Current drivers, challenges and trends of infrastructure asset management

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Abstract: Urban water infrastructures provide essential services to modern societies and represent a major portion of the value of municipal physical assets. Managing these assets rationally is therefore fundamental for the sustainability of the services and for the economy of societies. "Asset Management" (AM) is a modern term for an old practice – assets have always been managed. In recent years, significant evolution occurred in terms of the AM formal approaches, of the monitoring and decision support tools and of the implementation success cases. However, a long way is still to go. This paper presents the highlights of key recent developments in IAM main asset management , with an emphasis on the on-going Portuguese project AWARE-P. The paper also provides an overview, inevitably subjective, of the current drivers, challenges and trends of infrastructure asset management, at an international level. It finishes with some basic guidance on how to implement an infrastructure asset management approach and with some concluding remarks.

Key words: urban water systems, strategic asset management; infrastructure asset management, sustainability.

Introduction

Urban water infrastructures provide essential services to modern societies. Access to high levels of drinking water and wastewater services is fundamental for the protection of public health, the comfort and well-being of population, the sustainable development of the community and the environment protection (ISO 24510: 2007; ISO 24511: 2007; ISO 24512: 2007).

Urban water infrastructures are exclusive (*i.e.*, the same assets cannot be easily shared by various service providers), long lasting (*i.e.*, the average useful life of the assets is of several decades or even more than a century) and costly. In fact, urban water assets represent a major portion of the value of municipal public infrastructures. The economies and well-being of modern societies depend on these infrastructures performing well, which requires a sustainable asset management. It is therefore necessary to adopt a long-term approach and to manage these physical assets in an optimal way, striking a balance between performance, risk and whole of life costs.

'Asset Management' is a modern term for an old practice – managing urban infrastructure assets has been a continuous task beginning by the time of construction. Nevertheless, a more comprehensive and well-devised strategic approach has been evolving in recent years, from fundamental concepts to practical implementation.

Infrastructure Asset Management (IAM), as faced nowadays, is a series of organisational strategies, activities and systematic and coordinated practice by which an organisation manages its infrastructures rationally. It requires competencies in three fundamental areas of knowledge: management (financial, economic and organisational), engineering and information. IAM needs to be planned at three distinct levels – strategic, tactical and operational – requiring each one to be perfectly aligned with the others.

In recent years, significant evolution occurred in terms of the formal approaches, of the monitoring and decision-support tools and of the implementation success cases. However, there is still a long way to go. Many of the techniques, equipment and tools made available are too sophisticated and data seek, particularly for small and medium utilities. This is a very important shortcoming that needs to be sorted out. This paper addresses challenges and opportunities for small and medium utilities with regard to infrastructure AM (IAM). To put this into context,

The first sections of this paper discuss the need for IAM, highlight key recent developments, including a short description of a national project currently being developed in Portugal. The following sections identify IAM drivers, as well as research and development (R&D) gaps, priorities and products needed. The last sections advocate some basic guidance on how to implement an infrastructure asset management approach and present concluding remarks.

Need for IAM

The water supply and wastewater services are capital-intensive activities, where the main costs are directly related to infrastructure, in particular capital expense and manpower costs for construction, maintenance and rehabilitation. Nowadays, some of these service providers are infrastructure management companies. Consequently, it is in the field of infrastructure management that the biggest potential for efficiency and effectiveness gains are to be found in order to achieve a better global performance for an organisation.

Back in the eighties, the South Australian Public Accountants Committee, in partnership with New Zealand, published a series of eight reports in 1986-1987 alerting Australian State Governments for the need to seriously and urgently consider the problems of managing their infrastructure assets to avoid deterioration in public services (Burns *et al.*, 1999).

In the United States, a study carried out by the American Water Works Association in 2001 stated that «in 2030, the average operator will need to spend around three-and-a- half times more than today on replacing water pipes, due to the ageing». The Environmental Protection Agency also concluded that only an increase in charges of 3% would allow them to recover part of the current investment deficit over the next 20 years (AWWA, 2001).

In Canada, the annual cost of the maintenance, repair and renovation of total urban infrastructure is in the order of CND$100,000m. However, the National Research Council Canada estimates that the real costs of maintenance and repair are more than double this amount (Vanier, 2001).

In Portugal, between 5,000 and 6,000 million euros were invested in building work, expansion or renovation of infrastructure for water supply and waste water treatment in the period of the Strategic Plan for Water Supply and Waste Water Services 2000-2006 (PEAASAR I). The investments envisaged for PEAASAR II exceed 3,000 million euros. This means that, in order merely to guarantee the sustainable renovation of infrastructures built between 2000 and 2013, and allowing for a conservative estimate of an service life of 50 years, it will be necessary to invest, in the long run and on average, 160 million euros every year. To this sum must be added the costs of renovating all pre-existing assets (Alegre, 2008).

The European R&D network COST Action C18 (www.costc18.org) identified key research problems related to the management of urban water infrastructures that are currently not covered by on-going projects of the European Framework Program (EFP). Domains selected are: “efficient management of small communities”, “what makes a utility sustainable?”, and “common framework for capital maintenance suitable to medium and small European communities” (Alegre *et al.*, 2009).

These examples clearly demonstrate the size of the problem and the need for effective solutions.

Infrastructure asset management is, for the reasons outlined above, of prime importance for many countries. It is fundamental that utilities start to draw up plans at a strategic, tactical and operational level with a view to accurately define rehabilitation priorities and selecting intervention solutions which, in the long term, represent the best value for money.

Highlights of key recent developments in IAM

The leading role of Australia and New Zealand

The Australian and New Zealand AM 'school' is synthesised in the International Infrastructure Management Manual, which is dedicated to different types of public infrastructures and promotes the Total Asset Management Process. This publication was jointly elaborated by the IPWEA and by the NAMS Group and has greatly evolved over time. The currently available third edition (Ingenium & IPWEA, 2006) counted on contributions from other countries, such as the United States, South Africa and the United Kingdom, and is a true international reference.

The role of the National Research Council Canada

The National Research Council (NRC) Canada has had multiple initiatives directed to creating awareness and establishment guidelines for the implementation of AM approaches adequate to municipal infrastructures. The AM approach recommended by the NRC is incorporated into the InfraGuide: National Guide to Sustainable Municipal Infrastructure. This was a 4-year project starting in 2001, financed in the scope of the Infrastructure Canada Program (ICP) and managed by the Federation of Canadian Municipalities (FCM) in partnership with the NRC. This guide contains a good number of independent documents presenting the best practices applicable to the management of various types of municipal infrastructures. The main areas of the guide are (http://sustainablecommunities.fcm.ca/Infraguide, ref. May 2009):

- Governance and Integrated Sustainable Development ('Decision making and investment planning', 'Environmental protocols' and 'Integrated infrastructure');
- Water ('Potable water' and 'Storm and wastewater');
- Transportation ('Roads and sidewalks' and 'Transit').

The policy adopted of keeping the documents produced in the public domain, freely available in electronic version from the web, has greatly contributed to the dissemination of the knowledge created.

The European CARE-W and CARE-S systems

The twin systems CARE-W (Computer-Aided Rehabilitation of Water Networks) and CARE-S (Computer-Aided Rehabilitation of Sewer Networks) were developed under the 5th Framework Program of the European Union and aim at assisting water utilities in setting up strategic and tactical rehabilitation plans of piped systems (Sægrov, 2005, Sægrov, 2006). The projects ended respectively in 2004 and 2005, and since then a number of applications took place in various countries. The CARE systems comprise an integrated approach, providing tools that assist in the main phases of decision making process: characterisation, analysis and diagnosis, long term (strategic) planning and short term (operational) planning. The focus of the CARE systems is on buried assets. The emphasis is put on the engineering aspects.

The Common Framework for Capital Maintenance in the UK

The Common Framework for Capital Maintenance (United Kingdom) is a project undertaken with the support and collaboration of the Office of Water Services (OfWat), the Drinking Water Inspectorate (DWI), the Environment Agency (EA), the Water Industry Commissioner for Scotland and the Department for Environment, Food and Rural Affairs (DEFRA) together with the UK water industry (UKWIR, 2002). It currently adopted in the UK as a basis for the periodic prices review carried out by OfWat and had a major leverage effect on IAM.

Initiatives in Portugal

Portugal has a word to say in terms of asset management because the water sector has had a remarkable evolution in the past 15 years in terms of quality of the services provided, institutional and organisational framework, investments made in new infrastructures, regulatory environment, management skills and scientific developments. The organisation in Lisbon of LESAM 2007, the IWA leading-edge SAM Conference, and the on-going national project AWARE-P (advanced water asset rehabilitation in Portugal, www.aware-p.org) are just two examples of relevant initiatives for paving the way for a sustainable management of urban water infrastructures (e.g., Alegre, 2009). AWARE-P is presented in the next chapter of this paper.

Other relevant European initiatives

Many other relevant European initiatives could be presented. Examples are:

- The UK has a leading role in other aspects of the urban water infrastructures AM, such as in the formalisation of whole-life cost optimization approaches and in the scope of water losses control.
- In the Netherlands, AM policies are directed by service targets, much more than by economic reasons. VEWIN, the Association of Dutch Water Companies and the Dutch research laboratory KWR (former KIWA) are two reference organisations with this regard.
- Germany adopts a pragmatic approach to AM materialised in the form of DVGW standards for asset condition assessment and rehabilitation.
- In many European countries AM is more developed in sectors such as railways, telecommunications, energy, highways, and airport infrastructures.

USA: the case of Seattle Public Utilities and the USEPA Advanced AM Workshops

In the USA, water infrastructure AM is rapidly developing. The US Environmental Protection Agency (USEPA) plays a key role with this regard (Albee, 2005a, Albee, 2005b). Among the multitude of initiatives, the series of US EPA Advanced Asset Management Workshops is particularly important. The recommended approach is greatly inspired in the Australian and New Zealand ‘school’. Although there is still a long way to go in terms of practical applications, many success stories can already been told . One of the first utilities seriously facing AM (in general, and not only IAM) is Seattle Public Utilities, which started to implement a comprehensive AM approach in the early 2000’s, also in-line with the Australian and New Zealand ‘school’ (Kelly, 2005).

The US is hosting the next IWA LESAM (Miami, November 2009).

The role of consultants and IT providers

International consultants play a relevant role in advising water utilities on how to implement IAM systems. However, utilities must understand IAM is a corporate approach and not a plug and play system that can be purchased ready to use.

The same applies to providers of equipment to support condition assessment to information technologies (IT) providers. The availability of good commercial software applications in the scope of digital mapping (GIS - geographical information systems), of Enterprise Resource Planning (ERP) and of maintenance support systems, to mention just some of the most important types, greatly contributes to a better utility IAM information structure and therefore to an improved IAM, as a whole approach.

IAM specifications and standards

The availability of standards and guidelines for asset management defining the main concepts and terminology, and establishing the general principles and requirements may have a very significant leverage effect.

In the UK, the Publicly Available Specification *PAS 55*, which aims at defining the basic requirements for the optimised asset management of physical assets of infrastructure-based services, was

recently revised and enhanced (PAS 55-1: 2008 and PAS 55-2: 2008). In spite of being a national standard, PAS 55 is broadly used in many countries, in sectors such as highways, power infrastructures, roads, railways and, last but not least, urban water systems.

At the international level, a reference is due to the on-going work of the ISO/TC224/WG6 – Asset management. ISO/TC 224 is the Technical Committee of the International Standardisation Organization responsible for the development of the ISO 24500, which are guidelines for the activities relating to drinking water and wastewater services (ISO 24510: 2007; ISO 24511: 2007; ISO 24512: 2007). The working group ISO/TC224/WG6 is currently preparing a "Guideline for the asset management of drinking water and wastewater infrastructure", due to be fully drafted by 2011. This guideline expressly aims at being applicable to utilities of different size, complexity and stage of development, with an emphasis on small and medium utilities.

The project AWARE-P

Vision

AWARE-P stands for Advanced Water Assets Rehabilitation in Portugal (www.aware-p.org). The vision of the project partners is to promote the application of strategic asset management approaches to rehabilitation of urban water systems, by providing adequate and effective decision support tools to water utilities. Furthermore, to create awareness, contribute to change the current practice and improve technical know-how of utilities human resources. Rational investments together with higher levels of service for more sustainable urban water services.

Motivations

Utilities and municipalities manage the world's largest portfolio of infrastructure assets, and urban water assets are the most valuable part of these infrastructures. Today's managers and engineers have to cope with a plethora of challenges that our society is facing including climate change, water scarcity, increased expectations from the public, technological developments, health and risk related challenges. Conscience of limitation of resources imposes the need of a increasingly more effective and efficient practice for maintaining the systems, being integrated and sustainable management essential.

Portugal is not an exception. Much has to change with regard to the ways water infrastructures are managed. This is the motivation for AWARE-P.

Project objectives

The main objective of AWARE-P is to develop and implement in Portuguese water utilities a structured procedure for supporting strategic urban water infrastructures asset management. Starting from previous and current research outputs, the development of a professional computer application, manuals of best practice, and other materials are to being carried out. Thus, the project aims at providing Portuguese urban water utilities with the know-how and the tools needed for efficient decision-making in the scope of infrastructure rehabilitation. Specific objectives include:

- incorporation within the Portuguese water industry of structured and technically well supported forms of planning and implementation of rehabilitation actions in water supply, wastewater and storm water systems;
- dissemination of concepts among technical and political decision-makers on the need for structured decision-making approaches on the rehabilitation of water supply and wastewater drainage systems, and on adequate training of staff in this field.

Expected benefits

Expected benefits of the project are:

- improved framework for strategic, tactical and operational planning of rehabilitation of urban water infrastructures;
- freely available tools and documentation for all stakeholders of the urban water services;
- more sustainable rehabilitation approaches and solutions;
- better trained staff.

Partners, funding and duration

The project incorporates research and development partners and end-users. For the former, a technical and scientific partnership has been established between the National Civil Engineering Laboratory (LNEC), the Water and Waste Regulator Institute (IRAR), a software house (YDREAMS) and the Norwegian Building and Infrastructure institute (SINTEF).

LNEC and SINTEF, as R&D institutions, are responsible for the technical and scientific components of the project. IRAR provides close support and critical assessment as well as ensures dissemination and promotes the use of project results in Portugal, given IRAR structural regulatory role for the Portuguese water industry. YDREAMS is responsible for coding and production of a robust, user-friendly and ready for professional use software. YDREAMS is also responsible for technical support to end-users and promotion of the software outside Portugal.

The end user partners will ensure demonstration case studies with diverse characteristics and geographical locations and are participating with the following roles:

- act as an advisory board;
- collaborate in the test of methodologies and software;
- develop rehabilitation plans based on the methodologies and software developed (with the exception of IRAR);

Participating water and wastewater utilities are SMAS de Oeiras e Amadora, AGS group, AdP Serviços and Veolia Agua.

AWARE-P is funded by the Financial Mechanism of the European Economic Area (Contract Number: Project PT 0043), by the Institute for the Regulation of Water and Waste, IRAR, and by the participating water and wastewater.

The AWARE-P contract was signed in December 2009 and the project will finalise in 2011.

AWARE-P products

AWARE-P products include:

- Manuals of best practice;
- Software for planning and decision support in rehabilitation;
- Software user manuals;
- Pilot studies / demonstration cases results;
- Training courses (direct teaching);
- E-learning training courses;
- Web-based dissemination platform;
- Technical and scientific papers and reports.

Portuguese utilities will receive training and will have free (i.e., public, no charge) access to all products of the project by 2011. The Portuguese National regulator will encourage their use.

The software and its user manuals will be developed in Portuguese and in English and made also be publicly available at an international level.

IAM Drivers, research gaps, priorities and products needed

There is a need for joint initiatives, particularly in Europe, that create synergies, and allow for sharing and complementing competences and experiences. R&D has to be based on the joint work and cooperation between the key types of stakeholders, such as utilities, regulators, researchers, users, authorities and financial agencies. This is fundamental to create stakeholder awareness, change the existing culture of taking the water services for granted, implement adequate financial mechanisms, create know-how and develop effective decision-support tools.

During the World Water Forum, held in Istanbul in April 2009, LNEC, the Portuguese national laboratory of civil engineering, and the Strategic Asset Management (SAM) Specialist Group of IWA jointly organised a panel discussion aiming at identifying research challenges and opportunities for a sustainable asset management of urban water infrastructures. The objective was to get a multi-stakeholder perspective. Contributors included the IWA President, the IWA SAM SG Chair, a senior officer of the European Investment Bank, utilities CEOs, consultants, academics, researchers, and representatives of national professional associations, in order to try and identify the best paths to move forward. The outcome of this meeting is summarised in Tables 1 and 2.

Table 1 IAM Drivers and R&D gaps.

SAM drivers
• Promote adequate levels of service and strengthen services reliability
• Improve the sustainable use of water and energy while minimizing the carbon foot print
• Plan and promote climate change adaptations in a phased way
• Manage risk of service failure, taking into account users' needs and risk acceptability
• Give preference to rehabilitation of existing assets instead of building new, when feasible
• Promote investment and operational efficiency gains of water utilities
• Make a clear and straight forward justification of investment priorities
R&D gaps
• Innovative technologies for asset condition assessment (e.g., on-line monitoring) and better understanding of the relationship between asset condition and level of service
• Information management improvements and understanding organizational constraints
• Better understanding and incorporation in the SAM process of the stakeholders' needs and expectations
• Managing interactions between urban infrastructures (drinking water & wastewater; urban water and other)
• Better understanding and improved control of asset deterioration processes
• Economic assessment of indirect and external costs and benefits
• Reliable, long lasting and low cost rehabilitation materials
• Quantifying uncertainty in the different models
• Water security innovation

Table 2 IAM R&D priorities and products needed.

R&D priorities and products needed
• AM regional directives, international standards and guidelines (e.g. AM policy, AM methodologies and procedures, protocols for data collection and information management) • Guidelines and communication materials to promote the change of culture of the organizations with a continuing effort to implement SAM • Comprehensive, user-friendly and flexible SAM computer-based systems that promote a step by step SAM implementation • Common framework and plug & play software systems and models for SAM of small and medium size utilities and systems • Communication, training materials and guidelines expressly directed to the operational / field staff. • Finance models for single utilities, and at multi-utilities or regional levels • Reference methods for economic assessment • Enhanced construction and renewal materials and performance assessment of new materials • Standard risk management guidelines for urban water systems, including how to deal with risks associated to low probability hazards and catastrophic consequences • Effective international networks of SAM stakeholders, including service users • Processes for assessment of asset condition • New generation of information management systems for SAM that allow for integrating and incorporating different existing information systems • Best practice manuals and training materials (including for e-learning) addressed to the policy-makers, technical staff and operational staff and to utilities with different levels of complexity and development • Decision support tools to support water systems adaptation to climate change and efficient use of water and energy, assuring added flexibility and resilience.

How to implement an IAM approach

The core component of asset management of urban water systems is their rehabilitation. The identification of rehabilitation needs, the establishment of intervention priorities and the selection of the engineering intervention options may be straightforward in some cases, but in most situations this is not the case. From the conceptual point of view, there is nowadays a consensus on the need for supporting decision-making on a comprehensive approach that accounts for the cost of building, operating, maintaining and disposing of capital assets over their life cycles. There is also a general agreement on the ultimate aim of infrastructure asset management: optimise the balance between performance, cost and risk in the long run. However, this is much easier to say than to implement in practice. Utility managers recurrently claim that there is a need for guidance and training materials that assist them in the implementation of an integrated rehabilitation approach.

There is no one recommended formula for implementing an IAM strategy. Interpretations and solutions vary widely. IAM is a management concept that helps utilities to address and prepare for both anticipated and unexpected problems. IAM planning is based on the evaluation on infrastructure's current physical situation, as well as of the water system's financial and managerial situation. It requires that fundamental decisions are made about the water system's purpose, structure, and functions. In simple terms, there are five key questions that need to be answered in the implementation of an IAM approach:

- *What is the current condition of my infrastructure?* The answer requires inventorying the existing physical assets and assessing their condition and their current value, taking into account their expected remaining useful life and their replacement cost.
- *What level of performance can I expect from my infrastructure?* The answer requires an understanding of the performance objectives of each stakeholder, of legal and contractual requirements and of current levels of performance.
- *In my current system, what are the most critical components that will safeguard my required*

performance in a sustainable manner? This requires the analysis of under what circumstances failures occur, how they occur and with what probability. It is also necessary to understand the costs of repair and to assess the consequences of each failure mode.

- *What are the minimum costs over the lifecycle that I will have to allow for?* It is necessary to identify the main direct and indirect costs to budget for, and to estimate their respective amounts. It must also be borne in mind that operational and maintenance costs may not be constant over the life cycle, because the probability of some forms of failure increases with the age of the asset. This IAM strategic implementation phase involves identifying current investment, operational and maintenance practices and analysing the most viable alternative management options for the organisation in question.
- *What is the best long-term investment strategy to adopt?* To answer this question requires investment planning and identifying how to finance it.

The responses to the questions above may assume a greater or lesser degree of sophistication. An organisation shall not wait for all information to become available to start implementing an IAM approach. Efficient techniques exist which allow to overcome many of the difficulties and data shortcomings. IAM should start with the implementation of simple procedures and evolve gradually, via an iterative process of continuous improvement of the information and analytical techniques used. In fact, any IAM integrated approach should be based on the plan-do-check-act (PDCA) principles and be organized in three levels of planning - strategic, tactical and operational. The main activities to be carried out in each of these levels (*e.g.*, definition of objectives, establishment of assessment criteria and targets, diagnosis, action-plan development, implementation, monitoring and control), are illustrated in Figures 1 and 2. The main tools and technologies that are recommended to support each task in the decision-making process may include, among others, performance indicators, hydraulic simulators, statistical analysis and optimization algorithms.

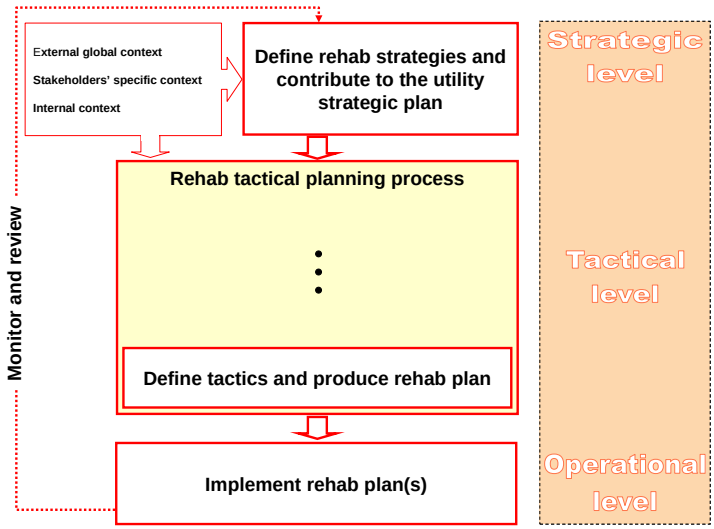

Figure 1 – Integrated rehabilitation process

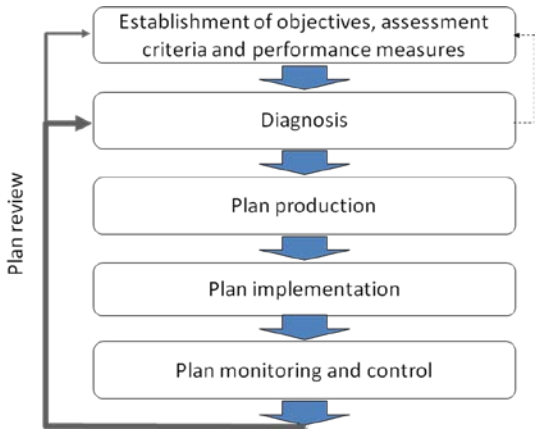

Figure 2 – Different stages of the planning process

Any utility implementing an IAM approach should:

- make the decision of changing the existing routine and reactive culture at the top level of the organisation;
- remember that people are the main component of a IAM program;
- start step by step, with small, realistic but decisive actions;
- look for external expert advice if needed (e.g. consulting services), but keep it within a limited portion: IAM is an internal process that cannot be outsourced;
- be aware that acquisition of any IAM software is not an adequate starting point for the implementation of IAM and does not replace the internal organizational process that is required;
- network with its peers, sharing problems and solutions;
- establish joint projects with other utilities, creating scale effect, in order to get assistance, develop and implementing methods and tools and provide training (see the example of Portugal with the on-going AWARE-P project, above referred).

The above listed items may look like obvious, but practice shows that failure stories may often be explained because one or several of these points have not been taken into consideration.

Concluding remarks

Water utilities tend to be seen by the other economic sectors, and particularly by the financing agencies, as organizations with high inertia and low efficiency. There is therefore the need for achieving efficiency gains, making clear and straightforward justification of investment priorities, and give preference to rehabilitation of existing assets, instead of building new, when feasible.

IAM methodologies and support tools developed in recent years tend to be directed to big and sophisticated organisations. This situation must change, and has already started to change. It is up to the utilities themselves to launch this process. It is also the role of academics, researchers, consultants and IT providers to participate in it. Last but not least, policy makers, the administration and regulators should promote the necessary changes and create the adequate incentives and conditions.

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