therefore reflect its contribution to both. Europe must urgently close its current productivity gap with major competitors, notably the US and Japan but also now India and China. Due to our ageing population, we have no choice. As the European Commission stresses in its 2009 Ageing Report: “Within a decade, labour productivity will become the main determinant of Europe’s future economic growth.”

The transformational Power of Digital Technologies -"Sector Examples"

Digital technologies will increasingly drive productivity, sustainable growth, innovation and employment throughout the European economy in a myriad of ways. These are best demonstrated at the disaggregated levels of industry sectors, individual organisations and individual empowerment. European trends, case examples and success factors from six sectors help to create a wider vision of productive, innovative digital Europe by 2020:

Energy: Europe's three long-term energy policy objectives are: greater energy independence, reduced greenhouse-gas emissions and a competitive, continental scale Single Market. Starting with our grid infrastructures and extending to consumer control over consumption.
Manufacturing / Automotive: The transformation in all manufacturing sectors to customer-driven innovation based on the sustainable use of resources and integrated manufacturing cycles will depend on the pervasive penetration and use of digital technologies.
Transportation and logistics (T&L): Transport and logistics companies are evolving from forwarding and warehouse-managing companies to highly industrialised, ICT-driven supply-chain providers.
Small- and medium-sized enterprises: Entrepreneurial activity represents 99% of an estimated 23 million enterprises in Europe, which needs access to digital tools, to help eliminate distance, assist in delivery of services, virtual organisations and enhance innovation.
Healthcare: The traditional healthcare delivery model, built around dealing with acute episodes, will no longer be sustainable as European society ages. Harnessing the transformational power of digital technologies is the key for moving to a "continuum of care", while improving quality and productivity.
Individual empowerment: Democratic societies will embrace and respond to the collective and individual voices of their people as they express themselves via digital platforms.

The Future of the ICT – "Sector Europe"

Europe must be both host and home to a dynamic ICT sector that is tightly interwoven with the manufacturing, environmental, cultural, and political fabric. Home-grown ICT is indispensable and nothing less than central to this newborn Digital Age.

No region of the world can maintain its economic strength solely on the basis of imported digital competencies, products and services. Indigenous skills, innovation, products and services are essential for growth and prosperity. No region of the world will be able to maintain the ICT sector needed if that sector is not a leading source of jobs and growth and a leader in global markets - these three sectors are where our future lies:

Next Generation Networks & Mobile Broadband: A vast global market for Mobile Broadband lays ahead, an area in which existing European leadership must be carefully nurtured and exploited as we face the fierce competition set to arrive, particularly Asia.

Software: The innovation necessary to create economic growth, drive societal change and address environmental challenges relies on ICT, at the heart of which is software. But software is moving from being used and perceived as a product to a service. This paradigm shift challenges all current market players and offers huge opportunities for Europe's software industry. This is a new world, with new rules, and Europe must compete.

Future Internet: Many, if not most of these software driven opportunities will arise from the continuous development of the Internet as the primary communications infrastructure of the Digital Age. Key in this respect will be the 'Internet of Things' and the 'Internet of Services'.

<u>Smart 2020 Vision - Enabling the low carbon economy in the information age</u>

The GeSI SMART 2020 report quantified the direct emissions from ICT products and services based on expected growth in the sector. It also looked at where ICT could enable significant reductions of emissions in other sectors of the economy and has quantified these in terms of CO2e emission savings and cost savings.

The enabling impact of ICT represents a significant proportion of the reductions of CO2e emission below 1990 levels that scientists and economists recommend by 2020 to avoid dangerous climate change, The Stern Review suggested that developed countries reduce emissions 20-40% below the 1990 levels would be a necessary interim target based on IPCC and Hadley Centre analysis (Source: Stern, N (2008), Key Elements of a Global Deal on Climate Change, London School of Economics and Political Science [1].

In economic terms, the ICT-enabled energy efficiency translates into approximately €600 billion ($946.5 billion) [2] of cost savings. Exact figures: €553 billion ($872.3 billion) in energy and fuel saved and an additional €91 billion ($143.5 billion) in carbon saved, assuming a cost of carbon of €20/tonne, for a total of €644 billion ($1,015 billion) savings. It is an opportunity that cannot be overlooked.

The analysis identifies some of the biggest and most accessible opportunities for ICT to achieve these savings.

Smart motor systems: Applied globally, optimised motors and industrial automation would reduce 0.97 GtCO2e in 2020, worth €68 billion ($107.2 billion). All value figures here include a cost for carbon of €20/tonne.

Smart logistics: The global emissions savings from smart logistics in 2020 would reach 1.52 GtCO2e, with energy savings worth 280 billion ($441.7 billion).

Smart (new generation) buildings: Globally, smart buildings technologies would enable 1.68 GtCO2e of emissions savings, worth €216 billion ($340.8 billion).

Smart (new generation) grids: through better monitoring and management of electricity grids, first with smart (intelligent) meters and then by integrating more advanced ICTs into the so-called energy internet. Smart (new generation) grid technologies were the largest opportunity found in the study and could globally reduce 2.03 GtCO2e, worth €79 billion ($124 billion).

In addition to the savings possible by supporting other sectors to become more energy efficient, there are also potential energy savings from dematerialisation or substitution – replacing high carbon physical products and activities (such as books and meetings) with virtual low carbon equivalents (e-commerce/e-government and advanced video conferencing). The study indicates that using technology to dematerialise the way we work and operate across public and private sectors could deliver a reduction of 500 MtCO2e in 2020 – the equivalent of the total ICT footprint in 2002, or just under the emissions of the UK in 2007. However, these solutions would need to be more widely implemented than they are today to realise their full abatement potential.

This is the opportunity the ICT sector has in the fight against climate change. But it does come at a cost. Emissions from the sector are estimated to rise significantly over the coming years – from 0.5 GtCO2e today to 1.4 GtCO2e in 2020 under BAU growth. As given in the Smart 2020 report, the scope of this analysis considers whole life emissions from PCs and peripherals, data centres, telecoms networks and devices. While the sector plans to significantly step up the energy efficiency of its products and services, ICT's largest influence will be by enabling energy efficiencies in other sectors, an opportunity that could deliver carbon savings five times larger than the total emissions from the entire ICT sector in 2020.

Emissions reductions in other sectors will not simply present themselves; the ICT sector must demonstrate leadership on climate change and governments must provide the optimum regulatory context. This report outlines the key actions needed.

These actions can be summarised as the **SMART transformation**.

- The challenge of climate change presents an opportunity for ICT to first **standardise (S)** how energy consumption and emissions information can be traced across different processes beyond the ICT sector's own products and services.
- It can **monitor (M)** energy consumption and emissions across the economy in real time, providing the data needed to optimise for energy efficiency.
- Network tools can be developed that allow **accountability (A)** for energy consumption and emissions alongside other key business priorities.
- This information can be used to **rethink (R)** how we should live, learn, play and work in a low carbon economy, initially by optimising efficiency, but also by providing viable low cost alternatives to high carbon activities. Although isolated efficiency gains do have an impact, ultimately it will be a platform – or a set of technologies and architectures – working coherently together, that will have the greatest impact.
- It is through this enabling platform that **transformation (T)** of the economy will occur, when standardisation, monitoring, accounting, optimisation and the business models that drive low carbon alternatives can be developed and diffused at scale across all sectors of the economy.

The ICT sector can't act in isolation if it is to seize its opportunity to tackle climate change. It will need the help of governments and other industries. Smart (intelligent) implementation of ICTs will require policy support including standards implementation; secure communication of information within and between sectors and financing for research and pilot projects.

Figure 15 Summary of Smart 2020 vision key actions as the SMART transformation –focused on bringing about transformation (produced by REViSITE to support vision development)

Other Visions

Green ICT Vision in UK

UK Government recognises the critical importance of ICT both as a large consumer of energy and primary resources and as an enabler for environmental and cultural change.

The Government's vision for ICT in central departments is:

• In line with the existing SOGE targets and SOGE definition for Carbon Neutrality, the energy consumption of Government ICT on the office estate will be Carbon Neutral by 2012. Work is ongoing with Defra to define Carbon Neutrality and how this can be delivered;

• By 2020 Government ICT will be carbon neutral across its lifecycle.

ICT-Enabled Environmentally Smart Buildings: Analysis of UK capabilities and development to 2015

Vision for the UK Industry, developed as a 2015 vision for the UK industry [3] which was considered 'Ambitious but achievable', this comprised the following elements:

1. An EU set of integrated standards for the 'Smart Home will be in place by 2015 to cover interoperability of technologies
2. There will be low cost technologies available (e.g. sensors) together with suitable power management technologies for operation in homes
3. Develop UK expertise in software for optimisation and control of networks of multiple buildings
4. The availability of an energy service offering, enabled by integrate technology offering and changes in OFGEM regulations
5. Building regulations improve to trigger the need for increased energy efficiency

6. A strong UK body exists for ‘Smart Buildings’ which drives standards, provides an effective forum and competence centre for members and lobbies government departments
7. Emergence of major Energy Service Providers in the UK
8. Government investment in UK software sector for development of network monitoring and optimisation software.

Appendix 3 - Trans-sectoral ManuFuture Roadmap: ICT for Manufacturing

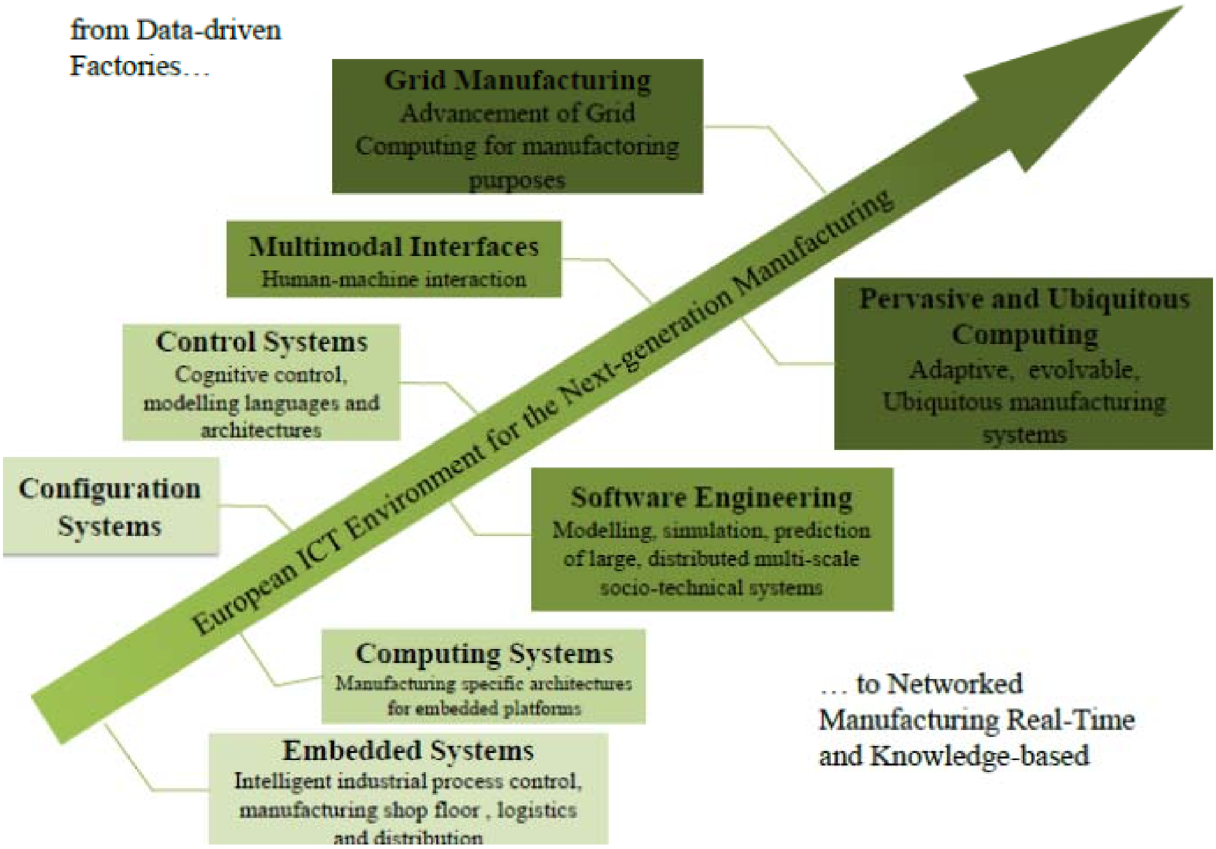

Figure 16 Trans-sectoral ManuFuture Roadmap: ICT for Manufacturing [2]

Appendix 4 - ManuFuture Trans-sectoral Roadmap: Digital, Knowledge-based Engineering

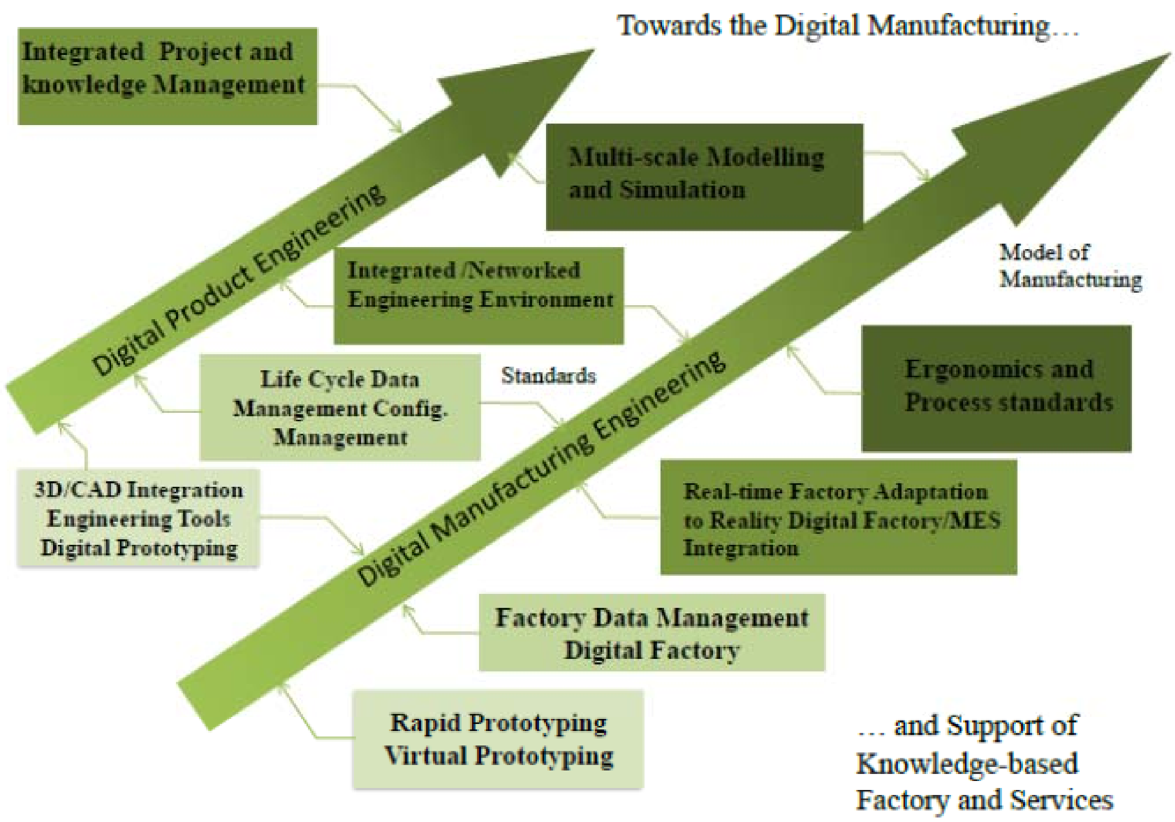

Figure 17 ManuFuture Trans-sectoral Roadmap: Digital, Knowledge-based Engineering [2]

Appendix 5 - Summary of REEB project

The scope is ICT supported energy efficiency of buildings (ICT4EEB). This topic is in the intersection of 3 disciplines: building/construction, ICT and energy. Some examples of relevant items for an integrative approach are listed in the below figure. The baseline of the work was provided by the EC policies and the visions and strategies of a number of related initiatives.

The key target groups the "ICT4EEB community" including e.g. European Technology platforms and RTD projects in the 3 core areas of focus, and the European Commission.

In the short term the immediate target group of the vision report is the REEB consortium for continued work and the REEB Special Interest Group, who advices REEB in the preparation of RTD strategy for the domain.

Most energy usage of buildings throughout their life cycle is during the operational stage (~80%). The decisions made in the conception and design stages of new buildings, as well as in renovation stages of existing buildings, influence about 80% of the total life cycle energy consumption. The impact of user behaviour and real-time control is in the range of 20%.

Currently the energy performance of buildings is mainly driven by regulations. The prevailing market practice is driven by initial investment cost with little attention to life cycle costs. The

awareness of energy efficiency is raising business incentives towards sustainable solutions beyond the required minimum level.

Most of the energy consumed by a building throughout its life cycle is consumed during its operational stage (see Figure 3). The decisions that influence energy consumption are mainly made in the design stage and also in (repeated) renovations. Altogether, many stakeholders, parallel processes and life cycle stages are involved.

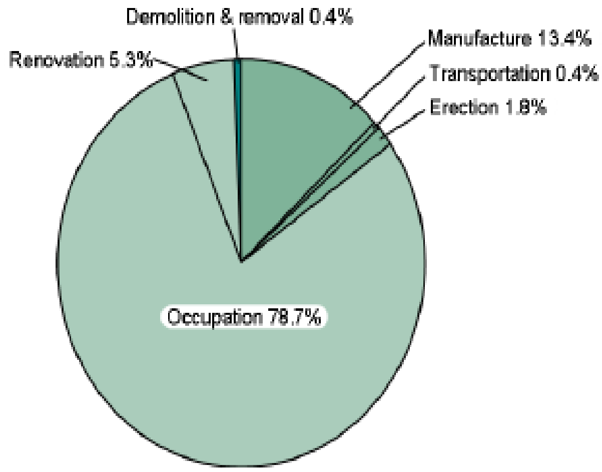

Figure 18 Energy use during life cycle of buildings [2]

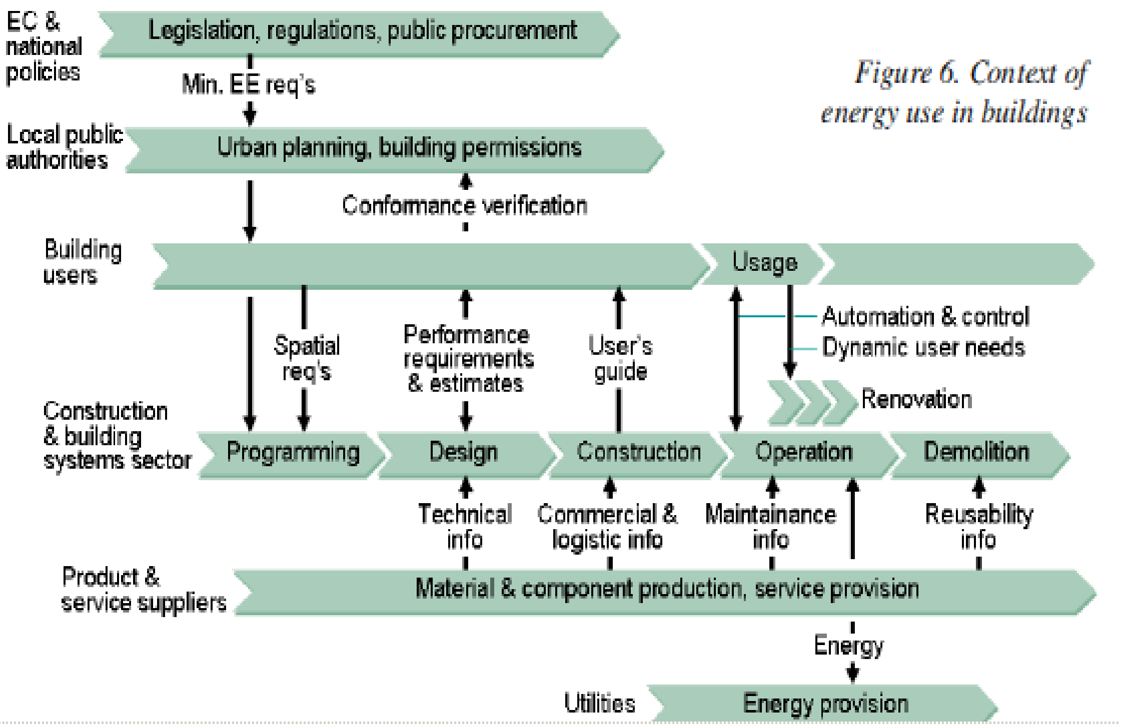

Figure 19 Context of energy use in buildings (as per REEB project)

REEB project has also organised the research topics according to the following structure:

1. Tools for EE design and production management
    - Design: CAD, configuration management, visualisation of design solutions.
    - Production management: contract & supply network management, procurement, logistics, on-site and off-site production management.

- Modelling: building & district modelling, ontologies, semantic mapping.
- Performance estimation: simulation, whole-life costing, life cycle assessment.

2. Intelligent control
    - Automat ion & control: system concepts, intelligent HVAC, smart (new generation) lighting, ICT for micro-generation & storage systems, predictive control.
    - Monitoring: instrumentation: smart (intelligent) metering.
    - Quality of service: improved diagnostics, secure communications.
    - Wireless sensor networks: hardware, operating systems, network design.
3. User awareness and decision support
    - Performance management: Understanding ICT impacts, performance specification, performance metrics, performance analysis and evaluation, conformance validation, commissioning, audits, labelling.
    - Visualisation of energy use.
    - Behavioural change by real-time pricing.
4. Energy management and trading
    - Building and district energy management: building management systems, metering infrastructure, on-demand energy management and optimisation, load and distributed energy resources forecast algorithms, smart (intelligent) appliances.
    - Smart (new generation) grids: demand response capabilities, real-time self-assessment, load balancing techniques, energy network design and integration, secure, ubiquitous and low-latency communications.
5. Integration technologies
    - Process integration: collaboration support, groupware tools, electronic conferencing, distributed systems, business work flows.
    - System integration: plug & play, connections, service oriented architectures, integration and service platforms, cabling, gateways, middleware, development methods and tools.
    - Interoperability & standards: BIM standardisation, simulation and interoperability, protocols for real time operation, energy trading protocols.
    - Knowledge sharing: access to knowledge, knowledge management, knowledge
    - Repositories, knowledge mining and semantic search, long-term data archival and recovery.
    - Virtualisation of the built environment.

Action field Digital, knowledge based Engineering refers to the ICT enabled manufacturing engineering which includes according to [6] the holistic engineering of products and production systems. This planning requires integrated knowledge based engineering tools "with a core in standardised factory data management and a full set of specific tools from process planning to multi scale modeling and simulation" [6].

A detailed Roadmap for the ManuFuture action field "Digital, Knowledge-based Engineering" is given in Appendix 1 - SMARTT taxonomy

Taxonomy of ICT applications in the 4 sectors as identified in D2.1

The Taxonomy has three levels –

8. Main category aligned to the Life cycle phases and following the SMARTT acronym.

a. Sub-category allowing for more granular categorisation

i. RTD's & ICT's detailing the specific areas of research and possible development giving existing or envisaged ICT exemplar's

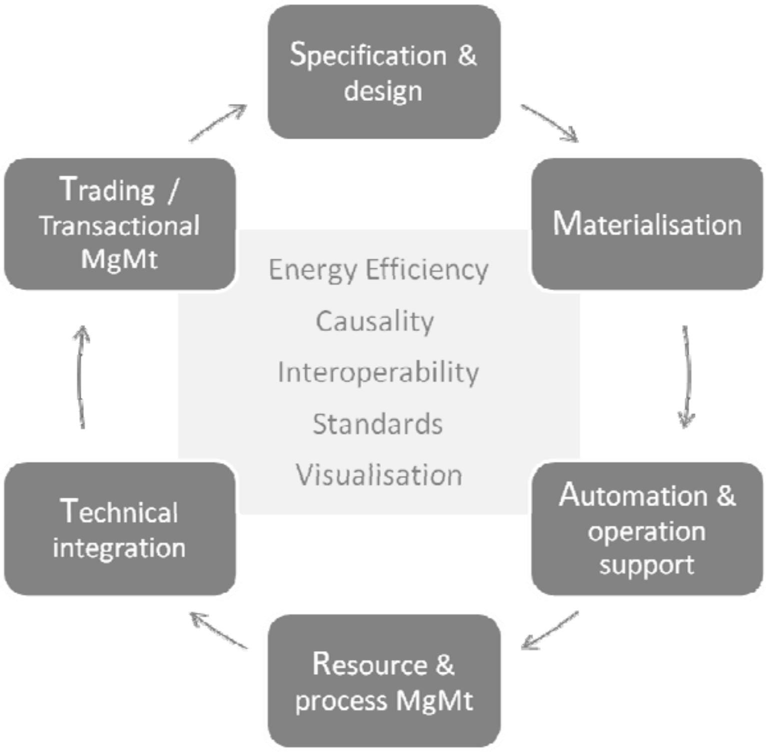

Figure 14 REViSITE SMARTT Taxonomy

9. Specification & design ICT's
    r. Design conceptualisation: requirement engineering/mgmt tools such as Quality Function Deployment tools, concept modelling for design ideation. Building and urban planning applications.
    s. Detailed design: Software design tools, CAD (e.g. Autodesk, 3D studio max), Multimedia (e.g. Flash, Silverlight), Graphics (e.g. Photoshop, Illustrator).
    t. Modelling: all types of technologies that are utilised to systematically describe the physical reality, Life cycle modelling, computer-aided diagramming (e.g. Sankey, Response flow, Cause and effect, influence diagrams etc) some Excel and some CAD applications. Also include are models for the rationalisation of decisions for example computer-interpretable representation and exchange of product/material manufacturing information for materials to be used in construction.
    u. Performance estimation: classical financial based IT applications, ROI, NPV, TCO. Various technologies used to analyse the performance of the target system e.g. Life Cycle Analysis, Finite Element Mode analysis and a wide variety of engineering analysis tools that could also be applied in both the design and materialisation phases.
    v. Simulation: Analysis of the dynamic behaviour of a system as part of the design function. All simulation requires modelling but not all modelling leads to simulation. Example technologies include - CFD, power system simulation, thermal simulation, Wide Area Network simulators etc

w. Specification & Product / component selection: technologies for design & specification realisation, component selection e.g. material characteristic database & retrieval. (bridge note)

10. Materialisation ICT's

x. Decision support & visualisation: technologies for visual representation of work flows focused on energy efficient task completion. What if - scenario simulation, & modelling to support real-time decisions in the field. May incorporate automated processing coupled with visual aids or alert mechanisms. Basically, any dynamic technologies that assist with the materialisation of the physical, whether that be a grid, building, factory or lighting infrastructure.

y. Management & control: adherence to performance requirements, conformance validation, commissioning and phase specific task management in terms of efficient materialisation of the physical building, grid, factory process or lighting infrastructure.

z. Real-time communication: Any real-time communications that facilitate decision making. E.G. sensor information regarding integrity of building materials during construction integrated into an alert mechanism such as a text or on-screen display.

11. Automation & operational decision support ICT's

aa. Automated monitoring & control: intelligent HVAC, smart (new generation) lighting, automated backend control with little or no human decision interaction. Smart (intelligent) monitoring (metering). Smart (intelligent) metering linked with machine self-actuation adjustment. E.G. energy consumption managed via intelligent control which responds automatically to say gradual electrical load consumption shifting, wastage of energy due to simultaneous heating and cooling, drifting or malfunctioning equipment operation.

bb. Operational decision support & visualisation: Performance management in the usage phase as in the occupancy of a building or in the manufacturing of products or in dynamic load provisioning within the grid. Visualisation and cognitive decision support in terms of energy dashboards and real-time communications regarding usage. What if - simulations to support operational changes for optimal running of manufacturing lines, heating systems or micro-power generation.

cc. Quality of service: backend service provisioning & rightsizing of communication networks. Quality assurance of applications in the field and self-healing of networks, SLA protocols.

dd. Wired/Wireless sensor networks: secure backend wired/wireless communications, dedicated high speed wired/wireless networks, sensor hardware/software so essential to sub-metering strategies, 6LoWPAN, ZigBee PLC etc

12. Resource & process management ICT's

ee. Inter-enterprise coordination: contract & supply network management, process planning & scheduling, procurement, Intra-logistics, elements of Enterprise Resource Planning systems etc ff. Process integration: collaboration support, groupware tools, electronic conferencing, distributed systems, social-media, business work flows, ERP (front end) systems

gg. Knowledge sharing: access to knowledge, knowledge management, knowledge repositories, knowledge mining and semantic search, long-term data archival and recovery. Technologies here are involved in moving data up the up the DIKW (Data, Information, Knowledge, Wisdom) chain in order to add value.

13. Technical Integration ICT’s

hh. Technical integration & interoperability: Context and semantic interoperability is as important as technical integration, for example agreement on business processes is as important as data exchange protocols. But the main focus here will be on technical integration. - Technical protocols, formats and standards for say data exchange. Technologies such as middleware, gateways, interfaces, complex-event processing (CEP) with automated response, service orientated architectures and platforms, BMS/FMS backend infrastructure. Backend infrastructure of BIM or ERP systems etc.

14. Trading / transactional management ICT’s

d) District energy management: Distributed ‘cloud’ based networks for the holistic and sustainable management, trading and brokering of energy resources beyond the limits of one enterprise. Demand response capabilities, real-time self-assessment, load balancing technologies, energy network and integration management, secure, smart (intelligent) interfaces with smart (the new generation) grids. Market Management Systems (MMS), Distribution Management Systems (DMS), transactional aspects of Energy Management Systems etc

e) Facility energy management: energy specific management systems, energy specific integration platforms and middleware. Smart (intelligent) metering infrastructure and protocols, Context Event Processing, on-demand energy management and optimisation, load and distributed energy resources forecast algorithms, smart (Intteligent) appliances.

f) Citizen (personnel) energy management: Personal CO2 quota system with interpersonal trade of pollution rights (scope is beyond the buildings category and includes activities like car refuelling). However we may want to include interaction of various agents within a district, those agents could be Buildings, Citizens, vehicles etc.

Appendix 2 - Major European vision on adoption of ICT

Europe 2020

It is worth commencing this section with the initial proposal given by José Manuel Barroso, President of the European Commission: “What I propose is to bring the different strategies and instruments together, adapting them where necessary. In particular, we need to revise the current Lisbon strategy to fit the post 2010 period, turning it into a strategy for an integrated vision of "EU 2020". This strategy for the "EU 2020" will comprise a more convergent and coordinated approach for the reform of Europe's economies through investment in new sources of growth.” As a result three mutually reinforcing priorities were identified: (i) EU to become a smart (which uses more ICT for intelligence across all sectors), (ii) sustainable and

(iii) inclusive economy should help the EU and the Member States deliver high levels of employment, productivity and social cohesion.

Concretely, the Union has set five ambitious objectives - on employment, innovation, education, social inclusion and climate/energy - to be reached by 2020. The 5 targets for the EU in 2020 are:

- Employment - 75% of the 20-64 year-olds to be employed
- R&D / innovation - 3% of the EU's GDP (public and private combined) to be invested in R&D/innovation
- Climate change / energy greenhouse gas emissions - 20% (or even 30%, if a satisfactory international agreement can be achieved to follow Kyoto) lower than 1990, 20% of energy from renewables and 20% increase in energy efficiency
- Education - reduce school drop-out rates below 10% at least 40% of 30-34–year-olds completing third level education (or equivalent)
- Poverty / social exclusion - at least 20 million fewer people in or at risk of poverty and social exclusion

From Europe 2020 report we can recall to major flagship initiatives;

Flagship Initiative: "A Digital Agenda for Europe"

The aim is to deliver sustainable economic and social benefits from a Digital Single Market based on fast and ultra fast internet and interoperable applications, with broadband access for all by 2013, access for all to much higher internet speeds (30 Mbps or above) by 2020, and 50% or more of European households subscribing to internet connections above 100 Mbps. Some areas that the EU commission has committed to work on at EU level are:

- To create a true single market for online content and services (i.e. borderless and safe EU web services and digital content markets
- To reform the research and innovation funds and increase support in the field of ICTs
- To promote internet access and take-up by all European citizens.

At national level, Member States will need:

- To draw up operational high speed internet strategies, and target public funding;
- To establish a legal framework for coordinating public works to reduce costs of network rollout;
- To promote deployment and usage of modern accessible online services (e.g. e-government, online health, smart home, digital skills, security)

Sustainable growth means building a resource efficient, sustainable and competitive economy, exploiting Europe's leadership in the race to develop new processes and technologies, to prosper in a low-carbon, resource constrained world while preventing environmental degradation, biodiversity loss and unsustainable use of resources. Europe must act for Clean and efficient energy: Meeting our energy goals could result in € 60 billion less in oil and gas imports by 2020. This is not only financial savings; this is essential for our energy security. Further progress with the integration of the European energy market can add an extra 0.6% to 0.8% GDP. Meeting the EU's objective of 20% of renewable sources of energy alone has the potential to create more than 600 000 jobs in the EU. Adding the 20% target on energy efficiency, it is well over 1 million new jobs that are at stake.

Flagship Initiative: "Resource efficient Europe"

The aim is to support the shift towards a resource efficient and low-carbon economy that is efficient in the way it uses all resources. At EU level, the Commission will work:

- To mobilise EU financial instruments as part of a consistent funding strategy, that pulls together EU and national public and private funding;
- To enhance a framework for the use of market-based instruments (e.g. emissions trading, revision of energy taxation, state-aid framework);
- To present proposals to modernise and decarbonise the transport sector thereby contributing to increased competitiveness. This can be done through a mix of measures e.g. infrastructure measures such as early deployment of grid infrastructures of electrical mobility, intelligent traffic management, better logistics, pursuing the reduction of CO2 emissions for road vehicles , for the aviation and maritime sectors including the launch of a major European "green" car initiative;
- To accelerate the implementation of strategic projects with high European added value, in particular cross border sections and inter modal nodes (cities, ports, logistic platforms);
- To complete the internal energy market and implement the strategic energy technologies (SET) plan, promoting renewable sources of energy in the single market;
- To present an initiative to upgrade Europe's networks, including Trans European Energy Networks, towards a European supergrid, smart (new Generation) grid;
- To adopt and implement a revised Energy Efficiency Action Plan and promote a substantial programme in resource efficiency;
- To establish a vision of structural and technological changes required to move to a low carbon, resource efficient and climate resilient economy by 2050, this will also contribute to improving global food security.

At national level, Member States will need:

- To phase out environmentally harmful subsidies, limiting exceptions to people with social needs;
- To deploy market-based instruments such as fiscal incentives and procurement to adapt production and consumption methods;
- To develop smart (intelligent), upgraded and fully interconnected transport and energy infrastructures and make full use of ICT;
- To ensure a coordinated implementation of infrastructure projects, within the EU Core network, that critically contributes to the effectiveness of the overall EU transport system;
- To focus on the urban dimension of transport where much of the congestion and emissions are generated;
- To use regulation, building performance standards and market-based instruments such as taxation subsidies and procurement to reduce energy and resource use and use structural funds to invest in energy efficiency in public buildings and in more efficient recycling
- To incentivise energy saving instruments that could raise efficiency in energy-intensive sectors, such as based on the use of ICTs.

Transformational Agenda from Digital Europe Vision

The Transformational Power of Digital Technologies

The Europe 2020 strategy is rightly focused on competitiveness as the essential condition for economic growth and job-creation in the global 21st century economy.

Competitiveness depends on permanent productivity growth and permanent innovation in products, services, business processes and business models. The priority of any Europe 2020 policy objective should therefore reflect its contribution to both. Europe must urgently close its current productivity gap with major competitors, notably the US and Japan but also now India and China. Due to our ageing population, we have no choice. As the European

Commission stresses in its 2009 Ageing Report: "Within a decade, labour productivity will become the main determinant of Europe's future economic growth."

The transformational Power of Digital Technologies -"Sector Examples"

Digital technologies will increasingly drive productivity, sustainable growth, innovation and employment throughout the European economy in a myriad of ways. These are best demonstrated at the disaggregated levels of industry sectors, individual organisations and individual empowerment. European trends, case examples and success factors from six sectors help to create a wider vision of productive, innovative digital Europe by 2020:

Energy: Europe's three long-term energy policy objectives are: greater energy independence, reduced greenhouse-gas emissions and a competitive, continental scale Single Market. Starting with our grid infrastructures and extending to consumer control over consumption.
Manufacturing / Automotive: The transformation in all manufacturing sectors to customer-driven innovation based on the sustainable use of resources and integrated manufacturing cycles will depend on the pervasive penetration and use of digital technologies.
Transportation and logistics (T&L): Transport and logistics companies are evolving from forwarding and warehouse-managing companies to highly industrialised, ICT-driven supply-chain providers.
Small- and medium-sized enterprises: Entrepreneurial activity represents 99% of an estimated 23 million enterprises in Europe, which needs access to digital tools, to help eliminate distance, assist in delivery of services, virtual organisations and enhance innovation.
Healthcare: The traditional healthcare delivery model, built around dealing with acute episodes, will no longer be sustainable as European society ages. Harnessing the transformational power of digital technologies is the key for moving to a "continuum of care", while improving quality and productivity.
Individual empowerment: Democratic societies will embrace and respond to the collective and individual voices of their people as they express themselves via digital platforms.

The Future of the ICT – "Sector Europe"

Europe must be both host and home to a dynamic ICT sector that is tightly interwoven with the manufacturing, environmental, cultural, and political fabric. Home-grown ICT is indispensable and nothing less than central to this newborn Digital Age.

No region of the world can maintain its economic strength solely on the basis of imported digital competencies, products and services. Indigenous skills, innovation, products and services are essential for growth and prosperity. No region of the world will be able to maintain the ICT sector needed if that sector is not a leading source of jobs and growth and a leader in global markets - these three sectors are where our future lies:

Next Generation Networks & Mobile Broadband: A vast global market for Mobile Broadband lays ahead, an area in which existing European leadership must be carefully nurtured and exploited as we face the fierce competition set to arrive, particularly Asia.

Software: The innovation necessary to create economic growth, drive societal change and address environmental challenges relies on ICT, at the heart of which is software. But software is moving from being used and perceived as a product to a service. This paradigm shift challenges all current market players and offers huge opportunities for Europe's software industry. This is a new world, with new rules, and Europe must compete.

Future Internet: Many, if not most of these software driven opportunities will arise from the continuous development of the Internet as the primary communications infrastructure of the Digital Age. Key in this respect will be the 'Internet of Things' and the 'Internet of Services'.

Smart 2020 Vision - Enabling the low carbon economy in the information age

The GeSI SMART 2020 report quantified the direct emissions from ICT products and services based on expected growth in the sector. It also looked at where ICT could enable significant reductions of emissions in other sectors of the economy and has quantified these in terms of CO2e emission savings and cost savings.

The enabling impact of ICT represents a significant proportion of the reductions of CO2e emission below 1990 levels that scientists and economists recommend by 2020 to avoid dangerous climate change, The Stern Review suggested that developed countries reduce emissions 20-40% below the 1990 levels would be a necessary interim target based on IPCC and Hadley Centre analysis (Source: Stern, N (2008), Key Elements of a Global Deal on Climate Change, London School of Economics and Political Science [1].

In economic terms, the ICT-enabled energy efficiency translates into approximately €600 billion ($946.5 billion) [2] of cost savings. Exact figures: €553 billion ($872.3 billion) in energy and fuel saved and an additional €91 billion ($143.5 billion) in carbon saved, assuming a cost of carbon of €20/tonne, for a total of €644 billion ($1,015 billion) savings. It is an opportunity that cannot be overlooked.

The analysis identifies some of the biggest and most accessible opportunities for ICT to achieve these savings.

Smart motor systems: Applied globally, optimised motors and industrial automation would reduce 0.97 GtCO2e in 2020, worth €68 billion ($107.2 billion). All value figures here include a cost for carbon of €20/tonne.

Smart logistics: The global emissions savings from smart logistics in 2020 would reach 1.52 GtCO2e, with energy savings worth 280 billion ($441.7 billion).

Smart (new generation) buildings: Globally, smart buildings technologies would enable 1.68 GtCO2e of emissions savings, worth €216 billion ($340.8 billion).

Smart (new generation) grids: through better monitoring and management of electricity grids, first with smart (intelligent) meters and then by integrating more advanced ICTs into the so-called energy internet. Smart (new generation) grid technologies were the largest opportunity found in the study and could globally reduce 2.03 GtCO2e, worth €79 billion ($124 billion).

In addition to the savings possible by supporting other sectors to become more energy efficient, there are also potential energy savings from dematerialisation or substitution – replacing high carbon physical products and activities (such as books and meetings) with virtual low carbon equivalents (e-commerce/e-government and advanced video conferencing). The study indicates that using technology to dematerialise the way we work and operate across public and private sectors could deliver a reduction of 500 MtCO2e in 2020 – the equivalent of the total ICT footprint in 2002, or just under the emissions of the UK in 2007. However, these solutions would need to be more widely implemented than they are today to realise their full abatement potential.

This is the opportunity the ICT sector has in the fight against climate change. But it does come at a cost. Emissions from the sector are estimated to rise significantly over the coming years – from 0.5 $GtCO_2e$ today to 1.4 $GtCO_2e$ in 2020 under BAU growth. As given in the Smart 2020 report, the scope of this analysis considers whole life emissions from PCs and peripherals, data centres, telecoms networks and devices. While the sector plans to significantly step up the energy efficiency of its products and services, ICT's largest influence will be by enabling energy efficiencies in other sectors, an opportunity that could deliver carbon savings five times larger than the total emissions from the entire ICT sector in 2020.

Emissions reductions in other sectors will not simply present themselves; the ICT sector must demonstrate leadership on climate change and governments must provide the optimum regulatory context. This report outlines the key actions needed.

These actions can be summarised as the **SMART transformation**.

- The challenge of climate change presents an opportunity for ICT to first **standardise (S)** how energy consumption and emissions information can be traced across different processes beyond the ICT sector's own products and services.
- It can **monitor (M)** energy consumption and emissions across the economy in real time, providing the data needed to optimise for energy efficiency.
- Network tools can be developed that allow **accountability (A)** for energy consumption and emissions alongside other key business priorities.
- This information can be used to **rethink (R)** how we should live, learn, play and work in a low carbon economy, initially by optimising efficiency, but also by providing viable low cost alternatives to high carbon activities. Although isolated efficiency gains do have an impact, ultimately it will be a platform – or a set of technologies and architectures – working coherently together, that will have the greatest impact.
- It is through this enabling platform that **transformation (T)** of the economy will occur, when standardisation, monitoring, accounting, optimisation and the business models that drive low carbon alternatives can be developed and diffused at scale across all sectors of the economy.

The ICT sector can't act in isolation if it is to seize its opportunity to tackle climate change. It will need the help of governments and other industries. Smart (intelligent) implementation of ICTs will require policy support including standards implementation; secure communication of information within and between sectors and financing for research and pilot projects.

Figure 15 Summary of Smart 2020 vision key actions as the SMART transformation –focused on bringing about transformation (produced by REViSITE to support vision development)

Other Visions

Green ICT Vision in UK

UK Government recognises the critical importance of ICT both as a large consumer of energy and primary resources and as an enabler for environmental and cultural change.

The Government's vision for ICT in central departments is:

• In line with the existing SOGE targets and SOGE definition for Carbon Neutrality, the energy consumption of Government ICT on the office estate will be Carbon Neutral by 2012. Work is ongoing with Defra to define Carbon Neutrality and how this can be delivered;

• By 2020 Government ICT will be carbon neutral across its lifecycle.

ICT-Enabled Environmentally Smart Buildings: Analysis of UK capabilities and development to 2015

Vision for the UK Industry, developed as a 2015 vision for the UK industry [3] which was considered 'Ambitious but achievable', this comprised the following elements:

9. An EU set of integrated standards for the 'Smart Home will be in place by 2015 to cover interoperability of technologies
10. There will be low cost technologies available (e.g. sensors) together with suitable power management technologies for operation in homes
11. Develop UK expertise in software for optimisation and control of networks of multiple buildings
12. The availability of an energy service offering, enabled by integrate technology offering and changes in OFGEM regulations
13. Building regulations improve to trigger the need for increased energy efficiency

14. A strong UK body exists for 'Smart Buildings' which drives standards, provides an effective forum and competence centre for members and lobbies government departments
15. Emergence of major Energy Service Providers in the UK
16. Government investment in UK software sector for development of network monitoring and optimisation software.

Appendix 3 - Trans-sectoral ManuFuture Roadmap: ICT for Manufacturing

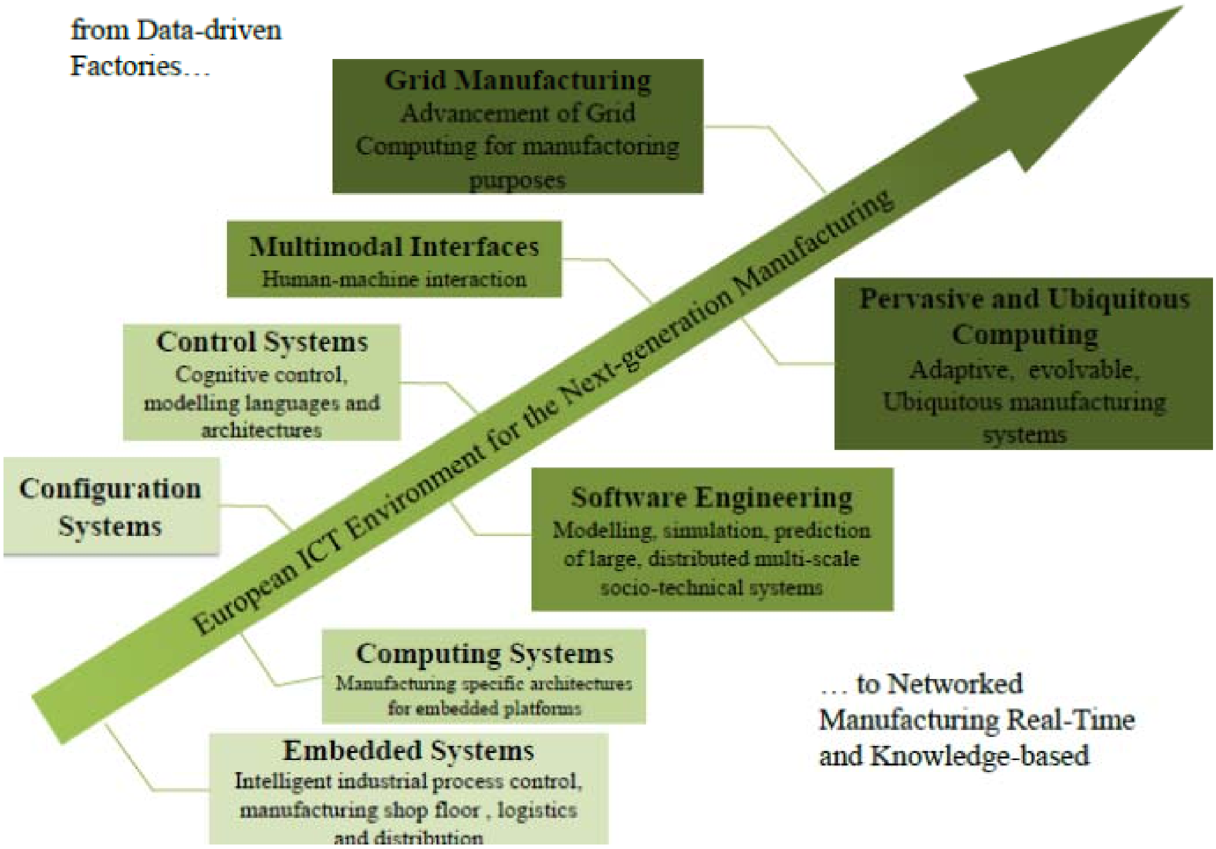

Figure 16 Trans-sectoral ManuFuture Roadmap: ICT for Manufacturing [2]

Appendix 4 - ManuFuture Trans-sectoral Roadmap: Digital, Knowledge-based Engineering

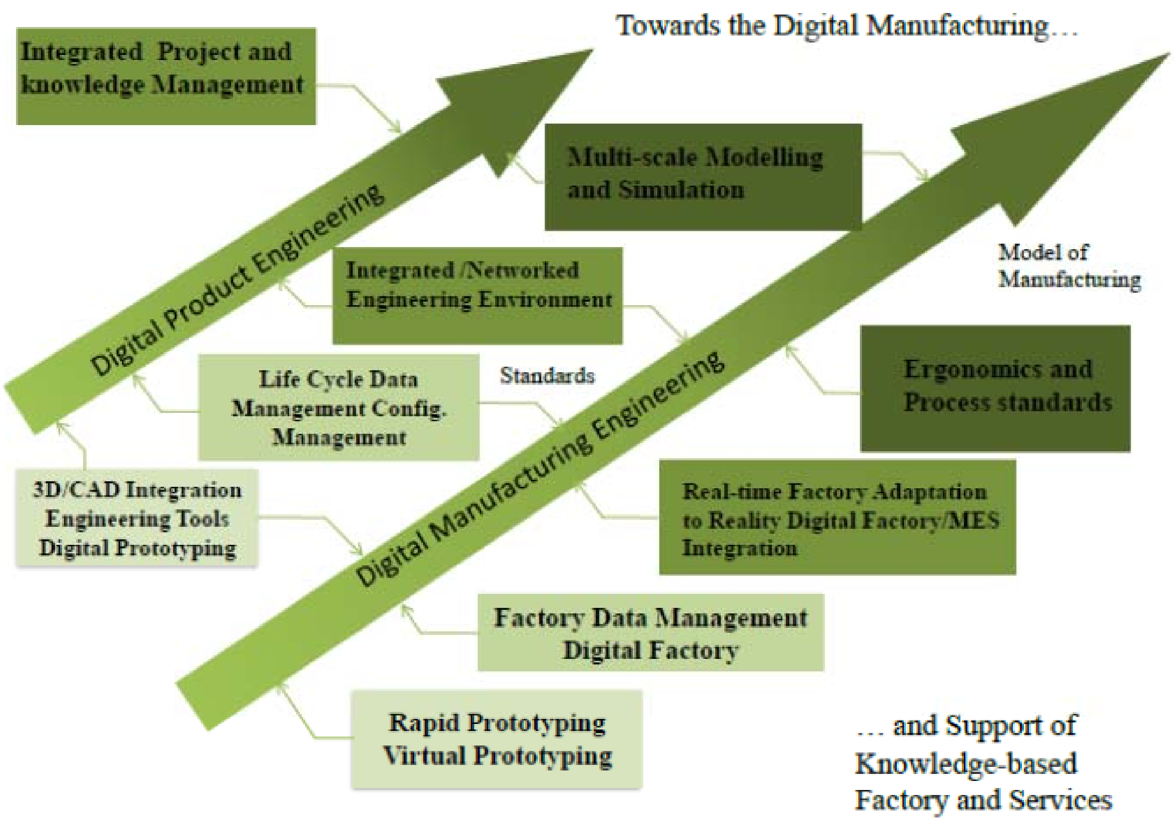

Figure 17 ManuFuture Trans-sectoral Roadmap: Digital, Knowledge-based Engineering [2]

Appendix 5 - Summary of REEB project

The scope is ICT supported energy efficiency of buildings (ICT4EEB). This topic is in the intersection of 3 disciplines: building/construction, ICT and energy. Some examples of relevant items for an integrative approach are listed in the below figure. The baseline of the work was provided by the EC policies and the visions and strategies of a number of related initiatives.

The key target groups the “ICT4EEB community” including e.g. European Technology platforms and RTD projects in the 3 core areas of focus, and the European Commission.

In the short term the immediate target group of the vision report is the REEB consortium for continued work and the REEB Special Interest Group, who advices REEB in the preparation of RTD strategy for the domain.

Most energy usage of buildings throughout their life cycle is during the operational stage (~80%). The decisions made in the conception and design stages of new buildings, as well as in renovation stages of existing buildings, influence about 80% of the total life cycle energy consumption. The impact of user behaviour and real-time control is in the range of 20%.

Currently the energy performance of buildings is mainly driven by regulations. The prevailing market practice is driven by initial investment cost with little attention to life cycle costs. The

awareness of energy efficiency is raising business incentives towards sustainable solutions beyond the required minimum level.

Most of the energy consumed by a building throughout its life cycle is consumed during its operational stage (see Figure 3). The decisions that influence energy consumption are mainly made in the design stage and also in (repeated) renovations. Altogether, many stakeholders, parallel processes and life cycle stages are involved.

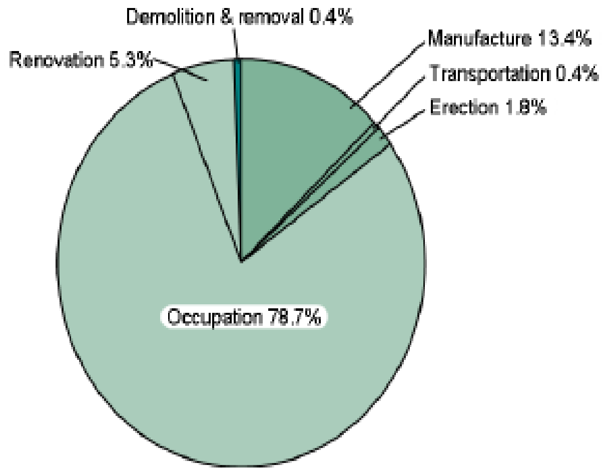

Figure 18 Energy use during life cycle of buildings [2]

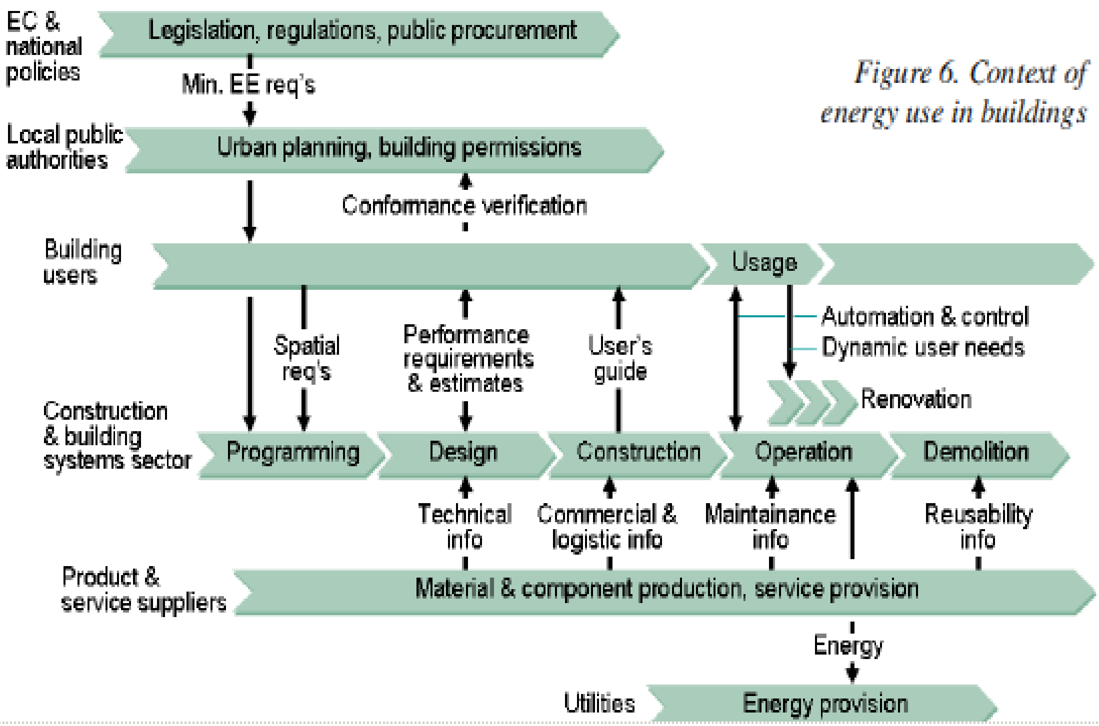

Figure 19 Context of energy use in buildings (as per REEB project)

REEB project has also organised the research topics according to the following structure:

6. Tools for EE design and production management
   - Design: CAD, configuration management, visualisation of design solutions.
   - Production management: contract & supply network management, procurement, logistics, on-site and off-site production management.

- Modelling: building & district modelling, ontologies, semantic mapping.
- Performance estimation: simulation, whole-life costing, life cycle assessment.

7. Intelligent control
    - Automat ion & control: system concepts, intelligent HVAC, smart (new generation) lighting, ICT for micro-generation & storage systems, predictive control.
    - Monitoring: instrumentation: smart (intelligent) metering.
    - Quality of service: improved diagnostics, secure communications.
    - Wireless sensor networks: hardware, operating systems, network design.
8. User awareness and decision support
    - Performance management: Understanding ICT impacts, performance specification, performance metrics, performance analysis and evaluation, conformance validation, commissioning, audits, labelling.
    - Visualisation of energy use.
    - Behavioural change by real-time pricing.
9. Energy management and trading
    - Building and district energy management: building management systems, metering infrastructure, on-demand energy management and optimisation, load and distributed energy resources forecast algorithms, smart (intelligent) appliances.
    - Smart (new generation) grids: demand response capabilities, real-time self-assessment, load balancing techniques, energy network design and integration, secure, ubiquitous and low-latency communications.
10. Integration technologies
    - Process integration: collaboration support, groupware tools, electronic conferencing, distributed systems, business work flows.
    - System integration: plug & play, connections, service oriented architectures, integration and service platforms, cabling, gateways, middleware, development methods and tools.
    - Interoperability & standards: BIM standardisation, simulation and interoperability, protocols for real time operation, energy trading protocols.
    - Knowledge sharing: access to knowledge, knowledge management, knowledge
    - Repositories, knowledge mining and semantic search, long-term data archival and recovery.
    - Virtualisation of the built environment.

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3.3 Vision for Buildings

3.3.1 Buildings holistic vision

Green House Gases production of our societies have been clearly outlined as the major cause of global warming and have been at the heart of the first real world wide action, the Kyoto protocol. These gases are essentially the by-products of fossil fuel consumption. The built environment is a prime contributor with an estimated average energy consumption , in most developed countries, of approximately 40%, with Green House Gases close to 33%. In most industrialized countries, the construction industry is aware of these facts and of its responsibilities.

The 20/20 targets are to reduce energy consumption by 20%, reduce CO_2 emissions by 20% and provide 20% of the total energy share with renewable energy. In order to help the construction industry reach the 20/20 targets and achieve energy neutral buildings and districts by 2050 the European Construction Technology Platform (ECTP) has set up the Energy Efficient Building European Initiative (E2B EI), steered by the Energy Efficient Buildings Association (E2BA) founded in November 2008.

The ECTP foresees in a near future, that the built environment in Europe could be designed, built or renovated with high energy efficiency, and at the same time improve the quality of life of European citizens. By 2050, most buildings and districts could become energy neutral, and have a zero CO_2 emission.

A significant number of buildings would then be energy positive, thus becoming real power plants, integrating renewable energy sources, clean distributed generation technologies and integrated the grids at district level.

ECTP has developed a Strategic Research Agenda (SRA) that was published at the end of 2005 (http://www.ectp.org/documentation/ECTP-SRA-2005_12_23.pdf)

ECTP SRA defines strategic research priorities, around three axes, in 13 chapters:

1. Meeting client and user requirements

2. Becoming sustainable

3. Transformation of the construction sector

In June 2007, ECTP published an associated roadmap:

(http://www.ectp.org/documentation/SRA_IAPv1.pdf) proposing an Implementation Action Plan of the SRA.

This SRA/IAP explains how exactly the research themes defined in the SRA should be implemented in the coming years and describes how ECTP and its stakeholders would facilitate this process, and which parties to involve. The Implementation Action Plan of the Strategic Research Agenda of ECTP explains how the research themes defined in the SRA should be implemented in the period 2007-2013 and describes how ECTP and its stakeholders would facilitate this process, and which parties to involve.

Nine ECTP priorities for the period 2007 to 2013

The selection of the most important and urgent research areas of the SRA, which should be strategically dealt with in the period 2007-2013, was carried out through a prioritization process organised from November 2005 to September 2006) in the framework of the ECTP and its comprehensive Network of National Technology Platforms.

From the 13 main areas of the SRA, a set of 9 major Priorities, with a limited number of well agreed research items (around 60, instead of 160 in the SRA), was selected for implementation in the period 2007-2013.

These nine priorities are following. They are presented according to their appearance order in the SRA and the sections of the SRA document relating to each priority which is indicated between brackets.

A. Technologies for Healthy, Safe, Accessible and Stimulating Indoor Environments for All (SRA §1.1)
B. Innovative Use of Underground Space (SRA §1.3)
C. New Technologies, Concepts and High-tech Materials for Efficient and Clean Buildings (SRA §2.1)
D. Reduce Environmental and Man-made Impacts of Built Environment and Cities (SRA §2.2-1.2)
E. Sustainable Management of Transports and Utilities Networks (SRA §2.3-1.4)
F. A Living Cultural Heritage for an Attractive Europe (SRA §2.4)
G. Improve Safety and Security within the Construction Sector (SRA §2.5)
H. New Integrated Processes for the Construction Sector (SRA §3.2-3.1-3.4)
I. High Added Value Construction Materials (SRA §3.3)

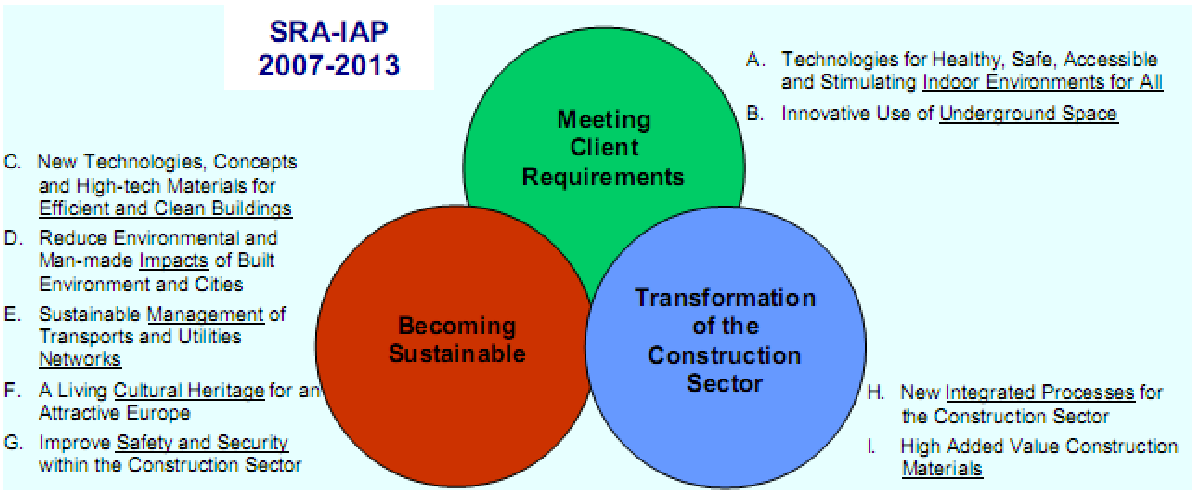

Figure 7 The 3 pillars of the ECTP SRA and the 9 IAP priorities

Priorities A and B focus on the "meeting client requirements" research area of the SRA, addressing the basic building block of indoor spaces plus the special situation of underground spaces.

Priorities C-G are orientated around the "becoming sustainable" research area of the SRA, moving from buildings, to built environments/cities, and then to the level of transport and utilities networks. In addition there are two cross-cutting priorities areas of heritage and safety/security.

Finally, Priorities H and I concern the "transformation of the construction sector" research area of the SRA and, logically for an assembly industry, focus on integrated processes and innovative materials."

In the scope of REViSITE, the priority H is particularly of importance as the ICTs have been identified as the main innovation driver in most industries and core enabler of economic growth in the 21st century (NESSI 2006). Process renewal, supported by ICT, is one of the main vehicles towards the vision of the ECTP.

The Vision, in that field, is that Construction is a highly information intensive industry which uses state-of-the- art technologies in all processes and products in order to satisfy client's expectations in a sustainable way. As a knowledge-based industry it offers attractive workplaces for skilled and well educated personnel. European construction industry works competitively on the open global market supported by flexible SME-based supply networks.

Aiming at this vision, the objectives of the proposed R&D are to develop the 8 following RTD topics:

1. Value-driven business processes

- Main drivers: Performance-driven process, value to customer, total life-cycle support, product and service customisation.
- Key R&D topics: Performance-driven processes, process orchestration, metrics, indicators, requirement engineering, mass customisation, life cycle performance assessment.

ICT should allow dealing with customer-centric definition of products and services, management of requirements being instrumental in providing what the end users want (especially how functional requirements are translated into design and production requirements), support for capturing and fulfilling predefined performance criteria. ICT should also support scheduling & planning with information transfer between applications used in different stages of the construction process.

2. Industrialised production

- Main drivers: Effective manufacturing and construction. Supply network management; Open market.
- Key R&D topics: ICT support for modular provision of customised constructions, logistics, on-site production and assembly. Integration of construction site in the process.

The RTD targeting Industrialised Production is driven by two main trends:

- evolving EU-wide open market in constructions,
- increasing productivity throughout the supply network including the construction site, as well as the challenge to be able to produce individually and tailor-made industrialised construction elements.

3. Digital models

- Main drivers: Semantics and interoperability, User and lifecycle orientation, Real-time adaptive models.

- Key R&D topics: nD models providing access to life time information for all stakeholders anywhere anytime. ICT applications for design, configuration, analysis, simulation, and visualisation.

  ICT should support scheduling & planning with information transfer between applications used in different stages of the construction process.

4. Intelligent constructions

- Main drivers: Integrated automation and control (connectivity), Remote diagnostics and control (serviceability) -> Context-aware seamless configurability (adaptability).
- Key R&D topics: Intelligent embedded systems & devices for monitoring and control, embedded learning & user support.

  The R&D targeting the intelligent constructions and buildings is to be developed around three fundamental pillars:

  - The "**intelligent" objects**: these objects (including multi-functional materials) must have embedded electronic chips, as well as the appropriate resources to achieve local computing and interact with the outside, therefore being able to manage appropriate protocol(s) so as to acquire and supply information.
  - The **communications**: these must allow sensors, actuators, indeed all intelligent objects to communicate among them and with services over the network. They have to be based on protocols that are standardised and open.
  - The **multimodal interactive interfaces**: the ultimate objective of those interfaces is to make the in-house network as simple to use as possible, thanks to a right combination of intelligent and interoperable services, new techniques of man-machine interactions (wearable computing, robots, …), and learning technologies for all communicating objects. These interfaces should also be means to share ambient information spaces or ambient working environments thanks to personal advanced communication devices.

5. Interoperability

- Main drivers: Migrate from data/file exchange to data sharing and ultimately to flexible interoperability.
- Key R&D topics: Model servers; Distributed adaptive components; Ontology's & open ICT standards for semantic communication; ICT infrastructures.

  R&D is required to transform the current eBusiness processes environment(s) into fully integrated / interoperable innovative semantical eServices supporting structured and harmonised processes in Construction, with a focus on all ICT technologies and tools that may support such an evolution. This includes:

  - Providing seamless semantic (forward and backward) communication (object exchange and sharing), to support both interfacing and synchronisation between actors;
  - Integrating (open and standardised) nD modelling technologies, Semantic Knowledge Technologies (SKT), Grid-based Computing, and Global Optimisation methods, along with intuitive visual and interactive user interfaces;
  - Developing and refining architectures for construction product/service life-cycles and their associated supply chains, that are adapted to the Construction sector (especially SMEs), with easy methods and techniques for specialisation;

- Offering flexible access to IT-based business services, semantic information resources and Content repositories / libraries of re-usable solutions, with standardized global identification of construction objects;
- Offering capability to provide services for installing, maintaining and monitoring these advanced systems (strengthening the role of system integrators in construction).

6. Collaboration support

- Main drivers: Rapid and easy connectivity - robust team interaction - seamless inter-enterprise integration.
- Key R&D topics: ICT tools for information sharing, project steering, negotiations, decision support, risk mitigation, etc.

7. Knowledge sharing

- Main drivers: Access to knowledge - sharing structured knowledge - context-aware knowledge.
- Key R&D topics: ICT for transforming project experiences into corporate assets. Object repositories. IPR protection of complex shared data. Context aware applications.

A wide range of different ICT based tools and services necessary for moving an organization towards a dynamic knowledge management will be developed in the next years. ICT should be essential not only for the storage of tacit and explicit knowledge in web based repositories but also as a communication device allowing ubiquitous access to organizational knowledge anywhere, anytime.

8. ICT enabled business models

- Main drivers: Business networking, customer orientation & sustainability, system integration, specialisation.
- Key R&D topics: New ways for sustainable exploitation of ICT as a key part of business strategy in the open European / global construction marketplace. Management tools and services to support inter-organisational collaboration across products and services

The ICT-based solutions should be, among others:

- Innovative e-Business solutions, especially for SMEs, supported by open, interoperable, modular and adaptive ICT-based platforms that would also allow integration of enterprise applications.
- Pan-European multi-lingual “information resource points” accessible and “valuable” all across Europe. This will be done through the promotion of the semantic web and its related technologies applied to the Construction needs.
- Solutions for Sustainability management, through optimised management of multi-constraints systems, and improved cooperative development towards “sustainable construction model(s)”.

ECTP has also analysed the potential synergies that these topics of the priority H could have with other ETPs. The results are presented in the table below.

Other European Technology Platforms *At least 18 other ETPs address construction related topics.*	**Prior. H →** **Synergy**	**H1 BP**	**H2 IP**	**H3 DM**	**H4 IC**	**H5 IO**	**H6 CS**	**H7 KS**	**H8 BM**
ARTEMIS – Embedded intelligence and systems	High	-	M	-	H	H	H	-	-
E-MOBILITY – Mobile and wireless communications	Medium	-	M	-	M	M	H	-	M
EPoSS – Smart systems integration (RFID, …)	Medium	-	H	-	M	-	-	-	-
ERRAC – Rail	Medium	L	L	L	H	H	-	M	L
ERTRAC – Road transport	High	H	H	H	H	H	M	H	H
ESTEP – Steel	Medium	M	H	-	-	-	-	M	M
ESTTP – European Solar Thermal Technology Platform	?	SRA not yet available							
ETPIS – Industrial safety	Low	-	M	-	-	-	-	M	-
EUMAT – Engineering materials and technologies	Low	-	-	M	-	-	-	M	-
EUROP – Robotics	Low	-	M	-	-	-	-	-	-
FTP – Forest	Low	-	L	-	-	-	-	-	-
MANUFUTURE – Manufacturing	High	H	H	H	H	H	H	H	H
NEM – Networked and electronic media	Medium		M		H	M	M	M	M
NESSI – Networked software and services	High	M	-	M	-	H	H	H	H
PLANTS	None	-	-	-	-	-	-	-	-
SMARTGRIDS – Electricity networks	Low	-	-	-	M	-	-	-	-
SUSCHEM – Chemistry	Low	-	-	-	M	-	-	-	-
WSSTP – Water supply & sanitation	None	-	-	-	-	-	-	-	-

Table 3 Relationships among ECTP-SRA/IAP priorities and other ETPs

3.3.2 ICT as an enabler of Buildings vision

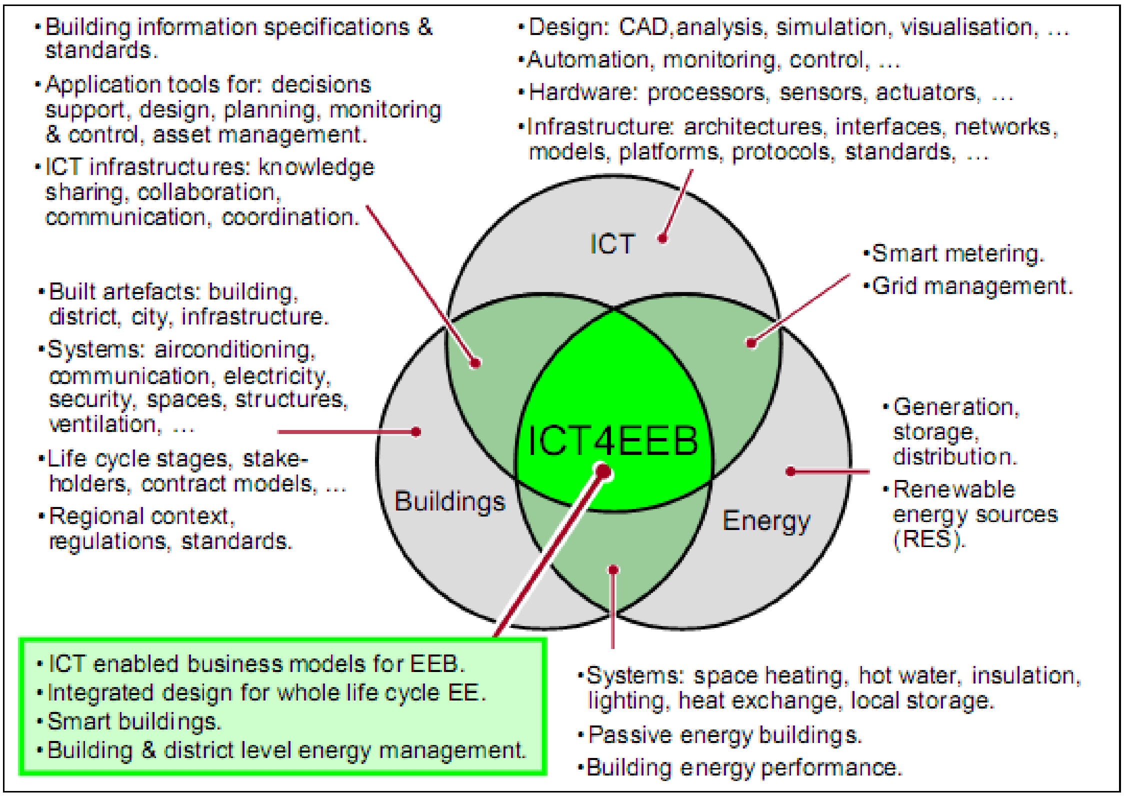

Figure 8 Scope of the ICT4EEB vision: integration of technologies for buildings, ICT and energy

The Term Smart Building will be understood in this chapter as “Energy Efficient” Building and therefore the scope will be here on ICT supporting energy efficiency of buildings (ICT4EEB). This topic is in the intersection of 3 disciplines: building/construction, ICT and energy. Some examples of relevant items for an integrative approach are listed in the below figure.

The relevance of ICT on the energy efficiency of buildings is mainly as follows:

- Short term: Assuring compliance to regulated minimum energy performance levels in design and renovation stages.
- Medium term: Decision support for life cycle cost/performance optimisation. Real time operation, control and user empowerment.
- Long term: Holistic optimisation of built environments considering: energy generation and usage of individual buildings, energy balancing between buildings within a district, responding to grid load and feeding excess energy into the grid. New business models driven by whole life time performance.

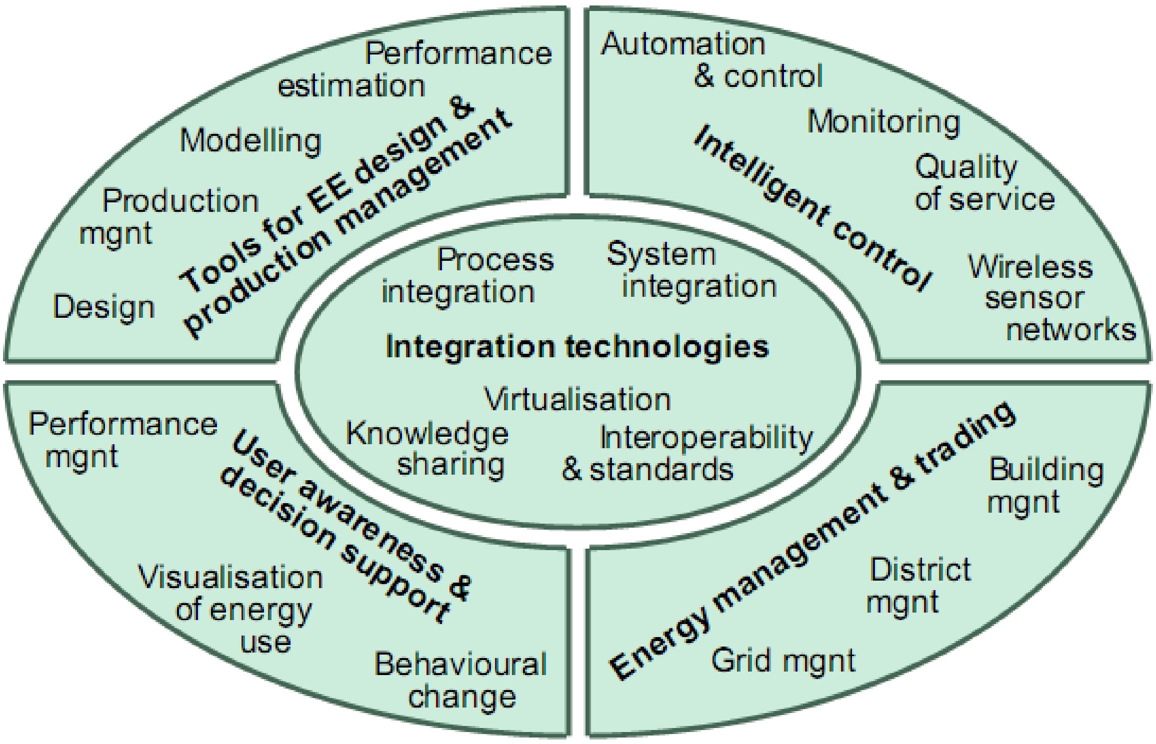

Figure 9 RTD priorities in the “ICT for energy efficient buildings” domain (REEB)

The REEB project (http://www.ict-reeb.eu/) has established a Roadmap regarding ICT4EE in Building. A summary on the REEB project can also be found in Appendix 5.

3.4 Vision for Lighting

3.4.1 Lighting vision

Current trends in lighting are the change from gas discharge lamps to LED lighting, increase in regulation and new features enabled by ICTs.

According to Haitz's Law LED light output per unit is increasing twenty times per decade while the price is decreasing to one tenth. According to U.S: DoE forecast white LED's luminous efficacy (lumen/watt) will be greater than 200 lm/W by 2015 [8]. Figure is for one LED without driver losses, size 1 mm^2 and continuous current 350 mA. At the same time LED luminaire efficacy would reach 170 lm/W (cool white LED including current driver and optical losses of the luminaire). These figures show that LED lighting systems have potential to overcome all existing light sources in efficiency performance.

Two practical consequences of Eco-design directive (EuP Directive 2005/32/EC and a recast of the Directive 2009/125/EC) will be that almost all incandescent lamps will be phased from the market by 2012 and high pressure mercury lamps by 2015.

LED have also the ability to reduce total costs. Even if the initial investment is higher that with conventional light sources, the maintenance and energy costs savings will cover the investment costs, because of the long lamp life and energy efficiency.

Photonics 21 sees that LEDs will have freedom in shape offering new design and application opportunities as well as full tenability of brightness and colour [9].

In addition to energy savings and thus greenhouse gas reduction LED will offer new features in human well-being and quality of light; safety and information with light. Enhancing the experience of a space is an important lighting function.

Technological developments in SSL open up new application areas. The manipulation of the light spectrum, intensity, spatial and temporal distribution will become increasingly important in future lighting products for ambiance, health and well-being applications.

Biological effects like the suppression of the sleeping hormone melatonin are mainly dependent on the blue portion of the light spectrum. The positive biological effects of light are so far commonly acknowledged for health care applications like the treatment of Seasonal Affective Disorder. By optimizing the blue content of lamps for daily use in home, office and industrial applications it is expected to positively influence the circadian rhythm and well-being of people.

Personal mobility is a basic component of our modern society. Light does not only guide and control the traffic, but is also a crucial element for road safety. In future, traffic lights, signal lamps, street lamps as well as displays and luminaires in vehicles will be joined by further intelligent optical systems. [8]

According to Bhardwaj *et. al.* A smart lighting system, which corresponds to the REViSITE smart lighting system, refers to a system where multiple luminaries with actuators and light sensors are connected in a network, and cooperate. This lighting system is composed of two or more heterogeneous networks based on different platforms as a heterogeneous lighting system. The objective of a lighting system is to provide adaptive light control that will continuously satisfy users' preferences for each activity. To achieve this in a heterogeneous lighting system, information regarding light state needs to be transferred to nodes and users across different network types through multiple communication protocols. In a heterogeneous network, low capacity nodes such as wireless sensors and distributed light actuators on the one side, and high capacity nodes such as mobile handhelds and laptops on the other side may coexist. The low capacity nodes need to function despite strict constraints on resources such as processing power, memory, storage, energy, bandwidth and transmission range. [10]

Miki *et. al.* are using the term ”intelligent lighting system”, which refers to a system where multiple lighting fixtures are connected to a network, and user needs are met by cooperation of the various lighting fixtures. Intelligent lighting system has the following features [11]:

1) Autonomous distributed control

In an intelligent lighting system, there is no element with control over the entire system. Illuminance at each location is controlled by having each light perform learning operation. There is no central control unit, so the system has high robustness against malfunction, and a high reliability system can be achieved even in large scale buildings. The system has outstanding features: It is easy to add lighting fixtures and lighting sensors, and there is no need, at installation, to set things like ID nos. and layout information for each lighting fixture or lighting sensor.

2) Achieving a switching pattern not dependent on wiring

In today’s illumination systems, the only switching pattern which can be realized is that determined by the wiring pattern. However, with the intelligent lighting system proposed here, it is possible to realize an arbitrary switching pattern which is not dependent on the wiring of lights. Furthermore, it is possible to switch on lighting devices with any desired luminance. Therefore, the system conserves energy by not switching on unneeded lights.

3) Achieving autonomous lighting control

With this intelligent lighting system, the user simply sets a target illuminance, and the system can automatically determine the necessary lighting, without making the user aware of the location of lights, and thus can provide the appropriate illuminance to the appropriate location.

In the lighting technology roadmap in 2020, lighting systems in buildings and other applications will [12]:

- Enhance the performance and well-being of people
- Adapt easily to the changing needs of any user
- Use all sources of light efficiently and effectively
- Function as true systems, fully integrated with other systems (rather than as collections of independent components)
- Create minimal impacts on the environment during their manufacturing, installation, maintenance, operations, and disposal

As a result, people will understand, value, and utilize the tangible, personal benefits provided by these lighting systems.

Achieving the visions will need different strategies to transform the market and develop technology. One of the technology development strategies is to develop lighting controls with high levels of intelligence, interface capabilities, multiple levels of control, and ease of configuration. The technologies should have following attributes/capabilities the three first ranked as #1. [11]

- Enable easy installation (e.g., self-configuring and friendly to non-experts).
- Develop controls that are self-teaching, intuitive, easy to use.
- Develop universal control and communication protocols for component interconnection (such as BACnet or Echelon).
- Create a dialogue with energy management companies and lighting control industry in an effort to develop simple, easy-to-use controls.
- Incorporate anticipatory logic so systems learn and adapt to user preference.
- Sense multiple inputs to configure and define lighting environments to user (color, room temperature, user temperature, user mood, eyesight of user, occupancy of room, motion, activity type, time of day, daylight levels).
- Allow ease of programming by time of day and date.
- Improve robustness (e.g., non-volatile memory).
- Establish interactive linkage between the lighting, HVAC, and other system controls.
- Provide some control at building level (range of levels, override).
- Develop a universal building interface (remote control and monitoring) for load shedding, optimization of lighting/heat, preventive maintenance.
- For public spaces, develop control systems that accommodate multiple uses of the space.
- Develop control systems that serve emergency-response needs.
- Develop control systems that monitor status of settings.

Smart Lighting Engineering Research Centre [13] have found following applications and impacts:

- Energy efficient lighting systems – lighting systems interfaced to external grid and building systems
- Comfort – the right light where you want it.
- Health – therapeutic lighting
- Productivity – adaptive lighting systems
- Information – lighting and data at the same time. Data as a modulation of light with high frequency.

Smart lighting systems integrate a range of technologies to simultaneously decrease energy usage while improving functionality. They also include commissioning and configuration tools, sensing, networking and on-board decision-making to deliver right kind of light. Beyond energy savings this lighting systems form the backbone of many buildings. Sensor-enabled fixtures collect data on usage patterns and provide that data to users for measurements and verification. Open interfaces enable cross-compatibility and are designed for simple integration with other building automation systems. These capabilities are the part of the transformation from simple inefficient illumination to value-added system.

Research is developing LEDs with improved efficiency, polarization, colour conversion, high-speed modulation, wavelength selectivity, and spatial distribution. LEDs are controlled by the feedback based on sensors. [14]

Zhang presents new technology landscape for lighting. In the technology side the benefits come from increase in efficiency, decrease in costs, miniaturization, retrofits, and forma and fixture revolution. On the other hand the function of illumination is enriched with new features related to health and wellbeing, emotion and perception, horticulture and food, mobility and safety and intelligence. Lighting will respond to people's biological, psychological and sociological needs. [15]

Road Lighting

Road lighting levels are excessive in many cases. For instance, in the case of low traffic volumes, the lighting levels are excessive and could be reduced. On the other hand, in specific situations and for traffic safety reasons, light levels could be increased even in the case of low traffic volume.

Telemanagement with networking and automation technology allows for control of individual lamps, adjustment of light levels, and instant lamp fault reports. In addition to the energy saving advantages, the adjustment of light levels can also contribute to the reduction of light pollution, while instant lamp fault reports can contribute to savings in maintenance and to increased safety.

Different words are used to describe lighting control systems, e.g. telemanagement, adaptive, dynamic and intelligent control systems. The names used are similar; nevertheless there are differences between them. The light levels in telemanagement lighting control systems can be adjusted adaptively, dynamically or intelligently. In the case when the light levels can be adjusted in real time or according to a predefined time schedule, the lighting system is called adaptive or dynamic. An adaptive or dynamic lighting control system can be intelligent when light levels are adjusted real time based on predefined parameters. [16]

Walraven estimates that total electricity for road lighting in Europe is 59, 76 TWh per year. From this it is possible to save 37 % by replacing the lamp, luminaire and ballast. Telemanagement in such an installation can be as high as 45% off this number when applied fully bringing the total energy savings up to about 66% of a conventional older installation.

Based on our total consumption calculations this means for Europe that we can save as much as 63.7 % on our energy consumption in outdoor light what would mean an annual saving of 38,06 TWh. [17]

An important document which has dealt with the Smart Lighting is the: Ad Hoc Advisory Group ICT for Energy Efficiency Consultation Group - Lighting & Photonic Technologies - Document drafted by Bruno Smets & Berit Wessler in consultation with Photonics21, ELC, CELMA & E2B [18].

3.4.2 ICT as an enabler of lighting vision

The technologies should have following ICT related attributes/capabilities:

- Easy installation (e.g. self-configuring and friendly to non-experts).
- Universal control and communication protocols for component interconnection (such as BACnet or Echelon).
- Simple controls, that are self-teaching, intuitive and easy to use.
- Anticipatory logic so that systems can learn and adapt to user preference.

- Sensing multiple inputs to configure and define lighting environments to user (colour, room temperature, user temperature, user mood, eyesight of user, occupancy of room, motion, activity type, time of day, daylight levels).
- Ease of programming by time of day and date.
- Interaction between electrical lighting, daylight use, blinds, shades, active facades, HVAC and other system controls. This interaction offers substantial energy savings.
- Improved robustness (e.g. non-volatile memory).
- Control at building level (range of levels, override).
- Universal building interface (remote control and monitoring) for load shedding, optimization of lighting/heat, preventive maintenance.
- Control systems that serve emergency-response needs.
- Control systems that monitor status of settings.
- Control systems that accommodate multiple uses of public spaces.

3.5 Mapping sector specific visions against taxonomy categories

This process was conducted through a mapping table (see Table 5), where ICT related components from the reviewed sector specific visions were clustered under SMARTT taxonomy categories as follows, Table 5 is a summary of all the components from the reviewed visions across the 4 sectors. It shows the comparison of sectoral visions against the proposed first stage REViSITE methodology (SMARTT taxonomy) through this sectoral table.

(The table is split over two pages due to size, if combined vertically, the halves will show the table). The colours used represent the SMARTT Taxonomy categories as shown in the following table:

Taxonomy Category	Coded colour	Taxonomy Category	Coded colour
Specification & design ICTs	[dark blue]	Resource & process management ICTs	[light blue]
Materialisation ICTs	[orange]	Technical Integration ICTs	[purple]
Automation & operational decision support ICTs	[green]	Trading / transactional management ICTs	[red]

Table 4 Showing the colour coding used the mapping table (Table 5)

The technical conclusions from this table were extracted through a mapping process as given under SMARTT bellow; further detailed analysis is given in section 4 of this document as to what is relevant to REViSITE vision/roadmap.

Specification & design ICTs

The main principal drivers of change for the future European sectors are:

Under Grid:

- Monitoring and control of transmission and distribution networks
- Design and build systems to process the monitoring data generated by relatively large distribution grids.

Table 5 Summary of all the components from the reviewed visions

	Vision for Grids	Vision for Manufacturing
Requirements	Minimum requirements to these networks are:	Main principal drivers of change for the future European Manufacturing sector,are given through ManuFuture's vision, the so-called "Knowledge based Competitive and Sustainable Manufacturing (CSM)". aiming at a holistic approach towards transforming the European manufacturing industry into a knowledge based sectorfollowing 4 main strategic objectives:
	· Flexible: fulfilling customers' needs whilst responding to the changes and challenges ahead;	· Increasingly competitive global economic climate "The industrial context … will depend even more on flexibility and speed, as well as on localised production. Manufacturing is also likely to become increasingly service intensive. This service orientation of manufacturing and the increased customer demand will have consequences for the organisation of production, supply-chain management and customer relations. Furthermore, there is a continuous increase in foreign direct investment in manufacturing outside Europe"
	· Accessible: granting connection access to all network users, particularly for renewable power sources and high efficiency local generation with zero or low carbon emissions;	· Environmental challenges and sustainability requirements "The manufacturing sector will also have to comply with stricter environmental regulations in the future, which should further stimulate the adoption of energy- and resource- saving technologies."
	· Reliable: assuring and improving security and quality of supply, consistent with the demands of the digital age with resilience to hazards and uncertainties;	· Socio-democratic aspects "new societal needs and the demands of an increasingly ageing public, having an impact on mobility, the size of the labour force, and on customer requirements. At the level of the labour supply, the manufacturing and research sectors will be confronted with the retirement of the currently large age groups, while innovation might require completely new sets of skills – the availability of which, in both manufacturing and research, could become a critical factor"
	· Economic: providing best value through innovation, efficient energy management and 'level playing field' competition and regulation.	· Regulations and standards "Stricter environmental and safety regulation will lead to changes in manufacturing. The intellectual property rights (IPR) system might have to respond to changes in an innovation process that is increasingly based on knowledge sharing and networking."
		· Values – public acceptability Ethical concerns need urgently to be taken into account, when science and new technology are being adopted and exploited
ICT as an enabler	Monitoring and control of transmission and distribution networks 1. Complete the existing data models (Common Information Model) and data definitions for transport grids, include definitions for distribution grids, and introduce DG, RES as well as DSM functionalities into the data models. 2. Design and build systems to process the monitoring data generated by relatively large distribution grids.	"The vision of long term development is the realisation of real time support with information and a distributed and open network including innovative technologies like wireless, ubiquitous computing, sensor integration, intelligent monitoring etc. The development of future ICT for manufacturing has to take care of the specific requirements of all these processes and specificities of companies." ICT role will be to:
	Control Mechanisms 1. Generation of electricity for large central generators as well as for relatively small scale DG, RES. Aggregation into VPP should be supported. Optimisation of financial result, environmental parameters and the stability of the grids, and security of energy supply to consumers. 2. Transport and distribution; always to minimise (technical) transport losses.	· "integrate new technologies with currently applied standards and methodologies (non-disruptive approach),
	Energy Markets A- If environmental aspects are to be taken into account in the choice for energy generators, then the market model should be changed. B - Market structures should allow for intermittent generators (wind and solar energy), and should not penalise intermittent schedule deviations.	· adapt new technologies according to users' needs, based on modeling at different levels,
	Prosumer User Interface For optimal results DG, or RES, may be controlled by a combination of the following groups: • Energy traders, with direct access to the electricity market; • Local installation owners, controlling their own electricity consumption profile; • Transport or distribution companies, mainly focused on stability of supply. Each one of the control interfaces must allow for complex decision-support functions.	· develop engineering methodologies for the ubiquitous computer environment in product/process design, control and simulation".
	Prosumer Installation Interface Besides the basic control of (local) generators, prosumers may also let electricity consumption patterns (profiles) be controlled. This would mean in case of a small scale industry, the control of a production line, with the ability (e.g.) consuming the bulk of the energy for a production cycle in off-peak hours. In case of households (or groups of households), this could mean (e.g.) delaying washing machine cycles until after midnight. Besides infrastructural modifications (installation of metering equipment within production processes or in washing machines. It would also mean an advanced data communication mechanism to acquire measured data and to control instruments.	

Vision for Buildings	Vision for Lighting	Taxonomy - REViSITE
The Vision in the field of Construction is highly information intensive industry which uses state-of-the- art technologies in all processes and products in order to satisfy client's expectations in a sustainable way.	The vision in lighting industry is to change from gas discharge lamps to LED lighting, increase in regulation and new features enabled by ICTs. In the lighting technology roadmap in 2020, lighting systems in buildings and other applications need to:	**Specification & design ICTs** a. Design conceptualisation b. Detailed design c. Modelling d. Performance estimation e. Simulation f. Specification & Product / component selection
The built environment in Europe could be designed, built or renovated with high energy efficiency, and at the same time improve the quality of life of European citizens. By 2050, most buildings and districts could become energy neutral, and have a zero CO2 emission.	• Enhance the performance and well-being of people	**Materialisation ICTs** a. Decision support & visualisation b. Management & control c. Real-time communication
A significant number of buildings would then be energy positive, thus becoming real power plants, integrating renewable energy sources, clean distributed generation technologies and integrated grids at district level.	• Adapt easily to the changing needs of any user	**Automation & operational decision support ICTs** a. Automated monitoring & control b. Operational decision support & visualisation c. Quality of service d. Wired/Wireless sensor networks
ECTP SRA defines strategic research priorities, around three axes, in 13 chapters: 1. Meeting client and user requirements 2. Becoming sustainable, 3. Transformation of the construction sector	• Use all sources of light efficiently and effectively	**Resource & process management ICTs** a. Inter-enterprise coordination b. Process integration c. Knowledge sharing
Aiming at this vision, the objectives of the proposed R&D are to develop the 8 following RTD topics: 1- Value-driven business processes;2- Industrialised production; 3- Digital models; 4- Intelligent constructions; 5- Interoperability; 6-Collaboration support;7- Knowledge sharing; 8- ICT enabled business models	• Function as true systems, fully integrated with other systems (rather than as collections of independent components)	**Technical Integration ICTs** a. Technical integration & interoperability
	• Create minimal impacts on the environment during their manufacturing, installation, maintenance, operations, and disposal	**Trading / transactional management ICTs** a. District energy management b. Facility energy management
Building and has also organised the research topics according to the following structure:	The technologies should have following ICT related attributes/capabilities: • Enable easy installation (e.g., self-configuring and friendly to non-experts). • Develop universal control and communication protocols for component interconnection (such as BACnet or Echelon).	
1. Tools for EE design and production management 2. Intelligent control 3. User awareness and decision support 4. Energy management and trading 5. Integration technologies	• Create a dialogue with energy management companies and lighting control industry in an effort to develop simple, easy-to-use controls • Develop controls that are self-teaching, intuitive, easy to use.	
	• Incorporate anticipatory logic so systems learn and adapt to user preference. • Sense multiple inputs to configure and define lighting environments to user (colour, room temperature, user temperature, user mood, eyesight of user, occupancy of room, motion, activity type, time of day, daylight levels).	
	• Allow ease of programming by time of day and date. • Establish interactive linkage between the lighting, HVAC, and other system controls. • Improve robustness (e.g., non-volatile memory). • Provide some control at building level (range of levels, override).	
	• Develop a universal building interface (remote control and monitoring) for load shedding, optimization of lighting/heat, preventive maintenance. • Develop control systems that serve emergency-response needs. • Develop control systems that monitor status of settings. • For public spaces, develop control systems that accommodate multiple uses of the space.	

Specification & design ICTs

The main principal drivers of change for the future European sectors are:

Under Grid:

- Monitoring and control of transmission and distribution networks
- Design and build systems to process the monitoring data generated by relatively large distribution grids.

Under Manufacturing:

- Environmental challenges and sustainability requirements
- Socio-democratic aspects "new societal needs and the demands of an increasingly ageing public, having an impact on mobility, the size of the labour force, and on customer requirements.
- Regulations and standards "Stricter environmental and safety regulation will lead to changes in manufacturing. The intellectual property rights (IPR) system might have to respond to changes in an innovation process that is increasingly based on knowledge sharing and networking."

The development of future ICT for manufacturing has to take care of the specific requirements of all these processes and specificities of companies." ICT role will be to:

- Adapt new technologies according to users' needs, based on modelling at different levels.

Under Building:

ECTP SRA defines strategic research priorities, around three axes:

- Meeting client and user requirements
- Becoming sustainable,
- Transformation of the construction sector

Within this sector specification and design ICTs focus on industrialised production

Under Lighting:

In the lighting technology roadmap in 2020, lighting systems in buildings and other applications need to:

- Create minimal impacts on the environment during their manufacturing, installation, maintenance, operations, and disposal.

Materialisation ICTs

Under Grid:

Control Mechanisms need to realise the:

- Generation of electricity for large central generators as well as for relatively small scale DG, RES. Aggregation into VPP should be supported. Optimisation of financial result, environmental parameters and the stability of the grids, and security of energy supply to consumers.
- Transport and distribution; always to minimise (technical) transport losses. Prosumer User Interface

For optimal results DG, or RES, may be controlled by a combination of the following groups:

- Energy traders, with direct access to the electricity market;

- Local installation owners, controlling their own electricity consumption profile;
- Transport or distribution companies, mainly focused on stability of supply.

Each one of the control interfaces must allow for complex decision-support functions.

Under Manufacturing, ICT role will be to:

- Develop engineering methodologies for the ubiquitous computer environment in product/process design, control and simulation".

Under Building:

The Vision in the field of Construction is highly information intensive industry which uses state-of-the-art technologies in all processes and products in order to satisfy client's expectations in a sustainable way. The built environment in Europe could be designed, built or renovated with high energy efficiency, and at the same time improve the quality of life of European citizens.

ECTP SRA defines strategic research priorities, around the three axes mentioned earlier. Aiming to develop the following RTD topics:

- Value-driven business processes
- ICT enabled business models

Under Lighting:

The vision in lighting industry is to change from gas discharge lamps to LED lighting. The technologies should have following ICT related attributes/capabilities:

- Develop a universal building interface (remote control and monitoring) for load shedding, optimization of lighting/heat, preventive maintenance.
- Develop control systems that serve emergency-response needs.
- Develop control systems that monitor status of settings.
- For public spaces, develop control systems that accommodate multiple uses of the space.

Automation & operational decision support ICTs

Under Grid the minimum requirement is:

- Reliable: assuring and improving security and quality of supply, consistent with the demands of the digital age with resilience to hazards and uncertainties;

In regards of monitoring and control of transmission and distribution networks. The main focus is to:

- Complete the existing data models (Common Information Model) and data definitions for transport grids, include definitions for distribution grids, and introduce DG, RES as well as DSM functionalities into the data models.

Under Manufacturing

The main principal drivers of change for the future European Manufacturing sector aiming at a holistic approach towards transforming the European manufacturing industry into knowledge based sector following 4 main strategic objectives: "The industrial context … will depend even more on flexibility and speed, as well as on localised production. Manufacturing is also likely to become increasingly service intensive".

"The vision of long term development is the realisation of real time support with information and a distributed and open network including innovative technologies like wireless, ubiquitous computing, sensor integration, intelligent monitoring etc".

Under Building:

ECTP SRA defines strategic research priorities under the automation and operational decision support ICTs, around three axes as shown earlier, in the following chapters:

- Meeting client and user requirements;
- Becoming sustainable;
- Transformation of the construction sector.

Aiming at this vision, the objectives of the proposed R&D are to develop the following RTD topics:

- Digital models;
- Intelligent constructions.

Under Lighting:

The current EU vision within the lighting industry is to increase in regulation and new features enabled by ICTs. In the lighting technology roadmap in 2020, lighting systems in buildings and other applications need to:

- Enhance the performance and well-being of people;
- Adapt easily to the changing needs of any user.

The technologies of the Lighting should have following ICT related attributes/capabilities:

- Enable easy installation (e.g., self-configuring and friendly to non-experts);
- Develop universal control and communication protocols for component interconnection (such as BACnet or Echelon);
- Sense multiple inputs to configure and define lighting environments to user (color, room temperature, user temperature, user mood, eyesight of user, occupancy of room, motion, activity type, time of day, daylight levels);
- Allow ease of programming by time of day and date;
- Provide some control at building level (range of levels, override).

Resource & process management ICTs

Under Grid the minimum requirement is:

- Accessible: granting connection access to all network users, particularly for renewable power sources and high efficiency local generation with zero or low carbon emissions;

Regarding the Energy Markets:

- If environmental aspects are to be taken into account in the choice for energy generators, then the market model should be changed;
- Market structures should allow for intermittent generators (wind and solar energy), and should not penalise intermittent schedule deviations.

Regarding the prosumer Installation Interface

Besides the basic control of (local) generators, prosumers may also let electricity consumption patterns (profiles) to be controlled. Infrastructural modifications (installation of metering equipment within production processes or in washing machines). It would also mean an advanced data communication mechanism to acquire measured data and to control instruments.

Under Manufacturing

Within the European vision axed towards transforming the European manufacturing industry into knowledge based sector following the service orientation of manufacturing and the increased customer demand will have consequences for the organisation of production, supply-chain management and customer relations. Furthermore, there is a continuous increase in foreign direct investment in manufacturing outside Europe"

The minimum requirement is:

- Values – public acceptability Ethical concerns need urgently to be taken into account, when science and new technology are being adopted and exploited.

ICT role will be to:

- Integrate new technologies with currently applied standards and methodologies (non-disruptive approach).

Under Building:

ECTP SRA defines strategic research priorities reported aiming at this vision, the objectives of the proposed R&D are to develop the following RTD topics:

- Collaboration support
- Knowledge sharing

Under Lighting:

In the lighting technology roadmap in 2020, lighting systems in buildings and other applications need to:

- Use all sources of light efficiently and effectively
- Create a dialogue with energy management companies and lighting control industry in an effort to develop simple, easy-to-use controls
- Develop controls that are self-teaching, intuitive, easy to use
- Incorporate anticipatory logic so systems learn and adapt to user preference
- Establish interactive linkage between the lighting, HVAC, and other system controls
- Improve robustness (e.g., non-volatile memory).

Technical Integration ICTs

Under Grid the minimum requirement is:

- Flexible: fulfilling customers' needs whilst responding to the changes and challenges ahead; SG.

Under ion Building:

ECTP SRA defines strategic research priorities; aiming at this vision, the objectives of the proposed R&D are to develop the following RTD topic:

- Interoperability.

Under Lighting:

In the lighting technology roadmap in 2020, lighting systems in buildings and other applications need to:

- Function as true systems, fully integrated with other systems (rather than as collections of independent components).

Trading / transactional management ICTs

Under Grid the minimum requirement is:

- Economic: providing best value through innovation, efficient energy management and ‘level playing field’ competition and regulation.

Under Manufacturing:

Main principal drivers of change for the future European Manufacturing sector aiming at a holistic approach towards transforming the European manufacturing industry into knowledge based sector following the strategic objective which is:

- Increasingly competitive global economic climate “The industrial context … will depend even more on flexibility and speed, as well as on localised production.

“The manufacturing sector will also have to comply with stricter environmental regulations in the future, which should further stimulate the adoption of energy- and resource- saving technologies.”

4. THE REVISITE CROSS SECTORAL VISION

4.1 Background to the development of the REViSITE vision

From Europe 2020 three mutually reinforcing priorities were revealed: EU to become a (i) smart, (ii) sustainable and (iii) inclusive economy which will help the EU and the Member States deliver high levels of employment, productivity and social cohesion. In the: "Digital Agenda for Europe" initiative the EU commission has committed to:

- Create a true single market for online content and services (i.e. borderless and safe EU web services and digital content markets)
- Reform the research and innovation funds and increase support in the field of ICTs
- Promote internet access and take-up by all European citizens.

The ubiquitous nature of ICT means it can be used as a powerful learning system which acts as a bed rock for sensing, understanding, deciding and acting in ways that promote “positive sustainable environments” and a move towards an “Energy Efficient economy”, see Fig 10. An economy which revolves around a true single market for online content and services: (i) pushing multidisciplinary ICTs to true cross sectoral usages; (ii) to test these capabilities toward standardised and homogenised adaptation cross sectors; and (iii) to communicate under similar interchangeable features and platforms. A comparative analysis of the four target sectors has been conducted to determine any apparent and potential commonalities for REViSITE vision development and to align the vision with the three pillars of sustainability: social, economic and environmental.

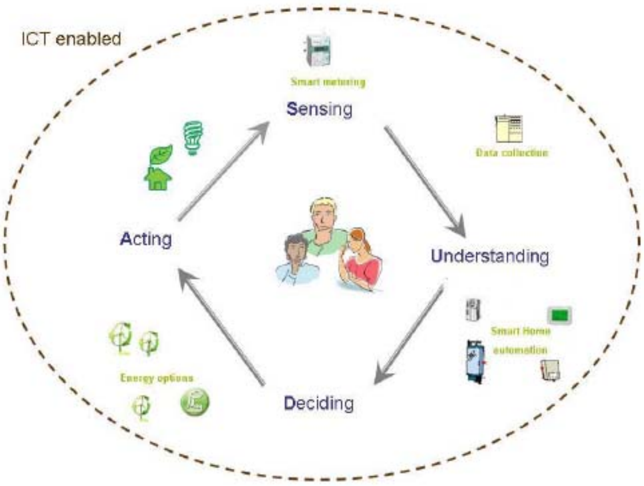

Figure 10 ICT enabling EU citizen decision making

Our prime focus is environmental as it deals with energy efficiency but its impact is also economic and does reflect deeply on many social aspects. The REViSITE approach proposes the common categorisation of sector RTD’s based on the SMARTT taxonomy, which was developed earlier in the project, coupled with life cycle / holistic thinking and an adapted capability maturity model, which leverages both quantitative data available together with the collective heuristics of sector experts. The methodology for the development of the SMARTT was undertaken as can be seen in Figure 11.

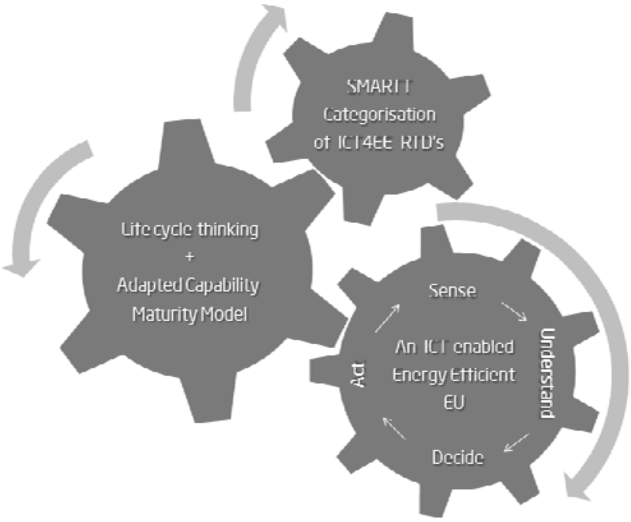

Figure 11 SMARTT categorisation of ICT4EE RTD's from the ICT enabled energy efficient EU

The REViSITE consortium deemed the taxonomy and methodology, outlined in detail in D2.1, to be useful and feasible approach in terms of qualitative common assessment. The methodology provides for an informed view on the impact of ICTs on energy efficiency and is a framework in which more detailed quantitative measures can be positioned. Figure 12 illustrates the REViSITE methodology and SMARTT Taxonomy utilised in the review of the four sectors.

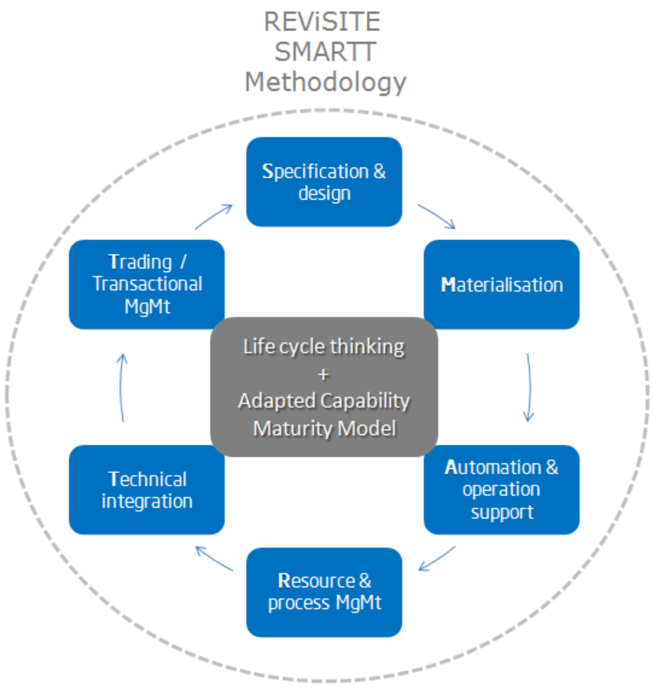

Figure 12 REViSITE methodology & SMARTT Taxonomy diagram for the four sectors harmonised vision

4.2 REViSITE Vision Development

Three parallel steps were employed to produce the REViSITE vision: (i) Review and analysis of general and sector specific ICT visions under SMARTT taxonomy categories;(ii) Validation through statistical content analysis of existing ICT visions; and (iii) Qualitative survey of domain experts vision views within the REViSITE Expert Group. The details of these steps are as follows:

4.2.1 STEP 1: Review and analysis of general and sector specific ICT visions under SMARTT taxonomy categories

A table summarising the relevant ICTs for EE from the reviewed visions is given in section 3.5. Its main components are clustered below under the SMARTT taxonomy categories. The common items among each of these categories are summarised at the end of this section, this will form one of the three steps toward generation of the REVISITE vision. The sector specific visions have been mapped and summarised against taxonomy categories. Once this synthesis was closed, STEP1 of this development action has been completed, as given below summarising the main components for the REViSITE vision. This synthesis was conducted with in mind the EC agenda in relation to ICT as an enabler for EE.

In 2008, Commission President José Manuel Barroso stated "...the real gains will come from ICT as an enabler to improve energy efficiency across the economy. ICT matters for energy reduction, especially in transport and the energy intensive sectors. ICT's ability to organise and innovate is a key factor". [19]

The EU Commissions has identified a "…clear need to create a level playing field based … and on a common understanding of commitments, targets and methodology" [20].

The main objective of the REViSITE co-ordinated action is to produce a common cross-sectoral ICT4EE roadmap to address this call. The set of taxonomy organised items which will form the core of the REViSITE vision, were extracted via the mapping table followed by a clustering of its components under the taxonomy categories for each sector (see section 3.5). The common items that can be adopted across the four sectors: "Grid, Manufacturing, Building and Lighting" to finally establish a wider ICT usage for an Energy Efficient Europe are listed below:

Specification and design ICTs addressing:

- Environmental challenges and sustainability requirements.
- Regulations and standards including intellectual property rights to respond to changes in an innovation process that is increasingly based on knowledge sharing and networking.
- Adaptation of new technologies according to users' needs, based on modelling at different levels.
- Developing engineering methodologies for the ubiquitous computer environment in product/process design, control and simulation".

Materialisation ICTs addressing:

- Usage of control mechanisms at various scales to optimise the financial results, environmental parameters and stability.
- The built environment in Europe could be designed, built or renovated with high energy efficiency, and at the same time improve the quality of life of European citizens under the two RTD topics which are: Value-driven business processes; ICT enabled business models.

Automation and operational decision support ICTs for

- Monitoring and control with systems to process the monitoring data.
- Transforming the European industry into knowledge based sectors.
- Adapting easily to the changing needs of any user.
- Developing universal control and communication protocols for component interconnection.
- Incorporating anticipatory logic so systems learn and adapt to user preference.

Resources and process management ICTs for:

- Accessibility: granting connection access to all network users, particularly for renewable power sources and high efficiency local generation with zero or low carbon emissions.
- The market model should be changed to take into account the environmental aspects.
- Values: public acceptability Ethical concerns need urgently to be taken into account, when science and new technology are being adopted and exploited.
- Collaboration support and knowledge sharing.
- Reliability: assuring and improving security and quality of supply.
- Enhancing the performance and well-being of people.

Technical Integration ICTs:

- Flexible: fulfilling customers' needs whilst responding to the changes and challenges ahead.
- Interoperability of systems and mechanisms for data exchange.
- Function as true systems, fully integrated with other systems (rather than as collections of independent components).
- Integrate new technologies with currently applied standards and methodologies (non-disruptive approach).

Trading/ transactional management ICTs:

- Economic: providing best value through innovation, efficient energy management and 'level playing field' competition and regulation.
- Increasingly competitive global economic climate, "The industrial context - will depend even more on flexibility and speed, as well as on localised production.
- Stimulate the adoption of energy- and resource- saving technologies.
- Shift from 'consumer culture' to 'prosumer culture'.

4.2.2 STEP 2: Validation through statistical content analysis of existing ICT visions (Content Analysis of the visions document related to the four sectors cross EU)

A content analysis has been carried out in order to extract the communalities in various documents inherent to the vision for ICT and energy efficiency in Europe. The respective documents of each single sector have been cross analysed and the results have been cross matched with the main common vision document. The documents analysed are as given in Appendix 7. The key concepts defined/used for this content analysis are: Cross Sectorial Methodology; Life Cycle; Reduce Green Gas Emission; Multidisciplinary; Energy and Climate change and Energy Efficiency; Sustainable development and ICT for Energy Efficiency. As an example for Cross Sectorial Methodology as a category all paragraphs of the various documents that recall concepts and/or needs and action from and related to other disciplines have been included into this category, the corresponding codes used are as follows: Life Cycle; Reduce Green Gas Emission; Multidisciplinary; Energy and Climate Change; Energy Efficiency; Sustainable development; and ICT for Energy Efficiency. The first content analysis was carried out between the documents belonging to the four specific sectors, the findings are summarised in the following table, and graphical representation is given in Appendix 7.

As can be seen from the table, the code: 'Cross Sectorial methodology' is the most common phrase within the documents analysed, followed by the code: 'multidisciplinary' and then: 'Common Vision for ICT'.

	Common Vision for ICT	Cross sectoral methodology	multidisciplinary	ICT for Energy Efficiency
Smart Manufacturing\ manufuture _vision_en[1]	7	8	7	1
Smart Manufacturing\smart-manufacturing_en	22	59	23	61
Smart Grid\UK-ensg_smart_grid_vision	0	0	0	0
Smart Grid\EU_smart grid_vision	10	14	2	5
Smart building\ICT enebled enviromentally smart buildings - UK	0	2	0	1
Smart building\ECTP-Vision2030-25Feb2005	0	0	1	0
Smart building\E2B - Scope and Vision_EI	4	6	5	5
Smart building\REEB_Book_Final	6	15	14	18
Smart Lighting\DOE lighting roadmap vision2020 (2000)	5	5	5	5
Smart Lighting\The next wave in solid state lighting	0	0	0	0

Table 6 Account of Codes per Documents from analysis between documents from the four sectors

A second analysis was carried out on the four general documents describing European General Visions, i.e. they are not sectoral specific. Europe 2020 expresses and recalls concept based on multidisciplinary and common vision for ICT were analysed. The following table summarises the findings.

	ICT for Energy Efficiency	Common Vision for ICT	Cross sectoral methodology	multidisciplin ary
General Vision\2020 vision for EU research area	0	0	1	0
General Vision\Europe 2020 (2)	1	0	5	2
General Vision\Postscript 2006 stern report	0	0	0	0
General Vision\ICT in EU of 21st centry	6	1	0	2

Table 7 Codes per Documents

These coresponding codes in their order of importance are: Common Vision for ICT; Cross sectoral methodology; Multidisciplinary; ICT for Energy Efficiency.

It has appeared that further exploration of the sections text within the various analysed documents which contained the identified communalities and possible linking concept which were prominent through some of the chosen codes was needed. These corresponding codes in their order of importance are: Common Vision for ICT; Cross sectoral methodology; Multidisciplinary; ICT for Energy Efficiency.

The extraction of the text sections as appeared in their original documents was conducted. The pieces of text which are useful for the formulation of the REViSITE vision were classified under the categories of the REViSITE taxonomy, which is given in Appendix 1.

4.2.3 STEP 3: Qualitative survey of domain experts vision views within the REViSITE Expert Group

The REG members have described their vision for ICT4EE in the following forms: ICT4EE vision must rely on full interoperability between all the different components from the conceptual stage up to the usage; EE provides the only short-term solution in the move towards low carbon economy and ICT is its most important enabler; Guidance and control is what ICT should offer together with optimization and consumer awareness. For both, one must have reliable (qualitatively and quantitatively) data, proper algorithms, enough control capabilities and good visualization tools; ICT is fundamental for the implementation of an energy generation/consumption system in which the use of RES and Distributed Generation is highly diffused.

Through the questionnaire the REG members have described how their visions align to the SMARTT taxonomy categories as follows:

1. *Specification and design*: Decision making support is key; Adequate modelling and simulation is essential for efficient control; Design of a system which is capable to simulate the consumption and generation patterns at different levels: buildings, and supergrid.
2. *Materialisation*: The complexity of the solution in most cases results in suboptimal performance; Energy data and real-time communications are essential for efficient control.
3. *Automation & operation decision support*: It is the key topic for ICT in the EE discussion; Proper control algorithms (are essential for establishing trust and confidence on automation and operational decision support; High speed communication provides the information of load/generation and forecasts. Deferrable loads, heat/cold/electricity storage are automatically controlled.
4. *Resource and process management*: Knowledge access is essential to create consumer awareness; Generation and demand response capacities are aggregated at district level or via an aggregator to allow matching of generation
5. *Technical integration*: Proper control algorithms need adequate technical integration.
6. *Trading & transactional management:* Can be a key area, if regulatory activity creates new market-structures; will be determined by the business models that really fly; Adequate algorithms for energy efficiency need trading features.

4.3 REViSITE Vision

The baseline for the development of the REViSITE vision is made by the current visions (sector and non sector specific) supplemented by expert views, analysis of state-of-the-art RTDs, ICTs and the potential of their application and anticipated impacts on a cross sectoral basis. The REViSITE vision builds on the interpretation of current visions and the envisioned implications of the full uptake of ICTs as an enabler for ICT4EE across various sectors. The REViSITE vision will lead to more transparency in identifying ICTs that can positively impact on energy efficiency, by categorising where ICT adoption and development should be focused, based on anticipated level of impact.

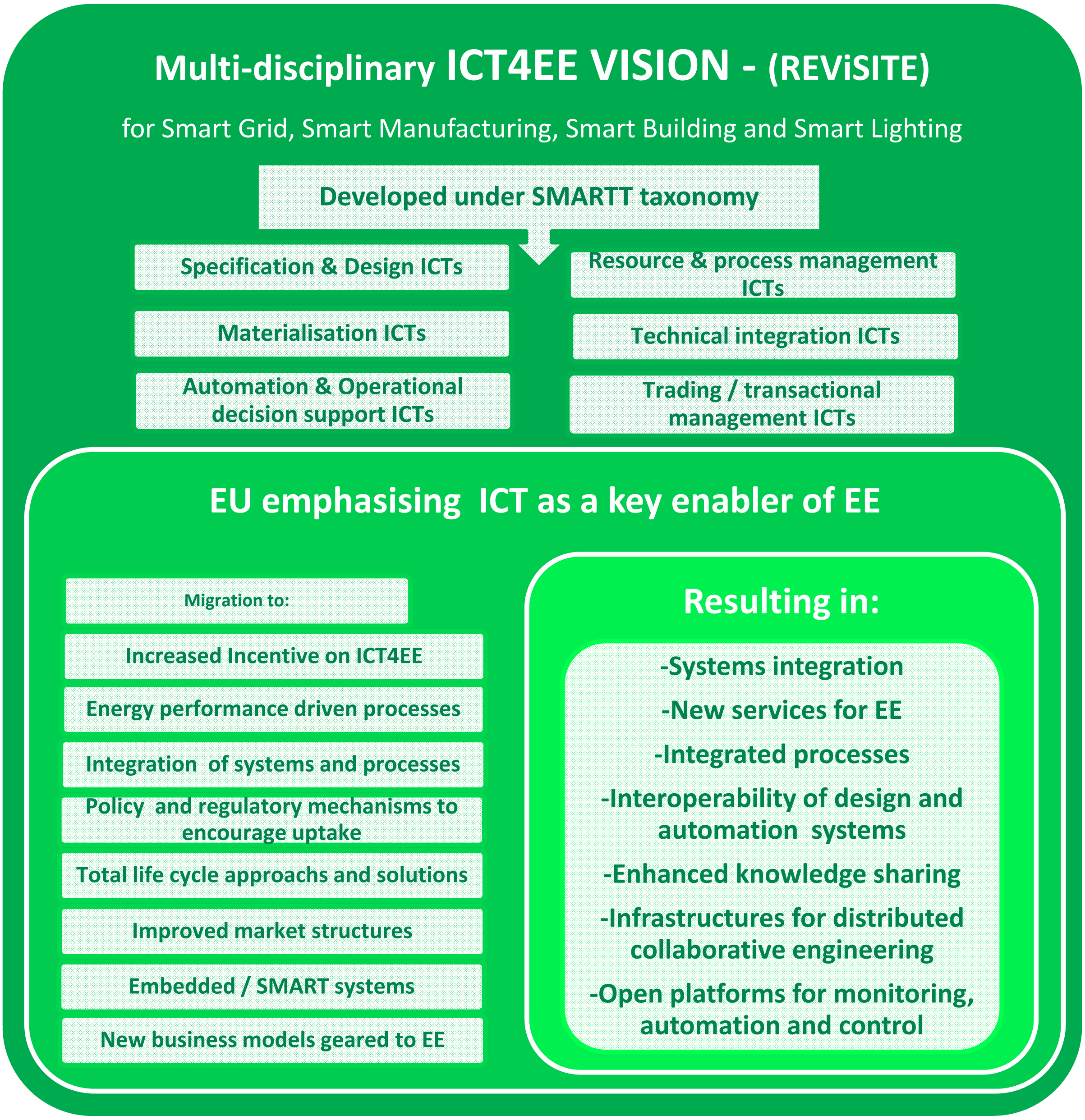

Figure 13 Schematic diagram of the ICT4EE vision (REViSITE)

The value of the cross sectoral approach to the sectors is based on the premise of abstracting sector specific issue to a more general issue, identify possible general ICT solutions, and then focus on adopting or adapting as a sector specific solution. The SMARTT Taxonomy was used to categorise ICTs, aligning them to a generalised life cycle that is recognisable to specific sectors. ICTs need to focus on: Specification & design, Materialisation, Automation & operation support, Resource & process management, Technical integration and Trading and transactional management. REViSITE can more clearly identify 'what' ICTs should be adopted or developed, 'where' they should be applied and 'how' they are likely to impact on sustainability. These ICTs are foreseen to contribute to the realisation of the vision where new services for EE are widely available; processes and systems are integrated; design and automation systems are interoperable with the availability of cross sectoral data exchange standards; knowledge sharing related to energy consumption and grids loads is enhanced and facilitated; Infrastructures for distributed collaborative engineering are available; Open platforms for monitoring, automation and control are widely used; embedded / SMART (which is the as per REViSITE) systems are in operation; and new business models geared to EE are implemented with a shift from 'consumer culture' to 'prosumer culture'.

Structured according to the SMARTT taxonomy the REViSITE vision for ICT enabled energy efficiency encompasses:

1. Specification & design ICTs

- Integrated design solutions toward ICT4EE covering technical, commercial and regulatory factors along with a shared vision (e.g. energy pricing structures, linking insurance incentives with energy consumption).
- Interoperability of design as a capability, the ability to share information model based collaboration.
- Electronic catalogues of design details for better energy efficiency.
- Models for energy consumption prediction at each layer, e.g. device level, location, process level etc.
- Energy performance estimation is practiced, via:
  - ICTs for identifying standards based performance indicators comparable to, for example, reference values other buildings or simulations.
  - Certified assessment software.
  - ICTs to predict total life cycle energy consumption taking into consideration the construction / materialisation stage.
  - ICT based globally agreed methodologies, approaches and metrics for predicting the performance and energy impacts of ICTs and for assessing the energy impact of technological changes in construction, production etc.
- Holistic simulation is utilised.
- ICT for rationalisation / selection of components for better energy efficiency.
- Electronic catalogues of products / components including relevant attributes of energy efficiency.
- Causal Modelling ICTs – physical systems
- Design conceptualisation ICTs
- Human factor Engineering ICTs
- Product / component specification and selection ICTs
- Visual / spatial design

2. Materialisation ICTs

- ICTs to optimise / select production / materialisation / procurement (e.g. strategies for on-site/off-site production in construction or make-or-buy in manufacturing) methods based on optimum energy consumption.
- ICTs to rationalise materialisation processes (in terms of planning) for more efficient energy efficiency (e.g. timing, sequence, etc.).
- Real-time communication.
- In the field Mobile Decision Support ICTs

3. Automation & operational decision support ICTs

- Embedded ICTs that permeate sectors providing the “intelligence” to monitor and control energy resources in smart sustainable ways.
- ICT systems that facilitate user control.
- ICT which act as learning systems, providing reliable, secure and affective decision support to energy producers and consumers alike.
- Building operating systems and district energy management systems with automation to install software in buildings or districts similar to installation on PCs and broker to serve energy trading similarly to software on computers now with varied level of interoperability.
- Predictive controls algorithms capable of solving optimisation problems in real time;

- Systems learn and adapt to user preference via incorporated anticipatory logic.
- Wired/wireless sensor networks act as a communication backbone to the Energy grid, a grid which interacts with both generation sources and storages aided by ICT enablers such as smart metering, electronic control technologies, wired and wireless modern communications means, and instruments for increasing customer awareness.
- Operational decision support ICTs that integrate high level diverse systems such as safety, security, weather & energy etc from individual, to district level.
- Embedded intelligent devices (micro architecture) for operational control, sensing & actuation at machine, plant or building level
- Software & algorithms for operational monitoring & actuation of devices at machine, plant or building level
- Inference sensing Software & algorithms for pattern & signal identification
- User centred Data Visualisation ICTs
- Secure/resilient wired, wireless & optical infrastructure for operations

4. Resource & process management ICTs

- Wide availability of ICT based services and infrastructure.
- Enhanced value-driven business processes and ICT enabled business models.
- ICTs to facilitate virtual enterprise business relationships.
- ICT integrated processes are adopted for EE (including: models developed within RTD initiatives, human, legal, contractors, economics, business models, liability).
- Video conferencing, groupware, social media and collaboration ICTs support process integration and new services while reducing needs for transport and commuting.
- Intellectual property rights are protected (legally and technically e.g. via encrypting methods).
- Enhanced knowledge sharing including: Infrastructure, knowledge mining, semantic mapping, filtering, knowledge consolidation algorithms, distributed data bases, catalogues of re-usable EE solutions etc.
- ICTs for data mining & analytics in terms of energy consumption & optimisation
- Modelling & simulation ICTs e.g.: What-if scenario planning across sector life cycle
- Inter-Enterprise ICTs for supporting coordination
- Knowledge Management & creation ICTs
- Process Integration and collaboration

5. Technical Integration ICTs

- ICTs support compliance to Regulations and standards.
- Integrated infrastructures are implemented to support all ICT tools and systems for EE: design, collaboration, sensing/monitoring, automation, control, operation, services, energy trading etc.
- Universal control and communication protocol standards for system integration and interoperability are agreed and adopted.
- Interoperability is achieved for all stake holders over all life cycle stages.
- True System integration is achieved.
- Middleware to facilitate interoperability amongst different devices and systems.
- Infrastructure for collaborative distributed engineering.
- Ability to share information in model based collaboration.
- Use of cloud based services for tasks such as data management, monitoring and analysis
- ICT standards and protocols for interoperability
- Real-time analytical ICTs e.g. Complex Event Processing
- Integration technology / approaches SOA & event driven architectures

6. Trading / transactional management ICTs

- Regulations and market models take into account the environmental aspects and ethical concerns of citizens (this may influence e.g. using ICT to track person's locations).
- Internet-style grid system supported by advanced hardware and management protocols for connections, whether for suppliers of power, for consumers or for network operators. The market structures and regulatory mechanisms provide the necessary incentives.
- ICTs to assist in harmonisation of energy consumption across the district by identifying peaks and troughs of consumption.
- Integrated approach toward ICT4EE covering technical, commercial and regulatory factors (e.g. energy pricing structures, linking insurance incentives with energy consumption).
- Building operating systems and district energy management systems with automation to install software in buildings or districts similar to installation on PCs and broker to serve energy trading similarly to software on computers now with varied level of interoperability.
- ICTs based on citizens' energy profiles assist in optimisation of citizens' energy consumption.
- Virtualisation, advanced and reliable video conferencing, in the future companies rely on virtual building market, which could sell rules to reduce physical building by making software for multi use of buildings, as an example school may become a restaurant at night, build in a certain fashion to change the need for transport with effect on EE.
- ICTs allowing interchanges of consumers to be prosumers and vice versa.
- Trading & Energy Brokerage ICTs

5. CONCLUSIONS

The methodology to generate the REViSITE vision uses three steps. STEP1: ICT related components which were extracted from the reviewed visions were clustered using the SMARTT taxonomy categories, the common items among each of these categories were summarised. STEP2: A content analysis of the text in the reviewed visions was carried out based on a number of codes. Sections of text which referred to these codes were extracted as they appeared in the various visions documents and were classified using the SMARTT taxonomy categories then analysed. STEP3: The third set of information used to generate the vision was the feedback following the two questions addressed to the REG which were: (1) ”In one or two sentences describe your vision for ICT4EE”; and (2) “Please describe (if applicable) how your vision aligns to any of the SMARTT taxonomy categories”.

As a result REViSITE suggests that Europe has to focus on a stronger role of ICT as an enabler of energy efficiency leading to migration to energy performance driven processes, integration of systems and processes, policy and regulatory mechanisms to encourage uptake of ICT, increased incentive on ICT4EE, total life cycle approaches and solutions, improved market structures and more embedded intelligent systems. This should ensure a wide availability of new services at reasonable costs to the providers and the users. Management, monitoring data analysis and decision making will become a service that is provided via a networked system similarly to the internet.

ICTs need to focus on: Specification & design, Materialisation, Automation & operation support, Resource & process management, Technical integration and Trading and transactional management. REViSITE can more clearly identify ‘what’ ICTs should be adopted or developed, ‘where’ they should be applied and ‘how’ they are likely to impact on sustainability. These ICTs are foreseen to contribute to the realisation of the vision where new services for EE are widely available; processes and systems are integrated; design and automation systems are interoperable with the availability of cross sectoral data exchange standards; knowledge sharing related to energy consumption and grids loads is enhanced and facilitated; infrastructures for distributed collaborative engineering are available; open platforms for monitoring, automation and control are widely used; embedded / SMART (which is the as per REViSITE) systems are in operation; and new business models geared to EE are implemented with a shift from ‘consumer culture’ to ‘prosumer culture’.

5.1 Recommendations for tasks T3.2 and T3.3

The vision in this deliverable will be further analysed in preparation for the development of the Strategic Research Agenda (SRA) and Implementation Action Plan (IAP). This analysis will be based on breaking down the vision into short / medium / long term requirements and may need to be refined in the next roadmap validation exercise including the relevant selected stakeholders drawn from the focus group together with the REG (REViSITE Expert Group). The identified items/areas toward the vision under the six SMARTT Taxonomy categories will steer the generation of the Strategic Research Agenda of task T3.2 leading to the development of the implementation plan in T3.3 and eventually the REViSITE roadmap.

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[20] EU commission 12/3/2009, avalable at: http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2009:0111:FIN:EN:PDF

7. APPENDICES

Appendix 1 - SMARTT taxonomy

Taxonomy of ICT applications in the 4 sectors as identified in D2.1

The Taxonomy has three levels –

15. Main category aligned to the Life cycle phases and following the SMARTT acronym.

    a. Sub-category allowing for more granular categorisation

        i. RTD's & ICT's detailing the specific areas of research and possible development giving existing or envisaged ICT exemplar's

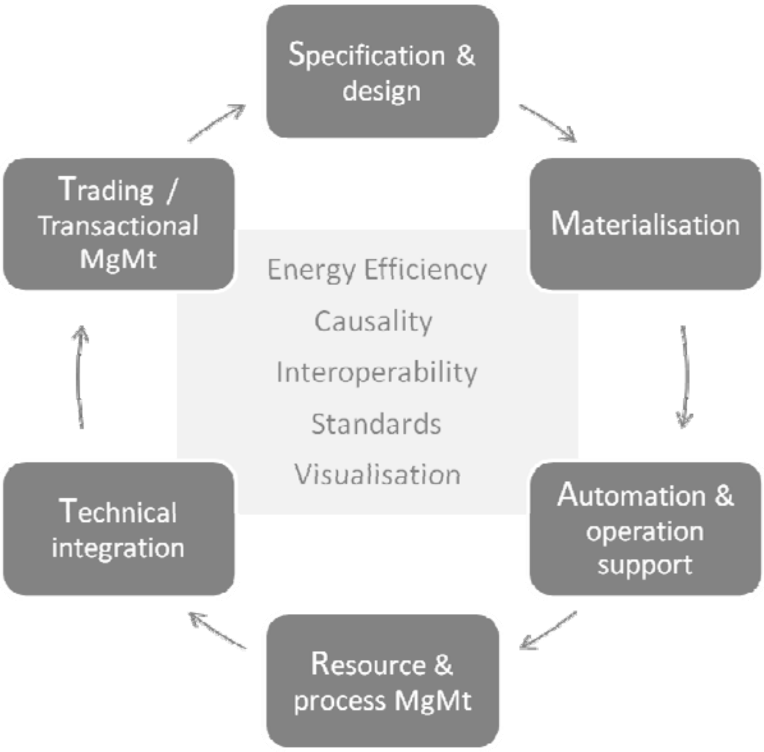

Figure 14 REViSITE SMARTT Taxonomy

16. Specification & design ICT's

    ii. Design conceptualisation: requirement engineering/mgmt tools such as Quality Function Deployment tools, concept modelling for design ideation. Building and urban planning applications.

    jj. Detailed design: Software design tools, CAD (e.g. Autodesk, 3D studio max), Multimedia (e.g. Flash, Silverlight), Graphics (e.g. Photoshop, Illustrator).

    kk. Modelling: all types of technologies that are utilised to systematically describe the physical reality, Life cycle modelling, computer-aided diagramming (e.g. Sankey, Response flow, Cause and effect, influence diagrams etc) some Excel and some CAD applications. Also include are models for the rationalisation of decisions for example computer-interpretable representation and exchange of product/material manufacturing information for materials to be used in construction.

ll. Performance estimation: classical financial based IT applications, ROI, NPV, TCO. Various technologies used to analyse the performance of the target system e.g. Life Cycle Analysis, Finite Element Mode analysis and a wide variety of engineering analysis tools that could also be applied in both the design and materialisation phases.

mm. Simulation: Analysis of the dynamic behaviour of a system as part of the design function. All simulation requires modelling but not all modelling leads to simulation. Example technologies include - CFD, power system simulation, thermal simulation, Wide Area Network simulators etc

nn. Specification & Product / component selection: technologies for design & specification realisation, component selection e.g. material characteristic database & retrieval. (bridge note)

17. Materialisation ICT's

oo. Decision support & visualisation: technologies for visual representation of work flows focused on energy efficient task completion. What if - scenario simulation, & modelling to support real-time decisions in the field. May incorporate automated processing coupled with visual aids or alert mechanisms. Basically, any dynamic technologies that assist with the materialisation of the physical, whether that be a grid, building, factory or lighting infrastructure.

pp. Management & control: adherence to performance requirements, conformance validation, commissioning and phase specific task management in terms of efficient materialisation of the physical building, grid, factory process or lighting infrastructure.

qq. Real-time communication: Any real-time communications that facilitate decision making. E.G. sensor information regarding integrity of building materials during construction integrated into an alert mechanism such as a text or on-screen display.

18. Automation & operational decision support ICT's

rr. Automated monitoring & control: intelligent HVAC, smart (new generation) lighting, automated backend control with little or no human decision interaction. Smart (intelligent) monitoring (metering). Smart (intelligent) metering linked with machine self-actuation adjustment. E.G. energy consumption managed via intelligent control which responds automatically to say gradual electrical load consumption shifting, wastage of energy due to simultaneous heating and cooling, drifting or malfunctioning equipment operation.

ss. Operational decision support & visualisation: Performance management in the usage phase as in the occupancy of a building or in the manufacturing of products or in dynamic load provisioning within the grid. Visualisation and cognitive decision support in terms of energy dashboards and real-time communications regarding usage. What if - simulations to support operational changes for optimal running of manufacturing lines, heating systems or micro-power generation.

tt. Quality of service: backend service provisioning & rightsizing of communication networks. Quality assurance of applications in the field and self-healing of networks, SLA protocols.

uu. Wired/Wireless sensor networks: secure backend wired/wireless communications, dedicated high speed wired/wireless networks, sensor hardware/software so essential to sub-metering strategies, 6LoWPAN, ZigBee PLC etc

19. Resource & process management ICT's

vv. Inter-enterprise coordination: contract & supply network management, process planning & scheduling, procurement, Intra-logistics, elements of Enterprise Resource Planning systems etc

ww. Process integration: collaboration support, groupware tools, electronic conferencing, distributed systems, social-media, business work flows, ERP (front end) systems

xx. Knowledge sharing: access to knowledge, knowledge management, knowledge repositories, knowledge mining and semantic search, long-term data archival and recovery. Technologies here are involved in moving data up the up the DIKW (Data, Information, Knowledge, Wisdom) chain in order to add value.

20. Technical Integration ICT's

yy. Technical integration & interoperability: Context and semantic interoperability is as important as technical integration, for example agreement on business processes is as important as data exchange protocols. But the main focus here will be on technical integration. - Technical protocols, formats and standards for say data exchange. Technologies such as middleware, gateways, interfaces, complex-event processing (CEP) with automated response, service orientated architectures and platforms, BMS/FMS backend infrastructure. Backend infrastructure of BIM or ERP systems etc.

21. Trading / transactional management ICT's

g) District energy management: Distributed 'cloud' based networks for the holistic and sustainable management, trading and brokering of energy resources beyond the limits of one enterprise. Demand response capabilities, real-time self-assessment, load balancing technologies, energy network and integration management, secure, smart (intelligent) interfaces with smart (the new generation) grids. Market Management Systems (MMS), Distribution Management Systems (DMS), transactional aspects of Energy Management Systems etc

h) Facility energy management: energy specific management systems, energy specific integration platforms and middleware. Smart (intelligent) metering infrastructure and protocols, Context Event Processing, on-demand energy management and optimisation, load and distributed energy resources forecast algorithms, smart (Intteligent) appliances.

i) Citizen (personnel) energy management: Personal CO2 quota system with interpersonal trade of pollution rights (scope is beyond the buildings category and includes activities like car refuelling). However we may want to include interaction of various agents within a district, those agents could be Buildings, Citizens, vehicles etc.

Appendix 2 - Major European vision on adoption of ICT

Europe 2020

It is worth commencing this section with the initial proposal given by José Manuel Barroso, President of the European Commission: “What I propose is to bring the different strategies and instruments together, adapting them where necessary. In particular, we need to revise the current Lisbon strategy to fit the post 2010 period, turning it into a strategy for an integrated vision of "EU 2020". This strategy for the "EU 2020" will comprise a more convergent and coordinated approach for the reform of Europe's economies through investment in new sources of growth.” As a result three mutually reinforcing priorities were identified: (i) EU to become a smart (which uses more ICT for intelligence across all sectors), (ii) sustainable and (iii) inclusive economy should help the EU and the Member States deliver high levels of employment, productivity and social cohesion.

Concretely, the Union has set five ambitious objectives - on employment, innovation, education, social inclusion and climate/energy - to be reached by 2020. The 5 targets for the EU in 2020 are:

- Employment - 75% of the 20-64 year-olds to be employed
- R&D / innovation - 3% of the EU's GDP (public and private combined) to be invested in R&D/innovation
- Climate change / energy greenhouse gas emissions - 20% (or even 30%, if a satisfactory international agreement can be achieved to follow Kyoto) lower than 1990, 20% of energy from renewables and 20% increase in energy efficiency
- Education - reduce school drop-out rates below 10% at least 40% of 30-34–year-olds completing third level education (or equivalent)
- Poverty / social exclusion - at least 20 million fewer people in or at risk of poverty and social exclusion

From Europe 2020 report we can recall to major flagship initiatives;

Flagship Initiative: "A Digital Agenda for Europe"

The aim is to deliver sustainable economic and social benefits from a Digital Single Market based on fast and ultra fast internet and interoperable applications, with broadband access for all by 2013, access for all to much higher internet speeds (30 Mbps or above) by 2020, and 50% or more of European households subscribing to internet connections above 100 Mbps. Some areas that the EU commission has committed to work on at EU level are:

- To create a true single market for online content and services (i.e. borderless and safe EU web services and digital content markets
- To reform the research and innovation funds and increase support in the field of ICTs
- To promote internet access and take-up by all European citizens.

At national level, Member States will need:

- To draw up operational high speed internet strategies, and target public funding;
- To establish a legal framework for coordinating public works to reduce costs of network rollout;
- To promote deployment and usage of modern accessible online services (e.g. e-government, online health, smart home, digital skills, security)

Sustainable growth means building a resource efficient, sustainable and competitive economy, exploiting Europe's leadership in the race to develop new processes and technologies, to prosper in a low-carbon, resource constrained world while preventing environmental degradation, biodiversity loss and unsustainable use of resources. Europe must act for Clean and efficient energy: Meeting our energy goals could result in € 60 billion less in oil and gas imports by 2020. This is not only financial savings; this is essential for our energy security. Further progress with the integration of the European energy market can add an extra 0.6% to 0.8% GDP. Meeting the EU's objective of 20% of renewable sources of energy alone has the potential to create more than 600 000 jobs in the EU. Adding the 20% target on energy efficiency, it is well over 1 million new jobs that are at stake.

Flagship Initiative: "Resource efficient Europe"

The aim is to support the shift towards a resource efficient and low-carbon economy that is efficient in the way it uses all resources. At EU level, the Commission will work:

- To mobilise EU financial instruments as part of a consistent funding strategy, that pulls together EU and national public and private funding;
- To enhance a framework for the use of market-based instruments (e.g. emissions trading, revision of energy taxation, state-aid framework);
- To present proposals to modernise and decarbonise the transport sector thereby contributing to increased competitiveness. This can be done through a mix of measures e.g. infrastructure measures such as early deployment of grid infrastructures of electrical mobility, intelligent traffic management, better logistics, pursuing the reduction of CO2 emissions for road vehicles , for the aviation and maritime sectors including the launch of a major European "green" car initiative;
- To accelerate the implementation of strategic projects with high European added value, in particular cross border sections and inter modal nodes (cities, ports, logistic platforms);
- To complete the internal energy market and implement the strategic energy technologies (SET) plan, promoting renewable sources of energy in the single market;
- To present an initiative to upgrade Europe's networks, including Trans European Energy Networks, towards a European supergrid, smart (new Generation) grid;
- To adopt and implement a revised Energy Efficiency Action Plan and promote a substantial programme in resource efficiency;
- To establish a vision of structural and technological changes required to move to a low carbon, resource efficient and climate resilient economy by 2050, this will also contribute to improving global food security.

At national level, Member States will need:

- To phase out environmentally harmful subsidies, limiting exceptions to people with social needs;
- To deploy market-based instruments such as fiscal incentives and procurement to adapt production and consumption methods;
- To develop smart (intelligent), upgraded and fully interconnected transport and energy infrastructures and make full use of ICT;
- To ensure a coordinated implementation of infrastructure projects, within the EU Core network, that critically contributes to the effectiveness of the overall EU transport system;
- To focus on the urban dimension of transport where much of the congestion and emissions are generated;
- To use regulation, building performance standards and market-based instruments such as taxation subsidies and procurement to reduce energy and resource use and use structural funds to invest in energy efficiency in public buildings and in more efficient recycling
- To incentivise energy saving instruments that could raise efficiency in energy-intensive sectors, such as based on the use of ICTs.

Transformational Agenda from Digital Europe Vision

The Transformational Power of Digital Technologies

The Europe 2020 strategy is rightly focused on competitiveness as the essential condition for economic growth and job-creation in the global 21st century economy.

Competitiveness depends on permanent productivity growth and permanent innovation in products, services, business processes and business models. The priority of any Europe 2020 policy objective should therefore reflect its contribution to both. Europe must urgently close its current productivity gap with major competitors, notably the US and Japan but also now India and China. Due to our ageing population, we have no choice. As the European Commission stresses in its 2009 Ageing Report: "Within a decade, labour productivity will become the main determinant of Europe's future economic growth."

The transformational Power of Digital Technologies -"Sector Examples"

Digital technologies will increasingly drive productivity, sustainable growth, innovation and employment throughout the European economy in a myriad of ways. These are best demonstrated at the disaggregated levels of industry sectors, individual organisations and individual empowerment. European trends, case examples and success factors from six sectors help to create a wider vision of productive, innovative digital Europe by 2020:

Energy: Europe's three long-term energy policy objectives are: greater energy independence, reduced greenhouse-gas emissions and a competitive, continental scale Single Market. Starting with our grid infrastructures and extending to consumer control over consumption.
Manufacturing / Automotive: The transformation in all manufacturing sectors to customer-driven innovation based on the sustainable use of resources and integrated manufacturing cycles will depend on the pervasive penetration and use of digital technologies.
Transportation and logistics (T&L): Transport and logistics companies are evolving from forwarding and warehouse-managing companies to highly industrialised, ICT-driven supply-chain providers.
Small- and medium-sized enterprises: Entrepreneurial activity represents 99% of an estimated 23 million enterprises in Europe, which needs access to digital tools, to help eliminate distance, assist in delivery of services, virtual organisations and enhance innovation.
Healthcare: The traditional healthcare delivery model, built around dealing with acute episodes, will no longer be sustainable as European society ages. Harnessing the transformational power of digital technologies is the key for moving to a "continuum of care", while improving quality and productivity.
Individual empowerment: Democratic societies will embrace and respond to the collective and individual voices of their people as they express themselves via digital platforms.

The Future of the ICT – "Sector Europe"

Europe must be both host and home to a dynamic ICT sector that is tightly interwoven with the manufacturing, environmental, cultural, and political fabric. Home-grown ICT is indispensable and nothing less than central to this newborn Digital Age.

No region of the world can maintain its economic strength solely on the basis of imported digital competencies, products and services. Indigenous skills, innovation, products and services are essential for growth and prosperity. No region of the world will be able to maintain the ICT sector needed if that sector is not a leading source of jobs and growth and a leader in global markets - these three sectors are where our future lies:

Next Generation Networks & Mobile Broadband: A vast global market for Mobile Broadband lays ahead, an area in which existing European leadership must be carefully nurtured and exploited as we face the fierce competition set to arrive, particularly Asia.

Software: The innovation necessary to create economic growth, drive societal change and address environmental challenges relies on ICT, at the heart of which is software. But software is moving from being used and perceived as a product to a service. This paradigm shift challenges all current market players and offers huge opportunities for Europe's software industry. This is a new world, with new rules, and Europe must compete.

Future Internet: Many, if not most of these software driven opportunities will arise from the continuous development of the Internet as the primary communications infrastructure of the Digital Age. Key in this respect will be the 'Internet of Things' and the 'Internet of Services'.

Smart 2020 Vision - Enabling the low carbon economy in the information age

The GeSI SMART 2020 report quantified the direct emissions from ICT products and services based on expected growth in the sector. It also looked at where ICT could enable significant reductions of emissions in other sectors of the economy and has quantified these in terms of CO_2e emission savings and cost savings.

The enabling impact of ICT represents a significant proportion of the reductions of CO_2e emission below 1990 levels that scientists and economists recommend by 2020 to avoid dangerous climate change, The Stern Review suggested that developed countries reduce emissions 20-40% below the 1990 levels would be a necessary interim target based on IPCC and Hadley Centre analysis (Source: Stern, N (2008), Key Elements of a Global Deal on Climate Change, London School of Economics and Political Science [1].

In economic terms, the ICT-enabled energy efficiency translates into approximately €600 billion ($946.5 billion) [2] of cost savings. Exact figures: €553 billion ($872.3 billion) in energy and fuel saved and an additional €91 billion ($143.5 billion) in carbon saved, assuming a cost of carbon of €20/tonne, for a total of €644 billion ($1,015 billion) savings. It is an opportunity that cannot be overlooked.

The analysis identifies some of the biggest and most accessible opportunities for ICT to achieve these savings.

Smart motor systems: Applied globally, optimised motors and industrial automation would reduce 0.97 $GtCO_2$e in 2020, worth €68 billion ($107.2 billion). All value figures here include a cost for carbon of €20/tonne.

Smart logistics: The global emissions savings from smart logistics in 2020 would reach 1.52 $GtCO_2$e, with energy savings worth 280 billion ($441.7 billion).

Smart (new generation) buildings: Globally, smart buildings technologies would enable 1.68 $GtCO_2$e of emissions savings, worth €216 billion ($340.8 billion).

Smart (new generation) grids: through better monitoring and management of electricity grids, first with smart (intelligent) meters and then by integrating more advanced ICTs into the so-called energy internet. Smart (new generation) grid technologies were the largest opportunity found in the study and could globally reduce 2.03 $GtCO_2$e, worth €79 billion ($124 billion).

In addition to the savings possible by supporting other sectors to become more energy efficient, there are also potential energy savings from dematerialisation or substitution – replacing high carbon physical products and activities (such as books and meetings) with virtual low carbon equivalents (e-commerce/e-government and advanced video conferencing). The study indicates that using technology to dematerialise the way we work and operate across public and private sectors could deliver a reduction of 500 $MtCO_2e$ in 2020 – the equivalent of the total ICT footprint in 2002, or just under the emissions of the UK in 2007. However, these solutions would need to be more widely implemented than they are today to realise their full abatement potential.

This is the opportunity the ICT sector has in the fight against climate change. But it does come at a cost. Emissions from the sector are estimated to rise significantly over the coming years – from 0.5 $GtCO_2e$ today to 1.4 $GtCO_2e$ in 2020 under BAU growth. As given in the Smart 2020 report, the scope of this analysis considers whole life emissions from PCs and peripherals, data centres, telecoms networks and devices. While the sector plans to significantly step up the energy efficiency of its products and services, ICT's largest influence will be by enabling energy efficiencies in other sectors, an opportunity that could deliver carbon savings five times larger than the total emissions from the entire ICT sector in 2020.

Emissions reductions in other sectors will not simply present themselves; the ICT sector must demonstrate leadership on climate change and governments must provide the optimum regulatory context. This report outlines the key actions needed.

These actions can be summarised as the **SMART transformation**.

- The challenge of climate change presents an opportunity for ICT to first **standardise (S)** how energy consumption and emissions information can be traced across different processes beyond the ICT sector's own products and services.
- It can **monitor (M)** energy consumption and emissions across the economy in real time, providing the data needed to optimise for energy efficiency.
- Network tools can be developed that allow **accountability (A)** for energy consumption and emissions alongside other key business priorities.
- This information can be used to **rethink (R)** how we should live, learn, play and work in a low carbon economy, initially by optimising efficiency, but also by providing viable low cost alternatives to high carbon activities. Although isolated efficiency gains do have an impact, ultimately it will be a platform – or a set of technologies and architectures – working coherently together, that will have the greatest impact.
- It is through this enabling platform that **transformation (T)** of the economy will occur, when standardisation, monitoring, accounting, optimisation and the business models that drive low carbon alternatives can be developed and diffused at scale across all sectors of the economy.

The ICT sector can't act in isolation if it is to seize its opportunity to tackle climate change. It will need the help of governments and other industries. Smart (intelligent) implementation of ICTs will require policy support including standards implementation; secure communication of information within and between sectors and financing for research and pilot projects.

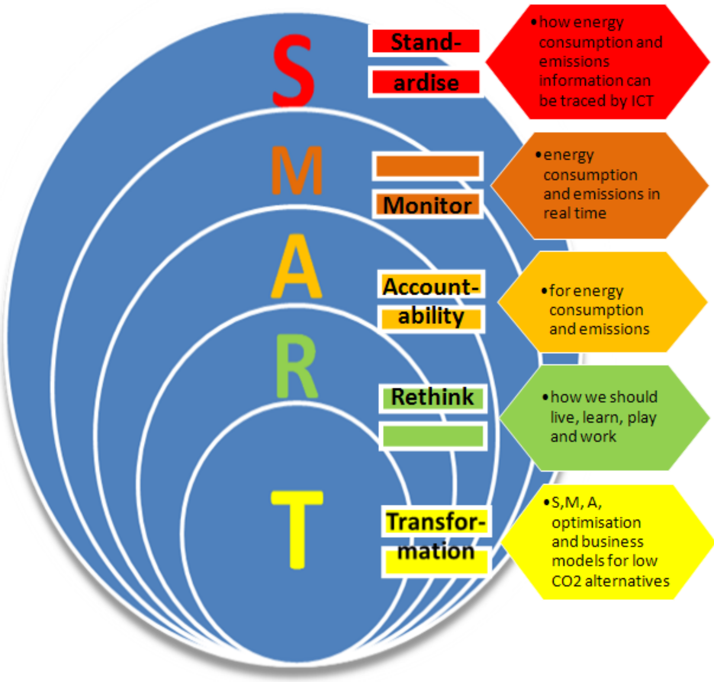

Figure 15 Summary of Smart 2020 vision key actions as the SMART transformation –focused on bringing about transformation (produced by REViSITE to support vision development)

Other Visions

Green ICT Vision in UK

UK Government recognises the critical importance of ICT both as a large consumer of energy and primary resources and as an enabler for environmental and cultural change.

The Government's vision for ICT in central departments is:

• In line with the existing SOGE targets and SOGE definition for Carbon Neutrality, the energy consumption of Government ICT on the office estate will be Carbon Neutral by 2012. Work is ongoing with Defra to define Carbon Neutrality and how this can be delivered;

• By 2020 Government ICT will be carbon neutral across its lifecycle.

ICT-Enabled Environmentally Smart Buildings: Analysis of UK capabilities and development to 2015

Vision for the UK Industry, developed as a 2015 vision for the UK industry [3] which was considered 'Ambitious but achievable', this comprised the following elements:

17. An EU set of integrated standards for the 'Smart Home will be in place by 2015 to cover interoperability of technologies
18. There will be low cost technologies available (e.g. sensors) together with suitable power management technologies for operation in homes
19. Develop UK expertise in software for optimisation and control of networks of multiple buildings
20. The availability of an energy service offering, enabled by integrate technology offering and changes in OFGEM regulations
21. Building regulations improve to trigger the need for increased energy efficiency

22. A strong UK body exists for 'Smart Buildings' which drives standards, provides an effective forum and competence centre for members and lobbies government departments
23. Emergence of major Energy Service Providers in the UK
24. Government investment in UK software sector for development of network monitoring and optimisation software.

Appendix 3 - Trans-sectoral ManuFuture Roadmap: ICT for Manufacturing

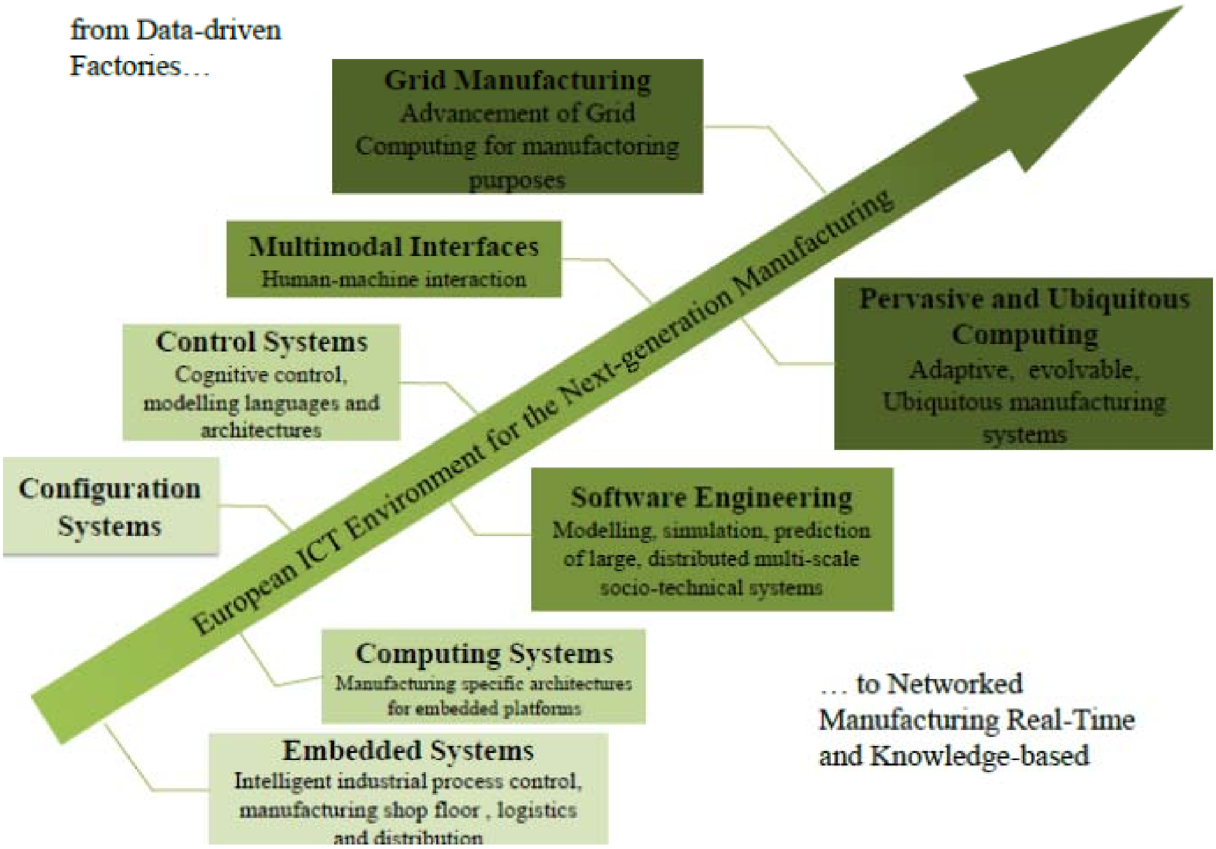

Figure 16 Trans-sectoral ManuFuture Roadmap: ICT for Manufacturing [2]

Appendix 4 - ManuFuture Trans-sectoral Roadmap: Digital, Knowledge-based Engineering

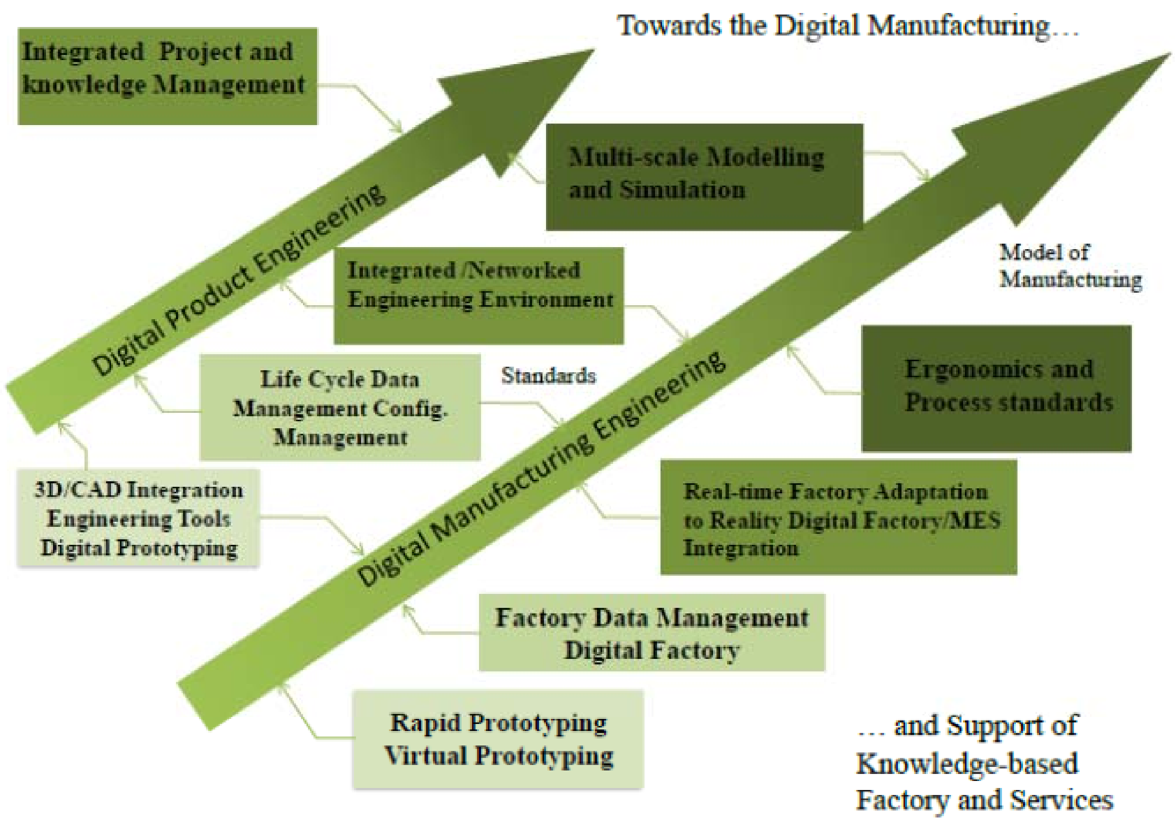

Figure 17 ManuFuture Trans-sectoral Roadmap: Digital, Knowledge-based Engineering [2]

Appendix 5 - Summary of REEB project

The scope is ICT supported energy efficiency of buildings (ICT4EEB). This topic is in the intersection of 3 disciplines: building/construction, ICT and energy. Some examples of relevant items for an integrative approach are listed in the below figure. The baseline of the work was provided by the EC policies and the visions and strategies of a number of related initiatives.

The key target groups the "ICT4EEB community" including e.g. European Technology platforms and RTD projects in the 3 core areas of focus, and the European Commission.

In the short term the immediate target group of the vision report is the REEB consortium for continued work and the REEB Special Interest Group, who advices REEB in the preparation of RTD strategy for the domain.

Most energy usage of buildings throughout their life cycle is during the operational stage (~80%). The decisions made in the conception and design stages of new buildings, as well as in renovation stages of existing buildings, influence about 80% of the total life cycle energy consumption. The impact of user behaviour and real-time control is in the range of 20%.

Currently the energy performance of buildings is mainly driven by regulations. The prevailing market practice is driven by initial investment cost with little attention to life cycle costs. The

awareness of energy efficiency is raising business incentives towards sustainable solutions beyond the required minimum level.

Most of the energy consumed by a building throughout its life cycle is consumed during its operational stage (see Figure 3). The decisions that influence energy consumption are mainly made in the design stage and also in (repeated) renovations. Altogether, many stakeholders, parallel processes and life cycle stages are involved.

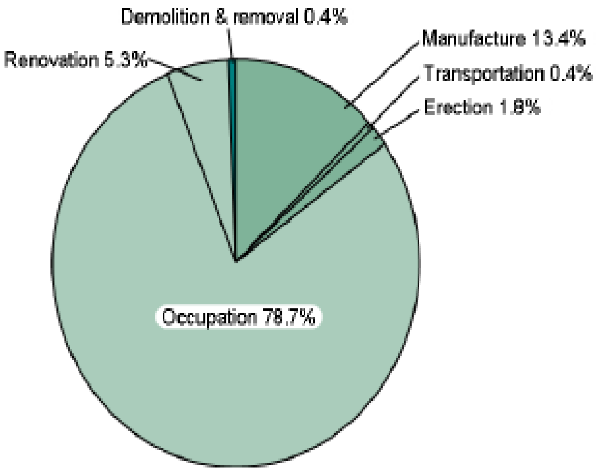

Figure 18 Energy use during life cycle of buildings [2]

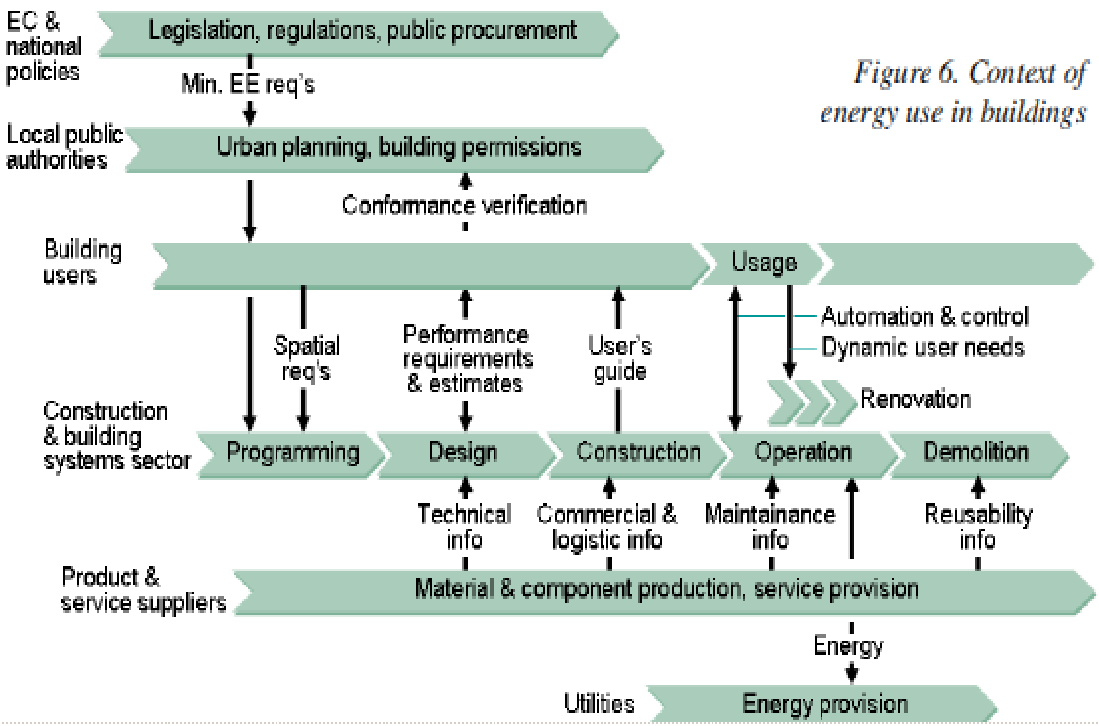

Figure 19 Context of energy use in buildings (as per REEB project)

REEB project has also organised the research topics according to the following structure:

11. Tools for EE design and production management
    - Design: CAD, configuration management, visualisation of design solutions.
    - Production management: contract & supply network management, procurement, logistics, on-site and off-site production management.

- Modelling: building & district modelling, ontologies, semantic mapping.
- Performance estimation: simulation, whole-life costing, life cycle assessment.

12. Intelligent control
    - Automat ion & control: system concepts, intelligent HVAC, smart (new generation) lighting, ICT for micro-generation & storage systems, predictive control.
    - Monitoring: instrumentation: smart (intelligent) metering.
    - Quality of service: improved diagnostics, secure communications.
    - Wireless sensor networks: hardware, operating systems, network design.
13. User awareness and decision support
    - Performance management: Understanding ICT impacts, performance specification, performance metrics, performance analysis and evaluation, conformance validation, commissioning, audits, labelling.
    - Visualisation of energy use.
    - Behavioural change by real-time pricing.
14. Energy management and trading
    - Building and district energy management: building management systems, metering infrastructure, on-demand energy management and optimisation, load and distributed energy resources forecast algorithms, smart (intelligent) appliances.
    - Smart (new generation) grids: demand response capabilities, real-time self-assessment, load balancing techniques, energy network design and integration, secure, ubiquitous and low-latency communications.
15. Integration technologies
    - Process integration: collaboration support, groupware tools, electronic conferencing, distributed systems, business work flows.
    - System integration: plug & play, connections, service oriented architectures, integration and service platforms, cabling, gateways, middleware, development methods and tools.
    - Interoperability & standards: BIM standardisation, simulation and interoperability, protocols for real time operation, energy trading protocols.
    - Knowledge sharing: access to knowledge, knowledge management, knowledge
    - Repositories, knowledge mining and semantic search, long-term data archival and recovery.
    - Virtualisation of the built environment.

Appendix 6 - Content Analysis

Content Analysis on multi-disciplinary Vision for ICT-enabled Energy Efficiency

> ***This work has been conducted to support the review of the relevant visions documents. Mainly, as a method to pinpoint to the sections of these documents which contained key statements that have a strong relevance to ICT and EE. The identified sections were re-analysed separately under their context and were assessed on their level of relevance to REViSITE. Many of the identified sections were out of scope for our vision context on"ICT and EE" and consequently were ignored. However, some have re-confirmed the findings which we extracted already during the general review/analysis of the documents. This exercise was not as fruitful as we hoped it would be, but it helped extraction of some more text passages which were overlooked***

during the review, and were added to the list of the finding with strong relevance to REViSITE.

Introduction to Content Analysis

According to Krippendorf (2004) [1], content analysis is a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the context of their use. It is a scientific tool since as a research technique it provides new insights, increases researchers' understanding of particular phenomena, or informs practical actions.

Content analysis has been defined as a systematic, replicable technique for compressing many words of text into fewer content categories based on explicit rules of coding (Berelson, 1952 [2]; GAO, 1996 [3]; Krippendorff, 2004; and Weber, 1990 [4]). Holsti [5] (1969) offers a broad definition of content analysis as, "any technique for making inferences by objectively and systematically identifying specified characteristics of messages". Under Holsti's definition, the technique of content analysis is not restricted to the domain of textual analysis, but may be applied to other areas such as coding student drawings (Wheelock, Haney, & Bebell, 2000 [6]), or coding of actions observed in videotaped studies (Stigler, Gonzales, Kawanaka, Knoll, & Serrano, 1999 [7]). In order to allow for replication, however, the technique can only be applied to data that are durable in nature.

Content analysis enables researchers to sift through large volumes of data with relative ease in a systematic fashion (GAO, 1996). It can be a useful technique for allowing us to discover and describe the focus of individual, group, institutional, or social attention (Weber, 1990). It also allows inferences to be made which can then be corroborated using other methods of data collection. Krippendorff (2004) notes that "much content analysis research is motivated by the search for techniques to infer from symbolic data what would be either too costly, no longer possible, or too obtrusive by the use of other techniques".

The assumption is that words and phrases mentioned most often are those reflecting important concerns in every communication.

REViSITE Content Analysis

This analysis has been conducted to find confirmation about the studies developed by the REViSITE project in order to assess the correct vision regarding the ICT for Energy Efficiency and its effectiveness in covering the four specific sectors in the specific: Building, Grid, Manufacturing and Lighting.

The all documents chosen to be part of this analysis are official document released by the most European entities and addressing the vision of each of the specific sectors.

Since the aim of this analysis is to prove that ICT for energy efficiency can be seen as a cross discipline affecting and influencing each of those sectors, the documents selected for this purpose are listed following:

The following content analysis has been carried out in order to understand the common concepts in relations to the various documents inherent the vision for the energy efficiency in Europe. Since the REViSITE project aims to define e Common Vision for ICT for Energy Efficiency seen as a cross sectoral discipline, the respective document of each single sector have been cross analysed and the results have been after cross matched with the main common vision document.

The documents used for this analysis have been:

General Vision:

1. 2020 Vision for EU research area
2. ICT in EU of 21st century
3. Europe 2020
4. Post script 2006 stern report (in partly)

Smart Manufacturing:

1. Manufuture vision en
2. Smart manufacturing en

Smart Grid:

1. EU smart grid vision
2. UK-eng smart grid vision (low level of information retrieved)

Smart building:

1. ICT enabled environmentally smart building
2. ECTP – Vision 2030 – 25 February 2005 (low level of information retrieved)
3. E2B – Scope and Vision EI
4. REEB Book Final

Smart Lighting:

1. DOE Lighting roadmap vision 2020
2. The next wave in solid state lighting (low level of information retrieved)

The various steps on how the Analysis has been developed are summarised in the following diagram:

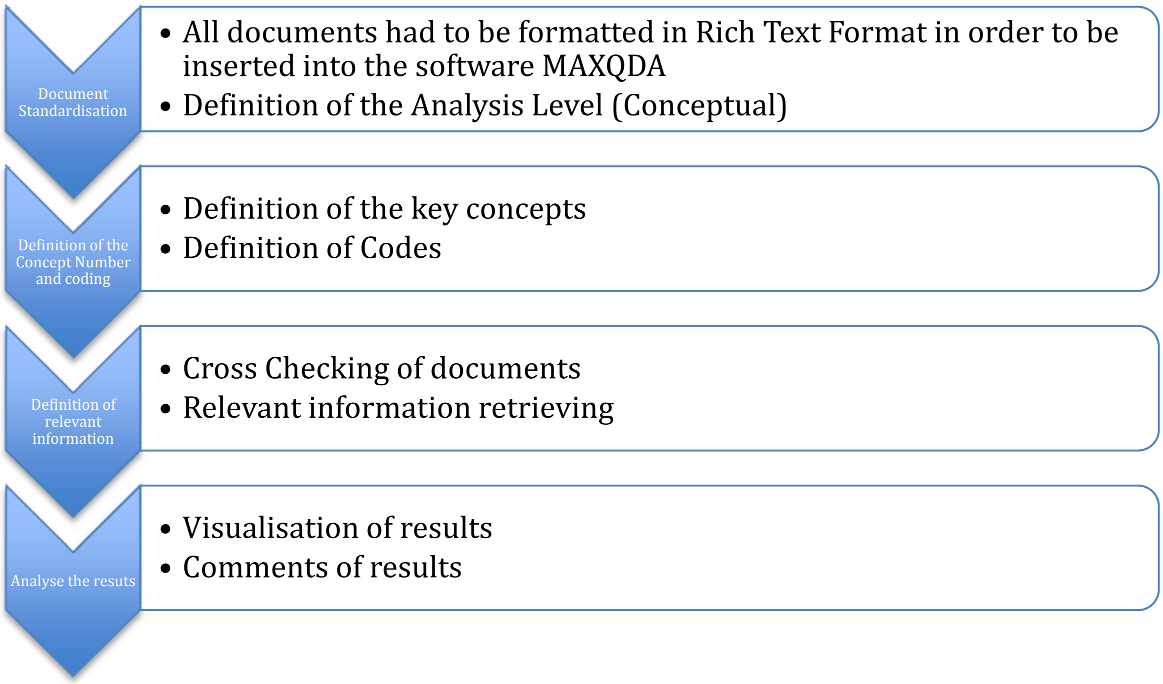

Figure 20 Processes for Content Analysis

Definition of the Analysis level

The categories of content analysis that can be carried out are generally two: conceptual analysis and relational analysis. Conceptual analysis can be thought of as establishing the existence and frequency of concepts in a text, or in a set of texts. Relational analysis builds on conceptual analysis by examining the relationship among concept in a text or in a set of texts.

The analysis category decided for this content analysis is the conceptual level. The choice has been made because of the purpose of the study.

In conceptual analysis, a concept, or a series of concepts are chosen for examination and the number of its occurrences within the text, or series of texts, are recorded. Because terms may be implicit as well as explicit, it is important to clearly define implicit terms before the beginning of the counting process.

As with most other research methods, conceptual analysis begins with identifying research questions and choosing a sample or samples. Once chosen, the text must be coded into manageable content categories. The process of coding is basically one of selective reduction, which is the central idea in content analysis. By breaking down the contents of the material analysed into meaningful and pertinent units of information; certain characteristics if the message may be analysed and interpreted.

In conceptual analysis, the researcher simply wants to examine presence with respect to his/her research question, i.e. whether there is a stronger presence of positive or negative words used with respect to a specific argument or respective arguments.

In fact the following content analysis has been developed in order to figure out the most important components from already existing visions to form the REVISITE Vision that could be shared among the four ICT for energy efficiency sectors, and in the specific new generation: Grid, Manufacturing, Building and Lighting.

Thus contents expressed in the various documents have been conceptualised in macro content and coded as shown in the following paragraph.

Definition of Key Concepts

The key concepts defined for this content analysis are represented by the following:
Cross Sectorial Methodology: this concept refers to the need from a sector of issues and topics and research that could be related to one of the other three ICT for EE sectors.
Life Cycle: In almost every single sector appears the relation about the life cycle study of product or service offered. This concept has been chosen also because of its relation with the common taxonomy developed by REViSITE
Reduce Green Gas Emission: One of the main objectives of the all four sectors analysed through their documents is related to this concept.
Multidisciplinary: this concept is defined as the cooperation of various sectors to achieve specific goal within a specified single sector.
Energy and Climate change and Energy Efficiency: most of the documents refers to the relation between Energy and Climate change, thus these concepts, are embedded in all sectors, and have been chosen as a commonality.
Sustainable development: as before.
ICT for Energy Efficiency: this concept refers to the use of the Information and Communication Technologies as a tool to be implemented through the all sectors analysed.

Definition of Codes

Each document, after a deep reading and contextualization of contents, has been coded according the following codes:

- **Cross Sectorial Methodology**: All paragraphs of the various documents that recall concepts and/or needs and action from and related to other disciplines have been included into this category
- **Life Cycle**: all paragraphs that recall concept related to the Life Cycle of products / facilities have been included here
- **Reduce Greenhouse Gas Emission**: all paragraphs that recall concept related to the Greenhouse Gas emission belong to this code

- **Multidisciplinary**: All paragraphs, sentences that refers to a multidisciplinary approach have been inserted into this code
- **Energy and Climate Change:** all the paragraphs or sentences that recall this concepts have been inserted into this code
- **Energy Efficiency:** all paragraphs and sentences that recall this concept have been inserted into this code
- **Sustainable development:** All paragraphs and sentences that recall to this concept have been inserted into this code
- **ICT for Energy Efficiency:** all paragraph and sentences that recall specifically to ICT for EE have been inserted into this code.

Content Analysis

The analysis has been carried out in two separate steps:

1. The first part has been aimed to analyse the content of the documents related to the four specific sectors
2. The second part has been focused on the analysis of the general documents focused on the general European Vision.

Specific Sector Documents Content Analysis

The first Content Analysis has been carried out between the documents belonging to the four specific sectors.

The documents belonging in specific to the various four sectors have been checked through the following codes and the number each code appears into the documents is reported in the table on the next page:

- Common Vision for ICT
- Cross Sectorial methodology
- Multidisciplinary
- ICT for Energy Efficiency

	Common Vision for ICT	Cross sectoral methodology	multidisciplinary	ICT for Energy Efficiency
Smart Manufacturing\ manufuture_vision_en[1]	7	8	7	1
Smart Manufacturing\smart-manufacturing_en	22	59	23	61
Smart Grid\UK-ensg_smart_grid_vision	0	0	0	0
Smart Grid\EU_smart grid_vision	10	14	2	5
Smart building\ICT enebled enviromentally smart buildings - UK	0	2	0	1
Smart building\ECTP-Vision2030-25Feb2005	0	0	1	0
Smart building\E2B - Scope and Vision_EI	4	6	5	5
Smart building\REEB_Book_Final	6	15	14	18
Smart Lighting\DOE lighting roadmap vision2020 (2000)	5	5	5	5
Smart Lighting\The next wave in solid state lighting	0	0	0	0

Table 8 above is graphically represented by the following figure

As it is visible from the above graphics most of the documents implicitly recall for the strong need for a common Vision for ICT for Energy Efficiency that would lead them to a common understanding and alignment of their activities and initiatives.

As it is visible the code 'Cross Sectorial methodology' is the more present in the all documents followed by the multidisciplinary code and after by the Common Vision for ICT code.

General Documents Content Analysis

The same analysis has been carried out also for the four general documents describing European General Visions, not sectoral specific.

The analysis showed, also in the contents expressed by this documents, the implicit need for a cross sectoral methodology, underlined in the 2020 vision for EU research area and into the Europe 2020, document that also expresses and recalls concept based on multidisciplinary and common vision for ICT. Following is reported, as for the previous analysis, the figure representing the four base codes used and their recurrence within the four documents.

	ICT for Energy Efficiency	Common Vision for ICT	Cross sectoral methodology	Multidisciplinary
General Vision\2020 vision for EU research area	0	0	1	0
General Vision\Europe 2020 (2)	1	0	5	2
General Vision\Postscript 2006 stern report	0	0	0	0
General Vision\ICT in EU of 21st centry	6	1	0	2

Table 9 above is graphically represented by the following figure:

Conclusion

Both conducted analysis, the one related to the specific sectors documents and the general documents, underline that there is, both explicit and implicit, a common need and utility for a cross sectoral methodology and for a common vision for ICT for Energy Efficiency.

Thus this common vision and cross-sectoral methodology, can only impact positively on each sector.

The documents underline the need for a common language to be shared to provide each sector with the possibility to communicate with the other, and hence build an interoperability bridge for the entire ICT for Energy Efficiency area.

The REViSITE project, once understood the common need for the four sectors for a cross-sectorial methodology, and for a common vision for ICT 4 EE, strengthens its thesis through the analysis conducted within the documents gathered.

Furthermore, the analysis, gave the opportunity, to REViSITE, also to understand which commonalities are stronger and with a major impact, and of a better usage in order to develop the common vision for ICT for Energy Efficiency.

<u>Generic text extracts</u>

ICT at the core of the energy efficiency effort and to enable reaching their full potential, making necessary to foster R&D into novel ICT-based solutions and strengthen their deployment and take-up — so that the energy demand of buildings can be further reduced by adding intelligence to components, equipment and services. • Integrated EE design and production management; • User awareness and decision support; • Integrated systems and solutions for EE.

Improving the potential of ICTs in EE focusing on the most promising domains (the power grid, buildings, lighting and ICT itself) through exchange of best practices, reinforce of RTD, take-up promotion and foster demand-driven innovation.

Foster the competitiveness of European industry and create new business opportunities. Progress must be made through more functionality and performance at lower cost as well as better adaptability and learning capabilities of ICT systems to facilitate user control; including stronger requirements for reliability and security of ICTs and the need to handle higher volumes and more complex digital content and services.

Three generic lifecycle stages are considered: • Definition – programming, conception, design; • Realisation – planning, production, manufacturing, procurement, assembly; • Usage – facility management, operation, maintenance.

Short to medium term research: ICTs for energy-smart buildings and districts, integration of Renewable Energy Sources in buildings and districts.

Joint open networks of virtual engineering and virtual manufacturing partners employing new business models.

Just like the internet, the electricity grid will be interactive for both power generation sources and power consumption sinks. Enabled by smart metering, electronic control technologies, modern communications means and the increased awareness of customers, local electricity supply management will play a key part in establishing new services that will create value for the parties involved.

Specification & design ICTs

Towards holistic simulation at different levels: (a) component level, field level; (b) machine level; (c) process and plant level.

Systematic fitting of models to experimental data including model structure discrimination and model-based experimental design.

Efficient use of models – that is, how to obtain solutions from model-based approaches.

Development of new ICT to support simulation, modelling, large-scale (wireless) monitoring and control.

Selection and promotion of proper efficiency indicators: •3D modelling tools. Used first in the design phase, they will be correlated with on-site measurements to improve the modelling accuracy and expertise. •Rapid on site measurement of actual performances.

"Standards based energy performance assessment software" concept include: • Link the core module with BIM applications by using a common standard for the description of the energy-related characteristics of a building (geometry, used materials, HVAC systems, etc.); • The implementation of dynamic simulation capabilities to better estimate summer comfort in the considered building. • The support of new, innovative HVAC systems (so that the calculations about energy consumption are more precise and better taken into account

3D tools, used to design various kind of objects (cars, furniture, small devices, as much as buildings) tend to be more and more common because of their user-friendly interfaces. Modelling tools are becoming more common because they offer integration with other tools.

Intersection of three disciplines: building/construction, ICT and energy. Some examples of relevant items for an integrative approach are listed in the below figure:

• Design: CAD, configuration management, visualisation of design solutions.

• Production management

• Modelling: building & district modelling, ontologies, semantic mapping.

• Performance estimation: simulation, whole-life costing, life cycle assessment.

Materialisation ICTs

Embedded computing systems that give “intelligence” to products and processes are of strategic importance as key factors in revolutionising industrial production processes, helping improve logistics and distribution – and so increasing productivity.

Software management solutions for large-scale infrastructures, e.g. for remote monitoring, remote diagnostics, predictive maintenance, etc.

Methods to allow information to flow to where it is needed.

Digital metering and components for real time information, e.g. energy audits integrated with business software, central collection of real time energy data, and interfaces with monitoring agencies.

An interoperable infrastructure that allows us to on-line monitor energy consumption down to discrete device level.

Embedded systems, standardised and interoperable communication protocols, Smart (New Generation) Grid and Internet applications. The whole building will be supervised by intelligent systems that should holistically control all sub-systems, components and equipments thanks to advanced control algorithms. Indeed, it will be able to combine information from all connected devices, from the Internet and from energy service providers to efficiently control HVAC (heating, cooling & ventilation), lighting and domestic hot water systems.

Web-Interfaces for Consumption Analysis: to access and analyse building performance data in a context-sensitive: • Data-Brokers, Decision Support algorithms will be needed. • Exploitation of Internet and web technologies for advanced building management using remote control.

Web-based services: instead of being sold as stand-alone applications, one can imagine that such tools would rely heavily on online materials and components databases that would be updated real-time by the providers themselves.

Creation of a metrics framework and key performance indicators based on reliable information is essential for evaluation and decision making.

Management of industrial energy efficiency is developed as an industry benchmark, e.g. through intelligent use of smart (intelligent) meters, sensor networks and benchmarking results should be published and their development monitored.

Information is essential for the management to measuring, planning and organisational change across the economy. Creating and promoting a public repository of energy efficiency measures and opportunities would help generate the appropriate mindset.

Research innovations in various fields, in particular also information and communication technologies, should be used as multi-implementation tools by bureaucrats and implementation strategies by governments.

A group of experts from different industries defines compatible metrics systems. This group should involve operators/end users, machine builders/OEM, suppliers of components, sensors and control systems and research institutes.

An efficient energy efficiency certification scheme for companies requires a standardised approach.

For a successful transition to a future sustainable energy system all the relevant stakeholders must become involved: governments, regulators, consumers, generators, traders, power exchanges, transmission companies, distribution companies, power equipment manufactures and ICT providers.

It is essential to have an integrated approach covering technical, commercial and regulatory factors along with the development of a shared vision. This will minimise risk and allow business decisions to be made by independent companies in an environment of stability.

Synergies and co-operation between construction, energy and ICT companies will enable a new range of business models where innovative local and regional small and medium enterprises will play a key role.

Decentralised Information Management and Supply Chain Management.

Automation & operational decision support ICTs

Align with global standards of technology, quality and sustainability

Motors can be equipped with variable speed drives (VSD) to achieve energy savings of up to 50%.

Availability of integrated ‘sense and respond’ technologies enabling building management systems to identify external and internal environmental conditions based on sensor and forecast data and optimize the environment accordingly: ·Technology standards for interoperability of key environment technologies ·Environment monitoring and optimization technologies that are easy to install and support (e.g. based on digital TV, broadband, mobile and other technology platforms).

Model predictive control capable of solving optimisation problems in real time. Embedded, smart (new generation) components and systems, sensor/actuator networks and control algorithms can be used to achieve a positive effect on emissions. Optimisation loops by enabling data exchange between the automation system.

Wireless networks that allow inter-machine and inter- system communication could improve energy efficiency across an entire factory.

Networked –Determining methods for the identification and verification of the manufacturing requirements of all involved parties in a network

Metering services will represent the gateway for access to the grid of the future.

Smart (New Generation) buildings: Most buildings will be "smart" (i.e. intelligent and responsive) and control themselves maintaining the required and optimal performance and responding proactively to external conditions and user behaviour anticipating them, rather than reactively. Holistic operation of subsystems is supported by integrated system architectures, communication platforms, and standard protocols for interoperability, sensors and wireless control technologies.

Building Sensing Infrastructures (SI) by development of seamless and dynamic end-to-end network compositions and service operations based on a wide range of components from sensor nodes, to Wi-Fi devices, RFID tags and readers.

• Integrated Management of Monitoring Data: for ‘Multi- dimensional Bulk Data Management and Data Analysis’; • Middleware: New middleware to facilitate interoperability amongst different devices will be needed; • Adoption of common, open architecture and advanced control protocols for communication platforms; • Innovative

Wireless Sensing, Metering Components; • Systems Integration / Communication Networks with new features: (1) Wide band Programmable Logic Controller (PLC) interfaces; (2) New Virtual Private Network (VPN) embedded interfaces; (3) Low Power communication interfaces; • Development Tools.

Intelligent control

• Automation & control: system concepts, intelligent HVAC, "smart" (i.e. intelligent and responsive) lighting, ICT for micro- generation & storage systems, predictive control.

• Monitoring: instrumentation: smart metering.

• Quality of service: improved diagnostics, secure communications.

• Wireless sensor networks: hardware, operating systems, network design.

User awareness and decision support

• Performance management: Understanding ICT impacts, performance specification, performance metrics, performance analysis and evaluation, conformance validation, commissioning, audits, labelling.

• Visualisation of energy use .

• Behavioural change by real-time pricing. IV. Energy management and trading

• Building and district energy management.

• Smart grids: demand response capabilities, real-time self-assessment, load balancing techniques, energy network design and integration, secure, ubiquitous and low-latency communications.

Resource & process management ICTs

Adopt standard ICT interfaces

Knowledge based and networked enterprises - Simultaneous activity in all areas:

Research, development, design, construction and assembly to satisfying global demand and shorten time-to-market. Special emphasis will also be put on embedding ICT within other techno-organisational developments

In this highly regulated sector, efficient knowledge sharing and the pooling of research and technological development resources of all disciplines are now critical.

Once the new grids are up and running, two-way flows will exist between provider and user. This type of exchange has characterised the popularity of the internet- how is Grids preparing.

The knowledge driven economy which are based on competitive R&D system, which is facilitated by favourable framework conditions

Integration Technologies, including:

• Business Work Flows: The development of new data exchange policies amongst different stakeholders was identified as a future R&D activity.

• There exists a huge business potential in development of robust, user driven decision support applications for BMS and energy management, providing energy calculations, simulation and visualisation.

Technical Integration ICTs

Interoperability with professional modelling applications through common standards.

Microelectronics and embedded systems make it possible for networked embedded devices to cooperate and provide almost real time information.

Multidisciplinary challenge combining several issues related to science, technology, information technology, ecology and common sense.

It requires a combination of approaches from ICT with disciplines such as mechanical engineering, economics and ecology. Interdisciplinary actions will be needed.

Role of ICT as an enabler of energy efficiency across the economy.

Integrating technologies into Europe's grids.

Necessary to foster research into novel ICT-based solutions and strengthen their deployment:• Building Automation: New and improved control and management systems. •Smart (intelligent) Metering: Meters that measure individual energy demand over time. •User Awareness Tools: Intuitive feedback to users on real time energy consumption. •Interoperability / Standards: Standardisation for the interfaces and communication.

Modernise their manufacturing base and strengthen the links between research and innovation. Adoption of new approaches to education and training, life-long learning to re-skill or up-skill the workforce, and encouragement of the mobility of researchers

Increasing convergence of the three most revolutionary industries: microelectronics, nano-technology and biotechnology.

ICT is also a generic enabler for integration of various processes, applications, systems and technologies: databases, collaboration & communication infrastructures, interoperability standards, knowledge management, modelling, optimisation, simulation, visualisation, etc.

Trading / transactional management ICTs

Concrete models for energy consumption prediction at each layer e.g. device level, location, process level etc.

New services.

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