CE51 TOGETHER D.T2.1.2

COMMON PROTOCOL

Common Protocol containing technical guidelines for savings measurement and verification

Version 2

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Finalized by the University of Maribor (PP3)

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Emended version in April 2017, with a clearer reference to the partners' countries(page 8)

A partner change procedure was started during the month of December 2016: Municipality of Paks (Hungary) has taken over the project, replacing the South Transdanubian Regional Development Agency. As this document was delivered before the partner withdrawal, the document makes reference to the original partnership composition.

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1. Introduction

One of the activities within the project is to prepare **a common protocol for savings measurement and verification**, which was discussed among partners and finalized by the University of Maribor.

In order to prepare a common protocol for saving and measurement verification, we have tried to firstly define a "protocol". Based on the Oxford Online Dictionary (2016), a protocol is defined as an official procedure or system of rules, which would in our case mean – an official procedure (or system of rules) for saving and measurement verification. Each procedure or system of rules has at least three requirements (premises), which are: a quality assurance, a process (set of interrelated or interacting activities that use inputs to deliver an intended result and includes establishing the processes to operate as an integrated and complete system) and a system approach (where a system consist of interconnected simple elements (rules). To fulfill these three requirements in our common protocol, three existing issues were considered as a framework:

a) A Deming cycle (integrated into ISO 9001)
b) International Performance Measurement and Verification Protocol
c) ISO 50001

which are below explained in more details to strengthening the understanding of the development of a common protocol.

1.1 A Deming Cycle

The PDSA Cycle is a systematic series of steps for gaining valuable learning and knowledge for the continual improvement of a product or process. Also known as the Deming Wheel, or Deming Cycle, the concept and application. The cycle begins with the Plan step. This involves identifying a goal or purpose, formulating a theory, defining success metrics and putting a plan into action. These activities are followed by the Do step, in which the components of the plan are implemented, such as making a product. Next comes the Act step, where outcomes are monitored to test the validity of the plan for signs of progress and success, or problems and areas for improvement. The Check step closes the cycle, integrating the learning generated by the entire process, which can be used to adjust the goal, change methods or even reformulate a theory altogether. These four steps are repeated over and over as part of a never-ending cycle of continual improvement (The Deming Institute, 2016). Furthermore, ISO 9001:2015 is also based on the Deming cycle and considers a process approach (ISO 9001, 2015).

1.2 International Performance Measurement and Verification Protocol[1,2]

Investment in energy efficiency offers the largest and most cost-effective opportunity for public sector organisations to limit the financial, health and environmental costs of burning fossil fuels. When organizations (also public) invest in energy efficiency (from both technological and social perspectives), the executives of the organizations would like to know how much they have saved. If we consider the energy generation, the measurement is usually trivial – installing a meter on the generation equipment, but when it comes to the saving, its determination presents a challenge, and requires accurate measurements and repeatable methodology, which will be defined, tested and implemented within our common protocol and will provide quantitative and qualitative results, proving the successfulness of the project.

Measurement and verification (M&V) methods are used to measure and verify, in a defined, disciplined, rigorous and transparent way, the energy savings resulting from implementation of Energy Conservation Measures (ECMs), which have been planned and designed to improve the energy performance of a specific facility or group of specific facilities. This is done without regard to the energy performance of any facility other than the one at which a change in energy infrastructure is implemented. M&V is an active and on-going process. In a generic sense, M&V is what good facility staff should do continuously: measure energy performance, make changes to their energy infrastructure and/or operations and maintenance, and verify that the changes work as planned and continue to work over time. M&V requires additional discipline and transparency in measuring and verifying savings than normally is provided for facility/energy management.

The United States Department of Energy and a coalition of international organizations developed the International Performance Measurement and Verification Protocol (IPMVP®), defining standard terms and suggests best practise for quantifying the results of energy efficiency investments and increase investment in energy and water efficiency, demand management and renewable energy projects.

1.3 ISO 50001[3] - Energy Management Systems

ISO 50001:2011 specifies requirements for establishing, implementing, maintaining and improving an energy management system to enable an organization to follow a systematic approach in achieving continual improvement of energy performance, including energy efficiency, energy use and consumption. It specifies requirements applicable to energy use and consumption, including measurement, documentation and reporting, design and procurement

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1 Adopted from: International Performance Measurement and Verification Porotocol – Concepts and Options for Determining Energy and Water Savings. Vol. 1. Avaliable online: http://www.nrel.gov/docs/fy02osti/31505.pdf (retrieved 28 Oct 2016).

2 Adopted from: A Best Practice Guide to Measurement and Verification of Energy Savings. A companion document to 'A Best Practice Guide to Energy Performance Contracts', 2004. The Australasian Energy Performance Contracting Association for the Innovation Access Program of AusIndustry in the Australian Department of Industry Tourism and Resources.

3 Adopted from ISO. Available online: http://www.iso.org/iso/catalogue_detail?csnumber=51297 (retreived 10 Novemeber 2016)

practices for equipment, systems, processes and personnel that contribute to energy performance. ISO 50001 applies to all variables affecting energy performance that can be monitored and influenced by the organization and does not prescribe specific performance criteria with respect to energy. The standard has been designed in a way to be used independently, but it can be aligned or integrated with other management systems. ISO 50001 is applicable to any organization wishing to ensure that it conforms to its stated energy policy and wishing to demonstrate this to others, such conformity being confirmed either by means of self-evaluation and self-declaration of conformity, or by certification of the energy management system by an external organization.

2 Methods

In order to prepare a common protocol that will be used by the partners, the following methods have been used:

- A desk research: we have prepared an in-depth literature review regarding the protocol and in order to determine the framework on which it will be based
- A questionnaire: a questionnaire regarding the M&V issues have been prepared and fellfield by the partners in order to define a country specific information
- Communication with partners: University of Maribor (PP3- Slovenia) as a lead for the deliverable was during the preparation of the deliverable frequently communicating with all the partners, who were giving comments and improvements of the common protocol, considering country's specific situation (e.g. Slovakian municipalities do not have developed Sustainable energy action plans)
- A literature review of possible methodologies, algorithms for evaluating M&V results.

3 Countries' specific information[4]

Investments in energy efficiency (technological and social) offers important solutions and giving an opportunity for facilities/organizations to limit their environmental impacts, financial costs and improve health conditions for individuals working and/or living in these facilities. Thus, we would like to examine national standards, protocols, methodologies to gather the data about national savings and measurement verification practices, which will further form a common protocol. To obtain countries' specific information regarding energy savings and their practices, a questionnaire has been developed. Partners provided answers to the following questions:

- Please list and provide a description of standards, protocols, methodologies for Energy Audits as defined at your National level (Short description of main elements).
- According to which standards, protocols, and methodologies will you perform Energy Audits? Please describe the whole process of the Energy Audit.
  Please let us know if the protocol is identical to the above mentioned one (National level).
- Are there any obstacles for performing Energy Audits? (The need for licensing of the person who is performing these Energy Audits, additional protocol for Energy Audits regarding to the state of Public Buildings etc.)

4 The countries' specific information has been obtained from the questionnaires. Please see annexes.

- Please, list any kind of standards, protocols, methodologies you are using for the energy management, especially energy savings (e.g. ISO 50001, also internal methodologies).
- Does in your country exist any national, regional, local protocol, methodology for energy savings, such as incentives for energy efficient (equipment, buildings, devices, …), other national schemes, … Please list all the existing national laws, acts (and provide links) that are linked to the energy efficiency, energy savings in (public) buildings, facilities. Please briefly describe each of the mentioned laws, acts.
- Describe best practices in the implementation process of energy efficiency, technological and non-technological (behaviors, knowledge, awareness, market …) obstacles and barriers. List ESCO companies related to the relevant experience in your country and other related important EU, national projects (max. 1000 characters).
- If you are using any kind of specific energy savings methods, please describe the process and methods of energy savings at your institutions/buildings (e.g. objectives and constrains, planning, selected calculating method, energy bookkeeping, etc.).

Table 1: A summary of national/international methodologies and standards/laws followed by partners' countries.

Italy
LP/Province of Treviso

Czech Republic
PP2/EAV
Energy Agency Vysočiny

Slovenia
PP3/University of Maribor

Croatia
PP4/City of Zagreb

Poland
PP5/PNEC - Association of Municipalities Polish Network

Hungary
PP6/STRDA – South Transdanubian Regional Development Agency
PP7/Municipality of the 12th District of Budapest Hegyvidék

Slovakia
PP8/ Slovak Innovation and Energy Agency

PP	Methodologies	Standards / Laws
LP Treviso Italy	ENEA - Definition of a methodology for Energy audits in residential and office buildings	UNI/TS 11300 (Parts 1 - 2 - 3 - 4 - 5 - 6); UNI 10349 (Parts 1-2-3)
PP2 EAV Czeck Republic		Energy Management Act n. 406/2000 Coll.
PP3 UM Slovenia	Rules on the methodology for the production and content of energy audits (Official Gazette of the Republic of Slovenia Act Nr. 41/2016)	SIST ISO 50002; SIST EN 16247 (Parts 1-2-3-4-5) - Energy Audit
PP4 City of Zagreb Croatia	Energy Efficient Law and Regulation for the Energy Audits and Energy Certification of the Buildings	Article 47 of the Law on Construction (NN 153/2013)
PP5 PNEC Poland	Regulation of 27 February 2015 on the methodology for determining the energy performance of a building or part of a building and on energy performance certificates.	Energy Efficiency Act, Act on energy performance of buildings
PP6 STRDA Hungary		7/2006 (V.24.) TNM statute; 40/2012. (VIII. 13.) BM statute; 176/2008. (VI. 30.) statute

PP7 HEGYVIDEK Hungary		EN 15459 - Economic evaluation procedure for energy systems in buildings MSZ EN ISO 15900 - Energy efficiency services, definitions and requirements EN 16231-2012 Energy efficiency benchmarking methodology EN 16212:2012 Energy Efficiency and Savings Calculation MSZ EN 16247/1 (2, 3, 4, 5) - Energy Audit
PP8 SIEA Slovakia	Directive of Ministry of Economy 179/2015	EN ISO 50001, EN ISO 14001, STN 73 0550, STN EN 16247, STN 73 0540, STN EN 12831

Table 1 represents a summary of international and national laws, and directives, which are existing in the partners' country. Each country has its own national laws/directives regarding the energy audits. The most commonly used are International Standardization Organization (ISO) standards and European Standard (EN).

Table 2 identifies the national methodologies and national laws identifying these methodology, including the processes of energy audits in partners' countries. It can be summarized that the partners will follow national laws, and that the auditing procedure consist in general from the following topics: identification of facility, current state of the facility, including consumption data, a review (identification of technologies and devices, analyses of energy flows, energy savings potentials, and measures of improvements. However, also some differences between the countries have been percieved, such as familirization of building owners with auditing process, optimizing management procedures (energy supply contract), consumption „soft“ measures, exeptions of paying a fee for the certification, financial structures (cost-benefit analysis), including cost improvement and a comparison, a detailed action plan, etc.

Table 2: Methodologies for performing energy audits.

PP	Methodologies for performing energy audits	The process of energy audit
LP Treviso Italy	full “form” and referring to the UNI standards	• visits and technical investigations (e.g. Cladding components, use of the building, etc.) • Retrieval and selection of the input data (e.g. projects, bills, performance, etc.) • Application of the correct calculation method with reference to the standards UNI 11300 and related standards (see standards written below) • Retrieval of the energy performance indexes (e.g. Energy Performance Indicators) and energy classification of the building • Identification of the interventions for improving energy efficiency
PP2 EAV Czeck Republic	Law 406/2000 Coll.,	Process of energy audit: • Local investigation and completion of document • Evaluation of the current state of

		the building (Heat technical evaluation of the building and technical systems in the building) • Proposed measures consultation with building owner (Definition of issues of the building and proposing of measures which eliminate this issues). • Selection of 2 appropriate measures; Recommendation – A selection of economically and energy efficient measure which should be implemented in the building. • Submission of audit, familiarization of building owner with the results
PP3 UM Slovenia	Official Gazette of the Republic of Slovenia Act Nr. 41/2016, based on European Directive efficiency 2012/27/EU, SIST ISO 50002 or SIST EN 164247	Main elements of the energy audits for the buildings are: • A summary • Purpose and a goal of the energy audit • Introduction (description of the building and main activities carried out in the building, its usage, basic construction and technical data, energy usage, a level of thermal comfort) • Scheme of the building management (financial costs flows, control over the energy consumption and costs, motivation for energy efficiency, the level of promotion of EE and RES) • Supply and use of energy (electricity, thermal energy, water, …) • A review of devices for energy conversion (heating system, system for hot water, ..) • A review of end consumption of the building (building envelope, electricity users, lightning, ventilation and air conditioning) • Energy supply (revision of contracts with the energy suppliers, electricity, drinking water, heating) • Analyses of energy flows in the building • An assessment of energy savings potential • Organizational measures • An assessment of a possibility to carry out investments
PP4 ZAGREB Croatia	Article 47 of the Law on Construction (NN 153/2013) and Regulation about Energy Audits and Energy	• Preparatory work • The process of conducting the energy audits (analysis relating to:

		Certification	building energy management, thermal properties of the outer shell, the heating system, cooling system, ventilation and air conditioning, system etc.) • An energy audit of the building in addition to actions and procedures referred to in paragraph 1 and the analysis referred to in paragraph 2 of this Article may contain other actions, procedures and analysis, depending on the type, characteristics and intended use of the building and the activities being carried out there. • The building energy audit is conducted in accordance with the Methodology and rules of the profession. • The methodology referred to in the paragraph 4 of this Article shall be made by the Minister's decision and published on the official Internet site of the Ministry.
PP5 Poland	PNEC	• Energy Efficiency Act from the 15th of April 2011 • Act on energy performance of buildings from the 29th of August 2014	The process will consist from the following steps: • selection of the auditor, • collection of relevant data and documents, including on-site visit (if possible, accompanied by the representative of PNEC) ✓ assessment of the current energy characteristics of the building (including annual demand for usable, final and non-renewable primary energy, calculated consumption of different energy carriers, estimated CO_2 emission per m2 per year and share of RES in annual demand for final energy), • assessment of the current technical and operational characteristics of the building, • providing recommendations concerning economically viable and technically feasible measures aiming at improving buildings energy characteristics, • development of the audit report and the energy performance certificate, • submission of the audit report and the energy performance certificate, • familiarization of the building

		owner and manager with the results of the audit.
PP6 STRDA and PP7 HEGYVIDEK (Hungary)	7/2006 (V.24.) TNM statute; 40/2012. (VIII. 13.) BM statute; 176/2008. (VI. 30.) statute; 105/2012 (V.30.) statute National law 2015./LVII.	The energy audit will be carried out, based on the national requirements and methodology • Overview of energy sources used by the institutions under examination (e.g. electric, gas, water, etc.) • Overview of equipment and systems used for heating, cooling, collecting and distributing energy. Overview of types of power consumption equipment in use. Identifying if there any smart metering or smart system that can be used for measuring the energy consumption. • Summarizing the amount of energy and the cost spent for every energy sources last year • Analyzing the efficiency of the systems and equipment currently used. • Analyzing the distribution of energy consumption by time, by area, by use • Calculating the annual theoretical consumption of each energy sources • Comparing and analyzing the theoretical and actual consumption • Estimating the energy waste yearly by improper use, by old equipment, etc. • Analyzing the typical consumer behaviors leading to waste of energy • Identifying the room for improvement o Defining technical improvements o Defining actions has to be taken for behavioral improvements o Evaluating possible real cost savings based on the above defined improvements • Working out the detailed action (project) plan • Working out KPIs (the key measures) and setting KPI targets in order to keep tracking the progress of the project • Identifying physical parameters to measure, and additional equipment that has to be installed in order to measure

		• Calculating the cost of improvement and comparing to the prognosis of savings
PP8 SIEA Slovakia	Law no. 321/2014	Procedure: • To identify the subject of energy audit • To detect and evaluate the current status of the subject of energy audit, • To prepare a draft of measures to reduce energy consumption • To develops an economic assessment of the measures and environmental assessment of the measures • To develop a set of recommended actions, • To prepare a written report of energy audit • To develop a comprehensive information sheet • To draw up a set of data for the monitoring system.

Partners also identified some obstacles, regarding energy audits, such as:

- difficulties to obtain the data e.g. on thermodynamic features,
- a complexity of the system (e.g. technological components),
- a typology of the calculation method adopted,
- individuals to perform energy audits must be authorized by national authorities

Table 3 represents the info about applied energy management systems in partners' countries. Mostly, international methodologies and protocols are used for the energy management, such as EMAS, ISO 50001, energy performance contract, SEAPs, energy consumption monitoring systems. Some partners also practice smart metering (e.g. Slovenia or Poland), while by others the energy management system is still underdeveloped (e.g. Slovakia).

Table 3: Standards, protocols, methodologies of energy management.

PP	Standards, protocols, methodologies of energy management
LP Treviso	✓ Municipality Carbonera – EMAS Certification ✓ Province of Treviso – Energy manager ✓ Province of Treviso – Energy Performance Contract
PP2 EAV	✓ Standard ISO 50001

PP3 UM	✓ UM has a contract with an external company Petrol d.d. for the energy management (e.g. Energy Performance Contract), energy management audits are performed based on the national methodology ✓ Smart metering
PP4 ZAGREB	✓ Croatian Law, the algorithm for the calculation of the Energy Audit of the buildings is based on the standard HRN EN ISO 13790
PP5 PNEC	✓ SEAPs ✓ Energy consumption monitoring systems (on a monthly basis) ✓ Energy manager ✓ More complex energy management systems (ISO 50001, SEAPs, smart metering, etc.)
PP6 STRDA AND PP7 HEGDYVIDEK	✓ Several national laws/directives/Parliament decisions exists regarding the energy management ✓ At the public buildings no special energy management system is applied
PP8 SIEA	✓ no standards on national level dealing with energy management (the energy management in public buildings in Slovakia is undeveloped, relying mainly on bill checking, bookkeeping or adjusting operation time) ✓ ISO 50001 and as a guideline for evaluation of savings serves IPMVP protocol

Table 4 introduces various national incentives, schemes in the partners' countries. From the table it can be observed that all the countries have introduced numerous incentives related to the energy efficiency, RES and energy savings in the building sector. Further it can be observed that numerous national scheme exists, such as national eco fund, national environmental protection fund, supporting energy efficiency and savings.

Table 4: National, regional, local protocols, methodologies for energy savings (e.g. incentives, other national schemes.

PP	Incentives	Other national schemes	Other
LP Treviso	✓	✓ (e.g. energy certification, energy diagnosis & monitoring, energy performance contract, green procurement)	✓ (e.g. ISO 50001)
PP2 EAV	✓	✓ (e.g. Operational Programme Environment, Operational Programme Business and Innovation for competitiveness, new green savings for renovation)	
PP3 UM	✓	✓ (e.g. Guidelines for the implementation of measures to improve the energy efficiency of buildings in the public sector according, Several energy distribution companies have open calls for financial incentives in energy efficiency)	
PP4 ZAGREB	✓ (incentives policies)	✓ (e.g. National Environmental Protection Fund, system for	

		monitoring, measurement and verification of energy savings SMiV)	
PP5 PNEC	✓ (e.g. “discount schemes”)	✓ (e.g. thermo-modernization of buildings, thermo-modernization and renovation)	✓ Local authorities playing a role models in energy management
PP6 STRDA AND PP7 HEGDYVIDEK	✓ (e.g. Territorial and Settlement Operational Programme)	✓ (e.g. Energy efficiency subsidies for residential EE purposes)	
PP8 SIEA	✓ (e.g. utilization of RES)	✓ (e.g. promotion of electricity from RES, energy efficiency of buildings, etc.)	

Table 5 shows best practices in partners' countries, which mostly focuses on technological improvements regarding energy savings and energy efficiency. Also, energy performance contracting is gaining its popularity. In all the partners' countries ESCO companies exist.

Table 5: Best practices and ESCO Companies

PP	Best practices	ESCO Companies
LP Treviso	A research by The Italian Federation for energy efficiency for the Enel Foundation in 2014 resumes 14 Italian experiences in energy efficiency in the building sector.	• In Italy there are more than 250 ESCO companies
PP2 EAV	One of the most efficient measure is thermal insulation of the building, but appropriate renovation of technological systems of the building customized to the new condition is not proceed. This is big problem of the energy efficient renovation of the buildings.	• The biggest ESCO companies in Czech Republic are: ENESA, MVE technika, Siemens, E-ON, ČEZ
PP3 UM	Best practices focus on technological improvements (e.g. connection to the district heating, energy efficient lighting, energy efficient envelop of the buildings, new heating boilers). Non-technological improvements are focusing on the following: appointing an energy manager for the buildings; education of individuals working in the buildings (e.g. switching off the lights, computers, and other activities to consume less energy); introduction to the ISO50001 or other energy	• ELTECH Petrol, Petrol d.d., GGE, ENERGEN, Javna razsvetljava, Gorenjske elektrarne, Istraben plini

	management procedure; implementing smart control system.	
PP4 ZAGREB	Zagreb Energy Efficient City, where City of Zagreb is renovating 89 buildings, not only replacing the carpentry and improving the envelope, but appropriate renovation of technological systems of the building customized to the new condition	
PP5 PNEC	Best practices include: • thermal retrofitting of the envelope • replacement of the heating source - either with more efficient fossil-based sources or with renewable sources • connecting the buildings to the district heating network • modernisation of internal lighting • modernisation of other internal installations • building new buildings in passive house standards	There are only few first examples of using it for EE projects - mostly related to energy modernisation of public buildings and modernisation of street lighting. But the municipalities are showing growing interested in this financing opportunity. There are several ESCO companies operating in Poland, including big players like Siemens or Philips.
PP6 STRDA AND PP7 HEGDYVIDEK	Best practices: • installing RES technologies - mainly PV, biomass or for larger investments geothermal – to reduce their energy consumption and related costs. • raising awareness on energy efficiency by elaborating projects for trainings held at schools for teachers on EE • energy management training for municipal employees, which included environmental aspects, financial possibilities and detailed explanation of the RES technologies and calculations to ease the decision making on the best fitting RES technology or EE action • Save@Work H2020 program) is an energy saving competition between 180 public office buildings over 10 participating European regions	• Energy-Hungary Zrt. Miskolc; Ener-G Energia technológia Zrt. Budapest; COTHEC Energia üzemeltető Kft. Győr; SAVEsco Energiagazdálkodási Tanácsadó és Szolgáltató Kft. Budapest.
PP8 SIEA	• Energy Performance Contracting	• AB Facility s.r.o. www.abfacility.com • Amper Savings a.s. www.ampersavings.cz • COFELY a.s. www.cofely.sk • e-Dome s.r.o. www.edome.sk • ENESA a.s. www.enesa.cz • Energocom s.r.o.

	www.energocom.sk • KOOR s.r.o. www.koor.sk • SE Predaj s.r.o. www.sepredaj.sk • Siemens s.r.o. www.siemens.sk

Some partners are also using other kinds of energy savings methods, such as:

- Energy Performance Contract that not only introduced technological devices for energy saving, but also promoted the change in people's behaviour;
- Network of Living Labs;
- 50/50 method, which is based on distribution of economic savings based on building users' behavior change. 50% of savings for building owner and 50% of savings for building operator;
- supporting integration of local energy strategies with energy management systems following ISO 50001 or other established standard
- smart meters at public buildings

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ISO 9001:2015. Quality Management Systems - Requirements (2015). International Organization for Standardization. Geneva, Switzerland.

4 A Common Protocol

As mentioned before a common protocol is based on Deming cycle (a reference to ISO standards), and IPMVP protocol.

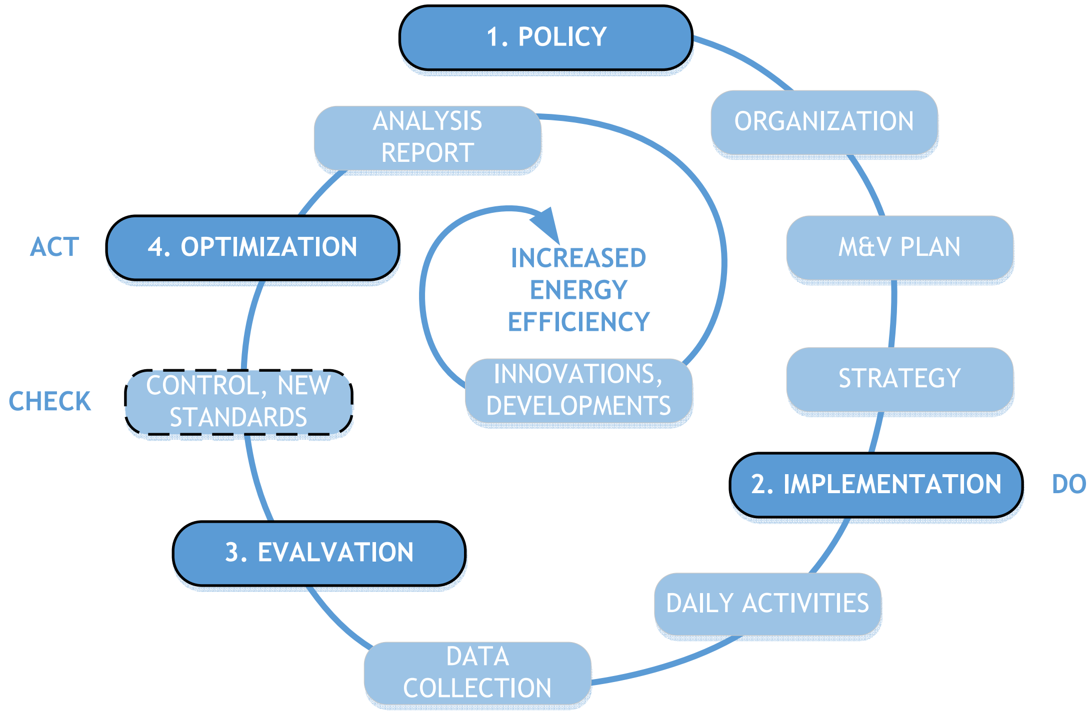

Fig. 1: The methodology for the Protocol and its execution.

The protocol is schematically showed on Fig. 1, representing its methodology, consisting of 4 steps:

1. Measurement and verification plan
2. Implement the plan and execute the process
3. Evaluations
4. Optimization

which are in more details described below.

4.1 Measurement and verification plan

This is an important activity for energy savings; it is essential to ensure the transparency of the process and the quality and credibility of achieved outcomes.

- ✓ Description of the outcomes/intended savings – a realistic prediction of potential savings linked to the technological/social interventions
- ✓ Identification of facility and "measurement boundary" (see Fig. 2) – an example: a campus facility – the facility boundary is the specific building, and the measurement boundary would be the same as the facility boundary. Sub-systems could be defined as: energy for electricity (lighting, other), energy for heating, … The measurement data will be: the billing data and/or data from utility meters (?), weather data, …

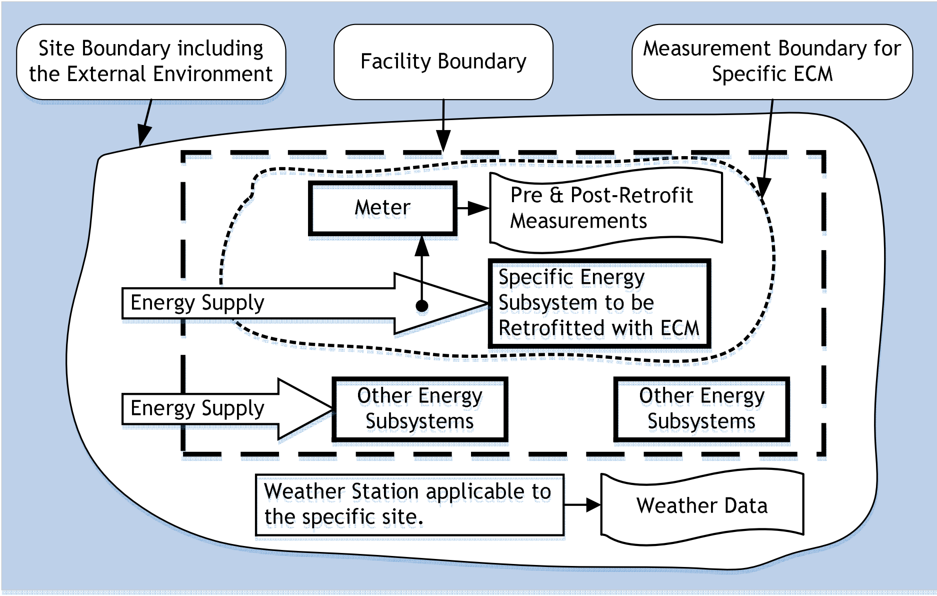

Fig.2: System's boundary (source: IPMVP, and ISO 14040, 14043 – LCA system's boundary).

- ✓ Determination of the facility baseline year[5,] (suggested to use the baseline year from SEAPs, due the fact that the municipalities are CoM members), documentation of the conditions and energy data, for example: baseline documentation would require documented audits, surveys, inspections, metering activities. This info should include: energy consumption and demand profiles of the facility; occupancy type, periods, time; space conditions for each period, season, equipment inventory (data, location, condition), equipment operating practices (schedules, actual temperatures/pressures, set-points, …), any significant equipment problems or outages, existing patters (linked to the users' profiles and management of the facility), etc. However, not all the partners have produced SEAPs (e.g. Slovakia). Thus, partners decided to use the same baseline year(s) to enable benchmarking between the countries and buildings. These years will be 2014, 2015, and 2016, since most of the improvements is to be done in 2017.
- ✓ Identification of planned changes (if any) – technological and behavioral/social
- ✓ Identification of post-retrofit period e.g. ensuring regular switching off of lighting, appliances and equipment, when not in use; introduction of ISO 50001; smart control system, …
- ✓ Set of conditions to which energy measurements will be adjusted (if needed), referring to the conditions from the pre-retrofit period.
- ✓ Specification of measurement and verification will be based on the following option:
    - o **Option C**: the whole facility/building – energy use is measured by utility meters for at least 12 months (billing data, regression analysis, using historical data [6]to develop a model of the energy performance of the building[7].

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5 Partners discussed to choose a suitable seasonal adjustment algorithm (simple linear adjustment might be the easiest option). However, we have found some models which could be used in our cases e.g. ARIMA models (Autoregressive Integrated Moving Average models. It is a forecasting technique that projects the future values of a series based entirely on its own inertia. Its main application is in the area of short term forecasting requiring at least 40 historical data points. Seasonality is a time series pattern in which data undergo regular and fairly predictable changes that recur every calendar year (periodic fluctuations, e.g. the Christmas.

6 Regarding historical energy consumption data, some municipalities are gathering them on a regular basis for all their buildings (but usually only few years back), while the others don't. Thus, we will have to use the energy invoices, which may be a time consuming process (so e.g. for 2016 we may have complete data around April). Some other possible obstacles that we might face regarding data collection from invoices are following: (1) in different regions there are different energy utilities and thus different types of invoices used. In some cases the invoices are issued for 2-month period, which means that we will have 2-month consumption instead of 1-month consumption; (2) in some cases the invoices (and thus the readings) do not exactly cover the

Other possible options are explained below, however, we suggest to consider option C for our cases.

- ✓ specification of data analysis
- ✓ procedures, methods, assumption details, including details of metering, missing data, uncertainties, etc.
- ✓ documentation and data sources, including their availability
- ✓ financial and other requirements

4.2 Implement the plan and execute the process

- ✓ Selecting the appropriate measurements and calculation method (should be suitable for all and ensuring a common indicators, so benchmark could be carried out)
- ✓ Implementing the plan, collecting the data, carry out measurements, calculating the base year data and energy savings, etc.
- ✓ Design, install, test any special equipment

4.3 Evaluations

- ✓ Study the actual results
- ✓ Carry out preventive/corrective activities to address the foreseen energy savings
- ✓ Calculating and reporting the savings

4.4 Optimization

- ✓ Propose/develop/design a new standard, procedure, methodology on how organization should act going towards “more energy efficient”
- ✓ Innovations, developments

Different options foreseen by IPMVP:

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calendar months (but are issued e.g. for the period 21st of January – 20th of February); (3) in some cases the utilities are settling their accounts on the consumption prognosis and then they issue one “balancing invoice” per year or semester (but this is mostly the case with private households which are not in the scope of the project).

[7] Another consideration - **possible changes in the buildings’ operation within the project duration**. E.g. schools in Poland facing an education reform, which might result in significant changes in the amount of pupils using some of the schools buildings (the amount can be either increased or reduced depending on the decision of joining some schools, moving the pupils, etc.). So in such cases we need to think of some **other energy saving indicator, e.g. kWh/pupil**?

OPTION A – Partially measured retrofit isolation

- Used at the **individual retrofit**, involving specific system's component(s): lighting, motors, heating, cooling, …
- The factors that drive energy savings are changes in "performance" (efficiency, capacity, demand, power) and "operations" (lighting, operational hours, …) e.g. savings with more efficient lamps and/or using lighting controls.
- Comprising end-use technologies
- Savings are determined by measuring the capacity, efficiency before and after retrofit and by multiplying the difference by a stipulated factor.

<u>Examples of calculating savings, with stipulated operation factors:</u>

Energy savings = ((performance factor)$_{before\ retrofit}$ – (performance factor)$_{after\ retrofit}$) X Stipulated Operations Factor

E.g. Energy savings for lighting case

((kW/Fixture X No of Fixtures) $_{before\ retrofit}$ – (kW/Fixture X No Fixtures) $_{after\ retrofit}$) X Stipulated Number of Operating Hours

OPTION B – Retrofit Isolation

- Similar to option A, but no stipulated factors are allowed, and measurements are made periodically.
- Intended for retrofits to performance factors (e.g. end-use capacity, demand, power) and operational factors (e.g. lighting operational hours).
- It is appropriate for a short-term measurement, when variations in operations are not expected to change.
- It is used for the following cases: simple equipment replacement, when interactive effects are ignored, when independent explanatory variables that affect energy use are not complex.

<u>Examples of calculating savings, with stipulated operation factors:</u>

Energy savings = (performance X operations)$_{before\ retrofit}$ – (performance factor X operations)$_{after\ retrofit}$

E.g. Energy savings for lighting case

(kW/Fixture X No of Fixtures X operating hours) $_{before\ retrofit}$ – (kW/Fixture X No Fixtures X operating hours) $_{after\ retrofit}$

OPTION C – the whole facility

- Continuous measurement data from utility meters or whole building sub-meters and/or regression modelling to determine energy savings for the total facility.
- This option involves collecting historical whole facility energy use and the continuous measurement of whole-facility post-retrofit energy use.
- Energy savings are estimated by statistically representative models of whole-facility energy consumption or by performing simple utility bill comparisons.
- This Option should be used when expected savings are above 10 % of the base year energy use.
- The most common Option C model is derived from regression analysis by correlating energy use with independent explanatory variables: weather[8], occupancy, …

[8] It was suggested that the weather data should include temperature (monthly average for specific area, heating degree days, possibly also cooling days, if available). By "standardized" we mean recalculated by heating degree days in order to include influence of external temperatures on the heat/fuel consumption. The calculation methodology and relevant equations may be found here: http://www.euronet50-50max.eu/en/component/content/article/2-uncategorised/51-energy-savings-calculation-tool. For electricity we used simple comparison of consumption between year A and year B but we may also include weather conditions in this case (e.g. weather impact on lighting requirements).

- In facilities where is a significant difference regarding the energy use in various periods (school year, holidays), separate regression models may be developed.

OPTION D – Calibrated stimulation

- Uses computer simulation software to predict energy use for the base year and/or post-retrofit period.
- The simulation model must be calibrated so that predicts an energy use pattern that matches actual facility consumption data.
- Option D is most useful when base year data do not exist or are unavailable - situation by a new facility or where there are no facility meters to provide base year data, but will be available in a post-retrofit period.
- Option D should be used instead of C, when expected savings are not large enough to be separated from variations in the facility‘s utility meter data.
- Option D is not used often for M&V of energy retrofits, as it requires the services of a trained energy simulation specialist.
- Option D may be used by energy engineers during investigation of the savings potential and during the design phase on an energy savings project.

4.5 Partners' comments on the options to be chosen

At the meeting held in Zagreb (25.-26. October 2016), a protocol and different options foreseen by the IPVMP were represented to the partners. Most of the partners' comments focused on the following issues:

- Which kind of data are to be used in the baseline years (whether the data will be analysed on monthly basis or annual, since come partners (e.g. Slovakia has a monthly flat rate for the electricity bills for public institution).
- Which option foreseen in the IPMVP is the best one for all the partners? Partners agreed that the best option would be option C, however, some partner decided to use also option A, because they foresee some difficulties in obtaining the data and information for the whole facility.

5 Conclusions

The protocol in a draft version has been represented to the partners at the meeting in Zagreb. During and after the meeting partners provided additional comments and suggestions to the protocol, which were later included in this version. Furthermore, this document includes also an elaboration of results of the questionnaires of the partners regarding energy savings and measurements, forming a framework for further project's activities.