Project: REViSITE - Roadmap Enabling Vision and Strategy for ICT-enabled Energy Efficiency (www.revisite.eu)

Title: D3.3 Implementation Action Plan (IAP)

http://www.revisite.eu/deliverables.html

Technical report:

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 other types of recommendations /suggestions to various stakeholders for timed & synchronised implementation actions.

REViSITE team suggested 11 themes that could be implemented as research calls 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
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.

Once the above process was completed partners have written the final calls using the filtered content and 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 of the 21 action tables. These included indication of areas requiring attention to 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).

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SEVENTH FRAMEWORK PROGRAMME

The resulting recommendations and suggestions to the various stakeholders are given in the following:

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

1.1.1 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).

1.1.2 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.

1.1.3 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.

1.1.4 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.

1.1.5 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.

1.1.6 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.

1.1.7 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 CO2 Impact (including CO2 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.

1.1.8 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.

1.1.9 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.

1.1.10 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.

1.1.11 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.

1.2 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).*

1.2.1 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).

1.2.2 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).

1.2.3 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).

1.2.4 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).

1.3 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).

1.4 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).

1.5 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.

1.6 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.

1.7 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).

1.8 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.

[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