

Assessing human resources renovation needs in water utilities

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Abstract

Human resources are one of the most important assets of water utilities being responsible for assuring systems' management and playing an important role in the tacit forms of the organisational knowledge. In organisations with the responsibility to manage vast, diverse and long life cycle infrastructures, with an adequate level of service and acceptable risk, knowledge transfer between peers should be assured to maintain a stable human resources framework. In water utilities, strategic asset management should include the long term planning of human resources alongside with urban water infrastructure assets to ensure service sustainability. Based on these assumptions and driven by the legal obligations in developing infrastructure asset management (IAM) plans, AGS (Administração e Gestão de Sistemas de Salubridade, S.A.) created and implemented a novel *Personnel Aging Index* (PAI) with the main goal of evaluating the human resources framework, including employees' age, its professional categories and the remaining time needed to transfer knowledge to new elements. The paper describes AGS' approach to human resources management under the asset management policy and the index formulation. A case study regarding standardised performance indicators to evaluate human resources and PAI will be analysed allowing utilities' comparison.

Keywords

Asset management; human resources planning; tacit knowledge; personnel aging index

INTRODUCTION

Strategic asset management in water utilities implies the challenge of managing vast and diverse infrastructure assets while meeting a required level of service in the most cost-effective way. In Portugal asset management policies have been assuming an increasingly important role being mandatory to develop infrastructure asset management (IAM) plans. For this reason national utilities' concerns are currently focused in long term planning of infrastructural assets. Nevertheless, in this process, human resources and the existing tacit knowledge inside organisations can be seen as an "asset" that should be properly managed alongside with infrastructures.

AGS is a Portuguese multi-operator owned by Marubeni and INCJ (Innovation Network Corporation of Japan) that manages 13 water utilities in Portugal and Brazil with long term concession agreements. IAM always played an important role in AGS due to its contracts obligations and more recently due to a legal planning requirement. Following these concerns, AGS has been participating in European research and innovation projects, such as CARE-W, AWARE-P and iWIDGET, enabling the establishment of an asset management policy inside the group and the implementation of a collaborative program to support utilities on developing IAM plans (Feliciano *et al.*, 2014).

The program's first edition followed the AWARE-P's approach focusing mainly on infrastructural assets. The second edition was implemented to monitor and improve IAM plans towards a closer alignment with the ISO 55 001 requirements. In the current edition, the human resources dimension was introduced in order to enlarge the plan's scope. In this dimension it is clear that teams should be properly sized with suitable professional skills. Teams' balance, considering the previous

concerns, should be aimed in order to ensure the service sustainability in a long term perspective.

HUMAN ASSETS AS AN AXIS OF ANALYSIS IN STRATEGIC ASSET MANAGEMENT

Organisational value and competitiveness depend mostly on the development, use and distribution of knowledge-based competences. As knowledge increasingly becomes a key strategic resource, the need of organisations to develop a comprehensive understanding of knowledge strategies, processes and tools for the creation, transfer and deployment of this unique asset is becoming critical (Mentzas *et al.*, 2003).

Within an organisation, knowledge can be passed by apprenticeship, through observation and guidance of a “mentor” (tacit knowledge) or by books, manuals or other procedures that clearly express information through language, images or other means of communication (explicit knowledge). Nonaka and Takeuchi (1995) argue that conversion of tacit to explicit knowledge is the most crucial knowledge creation method in organisations.

In this context, human resources are a valuable asset as they act as a knowledge vehicle in an organisation. In order to ensure a proper knowledge transfer, it is important to adopt a long term perspective on human resources management and to guarantee that human resources renewal processes are planned in advance allowing enough time for the young professionals to learn and the senior staff to transfer their know-how and experience to the younger employees.

HUMAN RESOURCES RENOVATION NEEDS

To ensure service sustainability, human resources asset management is as important as infrastructure asset management. Both are valuable assets, perform their activity during a given lifetime and require careful management and renewal after their useful life. However, while physical assets such as pipes, meters or valves can be instantly replaced without significantly affecting the quality of service, personnel renovation typically requires an adaptation and a learning period for the new element to become fully performant.

Additionally, when replacing an employee that reaches his/her retirement age by a new employee, performance is not the only issue. Tacit knowledge acquired by the elder employee during his lifetime career might be lost in the organisation, if not transferred in advance. As this type of knowledge is not easily documented, it needs to be passed from person to person within the working environment. This is particularly relevant in water utilities’ technical departments where a specific knowledge of the utility activity is required which is not easily obtained outside the organisation.

To prevent this lost, it is necessary to assess the organisation aging level, identifying teams with high or low maturity levels and to detect situations where low maturity teams can lead to lower performance levels or high maturity teams where renovation can be compromised due to potential gaps between time to retirement and available experienced employees to occupy their places.

PERSONNEL AGING INDEX DEFINITION

Portuguese Water Regulator (ERSAR, 2014) and International Water Association (Alegre *et al.*, 2006) assessment systems include performance indicators to evaluate the adequacy of human resources and the training frequency (explicit knowledge). However, these indicators were not thought to describe teams’ maturity level, which assumes an important concern in organisations like

water utilities (WU) where systems operational management have a higher dependence on personnel knowledge.

To respond to this gap, AGS developed a novel *Personnel Aging Index* (PAI) which describes human resources average work career as the ratio between the sum of the remaining useful professional life for all every employee and their total lifetime career:

$$PAI(t) = \frac{\sum_{i=1}^n RUpl_{i,t}}{\sum_{i=1}^n Cl_i}$$

where t = reference time (years); $PAI(t)$ = personnel aging index at time t (dimensionless); n = total number of employees; $RUpl_{i,t}$ = remaining useful professional life of employee i at time t (year); and Cl_i = career length of employee i (year).

The PAI can be computed for the entire organisation or single department. It can also be determined by professional category, since each one implies a different useful professional life according to the graduation level and/or period needed to acquire specific skills through working experience and internal training inside the organisation. For example, graduate employees begin their careers later than undergraduate employees and coordination responsibilities should only be assumed by technicians with some level of working experience. These differences are translated into distinct useful professional lives and total lifetime careers.

ASSESSING PAI IN WATER UTILITIES

It is recommended to compute PAI taking into account several assumptions that can be customized case by case or according to the organisations' best practices, legal framework, human resources policies, among others.

For water utilities it is suggested to compute PAI for the professional categories that are directly responsible for ensuring water services quality of service at technical level, such as:

- a) *unskilled technician* (UT), employees with compulsory education;
- b) *skilled technician* (ST), employees with compulsory education and certified skills;
- c) *undergraduate coordinator* (UC), coordinators with compulsory education and coordination responsibilities;
- d) *graduate technician* (GT), employees with university degree;
- e) *graduate coordinator* (GC), employees with university degree and coordination responsibilities.

For each category, it should be defined the useful professional lifetime according to graduation levels and work experience required inside the company.

While all of these careers are essential for the activities of a water utility, their paths are quite different. An employee working as a UT during his lifetime career typically starts working after completing compulsory education, without specific training, that one performs until reaching retirement age. This category includes unskilled plumbers, pumping station operators or water meter readers, among others.

A ST, on the other hand, starts his activity later since after completing compulsory education will need one year of training, according to AGS' practices, to achieve the aimed level of technical skill, acquired through formal education, practical training or other that can be evidenced by a certificate

or legal permit. Electricians, mechanics or heavy machinery drivers are examples of ST.

UC is a professional category that requires some level of knowledge and experience in the operation of water or wastewater systems. Therefore, there is a period required for these employees to acquire this degree of tacit knowledge and experience within the utility, usually as a UT or a ST. According to AGS’ practices, in Portugal, this period should not be less than 10 years. As a consequence, UCs like foremen have shorter professional lifetime careers than UTs or STs.

There are differences when approaching GT category. Typically, compulsory education is followed by a 5-year period with university education which implies starting the activity later and having a shorter professional lifetime career when comparing to UT or ST. Engineers are included in this category.

GC is a professional category that requires university education and some level of tacit knowledge in coordination activities. This type of knowledge is usually acquired by performing GT activities within the utility during a period of time that should not be less than 8 years, according to AGS’ practices. For these reasons, graduate coordinators as chief operating officers or general managers have the shortest professional lifetime careers.

In order to compute PAI for each category, the useful professional lifetime according to graduation levels and working experience required inside the company should be defined. Figure 1 presents the professional useful life by category (being defined by the difference between retirement age and the initial working age), illustrates possible employee flows inside the organisation (dashed arrows) and identifies the categories (UT, ST and GT) in which employees should be recruited from external labour market (filled arrows).

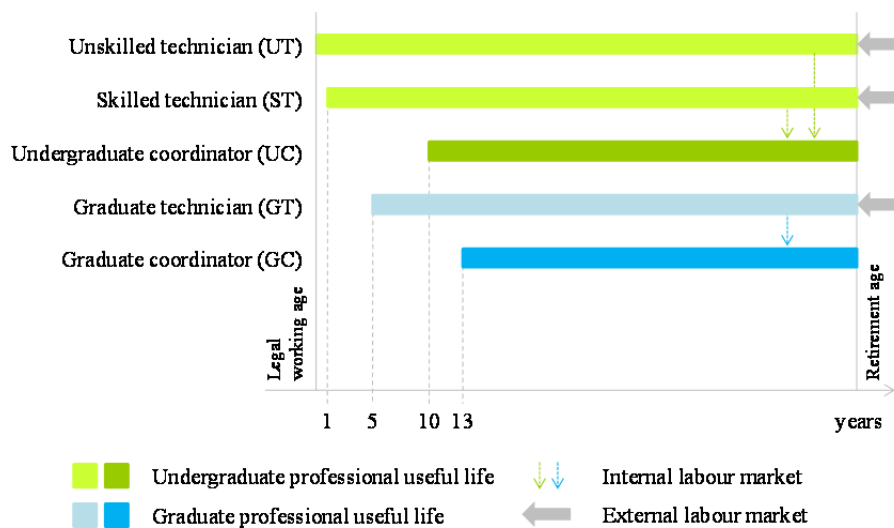


Figure 1. Professional useful life of each category.

Reference values were defined for the coordination categories (UC and GC) since these are especially relevant in terms of tacit knowledge level. They typically correspond to job functions that are more difficult to replace, becoming more critical for the organisation. The reference values were established taking into account legal working age, retirement age and graduation periods according to Portuguese legislation and learning periods within the utilities.

The learning periods in which employees acquire specific knowledge and capture organisation’s culture are crucial in a water utility. Failing in ensuring a proper knowledge transfer may have

consequences that are not easily overcome. Based on AGS' experience the UC category requires a minimum learning period of 10 years, while GC requires a minimum of 8 years. For these categories, poor PAI levels have two ranges. PAI values above 1 represent teams that did not accomplish the minimum learning period and PAI values below 0.26 (UC) or 0.23 (GC) represent older teams that may not be able to transfer knowledge in the defined minimum learning period. Fair values transmit alerts for teams which represent young coordinators or alerts for identifying employees to be prepared for the category.

Table 1 summarises PAI's reference values for UC and GC categories and their corresponding results interpretation.

Table 1. PAI reference values for UC and GC categories.

Category	Reference values		Interpretation
Undergraduate coordinator (UC)	]0.00 ; 0.26[	Poor ●	Teams without the required period to transfer knowledge
	[0.26 ; 0.32[	Fair ●	Alert for identification of UT or ST to initiate the minimum learning period
	[0.32 ; 0.95]	Good ●	Stabilised teams
	]0.95 ; 1.00]	Fair ●	Younger teams with coordination responsibilities
	]1.00 ; 1.26]	Poor ●	Teams that did not accomplish the minimum learning period
Graduate coordinator (GC)	]0.00 ; 0.23[	Poor ●	Teams without the required period to transfer knowledge
	[0.23 ; 0.29[	Fair ●	Alert for identification of GT to initiate the minimum learning period
	[0.29 ; 0.94]	Good ●	Stabilised teams
	]0.94 ; 1.00]	Fair ●	Younger teams with coordination responsibilities
	]1.00 ; 1.23]	Poor ●	Teams that did not accomplish the minimum learning period

Figure 2 presents the reference values for coordination categories and the qualitative relation in terms of good (green), fair (yellow) or poor (red) index level. Retirement age was considered 66 years.

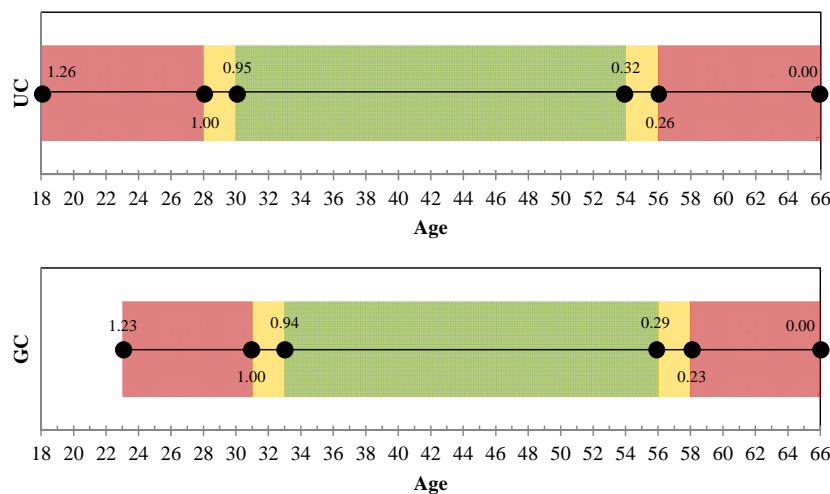


Figure 2. PAI reference values for UC and GC categories.

CASE STUDY

The main goal of the case study reported in this paper was to assess the maturity level of the technical department teams, for which working experience and knowledge transfer between peers is more critical for the sustainability of systems' operation and management from a long-term perspective.

The study was focused on the analysis of 10 AGS' utilities with a total of 1,233 employees. The utilities have different dimensions and organisational structures presenting a range of employees from 16 to 207 working in different departments. Table 2 presents an overview of utilities dimensions and organisational characteristics.

Table 2. Overview of AGS' utilities.

Variable	Network length (km)		Households with effective service (No.)		Departments (No.)	Employees (No.)
	water service	wastewater service	water service	wastewater service		
Minimum	404	17	18,278	16,593	2	16
Median	706	388	33,208	34,412	5	133
Maximum	1,376	767	102,733	102,719	10	211
Total	6,216	3,690	357,589	434,443	-	1,233

PAI was computed for all utilities and for the presented categories UT, ST, UC, GT and GC. PAI computation assumptions were established taken into account the legal working age, retirement age and graduation periods according to Portuguese legislation. PAI at a global level for all companies combined yield has a value of 0.45. PAI results for each organisation considering the total 1,233 employees of all departments are presented in Table 3. A qualitative analysis of UC and GC, according to the reference values presented in Table 1, is also included.

Table 3. PAI by category for all utilities.

Utility	UT	ST	UC	GT	GC
1	0.67	0.47	● 0.53	0.88	● 0.78
2	0.37	0.41	● 0.34	0.63	● 0.68
3	0.32	0.31	● 0.25	0.53	● 0.45
4	0.40	0.51	● 0.44	0.60	● 0.60
5	0.36	0.29	● 0.21	0.55	● 0.56
6	0.46	0.45	● 0.42	0.70	● 0.72
7	0.38	0.41	● 0.19	0.65	● 0.56
8	0.54	0.79	● 0.67	0.88	● 0.74
9	0.61	0.38	● 0.16	0.66	● 0.31
10	0.56	0.57	● 0.62	0.71	● 0.66

Considering PAI definition, in a stabilised team values should be kept in the range of 0.40 and 0.60. Younger teams (lacking senior elements and with a concentrated age pattern) correspond to values between 0 and 0.40, and values between 0.60 and 1 represent older teams (lacking younger elements being trained and bring the will for novel approaches and technologies, and with a concentrated age pattern).

Regarding the ungraduated categories UT, ST and UC, PAI results are very distinct. In the UT category there are four utilities with stabilised teams, two utilities with younger teams (PAI above 0.6) and four utilities with older teams (PAI below 0.40) which can represent the need for renewal in a medium-term period. The ST category also presents PAI values below 0.40 nevertheless most utilities present stabilised teams. The UC category has five utilities with low values representing older teams. From the analysis of the graduated categories, it's possible to understand that most utilities present young teams regarding the categories GT and GC. Most department managers present mean maturity levels.

When analysing specifically the technical department there are slight differences. Table 4 represents PAI results for the technical departments of AGS utilities, representing a sample of 608 employees.

Table 4. PAI by category for the technical department.

Utility	UT	ST	UC	GT	GC
1	0.69	0.40	● 0.53	0.85	● 0.77
2	0.34	0.54	● 0.36	0.64	● 0.79
3	0.28	0.32	● 0.27	0.57	● 0.66
4	0.38	0.49	● 0.47	0.59	● 0.54
5	0.35	0.30	● 0.14	0.54	● 0.33
6	0.49	0.43	● 0.43	0.75	● 0.69
7	0.36	0.40	● 0.19	0.68	● 0.41
8	0.54	0.79	● 0.67	0.88	● 0.74
9	0.58	0.38	● 0.16	0.55	● 0.27
10	0.56	0.56	● 0.55	0.70	● 0.61

The utilities 5, 7 and 9 present low values in the category UC, meaning it is important to identify potential substitutes in medium term. In these utilities the average team age of UC is 59 years old, being the retirement age in Portugal at 66 years.

Another important result is related to the category GC in WU9, where a PAI value of 0.27 represents an alert for identification of employees in the category GT that can potentially replace these team members in the future and for that reason should initiate the learning period in the short-term.

Utility 3 is an example of how PAI results can contribute to identify renovation needs as it presents the lower index of all utilities (0.32) in UT category at utility level. The utility high maturity level is evidenced by its age pyramid (Figure 3).

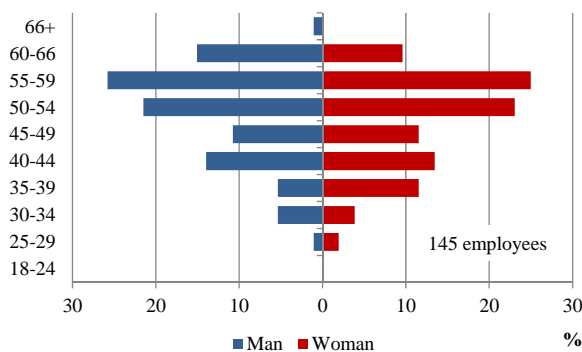


Figure 3. Age pyramid of utility 3.

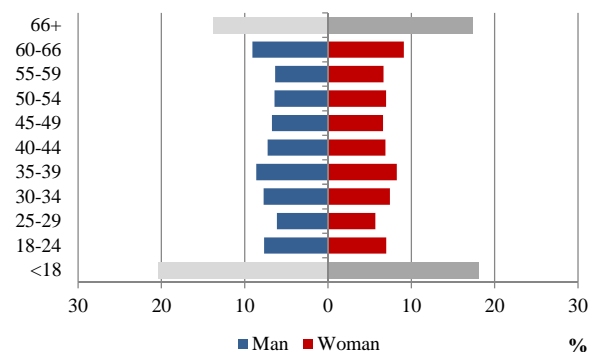


Figure 4. Age pyramid of utility 3 municipality.

When analysing the technical department (Table 4), results indicate that UT category present an even lower value (0.28) and that UT group is closer to retirement age than any other group in the utility technical department. This reflects the need to renew UT group by hiring new employees in the local external labour market (Figure 4), as the majority of the utility employees is recruited within the municipality.

CONCLUSIONS

In organisations with the responsibility to manage vast, diverse and long-life cycle assets, with an adequate level of service and acceptable risk such as urban water utilities, knowledge transfer between peers should be assured to maintain a stable human resources framework. This is particularly relevant in undocumented forms of knowledge in which this transfer is made from person to person – tacit knowledge.

Human assets being critical for the water services sustainability, a sound performance assessment system to support water utilities management needs to adequately address this issue. In the authors' view, the pre-existing regulatory (e.g. ERSAR PI system) or standardised assessment systems (e.g. IWA PI systems) do not respond to the needs. In order to overcome this situation, AGS developed an index that quantifies the average working careers of an organisation or department. This enables assessing teams' maturity level and identifying situations where appropriate forms of tacit knowledge transfer is at risk or situations where learning periods are lower than ideal in coordination categories, indicating the need for renewal and for long term planning of human resources management.

Application of PAI in AGS group allowed for identifying the water utilities in which human resources renovation is required in the short-term, reducing the operational risk and the service sustainability regarding this specific topic.

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