The VERYSchool Navigator - Intelligent ISO 50001 energy management decision making in school buildings

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ABSTRACT: This paper describes an innovative energy management methodology to support intelligent decision-making that ensures both energy efficiency and savings. Core is the EC VERYSchool project (VERYSchool 2014) and the effective action management based on the ISO 50001 standard (ISO 2011). The VERYSchool project development is supported by mature technologies, such as smart lighting, smart meters, control systems, energy simulation modeling, and the Enerit ISO 50001 software suite (Enerit 2014). The successfully integration of these ICTs realizes a complete Energy Navigator system; in practice a web based platform called VSNavigator. VSNavigator is currently being demonstrated and validated at 4 pilot schools in EU countries. The resulting VERYSchool methodology and ICT solutions have a high degree of repeatability to automate the energy management in other building sectors and large energy infrastructures. The ISO 50001 standard covers a wide range of requirements and all aspects of an energy management system with this paper focusing strongly on action management.

1 ENERGY MANAGEMENT SYSTEM (EnMS)

It is a common understanding, nowadays, that automated control system, even sophisticated ones, alone are not able to guarantee energy efficiency and optimal energy management.

A successful EnMS depends on commitment from all levels of the organization covering technical, organisational and people aspects (Fig. 1).

The standard application of the EnMS key elements is depicted in Figure 1.

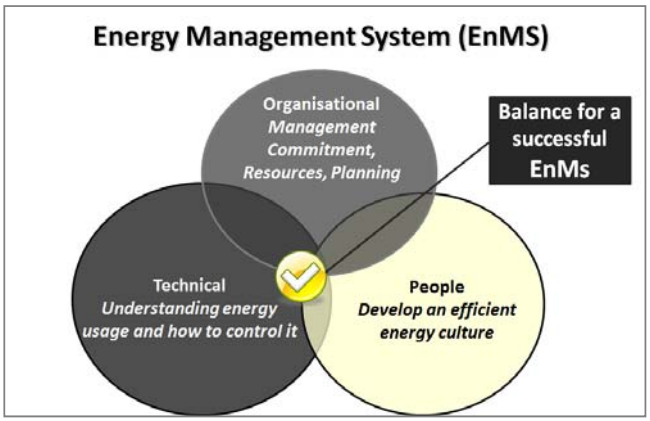

Figure 1. Key elements of an EnMS.

Knowledge on what technologies to select, what energy conservation measures to pursue first, how to implement choices in a systematic way, are simple barriers that limits the effectiveness on the creation of an optimal energy management program.

As research and technologies progresses with increasing velocity, the people that must take decisions and act upon to meet energy reduction targets are being left behind.

To get efficiency in energy management, Organizations need to apply a systematic approach to continuously improve their energy efficiency.

This means that the commitment of the organization has to define the overall results of the management system for energy instead of specific levels of energy performance to be achieved.

The ISO 50001 international standard was introduced to specify the requirements for establishing, implementing, maintaining and improving an Energy Management System (EnMS) in the form of a more efficient and sustainable energy.

Energy costs in most buildings are escalating year-on-year and owners/managers are keen to reduce these costs. However, energy consumption reduction efforts never seem to succeed in the medium and long term. Sometimes, the managers or owners of buildings will raise urgent concerns about energy costs. This can lead to reductions of energy in the short term, but, when management focus returns to other issues more directly related to the main mis-

sion of the business, energy consumption normally returns toward previous levels and costs tend to rise year on year.

The overall scenario for energy management can be depicted as shown in Figures 2a and 2b.

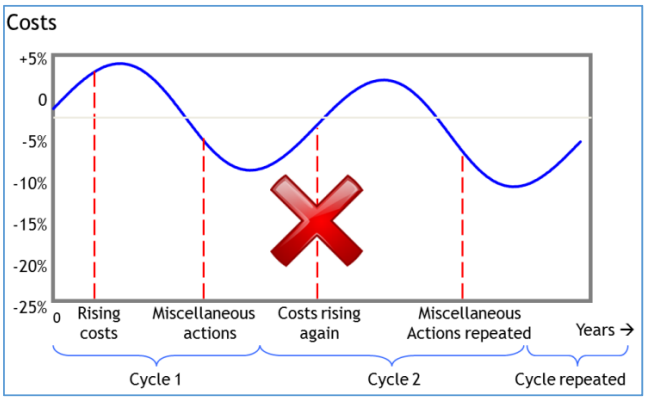

Figure 2a. EnMS - not optimized scenario.

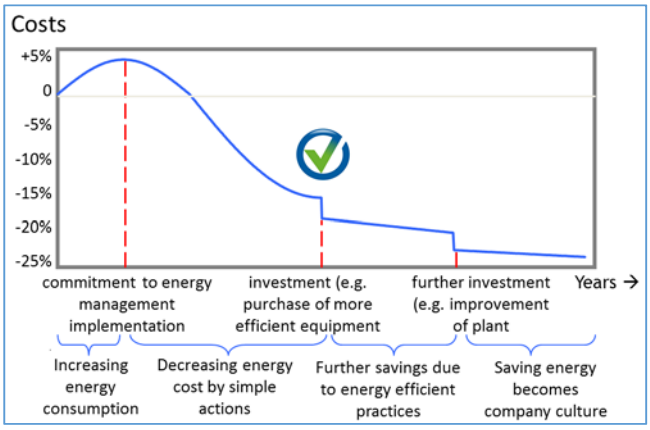

Figure 2b. EnMS - optimized scenario

Some of the key questions and challenges for energy managers are:

- *How can energy expertise and support be provided at modest cost*?
- *How can energy savings be achieved quickly*?
- *How can people who are consumed with critical day-to-day business issues be helped to support efforts to reduce energy cost at the sites*?
- *How can the EnMS be prevented from losing direction over time*?
- *How can energy consumption and cost continue to be reduced year-on-year*?
- *How can staff enthusiasm be maintained about energy savings*?

2 ISO 50001 IN THE VERYSCHOOL PROJECT.

Thus, to get the above challenges, the overall concept is to link all actors in the value chain under a common platform to provide "*how to*" information based on best practice ways of working and energy management strategies devoted to the needs of the building (and of its Organization).

ISO 50001 is applicable to all types and sizes of organizations. It provides a globally recognised framework to establish the systems and processes necessary to improve energy performance, including energy efficiency, use, and consumption.

ISO 50001 is based on the 'Plan-Do-Check-Act' (PDCA) method for control and continual improvement and incorporates energy management into everyday organizational practices (Fig. 3).

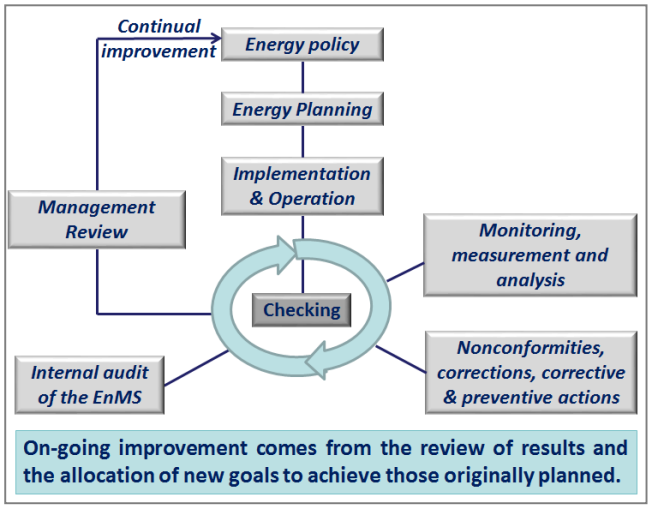

Figure 3. ISO 50001 EnMS model and relations

A review, carried out in the VERYSchool project, of many excellent best practices for energy management in schools from around the world, shows that these all follow a similar method to the ISO 50001 PDCA method (Carbon Trust 2008, Carbon Trust 2012, SEAI 2007, SEAI 2014, K-12, US DOE).

Core to the VERYSchool energy management programme is the way of working based on the ISO 50001 energy management system standard (ISO 2011). The overall PDCA methodology, together with mature technologies, such as smart lighting, smart meters, control systems, energy simulation modeling, as well as the ISO 50001 software suite, has been successfully integrated in the VERYSchool to deliver a complete Energy Navigator system that realizes a web based platform called VSNavigator customized for school energy management solutions.

3 VSNAVIGATOR.

The VSNavigator is a web platform for public school stakeholders that provides the tools necessary to develop and implement an Energy Management Program at organizational and building levels with respect to both policy and building operation.

The VSNavigator directly led to increased awareness and knowledge within that value chain of stakeholders, allowing users to act for establishing and maintaining an energy management programme both at territorial and building levels, based on the ISO 50001 energy management standard.

The VSNavigator integration process is performed through the development or the adoption of communication and interaction adapters, both at automation and management level.

The fundamental architecture of VSNavigator platform is depicted in Figure 4.

For the data model and the communication stream between VSNavigator and the Enerit software suite (Enerit 2014), three basic elements of synchronisation have been defined and formalized through XML schemas: users, schools and actions.

An FTP approach was adopted for data transfers: VSNavigator uploads XML files to the Enerit FTP server when a new user/school/action is created or an existing user/school/action is updated.

The Enerit software suite regularly checks the XML files for new or updated requirements (user/school/action).

A user friendly graphical interface (GUI) provides seamless integration of the navigational elements.

4 ACTION MANAGEMENT AND VSNavigator.

The specific ISO 50001 requirements that the action management meets are to identify, prioritize and record improvement opportunities (ISO 2011, clause 4.4.3) and to establish energy objectives, energy targets and energy management action plans (ISO 2011, clause 4.4.6).

With regard to action management, some of key features of VSNavigator, provided by the integration of the Enerit ISO 50001 software suite, which meet these requirements, are:

- My Tasks (specific to each user)
- Improvement Opportunities
- Action Plans
- Action Report Charts
- Objectives and Targets

These features provide an easy to access area to review, manage and assign actions related to improvement opportunities from optimisation scenarios and suggestions.

Access to the above is available to the users associated with a particular school. In the case of Decision Makers and the Energy Manager they will have access to these functions and information for all schools (district level).

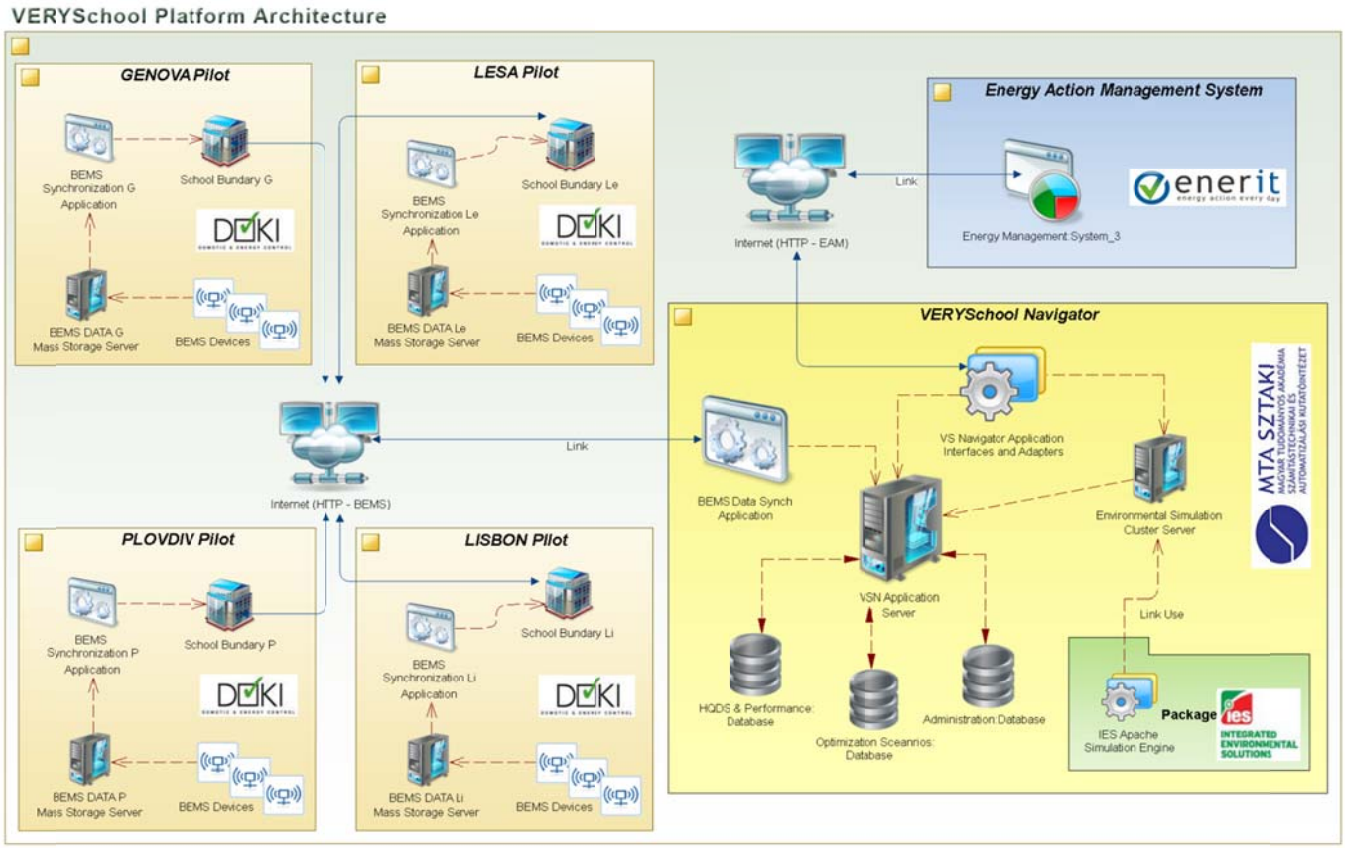

Figure 4. VERYSchool over-all architecture

The following points summarise an energy action life cycle:

- Actions are triggered automatically or manually from Optimisation Scenarios (OSs) suggested by the VSNavigator. The OSs are a set of best practices aimed at improving energy usage within schools suggesting either technical or behavioural actions. OSs are organized in a "Catalogue" and they include recommendations for building envelope, lighting, heating, ventilation, and air-conditioning (HVAC) systems; system setting strategies related to thermal comfort; and integration of renewable energy sources. These OSs account for school needs based on building structures, users' behaviour and usage of educational buildings (Galata et al. 2014).
- The Energy Manager is notified by email with a link to the created action (new or already assigned). The action also appears in the "My Tasks" section, and other views, in VSNavigator when the Energy Manager accesses the system online.
- The action contains the relevant details for the energy manager to review and for the assignee to implement the action.
- The action is prioritised based on the details on expected savings, payback, complexity and maintenance impacts which are passed through from the optimisation scenarios. The prioritisation of tasks can be viewed using an OS Prioritisation chart.
- The Energy Manager reviews the action and assigns it to suitable person e.g. a technician
- The action then progresses through the workflow (Assigned → For Validation → Awaiting Closure → Closed), to successfully satisfy the PDCA diagram.

A feedback loop function shows an indicator on the associated OS in the repository when an action in a school is going through the action workflow until it is closed.

5 RESULTS

The VERYSchool project has completed the hardware integration and the software development to deliver the Decision-Making and User Driven-Actions platform for Energy Management referred as "VERYSchool Navigator" or VSNavigator.

VSNavigator is currently under demonstration and validation at 4 European pilot schools, located in Lisbon (Portugal), Genoa and Lesa (Italy) and Plovdiv (Bulgaria).

In line with ISO 50001 standard, VSNavigator provides a base line and assists in the decision making for the 4 pilot schools, demonstrating that it is possible to implement an efficient energy management system, which allows the establishment of the necessary processes to improve the pilot schools overall energy performance.

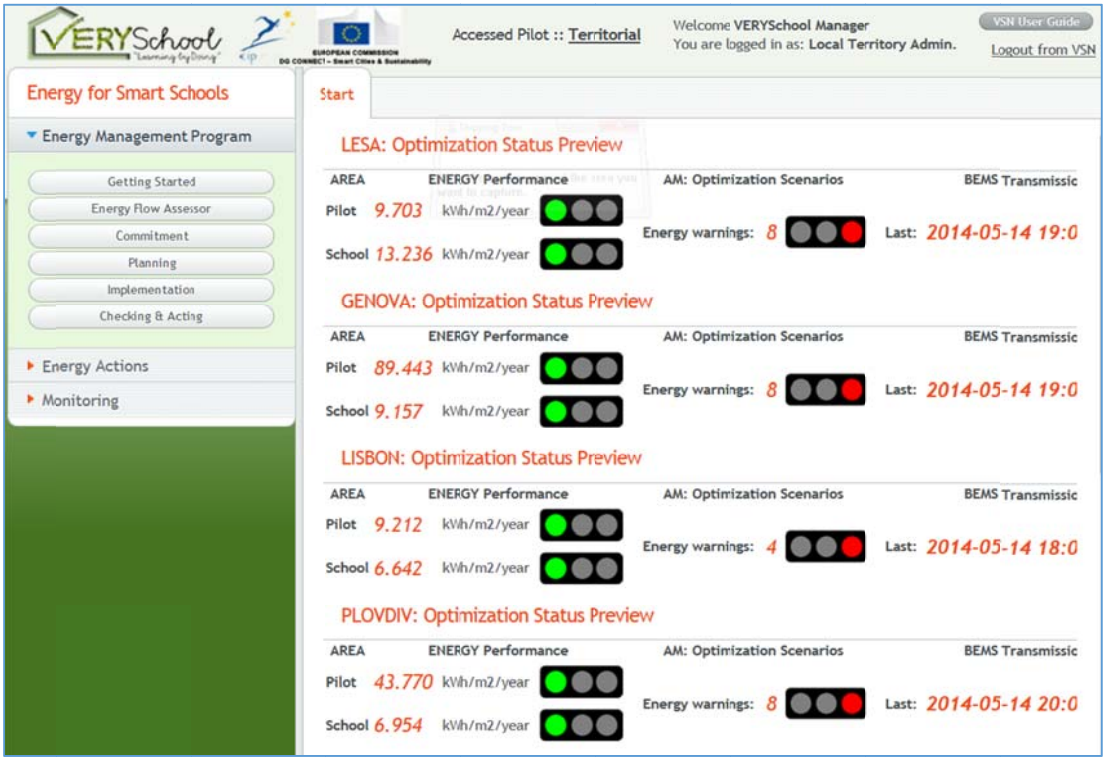

Figure 5. VSNavigator interface

With systematic energy management using VSNavigator (Fig. 5), the 4 pilot schools aim to plan the best ways to reduce energy consumption, reduce energy costs and reduce greenhouse gas emissions, as well as to reduce other related environmental impacts.

In order to fulfill the purpose intended with the implementation of the ISO 50001 standard on VSNavigator, pilot schools experience is described in the following simple steps:

1) *To define the different terms of energy, consumption of various types of existing energy, energy efficiency and energy performance*.
The Energy Review process is completed using the tool Energy Flow Assessor, on the Enerit software suite and part of VSNavigator.
The output of the Energy Flow Assessor is a Sankey diagram (Fig. 6) showing the relationship between energy sources and its use.
It is able to use energy data from BEMS, energy bills, results from energy audits or combination of the options available.

2) *Define and record the scope and limits of the energy management system in order to achieve continual improvement of its energy performance*.
To enable the achievement of energy usage reductions following the ISO 50001 standard, parameters will be defined about what the ISO 50001 EnMS covers and energy reduction targets and thresholds will be put in place. Energy reduction targets are set for each energy use (Fig. 7).

Different improvement opportunities are then identified which may be implemented to achieve these targets.

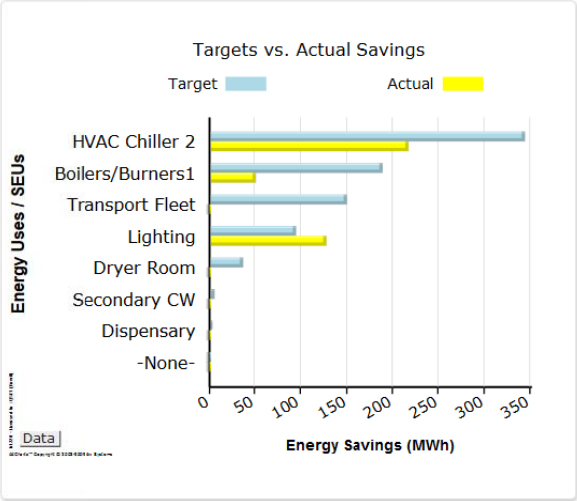

Figure 7. Example chart of energy use targets versus actual energy savings

In the Energy Uses area of the Energy Flow Assessor, that has previously been defined (Fig. 6), a "New Improvement Opportunity" can be created and associated with "OS action" in which measures, goals, savings and related payback are linked to the step to be implemented.
Both the expected and actual savings are recorded in the improvements opportunities.
The ability to meet and the realization of these targets can be tracked within the VSNavigator using this savings information.

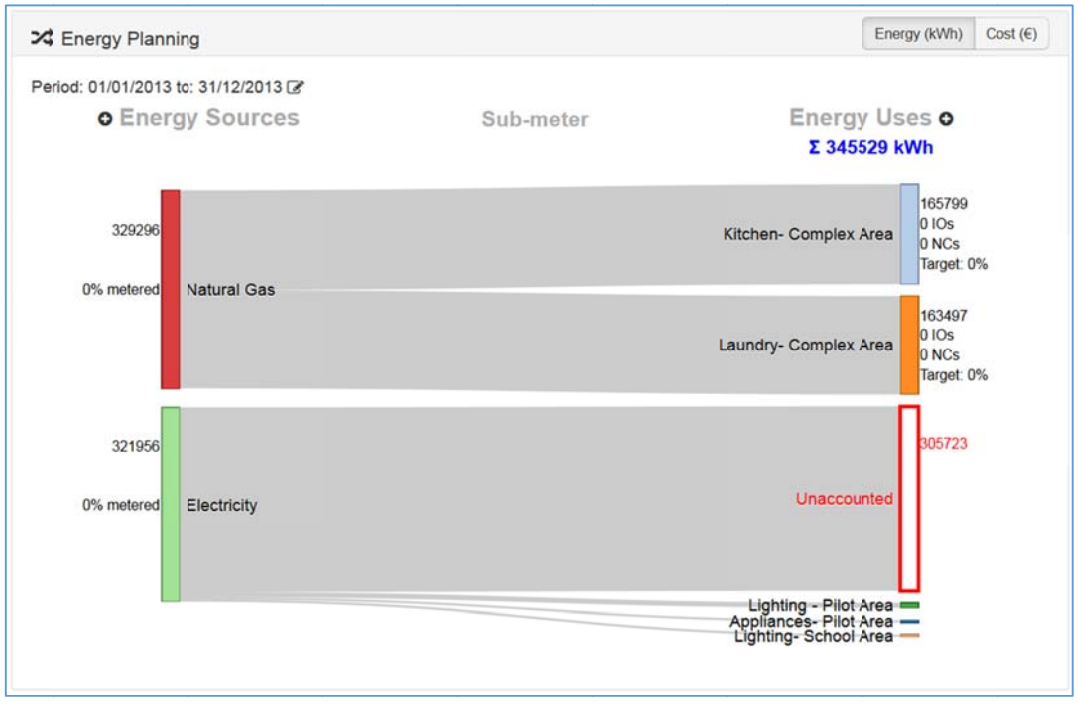

Figure 6. Energy Flow Assessor.

From the previous example, through the switch to more efficient lighting, a 10% energy saving was achieved keeping previous lighting level and energy quality (Fig. 8).

3) *Definition of management responsibility and energy policy including approval, implementation, monitoring, maintenance and improvement of the energy management system.*
After initial implementation and suggestion of EnMS, plans and commitments for follow-up and success of energy management are defined. These plans are supported by the creation and implementation of an Energy Policy. The user can create and manage these plans and other EnMS related documents using the integrated Enerit software.

4) *Implementation and operation strategy to meet the need for competent staff in terms of qualification, training and appropriate experience, document control, internal and external communication as well as the development of processes and energy services strategy*.
To accomplish this implementation, the user can create an action plan in VSNavigator according to the criteria of ISO 50001.

5) *Checking and monitoring the EnMS process*, users define monitoring, measurement and analysis to ensure effective implementation of the energy management system, identification of non-conformities and implement corrective and preventive actions in order to ensure the correct and continual improvement of the EnMS operation.

6 CONCLUSIONS

VSNavigator provides a multi-stakeholders approach to implement an effective EnMS centred on the ISO 50001 standard in schools.
The stakeholders in the value chain are:

- *Public Administrators*, who can overview cost savings, reward efforts to best energy schools, broadcast best practices and energy management to under performing schools.
- *Operational*, *Energy* and *Facility Managers*, take energy decisions to improve the energy management process to be more effective on the current operational energy scenario.
- *Technicians* who have the day-by-day responsibility to maintain and operate the buildings.

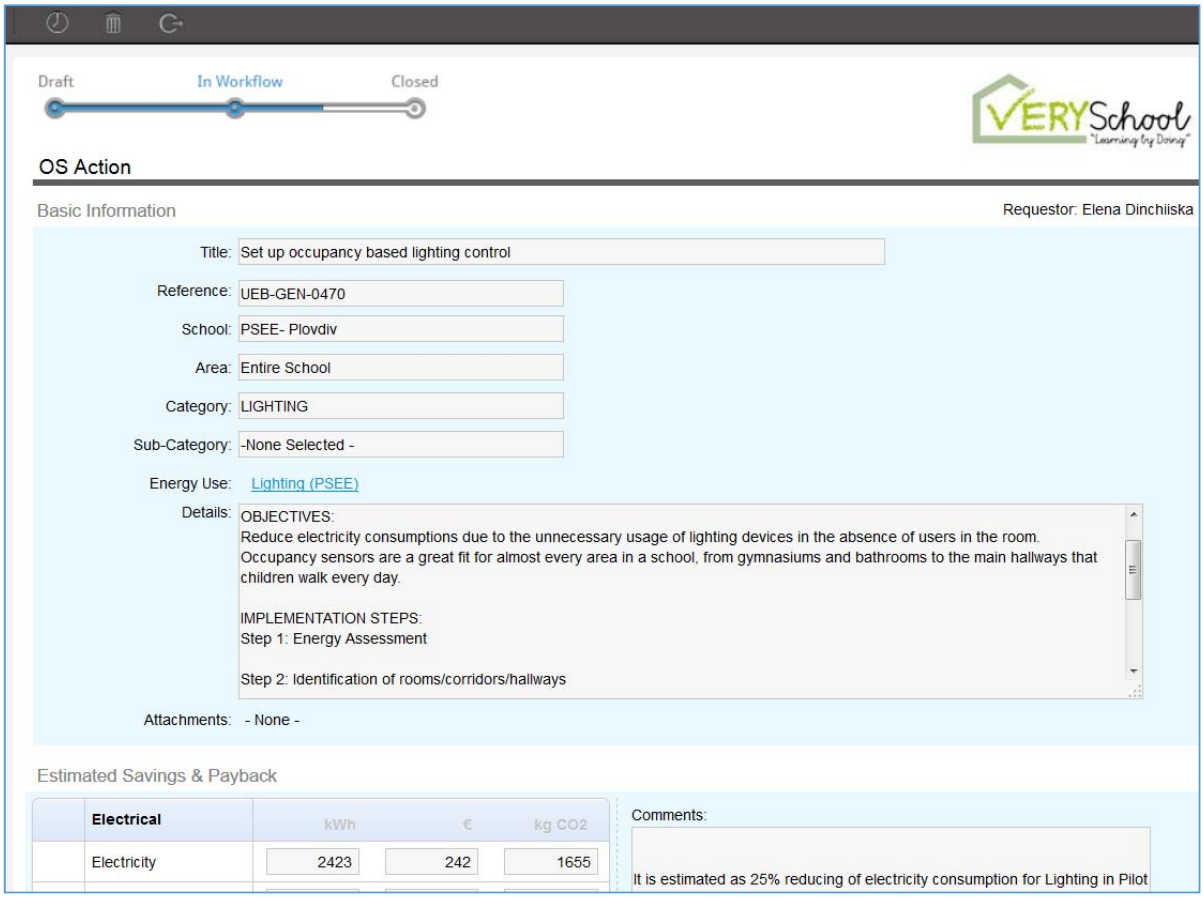

Figure 8. Lighting energy saving OS action

- *ESCO* and *Financial Institutions*, who can promote concepts of green economy where energy saving pays for investments.
- *ICT* and *Scientific Professionals* who present best practices and new technologies, while producing awareness on efficient scenarios and habits.
- *Practitioners* who can learn about best practices on energy efficiency.

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