The role of the community engagement towards the success of water reuse in isolated islands and tourist areas

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ABSTRACT

This paper presents and discusses the role of community engagement, i.e. attitudes of local stakeholders, engagement of elected officers and pricing, towards the success of water reuse on the island of Bora Bora, French Polynesia. To better preserve public health and overcome all constraints related to public perception, a membrane tertiary treatment was implemented for the production of high-quality recycled water. Consequently, the demand for the new recycled water has steadily increased during the last four years with a wide diversification of urban uses including irrigation, cleaning, industrial and commercial uses and fire protection. The primary keys to success of this water reuse scheme are the strong commitment of elected officers and large industrial users with the implementation of an adequate public communication and education programme. The resulting outcome is the public trust in recycled water and the recognition of the economic and environmental benefits of water reuse with perspectives for new water reuse projects.

Key words | benefits, community engagement, public acceptance, ultrafiltratrion, urban water reuse

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INTRODUCTION

Water reuse is a political and socio-economic challenge for the development of future water supply and sanitation services on a global scale. It has, in fact, the major advantage of providing an alternative resource at a lower cost to limit water shortages and to better preserve natural freshwater resources. The recycling of properly treated wastewater represents one of the most effective means to reduce water withdrawal, thus contributing to the sustainable development of our society. The arid and semi-arid regions were the first to recognize the importance of integrated resource management and the role of water reuse towards sustainable development (Jiménez & Asano 2008a). California and Florida are pioneers and world leaders in this field with 1.6 ± 0.1 million m^3 per day of municipal wastewater recycled for various non-potable uses and indirect potable reuse. Spain is the European leader in the field of water reuse with 408 million m^3 per year, which is encouraged by institutional and financial incentives (AQUA 2000; Plan Nacional de Reutilizacion 2009) such as, for example, the mandatory use of recycled water for golf course irrigation in Catalonia, Andalusia and the Canary Islands. China, Singapore and Australia are the countries with the highest growth in the production of recycled water at >20%/year. Currently, many large-scale projects (>200,000 m^3/d) are implemented in Spain (Barcelona), China (Beijing), Italy (Milan), Singapore and Australia (Western Corridor).

It is important to emphasize that water reuse is becoming an important element of national and local policies covering integrated resource management (Jiménez & Asano 2008b) often including well-defined targets, such as the goal to cover a portion of potable water demand by water recycling by 2010 (10% in Madrid, 13% in California, 20% in Singapore and Australia) or to recycle 100% of

doi: 10.2166/wrd.2012.057

treated wastewater (Israel, Cyprus, Hawaii). The most important benefit of urban water recycling is that it frees an equivalent volume of potable water for basic human needs. Reliability of supply of recycled water – in times of drought, when potable water may be withheld from use for landscape irrigation – becomes a particularly important benefit to those for whom maintenance of an attractive landscape at all times is critical, especially in tourist areas and islands. Thus, a great advantage of recycled water is that it is 'drought-proof', since the wastewater flow is largely unaffected by drought restrictions. The main constraint of this application is the greater probability of exposing the general public to recycled water in densely populated settlings. This is the main reason, combined with the lack of adequate regulations, that impedes the implementation of water reuse projects for golf course and landscape irrigation in France (Lazarova & Brissaud 2007). In fact, public health issues are a major concern of responsible institutions in regions where water reuse is not yet widely applied, such as Northern Europe, for example.

Further important constraints for implementation of water reuse initiatives include: public acceptance, lack of institutional incentives and political and community support (Asano *et al*. 2007). During the last decade, an increasing number of studies have focused on public acceptance of recycled water (Dolnicar *et al*. 2011). Most of these studies have demonstrated that people are very open to using recycled water for non-potable purposes, but significant opposition exists against potable reuse. This is the case, for example, in Australia, where a recent survey found that 92% of respondents would use recycled water for garden irrigation, but only 36% for drinking (Dolnicar & Hurlimann 2010). It is important to underline that consumer acceptance of recycled water largely depends on water availability and the perceived need for alternative resources: in areas or times of water scarcity, water reuse is better accepted by the public. The more than 40 years of direct potable reuse experience in Windhoek, Namibia, is an excellent example of public confidence and education showing that 'Water should be judged by its quality not its history' as mentioned by one of the pioneers of this project (Van der Merwe *et al*. 2008). Despite a few cases of public opposition to indirect potable reuse projects, some experts and public representatives believe that direct potable reuse is inevitable in the future, given the growing water supply concerns (Tchobanoglous 2011).

The majority of the published studies on public acceptance are based on surveys using qualitative methods such as interviews and focus groups. While this approach provides many useful insights for specific projects and local situations, their impact for the general development of water reuse and the improvement of public acceptance is limited. The methodology of the sociological research, the main assumptions, the sampling of the population and the formulation of the questionnaires highly influence the survey results and the transferability to other projects and/or populations (Hartley 2006). As stated by the various literature reviews (Lazarova *et al*. 2001; Po *et al*. 2003; Anderson *et al*. 2008; Dolnicar *et al*. 2011), in addition to the socio-demographic factors, many other criteria influence the acceptance of recycled water such as trust in authorities, knowledge and information, risk perception and health concerns, specific uses of recycled water, attitudes toward the environment, past experience and the cost of recycled water.

In this context, the main objective of this paper is to present and discuss the importance of other less discussed factors for the public acceptance of water reuse such as good governance and political engagement, environmental benefits and contribution to sustainable development, trust and credibility of the treatment process, water quality, availability and reliability of recycled water supply and economic viability of water reuse options.

The role of these factors for the success and public acceptance of water reuse will be illustrated using the example of the urban water reuse initiative implemented on the touristic island of Bora Bora, located in French Polynesia in the South Pacific. The water recycling programme has been initiated by the local municipality within a Public-Private Partnership with the company SPEA (Polynesian subsidiary of Suez Environnement), taking advantage of the extensive experience in research and development of water reuse projects, as well as design and operation of water and wastewater treatment and reuse.

Water reuse is playing a crucial role in the local resource management of Bora Bora. The freshwater resources of the island are not sufficient to provide freshwater for the resident population (8000 inhabitants) and the 200,000 tourists received each year. Following a growth in water

demand and increasingly severe dry seasons, the production capacity of drinking water was due to be increased several times, with the introduction of alternative resources such as seawater desalination (three desalination plants constructed in 2000, 2005 and 2007) and water reuse. The raw sewage of the island is collected and transported by a pressurized network by means of 70 pumping stations, then treated at two wastewater treatment plants (one on the north side and one on the south side of the island). The wastewater is treated to comply with the European standards for bathing water. In 2005, an existing water reuse project was upgraded for the production of high-quality recycled water for non-potable urban uses. Over the years, this project has been expanded with the diversification of water reuse applications and the design of a new project for indirect potable reuse.

MATERIALS AND METHODS

Communication and public participation in the water reuse programme

The development of sustainable water recycling schemes needs to include an understanding of the social and cultural aspects of water reuse. In order to ensure public acceptance of the water reuse scheme in Bora Bora, in terms of commitment of all stakeholders, the well-proven and recommended approach of community consultation has been applied (Asano *et al.* 2007; Anderson *et al.* 2008):

- Community consultation and information by the organization of forums with broad interest groups including local populations, local entities, municipalities, water utilities, legislative officers. Public meetings were the priority method employed (Figure 1).
- Consultation with interest groups to validate proposed technologies, treatment performance, associated risks, costs and benefits to catchment scale water conservation and sustainable development. The main methods used were workshops, scoping meetings and forums.
- Development of public education programmes (newsletters, school education programmes, open houses and tours, meetings with stakeholders). The public's knowledge and understanding of the safety and appropriate applicability of recycled water was considered as a key component of any successful water reuse programme. The main methods used were printed flyers and publications in local media.
- Collaboration with local media for the establishment of new marketing approaches to consider recycled water

Figure 1 | View of a workshop with a media release.

as a new product for sale and a component of the policy of sustainable development.

The approach of community consultation and communication was chosen as the best option to understand not only the attitudes of the local population, but also those of the various end-users and their willingness to use and pay for recycled water.

The public outreach actions have been launched from the earliest stage of development of the water reuse programme.

Technical and environmental factors influencing community acceptance of water reuse

Only a few existing studies have discussed the role of good governance and technical factors for the public acceptance of recycled water. Generally, technical issues are ranked as less important in the surveys of public perception of individual consumers (Po *et al.* 2003). However, these issues are crucial for the trust and acceptance of water reuse by large end-users such as industries, farmers and tourist facilities. In this case, water quality compliance, availability and reliability of the supply of recycled water are very important factors for the acceptance to supplement or replace potable water supply with recycled water.

In this study special attention was given to the political engagement for the choice of the most appropriate options for water and wastewater management in terms of sustainable development.

Economic and environmental factors influencing community acceptance of water reuse

One important factor to achieve public acceptance is the understanding of the cost of treatment and distribution and the associated pricing of recycled water. One of the tasks of this work was to evaluate the cost of recycled water, and in particular the operating cost and its adequacy with recycling water pricing.

Pricing decisions represent a crucial element for the economic viability of water reuse projects (Morris *et al.* 2005). They must reflect both the willingness to pay of the end-users and the reliability of supply of recycled water with the required water quality. As a rule, people expect to pay less for using recycled water (Po *et al.* 2003). This is not always true for large users, as in this case reliability of supply in case of droughts can be a more important factor.

The pricing of recycled water in Bora Bora has been set by the local government with a double objective to improve economic efficiency and to obtain the willingness to pay by end-users. A two-part tariff was chosen that consists of a fixed cost plus a cost per volume of water used. This pricing approach has become increasingly widespread in Europe and other countries such as Australia and the USA (Hatton MacDonald & Proctor 2008). With the diversification of water reuse applications, a new proposal for pricing of recycled water is under discussion in order to improve cost recovery and better acknowledge the environmental benefits of water reuse.

The role of economic factors and monetary or environmental benefits is not well studied and understood in terms of their contribution for community acceptance of recycled water. As emphasized by Po *et al.* (2003) and Anderson *et al.* (2008), attitudes towards the environment play an important role for public acceptance of water reuse projects. The importance of economic and environmental factors depends on local conditions and they are still considered the second least important factors. Nevertheless, in temperate regions such as Europe, as well as in tourist areas, the awareness of conservation of natural water resources can play a major role (Lazarova *et al.* 2001). This is the case both in France and on the island of Bora Bora.

Water quality monitoring

Water quality parameters have been monitored according to Standard Methods. Physico-chemical parameters are analyzed in 24 h composite samples. Sampling frequency was daily during the start-up period and monthly during routine operation. For the microbiological analysis, grab samples have been taken at the outlets of the ultrafiltration (UF) and the storage reservoir for the analysis of *Escherichia coli* and enterocci by the standard microplate technique.

RESULTS AND DISCUSSION

Impact of environmental factors to build public confidence in water reuse

Since 1998, the island of Bora Bora has regularly faced water shortages, due primarily to decreasing rainfall and frequent droughts combined with hotel development and population growth. As a result, severe water shortages have been observed with periodic interruptions of water supply. In 2000, to ensure a reliable water supply 24/24 h, the island was equipped with alternative resources such as desalination and a water reuse network. A municipal policy of sustainable development has been implemented and supported by an intense willingness of the elected representatives for a meticulous respect of the environment, preservation of the island's charm and water resources, as well as the design of buildings adapted to the landscape according to local tradition.

In addition to desalination and water reuse, the other measures adopted by the municipality within the programme framework for sustainable development are (1) the selective collection, treatment and valorization of various types of waste, (2) the use of geothermal energy for cooling and (3) the preservation of local traditions and employment throughout a social and economic development, taking advantage of revenues generated by tourist activity. In 2010, measures for the improvement of energy efficiency have been implemented with the use of solar energy (photovoltaic as the power key source) for seawater reverse osmosis desalination.

The sustainable development policy was the key issue of public forums and education programmes. Water reuse is included as an important element of this strategy as a complementary and cost-effective alternative resource to desalination. The highlights from the discussions on the perception of water reuse during the public forums and workshops are as follows:

- Strong support of the local population for the protection of the environment, and in particular the lagoon, from wastewater discharge.
- Recognition of environmental benefits of water reuse by all stakeholders not only for the protection of the environment, but also for the valorization of desalted water by its recycling for non-potable purposes.
- Understanding of the relevance of the holistic approach for sustainable development including water, waste and energy management with social and economic advantages for the local population.

It is important to highlight that in terms of a sustainable development policy, Bora Bora is a pioneer and a leader in Polynesia. Thus, Bora Bora is the only municipality of French Polynesia to be awarded the 'Blue Flag of Europe' and it has been able to preserve this award for ten consecutive years. This label is highly prized by foreign visitors, mostly from northern Europe, who tend to select their vacation resort based on environmental criteria.

As a result, the knowledge and the information of the stakeholders and local population on the environmental benefits of water reuse are one of the crucial factors in building the public acceptance of water reuse. The water reuse project of Bora Bora has been designed as a part of a broader water resource planning aimed at securing water supply, mitigating the negative impacts of droughts and protecting the fragile lagoon environment from wastewater discharge.

Impact of technical factors on the trust in water reuse

The first water reuse project in Bora Bora was initiated in the late 1990s. Initially, the recycled water was polished effluent by a maturation pond, the quality of which was not approved by health authorities for spray irrigation. Moreover, recurrent odour problems and bacteria regrowth (in particular sulphur-reducing bacteria) in the distribution network associated with the relatively high cost of recycled water led consumers, in particular the luxury hotels, to limit their water reuse demand. Consequently, poor quality of recycled water was an important constraint for the wide acceptance of water reuse.

A new water reuse programme has been proposed with the implementation of an advanced tertiary treatment for the production of high-quality recycled water. UF submerged membranes Zenon (ZeeWeed 500) have been chosen to polish a part of the secondary effluent and were implemented in the Povai wastewater treatment plant in

April 2005. The choice of UF as tertiary treatment was driven by the willingness to produce recycled water of high quality with almost total disinfection. Zenon's UF membranes have a pore size of 0.035 μm, which represents an effective physical barrier for all microorganisms and pathogens, including protozoa, cysts, bacteria and viruses. The downstream treatment for a daily flow of 6,250 m^3/d consists of conventional activated sludge designed for carbon and nitrogen removal. The existing maturation pond was upgraded for storage of storm water. Recycled water is stored in a covered reservoir and pumped into the industrial (non-potable) water distribution network following chlorination in order to maintain 0.5 mg/L chlorine residual. The excess sludge is treated and recycled by rhizocomposting (reed beds). The compost obtained (>1,200 m^3/year) is reused to fertilize the nutrient-limited coral-based soils of the hotel's landscapes, public areas and private gardens.

Table 1 illustrates the wastewater quality (raw sewage, secondary effluent and recycled water) for the period from 2005 to 2010. Despite the high variations in raw sewage characteristics, tertiary UF consistently produced an effluent of a very good quality, free of suspended solids and with a very low content of organic carbon chemical oxygen demand (COD) and biological oxygen demand (BOD) below the detection limits.

The tertiary UF treatment capacity was extended from 300 to 500 m^3/d in 2008. The recycled water distribution network has been extended to completely cover the demand of non-potable water of all luxury hotels. In 2010, a new storage reservoir of 450 m^3 was built, as well as a new pumping station, in order to increase the pressure to feed 20 hydrants for fire protection. The operation of the water reuse system was also completely automated.

Currently, new satellite recycling facilities are under construction for golf course irrigation and aquifer recharge.

Consultation with interest groups has been organized to validate the proposed technology, expected performances, associated risks and economic viability of water recycling. More than 20 workshops, scoping meetings and forums have been conducted to inform the public on water quality and outcomes of water reuse. In particular, the public forums organized in the water recycling plant were very successful and highly appreciated (Figure 2). During these meetings, not only were major stakeholders invited, but also different interest groups and representatives of the local population.

The analysis of the public consultations demonstrates that the adequate choice of treatment technology – UF ensuring almost total disinfection and removal of suspended solids – as well as the ability to provide high-quality recycled water without any interruption were key factors that ensured the public acceptance of water reuse. The high water quality and the reliable supply of recycled water were strongly appreciated by large users such as hotels and industrial companies.

As a result, a rapid growth in recycled water demand has been observed, as well as an increase in the number of end-users (Figure 3). The number of end-users doubled after the implementation of advanced tertiary treatment to reach 20 to 22 end-users compared to only six users in 2000.

Table 1 | Water quality characteristics[a] of the wastewater treatment and recycling facility of Povai for the period 2005–2010

		Secondary effluent		Recycled water (UF permeate)	
Parameter	**Raw sewage**	**Measured**	**Consent**	**Measured**	**Guide value**
COD (mg/L)	595 (270–837)	31 (21–65)	90	15 (4–34)	40
BOD_5 (mg/L)	349 (200–540)	7 (<5–22)	25	4 (1–6)	20
TSS (mg/L)	238 (125–275)	9.5 (4–19)	35	<5	20
N_{tot} (mg/L)	47 (30–70)	8.3 (2–18)	20	7.3 (2–17)	20
P_{tot} (mg/L)	6.8 (4.1–8.1)	2.5 (1.0–5.8)	–	1.9 (0.45–5.8)	–
E. coli/100 mL	ND	10^5–10^7	–	Non-detected	0/100 mL

[a]Average value and limit of variations (monthly composite samples, excluding *E. coli*, that was monitored in grab samples).

Figure 2 | Public forums organized at the water recycling plant.

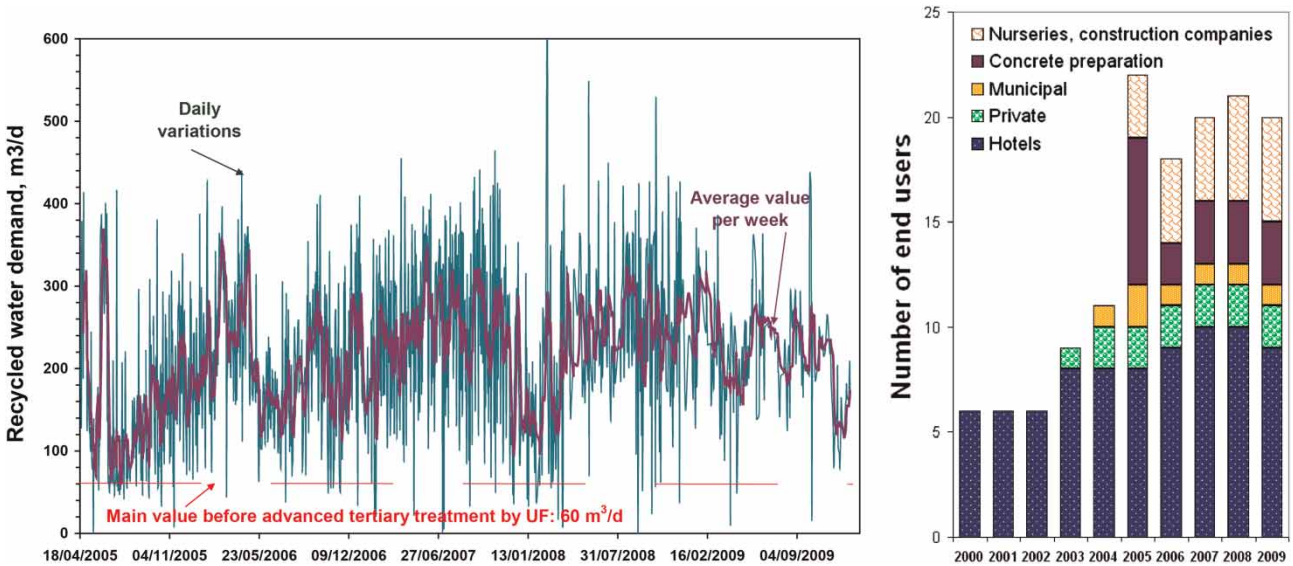

Figure 3 | Evolution of the recycled water demand and the number of end-users.

In contrast with the general trend ranking technical issues as less important towards gaining public acceptance (Po *et al.* 2003), the success of the water reuse project in Bora Bora demonstrated that the adequate choice of treatment technology and well-designed public information can play an important role in building public confidence in terms of water quality and management of health risks. Moreover, this approach enabled some negative attitudes of large end-users, which resulted from the poor past experience with low-quality recycled water, to be overcome.

Risk perception of specific recycled water applications

An important specificity of the new French regulation on water reuse for irrigation, published in August 2010, is the existence of several restrictions on spray irrigation in urban areas and golf courses, despite requirements on water quality and minimal distances. Health concerns and the precautionary principle were the main factors for some opposition of regulatory bodies for the implementation of landscape irrigation with recycled water (Lazarova & Brissaud 2007).

In this context, health authorities have been included in the public consultations since the beginning of the project and actively participated in the scoping meeting and workshops. The management of water quality and the reliability of operation were the critical factors for the trust of local authorities in the effective risk management. The positive feedback from operation and from large end-users allowed permits, not only for landscape irrigation, but also for various other urban uses, to be obtained.

Consequently, the increase in recycled water demand was associated with a diversification of water reuse applications for unrestricted urban uses, such as:

- Landscape irrigation, mostly for the luxury hotels (the traditional use of recycled water, private end-users, Figure 4).
- Cleaning and landscape irrigation in nurseries and a few construction and commercial end-users (private end-users).
- Boat washing (private end-users).
- Filling of the water reservoirs of all fire protection boats (municipal end-user).
- Supply of hydrants for fire protection (municipal end-user).
- Washing of construction engines and preparation and tests of concrete at three to seven building sites, depending on the year (private end-users).
- Municipal nursery for the production of flowers, shrubs and other plants.
- Municipal workshops (construction equipment, school buses).

In addition, recycled water is used for cleaning and landscape irrigation in all water and wastewater plants, as well as in the 71 pumping stations.

As a result of the good collaboration and communication with the local health authorities, negative risk perception of urban spray irrigation was overcome. The main lesson learned was that the strong community engagement with close cooperation between all stakeholders, including elected officers, regulators, operators, end-users and local communities, was the major key to success of the water reuse programme in Bora Bora. This project remains as the only example of unrestricted urban use of recycled water within an urban area in France and the French Islands, excepting the irrigation of a few golf courses. The good water quality and the reliability of operation of membrane treatment convinced the highly reluctant French regulatory bodies that health risks are well under control. In addition, a new project for indirect potable reuse by means of golf course irrigation for aquifer recharge is under development.

Role of economic factors and tariff policy for the public acceptance of water reuse

As mentioned previously, the strong political commitment to implementing a policy respecting the natural environment

Figure 4 | Views of end-uses and of recycled water.

Table 2 | User fees for recycled water in Bora Bora

Parameter	Criteria	First block	Second block	Third block
Volume for large users, m^3/month	>350 m^3	<550	550 to 800	>800
Recycled water charge, €/m^3		2.35	2.18	1.65
Volume for medium users, m^3/month	<350 m^3	<110	110 to 200	>200
Recycled water charge, €/m^3		1.16	1.08	0.88
Volume for small users, m^3/month	<30 m^3	<5	5 to 10	>10
Recycled water charge, €/m^3		0.76	0.71	0.67

was an important factor for the public acceptance of water reuse. Moreover, the strong public and political engagement enabled the required funds and financial arrangements to cover capital investments for the tertiary treatment and distribution network to be found. When the advanced treatment plant was commissioned, another very important challenge was water reuse pricing to recover at least a fraction of the investment and operating costs.

After dialogue with communities and stakeholders, the municipality of Bora Bora decided to implement a tariff policy in favour of the local population: a two-part tariff with an ascending rate structure (Table 2). The social signal of this decision was 'the less you use, the less you pay'. The progressive rate for increasing volumes of recycled water supply is a reminder of water scarcity and the necessity to save this precious resource. At the same time for a given category of end-users, a declining rate structure was implemented to encourage the use of recycled water.

According to this new recycled water pricing established since November 2005, recycled water charges vary from 30 to 100% of the potable water rate, depending on the user category (water demand). In addition to these consumption-based rates, a fixed annual charge of 187 € is required for each connection. For comparison, the previous recycled water charge for polished secondary effluent (maturation pond effluents are not allowed for spray irrigation and other urban uses) was fixed at 0.67 €/m^3 regardless of water consumption. It is important to emphasize that the use of recycled water (industrial non-potable water) and the subscription to this service are strictly reserved for the professional needs of the population and outdoor uses.

With the increasing number of end-users, a simplified pricing of recycled water was under discussion to provide additional financial incentives for water reuse (Table 3). In fact, it was observed that during rainy periods, a strong decrease in the demand for recycled water occurs. In such a context, the simplified pricing of recycled water that is expected to be implemented in 2011 will favour water reuse. The discount rate of recycled water will be from 26 to 48% of the drinking water rates for large users with a monthly consumption above 75 m^3.

High drinking water rates for large consumers due to desalination (200 to 700% of the rate for small consumers, i.e. local population), as well as increasing water demand of luxury hotels, and in particular the requirement for landscape irrigation and other non-potable urban uses, are important factors for the acceptance of water reuse. Consequently, the main challenge of plant operation was to minimize risk of failure of tertiary treatment at acceptable operation and maintenance costs below the cost of seawater desalination.

Operating costs of the recycling facility in Bora Bora include operation and maintenance not only of the tertiary membrane treatment, but also of the distribution system, which is predominantly underwater (submerged in the lagoon). The main expenses comprise fixed costs for labour, repairs and maintenance, membrane replacement

Table 3 | New user fees for recycled water in Bora Bora under validation

Category of end-users	Fixed annual charge, €	Volume of recycled water, m^3/month		
		0–30 m^3	31–75 m^3	>75 m^3
Small users DN 25	209	0.67 €	1.68 €	2.51 €
Medium users DN 32/40	293			
Large users DN >40	419			

and water quality monitoring, as well as variable costs for chemicals and energy consumption.

As shown in Figure 5, the major component of the operating costs is labour, accounting for 46% of total operation costs, which is close to the typical values in conventional activated sludge systems (45 ± 5%). Despite the very high price of electricity in this isolated tourist island (0.18 €/kWh), the contribution of energy costs is only 14%, which is relatively low compared to typical values for secondary treatment of 25 ± 5% and tertiary microfiltration/reverse osmosis (MF/RO) treatment of 26–32%. Chemical costs for membrane cleaning and final chlorination contribute to another 12% of operation costs. A new important part of operation costs is repair and maintenance, which rises to 21%, including membrane replacement. It is important to underline that the cost of spare parts and scouring equipment is also higher due to the remoteness of this island and, thus, the high transportation costs. Water quality monitoring remains relatively low, 4% of operation costs, but a great part of this expense is included in the labour costs. Average energy consumption is 0.3 kWh/m^3 at nominal flow and 0.95 kWh/m^3 at 30% of the hydraulic capacity of membrane treatment.

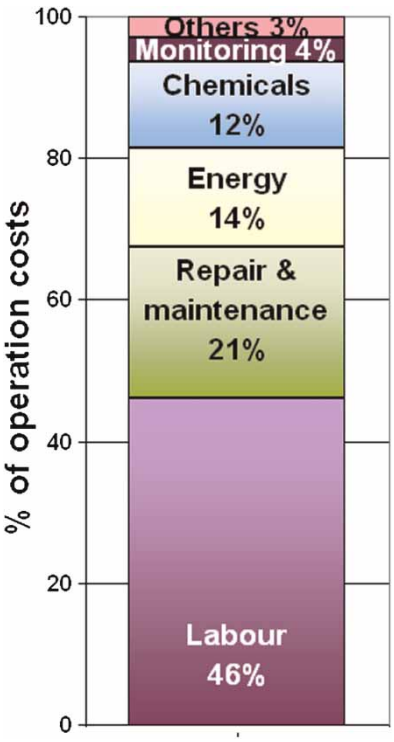

Figure 5 | Distribution of operation costs (tertiary treatment and distribution network).

The analysis of the influence of the economic factors demonstrates that good governance with an adequate pricing strategy of water services is another important factor for the public acceptance of water reuse. The local population has the benefit of low price of drinking and recycled water, because large end-users and tourism are providing funding for the expensive alternative water resources from desalination and advanced wastewater treatment.

Role of communication for the recognition of benefits of water recycling

One of the main outcomes of the public meetings and forums is the recognition of the benefits of water reuse. Large users such as luxury hotels were the first to recognize economic benefits of water reuse as the cost of high-quality recycled water is, in fact, 2.5 to 3 times less expensive than potable water. Consequently, recycled water demand is increasing, encouraged also by the declining price rate.

Another monetary benefit that can be easily estimated is the prevention of revenue loss of building and tourist companies. In fact, because of the severe drought at the end of 2005, the use of drinking water for non-potable purposes was forbidden and four important building sites were to be interrupted because of the lack of freshwater for concrete preparation and tests, as well as for landscaping (construction of one desalination plant and three hotel extensions, each with 100 luxury suites of 100 m^2 each). The economic damage that could be caused by the delay of construction has been estimated at 2 to 3 million €, without taking into account the potential loss of revenue during the peak tourist season that would have been over 50 million €.

The economic and social benefits of this new recycling scheme were also recognized by the local and regional authorities, as the start-up of the membrane facility enabled the construction of an additional desalination plant to be postponed, as well as water supply interruptions for local residents that were frequent and unavoidable during drought periods to be limited.

In addition to the increasing reliability of water supply, the local population highlighted another very important environmental benefit of the reuse of well-treated wastewater: the safeguard of the lagoon and its biodiversity. The fragile lagoon system of Bora Bora can be rapidly deteriorated by

human activities such as accidental discharge of wastewater and/or wastes, as observed in the late 1980s before the implementation of wastewater treatment and reuse.

For the local decision makers and elected officers, the most important benefit of water reuse was the protection of local natural freshwater resources, e.g. saving of 10% of drinking water for domestic and potable uses. The protection of the lagoon was also a crucial benefit. Consequently, Bora Bora became the only municipality of French Polynesia to be awarded the 'Blue Flag of Europe'.

The public education and outreach programme was an essential part of the water reuse project with strong involvement of local media. As a result, a number of brochures, flyers, articles in the newspapers, TV and radio speeches have been produced to convey information to a large number of people.

Following the great success of urban water reuse in Bora Bora, several new water reuse projects with extension of the existing recycling facility are under consideration:

- Extension of the fire protection network and construction of a new fire reservoir.
- Construction of a new membrane recycling facility with the production of multi-quality recycled water for golf course irrigation (150 ha) and aquifer recharge (UF/RO treatment facility).

CONCLUSIONS

The analysis of the impact of various factors towards the success of the water reuse programme for unrestricted urban uses in Bora Bora demonstrates that socio-economic, environmental and technical factors strongly influenced the public confidence and trust in water reuse, in particular those of large end-users. A well-designed communication programme can contribute to public acceptance not only by providing adequate information, but also via community engagement to explain the economic and environmental benefits.

The close involvement of local authorities, water professionals, stakeholders and local population have made it possible to recognize the economic viability of water reuse in Bora Bora and to identify clearly the numerous advantages and benefits, including the preservation of this outstanding environment and the availability of an equivalent volume of potable water for domestic purposes, local economic development and a reliable water supply to the local population in case of drought.

The key factors for the success of this reuse project can be summarized as follows:

- Strong commitment of elected officers to implement water reuse as an element of the sustainable development policy, with an integrated resource management respecting the natural environment, as well as the choice of an appropriate tertiary treatment and water reuse tariff, favouring both the local population and large end-users.
- Trust of the health authorities and local community in water reuse as a result of the organization of public meetings, forums, on-site visits and workshops to present the high quality of recycled water and the reliability of operation of the UF tertiary treatment to demonstrate that management of health risks is well addressed.
- Strong support by all stakeholders of water reuse with the recognition of economic and environmental benefits thanks to the consultations and the well-designed communication strategy with the active participation of local media.

The presence of luxury tourism on the island of Bora Bora is not a source of environmental degradation, as might be expected. On the contrary, thanks to a suitable pricing of water services, which calls for a greater contribution from the hotels, tourism provides funding for high-quality public services such as highly efficient desalination facilities and water recycling to compensate for the water stress and to protect the lagoon, the most precious heritage of the island. The strong effort of the community of Bora Bora for integrated resource management meant that the label 'Blue Flag of Europe', a symbol of an exemplary environmental quality, has been granted every year since 2000.

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First received 24 July 2011; accepted in revised form 4 January 2012