Roadmap Enabling Vision and Strategy for ICT-enabled Energy Efficiency

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# D3.3 - Implementation Action Plan (IAP)


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| Dissemination level | | |
|---|---|---|
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| PP | Restricted to other programme participants (including the Commission Services) | |
| RE | Restricted to a group specified by the consortium (including the Commission Services) | |
| CO | Confidential, only for members of the consortium (including the Commission Services) | |

SEVENTH FRAMEWORK PROGRAMME

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# Table of Contents

# EXECUTIVE SUMMARY

The REViSITE Implementation Action Plan (IAP) builds on the SRA priorities and provides recommendations in the form of research calls for proposals (i.e. EC calls, national programmes etc.) and other types of recommendations and suggestions to various stakeholders for timed & synchronised implementation actions. Partners, in collaboration with the REViSITE Expert Group and the REViSITE Community have translated the SRA results into ~21 suggested RTD topics (actions) detailed in the form of "action tables" template. The top half of the table included content gathered from the vision document and an analysis of the SRA topics, while the bottom part was allocated for generating the recommendations.

Before generating these recommendations a first validation check of the IAP was undertaken together with the REViSITE focus group. This was based on the content of the IAP action tables and the earlier REViSITE results. After refinement and re-prioritisation of the research topics/ideas, the action tables were presented for full validation by relevant expert stakeholders during the roadmap validation and refinement workshop.

Analysis of the finalised and validated action tables was conducted by LOU and all partners to reorganise the individual related actions into a bundle of 11 themes that could be implemented as research calls by funding bodies, e.g. EC calls, national programmes etc. This formed a basis for development of calls text for the different national, EU, and global funding schemes, e.g. (but not limited to) the European Technology Platforms, the Joint Technology Initiatives, etc. The following 11 identified themes were deemed sufficient to encapsulate all the technologies and the developments in the field of ICT4EE:

1. Integrated design
2. Component Catalogues
3. Data models
4. Application tools
5. Life cycle energy modelling and estimation
6. Metrics and methods for assessing energy efficiency and the impact of ICT on energy efficiency
7. Data visualisation and decision support
8. ICTs to facilitate new business models and work practices for improved EE
9. Cloud computing and network enabled energy services
10. ICT's for nodal Energy management
11. Integrated monitoring and control for improved EE

These themes were further supplemented by another 12th theme which is a coordination action which runs horizontal to cover all the 11 themes.

Once the above process was completed REViSITE partners have developed the final calls using the filtered content while drawing on their expertise in their specific subject areas. Recommendations and suggestions to other stakeholders were also produced through synthesis of the recommendations given in the cells corresponding to each type of stakeholders in the recommendation section of each of the 21 action tables. These included indication of areas requiring attention by policy makers and regulators, indication of needed activities by research performers, by industry, and suggested directions for education and training institutions (see D4.4) and standardisations bodies (see D3.4).

The IAP is designed to easily map with various research topics/ideas to different national, EU, and global funding schemes, e.g. (but not limited to) the European Technology Platforms, the Joint Technology Initiatives, etc. It is also expected that the identified recommendations will be relevant also to other sectors. It should be noted that different sectors will perceive these recommendation with different view on the deployment scale depending on maturity levels with respect to the technologies outlined, however the aim is to produce a holistic cross-sectoral view.

# ACRONYMS

| Acronym | Description |
|---|---|
| 3D | 3 dimensional |
| 4D | 4 dimensional (3 dimensions + time) |
| BIM | Building Information Model |
| CAD | Computer Aided Design |
| CFD | Computational Flow Dynamics |
| CIM | Common Information Model [Grids] |
| CO2 | Carbon Dioxide |
| DER | Distributed Energy Resources |
| DSOs | Distribution System Operators |
| EE | Energy Efficient/Efficiency |
| EMS | Energy Management System |
| ERP | Enterprise Resource Planning |
| IaaS | Infrastructure as a Service |
| ICT | Information and Communication Technology |
| ICT4EE | ICT for Energy Efficiency |
| LC | Life Cycle |
| LCA | Life Cycle Assessment |
| MgNFC | Near Field Communication |
| PaaS | Platform as a Service |
| PLM | Product Life cycle Management |
| RFID | Radio Frequency IDentifier |
| RSS | Rich Site Summary / Really Simple Syndication |
| RTD | Research and Technology Development |
| SaaS | Software as a Service |
| SLA | Service Level Agreement |
| SRA | Strategic Research Agenda |
| VE | Virtual Enterprise |
| Volt-VAR | Management of VOLTage levels and reactive power (Volt-Ampere Reactive VAR) control (throughout power transmission and distribution systems to reduce waste and to increase grid capacity) |
| VR | Virtual Reality |
| VPP | Virtual Power Plant. |

# 1. INTRODUCTION

## 1.1 Purpose

The REVISITE project is a Coordination Action supported by the European Commission under the FP7 programme in the area of ICT for Energy Efficiency. The aim of REVISITE is to identify opportunities for research synergies between sectors:

- Many ICT tools & systems are generic and can serve different industry sectors with no or reasonable adaptation. This offers opportunities for larger markets to the ICT providers and better services to ICT users.
- Synchronised development of energy management systems for different sectors offers opportunities for energy trading via energy information exchange.
- The geographical frame of reference for the studies is the EU-27 and the time frame in terms of impact assessment and vision is 1990 to 2020.

In relation to the description of work, the SRA was used as a basis to gather information to formulate the IAP recommendations. The SRA identified 21 topics which were consolidated into action tables to start with then undergone a filtering process to generate 11 research call themes as recommendations for research and innovation organisations and various recommendations for other stakeholders, including regulatory and policy makers, standardisation bodies, research performers, industry and education and training organisations. The IAP is designed to easily map with various research topics/ideas to different national, EU, and global funding schemes, e.g. (but not limited to) the European Technology Platforms, the Joint Technology Initiatives, etc. A first validation check of the IAP was done together with the focus group based on the content of the action tables (given in appendix 1). After refinement and re-prioritisation of research topics/ideas, it was presented for validation to relevant stakeholders during the roadmap validation and refinement workshop, which took place in Paris on the 9$^{th}$ of March 2012.

This document presents recommendations for research development, innovation and other actions in the domain of ICT for Energy Efficiency across several industry sectors in order to enable the implementation of the REViSITE SRA. The generated recommendations are presented in order to enable the implementation of the REViSITE SRA across four sectors, which are electricity grids, manufacturing, buildings and lighting. It is expected that the identified recommendations will be relevant also to other sectors. It should be noted that different sectors will perceive these recommendation with different view on the deployment scale depending on maturity levels with respect to the technologies outlined, however the aim is to produce a holistic cross-sectoral view. Two other complementary reports provide recommendations on specific actions to be taken by various stakeholders in line with the current IAP:

- D3.4 Recommendations for new standards to overcome interoperability barriers.
- D4.4 Recommendations to Education and Training Systems.

## 1.2 Contributions

LOU

- Lead partner of T3.3 and lead author of D3.3.

- Organization and management of the activities and the developments carried out by partners to generate the recommendations which are based on previous deliverables (D2.2, D2.3, D3.1 and D3.2) and draw on partners' expertise in their specific domains.
- Structuring the deliverable and performing a staged analysis and compilation of the contributions by partners.
- Reviews and suggestions to all contributions.

VTT

- Contribution to the organisation of the activities of T3.3 and planning the various stages of the IAP development while pointing out to the strategic research agenda (D3.2 SRA).
- Contribution to the population of the action tables (Appendix 1), the filtering matrix (Appendix 2) and the writing of the final calls (section 2).
- Reviews and suggestions to all sections from buildings and lighting perspective.

CSTB

- Contribution to the population of the action tables (Appendix 1), the filtering matrix (Appendix 2) and the writing of the final calls (section 2).
- Section on Technical Integration ICT's.
- Reviews and suggestions to all sections from buildings perspective.

KEMA

- Contribution to the population of the action tables (Appendix 1), the filtering matrix (Appendix 2) and the writing of the final calls (section 2).
- Section on Trading / transactional management ICT's.
- Reviews and suggestions to all sections from grid perspective.

INTEL

- Contribution to the planning of the various stages of the IAP development methodology.
- Contribution to the population of the action tables (Appendix 1), the filtering matrix (Appendix 2) and the writing of the final calls (section 2).
- Sections on Automation and operational decision support ICTs and Resource & process management ICTs.
- Reviews and suggestions to all sections from ICT perspective.

FHG

- Contribution to the population of the action tables (Appendix 1), the filtering matrix (Appendix 2) and the writing of the final calls (section 2).
- Section on Materialisation ICT's.
- Reviews and suggestions to all sections from manufacturing perspective.

## 1.3 Baseline

- The common priority themes across several sectors identified in D2.2 – ICT4EE Knowledge and Current Practices were used as the baseline for the preparation of D3.3 IAP.
- D3.1 – REViSITE Vision document was used to suggest the expected impacts of the recommended actions.
- D3.2 – REViSITE Strategic Research Agenda was used to suggest a selection and a combination of specific topics, the scope of each topic and the intended target outcomes in

combination with the findings of D3.1 were used to generate the recommendations for various stakeholders which eventually formed the IAP.

## 1.4 Methodology

The Implementation Action Plan (IAP) builds on the SRA priorities and provides recommendations in the form of research calls (i.e. EC calls, national programmes etc.) and recommendations to various stakeholders for timed & synchronised implementation actions. The IAP development methodology includes three steps as follows:

Partners have translated SRA results into ~21 suggested RTD topics (actions), which were further detailed to form what we have named “action tables” (see appendix 1). This was carried out through coordinated iterations between partners for the description of the actions related to each of the SRA topics that are already identified in D3.2 together with indicating their deployment time scale (next 3, 6 and 9 years). Figure 1 shows the transition process from D3.2 to D3.3.

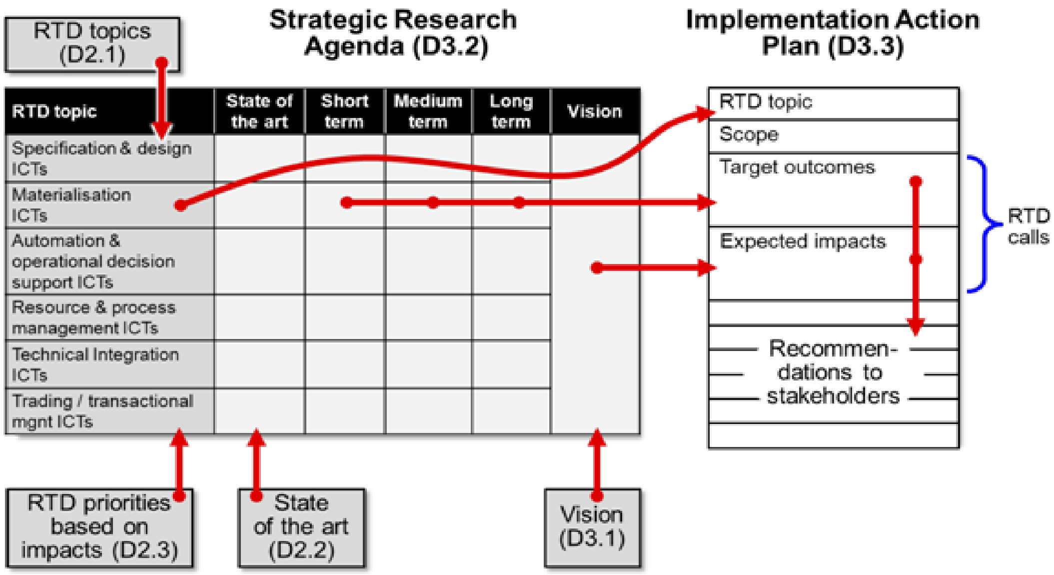


**Figure 1 diagram showing transition procedure from SRA tables to IAP action tables**

A template for the action tables was prepared. Each action table was based on one of the SRA topics (sub-categories) and was divided into two main parts:

(i) The top part included high level analysis of the SRA topics in preparation for an implementation stage. The analysis included defining the technical scope for each topic, the expected target outcome of the RTD work and its potential impact. In addition a cross relation to other SRA topics as seen by partners to be relevant to the current topic was indicated to complete this part.

(ii) The bottom part of the action tables was allocated for generating recommendations for the five chosen stakeholders, namely: policy makers and regulators; research and innovation funding organisations; research performers; education and standards organisations. This part was completed by partners first, who were assigned a number of action tables depending on their expertise (mainly split par SMARTT categories).

The produced action table’s drafts were validated at the IAP workshop which took place in Paris on the 9th of March 2012.

Each of the stakeholders invited to the workshop (in Paris) were experts in specific domains relevant to ICT4EE. They were asked to validate the suggested recommendations and provide comments together with additions (if any) in terms of recommendations which they may see relevant but missing so far. A full report on this workshop is found in D4.3-1d.

The initial output of the REViSITE-IAP resulted in 21 succinct action tables (the diagram in Figure 2 shows a typical action table and how it is populated) that were detailed as follows:

- The scope of each RTD Topic
- The target outcomes pertaining to any future research funding call.
- Expected impacts of achieving the identified target outcomes.
- Specific recommendations for the stakeholders identified
  - Policy makers + regulators
  - RTD funding organisations
  - Research performers
  - Industry
  - Education and training institutes

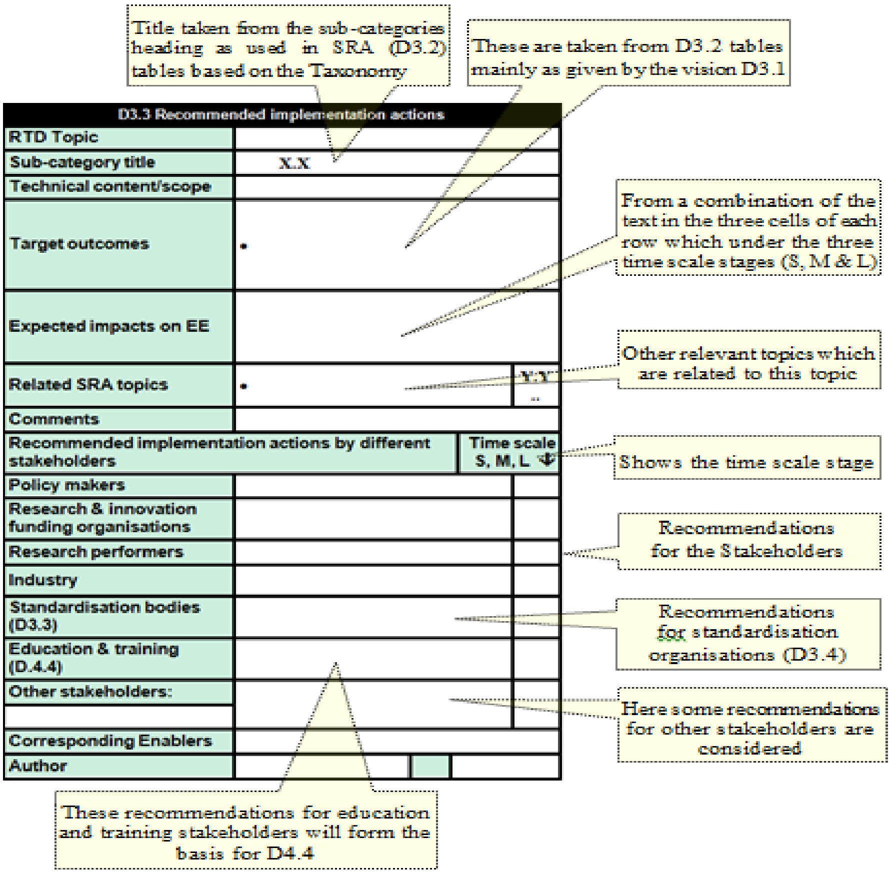


**Figure 2 Steps undertaken for populating the IAP action tables**

What follows is an example populated action table for the sub-category/RTD topic: ‘operational decision support and visualisation’.

| D3.3 Template for recommended implementation actions | | |
|---|---|---|
| Life cycle phase | Operational / Usage | |
| SMARTT category | 3.0 Automation & Operational Decision Support | |
| Sub-category | 3.2 Operational decision support & visualisation | |
| Technical content/scope | Operational visualisation decision support ICTs that integrate diverse systems such as safety, security, weather and energy at different levels of abstraction e.g. plant, building or district. To include SCADA, Business Activity Modelling, Management Dashboard ICTs & methodologies for analyzing situation awareness in complex sociotechnical & First Of A Kind systems. | |
| Target outcomes | Technology, standards & strategies supporting –<br>• Ability to understand Big Data volumes & diverse data sources via visualisation.<br>• Intuitive, dynamically adaptable visualisations incorporating streamed [real-time] & asynchronous data sources for effective energy related decision support<br>• Contextual rendering of data visualisations based on end-user device capabilities & information consumption preferences, again supporting effective EE related decisions | |
| Expected impacts on EE | • Improved energy performance management via integrative data visualization & decision support that augments automated management systems. | |
| Codes of related SRA topics under other taxonomy sub-categories (and add a linking statement if any) | • Interoperability between CAD tools, applications for design, performance analysis, simulation, libraries etc. Generation of requirements from related system models tying data sources to graphic components. Visual programming of performance indicators<br>• Connection to automated sensing & control technologies in the operational phase together with horizontally applicable themes - knowledge management, process/supply chain/ life cycle simulation & modelling | 1.1-1.5<br>3.1<br>4.1-4.4 |
| Comments | | |
| Recommended implementation actions by different stakeholders | | Time scale S, M, L ↓ |
| Policy makers and regulators | Encourage the adoption/application of standards to improve productivity and exploitation e.g. W3C | SML |
| Research & innovation funding organisations | • Encourage applied projects in the energy efficiency space that will test visualisation state of the art technologies in real world scenarios.<br>• Encourage the adoption of user-centred design process when engaging in use-case driven projects to ensure closer collaboration with end users/industry | S<br>S |
| Research performers<br>Industry | • Visual programming of performance indicators<br>• Methodologies for identifying user requirement in a manner that is directly relevant for visual design.<br>• Streamlining the design process by simplifying data acquisition, manipulation & assignment to graphical components | M<br>S<br>S |
| Standardisation bodies (D3.3) | Expand on the current ISO standards on usability and user centred design to include process roadmaps and assessment criteria e.g. ISO 9241-151 & work of ISO/TC 159 | M |
| Education & training (D.4.4) | Generate exemplars that clearly show design process applied in context | M |
| Other stakeholders: | | |
| Corresponding Enablers | | |
| Author | | Date |

Analysis of the finalised and validated action tables was conducted by LOU and all partners to first reorganise the individual related actions into a bundle of 11 themes that could be implemented as research calls for proposal by funding bodies, e.g. as EC calls, national programmes etc. This formed a basis for development of ICT calls text for the different national, EU, and global funding schemes, e.g. (but not limited to) the European Technology Platforms, the Joint Technology Initiatives, etc. The following 11 identified themes were deemed sufficient to encapsulate all the technologies and the developments in the field of ICT4EE:

1. Integrated design;
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8. ICTs to facilitate new business models and work practices for improved EE;
9. Cloud computing and network enabled energy services;
10. ICT's for nodal Energy management;
11. Integrated monitoring and control for improved EE.

These themes were further supplemented by another 12th theme which is a coordination action that runs horizontally to cover all the 11 themes.

A filtering matrix was developed to cluster the content of the 21 action tables under the 11 themes as an initial step toward writing the research calls (see Appendix 2). Once completed partners have written the final calls using the filtered content drawing on their expertise in their specific subject areas.

The second part of the analysis of the action tables was dedicated for extraction of recommendations for other stakeholders which were also produced through synthesis of the recommendations given in the cells corresponding to each type of stakeholders (see figure 2 bottom half) at a time from the 21 tables. These included: (i) policy makers and regulators; (ii) research performers; (iii) industry; (iv) standards organisations; (v) education and standards bodies and further (vi) other types of stakeholders. In section 2 of this deliverable, are presented in full details the 11 research calls for proposals and the other recommendations.

## 1.5 Instruments for the deployment of the IAP

In the following are given some of possible deployment instruments for the IAP recommendations, such as EU research and innovation funding organisations, national programmes, and other bodies for: standardisation (which is addressed in D3.4), policies, regulations, industry initiatives etc. Also to include are education & training institutions which are also addressed in D4.4.

EU programs:

- FP7, the Seventh Framework Programme for Research and Technological Development 2007-203 (http://cordis.europa.eu/fp7/).The most relevant sub-programmes are:
    - ICT, Information and communication technologies (http://cordis.europa.eu/fp7/ict/)

  - NMP, nanosciences, nanotechnologies, materials and new production technologies (http://cordis.europa.eu/fp7/cooperation/nanotechnology_en.html)
  - ENERGY (http://cordis.europa.eu/fp7/energy/)
  - ENVIRONMENT (http://cordis.europa.eu/fp7/environment/home_en.html)

  After 2013 FP7 will be succeeded by the Horizon 2020 programme.

- Horizon2020, The EU Framework Programme for Research and Innovation 2014-2020 (http://ec.europa.eu/research/horizon2020/)
- IMS, Intelligent Manufacturing System: Industry-led international research collaboration between EU and Norway, Mexico, Korea, Switzerland and USA (http://cordis.europa.eu/ims/)
- EUREKA: Market oriented European research supported by participating countries (http://www.eurekanetwork.org/)
- CIP: Competitiveness and Innovation Framework Programme (http://ec.europa.eu/cip/). The most relevant sub-programmes are:
  - ICT-PSP, Information and Communication Technologies Policy Support Programme (http://ec.europa.eu/cip/ict-psp/)
  - IEE, Intelligent Energy – Europe (http://ec.europa.eu/energy/intelligent/)
- EIT, European Institute of Innovation and Technology: Knowledge and Innovation Communities on climate change mitigation, ICT and sustainable energy (http://eit.europa.eu/)

National research and innovation programs for different EU member states e.g.:

- EPSRC, Engineering and Physical Sciences Research Council, UK (http://www.epsrc.ac.uk/)
- TSB, Technology Strategy Board, UK (http://www.innovateuk.org/)
- TEKES, the Finnish Funding Agency for Technology and Innovation (http://www.tekes.fi/)

Policy and Regulations:

- Relevant decision making and policy areas (e.g. climate action, energy, environment, information technology, research and innovation etc.).
- The main stakeholders could be the EU Council (national governments), the European Parliament and the EC (preparing & executing). The European Union: (http://europa.eu/about-eu/basic-information/decision-making/index_en.htm)
- IIEA, The Institute of International and European Affairs, Ireland (http://www.iiea.com/)

Industry initiatives and industry lead initiatives:

- The energy Technology Institute (ETI) is a partnership between global industries and the UK Government bringing together projects and partnerships accelerating the development of affordable, clean and secure technologies to help the UK meet its legally binding 2050 climate change targets.
- Industry lead initiatives", which could then include ETPs + JTIs + PPPs
- SEII, Solar Europe Industry Initiative: An industry-led initiative which has developed a 10 years Research, Development and Demonstration (R&D&D) roadmap for PV in Europe. (http://www.eupvplatform.org/news/solar-europe-industry-initiative-seii.html)

- EEGI, European electricity grid initiative (https://www.entsoe.eu/rd/eegi/): is one of the European Industrial Initiatives under the Strategic Energy Technology Plan (SET-Plan). With the objectives to:
  - to transmit and distribute up to 35% of electricity from dispersed and concentrated renewable sources by 2020 and a completely decarbonized electricity production by 2050;
  - to integrate national networks into a market-based, truly pan-European network, to guarantee a high-quality of electricity supply to all customers and to engage them as active participants in energy efficiency;
  - to anticipate new developments such as the electrification of transport;
  - to substantially reduce capital and operational expenditure for the operation of the networks while fulfilling the objectives of a high-quality, low-carbon, pan-European, market based electricity system.

# 2. Implementation Action Recommendations

## 2.1 Recommendation for Calls for proposals to be issued by Research and Innovation Funding organisations

### 2.1.1 Integrated design (IP)

**TECHNICAL SCOPE**

The life time performance of a product/system is largely determined in the design phase. This is especially the case when new products/systems are designed. Design for retrofitting of existing systems is also crucial as many products are renewed several times throughout their life time. Complex systems need to be optimised based on multiple and often conflicting criteria. The degree to which the designed energy efficiency potential will be actually materialised, depends on the downstream life cycle stages (materialisation, operation). Therefore integration between different information sources, stakeholders and stages is of fundamental importance for design.

**TARGET OUTCOMES**

The main targets for integrated design are interoperability of various ICT applications and the ability to share information at high semantic level between stakeholders over all life cycle stages:

- Enhancement of existing design, analysis and simulation applications as well as catalogues with energy related attributes and interoperable interfaces based on standards.
- ICT platforms to facilitate sharing of and negotiations about the evolving design information within and between organisations. The challenges include e.g. providing open access to relevant stakeholders, presenting information in context driven ways, supporting both the agreed inter-organisational transactions and internal workflows of each organisation, and protecting the IPR of semantically rich information.
- Holistic optimisation of the interactions between different subsystems considering technical, commercial, sustainability and regulatory factors.
- Methods for collaborative development of early stage design concepts and decision support with context driven visualisations.
- Tools for modelling existing products/systems/facilities for retrofitting design e.g. by scanning.
- Collaborative configuration design and customisation based on reference solutions, adaptation rules and catalogues of parametric objects.
- Methods and services for long time data archival and recovery over generations of standards, tools and storage media.
- Simulation based systems for refining requirements for highly interdependent complex systems and for validating the contributions of different subsystems to the overall energy performance in areas like major infrastructures.
- Definition of standardised energy performance indicators which can be calculated from available design and operation data. ICT-based validation. Certification of performance assessment software and methods.
- New design processes and collaboration forms.

**EXPECTED IMPACTS**

Integrated design has direct impacts on the design process itself as well as on the subsequent life cycle stages which depend on design information. The energy performance of the target system depends ultimately on the combined impact of design, materialisation and operation.

- Engagement and empowerment of relevant stakeholders in the design and decision making process.
- Enhanced use of proven reference design solutions with less reinvention.
- Awareness and improved understanding of stakeholders about the impacts of various design options and generally about the impacts of ICTs on energy efficiency.
- Improved quality of design with respect to compliance to requirements, consistency, number of errors, and predictable and optimised life cycle performance.
- Better information support to the downstream life cycle stages (materialisation, operation).

### 2.1.2 Component Catalogues (STREP)

**TECHNICAL SCOPE**

Catalogues of materials and components are needed to support the design of products/systems as well as procurement for materialisation. The catalogues should provide access to various commercial and technical information (including e.g. energy efficiency related properties). The information contents should be at high semantic level in order to meet the requirements of increasingly model based design tools.

**TARGET OUTCOMES**

- Catalogues with semantic information of materials, components and re-configurable design solutions. Parametric objects to support configuration/adaptation of component types for specific applications.
- User interfaces for semantic search and filtering for user specific data delivery.
- Standards-based interfaces / web-services for interoperability with various CAD tools and engineering applications for design, performance analysis, simulation, visualisation etc.
- ICTs for brokering information from several sources e.g. combining manufacturer specific catalogues to serve specific information users.
- Standardised data models of catalogue contents, in this context regarding especially energy related data e.g. embodied energy.
- Toolkits for catalogue authoring and maintenance.
- New business and service models for information providers and brokers.

**EXPECTED IMPACT**

- Improved efficiency and quality of design through use of pre-existing information.
- Improved energy efficiency through availability and re-usability of energy related data.
- Wide information coverage in key application areas in order to stimulate take-up.

### 2.1.3 Data models (STREP and/or CA)

**TECHNICAL SCOPE**

Achieving energy efficiency requires holistic management of information from many stakeholders over the product life time. Common concepts and language are prerequisites for communication, both between humans and ICT systems. Agreed data models (ontologies) are needed to bridge the gaps and to enable information sharing and re-use without error-prone interpretation, manual re-entry and loss of data.

**TARGET OUTCOMES**

- Existing data models for various application domains extended with EE specific concepts in the short term.
- Common cross-disciplinary concepts by alignment of sector specific ontologies to support balancing of energy provision (e.g. grids) and consumption (e.g. buildings).
- Definitions of metadata of shared information in distributed collaborative design and engineering, and catalogues of materials and products.
- Standardised representation of functional/parametric product/system objects with embedded configuration/customisation logic.
- Convergence of agreed models and ontologies for different inter-related applications areas, leading to standardized data models covering energy related aspects in a broad range of applications in the long term.
- Test cases, methods and procedures to validate the compliance of software tools and shared data with respect to agreed data models (ontologies).
- Forums bringing together developers of data models (ontologies) from inter-related application areas (e.g. buildings, process plants, grids etc.) to join forces towards harmonisation of ICT standards related to energy efficiency.

**EXPECTED IMPACT**

- Standardised data models (ontologies) covering energy related information and interactions within and between related application areas.
- Improved ease of access to EE knowledge through a common ontology.
- Interoperability of design software through compliance to standardised data models.
- Improved energy efficiency through holistic integration of information.

### 2.1.4 Application tools (STREP)

**TECHNICAL SCOPE**

ICTs for design include general purpose CAD tools with sector specific add-ons and a variety of specific tools for engineering analysis, life cycle performance estimation, simulation, visualisation etc. The main research needs are related to issues like: early stage design and decision making, enhancing the scope of existing tools to support design for EE, increased utilisation of previous good design solutions, information sharing between various ICT tools through interoperability and reducing the gap between predicted and actual energy performance of systems.

**TARGET OUTCOMES**

- Concept design – Profiles of user groups regarding their requirements and energy consumption behaviour. Tools for early stage conceptual design, life cycle energy performance estimation based on reference data, visualisation and decision support of design options. Methods, e.g. based on simulations, to derive detailed requirements from models of complex systems.
- Detail design – Configuration design based on templates, reference solutions, parametric adaptation rules and intelligent component catalogues. Modelling existing facilities for retrofitting design e.g. using scanning. Context aware visualisation of the evolving detail design solutions for cross-disciplinary decision making.
- Engineering analysis and simulation applications – Domain specific application tools enhanced with energy related attributes and interoperable interfaces based on standards. New tools for integrated assessment and visualisation of costs, environmental impacts, comfort etc. Holistic simulators of complex systems such as major infrastructures. Procedures and test cases for certifying software tools.
- Supply network management, production planning and management – Decision support for selection of materials, components and production strategies (e.g. offsite vs. onsite production). Simulation based real-time production management. Context related multimedia content provided to workers on portable devices. Inter-enterprise ICTs supporting coordination towards contractual goals, including energy efficiency.
- Visualisation and decision support – Besides informing stakeholders about real-time progress towards EE objectives and highlighting trade-offs between environmental and economic concerns, ICTs should also proactively suggest options for decision making.

**EXPECTED IMPACT**

- Awareness and ability of stakeholders to make grounded decisions about design and production options.
- Reusability of proven solutions through model based design technology, interoperability, configuration design and intelligent catalogues.
- Improved quality of design through holistic consideration of the interactions between various subsystems.
- Certified software tools reducing he gap between predicted and actual system performance.

### 2.1.5 Life cycle energy modelling and estimation (IP / STREP / CA)

**TECHNICAL SCOPE:**

In order to promote EE targets, continuous monitoring/estimation of (life cycle) energy consumption is necessary in every life-phase of the observed system. In early design it is needed for planning and testing and has a high impact on overall energy consumption of the system. Later stages require performance indication, data processing and visualisation as a foundation for management, decision making &control. A holistic (cross-sectoral) perspective needs new ways of integrating different EE evaluation methodologies of the respective sectors. Therefore multiple new approaches are needed for EE metrics, measurement & analysis methods, systems integration and knowledge repositories.

**TARRGET OUTCOMES**

- Metrics and validation methods for holistic static performance: technical, economic & environmental. Standardized energy performance indicators. Quality of Service & Service Level Agreements.
- New incentives and market propositions that drive efficiency measures;
- Energy related aspects included into decision support to select production strategies e.g. offsite / onsite production and materials;
- Tools & interfaces using data from multiple ICT systems (e.g. BIM/PLM/ERP) to analyse and visualize (e.g. in 3D/4D/VR) current state, energy related information, environmental impacts etc.;
- Simulation based real-time production management. Real time target/actual performance comparison.
- Direct feedback of changes into planning models / simulations;
- ICTs supporting innovation & holistic EE building life cycle optimisation, aiming at win-win between various stakeholders in moving beyond traditional division of role between disciplines & focus on lowest first investment cost per participant;
- Whole life cycle costing;
- Causal modelling ICTs used to describe / predict relationships in physical systems e.g. computer-aided diagramming (e.g. Sankey, cause and effect, influence diagram etc.), life cycle modelling,
- Established strategies / technologies to access integrate & process diverse EE data & information relating to entire life cycles & entire districts etc.;
- Increased technical & semantic integration of relevant information touch points used to improve analytics & modelling capability & accuracy;
- Knowledge sharing ICTs, knowledge management, knowledge repositories, knowledge mining and semantics search, linked data, long-term data archival and recovery at enterprise or inter-enterprise level;

**EXPECTED IMPACT**

- Awareness among stakeholders about the EE implications of decisions.
- Better access to EE information
- Holistic design of the interactions between different subsystems. Interoperability between CAD tools, applications for design, performance analysis, simulation, visualisation, libraries etc.
- Improved EE performance enabled by these libraries and data models.
- Energy conservation using a central hub for energy efficiency measures in buildings will improve efficiency based on market options and incentives.

### 2.1.6 Metrics and methods for assessing energy efficiency and the impact of ICT on energy efficiency

**TECHNICAL SCOPE:**

The importance of energy efficiency for the environmental sustainability and energy security of the EU is well understood, as is the potential offered by ICT in enabling real-gains in energy efficiency across Europe's economy. However, progress in realising that potential has at times been laboured and as recognised by many often the issue is not a lack of technological options, but rather a problem in understanding what choices will have the greatest impact. In short, there exists a real need for a common means of assessing the impact of ICT4EE. Much has been done already in developing a common framework for understanding the direct impact of ICT, for example the ITU in cooperation with other standardization organizations such as ISO, IEC, ETSI and ATIS have proposed a new methodology which is aligned with the Digital Agenda of the European Commission. However, while somewhat addressed in this new methodology, there is still a requirement for research in terms of assessing the enabling impact of ICT in other sectors. Aside, from ICT impact assessment, there exists a need for affective, common, yet contextual relevant, means of assessing energy and resource efficiency. Common metrics and measurement methods are required for comparison. Proposed methodologies for measurement, such as those in residential buildings[i] are a good starting point, but continued research is required into ICT enabled measurement, common assessment, verification/certification, best practice sharing and knowledge generation.

**TARGET OUTCOMES:**

- Agreement extension of existing methodologies for common metrics and measurement methods
- Agreed metrics and best practice for whole life cycle costing
- Metrics and validation methods for holistic static performance: technical, economic and environmental.
- Energy / resource KPIs for a neighbourhood / city
- Agreed methods for measurement system analysis
- Metric and measurement best practise repositories
- 'Use case' repository and knowledge exchange forums to demonstrate real-world examples of ICT impact on EE
- Self-diagnose calibration of measurement systems
- Causal models and logic used to describe and predict the resource / energy impact of relationships in physical systems
- Increased technical and semantic integration of relevant information inputs used to improve analytics /modelling capability and accuracy
- Tools to visualize real time progress to plan for energy sourcing options regarding cost and CO2 Impact (including CO2 certificates)
- Visual programming of that assists in the evolution of energy KPIs
- Means of dynamically evolving KPIs through links to analytics for EE optimisation, pattern identification and predictive diagnostics etc.
- Development of digital catalogues of products /sensors/services containing parametric information etc. including quantitative data from developer/manufacturer specifications to support the impact assessment of ICT on EE
- Trading and energy brokerage ICTs e.g. consumer/producer forecasting algorithms, energy source tracking, consumption/price negotiation

**EXPECTED IMPACT**

- Awareness among stakeholders about the EE implications of decisions.
- Evidence-based knowledge about the impacts of ICTs on energy efficiency.
- Understanding of the EE impacts of different design parameters and inputs on the behaviour of system solutions.

- Improved EE quality of design solutions.
- ICTs to optimise / select production / materialisation / procurement methods based on optimum energy consumption.
- Enhanced energy related knowledge creation, sharing and management including: Infrastructure, data mining and analytics, semantic mapping, filtering, consolidation algorithms, distributed data bases, catalogues of re-usable EE solutions etc.
- Local decision making of market actors, smart loads, decentralized generation and local storage improves the efficiency of renewables when grid management operations are able to align with the configuration changes.
- Energy management and demand side management functions will increase the efficiency of renewable resources and reduce load variations greatly. It might be fair to say these functions are required for the large scale integration of intermittent resources
- Energy conservation using a central hub for energy efficiency measures in buildings will improve efficiency based on market options and incentives.

### 2.1.7 Data visualisation and decision support

**TECHNICAL SCOPE:**

The ever increasing digitisation of modern life is fuelling a rapid upward trend in data. A move towards an 'internet of things' can only amplify that trajectory. Compelling data visualisation and decision support ICTs will be paramount in navigating the increased volume and complexity of data, including energy and resource efficiency data at the individual, home, enterprise and district level. In the context of future sustainable cities there will be a need for novel data visualisation and decision support solutions in coping with diverse complex data and in ensuring sustained user interest / engagement. Greater volumes of heterogeneous data will require dynamically adaptable visualisations on the fly. A basic requirement of this call theme should be the expanded use of cognitive data visualisation principles. The scope of ICTs includes but is not limited to the integration of diverse systems [safety, security, weather, energy etc.] at different levels of abstraction, SCADA, Business Activity Modelling, Management dashboards and methodologies for analysing situation awareness in complex systems.

**TARGET OUTCOMES**

- Ability to understand Big Data via visualisation; use data sources for effective energy related decision support
- Intuitive, dynamically adaptable visualisations incorporating streamed [real-time] & asynchronous data
- Contextual rendering of data visualisations based on end-user device capabilities & information consumption preferences, again supporting effective EE related decisions
- Additionally, visualisation of 'requirements' in terms of building to individual i.e. where occupancy changes overtime;
- Visual programming of performance indicators
- Methodologies for identifying user requirement in a manner that is directly relevant for visual design. Moving towards influencing for sustained interest
- Operational decision support ICTs that integrate high level diverse systems such as safety, weather and energy etc. at individual, building or district level for near / real-time decision support.

- Tools to visualize real time progress to plan for energy sourcing options regarding cost and $CO_2$ Impact (including $CO_2$ certificates)
- Decision support/recommendation to solve trade-offs between environmental and economic concerns
- Energy related aspects integrated / illustrated into planning tools (finance, logistic, scheduling) to define energy targets for production
- On the fly visualisations of operational energy consumption based on streamed data
- Dynamically adaptable planning models / simulations based on automatic feedback
- Mobile decision support ICTs and device aware visualisations that utilise real-time communication to facilitate in the field decision making particularly in construction or civil engineering tasks
- Compelling visualisation, decision support and recommendation incorporating holistic energy consumption data at the neighbourhood level.

**EXPECTED IMPACT**

- Greater understanding in terms of behavioural science and human factors with regard to the use of ICT4EE
- Intuitive data visualisation, based on cognitive principles, that sustain human interest
- Improved energy performance management via integrative data visualization and decision support that augments automated management systems and sustains user engagement. Linking to Automated monitoring and control in moving towards learning systems providing reliable, secure and affective decision support to energy producers and consumers.
- Increased support for optimise / select production / materialisation / procurement decisions based on optimum energy consumption.
- Improved urban planning systems visualisations incorporating heterogeneous data sources
- Augmented decision support in rationalising materialisation processes (in terms of planning and control) for energy efficiency (e.g. logistics, sequence, etc.).
- Tracking and visualisation of materialisation process in virtual planning models.
- Ability to dynamically visualise complex data streams aiding operational resource consumption decisions.
- More effective resource decision support systems at the neighbourhood / municipal level in terms of operations.

### 2.1.8 ICTs to facilitate new business models and work practices for improved EE (STREP)

**TECHNICAL SCOPE**

There is a need for new business models and work practices to support the paradigm shift of energy efficiency based delivery of products and services throughout the whole life cycle. This includes (but not limited to) new types of contractual relationships e.g. performance based contracts requiring tools and methods for estimation and modelling of energy consumption relating the contract to energy performance, e-commerce tools and collaborative working environments facilitating remote collaborative tele-working, incentives for environmentally friendly, low carbon / energy efficient design requiring supporting ICT tools and methods for modelling and simulation to estimate the appropriate incentive, transparency of energy consumption data facilitated by data visualisation.

**TARRGET OUTCOMES**

- Tools & interfaces using data from multiple ICT systems (e.g. BIM/PLM/ERP) to analyse and visualize (e.g. in 3D/4D/VR) current state, energy related information, environmental impacts etc.;
- Visualisation of trade-offs between environmental and economic concerns.
- Automated alerts to persons in charge on deviations in the production process;
- Tools and e-commerce platforms for waste re-use during materialisation;
- Pervasive Context related multimedia content provided to workers on portable devices & back office;
- ICTs supporting innovation & holistic EE building life cycle optimisation, aiming at win-win between various stakeholders in moving beyond traditional division of role between disciplines & focus on lowest first investment cost per participant in support of whole life cycle cost analysis
- Embedding EE criteria in technologies to support contract & supply network management, process planning, ERP, logistics, procurement and production
- Methods and tools for virtual enterprise (VE) & network setup & evolution. Short to medium-term development in terms of dependable, scalable & extensible networks platforms to support new devices & services in terms of knowledge & value creation;
- Inter-enterprise ICTs for supporting coordination e.g. contract and supply-network management in the context of reduced energy consumption
- Ubiquitous context-based access to inter-organisational knowledge platforms, with template solutions based on defined best practices;
- Development of new EE related services
- New coordination agreements to ensure the stability and reliability of the interconnected network;
- New functions for recovery and outage management through fault detection and self-healing equipment to reduce energy overheads during down time
- Trading and energy brokerage ICTs e.g. consumer/producer forecasting algorithms, energy source tracking, consumption/price negotiation
- Use of cloud based services for tasks such as data management, monitoring and analysis to assist remote working
- Integration technologies / approaches such as service orientation and event driven architectures to facilitate heterogeneous device data interoperability at enterprise, network and environment level

**EXPECTED IMPACT**

- Expected impact primarily relates to energy abatements brought about through reduced waste in leaning inter-enterprise processes.
- Promoting and facilitating virtual enterprise business relationships reducing energy demanding traditional working practices
- Adoption of ICT enabled integrated processes for EE [including: models developed within RTD initiatives, human, legal, contractors, economics, business models, liability].

- Following the scalable platform / network theme, adoption of fully validated machine readable service level agreement technologies with semantic based contract management & enactment
- Improving stability and reliability of the connected grid structures in cases where operational proceedings and fault management procedures are coordinated. As a result far greater amounts of distributed resources [both wind and solar] are acceptable in grid management operations.
- Energy conservation using a central hub for energy efficiency measures in buildings will improve efficiency based on market options and incentives.

### 2.1.9 Cloud computing and network enabled energy services (STREPs / IP)

**TECHNICAL SCOPE:**

Trusted network infrastructure and network architectures will be paramount in underpinning the sensors, actuators and analytics so crucial to energy and resource efficiency services. Additionally, 'cloud computing', which encompasses Infrastructure as a Service [IaaS], Platform as a Service [PaaS] and Software as a Service [SaaS], is transforming the software and service industry and will have a profound impact on the ICT strategies of multiple sectors. Much in terms of augmentation with regard to cloud computing and future networks is essentially independent of a 'sustainability' context. However, if not addressed, more generic issues such as those related to adoption[ii] identified below will negatively impact on cloud based energy and resource management services which are highly pertinent to sustainable context.

The top four actions that are important to most groups [small SME to LE] in terms of cloud computing adoption are:

- Greater accountability and liability for security by cloud services providers.
- Ensuring portability between cloud services.
- Improving Internet connections is important to non-users of the cloud overall and also to limited users.
- Security certification of cloud services vendors.

Add to this the important role data privacy will have for the adoption of energy related offerings and one begins to understand the immense role context independent issues such as dependability, scalability, flexibility and privacy of data will have for energy and resource related services. Trusted networks and cloud computing will be essential in providing dynamically scalable access to energy specific knowledge, knowledge management, knowledge repositories, knowledge mining and semantic search, long-term data archival and recovery as well as data/information mining and analytics.

**TARGET OUTCOMES**

- Innovative architectures supporting flexibility, scalability, dependability and privacy
- Dependable infrastructure - reliable, robust, secure, efficient, fault and delay tolerant networks and communications
- The ability to move between different clouds i.e. increased federation and interoperability
- Ability to dependably process/support/manage 'Big Data' volumes and diverse data sources
- Optimised cloud versus edge processing based on client aware logic.

- Fully validated machine readable service level agreement technologies with semantic based contract management and enactment
- Automated support of mobile and context-aware technologies / services

**EXPECTED IMPACT**

- Increased accessibility, extensibility, dependability and scalability of semantic information, energy data, analytics and compute, paramount to enabling innovative energy services
- True enterprise level dependable cloud management and energy services
- Increased adoption of cloud computing across sectors and organisational levels.
- Guaranteed Quality of Service, Security, Experience and Privacy with respect to energy data services.
- Agreed architectures, frameworks and systems supporting the interoperable interconnection of sensors, actuators and analytics.

### 2.1.10 ICT's for nodal Energy management (IP / STREP)

**TECHNICAL SCOPE:**

It is commonly agreed that the main concern related to Grid Management is the need to balance the demand with the production of Energy. This challenge will become even more important and hard to satisfy in the future with the emerging distributed way of producing energy over the grid (by comparison of the unidirectional current organisation from power plants to consumers). Positive energy Buildings, Smart Districts, Smart Cities are these different “artefacts” that will play a new role in the future Grid. ICTs are seen as the enablers to make this management possible, the approach being to describe under a common model the different nodes of the Grid as Virtual Power Plant (VPP). The VPP model contains a generic set of characteristics to allow connection & interaction between the smart grid and the above described artefacts. The objectives of this call are to investigate the different facets of the VPP model and to prepare the migration towards open platforms enabling the management of the energy at different scales like the building level, the district level, the city level, etc.

**TARGET OUTCOMES**

- Development of the VPP model(s): Extension of existing sectoral data models in order to encompass the ability of devices / buildings / districts / etc... to act as a power plant.
- Development of Service oriented architecture and platforms able to host needed services in order to act as information nodes for the management of energy distribution and Grid balancing. This development will also from a service oriented point of view
- Provide open solutions ensures that sectors/customers are not locked-in by proprietary solutions: (i) Development of common concepts by alignment of sector specific ontologies;
- New functions to allow alignment of centralized energy management (EMS) functions with distributed (local) decision-making equipment;
- New distributed functions for real-time energy demand-supply management, coordination with the regulated operators of the distribution network (DSOs) and interaction with competitive energy market parties (suppliers, aggregators);
- Support tools that enable the integration of renewable energy sources, both large scale production (e.g. wind and solar farms) and massively distributed production (e.g. residential and tertiary buildings);
- Innovative new methodologies for the bi-directional connection between storage systems, smart grids and buildings to warrant power quality;

- New functions for the configuration and maintenance of control constraints and preferences of local energy management functions;

**EXPECTED IMPACT**

- Local decision making of market actors, smart loads, decentralized generation and local storage improves the efficiency of renewables when grid management operations are able to align with the configuration changes.
- Energy management and demand side management functions will increase the efficiency of renewable resources and reduce load variations greatly. It might be fair to say these functions are required for the large scale integration of intermittent resources [DER].
- Optimization of underlying energy management control loops will improve the reliability of the infrastructure.
- Energy conservation using a central hub for energy efficiency measures in buildings will improve efficiency based on market options and incentives.
- Reliable and accurate information will improve the awareness of end-users and producers. It will cause prosumers to influence consumption & production behaviour according to market options, incentives and comfort preferences.

### 2.1.11 Integrated monitoring and control for improved EE

**TECHNICAL SCOPE:**

Information architectures that supports intelligent sensing & control with respect to energy efficient buildings, industries and grids that include resource automation, sensing and control software & hardware, control & optimization algorithms (energy management, demand response) and embedded microcontrollers etc. The information architecture relies on shared and open semantic definitions (ontologies) and metrics and covers the entire energy flow from generation to end-use.

**TARGET OUTCOMES**

- Information architectures and (embedded) intelligent devices for operational control, sensing & actuation at machine, plant or building;
- Tools to visualize in real time the progress to plan for energy sourcing and consumption options regarding cost, energy and carbon impact (includes CO2 certificates);
- Tools & interfaces using data from multiple ICT systems (e.g. BIM/PLM/ERP) to analyse and visualize the current state, energy related information, environmental impacts etc.; and react with adequate control to improve EE.
- Visualisation of trade-offs between environmental and economic concerns;
- Automated alerts to persons in charge on deviations in the production process;
- Automated tools for monitoring energy performance & validation of compliance to energy related requirements;
- Automatic calculation of energy consumed during production,
- Full integration & interoperability of sensor [sensor fusion] & actuation devices with optimized use of ambient resources [energy harvesting] while promoting EE in host systems;
- Autonomous localised level diagnostics, prediction & optimization, virtual sensors, inference technology & non-intrusive load monitoring;

- Embedded intelligent devices (micro architecture) for operational control, sensing & actuation at machine, plant or building;
- Software and algorithms for operational monitoring and actuation of devices at machine, plant or building;
- Inference sensing software and algorithms for pattern and signal identification at machine, plant or building level;
- ICTs for data mining and analytics in terms of energy consumption and optimisation, pattern identification, predictive diagnostics and analytics at enterprise or network level;
- Data management infrastructures to allow electricity production and consumption to be accurately measured, reported and controlled (and eventually credited or billed);
- Home energy management hubs to collect energy consumption data from smart household appliances, distributed resources, local storage and enable intelligent automation;
- Use of cloud based services for tasks such as data management, monitoring and analysis.

**EXPECTED IMPACT**

- Energy consumption and production facilities under energy management control to ensure the integration and utilisation of resources and demand response measures while ensuring the power quality, a reliable distribution network and a secure network operation;
- Optimization of underlying (local) energy management control loops in order to improve the reliability of the infrastructure and facilitates the energy market procedures;
- Reliable and accurate information in order to improve the awareness of end-users and producers. The information will enable prosumers to influence consumption & production behaviour according to market options (economics), incentives and comfort preferences. That include:
    - ICTs to optimise / select production / materialisation / procurement methods based on optimum energy consumption;
    - Real-time communication in the materialisation phase for the assessment of energy and carbon performance and its consequences;
    - Tracking and visualisation of materialisation process in relation to virtual planning models.

## 2.2 Recommendations for Policy Makers

**S = Short-term** *(~3 years to industrial usage; adaptation, testing & take up of new technologies, etc.).*
**M = Medium-term** *(~6 years to industrial usage; development of new applications & incremental technologies etc.)*

**L = Long-term** *(~9 years to industrial usage; radical technical developments, etc.)*

**C = Continuous** (*along the three terms and beyond).*

### 2.2.1 Vision, frameworks and guidelines

We recommend policy makers to formulate a (Global/European) holistic vision on an integrated energy infrastructure and market (role) models and derive applicable legislation that provide a balanced guideline of the environmental, economic and ethical concerns (M). To solidify the regulatory framework for inter-enterprise coordination across European regional and national energy network operators (M). Develop the basis for, and support the development of, a legal framework for realization of the virtual enterprise (S). Encourage increased reusability & interoperability across technologies, projects & sectors via energy related incentives (S). Increased support of joint research projects (M).

### 2.2.2 Efficiency assessment and verification

We are keen to point the attention of policy makers to the insufficient level of toughness of existing legislations on energy efficiency of buildings, the audit-ability, and verification process (energy labelling) (C). Regulations for mandatory labels for Energy Efficiency of buildings materials, machines, etc. (S). Agree on an assessment methods &metrics on the impact of ICT on EE (S). Thus encouraging ICT investment (S). To enforce policies and actions e.g. regulations for versatile impact assessments plus visualizations using: (M).

- Key energy performance indicators and concrete energy targets (M).
- Acceptable simulation based estimations (M).

### 2.2.3 Availability and integrity of data

We recommend policy makers to promote the holistic vocabulary/ontology in regulation and allow access to governmental & municipal data through open data and e-government initiatives (S) e.g. using products & materials catalogues (M). Regulatory requirements to provide model based (semantic) information designs (M). Provide regulatory frameworks that ensure privacy and transparency for participants in general and the end-users in particular (M). Develop directives in order to unify / promote / maintain the technologies and standards used to develop platforms and services among different sectors (S). The regulator should ensure that actual information infrastructures & platforms for data, information and knowledge are open and shared. Support a forum for progressively addressing data privacy & access (S). Encourage increased reusability & interoperability across projects & sectors (S).

### 2.2.4 Financial Instruments

We recommend financial and tax incentives for companies in case of fulfilment of EE targets (M). R&D grants for companies for implementation of communication technologies that benefit EE. Legislation in support of retro-fit / upgrade type projects through tax credits & ESCO type initiatives (S). Support the adoption of measures by all stakeholders in making EE networks economically feasible without mandating homogeneity at the technology level (S).

## 2.3 Recommendations for Research Performers

- Develop competencies in new EE business models, system integration, data modelling / ontologies, interoperability including methodologies to estimate and validate EE impacts of ICT.
- Build relations with other performers who can offer complementary competencies for holistic problem solving.”
- Development of requirement profiles for specific stakeholders and product types.
- Research in basic technologies, especially in Grid sector (M).
- Research on technics to lower down costs for communication is required in Western Europe, in other parts research on communication networks technologies is required (M).
- Research in implementation strategies (M).

- Dissemination of research results for technologies for EE (M).
- Both Industry & Academia should ensure self-demonstration utilizing their own campuses etc. (C).
- Conduct research / initiatives supporting target outcomes with emphasis on increased velocity in demonstrating high levels of interoperability (BIM/CIM/ebXML/etc…) (S, M, L, C).
- Conduct research / initiatives demonstrating the capacities of these new solutions (emphasis on cross sector interoperability) based for example on semantic web technologies implementations (S, M, L).

## 2.4 Recommendations for Industry

- Development of configurable system design templates with variable level EE performance (M).
  Development of BIM based customized systems dimensioning tools (M).
- Development of interfaces and support to standard based product data libraries in CAD tools (M).
- Creation of product contents in standard based product libraries (M).
- Development and differentiation of products and services based on LC performance metrics. Development of performance contracting (M).
- Live virtual models of supplied systems (L).
- Customizable product specific simulators supporting standard based data sources (data models, use profiles, weather data, … ) (L).
- Enhancement of product catalogues with dynamic behaviour (L).
- Product type specific selection tools (M).
- Catalogues of product/material/service information including EE aspects (M).
- Awareness raising for the impact of energy efficiency on cost and environment through workshops, reports, etc. (S).
- Establishment of compliance guidelines (M).
- Construction sector can directly adopt several technics from manufacturing (M).
- Definition of energy performance targets for the materialization process (M).
- Financial incentives for executives and departments for fulfilment of targets (S).
- Definition of targets the companies want to reach within the next years (M).
- Adaption of Web 2.0 applications (Social Media, RSS, Apps etc.) for industrial purpose utilizing portable devices (S).
- Organization of Materialization activities Workflows (PLM/BLM) (M).
- Conduct research / initiatives supporting target outcomes (C).
- Both Industry & Academia should ensure self-demonstration utilizing their own campuses etc (C).
- Industry needs to ensure strategic alignment with target outcomes (S).
- Industry should focus on articulating the business opportunity in target outcomes (S).
- Conduct research / initiatives supporting target outcomes with emphasis on increased velocity in demonstrating high levels of interoperability (C).
- Harmonized methods for process description (S).

- Definition of reference processes implementation guidelines (L).
- Design new components to be integrated seamlessly to existing systems or platforms (BIM/CIM/ebXML/etc…) (C).
- Conduct research / initiatives demonstrating the capacities of these new solutions (emphasis on cross sector interoperability) based for example on semantic web technologies implementations (S, M, L).
- New market procedures and use cases for the validation (by the network operator) of the exchange of production and flexibility (M).
- Develop flexible, modular and scalable solutions for regional control centres, sub-stations and distributed energy resources supported by advanced hardware and management protocols for connectivity. Improve the existing distribution network (S).
- Provide smart appliances (all energy consuming, producing & storing equipment) and a general infrastructure that allows interoperability of devices, market parties and users (M).
- Provide multi-functional appliances and home electronic devices that interoperate with appliances and the energy market (M).

## 2.5 Recommendations for Standardisation Organisations

In Deliverable 3.4 Recommendations for new standards to overcome interoperability barriers REViSITE has identified cross-sectoral research priorities covering the domains of grids, manufacturing, buildings and lighting, in support of ICT for Energy Efficiency (ICT4EE). The priorities are needed to direct the EC funding for Research in Technological Developments in this area. The initial analysis of recent and current research initiatives in the area of ICT4EE suggests that the following research areas are of high priority:

1. Technical interoperability and standardisation;
2. Design for energy-efficiency in all sectors;
3. Metrics and methods for quantitative assessment of ICT impacts;
4. Substantiating the casual connection between research and technical development;
5. Data visualisation and decision support particularly in the usage phase of each sector.

Cross sectoral standardisation opportunities and main barriers in interoperability standards for energy efficiency were also identified which was the main focus of the deliverable. Recommendations to bridge the identified standardisation gaps and to gain from cross-sectoral synergies are formulated as follows:

- Extension of existing ontologies for energy efficiency (eeBDM);
- Energy performance indicators (Metrics);
- Product catalogues that include energy dynamics;
- Data exchange protocols;
- Harmonisation and extension of the IEC Ontology.

## 2.6 Recommendations for Training and Education Stakeholders

The outcome of the D4.4 ‘Implications on education and training systems’ has clearly indicated that education on ICT for EE is very fragmented. There are many courses which use ICT only as a tool (e.g. tools for thermal analysis or computer aided lifecycle assessment) within a limited aspect of energy efficiency (e.g. energy efficient production). Following this path there is currently no domain for students to learn about impact of ICT on different stages of the lifecycle of systems.

As a conclusion 8 learning themes in the subject of ICT4EE have been identified as follows:

1. Integrated design;
2. EE data models;
3. Metrics and methods for quantitative assessment of the impact of ICT on EE;
4. Data visualisation and decision support particularly in the "usage" phase of each sector including behavioural science;
5. ICTs to facilitate new business models and work practices;
6. Life cycle energy modelling and estimation;
7. Integrated monitoring, analytics and control for improved EE;
8. Introduction to cloud computing and network enabled energy services.

## 2.7 Recommendations for other Stakeholders

**End users**

- Development of end user requirements for conceptual design and visualization (M).
- End user profiling (M).
- Information systems, e.g. social media, for sharing end users' experiences (M).
- Raise awareness of end users on LC performance (S, M).
- Requirements for simple simulators to end users. E.g. the energy system of a small house (M).
- End users requirements for specific components (M).

**IT Industry**

- The IT industry to facilitate data quality management through automated validation tools.
- Provide fast and flexible data exchange facilities (cloud).

## 2.8 Summary

In summary a holistic diagram showing the various recommendations and suggestions proposed by REViSITE to the different stakeholders is provide in the following:

# REViSITE - STRATEGIC RESEARCH AGENDA (Given under the 6 SMARTT taxonomy categories)

**Specification and Design ICTs (Cat.1)**
Design conceptualisation
Detailed design
Modelling
Performance estimation
Simulation
Specification & product/ component selection

**Materialisation ICTs (Cat. 2)**
Decision support & visualization
Management & Control
Real-time-communication

**Automation and operation Decision Support (Cat. 3)**
Automated monitoring & control
Operational decision support & visualisation
Secure Wired / Wireless control & sensor networks & Quality of Service ICTs visualisation

**Resources and Process Management (cat. 4)**
Inter-enterprise coordination
Business Process integration
Information/Knowledge management & analytics

**Trading/ Transactional Management ICTs (Cat. 6)**
Regional/ National/European energy management
Facility energy management
Personal energy management
District / Neighbourhood energy management

**Technical and Semantic Interoperability ICTs (Cat. 5)** Integration technologies & Infrastructures Interoperability & Standards

## Recommendations for Research and Innovation Funding Organisation:

**Integrated design**
**Component Catalogues**
**Data models**
**Application tools**
**Life cycle energy modelling and estimation**
**Metrics and methods for assessing energy efficiency and the impact of ICT on EE**
**Data visualisation and decision support**
**ICTs to facilitate new business models and work practices for improved EE**
**Cloud computing and network enabled energy services**
**ICT's for nodal Energy management**
**Integrated monitoring & control for improved EE.**

## Key proposals for Standardisation

- Extension of existing ontologies for energy efficiency
- Energy performance indicators (Metrics)
- Product catalogues that include energy dynamics
- Data exchange protocols
- Harmonisation and extension of the IEC Ontology.

## Recommendations for Research Performers

- Develop competencies in new EE business models, system integration, data modelling / ontologies, interoperability, including methodologies to estimate and validate EE impacts of ICT
- Build relations with other performers who can offer complementary competencies for holistic problem solving."
- Research in implementation strategies
- Dissemination of research results from technologies for EE
- Conduct research / initiatives supporting target outcomes with emphasis on increased velocity in demonstrating high levels of interoperability (BIM/CIM/ebXML/etc…)
- Conduct research / initiatives demonstrating the capacities of new solutions based for example on semantic web technologies implementations
- Integrated monitoring & control for improved EE.

## Recommendations for Training and Education Stakeholders

- Integrated design
- EE data models
- Metrics and methods for quantitative assessment of the impact of ICT on EE
- Data visualisation and decision support particularly in the "usage" phase of each sector including behavioural science
- ICTs to facilitate new business models and work practices
- Life cycle energy modelling and estimation
- Integrated monitoring, analytics and control for improved EE
- Introduction to cloud computing and network enabled energy services.

## Recommendations for Industry

- Development of configurable system design templates with variable level of EE performance
- Development of interfaces and support to standard based product data libraries
- Development & differentiation of products/services based on LC performance metrics
- Live virtual models of supplied systems. Harmonized methods for process description.
- Customizable product specific simulators for standard based data sources
- Enhancement of product catalogues with dynamic behaviour
- Catalogues of product/material/service information including EE aspects
- Definition of energy performance targets for the materialization process
- Adaption of Web 2.0 applications for industrial purpose
- Organization of Materialization activities Workflows (PLM/BLM)
- Initiatives supporting target outcomes with emphasis on high level interoperability
- Establishment of compliance guidelines. Guidelines for reference processes implementation.
- Design new components to be integrated seamlessly to existing systems/ platforms
- New market procedures for the validation of the exchange of production and flexibility
- Develop flexible, modular and scalable solutions for regional control centres & distributed energy
- Provide smart appliances and general infrastructure that allows interoperability
- Provide interoperable multi-functional appliances and home electronic devices and energy market.

## Recommendations for Policy Makers and Regulators

- Formulation of a global holistic vision, frameworks (i.e. regulatory, legislative) and guidelines on integrated energy infrastructure and market (role) models, virtual enterprise, increased reusability & interoperability across technologies
- Efficiency assessment and verification, attention to soft existing legislations on EE of buildings, agree metrics on the impact of ICT on EE and visualisation tools for users
- Availability and integrity of data promoting the holistic vocabulary/ontology in regulation, regulatory requirements to provide model based (semantic) information designs, regulatory frameworks that ensure privacy and transparency, directives to unify / promote / maintain the technologies and standards
- Financial Instruments including financial and tax incentives for companies for fulfilment of EE targets, R&D grants for communication technologies to benefit EE
- Legislation for retro-fit / upgrade type projects through tax credits & ESCO type initiatives for improved EE.

# 3. CONCLUSIONS

## 3.1 Compliance with DoW

According to DoW, T3.3 was to generate recommendations for various stakeholders in order to enable the implementation of the developed SRA. The work described in this deliverable responds fully to the DoW directions and addresses the requested development of calls for research and innovation funding organisations, recommendation for policy makers, for research performers, industry, standardisation bodies, and for educational and training institutions together with other stakeholders.

The findings of the REViSITE vision and the SRA combined with the finding from WP2 deliverables were translated into 21 actions tables corresponding to 21 topics, which formed the basis for producing the various recommendations. This was used as a tool to bring together partners and experts at the IAP workshop to reflect on the initial set of recommendations which were then updated and endorsed. The contents of action tables were further exploited into a filtering matrix to generate 11 themes overarching across the 21 topics and embracing most and novel technologies within the field of ICT4EE. The IAP workshop in Paris was essential to seal the recommendations and turn them into research calls and recommendation to other stakeholders. Instruments for deployment were also described by partners indicating how and who can take these recommendation to real application level.

## 3.2 Main findings

The work schedule described within this deliverable lead to the development of ICT calls text for proposals to be proposed by the different national, EU, and global funding schemes, e.g. (but not limited to) the European Technology Platforms, the Joint Technology Initiatives, etc. The following 11 identified themes were deemed sufficient to encapsulate all the technologies and the developments in the field of ICT4EE:

1. Integrated design;
2. Component Catalogues;
3. Data models;
4. Application tools;
5. Life cycle energy modelling and estimation ;
6. Metrics and methods for assessing energy efficiency and the impact of ICT on energy efficiency;
7. Data visualisation and decision support
8. ICTs to facilitate new business models and work practices for improved EE;
9. Cloud computing and network enabled energy services;
10. ICT's for nodal Energy management;
11. Integrated monitoring and control for improved EE.

These themes were further supplemented by another 12th theme which is a coordination action which runs vertical to cover all the 11 themes. Recommendations to other stakeholders were also produced through synthesis of the recommendations given in the 21 action tables. These included indication of areas requiring attention by policy makers and regulators, indication of needed activities by research performers, by industry, and suggested directions for education and training institutions (given in D4.4) and standardisations bodies (given in D3.4).

# 4. References

The ICT PSP methodology for energy saving measurement, Sep 2011, available [online] at http://esesh.eu/fileadmin/eSESH/download/documents/outputs/CIP_Common_deliverable_eSESH.pdf

IDC interim report on ‘Quantitative estimates of the demand for cloud computing in Europe and the likely barriers to take-up’ Feb 2012, [available] online at http://cordis.europa.eu/fp7/ict/ssai/study-cc_en.html

http://europamedia.wordpress.com/2011/06/22/horizon-2020-the-framework-programme-for-research-and-innovation/

# 5. APPENDICES

## 5.1 Appendix 1: Action Tables

The IAP builds on the SRA (Strategic Research Agenda) priorities developed within REViSITE and leverages future directions that are packaged into Action Tables for each topic (SMARTT sub-categories), which are expected to be the basis for future research work-programmes. Those action tables will prompt recommendation (i.e. EC calls, national programmes etc.) to various stakeholders to enable timed & synchronised implementation of the actions.

This section includes 21 action tables built on 21 sub-categories of the REViSITE SMARTT taxonomy. Each table provides the RTD topic and briefly describes:

1. The scope of the topic
2. Targeted outcomes based on: Short-term research priorities *(~3 years to industrial usage; adaptation, testing & take up of new technologies, etc.);* Medium-term research priorities *(~6 years to industrial usage; development of new applications and incremental technologies, etc.); and* Long-term research priorities *(~9 years to industrial usage; radical technical developments, etc.),* based on the SRA tables (D3.2).
3. The expected impact under the topic, which is based on the vision developed within REViSITE (D3.3) *(~desirable future situation based on currently foreseen developments).*

The remaining half of the action tables describes the recommended implementation actions to each of the targeted stakeholders, namely Policy makers; Research & innovation funding organisations; Research performers; Industry; Standardisation bodies; Education & training and may include other stakeholders if suitable. The action tables for the 21 topics are given in the following under the six SMARTT categories.

### 5.1.1 Specification and Design ICTs (Cat.1)

#### 5.1.1.1 Design conceptualisation (Sub-cat. 1.1)

| | | |
|---|---|---|
| Technical content/scope | Requirement engineering and management. Concept modelling for design ideation, configuration design, template/reference solutions, elements of PLM etc. | |
| Target outcomes | • Methods for early stage decision support. Templates for requirements and user profiles.<br>• Tools for concept development. Reference models for LC requirements and usage scenarios.<br>• Context aware visualisation based on EE criteria, with context specific content suggestion, all rendered based on device capability & user preferences. | |
| Expected impacts on EE | • Holistic design of the interactions between different subsystems.<br>• Integrated ICTs for holistic design, modelling and assessment covering energy interaction between the different subsystems, technical, commercial, sustainability and regulatory factors.<br>• Improved quality of conceptual designs in terms of EE and other life-cycle performance factors; reusability of design solutions due to model based design technology; improved efficiency of conceptual design process | |
| Related SRA topics | • Detailed design | 1.1 |
| | • Modelling | 1.3 |

| | | |
|---|---|---|
| | • Simulation | 1.4 |
| | • Operational ICTs | 3.2 |
| Comments | | |
| Recommended implementation actions by different stakeholders | | Time scale S, M, L ↓ |
| Policy makers / Regulatory bodies | Requiring versatile impact assessments + visualizations as part of major investments. | M |
| Research & innovation funding organisations | Promotion of the development of early stage design & decisions support tools. | M |
| Research performers | Development of requirement profiles for specific stakeholders and product types.<br>Intelligent conceptual design tools/environment based on component libraries, system models, configurable reference solutions, use of default values etc. Simulation, optimization, visualization, smart grid connected. | M |
| Industry | Development of configurable system design templates with variable level EE performance. | M |
| Standardisation bodies (D3.3) | Definition of key EE performance levels/indicators for early stage design. | M |
| Education & training (D.4.4) | Training courses related to configuration design, templates and visualization. | S |
| Other stake-holders:<br>End users | Development of end user requirements for conceptual design and visualization. | M |
| Author | Matti Hannus, Veijo Lappalainen | Date 2012-03-08 |

### 5.1.1.2 Detailed design (Sub-cat. 1.2)

| | | |
|---|---|---|
| Technical content/scope | Design tools, CAD, multimedia, graphics. | |
| Target outcomes | • Simulation based generation of detailed/technical requirements from EE performance requirements for highly interdependent complex systems.<br>• Interoperability between CAD tools, applications for design, performance analysis, simulation, visualisation, libraries etc.<br>• CAD tools with design templates and interoperable component libraries. Support for designing service oriented systems.<br>• Interoperability between CAD tools, applications for design, performance analysis, simulation, visualisation, libraries etc.<br>• Context aware visualisation based EE criteria, with context specific content suggestion, all rendered based on device capability & user preferences | |
| Expected impacts on EE | • Holistic design of the interactions between different subsystems.<br>• Interoperability of design ICTs in model based information sharing enabling improved quality of detailed designs in terms of EE and other performance factors; and improved efficiency of detailed design process through interoperability and new design methods. | |
| Related SRA topics | • Interoperable design tools through integration technologies. | 5.1 |
| | • Standard based interoperable design tools. | 5.2 |

| | | |
|---|---|---|
| Comments | | |
| Recommended implementation actions by different stakeholders | | Time scale S, M, L ↓ |
| Policy makers | Policies and actions e.g. regulations in order to require versatile impact assessments + visualizations as part of major investments. | M |
| Research & innovation funding organisations | Promotion of interoperability between tools. Promotion of BIM data model extensions for data exchange needs of design and analysis tools. | M |
| Research performers | Design & analysis methods and tools for integrated systems. Design methods and tools for management and control systems: hierarchical control systems; adaptive, optimal, model reference etc. control. | M |
| Industry | Development of BIM based customized systems dimensioning tools. | M |
| Standardisation bodies (D3.3) | Standards for e-catalogues of products etc. covering LC data for performance evaluation. | ML |
| Education & training (D.4.4) | Education on life cycle design of integrated systems. | M |
| Author | Matti Hannus, Veijo Lappalainen | Date 2012-03-08 |

### 5.1.1.3 Modelling (Sub-cat. 1.3)

| | | |
|---|---|---|
| Technical content/scope | Tools for representing physical artefacts with semantic information in machine-interpretable format enabling automated access & retrieval. | |
| Target outcomes | • Domain specific application tools enhanced with energy related attributes.<br>• Tools for modelling existing products/systems.<br>• Model based tools (design, performance estimation, state prediction, optimization, simulation, etc.) and object libraries.<br>• Libraries of re-usable design solutions with rich search capabilities.<br>• Functional (beyond data) product/system objects enabling new object oriented applications.<br>• Standardized data models covering energy related aspects. | |
| Expected impacts on EE | • Holistic design of the interactions between different subsystems. Interoperability between CAD tools, applications for design, performance analysis, simulation, visualisation, libraries etc.<br>• Improved EE performance enabled by these libraries and data models. | |
| Related SRA topics | • Planning & management | 2.2 |
| | • Automated monitoring (e.g. virtual real time live environments ) | 3.1, 3.2 |
| | • Operational ICT's.<br>• Resource & process management ICT's | 4. |
| | • Integration technologies and standards | 5.1, 5.2 |
| Comments | | |
| Recommended implementation actions by different stakeholders | | Time scale S, M, L ↓ |
| Policy makers | • Regulatory requirements to provide model based (semantic) design information. | M |
| Research & innovation funding organizations | • Promotion of semantics based ICTs. | M |

| | | |
|---|---|---|
| Research performers | • Semantic & ontology modelling approaches.<br>• EE & performance related extensions to data models / ontologies.<br>• System models and related plug & play technologies for auto-configuration of systems with components.<br>• Integrated system models covering process & control systems. | M |
| Industry | • Development of interfaces and support to standard based product data libraries in CAD tools.<br>• Creation of product contents in standard based product libraries. | M |
| Standardization bodies (D3.3) | • Standardized data models focusing in areas of high potential EE impacts. | M |
| Education & training (D.4.4) | • Education: Data models / ontologies. Population of models.<br>• Training: Product data libraries. Model based tools. | M |
| Other stake-holders:<br>End users | • End user profiling.<br>• Information systems, e.g. social media, for sharing end users' experiences. | M |
| Author | Matti Hannus, Veijo Lappalainen | Date 2012-03-08 |

### 5.1.1.4 Performance estimation (Sub-cat. 1.4)

| | | |
|---|---|---|
| Technical content/scope | ICTs for system performance analysis e.g. LCA, financial analysis, impact assessment & a wide variety of engineering analysis tools. | |
| Target outcomes | • Metrics and validation methods for holistic static performance: technical, economic & environmental. Standardized energy performance indicators. Quality of Service & Service Level Agreements.<br>• Visions and long term target setting for EE. | |
| Expected impacts on EE | • Holistic design of the interactions between different subsystems. Interoperability between CAD tools, applications for design, performance analysis, simulation, visualisation, libraries etc.<br>• Awareness among stakeholders about the EE implications of decisions. | |
| Related SRA topics | • Metrics and validation methods for holistic static performance: technical, economic and environmental. | 1.3/1.6 |
| | • Metrics dynamic performance. Simulation based validation methods. | 3.1 |
| | • Interoperability between CAD tools, applications for design, performance analysis, simulation, visualisation, libraries etc. | 5.2 |
| | • Metrics and validation methods for real time performance. | 3.1 |
| Comments | | |
| Recommended implementation action by different stakeholders | | Time scale S, M, L ↓ |
| Policy makers | • Enforcement of key energy performance indicators. | M |
| Research & innovation funding organisations | • Promotion of LC performance estimation methods & tools. | S<br>M |
| Research performers | • Development of LC performance estimation methods & tools. Systemic approach and district scale being of paramount importance. | M |
| Industry | • Development and differentiation of products and services based on LC performance metrics. Development of performance contracting. | M |

| | | | |
|---|---|---|---|
| Standardisation bodies (D3.3) | • Standardised energy performance indicators: Standardisation of EE performance metrics / KPIs and validation methods. | Static<br>Dynamic<br>Real-time | S<br>M<br>L |
| Education & training (D.4.4) | • Courses on LC performance metrics and estimation. | | M |
| Other stake-holders:<br>End-users | • Awareness of LC performance. | | S<br>M |
| Corresponding Enablers | | | |
| Author | Matti Hannus, Veijo Lappalainen | Date | 2012-03-08 |

#### 5.1.1.5 Simulation (Sub-cat. 1.5)

| | | |
|---|---|---|
| Technical content/scope | ICTs supporting dynamic analysis as part of design e.g. CFD, power system, thermal & occupancy simulation, Network simulators etc. | |
| Target outcomes | • Metrics and validation methods for real time dynamic performance.<br>• Simulation methods for design & validation.<br>• Dynamic/4D visualisation.<br>• What-if analysis methods using simulation, interfaced with models.<br>• Integrated cross-domain simulation of interactions within complex systems such as major infrastructures.<br>• Interoperability between CAD tools, applications for design, performance analysis, simulation, visualisation, libraries etc.<br>• Live virtual models enabled by simulators and models, capturing each system parameter & user experience / perception. | |
| Expected impacts on EE | • Holistic design of the interactions between different subsystems.<br>• Evidence-based knowledge about the impacts of ICTs on energy efficiency.<br>• Understanding of the EE impacts of different design parameters & inputs on the behaviour of system solutions.<br>• Improved EE quality of design solutions. | |
| Related SRA topics | • Materialization related decision support & visualisation | 2.1 |
| | • Operational decision support & visualisation | 3.2 |
| | • Integration technologies and standards | 5.1, 5.2 |
| Comments | | |
| Recommended implementation actions by different stakeholders | | Time scale S, M, L ↓ |
| Policy makers | • Approval of simulation based estimations. | M |
| Research & innovation funding organizations | • Promotion of simulation methods & tools. | M |

| | | |
|---|---|---|
| Research performers | • Development and certification of simulation tools.<br>• Creation of case (e.g. building) specific simulators utilizing data models.<br>• Simulator based test beds for controls development.<br>• Generic simulators (component equations, system models, product libraries, solver etc.)<br>• Simulator based live virtual models working in parallel of real systems. | ML |
| Industry | • Live virtual models of supplied systems.<br>• Customizable product specific simulators supporting standard based data sources (data models, use profiles, weather data, … ).<br>• Enhancement of product catalogues with dynamic behaviour. | L |
| Standardisation bodies (D3.3) | • Standardisation of component libraries (including equation & computer code for dynamic behaviour). | L |
| Education & training (D.4.4) | • Training courses for use of simulators.<br>• Education on simulation models, methods and algorithms. | M |
| Other stake-holders:<br>End users | Requirements for simple simulators to end users. E.g. the energy system of a small house. | M |
| Author | Matti Hannus, Veijo Lappalainen | Date 2012-03-08 |

### 5.1.1.6 Specification & product/component selection (Sub-cat. 1.6)

| | | |
|---|---|---|
| Technical content/scope | ICTs for design/specification realisation & component selection e.g. material attribute database & retrieval. | |
| Target outcomes | • Specification models & templates. Model based libraries of materials, products & suppliers. E-market platforms.<br>• Selection tools. | |
| Expected impacts on EE | • Holistic design of the interactions between different subsystems. Interoperability between CAD tools and applications.<br>• Optimally automated component selection & procurement. | |
| Related SRA topics | • Operational and user experience information on products for product selection. | 3.2 |
| | • Integration technologies and standards. | 5.1, 5.2 |
| Comments | | |
| Recommended implementation actions by different stakeholders | | Time scale S, M, L ↓ |
| Policy makers / Regulatory bodies | • Promotion of open availability of EE information about products & materials. | M |
| Research & innovation funding organizations | • Promotion of product selection tools and open catalogues of product/material information including EE aspects. | M |
| Research performers | • Development of product selection tools and catalogues of product/material information including EE aspects. | M |
| Industry | • Product type specific selection tools.<br>• Catalogues of product/material/service information including EE aspects. | M |

| | | |
|---|---|---|
| Standardization bodies (D3.3) | • Standardisation of key EE attributes in product/material/service catalogues. | M |
| Education & training (D.4.4) | • Education & training on e-catalogues. | M |
| Other stakeholders: End users | • End users requirements for specific components. | M |
| Author | Matti Hannus, Veijo Lappalainen | Date 2012-03-08 |

## 5.1.2 Materialisation ICTs (Cat. 2)

### 5.1.2.1 Decision support & visualization (Sub-cat. 2.1)

| | | |
|---|---|---|
| Technical content/scope | Technologies supporting visual representation of work flows & production methods focused on efficient task completion. Cognitively compelling visualization of streamed / asynchronous data, simulations & models to support in-the-field decisions. | |
| Target outcomes | • Tools to visualize real time progress to plan for energy sourcing options regarding cost & CO2 Impact (including CO2 certificates).<br>• Energy related aspects included into decision support to select production strategies e.g. offsite / onsite production and materials.<br>• Tools and e-commerce platforms for waste re-use.<br>• Tools & interfaces using data from multiple ICT systems (e.g. BIM/PLM/ERP) to analyse and visualize (e.g. in 3D/4D/VR) current state, energy related information, environmental impacts etc.<br>• Location based services to decide on optimum materials suppliers.<br>• Visualisation of trade-offs between environmental and economic concerns.<br>• Automated alerts to persons in charge on deviations in the production process.<br>• ICT for proactive decision making (instead of support only).<br>• Decision recommendation to solve trade-offs between environmental and economic concerns. | |
| Expected impacts on EE | ICTs to optimise / select production / materialisation / procurement methods based on optimum energy consumption. | |
| Related SRA topics | • Energy Sourcing<br>• Simulation of Energy Impact of Planning scenarios<br>• Integration of PMS; EMS; PLM; ERP etc.<br>• Interoperability regarding data input from multiple sources | 6.3<br>1.5<br>5.1<br>5.2 |
| Comments | | |
| Recommended implementation actions by different stakeholders | | Time scale S, M, L ↓ |
| Policy makers | • Regulations demanding labels for Energy Efficiency of buildings materials, machines, etc.<br>• Regulations for energy efficiency; concrete energy targets sharpening in regular intervals. | S<br>S |
| Research & innovation funding organisations | • Increased support of joint research projects . | M |

| | | |
|---|---|---|
| Research performers | • Development of new tools for tracking the status of process in the Materialisation phase to visualise the real time progress beside using traditional bar charts and flow-line schedules, in-time documentation etc. | M |
| Industry | • Awareness raising for the impact of energy efficiency on cost and environment through workshops, reports, etc.<br>• Establishment of compliance guidelines.<br>• Construction sector can direct adopt several technics from manufacturing. | S<br>M<br>M |
| Standardisation bodies (D3.3) | • Standardized methods, criteria and processes for decisions about building structure, layout of the production system, grid design etc. based on energy targets. | M |
| Education & training (D.4.4) | • Awareness raising for the impact of energy efficiency on cost and environment by presenting successful business cases<br>• Intensive Development/Usage of Case Studies describing different energy scenarios (Students need to calculate benefits of energy efficiency. | S<br>S |
| Author | Kai Lindow, Tom Buchert FHG | Date 2012-02-27 |

### 5.1.2.2 Management & Control (Sub-cat. 2.2)

| | | |
|---|---|---|
| Technical content/scope | ICTs supporting dependable ubiquitous data access with respect to adherence to performance requirements, conformance validation, commissioning & phase specific task management in terms of efficient materialisation of the physical infrastructure, building or otherwise. | |
| Target outcomes | • Energy related aspects integrated into planning tools (finance, logistic, scheduling) to define energy targets for production.<br>• Whole life cycle costing.<br>• Automated tools for testing energy performance & validation of compliance to energy related requirements.<br>• Automatic calculation of energy consumed during production<br>• Simulation based real-time production management. Real time target/actual performance comparison. | |
| Expected impacts on EE | ICTs to rationalise materialisation processes (in terms of planning and control) for energy efficiency (e.g. logistics, sequence, etc.). | |
| Related SRA topics | • Integrated platforms for supply chain coordination.<br>• Estimation of target energy Consumption.<br>• Integration of PMS; EMS; PLM; ERP etc.<br>• Interoperability regarding data input from multiple sources. | 4.1<br>1.5<br>5.1<br>5.2 |
| Recommended implementation actions by different stakeholders | | Time scale S, M, L ↓ |

| | | |
|---|---|---|
| Policy makers | • Regulations demanding labels for Energy Efficiency of buildings materials, machines, etc.<br>• Regulations for energy efficiency; concrete energy targets sharpening in regular intervals.<br>• Financial and tax incentives for companies and executives in case of fulfilment of targets. | S<br>S<br>M |
| Research & innovation funding organisations | • Increased support of joint research Support for Audits of industry partners.<br>• Competitions between companies for most innovative Management Processes and Tools. | M<br>S<br>S |
| Research performers | • Exploration and development of concepts and best practices.<br>• Consulting for EE Enterprise development. | M |
| Industry | • Definition of energy performance targets for the materialization process.<br>• Financial incentives for executives and departments for fulfilment of targets.<br>• Definition of targets the companies want to reach within the next years. | M<br>S<br>M |
| Standardisation bodies (D3.3) | • Standardized Guidelines, Best practices and Systems for Management of EE.<br>• Creation of EPIs and other Indicators to measure the progress of companies to improve EE. | M |
| Education & training (D.4.4) | • Training of “Best Practices” for EE implementation.<br>• Awareness Workshops and Seminars for Executives. | S<br>S |
| Author | Kai Lindow, Tom Buchert FHG | Date 2012-02-27 |

### 5.1.2.3 Real-time-communication (Sub-cat. 2.3)

| | |
|---|---|
| Technical content/scope | ICTs that facilitate decision making, mobile/fixed telecommunications, visual & audial feedback mechanisms etc. |
| Target outcomes | • Using RFID/ NFC tags or similar to track transport & status of components, enabling near real time manufacturing.<br>• Pervasive Context related multimedia content provided to workers on portable devices & back office.<br>• Direct feedback of changes into planning models / simulations. |
| Expected impacts on EE | • Real-time communication in materialisation phase.<br>• Tracking and visualisation of materialisation process in virtual planning models. |

| | | |
|---|---|---|
| Related SRA topics | • Communication between different entities using a variety of tools.<br>• RFID technology for monitoring the materialization process.<br>• Integration of PMS; EMS; PLM; ERP etc.<br>• Interoperability regarding data input from multiple sources. | 4.23.3<br>5.1<br>5.2 |
| Recommended implementation actions by different stakeholders | | Time scale S, M, L ↓ |
| Policy makers | • R&D grants for companies for implementation of communication technologies with benefit for EE. | |
| Research & innovation funding organisations | • Increased support of joint research projects (in a ratio of at least three industry partner on one research institute, scalable).<br>• funding for basic research initiatives for exploration of technologies and implementation strategies. | S<br>S |
| Research performers | • Research in basic technologies, especially in Grid sector.<br>• Research on technics to lower down costs for communication is required in Western Europe; in other parts research on communication networks technologies is required.<br>• Research in implementation strategies.<br>• Dissemination of research results for technologies for EE. | M<br>M<br>M<br>M |
| Industry | • Adaption of Web 2.0 applications (Social Media, RSS, Apps etc.) for industrial purpose utilizing portable devices.<br>• Organization of Materialization activities Workflows (PLM/BLM). | S<br>M |
| Standardisation bodies (D3.3) | • Standardized communication tools, protocols and formats<br>• establishment of workgroups and expert forums for company comprehensive exchange of information and experience | M<br>M |
| Education & training (D.4.4) | • Workshops and seminars for training in new technologies and "best practices" exchange in implementation | M |
| Author | Kai Lindow, Tom Buchert FHG | Date: 2012-02-27 |

## 5.1.3 Automation and Operational Decision Support (Cat. 3)

### 5.1.3.1 Automated monitoring & control (Sub-cat. 3.1)

| D3.3 Template for recommended implementation actions | |
|---|---|
| Life cycle phase | Operational / Usage |
| SMARTT category | 3.0 Automation & Operational Decision Support |
| Sub-category | 3.1 Automated monitoring & control |
| Technical content/scope | ICTs supporting intelligent sensing / control with respect to energy efficient building, industrial and grid resource automation including sensing/control software & hardware, control & optimization algorithms, embedded microcontrollers etc. |
| Expected impacts on EE | Embedded ICTs permeate sectors providing the "intelligence" to monitor & control energy resources in sustainable ways. Predictive control algorithms perform real time optimization. Systems learn & adapt to usage preference via incorporated anticipatory logic. |

| | | |
|---|---|---|
| Codes of related SRA topics under other taxonomy sub-categories | Connection to decision support & visualisation technologies in the operational phase together with both design phase & horizontally simulation / modelling.<br>Inherent links to entire technical integration category + Links to economic drivers & transactional management strategies / technologies in terms of holistic automated energy management at the plant, building or district level. | 3.2,1.3, 1.5, 4.4<br>5.0, 6.0 |
| Target Outcomes & Recommended implementation actions by different stakeholders | | Time scale S, M, L, C ↓ |
| Target outcomes | Technology, standards & strategies supporting –<br>1. Full integration & interoperability of sensor [sensor fusion] & actuation devices with optimized use of ambient resources [energy harvesting] while promoting EE in host systems.<br>2. Autonomous localised level diagnostics, prediction & optimization, virtual sensors, inference technology & non-intrusive load monitoring.<br>3. Additionally augmentation will facilitate optimisation of energy beyond the localised entities through holistic technical and semantic interoperability.<br>4. Demonstrate the energy savings achievable through automation & operational decision support clearly delineating those savings attributable to ICT as opposed to say mechanical motor efficiency<br>5. This will in addition require collaboration in terms of agreeing energy metrics & an impact assessment mechanism for clearly apportioning abatements or savings. | M<br>S<br>M<br>S<br>S |
| Policy makers | • Support open data initiatives in terms of government & municipal data in support of smart energy eco-systems<br>• Legislate in supporting retro-fit / upgrade type projects through tax credits & ESCO type initiatives<br>• Suggested that EC should mandate in this space. | S<br>S<br>S |
| Research & innovation funding organisations | • Encourage increased velocity in terms of deploying & validating ICT impact on EE.<br>• Encourage open standards & standards harmonization.<br>• Continue to fund and/or promote ESCO type collaborations in funding retro-fit & ICT4EE deployment in existing buildings & plants. | S<br>S<br>S |
| Academia / Research | • Conduct research / initiatives supporting target outcomes.<br>• Both Industry & Academia should ensure self-demonstration utilizing their own campuses etc. | C<br>C |
| Industry | • Industry needs to ensure strategic alignment with target outcomes<br>• Industry should focus on articulating the business opportunity in target outcomes. | S<br>S |
| Standardisation bodies (D3.3) | • Increase velocity & effort with regard to agreed generically applicable energy performance indicators & an ICT4EE impact assessment methodology / mechanism<br>• Collaborate with industry & other SO's in terms of harmonisation of standards with respect to automation integration & a holistic semantic ontology / data model framework. | |
| Education & training (D.4.4) | | |
| Author | Keith Ellis, Intel Labs Europe | Date: 2012-02- |

### 5.1.3.2 Operational decision support & visualisation (Sub-cat. 3.2)

| | | |
|---|---|---|
| Life cycle phase | Operational / Usage | |
| Technical content/scope | Operational visualisation decision support ICTs that integrate diverse systems [safety, security, weather, energy etc.] at different levels of abstraction e.g. plant, building, district or energy ecosystem. To include SCADA, Business Activity Modelling, Management dashboards & methodologies for analysing situation awareness in complex systems. | |
| Expected impacts on EE | Improved energy performance management via integrative data visualization & decision support that augments automated management systems & sustains user engagement. Linking to Automated monitoring & control in moving towards learning systems providing reliable, secure & affective decision support to energy producers & consumers. | |
| Codes of related SRA topics under other taxonomy sub-categories (and add a linking statement if any) | Interoperability between CAD tools, applications for design, performance analysis, simulation, libraries etc. Generation of requirements from related system models tying data sources to graphic components. Visual programming of performance indicators.<br>Connection to automated sensing & control technologies in the operational phase together with horizontally applicable themes - knowledge management, process/supply chain/ life cycle simulation & modelling. | 1.1-1.5<br><br>3.1<br>4.1-4.4 |
| Recommended implementation actions by different stakeholders | | Time scale S, M, L, C ↓ |
| Target Outcomes | Technology, standards & strategies supporting –<br>1. Ability to understand Big Data volumes & diverse data sources via visualisation<br>2. Intuitive, dynamically adaptable visualisations incorporating streamed [real-time] & asynchronous data sources for effective energy related decision support<br>3. Contextual rendering of data visualisations based on end-user device capabilities & information consumption preferences, again supporting effective EE related decisions<br>4. Additionally, visualisation of ‘requirements’ in terms of building to individual i.e. were occupancy changes overtime<br>5. Visual programming of performance indicators<br>6. Methodologies for identifying user requirement in a manner that is directly relevant for visual design. Moving towards influencing for sustained interest.<br>7. Streamlining the design process by simplifying data acquisition, manipulation & assignment to graphical components. | M<br>S<br>S<br>M<br>S<br>S |
| Policy makers | • Direction in terms of a holistic approach to Data privacy<br>• Open data & e-government initiatives to demonstrate the value, role model. | S<br>S |
| Research & innovation funding organisations | • Encourage applied projects in the energy efficiency space that will test visualisation state of the art technologies in real world scenarios.<br>• Encourage the adoption of user-centred design process when engaging in use-case driven projects to ensure closer collaboration with end users/industry. | S<br>S |
| Academia / Research<br>Industry | • Conduct research / initiatives supporting target outcomes. | C |

| | | |
|---|---|---|
| Standardisation bodies (D3.3) | • Expand on the current ISO standards on usability and user cantered design to include process roadmaps and assessment criteria e.g. ISO 9241-151 & work of ISO/TC 159, ISO STEP 10303 | S-M |
| Education & training (D.4.4) | • Generate exemplars that clearly show design process applied in context | S -M |
| Author | Keith Ellis, Intel Labs Europe | Date 2012-02- |

### 5.1.3.3 Secure Wired / Wireless control & sensor networks & Quality of Service ICTs (Sub-cat. 3.3)

| | | |
|---|---|---|
| Life cycle phase | Operational / Usage | |
| Technical content/scope | Secure Wired / Wireless control & sensor networks & Quality of Service ICTs: to include wired & mobile network infrastructure, network specific hardware e.g. routers, convertors. Manageability & optimization software/algorithms, network architectures, protocols & modulation strategies, cyber security, etc. | |
| Expected impacts on EE | The telecommunications network both fixed & mobile is the foundation for sensor / actuation networks & devices. The ICT network underpins the energy network integrating /linking the various components & providing the platform for 'smart control'.<br>Energy footprint of networks themselves is & will continue to be researched [given expected demand increase] in moving from an 'always on' to 'always available' paradigm. | |
| Codes of related SRA topics under other taxonomy sub-categories (and add a linking statement if any) | Strong links to all sub-categories at some level however specifically technical integration & transaction management, inter-enterprise coordination & of course other sub-categories of 'Automation & operational decision support' | 3.0<br>4.1<br>5.0<br>6.0 |
| Recommended implementation actions by different stakeholders | | Time scale S, M, L ↓ |
| Target Outcomes | Technology, standards & strategies supporting –<br>**1.** Network topologies & architectures, considering ubiquitous connectivity & smooth handover with respect to the EE operation of the network & connecting sensors/devices. Framework in the short term with implementation medium term | S/M |
| | **2.** Energy aware, energy efficient infrastructure, transceiver, antenna, routers etc | S |
| | **3.** Scalable Context aware, cooperative & opportunistic routing including traffic differentiation & self-management functionality & on-demand service provisioning | M |
| | **4.** Optimisation of communication protocols throughout the OSI stack with respect to integration of wireless networks / connections [deemed central to EE initiatives]. | M-L |
| | **5.** Guaranteed Quality of Service, Security, and Privacy. Together with an increased Quality of Experience [including simple deployment / integration] Network level automated SLA's. Framework in the short term with implementation medium term. | S/M |
| | **6.** Dependable infrastructure – reliable, robust, secure, privacy, networks, fault & delay tolerant networks & communications. | M |

| | | |
|---|---|---|
| Policy makers | • Support the adoption of measures by all stakeholders in making EE networks economically feasible without mandating homogeneity at the technology level.<br>• Enable the spectrum sharing. | SM |
| Research & innovation funding organisations | • Support experimental work which is potentially expensive, long-term and risky. A tentative example might be layer less communications network research. This could be done in a modular fashion with increased funding moving from simulation to real world demonstrators & proliferation. | SML |
| Academia / Research<br>Industry | • Conduct research / initiatives supporting target outcomes. | C |
| Standardisation bodies (D3.3) | • Continue to support open initiatives in defining common network topologies & ontology's that inherently consider EE, security, dependability & privacy<br>• Support the identification of metrics, test and validation criteria to be used in the assessment of the direct & indirect impact of communication networks on EE, collaborating with SO efforts in the broader assessment of ICTs, e.g. ITU-T SG5 & ETSI TS 103 199, in augmenting assessment to understand enable effects. | SM<br>S |
| Education & training (D.4.4) | | |
| Author | Keith Ellis, Intel Labs Europe | Date 2012-02- |

## 5.1.4 Resources and Process Management (cat. 4)

### 5.1.4.1 Inter-enterprise coordination (Sub-cat. 4.1)

| | | |
|---|---|---|
| Life cycle phase | Horizontal theme | |
| Technical content/scope | Technology or ICT related methods, frameworks, strategies & best practices supporting contract & supply network management, process planning & scheduling, procurement, Intra-logistics, elements of Enterprise Resource Planning systems etc. | |
| Expected impacts on EE | Expected impact primarily relates to energy abatements brought about through reduced waste in leaning inter-enterprise processes. Wide availability of ICT based services & infrastructure. ICT supported facilitate virtual enterprise business relationships. ICT enabled integrated processes are adopted for EE (including: models developed within RTD initiatives, human, legal, contractors, economics, business models, liability). | |
| Codes of related SRA topics under other taxonomy sub-categories | Strong links to entire technical integration category as augmentation in terms of inter-enterprise coordination involves integration of diverse systems & players.<br>Additionally strong linkages to the 'automation & operational decision support category'. | 5.0<br>3.0 |
| Recommended implementation actions by different stakeholders | | Time scale S, M, L, C ↓ |

| | | |
|---|---|---|
| Target outcomes | Technology, standards & strategies supporting –<br>1. ICTs supporting innovation & holistic EE building life cycle optimisation, aiming at win-win between various stakeholders in moving beyond traditional division of role between disciplines & focus on lowest first investment cost per participant<br>2. Contract & supply network mgmt., process planning, ERP, logistics, procurement, production etc. embed EE criterion in technology, practices & policy. Augmentation relates more to technical & semantic interoperability.<br>3. Methods for virtual enterprise (VE) & network setup & evolution. Short to medium-term development in terms of dependable, scalable & extensible networks platforms to support new devices & services in terms of knowledge & value creation.<br>4. Following the scalable platform / network theme, fully validated machine readable service level agreement technologies with semantic based contract management & enactment. | M<br>S<br>S<br>L |
| Policy makers | • Encourage increased reusability & interoperability across technologies, projects & sectors.<br>• Promote speedy agreement on an assessment method &metrics for understanding the impact of ICT on EE. Thus encouraging ICT investment.<br>• Develop the basis for, and support the development of, a legal framework for realization of the virtual enterprise | S<br>S |
| Research & innovation funding organisations | • Future funding should include transport in built environment related projects [includes manufacturing] | S |
| Research performers<br>Industry | • Conduct research / initiatives supporting target outcomes with emphasis on increased velocity in demonstrating high levels of interoperability | C |
| Standardisation bodies (D3.3) | • Drive harmonisation & integration in terms of data exchange / communication | S |
| Education & training (D.4.4) | • MBA type programs could promote the concept & value of virtual enterprises & inter-enterprise coordination | |
| Author | Keith Ellis, Intel Labs Europe | Date 2012-02- |

### 5.1.4.2 Business Process integration (Sub-cat. 4.2)

| | | |
|---|---|---|
| Life cycle phase | Horizontal theme | |
| Technical content/scope | Technology, standards & strategies supporting - collaboration support, groupware tools, electronic conferencing, distributed systems, social-media, business work flows, ERP (front end) systems. | |
| Expected impacts on EE | Expected impact primarily relates to energy abatements brought about through reduced waste in operational logistics, travel etc. Vision sees - enhanced value-driven business processes & ICT enabled business models. Video conferencing, groupware, social media & collaboration ICTs support process integration & new services reducing needs for transport & commuting while allowing for knowledge / value creation. | |
| Codes of related SRA topics under other taxonomy sub-categories | Strong links to entire technical integration category as augmentation in terms of inter-enterprise coordination involves integration of diverse systems & players.<br>Additionally strong linkages to the 'automation & operational decision support category'. | 5.0<br>3.0 |

| Recommended implementation actions by different stakeholders | | Time scale S, M, L ↓ |
|---|---|---|
| Target outcomes | Technology, standards & strategies supporting –<br>1. Augmentation in terms of business integration with respect to operational processes: design production, on/off-site production and make-v-buy etc.<br>2. Increased functionality in terms of social media & crowd sourcing type research / validation with respect to energy data sharing / integration.<br>3. Integration of heterogeneous data/ info sources in order to build inference type applications that add valued extensions aligning to the Information/Knowledge management & analytics sub-category<br>4. Widely adopted standards & interfaces for model / semantics based inter-enterprise collaboration. | S<br>S<br>M<br>L |
| Policy makers | • Encourage increased reusability & interoperability across technologies, projects & sectors via energy related incentives. | S |
| Research & innovation funding organisations | • As above, future funding should include transport in built environment related projects [includes manufacturing].<br>• Encourage research into possible rebound effects of distributed enterprise as part of relevant projects. | S<br>S |
| Research performers<br>Industry | • Conduct research / initiatives supporting target outcomes with emphasis on increased velocity in demonstrating high levels of interoperability. | S, M, L |
| Standardisation bodies | • Agree/extend carbon/energy accounting methods to included assessment of rebound effects of distributed work, standardise how this can be incorporated as an input to the likes of BIM type systems & corporate carbon/energy certification/reports. | S |
| Education & training | • Provide appropriate engaging contextual use-case materials within courses. | S |
| Corresponding Enablers | | |
| Author | Keith Ellis, Intel Labs Europe | Date 2012-02- |

### 5.1.4.3 Information/Knowledge management & analytics (Sub-cat. 4.3)

| Life cycle phase | Horizontal theme. | |
|---|---|---|
| Technical content/scope | Technology & frameworks supporting - access to knowledge, knowledge management, knowledge repositories, knowledge mining & semantic search, long-term data archival & recovery as well as data/information mining & analytics. Technologies here are involved in moving data up the DIKW (Data, Information, Knowledge and Wisdom) chain in order to add value. | |
| Expected impacts on EE | Enhanced energy related knowledge creation, sharing & management including: Infrastructure, data mining & analytics, semantic mapping, filtering, consolidation algorithms, distributed data bases, catalogues of re-usable EE solutions etc. | |
| Codes of related SRA topics under other taxonomy sub-categories | Strong links to entire technical integration category as augmentation in terms of inter-enterprise coordination involves integration of diverse systems & players.<br>Additionally strong linkages to the 'automation & operational decision support'. | 5.0<br>3.0 |
| Recommended implementation actions by different stakeholders | | Time scale S, M, L ↓ |

| | | |
|---|---|---|
| arget outcomes | Technology, standards & strategies supporting –<br>1. Agreed semantic ontology / data modelling best practise, with respect to describing/detailing energy flow at the district / intra-enterprise level.<br>2. Increased technical & semantic integration of relevant information touch points used to improve analytics & modelling capability & accuracy.<br>3. Development of digital catalogues of products /sensors/services containing parametric information etc.<br>4. Established strategies / technologies to access integrate & process diverse EE data & information relating to entire life cycles & entire districts etc.<br>5. Established scalable/extensible analytics for EE optimisation, pattern identification & predictive diagnostics etc.<br>6. Increased accessibility, extensibility & scalability of semantic information, energy data, analytics & compute paramount to enabling innovative energy services<br>7. Established cross-organisational repositories & methods for know-ledge consolidation & distribution.<br>8. Engaging community forums for sustained discussion.<br>9. Improved ease of access to EE knowledge which is modelled according to agreed reference data<br>10. Ubiquitous context-based access to inter-organisational knowledge platforms, with template solutions based on defined best practices. | S<br>S<br>S<br>M<br>M<br>C<br>S<br>S<br>M<br>L |
| Policy makers | • Policy maker should set a holistic vision, Regulator should ensure legislation supports & municipal could supply that actual infrastructure & platforms for data, information, knowledge sharing. One organization could conceivably constitute all three roles this would have implications for timelines.<br>• Promote agreement in terms of a holistic EE ontology [x-sector / city level].<br>• Encourage increased reusability & interoperability across projects & sectors.<br>• Support a forum for progressively addressing data privacy & access.<br>• Allow access to governmental & municipal data through open data initiatives. | S-M<br>S<br>S<br>S<br>S |
| Research & innovation funding organisations | • Insist on increased velocity in terms of deploying & validating ICT interoperability within funded projects<br>• Promote/require modularity & reusability of technologies within projects. | S<br>S |
| Research performers<br>Industry | • Conduct research / initiatives supporting target outcomes with emphasis on increased velocity in demonstrating high levels of interoperability. | S, M, L |
| Standardisation bodies | • Collaborate with industry, academia & other SO's to deliver standards harmonization with respect to a holistic x-sector EE data model<br>• Work to harmonize data exchange standards in promoting 'ubiquitous access' specifically linking back to data privacy & security. | S,M<br>S |
| Education & training | | |
| Author | Keith Ellis, Intel Labs Europe | Date 2012-02- |

## 5.1.5 Technical and Semantic Interoperability ICTs (Cat. 5)

### 5.1.5.1 Integration technologies & Infrastructures (Sub-cat. 5.1)

| | | |
|---|---|---|
| Life cycle phase | Horizontal theme | |
| Technical content/scope | Services, Platforms and protocols to support the diversity of tools and systems related to Energy Efficiency and their integration in ad hoc system allowing communication / knowledge sharing among concerned stakeholders. Knowledge exchange relies on use of shared vocabularies and models and from an ICT perspective on the use of semantic web technologies. | |
| Expected impacts on EE | At different life cycle stages, it allows the integration of the “Energy Efficiency dimension” since the early stages of the design phase (proposing existing & parametric models like occupant behavioral models, energy load balancing models, etc…) to the usage phase (from technical data acquisition to dynamic pricing forecast / instant energy consumption / etc…) | |
| Codes of related SRA topics under other taxonomy sub-categories | This is a transversal theme and therefore strong links exist with almost all categories. | 1.0<br>2.0<br>3.0<br>4.1 4.2 |
| Recommended implementation actions by different stakeholders | | Time scale S, M, L ↓ |
| Target outcomes | Services, Models and protocols supporting the definition of a global framework able to act as a concentration hub for knowledge exchange and sharing for the different life cycle stages and across sectors.<br>1. Convergence of existing / de facto standard systems & solution from the different sectors under the umbrella of Energy Efficiency/ Energy Trading<br>2. Definition of a common EE vision for the two models (BIM & CIM) by identifying overlapping areas;<br>• Integration of these EE Extensions into the BIM & CIM<br>• New trans sector models (i.e. Building/Grid) for EE specific needs<br>• Development of new services EE related | L<br>S,M<br>S,M<br>M,L<br>M,L<br>C |
| Policy makers | Development of directive in order to unify / promote / maintain the technologies and standards used to develop these platforms and services among different sectors | S |
| Research & innovation funding organisations | Obligation to use recommended solutions & standards by funded projects | C |
| Research performers | Harmonized methods for process description. | S |
| Industry | Definition of reference processes implementation guidelines<br>Design new components to be integrated seamlessly to existing systems or platforms (BIM/CIM/ebXML/etc…) | L<br>C |
| Standardisation bodies | Developments and maintenance of controlled vocabularies and services | C |
| Education & training ( | Integration of the EE cross dimension into existing courses<br>Publication of sector oriented guidelines / Training courses | C |
| Author | Bruno Fiès / CSTB | Date 2012-02- |

#### 5.1.5.2 Interoperability & Standards (Sub-cat. 5.2)

| | | |
|---|---|---|
| Life cycle phase | Horizontal theme | |
| Technical content/scope | Ensure efficient exchange at network, application and data levels. Promote solutions based on Open standards for communication protocols and data/knowledge exchange among heterogeneous applications and systems. Provide bridges among heterogeneous models and vocabularies. | |
| Expected impacts on EE | Provide mechanisms that allow to link high level abstract representations (Models / ontologies) to be linked/implemented down to the physical level ensuring thus the vertical integration of data and transforming these data into knowledge that could be integrated into decision/monitoring /reporting systems… | |
| Codes of related SRA topics under other taxonomy sub-categories | This is a transversal theme and therefore strong links exist with almost all categories. | |
| Recommended implementation actions by different stakeholders | | Time scale S, M, L ↓ |
| Target outcomes | Provide open solutions ensures that sectors/customers are not locked-in by proprietary solutions:<br>• Development of common concepts by alignment of sector specific ontologies<br>• Extension of existing models with EE specific concepts.<br>• Convergence of existing models and ontologies | S,M<br>S<br>L |
| Policy makers | Promote the agreed vocabulary/ontology by using it for future regulation / Revise the current regulations applying this agreed vocabulary/ontology. | S |
| Research & innovation funding organisations | Support the sectoral adoptions of this new framework by developing early demonstrators | S, M |
| Research performers<br>Industry | Conduct research / initiatives demonstrating the capacities of these new solutions (emphasis on cross sector interoperability) based for example on semantic web technologies implementations | S,M,L |
| Standardisation bodies | Provide the necessary openness, transparency and quality that will ease the adoption of these open standards and thus favour the migration towards this vision. | S,M,L |
| Education & training | Publication of sector oriented guidelines / Training courses | S |
| Author | Bruno Fiès / CSTB | Date 2012-02- |

### 5.1.6 Trading/ Transactional Management ICTs (Cat. 6)

#### 5.1.6.1 Regional/National/European energy management (Sub-cat. 6.1)

| | |
|---|---|
| Technical content/scope | Regional / National level energy management of large regional and nationals levels using support tools such as Energy Management Systems (EMS), distribution management, auxiliary services, automated generation control ,etc. |

| | | |
|---|---|---|
| Target outcomes | • New functions to balance generative capabilities of intermitted resources (wind & solar) across interconnected grids.<br>• New coordination agreements to ensure the stability and reliability of the interconnected network.<br>• New functions for recovery and outage management through fault detection and self-healing equipment.<br>• New functions to allow alignment of centralized energy management (EMS) functions with distributed (local) decision-making equipment. | |
| Expected impacts on EE | Interconnected, large area networks will leverage intermitted resource variations. The scale advantages also improve stability and reliability of the connected grid structures in cases where operational proceedings and fault management procedures are coordinated. As a result far greater amounts of distributed resources (both wind and solar) are acceptable in grid management operations. Local decision making of market actors, smart loads, decentralized generation and local storage improves the efficiency of renewables when grid management operations are able to align with the configuration changes. | |
| Related SRA topics | • Causal modelling<br>• Operational decision support<br>• Inter-enterprise coordination on national/European scope | 1.4<br>3.5<br>4.1 |
| Comments | | |
| Recommended implementation actions by different stakeholders | | Time scale S, M, L ↓ |
| Policy makers | Solidify the regulatory framework for inter-enterprise coordination across European regional and national network operators. | M |
| Research & innovation funding organisations | Support for proof of concept projects. | S |
| Research performers | Coordinative functions of centralized energy management (EMS) functions and distributed (local) decision-making equipment. | M |
| Industry | New market procedures and use cases for the validation (by the network operator) of the exchange of production and flexibility. | M |
| Standardisation bodies (D3.3) | Extension of the current network exchange mechanisms (ENTSO-E) to include energy management logic & self-healing procedures. | S |
| Author | Nico Vlug, KEMA Consulting | Date: 2012-03-16 |

### 5.1.6.2 District / Neighbourhood energy management (Sub-cat. 6.2)

| | |
|---|---|
| Technical content/scope | District/Neighbourhood level energy management. Managing energy exchanges between local generators, loads, local storages & the energy grids. Main drivers are a common (interruptible) energy supply & flexibility contract. |
| Target outcomes | • New distributed functions for real-time energy demand-supply management, coordination with the regulated operators of the distribution network (DSOs) and interaction with competitive energy market parties (suppliers, aggregators).<br>• Support tools that enable the integration of renewable energy sources, both large scale production (e.g. wind and solar farms) and massively distributed production (e.g. residential and tertiary buildings).<br>• Data management infrastructures to allow electricity production and consumption to be accurately measured, reported and controlled (and eventually credited or billed). |

| | | |
|---|---|---|
| Expected impacts on EE | Energy management and demand side management functions will increase the efficiency of renewable resources and reduce load variations greatly. It might be fair to say that these functions are required for the large scale integration of intermittent resources (DER). Optimization of underlying energy management control loops will improve the reliability of the infrastructure. | |
| Related SRA topics | • ICT-Standards and protocols<br>• Data mining and analytics<br>• Integration technologies / approaches. | 5.1<br>4.4<br>5.3 |
| Comments | Energy management: ensures reliable energy supply and optimizes financially under market conditions with regard for the constraints of the distribution grid and the preferences of the prosumer (energy producer and/or consumer). | |
| Recommended implementation actions by different stakeholders | | Time scale S, M, L ↓ |
| Policy makers | Formulate a (Global/European) vision on an integrated energy infrastructure and market models and derive applicable legislation that take the environmental aspects and ethical concerns into account. | M |
| Research & innovation funding organisations | Support the design a model for business cases that enables quantification of the returns in terms of the energy balance.<br>Support an integrated approach towards ICT4EE covering technical, commercial and regulatory factors. | S |
| Research performers | Design of, generally applicable, bidirectional power flow control mechanisms (Volt-VAR control, Load flow, state estimation etc.).<br>Design functions for the harmonization of energy consumption across the district by identifying peaks and dips of consumption and generation. | M |
| Industry | Develop flexible, modular and scalable solutions for regional control centres, sub-stations and distributed energy resources supported by advanced hardware and management protocols for connectivity. Improve the existing distribution network. | S |
| Standardisation bodies (D3.3) | Establishment of a generic ontology and applicable standards that support plug-and-play functionality for control centres and interoperability. | S |
| Other stakeholders: | The IT industry to facilitate data quality management through automated validation tools. Provide fast and flexible data exchange facilities (cloud). | |
| Author | Nico Vlug, KEMA Consulting | Date 2012-03-16 |

### 5.1.6.3 Facility energy management (Sub-cat. 6.3)

| | |
|---|---|
| Technical content/scope | Building (Energy) management that focuses on load shedding & economic options. Includes the management of local energy sources of various kinds (mainly solar, heat pumps etc.) & specific loads (e.g. electric vehicle charger). |
| Target outcomes | • Innovative new methodologies for the bi-directional connection between storage systems, smart grids and buildings to warrant power quality.<br>• Home energy management hubs to collect energy consumption data from smart household appliances, distributed resources, local storage and enable intelligent automation.<br>• New incentives and market propositions that drive efficiency measures. |

| | | |
|---|---|---|
| Expected impacts on EE | Energy conservation using a central hub for energy efficiency measures in buildings will improve efficiency based on market options and incentives. Energy consumption and production facilities under local (energy management) control will be better managed to prevent power quality issues and help ensure a reliable and secure network operations. | |
| Related SRA topics | • ICT standards and protocols<br>• Integration (Interoperability) technologies/approaches<br>• Human factors engineering<br>• Business process integration & collaboration<br>• Software & algorithms for monitoring & actuation | 5.1<br>5.3<br>1.2<br>4.2<br>3.3 |
| Comments | | |
| Recommended implementation actions by different stakeholders | | Time scale S, M, L ↓ |
| Policy makers | Toughen the existing legislation with regard to the energy efficiency of buildings and the audit and verification process (energy labelling). | C |
| Research & innovation funding organisations | Support the creation of building (facility) operating systems and energy management systems with automation to install software functions and local decision support algorithms | M |
| Research performers | Suggest innovative new materials and systems for the improvement of energy efficiency in buildings | S |
| Industry | Provide smart appliances (all energy consuming, producing & storing equipment) and a general infrastructure that allows interoperability of devices, market parties and users. | M |
| Standardisation bodies (D3.3) | Integrate the building energy ontologies (BIM, eeBDM) with grid semantic definitions (CIM) and publish related information exchange standards (common interface specification, messages and middleware). Extend the current scope of the CIM to include the building grid. | C |
| Author | Nico Vlug, KEMA Consulting | Date 2012-03-16 |

### 5.1.6.4 Personal energy management (Sub-cat. 6.4)

| | | |
|---|---|---|
| Technical content/scope | Future personal energy management tools are largely based on home automation systems & use multifunctional equipment (smart phone) to opt for new energy flexibility products & price incentives. | |
| Target outcomes | • Reliable information on the relationship of energy efficiency, wellbeing and financial consequences.<br>• New functions for the configuration and maintenance of control constraints and preferences of local energy management functions. | |
| Expected impacts on EE | Reliable and accurate information will improve the awareness of end-users and producers. It will cause prosumers to influence consumption & production behaviour according to market options, incentives and comfort preferences. | |
| Related SRA topics | Mobile decision support & real-time communication<br>Operational decision support & data visualization<br>Integration (Interoperability) technologies/approaches<br>Privacy legislation, security measures and transparency conventions | 2.1<br>3.5 & 3.6<br>5.3 |

| Recommended implementation actions by different stakeholders | | Time scale S, M, L ↓ |
|---|---|---|
| Policy makers | Provide a regulatory framework that ensures privacy and transparency for participants in general and the end-user (prosumer) in particular | M |
| Research & innovation funding organisations | | |
| Research performers | Develop ICTs based on personal energy profiles to assist in the optimization of the personal/local energy consumption/generation.<br>Design user friendly interfaces and specific functionalities that allow for distributed automated decisions, user preferences and constraints. | M |
| Industry | Provide multi-functional appliances and home electronic devices that interoperate with appliances and the energy market | M |
| Standardisation bodies (D3.3) | Formalize Trading & Energy Brokerage standards for personal use | M |
| Education & training (D4.4) | Raise awareness and prepare participants for new roles (e.g. prosumer) in the energy arena and support the transition towards energy management. | S |
| Author | Nico Vlug, KEMA Consulting | Date 2012-03-16 |

## 5.2 Appendix 2 IAP Filtering Table

| | | Call Themes → Call themes / Target outcomes | Integrated design (IP) | Component Libraries (STREP) | EE data models (STREP) | Application tools (STREP). | Metrics and methods for quantitative assessment of the impact of ICT on EE | Data visualisation and decision support particularly in the "usage" phase of each sector including behavioural science | ICTs to facilitate new business models and work practices | Life cycle energy modelling and estimation | Integrated monitoring and control for improved EE | ICT's for nodal Energy management | Network infrastructure and cloud computing | Coordination (CSA) | Potential Impact on EE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *(i), (ii),……………(m), … are the specific target outcomes under each sub-category* | IP | STREP | STREP | STREP | | | | | | | | CSA | *[a], [b],……………[z] are the specific potential impacts under each sub-category* |
| 1 | Specification & design | | | | | | | | | | | | | | |
| 1.1 | Design conceptualisation | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | i | Methods for early stage decision support. Templates for requirements and user profiles; | | | | c | | | | | | | | All | [a] Holistic design of the interactions between different subsystems. [b] Integrated ICTs for holistic design, modelling and assessment covering energy interaction between the different subsystems, technical, commercial, sustainability and regulatory factors. [c] Improved quality of conceptual designs in terms of EE and other life-cycle performance factors; reusability of design solutions due to model based design technology; improved efficiency of conceptual design process. |
| | ii | Tools for concept development. Reference models for LC requirements and usage scenarios; | | | | c | | | | | | | | All | |
| | iii | Context aware visualisation based on EE criteria, with context specific content suggestion, all rendered based on device capability & user preferences; | ab | | | | | | | | | | | All | |
| | iv | Design conceptualisation ICTs for requirement engineering and ideation; | | | | c | | | | | | | | All | |
| | v | Human factors engineering ICTs to gather and model data describing the behaviour of end users/ energy consumers (G/B/L) | | | | c | | | | | | | | All | |
| **1.2** | **Detailed design** | | | | | | | | | | | | | | |
| | i | Simulation based generation of detailed/technical requirements from EE performance requirements for highly interdependent complex systems. | | | | c | | | | | | | | All | [a] Holistic design of the interactions between different subsystems. [b] Interoperability of design ICTs in model based information sharing enabling improved quality of detailed designs in terms of EE and other performance factors; [c] and improved efficiency of detailed design process through interoperability and new design methods. |
| | ii | Interoperability between CAD tools, applications for design, performance analysis, simulation, visualisation, libraries etc. | ab c | | | | | | | | | | | All | |
| | iii | CAD tools with design templates and interoperable component libraries. Support for designing service oriented systems. | | c | | | | | | | | | | All | |
| | v | Context aware visualisation based EE criteria, with context specific content suggestion, all rendered based on device capability & user preferences | ab c | | | | | | | | | | | All | |

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| **1.3** | **Modelling** | | | | | | | | | | | | | | |
| | **i** | Domain specific application tools enhanced with energy related attributes. | | | | **ab** | | | | | | | | **All** | [a] Holistic design of the interactions between different subsystems. Interoperability between CAD tools, applications for design, performance analysis, simulation, visualisation, libraries etc. [b] Improved EE performance enabled by these libraries and data models. |
| | **ii** | Tools for modelling existing products/systems. | | | | **ab** | | | | | | | | **All** | |
| | **iii** | Model based tools (design, performance estimation, state prediction, optimization, simulation, etc.) and object libraries. | | | | **ab** | | | | | | | | **All** | |
| | **iv** | Libraries of re-usable design solutions with rich search capabilities. | | **a b** | | | | | | | | | | **All** | |
| | **v** | Functional (beyond data) product/system objects enabling new object oriented applications. | | **a b** | | **ab** | | | | | | | | **All** | |
| | **vi** | Standardized data models covering energy related aspects. | | | **ab** | | | | | | | | | **All** | |
| | **vii** | Causal modelling ICTs used to describe / predict relationships in physical systems e.g. computer-aided diagramming (e.g. Sankey, cause and effect, influence diagram etc.), life cycle modelling | | | | | **ab** | | | **ab** | | | | **All** | |
| **1.4** | **Performance estimation** | | | | | | | | | | | | | | |
| | **i** | Metrics and validation methods for holistic static performance: technical, economic & environmental. Standardized energy performance indicators. Quality of Service & Service Level Agreements. | **ab** | | | **b** | **ab** | | | **b** | | | | **All** | [a] Holistic design of the interactions between different subsystems. Interoperability between CAD tools, applications for design, performance analysis, simulation, visualisation, libraries etc. [b] Awareness among stakeholders about the EE implications of decisions. |
| | **ii** | Visions and long term target setting for EE. | | | | | **ab** | | | **b** | | | | **All** | |

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| **1.5** | **Simulation** | | | | | | | | | | | | | | |
| | **i** | Metrics and validation methods for real time dynamic performance; | | | | | **abcd** | | | | | | | **All** | [a] Holistic design of the interactions between different subsystems.<br>[b] Evidence-based knowledge about the impacts of ICTs on energy efficiency.<br>[c] Understanding of the EE impacts of different design parameters & inputs on the behaviour of system solutions.<br>[d] Improved EE quality of design solutions. |
| | **ii** | Simulation methods for design & validation; | | | | **b** | | | | | | | | **All** | |
| | **iii** | Dynamic/4D visualisation; | | | | **bc** | | | | | | | | **All** | |
| | **iv** | What-if analysis methods using simulation, interfaced with models; | | | | **bc** | | | | | | | | **All** | |
| | **v** | Integrated cross-domain simulation of interactions within complex systems such as major infrastructures; | **abcd** | | | | | | | | | | | **All** | |
| | **vi** | Interoperability between CAD tools, applications for design, performance analysis, simulation, visualisation, libraries etc; | **ad** | **d** | | | | | | | | | | **All** | |
| | **vii** | Live virtual models enabled by simulators and models, capturing each system parameter & user experience / perception; | | | | **b** | | | | | | | | **All** | |
| | **viii** | Grid/ Building/ Lighting: Simulation ICTs for predicting/estimating the dynamic behaviour of a system as part of the design function e.g. computational fluid dynamics, finite element mode analysis, power system simulation etc. (G/B/L) | | | | **b** | | | | | | | | **All** | |

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| **1.6** | **Specification & product/component selection** | | | | | | | | | | | | | | |
| | **i** | Specification models & templates. Model based libraries of materials, products & suppliers. E-market platforms. | | **b** | | **b** | | | | | | | | **All** | |
| | **ii** | Selection tools; | | **b** | | **b** | | | | | | | | **All** | |
| | **vi** | Dependable infrastructure – reliable, robust, secure, privacy, networks, fault & delay tolerant networks & communications; | | | | | | | | | | | | **All** | |
| | **vii** | Embedded intelligent devices (micro architecture) for operational control, sensing & actuation at machine, plant or building (M/L); | | | | | | | | | | | | **All** | |
| | **viii** | operational decision support ICTs that integrate high level diverse systems such as safety, weather and energy etc. at individual, building or district level for near real-time decision making (G/B/M) | | | | | | | | | | | | **All** | |
| **2** | **Materialisation** | | | | | | | | | | | | | | |

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| **2.1** | **Decision support & visualization**<br>**Decision support** | | | | | | | | | | | | | | |
| | **i** | Tools to visualize real time progress to plan for energy sourcing options regarding cost & CO2 Impact (including CO2 certificates); | | | **(a)** | | **(a)** | **(a)** | | | **(a)** | | | **All** | (a) ICTs to optimise / select production / materialisation / procurement methods based on optimum energy consumption. |
| | **ii** | Energy related aspects included into decision support to select production strategies e.g. offsite / onsite production and materials; | | | | | | | | | | | | **All** | |
| | **iii** | Tools and e-commerce platforms for waste re-use; | | | | | | | | | | | | **All** | |
| | **iv** | Tools & interfaces using data from multiple ICT systems (e.g. BIM/PLM/ERP) to analyse and visualize (e.g. in 3D/4D/VR) current state, energy related information, environmental impacts etc; | | | | | | | | | | | | **All** | |
| | **v** | Location based services to decide on optimum materials suppliers; | | | | | | | | | | | | **All** | |
| | **vi** | Visualisation of trade-offs between environmental and economic concerns; (vii) Automated alerts to persons in charge on deviations in the production process; | | | | | | | | | | | | **All** | |
| | **vii** | Automated alerts to persons in charge on deviations in the production process; | | | | | | | | | | | | **All** | |
| | **viii** | ICT for proactive decision making (instead of support only); | | | | | | | | | | | | **All** | |
| | **ix** | Decision recommendation to solve trade-offs between environmental and economic concerns; | | | | | | | | | | | | **All** | |

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| | **x** | Mobile decision support (i) ICTs that utilise real-time communication to facilitate in the field decision making particularly in construction or civil engineering tasks (G/B) | | | | | | | | | | | | **All** | |
| **2.2** | **Management & Control** | | | | | | | | | | | | | | |
| | **i** | Energy related aspects integrated into planning tools (finance, logistic, scheduling) to define energy targets for production; | **)a )** | | | | | | | | | | | **All** | (a) ICTs to rationalise materialisation processes (in terms of planning and control) for energy efficiency (e.g. logistics, sequence, etc.). |
| | **ii** | Whole life cycle costing; | | | | | | | | | | | | **All** | |
| | **iii** | Automated tools for testing energy performance & validation of compliance to energy related requirements; | | | | | | | | | | | | **All** | |
| | **iv** | Automatic calculation of energy consumed during production, | | | | | | | | | | | | **All** | |
| | **v** | Simulation based real-time production management. Real time target/actual performance comparison. | | | | | | | | | | | | **All** | |
| **2.3** | **Real-time-communication** | | | | | | | | | | | | | | |
| | **i** | Using RFID/ NFC tags or similar to track transport & status of components, enabling near real time manufacturing; | | | | | | | | | | | | **All** | [a] Real-time communication in materialisation phase. [b] Tracking and visualisation of materialisation process in virtual planning models. |
| | **ii** | Pervasive Context related multimedia content provided to workers on portable devices & back office; | | | | **(a )** | | **(a) (b)** | | | | | | **All** | |
| | **iii** | Direct feedback of changes into planning models / simulations; | | | | | | | | | | | | **All** | |

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| | **iv** | Mobile decision support ICTs that utilise real-time communication to facilitate in the field decision making particularly in construction or civil engineering tasks (G/B) | | | | | | | | | **(a) (b)** | | | **All** | |
| **3** | **Automation & operational decision support** | | | | | | | | | | | | | | |
| **3.1** | **Automated monitoring & control** | | | | | | | | | | | | | | |
| | **i** | Full integration & interoperability of sensor [sensor fusion] & actuation devices with optimized use of ambient resources [energy harvesting] while promoting EE in host systems; | | | | | | | | | | | | **All** | [a] Embedded ICTs permeate sectors providing the “intelligence” to monitor & control energy resources in sustainable ways.<br>[b] Predictive control algorithms perform real time optimization. [c] Systems learn & adapt to usage preference via incorporated anticipatory logic.<br>This will in addition require collaboration in terms of |
| | **ii** | Autonomous localised level diagnostics, prediction & optimization, virtual sensors, inference technology & non-intrusive load monitoring; | | | | | | | | | | | | **All** | |
| | **iii** | Additionally augmentation will facilitate optimisation of energy beyond the localised entities through holistic technical and semantic interoperability; | | | | | | | | | | | | **All** | |
| | **iv** | Demonstrate the energy savings achievable through automation & operational decision support clearly delineating those savings attributable to ICT as | | | | | | | | | | | | **All** | |

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| | | opposed to say mechanical motor efficiency; | | | | | | | | | | | | | agreeing energy metrics & an impact assessment mechanism for clearly apportioning abatements or savings |
| | **v** | Embedded intelligent devices (micro architecture) for operational control, sensing & actuation at machine, plant or building (G/M); | | | | | | | | | | | | **All** | |
| | **vi** | Software and algorithms for operational monitoring and actuation of devices at machine, plant or building (G/B/M/L); | | | | | | | | | | | | **All** | |
| | **vii** | Inference sensing software and algorithms for pattern and signal identification at machine, plant or building level (B/M/L) | | | | | | | | | | | | **All** | |
| **3.2** | **Operational decision support & visualisation** | | | | | | | | | | | | | | |
| | **i** | Ability to understand Big Data volumes & diverse data sources via visualisation; us data sources for effective energy related decision support; | | | | | | | | | | | | **All** | [a] Improved energy performance management via integrative data visualization & decision support that augments automated management systems & sustains user engagement.<br>[b] Linking to Automated monitoring & control in moving towards learning systems providing reliable, secure & affective decision support to energy producers & consumers. |
| | **ii** | Intuitive, dynamically adaptable visualisations incorporating streamed [real-time] & asynchrono | | | | | | | | | | | | **All** | |
| | **iii** | Contextual rendering of data visualisations based on end-user device capabilities & information consumption preferences, again supporting effective EE related decisions; | | | | | | | | | | | | **All** | |
| | **iv** | Additionally, visualisation of 'requirements' in terms of building to individual i.e. were occupancy changes overtime; | | | | | | | | | | | | **All** | |
| | **v** | Visual programming of performance indicators; | | | | | | | | | | | | **All** | |
| | **vi** | Methodologies for identifying user requirement in a manner that is directly relevant for visual design. Moving towards influencing for sustained interest; | | | | | | | | | | | | **All** | |

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| | **vii** | Streamlining the design process by simplifying data acquisition, manipulation & assignment to graphical components; | | | | | | | | | | | **All** | |
| | **viii** | (viii) operational decision support ICTs that integrate high level diverse systems such as safety, weather and energy etc. at individual, building or district level for near real-time decision making (G/M/L); | | | | | | | | | | | **All** | |
| | **ix** | Grid/ Building/ Manufacturing/ Lighting: User centred data visualisation ICTs to support system state awareness by human operators / users (G/B/M/L) | | | | | | | | | | | **All** | |
| **3.3** | **Secure Wired / Wireless control & sensor networks & Quality of Service ICTs** | | | | | | | | | | | | | |
| | **v** | Guaranteed Quality of Service, Security, and Privacy. Together with an increased Quality of Experience [including simple deployment / integration] Network level automated SLA's. Framework in the short term with implementation medium term; | | | | | | | | | | | **All** | |
| | **vi** | Dependable infrastructure – reliable, robust, secure, privacy, networks, fault & delay tolerant networks & communications; | | | | | | | | | | | **All** | |
| | **vii** | Embedded intelligent devices (micro architecture) for operational control, sensing & actuation at machine, plant or building (M/L); | | | | | | | | | | | **All** | |

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| | **viii** | operational decision support ICTs that integrate high level diverse systems such as safety, weather and energy etc. at individual, building or district level for near real-time decision making (G/B/M) | | | | | | | | | | | **All** | |
| **4** | **Resources and Process Management** | | | | | | | | | | | | | | |
| **4.1** | **Inter-enterprise coordination** | | | | | | | | | | | | | | |
| | **i** | ICTs supporting innovation & holistic EE building life cycle optimisation, aiming at win-win between various stakeholders in moving beyond traditional division of role between disciplines & focus on lowest first investment cost per participant; | | | | | | | **acd e** | | | | | **All** | [a] Expected impact primarily relates to energy abatements brought about through reduced waste in leaning inter-enterprise processes. [b] Wide availability of ICT based services & infrastructure. [c] ICT supported facilitate virtual enterprise business relationships. [d] ICT enabled integrated processes are adopted for EE [including: models developed within RTD initiatives, human, legal, contractors, economics, |
| | **ii** | Contract & supply network mgmt., process planning, ERP, logistics, procurement, production etc. embed EE criterion in technology, practices & policy. Augmentation relates more to technical & semantic interoperability; | | | | | | | **acd e** | | | | | **All** | |
| | **iii** | Methods for virtual enterprise (VE) & network setup & evolution. Short to medium-term development in terms of dependable, scalable & extensible networks platforms to support new devices & services in terms of knowledge & value creation; | | | | | | | **acd e** | | | | | **All** | |
| | **iv** | Inter-enterprise ICTs for supporting coordination e.g. contract and supply-network management in the context of reduced energy consumption (G/M) | | | | | | | **acd e** | | | | | **All** | |

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| | | | | | | | | | | | | | | | business models, liability]. [e] Following the scalable platform / network theme, fully validated machine readable service level agreement technologies with semantic based contract management & enactment |
| **4.2** | **Business Process integration** | | | | | | | | | | | | | | |
| | **i** | Agreed semantic ontology / data modelling best practise, with respect to describing/detailing energy flow at the district / intra-enter¬prise level; | a | | a | | a | | | | | | | All | [a] Enhanced energy related knowledge creation, sharing & mana¬gement including: Infra¬structure, data mining & analytics, semantic map¬ping, filtering, conso¬lida¬tion algorithms, distributed data bases, catalogues of re-usable EE solutions etc. |
| | **ii** | Increased technical & semantic integration of relevant information touch points used to improve analytics & modelling capability & accuracy; | a | | a | | a | | | | | | | All | |
| | **iii** | Development of digital catalogues of products /sensors/services containing para-met¬ric information etc; | | a | a | | a | | | | | | | All | |
| | **iv** | Established strategies / techno¬logies to access integrate & process diverse EE data & information relating to entire life cycles & entire districts etc.; | a | | a | | a | | | | | | | All | |
| | **v** | Established scalable/extensible analytics for EE optimisation, pattern identification & predictive diagnostics etc.; | | | a | a | a | | | | | | | All | |
| | **vi** | Increased accessibility, extensibility & scala¬bility of semantic information, energy data, analytics & compute paramount to enabling innovative energy services; | a | | a | | a | | | | | | | All | |
| | **vii** | Established cross-organisational repositories & methods for know¬ledge consolidation & distribution; | a | a | a | | a | | | | | | | All | |

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| | **viii** | Engaging com¬mu¬nity forums for sustained discussion; | a | | a | | a | | | | | | | All | |
| | **ix** | Improved ease of access to EE knowledge which is modelled according to agreed reference data; | a | a | a | | a | | | | | | | All | |
| | **x** | Ubiquitous context-based access to inter-organisational knowledge platforms, with template solutions based on defined best practices; | a | a | a | | a | | | | | | | All | |
| | **xi** | (xi) Knowledge sharing ICTs, knowledge management, knowledge repositories, knowledge mining and semantics search, linked data, long-term data archival and recovery at enterprise or inter-enterprise level (L); | a | a | a | | a | | | | | | | All | |
| | **xii** | ICTs for data mining and analytics in terms of energy consumption and optimisation, pattern identification, predictive diagnostics and analytics at enterprise or network level (B/M/L) | a | a | a | | a | | | | | | | All | |
| **5** | **Technical and Semantic Interoperability ICTs** | | | | | | | | | | | | | | |
| **5.1** | **Integration technologies & Infrastructures** | | | | | | | | | | | | | | |
| | **vi** | Development of new services EE related; | | | | | | | a | | | | | All | |

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| | **vii** | Integration technologies / approaches such as service orientation and event driven architectures to facilitate heterogeneous device data interoperability at enterprise, network and environment level (G/L); | a | | | | | | | | | | | All | |
| | **viii** | Use of cloud based services for tasks such as data management, monitoring and analysis (G/B/M) | a | | | | | | | | | | | All | |
| **5.2** | **Interoperability & Standards** | | | | | | | | | | | | | | |
| | **i** | Provide open solutions ensures that sectors/customers are not locked-in by proprietary solutions: (i) Development of common concepts by alignment of sector specific ontologies; | | | a | | | | | | | | | All | [a] Provide mechanisms that allow to link high level abstract representations [Models / ontologies] to be linked/implemented down to the physical level ensuring thus the vertical integration of data and transforming these data into knowledge that could be integrated into decision/monitoring /reporting systems… |
| | **ii** | Extension of existing models with EE specific concepts; | | | a | | | | | | | | | All | |
| | **iii** | Convergence of existing models and ontologies; | | | a | | | | | | | | | All | |
| | **iv** | ICT standards and protocols for interoperability across heterogeneous devices at an enterprise, network or environmental level (B) ; | | | a | | | | | | | | | All | |
| | **v** | Integration technologies / approaches such as service orientation and event driven architectures to facilitate heterogeneous device data interoperability at enterprise, network and environment level (G/L) | | | | | | | | | | | | All | |
| **6** | **Trading / transactional management ICTs** | | | | | | | | | | | | | | |

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| **6.1** | **Regional/ National/E** | | | | | | | | | | | | | | |
| | **i** | New functions to balance generative capabilities of intermitted resources (wind & solar) across interconnected grids; | | | **a** | | | | | | | | | **All** | [a] Interconnected, large area networks will leverage intermitted resource variations. [b] The scale advantages also improve stability and reliability of the connected grid structures in cases where operational proceedings and fault management procedures are coordinated. As a result far greater amounts of distributed resources [both wind and solar] are acceptable in grid management operations. [c] Local decision making of market actors, smart loads, decentralized generation and local storage improves the efficiency of renewables when grid management operations are able to align with the configuration changes. |
| | **ii** | New coordination agreements to ensure the stability and reliability of the interconnected network; | | | **b** | | | | **b** | | | | | **All** | |
| | **iii** | New functions for recovery and outage management through fault detection and self-healing equipment; | | | | **a** | | | **b** | | | | | **All** | |
| | **iv** | (iv) New functions to allow alignment of centralized energy management (EMS) functions with distributed (local) decision-making equipment; | | | | **c** | | | | | | **c** | | **All** | |
| | **v** | Trading and energy brokerage ICTs e.g. consumer/producer forecasting algorithms, energy source tracking, consumption/price negotiation (M) | | | | | **c** | | **b** | | | | | **All** | |
| **6.2** | **District / Neighbourhood** | | | | | | | | | | | | | | |

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| | i | New distributed functions for real-time energy demand-supply management, coordination with the regulated operators of the distribution network (DSOs) and interaction with competitive energy market parties (suppliers, aggregators); | | | a/b | a | | | | | | a | | All | [a] Energy management and demand side management functions will increase the efficiency of renewable resources and reduce load variations greatly. It might be fair to say these functions are required for the large scale integration of intermittent resources [DER]. [b] Optimization of underlying energy management control loops will improve the reliability of the infrastructure. |
| | ii | Support tools that enable the integration of renewable energy sources, both large scale production (e.g. wind and solar farms) and massively distributed production (e.g. residential and tertiary buildings); | | | | b | | | | | | b | | All | |
| | iii | Data management infrastructures to allow electricity production and consumption to be accurately measured, reported and controlled (and eventually credited or billed); | | | b | | | | | | b | | | All | |
| | iv | Trading and energy brokerage ICTs e.g. consumer/producer forecasting algorithms, energy source tracking, consumption/price negotiation (M) | | | | a | a | | | | | | | All | |
| 6.3 | Facility energy | | | | | | | | | | | | | | |
| | i | Innovative new methodologies for the bi-directional connection between storage systems, smart grids and buildings to warrant power quality; | | | | a | | | | | | a | | All | [a] Energy conservation using a central hub for energy efficiency measures in buildings will improve efficiency based on market options and incentives. [b] Energy consumption and production facilities under local [energy management] control will be better managed to prevent power quality issues and help ensure a reliable and secure network operations. |
| | ii | Home energy management hubs to collect energy consumption data from smart household appliances, distributed resources, local storage and enable intelligent automation; | | | a | b | | | | | b | | | All | |
| | iii | New incentives and market propositions that drive efficiency measures; | | | | | a | | | a | | | | All | |
| | iv | use of cloud based services for tasks such as data management, monitoring and analysis (G/B/M) | | | a | | | | a | | | | | All | |

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| **6.4** | **Personal energy** | | | | | | | | | | | | | | |
| | **i** | Reliable information on the relationship of energy efficiency, wellbeing and financial consequences; | | | **a** | | | | | | | | | **All** | [a] Reliable and accurate information will improve the awareness of end-users and producers. It will cause prosumers to influence consumption & production behavior according to market options, incentives and comfort preferences. |
| | **ii** | New functions for the configuration and maintenance of control constraints and preferences of local energy management functions; | | | | **a** | | | | | | **a** | | **All** | |
| | **iii** | use of cloud based services for tasks such as data management, monitoring and analysis | | | **a** | **a** | | | | | **a** | | | **All** | |

[i] The ICT PSP methodology for energy saving measurement, Sep 2011, available [online] at http://esesh.eu/fileadmin/eSESH/download/documents/outputs/CIP_Common_deliverable_eSESH.pdf

[ii] IDC interim report on 'Quantitative estimates of the demand for cloud computing in Europe and the likely barriers to take-up' Feb 2012, [available] online at http://cordis.europa.eu/fp7/ict/ssai/study-cc_en.html