How to communicate IAM in water losses and energy management – the experience of a collaborative project

R. Ribeiro*, H. Alegre*, D. Loureiro* and A. Mamade*

* LNEC – Laboratório Nacional de Engenharia Civil, Portugal. Avenida do Brasil, 101, 1700-066 Lisbon, Portugal (E-mail: *rribeiro@lnec.pt*; halegre@lnec.pt; dloureiro@lnec.pt; aisha@lnec.pt *)*

Abstract
Water utilities have to deal with different challenges including ageing infrastructures, climate change and increased societal expectations. The ISO 50 000 and 55 000 standards are effective tools for implementing procedures by which organizations can work strategically on energy and infrastructure asset management systems, respectively. The implementation success of these management systems is determined by the reliability and availability of information and the capacity of water utilities to progress in the direction of sharing knowledge and skills, breaking down information silos and boundaries resulting from functional specialism. Collaboration is essential to achieve improvements in the long term. This paper aims to outline potential synergies between collaborative knowledge production and the implementation of structured approaches to increase water services sustainability. In the iPerdas2014 project, 17 Portuguese water utilities developed their own water losses and energy management plan following a joint training and capacitation approach. Results indicate that the use of a collective problem framing and a defined framework for decision making allows working strategically with water losses and energy efficiency issues, with a clear integration in the infrastructure asset management system. Straightforward communication since day one is critical to achieve top management support and staff involvement, establishing conditions for continuous improvement.

Keywords
Communication barrier; energy efficiency; infrastructure asset management; water losses management; water supply systems

1. INTRODUCTION

It is a challenging task to develop feasible and implementable strategies to address water issues, mainly those related with climate change, concerning water demand and supply. Decision-makers are confronted with problems that are interrelated and demand competing solutions, which require a structured decision making process. Opening up processes of knowledge production to various stakeholders (researchers, practitioners, policy-makers and other actors) enables them to contribute with their knowledge to the complex water issues and proposed solutions (OECD, 2015).

There is a considerable potential for improving efficiency in water and energy use in urban water supply systems. Despite important advances in the provided service levels, the values of non-revenue water (unbilled authorized consumption and water losses) are still unacceptable in many utilities worldwide. For instance, in Portugal, non-revenue water averages 35% of the total water produced, whereas 24% corresponds to real losses and 11% corresponds to apparent losses and unbilled authorized consumption (ERSAR, 2013). On the energy side, drinking water and wastewater services are large energy consumers; energy is often the greatest component (30–40%) of operational costs (WWAP, 2014). Therefore, the enhancement of water supply services depends on the improvement of water losses and energy management systems.

Research results in industrial energy efficiency indicate that an energy management gap is often associated to the existence of barriers that inhibit the adoption of cost-effective measures (Backlund *et al.*, 2013). In order to overcome this energy efficiency gap it is necessary to work strategically with energy issues and to develop energy management systems. An energy management system is a tool for implementing the procedures defined by an organization to work strategically on energy

(Thollander and Palm, 2015). It is frequent to use interchangeably these two terms, energy management and energy management systems. This can be associated to the fact that the plan-do-check-act cycle (PDCA) model is often used to describe the implementation of energy management systems, assuming that operators will present a behaviour similar to the input-output model, *i.e*., a signal goes into the operator in the form of information, and the signal is transformed by the operator into an action or activity for the improvement of energy efficiency or the energy use reduction (Thollander and Palm, 2015). The existing energy efficiency gap in industry points at difficulties that go further the technological barriers. These difficulties (not technological) can stem from a lack of recognition of the potential for occurring inefficiencies in the associated PDCA cycle, for example, to an ineffective staff engagement (with consequences in terms of behaviour change), organizational obstacles (*e.g*. associated to an excessive functional specialism) and information asymmetries and imperfections. Good communication is a cornerstone in improved energy efficiency. The same reasoning can be applied to deal with water efficiency issues in organizations such as water utilities.

Advanced urban water infrastructure asset management (IAM) is part of high-quality service orientation for users, due to increased consumer demands for resource adequacy and improved quality that constitute challenges that require being addressed in the near future (Alegre and Coelho, 2012). Water losses and energy management belongs to the tactical decisional level (corresponding to a medium-term planning horizon up to 3 to 5 years), contributing to organization's strategic goals regarding the sustainability of the water service and the conservation of resources. The search for synergies with the IAM system can facilitate the implementation of a water losses and energy management system, by linking its objectives with those from the organization regarding the efficient use of resources (Alegre *et al*., 2015).

The implementation success of a water losses and energy management system depends, among other factors, in having top management support and the involvement of different departments of the organizations (operational, financial, etc.). The engagement of these stakeholders is a premise for the development process of collective knowledge. Different actors should be involved in the decision-making process, pooling existing knowledge together or generating new knowledge that will support decisions. The quality of the decision making processes is determined by the reliability and availability of information within the organization and by the staff will for the sharing of knowledge, while abolishing information silos and boundaries associated to functional specialisms.

Capacity-building is a process of implementing institutional developments (*e.g*. towards to an increased sustainability in the use of water and energy), incorporating activities related with transfer of knowledge, skills development and facilitating the use of these capacities (UNW-DPC, 2012). Networking has an important role in the capacity-building process by combining scattered strengths into a "critical mass", maximizing the use of local skills and enhancing knowledge ownership. In order to be effective, it is important that networks remain purpose-driven and demand-responsive, with members sharing a common vision, objectives and rules, and carrying out a set of common activities. Networking can be an important tool to deal with the water sector challenges.

The main objective of this paper is to illustrate – through an on-going research experience - the advantages of addressing water losses and energy management in water utilities with a focus on communication promotion and practitioners' capacitation, having a more integrated approach with other management system such as IAM. Herein, collaborative projects are presented as an enhancer to management systems implementation, focusing on communication role and impacts. It is also presented a concrete approach to deal with barriers to water and energy efficiency in collaborative projects. The paper concludes with the study's contributions to research and practice.

2. COLLABORATIVE WORK ON MANAGEMENT SYSTEMS IMPLEMENTATION

Collaboration is an effective tool to support the process of the change in organizations, as it creates conditions for different actors working together towards a common goal. The success of a collaborative project depends on aspects such as clear and shared objectives, alignment of the team, effective leadership, clear duties and obligations between the project lead and each participant, self-assessment and continuous-improvement practices, effective communication and trust. Another advantage of collaboration is the fact that it entails the process of learning, reflected in the construction and transformation of knowledge by the participants.

Collaborative projects are a tried, tested and well-accepted format that LNEC (National Civil Engineering Laboratory, Portugal) promotes in association with significant numbers of water utilities (WU) in Portugal, with joint teams of research developers and users of the research products, and with support from academic research and technology partners. This type of research project – denominated *Initiative* - has been successfully implemented in the last 15 years and allows for combining strategic research with practical problem solving, and industry hands-on capacitation (Alegre *et al*., 2014). The iGPI (Portuguese Initiatives on Infrastructure Asset Management of urban water services) and iPerdas (Portuguese Initiatives on Water Losses and Energy Management of urban water services) constitute recent deployments of these collaborative projects. In both initiatives, the AWARE-P approach (http://www.aware-p.org) is followed, which is a structured process for decision making in infrastructure asset management based in three main principles: (i) water infrastructures should be considered as part of a system, being their value only perceived in an integrated context; (ii) planning should consider long-term horizon, taking into account that the infrastructure has an indefinite life; (iii) selection of alternatives should consider performance, risk and cost aspects. More information regarding the iGPI (editions 2012/13 and 2015) and the iPerdas (edition 2014) initiatives can be found in Cardoso *et al*. (2015) and Alegre *et al*. (2015), respectively. Examples of comparable collaborative research used for “usable” knowledge production are the study of barriers that can affect the implementation of energy management systems in the Norwegian shipping sector, led by Johnson *et al*. (2014), and the study performed by Westling *et al.* (2014) together with a UK water utility technicians aiming to develop adaptive management capacity to climate change.

The development matrix of LNEC’s *Initiatives* is structured into four main areas of activity: (i) data and information; (ii) technical and technological; (iii) (project) management and communication; and (iv) management system plan development. This structure aims to frame the work that participating WU core teams have to develop for the implementation of the management systems regarding infrastructure assets or water losses and energy. Figure 1 illustrates the articulation of the different axis, stressing the importance of planning as the aggregation factor of the *Initiatives*.

Figure 1. Framework of LNEC collaborative projects: Initiatives iGPI and iPerdas

In the iGPI and iPerdas Initiatives, the management plan is structured in order to answer the three main questions: (i) "*Where do we want to be?*"; (ii) "*Where are we now?*"; (iii) "*How do we get*

there?". Answers to these questions can be summarised as follow: (i) the arrival point is defined through the establishment of goals and an assessment system (with criteria, metrics, reference values and targets) that will guide the process of organizational change; (ii) the characterization of a starting point is made by performing a baseline diagnosis using the assessment system defined in previous step; (iii) the route conducts the organization's process of change through prioritizing areas of analysis and intervention alternatives, with the scheduling of their implementation and the monitoring of achieved results. The Initiatives plan development approach has in mind the continuous improvement process established with the PDCA cycle, taking in consideration the ISO 50001 and ISO 55001 standards on energy management system and asset management system, respectively (ISO, 2011, 2014).

The elements of a "Plan of Water Losses and Energy Management" – PWLEM (developed within the iPerdas Initiatives) are defined in order to follow the logic involved in the planning process, notably in terms of submitting a response to the three questions presented above. To facilitate the planning process, the PWLEM comprises two types of documents: a general plan and a number of "area of analysis" documents (as many as required). The areas of analysis correspond, in principle, the functional subdivisions of the water supply system for which it is possible to evaluate the service provided. The general overall plan encompasses the overall assessment of the water supply system, with an analysis of the diagnosed baseline situation, the priority areas selection and the presentation of the selected interventions, their programming and resource allocation and, finally, the plan monitoring and review procedures. It should be developed an area of analysis document for each water supply system subsection considered as a priority in the diagnosis of the baseline situation. In these documents, it is necessary to further detail the diagnosis regarding the corresponding water system subsection, in order to support the establishment and prioritizing of intervention tactics aimed to manage water losses and energy efficiency.

The outcomes from LNEC's collaborative projects include direct results for the WU partners, such as the following: competences gained; enhanced processes for infrastructure asset management system (in the iGPI Initiatives) and water losses and energy management system (in the iPerdas Initiatives); management system plans developed by the participating teams; awareness and engagement of the several decision levels of the organization; improved communication and information flows between different departments of the organization; and, implementation of many new or enhanced procedures for data collection (Alegre *et al.*, 2014).

3. THE ROLE OF COMMUNICATION IN THE IPERDAS PROJECT

In the face of the challenges with regards of growing needs of sustainability and rapidly changing global environment (associated with climate instability and increasing regulatory demands, for example), there is an urgency to evolve to a more concrete way to address these issues. The learning and communication processes can accelerate innovation, as a more methodical approach to the design and implementation of effective solutions for the issues dealt in collaboration. Cornell *et al.* (2013) focused the need of liking knowledge with action for effective societal responses to persistent problems of unsustainability, which can be achieved by the opening the knowledge systems. Accordingly to these authors, it is necessary to ensure effective interface arrangements for translating knowledge to action, which can only be achieved if there is an evolution in research activity for a more integrated and understanding of global change issues.

To make our general description about the role of communication more concrete, we briefly present the efforts made in the iPerdas2014 project in terms of reducing the impact of this barrier in the implementation of a water losses and energy management system. This collaborative project was launched by LNEC, in partnership with IST (University of Lisbon, Portugal), ITA (Polytechnic

University of Valencia, Spain) and Addition (a software development company, Portugal) and 17 Portuguese water utilities (WU) which developed their own water losses energy management plans, following a joint training and capacitation approach (www.iperdas.org). The participating WU corresponded to 14% of the supplied drinking water in Portugal and presented different sizes of serving areas as well as the IAM and water losses management systems maturity. The iPerdas2014 project was structured into three main stages, four months each, and a preparatory phase, of one month. It started in November 2013 and ended in December 2014. Figure 2 presents the overall structure of the iPerdas2014 project.

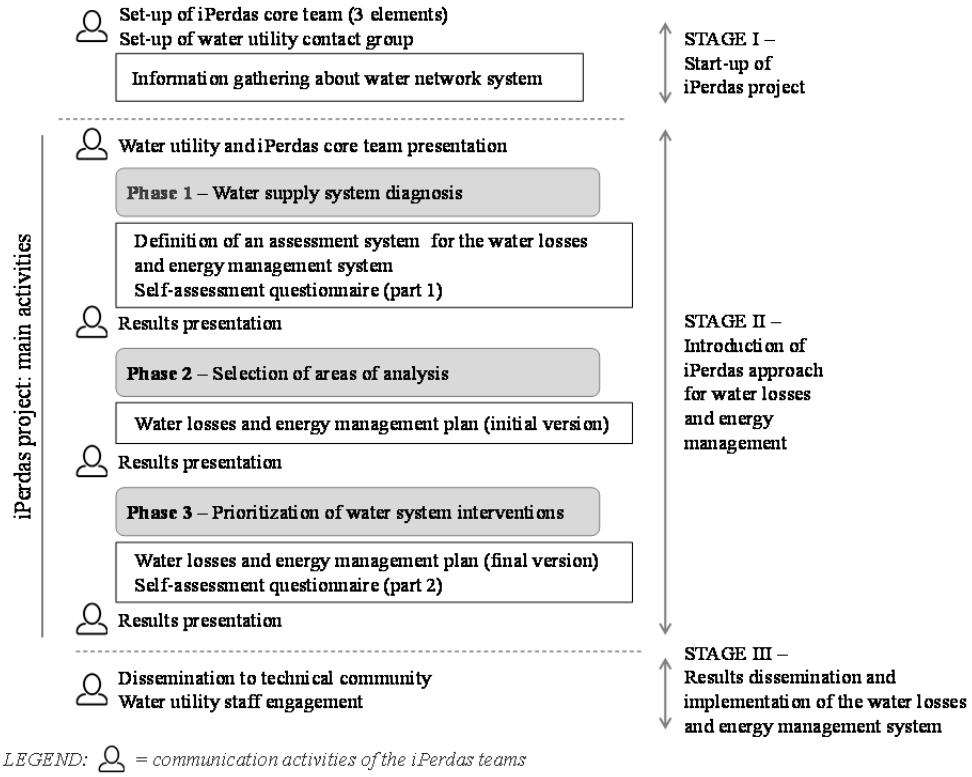

Figure 2. iPerdas2014 project organization

The LNEC Initiatives model presents a cyclic nature, as these projects can have different editions as long there is a demand from the water sector. For example, it is expected a new edition of the iPerdas project in 2016. The projects' format is essentially the same, being its specificity mainly related with the topics or knowledge areas that are to be addressed with the water utilities. In the launch of iPerdas2014, the Management and Communication axis (see Figure 1) was identified as a priority subject to improve, regarding previous editions of the Initiatives. Nonetheless, all aspects that have turned out to be key success factors in previous Initiatives were kept unaltered, such as the management plan template and corresponding guidelines, the plenary meetings for results presentation by the WU teams and the public dissemination forum.

In iPerdas2014, it was decided that the progress should focus in the creation of a more structured layout and organization of the written communication outputs and, also, the promotion of online solutions for the technicians' formation (webinars) and documents exchange (online platform). The most evident progress in terms of documentation in this project was the implementation of a new concept in the "phase" reports structuring, in order to reinforce individual communication between each participating teams and the consortium, with a clearer guiding for the work progress. These phase reports included a list of the expected results for the different phases and the criteria used in the progress assessment. This solution was well accepted by all intervenient and turned out to be an

important piece in the overall project success. The promotion of a "contact group" establishment within each WU, to help the engagement of different sectors in the water loss and energy management implementation process, corresponded to an innovation of the iPerdas2014 regarding intra-organizational communication enhancement. Finally, it is important to notice that some communication outcomes aren't tangible, such as the interventions done by the iPerdas project WU teams (c.f. Figure 2 for the identification of their scheduling).

In order to assess the perception of the participating teams regarding the development of capacities in the course of iPerdas 2014, a self-assessment questionnaire was prepared with two main objectives: (i) assessment of the degree of maturity of WU on the management of water losses and energy efficiency, based on the requirements set forth in the ISO 50001 (energy management system) and 55001 (asset management system) standards; (ii) setting of goals to be achieved during the initiative. The questionnaire was presented in two moments with reference to the beginning and end of the project (December 2013 and December 2014, respectively). Table 1 presents the self-assessment questionnaire structure, comprising two areas of assessment (water loss management and energy efficiency) with 43 questions organized into four thematic areas (equivalent to the PDCA cycle stages) further systematized in 13 sub-categories. The requested responses were of closed type, with provision of the following options: not applicable (corresponding to value 1); incipient (value 2); aware (value 3); under development (value 4); competent (value 5); excellent (value 6). Figure 3 presents the average result of reported values in the final assessment and can be understood as the teams perception about the organization positioning regarding the implementation of the water losses and energy management system.

Table 1. Structure of the iPerdas self-assessment questionnaire

Plan		Do	Check	Act
Commitment and policy	Planning	Implementation and operation	Monitoring and measuring	Management system review
Organizational commitment and policy Legal, regulatory and other requirements Actions to address risks and opportunities Objectives, metrics, targets and plans		Resources, roles, responsibilities and authorities Awareness, training and competence Communication Information support systems Control of documents Operational controls	Monitoring and assessment Non-conformities, corrective actions and preventive actions	Plan review

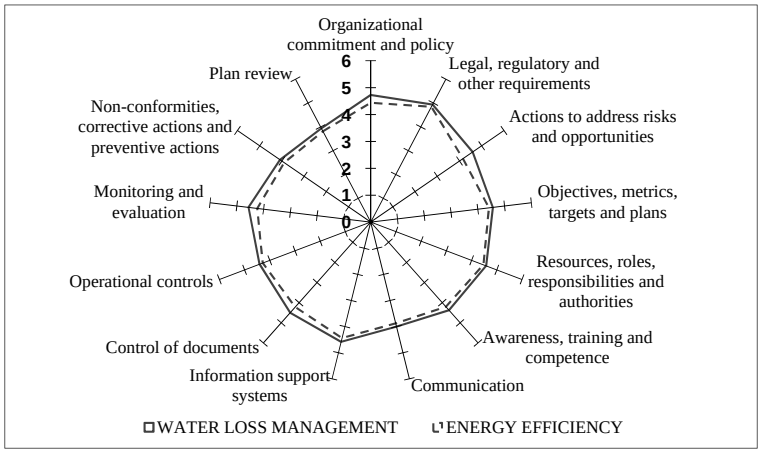

Figure 3. iPerdas WU self-assessment results referring to project's conclusion – December 2014

From Figure 3, it is possible to observe that at the end of the iPerdas 2014, the participating teams reported lower maturity in the three sub-categories: "communication", "non-conformities, corrective actions and preventive actions" and "plan review". It is possible to infer a link between

these aspects, as any fragility with intra-organizational communication will affect necessarily the completion of the PDCA cycle (namely the check and act stages), hampering a new iteration in the continuous improvement process. This fact

4. DISCUSSION

What lessons do the iPerdas2014 experience offers to others researchers and practitioners seeking to stimulate the production and communication of "usable" knowledge using interdisciplinary, collaborative projects? First, our experience underlines the importance of developing and maintaining strong communication between researchers and practitioners in order to promote a continuous alignment with the shared objectives. It is important not to underestimate the time and effort needed to build a strong relationship within the project network. Second, it is important that the WU participating teams expand this effort in communication to their own organizations, in order to achieve top management and staff commitment in an effective implementation of the selected management system. Third, and perhaps most importantly, the collaborative research process should support a reflexive analysis of existing barriers to water and energy efficiency and possible ways to overcome or reduce the impact of these barriers.

Chai and Yeo (2012) proposed a framework inspired in the systems thinking process aiming to highlight the interconnected nature of barriers to energy efficiency in industry and the need to address these barriers in a holistic manner. The MCIR framework (illustrated in Figure 4) has four stages, namely, motivation, capability, implementation and results, and a feedback loop. The MCIR framework offers an expedite approach to understand possible ways to overcome barriers in the implementation of water and energy efficiency systems in water utilities. Main benefits achievable through the use of a comprehensive approach for communication, as the one implemented in the Initiatives, are presented in Table 2, highlighting points of contact with the MCRI framework.

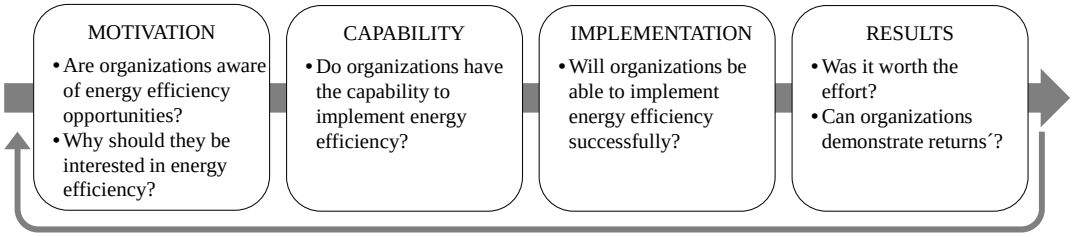

Figure 4. MCIR framework (Chai and Yeo, 2012)

Table 2. Benefits associated to the use of structured communication in collaborative projects

MCRI stages	Initiatives communication activities and products	Perceived value
Motivation	– Plenary meetings for team presentation (★, ⊙, ✪) – Self-assessment questionnaire (★, ⊙, ✪)	– Awareness and engagement of the several decision levels of the organization
Capability	– Sample templates planning documents (★, ⊙, ✪) – Basic guidelines for planning documents (★, ⊙) – Improved guidelines with theoretical background (✪) – Procedural templates (⊙) – Classroom and webinar training (★, ⊙, ✪)	– Competences gained with the training and assisted experience resulting in the development of management system and corresponding plans and enhanced procedures
Implementation	– Plenary meetings for results presentation (★, ⊙, ✪) – Basic progress individual assessment report (★) – Structured progress individual assessment report (⊙, ✪)	– Improved communication and information flows within project's network and between participating WU teams and consortium
Results	– Intra-organizational seminar (✪) – Assessment system regarding project participation (✪) – Public dissemination forum (★, ⊙, ✪) – Individual final assessment report with plan improvement recommendation (★, ⊙, ✪)	– Improved communication regarding benefits and barriers associated with management systems – Increased visibility of KPI

Legend: ★ - iGPI2012/13; ⊙ - iPerdas2014; ✪ - iGPI2015

5. CONCLUSION

Water utilities have to deal with different challenges, including those related to climate change, ageing infrastructures and increased societal expectations. Restrictions on resources (*e.g.*, energy, water and infrastructures) reinforce the need for effective management systems. The quality of the decision making processes is pivotal to achieve an effective water loss and energy management and it is determined by the capacity of water utilities to evolve in the direction of sharing knowledge and skills, breaking down information silos and boundaries resulting from functional specialism.

Collaborative projects are a tried, tested and well-accepted format that LNEC promotes in association with significant numbers of utilities in Portugal, with joint teams of research developers and users of the research products, and with support from academic research and technology partners. This paper presents the approach used in the iPerdas2014 project in terms of communication promotion. By defining a comprehensive framework for communication, integrating the production of planning and project management documents, and activities for networking and public dissemination of project results, this paper demonstrate the benefits of collaborative knowledge production in the implementation of management systems in water utilities.

Acknowledgements

The authors acknowledge the contributions from all the utilities, organizations and individuals that took part in the iPerdas and iGPI collaborative projects.

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