The iGPI collaborative project: moving IAM from science to industry

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Abstract
iGPI, the National Initiative for Infrastructure Asset Management (April 2012 - October 2013), is a Portuguese collaborative project led by LNEC (National Civil Engineering Laboratory, Portugal) through which 19 water utilities develop their own IAM systems and plans through a joint training and capacitation programme. Technical assistance to the participating utilities is ensured by LNEC, by a team from IST (Technical University of Lisbon) and by Addition, a software development company. The water utilities get collective as well as one-on-one support, specific training, and benefit from networking with the other utilities in a common and simultaneous process, with similar difficulties and challenges, leading to an effective sharing of solutions. The developed products, including training materials, templates and guidelines for developing strategic and tactical IAM plans, are available to the general public.
This project has greatly contributed to the establishment of reference methodologies and standards for IAM planning, demonstrated in a range of utilities of widely diverse size and context, effectively defining an accepted best practice. This paper discusses the project's format and its advantages, and goes on to describe the main outcomes, including selected cases and final products.

Keywords
Urban water services; infrastructure asset management; collaborative project; strategic planning; tactical planning.

INTRODUCTION

Portugal's public water service infrastructures in the 1970s were clearly below European average coverage levels. Significance convergence efforts undertaken in the 1980s and 1990s allowed those levels to sharply rise, and towards the end of the century all populations living in urbanized areas had full access to water supply and wastewater services.

This rapid growth was not matched by adequate capital maintenance levels of the previously existing infrastructure or by sufficient capacitation investment for the majority of the utilities. Although relevant structural reforms were undertaken as full coverage neared, the deficit in infrastructure asset management (IAM) continued to deepen to the present day.

A number of important measures have been undertaken in recent years to reverse the trend and to help equip the country's utilities with the means to redress the long-term sustainability of the existing assets. National legislation passed in 2009, effective 2013 (Decree-Law no 194/2009), requires an IAM system in all water supply services and urban wastewater management services serving 30 000 people and over. Following this legislation, the national Water and Waste Services Regulation Authority (ERSAR), in conjunction with LNEC and the Technical University of Lisbon, published two technical guides outlining an integrated IAM methodology and a set of supporting technologies (Alegre & Covas, 2010; Almeida & Cardoso, 2010).

This methodology approaches IAM as a management process, based on continuous improvement principles (Alegre & Coelho, 2012) and requiring full alignment between the strategic objectives and targets, and the actual priorities and actions implemented, thus embedding the key requirements of the forthcoming ISO 55000/55001/55002 standards on asset management (ISO, 2012a,b,c). The manuals were produced as part of a landmark project, AWARE-P, aimed at providing water and wastewater utilities with the know-how and tools needed for efficient decision-making in the scope of infrastructure asset management of urban water services (aware-p.org, Alegre *et al.*, 2013; Alegre & Coelho, 2012). AWARE-P was a direct successor to European R&D projects CARE-W and CARE-S, trying from the outset to reach the industry and society with useable, effective products that can make a difference in capacity building and support to the planning process. These included training courses and an open-source software family (Figure 1) that has a community of over 1000 registered users worldwide at the present time (Coelho *et al.*, 2013).

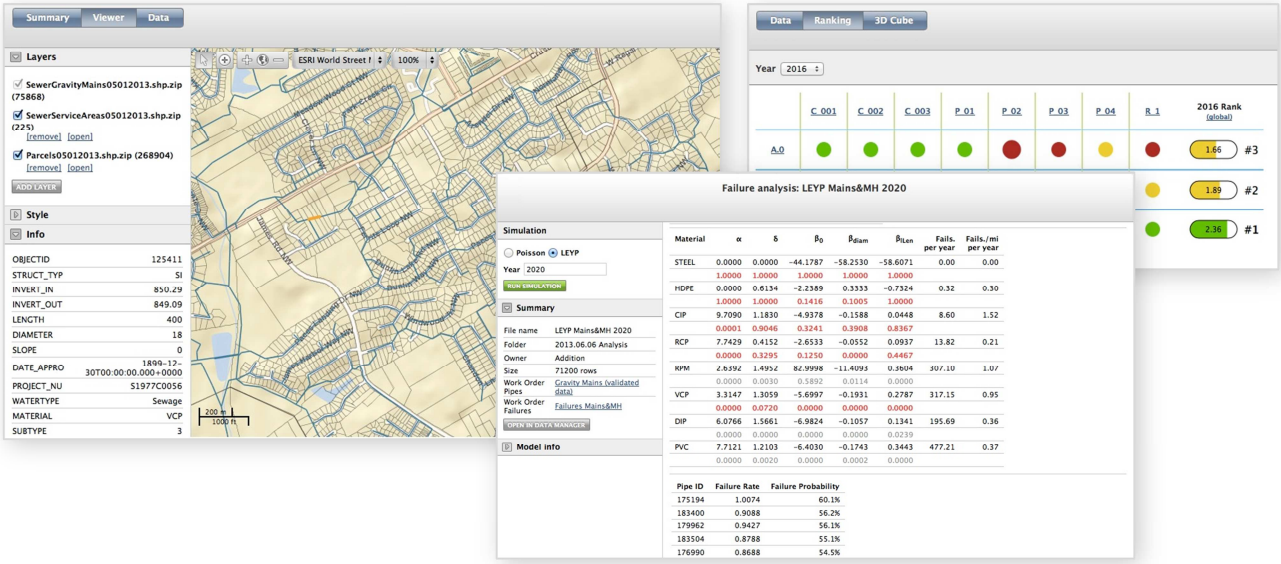


Figure 1. The AWARE-P software (www.baseform.org)

iGPI, the National Initiative for Infrastructure Asset Management (April 2012 - October 2013, www.iniciativaGPI.org), was launched to help broaden the impact of those methodologies and products and reach out to utilities nationwide in a significant way. It utilized a collaborative format pioneered by LNEC in the last decade, and aimed at assist a representative sample of utilities of diverse size and context develop their own IAM systems and plans through a joint training and capacitation program. This paper discusses the project's format and its advantages, and goes on to describe the main outcomes, including selected cases and final products.

Pursuing a national-level IAM initiative was driven by a number of goals:

- create awareness to the need for long-term sustainability and integrated IAM planning;
- establish a core set of fundamental concepts and best practice principles;
- consistently capacitate the utilities;

- generate a first batch of effective business cases that might create enough precedent for a broader roll-out;
- demonstrate that IAM is not a one-size-fits-all solution and emphasize the need for significant in-house development with strong involvement and alignment of the strategic, tactical and operational levels of the organization;
- bring to evidence that long-term sustainability and integrated IAM planning is as crucial and applicable to larger or more resourceful utilities as to the smaller or more challenged ones;
- generate enough scale as a project to be able to develop reference best-practice tools.

A COLLABORATIVE PROJECT: WHY AND HOW?

Why

In Portugal, as in most countries, generalized implementation of strategic infrastructure asset management of urban water systems requires a considerable mind-set shift for the water sector as well for decision-makers, politicians, the media, and society in general.

The collaborative project format is particularly effective in this kind of situation. Mutual validation and recognition from a peer group provides a greater comfort zone for early adopters. The scale of these projects ensures a high visibility and impact in national terms, contributing to creating the aimed awareness and appetite for the theme. Additionally, developing cases that are representative of a nation's reality have a significant leverage impact, demonstrating applicability and allowing for further learn-by-example training.

How

Collaborative projects are a tried, tested and well-accepted format that LNEC promotes in association with utilities in Portugal, with support from academic research and private industry. They are leading multi-stakeholder R&D projects, with joint teams of research developers and users of the research products, 'working with' instead of 'working for'. In general, this provides scale to the projects, produces a networking effect and allows for combining strategic research with practical problem solving, and industry hands-on capacitation.

The projects are launched on topics of national relevance where R&D is ready for rollout. An open proposal is issued defining objectives, methodology, schedule, training syllabus, partner roles, deliverables, and cost of participation. The public proposal is often further developed with the group of interested utilities. When relevant, the utility selection process may include criteria designed to ensure national representativeness. The project is launched if a break-even number of utility candidates is reached (usually around 10-12). The maximum number of participating utilities, usually 15 to 20, is limited by the promoting team's training and direct support capacity.

These projects follow a phased schedule, with 3- to 4-month phases and a total duration of 12 to 24 months. Each phase starts with face-to-face training, and with the specification of the work to be developed by each participant. Training is complemented with e-learning via webinars and on-line materials throughout each phase. While the utility teams develop their pilot cases, LNEC and its development partners analyze results, provide one-to-one assistance to the utilities and prepare the training materials, guidelines, templates or software that may be needed for the next phases.

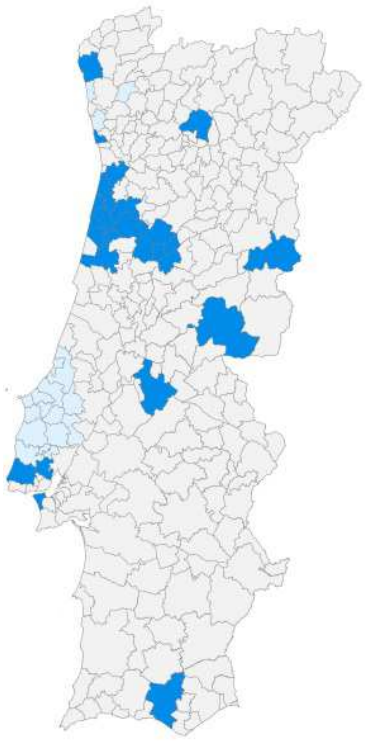
The ultimate aim is that by the end of the project the participating utilities are fully capable of developing and systematically applying by themselves the same kind of work to other cases in their organizations. With this in mind, the work carried out combines technical and management aspects, facilitating the implementation of organizational adjustments and the establishment of internal procedures leading to adequate management processes.

iGPI (April 2012 - October 2013) is the fourth of these projects, preceded by: PI-Water, on performance indicators of water and wastewater utilities (2000-2003), INSSAA, a national initiative on water network analysis and simulation (2004-2007), and PASt21, a national initiative on performance assessment of water and of wastewater treatment plants (2009-2011). iPerdas, on water losses and energy efficiency, has just been launched, and a second round of iGPI is under consideration at the time of writing.

Feedback on this model from participating utilities has been encouraging, emphasizing both the effective capacitation and the prolific networking with their peers. From an R&D viewpoint, data sharing in such large, multi-stakeholder projects usually produces vast amounts of representative data sets that are vital in the validation of methods and tools.

PARTICIPATING UTILITIES

Nineteen Portuguese urban water utilities take part in the iGPI project[1], ranging in population served from approximately 390,000 to 3,000, and with a large diversity of scope (water, wastewater, storm water), institutional framework (e.g., municipal, inter-municipal, concession) and complexity (Figure 2). The level of maturity in terms of information availability, technical sophistication and management processes implemented is also diverse.



	# Households served(*)	Water supply	Wastewater	Storm water	Other public services	Bulk	Retail	Municipal service	Municipal company	Multi-municipal company	Concession
Águas de Coimbra	73,927	✓	✓	✓	✓		✓		✓		
Águas da Região de Aveiro	131,694	✓	✓			✓×	✓			✓	
AQUAPOR - Águas do Planalto	30,738	✓				✓	✓				✓
CM Sabugal	11,929	✓	✓	✓	✓	✓×	✓	✓			
EMAR Vila Real	24,612	✓	✓	✓×	✓	✓×	✓		✓		
INDAQUA	172,375	✓	✓			✓×	✓				✓
Infraquinta	1,315	✓	✓	✓	✓		✓		✓		
Inframoura	12,874	✓	✓	✓	✓		✓		✓		
Infralobo	1,822	✓	✓	✓	✓	✓×	✓		✓		
INOVA - Cantanhede	17,580	✓	✓	✓	✓	✓	✓		✓		
SM Abrantes	22,143	✓			✓	✓	✓	✓			
SMAS Almada	94,968	✓	✓	✓		✓	✓	✓			
SM Castelo Branco	33,679	✓	✓	✓	✓	✓×	✓	✓			
SM Loures	153,754	✓	✓	✓	✓		✓	✓			
SMAS Sintra	170,378	✓	✓	✓		✓	✓	✓			
SMSB Viana do Castelo	37,128	✓	✓	✓×	✓	✓×	✓	✓			
Águas do Oeste	138,136	✓	✓			✓				✓	
AGERE	69,086	✓	✓	✓	✓	✓	✓		✓		
EAmb Esposende	16,488	✓	✓	✓	✓		✓		✓		

(*) - Source: ERSAR, audited data 2011 ✓× denotes partial fulfillment

Figure 2. Utilities taking part in the iGPI project

In parallel with iGPI, a twin initiative using the same format and materials was promoted by AGS, a water services holding, involving 14 of their concessions (Feliciano *et al.*, 2013a,b). AGS had been a partner in the AWARE-P project.

[1] Two independent consultants, Acquawise and Pedro Almeida, also take part in the project, in association with individual utilities.

PROJECT OUTCOMES AND PRODUCTS

The outcomes from LNEC's collaborative projects include direct results for the utility partners, products made available for professionals and society at large, and research results published in the form of MSc and PhD dissertations and articles. iGPI followed this path. The main outcomes for the participating utilities and the key industry products are summarized in the following sections.

Outcomes for the participating utilities

Adding to the competences gained with the training provided and the assisted experience achieved, each participating utility benefited from other project outcomes, summarized in Table 1.

Table 1. iGPI program: objectives and outcomes

Objectives	Outcomes
Phase 0	
Warming-up: project organization and start of baseline data collection	• Detailed planning of activities; • Definition of teams and project managers for each participant water utility; • Definition of information to be collected.
Phase 1	
Strategic planning level and tactical planning level: objectives and diagnosis	• Concise report containing: objectives, assessment criteria, metrics and targets to strategic and tactical planning (macro) levels; • Strategic level diagnosis; • Data survey priorities.
Phase 2	
Strategic planning level and tactical planning level: plan development	• Full version of the IAM strategic plan; • Prioritization of network sectors at tactical intervention level.
Phase 3	
Tactical planning level: formulation of IAM alternatives for the utility pilots	• First draft of the IAM detailed-tactical plan containing: - objectives, criteria, metrics and goals; - diagnostic of the priority area; - identification of infrastructural and non-infrastructural alternative solutions.
Phase 4	
Tactical planning level: evaluation and comparison of alternatives	• Full version of the IAM tactical plan, including the detailed tactical planning for the priority (pilot) area(s); • Procedures for the collection, organization and quality control of data relevant to IAM (GIS network records, work orders, condition assessment/inspection, accounting data, among others).

Products

One of the features of LNEC's collaborative projects is that the products developed in the scope of the project are placed in the public domain. In the case of iGPI, these included:

- Guidelines to produce IAM strategic and tactical plans, and sample MS Word® templates;
- Training materials (presentations slides, written materials);
- Significant improvements in the AWARE-P software;
- A national visibility public event where the participants reported mid-term results (in March 2013; around 200 attendants);
- Papers in industry publications.

IMPACT SO FAR

The impact of the project can be gauged individually through the participating utilities as well as from a broader perspective on the national water sector. Some of most relevant accomplishments for the participating utilities are:

- Effective harmonization of the organization' objectives, among the various management systems in place, such as certified quality of management systems (e.g. towards ISO 9000 and ISO 14000) and Balanced Score Cards implementation, as the most commonly represented in the group.
- Considerable alignment between decision levels and between management processes (e.g., the same performance indicators are now adopted across the entire organization in most cases).
- Effective use of the IAM strategic plan finalized in Dec. 2012 as a management tool.
- A change of attitude from the top managers towards IAM, both internally and externally, turning them into IAM advocates when addressing other utilities outside iGPI.
- Acquired competences of the organizations' human resources on IAM, including management skills and, on the technical side, greater familiarity with analysis tools such as hydraulic simulation, pipe failure analysis and forecasting and performance assessment.
- Leveraging a 'stone soup' effect as regards information systems: a directed, demanding horizontal requirement for data exerts positive stress on the ensemble of the utility's IS (such as GIS, customer service, work orders, maintenance and EPS, among others) and is a powerful driver for significant improvements in data depth, quality, focus and integration.
- Implementation of many new or enhanced procedures for data collection, particularly related to work orders and surveying of buried assets.

From a broader viewpoint, the project has contributed to changes in the water sector and society in a number of ways:

- for utilities that are not taking part in iGPI, it has helped raise awareness to the issue and made available software tools, documentation and planning templates, as well as a networkable community of iGPI users;
- the national water services regulator, ERSAR, has closely followed iGPI and helped promote it — the existence of a project of this size involving a representative sample of utilities provides ERSAR with a workable basis to further develop the current regulatory framework and public policies as regards IAM;
- the methodology and tools developed under AWARE-P and broadly validated through iGPI have made their way into graduate and postgraduate curricula in universities in Portugal (Technical University of Lisbon, Oporto Polytechnic, Évora University), Spain (Valencia Polytechnic University) and Norway (NTNU); expressions of interest have been received from other countries in Europe;
- iGPI has helped raise awareness to the issue and contributed to its definitive inclusion as a mainstream topic in all relevant national water services-related events.
- Outside Portugal the format and the results of iGPI are attracting direct attention from several countries (e.g. Brazil, China, India, Danube region countries) and already enabled changes in some cases (e.g., it has directly inspired Brazil's National Quality of Management Award-PNQS to incorporate IAM-related requirements for the 2014 edition).

METHODOLOGY AND GENERAL FINDINGS

From the technical viewpoint, the project followed the AWARE-P IAM planning methodology in a timeframe common to all participating utilities. The methodology (Figure 3) follows a continuous improvement, plan-do-check-act (PDCA) loop, driven by the stated objectives and by an educated choice of assessment criteria, supported by adequate metrics and quantifiable targets. The process is applied at the strategic, tactical and operational decisional levels in the utility, striving for alignment of objectives, metrics and targets between levels, as well as consistent feedback across levels (Alegre *et al*., 2013; Alegre & Coelho, 2012).

The schedule of works aimed at a first complete draft of the strategic IAM plans at month 8 (January 2013), and of the tactical IAM plans by month 16 (September 2013). Alongside with the

tactical plan, which has a corporate nature, there is one analysis document for each network sector where specific tactical intervention plans have been developed. In this project, those sectors were pilots selected during the first half of the schedule.

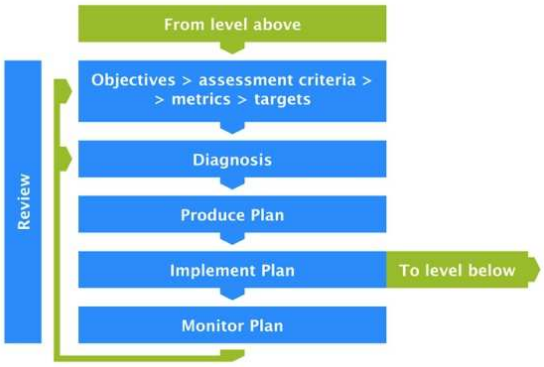


Figure 3. The IAM PDCA loop

All the participating utilities with water supply *and* wastewater services developed separate tactical IAM plans for each of the services. The strategic IAM plans were common to all services, and sought integration with (or in some cases, *as*) the organization's strategic plan. All the utilities decided to adopt the strategic and tactical plan templates that were developed by the project team; these formats proved to be flexible enough to fit the range of situations encountered (Figure 4).

The single most complex step involved in the development of the strategic plans (and later, again at the tactical level) was the choice of objectives, measurement criteria and corresponding metrics. This is an iterative, disruptive process as regards the established practice in this type of organizations, and where the involvement of the various decisional levels is most crucial. Utility staff are used to looking at indicators or other types of metrics as a final compliance check, but less accustomed to using them as everyday diagnosis and decision-support tools.

Such difficulties were patent in the participating utilities from the outset; however, project group dynamics were clearly useful as the difficulties and pitfalls encountered were often similar, and generated commonality in the solutions found. All utilities managed to develop consistent systems of strategic and tactical objectives, and their corresponding criteria and metrics; their availability is one of the most important gains of the project's networking and large number of cases generated.

Figure 4. Strategic IAM template and plans produced

Portugal's water services regulatory framework includes a well-established system of quality of service indicators for water supply, wastewater and solid waste (ERSAR and LNEC, 2010). This system was developed following ISO 24510/11/12 principles (ISO 24510: 2007, ISO 24511: 2007, ISO 24512: 2007) and reflects an *objectives* > *criteria* > *metrics* logic, in accordance with management best practice. On the other hand, and beyond incorporating the aspects directly related to economics and level of service — as followed by most water service regulators —, the Portuguese regulatory system also includes infrastructural and environmental sustainability objectives and PIs. This covers the core strategic objectives of most utilities, and the systems of objectives and metrics selected by the iGPI project's participating utilities reflected this in good measure — the regulator objectives, criteria and PIs were often selected by the participating utilities for their strategic or tactical IAM plans.

Several of the participating utilities had other strategic management systems in place, such as a Balanced Score Card (BSC). These systems are often 'strategic' by geographical or organizational scope, but not on the time dimension; because of that, the aspects that may effectively assess IAM's long term sustainability are almost inevitably missing. The fact that the above-mentioned regulatory system includes infrastructural sustainability metrics has facilitated both the recognition of their importance and the incorporation of IAM concerns in such strategic management systems.

A common feature to urban water services is their dependency on very long duration infrastructures where capital maintenance needs make up a much larger proportion of the total annual costs than in most other sectors and industries. The short-term bias in strategic management systems is consequently a common feature worldwide in the standard toolbox of management consultancies. It is important to recognize this problem. If strategic plans have a short time horizon — 3-5 years are common — the effects of low rehabilitation rates do not become evident on the quality of service and allow for a significant decrease in the annual total costs. Therefore, the easiest way to improve economic efficiency in the short term, increasingly a central goal of utility CEOs and service regulators, is to minimize capital maintenance through lowering rehabilitation rates. In the long run, this is not sustainable, but most short-term 'strategic' instruments fail to reflect this in any way.

CASES

The way in which the several participating utilities developed their strategic and tactical plans, and implemented their IAM processes, was shaped by their context, resources, organizational maturity, information availability and the existence of other management systems or instruments. Below are some cases illustrating the diversity of situations and solutions. Utility size is classed as follows: *Large utility*, above 100,000 households served; *Midsize utility*, above 40,000 and up to 100,000 households served; *Small utility*, above 15,000 and up to 40,000 households served; *Very small utility*, up to 15,000 households (not legally required to have IAM programs). The national average household occupancy is 1.8 persons, although with some significant regional variations.

CASE 1 Midsize	**Features:** technologically developed utility; well trained human resources available; good inventory; full coverage, reliable GIS; good monitoring systems; hydraulic models available for the entire water supply system.

- The availability of a large amount of information, mostly reliable, including all-mains calibrated hydraulic models for the entire water supply system, allowed this utility to use more sophisticated and data-demanding metrics to address aspects such as pressure adequacy and flow velocity adequacy. Full model coverage was not available to the other participating utilities during the course of the project.
- Automated procedures have been implemented in order to calculate the selected metrics.
- Some metrics at the strategic level result from the aggregation of more detailed metrics adopted at the tactical level.
- Despite the technological maturity, the use of work orders information for reliability analysis revealed room for improvement. Non-infrastructural tactics were established in order to address this problem.
- With an IAM metrics system in place, the fact that a significant part of the process has been automated shortens the time and manpower needed for detail diagnosis, which allow this utility to work simultaneously with 4 pilot network sectors at the tactical level (2 each for water supply and for wastewater) during the course of the project.

CASE 2 Very Small	**Features:** technologically aware utility at an early stage as an organization, having inherited their infrastructure; capable but limited human resources available; good inventory; full coverage, recent GIS; runs other municipal services. Serves a seaside tourist area.

- Seasonality causes overcapacity of the systems for a good part of the year; the utility is particularly interested in exploring flexible solutions in their IAM plans.
- Dependency on tourism increases the utility's exposure to the economic crisis, which required the consideration of diverse revenue-generation scenarios in developing and analyzing IAM capital maintenance plans.
- Successfully assessed and used the Infrastructural Value Index (Alegre & Coelho, 2012) as a prime metric for long-term scenario and intervention evaluation.
- After successful development of a strategic IAM plan for the water services, the utility decided to apply the same approach to the other services it runs (roads and public gardens).
- Due to the relatively small territory, a single stage was adopted in the tactical planning and the entire systems were the object of detailed analysis in the framework of the project.

CASE 3 Small	**Features:** technologically developed utility; capable human resources available; good inventory; mature BSC management system; quality of management certifications; full coverage, reliable GIS for the whole area; good monitoring systems.

- The existence of certified management systems was felt to be an advantage in terms of maturity, but also a challenge, given that the existing systems did not address the long term effect of managerial decisions.
- Top management agreed to review the BSC and introduce some small but critical changes. Due to the management's committed efforts and the small size of the utility, by the project's midterm a considerable harmonization of all existing management systems had been successfully implemented, with an adequate consideration to long-term sustainability, previously not present.
- The IAM planning approach is being applied to the other services this utility is responsible for.
- The detailed analysis of the water supply pilot area was thought to justify a hydraulic model. LNEC assisted the utility in generating a basic model file from the GIS and loading nodal demands in a simplified but effective way for planning purposes. This allowed for a sound diagnosis and assisted the development and comparison of intervention alternatives. The process and results achieved showcased the solution for the other utilities in a similar situation.

CASE 4 Large	**Features**: utility is the result of the recent merger of 10 municipal water and wastewater services; very diverse contexts, challenges, and data availability and quality among the municipalities; certified BSC management system; GIS available, but reflecting the disparity in information availability, depth and quality among the municipalities.

- iGPI was seen by the utility as a golden opportunity to help establish sound organizational processes.
- One of the challenges for this utility was to prioritize the municipalities with higher rehabilitation needs, in a sound, transparent and accountable way, in a context of local political sensitiveness where consensus-driven negotiation is crucial. The results from iGPI helped respond to this challenge, particularly through a sound IAM metrics system.
- The existing BSC implementation did not address the long-term effect of the managerial decisions. Although changes are more difficult to implement given the size and complexity of the organization, several new metrics have been included and a transition process has been devised towards a fully satisfactory BSC implementation.
- iGPI also gave rise to multiple new data collection procedures, particularly related to GIS, work orders, and harmonization among information systems.

CASE 5 Very Small	**Features: an** inland region municipality with the lowest population density in the project, with one main town and several dozen small rural villages scattered across a large expanse, several hours away from the country's main metropolitan areas. Small but capable and very motivated team. Strong mayor support to the project . In-house GIS implementation, based on open-source software.

- This utility is challenged by their limited human resources, who must share their time among multi-service responsibilities, and by the high time and cost of any operational or maintenance intervention outside of the main town. The utility took part in the project because they have long recognized a vital need for streamlining and maximizing efficiency, due to the resource limitations, as well as supporting their priorities on a sound basis. They also perceived that the collaborative format of the project would provide them with access to experiences, assistance and networking which would be unattainable in other circumstances.
- The project allowed this utility to establish clear priorities in terms of intervention needs and start addressing the most problematic cases, related to aged networks and very high non-revenue water. Infrastructural and non-infrastructural tactics have been established and a short-term action plan is being under way.

CONCLUSIONS

Although with a long way to go, the authors believe that Portugal is progressing rapidly and with steady steps in terms of IAM of urban water services. Having recognized the need for change in this field, LNEC initiated the process by developing a well-structured IAM approach, supported by technical guides, training courses and leading-edge open-source software (aware-p.org, 2008-2012). Learnings from countries such as Australia and New Zealand were fundamental to this process. AWARE-P helped lay the foundations for new regulatory requirements and for launching iGPI. The results achieved are having a major impact not just on the participating utilities, but the country as a whole, as well as internationally. The variety of cases covered demonstrates how, in practice, systematic and well-devised IAM processes can be tailored and successfully implemented in many different contexts. The collaborative project format has proven to be particularly suited to the task, enabling a quicker and more effective cultural change, technical uptake and process implementation. The authors hope that the IAM story in Portugal may help inspire other countries or regions to follow a similar path.

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ISO 24512: 2007. *Service activities relating to drinking water and wastewater - Guidelines for the management of drinking water utilities and for the assessment of drinking water services.*