Short Technical report for deliverable 3.4
Recommendations for New Standards to Overcome Interoperability Barriers

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Deliverable Administration & Summary	
Issue Date	1 December 2011
Deliverable No.	D3.4 (Technical report)
Version	V1.0
WP Number	**WP3 RTD Roadmap for multi-disciplinary ICT-enabled energy efficiency**
Status	☐Draft ☐ Working ☒ Final for submission to the EC

Document history

V	Date	Author	Description
1.0	2012-04-27	NVl	CSTB, INTEL, FHG, VTT, INN, LOU & KEMA

INTRODUCTION

REViSITE is working for the European Commission to identify 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 EC funding for Research in Technological Developments in this area.

The REViSITE 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

The focus of the D3.4 document is on interoperability and it provides recommendations on standards for overcoming interoperability barriers to cross-sector opportunities. The purpose of this document is to:

- Identify the relevant existing and emerging standards that affect energy consumption in the target sectors.
- Identify the commonalities and opportunities for convergence of these standards across the four sectors.
- Identify the opportunities for enhancing interoperability between the four target sectors.
- Formulate recommendations for standards bodies and relevant organisations to facilitate convergence of standards for ICT for energy efficiency in a non sector specific way.

The D3.4 document provides an overview of pertinent standards for energy efficiency in each of the four sectors. Subsequently it documents the cross-sectoral standardisation opportunities and the main barriers in interoperability standards for energy efficiency. Finally the D3.4 document provides recommendations to bridge the identified standardisation gaps and to gain from cross-sectoral synergies.

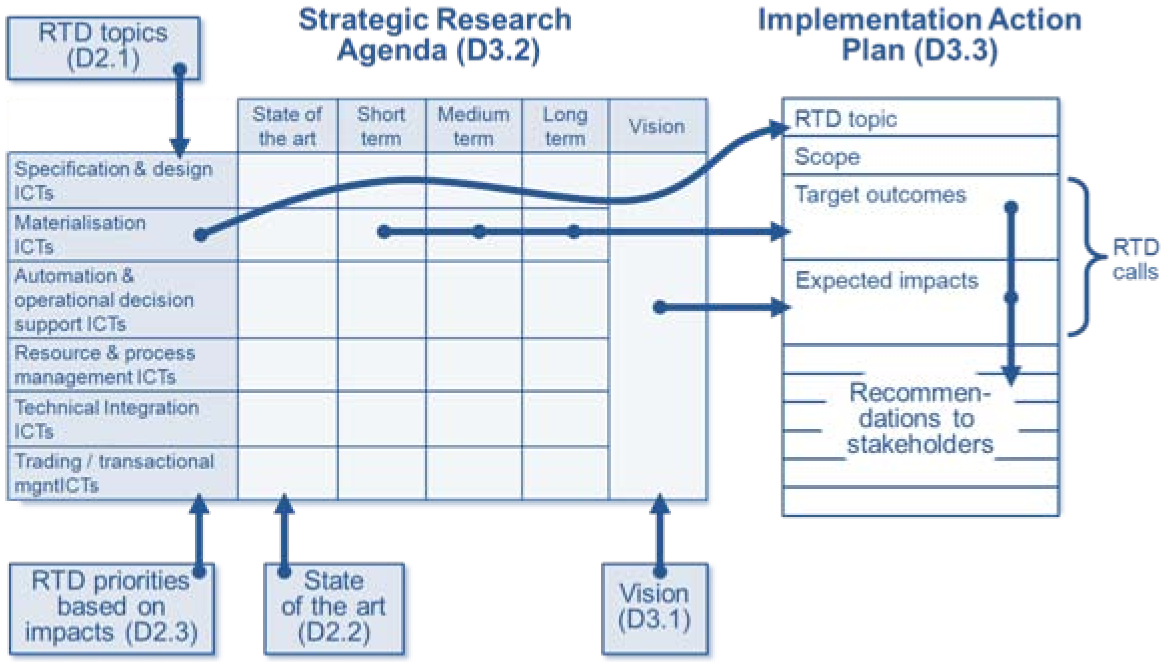
Through the construction of the Strategic Research Agenda (SRA), the REViSITE Framework and SMARTT Taxonomy, an overview of standardisation requirements have been compiled. In terms of rigour, this overview was put through a sanity check, a review by sector specialists and a validation workshop to add ranking and priorities. The process provided an insight into the urgency, contents and scope of standards that are widely considered to be essential for energy efficiency. The key recommendations for these standards are:

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

The D3.4 document underpins the need for these recommendations and offers additional details for each of the suggestions from a cross-sectoral viewpoint. The recommendations have been aligned with the members of the REViSITE expert group and the participants of the REViSITE workshops.

Methodology

The standardisation recommendations in the D3.4 document were prepared using the surveys for the Implementation Action Plans (IAP as documented in the REViSITE D3.3 deliverable). Specific experts provided inputs with regard to the standards that would be required to bridge gaps and overcome barriers for cross-sectoral cooperation. These inputs have been put through a sanity check in order to verify the validity in each of the specific sectors. IAP's have been defined for each of the 23 SRA research topics subsequently. Most of these IAP's contain recommendations for standardisation bodies as a measure to enable the cross-sectoral interoperability. These items have been synthesized into more generic topics, five in total, that apply to multiple sectors and capture the breath of the recommendations. The 5 high-level standardisation topics were presented for validation and ranking at the REViSITE workshop which was held in Paris on 9th March 2012. The results of the validation were used for the final REViSITE recommendations that are documented in the deliverable (D3.4). The workflow on the process is shown in the figure below. The D3.4 report focuses on the recommendation for the stakeholder "standardisation bodies" in the Implementation action plans (D3.3).



RECOMMENDATIONS

Extension of existing ontologies for energy efficiency

The current models developed in each sector are too vertical and even if there is some overlapping among the ontologies, there is no alignment between the concepts that overlap. The need is therefore to find an efficient approach to identify these overlapping areas. The suggestion here is to rely on the notion of Virtual Power Plant (VPP). The concept of VPP is not new. It comes from the Grid sector and has been advanced as a generic model or modelling approach to represent all elements or devices concerned in the field of Energy production. The REViSITE proposal is to extend the notion of VPP to all "artifacts" concerned both the production and the consumption of energy. This dedicated model has to be seen from the building sector point of view as a specific facet of the BIM and eeBDM ontologies.

The concept of VPP is a very interesting tool. It allows for a defined model (the VPP model) that contains a generic set of characteristics to allow connection and interaction between the smart grid and the building sector. On the Construction side, this model could be seen as a subset of BIM and eeBDM. This approach applies also at different scales as it can be imagined and defined a VPP model well suited to represent the needs from the most "atomic" VPP (a generating device, i.e: a battery) to the most complex like the energy grid as a whole. In between these two extreme elements, we can already think of relevant steps regarding our needs like the definition of a VPP for buildings (aggregation of smaller VPP like washing machines, CHP, Electric Vehicles, Solar Panels, etc…), a VPP for the districts (aggregation of buildings), a VPP model for so called "smart cities" (aggregation of District VPP…).

A VPP from the building point of view is a kind of "identity card" that should contain information in a structured manner in order to allow interconnection of ontologies from the Grid and the construction sectors. In a recent report OECD mentioned also the VPP approach as an enabler to reshaping the energy system by giving rise to scenarios and transactions that can only be solved by digital continuous integrated exchanges among prosumers. The VPP modelling approach is an answer to tackle the gradual decentralization of power generation, by providing a simplifying instrument to deal with the complexity of energy systems.

Energy performance indicators (Metrics)

Performance targets, driven by politics or company standards, are required in order to provide incentives to design buildings and production systems etc. in a more energy efficient way. The parameters which constitute a target are defined by certain metrics which need to be continuously monitored to ensure that target values are reached. There are no cross sectoral standards available for EE metrics and even within the sectors the maturity of standards is on a generally low level. There is still ongoing research about the statistical advantages and drawbacks of different indicators and evaluation methods leading to several frameworks used to measure the EE of a building or a "device". It is very hard to compare two solutions that have been assessed by two different frameworks. Therefore concrete objectives consistent for different companies or even different sectors are difficult to find. These methodology barriers also prevent benchmarking and the diffusion of best practices since it is not possible to find the most efficient technologies. Thus in order to have an integrated approach, it is necessary to come to a common and harmonized set of metrics. There is also a need to define the whole chain of measurement in order to ensure the reliability / accuracy of the data collected but also

their meaning and their privacy. In this context, the potential of synergies for the four target sectors also needs to be assessed.
There are two major ways for assessing energy efficiency. Energy Indicators are ratios of energy consumption/emissions of carbon dioxide equivalent in relation to a physical or economical dimension. "There is no unequivocal quantitative measure of 'energy efficiency Instead, one must rely on a series of indicators relevant to the context…" according to the "International Energy Agency" (IEA). IEA developed a hierarchical overview how energy indicators can be structured according to the level of their respective aggregation

Highly aggregated indicators usually reflect the economical perspective of energy use in order to compare different sectors, countries etc. regarding energy efficiency, e.g. kwh/GDP. On the lowest level of aggregation indicators are measuring the efficiency of machines, processes different subsystems of buildings, etc. Within the REViSITE scope performance measurement on plant/building level seems sufficient. Nevertheless, indicators at this level of aggregation are usually based on a physical unit related to a special sector. The "Energy Use Intensity" is the most often used example in this category. It simply relates energy consumption to the unit of outcome e.g. kwh/square meter in the building sector or Gj/ton of product produced in manufacturing. Whereas the efficiency of buildings, lighting and grids can be determined using the same indicator manufacturing cannot be integrated easily since the most significant ratios are related to physical units of their respective sectors (kwh/square meter vs. kwh/unit produced). Nevertheless there may be some indicators applicable to both (e.g. energy saved per year).

As an alternative to indicator-based evaluation schemes rating systems can be used to evaluate EE. Contrasting to indicators they do not produce real values or ratios as a result. An own metric is produced which consists of different EE classes/categories. Prominent examples in the building sector is "LEED" developed by the US green building council and the English governmental program "Code for sustainable homes". Since the result is not directly linked to a sector, rating schemes offer a good potential for integrating multiple sectors in Energy efficiency assessment. Because of the result's independence from physical values rating systems may have a higher potential for cross sectoral efficiency evaluation. The criterion which lead to an efficient outcome of the sectors (like electrical efficiency of power supply, efficiency of machines and production facilities etc.) could be integrated in catalogues evaluating the performance of the building itself.

Although the composition of indicators/rating schemes seems simple it is the result of a complex measuring process. Different methodologies are used (e.g. embodied/operational energy assessment, calculating with on-site or off-site energy, different system boundaries etc.) which makes comparisons difficult and often leads to misunderstandings. Therefore there is a clear need for standardization. Harmonization of metrics, test procedures and integration of frameworks for different sectors may lead to an EU-wide or preferably global methodology to assess energy efficiency. International working groups and expert forums need to be formed in order to support dialogues in best practices and standardization opportunities. An example for efforts in this direction is the "Common Carbon Metric" programme in the building sector developed by the UNEP. It is currently evaluated by the ISO regarding applicability as a new standard and could be an example for other sectors.

Product catalogues that include energy dynamics

Information on available real products is needed during the design stages when specifying the actual components or modules which implement the designed functional units. If the design tools are CAD based then the product information has to be modelled into the format compatible with the CAD tool in use. Usually CAD tool providers have taken care of the development extensive add-on product catalogues/libraries to their tools to improve the usability and attractiveness of the tools. These add-ons have a great competitive importance for tool provider companies. Alternatively, product manufacturers can develop data models for such CAD tools they want to get support for their products. These product models can be published on the web so that their users (tool providers and end-users) can download and install them in their design environments. Examples on existing product catalogues mostly on the building sector are shown as follows.

- ArchiCAD based Parametric object technology contains all the information necessary to completely describe building elements as 2D CAD symbols, 3D models and text specifications for use in drawings, presentations and quantity calculations; tens of thousands of intelligent objects available and in use around the world.
- The Autodesk® Seek web service enables designers to discover, preview, and download BIM models, drawings, and specifications covering the following product libraries: Revit MEP, AutoCAD MEP, Revit Structure, Revit Architecture and AutoCAD Architecture.
- SMARTBIM Object Catalog is a collection of over 45,000 generic and manufacturer product BIM families and types (Autodesk® Revit® based) Where appropriate, they are parametric, representing different types of the same product. Objects are available FREE.
- MagiCAD http://www.magicad.com/en/content/design-real-products building services design tool on AutoCAD and Revit MEP having database containing hundreds of thousands of 3D models of real products. The models have correct dimensions and the technical data needed to make accurate calculations.
- Edibatec (in France): basic parts being dictionary, database and web service interface; the dictionary contains more than 250 classes of products (heating, cooling, ventilation, electrical equipment, insulation, doors, windows, glazing); a public on line database of more than 50000 products with their technical data, pictures and documentations; updated by the manufacturers; web services facilitating the use of technical database for buildings professionals having in 2011 more than 10 000 connections.
- Modelica is a non-proprietary, object-oriented, equation based language to conveniently model complex physical systems containing, e.g., mechanical, electrical, electronic, hydraulic, thermal, control, electric power or process-oriented subcomponents. Libraries with a large set of dynamic models are available. The open source Standard Library contains about 1280 model components and 910 functions from many domains. Modelica represents an extension to the pure data modelling.

Main standardisation committee in the field of product libraries (building domain) is ISO TC 59 / SC 13 Organization of information about construction works having several BIM related activities going on. The working group WG 11 Product data for building services systems model with the work item ISO/CD 16757 Product Data for Building Services Plant Models is directly related to product libraries. Its work is based on the German VDI 3805 standard describing catalogue information for Building Services products. VDI 3805 has been developed over the last 20 years having specifications available for a big number of product groups. A parametric product modelling approach is used with computational properties. Another new work item in TC59/ SC 13 is related to the French building products industry’s approach Technical Dictionary of Harmonised Properties (DTH). That approach is based on product description via properties.

Standard based product data catalogue systems have in principle two different data repositories: product data dictionary and product data library. The data dictionary contains the metadata of the type product such as attribute names and the data library contain the instantiated product types i.e. attribute values.

The data dictionary attributes (their values) are mapped directly to the attributes of the product type. In addition to these attributes directly inherited from data dictionary, the product catalogue item can have additional attributes to be computed or used as input to generate other attributes. The following alternatives were identified.

- The library and directory types have exactly the same attributes.
- The library type has computational attributes. These are the additional attributes to those inherited from the directory product type.
- The library type has computational attributes. Some of the inherited attributes are computational and generated from additional attributes through parameterisation.
- The library type has computational attributes. Some of the inherited attributes are computational and generated from additional attributes rule based.
- The product type contains dynamic model(s).

A specific requirement for the contents of product data models concerns energy related attributes of the products. The new energy efficiency standards will increase demand for technical data. Each manufacturer or professional organization must also use the same standard and the same method to describe construction product data. Proposed standardisation concerns 1) the contents of the product data models for attributes needed for standardized energy performance evaluation, 2) standardisation application areas related to directory/library/1-1 mappings, 3) standardisation application areas related to mature parametric applications.

Data exchange protocols

Any information exchange requires a set of conventions shared by the sender of data and its recipient: both must know when the communication begins, what procedure it follows, and when it ends. Such sets of conventions are called protocols. A data exchange protocol is a standardised format for transmitting data between two devices. The type of protocol used can determine such variables as the error checking method, the data compression method, and end-of-file acknowledgements. If all networks and devices were constructed in the same manner and all networking software and equipment behaved similarly, only one protocol would be necessary to handle all of our data transmission/exchange needs. In reality, the ICT industry includes millions of different networks running a wide array of hardware and software combinations.

The issue is that most mechanical and electrical systems have embedded digital controls, these lower-level devices are low cost and/or low power and typically cannot support a full OSI stack i.e. they are not directly controllable. At this physical layer data exchange is handled by dedicated communications wiring or a wireless equivalent. Typically, these individual devices operate separately, without exchanging information and, as a consequence, the building or factory is not considered and controlled as one single system, but as a number of individual subsystems. This leads to sub-optimal results in terms of energy flow, comfort, cost and controllability. The world of lower level protocols is essentially a jungle of heterogeneous often competing offerings and standards harmonisation at this level is extremely onerous and highly unlikely.

The most appropriate solution is the use of interoperable control systems, governing all HVAC, lighting and other electrical applications, and related sub-systems installed in a facility. However, as described above integrating the myriad of sub-systems and devices, which are manufactured and often installed by different companies with different data interfaces and communication protocols, is an arduous process. There is a big challenge to effectively and efficiently integrate all these sub-control systems into one intelligent application.

Several well established protocols [e.g. BACnet, KNX, LonTalk etc] utilised in BAS BMS type systems that attempt to do just that, essential acting as aggregators allowing for homogeneity in terms of controlling lower level heterogeneous devices. However, while these data exchange protocols can be used over TCP/IP networks they themselves have challenges when dealing with other network applications with respect to interoperability, routers, firewalls and security etc. REViSITE would suggest that while feasible and very much needed harmonisation is not, all things considered, likely at the lower level. When considering connection from aggregators to the network typically IP/TCP compatible solutions are available but more-often-than-not this requires adaptive coding because the structures of the messages exchanged are not standardised.

The most obvious way forward is one many in the built environment have already set out to employ. That is the development and standardisation of common ontologies, open interfaces, XML and web-services based mechanisms whereby one abstracts away from the jungle of lower level and less crowded data exchange protocols [such as BACnet, KNX etc.] enabling integrated communication between building systems and enterprise applications. As such, REViSITE would suggest there is a research and standardization need with respect to:

- Non-alignment of open solutions, above the IP layer, as the structure / content of messages is not commonly defined.
- Defining a uniform approach towards application with respect to building control systems.
- Investigating the interoperability of different information sources in buildings i.e. further consideration with respect to harmonisation of data models between BIM and BACS.
- Understanding the advantages and disadvantages of traditional data exchange approaches [BACnet, LonTalks, KNX etc.] and web-service based mechanisms, so industry can find the right balance in developing an optimised and standardised approach that addresses interoperability while allowing for heterogeneity and innovation.

But effort in this regard would not be starting anew and any effort should consider existing initiatives, which include but are not limited to:

- W3C
- OASIS Open Building Information eXchange [oBIX]
- CABA
- BuildingSmart
- BACNet XML working group
- LonMark interoperability association
- The XPL project
- BuildingSmart

Harmonisation and extension of the IEC Ontology

Applications of the IEC 61970 and IEC 61968 Common Information Model (CIM) have been expanding from its traditional usage in power system modelling and data exchange into the role of a standardized semantic model for the Smart Grid. The Smart Grid Interoperability Road Map has identified the need for a semantically consistent framework on which to base the Smart Grid and has selected the CIM as a central element across many functional areas of the Smart Grid not traditionally addressed by the CIM. One such area relates to how CIM works with the IEC 61850 power system communications standard that has also become an important part of the Road Map for both substation communications and as the basis for other Smart Grid oriented communications. This has made harmonization of CIM and IEC 61850 critically important to the goal of interoperability.

The IEC reference architecture finds it origin in the technical operation of transport and distribution grids and therefore lacks support for more recent roles and responsibilities. Although ontology packages for competitive market roles have been designed these are regarded to represent a different maturity level than the core packages. In the smart grid vision even newer roles and tasks such as the “Aggregator” have been identified that are not yet represented in the existing ontologies. The main items for expansion of the current ontologies include support for the use-cases listed:

- Flexible energy prices, flexible grid tariffs and the interfaces between consumers and producers, TSOs, DSOs and suppliers/traders/aggregators
- Clearing & settlement and interaction with data collection, data exchange, and electricity flows
- Products and features fostering producers and consumers’ flexibility in relation to capacity management, communication needs, etc.
- Efficient ways to communicate with customers, such as e-mail, SMS, signals to the meter, In-Home display, digital TV etc.
- Ensuring that consumers receive accurate, timely, understandable and usable information on consumption.

A set of tools and rules is needed for cross domain information exchange and representation. Activities that have been happening in parallel in various sectors need to be able to converge in a controlled fashion. Standards already exist across the semantic and pragmatic boundaries. The challenge is to formalize these into an ontology that covers the Energy Efficiency applications domain.

The semantics of the built environment and the grid are connected at a functional level as both domains are part of the same energy flows. The smart grid projects already defined domain ontologies that have become part of an IEC standard. These ontologies have limited support for the built environment however. In that respect both ontology domains could benefit from each other on shared topics such as energy efficiency measures. Ontology mappings may be required to effectively exchange information between the grid domain (infrastructure operators, energy market and such) and the built environment (developers, owners, occupants etc.). A mutual approach of grid and build environment experts could help interconnect the semantic definitions of the two sectors and prepare for collaboration in the field of energy efficiency. The new emerging standards on energy efficiency of buildings, general energy terminology, the carbon footprint standard (the future ISO 14067) and energy management systems (the future ISO 50001) will help establish global conventions.

Conclusions

This document identifies the needs and opportunities for enhanced interoperability in the four focus areas and suggests actions forward based on a consolidated view as part of the roadmap. It highlights areas where data exchange should be defined, or where projects concerning this definition should be integrated.

The ranked proposals for standardisation exhibit great complexity. The Paris workshop indicated that the standards and the processes that create and maintain the standards are difficult to grasp. An overview is difficult as lots of different and partially overlapping standards already exist. This is the case particularly in the area of communication protocols.

A further barrier identified was in relation to the time it would take to establish a mature international cross-sectoral standard or ontology in the ICT4EE domain. The CIM ontology took some 20 years to achieve its current maturity level. Current developments in technology however are much faster and would require a more flexible and agile standardisation creation and maintenance process.

Some of the disciplines involved in the discussions are relatively young (semantic web technologies, remote sensing, energy and carbon metrics, etc.). Some of these may require more context specific research before being stable enough for definitive standards. The subject matter knowledge that is needed for the standardisation may need further development.

The recommendations focus on the selection, extension and harmonisation of existing standards or development of new standards in order to overcome the barriers listed in this paragraph. This underpins the suggestions to further develop the following areas:

- The extension of existing ontologies for energy efficiency
- Energy (and carbon) performance indicators (Metrics)
- Product catalogues that include energy dynamics
- Generic data exchange and communication protocols
- Harmonisation and extension of the IEC Ontology

The overall conclusion would indicate that energy efficiency requires a cross-sectoral and life-cycle perspective to achieve energy efficiency in its full potential. The design stage requires faithful insights in energy requirements of processes and buildings while the operational phase includes information exchanges across sectoral boundaries that require common semantic definitions. The recommendations of the REViSITE project cover the actors in the full scope of the energy flows and support monitoring, assessment and control.