This best practice is an extract from the report *Best Environmental Management Practice in the Tourism Sector*.

5.4 Optimised small-scale laundry operations

Description

Water consumption

Accommodation providers generate a considerable amount of laundry (section 5.3), comprising bed sheets, pillow cases, duvet covers, towels, tablecloths and napkins, and staff uniforms. The latter items are also common to eateries. The provision of clean, crease-free bedclothes is a particularly important quality control point for accommodation establishments: unclean or creased bedclothes can give guests an instant bad impression. Effective and professional laundry operations are therefore a priority, and may be performed on site or off site by subcontracted commercial laundries. It is common for hotels to launder towels and smaller items on site, whilst outsourcing the laundering of sheets to commercial laundries that have the large-scale specialist equipment (e.g. continuous batch washers and roller irons) to deal with such items efficiently whilst guaranteeing a high-quality, crease-free finish (section 5.5). This technique refers to laundry operations located on accommodation premises, whilst the next technique (section 5.5) deals with large-scale (processing over 250 kg textiles per hour) on-site and commercial laundry operations using highly automated systems and continuous batch washers.

Within the accommodation subsector, daily laundering of bed linen and towels weighing in the region of 2.5 kg to 6 kg per room\(^1\) can consume up to 100 litres of water – considerably more than half the total water consumption of a best practice hotel (see Figure 5.3 in section 5). Laundry operations represent the second greatest potential for water saving within a hotel, and also represent considerable potential for savings in energy and chemical consumption. High-temperature washing, tumble drying, multi-roll ironing and garment tunnel finishing are energy-intensive laundry processes. For the washing phase, water efficiency is closely related to energy efficiency: lower water consumption means lower water heating requirements.

Table 5.17 provides an overview of best practice measures to minimise water (and energy) use in laundries. In the first instance, laundry volumes should be minimised through efficient housekeeping (section 5.3). Then, accommodation managers must decide whether to outsource laundry services or perform laundry operations onsite (best practice for large-scale onsite and commercial laundry operations is described in section 5.5). Efficient washing processes are based on optimisation of the following four factors in relation to the washing requirements of specific wash loads, through equipment selection and programming:

- mechanical action
- chemical action
- temperature
- time.

Equipment selection

Accommodation SME, such as B&Bs, may use domestic machines, while small laundries use washer extractors of similar design to domestic machines but more robust and sometimes containing programmable micro-processor controls. These machines comprise a rotating drum that generates mechanical action and applies a high gravitational spin to extract water and detergent from the laundry following washing and rinsing. Front-loading machines, with doors on the front rather than on top, apply a full rotation around a horizontal axis, generating a laundry free-fall motion that maximises efficient flow-through and compression whilst minimising abrasive rubbing (EC, 2007). Front-loading machines use up to 60 % less water than top-loading machines (Smith et al., 2009), but nonetheless can consume up three times more

---

\(^1\) Accor (2007) refer to 4 kg per room per night, O’Neill et al. (2002) refer to median laundry of 5.4 kg per room per night from a US study, ranging from 2.4 to 5.8 kg per room per night
water and two times more energy than a continuous batch washer used in large laundries – hence large laundries are described in a separate technique (section 5.5).

The selection of efficient equipment is one of the most important measures to save water and energy in laundry operations. Average specific water consumption in domestic washing machines decreased from 13.9 L per kg of laundry in 1997 to 9.6 L per kg in 2005, and average energy consumption now stands at 0.17 kWh/kg laundry (AEA, 2009). However, there is considerable variation in water efficiency across models. A UK survey of new domestic washing machines found that optimum-rated water consumption varied from 6.2 to 11.8 litres of water per kg cotton laundry across models with 5 kg capacity (Which, 2011). For domestic machines, the EU Energy label provides a useful indication of energy- and water-efficiency.

Efficient batch management
Washing machines are more efficient at full capacity than partial capacity, even when a half-load programme is used. Washing can be optimised by:

- separating laundry into batches depending on washing and drying requirements;
- fully loading washing machines with these batches;
- storing rinse water and reusing to prewash the next load;
- selecting the appropriate programme settings (especially timing and temperature) to minimise water and energy consumption;
- appropriate dosing of a detergent that enables effective cleaning at low washing temperatures.

Drying and finishing
Forced thermal drying of laundry is a particularly energy-intensive process that uses up to 1.4 kWh/kg textiles in large laundries (see Figure 5.24 in section 5.5). Small laundries dry products in tumble-dryers that use considerable amounts of gas or electricity to evaporate water. Combined washer-dryers also use a continuous flow of water to condense moisture, which can increase total water use to over 170 L per 5 kg load (UK Environment Agency, 2007). In small laundries, large flatwork such as sheets are typically finished on a single roll ironer that passes tensioned flatwork under a rotating roller heated by electricity or gas. Roller ironers simultaneously dry damp flatwork that has undergone mechanical extraction (e.g. a high speed spin in a washer extractor). A range of hand finishing equipment may also be used, including free steam-ironing tables, and automatic finisher for shaped garments.

Small accommodation premises may be able to naturally dry clothes, at least for some of the year, saving a considerable amount of energy. However, for most accommodation establishments, this is not practical, and best practice involves minimisation of energy required for forced thermal drying. As indicated in Table 5.17, energy required for laundry drying can be minimised by: (i) maximising mechanical drying by, for example, selecting washing machines able to generate high a g-force spin (350 g for domestic machines, over 1 000 g for commercial machines); (ii) selecting and correctly maintaining an efficient dryer; (iii) optimising the drying-ironing process to prevent excessive drying.

Finally, there are a number of opportunities for water reuse, and heat recovery from waste water and dryers, that may be exploited to improve the efficiency of laundry operations.
### Table 5.17: Portfolio of best practice measures for small-scale laundry operations

<table>
<thead>
<tr>
<th>Stage</th>
<th>Measure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housekeeping</td>
<td>Reduce volume of laundry generated</td>
<td>– Encourage guests to reuse towels and bed linen (section 5.3). Minimise use of tablecloths and napkins in restaurants.</td>
</tr>
<tr>
<td>Washing</td>
<td>Purchase efficient washing machines</td>
<td>– Purchase the most efficient front-loading washing machines (e.g. 'A++' EU energy rating for domestic machines, or efficient microprocessor-controlled, variable motor speed commercial machines).</td>
</tr>
<tr>
<td>Load optimisation</td>
<td></td>
<td>– Install stepped capacity machines to cope with different loads. Separate laundry into batches based on washing requirements (e.g. textile type and degree of soiling), and wash batches at full machine capacity. Optimise temperature and detergent dosing.</td>
</tr>
<tr>
<td>Wash programme optimisation</td>
<td></td>
<td>– Match wash programme to textile type and degree of soiling. Use low temperature wash and efficient detergents. Use single-step wash with two rinses, and calibrate micro-processor water-level control where necessary.</td>
</tr>
<tr>
<td>Water recycling</td>
<td></td>
<td>– Recover and store rinse water, and possibly wash water following microfiltration, and use for wash or prewash step.</td>
</tr>
<tr>
<td>Heat recovery</td>
<td></td>
<td>– Recover heat from waste water, and if possible also from tumble dryer exhaust, to heat incoming fresh water.</td>
</tr>
<tr>
<td>Green procurement of detergent and efficient dosing</td>
<td></td>
<td>– Avoid hypochlorite and use ecolabelled detergents. Match detergent dosing to recommendations and laundry batch requirements. Optimise with machine cycle. Soften hard water.</td>
</tr>
<tr>
<td>Drying</td>
<td>Purchase efficient equipment</td>
<td>– Purchased washing machines can achieve high g-force spin cycles (350 – 1 000 g depending on size) to minimise thermal drying requirements. Avoid flow-through water-condensing dryers.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Purchase heat-pump or gas-fired dryers.</td>
</tr>
<tr>
<td>Optimise laundry cycle</td>
<td></td>
<td>– Optimise drying time in relation to target moisture content – use moisture sensors.</td>
</tr>
<tr>
<td>Ironing and finishing</td>
<td>Minimise ironing energy use</td>
<td>– Use an efficient roller ironer. Where relevant, use condensate from HVAC systems in steam irons. Aim for final textile moisture content in equilibrium with atmospheric conditions.</td>
</tr>
<tr>
<td></td>
<td>Minimise chemical use for finishing</td>
<td>– Avoid or minimise use of water and dirt repellent chemicals.</td>
</tr>
<tr>
<td>Entire process</td>
<td>Optimisation through water and heat recovery, and maintenance</td>
<td>– Optimise the entire laundry process. Recover heat from dryer and waste water to heat incoming freshwater. Send staff on specialist training courses and seek expert advice.</td>
</tr>
</tbody>
</table>

**Achieved environmental benefit**

**Washing process**
Careful control of water levels in washer extractors (damped dip tube connected to a microprocessor control unit) can reduce water and energy consumption by 30% (Carbon Trust, 2009). Reusing rinse water in washer-extractor machines can reduce water consumption by...
Best practice 5.4 – Optimised small-scale laundry operations

between 30 % and 40 %, heating energy consumption by up to 45 %, and detergent consumption by up to 30 % (EC, 2007; Smith et al., 2009).

The use of lower temperature washing, in combination with effective low-temperature detergents, can reduce washing energy consumption considerably. For example, reducing the temperature of the main wash from 60 °C to 40 °C can reduce electricity consumption by 0.7 kWh per wash for a 10 kg load, equivalent to 40 % of average specific energy consumption (assuming 3 L of water per kg textiles in the main wash).

Figure 5.18 presents the magnitude of water and energy savings achievable for the washing process. For a small 10-room hotel, the purchase of an efficient washing machine using 7 L water per kg laundry instead of the European average of 9.6 L/kg, and washing predominantly at 40 °C instead of 60 °C, could reduce water consumption by 14 m³ and energy consumption by 383 kWh per annum. For a large hotel of 100 rooms, installation of rinse water recirculation alongside efficient machines and a default wash temperature of 40 °C could save 252 m³ of water and 5 475 kWh of energy per annum.

![Figure 5.18: Annual water and energy savings achievable for the washing process in different sizes of establishment (assuming 75 % occupancy and on average 2 kg laundry per occupied room per night)](image)

Drying and finishing processes
Heat-pump driers and gas-fired driers can each reduce primary energy consumption for tumble drying by around 45 %, compared with standard electric tumble driers (Bosch, 2011; Miele, 2010; Miele Professional, 2011). Optimal use of efficient roller ironers can reduce ironing energy consumption by a similar percentage. Figure 5.19 indicates the magnitude of energy savings achievable through implementation of best practice for different sizes of establishment, based on the same assumptions as those applied in Figure 5.18, and that half of the laundry is dried in driers, whilst the other half (sheets) is dried in flat bed ironers.

On a laundry weight basis, drying and ironing are associated with energy savings twice as high as for washing. However, given that drying is divided between tumble drying and ironing for different laundry groups, the magnitude of energy savings achievable for each of the three laundry processes is similar – e.g. for a 100-room hotel, energy consumption for washing, tumble-drying and ironing can typically be reduced by 5 475, 5 475 and 6 023 kWh/yr, respectively, leading to a total laundry energy saving of 16 973 kWh/yr.
Figure 5.19: Energy savings achievable from the implementation of best practice washing, drying and ironing for different sizes of establishment

**Appropriate environmental indicator**

**Appropriate indicators**

The European energy label (EC, 2010) requires manufacturers of domestic washing machines to display on clear labels total annual machine energy and water consumption based on the following use pattern:

- 220 washes per year
- 3/7 of which are at full load and 60 °C cotton programme
- 2/4 of which are at half-load and 60 °C cotton programme
- 2/4 of which are at half-load and 40 °C cotton programme.

Power consumption during 'standby' and 'on' modes is included in calculations, and lower percentage loading rates are assumed for larger machines. Based on these data, machines are awarded energy ratings of A+++ (most efficient) to G (least efficient). For example, one A+++ rated machine\(^2\) with a load capacity of 8 kg uses 11 880 L of water and 182 kWh of electricity per year over 220 wash cycles according to EU energy label calculations, approximating to specific consumption of 9.4 L and 0.145 kWh per kg washing. EU energy ratings are strongly related, but not directly proportionate, to specific energy and water consumption across different domestic machine sizes. Specific energy and water consumption figures approximated from EU energy labelling are higher than what is achievable under optimum operating conditions – tourism enterprises may be expected to operate washing machines more efficiently under higher average load rates compared with an average domestic situation.

In addition, the Energy label grades machines according to their spin drying efficiency, with classes A-G based on the weighted average percentage moisture remaining following the above ratios of wash cycles. An 'A' rating represents ≤45 % moisture, a 'G' rating ≥90 % moisture. Table 5.18 lists appropriate indicators and possible benchmarks of best practice for on-site laundry processes.

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\(^2\) Miele W5000 WPS Supertronic Washing Machine: [http://www.miele.co.uk/washing-machines/w5000/w5000wpssupertronic-393/](http://www.miele.co.uk/washing-machines/w5000/w5000wpssupertronic-393/)
Table 5.18: Indicators and benchmarks (BM) of best practice for water, energy and chemical use efficiency in laundry processes

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Indicators and benchmarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>€EU energy rating for domestic machines (BM: 'A+++')&lt;br&gt;π Optimisation of water level and programming in commercial machines&lt;br&gt;π Installation of rinse-water recycling system&lt;br&gt;π Water consumption (L) per kg laundry washed for commercial machines (BM: ≤7 L per kg textile)</td>
</tr>
<tr>
<td>Energy</td>
<td>€EU energy label rating for domestic washing machines (BM: 'A+++')&lt;br&gt;π EU energy label spin dry rating for domestic washing machines (BM: 'A')&lt;br&gt;π Moisture content of textiles following spinning (BM: ≤45 %)&lt;br&gt;π Energy consumption (kWh) for: (i) washing; (ii) drying; (iii) the entire process (BM: 2.0 kWh per kg textile)&lt;br&gt;π Implementation of natural drying of laundry where possible&lt;br&gt;π Installation of heat-pump or gas-fired tumble-dryers&lt;br&gt;π Implementation of heat recovery</td>
</tr>
<tr>
<td>Chemical use</td>
<td>π Average weight (grams) of active ingredient used per kg laundry&lt;br&gt;π Average critical dilution volume of chemicals used per kg laundry&lt;br&gt;π Implementation of automatic dosing&lt;br&gt;π Percentage of chemicals used that are ecolabelled (BM: ≥80 %)</td>
</tr>
</tbody>
</table>

Benchmarks of excellence

Water and energy efficiency are closely related for washing machines. Hohenstein Institute (2010) report that state-of-the-art water efficiency for washer-extractors has improved considerably since 1995, and over the five years from 2005 to 2010 stood at 8 L per kg textiles. This could be further reduced through collection and recycling of rinse water. Carbon Trust (2009) report that small commercial laundries and on-premises laundries processing fewer than 100,000 pieces per week consume 2.0 to 2.9 kWh per kg textiles (total consumption, including for non-laundry processes such as lighting). The following benchmarks of excellence are proposed for small-scale laundry processes.

**BM:** laundry is outsourced to efficient commercial laundry service providers complying with benchmarks specified in section 5.5.

**BM:** 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.

**BM:** total laundry process energy consumption ≤2.0 kWh per kg textile, for dried and finished laundry products.

**BM:** at least 80 % by active-ingredient-weight of laundry detergent shall have been awarded an ISO Type I ecolabel (e.g. Nordic Swan, EU Ecolabel).
Cross-media effects
Optimising laundry operations reduces water and energy use, and can also reduce chemical use. The higher resource consumption required to manufacture detergents containing enzymes is small compared with energy savings that can be realised by the use of such detergents through effective cleaning at lower temperatures (Henkel, 2009).
In terms of replacing older machines, approximately 90% of the lifecycle impact of white goods is due to operation compared with 10% due to manufacture and disposal, and it can be more environmentally responsible to replace an older machine with a more efficient one rather than have it repaired (Environment Agency, 2007).

There may be some trade-off between hygiene and environmental objectives in relation to temperature settings. The minimum temperature compatible with hygiene requirements should also be sought.

Operational data
Washing machine selection
When installing new washing machines, the first factor to establish is the required total capacity. The maximum total required washing machine capacity can be calculated from the following equation:

\[
C = \left( \sum \left( \frac{M_{1,n}}{R_{1,n}} \times T_{w1,n} \right) \right) / T_L
\]

<table>
<thead>
<tr>
<th>C</th>
<th>Maximum total machine capacity in L</th>
</tr>
</thead>
<tbody>
<tr>
<td>M_{1,n}</td>
<td>Maximum mass of laundry expressed as kg per day</td>
</tr>
<tr>
<td>R</td>
<td>Load ratio (see Table 5.19)</td>
</tr>
<tr>
<td>T_{w}</td>
<td>Wash cycle time for batches 1 to n expressed as hours</td>
</tr>
<tr>
<td>T_L</td>
<td>Time allocated for laundry washing expressed as hours per day</td>
</tr>
</tbody>
</table>

The mass of different items (towels, sheets, duvet covers) can be taken from known specifications or measured directly, and multiplied up to calculate total mass per batch according to room changing rates (see section 5.3). Note that T_L can also be expressed as the number of hours dedicated to laundry over a number of days where peak loads occur on particular days (e.g. weekend changes) and can be worked through during subsequent days.

Once the maximum total machine capacity requirement has been calculated, the machine combination to achieve this volume can be defined. Where workloads are variable, for example across seasons, a modular approach enables a higher frequency of optimised loading. For example, Picafort Pallace in Mallorca has a maximum laundry volume of 700 kg per day that varies considerably over the year. Mab Hoestelero (2004) reported the following optimised solution capable of 650 kg washing per day with two operators working seven hours:

- one 55 kg washer-extractor
- one 22 kg washer-extractor
- one 12 kg washer-extractor.

The above 'stepped' capacities create a range of combined wash capacities depending on the combination of machines in operation, i.e. 12, 22, 34, 55, 67, 77 or 89 kg. This maximises the opportunity for optimised loading of the machines in operation. It is worth noting that large drums offer greater mechanical cleaning owing to a higher drop height and consequent compression effect (EC, 2007).
Once the required machine capacities have been decided, specific models may be selected. Durability and reliability are important factors for hospitality use. Once these criteria have been met (e.g., through testimonials of other hospitality users), energy and water efficiency are key criteria for both environmental and lifecycle economic performance. As mentioned under 'Appropriate environmental indicators', the EU energy label provides a useful guide for the energy and water efficiency of domestic machines. For commercial machines, the optimum efficiency may be calculated from technical specifications, though these will not be directly comparable with EU energy ratings that assume sub-optimal average use characteristics. The incorporation of micro-processor controls, variable speed drives, damped dip tubes (to measure water level), and integral load weighting system are important features that can be specified on new commercial machines or retrofitted to enable accurate adjustment of water levels, chemical dosing and wash programmes.

Another important factor to consider when selecting washer-extractors is the maximum gravitational \((g)\) force generated during the spin cycle, as this determines the mechanical drying capacity of the machine. Many washing machine manufacturers quote spin speed in revolutions per minute \((rpm)\). \(g\)-force is a function of both drum diameter and spin speed:

\[
g = 0.56 \times D \left(\frac{n}{1000}\right)^2
\]

<table>
<thead>
<tr>
<th>D</th>
<th>Diameter of the wash drum in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>rpm for the spin cycle</td>
</tr>
</tbody>
</table>

Therefore, at a given spin speed, the \(g\)-force is proportional to drum diameter. Modern large washer-extractors are able to generate up to 1 000 \(g\) (Hohenstein Institute, 2010). The option of different spin speeds is also important so that a lower spin speed can be selected for delicate fabrics.

Laundry installation

Figure 5.20 provides an example of an optimised laundry configuration. Water from the final rinse may be reused either in the prewash, the main wash, or the first rinse of the subsequent load. Rinse water from earlier rinses may be used in the prewash or the main wash of the subsequent load, in which case detergents will be carried over and dosing can be reduced accordingly (by up to 30 %: EC, 2007). Water tanks are easily retrofittable and may be installed on top of washer-extractors, or anywhere nearby. The installation of pipework from the machine to the water tank, and modification of machine wash programmes to manage water recycling (operation of correct input and output valves depending on the cycle position) are straightforward. Meanwhile, the installation of a simple heat exchanger can recover heat from prewash and main wash waste water. Microfiltration of waste water can be introduced at the heat recovery point as shown in Figure 5.20, enabling further water recovery and up to an 80 % reduction in freshwater consumption (EC, 2007). For heat recovery, the EC (2007) recommend corrugated pipe heat exchangers owing to their efficiency, robustness and tolerance of soiled water. The following check criteria are important to optimise heat exchange performance:

- the flow directions are connected in countercurrent direction
- there are turbulences in the liquids
- there is a large heat transfer surface
- the mass flow and the temperature differences in both directions are the same
- as much time as possible is provided for the heat exchange.
**Batch management**

In a typical accommodation establishment, laundry comprises: (i) towels and bath mats; (ii) sheets and other bedclothes; (iii) tablecloths and napkins; (v) garments. Incoming laundry should be separated into batches according to washing and drying requirements. Towels and bath mats should be separated from bed linen, and these batches further divided depending on the degree of soiling (Table 5.20) and thus required cleaning intensity. For example, tablecloths and napkins are likely to require more intensive washing to remove fats, oils and greases. It may be more efficient for housekeeping to sort laundry at source, and send to the laundry room in separated batches. It is common for accommodation providers to outsource the laundering of bedclothes to commercial laundries that have the equipment to efficiently provide a high-quality, crease-free finish to sheets, duvet covers and pillow cases.

The rated load capacity of most washer-extractors is based on a standard material weight to drum volume ratio of 1:10. However, to ensure proper washing, load factors and consequently load volumes should be adjusted according to the type of textile and degree of soiling (Table 5.19). Reducing the rotational speed of the wash cycle in variable speed extractors for polyester cotton can reduce creasing and enable higher load rates (Carbon Trust, 2009). In order to load machines correctly, it is necessary to define various types of full load in terms of number of towels or sheets, etc., based on sampling of laundry item weights (Table 5.19). Underloading reduces efficiency in proportion to load, because the same quantity of water, energy and detergent is used, and half-load programmes are less efficient. Overloading also reduces efficiency because mechanical and chemical action is impeded by textiles being bundled closely together, and items may require re-washing.

---

**Figure 5.20:** Schematic example of an optimised small-scale laundry washing process, with rinse water reuse and heat recovery from waste water (based on information in EC, 2007)
Table 5.19: Load ratios for different textiles with light and heavy soiling, and example number of items that can be washed in a 100 L (10 kg rated capacity) machine

<table>
<thead>
<tr>
<th>Material</th>
<th>Soiling</th>
<th>Load ratio</th>
<th>kgs full load (examples)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>Light</td>
<td>1:12</td>
<td>8.3 (16 towels)</td>
</tr>
<tr>
<td></td>
<td>Heavy</td>
<td>1:12.5</td>
<td>8.0 (16 towels)</td>
</tr>
<tr>
<td>Polyester-cotton (linen)</td>
<td>Light</td>
<td>1:15</td>
<td>6.7 (8 sheets)</td>
</tr>
<tr>
<td></td>
<td>Heavy</td>
<td>1:17</td>
<td>5.9 (7 sheets)</td>
</tr>
<tr>
<td>Duvet quilts (internal)</td>
<td>Light</td>
<td>1:20</td>
<td>5.0 (3 duvets)</td>
</tr>
<tr>
<td></td>
<td>Heavy</td>
<td>1:22</td>
<td>4.5 (2 duvets)</td>
</tr>
<tr>
<td>Mops</td>
<td></td>
<td>1:9.5</td>
<td>10.5 (35 mop heads)</td>
</tr>
</tbody>
</table>

NB: Assumes 0.5 kg per cotton towel, 0.8 kg per polyester-cotton sheet, 1.6 kg per duvet (2 m x 2 m), 0.3 kg per mop head.


Chemical dosing
Chemical dosing should be matched to the size and cleaning requirements (Table 5.20) of different loads. Excessive dosing not only wastes detergent, but can increase rinse requirements. Heavily soiled laundry can be pre-dosed or 'spotted' with strong detergents, for example containing hydrogen peroxide, and/or sent to more intensive wash cycles. For the main wash, the use of low-temperature detergents, especially biological detergents containing enzymes, is associated with a number of advantages:

- reduced energy costs
- possible reduced rinsing requirements
- reduced risk of colour run
- increased fabric longevity (lower fade rate).

Where low temperatures are used, chemical disinfection is recommended, using hydrogen peroxide or peracetic acid (Hohenstein Institute, 2010). Large commercial washing machines have built-in programmable chemical dosing. Automatic chemical dosing units can be easily retrofitted to smaller wash-extractor machines, and enable more accurate control of detergent and conditioner quantity and timing. Automatic dosing pumps can be programmed for different settings according to different wash load requirements: for example, low, medium and high soiling. It is important to periodically check the calibration of the auto dosing pumps.

Table 5.20: Typical degree of soiling for hospitality laundry

<table>
<thead>
<tr>
<th>Light soiling</th>
<th>Medium soiling</th>
<th>Heavy soiling</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Bed sheets, bedclothes, towels</td>
<td>- Service staff clothes</td>
<td>- Kitchen and technical staff clothes</td>
</tr>
<tr>
<td>- Cloth hand towels</td>
<td>- Tablecloths, napkins</td>
<td>- Clothes, dish towels, etc.</td>
</tr>
<tr>
<td></td>
<td>- Mops and mats</td>
<td></td>
</tr>
</tbody>
</table>


Programme setting
Table 5.21 summarises the main processes performed by washer-extractor machines. Washing machines are programmed to vary the intensity of the mechanical action, the time and the temperature of the wash cycle. For example, programmes for delicate fabrics apply: (i) a higher water fill-level in
order to reduce the drop-height and associated mechanical action of front-loader extractors; (ii) a shorter wash time (e.g. 5 – 10 minutes at wash temperature) and fewer rotations per minute to reduce mechanical action; (iii) lower temperature; (iv) lower detergent concentrations (Laundry and dishwasher info, 2011). Such programmes use more water and energy, and should only be used for genuinely delicate fabrics – they can usually be avoided for hospitality laundry.

For lightly soiled hospitality laundry, a single-stepped wash with two rinses and inter-extracts (spins) is sufficient, saving up to 30 % water and energy compared with a standard two wash and three rinse process (DTC LTC, 2011).

Table 5.21: Main stages of the washing and drying process performed by washer-extractors

<table>
<thead>
<tr>
<th>Stage</th>
<th>Functions</th>
<th>Conditions</th>
<th>Time</th>
<th>Chemicals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prewash</td>
<td>Rapid wetting</td>
<td>20 – 25 ºC (blood)</td>
<td>8 – 12 minutes</td>
<td>50 – 70 % detergent dose</td>
</tr>
<tr>
<td></td>
<td>Swelling of soil</td>
<td>50 – 60 ºC (fat, oil)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Removal of heavy soil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dissolving and swelling of spots</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main wash</td>
<td>Removal of soil</td>
<td>30 – 90 ºC</td>
<td>10 – 15 minutes</td>
<td>30 – 50 % detergent dose</td>
</tr>
<tr>
<td></td>
<td>Dissolving and swelling of spots</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rinse</td>
<td>Removal of soil residues</td>
<td>25 – 60 ºC</td>
<td>8 – 12 minutes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Removal of detergent residues (surfactants, alkali and bleaching agents)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neutralisation</td>
<td>Reduction of textile pH to 6.0-6.5, in order to prevent discolouring during ironing</td>
<td>20 – 25 ºC</td>
<td>2 – 4 minutes</td>
<td>Formic or acetic acid</td>
</tr>
<tr>
<td>Spinning</td>
<td>Mechanical dewatering</td>
<td>Up to 600 g</td>
<td>5 – 10 minutes</td>
<td></td>
</tr>
</tbody>
</table>


Modern washer-extractors are controlled by micro-processors connected to sensors that control the water level (the 'dip') in the drum at all stages of the washing cycle. Carbon Trust (2009) recommend that water levels be adjusted (by trial and error if necessary) to the following:

- prewash dip of 125 mm
- wash dip of 75 mm
- rinse dip as low as possible without leading to yellowing of textile following drying.

Some detergents contain brighteners that only become activated above 60 ºC. Constant low temperature washing can lead to blockages in machines and pipes from the accumulation of unused detergent agents. Periodic high temperature washes, and the avoidance of detergents with brighteners, can prevent this problem. Thermal washing at 60 ºC for two minutes disinfects laundry, which is recommended but not essential for hospitality laundry (Carbon Trust, 2009) – chemical disinfection may be used instead. If low temperatures are used for the main wash cycles, laundry may be periodically disinfected by washing at high temperatures. Some machines offer sluice programs that introduce a short, high temperature cycle to the wash. However, it has been demonstrated that washing at 40 ºC with standard domestic detergents is sufficient to destroy viruses (Heinzel et al., 2010). Alternatively, chemicals may be used to achieve low temperature disinfection, as specified in the European standard for control of bio-contamination in laundries, EN 14065.
The maximum spin speed should be selected within the constraints of the fabric. At temperatures above 40 ℃, mixed polyester cotton fabrics can become creased at high spin speeds or long durations (EC, 2006). For commercial machines with micro-processors, the final spin speed and time should be adjusted for different fabrics. For cotton fabrics, the spin speed should be set to the maximum possible and the spin time adjusted in one minute increments until no further water is extracted. For polyester-cotton garments, the spin time and spin speed should be adjusted by trial and error to obtain the minimum moisture content with no pressure creases.

Programme optimisation should be performed by laundry technicians and consultants. Once programmes have been pre-set, they should not be changed by laundry operatives, and it is imperative that operatives use the correct preset programmes, and this should be clearly guided by charts visible at the point of use.

Quality control and wash optimisation
A quality control inspection should be performed to identify items that require re-washing. The rate of re-washing is a useful guide to optimisation, with an optimum rate of 3 – 5 % proposed (Business Link, 2011). A rate of less than 3 % indicates that laundry is being over-washed (time, temperature and/or dosing should be reduced), whilst a rate of more than 5 % indicates inadequate washing (time, temperature and/or dosing should be increased).

Washer-extractors should be checked for leaking drain and water inlet valves, and correct operation of thermostats.

The hygienic quality of laundered textiles may be checked by independent testing. For example, many commercial laundries in Germany are awarded with the RAL-GZ standard (Hohenstein Institute, 2011).

Drying
Thermal drying is a highly energy-intensive process and should be minimised through the maximisation of mechanical water extraction (high g-force spinning in washing machines) and, wherever practical, natural line drying – see, e.g. from Travel Foundation under ‘Economics’. However, in large accommodation establishments, thermal drying is unavoidable. In small-scale laundries, thermal drying is performed in dedicated tumble-dryers and during ironing. Where a commercial flatwork ironer is used, bedclothes do not require a separate thermal drying stage. Mab Hoesteleroe (2004) refer to Picafort Pallace in Mallorca where only towels require drying.

In the first instance, it is important to select efficient tumble-dryers. Most new tumble-dryers are of the condenser type, in which a heat exchanger removes heat from hot moist air from the drum to the surrounding atmosphere, resulting in moisture condensation within the machine, before the air is recirculated into the drum via a heating element. Compared with dryers that vent hot moist air from the drum directly outside, condenser dryers retain more heat energy (heat of condensation), but require good ventilation (and sometimes active cooling) of the room in which they are located. Recently, heat-pump dryers have become commercially available. These dryers use a heat-pump to extract heat from the cooling (condensation) phase and release it to the heating phase, resulting in up to 50 % less energy consumption than a conventional condensing dryer, and less heat transfer to the surrounding atmosphere. Domestic-sized heat-pump driers use less than 0.5 kWh per litre moisture removed from textiles, resulting in specific energy consumption of approximately 0.25 kWh per kg, to dry laundry at 45 % moisture content (Bosch, 2011; Miele, 2010). Meanwhile, tumble-dryers can be purchased that use gas instead of electricity to heat the drum air. These can reduce primary energy consumption and associated environmental impacts such as GHG emissions by over 50 % (Miele Professional, 2011), and result in environmental benefits where electricity is supplied primarily from fossil-fuel sources. However, where electricity is sourced from largely renewable sources (e.g. where an establishment has a genuine green electricity supply contract: see section 7.6), electric tumble dryers are more environmentally friendly. Tumble-dryers can be selected with moisture sensors that halt the drying process when a pre-programmed moisture content is reached (e.g. ‘cupboard dry’ or ‘ironing’ settings).
Laundry rooms often require high ventilation rates to avoid overheating. In buildings with centralised controlled ventilation and heat recovery, this heat will be distributed throughout the building and will reduce heating demand in winter. In buildings without such systems, it may be possible to install a heat-recovery system that uses waste heat from dryers to heat ventilation air in winter (Figure 5.21).

![Figure 5.21: A heat recovery system installed in a hostel laundry](image)

The most important management action to minimise energy consumption in the drying process is to ensure correct drying times, and avoid over-drying that wastes energy and damages textile fibres, leading to higher replacement rates (Figure 5.31 in the next section shows the significant contribution of textile wear towards washing costs). The purpose of drying is to remove excess water from textile products, relative to their moisture content under normal atmospheric conditions (e.g. 6 – 8 % for cotton: EC, 2007). This should be the target moisture content after ironing. Thus, the equilibrium moisture content and the drying potential of the ironing should be subtracted from laundry moisture content after the washing stage when calculating dryer times, or when programming dryers containing moisture sensors. Sheets and other bedclothes may not require tumble drying where commercial ironers are used. Further points to reduce energy consumption during laundry drying are to fill machines to their rated capacity, to clean the lint trap at least once per day, and to check for correct operation of end-point moisture sensors, fans, and to clear ducting.

Ironing
It is common for accommodation providers to outsource the laundering of bedclothes to commercial laundries. Where bedclothes are laundered onsite, it is financially worthwhile to invest in a commercial flatbed ironer that can save a lot of labour and negate the need for the separate thermal drying of sheets.

In the first instance, it is important to select an efficient flatwork ironer. EC (2007) report that specific direct energy consumption of 0.9 kWh per litre of moisture removed for new steam-powered roller ironers, compared with 1.4 kWh per litre of moisture removed for older steam-powered ironers. These values correspond to energy consumption of 0.35 and 0.55 kWh per kg textiles at 45 % moisture content, respectively, indicating a machine efficiency differential of at least 0.2 kWh per kg textiles. Smaller scale ironers may be heated using either electricity or gas. As for driers, gas heating results in
environmental benefits where electricity is supplied from primarily fossil-fuel sources, whilst electric heating is environmentally superior where ‘green electricity’ (section 7.6) is sourced.

Energy consumption during drying can be minimised by operating flatwork driers as close to the rated capacity as possible, and in large batches to reduce the number of machine heat-ups required. The roller speed should be adjusted to ensure that flatwork leaving the ironer is dried to equilibrium moisture content in one pass, and as much of the ironer surface as possible is covered with flatwork at all times of operation (batch preparation and purchasing the correct width of ironer is important). Condensation water from the tumble driers or air-conditioning units can be used for steam irons, avoiding the need to purchase distilled water.

**Laundry optimisation**

The following points provide guidance on optimisation of the entire laundry process (also refer to washing optimisation, above).

<p>| | |</p>
<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Firstly, ensure that batch management is optimised to maximise machine loading rates.</td>
</tr>
<tr>
<td>2</td>
<td>Based on typical batch characteristics, assess the potential to reduce wash temperature. The potential for this may be high for typically lightly soiled accommodation laundry – it is worthwhile to experiment with different temperature and chemical dosing settings. Aim for a rewash rate of 3 – 5%. Additional chemical costs will be compensated by reduced energy consumption and textile wear.</td>
</tr>
<tr>
<td>3</td>
<td>For commercial-sized machines, install tanks and modify wash programmes to reuse rinse water in earlier rinse or prewash cycles. In areas of water stress, assess the economic viability of installing a microfiltration system to reuse prewash water in the prewash or wash cycle. Account for water, energy and chemical savings.</td>
</tr>
<tr>
<td>4</td>
<td>Ensure all economically viable heat recovery opportunities are being exploited. Install a basic heat exchanger (e.g. corrugated pipe system) to transfer waste water heat to incoming freshwater. Identify any opportunities to use waste heat from the drying process to heat incoming wash water.</td>
</tr>
<tr>
<td>5</td>
<td>Minimise use of tumble-dryers by extracting as much moisture as possible during washer extractor spin cycles, transferring flatwork directly to roller ironers, and ensuring laundry is not over-dried (should aim for equilibrium moisture content at end of finishing process).</td>
</tr>
<tr>
<td>6</td>
<td>Adjust the speed of roller ironers to ensure adequate drying in one pass, and utilise at as high a capacity as possible (correct sizing important).</td>
</tr>
<tr>
<td>7</td>
<td>Calculate when it would make financial sense to invest in new equipment based on annual energy and water savings (see Table 5.22).</td>
</tr>
</tbody>
</table>

Realisation and maintenance of optimum efficiency requires monitoring and reporting of key performance indicators for energy and water use efficiency. These should be expressed as kWh energy and L water consumed per kg laundry processed, and reported weekly or monthly in charts that enable easy tracking of progress over time. These data require sub-metering of all energy (electricity, gas, oil, steam) and water consumed in the laundry, and information on the number of pieces laundered. The average piece weight of mixed laundry items is around 0.5 kg (Carbon Trust, 2009), but this may vary for hospitality laundry and can be established for individual laundries through weighing a sample of laundry items.

**Economics**

**Consumable costs**

Figure 5.22 presents the difference in consumable cost of laundry operations per kg textile for an average laundry, consuming 12 L of water, 1.5 kWh energy and 15 grams of detergent per kg textile, and a best practice laundry consuming 6 L water, 1.0 kWh energy and 10 grams of detergent per kg textile.
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textiles. Consumable costs are dominated by chemical use, and can typically be reduced by one third, from EUR 0.40 to EUR 0.26 per kg textiles, through the implementation of best environmental management practice. Where electricity is used for all process heating, energy costs can be considerably higher than indicated in Figure 5.22. For example, in Germany the energy costs for laundries using electricity for process heating would be twice as high as indicated in Figure 5.22.

Efficient management, such as batch sorting and full machine loading, results in economic savings at little or no additional cost. For example, the Travel Foundation (2011) refer to a Moroccan hotel where linen is line dried on sunny days. Over nine months between January and September 2010, air drying 12 465 kg of linen saved EUR 700 of electricity and EUR 800 of gas.

Given the large contribution of chemicals towards consumable costs, increased efficiency of chemical use can represent a significant driving force for wash processes optimisation that also reduces water consumption. This may offset any increase in chemical costs associated with the avoidance of environmentally harmful chemicals and green procurement of ecolabelled detergents.

Equipment selection and installation
The installation of efficient equipment associated with best practice may increase capital costs. Energy and water savings achievable through the use of more efficient equipment are presented in Table 5.22, assuming efficient management of the laundry process. The average lifetime of white goods is eight years. Efficient washing machines are not necessarily more expensive than less efficient ones (Environment Agency, 2007), but the annual energy and water savings of such machines (Table 5.22) would justify an additional investment of several hundred euro during procurement selection in a small establishment. In a larger establishment with 100 rooms, the energy and water savings of efficient machines combined with rinse water reuse justify a total additional investment of several thousand euro for these features – based on a two to three year payback time and a low electricity price of EUR 0.10 per kWh. The payback times for installation of water recycling tanks and basic heat recovery systems such as corrugated pipe heat exchangers are short (EC, 2007).

The cost of tumble-dryers, and the price premium demanded for efficient heat pump or steam compression dryers, is highly variable. Some domestic-sized tumble-dryers use a continuous flow of
freshwater to condense water out of hot moist air from the drum, using approximately 3 L of water per kg laundry. Therefore, selection of an efficient dryer can reduce both energy and water consumption in a small accommodation establishment (Table 5.22), justifying an additional procurement cost of several hundred euro for an efficient machine. In a 100-room hotel, annual energy savings for efficient driers would justify an additional investment ranging between approximately EUR 800 and EUR 2 400 depending on energy prices (Table 5.22).

The magnitude of energy savings from efficient ironers, and thus the justified price premium for efficient new machines, are similar to those from efficient tumbler driers (Table 5.22).

Gas is a cheaper energy source than electricity, and some laundries are switching to gas-fired tumble-driers and ironers for this reason.

Table 5.22: Examples of savings achievable from implementation of best practice under different situations

<table>
<thead>
<tr>
<th>Situation</th>
<th>Water</th>
<th>Energy</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prices</td>
<td>EUR 2 / m³</td>
<td>EUR 0.05 / kWh (gas)</td>
<td>EUR 0.10 / kWh</td>
</tr>
<tr>
<td>10-room hotel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficient washing machine, 40 ºC wash</td>
<td>27</td>
<td>-</td>
<td>38</td>
</tr>
<tr>
<td>Efficient heat-pump dryer</td>
<td>32</td>
<td>-</td>
<td>55</td>
</tr>
<tr>
<td>Efficient ironer</td>
<td>-</td>
<td>60</td>
<td>90</td>
</tr>
<tr>
<td>100-room hotel,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficient washing machine, 40 ºC wash, rinse water reuse</td>
<td>504</td>
<td>-</td>
<td>548</td>
</tr>
<tr>
<td>Efficient heat-pump or mechanical steam compression dryer</td>
<td>238</td>
<td>548</td>
<td>821</td>
</tr>
<tr>
<td>Efficient flatwork ironer</td>
<td>301</td>
<td>642</td>
<td>903</td>
</tr>
</tbody>
</table>

Driving forces for implementation
Efficient laundry operations can reduce energy and water costs. In some Member States, governments provide financial incentives for the installation of efficient laundry equipment. In the UK, efficient laundry equipment is covered by the Enhanced Capital Allowance scheme that deducts the costs of efficient new equipment from tax liability in the year of purchase.

Many tourist destinations, especially around the Mediterranean, suffer water stress during peak season, and there is pressure to reduce water use associated with tourism. Economic driving forces may be stronger in such destinations if authorities impose higher water charges.

Emerging techniques
At the larger commercial scale, mechanical steam compression driers may soon become commercially available, and can achieve similar energy savings to heat-pump driers (Palendre and Clodic, 2003).
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References

- Brightwell, Laundry dosing systems, Brightwell, 2011, UK. Available at: http://www.opcsolutions.co.uk/extradocs/BrightLogic_Laundry.pdf
- Business Link, water resources webpage accessed July 2011: http://www.businesslink.gov.uk/bdotg/action/detail?itemId=1082900820&type=RESOURCES
- DTC LTC, personal communication with DTC LTC laundry consultants UK, 16.08.2011.
- Henkel, Case study Persil Megaperls by Henkel AG and Co. KGAA Documentation Case Study undertaken within the PCF Pilot Project Germany, PCF Germany, 2009.
- Hohenstein Institute, Sonderveröffentlichung: zum 60 Geburtstag von Dr. med. Klaus-Dieter Zastrow, Hohenstein Institute, 2010, Bönnigheim.
- Mab Hostelero, A 4 star laundry in the hotel Can Picafort Palace (Mallorca – Spain), Mab Hostelero, 2004, Spain.
- Miele, Operating instructions for heat pump tumble dryer T 8826 WP, M.-Nr. 07 966 690 / 00, Miele UK, 2010, Oxon.
- Miele, Miele washing machine products UK home page, accessed November 2011: http://www.miele.co.uk/washing-machines/features/
- Miele Professional, Environment page, accessed November 2011: http://www.miele-professional.co.uk/gb/professional/65.htm
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Best practice 5.4 – Optimised small-scale laundry operations

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