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VIRTUAL ENVIRONMENTAL SIMULATION AND ENERGY MANAGEMENT IN PUBLIC BUILDINGS

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Abstract. *The paper reports on a project in progress, aimed at providing a comprehensive knowledge building, sharing, management, decision support, simulation and control platform for the energy management of public buildings. The targeted application range of the three-year VERYSchool project are public schools that share characteristics which make them a clearly defined application segment. The paper outlines the solution concept, the commercially available components to be integrated and the selected application pilots of the project.*

1 INTRODUCTION

As sustainability has become an issue of pivotal concern for society, solutions for energy efficiency—including retrofitting of "legacy" facilities and appliances—are being considered and introduced more and more[5,8]. Also, rapidly rising costs of energy and natural resources are making efficiency more than a "matter of principle", for the public sector, private enterprises and consumers alike.

Today's changing energy management presents both concerns and opportunities. Observing present-day energy consumption practices with more scrutiny sheds light on potential sources of concerns, both regarding the—often inadequate—efficiency of utilization, and the rising amounts of energy consumed[2,4]. The introduction of more sophisticated energy management schemes, however, reveals just as many new opportunities for improvement[6]: with the rapid development of information and communication technologies (ICT), new solutions become feasible—both technologically and economically—in the form of better design and energy control schemes, as well as more comprehensive collection, processing and sharing of data, knowledge and best-practice experience[3]. The last decades have witnessed advances in energy-related technologies as well, such as new materials and renewable energy technologies becoming ripe for commercial use[2,9].

However, despite all pressure and efforts, both from governance and the industry, technological advances do not yet sufficiently penetrate the market, or leave potential users with inadequate strategic orientation[3]. Barriers include knowledge on what technologies to select, what energy conservation measures to pursue first, and how to implement these choices in a systematic way (e.g., how to create an *energy management program*). While the progress in research and technologies accelerates, people who are in charge of taking decisions and meeting energy efficiency targets are gradually left behind. Some examples of this are readily apparent:

- Options are overwhelming: there are literally thousands of ICT solutions in the market, and decision makers or even implementers of energy management schemes do not have the expertise, time, or resources to digest this rapidly evolving environment.
- Guidelines for energy audits and the implementation of energy efficiency directives are not yet fully standardised and harmonised across different levels (regional/national/European). This process is also hampered by the unbalanced availability of preliminaries, with certain assessment tools and guidelines being already available but data still being scarce and targets remaining unclear.

- Customisation is needed: the best available standards and regulations were conceived for large-scale industry (e.g., multi-million euro investments). Targeted solutions that address specific stakeholders using the methodology of these codes are needed—organisations need to know specifically how it applies to them and this must be made readily understandable to those merely using already elaborated technologies.
- The need is misunderstood: technology providers often overestimate the level of expertise of users and the depth to which they are able to comprehend and manually fine-tune their energy solutions. To use the analogy of an automobile, most organisations simply need a "baseline navigator" to get where they are going.
- Timing is misunderstood: the success of a complex energy efficiency scheme, especially in facilities used by many individuals, depends very much on the insight and willingness of everyone involved in implementing the scheme and making it work. Abrupt and forced introduction of measures does not facilitate the development of an "energy efficiency culture" where consistent action of all individuals concerned is led by routine and insight that needs to be established incrementally. Similarly, the economy of energy savings can only be recognised via incremental measures, with sufficient flexibility to be exercised until savings start to pay for investments.
- The business model is misunderstood: energy efficiency schemes are too complex and long-term to be dealt with in the usual "one-shot" ways of direct sales and consulting. In fact, many measures can only work if local characteristics are addressed—often with a healthy portion of outside-of-the-box thinking—and a long-term relationship between user and technology provider can develop, leaving enough space for adaptation and fine-tuning of all parties involved.

Clearly, there is a definite need for solutions bridging gaps in technology and problem awareness, as well as availability of support and incremental development[1]. While a solution framework aiming to bridge these gaps in a generic way may be too ambitious, it can be a realistic undertaking if a specific application segment is addressed.

The paper introduces one of such segment-specific efforts, the EU FP7-financed project VERYSchool (Valuable Energy for a Smart School), targeting the support of energy efficiency in the application segment of public schools. While many criteria of energy management show considerable variation from region to region[4,6], certain characteristics of survey, assessment and decision processes, as well as implementation, supervision and control are shared by the application area across Europe. This suggests the feasibility of an assessment, planning and control tool that could be deployed in public schools is various regions of Europe, integrating several components and solutions that have already existed side-by-side.

Being a work-in-progress report, the paper is organised as follows. First, the concept of VERYSchool is presented, stating the working assumptions and the recognised fundamental requirements and preliminaries leading up to the *VERYSchool Navigator* framework. Next, the architectural design of the platform is presented, specifying what is already available as a tried-and-proven commercial solution and what added values will be offered with the integration. Finally, application pilots will be addressed briefly.

2 PROBLEM STATEMENT AND SOLUTION CONCEPT

While their energy parameters may largely differ in detail, schools still form a specific segment of public buildings and share a number of key characteristics that makes it possible to tailor an energy management and decision support platform to this segment's needs. Most public schools across Europe are alike or reasonably comparable in the following characteristics[4,6,7]:

- Patterns of building utilisation (daily, seasonal schedules, etc.);
- Dimensions of comparable facilities;
- Requirements regarding temperature, air flow and lighting (including natural and artificial light).

In addition, public schools are typically embedded in larger financing and management structures (e.g., districts) that makes certain patterns in local (operational) and long-term (strategic) measures prevail. As in any complex hierarchy of survey, decision, planning and implementation with a multitude of actors involved (see also Figure 1), it is not uncommon that intended improvements do not perfectly materialise due to limited communication between organisational units or levels of hierarchy. It should also be pointed out that energy management is only one of numerous aspects decision makers have to deal with, hence they rarely have up-to-date technical expertise at hand.

The goal of VERYSchool is the elaboration of energy management roadmaps for the targeted sector, and the integration of up-to-date knowledge and existing, commercially available technologies into a comprehensive ICT support framework that can improve assessment, decision and communication processes in energy management. The pivotal output of the project will be the *VERYSchool Navigator* (see also Figure 2), a framework bringing up-to-date and applicable knowledge to users concerned, and providing a uniform web-based interface integrating the tools needed for planning and implementing energy management. The *VERYSchool Navigator* will be customised for users and stakeholders acting in schools and it will provide the necessary instruments to establish, implement and maintain an Energy Management Programme (EMP) or Energy Management System (EnMS), both at territorial and building levels, making effective policy planning and building operation. As part of that EMP energy-saving-oriented actions and energy-saving-related contents will be managed systematically to Closure (*i.e.*,Identified, Prioritised, and included in an Action plan, Assigned, Target dates set, and method of verification of energy savings detailed) using the *VERYSchool Navigator*..

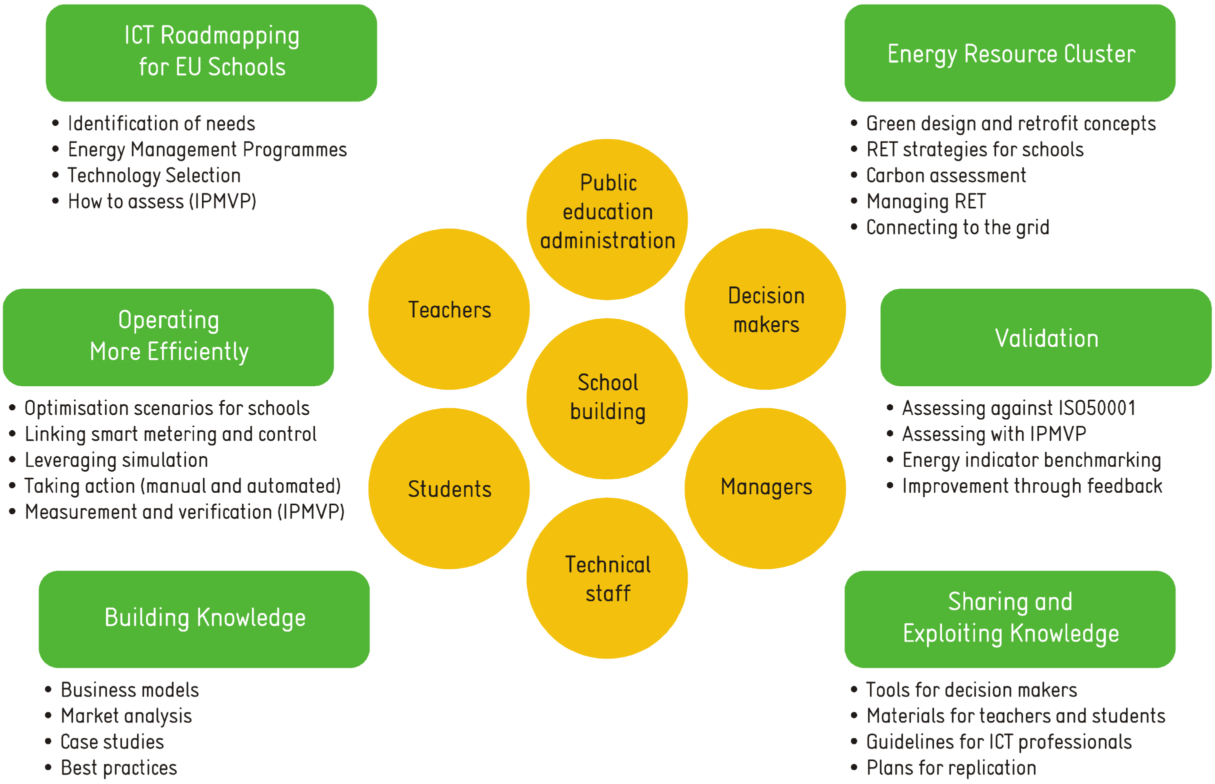

Figure 1. Components and actors in the *VERYSchool Navigator* concept

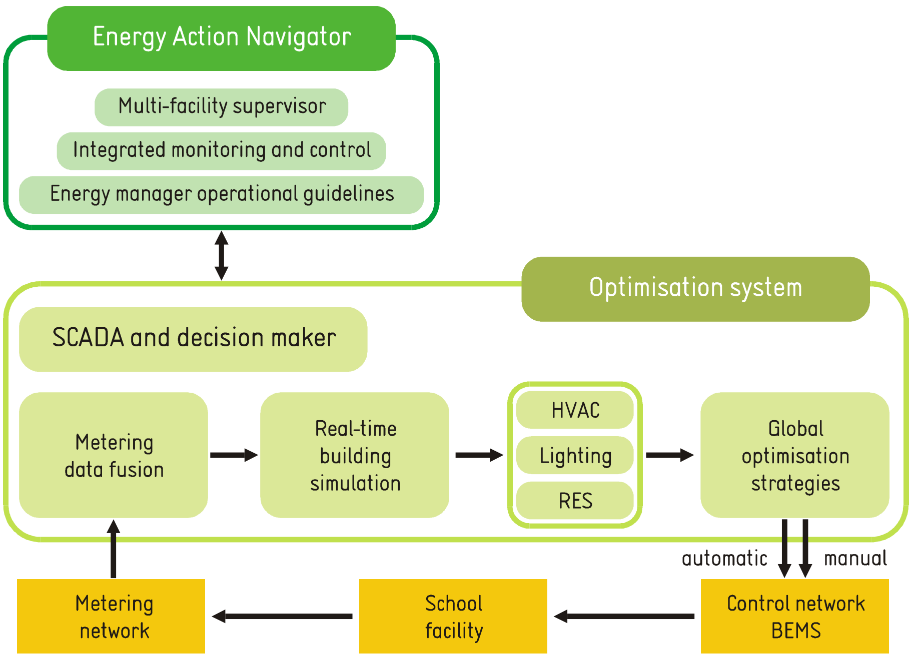

Figure 2. Decision structures and components in the application of the *VERYSchool Navigator*

3 ARCHITECTURAL DESIGN

While vital components of energy management systems have existed side-by-side, the VERYSchool Navigator adds value by:

- Integration of existing solution elements into one consistent system (and thus providing the overview and transparency needed for comprehensive action);
- Addition of a knowledge base and networking of previously disjoint application sites.

The VERYSchool Navigator consists components of previously existing tried-and-proven are solutions commercially offered by their respective developers. Smart metering and Building Energy Management System (BEMS) components are supplied by the Italian SME *DOKI* (SCE Group): these devices form the immediate periphery executing energy-related automation measures and are considered a low-level (closed) control loop in the context of the VERYSchool Navigator (see Figure 2). DOKI technology realizes an innovative Climate Control and Building Management System (CCBMS) designed to respond to the need of controlling the new generation of Climate Control Systems inspired to saving energy while providing more comfort to the user without his direct intervention. Thanks to a number of pre-programmed scenarios the user can implement 24/7 control scenarios to optimize the energy consumption during the different part of the day/week. While BEMS components can be operated locally, further advantages are expected by allowing secure remote access by the VERYSchool Navigator (e.g., collection of a large application data corpus for analysis, or consistently planned action at several locations).

Enerit Ltd. of Ireland, provides the world's first comprehensive Systematic Energy Management (SEM) software which guides Energy Managers, Decision Makers, and staff alike towards best practice SEM. Once users have fully established, implemented and maintained an EnMS they can apply for ISO 50001 certification. Unlike SCADA, the Enerit software collates all EnMS information (energy policy, audits, data, opportunities, ideas, processes, documents, records) into one place to create systematic action plans that get a customer's team working together to drive down energy costs. The Enerit software helps to manage a wide range of energy-related information and handles several user perspectives tailored to the needs and typical tasks of various user groups. Use of the software typically saves 10–20% of energy cost through low-cost or no-cost actions. Enerit software allows further adaptation to application needs if the targeted sector is clearly defined—with VERYSchool focusing specifically on public school buildings, this reserve of targeted refinement will be fully exploited.

The <VE> (Virtual Environment) performance analysis software suite offered by the UK-based SME *IES* (*Integrated Environmental Solutions*), allows architects and engineers to facilitate a sustainable design process. Building mass and form, the climate, natural resource availability, occupancy, materials and services are taken into account to "virtually" test the feasibility of different energy saving strategies and low-carbon/renewable technologies. It also assists in showing regulation, LEED, BREEAM and Green Star compliance, and producing UK Energy Performance Certificates. In the VERYSchool project, <VE> will be used for environmental simulation of several application pilot sites across Europe.

The key added value in the VERYSchool Navigator is attributed to the networking, i.e., the transparent combination of these mature technological solutions in a way that allows knowledge to be gathered and deployed in a wider range than it is practiced currently. With the help of the VERYSchool Navigator, consistent actions can be taken in several schools across a larger area or organisation, and information can be more efficiently tailored to the specific needs of personnel in different positions. Moreover, increased transparency is expected to bridge communication gaps that were, to a considerable degree, inherent to the organisational structure of present-day school management. Much of the integration of existing components into one framework (see Figure 3 for an architectural outline and Figure 4 for a GUI snapshot) is carried out by the R&D consortium member MTA SZTAKI (Institute for Computer Science and Control of the Hungarian Academy of Sciences) and the industrial partner Enerit, while some specific adaptation steps of existing components will be performed by the commercial providers of the respective technologies.

It is important to emphasize that integration alone is only one part of the added values of the VERYSchool Navigator—in fact, the solution is only complete with the adequate population of the knowledge base with energy optimisation scenarios that are to be elaborated during the project, relying on findings gathered from application pilots conducted at schools in various regions of Europe. This will result in an extensible "optimisation scenario playbook" comprising around 79 optimisation scenarios that have been elaborated and actually tested at the pilot locations. Scenarios will cover measures and expected effects on different levels, ranging from no-cost actions that can be put in effect immediately, to long-term improvements that need in-depth analysis and assessment of feasible options.

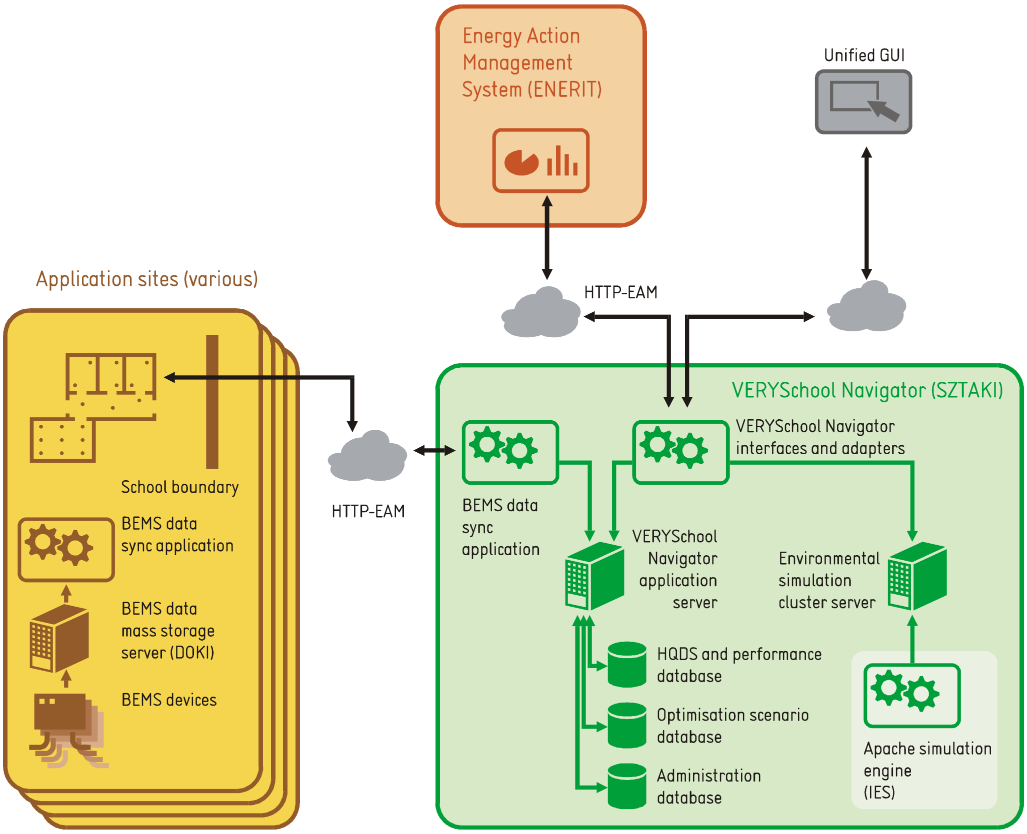

Figure 3. Architecture outline of the *VERYSchool Navigator* and its application environment

Figure 4. User interface of the *VERYSchool Navigator* unifying several commercially offered components

4 APPLICATION PILOTS AND FURTHER DEPLOYMENT

Started in late 2011, the EU FP7-funded project VERYSchool spans three years of development and pilot evaluation. Unlike many other projects, VERYSchool relies heavily on processing and evaluating experience gained already with the application pilots, in a “learning by doing” manner. Being a development-oriented project, work on establishing technical conditions for integration and scenario development started right away, allowing an early and gradual ramp-up of activities at four selected pilot locations. Field work began in the second half of the first project year with surveys, followed by installation of required equipment by the middle of the second project year. Being in its last year, the project now focuses on validation of the implemented solutions and the consolidation of scenarios with the findings gathered in field tests.

However, application pilots at selected sites are not the only target of the project—extensibility of the results to school buildings in general is an important consideration. In order to achieve the latter, a four-step plan of ensuring replicability is pursued. The first step to a wider deployment is to build a customised solution for *a client base where it adds value*. VERYSchool ensures this by selecting and developing customised solutions that address the unique needs of and for the entire value chain of schools (e.g. city councils, public managers, energy managers, technicians, maintenance workers, global service, students and teachers).

The second step is to *offer competitive products*. VERYSchool is integrating cutting edge technologies that include Enerit’s Systematic Energy Management platform, IES’s simulation suite that ties into CAD and Google SketchUp, and DOKI smart meters and BMS systems which offer customised scenarios for building management. With such preliminaries, as well as the proven integration expertise at the disposal of the consortium, VERYSchool can realistically manage this step.

The third step to ensure wider exploitation is to be prepared, organised, and be *backed by a consistent plan*. It has been a deliberate choice to structure the VERYSchool project as essentially a living replication plan. The Energy Navigator and work program is designed to bring a targeted audience with unique needs to the field of ICT for energy efficient solutions. Moreover, the VERYSchool project also explicitly develops replication plans, with participating users receiving customised support.

The fourth and final step detailed here in achieving a wider deployment and use is to *build and maintain networks*. VERYSchool benefits from prominent and established professionals and organisations that are sufficiently powerful and acknowledged in their field and provide a growing network with a solid technical and business foundation, but are at the same time small and agile enough to enable timely take-up and keep the network fit for adaptation to changing conditions.

5 CONCLUSIONS

The paper presented the EU FP7-funded project VERYSchool which aims to develop a platform for the energy assessment and energy management of public school buildings. While the current situation of energy efficiency in European public buildings exhibits gaps between available technologies and exploited potentials, these can be bridged by the focused application of existing ICT technologies. The VERYSchool Navigator, the main output of the project, builds upon this recognition and integrates commercially offered, competitive components with a unified user interface. In addition to facilitating transparency and connectivity of hitherto disjoint components and application sites, the VERYSchool Navigator adds more value by gathering and presenting knowledge tailored to the specific needs of actors in the targeted application field. Ensuring lasting application of the project outputs is a key factor to the project’s usefulness. To this end, a four-step plan is prepared to keep the VERYSchool Navigator flexible to adapt to varying needs, and replicable to enable sustainable market penetration. The project is now in its final year, and crucial results of field tests are expected in the coming months.

ACKNOWLEDGEMENT

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