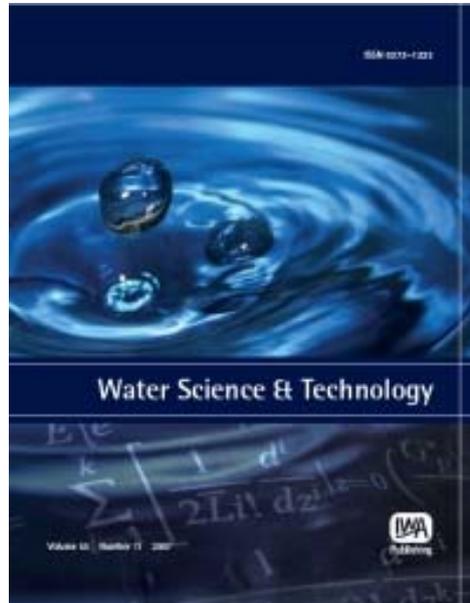


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Boosting innovation in the water sector – the role and lessons learned from collaborative projects

H. Alegre, S. T. Coelho, J. F. Feliciano and R. Matos

ABSTRACT

A key worldwide challenge in most sectors is to boost the effective adoption of innovation, as underpinned by the new European Union research programme Horizon 2020, which focuses on increasing innovation in Europe from 2014 to 2020. This is particularly relevant in the water sector, often perceived as conservative and averse to change. This paper discusses the role that collaborative knowledge-transfer projects can play in effectively rolling out R&D in the water industry. LNEC (Laboratório Nacional de Engenharia Civil) has designed a structured model based on a phased programme and a network of utilities and researchers. The paper presents the core principles, the rationale, the model and methods used, and the theoretical background, as well as the project's impact, outcomes and products. The discussion highlights the lessons learnt and provides a formal analysis of the advantages of focusing on middle management as an effective entry point, even if innovation is needed across the organization. Making training materials, guidelines, use cases, data and software publicly available after the project's end has proven to have a decisive multiplying effect. The paper also argues in favour of the collaborative model as a basis for R&D sustainability, and details on-going and planned developments.

Key words | boosting innovation, capacity building, collaborative projects, management processes, research rollout, water utilities

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INTRODUCTION

Practice shows that much of the research carried out in universities and R&D organizations fails to be incorporated by the targeted end-users. However, innovation is increasingly needed in the water sector, often perceived as conservative and displaying high inertia against process or technology changes. The monopolistic nature of urban water services, their inherent low appetite for risk, and the long duration of the infrastructure assets are some of the underlying reasons. The medium or small size of most water utilities, with limited skills and resources, represents an added challenge. Innovation is easier for off-the-shelf products that respond to immediate needs and do not require significantly new competences or organizational changes. Challenges increase when innovation requires changes in internal processes or organizational features and/or the acquisition of new competences, particularly in cross-cutting activities.

R&D organizations must recognize this challenge and address the issue of uptake at least with as much intensity as they create new technologies, tools and methods. A

successful vehicle is provided by collaborative projects where research and industry partners create a network and work together for mutual benefit. Although collaborative projects have been used for a long time, the model designed and implemented by LNEC (Laboratório Nacional de Engenharia Civil) is supported by a set of core principles that have turned out to be key success factors (Table 1).

COLLABORATIVE PROJECTS: WHY?

The collaborative project format is particularly effective for topics or knowledge areas that require a considerable shift in mind-set for the industry, as well as for decision-makers, politicians, the media, and society in general. This may include technologies, processes and management practice. Mutual validation and recognition from a peer group provides a crucial comfort zone for early adopters. The scale of these projects ensures higher visibility and impact on

Table 1 | Core principles of the collaborative format

Principle 1	Researcher needs to work WITH the utilities, not FOR the utilities.
Principle 2	Every participant (researcher or practitioner) needs to be prepared to share their experience, views and know-how with the other partners, and be prepared to learn from them as well.
Principle 3	The materials developed in the scope of these projects by the research team are made publicly available.

regional or national terms, contributing to creating the aimed awareness and appetite for the theme, and increasing the returns in terms of recognition and image. Developing a range of cases that are representative of a nation's reality significantly leverages the impact, allowing for further learn-by-example training and spawning learning communities.

COLLABORATIVE PROJECTS: MODEL AND METHODS USED

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 (Table 2). This provides scale to the projects and produces significant networking. It also allows for combining strategic research with practical problem solving, and industry hands-on capacitation.

The project website has a public area focusing on promotion and visibility of the project, and dissemination of publicly available end products. The private area, accessible by the project partners, makes available all the training materials, guidelines and templates, recorded webinars, publications, frequently asked questions, discussion forums and project management tools.

Table 2 | Format and features of LNEC's collaborative format

Topics	The projects are launched on topics of national relevance where R&D is ready for rollout.
Proposal	An open proposal is issued defining objectives, methodology, schedule, training syllabus, partner roles, deliverables and expected benefits, and cost of participation. When relevant, the utility selection process may include criteria designed to ensure national representativeness.
Number of participating utilities	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 capacity to provide one-to-one assistance to all participants.
Scheduling	A phased schedule is followed, with 3- to 4-month phases and a total duration of 12 to 24 months. Each phase starts with face-to-face training and the specification of the work to be developed by each participant.
Training	Training is complemented with e-learning via webinars and on-line materials. While the utility teams develop their pilot cases, LNEC and its development partners assist them and analyse results.
Competences created	The 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. 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.
Benefits for participating utilities	Each project being focused on a theme that is recognized as an issue for every participating utility, a direct benefit is to address and sort out this issue within the organization based on leading-edge knowledge and expert support. Direct gains for the participating utility are, in general, improved productivity, improved quality of the service delivered, higher efficiency in the use of resources and business risk management and improved business risk management.
Benefits for researchers and IT partners	Comments and suggestions from the utilities are fundamental to leverage knowledge building and advance methods and supporting tools. Many scientific and technologic advances have been achieved as a direct result of these projects. Additionally, the projects provide cases and standardized and quality controlled data that are used during and after the projects as core material for new academic research, in particular for MSc and PhD theses, and for IT developments.

Experience has shown that the success of these projects requires the following:

- *Relevance of the topic for the utilities*: the topic and objectives of a collaborative project must address areas where there is appetite for evolution; drivers often include awareness for previous projects or successful pilots, competitive peer pressure, legislation, regulatory pressure, perceived efficiency gains, economic reasons or societal pressure. Utilities need to recognize the topic as an issue for them, so that they acknowledge the value of the project outcomes as relevant direct benefits for them.
- *Affordable participation cost*: assuming a need for reasonable cost coverage, the share of cost of each participating utility to ensure project break-even for the project lead organization is low compared to a standard one-to-one consultancy/research contract of similar scope and depth (particularly in terms of assistance and products delivered); the high value of the created peer network adds to the perceived return.
- *Trust*: such projects require an adequate balance between the non-disclosure of sensitive information and the benefits of sharing problems, experiences and results among peers. The participation contract establishes general principles, but the key for success is the level of trust that utilities need to feel with regard to the lead organization. Practice has shown that this level of trust is built over time, and that the utilities share much more than might be initially expected, as they realize the benefits and net result over time of sharing information with peers.
- *Contracted duties and obligations between the project lead organization and each participating utility*: established on publicly available terms, the individual contracts are designed to exert positive pressure on all partners. They imply the commitment of the top managers to the lead organization, along with external exposure, which creates internal pressure on the utility's project team and its middle-management lead; the contracts also promote the allocation of internal resources to the project, including time, chain-of-command and responsibility.
- *Peer competitiveness*: a collective project with frequent plenary progress meetings and networking opportunities places significant positive pressure on all utility teams for staying on schedule and avoiding lagging behind with implementation and result reporting. The pressure thus created is often crucial in early adoption, as making space for novel tools, methods or processes is

inevitably an uphill struggle in the intense environment of daily utility management and operation.

- *The self-assessment and continuous-improvement reporting scheme*: the projects include a self-assessment system and confidential continuous improvement-based reports by the coordination team that boost feedback at each phase; final (confidential) individual utility reports, as well as an open analytical digest of cross-project results, extract the main conclusions and provide the means for anonymous benchmarking.

PAST AND ON-GOING COLLABORATIVE PROJECTS

This collaborative model has been in use by LNEC since 2000. AGS, a private group of water operators and a partner in most of LNEC's collaborative projects, would later adapt the model to build capacity and promote innovation within their own group (Table 3).

THEORETICAL BACKGROUND

Although the current model followed by LNEC's collaborative projects has evolved essentially through a learn-by-experience process, its successful application has been more recently examined from a more formal viewpoint. Not coincidentally, much of the approach is aligned with existing theoretical concepts.

It is important to understand and distinguish two different concepts: knowledge creation and knowledge transfer. Both are fundamental in order to speed up the dissemination of a particular process and to promote the organization's productivity and its inherent competitiveness.

A company is not a machine but a living organism, where human assets are crucial in all forms of activity. Therefore, in order to achieve higher levels of innovation, knowledge creation should be at the very centre of an organization's human resources strategy (Nonaka 1991).

The effectiveness of collaborative projects depends on the knowledge transferred and on the internal growth spiral within the organization (Nonaka & Takeuchi 1995). There is often a cognitive dissonance when transferring methods from an expert community, in an explicit form, to a technical community that normally deals with tacit knowledge (Feliciano et al. 2013). It is important to be aware of this difficulty and to find ways to overcome it. This is particularly

Table 3 | Collaborative projects led by LNEC and by AGS

	Project	Topics	Dates	No. of utility partners
By LNEC	PI-Waters	Performance indicators of water and wastewater utilities	2000–2003	16
	INSSAA	National initiative on water network analysis and simulation	2004–2007	11
	PASi21	National initiative on performance assessment of water and of wastewater treatment plants	2009–2011	15
	AWARE-P	Applied research project on infrastructure asset management of urban water services	2009–2011	8
	iGPI	National initiative on infrastructure asset management of urban water services (Leitão <i>et al.</i> 2014) <i>Note: a second round of iGPI is scheduled for Jan.–Dec. 2015</i>	2012–2013	18
	iPerdas	National initiative on water losses and energy efficiency	2013–2014	15
By AGS	PIMSAA	A direct follow up of INSSAA; four editions	2007–2008, 2009, 2010 and 2011	15 in each edition
	AGS-GPI	A twin project of iGPI, running in parallel and sharing the same approach and many of the materials (Feliciano <i>et al.</i> 2013)	2012–2013	11
	AGS-PSA	Water safety plans	2012–2013	8

challenging when the new processes and associated knowledge are cross-cutting within the organization.

These collaborative projects promote a way to respond to the concerns related to process standardization in the utilities. Nonaka & Takeuchi's (1995) approaches can be followed; tacit and explicit knowledge exist in all organizations. As an example in the AGS group of utilities, the methods imported from the AWARE-P project (www.aware-p.org) and the technical guides of the national regulator ERSAR (Entidade Reguladora dos Serviços de Águas e Resíduos) (Alegre & Covas 2010; Almeida & Cardoso 2010) to the holding company's engineering teams are a form of explicit knowledge; the utility teams' operational experience is a form of tacit knowledge. The initiative must interact with both knowledge forms and grow spirally (Nonaka & Takeuchi 1995).

It can be fruitful to consider adapting knowledge creation methodologies to knowledge transfer forms. The biggest concern regarding knowledge creation methodologies is how to generate value systematically and continuously in the organization. The virtue that needs to be explored is the efficiency that these methods can add to the organizations in internal and/or external knowledge transfer (e.g. from research bodies, universities, government agencies, public and private utilities). Projects such as the implementation of infrastructure asset management policies in utilities may, and probably will, span the organization's structure horizontally and vertically; so alignment is obviously needed, and an efficient way of achieving it with all parties concerned is crucial.

ENTRY POINT: KNOWLEDGE TRANSFER THROUGH MIDDLE MANAGEMENT

All of the collaborative projects listed in Table 3 have been mainly directed at middle managers, with the engagement and commitment of top management, which is critical for the project success and long-term footprint within the organization (Figures 1 and 2).

This has proved to be an effective way of speeding up growth spirally. It is then the middle managers' responsibility to carry out an internal transfer process in the 'middle-up' and 'middle-down' directions within their organizations. Middle managers are at the centre of gravity of an organization, at the intersection of the vertical and horizontal flows inside the business; they act as a bridge between the vision of top management and the often-chaotic reality of those at the front line. Middle managers mediate between 'what is' and 'what should be' (Nonaka 2007). Whenever top management is committed, it is possible for the new learnings and competences to flow top-down and bottom-up effectively.

With the crucial formal commitment of top management, the participating utility team is built around three permanent members, one of which is the utility project manager. The utility team has a duty to learn and communicate the learnings within the organization. All supporting materials accessible to the core team may be reused internally by the participating utilities. In some cases utilities set up an interest group that observes and indirectly takes part in the project.

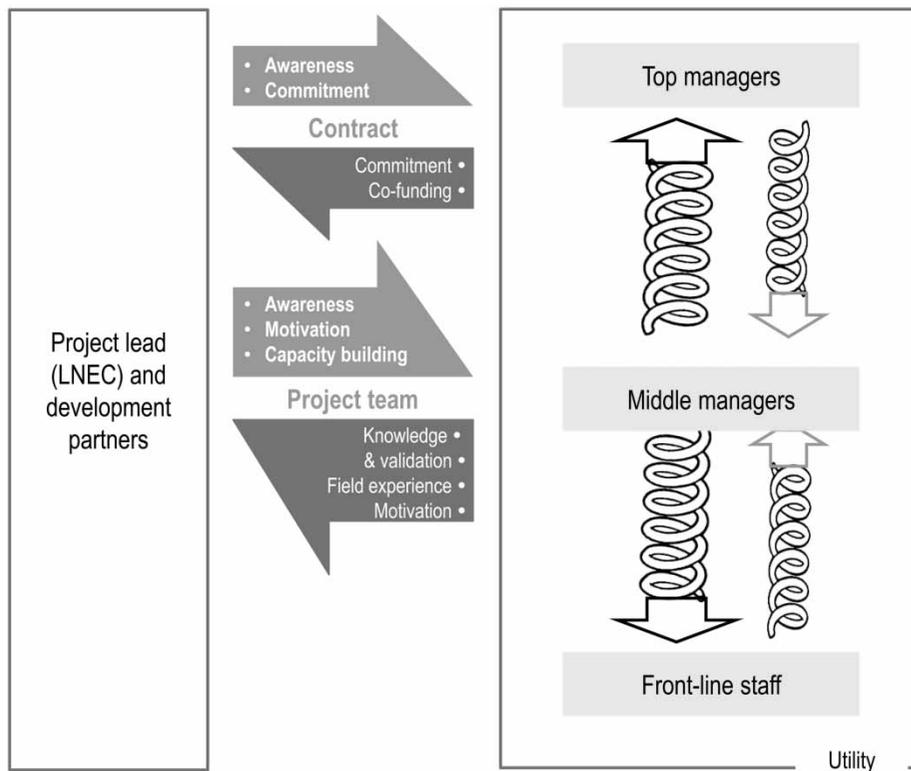


Figure 1 | Relationship between the leading R&D consortium and each participating utility.

In the case of AGS's collaborative projects, the holding corporation's engineering support division played the lead role. Under agreement from LNEC, the training and support materials have been made available and are used by AGS for their own projects, thus effectively giving rise to replicated experiences at a wider scale.

PROJECT IMPACT, OUTCOMES AND PRODUCTS

The outcomes of LNEC's collaborative projects include direct results for the utility partners as well as products placed in the public domain and made available for professionals (Table 4), in addition to published research results. Broad dissemination is systematically made to other utilities, policy-makers, regulators, academics and researchers, consultants and society at large. One of the most effective means in local terms is the final Open Forum where the opportunity is given to all project participants to report their own experience. This adds to papers in journals, media publications, keynotes and communications in conferences, interviews, and project and corporate websites.

The continuity in industry-sourced R&D funding generated in this way allows for long-term strategies in the

production of a series of technical documentation and of coherent and professionally supported open-source software (Table 5).

From a broader viewpoint, these projects also have a significant impact and have contributed to recognizable changes in the water sector and society in a number of ways. The large-scale adoption of methods and technologies helps create a market for suppliers and helps standardize good practices and technical standards. It also has a relevant effect in knowledge transfer: the main learnings are integrated in professional courses and university post graduate courses.

ON-GOING AND PLANNED DEVELOPMENTS OF THE COLLABORATIVE MODEL

While staying faithful to the core principles, 15 years of implementing collaborative projects at LNEC have allowed for the continuous improvement of the model.

- From an initial duration of 2–3 years, projects have become shorter; topics such as water losses and energy efficiency management or infrastructure asset management have been successfully condensed into 12-month projects, to be

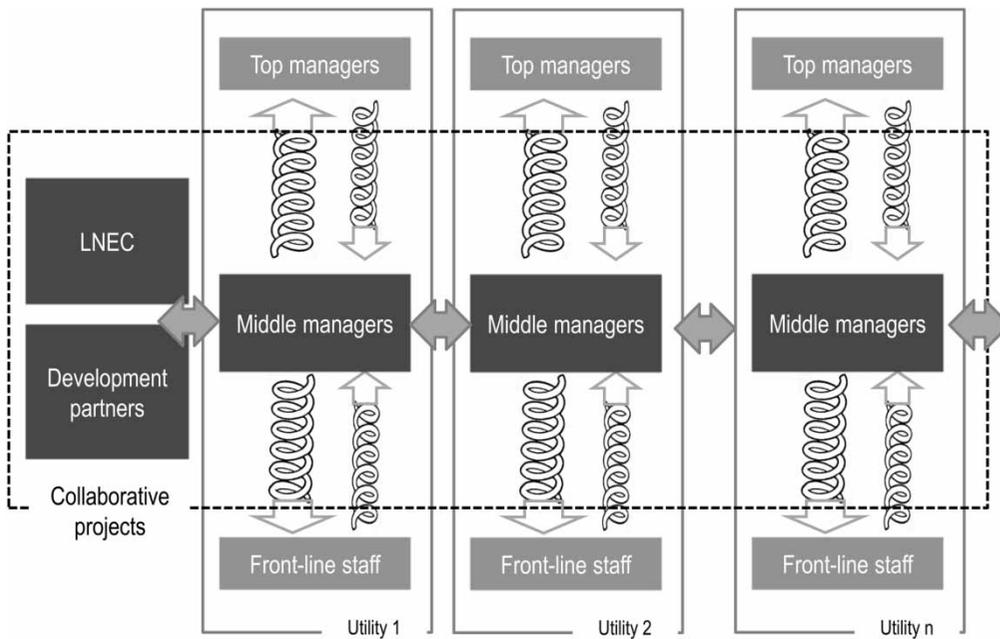


Figure 2 | The core team in LNEC's collaborative projects.

Table 4 | Project impact and outcomes

For the participating utilities	<ul style="list-style-type: none"> • Competences gained with the training and assisted experience; • Actual products developed by the participating teams (e.g. plans, models, new or enhanced processes); • Awareness and engagement of the several decision levels of the organization; • Improved communication and information flows between different departments of the organization; • Implementation of many new or enhanced procedures for data collection.
For the water sector and society	<ul style="list-style-type: none"> • For utilities that do not directly take part, the projects: <ul style="list-style-type: none"> – help raise awareness of the issues under analysis; – make available software tools, documentation and planning templates; – give rise to networkable communities of 'initiated' practitioners. • The national water services regulator, ERSAR, has closely followed or been partner of every collaborative project promoted by LNEC, and has helped to promote and validate them – the existence of projects 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. • Several methodologies and tools developed and broadly validated through the projects have made their way into graduate and postgraduate university curricula in Portugal and other countries.

repeated biennially for newcomers as well as for more advanced participants who have successfully taken part in earlier editions. This solution aims to achieve repeatability, added impact and sustainability of the capacitation.

- From 100% face-to-face training, concentrated at the start of each phase, in recent editions project meetings are increasingly used for hands-on exercises and group discussions; formal presentations are provided in weekly 1-hour webinars; this maximizes the effect of group meetings.

- Standardized procedures for any collaborative project have been informally built over the years; this is currently being documented.

The model has proved effective in a specific region such as Portugal, and applied to novel yet relatively consensual topics attracting mostly the early adopters from the industry. It will probably need adjustment in order to become suitable for multi-region implementation or for scaling-up of the

Table 5 | Types of project products placed in the public domain

For the water sector and society	Guidelines and sample templates for procedural and planning documents Training materials (presentations slides, recorded webinars, written materials) Software Industry events to disseminate use cases and products Papers in industry and scientific publications Postgraduate (MSc and PhD) dissertations
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capacity building effect. If any other research organization would like to copy the approach, they should not be afraid of major difficulties if the recommendations summarized in this paper are followed. In any case, LNEC is prepared to share more of its experience if and as appropriate.

Most projects have been first rounds of innovation in each specific area, although AGS have successfully pursued repeat runs of one specific topic. LNEC are now in the process of turning the most recent projects into permanent fixtures, repeated biannually, and scaling up to an international scale in Brazil and Europe.

On-going efforts are in the establishment of clusters, where local hubs of R&D and consultants can provide individual assistance to the utilities. The role of e-learning becomes crucial in this regard. The recent establishment of the Urban Water Commons (www.uwcommons.org), a collaboration between LNEC, ITA (a research group of Universitat Politècnica de Valencia, Spain) and Instituto Superior Técnico (Portugal) is the foundation for this new approach.

A SUSTAINABLE MODEL FROM THE R&D VIEWPOINT

From the viewpoint of R&D effectiveness and viability, this format provides several important advantages:

- A more sustainable source of funding than classical, national- or international-level R&D funding programmes; in short, a form of mutualization of the R&D effort, paid for – and co-developed – by its direct beneficiaries, who would not single-handedly have the means to invest in generating their own innovation.
- The coherent and systematic generation of large-scale data and good numbers of representative cases.
- A much closer relationship between researchers and the ‘real world’ of the industry, its needs, the problems to

be solved, and the organizational structures that must be taken into consideration in devising any kind of solution – this is instrumental in establishing successful short- and long-term R&D priorities.

CONCLUSIONS

LNEC’s model of collaborative projects has proven to be an effective format in rolling out research and boosting innovation in the Portuguese urban water services industry. It also proved to be adaptable to non-research environments, such as groups of utilities, when there is a need to leverage significant changes in organizational processes in a structured and coherent way among several operators.

Feedback from participating utilities has been supportive from the outset, 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 has produced vast amounts of representative data sets that are vital in the validation of methods and tools, as well as a variety of representative cases.

The success of these projects at the national level in a country whose water sector is as diverse as Portugal’s, both from the institutional framework, size, level of sophistication, public/private nature, and many other viewpoints, provides substantial evidence of their suitability as a template for international cooperation and cluster-based cross-border efforts. Scaling up to international level is an important next step in the quest for wider impact and exponential growth of both the networking effect and the ability to generalize uptake of proven technical methodologies and tools.

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First received 9 January 2015; accepted in revised form 2 July 2015. Available online 15 July 2015