Supporting Guide

Energy and Resource Efficiency in Hospitals and Healthcare Facilities

ARUP

Hospital Can Misses, © Arup

Energy and Resource Efficiency in Hospitals and Healthcare Facilities

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Introduction & Contents

1.1 | BACKGROUND

Hospitals and healthcare facilities are some of the most resource-intensive buildings in terms of energy, water and other resources. This is driven by the strict, wide-ranging requirements for a quality, healthcare-compliant indoor environment.

Resource-intensive facilities and technical systems are an integral part of hospitals and healthcare facilities. They include demanding thermal comfort requirements, rooms kept at different air low pressure rooms, a need for sufficient clean, fresh air all year around, substantial hot water and power requirements supported by a reliable power supply, robust fire protection, vertical transport systems, and much more.

Hospitals contain many specialised facilities – operating theatres; clean rooms; laboratories that handle hazardous and infectious material; intensive care, neonatal, oncology, critical and post-critical units, etc. Each of those facilities has its own requirements in terms of access, indoor environment, humidity, cleanliness and levels of air filtration, availability of water, power, and communication to other parts of the hospital.

Those requirements present a number of design challenges and lead to operational buildings that are intensive users of energy, water and other resources. Focusing on efficiency at the design stage of a healthcare facility and its technical systems can generate operational cost savings and so allow more affordable medical services.

The COVID-19 pandemic

The COVID-19 pandemic has severely stress-tested existing healthcare infrastructure and has compelled governments to spend significant sums to up-grade and expand existing healthcare facilities. Some countries have allocated significant resources to the rapid construction of new healthcare facilities or the repurposing of existing buildings as hospitals. Existing healthcare facilities have been rapidly adapted or expanded to create additional capacity for infection treatment.

This guide aims to support a sustainable response to the challenges generated by COVID-19, by focusing on energy and resource efficiency in new-build and refurbished healthcare facilities. Resource efficiency and sustainability must be an integral part of the expansion of built healthcare capacity while safeguarding the safety of patients and medical personnel.

Purpose of this EBRD Guide to Energy & Resource Efficiency

In the light of the issues set out above and the need for affordable, efficient, good quality healthcare infrastructure, the European Bank for Reconstruction and Development ("EBRD" or the "Bank") has appointed Arup to develop an "Energy and Resource Efficiency Guide to the Design, Refurbishment and Operation of Healthcare Facilities".

This Guide sets out key considerations and techniques that can help healthcare providers to reduce operating costs while managing resources safely and effectively. More specifically, the Guide will identify strategies that lead to reduced utility bills for energy, water, and other resources that are needed to create quality environments within healthcare facilities and identify resource management best practice.

The Guide recommends efficiency measures, informing on its estimated costs, relating to:

- The design and construction of new healthcare facilities.
- The refurbishment and upgrade of existing healthcare facilities.
- Reducing utility costs for operational healthcare facilities and associated technical systems.
- Waste Management and Fire Safety elements identified as key infrastructure in healthcare facilities.

1.2 CONTENTS OF THIS GUIDE

This report is divided into the following seven principal sections:

1. Introduction & Contents.
Chapter 1 gives a brief introduction, presenting the background and relevance of the Guide to Energy and Resource Efficiency in Healthcare Facilities commissioned by the EBRD, followed by an outline of the principal contents.

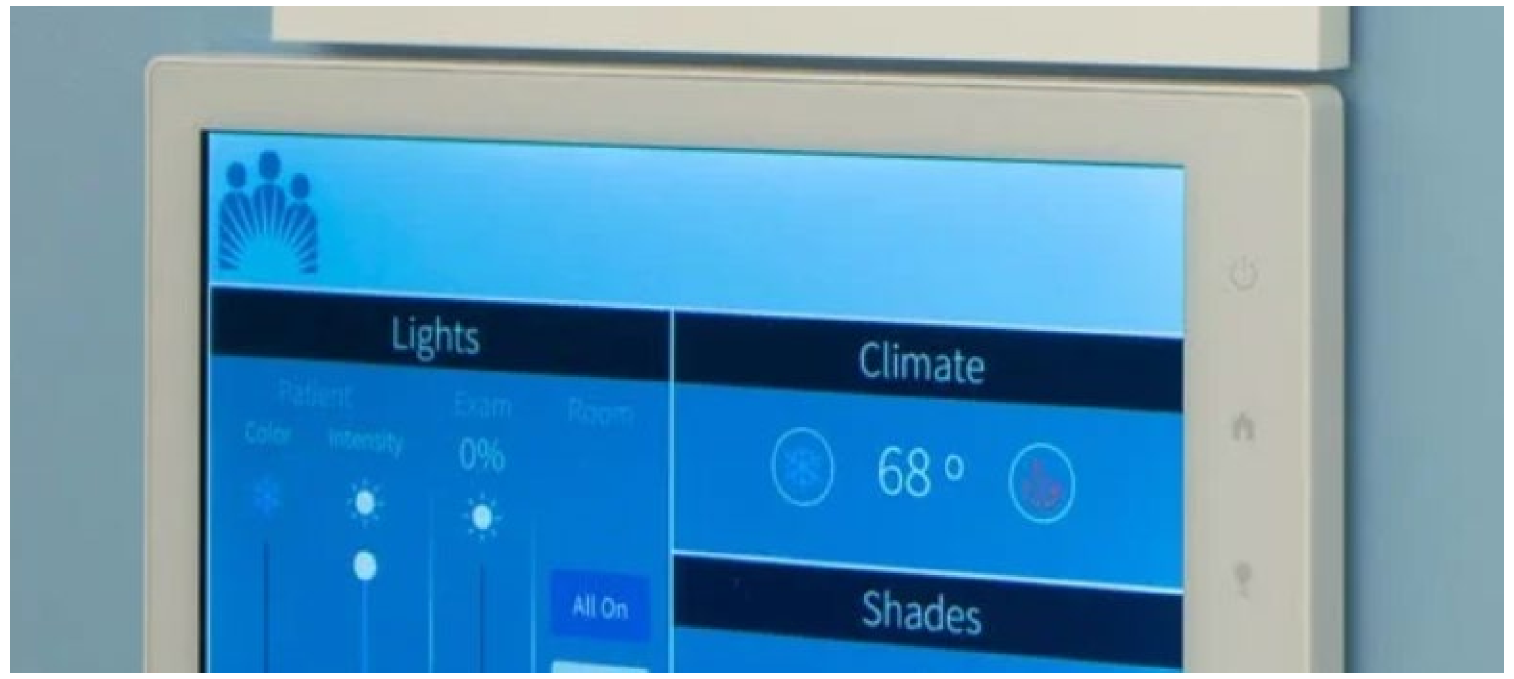
2. Energy efficiency in healthcare facilities.
New-build & refurbishments.
Chapter 2 sets out key energy efficiency considerations for the design and construction of new buildings and refurbishments.

The first part of the chapter describes the general energy efficiency strategy and key aspects of the design of efficient healthcare facilities: passive design, active design and renewable energy. Operational issues are addressed in the next chapter. The second part of the chapter contains a more granular list of energy efficiency opportunities based on the key solutions mentioned above. The list identifies which opportunities are more suitable for new-build or alternatively for refurbishments of existing buildings, ease of implementation and a qualitative evaluation of energy savings and CAPEX.

3. Energy efficiency in operational healthcare facilities.
This chapter gives energy efficiency recommendations relating to the operation of healthcare facilities. It focuses on opportunities to reduce operational energy expenditure through improved management and maintenance practice. For example, by optimising building system controls and improving energy management and energy data analysis.

4. Water efficiency
This chapter recommends a range of water saving techniques and technologies to promote the more efficient use of water in healthcare facilities. The recommendations include best-in-class sanitary equipment and opportunities for water reuse. The recommendations also address situations of water-stress and locations where the quality of the water supply to the facility does not meet health and safety standards.

5. Waste management
This chapter identifies and describes the main types of healthcare waste, including hazardous materials, biological waste and contaminated waste which are strictly regulated. It also identifies common waste storage and disposal facilities and makes recommendations based on international standards and waste disposal procedures approved by competent authorities. The recommendations may need to be adapted to comply with local laws and the standards that apply in each country.



6. Well-being and safety healthcare infrastructure
This section focuses on improving well-being and safety **infrastructure** in healthcare facilities.

It makes recommendations on how to improve **the well-being** of occupants based on international standards. The section also makes **COVID-19 infection control** recommendations. The last section contains recommendations based on international good practice for improvements to fire safety in healthcare facilities. Ensuring safety is critical within a healthcare facility because some admitted patients are immobile.

7. International guidance, standards.
The final section of the report presents a review of selected international standards and guidance focusing on the topics covered in the Guide. The review highlights key documents from the listed sources of reference.

2

Energy Efficiency in Healthcare Facilities: New-Build & Refurbishments

2.0 | OBJECTIVE & CONTENTS OF THIS CHAPTER

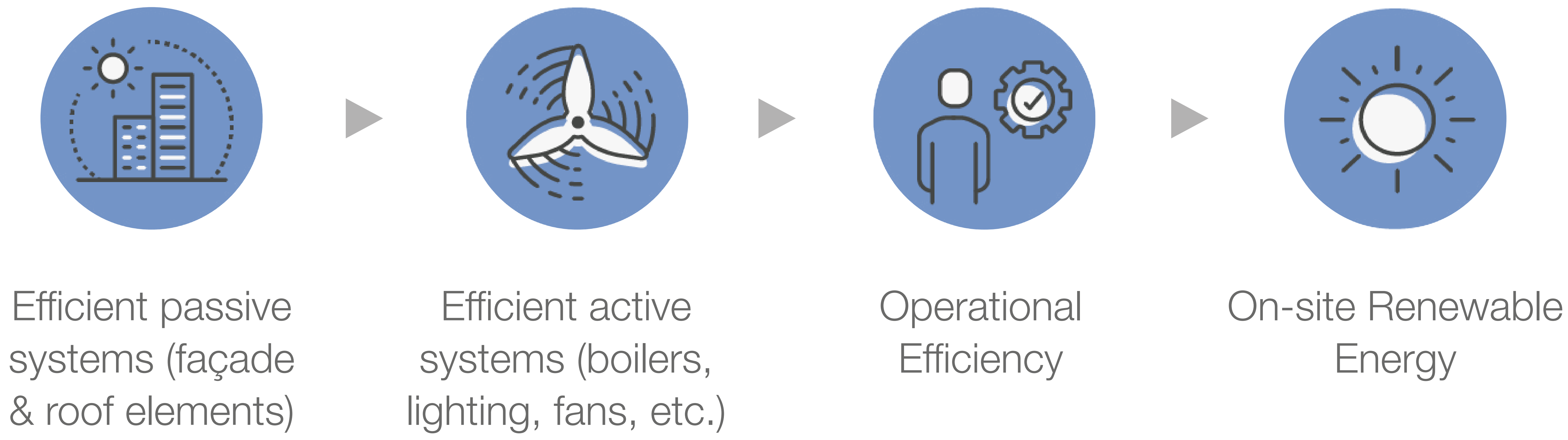
This chapter is about Energy Efficiency in New-Building and Refurbishments. The chapter describes the general energy efficiency strategy and key aspects of the design of efficient Healthcare facilities.

2.1 | ENERGY EFFICIENCY: GENERAL STRATEGY

The diagram on the right summarises the general strategy for improving energy efficiency in a building. It shows the stages to be followed to achieve a Low Energy design. Each stage of the process contributes to the overall outcome and is essential to a successful outcome.

The strategy begins with a robust passive design (efficient building envelope), decreasing the demand for energy. In Stage 2, the aim is to minimise energy needs through efficient building services (active systems). The third stage optimises the operation of the building. Stage 4 maximises the use of renewable power in the building. The four stages should be gone through in sequence, in the order of their importance.

This chapter describes the passive, active and renewable energy stages. Operational efficiency is addressed on its own in the next chapter, due to its importance. Rigorous implementation of the measures recommended at each stage could ultimately lead to a Net-Zero healthcare facility.



2.2 | PASSIVE DESIGN FOR ENERGY EFFICIENCY: KEY ELEMENTS

Incorporating passive features in the design is an important first step to reducing energy demand which is critical to lowering the carbon emissions from healthcare buildings.

Passive efficiency measures are energy improvements incorporated into the envelope of the building or its shape, not its heating facilities (e.g. boilers), for example increasing insulation to the walls.

Passive features can be used, for example, to prevent excessive solar gain during the summer by shading windows or loss of heat during the winter by increasing the insulation of walls or windows. Passive features can reduce the need for artificial lighting and climate control, and maximise opportunities for daylighting and natural ventilation where appropriate. The following pages outline key ways in which improved **passive design** can be used to reduce energy demand in healthcare facilities.

Ventilation and Building Shape

The orientation and shape of a building can have a significant direct impact on its energy efficiency and may limit the scope for the inclusion of further additional passive design features. For example, the depth of a building (the distance between opposite sides of the building) may limit the effectiveness of natural ventilation.

Healthcare buildings have numerous highly technical spaces that require strict temperature control or high ventilation rates for infection control. This often leads to design solutions where façades are sealed, and centralised mechanical ventilation is used to supply and extract air. However, healthcare buildings also include spaces that can be designed with either natural ventilation or a mix of natural and mechanical ventilation. Early consideration of the proposed spatial arrangement can help to maximise the opportunities for such an approach.

For example, in many instances general wards, circulation spaces, offices and open-plan waiting areas can be located so as to take advantage of natural ventilation opportunities and avoid fully mechanical solutions, reducing operational carbon emissions. Spaces with a depth to height ratio between 2-2.5 allow single-sided ventilation in cold and cold-mild climates. This can work well for wards, single bedrooms and consulting rooms.

Glazing and Daylight

A well-designed building envelope (i.e facade and roof) should respond to external factors such as orientation and climate and where possible take account of occupancy. The balance between daylighting, solar gain and artificial light should be considered during the design process.

Shading can be a positive way of reducing solar heat gain within spaces, and so help to reduce operational carbon emissions or energy demand. A poorly orientated building with a high level of glazing (60-75%) may require excessive external shading to limit solar heat gain. On the other hand, low levels of glazing (below 20%) may require more artificial lighting, potentially leading to higher operational carbon emissions (i.e. greater demand for electricity).

Access to natural light in healthcare facilities through good lighting design has been found to improve patient well-being, potentially aiding and speeding recovery and therefore leading to reduced lengths of stay.

Envelope Thermal Efficiency. Thermal U-values

The thermal transmittance (U-value) of a building element (e.g. the façade) quantifies the amount of heat that can be transmitted through it. The lower the U-value, the less the heat that is transmitted. Different U-values are assigned to each element of a building's envelope (walls, windows). For example, increasing the thickness of insulation in a wall will reduce the amount of heat that can pass through it and so lower the wall's U-value.

A good U-value for the façade will reduce the energy consumption of the building, thereby reducing carbon emissions and saving on energy bills. However, U-values should be considered for their overall effect as excessive insulation can lead to overheating, for example in areas with likely high internal heat-gains from equipment or in warm climate countries.

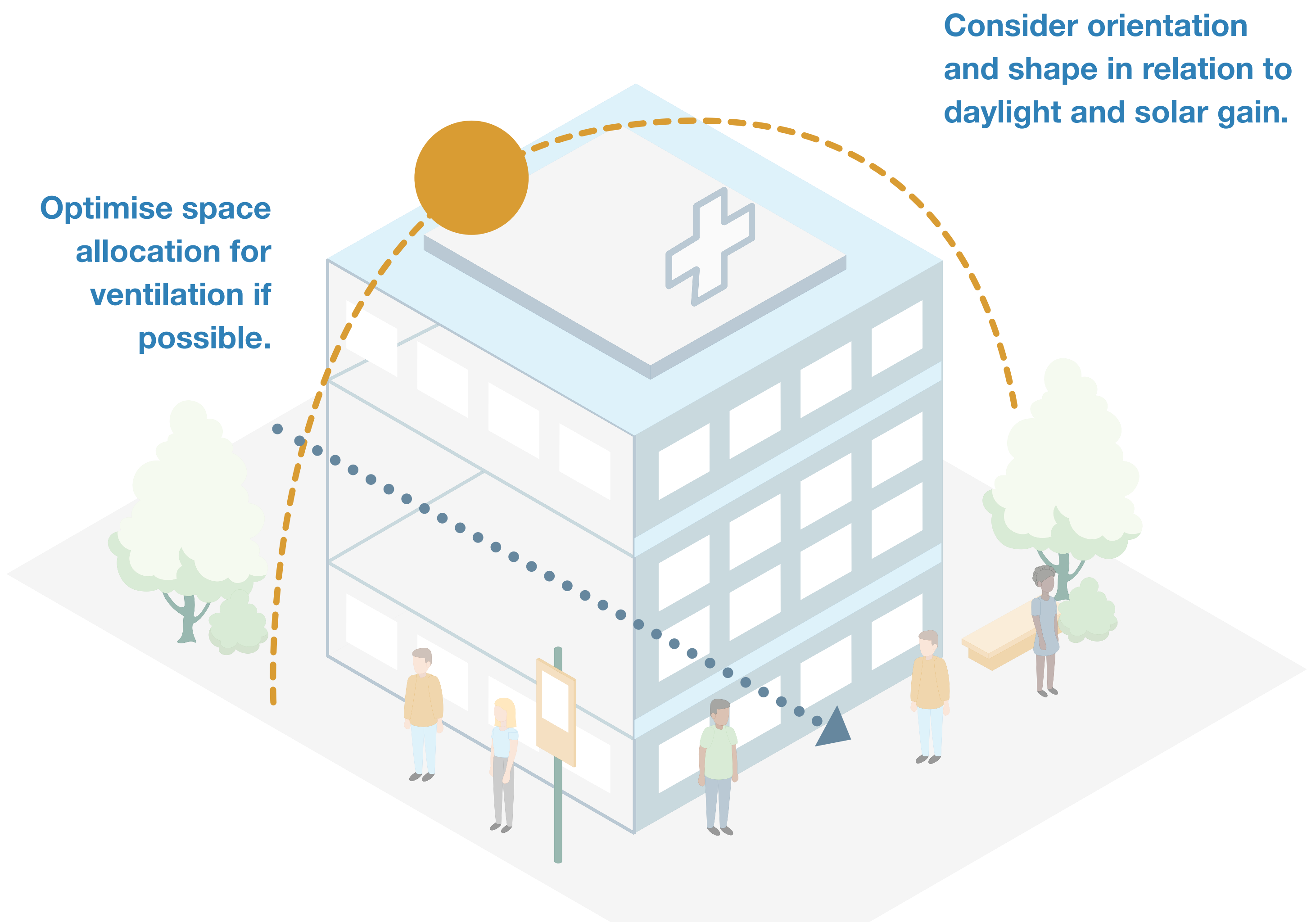


Figure 1: Lean Design Factors: U-values, solar radiation avoidance factor of windows (G-value), Air Leakage and Maximum Daylight.

PASSIVE EFFICIENCY

Air Leakage

Internal air leaks from buildings increase heating or cooling loads if the building is not sufficiently airtight. With any type of building, low levels of air leakage can reduce the heat lost to the external environment and so lower the carbon emissions associated with ventilation and heating or cooling.

Fabric-first approach considering air leakage & thermal transmittance (U-Value).

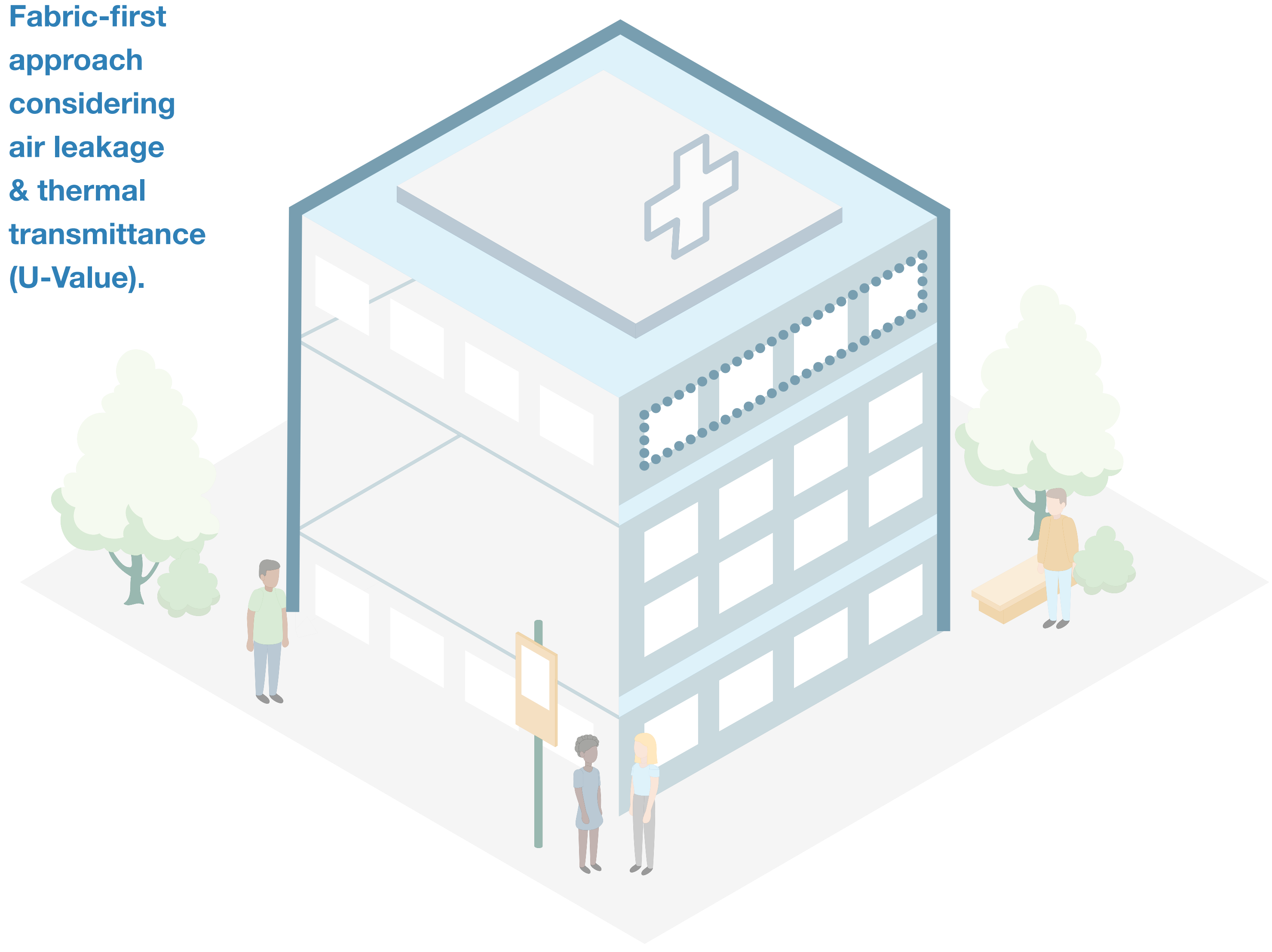


Figure 2: Lean Design Factors:
U-Value, Air Leakage and Maximum Daylight.

Recommendation for an integrated design process: Energy Modelling Approach

Balancing all the issues identified to determine the optimum, most sustainable, low operational carbon emissions solution can be challenging. Using energy modelling software during the design stage of the building can help to optimise the design. Building energy modelling takes into account all the parameters that affect the final operational carbon emissions to be expected from the design.

For example, the table below shows how an energy modelling program was used to generate energy reductions in a case study. The study shows how changes to a building's shape and façade can reduce its operational carbon emissions (or energy use), before considering engineering systems.

Energy Modelling Case study	Description	Cumulative Calculated Energy Savings
0. BASELINE	Starting point - initial concept model	-
1. ORIENTATION	Orientation adjusted by 10° - to optimise heating and cooling performance.	0.5-1.5%
2. GLAZING HEAT TRANSMITTANCE (G-VALUE) OPTIMISATION	Using energy modelling optimisation, the g-value for the glass (a measure of the amount of solar energy entering the building) can be tested and an optimal value calculated - in this case there is a delicate balance between heating and cooling loads, but a clear saving is possible.	2.5-3%
3. U-VALUE OPTIMISATION	The thermal performance of the façade can also be optimised for further savings.	4.5-6%
4. OPTIMISATION OF AIR PERMEABILITY	Lower air permeability can offer a significant energy saving. However, there is a balance to be struck between heating and cooling performance.	11-13%

Using energy modelling programs during project development ensures that initial design decisions are informed and lead to the best solution. Energy modelling programs support the design of efficient façades and glazing strategies, including issues such as solar gain, daylighting, external shading and PV/solar thermal analysis. The second section of this chapter gives a detailed schedule of opportunities for passive design in new and existing buildings.

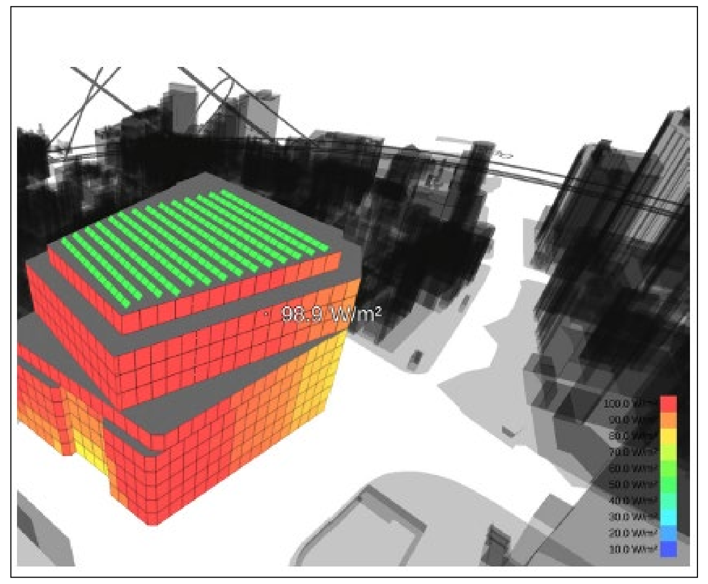


Figure 3: This is an example of energy modelling analysis useful in determining the optimum shape of the building to minimise solar radiation and maximise daylight.

PASSIVE EFFICIENCY

2.3 | ENERGY EFFICIENCY OPPORTUNITIES. PASSIVE (BUILDING ENVELOPE) DESIGN OPPORTUNITIES

Passive Energy Efficiency Opportunities for different climatic zones

The following table includes different energy efficiency envelope recommendations based on the local climate of a healthcare facility. Different energy efficiency opportunities have been identified for four climatic zones. The zones group typical climatic conditions reflecting the EBRD countries of operation.

- Zone 1: Warm and dry (SEMED).
- Zone 2: Mild marine (Mediterranean, Black Sea coast).
- Zone 3: Mild and humid (Central and Eastern Europe).
- Zone 4: Cold and dry (e.g. Mongolia, northern Central Asia).

As mentioned in the previous section, both for design of new hospitals and for large refurbishments, the energy efficiency recommendations below should be modelled for the whole building to determine the annual energy savings available against an agreed baseline.

Table 1

Ref.	System	Element	Component	Recommendation	Energy Savings (more leaves, more efficient)	Building CAPEX (more €, more expensive)	Suitable for Building Refurbishment or Minor Renovation?
P1	Envelope	Walls, floors, roof and doors	Increase the level of insulation of these elements	Additional wall, roof and floor insulation is achieved with new or added layers of insulation material. In existing buildings, it can be installed externally or internally to the existing walls. Higher insulation decreases heating loads. In warm countries insulation may not need to be very high to avoid increased internal cooling loads. Different insulation levels are recommended for each envelope element for each climatic zone. **Refer to Appendix 4 Table 4.** The insulation levels recommended for new-build are set out in Table 4. These insulation values are also valid for existing buildings, but the payback of the construction cost of adding new insulation may not be below the 10-year payback value. Typically, windows should not exceed 40% of the wall area (floor to ceiling wall area) to avoid excessive thermal load in a space.	2 leaves	€€€	Yes.
P2	Envelope	Shape/space planning	Recommendations for building zoning or shaping for daylighting gain.	Glass should be selected to reflect certain type of sun radiation to avoid solar gains and excessive internal heat. Windows should be sufficiently insulated to avoid excessive heating load in the spaces. Recommendations for window insulation and solar reflectance for facilities in each climatic zone are shown in **Appendix 4 Table 4.**	2 leaves	€€€	Yes.

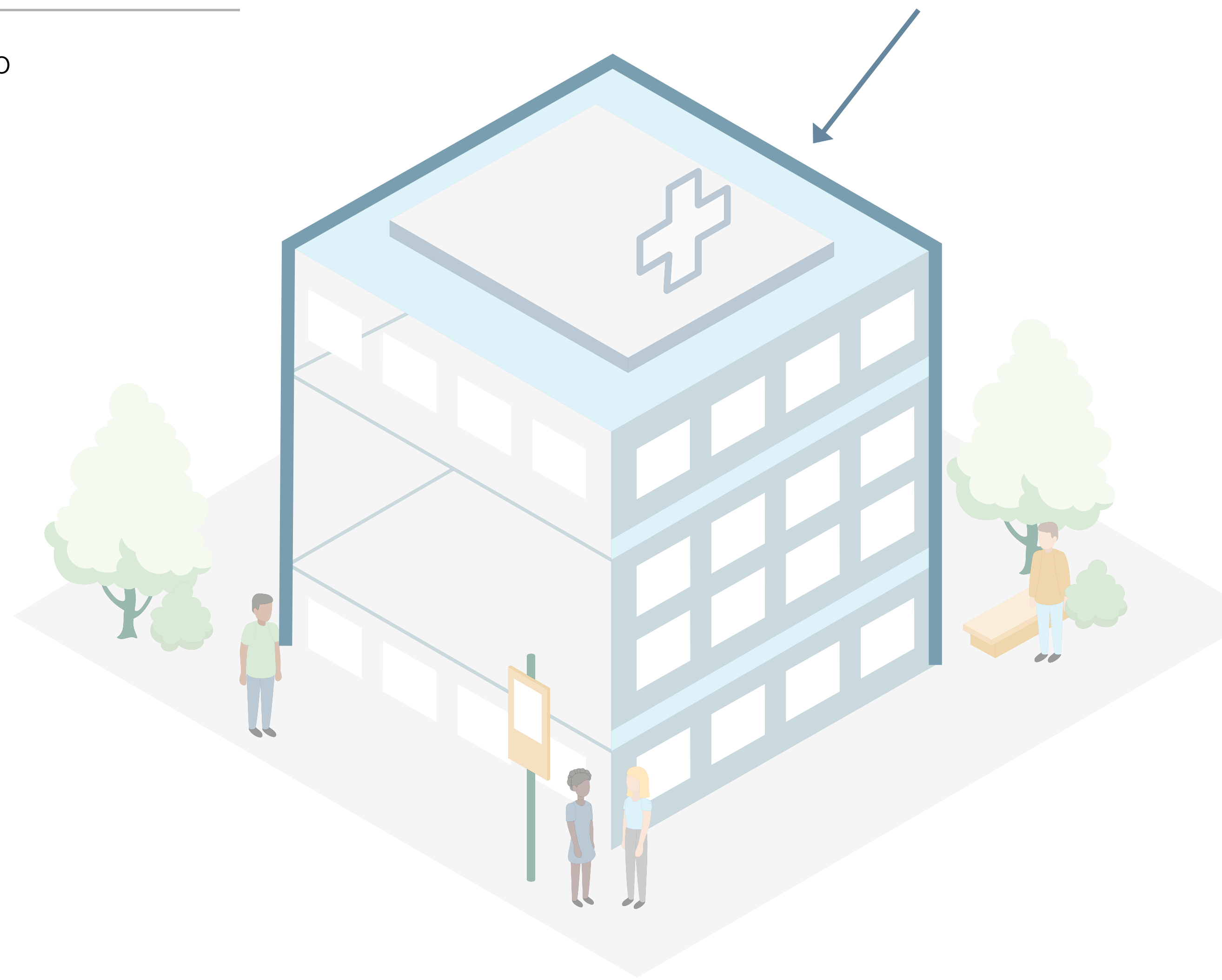
In existing buildings new insulation can be installed internally or externally to the façade. External installation may avoid impacts on the operation of the facility.

PASSIVE EFFICIENCY

Passive Energy Efficiency Opportunities for all climatic zones.
The following table presents the remaining passive energy efficiency opportunities unrelated to specific climatic zones. The analysis includes ease of implementation, energy savings and capex and whether the opportunity is considered suitable for full refurbishment or minor renovation of health care facilities.

Ref.	System	Element	Component	Recommendation	Energy Savings (more leaves, more efficient)	Building CAPEX (more €, more expensive)	Suitable for Building Refurbishment or Minor Renovation?
P3	Envelope	Roofs	Solar reflectance index (SRI)	A roof with high solar reflectance keeps much of the sun's energy from being absorbed, allowing the roof to cool more rapidly and so saving cooling energy. A white (PVC) roof is an example of a high SRI roof. **Refer to Appendix 4 Table 4**. for recommendations on SRI values for facilities in each climatic zone.	1 leaf	€	Yes
P4	Envelope	Shape/space planning	Recommendations for building zoning or shaping for daylighting gain.	**Building Shape and Daylight** The best daylight results come from limiting the depth of the floorplan and minimising the distance between the outside and any interior space. In most cases, narrowing the floorplan means including courtyards and articulating the footprint to allow better daylight penetration. **Healthcare areas. Layout recommendations for greater daylighting** Public Spaces (Halls, Reception, Waiting Areas, Transitional Spaces). These spaces provide the best opportunity for high ceilings with high, large-scale fenestration and offer the greatest potential for daylight harvesting. **Inpatient units**. Ensure that 75% of the occupied space (excluding patient rooms) is within 6 m of an outside wall. **Diagnostics and treatment block** Configure the building footprint and shape so that the area within 4.5 m of an outside wall is more than 40% of the floorplan. Staff Areas (Examination Rooms, Nursing Stations and Offices). Putting staff spaces against outside walls is essential for staff performance and is a design strategy that supports energy conservation by reducing the need for electric lighting and cooling. Configure the shape of the building to maximise access to natural light through side lighting and top lighting. **Building Orientation & Daylight** For most spaces, the vertical façades that provide daylighting should be oriented within 15° of north-south.	2 leaves	€	No
P5	Envelope	Lobbies	At principal visitor entrance	All doors giving access to the exterior should have a lobby or revolving door	2 leaves	€€	Yes
P6	Envelope	Interior finishes	Average reflectance of room internal surfaces	Select light colours for internal walls and ceilings to increase light reflectance and reduce lighting and daylighting requirements. The colour of the ceilings, walls, floor, and furniture have a major impact on the effectiveness of the daylighting strategy. Refer to **Appendix 4 Table 5**. for recommended colours and surface reflectance values.	1 leaf	€	Yes

Narrowing the floorplan of the building maximises daylighting.



2.4 | ACTIVE THERMAL SYSTEM DESIGN FOR ENERGY EFFICIENCY & NET ZERO EMISSIONS

Once the building's shape, orientation and façade have been optimised, the strategy to achieve further reductions in energy consumption is focused on minimising energy demand from building services and equipment (active systems).

Active Building systems are:

- **SPACE HEATING**
- **HOT WATER**
- **SPACE COOLING**
- **LIGHTING**
- **AUXILIAR LOADS (PUMPS, FANS AND CONTROLS)**

Optimising energy in building systems

The definition of energy-consuming building elements should be optimised during building design or refurbishment. For example, consideration should be given to define the efficiency of the proposed heating system (i.e. boilers) and to the efficiency of the lighting system and its controls.

For example, specifying luminaires to incorporate lighting regulators (dimmers) can help to reduce lighting levels to the minimum required by international standards and so save energy. Lighting controls not only reduce operational demands but can also modify the output and colour of lighting throughout the day.

As mentioned in the previous section, energy building modelling, as suggested by ASHRAE 90.1 for example, are an effective way to optimise active energy systems (lighting, cooling, heating, etc) during the design stage of new healthcare facilities and large-scale refurbishments. Energy modelling can help with the specification of efficient energy systems such as thermal, ventilation and lighting systems.

2.5 OPTIMISING ENERGY IN BUILDING EQUIPMENT

Equipment systems

- **VERTICAL TRANSPORTATION**
- **COMPUTERS**
- **PLUG IN DEVICES**
- **LAB & MEDICAL EQUIPMENT (MRI, LINAC, ETC)**
- **CATERING ENERGY CONSUMPTION**

Understanding Medical Equipment

As well as building systems, it is important to target energy intensive equipment such as medical equipment, which can be a significant contributor to energy consumption through direct use of electricity and as a source of internal overheating. Understanding the size, capacity and resilience requirements for key medical equipment is critical as it can have a large, unregulated energy demand, more than any other common building systems. For example, the energy efficiency of sterilisers, washer disinfectors and imaging equipment should be taken into account when specifying this equipment.

Energy Benchmarks

For both energy modelling of new-build and for operational efficiency (strategy is covered in the next chapter), Energy Use Intensity (EUI), kWh/m^2, should be used as the key metric for assessing the overall energy consumption and efficiency of a facility and benchmarking against similar buildings. Appendix 5 to this report includes international EUI benchmarks for healthcare buildings.

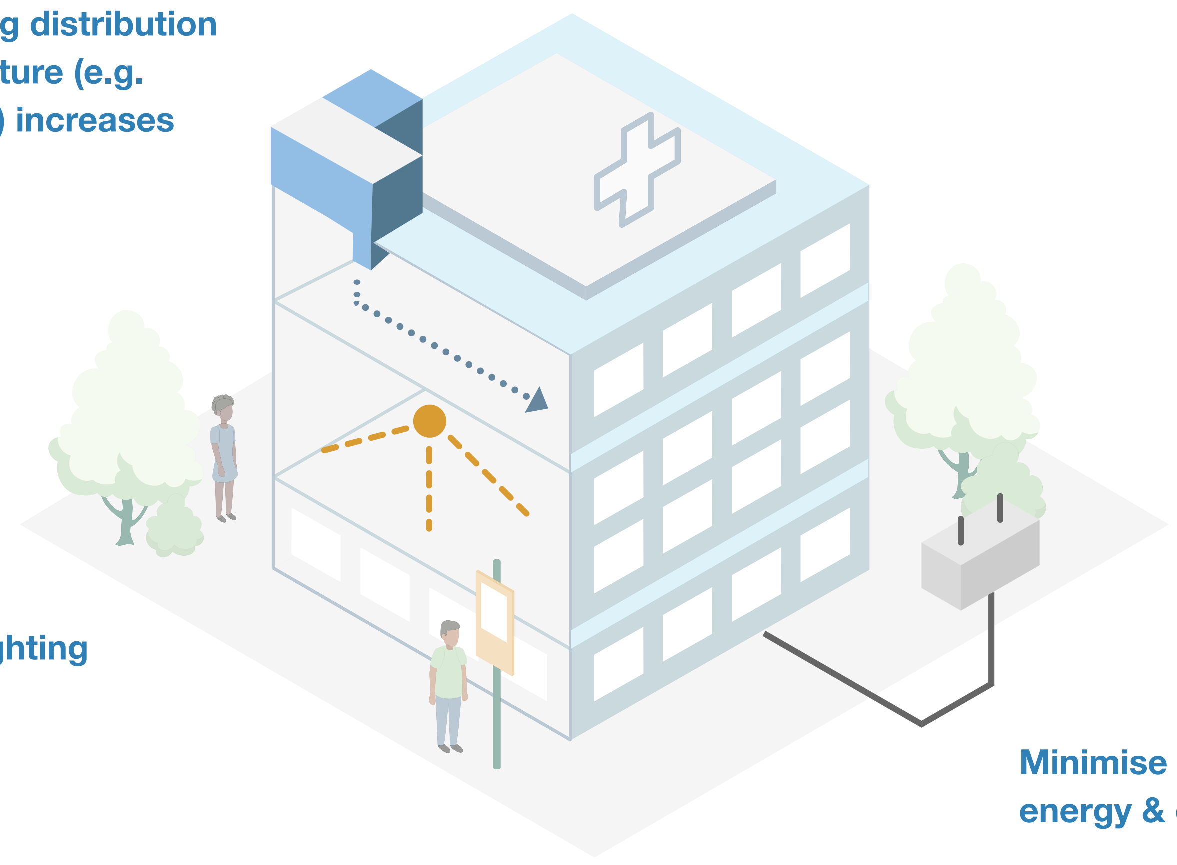


Figure 4: Efficiency opportunities for active systems.

Net Zero Carbon Buildings. Fossil fuel-free facilities.

A recent trend in the decarbonisation of buildings (which requires lower energy consumption) is targeting operational net zero carbon emissions for a building. Net zero means the carbon emissions associated with the building's operational energy consumption is balanced by onsite renewable energy sources and the remnant energy not covered by the previous should be fed from off-site generation ***(source: UK Green Building Council. Bibliography ref 24***).

The steps in the strategy for achieving net zero are also the steps identified at the start of this chapter: efficient passive design, efficient active design, efficient operation and renewable energy production. One of the key things for achieving net zero is focusing on avoiding the onsite combustion of fossil fuels and prioritising electricity supply systems. This strategy is suitable for countries where the electricity from the grid is expected to be decarbonised in the future (i.e. electricity is expected to be increasingly produced using renewable sources). If the electricity supplied to the premises is decarbonised, the emissions attributable to the building also go down.

Example Fossil fuel-free Hospital: Heat Pump in place of boilers
As noted, where the electricity grid is expected to be increasingly decarbonised, developing a combustion-free strategy, where heat pump technology is the primary heat source, can lead to continuing reductions in carbon emissions. Energy demand is also reduced thanks to the higher efficiency of a heat pump relative to a boiler. The third benefit is that not burning gas leads to improved local air quality. Table 2 on this page shows an analysis of two different types of heat pumps, air source and ground source.

Natural Gas Equipment. Combined Heat and Power (CHP)

In countries where the decarbonisation of electricity is not expected in the mid-term, a transition based on efficient gas systems should be considered in the design of the building. Transitional solutions may include high-efficiency gas boilers or gas fuelled Combined Heat and Power (CHP) systems. The review of opportunities in the last part of this chapter presents recommendations to support the choice of the best CHP system and optimisation of its operation depending on fuel prices.

Sustainable refrigerant in thermal equipment. EU F Gas regulation

Heat pumps and refrigeration equipment (fridges) should be specified with refrigerants recommended by the EU F-gas regulation. That regulation prioritises the use of refrigerants with low global warming potential for example Refrigerant R1234ze or Refrigerant R513A.

The impact of a Localised Plant Strategy. Plant Efficiency

Decentralised plant is often used in key technical spaces, such as operating theatres and critical care units, reducing risers and distribution losses with positive effects on operational carbon emissions (higher energy efficiency). For example, large risers occupy space on each floor, increasing the building's floor area and create long distribution runs, increasing distribution losses and energy demand. A localised plant strategy may lead to reduced operational carbon.

Table 2 **Efficient Technology**	**Economic Viability**	**Environmental & Sustainability Performance**	**Operation & Maintenance Requiements**	**Impact on Site & Building Design**
ASHP (AIR SOURCE HEAT PUMPS) Air source heat pumps are suitable where heating and cooling systems require relatively moderate temperatures, such as underfloor heating and chilled beams.	€ € (More €, more viable)	2 leaf icons	2 tool icons (More tools, more maintenance)	1 brick icon (More bricks, more impact)
GSHP (GROUND SOURCE HEAT PUMPS) Ground source heat pumps heat or cool via extraction or dissipation of energy from or to the ground through an underground network of water-filled pipes. This approach provides even higher operational efficiencies than Air Source Heat Pumps and has very little impact on visible infrastructure. However, Ground Source Heat Pumps are more expensive than Air Source Heat Pumps and are therefore less economically viable.	€	3 leaf icons	2 tool icons	2 brick icons

Table 2. Examples of efficient low emissions active systems.
Heat Pumps are key to decarbonisation in countries where electricity is expected to decarbonise over the mid-term.
Air source heat pumps are more economically viable than ground source heat pump (GSHP) over the full life cycle due to the higher CAPEX of GSHP.

ACTIVE EFFICIENCY

2.6 | ACTIVE SYSTEMS: ENERGY EFFICIENCY OPPORTUNITIES

Energy Efficiency Opportunities for all climatic zones

Following the format used in the efficient passive design section, the tables below identify efficient active (thermal) systems opportunities for use in designs for new-builds and refurbishments. The opportunities are not tied to specific climatic zones. The analysis includes ease of implementation, energy savings and capex and whether the opportunity is suitable for full refurbishment or minor renovation of health care facilities.

Ref.	System	Element	Component	Recommendation	Energy Savings	Building CAPEX	Suitable for Building Refurbishment or minor renovation?
A1	Lighting	Internal lighting	Lighting type	LED luminaires offer the most cost-effective solution in all hospital areas. Replace existing fluorescent units with LED lighting at end of life.		€	Yes
A2	Lighting	Internal lighting	Dimming type	LED luminaires can be non-dimming or dimming (e.g. Dali driver). Dimming luminaires can be dimmed during building commissioning to the minimum lighting level required by the applicable Lighting standard, thus saving energy.		€ €	Yes
A3	Lighting	Internal lighting	Dimming controls daylight harvesting	Particularly for staff areas (examination rooms, nurse stations, offices, corridors) and public spaces (waiting areas, reception). Add daylight lighting controls to any space within 4.5 m of an outside window. Daylighting controls dim perimeter lighting when daylighting in a space is high enough as measured by local daylighting sensors.		€	Yes
A4	Lighting	Internal lighting	Presence lighting controls - General	Consider presence control sensors in general in addition to or instead of auto/timed OFF luminaires in all areas as possible. Switching on may be manual or automatic.		€	Yes
A5	Lighting	Internal lighting	Luminaire Circuit Configuration	Daylighting control and presence controlled luminaires require circuits that separate internal and perimeter lighting to create a more cost-effective control of luminaires.		€	Yes
A6	Lighting	Exterior lighting	All other exterior lighting	Exterior lighting should also use LEDs. Exterior lighting should be controlled by daylighting sensors and turn down automatically to 0% when daylight is sufficiently bright.		€	Yes
A7	Domestic hot water	Service water heating	Gas water heater (condensing)	Domestic Hot water should be produced by high-efficiency equipment and all pipework should be insulated. Heating equipment options are as follows: – Domestic Hot water heat pumps with 2.33 (SCOP) efficiency (preferred option) – Condensing gas water heater 95% efficiency Do not use steam for water heating. When boilers are used consider specification of 'point of use' water heaters rather than central heating systems to avoid distribution energy losses from long pipework runs.		€	Yes

Figure 5: LED lighting & daylighting controls are efficient systems.

Figure 6: Domestic hot water sinks are common in all healthcare areas.

ACTIVE EFFICIENCY

Ref.	System	Element	Component	Recommendation	Energy Savings	Building CAPEX	Suitable for Building Refurbishment or minor renovation?
A75	Equipment (Plug) Loads	Equipment choices	Efficient Computers	Each Hospital should develop an Equipment Management Plan along these lines: 1. Use laptops as much as possible because they are more efficient than desktops. Recommended minimum number of Laptops: two thirds of all computers. All others = mini desktop computers. 2. Specify all computers, other equipment (e.g. vending machines with LED) and appliances as ENERGY STAR® rated. This is an international equipment energy efficiency certification.		€	Yes
A8	Equipment (Plug) Loads	Equipment controls	Computer or Screen power control & Time switches	– Install Network controls with power saving modes and monitoring during unoccupied hours or an IT power management program (e.g. to switch screens in outpatient areas off at night). – Install time switches in water coolers, coffee makers, small appliances = auto OFF during unoccupied hours.		€	Yes
A9	Equipment (Plug) Loads	Kitchen equipment	Cooking equipment and Refrigeration equipment and Exhaust hoods	– Cooking equipment should be specified ENERGY STAR rated or equivalent internationally recognised standard (e.g. EU energy labelling). – Refrigeration equipment should have at least 15 cm insulation on low-temp walk-in equipment, insulated floor, LED lighting, floating-head pressure controls, liquid pressure amplifier, subcooled liquid refrigerant, evaporative condenser. – Exhaust hood should include long overhangs, local air supply compensation and be Variable Air Volume type. Exhaust flow to vary based on cooking activity level (e.g. steam sensor). Note 1: It will not be expensive to install these systems in new buildings relative to other standard solutions		€ €	No. Note 1
HVAC System Recommendations							
A10	HVAC	Steam	Heating or Water heating	Avoid steam systems for heat production systems, specify low temperature water heating systems because heat pumps and condensing boilers are more efficient.		€ € €	Suitable for refurbishments, not suitable for minor renovations
A11	HVAC	HVAC system for Surgical Areas	Central air-handling system & cooling equipment	**Surgical Areas** typically have Central Air Handling systems (AHUs) (no fan coils or room HVAC equipment are allowed in surgical areas for reasons of hygiene) Common means of production of cold water for these AHUS include: Water-cooled chillers, water circulation pumps, cooling towers, heat recovery systems and equipment fans. If installed, a minimum efficiency should be specified for these units. Refer to Appendix 4 Table 4 for a summary of minimum recommended efficiencies.		€ € €	Suitable for refurbishments, not suitable for minor renovations

Figure 7: Every hospital should have an Equipment Energy Management Plan. Source: Energy Star ®

Figure 8: Night Controls for IT equipment or cooking equipment switches off supply at night to save energy. Source: Vaillant ®.

Figure 9: Exhaust flows from cooking hoods can be variable based on cooking activity with local non-treated air supply (compensated air hood).

ACTIVE EFFICIENCY

Ref.	System	Element	Component	Recommendation	Energy Savings	Building CAPEX	Suitable for Refurbishments?
A12	HVAC	HVAC system for Non-Surgical Areas	Fan coil system with Fresh Air System & other production systems	**Non-Surgical Areas may be HVAC treated** with many different systems. For example, a typical system for these areas is the fan coil system with Fresh Air served from an All Fresh Air - Air Handling unit with heat recovery. The system typically receives chilled and hot water from a chiller with or without cooling tower, boiler or heat pump and water circulation pumps. As with the previous recommendation, Table 4 in Appendix 4 includes the minimum energy efficiency recommended for these systems.	3	€€€	Suitable for refurbishments, not suitable for minor renovations
A13	HVAC	Heat recovery devices	Simultaneous heating and cooling heat recovery heat pump	In new-builds, consider specifying heat pumps with simultaneous heating and cooling capability (e.g. simultaneous cooling and dehumidifying require cooling and heating). During cooling, the heat pump does not accept heat. Heat is used in the same unit to heat water with no need for a dedicated boiler with consequent energy savings. VRF equipment also offers simultaneous heating and cooling capability and it could be an option for all-year cooling of internal areas, for example office spaces.	2	€€	Suitable for refurbishments, not suitable for minor renovations
A14	HVAC	HVAC Ventilation Ducts & damper recommendations	Air Heat Recovery	Exhaust ductwork should incorporate heat recovery from exhaust air. Heat recovery systems pre-heat incoming cold air as it enters the ventilation system using treated warm exhaust air as it leaves the building. For reasons of hygiene, do not incorporate heat recovery from exhaust air from labs, fume hoods, nuclear medicine, vivarium or autopsy spaces.	2	€€	Suitable for refurbishments, not suitable for minor renovations
A15	HVAC	Good ductwork design and ductwork and pipework insulation		Good practice in duct design leads to lower energy use. Low pressure loss and low air leakage in duct systems are critical to lowering overall fan energy draw. Lowering the pressure needed to overcome dynamic pressure and friction losses allows for a smaller fan motor with correspondingly lower energy requirements. The ductwork specified below should be insulated to prevent heating or cooling of the air before it reaches its destination: supply air ductwork, outdoor air ductwork, ductwork located in unconditioned spaces or outside the building envelope, others. On-site inspection is necessary to assess and repair insulation in ductwork, LTHW, CHW, steam & refrigeration pipework	2	€€	Suitable for refurbishments, not suitable for minor renovations
A16	HVAC	Heat pumps for heating		As mentioned in the first section of this chapter, heat pumps should be the preferred heating systems in new buildings in countries where electricity generation is expected to decarbonise. The benefits of heat pumps are: The electricity supplied to a heat pump is greener (renewable electricity). Associated CO_2 emissions attributable to the building also decrease, making it more sustainable. Heat pumps are more efficient relative to a boiler and have a lower energy cost.	3	€€€	Suitable for refurbishments, not suitable for minor renovations

Figure 10: Air handling units should have efficient fans. Air handling equipment ventilates, cools and heats space, it has fans that need to be specified with a minimum energy efficiency.
Source: TROX ™.

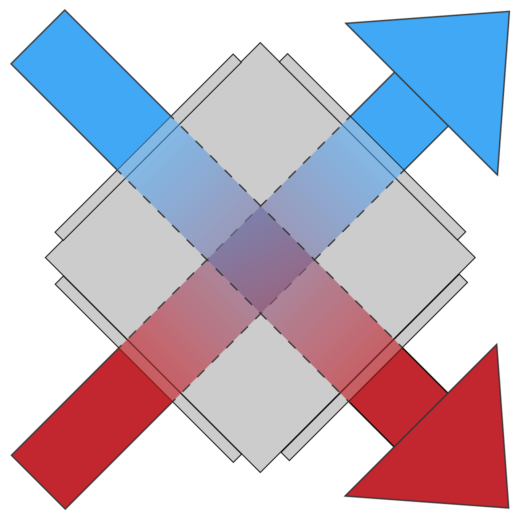


Figure 11: Plate heat recovery devices are installed in the ductwork next to exhaust fans or inside AHUs.

ACTIVE EFFICIENCY

Ref.	System	Element	Component	Recommendation	Energy Savings	Building CAPEX	Suitable for Refurbishments?
A17	Simultaneous heat and electricity generation	Combined Heat & Power System (CHP)		In countries where the electricity is not going to be decarbonised in the next 20 years, the use of natural gas combined heat and power can reduce emissions and have a reasonable payback. Existing data show that CHP performance is variable within the following parameters: – Cost Electricity kWh / Cost Natural Gas kWh > 0.3 – Hours of operation of CHP in excess of 4500 hours per year (CHP to be sized to maximise satisfaction of building heating loads) – CHP electrical power 65% of peak load – System may require absorption chiller and water storage to operate within cost-effective parameters ROI >5 years – CHP sizing should meet local CO_2 emission requirements in each country.	2 of 3	€€€	No
A18	Renewable energy	Solar panels and PV Panels		See section 2.8 below and the table in the first section of this report.			

Figure 12: Metal ductwork should typically be insulated.

Figure 13: Cogeneration (CHP) example installation.

The energy efficiency strategy at the beginning of this chapter contains these four steps:

1. Passive Systems Efficiency.
2. Active Systems Efficiency.
3. Operation Efficiency.
4. Renewable Energy.

The next section of this chapter covers Renewable Energy. Operational Efficiency is addressed in the next chapter because it is a very large topic.

2.8 | RENEWABLE ENERGY

Once energy requirements have been optimised, the remaining energy demands should ideally be met using 'green' or renewable energy sources. The viability and performance of renewable systems will be affected by project and site-specific factors.

Table 3 gives an overview of the most important renewable energy systems.

On-site renewables. Generation of electricity

It is important to assess the potential role of on-site renewable electricity generation. Modelling of renewable energy (e.g. photovoltaic panels) using local solar data is a good way of assessing the availability of solar sourced energy available yearly at a site and seeing how much of energy demand of the building it could meet.

Figure 14: On-site photovoltaic generation of renewable electricity.

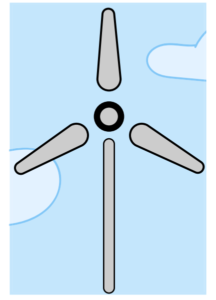
Table 3. Renewable Supply	Systems	Economic Viability	Environmental and sustainability Performance	Operation and Maintenance Requirements	Impact on Site and Building Design
WIND Electricity can be generated from wind by ground or building mounted wind turbines. Visual impact and vibration are key issues. Building-integrated wind energy is not generally a viable option because of its limited energy yield and high cost per unit of energy delivered.	Electricity	€ (More €, more viable)		(More tools, more maintenance)	(More bricks, more impact)
SOLAR PV Solar PV panels consist of photovoltaic cells made of semiconducting material that directly convert sunlight into electricity. PV panels can be installed on a roof, integrated within façades, integrated into car park canopies or ground mounted.	Electricity	€ € €			
SOLAR HOT WATER Solar energy can be harvested by vacuum tube or flat collectors to produce hot water for low temperature building heating and domestic hot water. Solar hot water is generally used on individual buildings with unused roof space to generate hot water for the building below. Hot water generated by solar collectors can be used to supplement conventional boilers and displace gas consumption. The technology is scalable and systems can be any size from 1 kW upwards.	Domestic Hot water heating	€ €			
BIOMASS Biomass boilers can burn a variety of solid biomass, such as virgin or recycled woodchip and wood pellets. These systems can affect local air quality, therefore location of this system in urban areas may require careful consideration.	Hot water heating & space heating	€ €			

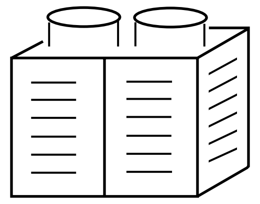
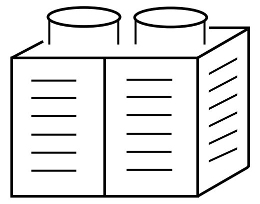
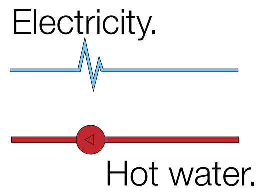
Table 3: Common renewable energy sources at sites of relevance to healthcare facilities. Note: wind energy is shown for information but is rarely seen adjacent to a building.

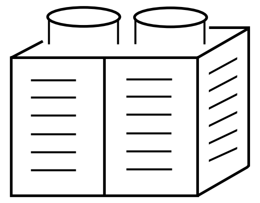
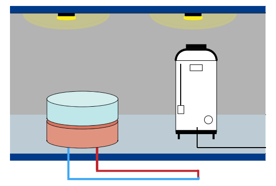
Case studies. Economic and Technical analysis

The following analysis presents a selection of the energy improvement opportunities identified in this chapter. The analysis compares the CAPEX and energy of a base case with the CAPEX and annual energy of an improved alternative design. The difference between the cases allows payback to be evaluated.

Ref.	Improvement Implementation	Base Case		
	Description of Improvement	**Description of Base Case**	**CAPEX Difference (Improvement - Base Case)**	**Payback (years)**
Case 1 	New-build 100 m² of wall with recommended increased insulation (U_{wall} = 0.2 W/m²K).	New-build 100 m² of wall with standard insulation (U_{wallj} = 0.5 W/m²K).	€400 - €700	2-5
Case 2 	Refurbishment in an existing building 100 m² of wall with recommended increased insulation (U_{wall} = 0.2 W/m²K).	Building as currently operated with standard insulation (U = 0.5 W/m²).	€10,000 - €15,000	>20
Case 3 	New-build, 50 windows 1.5 m² each, triple pane window (U = 0.6 W/m²).	New-build, 50 windows 1.5 m² each, double pane window (U = 2.7 W/m²).	€8,000 - €15,000	14-20
Case 4 	Existing building, 50 windows 1.5 m² each, triple pane window (U = 1 W/m²K).	New-build with double glazing (U = 2.7 W/m²)).	€27,000 - €45,000	>20

Ref.	Improvement Implementation	Base Case		
	Description of Improvement	**Description of Base Case**	**CAPEX Difference (Improvement - Base Case)**	**Payback (years)**
Case 5 	Installation of small wind turbines in a location with high enough average wind speed. Wind turbine 20 kW (10 m diameter) in a windy area (average speed 5 m/s) wind head 20 m above ground.	Operational building with no turbine.	€65,000 - €90,000	14-20
Case 6 	Hospital building with additional 100 m² PV (16 kW) panels to supply electricity to the hospital.	Operational building with no panels.	€17,000 - €25,000	5-10
Case 7  Source: Viessman.	Hospital building with 100 m² new solar panels to heat domestic hot water.	Operational building with no panels.	€150,000 - €230,000	10-20
Case 8 	Operational building with a biomass boiler, 5,000 m² healthcare facility & 500 kW.	Operational building with an old gas boiler.	€325,000 - €500,000	15-20
Case 9  .	Replacement of existing luminaires with LED luminaires.	Operational building with fluorescent lighting.	€700 - €1000	4-10
Case 10  Source: Philips™.	Operational building with additional lighting presence control.	Operational building in operation without lighting presence control.	€70 - €150	7-10

Ref.	Improvement Implementation	Base Case		
	Description of Improvement	**Description of Base Case**	**CAPEX Difference (Improvement - Base Case)**	**Payback (years)**
Case 11	Operational building with added lighting daylighting control.	Building in operation without daylighting control.	€150 - €225	5-10
Case 12 	Replacing existing air handling units with new units with more efficient fans. Replacement should be carried out at the end of equipment's life.	Operational building with standard efficiency AHUS (50,000 m^3/h flow).	€80,000 - €125,000	10-15
 Case 13	Adding a heat pump with four-pipe connection with capacity to heat and cool water at the same time saves energy relative to a boiler and a chiller heating and cooling water independently.	Operational building with a standard gas boiler (efficiency 0.85) and a standard chiller (efficiency COP 2.5), 500 kW size and 5000m^2.	€36,000 - €60,000	5-10
 Case 14	High-efficiency chiller instead of a standard chiller.	Operational building with a standard gas boiler.	€50,000 - €75,000	4-10
 Case 15	A combined heat and power unit is added a boiler. CHP unit 500 kW thermal in a 5000 m^2 healthcare facility.	Operational building with a standard gas boiler.	€450,000 - €675,000	4-10
 Case 16 Source: Trane ™.	Boiler replaced by Air source heat pumps 500 kW in a 5,000 m^2 healthcare facility.	Operational building with a standard gas boiler.	€350,000 - €600,000	4-10

Ref.	Improvement Implementation	Base Case		
	Description of Improvement	**Description of Base Case**	**CAPEX Difference (Improvement - Base Case)**	**Payback (years)**
 Case 17	High efficiency chiller instead of a standard chiller 500 kW in a 5,000 m^2 healthcare facility	New standard chiller	€50,000 - €75,000	7-14
 Case 18	Boiler replaced by Ground source heat pumps. 500 kW in a 5000 m^2 healthcare facility.	Operational building with a standard gas boiler.	€750,000 - €1,000,000	14-25
 Case 19 Source: Shneider ™.	Installation of a BMS in a hospital 250 beds.	Operational building with a standard gas boiler.	€150,000	14

Disclaimer: Costs are approximate and were sourced from EU manufacturers and suppliers in 2021. Payback is calculated using approximate energy savings based on typical scenarios. The purpose of the table above is solely to demonstrate the possible order of magnitude of capex and payback for improvements. Each project should perform its own analysis based on its actual situation. In practice, payback and capex may vary from what we have set out in function of local factors.

3

Operational in Healthcare Facilities Energy Efficiency

3.0 | OBJECTIVE & CONTENTS OF THIS SECTION

This chapter focuses on Energy Efficiency in Operational Healthcare Facilities. The chapter is split into two sections. The first section identifies key operational aspects with an impact on the energy efficiency of hospitals: Energy Management Plan, Optimised Building Service Control and Maintenance Plan.The second section presents a detailed schedule of improvements opportunities associated with those aspects. The schedule contains an analysis of cost and energy savings and ease of implementation for each opportunity.

3.1 | SECTION 1. OPERATIONAL ENERGY STRATEGY EFFICIENCY

To optimise the energy efficiency of the operation of a healthcare facility, the building's operator should have and implement the following programmes.

3.1.1 Energy management plan

An energy management plan is essential to the efficient operation of a healthcare facility. The diagram below shows the principal steps recommended for the implementation of an energy management plan These steps are sourced from British guidance HTM 07-01 (***ref 45***).

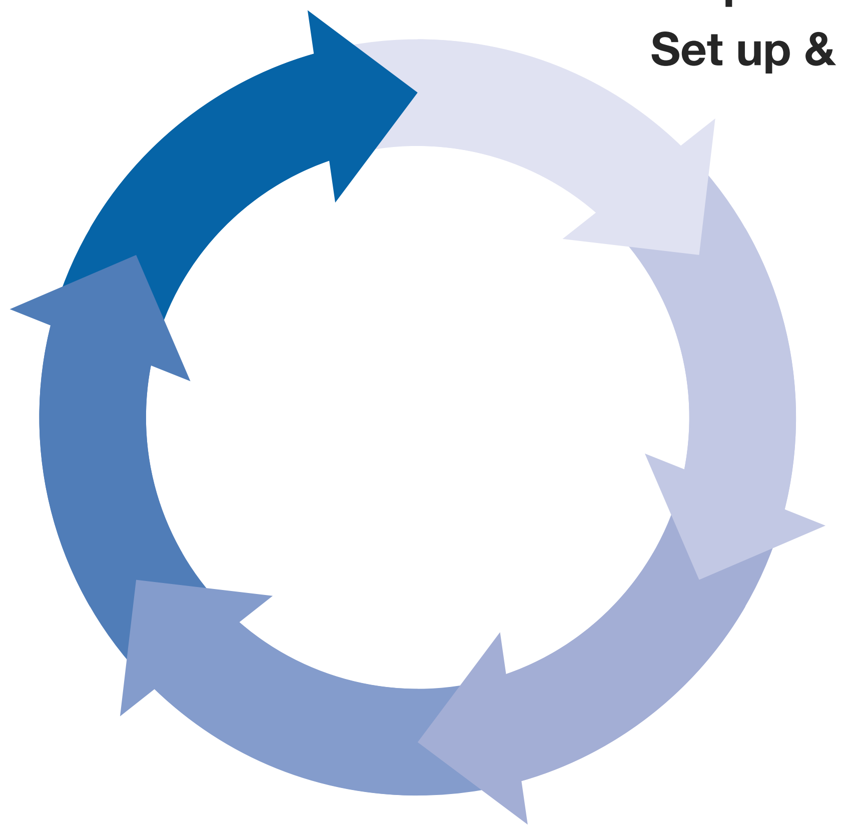
Step 1: Get commitment at the highest level of the organisation to adoption and implementation of an energy efficiency plan.

Step 2: Understand the current performance of your organisation. Use the analysis matrix in Appendix 6. Energy management analysis matrix.

Step 3: Decide what resources will be needed to manage energy usage across the organisation, determine actions, responsibilities and resources.

Step 4: Audit existing energy performance of the facility so that actions can be prioritised. An energy audit will provide a better picture of the energy consumption and identify opportunities for improvement, often delivering immediate cost savings. An audit can also demonstrate compliance with legal obligations that require organisations to undertake energy audits.

Step 5: Ongoing energy monitoring to underpin remedial action and maintenance for efficiency and to identify possible improvements. The plan should include an energy data collection (energy metering) plan and verification and analysis procedures.



3.1.2 Improved building systems controls.

In addition to a management plan, the following improvements for operating the hospital efficiently are recommended.

Digital Energy monitoring and verification system
Smart metering, energy monitoring devices and energy management software (Building Energy Management Software , BEMS) allow building managers to review energy use and optimise accordingly.

This system takes remotely readings from all meters in the building to periodically report all systems energy. The reporting should include sufficient information for the operator to analyse the energy behaviour of the building and improve efficiency. For example, energy reporting should show the operator energy systems trends by day, week and month, with comparisons against benchmarks and allow the configuration of alarms based on pre-fixed energy consumption baselines for different systems. As well, energy metering can be used on post-commissioning evaluation to help fine tune systems, having a significant impact on overall operational carbon emissions.

Building digitisation, automation and controls
Control of the heating, cooling, ventilation and lighting systems is fundamental to operational energy efficiency. To minimise energy use, buildings need to have a building operation system. The system needs to target specific pre-set parameters (e.g. room temperature) but also needs to be programmable in operation and allow monitoring of the variables it controls. For example, using technology to create zoned and programmable heating and water systems allows maximum flexibility and minimises heating demand. Similarly, lighting controls based on occupancy or hours of operation can minimise unnecessary use.

Building Control Operation Plan
The building Facilities Management (FM) team should develop a Building Operations Plan. The Plan does not need to be a complex or lenghty document. It summarises the building's operational parameters (e.g. systems control method, operational set points and operational hours for HVAC and lighting), equipment and expected building performance.

The Building Operation Plan covers the following systems:

- HVAC Systems
- Water Systems
- Lighting Systems
- Fire, Life Safety Systems
- Large equipment with operational control

Having a plan allows the identification of operational energy efficiency opportunities during, for example, energy audits.

3.1.3 Operation and Maintenance at design stage and in use

O&M is critical and will probably have a big impact on a facility's energy use over its lifetime.

Healthcare buildings should be designed with consideration of O&M from the onset of the project to help ensure that energy savings are made year after year. For example, Appendix A of ASHRAE/ASHE Standard 170 states equipment maintenance requirements in healthcare facilities. See the bibliography for an url for this document, ref 32.

Preventive maintenance programme
An important step in maintaining optimal energy performance is to make sure that energy-related scheduled maintenance tasks are carried out. An example of a simplified maintenance plan can be seen in Appendix 3 of this report.

Training Plan
Training gives staff the knowledge to make the right changes to achieve desired energy efficiency outcomes. Most importantly, engineers have to be taught to solve underlying issues rather than making changes to setpoints every time there is a complaint.

3.2 SCHEDULE OF ENERGY EFFICIENCY OPPORTUNITIES

The following table presents a summary of the recommendations mentioned in the preceding section of this chapter with further energy saving opportunities to be implemented during the operational phase.

Ref.	System	Element	Component	Recommendation	Energy Savings	Building CAPEX
O1	Operational	Energy Management	Energy Management System	We recommend that hospital building have a digital energy management system. That system may be part of the Building Management System or separate. The system should take readings from all meters in the building to periodically report all systems energy use.		€
O2	Operational	Energy Management	Improved Metering and Energy Monitoring Plan	In line what has been said, every hospital should have a metering plan. We recommend that energy meters should cover heating, cooling, mains electricity mains, mains gas, pumping, hot water, cold water, ventilation and electricity by department. The metering plan should ideally be taken into account at the design stage for new buildings. For example: designing the electrical distribution system to be sub-metered reduces complexity, minimises the number of meters, shortens installation time and minimises rewiring.		€ €
O3	Operational	Energy Management	Monitoring Post-Commissioning Performance	Measurement and verification procedures to monitor actual building performance after commissioning can help to identify when corrective action and/or repair is required to maintain energy performance. – The energy management system should monitor and record utility consumption and related factors to determine building performance during the first year of operation for comparison with performance in subsequent years. – Another purpose of post-occupancy evaluation (POE) is to determine the actual energy performance of low-energy buildings to verify achievement of design goals and to document energy savings.		€
O4	Operational	Energy Management System	Measurement and Verification (M&V). Data Management	Detailed M&V systems (or Energy Management Systems) can produce an overwhelming volume of data. The success of an M&V system depends on management of that data and reporting quality. Collect sub-metered data at resolutions appropriate for the intended use (e.g. daily, weekly, monthly and annual trends).		€

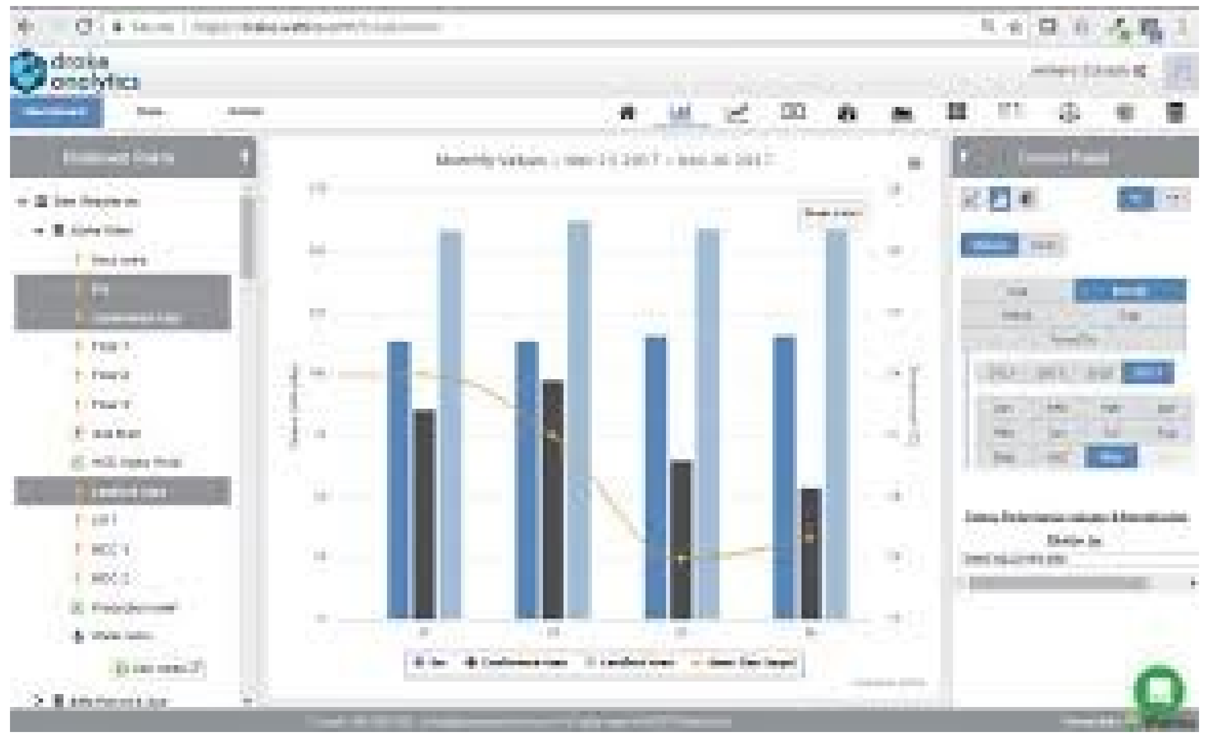


Figure 15: Digital Energy management system. (Source: Wattics™).

Source: SIEMENS™.

OPERATIONAL
ENERGY EFFICIENCY

Ref.	System	Element	Component	Recommendation	Energy Savings	Building CAPEX
O5	Operational	Energy Management System	Measurement and Verification Benchmarking analysis	Utility bills and sub-metered data should be benchmarked to ensure that energy performance targets are met and operators should be prepared to repeat this exercise monthly. Sub-metered data can be benchmarked against previous trends, energy models and other facilities with sub-metered data. Refer to international hospital benchmarks in Appendix 5 to this report		€
O6	Operational	Energy Management	Training	Training for FM staff to make the right changes to achieve the desired operational outcomes, to be able solve underlying issues rather than making changes to setpoints every time there is a complaint.		€
O7	Operational	Energy Management	Staff awareness-raising	Organise a staff awareness-raising campaign to make staff aware of good energy management practice.		€
O8	Operational	Efficient Ventilation	Adjust ventilation flows to spaces	Commission ventilation systems to operate without over-ventilation. Configure ventilation rates as required by local healthcare requirements. Ventilation standards mentioned in this guide could be an alternative. It may be necessary to balance existing ventilation systems		€ €
O9	Operational	Efficient CHW and LTHW water supply	Install pressure control valves in terminal units	Commission water flows in each terminal unit. When control valves reach end of life, consider replacing them with pressure-independent control valves. Those valves require less commissioning effort and offer better temperature control		€ € €

Figure 16: Benchmarks analysis compares energy intensity per surface area to typical international values. The analysis helps in the assessment of the energy performance of a facility.

OPERATIONAL ENERGY EFFICIENCY

Ref.	System	Element	Component	Recommendation	Energy Savings	Building CAPEX
Improved building systems controls						
O10	Building Automation and Control Systems	Controls	Digital control of the building	Every health care facility should incorporate a building management system (BMS) to control as a minimum the following building systems: HVAC, Public Health, Lighting (configuring working hours per zone and time), energy metering (if there is no energy management system in place). The following opportunities show improvements that can be made to the BMS to increase efficiency of the operation of the system.	1	€€
O11	Building Automation and Control Systems	BACS	Temperature set points	Lower heating and raise cooling temperature set points in line with the comfort range prescribed in ASHRAE Standard 55. A consumption saving of approximately 7% is seen from a reduction of 1 °C in the temperature set point for heating. Consider configuring the following temperature set points in non-specific healthcare areas, such as administrative areas. – Winter set point 20 °C – Summer set point 26 °C	1	€
O12	Building Automation and Control Systems	BACS	Night setback	Use night setback or turn off HVAC equipment when building is unoccupied.	1	€
O13	Building Automation and Control Systems	BACS	Occupancy controls	Install occupancy sensors with VAV systems, setback temperatures and shut off boxes.	1	€
O14	Building Automation and Control Systems	BACS	Temperature set points	Install system controls to reduce cooling/heating of unoccupied space.	1	€
O15	Building Automation and Control Systems	BACS	Temperature set points.	Optimising the configuration of the heating system in order to maintain the temperature as close as possible to the required level. That could mean changing the control valves of terminal units and adding digital thermostats for more efficient and comfortable temperature control.	2	€€
O16	Building Automation and Control Systems	BACS	Digital control	Schedule out-of-hours meetings in a place that does not require HVAC to be on throughout the facility.	1	€

Figure 17: Well-designed and maintained building management systems (e.g. digital systems) help facilities to operate more efficiently.

OPERATIONAL ENERGY EFFICIENCY

Ref.	System	Element	Component	Recommendation	Energy Savings	Building CAPEX
Improved building systems controls						
O17	Building Automation and Control Systems	BACS	Zone control	Retrofit multi-zone VAV systems with direct digital controls (DDC) at the zone level and implement supply air duct pressure reset to reduce supply air duct pressure until at least one zone damper is nearly fully open.		€
O18	Building Automation and Control Systems	BACS	Water temperature optimisation	Adjust hot water and chilled water temperatures to develop peak-shaving strategies based on an outdoor air temperature reset schedule.		€
O19	Building Automation and Control Systems	BACS	Housekeeping schedule	Adjust housekeeping (cleaning) schedule to minimize HVAC use.		€
O20	Building Automation and Control Systems	BACS		Install programmable zone thermostats with appropriate deadbands.		€
O21	Building Automation and Control Systems	BACS	Reduce scheduled hours of operation	Reduce operating hours of balanced heating and cooling systems. Ensure proper location of thermostats to provide balanced space conditioning.		€
Efficient Operational Control of Equipment				**The following are efficient operation recommendations for equipment in the building, including IT and Refrigeration equipment.**		
O22	Appliances	Appliances	Plug load control	Reduce plug loads, using cut-off for unused equipment (use occupancy sensors or timers). E.g. water boilers in the kitchen and refrigerated food stands in the canteen.		€
O23	Appliances	Appliances	Equipment control	Install vending-machine time controllers.		€
O24	Refrigeration Equipment	-	Condensation temperature	Decrease the operational condensation temperature. A reduction of 1 °C in the condensation temperature leads to a 3% increase in the electricity consumption of a cooling unit.		€
O25	Plug loads	Controls	Computer power control	Network control with power saving modes and control during non-work hours or IT enterprise power management programs.		€
O26	Plug loads	Controls	Occupancy sensors	Install office lighting occupancy sensors.		€
O27	Plug loads	Controls	Timer switches	Water coolers, coffee makers, small appliances = auto OFF during non-work hours.		€

Figure 18: Review of room temperature configurations can help with energy efficiency. For example, in non-healthcare areas, the room temperature set point can be set to 26 °C in summer and 20 °C in the winter.

4

Water Efficiency in Healthcare Facilities

4.0 | OBJECTIVE & CONTENTS OF THIS CHAPTER

This chapter includes water saving opportunities for healthcare facilities. They have mostly been sourced from the guide “Environment and Sustainability Health Technical Memorandum (HTM) 07-04: Water management and water efficiency – best practice advice for the healthcare sector” issued by the Department of Health - UK government.

4.1 | WATER EFFICIENCY OPPORTUNITIES FOR OPERATIONAL NEW AND EXISTING BUILDINGS

Water efficiency measures can generate financial savings of up to 20% with little or no investment cost required. For example, in the case of the National Health Service in England, water efficiency measures translate into possible annual savings of €9.5 million (source HTM 07-04).

Many of those savings can be achieved immediately through minor repairs to existing infrastructure and through changes to staff behaviour, while others may require an initial capital investment that can be recovered within a payback period.

The importance of water audit

Water audit is encouraged as a tool for analysing the potential savings in existing hospitals on-site. The purpose of a water audit is to promote efficient water management and thus achieve the financial and environmental benefits that are available.

Other water saving opportunities

Opportunities with low implementation cost or equipment requirements, geared towards greater accessibility for EBRD countries of operation have also been identified. The following section contains a table that summarises recommendations for increased water efficiency, calibrates the difficulty of implementation including its qualitative Capex requirements.

4.2 | RECOMMENDED COMPONENTS OF A WATER STRATEGY.

The table below shows water efficiency recommendations with comparative data for healthcare facilities equipment. The analysis and recommendations consider the principal building elements that consume water in hospitals.

The table includes an analysis of qualitative implementation and operational water cost savings and ease of implementation for each recommendation. It should be noted that hot water saving and water saving recommendations for steam systems will also have an impact on energy savings for water heating.

Figure 19: Steam boiler. Source: Bosch thermotechnology™.

System	Recommendation	Estimated Water Saving	Implementation CAPEX
Boiler house water saving opportunities			
Steam Boiler House Maintenance	Optimising boiler performance and regular system maintenance can save large amounts of water. This can be very cost-effective and will have a significant impact on reducing a facility's carbon footprint, because hot water and steam have a great deal of embedded energy.	🍃	€
Reduce feed water supply to the boiler via boiler water conductivity & blowdown control or water demineralization	In steam generation, boiler water dissolves minerals that create solid deposits or solid beds in the boiler that are detrimental to the operation of the boiler. Feedwater or make-up water needs be fed to the boiler to reduce formation of these solid deposits (regeneration process). 1- One way to avoid the need for fresh make up water at regular intervals is to run the regeneration process (blowdown) only when necessary. Trigger levels for water blowdown and regeneration can be set by setting a conductivity sensor in the boiler and associated valves and controls that blow down water only when really needed by the boiler, thus saving water and heating energy. 2- Another way to decrease the need for makeup water is to demineralise it before being fed to the boiler in order to reduce solid deposits in the system. Water demineralization energy effectiveness depends on local water quality and the cost of the demineralization equipment. Therefore, an ad hoc viability exercise is recommended before its implementation.	🍃🍃	€€

WATER EFFICIENCY

System	Recommendation	Estimated Water Saving	Implementation CAPEX
Steam losses, leaks and condensate recovery	As steam travels through the outlet pipes of a boiler, its temperature decreases, and water condenses in the pipes. This condensate can be collected and recycled into the boiler system, reducing energy and water consumption as well as slowing the build-up of solid deposits, as condensed water tends to have a much lower mineral content.	2	€€
Steam losses, leaks	Approximately 80% of the energy used in a boiler is used to provide the necessary latent heat to produce steam, with only 20% for raising water to boiling point. Therefore, losing steam though leaks is less efficient than losing steam temperature and care should be taken to prevent steam losses from the system and to ensure that the necessary safety precautions are in place. The steam pipework system should be inspected for leaks.	1	€
Cooling towers	Cooling towers are used to cool heated water from building processes (i.e. cooling air in summer for air conditioning). The process involves pumping water to the cooling tower where some of the water evaporates and the remaining water is cooled. As with boilers, when water is lost through evaporation, the mineral concentration increases. In order to prevent the build-up of solid materials in the tower, water must occasionally be bled from the system and make-up water introduced. Similar to the boiler blow down control improvement mentioned in previous page, the cooling tower can also implement a conductivity and blowdown control.	1	€
Catering department	Staff awareness of efficient use of water in food preparation and post-preparation clean up should be raised in relation to the following aspects: taps, defrosting, recycling, automatic potato peelers, waste reduction, dishwashing and laundry, and washing food-preparation areas.	1	€
Washing and preparing food	Taps: A running tap can typically consume 12 L/min. In order to limit this consumption, unused taps should not be left running and signs next to taps can be an effective reminder to staff. Additionally, technology such as flow restrictors and automatic shut-off mechanisms will help reduce unnecessary water consumption.	1	€
Washing and preparing food	Defrosting: Defrosting food under running hot water should be avoided when possible to save water and possibly be more energy efficient.	1	€
Waste disposal	Recycling: When preparing packaging for recycling, the recycling authority should be consulted on whether it is necessary to wash or rinse packaging.	1	€

Figure 20: Cooling tower example. Source: Evapco™.

WATER EFFICIENCY

System	Recommendation	Estimated Water Saving	Implementation CAPEX
Waste disposal	Automatic potato peelers: Peelers often require a water supply to flush out potato peelings. Flows should be set at the minimum amount required using a flow restricting valve if possible.	●	€
Washing	Dishwashing and laundry: The need to use dishwashers and washing machines every day should be reviewed. Washing protocols should ensure that machines are fully loaded before they are run. Water-efficient models should be selected when replacing machines, while in larger facilities where industrial machines are required, procurement should be based on the most efficient model on the basis of whole-life costings.	●	€
Washing	For smaller facilities where domestic washers are used, a database of domestic dishwashers and their efficiency ratings is available from the Waterwise website . www.waterwise.org.uk	●	€
Washing	Washing food preparation areas: In larger kitchens, surfaces and equipment are often washed down with a hose. If hoses are used, there is a risk of aerosol formation that must be reduced.	●	€
	Important considerations before implementation of water savings in patient areas: The use of water-efficient fittings and appliances may not be appropriate in the context of patient needs and may adversely affect the incidence and communication of infections. Building Managers should consult the Infection Control team of the healthcare facility before taking any measures.		
Efficient WCs & other appliances	Water consumption per flush for WCs and upgrade and retrofit options depend on the age of the model. Often WCs are the first target for water efficiency, as they constitute a large portion of domestic use. Older models may use as much as 12 L per flush, whereas newer models consume around 4–6 L. The water label guide can be consulted as a reference. The recommendations below reflect low-water consumption equipment available today in the EU market a. Water tap Flow ≤ 1.9 L/m b. Shower. Flow ≤ 5.7 L/m c. WC. Flow 4/2 o 5/2.5 L/flush d. Urinal Flow ≤ 1-3 L/flush e. Kitchen sinks. Flow ≤ 3.5 L/m (flow viability to be confirmed by kitchen consultant) Equipment can also be specified to comply with the European water label rating http://www.europeanwaterlabel.eu/pdf/scheme-march2019-en.pdf. Green means a higher water efficiency. This note also applies to all water appliance recommendations mentioned in the following page.	●●●	€

WV

Figure 21: Kitchen hospital area.

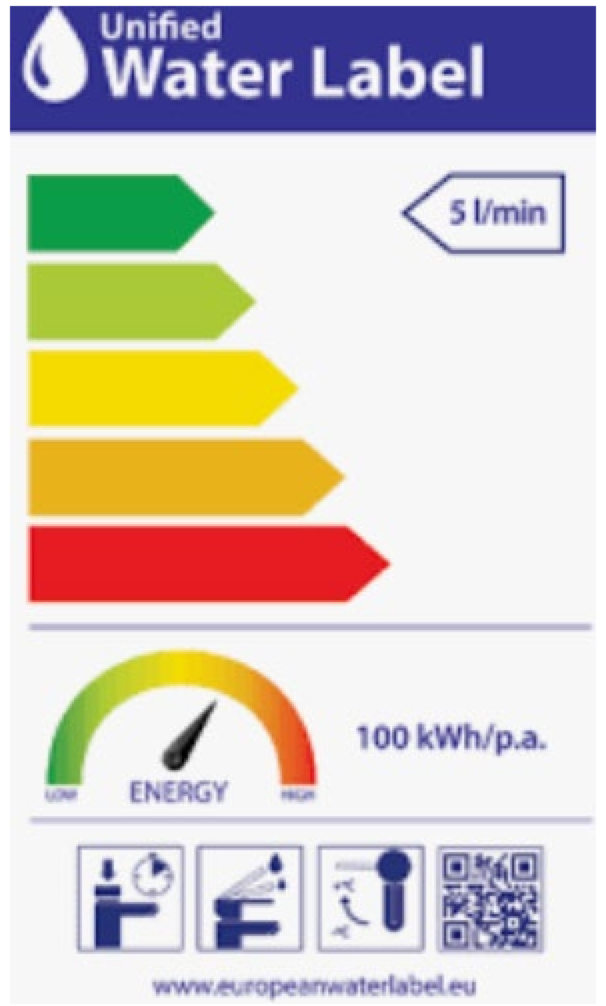


Figure 22: The water label sets different performance ratings for water appliances. Source: Europeanwaterlabel.

WATER EFFICIENCY

System	Recommendation	Estimated Water Saving	Implementation CAPEX
Cistern displacement devices (CDDs)	A cistern displacement device (CDD) can be used to displace a set volume of water inside the WC cistern, typically saving about 1 L of water per flush. Consideration should be given to whether it is better to use CDDs (i.e. retrofit) or to upgrade WCs to low-flush models. Low-flush models offer easier maintenance and better ergonomics.		
Urinals	Urinals are often controlled by an automatic flush system which runs at regular intervals. A typical system will flush approximately 7.5 – 12 litres of water at 20 minute intervals, reaching a total consumption of up to 197 m³ per year per urinal, resulting in unnecessary water and sewerage charges. There are many water reduction solutions. First, the installation of passive infrared detectors in urinals can reduce water consumption by 60%. Although the initial cost is €140 - €170, payback is quick. Secondly, more water-efficient models should be considered for any upgrade. Thirdly, waterless urinals and ultra low-flush urinals can be considered for some areas. The infection control team should be consulted before installing waterless urinals.	⊘	€ €
Taps	Leakage: Taps are prone to leakage. It is estimated that 15 L may be consumed each day by a dripping tap. Every healthcare facility should have a reporting system or programme in which staff are informed of the importance of reporting leaks and understand how to make a report.	⊘	€
Taps	Design: What taps will be used for should be considered before reducing flow rates. In some cases, reduced flow rates may be inappropriate. For example, when taps are used to fill containers, reduced flow rates will only increase the time taken and have little effect on efficiency. In other cases, where there is a high risk of spread of infection, for example during surgical scrubbing, sensor, lever or foot-operated taps may be most suitable.	⊘	€
Taps	As taps typically use about 9 L of water per minute but may use as much as 18 L per minute, staff should be informed about the importance of using taps appropriately.	⊘	€
Taps	Sensor (non-touch) taps conserve water and reduce the risk of spread of infection, making them an ideal option in some hospital settings.	⊘	€
Taps	Flow regulators may also be fitted to taps, as appropriate.	⊘	€
Baths and showers	Baths typically use around 80 L per bath and showers around 9 L per minute. Where possible, showers should be preferred over baths; however, the care needs of patients must take priority. Reducing the water used for showers and baths may also reduce energy bills by reducing hot water consumption.	⊘	€

Figure 23: Urinals can be more water efficient if controlled by presence sensors.

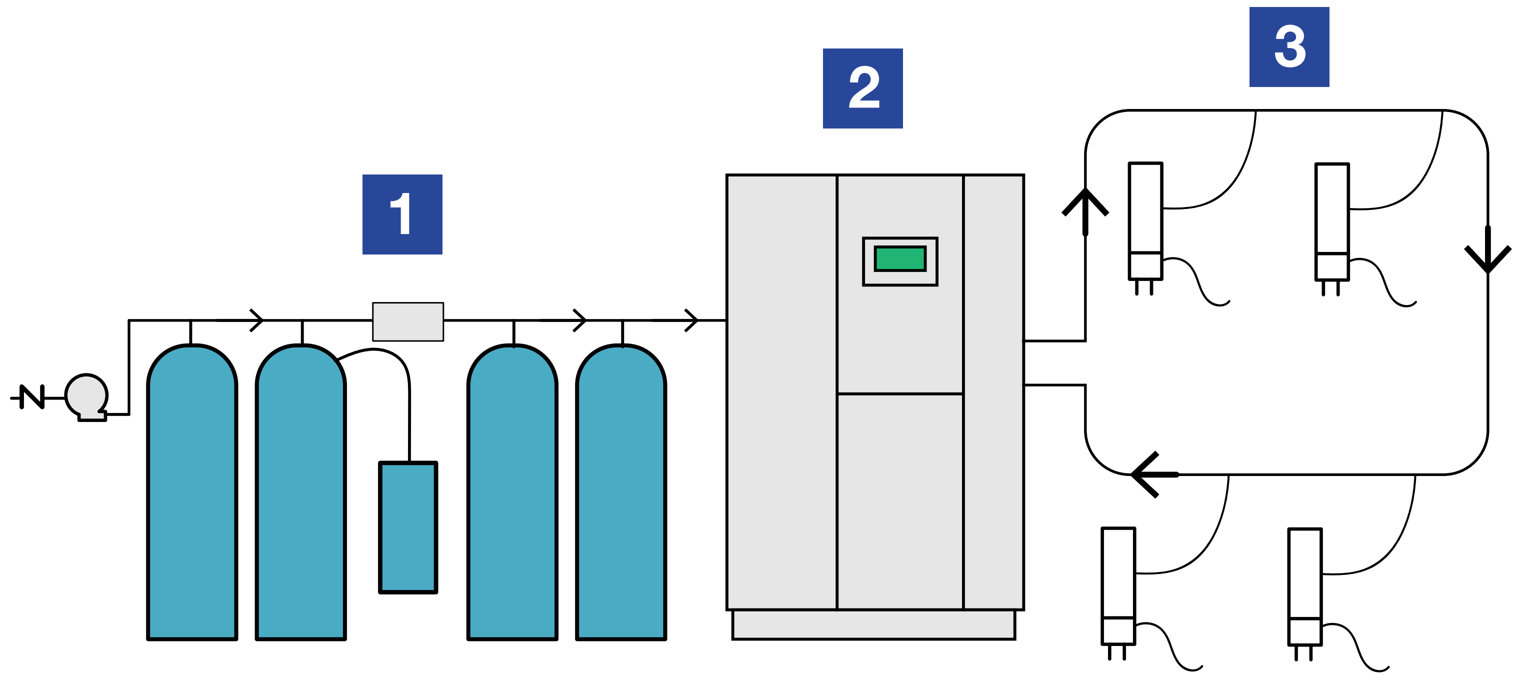
Figure 24: Healthcare HTM approved low-flow sink. Source: Home.

WATER EFFICIENCY

System	Recommendation	Estimated Water Saving	Implementation CAPEX
Baths and showers	**Shower technology:** Flow restrictors, if approved by infection control, may be used to reduce the flow rate of water in showers. Fitting water-efficient showerheads may significantly reduce water consumption.		€
Baths and showers	**Shower technology:** Shower location and design can play a key role in significantly reducing the volume of water wasted while waiting for showers to reach the desired temperature. In healthcare facilities, the risk of scalding for vulnerable patients such as the very young, older people and patients with mental illness, can be minimised through upgrading to thermostatic mixing valves.		€
Surgical scrubbing	Scrub taps are generally lever or sensor operated and are a key area of water use. Reduced flow taps should not be used in this setting (refer to Health Technical Memorandum 00 UK Gov: Policies and principles of healthcare engineering, ref 42).	NA	NA
Dialysis unit	Water quality in a renal unit should meet the recommendations in the European Renal Association-European Dialysis and Transplant Association's (ERA-EDTA) 'European best practice guidelines for haemodialysis'. To ensure purity, water is passed through a reverse osmosis (RO) unit. This means that water can be reused (for WC flushing, for instance) as the RO unit can remove almost any level of contamination, as illustrated in the picture opposite.		
Patient care	Patient bathing, WC use, washing and drinking can use large volumes of water, but these actions cannot be so easily restricted because they are fundamental to patient care. Patients should be encouraged to use water to maintain hydration and for personal hygiene. All hospitals should provide easy access to drinking water for patients and the promotion of good hydration should be included in any water management plan. Due to the fundamental nature of these water uses, the best way to reduce consumption in these settings is by ensuring the efficiency of appliances used by patients.		
Laser cooling	Medical lasers are generally water-cooled. Owing to the cost and sensitivity of the equipment, water efficiency should be secondary to ensuring water purity (to prevent corrosion) and cooling efficiency. Depending on the type of laser, it may be possible to use thermoelectric cooling or air cooling, but water efficiency should not be a deciding factor in the choice of cooling system.		
Hydrotherapy pools and swimming pools	Hydrotherapy pools are usually different from ordinary pools because the temperature and movement of water is regulated and changed according to who is using the pool and why. Pool covers can be installed to reduce evaporation losses and filtration units can be used to recirculate water.		€
Decontamination: Sterile services departments	As in an endoscopy setting, it is very difficult to improve water efficiency in essential support services such as sterile services. The decontamination process should not be compromised in any way for the sake of water efficiency.		€

Figure 25: Steriliser.
Source: Steris.

Figure 26: Hydrotherapy.
Source: Revalcc.



1 Pre-treatment filters. 2 RO water plant. 3 Loop & machines.

Figure 27: Water treatment schematic for a dialysis department: Left to Right. Untreated mains water, carbon filter, reverse osmosis plant and water pipework, water supply to dialysis chairs in loop arrangement. Picture sourced from hospitecnia.es.

WATER EFFICIENCY

System	Recommendation	Estimated Water Saving	Implementation CAPEX
Decontamination: Sterile services departments	In light of the issues identified, we recommend that all decontamination equipment (washer disinfectors and sterilisers) is operated with full loads and wash cycles are evaluated for water efficiency.	2 of 3	1 of 3
Outdoor water use			
Outdoor water use	Few healthcare facilities have examined the volume or type of water used for outside watering or the selection of plants. Given that a single water sprinkler may consume as much as 900 litres of water every hour, the cost of outdoor use is potentially large. Four key solutions should be considered to reduce outdoor use: rainwater harvesting, plant choice, drip irrigation with timing and mulching.		
Outdoor water use: Rainwater harvesting	Water from rainwater harvesting may be ideal for irrigation, as the water collected requires little or no treatment. Rainwater harvesting can also be economically viable for larger buildings that collect the rainwater on their roofs and use it for low-quality purposes such as WC/urinal flushing in non clinical areas.	2 of 3	3 of 3
Outdoor water use: Plant choice	Consideration should be given to planting drought-resistant or perennial plants, which require little watering and increase diversity.	1 of 3	1 of 3
Outdoor water use: Sprinkler timing	Sprinkler timing should be adjusted such that sprinklers are active in the early morning or late afternoon, reducing water loss from evaporation; sprinkler controls should include rain and moisture sensors.	1 of 3	2 of 3
Outdoor water use: Mulching	Mulch and bark should be used in flower and tree beds, reducing water loss through evaporation by up to 70%.	1 of 3	1 of 3

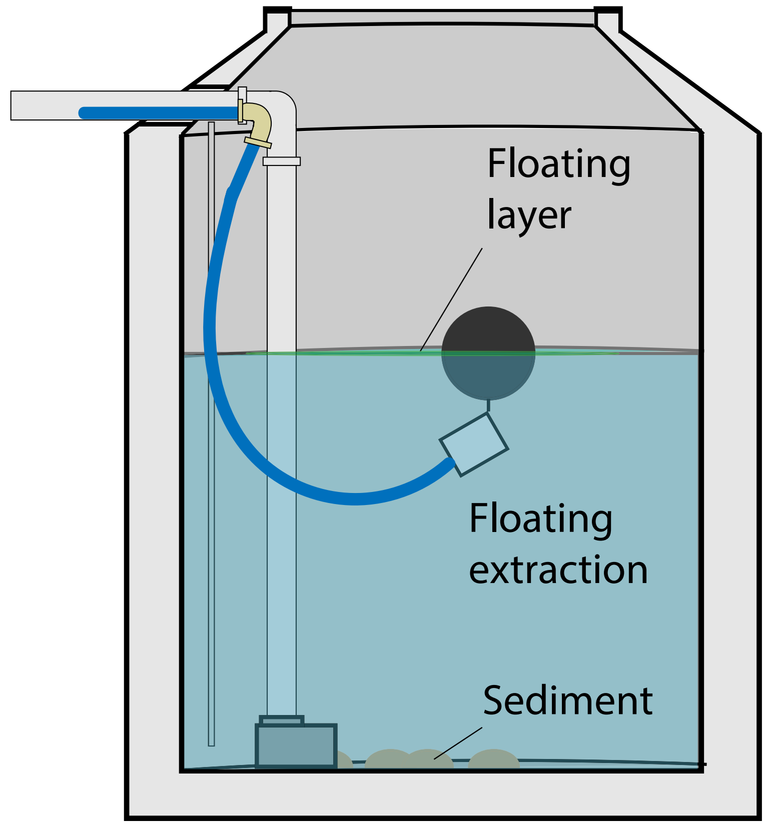


Figure 28: Rainwater harvesting tank.
Picture Inspired by aqua-lity.
Supply to the tank should include a strainer. Rainwater harvesting can be used for irrigation at hospitals.

5

Waste Management in Healthcare Facilities

5.0 | OBJECTIVE & CONTENTS OF THIS CHAPTER

This chapter focuses on waste management in healthcare facilities. The management of healthcare waste is an essential part of ensuring that healthcare activities do not pose a risk or threat of infection and are safely managed.

The following pages summarise examples of best waste management practice in order to inform healthcare organisations how to further minimise waste and reduce the environmental impact from waste management.

The chapter is divided into the following sections:

- A recommendation to have a waste policy and suggested principal content.
- Definition of each type of healthcare waste, the type of material it includes, and the infrastructure needed for its management.

The infrastructure described in this guide originated from a public healthcare authority protocol (***Ref 45, UK Guide HTM 07-01 & ref 44***). However, different countries and agencies may have their own protocols that require different management, categorisation or infrastructure.

5.1 | HEALTHCARE WASTE MANAGEMENT. WASTE POLICY

Every healthcare facility should develop its own Waste Policy. The Waste Policy should determine responsibilities, objectives and detailed procedures for the safe management of healthcare waste.

As a minimum, a healthcare waste policy should contain:

- A clear statement of the aims and rationale of the policy, signed off at board level to demonstrate high-level commitment.
- Legal and statutory obligations including transport.
- Current waste management contracts and arrangements, including contingency arrangements in the event of service failure.
- Who is responsible for waste management and lines of accountability, particularly in community healthcare due to the variety of activities and settings in which waste is produced.
- The provision of information, instruction and training on safe transport, identification of the containers and bags to be used, management of spillages, cleaning containers and disposal procedures.
- Arrangements for policy implementation.
- Processes for identifying improvement programmes and monitoring progress.
- Details of staff training, induction training and updates for different staff groups
- Sources of information and guidance (for example a healthcare organisation's waste guidance).

Waste minimisation

Although much of this guide focuses on managing waste once it has been produced, the best financial and environmental option is not to produce waste in the first place. This is because whether waste is sentenced to recovery, recycling or disposal, it is still a product that has generally been bought, handled and then disposed of at a cost. Avoiding the generation of waste would reduce both purchase and disposal costs.

Waste policies should include a programme of critical review of the volume and types of waste produced, with a view to identifying and taking practical steps to reduce waste volumes.

When products are selected during the procurement stage, environmental aspects should be taken into account. It may initially be cheaper to buy a particular product, but savings could be lost further down the line simply because more waste is produced, or because the waste is harder to recycle or to dispose of.

Finally, waste policies should have a clear and timebound goal of total waste generation reduction regardless of the eventual disposal method for that waste. That goal should be supported by practical delivery programmes and should address the root causes identified during review.

5.2 | DEFINITION OF TYPES OF HEALTHCARE WASTE.

The categorisation of healthcare waste is complex. There are different types of waste based on the source, level of hazard, degree of infectiousness or offensiveness.

The following is a non-exhaustive description of the principal types of waste that can arise in a healthcare facility.

Healthcare waste

All waste generated in a healthcare establishment should be considered healthcare waste. All healthcare equipment should be considered healthcare waste from the moment the use of the equipment ends.

Healthcare waste can be divided into the following categories:

Clinical or non-clinical waste
The waste item is classified as clinical waste if it contains or is contaminated with a medicine containing either:

- A pharmaceutically active substance
- A dangerous substance (for example a chemical) at sufficient concentration to cause a hazardous reaction.

Hazardous or non-hazardous waste:
A waste item is classified as hazardous (under the definition in the Waste Framework Directive (***ref 47, Chapter 7: Guidelines***), if it contains or is contaminated with a cytotoxic or cytostatic medicine (H6: Toxic; H7: Carcinogenic; H10: Toxic for reproduction; H11: Mutagenic). Those are the properties of a cytotoxic medicine.

Infectious waste:
Waste that has the hazardous property “H9: Infectious” – that is, substances containing viable microorganisms or their toxins, which are known, or reliably believed, to cause disease in man or living organisms.

Offensive/hygienic waste:
Offensive/hygienic waste is waste that is non-infectious but may cause offence due to the presence of recognisable healthcare waste items, body fluids, or odour.

Domestic (municipal) waste:
Domestic waste means mixed municipal waste from healthcare and related sources that is the same as, or similar to, black-bag domestic waste from households

The following table aims to group these type of wastes:

WASTE EFFICIENCY

Types of healthcare waste.

Healthcare waste

Non-hazardous waste.		**Hazardous waste**	
Clinical waste	Medicines other than those that are cytotoxic and cytostatic.	**Clinical waste**	Non-infectious anatomical waste, chemicals present.
Non-clinical waste	Non-infectious anatomical waste, no chemicals present.		Cytotoxic and cytostatic medicines and sharps.
	Sharps not contaminated with body fluids or medicines.		Infectious anatomical waste, no chemical present or chemical present.
	Non-infectious gypsum (plaster) waste.		Non-medicinally contaminated sharps.
	Offensive/hygienic waste.		Infectious gypsum (plaster).
	Mixed municipal (domestic) waste.		Infectious waste containing dental amalgam.
	Recyclables	**Non-clinical waste**	Healthcare chemicals without hazardous properties.
	Healthcare chemicals without hazardous properties.		Dental amalgam.
			X-ray fixer and developer.

5.3 | WASTE MANAGEMENT AND DISPOSAL.

This section provides information on the segregation, colour coding and storage of different waste streams. It also provides advice on how to avoid producing waste in the first place.

Importance of waste segregation

Segregation of waste at the point of production into suitable colour-coded receptacles is vital for good waste management. Health and safety, carriage and waste regulations require that waste is handled, transported and disposed of in a safe and effective manner. The colour-coded waste segregation guidance in the paragraphs that follow represents best practice and ensures compliance with existing law.

In some circumstances, further segregation of waste into sub-categories may also be required, for example in the case of chemically incompatible materials or medicines.

Container labelling

Each container must be labelled in accordance with legal requirements for transporting and packaging the waste.

The container labels should clearly identify the waste type(s) in them. The purpose of labelling is to ensure that waste such as anatomical waste and medicines not transported in non-specific yellow bins with subsequent mismanagement.

Container colour coding

The colour-coded segregation system outlined in this section identifies and segregates waste on the basis of categories of waste and appropriate treatment/disposal options. All waste that requires incineration must be handled by a suitable authorised or licensed facility.

Proper segregation of different types of waste is critical to safe management of healthcare waste and helps to manage the cost of waste management. The use of colour coded receptacles is key to good segregation practice.

Colour	Description
Yellow	Waste that requires disposal by incineration.
Orange	Waste that may be treated.
Purple	Cytotoxic and cytostatic waste.
Yellow/black	Offensive/hygienic waste (landfill).
Red	Anatomical waste for incineration.
Black	Domestic (municipal) waste. (recyclable components).
Blue	Medicinal waste for incineration.
White	Amalgam waste for recovery.

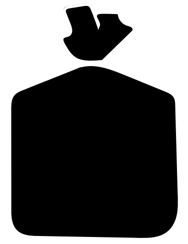
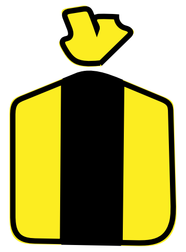
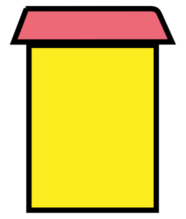
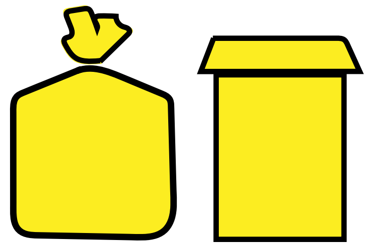
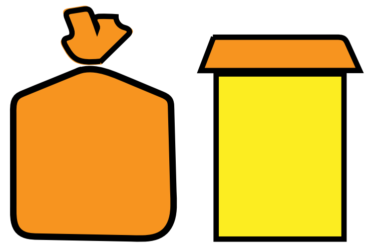
Sourced from Ref 45 Chapter 7 Guidelines.

Waste management and disposal

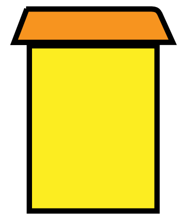
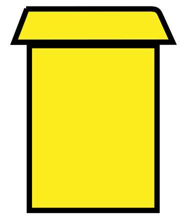
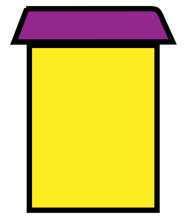
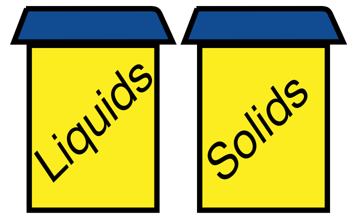
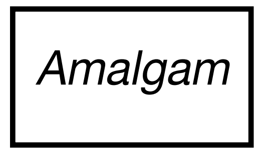
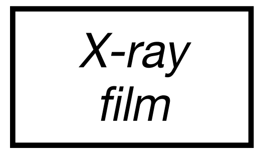
The following table can be used as a summary guide to waste management. It identifies waste types, with examples, required waste receptacles, degree of hazard, waste disposal method.

The table has been sourced from "Management and disposal of healthcare waste (HTM 07-01)" ***ref 45, Chapter 7. Guidance***. ***Ref. 45***, should be considered when developing a waste management policy. If different local or national requirements exist they must be followed.

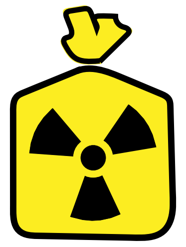
WASTE EFFICIENCY

Waste type	Example description	Waste receptacle	Waste receptacle	Hazardous?	Waste management requirements	Additional comments.
Mixed municipal waste.	Domestic type waste.		Black bag.	No.	Landfill Municipal incineration Energy from waste Other authorised disposal or recovery	Hazardous waste may not be inserted into this waste stream. Recycling should be considered.
Offensive/hygiene waste (healthcare).	Offensive/hygiene waste from human/animal healthcare.		Yellow and black striped bag.	No.	Landfill Municipal incineration Energy from waste Other authorised disposal or recovery	This is restricted to offensive waste from healthcare and related activities (including autoclave waste from laboratories).
Offensive/hygienic waste (municipal).	Offensive/hygienic waste (municipal).					This includes municipal hygiene wastes from primary care settings.
Infectious Anatomical waste. Chemicals present.	Clinical waste, human/animal anatomical, chemical preserved, for incineration only.		Red-lidded, rigid yellow container.	Yes.	Clinical waste incineration.	Note: If the waste is not classified as infectious then: • Tissue preserved in chemicals is still clinical waste and transport requirements may be determined by the chemical preservatives, and • Where not preserved in chemicals, tissue would not normally be clinical waste.
Infectious Anatomical waste. No chemical present.	Clinical waste, human/animal anatomical, not chemically preserved, for incineration only.					
Other Infectious clinical waste containing chemicals.	Clinical waste, infectious, containing chemicals from human/animal healthcare, for incineration only.		Yellow bag or yellow-lidded, rigid yellow container.	Yes.	Clinical waste incineration.	Note: Waste chemicals must not be placed in this waste stream. This waste stream is for infectious materials containing or contaminated with chemicals (e.g sample vials and used diagnostic kits).
Infectious/anatomical waste. No chemicals present.	Clinical waste, infectious, from human/animal healthcare, suitable for alternative treatment.		Orange bag or orange-lidded, rigid yellow container.		Clinical waste incineration.	This assumes healthcare, offensive and domestic wastes are also separately segregated.

WASTE EFFICIENCY

Waste type	Example description	Waste receptacle	Waste receptacle	Hazardous?	Waste management requirements	Additional comments.
Non-medicinally contaminated sharps	Clinical waste, sharps, infectious, non-medicinally contaminated, suitable for alternative treatment.		Orange-lidded, rigid yellow container.		Alternative treatment Or clinical waste incineration	This assumes healthcare offensive and domestic wastes are also separately segregated.
Other, medicinally contaminated sharps.	Clinical waste, mixed sharps and pharmaceutical waste (not cytotoxic or cytostatic), infectious, for incineration only.		Yellow-lidded, rigid yellow container.		Clinical waste incineration.	Note: This may include associated vials, bottles and ampoules of medicine.
Cytotoxic and cytostatic sharps.	Clinical waste, mixed sharps and cytotoxic and cytostatic waste, infectious, for incineration only.		Purple-lidded, yellow sharps box.		Clinical waste incineration.	Note: This may include associated vials, bottles and ampoules of cytotoxic and cytostatic medicines.
Medicines other than those that are cytotoxic and cytostatic (in original packaging).	Clinical waste, medicines (not cytotoxic or cytostatic) from animal/human healthcare, for incineration only.		Two blue-lidded, rigid yellow containers (one for solids, one for liquids).		Clinical waste incineration.	For separately collected municipal fractions (e.g. outpatient returns to pharmacies).
Dental amalgam	Dental amalgam and mercury including spent and out-of-date capsules, excess mixed amalgam and contents of amalgam separators.		Leak-proof rigid container with Hg suppressant		Recovery	Where teeth containing amalgam are present, H9: Infectious may also apply
Photographic (X-ray) wastes (cont.)	X-ray film containing silver.				Recovery	

WASTE EFFICIENCY

Waste type	Example description	Waste receptacle	Waste receptacle	Hazardous?	Waste management requirements	Additional comments.
Gypsum and plaster-cast waste	Non-infectious gypsum and plaster waste from healthcare	Gypsum			Gypsum recovery or specialist landfill in separate gypsum cell	See supporting text under ‘Gypsum and plaster casts’ for advice on the small proportion of this material that may be infectious clinical waste
Radioactive waste	Healthcare waste. Contaminated with radioactive material				Incineration in hazardous waste incineration facility subject to Radioactive Substances laws (local)	

WASTE EFFICIENCY

5.4 | OTHER DOMESTIC (NON-HEALTHCARE RELATED) WASTE

The last Appendix to this report identifies waste management requirements for the full range of non-healthcare related waste items and streams that may be produced in a healthcare facility.

This waste is subject to the same management and recycling requirements than any other urban or municipal waste.

6

Well-Being & Safety Healthcare Infrastructure

6.0 | CONTENTS OF THIS SECTION.

1. Well-Being Recommendations
This chapter presents a summary of the key systems that affect human well-being. The recommendations are sourced from the the “WELL Building Standard™ International framework.

2. COVID 19 Prevention Recommendations
Summary of recommended steps to prevent the spread of COVID 19 infection within healthcare facilities. These recommendations are internationally sourced and focus on ventilation and water systems.

3. Fire Safety infrastructure
Healthcare facilities are required to follow good international design standards in relation to fire safety because some patients are immobile. Fire safety design features and fire protection infrastructure are essential to the good design and operation of a hospital or healthcare facility.

6.1 | WELL-BEING HEALTHCARE OPERATION RECOMMENDATIONS

INTERNATIONAL WELL BUILDING INSTITUTE™

The impact of building operation on well-being.

Human health and well-being should be at the centre of Hospital and Healthcare Facility design.

Healthcare facilities care for the most vulnerable and strategies for their design and operation must address the needs of the sick and recovering, creating conditions that are conducive to healing by alleviating stress, mitigating the spread of disease, providing nutritious food and improving occupant comfort.

The “WELL Building Standard™” international framework, from the International WELL Building Institute | IWBI ™ takes a holistic approach to health in the built environment addressing behaviour, operations, and design. The WELL Standard is grounded in medical research that explores the connection between buildings and their health and wellness impacts on occupants.

The Standard recommends, through a certification scheme, different design considerations for buildings, aiming to create a built environment that improves the nutrition, fitness, mood, sleep patterns and performance of its occupants.

Appendix A1 to this guide includes selected recommendations that impact the Energy and Water infrastructure systems of a healthcare facility. For further information about the standard see ***reference 52 (chapter 7: Guidance***). It should be noted that these recommendations apply to all types of building. There is as yet no WELL Standard Guidelines specific to healthcare facilities.

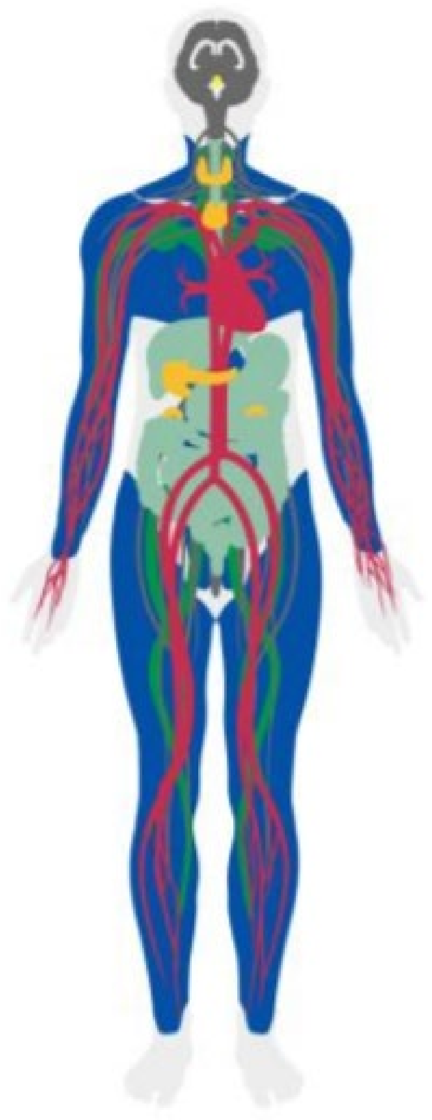


Figure 29: Air Supply and Water Supply quality levels recommended by the WELL Standard can improve human health.

Body Figure and icon are sourced from the International WELL Building Institute™ WELL™ Standard documentation (All rights reserved).

6.2 COVID-19 RECOMMENDATIONS FOR HEALTHCARE FACILITY OPERATION

A summary of the recommendations in REHVA © COVID-19 Guidance (***ref 19 chapter 7: Guidance***) is set out below. REHVA is the Federation of European Heating, Ventilation and Air Condtioning Associations, its recommendations are internationally accepted.

These operational recommendations help to prevent the spread of the COVID 19 virus in the air and also guard against water infection risks in a COVID-19 environment. A summary of operation recommendations in the guide (ref 19) are shown below:

1. Ventilation rates
2. Ventilation operation times
3. Overrule of demand control settings
4. Window opening
5. Toilet ventilation
6. Windows in toilets
7. Flushing toilets
8. Recirculation
9. Heat recovery equipment
10. Fan coils and split units
11. Heating, cooling and possible humidification setpoints
12. Duct cleaning
13. Outdoor air and extract air filters
14. Maintenance works
15. Indoor air quality (IAQ) monitoring
16. Recommended ventilation rates (hospitals).
17. Specific recommendations for patient rooms.

A more detailed description of these measures can be seen in Appendix A1 to this report.

REHVA
Federation of European Heating, Ventilation and Air Conditioning Associations

Source REHVA ©

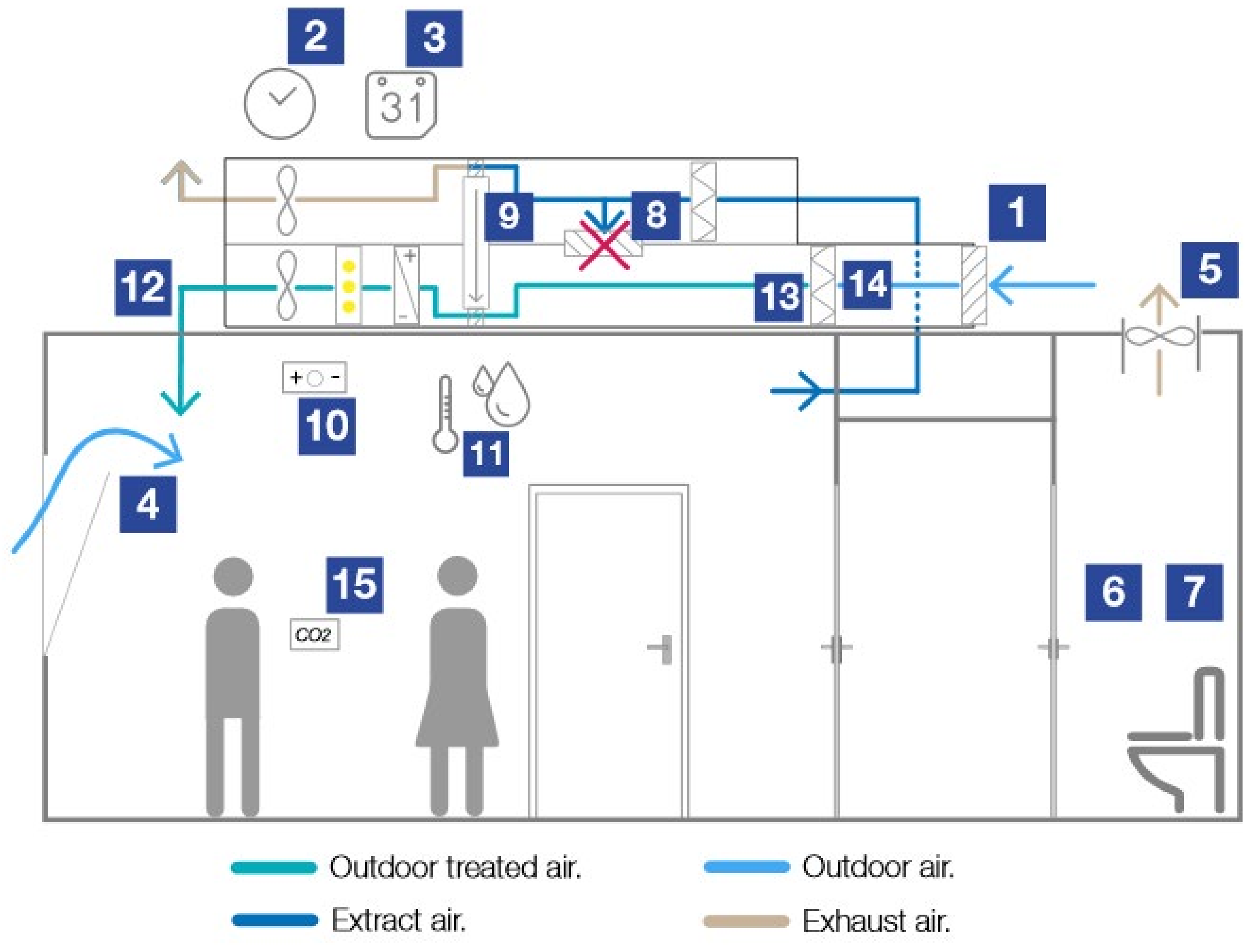


Figure 30: Schematic of recommendations (figure derived from Rehva Covid-19 guidance document).

6.3 FIRE SAFETY INFRASTRUCTURE

Fire safety design features and fire protection infrastructure are essential to the good design and operation of a hospital or healthcare facility. Key fire safety infrastructure is identified as follows:

Fire Detection and Fire Alarm Systems, Fire Water Supply Systems Fire Hydrant Systems, Fire Extinguishers, Fire Hoses, Dry Column Systems, Fixed Automatic Sprinkler Systems, Fixed Foam Extinguishing Systems, Fixed Powder Extinguishing Systems, Fixed Gas Extinguishing Systems, Smoke and Heat Control Systems, Emergency Lighting Systems, Maintenance & Periodic Inspections.

Appendix 2 contains a more detailed description of this infrastructure and applicable design criteria. Appendix 2 also provides further high level information on fire safety design and construction.

7

Guidance & Standards

7.0 | OBJECTIVE & CONTENTS OF THIS CHAPTER.

This chapter contains a review of applicable standards, guidelines, requirements and studies highlighting international best practice.

Different types of standards and guidance

The standards and guidance in this chapter are classified based on the following sections of the Guide:

- Energy Efficiency Guidance that provides information on energy efficiency approaches for new-build and existing buildings.
- HVAC Guidance that gives information about adequate ventilation design for healthcare premises, including infectious disease areas.
- Water Efficiency Guidance applicable to healthcare buildings and water-borne infection prevention guidance.
- COVID 19 prevention guidance.
- Fire protection guidance.
- Waste Management guidance.

Key standards. “ ✓ ”

The review of standards shown below, uses the ✓ symbol to identify key documents that readers are advised to read and review in more detail to complement the material in this Guide.

Bibliography Reference	Type	Key Document?	Type of Building	Organisation	Name	Description & Source
1	Energy Efficiency	✓	Healthcare	ASHRAE	Advanced Energy Design Guides (AEDG) for Large Hospitals. Achieving 50% Energy Reduction	ASHRAE Guide containing energy efficiency design recommendations for new and existing healthcare facilities. Many of the recommendations in this Guide have been taken from the ASHRAE guide: https://www.ashrae.org/technical-resources/aedgs/50-percent-aedg-free-download.
2	Energy Efficiency	✓	General	ASHRAE	Standard 100-2018, Energy Efficiency in Existing Buildings	The standard includes recommended ventilation rates for healthcare facilities. Source https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards.
3	Energy Efficiency	✓	General	ASHRAE	Standard 189.1-2017, Standard for the Design of High-Performance Green Buildings	Energy efficiency standard for green buildings, not limited to hospital buildings. Source: above.
4	Energy Benchmarks	✓	General	CIBSE	Guide F: Energy efficiency in buildings (2012)	Energy efficiency standard for buildings in general.
5	Ventilation. COVID-19 Guidance	✓	COVID-19 Guidance	REHVA	COVID-19 guidance	This guidance document describes operational measures for use in healthcare facilities to prevent the spread of COVID-19. Most of those measures related to ventilation and water quality.
6	Operational Energy Policy		Healthcare	UK Government	Health Technical Memorandum (HTM 07-02) Part A.	Making energy work in healthcare . (HTM) 07-02 provides guidance on managing responsible energy use within the health sector.
7	Energy Policies		Healthcare	UK Government	Health Technical Memorandum 07-02. Part B. EnCO2de 2015 -	Making energy work in healthcare. Procurement and energy considerations for new and existing building facilities.
8	Energy Efficiency		Healthcare	Ademe - France Agence de la transition ecologique.	L´energie des hopitaux et cliniques. Des conseils pour agir	Energy Efficiency guidance for hospitals. https://www.ademe.fr/entreprises-monde-agricole/performance-energetique-energies-renouvelables/dossier/lenergie-hopitaux-cliniques/conseils-agir
9	Energy Efficiency		Healthcare	AFD - France	Website. Agence Française de Développement. Health and Energy Efficiency towards greener hospitals.	Agence Française de Développement's Programme for Energy Efficiency in Buildings.
10	Energy Efficiency		Healthcare	Arup	Net Zero Carbon Healthcare Guide.	High level Arup guide to designing new net zero healthcare facilities.
11	Energy Efficiency		Healthcare	EPTA Ltd & EU Funded	Guidelines for Energy Efficiency in Hospitals.	Hospital Energy Efficiency Guidelines.

Bibliography Reference	Type	Key Document?	Type of Building	Organisation	Name	Description & Source
12	Energy Efficiency		Healthcare		The Green Guide for Healthcare (2010)	Hospital Energy Efficiency Guide
13	Energy Efficiency		Healthcare		Energy Efficiency Lighting Technical guide.	Energy Efficiency guide for lighting design
14	Energy Efficiency		Healthcare		Relevant best practice case studies, including from the EBRD region (e.g. the PPP Hospital Programme in Turkey).	EBRD Best Practice case studies
15	Energy Efficiency		Healthcare	WHO	Emergency pandemic hospital designs as provided by the WHO.	
16	Energy Efficiency		General	CEN standards	Relevant provisions of standards related to energy efficiency in buildings - ISO 52000-1, 52003-1, 52010-1, 52016-1 and 52018-1	International energy efficiency standards
17	Circular Economy Building Services		General	Arup	Circular economy design guide: Guide to Building Services Design inspired by the 'cradle to cradle' concept	Circular economy guidance from Arup that addresses building services. For information only
18	Energy Efficiency		General	hospitecnia.com	Energy efficiency in IT Services	Energy availability and energy efficiency in critical facilities with IT scheme. Source https://hospitecnia.com
19	Energy Efficiency		Steam production	Bosch	BOSCH Steam boilers efficiency guide	Energy Efficiency guide for the design of Steam systems. Steam Systems can be found in hospitals serving the sterilisation departments or as part of heating plant. https://www.bosch-thermotechnology.com/global/en/commercial-industrial/service/technical-documentation/technical-guides/
20	Net Zero Carbon Design Guide	✓	General	LETI	Climate Emergency Design Guide	Net zero building design recommendations for the UK. Source: https://www.leti.london/cedg
21	Net Zero Carbon Design Guide	✓	Offices	ASHRAE	Net Zero Guide for Small Offices	Net zero building design recommendations for offices in the USA. Very advanced guide that we recommend. Its principles are applicable to all types of buildings. Some of the ventilation systems will not be relevant to healthcare facilities. https://www.ashrae.org/technical-resources/aedgs/zero-energy-aedg-free-download
22	Net Zero & Benchmarks		General	EU	CRREM Tool	Recommendations for net zero building design in Europe. For policy makers only

V

Bibliography Reference	Type	Key Document?	Type of Building	Organisation	Name	Description & Source
23	Energy Benchmarks		General & Healthcare	US Government	Building energy performance database	This database gives information about energy benchmarks for different types of buildings in different climatic conditions. Very useful guide to identify energy benchmarks for healthcare facilities based on the particular climatic conditions of a facility. https://bpd.lbl.gov/
24	Net Zero Carbon Design Guide	✓	General	UK Green Building Council	Building the Case for Net Zero. Guide to net zero development	Net zero building design recommendations for the UK. https://www.ukgbc.org/ukgbc-work/building-the-case-for-net-zero/
25	Worldwide Climatic Zones	✓	General	ASHRAE	Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings	State-of-the-art standard that gives information about how to design efficient buildings in general (not healthcare specific).
26	Health and Safety. Biosecurity			WHO	WHO Guidance on Implementing Regulatory Requirements for Biosafety in Biomedical Laboratories	https://www.who.int/topics/medical_waste/manual_bioseguridad_laboratorio.pdf
27	Ventilation Design Guide	✓	Healthcare	ASHRAE	Standard 170-2017, Ventilation of Healthcare Facilities	Ventilation design guide for healthcare facilities from ASHRAE
28	Ventilation Standard		Healthcare	CEN standards	N 1605 Ventilation for Hospitals or relevant parts of standards relating to energy efficiency in buildings - ISO 52000-1, 52003-1, 52010-1, 52016-1 and 52018-1	Ventilation standards.
29	Ventilation. COVID Guidance	✓	COVID-19 Guidance	REHVA	Water infection and Ventilation COVID-19 prevention guidance	For all type of buildings, including hospitals. Note REHVA may update this document frequently
30	Healthcare ventilation		Healthcare	ASHRAE	Manual A09 Healthcare Facilities	
31	Healthcare ventilation		COVID-19 Guidance		Guidelines for the classification and design of isolation rooms in Healthcare facilities, Victorian Advisory Committee on Infection Control 2007.	http://docs2.health.vic.gov.au/docs/doc/4AAF777BF1B3C40BCA257D2400820414/$FILE/07030
32	Healthcare ventilation		Healthcare	ASHRAE	ASHRAE Standard 170-2013	Healthcare Ventilation standard. For example, it contains recommended ventilation rates and filtering levels for healthcare facilities.
33	Healthcare ventilation		Healthcare	German Standard	VDI 6022 Hygiene and Hygiene Inspections of HVAC Systems	https://www.vdi.de/richtlinien/unsere-richtlinien-highlights/vdi-6022

Bibliography Reference	Type	Key Document?	Type of Building	Organisation	Name	Description & Source
34	Healthcare ventilation		Healthcare	WHO	Infection prevention and control in healthcare when coronavirus disease (COVID-19) is suspected or confirmed.	https://www.who.int/publications/i/item/WHO-2019-nCoV-IPC-2020.4
35	Healthcare ventilation		Healthcare	CDC	CDC Guidelines for Environmental Infection Control in Healthcare Facilities	https://www.cdc.gov/infectioncontrol/guidelines/environmental/appendix/air.html#tableb2 12
36	Ventilation guide		Healthcare	UK Government	Health Technical Memorandum 03-01 – 'Specialised ventilation in healthcare premises'	Healthcare Ventilation standard. For example, it contains recommended ventilation rates and filtering levels for healthcare facilities.
37	Ventilation Equipment Efficiency Directive.		General	European Commission	European ErP-Directive 2009/125/EC (energy-related products directive), also called the Ecodesign Directive	The Directive stipulates the minimum requirements for energy-related products. The objective of the ErP Directive is the reduction of energy consumption and CO2 emission rates and an increase in the overall share of renewable energies. For example, the efficiency (thermal or electric) of all building ventilation units (AHUs) has to comply with the minimum required energy efficiency for use in the EU required by the directive.
38	Water services design guide		General	UK Government	Health Technical Memorandum 04-01: Safe water in healthcare premises	Best practice in water services design and operation.
39	Water efficiency	✓	General	UK Government	Water management and water efficiency (HTM 07-04)	Best practice water efficiency guide. https://www.gov.uk/government/publications/water-management-and-water-efficiency-best-practice-advice-for-the-healthcare-sector
40	Online guide to water efficiency		General	US Government	Best practice water efficiency guide.	
41	Water-efficient equipment	✓	All	European Union	Efficient Equipment flow rates	Relevant water appliances will need to meet the flow rates identified by the EU Water Label. http://www.europeanwaterlabel.eu/pdf/scheme-march2019-en.pdf Details of flow rates and testing method: http://www.europeanwaterlabel.eu/pdf/scheme-march2019-en.pdf
42	Water-efficient equipment		Healthcare	UK Government	HTM-00: Policies and principles of healthcare engineering.	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/299276/HTM_00.pdf
43	Steam boiler controls		All	Safety Assessment Federation & Others (UK)	Guidance on Safe operation of Steam boilers	Sourced 2020 https://www.safed.co.uk/wp-content/uploads/2019/04/BG01-Edition-2-2019.pdf

Bibliography Reference	Type	Key Document?	Type of Building	Organisation	Name	Description & Source
44	Steam boilers, water and energy efficiency		All	Bosch	Steam boiler systems	Manual on efficiency of steam boilers https://www.safed.co.uk/wp-content/uploads/2019/04/BG01-Edition-2-2019.pdf
45	Waste Management	✓	Healthcare	UK Government	Management and disposal of healthcare waste (HTM 07-01)	Best practice guide to waste management and ways to improve the environment and carbon impacts of managing waste.
46	Waste Management	✓	Healthcare	Spain	SESCAM Waste Management Protocol	Best practice guide to waste management and ways to improve the environment and carbon impacts of managing waste. https://www.chospab.es/enfermeria/Documentos/Protocolo_Residuos.pdf (in Spanish)
47	Waste Management	✓	All	EU	European Waste Catalogue (EWC)	The EWC is produced by the European Commission to provide common terminology for describing waste throughout Europe. The EWC is reviewed periodically and incorporates the European Hazardous Waste List pursuant to the Waste Directive 91/689/EEC.
48	Waste Management		Healthcare	Spain	Waste Management Protocol - Junta de Extremadura	Practice guide as an example. (In Spanish).
49	Electrical (HV) Safety		Healthcare	UK Government	Electrical safety guidance for high voltage systems in healthcare premises (HTM 06-03)	Electrical safety guidance for high voltage systems in healthcare premises.
50	Fire Safety		Healthcare	UK Government	Fire safety in the design of healthcare premises (HTM 05-02)	Health Technical Memorandum (HTM) 05-02 provides information on fire safety in the design of new healthcare buildings and extensions.
51	Fire Safety	✓	Healthcare	Spain	Codigo Tecnico Edificacion & Real Decreto de Instalaciones de Proteccion contraincendios	Fire protection building design code in Spain. Covers health facilities and all other types of building. https://www.codigotecnico.org/DocumentosCTE/SeguridadEnCasoDeIncendio.html
52	WELL Being Standard	✓	Healthcare	Well Being institute	WELL being recommendations	WELL is the state-of-the-art tool or guide for promoting health and well-being in buildings globally. https://resources.wellcertified.com/tools/
53			Healthcare	Health Service Executive	Procedure for maintenance plan.	Maintenance Plan that assists in the provision of an efficient and safe environment for the delivery of Health Care https://www.hse.ie/eng/services/publications/pp/corporate-services/estates/104.pdf

A1

Appendix 1
Well-being & COVID-19 operational infection control recommendations

A1.0 | WELL-BEING & COVID 19 RECOMMENDATIONS

1. Well-Being Recommendations

Summary of the key system implementations that affect human well-being. These recommendations have been taken from the international framework of the WELL ™ Standard.

2. COVID 19 Prevention Recommendations

Summary recommendations for the prevention of the spread of COVID 19 infection within healthcare facilities. The recommendations focus on ventilation and water systems.

A1.1 | WELL-BEING HEALTHCARE OPERATIONAL RECOMMENDATIONS

The impact of building operation on wellbeing.

Human health and wellbeing is at the core of Hospital and Healthcare Building design. The “WELL™ Building Standard” international framework takes a holistic approach to health in the built environment addressing behaviour, operations and design. The WELL™ Standard is grounded in a body of medical research that explores the connection between buildings and their health and wellness impacts on occupants.

The Standard recommends different design considerations for buildings aiming to create a built environment that improves the nutrition, fitness, mood, sleep patterns and performance of its occupants.

The following pages include a selection of those recommendations that have an impact on the Energy and Water infrastructure systems of a hospital building or healthcare facility. For further detail on the standard refer to ***ref.52 chapter 7: Guidance***. It should be noted that the recommendations apply to all types of building. The WELL™ Standard for healthcare facilities has not yet been issued.

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Selected Air Quality Recommendations

Air Quality Standards
Pollutants generated indoors can lead to a variety of symptoms and health conditions. Air quality in a building should be measured to check that the following limits in the standard for each pollutant are not exceeded (refer to Appendix A1.2) Out of range levels require corrective action, such as more filters in air handling units or increased ventilation rates.

No Smoking
Smoking and the use of e-cigarettes should be prohibited indoors and near entrances, openable windows and air intakes.

Ventilation Effectiveness
Ventilation rates should comply with the requirements of ASHRAE 62.1-2013 or an equivalent standard. For healthcare facilities, ASHRAE 170 Ventilation for Healthcare facilities also applies.

In areas where it is allowed (not medical areas therefore), demand-controlled ventilation can be used to regulate the ventilation rate of outdoor air to ensure carbon dioxide levels in the space are kept below 800 ppm. HVAC systems should be tested and balanced after completion.

WELL Building Standard: selected Water Quality recommendations

Fundamental Water Quality Requirement
All water delivered to the project area, except water not for human contact, must meet the turbidity and bacteria level requirements of the standard (refer to Appendix 1.2). Filtering can be used to achieve compliance.

WELL Building Standard: selected lighting recommendations.

Visual Lighting Design
The WELL™ Standard sets light levels for basic visual performance which require the ambient lighting system to be able to maintain different light intensity based on the type of the activity of the space.

Circadian lighting design
Light is one of the main drivers of our circadian rhythm, which originates in the brain and regulates physiological rhythms throughout the body’s tissues and organs, affecting hormone levels and the sleep-wake cycle.

The WELL™ Standard requires artificial lighting to include a certain level of “melanopic lux”, within a range of light frequencies, that affects the circadian system of patients and staff. The standard includes a method to calculate the melanopic lux level for each type of luminaire.

A1.2 | WELL STANDARD . TESTING PARAMETERS.

Air Quality Standards

Pollutants generated indoors can lead to a variety of symptoms and health conditions. Air quality should be measured to check that the following limits per pollutant are not exceeded:

- Formaldehyde: below 27 ppb.
- Total volatile organic compounds: below 500 µg/m³.
- Carbon monoxide: below 9 ppm.
- PM10: below 15 µg/m³.
- PM2.5: below 50 µg/m³.
- Ozone: below 51 ppb

Selected recommendations for Water Quality Parameters

Fundamental Water Quality

All water supplied to the project area, except water not for human contact, must meet the following requirements:

- Turbidity of the water sample is less than 1.0 NTU.
- Coliforms (including E. coli) are not detected in the sample.

Source :International WELL Building Institute™ WELL™ Standard documentation (All rights reserved).

Inorganic Water Contaminants

All water supplied to the project area for human consumption, which must include at least one water dispenser per project, must meet the following limits:

- Lead: below 0.01 mg/L. 53
- Arsenic: below 0.01 mg/L. 54
- Antimony: below 0.006 mg/L. 54
- Mercury: below 0.002 mg/L. 54
- Nickel: below 0.012 mg/L. 43 f. Copper: below 1.0 mg/L.

Organic Water Contaminants

All water supplied to the project area for human consumption, which must include at least one water dispenser per project, must meet the following limits:

- Styrene: below 0.0005 mg/L. 45
- Benzene: below 0.001 mg/L. 44
- Ethylbenzene: below 0.3 mg/L. 44
- Polychlorinated biphenyls: below 0.0005 mg/L. 54
- Vinyl chloride: below 0.002 mg/L. 54
- Toluene: below 0.15 mg/L. 44
- Xylenes (total: m, p and o): below 0.5 mg/L. 53
- Tetrachloroethylene: below 0.005 mg/L.

Further detail o the previous and other well-being parameters can be found in the WELL™ Standard reference, available at https://www.wellcertified.com/

Figure 31: Water treatment equipment is usually required for hospital mains if water quality does not meet standards.

Figure 32: Example. Circadian Lighting Control in a Hospital can adapt lighting to patients' circadian rhythms.

A1.3 | COVID-19 PREVENTION GUIDANCE

COVID-19 Recommendations for Healthcare Facility Operation

This section summarises international guidance (source: REHVA) on the operation and use of building services during the coronavirus pandemic (COVID-19), to prevent the spread of COVID-19 through HVAC (Heating, Ventilation, and Air Conditioning) or plumbing systems. The advice in the following paragraphs summarises the recommendations in the REHVA COVID-19 Guidance Document and should be treated as provisional; it covers all types of building, except the last section that applies to healthcare environments.

For more detail refer to the guidance included in the chapter 7: Guidance & Standards. This Guidance Reference (REHVA guide) should also be reviewed in the future in case of further updates.

REHVA Federation of European Heating, Ventilation and Air Conditioning Associations

Source REHVA ©.

Practical measures for the operation of building services during an epidemic

1. Increase air supply and exhaust ventilation

In buildings with mechanical ventilation systems, extended operating times are recommended. Adjust the settings of system timers to start ventilation at the nominal speed at least 2 hours before the building opening time and switch to a lower speed 2 hours after the end of building use time.

2. Use openable windows more frequently.

The general recommendation is to stay away from crowded and poorly ventilated spaces. In buildings without mechanical ventilation systems, it is advisable to open openable windows much more than normal, even when this it makes a space feel cold.

3. Humidification and air-conditioning have no practical effect.

The transmission of some viruses in buildings can be altered by changing air temperatures and humidity levels to reduce the viability of the virus. In the case of SARS-CoV-2, this is unfortunately not an option as coronaviruses are quite resistant to environmental changes.

4. Safe use of heat recovery systems

Virus particle transmission via heat recovery devices is not an issue when an HVAC system has a twin coil unit or another heat recovery device that guarantees 100% air separation between the return and supply sides.

5. No use of central recirculation

Viral material in extract (return) air ducts may re-enter a building when centralised air handling units are equipped with recirculation sections. It is generally recommended to avoid central recirculation during SARS-CoV-2 episodes: close the recirculation dampers either using the Building Management System or manually.

6. Room level circulation

In rooms with fan coils only or split units (all-water or direct expansion systems), the first priority is to achieve adequate outdoor air ventilation. In such systems, mechanical ventilation is usually independent of the fan coils or split units and there are two possible means of ventilation:

- Opening windows and installing CO_2 monitors to measure outdoor air ventilation;
- Installation of a standalone mechanical ventilation system (either local or centralised, depending on technical constraints).

7. Duct cleaning has no practical effect.

Duct cleaning is not effective against COVID 19 room-to-room infection because the ventilation system is not a contamination source if the guidance given on heat recovery and recirculation is followed.

8. Changing external air filters is not necessary
Modern ventilation systems (air handling units) are equipped with fine outdoor air filters immediately after the outdoor air intake (filter class F7 or F88 or ISO ePM2.5 or ePM1), which effectively filter particulate matter from the outdoor air. That means that standard fine outdoor air filters provide reasonable protection against low viral concentrations and occasional occurrence of viral material in outdoor air.

9. Safety procedures for maintenance personnel
HVAC maintenance personnel may be at risk when conducting scheduled maintenance, inspection or replacement of filters.

10. Room air cleaners and UVGI can be useful in specific situations.
Room air cleaners remove particles from the air, which has a similar effect to ventilation with outdoor air. To be effective, air cleaners need HEPA filter efficiency, i.e. they need to have a HEPA filter as the last step. Special UVGI disinfection equipment can be installed in return air ducts in systems with recirculation, or installed in-room, to inactivate viruses and bacteria.

11. Toilet lids
If toilets have lids, it is advisable to flush the toilet with the lid closed.

12. Risk of Legionellosis after shut-down
Prolonged low use or periods of non-use can lead to stagnation of water in parts of the HVAC and water systems, increasing the risks of an outbreak of Legionnaires' disease (Legionellosis) on resumption of full operation.

13. Internal Air Quality (IAQ) monitoring
The risk of indoor cross-contamination via aerosols is very high when rooms are not well ventilated. If ventilation control requires occupant involvement (hybrid or natural ventilation systems) or there is no dedicated ventilation system in the building, installing CO_2 sensors in occupied zones is recommended to detect underventilation.

14. Recommended Ventilation rates (hospitals)
In hospitals with an excellent 12 air changes per hour (ACH) ventilation rate, aerosol transmission is mostly eliminated; but in poorly ventilated spaces, it may be dominant.

In Hospitals: Ventilation of patient rooms

For normal areas/patient rooms:
Standard patient rooms not intended for patients with infectious diseases need at least 4 air changes per hour (ACH). - If ventilation is used to prevent transmission, ACH settings should be adjusted for isolation rooms, where adequate ventilation is considered to be at least 6 ACH (equivalent to 40 L/s/patient for a 4x2x3 m^3 room).

For isolation rooms with airborne infections:
Air must be exhausted directly to the outdoors, using HEPA filter when possible to avoid possible cross-contamination if the exhaust air outlet are near windows or outdoor air intakes. - Ensure supply air ducts are independent of the common building supply air system. - The supply airflow rate should be 6-12 ACH (e.g. equivalent to 40-80 L/s/patient for a 4x2x3 m^3 room) for existing isolation rooms, ideally at least 12 ACH for new-build. The recommended negative pressure differential is ≥5 Pa to ensure that air flows from the corridor into the patient room.

Extract air from the patient room and toilet should not be recirculated and returned to the room. - Fit a local audible alarm or local visual signal to warn of fan failure and loss of negative differential pressure.

A separate exhaust system for each room that removes a volume of air greater than the volume from the supply system. - If possible, an anteroom or air lock should be used.

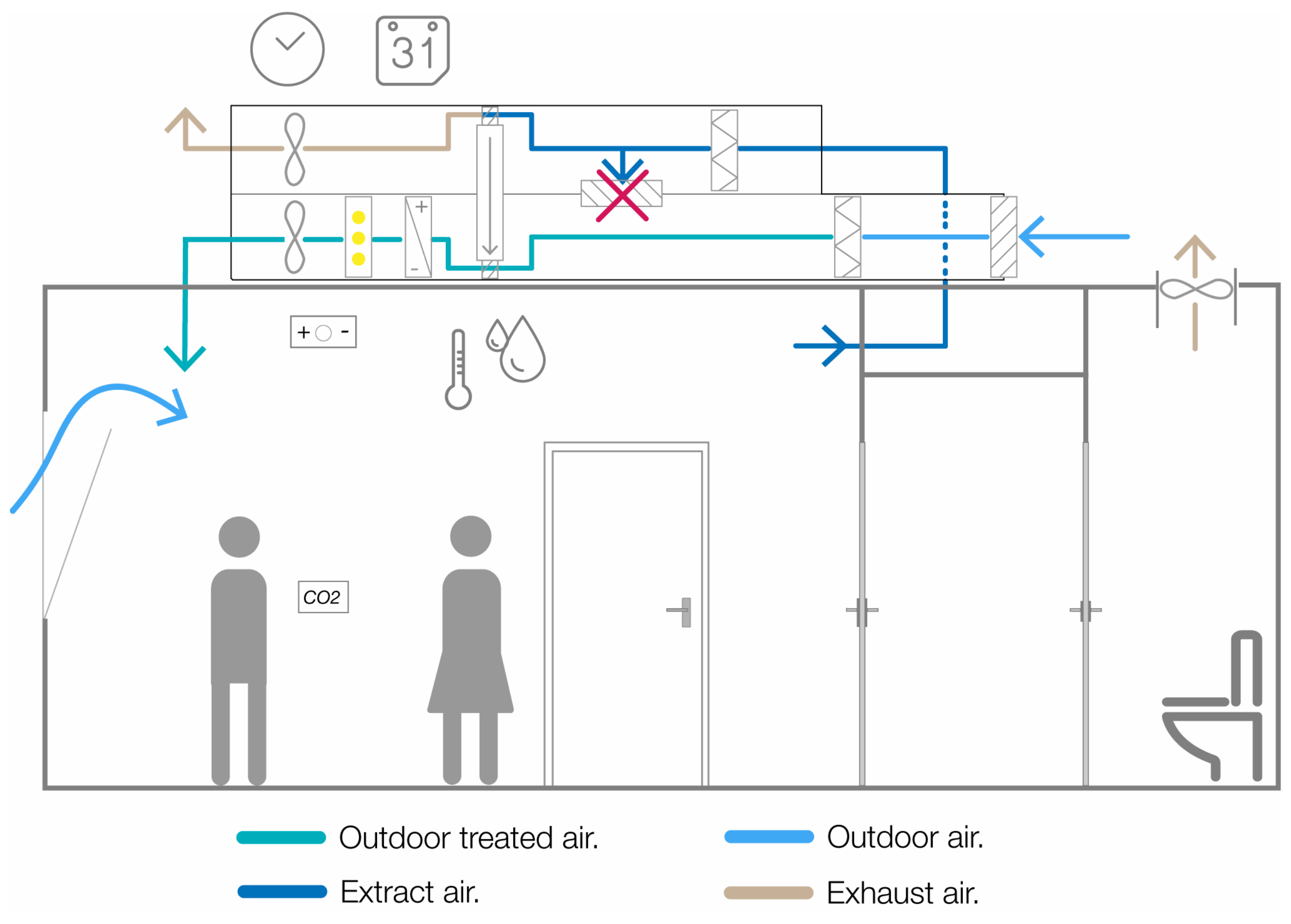


Figure 30: Schematic of recommendations (figure derived from Rehva Covid-19 guidance document).

A2

Appendix 2
Fire Safety Infrastructure

A2.0 | OBJECTIVE & CONTENTS OF THIS SECTION.

Healthcare facilities are required to follow international good design standards in relation to fire safety because some patients are immobile.

Fire safety design features and fire protection infrastructure are essential to the good design and operation of a hospital or healthcare facility.

This chapter identifies key fire protection design guidance, systems or elements based on international standards or international good practice guidance applicable to Hospital buildings and healthcare facilities.

The recommendations focus specifically on fire safety in the design of new healthcare facilities and major refurbishments of existing buildings.

While not intended to cover every possible scenario or comply with every local regulation, the standards and principles presented in this chapter are intended to give a useful overview, recognising that fire safety in healthcare facilities is dependent on the interaction between physical fire precautions, the dependency of the patient, specific fire hazards and the availability of sufficient, appropriately trained staff to safely evacuate patients in the event of a fire.

A2.1 | CONTENTS OF THIS SECTION

The first section of this chapter describes the principal fire protection systems and describes design considerations relevant to hospitals based on specific applicable building regulation (***ref 51 Chapter 7: Guidance***).

The second section makes recommendations about building layout, based on the same standard (***ref 51 Chapter 7: Guidance***).

The recommendations are for information. This Guide is not intended to cover all possible fire safety infrastructure that might be relevant to the design of a hospital, but to identify key infrastructure.

Incorporating these recommendations in the construction of a new or a refurbished hospital should first be reviewed by the project designer & fire consultant, ensuring compliance with local regulations, standards and the local fire department requirements.

Figure 34: Great Ormond Street Hospital, UK.

A2.2 | FIRE PROTECTION DEVICES AND SYSTEMS.

This section gives further detail of 15 active fire protection systems and devices that can be used in hospital and healthcare building design.

Fire Detection and Fire Alarm Systems

This first infrastructure proposed combines three different systems: automatic fire detection, manual fire alarms and alarm communication systems.

Figure 35: Fire protection devices and systems.

Design Principles

These systems should be planned and designed to comply with locally applicable regulation. That said, indicative parameters for fire detection and alarm systems in hospital settings are as follows:

- Use smoke detectors and manual fire alarms that trigger local alarms, general alarms and voice alarms.
- Hospitals with more than 100 beds should have a direct telephone line to the local fire service
- An automatic fire detection system should be installed in hospitals with a built area in excess of 2000 m^2.
- The alarm system should emit visual as well as sound signals.

Figure 36: Manual fire alarm.

Fire Water Supply Systems

Fire water supply systems are comprised of a set of water sources (e,g. water storage), supply devices (pump sets) and a distribution network to ensure that one or more specific fire protection system (e.g. sprinklers or hoses) are supplied with the required water flow and pressure during the time required.

Design Principles

Planning and design principles should reflect local building codes or other recognised standards such as NFPA 20. For pumps sets vary significantly in both the safety mechanisms and the type of valves used, and different pump sets may be required by different standards. Water storage is usually divided across at least two tanks to allow one to be maintained while the other one remains in service.

Figure 37: Fire water supply systems.

Fire Hydrant Systems

Fire hydrant systems are composed of a network of pipes linking underground hydrants.

Design Principles
Hydran location around the building and water flow capacity of these units should be compliant with the site local requirements. The following recommendations could also be followed:

Figure 38: Fire hydrant.

- Fire hydrants should be easily accessible, away from traffic and car parks and clearly signposted.
- The horizontal distance to a hydrant in urban areas should be 100 m. In all other areas 40 m is recommended.
- One hydrants should if possible be located at the entrance to the building.
- Any specific local requirements should be confirmed.
- The flow rate of each hydrant nozzle should be equal to or greater than 500 L/min.
- Hydrants can be connected to the public water supply, if local requirements and/or fire officials permit; if not permitted, a dedicated fire water supply system within the facility will be required.

Recommended hydrant density for hospitals:

- Install one fire hydrant if the total built area is greater than or equal to 2000m^2 and less than or equal to 10,000 m^2.
- Install one additional fire hydrant for every additional 10,000 m^2 or fraction of 10,000 m^2.

Fire Extinguishers

“Portable” fire extinguishers can be carried by hand and weigh less than 20 kilograms; “mobile” fire extinguishers, are manually operated but moved on a wheeled trolley.

Design Principles
Design considerations include:

- Fire extinguishers should be easily visible and accessible.
- Fire extinguishers should be located in close proximity to areas with the highest fire risk.
- In areas of the hospital with particularly high risk that have a built area greater than 500 m^2, one mobile fire extinguisher with 25 kg of powder or CO should be installed for every 2,500 m^2 of surface area.
- Fire extinguishers should be placed close to the emergency exits.
- Fire extinguishers should be placed on supports fixed to vertical walls, so that the upper part of the fire extinguisher is 80-120 cm from the floor, measuring from the top. Note: This is a recommendation, the legally required installation height may vary from country to country.
- Fire extinguishers on each floor of the hospital should be at a maximum distance of 15 m from any emergency exit.

Figure 39: Fire extinguisher.

Fire Hoses

Fire hose infrastructure includes the fire water supply and pipework connecting the water supply to the fire hoses. Design considerations regarding diameter and length are:

- Hoses should have a 25 mm inner diameter for semi-rigid hoses and a 45 mm inner diameter for flat hoses.
- Flat hoses should be 20 m long, while semi-rigid hoses should be slightly longer at 30 m.
- In all hospital settings, fire hoses should be 25 mm.

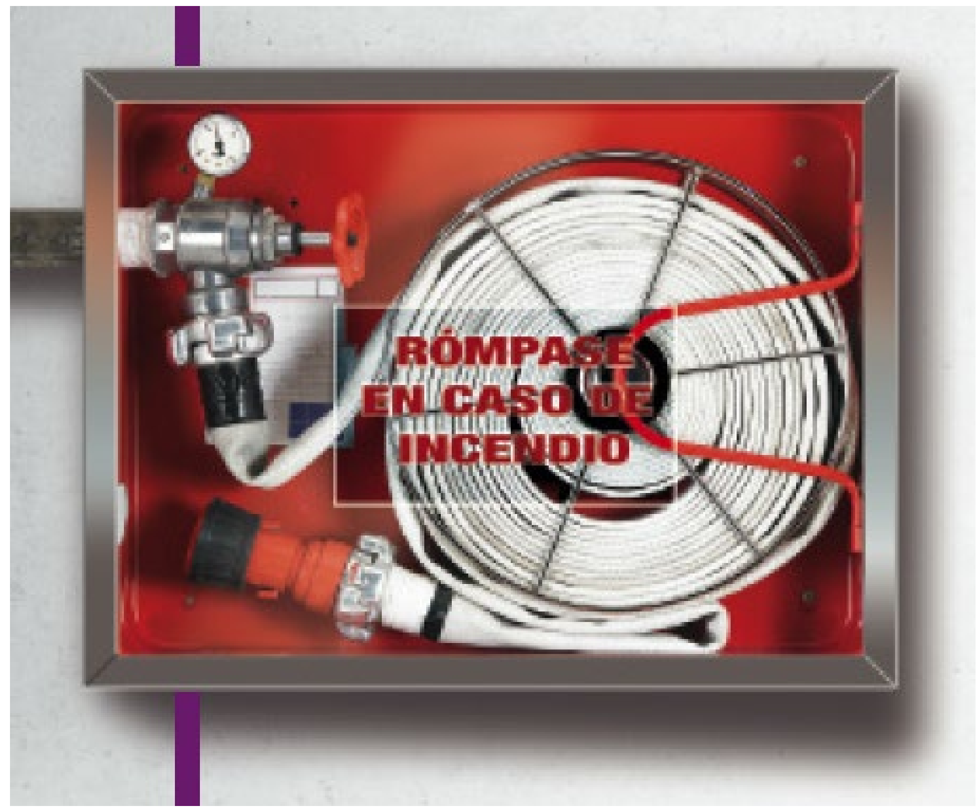


Figure 40: Fire hose.

Typical Location and Distribution of Fire Hoses

Design considerations regarding location and distribution are as follows:

- Fire hoses should be mounted on a rigid base, so that the nozzle and the manual opening valve and the cabinet opening system, if any, are at or below 1.50 m from the floor.
- Fire hoses should be located at or within 5 m from the fire exits, measured along an evacuation route.
- The number and distribution of the fire hoses in open-plan and divided spaces should be such that the entire area of the fire compartment in which they are installed is covered by at least one fire hose, with the shortest distance less than or equal to 50 m, regardless of whether the hose exceeds 20 m in length.
- A fire hose located in one fire compartment cannot cover part of the area of a different compartment or any part of a floor other than floor on which it is located.
- It is not necessary to install fire hoses in a hospital kitchen with an installed power greater than 50 kW, as the main fire risk in this setting is from liquid fuels, not solids.

Dry Column Systems

Water connection on the façade or in an area easily accessible by the Fire Department, marked “EXCLUSIVE USE OF FIRE FIGHTERS”, equipped with a pipe column and floor connections.

Design Principles

The following design considerations should be taken into account:

- Dry column systems should be considered in hospitals where the evacuation height is greater than 15 m.
- Each building should have enough of dry columns to give a maximum distance of 60 m or less from wherever a person may be to the nearest dry column following an evacuation route.
- Each ascending or descending column will have an independent nozzle on the façade or will be easily accessible by the Fire Department. The area should be free of obstacles and appropriate signs should be easily visible to the driver of a fire engine.
- Ascending dry column systems should have outlets on even floors up to the eighth floor and on all floors above that.

Figure 41: Dry column system.

Fixed Automatic Sprinkler Systems

Fixed automatic sprinkler fire-extinguishing systems have open nozzles for spraying water. They require a greater volume of water than conventional sprinklers but offer faster extinction. The principal main components of these systems are: water supply pipework, control station and discharge nozzles.

Design Principles
The design principles for automatic sprinkler fire extinguishing systems should follow EN 12845 and the following:

- There are different type of sprinkler systems and the selection must be compliant with locally applicable requirements.
- This type of system should be installed in any building with an evacuation height greater than 80 m.
- This type of system should be considered for hospital kitchens with an installed power greater than 20 kW.
- WATER SPRAY systems or water mist systems are a variant of sprinkler systems and are more expensive. Water spray systems could be used for highly sensitive IT rooms.

Figure 42: Fixed automatic sprinkler.

Fixed Foam Extinguishing Systems

These systems discharge mixtures of water, foaming agents (via dosing or supply equipment) and air from the supply air to the generators. They are used to protect fuel oil tanks for emergency generators or boilers.

Design Principles
Design Principles should follow the EN 13565-2 standard.

The system has the following main components: network of pipes, foam storage tank, dispenser or supplier and discharge nozzles. As this is a fixed fire-extinguishing system, the same design principles apply as for automatic sprinkler and water spray systems.

Figure 43: Foam system.

Fixed Powder Extinguishing Systems

These are systems that use powder (a chemical extinguishing agent that may be the same as the agents used in manual fire extinguishers).

As they are fixed fire-extinguishing systems, the same principles apply as for automatic sprinkler and water spray systems. For example, powder systems may be used to protect fuel oil boiler burners.

Figure 44: Fixed Powder Extinguishing system.

Fixed Gas Estinguishing Systems

These systems release gases of varying composition and are particularly suitable for the protection of items such as **computer systems**, given that they cause less incidental damage compared to water or powder systems. They may also be used in kitchen areas

The gas can be released either by automatic detectors or manually. They can only be used in areas are well sealed enough to allow the concentration released to be effective.

Figure 45: Fixed gas extinguishing system.

Design Principles
Design Principles should follow the EN 15004-1 standard, together with the relevant standard from the EN 15004 series depending on the extinguishing agent used (CO_2 systems follow ISO 6183).

These systems have the following main components: drive devices, operational controls, pressurised gas containers, distribution pipes and discharge diffusers.

These systems can only be used when the safety or evacuation of personnel is guaranteed. The triggering mechanism should include a delay and a warning alarm to allow occupants to evacuate before the release of the extinguishing agent. As they are fixed fire-extinguishing systems, the same design principles apply as for automatic sprinkler and water spray systems.

Note: Common extinguishing gas currently on the market are NOVEC 1230 and FM 200 (registered trade names).

Smoke and Heat Control Systems

These systems limit the effects of heat and smoke in the event of a fire, extracting the hot gases generated at the start of a fire and creating smoke-free areas underneath layers of floating smoke, thus facilitating the evacuation of occupants and facilitating extinguishing efforts.

Heat and smoke control systems are subdivided into four subgroups, depending on the strategy followed. Two of them are shown as follows:

Hot gas buoyancy (buildings with high ceilings).
Also known as smoke control and evacuation systems. Composed of a set of openings (natural aerators) or mechanical extraction equipment (mechanical aerators) for the extraction of smoke and hot gases from combustion, clean air intake openings or mechanical fans for the supply of clean air and, where appropriate, smoke control barriers, sized so as to generate a smoke-free layer above the floor local to the fire and maintain the average temperature of the smoke within acceptable levels.

Smoke extraction (in car parks or after activation of a fire suppression system).
Direct systems for extracting the smoke generated during a fire, operating during and/or after it, preferably by means of mechanical extractors and a network of ducts; the capacity of the system is defined by its refresh rate per hour or other metrics.

Figure 46: Smoke & heat control systems.

Emergency Lighting Systems

Emergency lighting installations must ensure that lighting is provided in corridors and near emergency exits in the event of failure of normal lighting in order to ensure the safety of people evacuating the building. Emergency lighting must also allow fire-fighting equipment and means of protection to be seen.

Luminescent Signalling Systems

Systems to allow location of fire protection equipment and facilities. These systems are intended to provide information about the location of fire protection equipment and facilities for manual use, in case of failure of the normal lighting. They include signs identifying the position of fire protection equipment and facilities.

Maintenance & Periodic Inspections

The installation and commissioning of fire systems, can only be carried out by an authorised installer certificate and contracted maintenance provider. In cases where the inspection of active fire protection installations is not subject to specific legal requirements, they should be inspected at least every ten years by an Accredited Inspection Body, to assess compliance with applicable regulation.

Figure 47: Emergency lighting system.

Figure 48: Luminiscent signalling system.

A2.4 | HEALTHCARE FIRE PROTECTION LAYOUT DESIGN RECOMMENDATIONS

There follow selected recommendations for hospital building fire protection design. These recommendations have been taken from ***ref 51, Chapter 7 Guidance***. They are only examples of design principles that hospitals should incorporate in their layout designs and are by no means exhaustive. The values below are for information only. As mentioned at the start of this chapter, these recommendations are subject to local legal requirements and should be implemented by a locally authorised designer. As well, indication from the project fire consultant and requirements from the fire departament will take precedent over any recommendation that follows.

Fire compartments

Floors with wards or special units (surgery, intensive care, etc.) should be divided into at least two fire compartments, each with an area of no more than 1500 m^2 and with enough space to take all the patients from one of the adjoining compartments.

Floors with an area of less than 1500$m^2$with direct exits to a secure outdoor space and evacuation routes of no more than 25m are exempt from that requirement. In other areas of the building, the area of each fire compartment should not exceed 2500m^2.

Fire resistance

The fire resistance of walls, ceilings and doors that delimit fire compartments within hospitals can be different for underground floors and above ground floors.

Special risk zones

Special risk zones within hospitals are classified as low, medium, or high risk, depending on their built volume, with greater volume signifying greater risk.

There are three important special risk zones in a hospital: storage of pharmaceutical and clinical products, sterilisation and attached warehouses, and clinical laboratories. These areas should have fire-resistant supporting structures, fire-resistant walls and ceilings, an independent lobby in each communication zone with the rest of the building, communication doors with the rest of the building, and a maximum exit route of 25 m.

Evacuation

Floors or enclosed areas must have more than one exit.
The length of evacuation routes from their origin to a point where there are at least two alternative routes should not exceed 15 m on ward or intensive care floors. In all other hospital settings, the distance from the origin to a point where at least one alternative route exists should not exceed 15 m.

Emergency lifts

The minimum size of an emergency lift cabin should be 1.20 m x 2.10 m. In the event of power cut, power for the lift should be automatically supplied from its own power source that can operate independently for at least one hour. The required number of emergency lifts will be determined by an estimate of the number of occupants in the whole building with one emergency lift for every 1000 occupants.

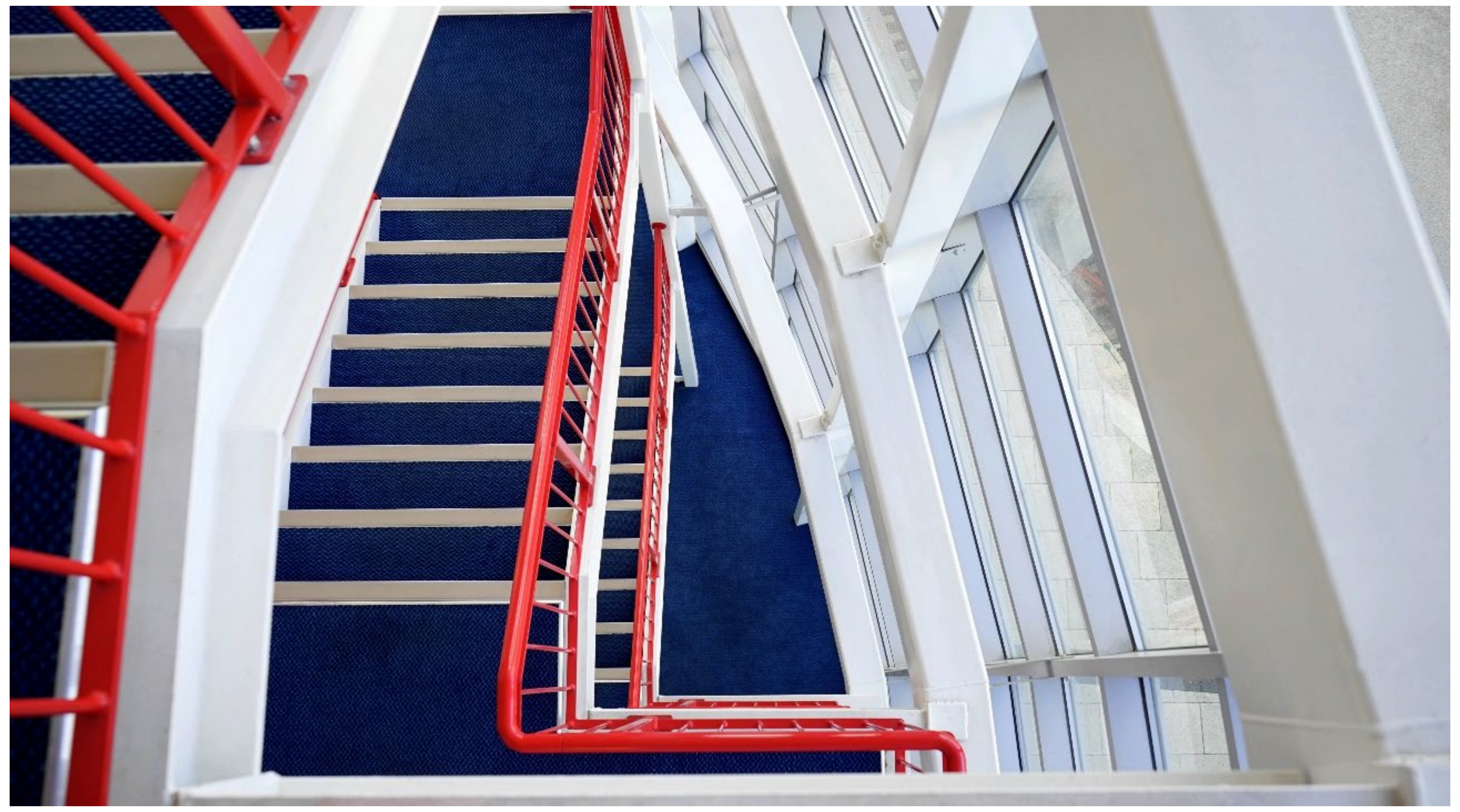


Figure 49: Hospital evacuation route.

A3

Appendix 3
Maintenance Plan

A3.0 | EXAMPLE MAINTENANCE PLAN

The following is an suggested structure for a preventive maintenance plan for a healthcare building:

Daily Tasks

- Review electric, steam, and chilled-water consumption and compare to target.
- Review BMS (Building management System) to identify any critical setpoint changes.
- Review BMS alarm list for issues.
- Review BMS information to check that all points are functional.
- Review setpoint versus actual real operation parameters to identify poor performing spaces (temperature >3 °C from setpoint).

Weekly Tasks

- Review weekly trends on air handlers, hot-water valve performance, supply and exhaust air trends, box-count trends (boxes that exceed 90% heating or cooling loop-out).

Monthly Tasks

- Coordinate and assist on any critical point calibrations.
- Review the Turn off unoccupied schedule/timings for lights and equipment. Note: Lights should be turned off by the building controls.
- Provide staff training on an energy saving topic.

Semi-annual Tasks

- Calibrate hot and cold water temperature sensors.
- Calibrate and check economy sensor and damper operation.

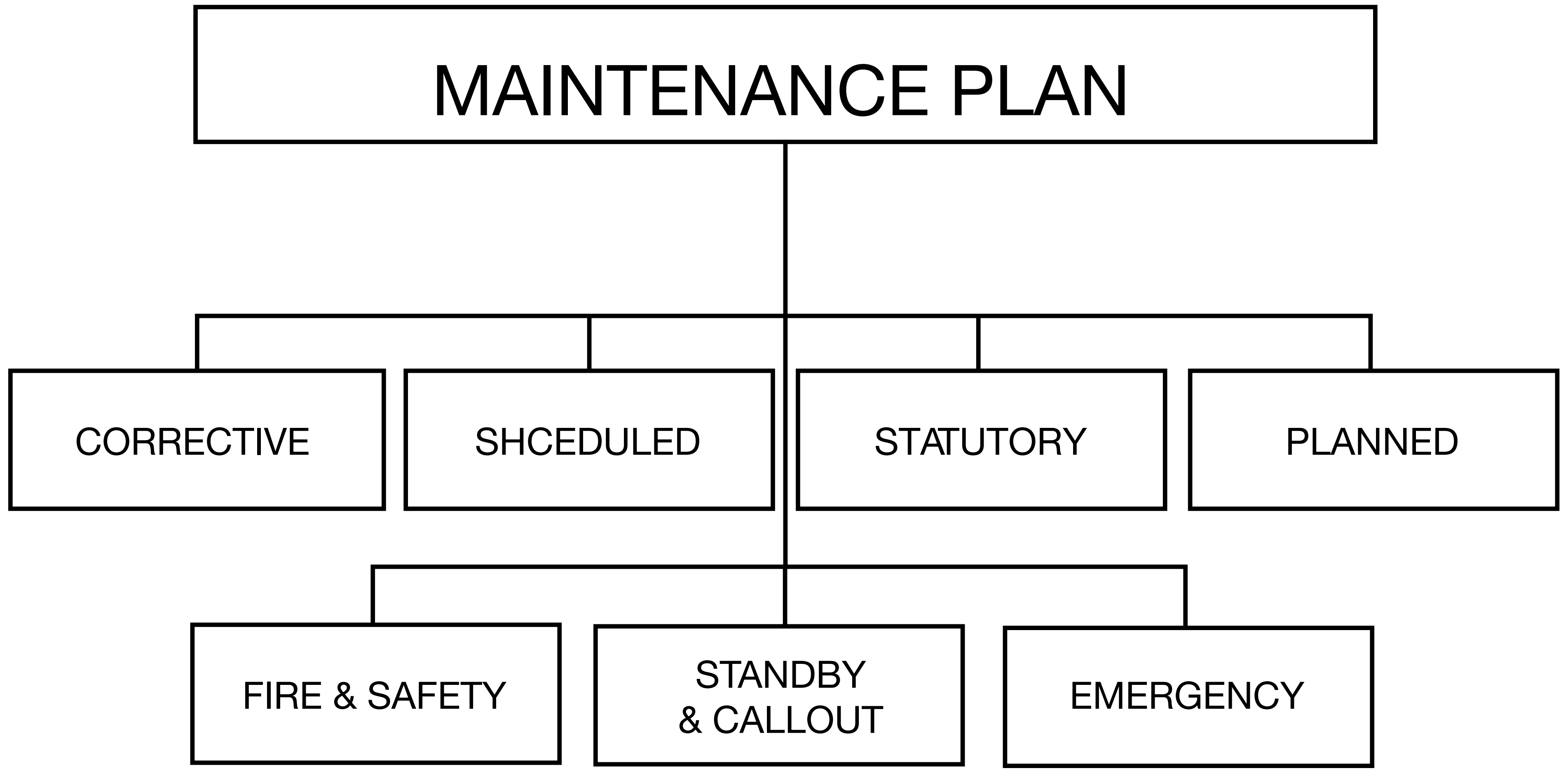
Annual Tasks

- Calibrate large air-handler discharge temperature sensors if used for control.
- Steam trap maintenance.

A comprehensive fully resourced Maintenance Plan will incorporate Property, Plant and Equipment and should include the following programmes:

- Corrective Maintenance.
- Scheduled Maintenance.
- Statutory Maintenance.
- Planned Maintenance.
- Emergency Maintenance.
- Standby and Call Out Maintenance.

Refer to chapter 7: Guidance ref. 53.



A4

Appendix 4
Insulation Values

A4.0 | INSULATION VALUES

Table 4. Minimum insulation values for healthcare facility envelope elements for different climatic zones and minimum recommended solar reflectance indexes (SRIs) for each climatic zone.

	Zone 1	Zone 2	Zone 3	Zone 4
Roof U-value - W/m²K	0.22	0.22	0.17	0.15
Frame walls above ground U-value - W/m²K	0.44	0.36	0.29	0.27
Mass walls above ground. U-value - W/m²K	0.56	0.43	0.33	0.29
	Zone 1	**Zone 2**	**Zone 3**	**Zone 4**
Windows Maximum U-value - W/m²K	2.4	2.3	1.9	1.6
Windows Maximum Shading Coefficient SHGC	0.24	0.24	0.36	0.38
Swing doors U-value - W/m²K	0.37	0.37	0.352	0.352

Table 5. Recommended colours and surface reflectance values. For interior surfaces, select light colours (white is best) with a matte finish for walls and ceilings to increase light reflectance, mitigate glare, and reduce lighting and daylighting requirements. Minimum surface reflectance values are shown below.

	Min. Reflectance
Ceiling	70%
Wall Segment	70%
Floor	20%

Source: Achieving Net zero. ASHRAE guide, Advanced Energy Design Guide for Small to Medium Office Buildings

Climatic zones, as described in Chapter 2: Energy Efficiency in healthcare facilities: New & Existing facilities are grouped by typical climatic conditions in the EBRD countries of operation:

- Zone 1: Warm and dry (SEMED).
- Zone 2: Mild marine (Mediterranean, Black Sea coast).
- Zone 3: Mild and humid (Central and Eastern Europe).
- Zone 4: Cold and dry (e.g. Mongolia, northern Central Asia).

Table 6. Minimum Equipment Cooling, Heating and Ventilation Efficiency.

	All Zones
Water-cooled chillers	6.5 COP
Cooling tower	VSD on fans
Air-cooled chiller efficiency	Meet or exceed ASHRAE/IES Standard 90.1 (ASHRAE 2016b) requirements: <150 tonnes; 10.1 EER; 13.7 IPLV @ AHRI conditions <150 tonnes; 12.2 EER; 15.5 NPLV @ 55°F chilled water temperatureVSD compressor control
Water circulation pump CHW	VSD & >16 W/gpm
Water circulation pump LTHW	VSD & >12 W/gpm
Boiler efficiency	Over 92% efficiency
Air Handling Heat recovery min efficiency	Humid (A) zones and marine (C) zones: 72% enthalpy reduction Dry (B) zones: 72% dry-bulb temperature reduction
Air Handling Heat recovery min fan efficiency	Recommended specific fan power 1.7
Fancoil Fan efficiency	<0.38 W/cfm at design

A5

Appendix 5
Energy Benchmarks

A5.0 | ENERGY BENCHMARKS

The following table presents various international energy benchmarks for hospitals. International energy benchmarks from various sources are expressed in kWh/yr-m² or MWh/yr-bed.

	Thermal electricity	Thermal energy consumpption	Electricity consumption	Thermal energy consumption	Electricity consumption
Reference	kWh/yr-m²	kWh/yr-m²	kWh/yr-m²	kWh/yr-bed	kWh/yr-bed
ASHRAE, 2012	382				
Australia		230	180	36	28.1
Belgium		270	85	30	10.5
		224	115	24	11.06
Flanders		255	100		
Wallonia		219	116		
Brussels		198	130		
Canada		620	339	42.8	23
Denmark without Greenland		175	54		
Denmark with Greenland		355	72		
Japan		414	253		
Italy				23	5
France					
The area by bed is	155	67			
- 123 m² in the public sector					
- 87.5 m² in the private sector					
Germany					
0-250 beds				24	5
251-450 beds				23	6
451-650 beds				26	6
651-1000 beds				25	6
over 1000 beds				41	13
Greece		300	110		
		299	108		
50%		265	87		
Norway		139.3	249		
Sweden		168	100	34	20
Switzerland		195	61		

	Thermal electricity	Thermal energy consumpption	Electricity consumption	Thermal energy consumption	Electricity consumption
Reference	kWh/yr-m²	kWh/yr-m²	kWh/yr-m²	kWh/yr-bed	kWh/yr-bed
Netherlands (usually local co-generation) The surface by bed is 93 m²		330	90	37	9.95
		254.9	119		
UK (2015)		500	105		
		358.2	133.4		
Hospital – clinical and research		420	90		
General Acute Hospital		311	118		
Teaching/Specialist Hospital		265	132		
US		690	240		
US-NREL – Baseline Model-Climate Zone 4A		533	729		
US-NREL – Baseline Model-Climate Zone 4B		440	742		
US-NREL - Low-Energy Models 4A		159	480		
US-NREL - Low-Energy Models 4B		73.9	406.6		

Table 1. International energy benchmarks.

International energy benchmarks sources are coded in the table using the colour coding showed below:

ASHRAE 2012, Hospitals energy saving guide for reduction of 50% of energy in hospitals

EC Energy Union, "Appendix - EPLabel WP2: Review of benchmarks and energy data", April 2005 Available: ec.europa.eu/energy/intelligent/projects/sites/iee-rojects/files/projects/documents/eplabel_energy_benchmarks_in_public_buildings_Appendix.pdf

CADDET –IEA-Hospital energy efficiency

Department of Health, UK, "Health Technical Memorandum 07-02: EnCO$_2$de 2015 - making energy work in healthcare - Part A: Policy and management", 2015, Table 8 - CIBSE TM46

Department of Health, UK, "Health Technical Memorandum 07-02: EnCO$_2$de 2015 - making energy work in healthcare - Part A: Policy and management", 2015, Table 10 – An Analysis of Display Energy Certificates for Public Buildings, 2008 to 2012 conducted by the Energy Institute of the University College London

NREL-50% energy saving in large US Hospital, 2012, based on energy modelling for a Hospital in Turkey Izmir , ASHRAE Climate category 4A, 4B

Energy Conservation for Hospital", The Energy Conservation Center, Japan - Internet URL: http://www.eccj.or.jp. According to an investigation into energy conservation use in buildings (FY2003) by the Energy Conservation Centre, Japan. Data are based on total intensity of source energy (primary energy) of 4100 MJ/yr-m² (683 kWh/yr-m²) and source energy ratio electricity/fuel 60/40%. Primary energy multiplier 2.7 for electricity and 1.1 for fuel.

A6

Appendix 6
Energy Management Analysis Matrix

A6.0 | ENERGY MANAGEMENT ANALYSIS MATRIX

See where your organisation fits. The energy management matrix shows five levels of performance. For further detail about the matrix, refer to ***Ref. 7, chapter 7: Guidance.*** (Health Technical Memorandum 07-02: EnCO2de 2015 – making energy work in healthcare, page 28).

Source: https://www.seai.ie/publications/SEAI-Energy-Audit-Handbook.pdf

Level	Energy Policy	Organising	Motivation	Information systems	Marketing	Investment
4	Energy policy, action plan and regular review, get commitment from top management.	Energy management fully integrated into management structure. Clear allocation of responsibility for energy consumption.	Formal and informal channels of communication regularly used by energy manager and energy staff at all levels.	Comprehensive system sets targets, monitors consumption, identifies faults, quantifies savings and provides budget tracking.	Marketing the value of energy efficiency and the performance of energy management both within the organisation and outside it.	Preference for ‘green’ schemes, with detailed investment appraisal of all new build and refurbishment opportunities.
3	Formal energy policy, but no active commitment from top management.	Energy manager accountable to energy committee representing all users, chaired by a member of the board.	Energy committee used as a main channel together with direct contact with major users.	M&T reports for individual premises based on submetering, but savings not reported effectively to users.	Propramme of staff awareness and regular publicity campaigns.	Same payback criteria employed as for all other investment.
2	Informal energy policy set by energy or senior departmental manager.	Energy manager in post, reporting to ad hoc committee, but line management and authority are unclear.	Contact with major users through ad hoc committee chaired by senior departmental manager.	Monitoring and tageting reports based on supply meter data. Energy unit has ad hoc involvement in budget settings.	Some ad hoc staff awareness training.	Investment using short term payback criteria only.
1	An unwritten set of guidelines.	Energy management is the part time responsibility of someone with limited authority or influence.	Informal contacts between engineer and a few users.	Cost reporting based on invoice data. Engineer compiles reports for internal use within technical department.	Informal contacts used to promote energy efficiency.	Only low-cost measures taken.
0	No explicit policy.	No energy management or formal allocation of responsibility for energy consumption.	No contact with users	No information system. No accounting for enrgy consumption.	No promotion of energy efficiency.	No investment in increasing energy efficiency of the facility.

A7

Appendix 7
Non-Clinical Waste

A7.0 | OTHER DOMESTIC (NON-HEALTHCARE RELATED) WASTE.

This section covers the full range of non-healthcare related waste items and streams that might be produced in a healthcare facility. This waste is not subject to special requirements for its management either inside or outside a healthcare setting, and is not therefore subject to different requirements from other urban or municipal waste.

Category	Description	Management
Fluorescent	These wastes could be considered non-hazardous if they are included within an Integrated Management System.	Containers and warehouses without specific requirements. Deliver to supplier when fluorescent luminaires are acquired to replace the used luminaires (new luminaire does not have to match the brand or model). If another fluorescent luminaire is not purchased to replace the used luminaires, the supplier of the luminaires to be discarded will be contacted for their removal. If it is not possible to trace the supplier of the equipment to be disposed of and it is not going to be replaced, the equipment should be disposed of by an authorised waste manager (typically for non-hazardous waste) however the authorisation required will depend on local law.
Lead Batteries	Generally from generator sets.	Situation 1: If the maintenance is carried out by an external company, the management of this waste is that company's responsibility. Situation 2: If maintenance is carried out by direct staff: Situation 2.1: If new replacement batteries are purchased to replace the old ones, the old ones will be delivered to the supplier. Situation 2,2: If new batteries are not purchased and/or the supplier of the batteries to be disposed cannot be traced the hospital should pass them to an authorised manager of this type of hazardous waste and bear the cost.
Batteries containing mercury.	Button batteries: Most of these batteries contain mercury Alkaline batteries: The mercury content is lower than for button batteries, but they need to be managed as hazardous waste. Saline batteries: They contain mercury.	They must be passed to an authorised waste manager. Generally, municipal waste authorities accept this type of waste.


Figure 50: Examples of fluorescent luminaires.

Figure 51: Examples of lead batteries.

Figure 52: Examples of batteries containing mercury.

Category	Description	Management	
Used Kitchen Oils	From cafes and kitchens.	Drums, jugs or similar supplied by authorised waste managers.	 **Figure 53:** Used cooked oil containers.
Glass	Mostly from cafeterias and kitchens.	Management in differentiated containers for subsequent recycling by the manager (private manager or waste disposal authority). It can be compacted.	 **Figure 54:** Glass containers.
Packaging	Mostly from cafeterias and kitchens.	Management in differentiated containers for subsequent recycling by the manager (private manager or waste disposal authority).	 **Figure 55:** Packaging container.
Bulky and inert waste.	Bulky waste is made up of furniture, mattresses, scrap… Waste such as soil, debris, gardening waste.	Containers and warehouses without specific requirements	 **Figure 56:** Bulky and inert waste possible containers.

Category	Description	Management	
Electrical and Electronic Equipment	These wastes may be considered non-hazardous based on previous coding ***(ref 45, chapter 7: Guidance.)***. They are considered non-hazardous when included in an Integrated Management System.	Containers and warehouses without specific requirements. Deliver to the supplier when purchasing equipment with similar characteristics to the equipment to be discarded (the brand or model does not have to match). If no equipment is purchased to replace it, the supplier of the equipment to be discarded will be contacted to proceed with its removal. If it is not possible to trace the supplier of the equipment to be disposed of and it is not going to be replaced, the equipment should be disposed of by an authorised waste manager (typically authorised to manage non-hazardous waste). Local law will determine the level of authorisation required. Note: Electrical and electronic equipment can be large or small electrical appliances: computer and telecommunications equipment, electronics, lighting devices, electrical and electronic tools, toys, sports and free time equipment, medical devices (except implanted and infected products), monitoring and control instruments (smoke detectors, heating regulators, thermostats, control panels…), vending machines.	 **Figure 57:** Electrical and Electronic waste possible containers. Electronic equipment.
Paper/Cardboard	Mostly from administrative areas, offices, warehouses, cafeterias and kitchens.	Management in differentiated containers for subsequent recycling by the manager (private manager or waste disposal authority). It can be compacted.	 **Figure 58:** Electrical and Electronic waste possible containers. Electronic equipment.
Industrial Oils and Dirty Rags.	From the maintenance operations of the facilities.	Situation 1: If maintenance is carried out by an external company, the management of this waste is that company's responsibility. Situation 2: If the maintenance is carried out by direct staff, the waste should be placed in containers (drums) supplied by an authorised waste manager.	 **Figure 59:** Paper/Cardboard containers