



D4.4 Recommendation to Education and Training Systems

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Executive summary

This deliverable provides recommendations to the education and training community on the introduction of selected multidisciplinary topics on ICT4EE identified from the REViSITE Roadmap.

The main aim is to raise awareness of the impacts of ICT4EE in the European education and training community and to provide recommendations on introducing “plug-in” multidisciplinary courses at early stages for ICT4EE on selected themes identified from the roadmap. The Implementation Action Plan (IAP) was the basis for developing the courses, recommendations to the education community; which involved a process where recommendations for research and innovation funding organisations were carefully studied to extract the possible and immediate learning material. This has been undertaken in combination with a desktop research on existing ICT4EE programmes across the world and investigation by partners with their direct contacts in their specific sectors.

The outcome 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: 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.

Acronyms and Glossary of Terms

Acronym	Description	Acronym	Description
3D.....	3 dimensional	ICT4EE.....	ICT for Energy Efficiency
4D.....	4 dimensional (3 dimensions + time)	IT.....	Information technology
ASEAN.....	Association of Southeast Asian Nations	ISO.....	International Organisation for Standards
BIM.....	Building Information Model	KPIs.....	Key Performance Indicators
BMS.....	Building Management System	LC.....	Life Cycle
CAD.....	Computer Aided Design	LCA.....	Life Cycle Assessment
CIM.....	Common Information Model	MBA.....	Master of Business Administration
CO2.....	Carbon Dioxide	NEM.....	New Electricity Market
EE.....	Energy Efficient/Efficiency	PLM.....	Product Life cycle Management
EMS.....	Energy Management System	RFID.....	Radio Frequency Identifier
ERP.....	Enterprise Resource Planning	SCADA.....	Supervisory Control and Data Acquisition
HVAC.....	Heating, Ventilation, and Air Conditioning	SRA.....	Strategic Research Agenda
IAP.....	Implementation Action Plan	SMARTT....	(see appendix 3)
IAQ.....	Indoor Air Quality	VE.....	Virtual Enterprise
ICT.....	Information and Communication Technology	VR.....	Virtual Reality

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. Among the aims of REViSITE is to identify opportunities for education and training of pertinent knowledge which can boost and help implement the strategies on ICT for energy efficiency.

This document suggests a number (total of 8) of themes for education and training based on the main topics identified within the REViSITE Roadmap and relates tightly to the call themes suggested for future research in the area of ICT 4 EE. These are seen to have the highest potential for impact through development and dissemination as training and education in those proposed subject areas. These education themes are expanded into education /training material at a high level of details, composed of the standard components of: scope, intended learning outcomes and an overview of content.

It is expected that the identified learning material will be valid for the four industrial sectors of: Building, Manufacturing, Grid and lighting and can also be relevant to other sectors.

1.2 Contributions

LOU

- Undertake a desktop search to identify existing education programmes on ICT 4 EE.
- Gather information from direct contacts within various academic institutions at an international level with the aim to identify existing education programmes on ICT 4 EE.
- Analysis and synthesis of other REViSITE deliverables to extract themes which have high potential for impact if taken into education and training programs.
- Lead the writing of the deliverable, including the review of existing programmes (section 2), synthesis of the findings from the SRA and the IAP deliverables (section 3), formulate the learning themes and high level, including scope, learning outcome and content, plus writing of other sections such as the introduction and conclusion.

FHG

- Contribution to the writing of the deliverable, partly in the review of existing programmes (section 2), involvement in the synthesis of the findings from the SRA and the IAP deliverables (section 3) and the recommendations to the education and training organizations (section 4).
- Summary of existing taught programmes on ICT for EE.
- Gather specific information (on taught programmes) from stakeholders within their corresponding countries or their direct contacts who are involved in teaching / training of ICT for EE subjects.
- Reviews and suggestions to all sections from manufacturing perspective.

INN

- Undertaken a desktop search and gathering information from direct contact within various academic institutions in the ASEAN region (Asia) to identify existing education programmes on subjects related to ICT4EE.

1.3 Baseline

Three documents were useful to identify and expand the learning material on ICT4EE as follows:

- D3.2 Strategic Research Agenda.
- D3.3 Implementation Action Plan.
- D3.4 Recommendations for new standards to overcome interoperability barriers.

1.4 Methodology

The overall methodology used to identify the learning themes included a review of existing relevant courses, extraction of recommendations from the SRA and the IAP and generation of learning themes at high level of details as follows:

- Conduct a review which includes a desktop search to identify any existing learning programmes (course, lectures, modules and industrial trainings) on ICT for EE. This has been complemented by input from all REViSITE partners who investigated within their sectors of expertise and through their contacts if any of these programmes are known to them, or if they do know of any other programmes.
- Extraction of recommendations dedicated to the education stakeholders as suggested in the REViSITE Implementation Action Tables (see example in Appendix 1) and mapping them against the 11 themes identified within the IAP document (given in Appendix 2) which were identified as most prominent themes and comprised all the ICT4EE technologies explored under the SMARTT sub-categories and were recommended for consideration in the future research calls by research and innovation funding organisation.
- Finally, consolidate the outcome of the mapping of recommendations and write the education themes expanded as: study/training material at high level, which are comprised of: the scope, the intended learning outcome and a description of content. These may be regarded as too ambitious; however, they can be customised, adapted, grouped or split by education bodies as they see fit and according to each organisation requirements and baseline.

1.5 Instruments for implementation

The envisaged instruments for implementation of the themes proposed for education and training will mainly be: the education departments, universities, training organisations and industry. The outcome of this task is scheduled for large dissemination activities together with other REViSITE project outcomes. These will include dissemination using two types of vehicles:

- An online publication of the learning themes and their high level details for wide access on the REViSITE website.
- Production of an electronic brochure supported by posted leaflet to point potential stakeholders within the REViSITE community to produced learning material.

2 REVIEW OF EXISTING EDUCATION COURSES RELATED TO ICT4EE

An initial review of what is already available on education courses related to ICT4EE was conducted. Partners have provided information from their countries perspective and/or on any other relevant courses they know of. LOU, FHG, and INN had to identify relevant education lectures, courses, or modules focusing on EE within Europe (especially Germany and UK), Asia and the USA regarding Building, Manufacturing, Grid and Lighting and other sectors. The following is what was identified:

Course/Programme Name	Description	Country	University
Advanced Thermal Modelling	The aims of this module are for the student to understand the principles of building thermal modelling and HVAC plant simulation, and be given a perspective on the applications of these techniques to the design process; including whole building thermal simulation, modular simulation techniques, system analysis, information flow diagrams	UK	Loughborough university
Sustainable Product Design	This module aims to provide an understanding of the tools and techniques available to facilitate sustainable product design and provide knowledge of the product design processes that can reduce environmental impacts and promote sustainable practices; including ICT tools such as CIMA Professional Gateway Assessment	UK	Loughborough University
Energy efficient production	Focuses on interaction between technical building services and production process and arrangements to improve energy efficiency in production.	Germany	University of Kassel
Ecodesign	Usage of Computer Aided Life Cycle Assessment of products and improvement of existing products regarding sustainability issues (to save energy by longer product lifecycles)	Sweden	KTH Stockholm
Modelling for Low Carbon Buildings: What Clients, Architectural Technologists and Engineers need to know	Course about the following topics: Benefits of modelling; when does modelling work; modelling for compliance versus modelling for design; types of models; understanding consultant reports; understanding how ventilation, lighting, HVAC systems and the fabric are modelled etc.	UK	University of Exeter

Sustainability in Production Engineering	Analysis and evaluation of production systems; teaching of fundamentals of energy efficiency in the context of production; exercises are including computer supported planning for energy efficient production designs.	Germany	University of Braunschweig
State of the art in building performance simulation	Benefits, concepts, assumptions and limitations of state of the art building performance simulation methods.	Netherlands	TU Eindhoven
Continuing Professional Development in Smart Grids and Smart Metering	Integrated series of modules centered around topics related to communications and networking for Smart Metering and Smart Grids; modules include: Power System Fundamentals, Smart Metering and Smart Grid Practical and Advanced Communication Architectures and Networks	UK	University of Manchester
Lighting In Buildings	Design of illumination systems in buildings in order to achieve energy efficiency and visual comfort; analytical lighting calculation techniques; radiative transfer; electric lighting system design and control for calculation of required indoor illumination levels; Day-lighting systems, including state-of-the-art day-lighting prediction models as well as design and control of such devices and advanced metrics.	USA	Purdue
Energy efficient production	includes e.g. “reduce of energy consumption of tools”, “determination of minimum process energy using modelling and simulation of the production process”	Germany	University of Magdeburg
IT for Energy in Buildings	Environmental Networks and Thermal Comfort. Introduction to a range of HVAC Systems in buildings; analysis and Design of advanced HVAC systems including renewable energy systems; electrical and IT systems and networks for buildings; building Management Systems (BMS); development of advanced computer based energy simulation models (BIM); building Life Cycle Management	Ireland	University of Cork
CA Facility Management	Introduction to facilities management; CA-facilities management; (mobile) data acquisition in the field; decentralised data management (RFID); long term data management; life cycle analysis (LCA); sustainability and facilities management.	Ireland	University of Cork

Sustainable Building Technologies	Concepts for Zero-emission buildings; usage of renewable resources and technologies; introduction of IT tools for sustainable construction.	Switzerland	ETH Zürich
Integrated Building Management Systems for Energy Efficiency	Provides an integrated system approach to understanding building automation and facility management systems, and their applications for EE. It covers the system architectures, hardware and software integration, digression, communication methods, and application software of modern building automation systems. It also provides good working knowledge of how to specify, design, install, commission, operate, and maintain an Integrated Building Management System.	SG	Singapore Polytechnic
Energy Management and Auditing	Provides students with the knowledge of the main features of energy management and auditing techniques. Identify the main energy intensive areas within a facility; thereby suggest appropriate energy management technologies and systems to reduce the operating cost of the facility while improving efficiency. Also address the impact of the New Electricity Market (NEM) in Singapore on facilities. The various ways to reduce energy cost of the facility, understanding and assessing the historical energy usage pattern, and types of audit tools/instruments used will be outlined.	SG	Singapore Polytechnic
Energy Efficiency and Efficient Drive	This subject covers the energy efficiency in different types of facility and the optimization of motor driven system to save energy. Students will learn the importance of energy efficiency in building, industry, power generation, transportation and motor driven systems. Energy efficiency analysis and computation will be introduced.	SG	Temasek Polytechnic – School of Engineering
Clean Energy Process Integration	This subject provides an integration of the various clean energy manufacturing processes. The students will learn the equipment used and the energy balance models of industrial processes. The system integration of different clean energy sources will be introduced. Other technical aspects such as smart metering and micro-grid will also be covered.	SG	Temasek Polytechnic – School of Engineering
Lighting &	This subject covers two key aspects in building physics. The lighting design	SG	Temasek Polytechnic –

Accoustics	covers both functional and aesthetics aspects for interior design. Building acoustics covers office and residential acoustics such as source of noise, sound transmission and absorption.		School of Engineering
Total Building Performance and Integration	This module aims to provide the concept and principles of total building performance and diagnosis, and introduces the methodology for building performance evaluation and rectification. It also considers four systems of integration in buildings – Structures, Envelope, Mechanical and Interior. The module discusses trends in office evolution.	SG	National University Singapore – MSc in Building Performance and Sustainability
Green Building Integration and Evaluation Studio	This is a studio-based module that synthesizes the theoretical and practical aspects of building performance and detailed design development, bringing sustainable design concepts and elements to the forefront. The need for sustainable design and its integration into a holistic performing building will be a key principle of studio learning. Design decision support using simulation tools will be brought to life in studio environment in the realization of holistic sustainable building. Simulation tools will be used for thermal, ventilation, IAQ, lighting and acoustics. Current sustainable building assessment techniques will be applied.	SG	National University Singapore – MSc in Building Performance and Sustainability

The result from the review of existing courses clearly indicates 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 argument we found that there is no space where students are taught subjects regarding the impact of ICT on different stages of the lifecycle of systems.

Moreover, the holistic perspective of the REViSITE scope (grids, buildings, lighting & manufacturing) is also missing in current curricula. Most courses offer only one perspective. Awareness regarding interconnections and interferences of different subsystems cannot be raised, caused by the usage of sector specific IT systems. Therefore, it can be concluded that there is a lack of courses with ICT for EE as a main topic.

Nevertheless, there was one example found during research which fits to the ICT for EE definition within REViSITE. The course was identified at the University of Oldenburg in Germany and is entitled “Information technology to energy efficiency”. It consists of a series of lectures hosted by different professors from different universities from all over Germany. It includes e.g. “Education for a sustainable energy supply – also in informatics”, “Smart grid and Electro mobility – challenges and potentials for ICT”, “Demand side management – why and how can within a grid the consumption follow the production”, “Simulation of traffic for the construction of transport systems and infrastructure”, “Green IT: energy efficiency in ICT

systems” and “Robot path planning for Saving Energy and Exploration”. The lectures cover various ICTs for EE related topics from different sectoral perspectives. Therefore, this course model could be a possible blueprint for educating students about different issues related to ICT for EE in a compact way.

To offer a broader and global view about the courses undertaken by the various institutions, in the ASEAN countries; ICT 4 EE is most considered as very important topic in Singapore.

Although there are no any specific ICT for energy efficiency courses, many institutions are active in teaching closely related subjects.

3 IDENTIFICATION OF THEMES FROM IAP ACTION TABLES

The following table is based on synthesis of the results from the IAP (D3.3) 21 action tables (one for each of the 21 topics) suggesting recommendations for the education and training sectors classified under the categories and the 21 sub categories of the SMARTT taxonomy.

Where S= Short term; M= Medium term; L= Long term; C= Continuous term

	Sub-Cat	Recommendations for Education	Time scale S, M, L, C
Cat.1	1.1	Training courses related to configuration design, templates and visualization.	S
	1.2	Education on life cycle design of integrated systems.	M
	1.3	Education: Data models / ontologies. Population of models.	M
		Training: Product data libraries. Model based tools.	M
	1.4	Education on LC performance metrics and estimation.	M
	1.5	Training courses for use of simulators.	M
Education on simulation models, methods and algorithms.		M	
1.6	Education & training on e-catalogues.	M	
Cat.2	2.1	Awareness raising for the impact of energy efficiency on cost and environment by presenting successful business cases	S
		Intensive Development/Usage of Case Studies describing different energy scenarios (Students need to calculate benefits of energy efficiency)	S
	2.2	Training of “Best Practices” for EE implementation Awareness Workshops and Seminars for Executives	S S
2.3	Workshops and seminars for training in new technologies and “best practices” exchange in implementation	M	
Cat.3			
3.2	Generate exemplars that clearly show design process applied in context	S-M	
Cat.4	4.1	MBA type programs could promote the concept & value of virtual enterprises & inter-enterprise coordination	
	4.2	Provide appropriate engaging contextual use-case materials within courses	S
Cat.5	5.1	Integration of the EE cross dimension into existing courses Publication of sector oriented guidelines / Training courses	C
	5.2	Publication of sector oriented guidelines / Training courses	S
Cat.6	6.4	Raise awareness and prepare participants for new roles (e.g. prosumer) in the energy arena and support the transition towards energy management.	S

Based on this synthesis, we propose eight modules related to ICT4EE to be considered by the education and training community. These are presented in the following section.

4 RECOMMENDATIONS FOR MODULES TO THE EDUCATION AND TRAINING COMMUNITY

4.1 Integrated design

SCOPE

This module introduces the life time performance of a product/system which is largely determined in the design phase especially when new products/systems are designed. The basis will be set for design for retrofitting of existing systems especially for products which are renewed several times throughout their life time. Notion of complex systems optimisation based on multiple and often conflicting criteria will be given and the degree to which the designed energy efficiency potential will be actually materialised, depending on the downstream life cycle stages (materialisation, operation). Therefore integration between different information sources, stakeholders and stages which is of fundamental importance for design will be core in this module.

INTENDED LEARNING OUTCOMES

Students will learn about the main targets for integrated design which are interoperability of various ICT applications and the ability to share information at high semantic level between stakeholders over all life cycle stages, this will include learning of:

- Techniques for enhancement of existing design, analysis and simulation applications as well as catalogues with energy related attribute and interoperable interfaces based on standards.
- Interaction with ICT platforms to facilitate sharing of and negotiations about the evolving design information within and between organisations. Methods for 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 term, 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. New design processes and collaboration forms.

CONTENT

Integrated design through interoperability of various ICT applications and sharing information; analysis, simulation applications and catalogues with energy related attribute;

interoperable interfaces based on standards; ICT platforms to facilitate sharing of and negotiations of design information; holistic optimisation of the interactions between subsystems; collaborative development of early stage design concepts and decision support with context driven visualisations; modelling existing products/systems/facilities for retrofitting design e.g. by scanning; configuration design and customisation based on reference solutions; Methods and services for long time data archival and recovery over generations of standards, tools and storage media; Simulation based systems for refining requirements; standardised energy performance indicators; New design processes and collaboration forms.

4.2 EE data models

SCOPE

The module will introduce the methods for holistic management of information from many stakeholders over the product life time. Common concepts and languages which are pre-requisites for communication; both between humans and ICT systems. Agreed data models (ontologies) which 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.

INTENDED LEARNING OUTCOMES

- Understanding of existing data models for various application domains extended with EE specific concepts in the short term.
- Awareness of 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.
- Test cases, methods and procedures to validate the compliance of software tools and shared data with respect to agreed data models (ontologies).

CONTENT

Data models for various application domains extended with EE specific concepts; 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; 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.

4.3 Metrics and methods for quantitative assessment of the impact of ICT on EE

SCOPE

This module will highlight the importance of energy efficiency for the environmental sustainability, for energy security and existing real need for common means of assessing the

impact of ICT for EE through provision of education and training. It is based on a structured learning of tools and methods for assessing the enabling impact of ICT in various sectors, the common metrics and measurement methods which can be used for comparison. These are ICT enabled measurement, common assessment, verification/certification, best practice sharing and knowledge generation. To undertake and intensive development/usage of case studies describing different energy scenarios (Students need to calculate benefits of EE).

INTENDED LEARNING OUTCOMES

- Student will gain insight into existing methodologies for metrics, measurement methods, measurement systems analysis & metric and measurement case studies.
- Learn about metrics and best practice for whole life cycle costing, and metrics and validation methods for holistic static performance: technical, economic and environmental.
- Learn about the energy / resource KPIs for a neighbourhood / city.
- Student will use case repository and knowledge exchange to understand real-world examples of ICT impact on EE.
- Will become familiar with self-diagnose calibration of measurement systems and with causal models and logic used to describe and predict the resource / energy impact of relationships in physical systems.
- Familiarise with technical and semantic integration of relevant information inputs used to improve analytics /modelling capability and accuracy.
- Develop practical skills on tools to visualize real time progress to plan for energy sourcing options regarding cost and CO2 Impact (including CO2 certificates) and to carry out visual programming of that assists in the evolution of energy KPIs.
- Learn about the means of dynamically evolving KPIs through links to analytics for EE optimisation, pattern identification and predictive diagnostics etc.
- Acquire skills to exploit and to contribute to the 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.
- Understand the business of trading and energy brokerage ICTs e.g. consumer/producer forecasting algorithms, energy source tracking, consumption/price negotiation.

CONTENT

Methodologies for metrics, measurement methods, measurement systems analysis & metric and measurement case studies; whole life cycle costing, methods for holistic static performance; energy / resource KPIs for a neighbourhood / city; case repository and knowledge exchange; technical and semantic integration of information inputs to improve analytics /modelling capability and accuracy; tools to visualize real time progress; dynamically evolving KPIs, pattern identification and predictive diagnostics etc.; digital catalogues of products /sensors/services; trading and energy brokerage ICTs e.g. consumer/producer forecasting algorithms, energy source tracking, consumption/price negotiation.

4.4 Data visualisation and decision support particularly in the “usage” phase of each sector including behavioural science

SCOPE

This module will expand the use of cognitive data visualisation principles. 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. 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, Business Activity Modelling, Management dashboards and methodologies for analysing situation awareness in complex systems.

INTENDED LEARNING OUTCOMES

- Acquire the 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.
- Learn about contextual rendering of data visualisations based on end-user device capabilities & information consumption preferences, again supporting effective EE related decisions.
- Be able to extract data from visualisation of ‘requirements’ in terms of building to individual i.e. where occupancy changes overtime.
- Learn about methodologies for identifying user requirement in a manner that is directly relevant for visual design. Moving towards influencing for sustained interest.
- Use of 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. And use of decision support/recommendation to solve trade-offs between environmental and economic concerns.
- Be able to perform visual programming of performance indicators. And use tools to visualize real time progress to plan for energy sourcing options regarding cost and CO2 Impact (including CO2 certificates). Use of dynamically adaptable planning models / simulations based on automatic feedback.
- Understand how to capture 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.
- 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.

CONTENT

Data visualisation; use of data sources for effective energy related decision support; Contextual rendering of data visualisations; Data extraction from visualisation of ‘requirements’; Methodologies for identifying user requirement; Operational decision support ICTs integrating high level diverse systems; Decision support/recommendation to solve trade-offs issues; Visual programming of performance indicators; Tools to visualize real time progress; Dynamically adaptable planning models / simulations; Mobile decision support ICTs and device aware visualisations.

4.5 ICTs to facilitate new business models and work practices

This can be framed as an MBA type program to promote the concept & value of virtual enterprises & inter-enterprise coordination and facilitate new business models and work practices.

SCOPE

The module will stress the 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 will introduce the student to (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 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.

INTENDED LEARNING OUTCOMES

- Learn about 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.
- Comprehend the function and usage of the ICTs supporting innovation & holistic EE building life cycle optimisation; Learn about embedding EE criteria in technologies to support contract & supply network management, process planning, ERP, logistics, procurement and production. Integration technologies / approaches such as service orientation and event driven architectures to facilitate heterogeneous device data interoperability at enterprise, network and environment level.
- Learn about 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.
- Understand the process of development of new EE related services and establishing new collaboration agreements to ensure the stability and reliability of the interconnected network.
- Acquire knowledge on new functions for recovery and outage management through fault detection and self-healing equipment to reduce energy overheads during down time.
- Have a good understanding of trading and energy brokerage ICTs e.g. consumer/producer forecasting algorithms, energy source tracking, consumption/price negotiation.
- Be able to use of cloud based services for tasks such as data management, monitoring and analysis to assist remote working.

CONTENT

Tools & interfaces for multiple ICT systems data analysis and visualisation; Tools and e-commerce platforms for waste re-use during materialisation; Pervasive context related multimedia content; ICTs supporting innovation & holistic EE building life cycle optimisation and cost analysis; Integration technologies / approaches for heterogeneous device data interoperability; Methods and tools for virtual enterprise (VE) & network setup & evolution; New functions for recovery and outage management; Trading and energy brokerage ICTs; Cloud based services for data management, monitoring and analysis.

4.6 Life cycle energy modelling and estimation

This can be formulated in three ways; as a course on LC performance metrics and estimation; a training courses for use of simulators; or education on simulation models, methods and algorithms.

SCOPE

This module will set base to promote EE targets, through continuous monitoring/estimation of (life cycle) energy consumption in every life-phase of the observed system. In early design planning and testing and later stages of performance indication, data processing and visualisation as a foundation for management, decision making & control. A holistic (cross-sectoral) perspective will be provided with new ways of integrating different EE evaluation methodologies of the respective sectors. Therefore much needed multiple new approaches for EE metrics, measurement & analysis methods, systems integration and knowledge repositories will be established and studied.

INTENDED LEARNING OUTCOMES

- Students will become familiar with metrics and validation methods for holistic static performance: technical, economic & environmental. Standardized energy performance indicators. Quality of Service & Service Level Agreements.
- Learn about the new incentives and market propositions that drive efficiency measures.
- Learn about energy related aspects included into decision support to select production strategies e.g. offsite / onsite production and materials;
- Learn how to use tools & interfaces based on 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.
- Be able to carry out simulations based real-time production management. Real time target/actual performance comparison.
- To understand the operations of whole life cycle costing; and 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.
- Establish strategies / technologies to access integrate & process diverse EE data & information relating to entire life cycles & entire districts etc.
- Learn how to undertake and support increased technical & semantic integration of relevant information touch points used to improve analytics & modelling capability & accuracy.
- Learn about 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.

CONTENT

Metrics and validation methods for holistic static performance; Energy performance indicators; Quality of Service & Service Level Agreements; Incentives and market propositions for energy efficiency; Decision support for production strategies; Tools & interfaces based on data from multiple ICT systems; Simulations based real-time production management; Operations of whole life cycle costing; and causal modelling ICTs; Strategies / technologies to access integrate & process EE data & information; Technical & semantic integration; Knowledge sharing ICTs, knowledge management, knowledge repositories, knowledge mining and semantics search.

4.7 Integrated monitoring, analytics and control for improved EE

SCOPE

This module is an initiation to ICTs supporting intelligent sensing / control with respect to energy efficient building, industrial and grid resource automation including sensing/control software & hardware, control & optimization algorithms and embedded microcontrollers.

INTENDED LEARNING OUTCOMES

- Study the information architectures and (embedded) intelligent devices for operational control, sensing & actuation at machine, plant or building.
- Learn about 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. Automated tools for monitoring energy performance & validation of compliance to energy related requirements; and automatic calculation of energy consumed during production.
- Acquire an understanding of full integration & interoperability of sensor (sensor fusion) & actuation devices with optimized use of ambient resources [energy harvesting] while promoting EE in host systems; 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.
- Become familiar with autonomous localised level diagnostics, prediction & optimization, virtual sensors, inference technology & non-intrusive load monitoring.
- Be able to use ICTs for data mining and analytics in terms of energy consumption and optimisation, pattern identification, predictive diagnostics and analytics at enterprise or network level; and data management infrastructures to allow electricity production and consumption to be accurately measured, reported and controlled (and eventually credited or billed introduction to using cloud based services for tasks such as data management, monitoring and analysis).

CONTENT

Information architectures and (embedded) intelligent devices; tools for visualization in real time of the operation progress; Tools & interfaces using data from multiple ICT systems; Visualisation of trade-offs between environmental and economic concerns; Automated tools for monitoring energy performance and automatic calculation of energy consumed during production; Integration & interoperability of sensor (sensor fusion) & actuation; Software and algorithms for operational monitoring and actuation; Inference sensing software and algorithms; Autonomous localised level diagnostics, prediction & optimization, virtual sensors, inference technology & non-intrusive load monitoring; ICTs for data mining and analytics; Data management infrastructures; home energy management hubs to collect energy consumption data; Cloud based services.

4.8 Introduction to cloud computing and network enabled energy services

SCOPE

This module will provide an introduction to trusted network infrastructure and network architectures which will be paramount in underpinning the sensors, actuators and analytics

which are so crucial to energy and resource efficiency services. Much in terms of augmentation with regards to cloud computing and future networks, all independently of a 'sustainability' context. The module will emphasise the following key concepts:

- Greater accountability and liability for security by cloud services providers.
- Importance of portability between cloud services.
- Security certification of cloud services vendors.
- The important role data privacy will have for the adoption of energy related offerings.
- Understanding the immense role context independent issues such as dependability, scalability, flexibility and privacy of data will have for energy and resource related services.

INTENDED LEARNING OUTCOMES

- Learn about the concept and main principles of cloud computing
- Learn about innovative architectures supporting flexibility, scalability, dependability and privacy; Dependable infrastructure - reliable, robust, secure, efficient, fault and delay tolerant networks and communications.
- Understand the means for the ability to move between different clouds i.e. increased federation and interoperability.
- Acquire the ability to dependably process/support/manage 'Big Data' volumes and diverse data sources.
- Understand the advantages to be gained from optimised cloud versus edge processing based on client aware logic; and fully validated machine readable service level agreement technologies with semantic based contract management and enactment.

CONTENT

Designing innovative architectures for flexibility, scalability, dependability and privacy; Means to move between different clouds i.e. increased federation and interoperability; Methods to process/support/manage 'Big Data' volumes and diverse data sources; Methods for optimised cloud versus edge processing.

5 Conclusions

5.1 Compliance with the DoW

Deliverable D4.4 provides recommendations to the education and training community on the introduction of selected multidisciplinary topics on ICT4EE identified from the REViSITE Roadmap as per the DoW. The main aim is raising awareness of the impacts of ICT4EE in the European education and training community and providing recommendations on introducing “plug-in” multidisciplinary courses at early stages for ICT4EE on selected topics identified from the roadmap. The IAP was the basis for developing the courses; recommendations to research and innovation funding organisation were carefully studied to extract the possible and immediate learning material in combination with a desktop research on existing ICT4EE programmes and an investigation by all partners with their ICT for EE contacts within their specific sectors.

5.2 Main findings

The desktop search and the wide investigation of partners with their direct contacts with their specific sectors have 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 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 were produced and detailed with sufficient level of details to be used by interested stakeholders. These are: (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. The contents of these themes may be regarded as ambitious; however, they can be customised, adapted, grouped or split by education bodies as they see fit and according to each organisation requirements and baseline.

6 Appendices

6.1 Appendix 1 - Example of an IAP action table populated

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 analysing situation awareness in complex sociotechnical & First Of A Kind systems.	
Target outcomes	Technology, standards & strategies supporting – <ul style="list-style-type: none"> • Ability to understand Big Data volumes & diverse data sources via visualisation. • Intuitive, dynamically adaptable visualisations incorporating streamed [real-time] & asynchronous data sources for effective energy related decision support • Contextual rendering of data visualisations based on end-user device capabilities & information consumption preferences, again supporting effective EE related decisions 	
Expected impacts on EE	<ul style="list-style-type: none"> • 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)	<ul style="list-style-type: none"> • 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 • 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 3.1 4.1-4.4
Recommended implementation actions by different stakeholders		Time scale S, M, L ↓
Policy makers	Encourage the adoption/application of standards to improve productivity and exploitation e.g. W3C	SML
Research & innovation funding organisations	<ul style="list-style-type: none"> • Encourage applied projects in the energy efficiency space that will test visualisation state of the art technologies in real world scenarios. 	S
	<ul style="list-style-type: none"> • Encourage the adoption of user-centred design process when engaging in use-case driven projects to ensure closer collaboration with end users/industry 	S
Research performers	<ul style="list-style-type: none"> • Visual programming of performance indicators • Methodologies for identifying user requirement in a manner that is directly relevant for visual design. 	M S
Industry	<ul style="list-style-type: none"> • Streamlining the design process by simplifying data acquisition, manipulation & assignment to graphical components 	S
Standardisation bodies (D3.3)	Expand on the current ISO standards on usability and user centered 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
Corresponding Enablers		
Author		Date

6.2 Appendix 2 - IAP research themes

The 11 identified research 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.

6.3 Appendix 3 - SMARTT

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

1. **Specification & design ICTs**

a- Design conceptualisation; b- Detailed design; c- Modelling; d- Performance estimation; e- Simulation; and f- Specification & Product / component selection

2. **Materialisation ICTs**

a- Decision support & visualisation; b- Management & control; and c- Real-time communication

3. **Automation & operational decision support ICTs**

a- Automated monitoring & control; b- Operational decision support & visualisation; c- Quality of service; and e- Wired/Wireless sensor networks

4. **Resource & process management ICTs**

a- Inter-enterprise coordination; and b- Process integration: Knowledge sharing

5. **Technical Integration ICTs**

a- Technical integration & interoperability

6. **Trading / transactional management ICTs**

a- District energy management; b- Facility energy management; and c- Citizen (personnel) energy management