Sustainable Hotel *Siting, Design and Construction*

The industry guide to good practice

Conservation International

International Tourism Partnership

5 OPERATIONAL DESIGN

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5.1 Energy

Harnessing the power of nature to provide sustainable energy, the High Hedley Hope wind farm, County Durham, UK.

Picture courtesy EDF Energy.

Energy, in its various forms, is essential for heating, cooling, lighting and circulating water around buildings, and for ensuring a comfortable internal environment. However, its generation and consumption are not without environmental impact, the global effects of which are becoming more widely understood and increasingly legislated against.

Extracting energy from conventional fossil fuels such as oil, gas and coal for fuel or to generate electricity is in itself an energy-intensive process. Habitats can be disrupted or destroyed by pollution in the extraction, refining or transportation processes and the landscape spoiled. The burning of fossil fuels releases emissions of CO_2 which is a major contributor to global warming and is also responsible for the creation of smog and acid rain. Alternatives such as hydroelectric power and nuclear generated power also have their critics as they have significant environmental impacts.

As global awareness of these issues grows, so does the demand for energy efficiency and the use of renewable energy. This is increasingly reflected in legislation around the world. For example, the new EU Energy Performance of Buildings Directive (EPBD)[32] requires incorporation into national legislation by member states by January 2006.[33] The directive will ensure that building standards across Europe place a high emphasis on minimising energy consumption and are a vital component of the EU's strategy to meet its Kyoto Protocol commitments and beyond.

A hotel building designed with sustainability in mind should operate at optimal operational performance efficiency. In order to design energy efficiency into the establishment it is important to make use of available natural systems as much as possible. The choice of energy supply and careful consideration of materials will also reduce energy use, as will investment in appropriate technology and the adoption of cost-effective practices. Most energy efficiency measures will provide relatively rapid returns on investment (a payback period of typically less than three years) which will improve if energy costs then rise. There can also be additional benefits such as a reduction in the size of plant and its requirement for space.

[32] Directive 2002/91/EC, OJ L1 of 4.1.2003, http://ec.europa.eu/energy/efficiency/buildings/buildings_en.htm

[33] Key provisions of the EPBD are: minimum requirements for the energy performance of all new buildings and of large existing buildings subject to major renovation; energy certification of all buildings (with frequently visited buildings providing public services being required to prominently display the energy certificate); and regular mandatory inspection of boilers and air-conditioning systems in buildings.

5.1.1 Energy efficiency

Depending on the climate, expenditure on energy typically represents 30–35% of a hotel's total operating costs, so any energy efficiencies that can be designed into the building will reduce CO_2 emissions and operational costs over the life of the building.

a. Make provision for **departmental metering** of water and energy consumption in the overall design. This will enable realistic **targets** for annual energy consumption to be set early in the design stage, together with aspirational five and ten-year targets. *See **Section 9** Monitoring performance.*

b. Professional **commissioning** of building systems will be essential to ensure that all major systems perform in accordance with design. Plan the commissioning process to take place from the design phase through to completion.

c. **Link final payments** for the architect, designers, contractors and building systems suppliers to the actual overall demand and consumption once the building is operational.[34]

d. **Specifications for guest rooms** should include key-card activated master switches so that the HVAC, lighting, TV and other services are only turned on when the guest enters the room and are automatically shut down when the room is vacated. Energy-saving minibars and energy-efficient and standby functions for televisions should be specified.

e. **Office equipment** should also have energy-efficient and standby functions.

5.1.2 Energy sourcing

a. When looking at how energy will be supplied to the new development, consider whether all or some of the energy can be provided by **alternative or renewable resources** such as solar photovoltaic or passive solar systems, biomass or waste-to-power systems, geothermal, wind or water (e.g. wave power).

b. If power can only be sourced from conventional resources, consider purchasing **electricity** from a utility supplier that uses renewable resources to generate it.

c. **Natural gas** is preferable to other fossil fuels as it has lower overall CO_2 emissions and does not produce the toxic chemicals and particulates that are a result of oil combustion *(see **Table 1**)*.

5.1.3 Use of natural systems

Consider heat gain issues and heat transmission losses when deciding upon the orientation of buildings, facilities and windows. Capitalise on 'free energy' by meeting as much of the energy requirement as possible through sources available on the site such as sun, wind and light.

[34] The building must obviously be capable of achieving its efficiency criteria and the actual resource consumption will depend on how it is operated. The UK implementation of energy labelling under the EU EPBD is likely to have two values for building energy consumption—the design capability and actual consumption.

Use of Natural Systems

Table 1: CO_2 emissions from different energy sources

Note: these values are approximate. For example, grid electricity rates will differ depending on the type of coal, oil or gas that is used to generate it.

ENERGY SOURCE	Kg CO_2/kWhr
Natural gas	0.19
Liquefied petroleum gas (LPG)	0.21
Gas/diesel oil	0.25
Heavy fuel oil	0.26
Grid electricity*	0.43
Renewables (solar, wind, wave)	0.00

*Calculated from UK grid fuel mix 1998–2000

Source: DEFRA Guidelines for Company Reporting on Greenhouse Gas Emissions

Below:

The city of **Yazd** in Iran uses the ingenious principle of wind towers or 'badguirs' (wind catchers) to cool hot air from the desert in summer. The towers suck air into an area below the roof where it is cooled by a pool of water around which is a lounge area where people can relax and entertain. In modern Iranian buildings this technique has been replaced by air-conditioning units but Western 'eco-architects' still make special trips to Yazd to see how the towers work.

Picture courtesy R. Dehdashti, IranPIX, www.iranpix.com

a **Solar gain** from the hotel's roof, walls and windows can benefit or detract from the building's energy performance. Optimising the hotel's siting, orientation, form, openings, assemblies and systems will reduce lighting, heating and cooling loads. Well-insulated walls will help offset heat from solar gain.

b In hot climates, advantage should be taken of passive design features such as using **prevailing winds** for ventilation and cooling. Specify louvered doors and window shutters to ensure a through draft. High internal ceilings will facilitate air circulation whilst balcony and window overhangs and deep reveals will increase shading.

c **Windows**, when properly located, provide views, daylight, ventilation and solar gain at appropriate times. Determine the size and positioning of windows, doors and vents according to lighting, heating, cooling and ventilation requirements and select window glazing to balance lighting requirements with insulation and shading needs.

d Thermal mass is the ability of a material to absorb heat and different materials are suited to different climates. Concrete, masonry and water have a much better storage capacity for heating and cooling than the surrounding air. The use of materials with good thermal mass is best suited to climates where there is a difference in temperature between day and night. Ventilating at night using cool air removes the heat stored in the mass during the day.

e Heat can be **recovered** from waste water, ventilation and refrigeration equipment and used for heating the building.

f Reduce the overall hotel **floor area** to limit the total space that will require temperature control.

g Locate **areas of low occupancy** (such as storage areas and toilets) towards the centre of the hotel and position areas of higher occupancy in perimeter areas with access to natural lighting and ventilation.

h If there is little natural light available, light levels can be improved through the choice of interior finishes (such as light coloured or mirrored surfaces) to **maximise daylight**.

5.1.4 Building management systems

Building management systems (BMS) perform many functions. They can monitor and control equipment and lights, interface with other computer systems such as those for the fire alarm, front office, preventive maintenance or security and alert staff to critical conditions before breakdowns occur or guests complain.

BMS systems are specialist computer systems that require an appropriate amount of knowledge, understanding and training to operate them correctly and for the full potential of the system to be realised.

The **energy management** functions of BMS are sophisticated and powerful. Among other functions they can:

- **Monitor consumption** of main and sub-meters for electricity, energy and water.
- **Set operating times** in accordance with occupancy.
- Change from **summer to winter mode** and vice versa.
- **Reset kitchen supply and exhaust fans** to different air volumes based on time of day and activity.
- **Provide free cooling** by using up to 100% outside air before engaging mechanical systems.
- **Float set points within the comfort range**, for example between 21–24°C.
- Be programmed to **reduce temperatures at night**.
- Modulate **chilled and hot water temperatures**.
- **Reset air supply temperatures** in multi-zone systems to the area with the highest load and reduce air volumes to the others **according to their load**.
- **Modulate fresh air quantity with actual occupancy** by monitoring CO_2 concentration.
- Combine air handling units and fan coils with motion detectors to **operate only when an area is physically occupied**.
- **Interface with front desk computer systems** to run fan coils only when occupied.
- **Optimise start/stop sequences** by using adaptive control sequences.

- Use **dynamic controls** by changing static pressure in variable air volume systems in accordance with actual load conditions.
- **Control peak demand** for electricity, district heating and cooling.
- **Pre-cool selected areas** at night.

5.1.5 Heating, ventilation and air conditioning (HVAC)

Operating expenditure on HVAC systems can range from 20% of the building's total utility costs in moderate climates to as much as 50% in tropical areas. However, the potential to create efficiencies within HVAC systems is, in most cases, very high.

a SYSTEM SELECTION

- HVAC systems vary widely in their **capital, maintenance and utility costs**. **Professional advice** will be necessary in order to select the most appropriate system for the needs of the building and to deliver optimal energy efficiency and comfort.
- A **variety of systems** are available including fancoil, induction, re-heat, dual duct, single zone, multi-zone, variable volume, heat pump and individual units. The selection of systems with variable volume control in preference to those which run at constant volumes will considerably reduce emissions of both CO_2 and sulphur dioxide (SO_2) and can cost up to 70% less to operate through the energy saved.

b MATCHING SOURCE TO LOAD

- The basic rule is **not to move more air, water, steam, or refrigerant than is needed** to satisfy demand (the load condition). As a result, the greatest efficiency improvements can be made by matching the operation of all major equipment to the actual load conditions.
- Ventilation, heating and cooling loads can vary greatly throughout the day (by between zero and 100%). There are constant changes in climate, season, solar load, time of day, internal loads such as occupancy, lighting and equipment operation etc. Therefore, equipment such as chillers, boilers, pumps, cooling towers, air handling units, fan coils and heat pumps should have **variable speed drives** and **operate efficiently over their entire load range**.

c REDUCING LOADS

- Energy efficient **compact fluorescent lights** radiate much less heat than incandescent ones, creating less strain for the air-conditioning system.
- **Match the supply of fresh outside air** to the number of persons actually present in an area. This is done through sensors that monitor the amount of CO_2 present.
- **Divert loads** to other sources.
- **Control peak demand**.
- **Reduce solar load** by installing internal blinds, curtains, and/or reflective glass.
- **Locate heat-generating equipment** such as vending machines and dishwashers away from air-conditioned spaces as it will force them to work harder than necessary. Where this is not possible, fit an extractor or use a curtain or other barrier.

d RECOVERING WASTE ENERGY

- Energy that is normally lost to the exterior can be **recovered and used to preheat or cool** air or water from the exhaust system, boiler flue, flash steam, condensate, condenser water or latent heat from the swimming pool.
- The most efficient exhaust system is the **thermal wheel**, which has an efficiency of more than 60% or much higher if the air face velocity is reduced.

e **HEATING**

- High efficiency **condensing boilers** are the most efficient available. They can convert more than 88% of the fuel used into heat, compared with up to 80% for conventional types. These boilers have either a larger or second heat exchanger which captures the heat that would normally escape up the flue from conventional boilers. This reduces the temperature of the flue gases to a point where water vapour produced during combustion is 'condensed out'. They can run on oil, gas and liquefied petroleum gas (LPG) and can operate either as combination boilers, to heat up hot water on demand, or as conventional system boilers, where a separate hot water cylinder is required.
- Fit **horizontal thermostatic radiator valves** (TRVs) to individual radiators so that each room or area in the hotel can be warmed as required. These are preferable to vertical TRVs which are warmed by the pipe below and can fail to control the room temperature accurately.

f **HOT WATER**

Unless unlimited supplies of solar power are available, the provision of hot water is an **inherently inefficient** process. The major energy losses are standing losses during storage and through pipes before the water emerges through the tap. These losses can be mitigated through:

- **Proper insulation** of pipes and lagging of hot water tanks.
- Ensuring **pipe runs** are kept short.
- Using a local hot water heater close to the point of use for **areas of light use**.
- Ensuring boilers for the hot water service are controlled so that heating takes place **only when large quantities are required**. Stored hot water can satisfy demand for several hours, during which time the boiler need not be operating.
- Use of energy-efficient technologies such as **condensing boilers**.

g **CHILLERS AND COOLING TECHNOLOGY**

Chiller technology is continually improving with recent advances resulting in **improved efficiencies** over the entire load range, reduced maintenance costs and the chiller control's ability to interface with connected equipment such as pumps and cooling towers, thus improving the efficiency of the entire system.

- The **refrigerant** used in the chiller can have a significant bearing on its contribution to global warming through the emission of greenhouse gas. Some refrigerants, notably HFCs,[35] have a high global warming potential (GWP)[36] which needs to be considered. *See **Section 5.6.2** Refrigeration and ozone depleting substances.*
- When cooling is required in moderate climate zones at outdoor air temperatures <13°C, **free (or nearly free) cooling** can be obtained by installing a heat exchanger to bypass the chiller. The cooling tower will then directly satisfy the cooling load.
- Certain chillers can **preheat hot water** for improved efficiency. However, the demand for heating energy fluctuates widely throughout the day and with occupancy. A thorough analysis is required in order to assess feasibility.
- Depending on local energy prices, **gas-fired absorption chillers** can be energy-efficient. However, when taking into account the overall impact on global warming for the energy required to run an absorber machine, the balance becomes less favourable (unless for example it can be provided as a by-product of cogeneration). One benefit is that they create very little noise and vibration. The wide variety of models available increases the options for air-conditioning and many units are available as chiller/heaters, providing cooling and heating from a single unit. Also, their energy requirements can be supplemented directly from CHP plants. *See **Section 5.1.5.i** Combined heat and power (CHP) systems.*

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[35] Hydrofluorocarbons.

[36] Global warming potential (GWP) is a measure of how much a given mass of greenhouse gas is estimated to contribute to global warming. It is a relative scale which compares the gas in question to that of the same mass of CO_2 whose GWP is one.

- Where **cooling towers** are installed, the most efficient types are induced draft[37] with variable speed drives. Automatic water treatment and blowdown[38] should also be provided. Maintenance of cooling towers must be kept to a very high standard. *See **Section 5.1.5.h** Legionnaires' disease.*
- **Air-cooled chillers** are often preferred to water-cooled types to prevent the spread of Legionnaires' disease although they are generally less energy-efficient. They do not use water or require treatment chemicals but they do create higher noise levels. Corrective measures can be taken to reduce noise so that neighbours or guests are not disturbed. The total operating costs need to be evaluated on an individual basis.

Chiller technology is continually improving with recent advances resulting in improved efficiencies over the entire load range.

h LEGIONNAIRES' DISEASE

Legionnaires' disease is a rare form of **pneumonia** that can be fatal in around 10% of cases. It can be contracted through inhalation of droplets of contaminated water transmitted in the form of spray. The risks are associated with poor maintenance of showering facilities, whirlpool and spa baths, air-conditioning systems and fountains. In order to minimise the risks:

- **Hot water** should be stored above 60°C (thermostatic mixing valves should be installed on showers and taps to prevent scalding).
- The direction of prevailing winds should be considered when **siting cooling towers** and **strict maintenance procedures** observed.
- Ventilation **fresh air intakes** should be located away from cooling towers.
- Care should be taken in the choice of **materials in contact with warm water** to ensure they do not serve as nutrients for the *Legionella* bacteria.
- **Shower-heads** and **spa jets** should be regularly cleaned and flushed through with a 5–10mg/litre chlorine solution.

i COMBINED HEAT AND POWER (CHP) SYSTEMS

CHP or cogeneration plants generate electricity and recover most of the waste heat that is normally lost to the atmosphere. They can achieve an outstanding total efficiency of more than 80% compared with the conventional 35–55% efficiency of most public power plants.

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37 Fans are installed at the top of the tower to pull the air through.

38 Blowdown is the continuous bleeding of tower water into the drain in order to prevent high concentrations of salt.

- CHP plants are best sited at hotels where **electricity and thermal loads are coincident** on both a daily and seasonal basis. In moderate to cold climate zones this occurs during winter heating periods. However, during summer, a hotel's hot water requirements are often insufficient to absorb all of the available heat. It would then have to be rejected, thus lowering efficiency and payback. However, if a suitable absorption chiller is available, CHP may be viable provided utility rates are favourable.
- The **feasibility** of CHP will depend on the current costs of externally supplied electricity versus fuel oil or gas. Other factors to consider include what the heating and cooling systems will be, the available space, local regulations and load pattern.
- Should the hotel require an **emergency generator**, the CHP unit may provide a viable alternative.

5.1.6 Lighting

Effective use of daylight enables artificial lighting at the **InterContinental Le Grand Hotel**, Paris to be reduced.

Lighting plays an important role in projecting the image and style of the hotel, in safety and in security. The lighting design must create an ambiance that welcomes guests and make them feel relaxed. Depending on the type of hotel, lighting accounts for around 15–25% of a hotel's electricity consumption, so it is important to make maximum use of energy-efficient lighting without adversely influencing comfort.

a Make **maximum use of daylight** to minimise lighting requirements.

b Use **energy-efficient lamps** wherever possible as they consume roughly a quarter of the electricity it takes to power an incandescent lamp. They also last eight times longer and produce less heat. By replacing one incandescent lamp with a fluorescent lamp, production of three-quarters of a ton of CO_2 and 7 kg of SO_2 can be avoided over the lifetime of the lamp. This saves between US$30–50 in energy costs over the lamp's life.

c The major criterion for light output is not wattage, but **lumens**. Efficacy is expressed in terms of lumen per watt. Other factors to consider are lamp life in hours and colour.

d Select **reflective light fixtures** and **translucent shades** to increase light output.

e **Position** lighting correctly and where it is required for working. Install lamps in work areas at the lowest possible height.

f Decorating walls, ceilings and other surfaces in **light and bright colours** will help to reflect light.

g **Install timers, motion detectors, dimmers and photo-cells** in order to turn off or reduce lights in accordance with occupancy.

h Allow for **individual switching** of rooms and zones so that lights can be easily and flexibly operated.

i Make sure that low energy bulbs have a **low mercury content** (such as ones with a European Eco-label) as this can create a waste collection problem.

j **Table 2** is a guide to the **efficiency and light output** of fluorescent versus incandescent lamps for interior use and low pressure sodium versus metal halide lamps for exterior use.

More information

Chillers
Know how number four, green**hotelier** issue 30, January 2004
www.greenhotelier.org

CADDET (Centre for the Analysis and Dissemination of Demonstrated Energy Technologies)
Information on commercial energy-saving and renewable energy technologies.
www.caddet-re.org

CANMET Energy Technology Centre
Research arm of Natural Resources Canada.
www.cetc-ctec.gc.ca

Centre for Energy Studies, Ecole des Mines de Paris
www.cenerg.ensmp.fr

Energy Saving Lighting
Know how number two, green**hotelier** issue 28, July 2003
www.greenhotelier.org

EU Energy Performance in Buildings Directive 2002/91/EC
http://ec.europa.eu/energy/efficiency/buildings/buildings_en.htm

Greening the Building and the Bottom Line: Increasing Productivity Through Energy-Efficient Design
Rocky Mountain Institute, 1994
www.rmi.org

Minimising the Risk of Legionnaires' Disease
The Chartered Institution of Building Services Engineers, 2000
www.cibse.org

Lighting efficiency and output

Table 2: Comparative efficiency and light output of various lamps

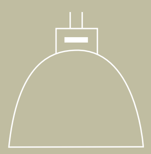
Lamp type (Watts)	Lamp life (hours)	Lumen 120/240 Volts	Lumen / Watt 120/240 Volts
INTERIOR			
INCANDESCENT			
25	2.500	232 / 225	9 / 9
40	1,500	505 / 420	12 / 10
60	1,000	890 / 710	15 / 12
75	850	1,210 / 940	16 / 13
100	750	1,710 / 1,360	17 / 14
150	750	2,850 / 2,150	19 / 14
COMPACT FLUORESCENT (Watts: lamp only / total (incl. choke))			
7 / 12	8,000	400	57
9 / 14	8,000	600	67
13 / 16	8,000	900	69
20 / 24	10,000	1,300 / 1,000	54 / 42
30 / 35	10,000	2,360 / 2,000	67 / 57
40 / 45	10,000	3,200 / 2,700	71 / 60
EXTERIOR			
LOW PRESSURE SODIUM			
35 / 44	18,000	4,795	137
90 / 113	18,000	12,690	141
180 / 225	18,000	32,940	183
METAL HALIDE (CLEAR)			
70 / 92	6,000	5,000	71
150 / 197	15,000	11,250	75
175 / 210	10,000	14,000	80

Source: International Tourism Partnership working group

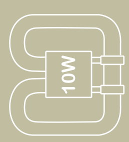
Common bulb types

INCANDESCENT


Tungsten filament


Tungsten halogen

FLUORESCENT



Compact fluorescent 2D type


Tube fluorescent


Compact fluorescent PL type

5.2 Water

Water, essential for life, and a vital component in many Hotel systems: from kitchens and laundry to guest rooms and swimming pools. Its careful use, and re-use, can convey great savings.

Picture courtesy The Portland Hotel, Jamaica.

Sustainable tourism growth can only be achieved if the physical and social environment on which the hotel and tourism industry depends is able to satisfy the additional demands that will be placed upon it. Failure to provide reliable and good quality water resources will jeopardise the future of the industry (especially leisure tourism) and the contribution it makes to the economies of many countries. This in turn will undermine their ability to use tourism as a potential means to achieve more sustainable forms of development.

The **availability of fresh water** is already a problem in many areas of the world and, although it is often seen as one that is limited to developing countries, many prime resort areas face potential water shortages over the coming years. One cause of conflict can be the relatively higher water consumption of tourists in comparison to resident populations that are better adapted to living within the natural constraints of their immediate environment.

The **resource requirements of the planned hotel** should not negatively affect the community's access to and requirements for water. Minimum requirements for water efficiency should be set early in the design process and carried through by setting targets in the detailed design and construction documents. Building systems should then be designed, installed and calibrated to meet these targets.

Conserving water reduces the amount that needs to be withdrawn from underground aquifers, reservoirs, rivers and other natural bodies of water. It is particularly important in fragile ecosystems and areas where water is scarce, such as coastal locations where a desalination plant (with its high energy demand) may be the only way of supplying it. Reducing overall water use also reduces the amount of energy to heat, cool and pump it around the building, and the chemicals involved in water distribution and treatment. These will all have a bearing on the future operating costs of the establishment.

5.2.1 Water quality

Guests who are accustomed to a high quality of drinking water in their own country are very likely to suffer an upset stomach with a change of water. It is vital that the hotel is able to provide them with a supply of safe water for drinking, bathing and other purposes and that this is regularly tested.

a Potable (drinkable) water and water used for food preparation, sanitary needs or for other purposes where it may be ingested should be provided according to **World Health Organisation (WHO)** standards[39] as a minimum.

b Drinking water should be stored at a temperature of below 20°C to ensure that water-borne **micro-organisms** cannot proliferate.

5.2.2 Water efficiency

Investment in water conservation measures in hotels can result in a rapid payback. By combining investment at the design stage with good operating practices water usage can be reduced by around 30% or more. For example, if a building has 650 occupants, each using an average of 97 litres of water per day, low-flow fixtures coupled with sensors and automatic controls can reduce this to 80 litres per day, saving a minimum of 4,000 cubic metres (m^3)[40] of water per year (or 17.5%).

Future legislation, such as the EU Water Framework Directive,[41] will be an increasing incentive for developers to implement improvements in water management.

a Set minimum **water efficiency targets** early in the design process and carry them through in the detailed design and construction documents.

b In areas where water is scarce, **grey water recycling** facilities should be considered to maximise water efficiency. *See* ***Section 5.2.3*** *Recycling and reuse.*

c Ensure that the water system includes **meters** and, more specifically, **sub-meters** in all large water-consuming departments such as kitchens, rooms, staff lockers, gardens and laundry.

d Specify **high water-efficiency equipment** for kitchens, laundry (if there is one) and cooling towers where these are installed.

e Because water **flow rate** is related to **pressure**, the maximum water flow from a fixture operating on a fixed setting can be reduced if the water pressure is reduced. For example, a reduction in pressure from 100 pounds per square inch (psi) to 50 psi at an outlet can reduce water flow by around one third. Lower water pressure can also reduce the likelihood of leaking pipes, water heaters and taps. It can also help to reduce dishwasher and washing machine noise and breakdown in a plumbing system. Note however that it may have a marked effect on the apparent effectiveness of existing shower heads. Limit the pressure of water supplied to taps and bathroom fixtures to a maximum of 3 bar and no less than 1.5 bar.[42]

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[39] 'Guidelines for Drinking Water Quality', World Health Organisation, Geneva, 1984, **www.who.int/water_sanitation_health**

[40] 1 cubic metre = 1000 litres

[41] EU Water Framework Directive 2000/60/EC, **http://ec.europa.eu/environment/water/water-framework/index_en.html**

[42] Conversion rates: 1 bar = 14.5 psi and 1 psi = 0.069 bar

Low flow technology

With hotel guests using an average of 97 litres of water per day, opportunities to limit this will not only reduce operating costs, but also reduce the burden on the local environment and infrastructure. Many modern fixtures are flow-limiting: aerators can be fitted to faucets, flow-controllers to showerheads, and simply by lowering the water pressure wastage can be significantly reduced.

f In guest bathrooms and toilet facilities in staff and public areas, the use of **low-flow fixtures, sensors, automatic controls** and **water saving urinals** will reduce water consumption and therefore the amount of waste water that has to be treated.

- **Flow-controllers** should be fitted to all showerheads and consumption limited to 8.5 litres per minute.[43]
- **Faucet (tap) aerators** are small valves that break the flow of water into fine droplets and entrain air while maintaining wetting effectiveness. They can be fitted to all taps except baths, are inexpensive and can reduce the water use at each tap by as much as 60% whilst maintaining a strong flow. Typically, they use 7.5 litres of water per minute but flow can be restricted to 5–6 litres per minute.
- Some shower head models incorporate a **vacuum flow valve** which aerates and compacts the water so it leaves the showerhead in a powerful stream but consumption is only 5.7 litres per minute. If these are fitted, test that they operate effectively throughout the hotel (especially the top floor), as they require a set water pressure to operate effectively.
- Fit **push button**-operated showers in pool and staff areas. **Self-closing percussion or push taps** which close automatically after up to 30 seconds are particularly suitable for cloakroom facilities in public areas. These can be activated by **passive infra-red (PIR) sensors** to further reduce consumption. Some types can be supplied in kit form to fit on to existing standard tap bodies without disturbing pipework.
- **Toilet cisterns** should have dual-flush mechanisms and the maximum flow should be no more than 6 litres per flush.
- **Vacuum toilets**, often used on aircraft and trains, can be very cost effective where the hotel building is spread over a relatively large area. Each flush uses less than 2 litres of water. However they require special maintenance and a reliable supplier of service and spare parts should be identified.
- **Urinals** that flush every 15 minutes can use as much as 150,000 litres of water a year. Set them to flush at longer intervals at off-peak times and to flush for no more than 10 seconds at a time.
- Consider the use of **waterless urinals** where water is only necessary for cleaning.
- Use **proximity devices** for faucets and urinals in public toilets and staff areas. PIR devices initiate a flush only when they detect activity.

[43] 'The European Eco-label for Tourist Accommodation Service', European Commission, Commission Decision 2003/287/EC, 2003, http://ec.europa.eu/environment/ecolabel/products-groups-and-criteria.html

- **Composting toilets** reduce pollution and eliminate water and sewerage costs. They are particularly suitable for operation in remote areas and ecologically sensitive environments where there is no waste water infrastructure and are not suitable for large-scale hotel operations.
- **Faucets on kitchen sinks** should be limited to use no more than 6 litres per minute.
- Use **pedal-operated** valves in kitchens and bars.

g Include systems to **collect rain water** to use for irrigating the grounds wherever possible.

h Install high-efficiency **irrigation systems** in gardens. These may feature humidity controls or moisture sensors located in strategic parts of the grounds so that water is only called for when needed and automatic shut-off devices that activate when it rains.

5.2.3 Recycling and re-use

Non-potable water can be captured in various ways for reuse by means such as rainwater harvesting and collecting storm water run-off from roofs and other hard surfaces on the site.

Thawed water from the ice house is stored in the fish pond and used for irrigating the gardens at the Sandals Negril Beach Resort and Spa, Jamaica.

See Case Study 19, Appendix 1.

a **Grey water** is water effluent recovered from baths, showers, sinks and laundry that does not contain waste from food processing or human waste. This waste water can be treated and re-used for toilet flushing, irrigation, cleaning floors and in cooling towers. Such systems require separate plumbing and treatment equipment. Any areas within the hotel and grounds where properly treated grey water can be used instead of potable water should be identified at the outset of the project and the appropriate systems designed in to the building at that stage.

b **Rinse-water circulation systems** take the water discharged with the last rinse of a laundry washing cycle and re-use it for the first wash process of the next cycle. The payback period of such systems is usually two years or less.

c Water from backwashing the filter from **swimming pools** can be reused for irrigation. *See **Section 4.7**.*

5.2.4 Waste water treatment

The Four Seasons Resort, Chiang Mai in Thailand, **pumps treated waste water into the resort's lakes and to its rice fields.**

Picture courtesy Four Seasons Resort, Chiang Mai

See Case Study 20, Appendix 1.

Raw sewage must undergo primary, secondary and tertiary treatment before it can be reused or discharged to the aquatic environment. Larger hotel facilities will usually require their own waste water treatment plant.

Waste water can be treated on site by a variety of systems, some of which can even double as decorative features and/or can be used near to guest areas where site space is limited. Where possible, preference should be given to treatment systems that use natural rather than chemical processes. Minimising waste water treated through public facilities reduces energy and chemical use and the need for public infrastructure.

Any system will require careful management of inputs into the waste water cycle and careful checking of treated effluent. Chemicals kill the micro-organisms that break down the effluent and many treatment plants cannot break down grease properly.

a TREATMENT SYSTEMS

- The **success** of waste water treatment technologies depends on accurate design information and procedures (taking into account factors such as the level of the water table), adequate safety measures, flow control, correct installation and ongoing maintenance.
- **Raw sewage** should never be released anywhere except to a dedicated local sewage treatment system.
- The World Bank recommends the **stabilisation pond system** of secondary effluent treatment as being effective in meeting health criteria economically, particularly in warm climates wherever land is available at reasonable cost.

- For secondary treatment, consider the use of a **natural wetland system**. Known as 'root zone' or reed bed systems, they comprise a series of tanks or engineered wetlands planted with reeds (*Phragmites australis*) or other plants which treat the waste water in a cascade. The system has an impermeable base to prevent untreated water from leaving the system and to facilitate the reuse of resultant water. By evolving their own ecosystem, root zones effectively reconstruct hydrological, nutrient and mineral cycles that mimic those of natural water courses. As waste water travels through the system, the organic matter is consumed by bacteria growing on the plant roots which convert it into water and CO_2. Root zone systems can be incorporated into the hotel landscape although they do require a relatively large amount of space. The final process is usually a pond of water which can be safely released into the environment or used for irrigation after further, tertiary treatment.

- Various methods of **tertiary treatment** do not involve the use of chemicals including UV disinfection, ionisation and micro filtration with disinfection.

b ISSUES TO CONSIDER

- If the hotel has **large grounds** or a **golf course**, sewage can be treated for reuse in irrigation and as fertiliser. Note that because most golf course irrigation is via sprinklers, the quality of the water must be to virtually potable standards, to avoid the danger of inhalation of contaminated droplets. *See* ***Section 5.1.5.h*** *Legionnaires' disease*.

- Treated waste water contains **dissolved salts** which are difficult to remove. The soil type needs to be taken into account if treated waste water is to be used for irrigation as salt build-up can lead to problems over time. Salt is less likely to accumulate in fast draining soils.

- Once the building is operational, liquid effluents should be **monitored** daily for pH and chlorine and weekly for all other parameters. The data should be analysed and reviewed regularly to ensure that it conforms to operating standards and any corrective measures can be taken.

- Changes in alkalinity, temperature and other parameters can upset or destroy local ecosystems when waste water is discharged. **Effluent from treatment plants** should conform to local and national standards or those of the World Bank Group,[44] whichever are the higher. *See* ***Tables 3*** *and* ***4***.

- Any **temperature increase** in discharged treated waste water should be no more than 3°C at the edge of the zone where initial mixing and dilution take place. Where the zone is not defined, this distance should be taken as 100 metres from the point of discharge.

- All **effluent from kitchens** should pass through grease traps, as grease clogs waste pipes and drains and inhibits the efficient working of all waste treatment systems.

- **Effluent from laundry** must be corrected for pH if it is outside the permissible range.

- **Chlorination** should not be considered as a first option as it is difficult to maintain a uniform and predictable level of disinfecting efficiency. Not only will it be expensive to operate, but chlorinated, organic by-products may be toxic, mutagenic or carcinogenic.

[44] 'Pollution Prevention and Abatement Handbook: Part III Tourism and Hospitality Development', World Bank Group, September 2001, www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/ifc+sustainability/publications/publications_handbook_ppah__wci__1319577543003

Table 3: Liquid effluent requirements for direct discharge to surface waters

PARAMETER	MAXIMUM VALUE
pH	6–9
BOD (Biochemical Oxygen Demand)	50 mg/litre
Oil and grease	10 mg/litre
Total suspended solids	50 mg/litre
Total residual chlorine	0.2 mg/litre
Coliforms	400 MPN / 100 ml [45]
Temperature increase	≤ 3°C

Table 4: Water quality guidelines for treated waste water used for irrigation

PARAMETER	MAXIMUM VALUE
Coliforms	< 100 MPN / 100 ml
Helminth standard [46]	<1 viable intestinal nematode egg / litre (99% egg removal)

Sources: World Bank Group Pollution Prevention and Abatement Handbook

More information

Design Manual for Waste Stabilisation Ponds in the UK
Regularly updated Internet-based manual.
Professor Duncan Mara, School of Civil Engineering, University of Leeds
www.leeds.ac.uk/civil

Pollution Prevention and Abatement Handbook: Part III Tourism and Hospitality Development
World Bank Group, September 2001
www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/ifc+sustainability/publications/publications_handbook_ppah__wci__1319577543003

Rainwater and Greywater in Buildings: Project Report and Case Studies
BSRIA, 2001
www.bsria.co.uk

UK Rainwater Harvesting Association
www.ukrha.org

US Environmental Protection Agency Office of Waste Water Management
www.epa.gov/OWM

Wastewater Gardens®
www.idepfoundation.org

Water Collection and Saving
green**hotelier** issue 24, November 2001
www.greenhotelier.org

Water Quality Association
www.wqa.org

Water Reuse Association
www.watereuse.org

Water Saving: Bathrooms and Toilets
Know how number three, green**hotelier** issue 29 October 2003
www.greenhotelier.org

World Health Organisation: Water, Sanitation and Health
www.who.int/water_sanitation_health/en

[45] Most probable number (MPN)

[46] The helminth standard is an indicator for all of the large pathogens (that settle readily) including the protozoa amoeba and *Giardia*.

5.3 Waste

Solid and hazardous wastes levy costs to society and to the environment through inefficient use of resources, the dispersion of toxins into ecosystems, and the collection, transport and disposal of waste. These costs can be greatly reduced by waste reduction (for example by insisting suppliers minimise packaging) and replacing conventional waste disposal activities with practices aiming for reuse, disassembly, recycling, and composting.

Waste is a valuable resource and, in principle, all waste should be segregated and sent for recycling. Eventually it will be become our main source of raw materials for consumer products to keep our 'consumer society' going. This is the background to new European legislation on recycling and end-of-use take-back, etc. The EU Landfill Directive,[47] will be an increasing driver to reduce the creation of waste and specifically, the amount sent to landfill or for incineration.

Waste from hotels is created:

- As a result of **site clearance** and **construction**.
- Throughout the **operational life** of the hotel.
- During **refurbishment**.
- At the **end of the building's life** or if there is a **change in use**.

The most significant percentage of this waste will be created by the normal operation of the hotel throughout its life. This will require staff training and good waste management practices, which are outside the remit of these guiding principles. However, developers should anticipate waste management requirements and the need for space and facilities for sorting, compacting and storing waste for reuse or recycling. These considerations need to be designed-in at an early stage of the hotel development.

5.3.1 Facilitating waste management

a In many countries, inexpensive **solid waste management technologies** are now available that allow for a significant percentage of solid waste to be recycled with an economic return to the hotel. For example, it may be possible to install 'total waste treatment technology' whereby kitchen wastes, sewage and waste water can be treated to produce compost, biogas and useable water.

b In order that the hotel, once operational, can deal with its waste in the most efficient manner, thought must be given at the design stage to allocating **specific and well-marked spaces** and facilities for collecting, sorting, compacting, baling and storing materials for recycling and for composting. Separation categories will include glass, metals, office paper, newspaper, cardboard, plastic, cooking oils and organic waste, among others. Some hotels already separate their waste into as many as 15 separate fractions.[48]

- **Locate** the central waste collection and storage area in a basement or on the ground level with easy access for collection vehicles.
- **Allow space** in or near kitchens for separating solid wastes into categories (foodstuffs, paper, plastic, metals etc.) and for separate storage of each.

[47] EU Landfill Directive 75/442/EEC and subsequent directives and decisions, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31999L0031

[48] See Case Study 21, Hilton Tokyo Bay Hotel, Appendix 1

- Allocate adequate space in the grounds for **composting** facilities. Composting of garden waste (e.g. cut grass, shrub limbs and dead flowers) together with organic kitchen waste such as vegetable and fruit peelings, eggshells, tea leaves and coffee grounds produces compost, a nutrient-rich substance which replenishes soil and replaces the need for fertilisers. It may be necessary to have **several bins** at various stages of decomposition to satisfy supply of composting material and the demand for finished fertiliser.

c Where there is **no existing waste collection** and disposal service, developers will need to design and implement adequate waste disposal systems. The development of a new hotel or resort may provide a **catalyst for new local businesses** to collect the waste and possibly process it as a feedstock for locally-made goods.

d If it is necessary to select an appropriate site for landfill, factors to consider include:

- Obtaining approval from the local **community** as well as the local authority.
- Ensuring that it is sited where the soil is **impermeable** or that liners are used to prevent pollution entering groundwater.
- Ensuring there are **no drainage channels** entering or leaving the site.
- Making sure that the excavated site is above the **highest groundwater levels** (factoring in periods such as the rainy season).
- **Locating the site** at least 30 metres away from wells, boreholes, streams, rivers or other water bodies. Local legislation will need to be checked in this regard.

5.3.2 Hazardous wastes

a Many hotels built during the 1950s and 60s contain **asbestos**, for which there is strict health and safety legislation in many parts of the world. Asbestos should be safely removed by a specialist contractor and properly disposed or encapsulated in order to avoid human exposure.

b **Sludge** from water treatment and sewage treatment must be disposed of in a manner to prevent the contamination of soil, groundwater and surface water.

c **Spent oils, lubricants, and solvents** should be sent to an authorised disposal or recycling company.[49] However, an **increasing range** of waste (including paint, chemicals, light bulbs and electrical equipment) is being classified as hazardous waste. Local legislation will need to be checked in this regard.

d Non compostable **food wastes** (such as raw and cooked fish and meat) should be disposed of separately and kept out of the animal food chain.

More information

Better waste management
Know how number six, green**hotelier** issue 32, July 2004
www.greenhotelier.org

International Solid Waste Association
Includes waste legislation developments around the world.
www.iswa.org

Global Recycling Network
Waste collection, disposal and recycling marketplace with links to glass, battery, paper, textile and plastics recycling, food waste and composting information.
www.grn.com

[49] 'Pollution Prevention and Abatement Handbook: Part III Tourism and Hospitality Development', World Bank Group, 2001, www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/ifc+sustainability/publications/publications_handbook_ppah__wci__1319577543003

5.4 Materials

The choice of materials used for buildings not only plays a substantial role in the comfort of their occupants, but also has important environmental effects. These result from the process of extracting materials from the earth, chemical production processes, transportation energy use and final disposal. Extraction and disposal can negatively affect the environment by using up non-renewable resources and by emitting pollutants to air, soil and water. Communities may experience unhealthy living conditions (from the emissions from paint and varnish manufacturing, for example) and the loss of attractive natural environments. These impacts can be reduced by eliminating certain materials and chemical manufacturing processes, by selecting materials that are not detrimental to health, and by recycling and reusing materials.

According to US government data, buildings account for 60% of raw materials used and around 40% of non-industrial solid waste.[50] The most effective approach to minimising the environmental impacts of material use therefore is to reuse buildings as much as possible, and to minimise the use of materials for new buildings.

Careful and appropriate choice of materials will reduce the overall environmental impact of the building in the following ways:

- **Reducing the use and depletion** of finite non-renewable materials (e.g. marble and slate quarrying).
- Encouraging **sustainable forest management**.
- Promoting **'green' manufacturers** and suppliers.
- **Phase out** of harmful substances.
- **Extending life cycles** through recycling.

5.4.1 Selection criteria

In considering the sustainability of a building material it is important to consider all aspects of its life cycle. Although it may be natural and have 'green' properties, is it sustainable in terms of the ethics of its production or the environmental impacts of its distribution and supply? For example, has its production involved the use of child labour or required transportation across several countries?

Consideration should be given to reducing the total volume of materals used and choosing materials that will reduce the frequency of replacement. When selecting raw materials and products, look for the following characteristics:

a RECYCLED CONTENT, RECYCLABILITY AND WASTE AVOIDANCE

- Apply a **reuse strategy** early in the design phase to include salvaged and refurbished building materials and identify potential local sources.

[50] www.greenerbuildings.com

- Give preference to materials made with a high proportion of **recycled content** (preferably post-consumer recycled content) that might otherwise be disposed of as waste in landfill, ensuring that they perform equally or better than virgin materials in terms of strength, maintenance and durability. Materials that can contain recycled content include concrete, masonry, acoustic tile, ceramic tile, metals (steel and aluminium), carpeting and insulation.
- Select materials with highest possible levels of recycled content that can themselves be **recycled or reused** at the end of the building's life.
- Where possible **avoid mixed materials** and give preference to those that have been joined together using mechanical fixings rather than adhesives. This permits dismantling and disassembly, allowing for recycling or reuse of materials.
- Look for products that help eliminate or **reduce packaging** or enable its reuse, and ask suppliers to take back their packaging for recycling.

b SUSTAINABLE SOURCES, BY-PRODUCTS, BIODEGRADABILITY

Adrère Amellal Oasis is built using local natural materials. The architecture also creates a sense of place.
See Case Study 5, Appendix 1.

- Research **regionally-sourced** building materials for performance, durability and environmental qualities. Local or regional building materials are often more responsive and **attuned to the local climate** and **aesthetics** compared with materials from other regions.
- Giving preference to locally produced materials will help support the **local economy** and minimise **transportation impacts**. Specify the chosen materials in the construction documents.
- Look for materials that contain **agricultural by-products**, use **abundantly available raw materials** and have advanced levels of **biodegradability**.

c RENEWABLE MATERIALS

- Rapidly **renewable materials** such as wool and bamboo are replenished faster than conventional resources, and often require less input of energy and water, capital and time than conventional building materials. They may require less land to produce the same quantity of material and also have a faster return on investment for producers. Products include: wool carpet, linoleum and bamboo flooring, wheatgrass cabinetry and cotton batt insulation.[51]

[51] See Leadership in Energy and Environmental Design (LEED) , US Green Building Council, www.usgbc.org

d REDUCED GREENHOUSE GAS RELATED IMPACTS

- Choose materials in their **least processed state** which are sustainable and **energy-efficient** during their manufacture (referred to as having low embodied energy), through their transport and lifetime usage to recycling.

e LOW TOXICITY

Qualities to look for include:

- Substantially **reduced emissions** of substances such as VOCs.
- Low or **non-toxic treatments** (e.g. for timber).
- **Non-toxic emissions** from the production process.
- **No listed carcinogens** emitted during production.
- **Low environmental impacts** on disposal.

f OTHER INFORMATION

Other information that should be provided by suppliers/manufacturers in support of more sustainable materials includes:

- **Material safety data sheets** (MSDS).
- The **environmental policy** of the company supplying, manufacturing or extracting them.
- **Independently verified** environmental claims.
- Eco-labels (Type I eco-label schemes), awards and other **relevant accreditation**.
- An accredited EMS such as ISO 140001 or EMAS.
- Information on **maintenance**.

It is worth noting that despite setting sustainability criteria, it is not always possible to choose the most eco-friendly material for construction or interior fittings. Factors such as availability, appropriateness, practicability, cost, maintenance, durability, fire resistance and existing hotel company standards all have to be taken into account and evaluated before a decision is made. For example, although 100% wool carpets may be the most environmentally friendly, some hotel companies find that a mixture of 80% wool and 20% nylon carpet is the best balance between value, durability and causing the least damage to the environment.

5.4.2 The A-to-Z of building materials

See pages 23–24.

5.4.3 Harmful materials

Table 5 shows some materials and substances that might be encountered during hotel construction or refurbishment and which should be avoided wherever possible. Some substances, such as asbestos, should only be handled by specialist contractors. Where alternatives for substances are not available (such as epoxy sealants), ensure that those using them take appropriate health and safety precautions.

5.4.2 The A-to-Z of building materials

Adhesives and sealants (A)

The issue with glues and adhesives is that once something has been stuck to the wall or floor it usually means it cannot be reused or recycled. Consider whether there are other ways of fixing the material in place before using synthetic adhesives. Glues can be produced from either animal (bone, hide or casein/soured milk) or vegetable (starches, gum arabic, tragacanth) products.

- Use **water-based** or **low-solvent** synthetic glues and hot-melt adhesives. Most water-based adhesives today perform as well as or better than solvent adhesives but are generally only suitable for internal use. Water based adhesives include glues made from soya, blood albumen, casein and animal products. These have lower toxicity than their synthetic counterparts and are not derived from petrochemicals. Hot-melt adhesives contain little or no solvents, though they may release VOCs when heated.
- **Water soluble** casein or **PVA-based** plain white glue is the lowest in toxicity. These are suitable for woods, paper and leather.
- **Avoid glues** containing nonylphenolethoxylates, isocyanates and formaldehyde.
- **Avoid sealants** with polyurethane, sealant foam and asphalt sealing (tile walls).

Aluminium

- The production of **primary aluminium** by bauxite mining and refining involves significant energy consumption and CO_2 or greenhouse gas emissions. However, it can be recycled in a way that pays for itself and is sustainable.[52]
- Aluminium panels are **corrosion resistant** and therefore virtually maintenance free. Their lightness means easy construction, while their thermal insulation properties derived from the ability to design thermal breaks in extrusions, and from aluminium foil's reflectivity, can be used to conserve heating energy.

Cement (C)

- Cement is a fine grey powder made by burning **clay and limestone**. Its manufacture produces significant CO_2 or greenhouse gas emissions.
- Displacing a portion of cement with **recycled content** reduces the carbon dioxide (CO_2) produced proportionally. The recycled content can contain fly ash (a waste product from coal-fired power generators), slag and crushed concrete, tiles and bricks.

Concrete

- Concrete is a **mixture** of crushed stone or gravel, sand, cement and water, that hardens as it dries. Though these are natural materials, stone and gravel extraction are associated with high CO_2 or greenhouse gas emissions through the use of heavy extractive equipment and transportation lorries.
- Concrete has excellent **thermal mass** properties that help to moderate the temperature of occupied spaces, minimise the need for mechanical cooling and reduce winter heating requirements. To do so it must be 'coupled' to heat sources and some means of distribution such as the air handling system. Although greater mass in a building means that more heat can be stored, practical issues limit the useful amount.[53]
- Autoclaved aerated concrete (AAC) can be used as a **brick substitute** for external walling. It has good thermal insulation properties and a better sound absorption coefficient than ordinary bricks.
- **Blast furnace slag** concrete aggregate is a by-product of iron manufacture. For every tonne of slag substituted for ordinary cement, a reduction of half a tonne of CO_2 emissions is made. Using slag conserves energy already expended in iron production.
- Concrete can be stained with a variety of permanent colours and can also be polished to give an exciting and attractive finish for internal walls and floors.

Flooring (F)

See ***Section 8.2****, Floors.*

Glass / glazing (G)

- Specify windows and glazing products with high **K-values** (European standard) or low **U-values** (UK and US standards). This reduces heat loss in cold weather, lowering the heating requirement and also resists penetration of heat into cool areas in hot weather, resulting in energy savings.
- When specifying, look for **thermal efficiency**, **acoustic efficiency** (for noise reduction), **longevity** and **ease of maintenance**.
- Choose **window frames** made from sustainably sourced timber in preference to non-traceable hardwood sources, or recycled aluminium in preference to PVC frames.

Insulation (I)

- Natural insulation materials help regulate moisture in buildings and also help them to breathe whilst providing good thermal and acoustic insulation. Suitable materials include **wool or wool-blends**, **wood fibre boards**, **straw**, **cellulose** and **newspaper fibre**.
- **Avoid** cellular plastic insulation, which releases toxic smoke in the event of fire.

Masonry (M)

- Select bricks that are **fully recyclable** and, if possible, manufactured from other **recycled products**.
- Choose **high-density** bricks for sound-proofing and reduced temperature variation.

Metals

- **Stainless steel** has a long life and helps maintain hygienic conditions.
- Where possible, **avoid chromed metals**. The chroming process involves the use of toxic chemicals. Chrome radiators are 10% less thermally efficient than those finished in a spray painted coating.

[52] At the current primary aluminium production level, known bauxite reserves will last for hundreds of years. More than 55% of the world's aluminium production is powered by renewable hydroelectric power. Products made from aluminium can be recycled repeatedly to produce new products, saving energy and mineral resources. Source: International Aluminium Institute, **www.world-aluminium.org/environment**

[53] Santa Monica Green Building Program **www.smgov.net/departments/ose/categories/buildGreen.aspx**

Plaster and paint

P

*See **Section 8.1**, Walls.*

Plasterboard

- The use of plasterboard eliminates the need for curing and plastering. Choose plasterboard made from waste products that is recyclable and utilises **non-toxic natural materials**, with paper liner manufactured from 100% recycled paper.
- Check with suppliers regarding waste collection and recycling programmes and **encourage recycling** as this can have a large impact in reducing the volume of construction waste.

Steel

S

- There are many environmental impacts associated with steel production, particularly in terms of **energy use** and the associated carbon dioxide (CO_2) emssions. However, steel has proved itself as a strong and versatile buildning material.
- Ask the **supplier** about whether they are addressing environmental impacts through, for example, integral energy management, the use of closed-loop water systems and the avoidance or recycling of production waste.

Varnishes, waxes, oils & other finishes

V

- Choose finishes based on **natural plant oils**, natural **resins**, natural **pigments** and **solvents**. Check that no toxic solvents or heavy metals are used in the production process.
- **Avoid** the use of **solvent-based lacquers**. As an alternative to conventional polyurethane varnishes with a high VOC content, there are acrylic, water-based products which are hard-wearing and should not alter the natural colour of the wood . Often the varnishes are milky on application and dry to a clear, waterproof finish. Pigments can be added to 'tint' the varnish if desired.
- Various components go into the making of **natural protective waxes** including beeswax, larch resin and essential oils. There are different types of wax for different uses and finishes. For example, some waxes are more breatheable and polish to a low sheen, whilst 'antique' wax polishes to a high sheen and is water and dust repellent. Some water-borne light waxes contain ingredients such as carnauba palm oil and are used in diluted form. Over time some waxes mellow and darken the wood. Check with your supplier for the effect you wish to achieve. Wax can also be used as a 'liming' agent by adding vegetable, earth or mineral pigments to highlight the natural grain and surface of the wood.
- Wood panelling such as pine or oak can be fed with **natural oils** made from herbs and resins. These can be brushed on for a matt finish or used as a primer before waxing and varnishing.

Wall coverings

W

*See **Section 8.1**, Walls.*

Wiring[54]

- Polyvinyl chloride (PVC) is the most common insulation and jacketing material for wiring in buildings, owing largely to its flame resistance and low cost. However, some PVC wire insulation and jacketing contains 5–10% lead by weight. Halogen-based compounds, especially fluorinated ethylene propylene (FEP), are common in data wiring insulation.
- If possible, specify halogen-free products such as polyolefin products and avoid wire and cable insulation and jacketing that contain PVC, chlorinated polyethylene, FEP, or products containing brominated flame retardants. Fibre-optics require less insulation and jacketing than copper wiring because they transmit light signals instead of electricity. Consider running fibre-optic trunk lines to smaller copper distribution lines, thus reducing total insulated cable use.

Wood

- Wood is **versatile** and **hard-wearing**, and its appearance often **improves with age**.
- Select **reclaimed**, **recycled** or **salvaged** wood. Salvaged wood is recovered from urban developments and would otherwise be destined for the waste stream. However care should be taken not to use wood that may have been chemically treated for woodworm etc.
- **Veneers** made from reclaimed or recycled wood will not only conserve virgin resources but reduce waste. Reclaimed wood can be used to dramatic effect as the natural grain and distress marks add to its character.
- If using virgin timber, purchase it from **sustainable sources**. There is no global **certification** scheme for forests, but there are various national and regional schemes such the Forest Stewardship Council (FSC), the Sustainable Forestry Initiative (SFI) and the Pan-European Forest Certification framework (PEFC).
- **Avoid** processed wood (such as compressed chipped wood) containing formaldehyde.
- **Avoid exotic woods** such as teak and mahogany and species such as oak, cherry or maple, which take between 30 and 200 years to reach maturity.

54 'Getting Down to the Wire', Architectural Record, 2004, **www.archrecord.construction.com**

Table 5: Harmful substances encountered in construction

SUBSTANCE	FOUND IN	AFFECTS / CAUSES
Acrylates	Paint	Skin contact sensitisation (eczema). May also cause respiratory symptoms such as asthma
Asbestos	Used widely in buildings of the mid 20th century in, for example, pipe insulation, ceiling panels, textured paint coatings, roofing felt and wall board. Use is now widely prohibited. Removal must be carried out by specialist contractor	Asbestosis (scarring to lung tissue), lung cancer and malignant mesothelioma. Greatest risk is from long-term exposure or disturbing fibres during refurbishment
Creosote, coal tar	Used as wood preservative to protect against weather breakdown and wood-dwelling pests	Poisonous if it enters the body through the lungs, stomach or intestines
Epoxy resins	Used for adhesives, coatings and sealants	Skin, eye, nose and throat sensitisation have all been reported
Formaldehyde	Widely used in building materials and household products. Pressed wood is bound together with adhesives containing urea-formaldehyde (UF) resins. Products for indoor use include: particleboard, hardwood plywood panelling and medium density fibreboard (MDF). MDF contains a higher resin-to-wood ratio than any other UF pressed wood product and is generally recognised as being the highest formaldehyde-emitting pressed wood product. Pressed wood products for use in exterior construction include softwood plywood and flake or oriented strandboard and contain dark, or red/black-coloured phenol-formaldehyde (PF) resin	Can cause watery eyes, burning sensations in the eyes and throat, nausea, and difficulty in breathing in some humans exposed at elevated levels (above 0.1 parts per million). High concentrations may trigger attacks in people with asthma. There is evidence that some people can develop a sensitivity to formaldehyde. Shown to cause cancer in animals and may cause cancer in humans
Glycol ether	Solvents in paints, cleaners and inks	Toxic if ingested. Care should be taken to minimise inhalation and skin contact
Isocyanates such as toluene diisocyanate (TDI), methylene bisphenyl isocyanate (MDI), hexamethylene diisocyanate (HDI) and isophorone diisocyante (IPDI)	Used in the manufacture of flexible and rigid foams, fibres, coatings such as paints and varnishes, and elastomers	Danger is mainly to production workers. Short-term inhalation may cause sensitisation and asthma. Skin contact can induce dermatitis and eczema. Long-term inhalation exposure has been shown to cause asthma, dyspnea, and other respiratory impairments
Lead	Paint (particularly paint that has been applied around 40 years ago). Less likely to be found in current formulations, but it is important to check	Linked to incidence of blood cancers such as leukaemia
Phthalates	Softeners used in plastics	Linked with hormone disruption and reproductive problems
Radon	Gas arising from decay of radium-226 found in nearly all soils to varying degrees and dissolved in groundwater. New construction projects should include a radon barrier to mitigate effects where radon is present. This is mandatory in building regulations in some countries	Not well defined, though there is evidence of increased likelihood of lung cancer through prolonged exposure, particularly among smokers

Source: International Tourism Partnership working group

More information

International Aluminium Institute
www.world-aluminium.org

ATHENA Sustainable Materials Institute
www.athenasmi.ca

Coatings Technology Centre
Information on environmentally friendly paints from the Paint Research Association.
www.pra-world.com

The Concrete Centre
Promoting and assisting more sustainable concrete design and construction.
www.concretecentre.com

Cornell University Centre for Materials Research
www.ccmr.cornell.edu

Forest Stewardship Council
www.fsc.org

Green Building Handbook: Volume 2
Spon Press, 2000
www.sponpress.com

GreenSpec Directory: Fourth edition
Internet and printed product directory with guideline specifications.
BuildingGreen, 2003
www.buildinggreen.com

Pan-European Forest Certification framework (PEFC, *now the Programme for the Endorsement of Forest Certification***)**
www.pefc.org

Sustainable Forestry Initiative (SFI)
www.sfiprogram.org

World Steel Association
www.worldsteel.org

5.5 Noise

Hotels are subject to many sources of noise, both internally and externally. Noise pollution must be mitigated for legal and safety reasons and to protect the quality of the guest experience. Noise management is largely controlled at the design and construction stages of hotel development. Hotel operators must work closely with architects, engineers and the construction team to ensure appropriate noise-control measures are taken.

Table 6 shows recommended ambient noise levels for various types of building during the day and at night. Noise abatement measures should achieve these levels or a maximum increase in background levels of 3dB(A). Measurements should be taken at noise receptors located outside the project boundary.

Table 7 shows the recommended maximum noise levels for various areas in luxury hotels. Typical noise levels for lower-range hotels would differ from the above values; for example, guest room noise curves would be 2–4 dB higher.

5.5.1 Areas where noise transmission can be reduced

a WINDOWS

- Ask suppliers for information regarding window sound reduction factors and specify **sound transmission levels** for windows based on maximum noise levels.
- Allow guests **limited opening** of the windows.

b ROOM TO ROOM

- Specify that **wall penetrations** must not be made from guest room to guest room for sockets, switches, ducts and cables.

c **BATHROOM TO BATHROOM**

- **Isolate baths** and acoustically insulate the drain pipework.
- **Offset exhaust ducts** against each other to prevent direct connections.
- Install **soundproofing insulation** underneath floor tiles in bathrooms.

d **GUEST ROOM DOOR TO CORRIDOR AND ADJACENT ROOMS**

- For luxury hotels, the entrance door should have a **sound transmission class (STC) of 45**. This will reduce noise originating from the corridor by 45 dB. Such doors also satisfy 30-minute fire rating requirements. For lower range and budget hotels specify 35–40 dB.
- Fit **door gaskets** around frames and a drop seal at the bottom.
- Specify **double doors** between rooms. The STC for room to room reduction should be 50 dB.

e **FAN COILS**

- Specify **acoustic lining** within the supply ducts.

f **COMPARTMENTATION**

- Inspect the building regularly throughout construction to ensure that any **openings** between floors and rooms are properly sealed off. This is also a vital requirement for fire prevention.

g **KITCHENS TO RESTAURANT, BANQUETING AND MEETING ROOMS**

- Install **double doors** between the kitchen and the rooms it services.

h **FUNCTION ROOMS SEPARATED BY MOVABLE PARTITIONS**

- Specify the **sound transmission** class (STC) of the separation. A suitable value would be 46 dB.
- **Seal the space** above any false ceilings and run air-conditioning ducts separately from the outside main supply and exhausts.

i **EQUIPMENT**

- Install noisy equipment on **separate foundation bases** and provide acoustic rubber isolation pads made with reinforced rubber.
- Position, enclose, and **isolate** noisy equipment in order to prevent noise disturbance to guests and the neighbourhood or minimise it to acceptable levels. Permit space or buffer zones encompassing two walls between noisy equipment rooms (such as the laundry) and public areas.
- Design-in **physical space** between elevators or rooms such as housekeeping store rooms and guest bedrooms.
- Provide **separate isolated rooms** for ice machines. Use water, not air-cooled compressors.
- **Locate** emergency generators and diesel engine equipment away from public areas.
- When construction is complete, check the sound levels against **specified acoustics**.
- On air-cooled equipment, use **larger cooling fans** to reduce speed.

Table 6: Recommended ambient noise levels

MAXIMUM ALLOWABLE EQUIVALENT SOUND LEVEL (L_{eq} hourly in dB(A))		
RECEPTOR	DAY: 0700–2200	NIGHT: 2200–0700
Residential, institutional & educational	55	45
Industrial and commercial	70	70

Source: World Bank Group Pollution Prevention and Abatement Handbook

Table 7: Recommended maximum noise levels in luxury hotels

AREA	NOISE CURVE (dB)
Guest rooms	27 (night) 30 (day)
Public rooms	35–40
Meeting rooms	30–35
Offices	30–35
Kitchens / Laundry	40–45
Service work areas	45

Source: International Tourism Partnership working group

5.6 Air quality and emissions

5.6.1 Emissions to atmosphere

Emission levels for the design and operation of the building must be established during the pre-design stage during the environmental impact assessment. Boilers and incinerators may require filters or other mechanisms to control particulate matter.

It is suggested that the recommended emission levels shown in Table 8 are followed together with the appropriate national legislation, and the more stringent values adopted. The values are expressed as concentrations to facilitate monitoring.

Table 8: Air emissions requirements

PARAMETER	MAXIMUM VALUE*
Particulate matter	
Fossil fuels	100 mg/Nm^3
Other fuels (such as wood and biomass)	150 mg/Nm^3
Nitrogen oxides from boilers as NO_2	
Coal fired	750 mg/Nm^3
Oil fired	460 mg/Nm^3
Gas fired	320 mg/Nm^3
SO_2	2000 mg/Nm^3

* Maximum levels should be achieved for at least 95% of the time that the plant or unit is operating to be calculated as a proportion of annual operating hours. These are expressed in Nm^3 or Normal cubic metres (gas measured at 1 Atmosphere and 0°C).

Source: World Bank Group Pollution Prevention and Abatement Handbook

5.6.2 Refrigeration and ozone-depleting substances

Hotels and the tourism industry use chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), halons and other ozone-depleting substances (ODS) in various applications: for air-conditioning, in refrigerators, freezers and cold rooms and in fire protection. However, these substances all damage the earth's protective ozone layer, which absorbs the ultraviolet radiation that is harmful to living organisms and human health.

Because of the damage that they do to our atmosphere, there are strict controls over the production and consumption of certain refrigerants and other ODS under the Montreal Protocol—an international treaty to which nearly all the countries in the world are signatories. Many substances have already been banned in developed countries and there are strict deadlines governing the phase-out of production and consumption in the developing world. In the European Union, for example, the supply of CFCs and their use for maintenance of existing equipment is banned, and it is not legally possible to buy them. HCFCs are also subject to restrictions: it will be illegal to both 'place on the market' and to 'use'[55] new HCFCs after January 2010 and illegal to use any HCFCs after 2015.

For virtually all ODS applications there are alternatives available (see **Table 9**). Some are better than others for certain applications and all have performance, safety, cost and environmental trade-offs that must be carefully considered by hotel developers and owners.

Table 9: Key refrigerants used in the hotel industry and their alternatives

Note: Never substitute alternatives without first checking compatibility with your equipment supplier. In some cases, modifications may be necessary before using replacements or it may be necessary to replace the equipment altogether.

CFC	HCFC	HFC *	'NATURAL REFRIGERANT'
R11	R123		
R12	R401A R401B R409A R409B	R134a R413A	R290 R600a R717
R502	R402A R402B R403B R408A R411B	R404A R407A R407B R507	R290 R717
	R22	R404A R407C R410A R417A	R290 R717

* With the exception of R413A and R417A, the HFCs do not use the same compressor oil as CFC and HCFCs.

Sources: ISCEON Distribution Services and Enviros

55 The definition of 'use' is important, as it is defined as including 'refilling' the refrigerant into a refrigeration system. This appears even to include a ban on replacing refrigerant that has been removed from the equipment for maintenance.

As a guide:

- **CFCs** and **HCFCs** are ozone-depleting.
- **HFCs** are non-ozone-depleting (zero ODP), but have significant global warming potential (GWP).
- **Natural refrigerants**: Ammonia has zero ODP and zero GWP and hydrocarbons (HCs)—i.e. propane and butane—have zero ODP and negligible GWP.

Currently, the most environmentally responsible choice is to select systems using natural refrigerants. In the future, as research into alternative refrigerants progresses, it may be possible to use CO_2 or water as a refrigerant for air-conditioning applications.

More information

UNEP Division of Technology, Industry and Economics (DTIE) OzonAction Programme
www.unep.org/ozonaction/

How the Hotel and Tourism Industry Can Protect the Ozone Layer
UNEP, 1998
www.unep.org/ozonaction/

5.6.3 Indoor air quality

Factors affecting indoor air quality include levels of outdoor pollution, sources of indoor pollution, the rate of exchange between indoor and outdoor air, ventilation rates and distribution, the characteristics and furnishings of the building and the amount of moisture in the indoor environment.

There is a general belief that indoor air quality can be improved only at the expense of energy conservation. However, using proven energy conservation technology for increased ventilation system efficiency could significantly improve indoor air quality without significantly increasing energy consumption.

The following need to be considered during the pre-design and design stages in order to avoid problems:

a. Total **air flow** requirements, required **temperature ranges** and ambient **humidity** levels.

b. Air **cleanliness** (specify high-efficiency filters).

c. The **hotel indoor environment** and **furnishings**.

d. **Fresh outside air** requirements, **minimum ventilation rates** and **indoor air quality levels** need to be set in accordance with ASHRAE standards (American Society of Heating, Refrigerating and Air-Conditioning Engineers).[56]

e. **Variable outside air** provision of up to 100% (providing free cooling and excellent air quality).

f. The installation of **CO_2 monitoring systems** as part of the BMS, which not only provide feedback on ventilation performance, but can also modify air volumes in relation to actual occupancy. These systems will require periodic recalibration to ensure optimal performance.

g. **Energy recovery** (via an energy wheel or other heat recovery devices), which also permits higher fresh air quantities.

h. **Displacement systems** that provide excellent air quality (suitable for moderate climate zones).

[56] 'Ventilation for Acceptable Indoor Air Quality' (Std 62-2001 and addenda), ASHRAE, **www.ashrae.org**

i Natural cross-ventilation. This involves locating windows on both sides of the room, creating airflow across the space. The cross-ventilation principle is, like all natural ventilation principles, based on the requirement of ensuring a fresh and comfortable indoor climate with minimal energy consumption at low cost.

j Location of the **fresh air intakes** relative to exterior pollution sources (such as directly over car parks or loading bays or at street level) to avoid taking in toxic fumes. Also ensure the air intake is not located near the hotel's own emissions from garages, kitchen, laundry and toilet exhausts, sewage tanks and treatment systems, boiler flues or cooling towers (in the latter case because of the danger of *Legionella* contamination).

k Specify adequate **extraction** over cooking appliances and laundry equipment to avoid 'spillage' into the other areas. Kitchens, laundry and toilets must be under negative pressure. Pressurised systems can spread odours inside the building through duct leakages.

l **Duct system layout**. Exhaust fans should be located outside the building and pull the air through the ducts.

m **Ease of maintenance**, particularly ease of access for maintenance to air-conditioning and ventilation equipment.

n It is important to protect all air handling systems during construction and to perform a **building flush-out** prior to occupancy.

o Professional **commissioning** will be necessary to balance all ventilation and air-conditioning systems.

p Choose low-VOC-emitting **building materials**, cleaning chemicals and furnishings. Request emissions test data from product manufacturers. *See **Section 5.4** Materials.*

Table 10: Common sources of indoor air pollution

POLLUTANT	SOURCES	HEALTH EFFECTS
Ammonia	Cleaning products	Eye and mucous membrane irritant
Bacteria	Moulds and mildew	Can cause worsening of respiratory complaints
CO_2	Respiration, combustion	Can cause feelings of stuffiness, drowsiness
Dust and particles	Carpets, surfaces, smoking	Dependent on particle size and nature
Formaldehyde	Foam insulation, fabrics, furniture, fire retardants, adhesives, carpet backing, cigarette smoke	Eye, skin and mucous membrane irritant. Can cause headaches and asthma
Nitrous Oxides (NO_x)	Combustion (boilers, cookers)	Worsening of respiratory complaints
Odours	Cooking, smoking, perfume, etc.	Annoyance and/or stress
VOC	Solvents, aerosol sprays, cosmetics, dry cleaning, paints, pesticides	Wide-ranging, including eye, skin and mucous membrane irritant

Source: Ecospecifier.rmit.edu.au

5.6.4 Non-smoking areas

For health, comfort (and increasingly in many countries, legal reasons) no building occupants who are non-smokers should be exposed to tobacco smoke. According to the WHO, tobacco is responsible for five million deaths annually around the world and the figure is expected to rise to 10 million people each year by 2025 if current smoking patterns continue. The WHO has issued an International Framework Convention on Tobacco Control[57] to which 100 countries are now signatories.

- If national legislation does not already require it, consider making the building totally **smoke-free**.
- Alternatively, provide **separate designated smoking areas** in public spaces and separate non-smoking guest room floors.
- **Air** from smoking areas should be extracted directly to the outside.

More information

Air-Conditioning and Refrigeration Institute
www.ari.org

American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE)
www.ashrae.org

Building Owners and Managers Association International
www.boma.org

Multilateral Fund for the Implementation of the Montreal Protocol
www.multilateralfund.org

5.7 Use of hazardous substances

The storage and handling of all hazardous materials must be in accordance with local regulations and international standards such as COSHH[58] and be appropriate to their hazard characteristics.

- Design to **isolate activities** associated with chemical use, including providing secure storage areas for housekeeping equipment and products, cleaning agents and pesticides. These areas should contain sinks and drains plumbed for adequate disposal of waste and separate exhausts vented to the outside that are operated under negative pressure.
- Potentially harmful products should be stored in **well-ventilated, locked facilities**. These should be included in the design of the building and ancillary areas.

More information

REACH (the registration, evaluation and authorisation of chemicals)
European initiative which will require companies that produce and import chemicals to assess and manage the risks arising from their use, making industry rather than the authorities liable for ensuring the safety of chemicals on the market.

Likely to become law by end 2005 or early 2006 REACH will list around 100,000 different substances with data on their environmental and health effects.
http://ec.europa.eu/enterprise/sectors/chemicals/reach/index_en.htm

57 World Health Organisation International Framework Convention on Tobacco Control, www.who.int/tobacco

58 'Control of Substances Hazardous to Health Regulations 2002 (COSHH)' which require employers to control exposure to hazardous substances to prevent ill health, www.coshh-essentials.org.uk