Water management in the European hospitality sector: Best practice, performance benchmarks and improvement potential

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Water management in the European hospitality sector: best practice, performance benchmarks and improvement potential

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Keywords: Benchmarking; Water efficiency; Water conservation; Environmental management; Sustainability; Hotels; Tourism

Highlights

Best practice in hospitality water management was determined at the process level

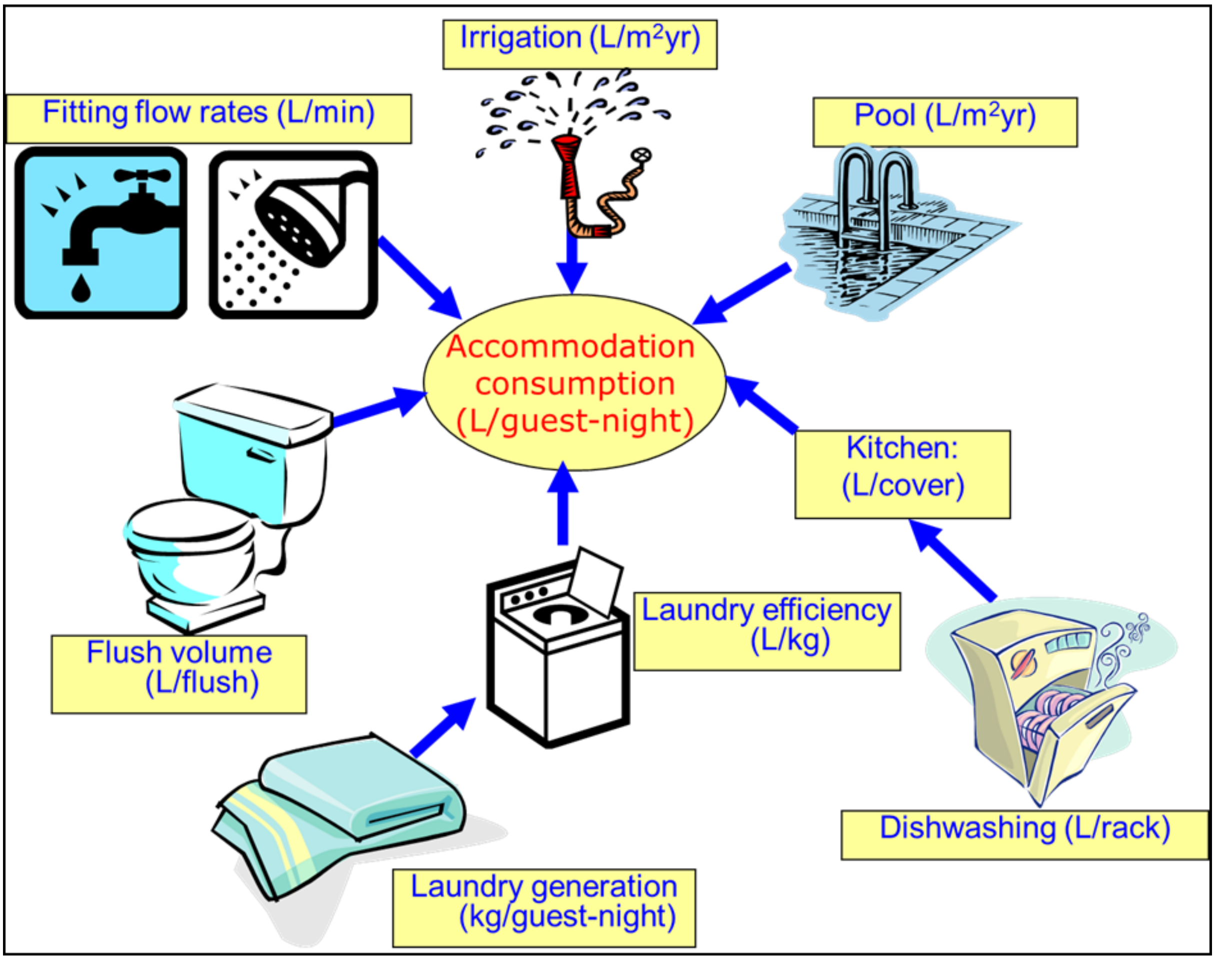
Benchmarks range from ≤ 58 L/guest-night on campsites to ≤140 L/guest-night in hotels

Achievable water savings amount to 227 and 128 L/guest-night for hotels and campsites, respectively

Annual savings for a 100-room hotel amount to 16 573 m^3 water, 209 541 kWh energy and €58 436

Best practice across European hotels and campsites could save 422 million m^3 water per year

Graphical abstract



Abstract

Water stress is a major environmental challenge for many tourism destinations. This paper presents a synthesis of best practice, key performance indicators and performance benchmarks for water management in hospitality enterprises. Widely applicable best practices and associated performance benchmarks were derived at the process level based on techno-economic assessment of commercial options, validated through consultation with expert stakeholders and site visits to observe commercial implementation. A simple model was applied to calculate potential water and energy savings achievable through implementation of best practice for a 100-room hotel and an 80-pitch campsite. In aggregate, technically-derived process-level best practice benchmarks corresponded closely with enterprise-level benchmarks derived from empirical data. Frontrunner enterprise benchmarks, expressed as total water use per guest night (g.n), were: ≤140 L/g.n in fully serviced hotels; ≤100 L/g.n in hostels; ≤ 94 L/g.n in fully serviced four- and five star campsites; ≤ 58 L/g.n on all other campsites. Water savings achievable through implementation of best practice were estimated to be at least 228 L/g.n and 127 L/g.n for fully serviced hotels and campsites, respectively, excluding large potential savings for non-universal processes such as outdoor irrigation. Best practice in water management could reduce annual water and energy use by 16 573 m^3 and 209 541 kWh, respectively, for a 100-room hotel, saving EUR 58 436 in utility bills. Universal implementation of best practice applied across hotels and campsites could reduce water use by at least 422 million m^3 per year throughout Europe, making a significant contribution to the sustainability of water-stressed tourism destinations. Possible barriers to best practice implementation include divided responsibilities within large organisations, lack of awareness, and water charges accounting for a relatively small share of overall costs.

1. Introduction

1.1.Tourism and water stress

Gössling et al. (2011) estimated tourism to be directly responsible for the use of 9 274 million m^3 of fresh water in 2000 – representing approximately 3.4 % of domestic water use and 0.3% of total water use globally. Water use in the tourism sector is environmentally significant owing its geographic concentration in dry regions, islands and coastal destinations with limited reserves of renewable freshwater (Essex et al., 2004; Dworak et al., 2007; Tortella and Tirado, 2011). These areas are often hotspots for water stress, which poses a significant threat to both the economic viability and environmental sustainability of tourism in parts of the Mediterranean and beyond (Essex et al., 2004). Tourists directly account for 19%, 14% and 12% of domestic water use in Cyprus, Malta and Spain, respectively (Gössling et al., 2011), and dominate demand within the localities of particular resorts (Dworak et al., 2007). Peak tourism demand in sun-holiday destinations prone to water stress often occurs during summer, when water availability is at its lowest and agricultural demand is at its highest. Tortella and Tirado (2011) reported that 20% of water use on Mallorca in 1999 occurred in July of that year. Furthermore, tourism demand for water is projected to increase considerably over the coming decades, while climate change is projected to reduce precipitation in lower mid-latitude regions such as the Mediterranean and increase the frequency of severe droughts (Gössling et al., 2011). Consequently, water demand from tourism-related hospitality is responsible for significant environmental impact via its contribution to extreme water stress, the depletion of groundwater and associated problems such as salinisation and subsidence, and demand for energy-intensive desalination and water importation (Tortella and Tirado, 2011). Despite these problems, which can lead towards social tensions within tourism destinations (Tortella and Tirado, 2011), regulation of tourism water use has been lacking across many destinations (Alvarez-Gil et al., 2001; Trung and Kumar, 2003; Kozac and Nield, 2004; Charara et al., 2011). Tortella and Tirado (2011) suggest that public institutions in European tourism destinations beginning to shift policy emphasis from meeting to reducing tourism water demand.

1.2.<u>Benchmarking tourism and hospitality water demand</u>

An average tourist within Europe uses over 300 L/day of water, against approximately 150 L/day for an average European resident (EEA, 2009; EC DG ENV, 2009, Eurostat, 2009; Gössling et al., 2011). However, statistical data on tourism water use are lacking (Eurostat, 2009; EEA, 2010; Gössling et al., 2011), in part because tourist water use is often subsumed within ‘urban’ water use statistics (Tortella and Tirado, 2011). There is considerable variation in reported water use by tourists, ranging from 300 to 880 L/day for tourists in the Mediterranean according to Dworak et al. (2007), up to 2000 L per person per day (UNEP, 2004; Gössling et al., 2011). Much of this water use arises in accommodation enterprises, especially mid-range (three and four star) hotels (Dworak et al., 2007; Tortella and Tirado, 2011).

There is some evidence that water use is related to the level of service provided across accommodation enterprises, based on data reported by hotel groups synthesised in Figure 1. Accor (2010) report average water use ranging from 187 L per occupied room per night in one star Etap hotels, up to 1568 L per occupied room per night in five star Sofitel hotels. NH Hoteles (2011) reported water use ranging from 184 L/g.n in German urban hotels to 698 L/g.n in resort hotels of the same star rating, with average urban hotel water use of 215 L/g.n. Bohdanowicz and Martinac (2007) reported mean water use of 216 and 516 L/g.n across Scandic (three and four star) and Hilton (four and five star) hotel chains, respectively. Hof and Schmitt (2011) report average water use in an area of Mallorca dominated by luxury holiday homes of 1181 L/person/day, compared with 210 L/person/ day in an area dominated by mass tourism. Ecotrans (2006) reported average water use ranging from 115 L/g.n in hostels, through 226 L/g.n in B&Bs to 312 L/g.n in hotels. For campsites, average water use has been reported at between 96 and 148 L/g.n (Ecotrans, 2006; Eco Camping, 2011). Dworak et al., (2007) link best practice in hotels with water use of 224 L/g.n, and estimate savings potential of 30-50% across the European accommodation sector. Some published benchmarks for water use in accommodations are summarised in Figure 2. [Insert Fig 1 and Fig. 2 about here].

Bohdanowicz and Martinac (2007) presented comprehensive statistical analyses of factors related to resource efficiency across Scandic and Hilton hotels. Other studies have used a similar approach to statistically relate water consumption across enterprises (mainly hotels) to factors such as occupancy rate, food covers sold, onsite laundry operations, and presence of a pool (Deng and Burnett, 2002; Scanlon, 2007; Charara et al., 2011; Totella and Tirado, 2011). Some studies have provided useful technical guidance on best practice at the process level (e.g. ITP, 2008; Travel Foundation, 2011; TUI, 2011). However, we are not aware of any published studies that have comprehensively combined technical information on process-level best practice with empirical data on frontrunner performance at the enterprise level to derive benchmarks for hotel or campsite water efficiency.

1.3.<u>Breakdown of water use in accommodations</u>

Reasons why people use more water as tourists than when at home include: (i) hygienic maintenance operations in accommodation (daily room cleaning; daily laundry); (ii) leisure activities (requiring water intensive maintenance of green areas and swimming pools); (iii) a 'pleasure approach' to food (more elaborate food preparation), showers and baths (Eurostat, 2009). Ensuite bathrooms account for approximately 30-40% of hotel water use (Deng and Burnett, 2002; Dworak et al., 2007). Inefficient fittings can lead to 90 L/g.n being used for showers, and 40 L/g.n for toilets and taps, while a leaking toilet can lose up to 750 L/day, and a leaking tap up to 70 L/day (ITP, 2008). Smith et al. (2009) estimate that leaking taps alone can increase hotel water use by 5% on average. Barberán et al. (2013) calculated that leaking fittings resulted in water losses of 13,986 L per day for a 117-room hotel. Based on O'Neill et al. (2002), AEA (2009) and Accor (2010), laundering bed clothes and towels can consume in the region of 100 L per occupied room per night, and account for between 12% (Dworak et al., 2007) and 47% (Deng and Burnett, 2002) of hotel water use. Laundry operations may be undertaken on-site or outsourced.

Ecotrans (2006) estimated that onsite swimming pools increase water consumption by an average of 60 L/g.n across hotels and camping sites in Germany and Austria. Hof and Schmitt (2011) estimated that irrigation of green areas and swimming pool water replenishment accounted for 931 and 108 L/g.n, respectively, in luxury Mallorcan holiday homes, compared with 61 and 7 L/g.n, respectively, in neighbouring 'mass tourism' accommodation.

Data on water use in kitchens are scarce. Deng and Burnett (2002) report that 22% of water use in a luxury hotel occurred in the kitchen. Bohdanowicz and Martinac (2007) refer to average water use of between 35 and 45 L per cover (dining guest) served in hotels. Data obtained for a mid-range hotel (anonymous, pers. comm.) with a small restaurant serving breakfast to all guests plus meals to conference and à-la-carte guests numbering less half the number of overnight guests, was reported to be approximately 20 L per guest-night, representing 15% total use. Water use in kitchens is dominated by dish-washing. Pre-rinse spray valves (PRSVs) have flow rates ≥ 15 L/min (Smith et al., 2009) and dishwashers typically consume around 4 L/rack (4 standard place settings) (Alliance for Water Efficiency, 2011b).

1.4. Water related energy and chemical use

There is considerable overlap across measures to improve water, energy and chemical management. Approximately 10-20% of energy consumption in hotels is for water heating (HES, 2011). Reducing water use, especially flow rates in showers and taps, can result significant heating-energy savings. Barberán et al. (2013) calculated annual water and energy savings totaling €12,146 after retro-fitting flow reducers to water fittings in a 113-room hotel, representing a 50-fold return on investment over a 12-yr operating lifetime. Reductions in water use that translate into avoided desalination can also yield large upstream energy savings, in the region of 4 kWh of electricity per m^3. Reducing water use for laundry processes and backwashing of heated swimming pools can lead to energy and chemical (detergent and disinfectant) savings. According to water footprint methodology (Hoekstra et al., 2011), the volume of water required to dilute discharged contaminants down to a maximum acceptable concentration threshold is categorised as the grey-water component of a water footprint, and can be substantial in relation to direct water use. The environmental impact of water discharges from the hospitality sector is particularly significant in water stressed regions. Such discharges include fats and oils from kitchens, hygiene products and detergents from accommodations and disinfectants from recreational facilities (Chan et al., 2009). When defining best practice for water-using processes in the hospitality sector, it is relevant to consider complementarities and trade-offs with water pollution minimisation in relation to the overall water footprint of the sector.

1.5. Performance oriented environmental management systems

Voluntary environmental management systems (EMS) have traditionally focussed on a check-box approach to reporting, sometimes complemented with selective reporting of metrics that support a narrative of continuous improvement (Kozak and Nield, 2004; Testa et al., 2014). Despite improvements in corporate social responsibility (CSR) reporting within the hospitality sector, comprehensive and systematic reporting of pertinent environmental performance indicators (e.g. Scandic, 2011) remains the exception. Styles et al. (2012a;b) observed a wide disparity between stated ambitions and concrete actions in retailer CSR reports, and found that some sustainability frontrunners, defined by key performance metrics, stated more modest ambitions and claims in their CSR reports than many sustainability laggards. Even ecolabels, which are intended to distinguish environmental frontrunner accommodation enterprises, do not necessarily align with quantitative water efficiency performance. Warnkin et al. (2005) reported water use of between 390 and 1090 L/gn across four 'eco' hotels accredited by the Queensland National Eco-tourism Accreditation Programme, compared with an overall range of 390 to 1410 L/g.n across 10 hotels studied. Against this backdrop of confusion caused by disparities between actual and reported environmental performance, there is a need for independent scientific assessment of best practice and key environmental performance indicators, to provide an objective evidence base for enterprise managers, shareholders, consumers and policy makers.

Article 46 of regulation (EC 1221/2009) regarding revision of the Eco Management and Audit Scheme (EMAS) lays the foundation for more rigorous performance-orientated EMS accreditation and reporting: "The Commission shall, in consultation with Member States and other stakeholders, develop sectoral reference documents that shall include: (a) best environmental management practice; (b) environmental performance indicators for specific sectors; (c) where appropriate, benchmarks of excellence and rating systems identifying environmental performance levels" (EC, 2009). Although implementation of best practice is not mandatory for EMAS accreditation, enterprises must demonstrate regard to sectoral reference document (SRD) content. SRDs and accompanying technical reports are prepared at the JRC in Seville, following a similar approach to that for industrial best available techniques reference documents (BREFs) outlined in Schoenberger (2009). SRDs are publically available for use by any enterprise wishing to improve environmental performance or, indeed, operational efficiency more generally. Techno-economic descriptions of best environmental management practice (BEMP) already implemented by frontrunners, and quantitative performance benchmarks at the process level, should provide guidance on environmental management and resource efficiency that is broad applicability. At the time of writing, the tourism SRD is undergoing the formal adoption process, and the accompanying technical report has just been published (Styles et al., 2013).

1.6. Aim and scope

The primary objectives of this paper are to: (i) synthesise conclusions on best practice and benchmarks for hospitality water management at the process and enterprise level presented in Styles et al. (2013); (ii) elaborate key evidence used to underpin these conclusions, including models of water consumption in hotels and campsites; (iii) extrapolate the magnitude of water savings achievable through best practice implementation at the European level.

2. Methods

2.1. Stakeholder involvement in best practice definition

Following preparation of a preliminary report by Grontmij-CarlBro consultants, stakeholders from relevant companies, trade associations, non-governmental organisations, EMAS verifiers and the Environment Directorate Generate of the European Commission convened as a Technical Working Group (TWG) to: (i) agree on the organisations and activities to be considered within the scope of the tourism SRD; (ii) agree on a preliminary list of BEMPs; (iii) provide links to sources of information on, and examples of, best practice.

The target audience of the SRD includes destination managers, tour operators, hotel, hostel, B&B, campsite, and food catering managers. Alongside water management synthesised in this paper, the SRD addresses energy efficiency and GHG emissions, waste minimisation and biodiversity management. Best practice measures were identified with respect to environmental performance, practical and economic viability, through consultation with TWG members and operational managers within the sector, including through site visits. A finalised list of BEMP and benchmarks of excellence was agreed by the TWG in November 2011, and a final draft of the tourism technical report supporting the SRD is available (Styles et al., 2013). Although the technical report and SRD also contain water management BEMP for destination managers, the scope of this paper is water management in hospitality enterprises.

2.2. *Techno-economic descriptions of best practice*

BEMP and benchmarks of excellence are defined as commercially viable practices and associated environmental performance levels that minimise lifecycle environmental burdens, based on the approach outlined in Schoenberger (2009), Styles et al. (2012) and Galvez Martos et al. (2013). Water management BEMPs were selected according to their effectiveness at reducing water use and water pollution. Information gathering was targeted at frontrunner organisations and technologies demonstrating high levels of performance at the process level, guided by the TWG, industry consultation and extensive searches of academic and grey literature, including sustainability reports. Techno-economic descriptions of BEMP follow a standard format designed to demonstrate the effectiveness and commercial applicability of techniques and to offer consistent, systematic guidance on implementation: (i) Description; (ii) Appropriate environmental indicators; (iii) Achieved Environmental Benefit; (iv) Cross-media effects (trade-offs); (v) Operational data; (vi) Applicability; (vii) Economics; (viii) Driving forces for implementation; (ix) Reference organisations; (x) Reference literature. A focus on the process-level is critical to enable the development of widely applicable technical guidelines and benchmarks. In this paper, each BEMP is summarised by means of a brief description, a list of relevant key performance indicators (KPIs), associated benchmarks of excellence, and any applicability constraints.

Benchmarks of excellence were derived at the enterprise (site) and process level, providing a top-down and bottom-up approach, using empirical data and technology specifications provided by the TWG, equipment manufacturers, hospitality managers and literature searches. Benchmarks of excellence were set at the top tenth percentile performance level for enterprises, and performance achievable with best available technology for processes. Owing to variation in water use between fully-serviced hotels, hostels, and campsites, and based on data availability, separate benchmarks of excellence were derived for: (i) mid-range hotels; (ii) hostels, and; (iii) campsites. Fig. 3 shows the relationship between key KPIs underpinning benchmarks at the process and enterprise level. [Insert Fig. 3 about here]

As per the structure of Styles et al. (2013), information is presented systematically for the most important water-consuming and water-polluting processes that arise within accommodation and other hospitality establishments. These include laundry, kitchen and pool processes in addition to guest washing.

2.3. Calculated water savings and economic payback

The water saving potential of each BEMP is calculated as the difference between benchmark performance and 'unimproved' performance. 'Unimproved' performance represents average performance to the extent that this was possible to calculate from available data, or to estimate through consultation with stakeholders and the TWG. To demonstrate the magnitude of water savings achievable at the enterprise level, annual savings were modelled for a fully-serviced 100-room hotel and a 60-pitch campsite. The model hotel comprises a 100 m^2 swimming pool, a restaurant serving breakfast to all 100 overnight guests in addition to a full meal to 25 diners per day. It is assumed that, on average through the year, 80% of rooms are occupied, including 20% doubled-occupied, equating to continuous occupancy by 100 overnight guests. The campsite has, on average, 100 guests staying for six months of the year, and a 100 m^2 pool. The basic model can be simplified thus:

$$V_s = \sum_{p=1}^{20}(Qu \times tu \times fu) - \sum_{p=1}^{20}(Qo \times to \times fo)$$

Where V_s is the volume of water saved through process optimization in the enterprise (L/day); *u* and *o* suffixes = unimproved and optimized performance, respectively; Q is flow rate (e.g. L/min for fittings; L/kg laundry; L/rack for dishwashers); *t* is duration of flow where relevant (e.g. minutes per use for fittings); *f* is frequency per day (e.g. number of flushes or tap uses, kg laundry generated, racks (covers) for dishwashers) – derived from guest-nights and employee numbers; all expressed at the process level for 20 processes (*p*=1-20) listed in Table 1, alongside parameter values. An annual reporting period was considered, and seasonal water use was not differentiated.

Economic savings arising from water and energy savings achieved by water efficiency measures can be summarised in the following equation:

$$S = V_r \text{ x } (P_s + P_{ww}) + VH_r \text{ x } (\Delta T \text{ x } C \text{ x } (1/\eta) \text{ x } P_{en})$$

Where S is the economic saving (EUR), V_r is the volume reduced (m^3), P_s is price of supplied water (EUR/m^3), P_{ww} is price of wastewater disposal (EUR/m^3) (typically, $P_s + P_{ww} = 2\text{-}4$ EUR/m^3), VH_r is the reduced volume of heated water (m^3), ΔT is the temperature rise of heated water (ºC), C is the specific heat capacity of water (1.16 kWh/m^3/ºC), η is heating energy efficiency (fraction, from 0.85 for non-condensing oil boilers to 0.97 for electric elements: Gustavsson and Karlsson, 2002), P_{en} is the price of energy (EUR/kWh; from 0.06 for natural gas to 0.22 for electricity according to Energy.EU 2012).

Simple economic payback times were calculated based on water savings multiplied by an average water supply and disposal cost of EUR 2.5/m^3, and a fuel energy cost of EUR 0.08/kWh for oil-based water heating (Energy.eu, 2012). It was assumed that the temperature of water used for showering is elevated by an average 30°C throughout the year, and water used in basin taps is elevated by an average 20°C throughout the year – sufficient to supply water exit temperatures of approximately 40 °C from showers and hot taps after heat losses. Economic payback for laundry and kitchen processes was calculated based on the above water price, an electricity price of EUR 0.10 to EUR 0.20 per kWh, and chemical detergent prices of EUR 15 per kg for small-scale laundries, EUR 1.00-1.80 per kg for large-scale laundries and EUR 2-3 per L for dishwasher detergents. For brevity, most economic data are based on the 100-room hotel; additional camp site data are presented where pertinent, but kitchen, pool and public toilet data are applicable across all types of accommodation.

3. Results

3.1.<u>Overview of water saving potential</u>

Table 1 describes unimproved and best practice situations at the process level with reference to equipment specifications and operational aspects for the model hotel. Aggregate unimproved and best practice at the enterprise level water use is presented as L/g.n in Fig. 4. The achievable water saving for a 100-room hotel amounts to 15 543 m^3/yr through implementation of best practice. Where it is possible to use grey- or rain-water for toilet flushing, the achievable water saving amounts to 16 573 m^3 /yr of potable water (Table 1). Water use can be reduced from 565 to 139 L/g.n (reduction "a" in Fig. 4), and to 111 L/g.n potable water if grey- or rain-water is used to flush toilets ("a" + "e" in Fig. 4). Excluding potential cooling tower and irrigation water use results in modelled unimproved water use of 390 L/g.n and an achievable saving of 9152 m^3/yr (Table 1 and reduction "c" in Fig. 4). Excluding cooling tower, irrigation and pool water use results in unimproved water use of 353 L/g.n and an achievable saving 8315 m^3/yr (Table 1 and reduction "d" in Fig. 4). [Insert Table 1 and Fig. 4 about here]

Modelled hotel water use calculated by aggregating unimproved and best practice use for individual processes corresponds well with empirical water use data reported by hotels (Fig. 1). One hotel chain provided frequency distribution data for water use across their hotels in 2010 (Fig. 5). The top 10 percentile performance level for this chain was 140 L/g.n, corresponding closely with modelled best practice of 139 L/g.n. [Insert Fig. 5 about here]

Modelled water-heating energy savings for a 100-room hotel amount to 209 541 kWh per year (Table 1). If the total water savings translate into avoided desalination, a further 83 000 kWh of upstream energy (primarily electricity) consumption could be avoided, assuming reverse osmosis desalination requiring 5 kWh per m^3 water desalinated (Al-Karaghouli and Kazmerski, 2013). Table 1 also lists potential economic savings arising from achievable water and associated energy use reductions for different processes. In aggregate, these savings amount to a maximum annual saving of EUR 58 436 for the modelled 100-room hotel. The following sections systematically describe key aspects of BEMP, including KPIs, benchmarks, applicability and economic considerations for accommodation enterprises in more detail.

3.2. Best practice descriptions for built accommodation

3.2.1. Water management plans

Implementation of a water management plan involves the monitoring and benchmarking of water consuming processes in order to identify leaks and opportunities to reduce water use, and is regarded as a prerequisite to systematic implementation of technical water efficiency measures. Best practice involves: (i) sub-metering water use across accommodation zones, kitchens, laundry areas, public toilets, pool areas, and feed lines to steam heat-exchangers; (ii) periodic inspection of water using equipment, fittings and 'leak points', at least every six months (Table 2), especially toilet cisterns, taps, basin drain plugs, urinal flush-control systems, HVAC circuits (especially heat exchangers), dishwashers. Scandic Hotels (2011) attribute a 25% reduction in specific water use across the organisation to widespread benchmarking implemented since 1996. Accor Hotels have a dedicated team of engineers who visit hotels with high water use KPIs to identify causes and solutions (Accor, pers. comm. 2011). [Insert Table 2 about here]

Another important aspect of water system management is to avoid excess water heating and to adequately insulate pipes. Water is often heated to over 80 ºC on accommodation premises, despite 45 ºC being adequate for most needs (Lamei, 2009), though periodic heating to 60 ºC may be required to minimise the risk from legionnella bacteria. Twenty mm of insulation can reduce heat loss by almost 400 kWh per year for every metre of 5 cm diameter piping, and reduces water use by reducing lag times for hot water to arrive at opened fittings.

3.2.2. Efficient fittings

Best practice is to install low flow fittings when renovating guest and public area bathrooms, and in the interim to retrofit with low-flow shower heads, aerators and, where compatible with flush performance, cistern-volume-reducing-devices (Table 2). Unimproved shower and tap flow rates displayed in Table 1 reflect information on average performance reported in EC DG ENV (2009), EEA (2009) and Eurostat (2009). A study of water use in hotels found that toilet cisterns were discharged on average six times per day (NH Hoteles, 2011). This corresponds with the modelled assumption of four flushes per guest-night, plus two flushes per occupied room per day during cleaning in the unimproved scenario. Baths are not included in the model, but will be similar to shower performance: i.e. unimproved and best practice (optimised bath tub size and shape) of 90 and 42 L per use, respectively.

Flow rates as low as 2 L/minute can be achieved for new spray taps in bathrooms (EEA, 2012), whilst flow rates of <6 L/min can be achieved by retrofitting aerators to existing taps. Best practice in Fig. 4 is based on taps with a maximum flow rate of 4 L/min fully opened during use. Dual-flush 6L/3L toilets have an effective flush volume of 4.5 L. Best practice for showers includes installation of thermostatic temperature control and a maximum flow rate of 7 L/min. Low-flow or 'waterless' urinals can reduce water use to less than 17 L per urinal per day. In public toilet areas, spray taps with < 2 L/min can be installed, potentially saving a further 1.5 L/guest-night compared with best practice displayed in Fig. 4. Infra-red sensor control of taps in public areas can minimise water consumed during hand washing, but this effect was not modelled. In aggregate, installation of low-flow fittings in guest rooms and public toilet areas can reduce water use by 151 L/g.n, or 5505 m^3 per year, equivalent to a 43% reduction relative to the baseline without cooling tower, irrigation or pool.

Table 3 provides economic data for low-flow fittings, providing simplified estimates of payback time based on installation costs equivalent to the equipment price. Payback times are shorter than 3 years in all cases except where existing basin taps and toilets are replaced by new low-flow taps and low-flush toilets in guest bathrooms. Payback times will be considerably shorter, even immediate, if efficient equipment is selected at the stage of bathroom renovation as price premiums for low-flow fittings are small. Payback times on efficient water fittings in shared bathrooms (e.g. hostels) will be considerably shorter than for en-suite bathrooms as reported in Table 3 (see also campsite section, below). Use of aerators, and low flow taps and low-, dual- flush toilets in new bathrooms, is widespread, but low-flow showers are less common. [Insert Table 3 about here]

3.2.3. Best practice for housekeeping

Best practice is to flush toilets only once and to run taps for a maximum of one minute during cleaning. The large water saving (986 m^3) attributed to room cleaning in Table 1 also includes the effect of installing more efficient water fittings. Housekeeping is critical to efficient operational management of accommodations, and a range of benchmarks are listed in Table 2, including reducing laundry volume by not taking bedclothes and towels for washing unless guests specifically request it. Green procurement of cotton-polyester with lower laundry energy demands (compared with pure cotton) and eco-labelled sanitary detergents (in multi-use dispensers) are additional aspects of best practice. Commercial implementation of best practice in green procurement of textiles and chemical cleaning products is demonstrated by small hotels (e.g. Garvarni Hotel, 2011) and systematically across large chains (e.g. Scandic Hotels, pers. comm. 2011).

3.2.4. Best practice for laundry

Table 4 refers to BEMP and benchmarks for laundry operations. Laundry operations make a significant contribution towards unimproved water use (30 L/g.n), and also towards energy and chemical use (grey water footprint). Best practice measures thus include criteria to minimise energy and chemical consumption. In general, measures to reduce water use also reduce energy and chemical consumption, although total laundry energy requirements are dominated by drying. Fig. 6 displays the relative contribution of different laundry processes to energy and economic costs, for unimproved and optimised large-scale laundries based on data in Bobák et al. (2011) and EC (2007). Annual water, energy and economic savings attributable to best practice in laundry equate to 712 m^3, 80 483 kWh and EUR 8219, respectively, for a 100-room hotel, although these savings are likely to be realised off-site in the case of outsourced laundry. [Insert Fig. 6 and Table 4 about here]

Owing to much higher efficiencies achievable in large-scale laundries (processing over 250 kg textiles per hour) with continuous batch washers (CBW), best practice is for accommodation enterprises to outsource laundry to large laundries that demonstrate high levels of environmental performance, preferably via certification. Assuming a transport distance of 30 km in a small van, diesel consumption of approximately 0.042 kWh per kg of laundry is minor compared with potential energy savings in the region of 0.5 – 1.0 kWh per kg laundry attributable to optimised large-scale laundry. Very large accommodation premises may install CBW on site. Specific best practice technologies include heat recovery from waste water and waste water recovery for the pre-wash cycle using micro-filtration units. Small accommodation enterprises for which outsourcing is not possible (e.g. in rural locations) can still significantly reduce laundry water and energy use by minimising laundry loads (housekeeping) and selecting the most efficient washing machines.

3.2.5. *Best practice in kitchens*

Sub-metering and monitoring of kitchen water use was found to be rare (Styles et al., 2013). Therefore, the first aspect of best practice is for kitchen managers to devise a kitchen water management plan that includes benchmarking of water use per cover (dining guest served) (Table 5). Selection of efficient fittings and washing equipment is the next key aspect of best practice for kitchens. A range of best practice guidance indicators are presented in Table 6, and achievable annual savings for a small-medium sized commercial kitchen are presented in Table 7. Best practice includes installation of efficient PSRVs with trigger operation, lower-flow taps with pedal operation, avoiding thawing under running water, and waterless steamers (Tables 6 and 7). In relation to the array of technical measures available to optimise kitchen operations in terms of water, energy and chemical usage, best practice is to implement as many of these measures as are relevant and economically viable in specific kitchens. [Insert Table 5 about here]

Water use decreases from 3.8 L/rack for under-the-counter type dishwashers with a capacity for up to 35 racks (<100 meals) per hour to 2 L/rack for conveyor (tunnel-type) dishwashers with a capacity of 1000 racks (2000+ meals) per hour (Koeller et al., 2010). The latter type of dishwasher is only likely to be applicable in very large hotels or restaurants, though there may be some marginal cases where dishwashing logistics can be optimised to allow installation of a larger, more efficient dishwasher type that can be operated at full loads to minimise water and energy use. Otherwise, best practice is to ensure full loads through appropriate dishwasher sizing and dishwashing management, and to select the most efficient dishwasher available at the appropriate size. Recommended specifications that define the most efficient dishwashers include: rinse-water recycling for wash and prewash (multiple tanks); rated water use ≤2.5 L per basket (tunnel type) or ≤3.5 L per basket (hood type); drying-air heat recovery system; at least 20 mm of insulation; at least two speed settings for standard and dirty dishes (tunnel type dishwashers); automatic process control in response to loading (tunnel type dishwashers). [Insert Table 6 about here].

Koeller et al. (2010) estimate a 20% price premium for the most efficient (Energy Star labelled) dishwashers in the US would be paid back within one to two years, mainly owing to energy and chemical savings that parallel water savings. At current European energy and water prices, payback time is very short (Fig. 7). Meanwhile, published prices for retrofit water-, energy- and chemical- saving modules that can be added to basic machines from one European manufacturer (Meiko UK, 2011) would be paid back within two to seven years, depending on the specific module and consumable prices. For another European manufacturer, payback times for dishwasher efficiency modules range from 14 to 18 months (Kromo, 2011). [Insert Fig. 7 about here]

3.2.6. Best practice for swimming pools

Data on pool area water consumption can be benchmarked on a m^2 pool area basis, and will vary considerably for accommodations depending on usage rates which can be low. Modelled pool area water consumption of 37 L/g.n (Fig. 4) is lower than reported in ITP (2008). Sub-metered water use data from a German hotel indicate water consumption of 52 litres per guest-night for the large outdoor pool area, including showers (Hotel Colosseo manager, pers. comm., 2011).

Hazell et al. (2006) found that the majority of public swimming pool managers surveyed could not provide annual water use data. Monitoring and benchmarking of water, energy and chemical use in pool areas is therefore the preliminary best practice benchmark for pool and accommodation managers (Table 5).

For outdoor pools with low usage rates, it is possible to avoid chemical disinfection through incorporation of natural filtration systems which can be specified during construction or retrofitted (Ecotrans, 2006; Uhlenköper Campsite, 2011). Natural filtration systems comprise a regeneration zone in which specially selected plants and an aggregate substrate filter nutrients, algae and microorganisms out of the water, separated from the swimming area with a dividing wall reaching approximately 100 mm below the water surface. This is best practice for outdoor low-usage pools (Table 5), especially for campsites; examples include Uhlenköper campsite in Germany (Uhlenköper manager, pers. comm. 2011). There may be marketing (perception) barriers for this best practice in some built accommodations.

For conventional swimming pools, backwashing of filters, showers, amenities, replacing evaporative losses and leakage account for 30%, 25%, 19%, 15% and 10%, respectively, of water use (Hazell et al., 2006). Amenity best practice is represented in the section on public toilet areas. Water savings from the other factors are specified for the 100-room model hotel in Table 1.

Backwashing sand filters is often performed according to a fixed schedule, once or twice per day, and can use between 250 and 450 L per minute for a typical hotel pool (Travel Foundation, 2011). Optimising filter backwashing based on pressure-drop rather than a fixed schedule can reduce backwashing to four minutes once per 2.5 days on average, reducing use to 6.4 L/g.n (Travel Foundation, 2011). Evaporation from a 100 m^2 indoor pool is in the region of 650 L per day, and can be reduced to 325 L/day through use of a well-fitting pool cover for 12 hours per day (ThermExcel, 2012). Low-flow showerheads and push-button timer controls can minimise shower water consumption. Given the low rate of monitoring, and variability depending on conditions (e.g. outdoor climate), a quantitative benchmark of excellence was not proposed for pool water use. As an initial reference point, best practice as described here would translate into a figure of 5.3 m^3/m^2/yr.

3.2.7. Cooling and irrigation

O'Neill et al. (2002) report water use for cooling towers in Seattle hotels equivalent to 53 – 95 L/room/night. Unimproved performance in Table 1 and Fig. 4 is based on the low end of this range, and many European hotels use alternative cooling systems. Best practice for energy management is to install geothermal cooling, as demonstrated for both large hotels (e.g. Crowne Plaza, 2011; 2012) and small hotels (Hotel Victoria manager, pers. comm. 2011), resulting in virtually no water use for cooling.

Eurostat (2009) estimate that irrigation accounts for 22.5% of total accommodation water consumption. Not all accommodations will have green areas, and irrigation is only applicable in some cases. Best practice is to avoid irrigation with potable water through appropriate landscaping and use of harvested rainwater or grey water (Table 8). Commercial examples range from campsites to a five-star city hotel (Rafayel Hotel technical manager, pers. comm. 2011). At Kühlungsborn Camp in Germany, grey water from the wash house is sent to a tank where heat is recovered to pre-heat incoming freshwater for showers via a heat pump, before being pumped to irrigate garden areas (Kühlungsborn Camp manager, pers. comm. 2011). Where irrigation systems are deemed necessary, various technical measures can be implemented to minimise water use, in particular the installation of controlled drip-irrigation (Table 8). [Insert Table 8 about here]

3.3. Campsite and hostel benchmarks

Water use is much lower on campsites than in hotels. Average consumption across 99 campsites within the Ecocamping network in 2009 was 103 L/g.n (Walter, 2011), whilst Ecotrans (2006) report average consumption of 174 L/g.n across 55 campsites. Nonetheless, there is significant potential to reduce water use, especially on campsites with extensive amenities (Fig. 8). Modelled water use for an 80-pitch campsite with 100 guests under unimproved water management amounted to 282 L/g.n, including 50 L/g.n for irrigation in a high consumption scenario. Against this baseline, reductions of up to 195 L/g.n are possible through implementation of best practice ("a" + "d" in Fig. 8). Against a baseline without irrigation or a pool, best practice equates to potable water use of 80 L/g.n (88 L/g.n excluding water recycling) and achievable reductions in water consumption amount to 127 L/g.n ("c" + "d" in Fig. 8). The benchmark of excellence for campsite water use is based on top ten percentile performance from Ecocamping data (Walter, 2011), and corresponds with modelled process-level best practice: total water consumption of ≤ 94 L/g.n on fully serviced four- and five star campsites, and water consumption of ≤ 58 L/g.n on all other campsites. [Insert Fig. 8 about here].

Much of the technical information on best practice in water management for hotels applies equally to campsites; e.g. benchmark flow rates for low-flow fittings. However, differing usage rates can change the economics. Payback times for efficient water fittings are short in campsites and compare very favourably with those reported for built accommodation in Table 3, owing to high usage rates in wash rooms. Maximum payback times for installation of low-flow basin taps and shower heads are 4 and 5 months, respectively, whilst maximum payback time for low-flush toilets is 33 months (worst case, accounting for full fitting cost). Food preparation by guests and kitchen water use is relatively more important for campsites than built accommodation, and flushing toilets with pool backwash water is an additional possible water saving measure (Fig. 8).

3.4. Extrapolation to European tourist accommodation

According to Eurostat (2013) there were approximately 2.439 billion guest-nights spent in tourist accommodation establishments within the EU27 plus Norway and Switzerland during 2011. Of these, approximately 1.65 billion guest nights were spent in hotels or similar and 360 million guest nights were spent in campsites. Multiplying these figures by hotel and campsite guest-night water use improvement potentials displayed in Fig. 4 and Fig. 8 (excluding irrigation and cooling tower water use to be conservative) indicates that universal application of best practice in water management across European hotels and campsites could reduce potable water use by 376 million m^3 and 46 million m^3 per year, respectively. Implementation of process level best practice in water management described here across other accommodation types, kitchens serving food and drink outlets and leisure centers, amongst other hospitality establishments, would considerably increase this saving potential.

4. Discussion

4.1. Study approach and scope

This study generated technical guidance on commercial best practice in water management within the hospitality sector, using quantitative benchmarks based on the most relevant KPIs. The following two criteria underpinned the approach. Firstly, a focus on the technical process level, and associated management control points, to address water use hotspots identified through systems analysis. Secondly, commercial applicability of best practice as determined by simple payback times ≤ three years, existing implementation by industry frontrunners, and validation by the expert technical working group (TWG, 2011).

Best practice in water management overlaps with best practice in energy management, green procurement and management of outdoor areas (Styles et al., 2013). Destination managers, including public authorities, can play an important role driving water efficiency within destinations, for example by reducing high rates of water leakage in the water supply network and introducing water pricing/taxation schemes that further incentivise water saving (Styles et al., 2013). Although focusing on accommodations, best practice descriptions for water fittings, kitchens and pool areas are applicable across the wider hospitality sector. Consequently, this work indicates high potential to reduce water use and pollution across the tourism sector – issues of strategic importance for sustainable tourism development.

Gössling et al. (2011) estimated that a tourist may consume up to 7500 L of water per day indirectly, and Accor (2010) reported that 86% of their guests' water footprint arises upstream, mainly for irrigation in food production. However, insufficient data on indirect water footprints and effective mechanisms to reduce them make it difficult to develop robust best practice guidance to minimise indirect water footprints at present (Styles et al., 2013). In addition, indirect footprints may not contribute to the acute local water stress in tourism hotspots, and were outside the scope of this paper.

4.2. Applicability of best practice conclusions

Acceptable payback times in the hospitality sector are short (Trung and Kumar, 2005). Payback times for best practice measures calculated here based on European average water and energy prices will vary according to local pricing, but are typically less than three years, as also reported by Dworak et al. (2007) for tourism water saving measures, and therefore should be acceptable to enterprise managers. Technical best practice measures implemented in exceptional circumstances, such as recycling of shower water to flush toilets (NH Campo de Gibraltar, 2011), were excluded from best practice recommendations where payback times were estimated to be high under typical water pricing. March et al. (2004) also found grey water reuse for toilet flushing to be too expensive for widespread implementation in Spain. Ultra-low-flow spray taps were not included as best practice for en-suite bathrooms owing to probable negative guest perception (TWG, 2011). Low-flow fittings were observed in all bathrooms of one five-star hotel in London (Rafayel Hotel, pers. comm. 2011), but rejected as unacceptable to guests in another five-star London hotel (Anonymous, 2011), highlighting different prioritization of water efficiency measures across managers in high-end hotels.

Although best practice measures presented here are widely applicable, they may take some time to fully implement as retrofit measures. Enterprise managers are likely to synchronise major equipment retro-fitting with maintenance and renovation programs. Corporate level water efficiency strategies take time to roll out across enterprises, as evidenced by the decadal timescale of ongoing water efficiency improvement across hotels in the Scandic chain (Scandic Hotels, 2011).

4.3. Added value of process level benchmarks

Quantitative data on water use across many important processes within the hospitality sector are scarce. Proposed benchmarks of excellence presented here based on process level benchmarks associated with best available technology and frontrunner performance are considerably more ambitious than those proposed in other references (Ecotrans, 2006; Dworak et al., 2007; IFC, 2007; Nordic Ecolabelling, 2007; ITP, 2008). Notably, ITP (2008) proposed an 'excellent' benchmark of <400 L/g.n for mid-range hotels in temperate climates, compared with a benchmark of excellence derived in this study of < 140 L/g.n. Although Dworak et al. (2007) assume that water saving measures are already extensively implemented across European hotels, data presented here highlight a large improvement potential. Water saving potentials may be even greater outside of Europe. Despite a 21% reduction in specific water consumption in Hong Kong hotels over six years up to 2002, largely attributable to the installation of flow regulators and sub-meters, water consumption remained at 874 L per occupied room per night (Chan et al., 2009), suggesting very high remaining improvement potential.

Wide disparities in resource efficiency across enterprises have been reported for other sectors following process-level best practice assessment by the JRC (ICLEI, 2012; Styles et al., 2012; Galvez Martos et al., 2013; Schoenberger et al., 2013), implying that significant opportunities for win-win economic and environmental savings are often overlooked. Various factors could explain economically sub-optimal water management: complacency; lack of data owing to inadequate sub-metering; poor communication between technicians with knowledge of process efficiencies and accountants making strategic investment decisions; the relatively low share of overall costs represented by water and energy use. Even for hotels in Barbados with high average water consumption of 839 L/g.n, water use was reported to represent just 5% of running costs (Charara et al., 2011). Alvarez et al. (2001) found a significant positive correlation between environmental management, operations management and profitability, with larger, newer and chain-affiliated hotels performing better, suggesting some of the aforementioned barriers are greater for older and independent establishments.

Publishing ambitious and transparently-derived process-level best practice benchmarks and improvement options should support direct best practice implementation by technical managers, complementing top-down strategies that can take time to be systematically implemented across organisations. Published examples of frontrunner performance could provide a competitive motivation for enterprise managers to prioritise water efficiency measures. Technically defined performance benchmarks provide much needed transparency for all hospitality stakeholders who may be confused by selective CSR reporting and a proliferation of green labels and awards that rarely guarantee high levels of environmental performance (Kozak and Nield, 2004; Warnken et al., 2005; Styles et al., 2012; Testa et al., 2014).

5. Conclusions

Extensive literature review, site visits and consultation with operational managers and other stakeholder experts in the hospitality sector underpinned the development of techno-economic descriptions of best practice in water management and benchmarks of excellence at the process and enterprise level. Process level benchmarks were based on commercial applications of best available technologies with a simple payback period ≤ three years at average European water and energy prices, whilst enterprise benchmarks were based on the top ten-percentile performance level across frontrunner enterprises. These benchmarks provide challenging but achievable targets and highlight considerable improvement potential for hospitality managers. Bottom-up modelling of best practice at the process-level corresponded closely with enterprise level benchmarks derived from empirical data for water-efficiency frontrunners .

Derived benchmarks expressed as total water use per guest night were: ≤140 L/g.n in fully serviced hotels; ≤100 L/g.n in accommodation where the majority of the bathrooms are shared across rooms (e.g. hostels); ≤ 94 L/g.n in fully serviced four- and five star campsites; ≤ 58 L/g.n on all other campsites. Excluding high-water-use and non-universal processes such as cooling-tower evaporation and irrigation, achievable water savings were estimated at 228 L/g.n for fully serviced hotels and 127 L/g.n for fully serviced campsites. Implementation of best practice in water management across hotels and campsites at the European level could reduce water use by 422 million m^3 per year. Crucially, much of this water reduction could occur in areas of high water stress, such as cities and Mediterranean resorts, thus making a significant contribution towards improving the sustainability of tourism. Many water saving measures also reduce energy consumption, and are financially attractive, but may not be implemented due to divided responsibilities within large organisations and lack of awareness.

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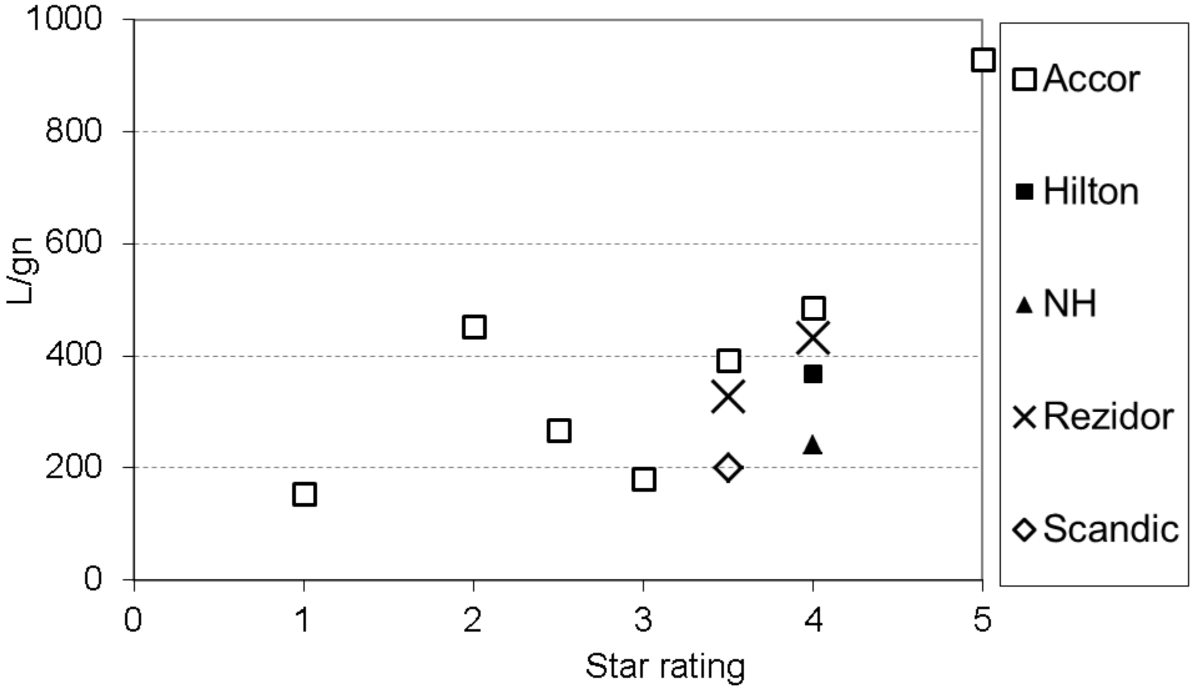
Figures



N.B. Assumes 1.4 guests per occupied room for Accor hotel brands. From sustainability reports (Accor, 2010; NH Hoteles, 2010; Rezidor Group, 2010; Scandic, 2011) and Bohdanowicz and Martinac (2007). The comparability of methodologies used to derive benchmarks in different sustainability reports has not been verified.

Fig. 1. Average water consumption of hotel brands reported by hotel groups, compared with average star ratings for those brands

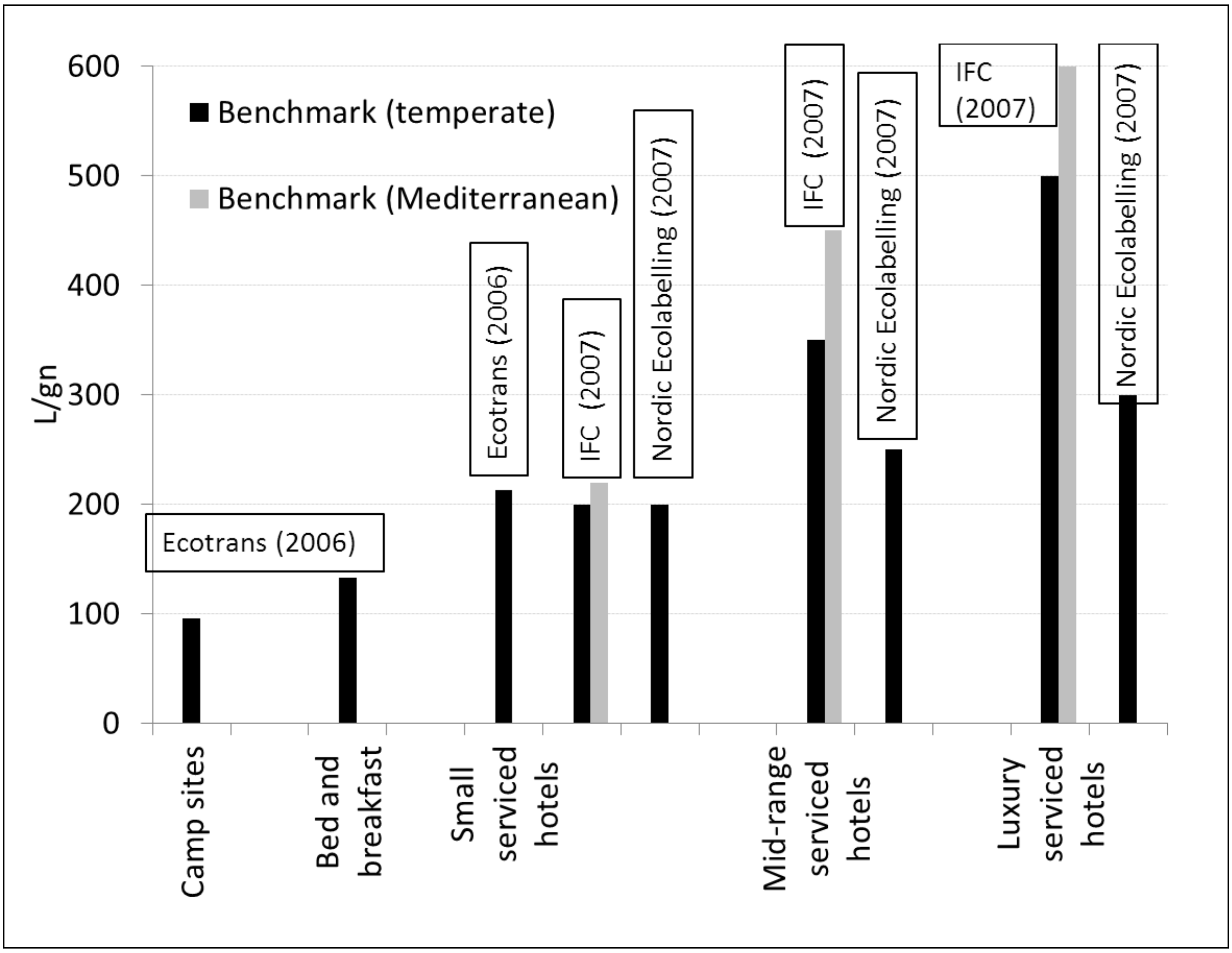


Fig. 2. Existing benchmarks for accommodation enterprises

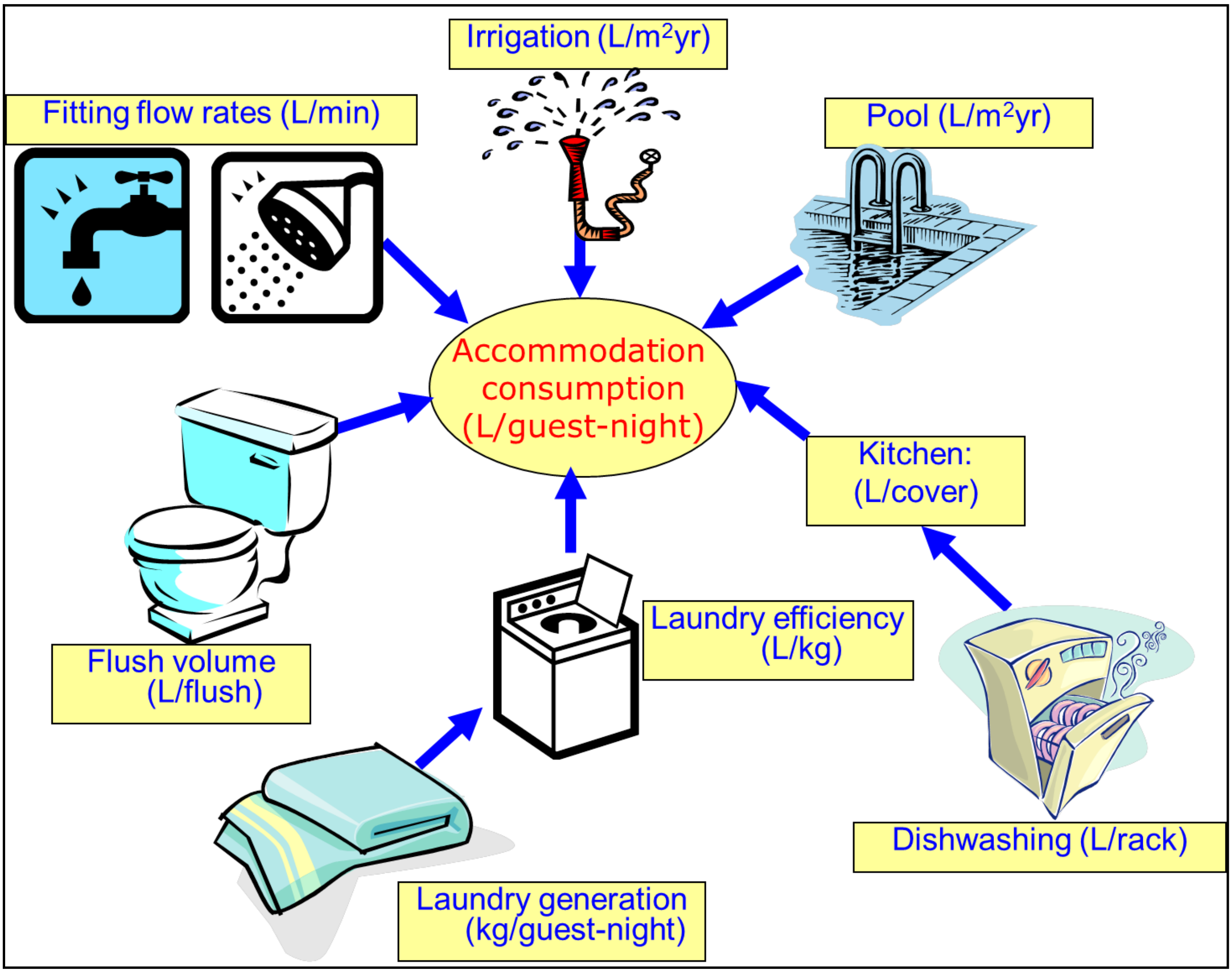
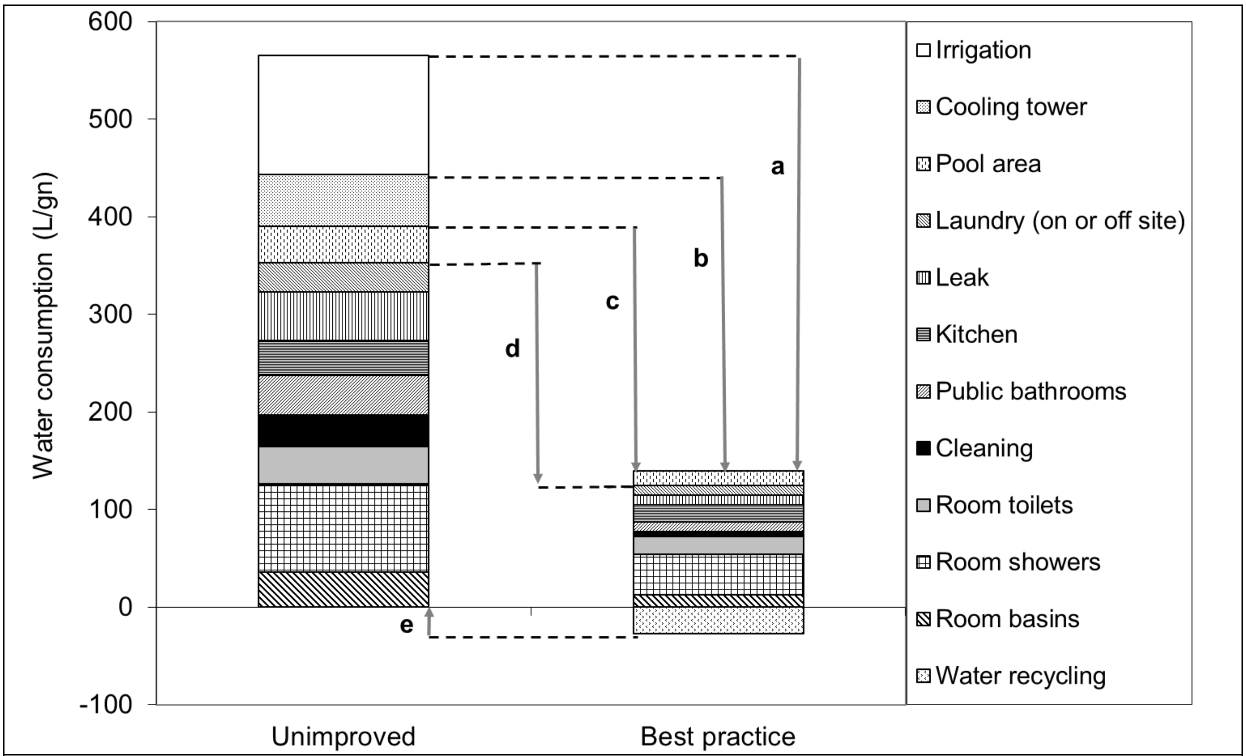


Fig. 3. Major processes, and relevant performance indicators for benchmarking, that contribute to water consumption within an accommodation enterprise



a (+e) = maximum reduction relative to hotel with irrigation, cooling tower and pool; b (+e) = reduction without irrigation; c (+e) = reduction without irrigation or cooling tower; d (+e) = reduction without irrigation, cooling tower or pool; (+e) = with water recycling

Fig. 4. Modelled water consumption for a 100-room hotel with 'unimproved' and best practice water management across all major water-consuming processes (process details in Table 1)

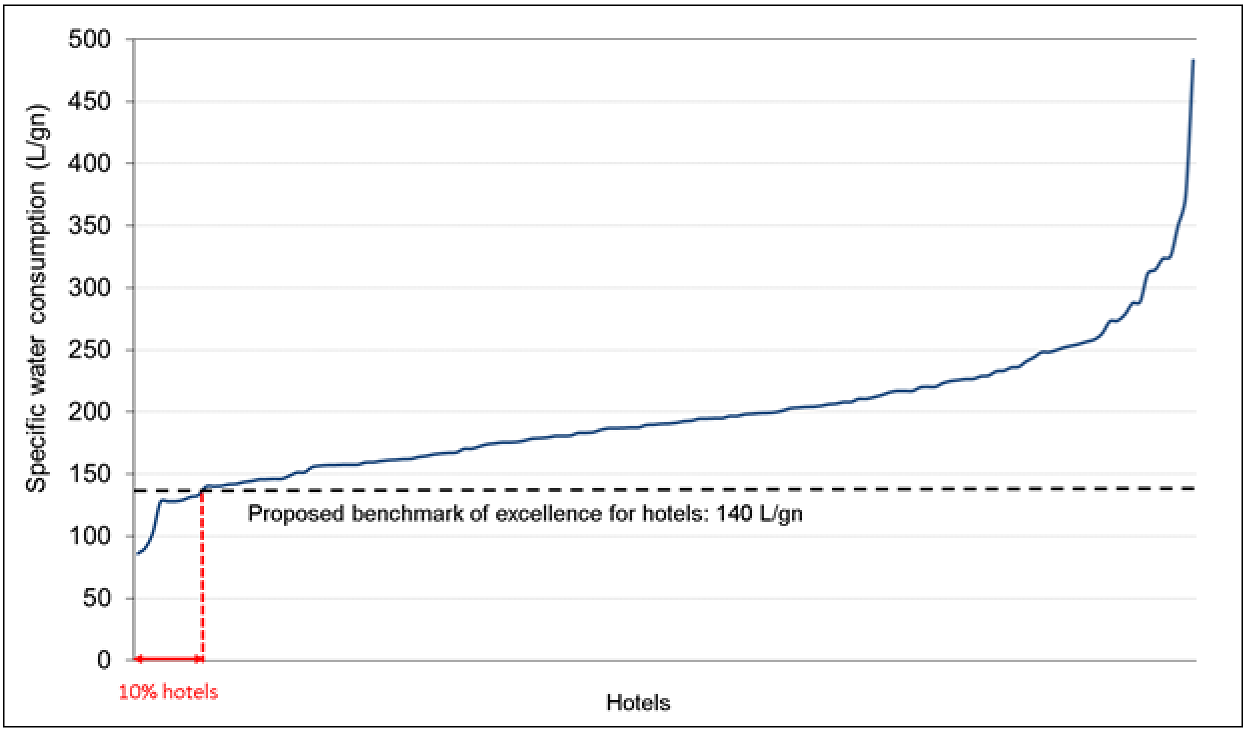
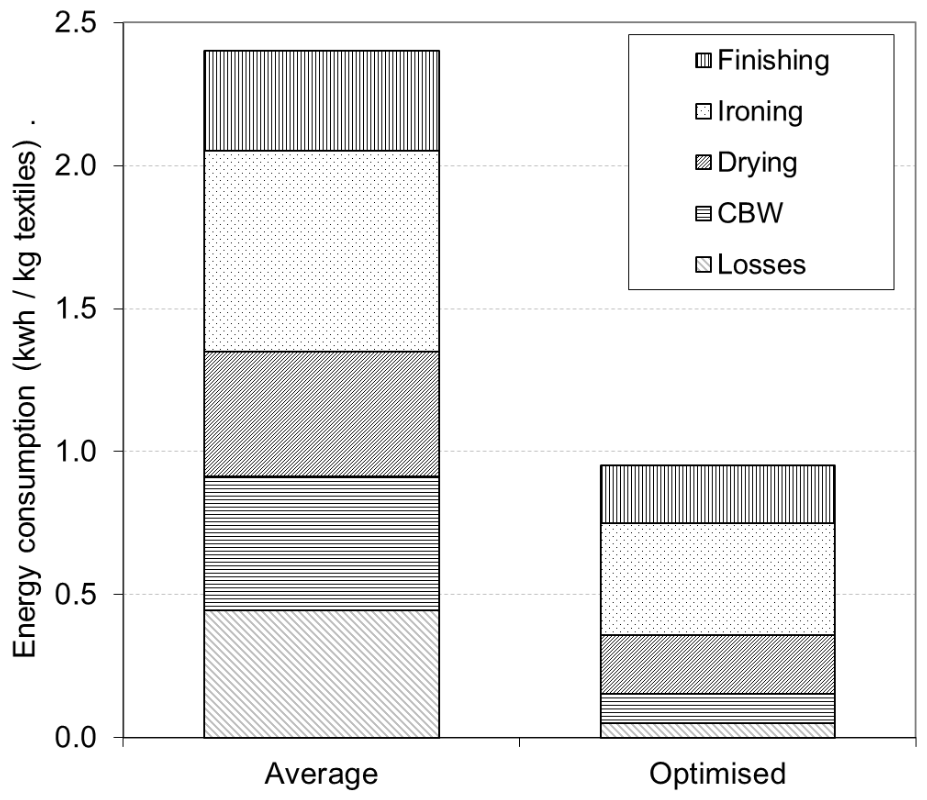


Fig. 5. Enterprise level performance data for a mid-range hotel group, showing top ten percentile performance level used to empirically derive a benchmark of excellence for mid-range fully serviced accommodation



CBW = Continuous batch washer. Data from Bobák et al. (2011).

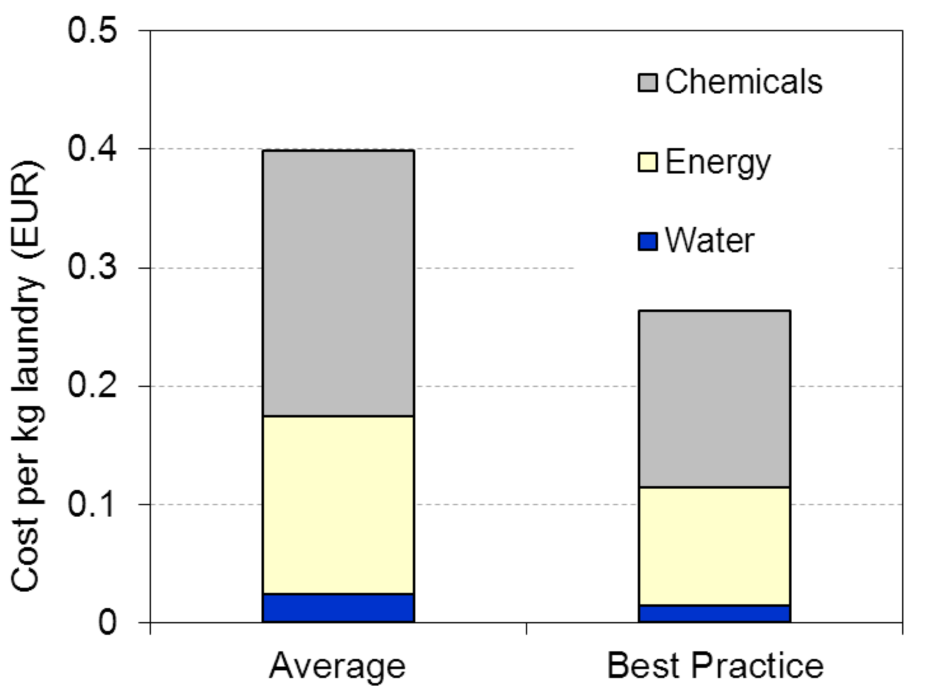
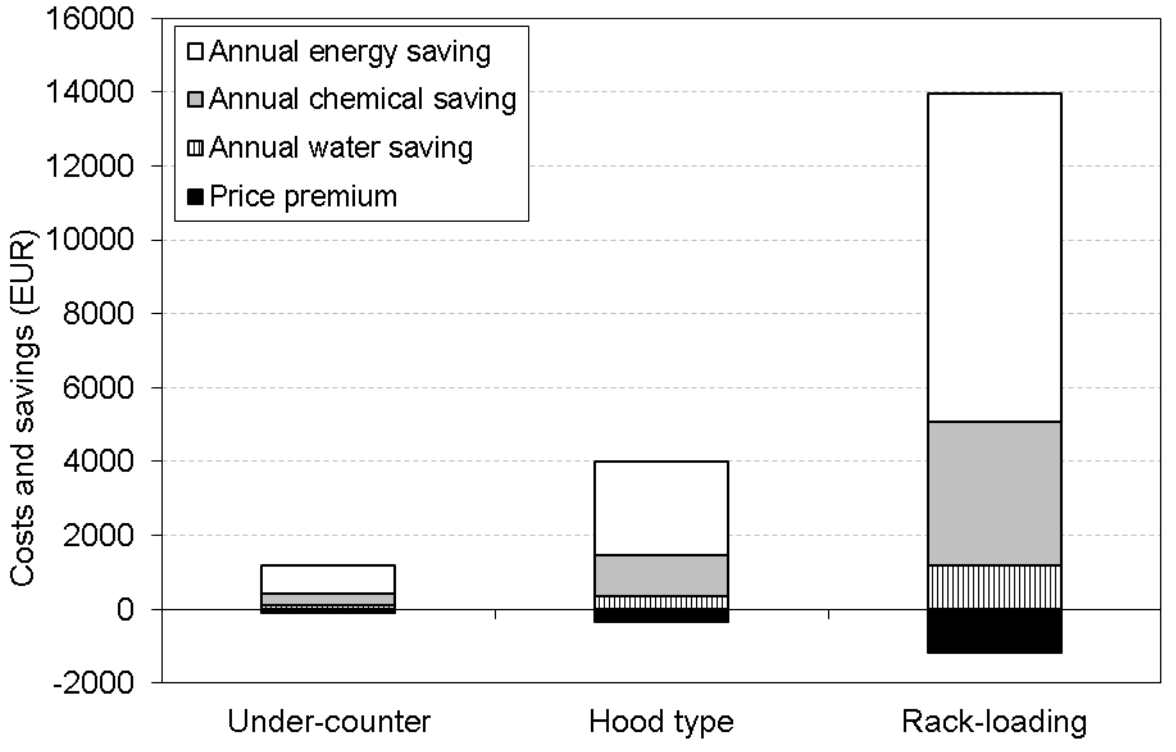
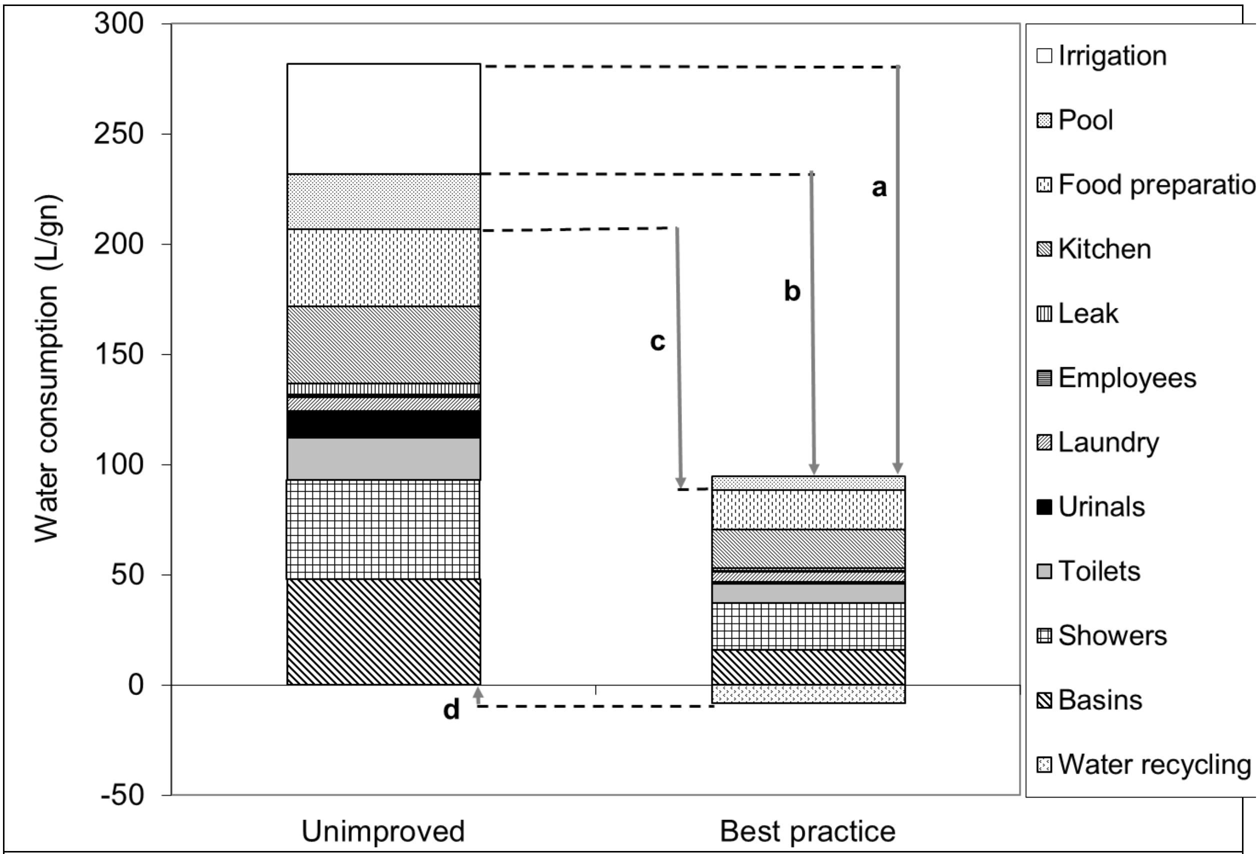


Fig. 6. A breakdown of energy demand and costs for average and optimised large scale laundry operations



NB: Price premium, annual loading rates and water savings derived from Koeller et al. (2010) as difference between Energy Star and average dishwashers; energy savings based on avoided water heating to 90 ºC; water price of EUR 2.5/m^3, chemical price of EUR 2/L, and energy price of EUR 0.20/kWh (electricity) except for rack-loading (EUR 0.10/kWh assuming combination of oil/gas water heating plus electricity).

Fig. 7. Annual savings in water, energy and detergent achievable by selecting the most efficient new dishwashers of under-counter, hood and rack-loading (conveyor) types, compared with the initial price premium for purchasing more efficient equipment



a (+d) = maximum reduction relative to campsite with irrigation and pool; b (+d) = reduction without irrigation; c (+d) = reduction without irrigation or pool; (+d) = with water recycling

Fig. 8. Modelled water consumption for an 80-pitch serviced campsite with 'unimproved' and best practice water management

Table 1. Summary of non-optimised and optimized performance across key processes, and potential annual water, energy and economic savings, for a 100-room hotel

Fitting/ process	Non-optimised performance (daily)*	Optimised performance (daily)**	Annual saving for 100-room hotel		
			Water (m^3)	Energy (kWh)	EUR***
Showers	100 guests x 6 min @ 15 L/min	100 guests x 6 min @ 7 L/min	1752	67744	9800
Room toilets	100 guests x 4 flushes @ 9.5 L/flush	100 guests x 4 flushes @ 4.5 L/flush	730		1825
Room taps (retro-fitted)	100 guests x 3 min @ 12 L/min	100 guests x 3 min @ 4 L/min	876	22581	3996
Room cleaning	75 occupied rooms x (2 flushes @ 9.5 L/flush + 2 mins @ 12 L/min taps)	75 occupied rooms x (1 small flush @ 3 L/flush + 1 min @ 4 L/min taps)	986	11291	3367
Sub-total room fittings			**4344**	**101616**	**18989**
Public toilets	33 guests x 1 flush @ 9.5 L/flush plus 50 staff x 2 flushes @ 9.5L/flush	30 guests x 1 flush @ 4.5 L/flush plus 50 staff x 2 flushes @ 4.5 L/flush	243		608
Public urinals	5 urinals x 4 flushes per hour @ 4.3 L/flush (ITP, 2008)	5 urinals x 4 flushes per day @ 4.3 L/flush	722		1805
Public taps	33 guests x 0.5 min @ 12 L/min plus 50 staff x 1 min @ 12 L/min	33 guests x 0.5 min @ 4 L/min plus 50 staff x 1 min @ 4 L/min	196	5043	893
Sub-total public area fittings			**1161**	**5043**	**3306**
Laundry generation	75 occupied rooms x 4kg/room	75 occupied rooms x 2.8 kg/room	329	45990	4502
Laundry processing	210 kg @ 10 L/kg and 1.4 kWh/kg	210 kg @ 5 L/kg and 0.95 kWh/kg	383	34493	3717
Sub-total laundry			**712**	**80483**	**8219**
Pool backwashing	5 min/day @ 400 L/min (Travel Foundation, 2011)	4 min/2.5 days @ 400 L/min	496	9589	2007
Pool evaporation	650 L/day	325 L/day	119	2300	482
Pool showers	25 guests x 2 min @ 15 L/min	25 guests x 2 min @ 7 L/min	145	5607	811
Pool leakage	10 % of above	10 % of above	76	1469	308

Sub-total pool area			**836**	**18965**	**3607**
Kitchen pre-washing	70 min/day @ 20 L/min	35 min/day @ 6 L/min	434		1085
Kitchen dishwasher	50 racks/day @ 5 L/ rack	50 racks/day @ 3 L/rack	37	3434	608
Kitchen other	See table x	See table x	168		420
Sub-total kitchen			**639**	**3434**	**2113**
Leaks	10 toilets @ 500 L/day	2 toilets @ 500 L/day	**1460**		**3650**
Cooling tower	53 L per occupied room per night	Zero (e.g. geothermal cooling)	**1935**		**4836**
Irrigation	22.5% of water consumption	Zero (native planting, rainwater harvesting)	**4456**		**11139**
Water recycling	Zero	All toilet flushing	**1030**		**2575**
TOTAL			**15543**	**209541**	**58436**
TOTAL POTABLE			**16573**		

*Based on average data where available, otherwise representative of older fittings
**Based on the most efficient, commercially-viable technologies at average European water and energy costs (simple payback ≤ 3years), verified by the TWG (2011).
***Water price EUR 2.50 m^{-3}; energy price EUR 0.08 per kWh (except dishwasher – electricity at EUR 0.15 per kWh).

Table 2. Key performance indicators and benchmarks for water management plans, efficient fittings and housekeeping best practice

Best practice	KPIs	Benchmarks	Applicability comments
Water management plans	sub-metering benchmarking inspections L/g.n.	implementation of a site-specific water management plan that includes: (i) sub-metering and benchmarking all major water-consuming processes and areas; (ii) regular inspection and maintenance of water system "leak points" and appliances	Universal
		total water consumption ≤140 L per guest-night in fully serviced hotels, and ≤100 L per guest-night in accommodation where the majority of the bathrooms are shared across rooms (e.g. hostels)	
Efficient fittings in guest areas	L/min L/flush L/g.n. kWh/g.n	water consumption, and associated energy consumption for water heating, of ≤100 L and 3.0 kWh per guest-night, respectively, for ensuite guest bathrooms	Ensuite bathrooms
		shower flow rate ≤ 7 L/min, bathroom tap flow rate ≤6 L/min (≤ 4 L/min new taps), average effective toilet flush ≤ 4.5 L, installation of waterless urinals	Ensuite bathrooms, pool change areas
Efficient housekeeping	kg laundry/g.n. % reduction through reuse grams/g.n. active chemical ingredients used light-weight bedclothes ecolabel textiles	reduction in laundry achieved through reuse of towels and bedclothes of at least 30 % (best practice calc. assumes 2.8 kg per occupied room per night)	Depends on average length of stay
		consumption of active chemical ingredients within the tourist accommodation of ≤10 grams per guest-night	Universal
		at least 80 % of bedclothes are cotton-polyester mix or linen, and at least 80 % of bedroom textiles have been awarded an ISO Type 1 ecolabel or are organic	
		at least 80 % by active-ingredient weight of all-purpose cleaners, sanitary detergents, soaps and shampoos used by the tourist accommodation shall have been awarded an ISO Type I ecolabel	

Table 3. Simple payback times estimated from fitting costs and annual water and energy savings relative to average performance

Fitting	Cost	Saving			Payback
		Water	**Heating (oil)(*)**	**Total**	
	EUR	EUR/yr			Months
Low-flow basin taps(**)	100 – 200	22	18	**40**	**30 – 60**
Combined flow-restrictor and aerator(***)	10	16	14	**30**	**4**
Low-flow showerhead	20 – 50	44	54	**98**	**2 – 6**
Combined flow restrictor and aerator(***)	10	33	41	**74**	**2**
Shower push-button timer	150 – 200	164	203	**367**	**5 – 7**
Low-flush toilet(**) (bathroom)	70 – 150	23		**14**	**36 – 78**
Cistern displacement/dual-flush retrofit (bathroom)	20	23		**14**	**10**
Low-flush toilet (public)(**)	150	137		**137**	**13**
Bathroom cistern displacement/dual-flush retrofit (public)	20	137		**137**	**2**
Urinal flush control (from uncontrolled)	200	375		**375**	**7**
Waterless urinal (from controlled flush)	150	375		**375**	**5**

(*)Water used in showers and taps has temperature elevated by 30 ºC and 20 ºC, respectively, using a 90 % efficient oil-fired boiler.
(**)Based on cost of new fittings.
(***)Assumes 6 L/min and 9 L/min achievable through retro-fitting aerators to basin taps and showers, respectively.

Source: Alaris Avenue (2011); Bathroom Supplies (2011a;b); Not Just Taps (2011a;b); Plumbing Supply Services (2011); Plumb World (2011); Discounted Heating (2011); Waterless Urinals (2011).

Table 4. Key performance indicators and benchmarks for small- and large- scale laundry best practice

Best practice	KPIs	Benchmarks	Applicability comments
	Green procurement	laundry is outsourced to efficient commercial laundry service providers complying with benchmarks specified for large-scale laundries	Universal
Small-scale laundry optimisation	L/kg laundry Appliance energy rating Detergent ecolabels	all new domestic washing machines have an EU energy label rating of 'A^{+++}', or average annual laundry water consumption ≤7 L per kg laundry washed in laundries with commercial machines	In-house laundries < 250 kg/hour capacity
		at least 80 % by active-ingredient-weight of laundry detergent shall have been awarded an ISO Type I ecolabel (e.g. Nordic Swan, EU Flower)	
Large-scale laundry optimisation	Nordic ecolabelled laundries L/kg Detergent ecolabels Appropriate wastewater treatment	all laundry is outsourced to a provider who has been awarded an ISO type-1 ecolabel (e.g. Nordic Ecolabelling, 2010), and all in-house large-scale laundry operations, or laundry operations outsourced to service providers not certified with an ISO Type-1 ecolabel, shall comply with the specific benchmarks for large-scale laundries described below	Applies to both in-house and out-sourced laundries > 250 kg/hour capacity
		total water consumption over the complete wash cycle ≤5 L per kg textile for accommodation laundry and ≤9 L per kg textile for restaurant laundry	
		exclusive use of laundry detergents compliant with Nordic Swan ecolabel criteria for professional use (Nordic Ecolabelling, 2009), applied in appropriate doses	
		wastewater is treated in a biological wastewater treatment plant having a feed-to-microorganism ratio of <0.15 kg BOD_5 per kg dry matter per day	Usually dependent on local authority

Table 5. Key performance indicators and benchmarks for kitchen and swimming pool area best practice

Best practice	KPIs	Benchmarks	Applicability comments
Optimised dish washing, cleaning and food preparation	L/cover Management plan L/rack (dishwashers) L/min (pre-rinse spray valve)	implementation of a kitchen water management plan that includes monitoring and reporting of total kitchen water consumption normalised per dining guest, and the identification of priority measures to reduce water consumption	Universal
		installation of efficient equipment and implementation of relevant efficient practices described in Table 6	Universal, greatest scope when retrofitting or buying new equipment
	Ecolabel chemicals	at least 70 % of the purchase volume of chemical cleaning products (excluding oven cleaners) for dish washing and cleaning are ecolabelled*.	Universal
Optimised pool area management	Natural pool L/m^{2}yr L/g.n. kg chemicals/m^{2}yr kg chemicals/g.n. kWh/m^{2}yr kWh/g.n. Benchmarking	the on-site swimming pool(s) incorporate(s) natural plant-based filtration systems to achieve water purification to the required hygiene standard	Pools with lower usage rates
		implementation of an efficiency plan for swimming pool and spa areas that includes: (i) benchmarking specific water, energy and chemical consumption in swimming pool and spa areas, expressed per m^2 pool surface area and per guest-night; (ii) minimisation of chlorine consumption through optimised dosing and use of supplementary disinfection methods such as ozonation and UV treatment*	Universal. Scope for alternative disinfection system installation during construction or renovation
		optimise backwash control based on pressure-drop data, use of a pool cover overnight to reduce evaporation and install low-flow timer-controlled showers	Universal
*chemical consumption/g.n. benchmark (housekeeping section) also applies			

Table 6. KPIs and technical details of best practice in small-medium sized, or larger, commercial kitchens

Aspect	Indicators of best practice
Monitoring	– Kitchen water consumption is monitored separately and recorded at least once per month(*)
Dish washing	– Waste grinders not used – Pre-rinse spray valves are fitted with trigger operation and have a maximum flow rate of ≤6 L/min – New stationary (under-counter or hood type) dishwashers have rated water consumption ≤3 L per rack – Tunnel dishwashers are installed with heat recovery and heat pump – Dishwashers are connected to hot water supply, or to a dedicated gas boiler in the case of tunnel washers – New conveyor dishwashers have rated water consumption of ≤2 L per rack equivalent – Dishwasher racks are filled before loading into the dishwasher
Food preparation	– Sink taps are installed with foot pedal or sensor operation and have maximum flow rate ≤12 L/min – Steam cookers consume ≤8 L water per hour of operation – Thawing under running water is avoided
Cleaning	– The use of hoses to wash floors is avoided (mops or "water brooms" used instead) – Cleaning agents do not contain the following: alkylphenolethoxylates (APEO) and alkylphenol derivatives (APD), dialkyl dimethyl ammonium chloride (DADMAC), linear alkylbenzene sulphonates (LAS), reactive chlorine compounds (exemption if required by authorities for hygiene reasons(*) – At least 70% of the purchase volume of chemical cleaning products (excluding oven cleaners) for dish washing and cleaning are ecolabelled(*)
(*) Nordic Ecolabelling (2009) criteria.	

Table 7. Achievable water savings from best practice measures implemented in a small-medium sized commercial kitchen

Measure	Achievable reduction in specific consumption	Typical SME annual saving
Efficient PRSVs	67 % (from 15 to 5 L/min)	200 m^3
Efficient dishwasher	50 % (from 4 to 2 L/rack)	150 m^3
Low flow sink taps	40 % (from 20 to 12 L/min)	50 m^3
Efficient steam cookers	92 % (from 100 to 8 L/ hour)	200 m^3
Waterless thawing	100 % (from 10 hrs per week under running water)	10 m^3
Source: Smith et al. (2009); Alliance for Water Efficiency (2011a;b); Karas (2005).		

Table 8. Key performance indicators and benchmarks for water recycling, irrigation and on-site wastewater treatment best practice

Best practice	KPIs	Benchmarks	Applicability comments
Water recycling and irrigation	Water recyling system L/g.n. recycled % recycled water	– installation of a rainwater recycling system that supplies internal water demand, or a greywater recycling system that supplies internal or external water demand – (best practice scenario assumes recycled water supplies all toilet flushing - 28 L/g.n., 20% gross best practice water consumption)	Greywater recycling economically feasible for campsites but usually not for built-accommodation.
	controlled irrigation systems L/m^2 outdoor area	– minimise water consumption by planting native species and mulching, and by installing controlled irrigation systems fed with greywater where possible – (best practice assumes zero use of non-recycled water for irrigation)	All premises with outdoor areas.
On-site wastewater treatment	BOD_5 , COD, total nitrogen, total phosphorus removal efficiency (%) BOD_5 , COD, total nitrogen, total phosphorus concentration in final effluent (mg/L)	– where it is not possible to send wastewater for centralised treatment, on-site wastewater treatment includes pre-treatment (sieve/bar-rack, equalisation and sedimentation) followed by biological treatment with >90 % BOD_5 removal, >90 % nitrification, and (off-site) anaerobic digestion of excess sludge	Where not connected to municipal sewer.