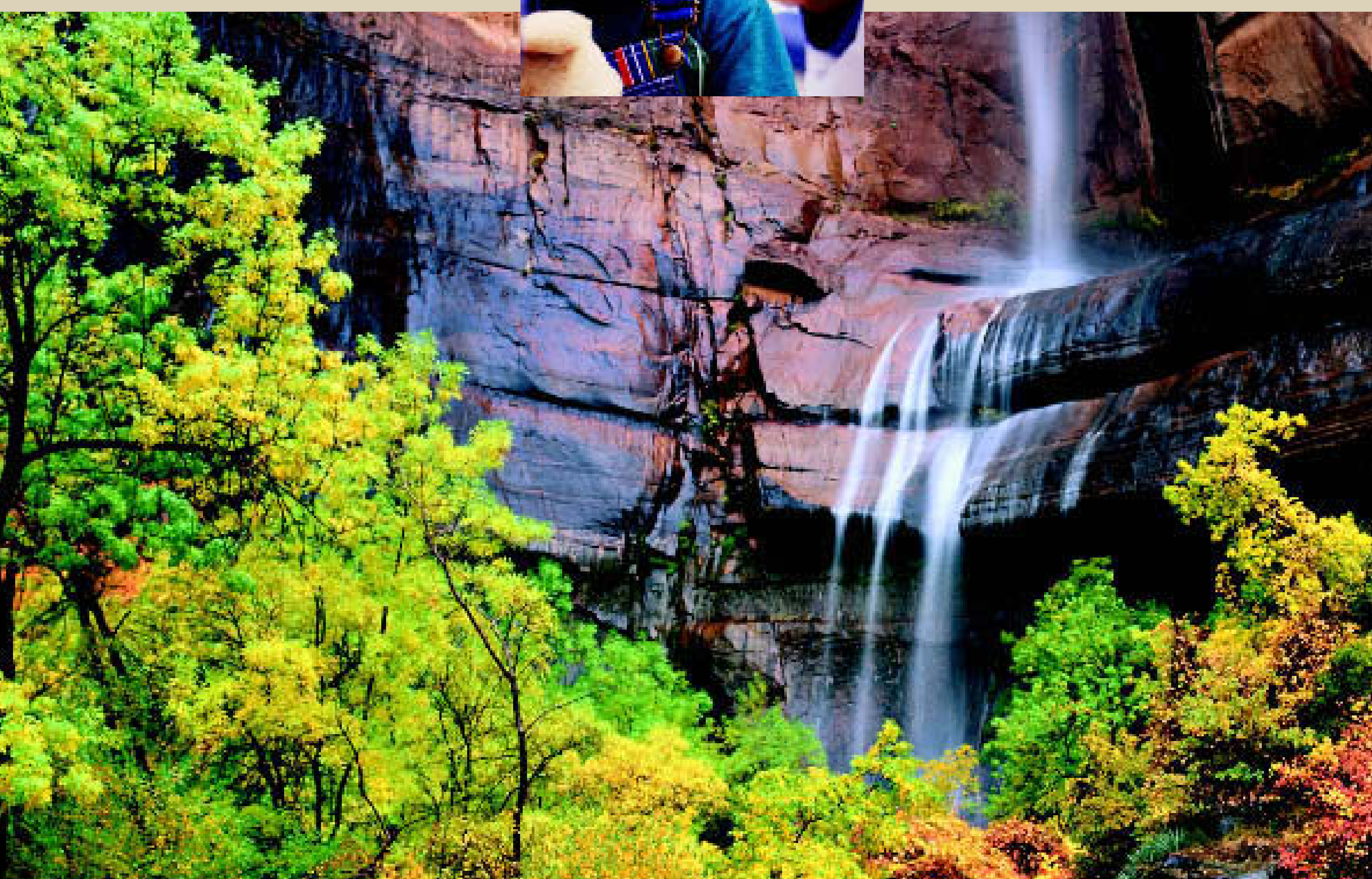
Greener Hospitals

Improving Environmental Performance



Edited by: Environment Science Center, Augsburg, Germany
With support from: Bristol-Myers Squibb Company

We would like to thank all the individuals and organizations that contributed to this manual. Reviewers included: Kai Abelkis - Boulder Community Hospital, Boulder, Colorado; Laura Brannen - Hospitals for a Healthy Environment, Lebanon, New Hampshire; Bonnie Eskenazi - The Deirdre Imus Environmental Center for Pediatric Oncology, Hackensack, New Jersey; John N. Gamble - The UTMD Anderson Cancer Center, Houston, Texas; Jill Kavoukian - Stony Brook University, Stony Brook, New York; Dr. Klaus Kümmerer - University Hospital, Freiburg Institute for Environmental Medicine and Hospital Epidemiology, Germany; Melissa Leone RN, BSN - Apria Healthcare, Hamden, Connecticut; Dr. Uta Müller - Institut für Management und Umweltschutz; Martin Scherrer - University Hospital Freiburg. Institute for Environmental Medicine and Hospital Epidemiology, Germany; Isabelle Secher - World Environment Center, Europe, Augsburg, Germany; Karen Shapiro - Tellus Institute, Boston, Massachusetts; Dr. Francesco Violante - University of Bologna, Bologna, Italy; Marian Condon - College Park, Maryland; Charlotte Burg - Gentofte County Hospital, Hellerup, Denmark; Bo Jonoe - Sonderbrog Hospital, Sonderbrog, Denmark; Erica Stewart and Kathy Gerwig, Kaiser Permanente, Oakland, California; the American Society for Healthcare Environmental Services, Chicago, Illinois; Klaus Meier - European Society of Oncology Pharmacy, Hamburg, Germany; James G. Veras - World Environment Center, Executive Vice President Emeritus, Palm Beach, U.S..

This manual has been prepared by Wissenschaftszentrum Umwelt, Augsburg, Germany, with support of Bristol-Myers Squibb.

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Supported by:
Bristol-Myers Squibb Company
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ISBN 3-00-012582-5

As a leading pharmaceutical company, Bristol-Myers Squibb's mission is ...to extend and enhance human life. The company's core values, as embodied in the Bristol-Myers Squibb Pledge, focus on sustaining and improving the lives of people throughout the world. We feel that our support of this document is tangible evidence of our firm commitment to be a global environmental leader while helping healthcare facilities become more aware of their environmental impacts and responsibilities. For more information on Bristol-Myers Squibb Company, please visit our website at www.bms.com. For more information on the Wissenschaftszentrum Umwelt University Augsburg, Germany, please visit their website at www.wzu.uni-augsburg.de.

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This manual sets forth broadbased general guidance relating to environmental management systems, and does not address all issues in any given country. With regards to country-specific legal regulatory requirements, it is the reader's responsibility to seek competent professional guidance. Editors, coordinators, supporters, suppliers and reviewers do not assume any liability.

This manual has been prepared with an environmental focus throughout the production process.
It is printed on paper made of 100 percent post consumer waste fiber, processed chlorine free, using vegetable-based inks.

Forward

Throughout the world, hospitals and other healthcare facilities are dedicated to providing innovative and compassionate patient care that meets high standards of quality in a cost-effective manner. However, in fulfilling this important mission to care for patients, healthcare facilities have an impact on the natural environment. Over the past few years, regulatory agencies and local communities have pushed for greater environmental controls within the healthcare setting. From energy conservation to the proper disposal of medical waste and the safe handling of highly potent pharmaceuticals, healthcare facilities are discovering that the adage “do no harm” is applicable not only to their patients but to the natural environment and communities around them.

Healthcare facilities across the globe are rising to this challenge by identifying and reducing the negative enviromental impact of their operations. In particular, hospitals, clinics, and doctors’ offices are adopting formal environmental management systems and sharing best practices that have been successfully used by other organizations in the healthcare sector.

This manual provides practical advice to help healthcare facilities improve their environmental management systems and performance. By clearly outlining the benefits of sharing best practices and developing formal environmental management systems, we feel that this document will better prepare healthcare facilities to meet the rising expectations of regulators and their local communities.

Key features of this manual include:

- Internet addresses for more than 40 sites that provide additional background information and case studies from Europe, Asia, and the United States
- Self-assessment checklists covering:
    - Environmental management systems
    - Laboratory, cleaning, laundry, kitchen
    - Waste management
    - Energy management
    - Hazardous substances
    - Water management
    - Wastewater management
    - Air emissions
    - Purchasing and material management

Due to space limitations, this document does not address employee health and safety issues. However, we recognize that protecting healthcare workers is an important responsibility that is connected not only to environmental stewardship, but also to the mission of healthcare facilities.

Prof. Dr. Armin Reller, Chairman Wissenschaftszentrum Umwelt, Augsburg, Germany

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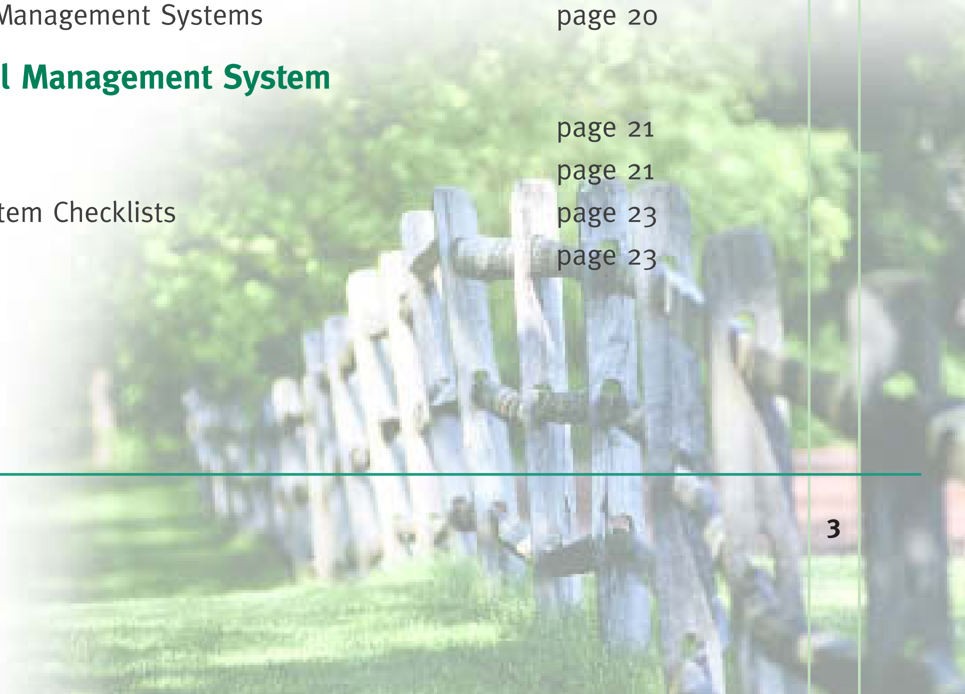


5. Specific Areas for Potential Improvement

1. Introduction

1.1. Why an Environmental Management System is Important for Healthcare Facilities

Healthcare facilities:

- generate hazardous and non-hazardous waste, air emissions, and wastewater that can, if not properly managed, contribute to air, water, and soil pollution
- rank second only to manufacturing facilities in electricity usage per square foot, in the United States[1]
- must comply with a growing number of increasingly complex regulations
- can — with help from this manual and other tools — strive to proactively minimize pollution, while increasing the quality of care, reducing risk and saving money

The global number of hospitals is not readily known, but their combined environmental impacts are significant. The American Hospital Association estimated in 1999 that there were about 6,000 hospitals in the United States alone. Also, the World Health Organization estimates that there are about 1,650 medical schools in 155 countries.

By implementing an environmental management system healthcare facilities can prevent pollution, and analyze and potentially address the life-cycle impacts of their products and services. This will allow them to more effectively comply with applicable regulations, foster good community relations, provide better healthcare services, and stay competitive within the industry.

1.2. What is an Environmental Management System and How Can It Benefit Healthcare Facilities and Their Patients?

As explained in more detail later in this manual, an environmental management system is a framework for continuous improvement that encompasses:

- establishing an environmental policy
- assessing the impacts of the organization on the environment
- implementing standards, programs and procedures
- raising awareness and changing behaviors
- measuring and auditing results
- reviewing progress and revising the environmental management system as needed

In essence, an environmental management system enables a facility to transform its environmental goals into reality.

The potential benefits of an environmental management system for the healthcare industry and the public are great. Waste disposal, energy consumption and wastewater are major hospital

[1] Environmental Challenges and Visions of Sustainable Healthcare

costs with significant potential for environmental impacts. Many healthcare facilities are unaware of the environmental effects they may create. They may not have an infrastructure or organization that includes environmental program management, or are not budgeted to implement efficient environmental management programs.

With an environmental management system, a healthcare facility can:

- identify and reduce environmental pollution
- reduce energy, water and waste disposal costs
- control the handling of hazardous substances
- limit air emissions
- improve the quality of patient care
- enhance its image as an ethical, responsible community business
- comply with applicable laws and regulations
- reduce operating costs

A healthcare facility should commit to improving its environmental performance by encouraging all employees to actively strive to reduce pollution, improve performance and cut costs. The sooner an environmental management system is established, the better positioned the facility will be for accessing future innovations and complying with new regulations.

1.3. What is Covered in the Manual?

This manual explains and provides suggestions regarding the implementation of environmental management systems for environmentally friendly activities in hospitals, doctors' offices, clinics and other healthcare facilities. It outlines how to:

- target and assess environmental impacts
- develop ways to reduce identified impacts
- gain management and staff support
- identify personnel, training and equipment requirements for implementation

The target audience for this manual includes: doctors, pharmacists, nurses, technical managers, administrators, and anyone interested in improving the environmental performance of a healthcare facility.

The overall manual is organized into six sections. Section 2 briefly describes the current situation within hospitals. Section 3 outlines the characteristics of an environmental management system, including ISO 14001 and the components of an environmental "aspects analysis." Section 4 offers some practical tips for implementing an environmental management system, while Section 5 provides an outline of specific areas for improvement. Finally, Section 6 contains a checklist to help healthcare facilities identify potential opportunities for improvement.

2. Hospitals Today

Trust is the cornerstone of a hospital's public image. To preserve and enhance this image, a hospital should develop an environmental-performance plan tailored to its unique:

- medical activities and practices
- industry competition
- environmental regulations
- culture

Good environmental practices — no longer optional — can enhance a hospital's bottom line (through cost-control and by attracting new patients), and public image, as well as a community's quality of life.

2.1. Stakeholders in Hospitals

Increasingly, hospitals are responsible and accountable to a broad network of interested parties or stakeholders who use, render, regulate and benefit from hospital services (see Figure 2.1). To promote and protect themselves, hospitals should develop clear environmental management strategies, and communicate them to all stakeholders.

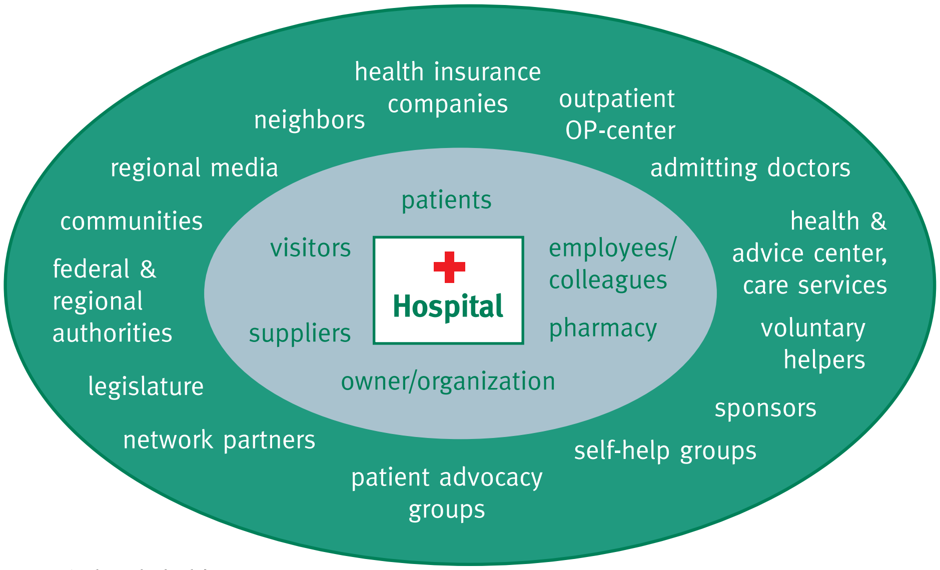


Figure 2.1 Hospital stakeholders

As the healthcare industry gets more competitive, regulated, and litigious, it must work vigorously to let the world know it is committed to protecting the environment.

Communication campaigns must emphasize good corporate citizenship. They usually include — but are not limited to — advertising, public relations and community relations. The most effective ones channel their messages to all stakeholders.

2.2. Hospitals as "Role Models"

Hospitals can serve as environmental role models, for their staff, patients, visitors, and the general public by:

- designing and maintaining energy-efficient buildings
- implementing programs to conserve energy and water
- using non-disposable, multi-use materials
- recycling paper products and packaging
- serving non-packaged food

Hospitals as well as their staff can serve as "positive examples" by promoting understanding and acceptance of environmentally responsible behavior.

2.3. Environmental Impacts and Prevention

As preventive healthcare advocates, hospitals must lead the way in environmental awareness and protection — especially now that man-made pollution has been potentially associated with increases in certain types of human illnesses, such as cancer, neurological, reproductive and developmental effects and allergies. The recent growth of environmental medicine as a medical specialty reminds us to carefully address and monitor environmental conditions in hospitals. Figure 2.2 illustrates how pollution can increase the need for medical services, which can, in turn, result in increased pollution.

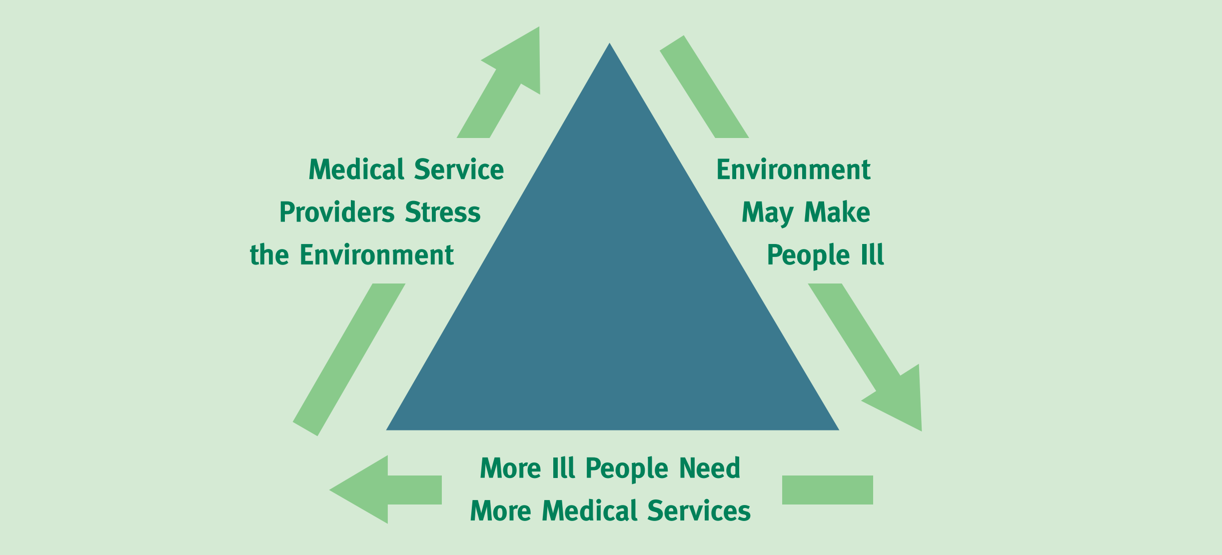


Figure 2.2 Relationship of environmental damage, increased illness, and environmental impacts of healthcare services

2.4. Evaluating and Benchmarking Environmental Impact

Hospitals consume more energy and water[2], and generate more waste, than many other industries[3]. To control costs and environmental pollution, they should develop guidelines for conserving energy and water, and for using more environmentally friendly products. Figure 2.3 demonstrates that an input-output model helps to identify environmental impacts.

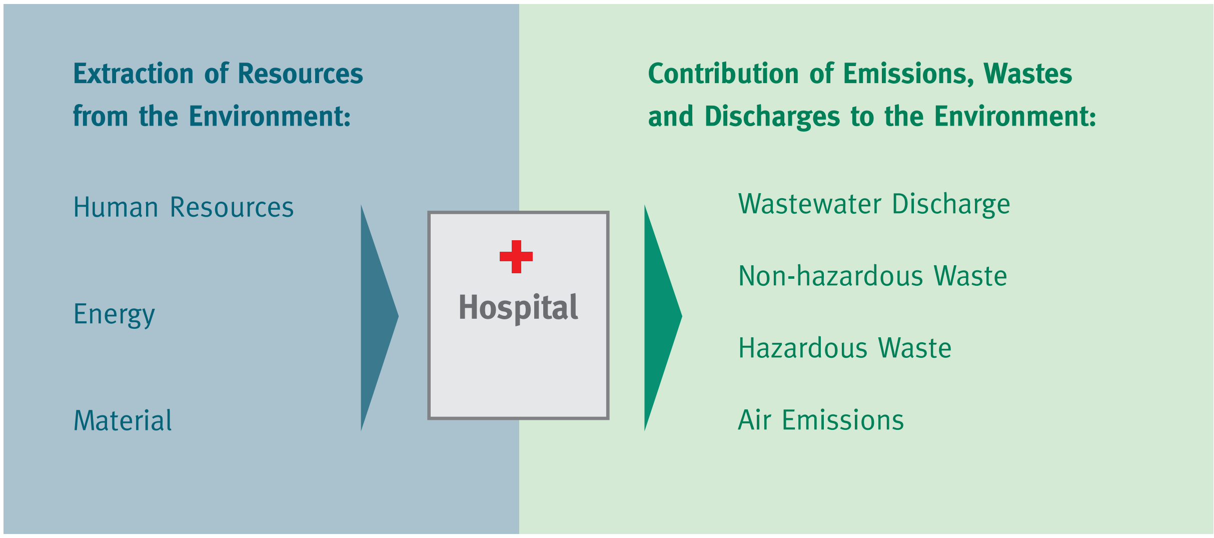


Figure 2.3 Input-output principle

2.4.1. Influence of Hospital Characteristics on Environmental Impact

The studies and interpretations in the following sections strongly suggest that the larger the hospital, the greater the opportunity to benefit from an environmental management system. This is particularly true among hospitals in Europe, the U.S., and in other developed countries.

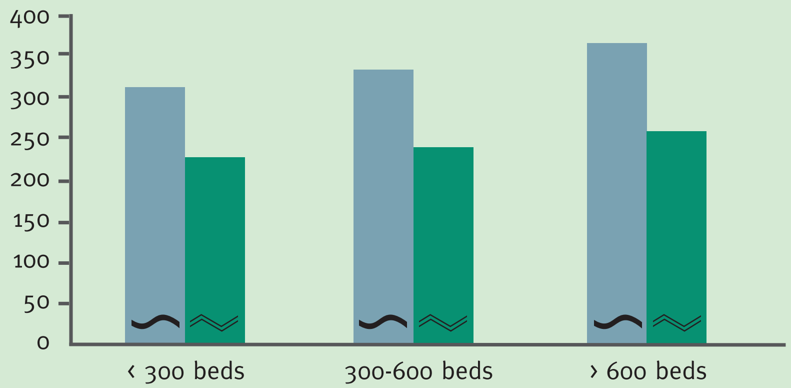
When comparing the environmental impact of different hospitals, it is important to factor in characteristics, such as:

- size
- number of beds
- age
- type of research and teaching conducted
- type of medical treatments provided (such as emergency room)
- outsourcing of procedures (such as laundry or sterilization of equipment)
- climate
- level of infrastructure development in the local community

[2] Studies conducted by Folkhard (1999), Pomp (1998), Pomp / Hackelberg (1999)
[3] Study conducted by the German Umweltbundesamt (1998)

As expected large hospitals consume more resources and produce more emissions than small ones. However, as hospitals add beds their per-bed water and energy demands may also actually increase, as illustrated in Figure 2.4.

Consumption of Water and Electricity per bed/day



	‹ 300 beds	300-600 beds	› 600 beds
Water (liter)	312	335	367
Electricity (kWh)	228	241	261

Figure 2.4 Per-bed water and electricity consumption in European hospitals grows as hospitals grow [4]

This unexpected finding has an explanation. Financial pressures constantly drive hospitals to find ways to operate more efficiently. As a result, the hospitalization period per patient is reduced, as well as the number of beds per habitant of the surrounding community. This results in more procedures being performed per day, thus increasing the environmental impact per bed even as it may be improving on a per-patient basis.

2.5. Environmental Impacts

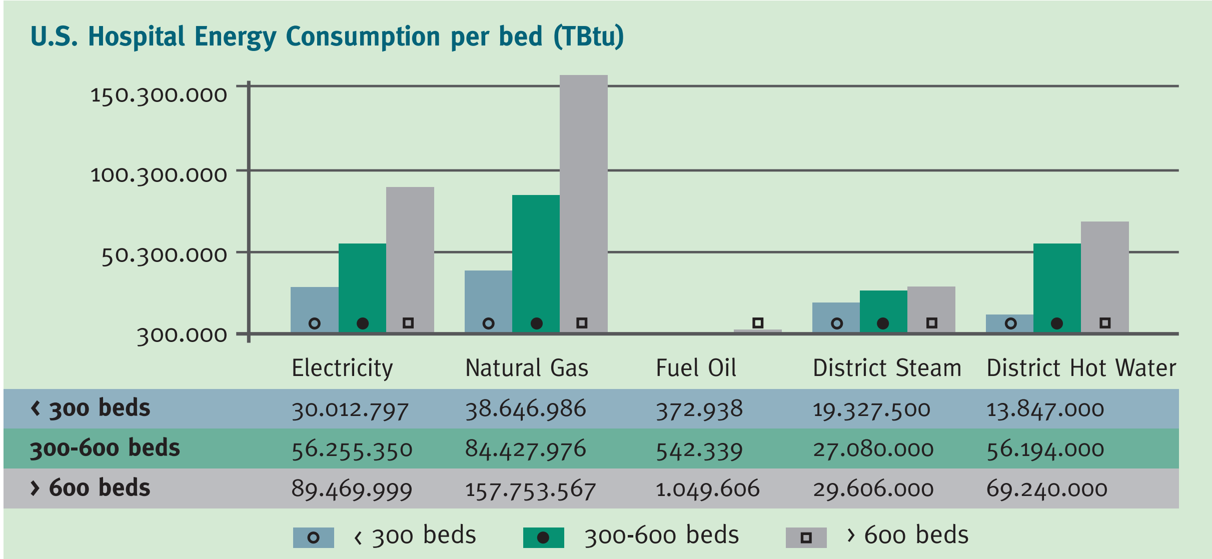
Hospitals must explore new and more efficient environmental management techniques to reduce pollution and cut costs. Hospitals can become more competitive by reducing the amount of natural resources they use. In turn, they will end up with more capital to invest in new technologies and research.

2.5.1. Energy Consumption

Many hospital managers have reported that their environmental management plan saves primary energy costs. Implementing simple energy conservation techniques (for which no special budget should be needed) can save 10% of primary energy consumption [5]. To identify areas of potential savings, high-cost energy categories should be targeted and monitored.

[4] IMU, Study of 30 European Hospitals (2002)
[5] CADDET - Energy Efficiency in Hospitals, Maxi Brochure 05 – www.caddet-ee.org

Figure 2.5 demonstrates overall that smaller hospitals utilize smaller amounts of energy.



	Electricity	Natural Gas	Fuel Oil	District Steam	District Hot Water
‹ 300 beds	30.012.797	38.646.986	372.938	19.327.500	13.847.000
300-600 beds	56.255.350	84.427.976	542.339	27.080.000	56.194.000
› 600 beds	89.469.999	157.753.567	1.049.606	29.606.000	69.240.000

Figure 2.5 Energy consumption in U.S. hospitals with different size [6]

Figure 2.6 approximates a hospital's average annual, per-square meter thermal and electrical energy consumption [7].

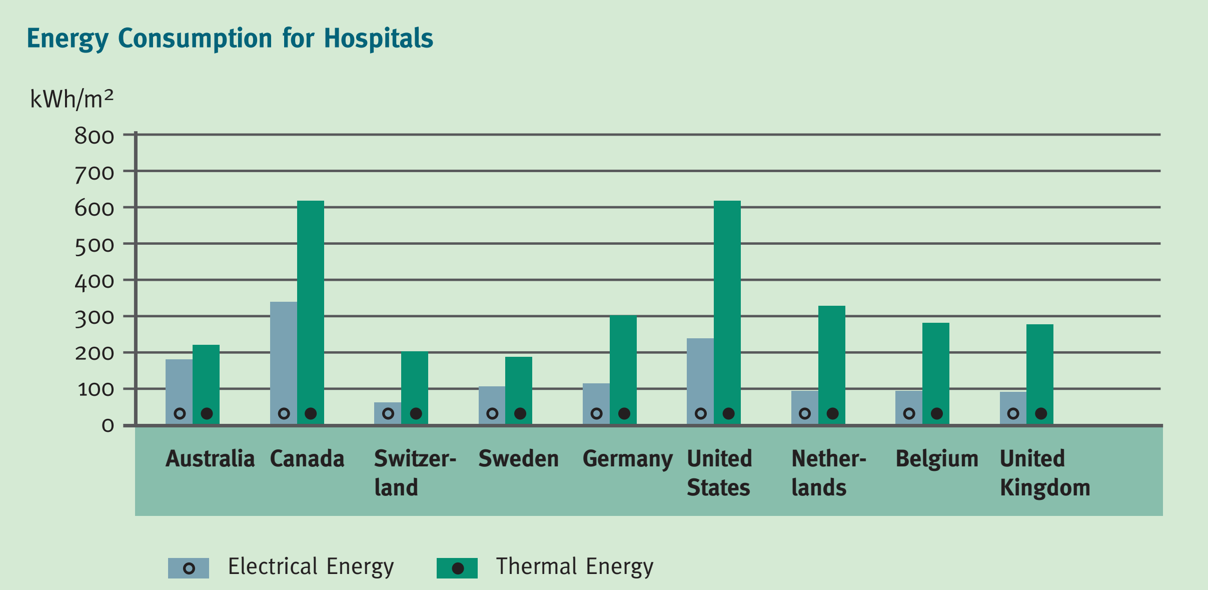


Figure 2.6 Energy consumption for hospitals (kWh/m^2)

[6] Energy Information Administration, 1995 Commercial Buildings Energy Consumption and DOE www.eia.doe.gov, Joelle Davis Michaels

[7] Center for the Analysis and Dissemination of Demonstrated Energy Technologies CADDET, Energy Efficiency Organization Study on Hospitals Maxi Brochures

Figure 2.7 outlines how energy consumption is broken down by major applications. The thick line separates electricity from thermal (fuels) energy. The precise split depends upon hospital type and the complexity of equipment and services. New hospitals often spend more on air conditioning (larger-capacity chiller plants and ventilation systems add cost) than older hospitals.

Fuel is mainly used for space heating and to produce domestic hot water. Electricity is primarily used for lighting and ventilation. These areas may account for 75% of a hospital's energy costs.

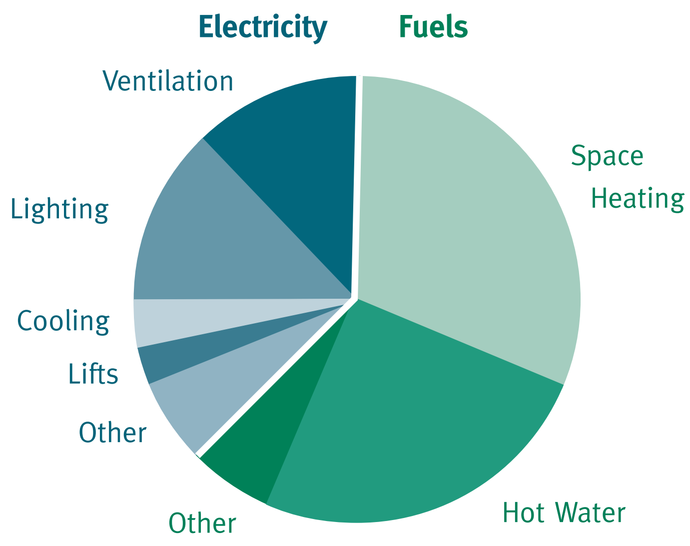


Figure 2.7 Hospital energy consumption by major applications [8]

2.5.2. Water Consumption

U.S. hospitals typically use 80 to 150 gallons (300 – 550 liters) of water per bed per day[9]. German hospitals use about 80 to 162 gallons (300 – 611 liters) of water/bed/day[10] or 80 to 272 gallons (300 – 1000 liters) per client/day[11]. Water use is driven by the number of inpatients and outpatients, equipment used, facility size, number and types of services, facility age and maintenance requirements. Other contributors include steam sterilizers, autoclaves, medical processes, heating ventilation and air conditioning (HVAC), sanitary, x-ray equipment, laundries and food services. It is recommended that all these areas be evaluated to identify activities to help reduce water consumption.

Figure 2.8 shows average water use by category for seven randomly selected hospitals ranging from 130 to 500 bed capacities, with water consumption of 15 million to 145 million gallons[12].

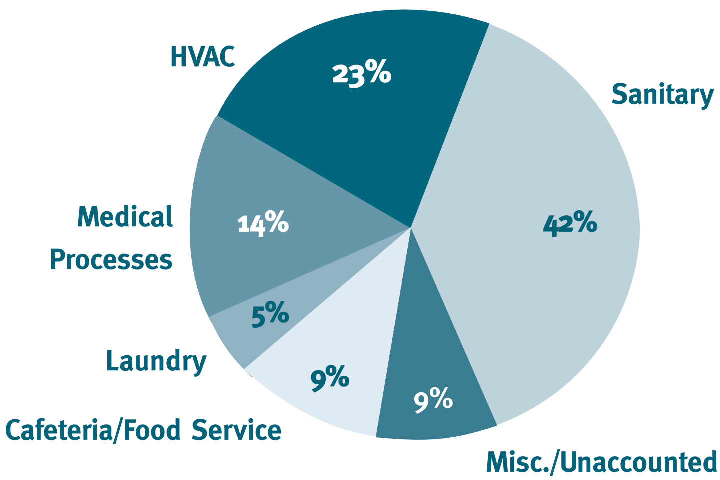


Figure 2.8 Water consumption by major sectors

8 CADDET – Energy Efficiency in Hospitals, Maxi Brochure 05 - www.caddet-ee.org/index.php
9 FEMP-Federal Energy Management Program - www.eren.doe.gov/femp/ resources/indices.html & Smithfield Design and Construction Standards, pg. 62
10 Extracted from Daschner F. D. / K. Kummerer / M. Scherrer / P. Hubner / L. Metz: Handbuch Umweltmanagement
11 Studies conducted by Folkhard (1999), Pomp (1998) / Hackelberg (1999)
12 Massachusetts Water Resource Authority - www.mwra.state.ma.us/water/html/bullet1.htm

2.5.3. Waste Management

Solid waste accounts for the majority of potential healthcare industry pollution. Figure 2.9 shows the percentage of solid waste by composition generated by nine Los Angeles, California, hospitals (Source: The California Integrated Waste Management Board).

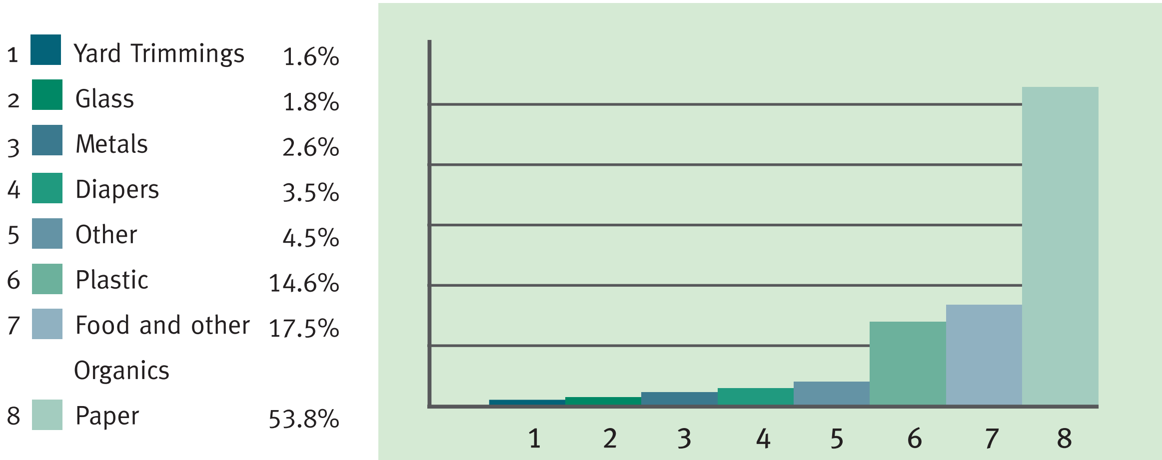


Figure 2.9 Percent solid waste composition (by weight) in hospitals[13]

In terms of actual quantity of solid waste generated, U.S.[14] and European[15] hospitals each produce about 2 million tons of solid waste per year, and this number is rapidly increasing.

Estimates of quantities (in kilograms per bed per day) of solid waste generated by hospitals in Europe, India and the U.S. are shown in Figure 2.10.

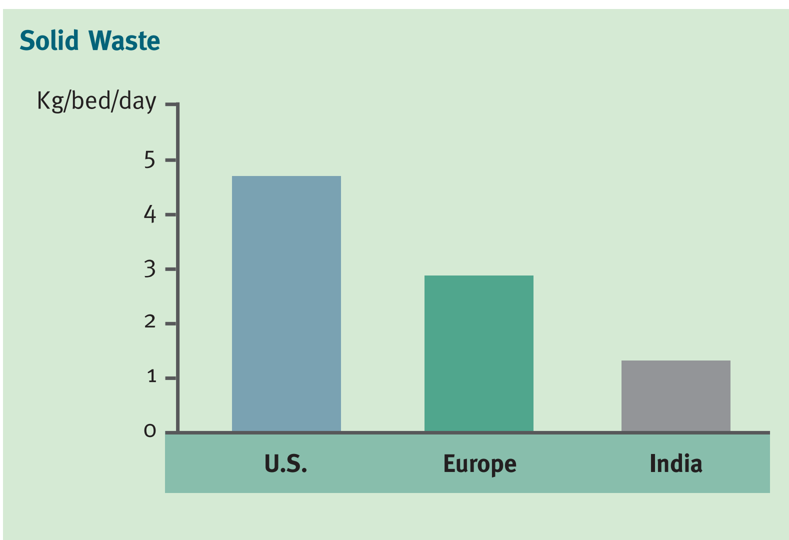


Figure 2.10 Solid waste in comparison between different countries in kg/bed/day[16]

[13] www.ciwmb.ca.gov/bizwaste/factsheets/hospital.htm
[14] "Greening" Hospitals-Healthcare Without Harm, June 1998, Environmental Working Group/The Tides Center, www.ewg.org//pub/home/reports/greening/greening.pdf
[15] Commission of European Community, Analysis 01 Priority Waste Streams HealthCare Waste, August 1994
[16] Numbers from Waste Graph: www.kgmoas.com/july.htm, www.lboro.ac.uk/departments/cv/wedc/garnet/swmnew2.html, www.unescap.org/stat/envstat/stwes-12.pdf, www.cmc.gov.za/peh/soe/waste_a.htm#Medical waste, www.emcentre.com/unepweb/tec_case/health_85/house/h2.htm

While most hospital waste is similar to household waste, regulated medical waste (hazardous waste) accounts for approximately 10 to 15% of U.S.[17], and about 25% of European[18], hospital waste. In other parts of the world, infectious, pathological, and chemical waste may be categorized as hazardous waste.

Solid waste accounts for the majority of hospital waste disposal costs. Regulated medical waste, a smaller but pound-for-pound more costly disposal expense, can also offer major cost savings opportunities. Effective waste management reduces costs, contributes to a healthier, cleaner world and may help protect the facility from fines or litigation.

Figure 2.11 illustrates that the criteria for hazardous waste vary from country to country in Europe. In fact, in Great Britain, all hospital wastes are assessed as hazardous waste. As mentioned before, the management of regulated medical waste offers a lot of opportunities for cost savings.

Waste in European Hospitals

Countries	Hazardous Waste tons/year	Other Waste tons/year	Total tons/year	Year
Great Britain	308.000	—	308.000	1991
France	105.000	595.000	700.000	1990
Italy	55.000	150.000	205.000	1991
Germany	33.000	59.000	92.000	1990
Spain	23.000	190.000	213.000	No info
Portugal	15.000	35.000	50.000	No info
Belgium	13.750	96.250	110.000	1992
Denmark	10.000	—	10.000	1989
Ireland	9.000	12.500	21.500	No info
Netherlands	8.500	147.000	155.500	1992

Figure 2.11 Waste in European hospitals[19]

[17] "Greening" Hospitals-Healthcare Without Harm, June 1998, Environmental Working Group/The Tides Center, ww.ewg.org/pub/home/reports/greening/greening.pdf
[18] Commission of European Community, Analysis 01 Priority Waste Streams HealthCare Waste, August 1994
[19] Commission of European Community, Analysis 01 Priority Waste Streams HealthCare Waste, August 1994

3. Environmental Management System

3.1. What is an Environmental Management System?

Environmental management systems are coordinated efforts to integrate "environmental protection" into an organization. The environmental protection measures are designed to persist in spite of changes in personnel. Environmental management systems should be reviewed regularly to help ensure compliance and to monitor continuous improvement.

3.2. Eco-Management and Audit Scheme (EMAS) and International Standards Organization (ISO)

EMAS is a voluntary program created in 1993 that originally covered European industrial companies only, but now includes all sectors, including hospitals. Continuous improvement of environmental performance and compliance with legislation are integral parts of EMAS. As of March 2003, there are about 70 hospitals registered for EMAS European Union-wide. The majority of these are in Germany.

ISO has also developed a series of international standards in the area of environmental management. ISO 14001 sets forth the elements of an environmental management system and provides for third-party certification of conformance to this standard. As of March 2003, there are about 20 hospitals registered to ISO 14001. They are located around the world including the U.S., Canada, England, India, Sweden, Scotland, Northern Ireland, Thailand, Belgium, Australia and China.

Many organizations can benefit from establishing an environmental management system without necessarily going through the formal process of registration to a specific voluntary standard.

3.3. ISO 14001 and Aspects Analysis

3.3.1. Key Elements of ISO 14001

ISO 14001 was developed for industry as a way to integrate good environmental practices into an organization through pollution prevention and continuous improvement. This manual is not intended as an instruction guide to achieve ISO 14001 certification. Rather, it is a means to interpret the beneficial components of ISO as they may pertain to a healthcare institution.

The key elements of ISO 14001 are depicted in Figures 3.1 and 3.2.

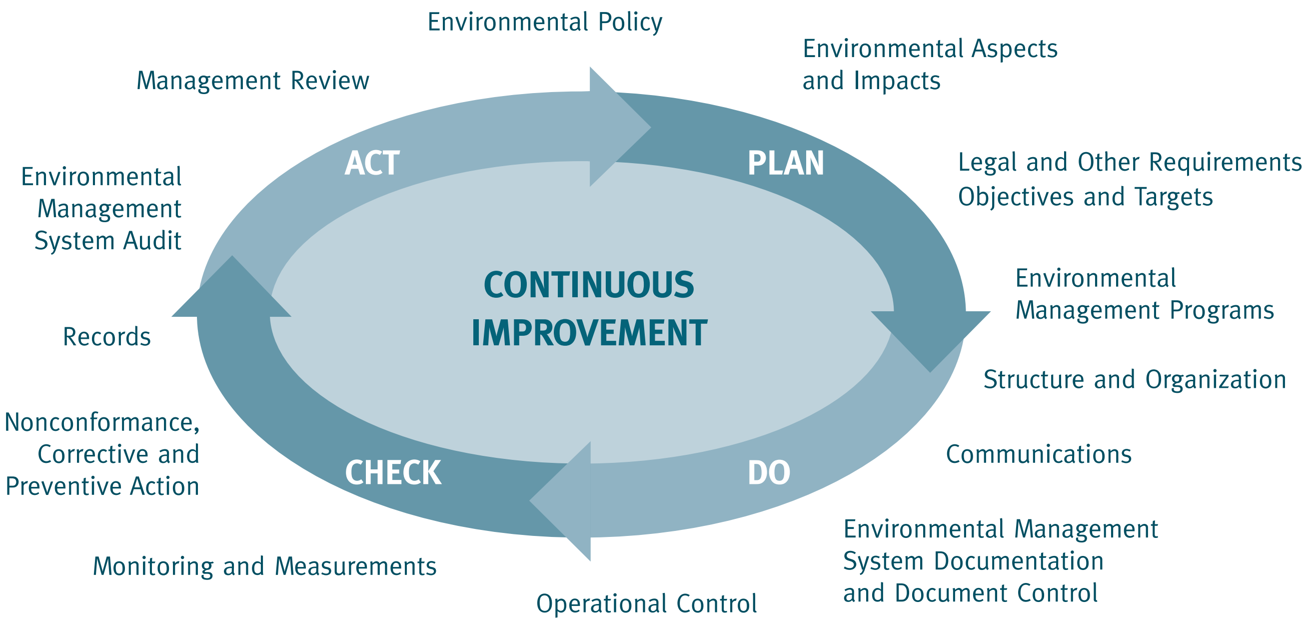


Figure 3.1 Key elements of ISO 14001[20]

To conform to ISO 14001, organizations must implement a rigorous management system that includes:

Plan	■ developing an environmental policy ■ identifying environmental aspects and impacts ■ establishing goals and objectives
Do	■ developing programs, establishing an organizational structure, and documenting activities ■ communicating and training staff
Check	■ monitoring and measuring performance ■ certification requires passing periodic audits by a qualified, third-party registrar
Act	■ implementing corrective actions ■ reviewing performance

[20] Science Application International Corporation (SAIC), www.saic.com/environ/success/ISO-14000.pdf

Figure 3.2 is a graphic representation of the ISO 14001 organization followed by a description of each key ISO 14001 element.

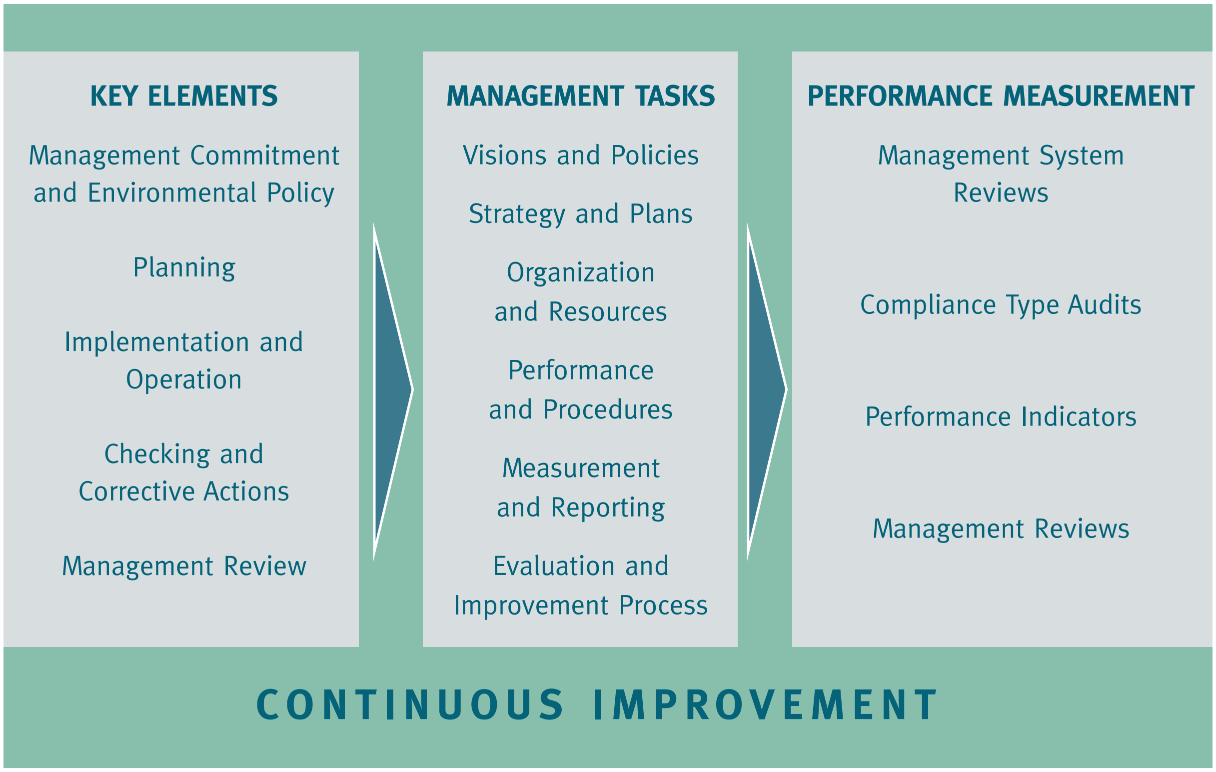


Figure 3.2 ISO 14001 organization[21]

Environmental Policy:	Defined by senior management, it commits organizations to continually improve their pollution prevention, and to comply with all applicable regulations. It is made available to all employees and the general public.
Planning:	Organizations identify environmental objectives and targets based on an assessment of their environmental impacts.
Implementation and Operations:	This section defines the structure of, and responsibilities for, international standards. It covers: ■ employee training ■ communication (internal and external) ■ emergency response guidelines

[21] Science Application International Corporation (SAIC), www.saic.com/environ/success/ISO-14000.pdf

Checking and Corrective Action:	This section sets standards to help: ■ monitor an environmental management system ■ correct deviations ■ evaluate compliance ■ identify nonconformance ■ initiate corrective measures
Management Review:	Senior management continually reviews, monitors and improves the environmental management system.

3.3.2. Aspects Analysis

3.3.2.1. Categories of Environmental Aspects

Aspects Analysis — the most critical part of an environmental management system — projects potential environmental impact under reasonable, foreseeable conditions, including:

- absence of voluntary or regulated environmental controls
- releases of air emissions and wastewater effluents above regulated limits
- accidents
- breakdowns of environmental pollution controls
- product misuse or improper end-of-life product disposal

3.3.2.2. Aspects Analysis Methodology

The methodology of aspects analysis sets environmental benchmarks for processes, products, services, activities, and buildings, and establishes thresholds for:

- severity (very serious, harsh, extremely violent, or intense)
- likelihood (the probability of an occurrence)
- frequency (the repetition of an activity)

Using these three criteria (severity, likelihood and frequency), an organization can evaluate a typical activity (see the following example) and determine the likelihood that a specific activity will result in an adverse environmental impact.

Aspect (or the actual activity, process, product or service) analysis example:

A hospital might review the consequences of a fuel oil delivery and the potential impact to the environment.

1. Activity without containment

	High	Medium	Low	Comments
Severity	○			Potential release to stormwater; soil
Likelihood		○		Estimated odds of a release to the environment 1/120
Frequency			○	Delivery occurs once a month

Results – If all three criteria rate "high," the probability of an adverse environmental outcome is also high. Risk factors could include an improperly closed valve or drain in the area. The open valve or drain may allow any spilled oil to flow into adjacent soil or water sources, causing potential contamination on-site and possibly off-site as well.

2. Activity with containment

	High	Medium	Low	Comments
Severity		○		Potential much smaller release; does not reach stormwater, limited soil contact
Likelihood			○	Estimated odds of release and containment over flowing 1/12,000
Frequency			○	Delivery occurs once a month

Results – If valves and drains are closed prior to delivery, the potential environmental outcome is reduced. If a spill or release does occur with the proper secondary containment, the release remains controlled on-site and is easier to clean up.

Decisions on evaluation criteria and environmental consequences, outcomes, or impacts are best made by teams, that should include (but not be limited to) representatives from:

- operations
- engineering
- management
- administration
- environment, health, and safety

The team should include individuals most knowledgeable about the process, product or service.

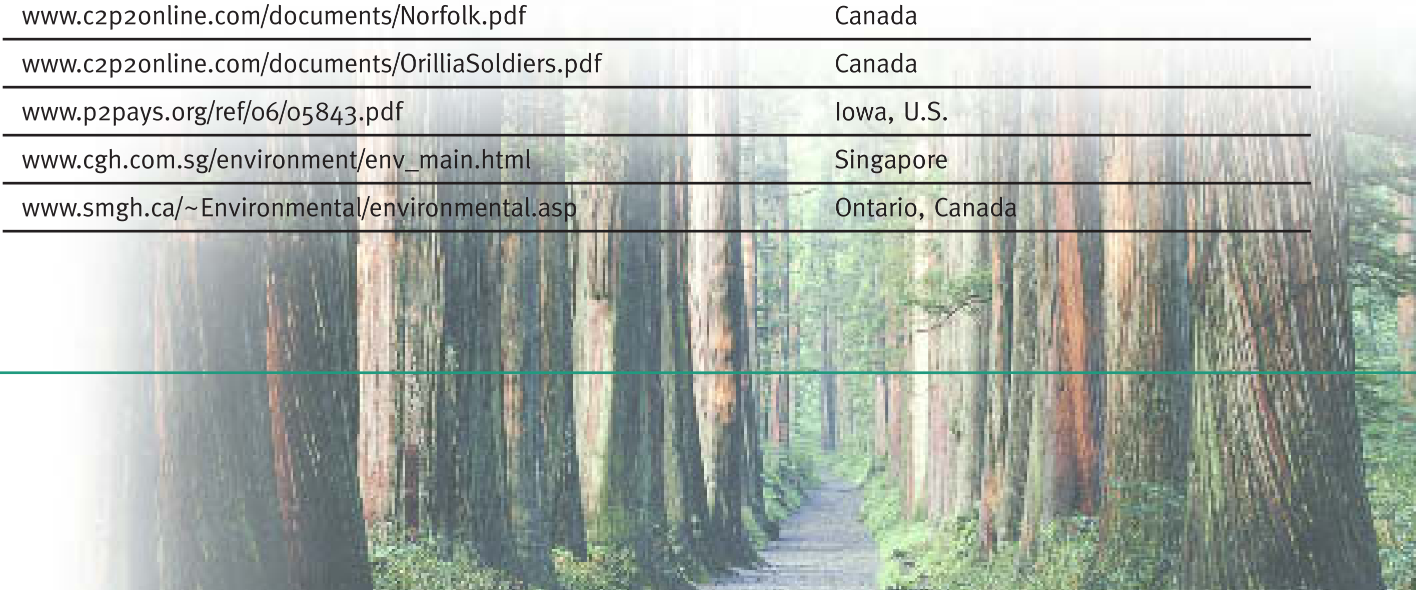
3.4. Web Addresses: Environmental Management Systems

General

Website Address	Name of the Organization
www.noharm.org	Healthcare Without Harm
www.hospitalmanagement.net	International Hospital Federation
www.hospitalconnect.com/ashe/recognition/sustainable.html	American Society for Healthcare Engineering
www.h2e-online.org	Hospitals for a Healthy Environment
www.greenhealthcare.ca/index2.htm	Canadian Coalition for Green Healthcare
www.envirn.umaryland.edu	Virtual resource for environmental health and nursing
www.nursingworld.org/mods/working/ehhcs/cehcfull.htm	Environmental Health in the Healthcare Setting
www.epa.gov/region2/healthcare/violations.htm	Common violations and problems found at hospitals
www.iso14000.com	ISO 14000 Information Center
www.ecology.or.jp/isoworld/english/analy14k.htm	ISO World
www.iso.ch/iso/en/isoonline.frontpage	International Organization of Standardization (ISO)

Case Studies

Website Address	Location of the Case Study
www.c2p2online.com/documents/CambridgeHospital.pdf	Cambridge, Ontario, Canada
www.sustainablehospitals.org/HTMLSrc/IP_Merc_CaseStudies.html	Several case studies, U.S.
www.c2p2online.com/documents/SickChildrenHospital.pdf	Canada
www.c2p2online.com/documents/Norfolk.pdf	Canada
www.c2p2online.com/documents/OrilliaSoldiers.pdf	Canada
www.p2pays.org/ref/06/05843.pdf	Iowa, U.S.
www.cgh.com.sg/environment/env_main.html	Singapore
www.smgh.ca/~Environmental/environmental.asp	Ontario, Canada



4. Implementing an Environmental Management System

4.1. General

An environmental management system requires support from all levels of management. Participation from all is essential for implementing a successful environmental management system.

Motivational training, information, and the presentation of success stories generate enthusiasm and help guarantee the environmental management system's success. Major components of successful environmental management systems include environment, people and cost as shown in Figure 4.1.

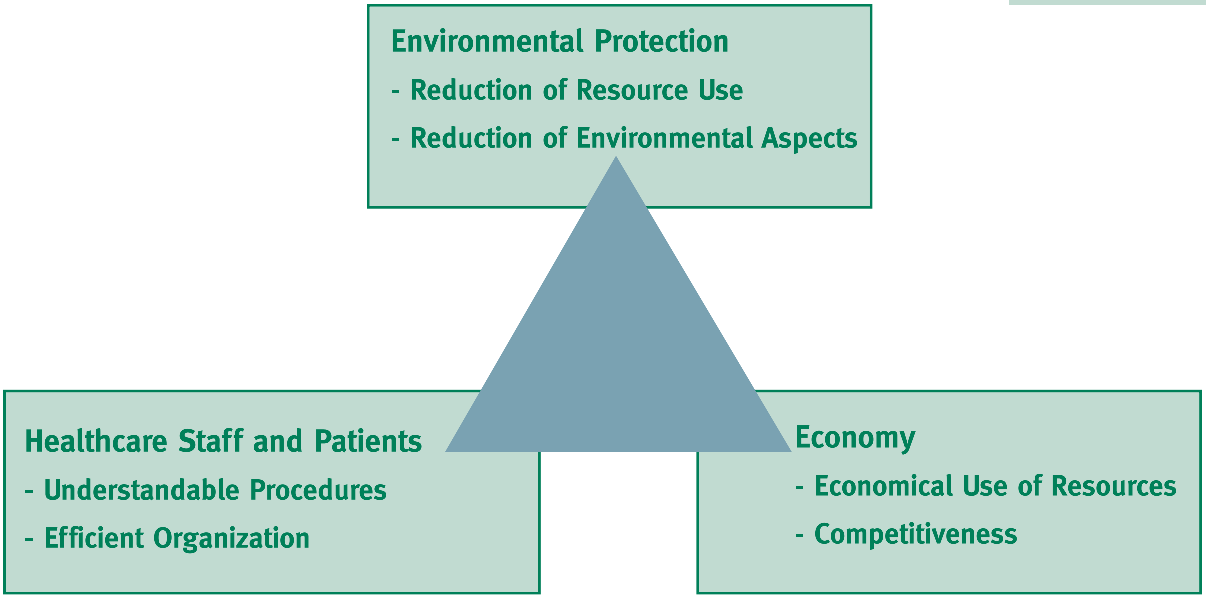


Figure 4.1 Cornerstones of a successful environmental management system

4.2. Practical Tips

Environmental management systems may originate from a variety of internal and external sources including:

- management
- employees whose work relates to safety, finance, or the environment
- patients and visitors
- local politicians
- legislators
- emergency services and ambulance teams

From a timing standpoint, it is sometimes better to improve the basic environmental parameters first, and introduce the environmental management system later. Potential projects may be prioritized by first doing those with the greatest benefits and the lowest investments in time and money.

Environmental management systems need senior management support to get adequate funding and human resources. Fig. 4.2 illustrates the steps involved in setting up a hospital environmental management system.

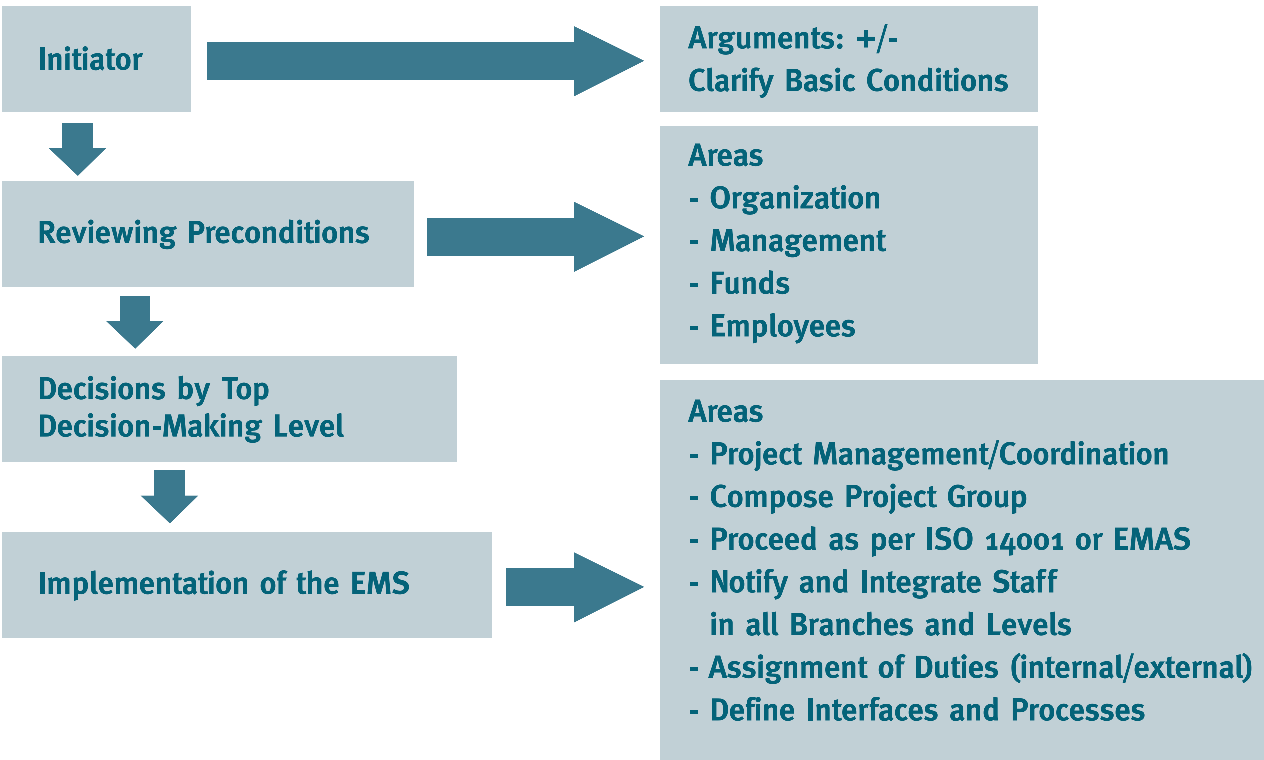


Figure 4.2 Establishing hospital environmental management system plans and procedures

ISO 14001 guidelines allow flexibility in setting an environmental management system framework, parameters and conditions. For example, piloting an environmental management system in a ward or specific department may be an ideal way to test its viability.

Hospital staff should be asked for input and suggestions during staff meetings, training seminars, and instruction sessions. After deciding to launch an environmental management system, an Environmental Management System Project Group should be set up, and a leader selected. People from management, administration, nursing/medical services, supply, and environmental protection should be included, and temporary operative-level sub-groups representing wards, engineering, administration, etc. should be formed to help identify areas to reduce waste and cut costs. Involvement of staff from all departments and levels is key for the success of an environmental management system.

4.3. Environmental Management System Checklists

Section 6 of this manual contains a sample checklist that may be used to help identify areas at your facility that require "environmental" improvements.

4.4. Training

A well-trained staff can better implement good environmental management systems and practices, and incorporate them within the hospital and potentially improve practices in the community. The information in this manual may be a great start; but to be useful, it must be part of an overall training plan. Your success depends on the competence of doctors, nurses, technicians, and all other staff members. With effective training you can potentially improve performance and cut costs.

5. Specific Areas for Potential Improvement

5.1. Hazardous Substances [22]

The definition and classification of a hazardous substance varies throughout the world. However, the management of these substances is an essential part of a hospital's day-to-day activities. Proper registration, handling, and training are necessary to guarantee a safe workplace and to prevent potential risks to employees, patients and the environment.

5.1.1. Hazardous Substances and Risks

Potentially hazardous substances used in hospitals may include halogenated and non-halogenated organic compounds (e.g., solvents), inorganic compounds, caustic materials (acids/bases), prescription pharmaceuticals, disinfectants or other compounds that may be carcinogenic, mutagenic, or reproductive toxins.

Some examples of potentially hazardous substances handled in hospital environments that should be assessed, monitored, and controlled include:

- fixer and developer baths from X-ray departments
- heavy-metal-based compounds containing silver, lead, copper, cadmium, chromium, mercury, or manganese
- reactive/explosive substances such as azides and peroxide compounds such as hydrogen peroxide, perchloric acid, peracetic acid, and perborates
- hazardous microbiological cultures, dyes and solvents (gentian violet, etc.)
- tissue fixing chemicals (osmium tetroxide, aldehydes or ethidium bromide used in genetic analysis)
- substances from nuclear medicine/radiology (including radioactive substances and iodo-organic contrast media)
- used oil, thinners, varnish, and paint residues
- concentrates of disinfectants and cleaning agents, bleaches and detaching agents
- solvent mixtures (including turpentine and nitro thinners)
- sterilization gases (for example, ethylene oxide)
- anesthesia gases
- formaldehyde (formalin), ethanol, and xylene from pathology operations

5.1.2. Managing Hazardous Substances

A critical part of any environmental management system includes strict standards that must be set and followed for hazardous substance management. Written procedures should be developed for receiving, handling, storage and disposal. To make the process complete, the

[22] Extracted from Daschner F.D./K. Kümmerer/M. Scherrer/P. Hubner/L. Metz: Handbuch Umweltmanagement

purchasing department should also be integrated into the system. All potentially hazardous substances should be evaluated and approved before being used. Information on potential hazards is available from material safety data sheets (MSDS) provided by manufacturers or vendors.

A written procedure for safely managing a hazardous material in a healthcare facility should include:

- work area and place of work/activity
- environmental and human risks
- emergency instructions and first aid
- substance description (chemical and synonym)
- protective measures and handling instructions
- proper disposal information

A registry of environmentally hazardous substances and materials used by a healthcare organization should be created to include:

- name of compound
- usage (process, amount per year)
- waste disposal requirements
- hazardous classification
- safety and environmental precautions required
- medical surveillance required

All hospital departments and functional areas should be examined for the presence and use of hazardous substances.

5.1.3. Minimizing the Use of Hazardous Substances [23]

Highly hazardous substances — e.g., benzene, chromosulphuric acid, mercury, chrome VI compounds, and hydrazine — should be replaced with less hazardous ones whenever feasible. Benzene, for instance, can often be replaced with less hazardous toluene or xylene. Since many pesticides are considered hazardous substances, an integrated pest management plan may be utilized to reduce/eliminate the use. Hazardous substances in hospitals may be mutagenic, carcinogenic, or reproductive-toxic. Staff should be trained on how to safely use potentially hazardous substances.

5.2. Waste Management

The shortage of landfill space, and waste incineration facilities, and the increasing environmental awareness of the general population is causing waste disposal to become ever more controversial and expensive.

Therefore, in priority order, prime waste-management criteria include:

[23] Extracted from Daschner F.D./K. Kümmerer/M. Scherrer/P. Hubner/L. Metz: Handbuch Umweltmanagement

Developing an action plan is a key element to waste management and should include:

- avoiding waste by modifying a process/procedure (for example, emphasize electronic rather than paper record-keeping systems)
- buying environmentally friendly products
- managing waste (separation of different kinds of waste; recycling)
- examining materials to see if they pose a potential risk for the environment before purchasing or using them
- reducing the amount of polyvinyl chloride (PVC) containing products or equipment
- identifying toxic substances, including lab chemicals and reducing the amount used; not using persistent bio-cumulative toxins (PBT)
- evaluating waste and waste sources regularly and looking for opportunities to sell waste

5.2.1. Waste Avoidance

All products used should be evaluated for environmental friendliness. It may be found that some of them are not needed or can be replaced with less wasteful ones. Again, it is critical that the purchasing department is integrated at a very early stage.

Examples:

- reduce or eliminate the use of disposable overshoes since many hygiene experts agree they are not needed to maintain good hygiene. Please note, however, that in areas where chemotherapy is being administered, overshoes may be recommended as a strategy to control surface contamination.
- consider using empty cleaner or disinfectant containers as syringe disposal bins, provided they are puncture resistant, properly labeled, and sealed before disposal
- avoid unnecessary packaging
- consider changing infusion systems and dressings in the nursing sector less often, i.e., every 72 hours[24], since studies suggest this can be done without risk of infection
- help avoid expired chemical laboratory waste by buying limited quantities to meet immediate needs
- establish a chemical exchange program whereby surplus chemicals that are still usable are passed on to other users

Avoiding waste at its source is always preferable to recycling and incineration.

[24] Maki, DG (1992 Infections due to infusion therapy / 2. Widmer, AF 81993) IV-related infections

The following Table 5.1 provides some examples of disposable medical products and possible alternatives [25].

Disposable Product	Alternative
Suction hoses and appliances, Respiration hoses	Reusable
Respiratory trainer	Reusable
Body bags	Use PVC free bags, made of polylefin film
Office supplies	Look for supplies that do not contain PVC
Blood bags	Utilize non-PVC bags
Abdominal sheets	Reusable
Bed cover cowlings	None, or bed covers
Disposable razors	Reusable razors, electric razor
Disposable scissors, disposable pincers	Reusable
Disposable slips	String slips, or none
Disposable draw-sheets (Moltex)	Reusable (no PVC), or none
Infusion bottle holders	Reusable
Catheter sets	(Own) assembly
Forceps unit, remover	Reusable
Medicine cups	Reusable
Knives, scalpels	Reusable (metal)
Oral hygiene beakers	Reusable
Kidney bowls	Reusable (metal), recycled carton depending on use and preparation
Redon bottles	Reusable
Oxygen masks	Reusable
Infant feeding bottles	Reusable
Dummies	Reusable
Spatula, mouth spatula, non-sterile	Reusable (metal, plastic)
Thermometers	Mercury-free thermometers, electric thermometers
Thermometer sleeves	Only rectal use, wipe thermometer with isopropylene alcohol
Thorax drainage	Reusable
Face flannels, gloves	Reusable
Laundry bags	Textile bags
Diapers	Reusable (cotton)

[25] Complete list in: Bauer, M.; Mari, M.; Daschner, F.: AOK-Handbuch - Umweltschutz im Krankenhaus

To eliminate cross contamination, any articles being reused must be cleaned, disinfected and, if necessary, sterilized, which may cost more, and/or be less environmentally friendly, than using a disposable product. This needs to be investigated on a case-by-case basis.

Investigations in Germany showed that by re-using redon bottles, thorax bottles, and suction systems, healthcare facilities can save about 50% or more when compared to the costs for using the same disposable items.

5.2.2. Waste Re-use and Recycling

The following wastes should be collected for recycling:

- paper, cardboard, cartons
- glass (white, brown, green)
- certain plastics, including expanded polystyrene (Styropor®)
- metal
- office equipment
- organic waste (e.g., flowers)
- food leftovers
- textiles
- electronic scrap
- scrap metal
- fluorescent tubes
- used solvents
- fixing and developer chemicals
- radioactive chemicals

Recyclable materials should be collected in areas where they accumulate (for example, store, kitchen, laundry, pharmacy, and workshops) and then delivered to central storage areas to be prepared for transportation.

If a facility stores any hazardous substances for recycling or re-use, the storage area should be evaluated to determine if special requirements are necessary (for example, special storage containers).

5.2.3. Waste Disposal

Non-hazardous hospital waste

- can be disposed of with normal domestic waste

Infectious waste

- is defined differently from country to country. For example, Figure 5.1 illustrates that hospital-specific (infectious) waste (in dark blue) as a percentage of total waste varies among European hospitals including: Forlĺ (Italy), Grenoble (France), Nottingham (Great Britain), Sabadell (Spain) and Freiburg (Germany)[26]. At the two extremes, the hospital in Freiburg, assesses about 2% of its waste as infectious, whereas the hospital in Forli (Italy) assesses nearly 50% of its waste as infectious.

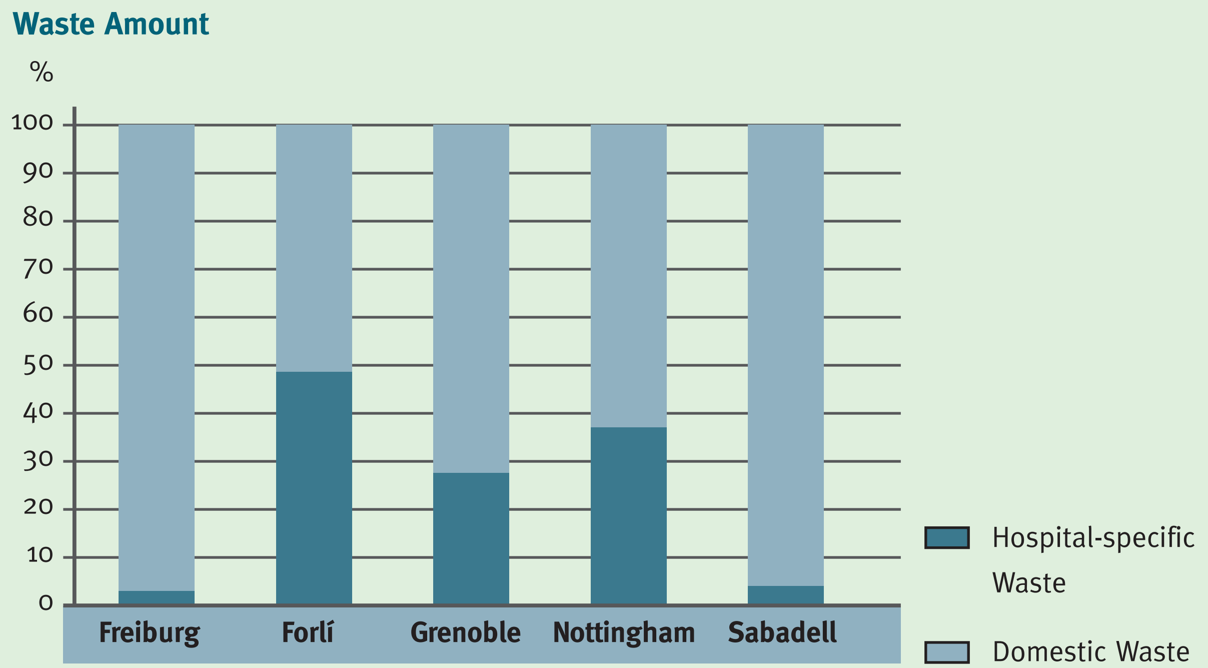


Figure 5.1 Hospital specific (infectious) and domestic (non-infectious) waste designations among five European hospitals

Possible disposal methods for infectious waste include:

- pre-treatment (disinfection) prior to disposal together with normal domestic hospital waste; thermal disinfection using steam is the most cost-effective
- incineration

[26] M. Scherrer, M. Mühlich, M. Dettenkofer and F.D. Daschner/Institute of Environmental Medicine and Hospital Epidemiology; Freiburg University Hospital, Germany.

Chemical Waste

Certain groups of chemicals require special disposal procedures.

Group	Examples:
Solvent, halogen-free, water soluble	Methanol, Ethanol, n-Propanol, Isopropanol, Acetone, Acetonitrile, Tetrahydrofuran, Acetone, Ether
Solvents, halogen-free, non-water soluble	Ethyl acetate, Xylene, Toluene, Rotihistol
Halogenated solvents	Chloroform, Dichloromethane, Carbon tetrachloride. Trichloracetic acid, Trifluoracetic acid, Chloronaphtol
Rinses and washes	Saline solutions, Buffers, Formaldehyde solutions, Aqueous dye solutions
Rinses containing cyanide	
Acids	Hydrochloric acid, Nitric acid, Sulfuric acid, Perchloric acid, Acetic acid, Formic acid, Propionic acid
Alkalines	Caustic soda, Potash solutions, Ammonia solutions
Ethidium bromide wastes	
Old and/or expired disinfectants	
Old and/or expired cleaning agents	

Table 5.2: Groups of chemical waste materials requiring special disposal

- It is recommended that you check with pharmaceutical companies for specific information on proper disposal of expired product. Pharmaceutical waste should be disposed of properly according to local regulations and requirements.

Other waste

- Other types of waste may also require special disposal, including batteries (wet and dry), mercury, and residues and products containing mercury (e.g., mercury thermometers, vapour lamps, and fluorescent tubes).

Radioactive waste

- Healthcare facilities have the potential to use a variety of products and devices that contain varying types of radioactive materials. Eventually, these products and devices become radioactive waste as shown in the following table.

Type of Waste	Radionuclides
Radiopharmaceutical product and vials	Thallous-201 Chloride (Tl-201), Gallium-67 Citrate (Ga-67), Xenon-133 Gas (Xe-133), Technetium-99m (Tc-99m) in eluate and lyophilized vials
Mo99/Tc99m Generators	Molybdenum-99/Technetium-99m (Mo-99/Tc-99m)
Contaminated trash (e.g., gloves, lab coats, wipes, papers, etc.)	Same as above
Contaminated syringes and other sharps	Same as above
Contaminated body fluids (e.g., blood, urine, feces, etc.)	Same as above
Wastewater (from Nuclear Medicine department sinks)	Same as above
Instrument calibration sources	Cobalt-57 (Co-57), Cesium-137 (Cs-137)

Table 5.3: Types of radioactive waste and list of possible radionuclides

Waste Disposal

Products:

- Used radiopharmaceutical products and vials
- Tc-99m eluate vials
- Lyophilized drug product vials (containing Tc-99m)

Disposal:
Used vials should be stored in their original lead-shielded containers, using additional lead shielding if necessary, for at least ten half-lives; then monitored with a suitable radiological survey instrument (see following Table 5.4 for a partial list of radionuclide half-lives).

Radionuclide	Half-life (rounded to nearest whole hour)
Tl-201	73 hours
Ga-67	78 hours
Xe-133	126 hours
Mo-99/Tc-99m (generators)	66 hours
Tc-99m (in vials)	6 hours

Table 5.4: List of radionuclide half-lives

If no radioactive material is detected:

- Vials should be removed from their lead containers
- Labels should be defaced to obliterate the radiation symbol and words "radioactive material"; the lead shield is considered hazardous waste and should be sent to a licensed lead recycling facility or returned to the product manufacturer
- Vials should be disposed of with normal glass waste

If radioactive material is detected during the monitoring, vials should be held for further decay, and surveyed prior to disposal.

Mo-99/Tc-99m Generators:

Storage: Because they contain large amounts of radioactive material, Mo-99/Tc-99m generators should be stored as far from the routine operating area as possible, with additional lead shielding, to minimize radiation exposure to workers and patients.

Disposal: Generator manufacturer should be consulted to discuss disposal options. (Some manufacturers offer a generator-return service, whereby generators are sent to licensed radioactive materials facilities for breakdown, lead-recycling, and radioactive-component disposal.)

Contaminated Trash (with short-lived radioactive material):

- Should be stored in an appropriate receptacle for a minimum of 10 half-lives and
- Monitored with a suitable radiological survey instrument — and if no radioactive material is detected, dispose of with normal hospital trash

Contaminated Syringes and other Sharps (with short-lived radioactive material):

- Should be stored in an appropriate sharps container, using lead shielding as necessary, for at least 10 half-lives and
- Monitored with a suitable radiological survey instrument and, if no radioactive material is detected, dispose of along with normal syringe waste

Instrument Calibration Sources:

Disposal: Manufacturer should be consulted for return and proper disposal.

Storage: Instrument calibration sources contain long-lived radionuclides, making them useful for a long time. They typically contain Co-57 and Cs-137, half-lifes of 271 days and 30 years, respectively. They may also contain millicurie quantities of radioactive material. They should be stored well-shielded and away from immediate work areas, to minimize radiation exposure to hospital personnel and patients.

5.2.4. Web Addresses: Medical Waste

General information

Website Address	Name of the Organization
www.nihe.org/elevreng.html	The Nightingale Institute for Health and the Environment
www.p2pays.org/ref/13/12337.htm	Integrated Waste Management Board
www.sustainablehospitals.org/cgi-bin/DB_Index.cgi	Sustainable Hospitals
www.noharm.org/details.cfm?type=document&id=540	Healthcare Without Harm
www.dienviro.com/index.asp	The Dierdre Imus EnvironmentalCenter
www.uml.edu/centers/LCSP/hospitals/HTMLSrc/IP_Merc_CS_BMP.htm	Sustainable Hospitals
www.epa.gov/Region9/cross_pr/p2/projects/hospart.html	EPA – Hospital Pollution Prevention
www.epa.gov/NE/assistance/reuse/med.html	EPA – New England medical equipment reuse organiza-tions
www.sustainableproduction.org/proj.shos.abou.shtml	Draft Wisconsin Mercury Sourcebook: Hospitals

Case Studies

Website Address	Location of the Case Study
www.ewg.org/pub/home/reports/greening/hospitals.html	Various U.S. case studies
www.emcentre.com/unepweb/tec_case/health_85/house/h2.htm	Australia
www.otzo.most.org.pl/en/docs/HWMPoland.pdf	Poland
www.cmc.gov.za/peh/soe/waste_a.htm#Medical	South Africa
www.epa.state.oh.us/opp/hospital.html	Ohio, U.S.

5.3. Energy Management

Energy conservation saves money, and helps organizations be more competitive. To begin saving energy, an Energy Management Team is needed to:

- audit energy use
- identify areas/equipment/systems having maximum energy consumption
- develop and implement projects such as buying and installing energy-efficient equipment
- perform preventive maintenance
- consult with experts on energy conservation ideas
- implement a program for energy savings
- meet periodically to review programs and seek management assistance as required
- keep the process moving

Figure 5.2 is an engineering diagram that demonstrates the typical energy flow through a hospital.

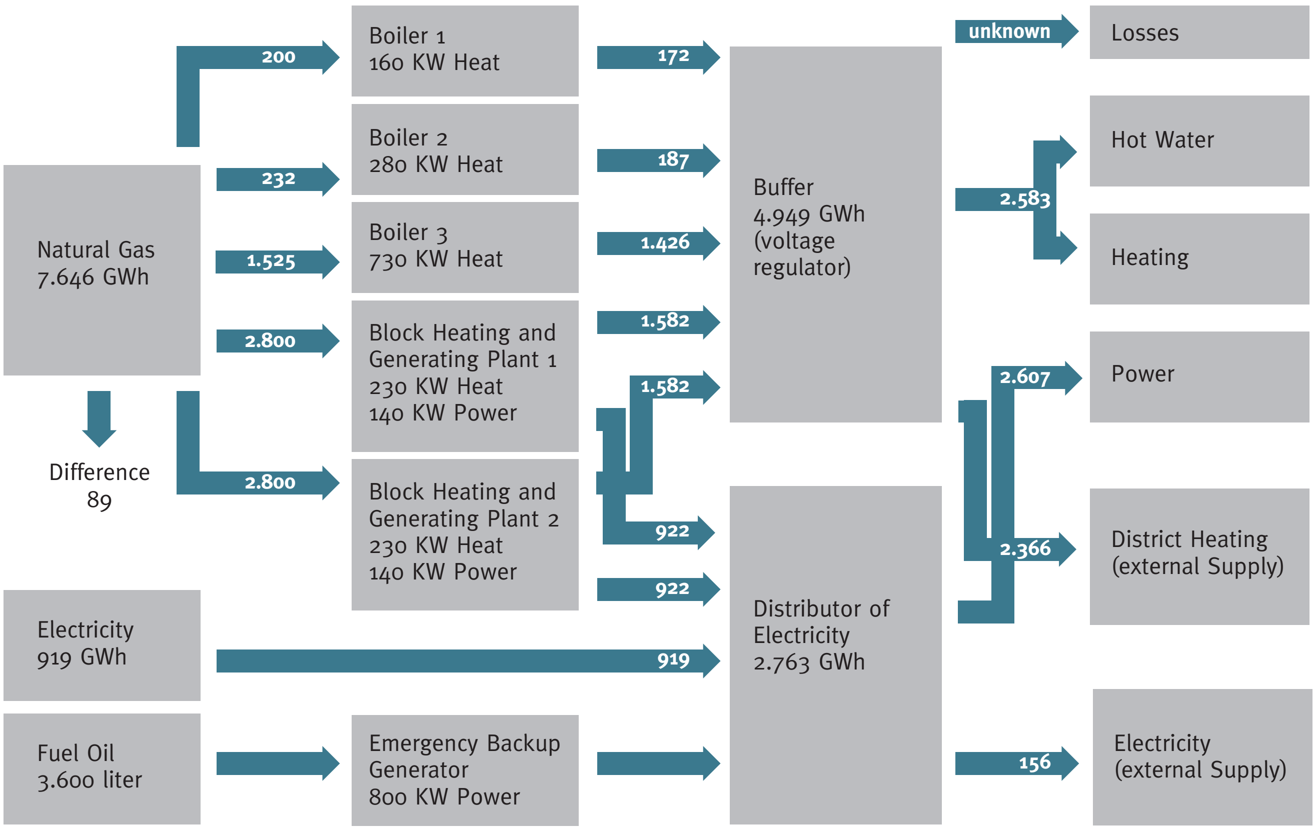


Figure 5.2 Example of how energy flows in a relatively small hospital [27]

[27] Hospital Tulln (1999) Austria

After identifying areas of opportunity where energy consumption can be reduced, the team should set goals, develop a plan of action, calculate potential cost savings and outline achievable short- and long-term benefits. Actions should include:

- inspecting or installing a combined heat and power system
- inspecting and cleaning HVAC systems
- improving heat insulation
- evaluating energy-consumption profiles for office equipment, motors, steam, services, etc.
- improving lighting efficiency

5.3.1. Combined Heat and Power Systems

Combined heat and power systems can reduce energy use by simultaneously generating electricity (and/or mechanical energy) and thermal energy. They recover waste heat and reduce energy use. Systems should be inspected and regularly maintained.

5.3.2. Heating Ventilation and Air Conditioning Systems

Opportunities for reducing heating ventilation and air-conditioning costs may include:

- re-circulating air
- adjusting optimum temperature
- recovering heat from exhaust air
- reducing air-supply volume
- installing variable air-handling units
- improving building insulation

5.3.3. Lighting

Electricity costs may be reduced by replacing incandescent (bulbs) with fluorescent lamps, reducing overhead lighting, installing motion-sensors on light switches, using T5 lamps, incorporating monitoring of lighting-control settings and natural light (daylight) into new buildings or building renovations.

5.3.4. Alternative Energies

Solar panels can greatly reduce the amount of fossil fuel used. In Germany, and in certain other parts of Europe, solar panels for hot water production are widely used. Wind and geothermal energy should also be considered as potential energy sources.

5.3.5. Additional Energy Saving Tips

For Building Engineering, Use:

- site selection for best building location
- energy-favorable layout
- protective thermal glazing
- brightly-colored facades
- natural lighting (i.e., daylight)
- compact building design
- heat-storing materials
- solar protection systems (e.g., outside blinds) to avoid thermal loads
- "green building" design criteria

Design of new buildings and major renovations provide a healthcare facility with an opportunity to incorporate green/environmental principles into its design, construction, and operations.

For Heating Engineering, use:

- solar collectors for hot water
- night-time temperature lowering thermostats
- adequately sized hot water storage tanks
- several small boilers in lieu of one large boiler for load-dependent operation
- thermal insulation on pipes, heat generators, and storage units

For Electrical Engineering, buy or install:

- modern lighting elements with better light yield
- electronic ballast units
- night switch-off
- use-dependent controls (daylight and/or motion sensors)
- power-efficient instruments, equipment and appliances

For Air Conditioning Engineering, check:

- specific room parameters (temperature, humidity, air exchange)
- control settings (temperature, humidity)
- lagging/insulating pipes and conduits
- air flow reductions are in place when rooms are unoccupied
- air flow reductions in fume hoods and bio-cabinets when not in use
- use absorption refrigeration machines
- heat-recovery preheat loop
- variable speed pumping
- cooling coil condensate recovery

For example, Bellin Hospital, in Wisconsin, U.S., saved $21,000 per year by using variable speed drives in hot water pumps, eliminating exhaust in unnecessary areas, and recovering boiler heat [28].

Additional miscellaneous strategies for saving energy:

- use of photo-voltaic panels to generate electricity
- use of trees and plants to reduce solar gains and block winds
- supply air located on windward side to increase positive pressure
- increased duct size and reduced sharp turns within ductwork to reduce pressure drops
- fan size matched with fan loads
- motor controls installed to reduce the speed of electric motor systems
- installation of a building automation system
- films on the windows to prevent heat loss
- option to use both mechanical and natural ventilation
- reduced redundancy in controls and equipment
- multiple circuits to turn lights on and off

[28] Bellin Health, Check-up Reveals Savings Opportunities, www.wifosonenergy.com

5.3.6. Web Addresses: Energy Management

General Information:

Website Address	Name of the Organization
www.hospitalconnect.com/ashe/currentevent/heprojectinfo.html	American Society of Healthcare Engineering

Case Studies:

Website Address	Location of the Case Study
www.tacisinfo.ru/en/reports/health/index1.htm	Ekaterinburg, Russia, comparison with Denmark and Germany

5.4. Water Management [29]

It is a well-known fact that every living thing is dependent on water for its very existence. Although about 70 percent of the world's surface is covered with water, most of it is too saline to drink or even use for agricultural or industrial purposes. Many parts of the world are water stressed, and the ever-increasing population intensifies the problem. Prudent use of this invaluable natural resource is essential from a resource conservation perspective.

5.4.1. Water Use

To identify areas to reduce water use, meters should be installed in departments that potentially utilize/consume larger amounts of water (laundry, sterilization, power plant, workshops, and technical areas).

Ask employees for ideas on how the facility could reduce water consumption. Organize a water saving competition, or offer employees incentives to reduce water consumption.

A number of opportunities are available for reducing water use, including:

- autoclavable bubble fittings that inject air into the water stream
- electronically controlled valves that open only when a person washes his/her hands, and close as soon as the hands are withdrawn
- automatic water volume controls that operate independently of the water pressure to control the amount of water
- shorter hand-wash cycles (reducing the time the water runs from three minutes to one minute results in savings of about 16 liters of water per hand-wash)

[29] Extracted from Daschner F.D./K. Kümmerer/M. Scherrer/P. Hubner/L. Metz: Handbuch Umweltmanagement

- reduced-flow showerheads, thermostats, and single-lever fittings or self-closing mixing taps, saves as much as 50 liters per shower
- waterless urinals
- water containing cisterns, normally set for a capacity of 10 liters, may be reduced to 6. (Short-flush buttons allow the flush water volume to be controlled individually depending on the need. As a rule, these kinds of investments are amortized within the first couple of years after installation.)
- less unnecessary cleaning
- cisterns to collect rainwater for irrigation

5.4.2. Wastewater

Hospital staff should understand that pharmaceuticals such as antibiotics, cleaning agents, and other environmental pollutants, could potentially affect the ability of microorganisms to break down and detoxify waste in sewage-treatment plants.

Pathogenic microorganisms, such as salmonella bacteria and hepatitis viruses may be found in typical city wastewater and are, therefore, not regulated in most areas. Some wastewater streams may carry extraordinary types or amounts of pathogenic microorganisms and, therefore, may need to be segregated and isolated. Effluent should be examined to determine if additional precautions need to be put in place (e.g., isolation wards).

Hospitals should not put in sewer systems substances that:

- endanger personnel during the maintenance and service of technical wastewater treatment systems
- impair the structural state and the proper function of wastewater systems (e.g., pipes, treatment plants), the actual wastewater treatment process, and the slurry processing
- are likely to block the sewer system
- are likely to impair the condition of the water in the long term (e.g., disinfectants)
- are likely to form poisonous, malodorous, or explosive vapors (e.g., methanol or formaldehyde concentrates) in large quantities
- may have any other environmentally harmful effects

In principle, it should always be assumed that waste materials, until properly evaluated, should not be disposed of in the wastewater system.

5.4.3. Water and Wastewater Management

Hospitals should strive to:

- use water resources carefully
- reduce wastewater pollutants
- monitor and control water cycles

To reduce volume and improve quality of wastewater, hospitals should assess and monitor:

- water consumption
- wastewater quantities and quality
- wastewater sources
- partial flows
- ecological improvement

Figure 5.3 is an engineering diagram that demonstrates water flow through a small hospital.

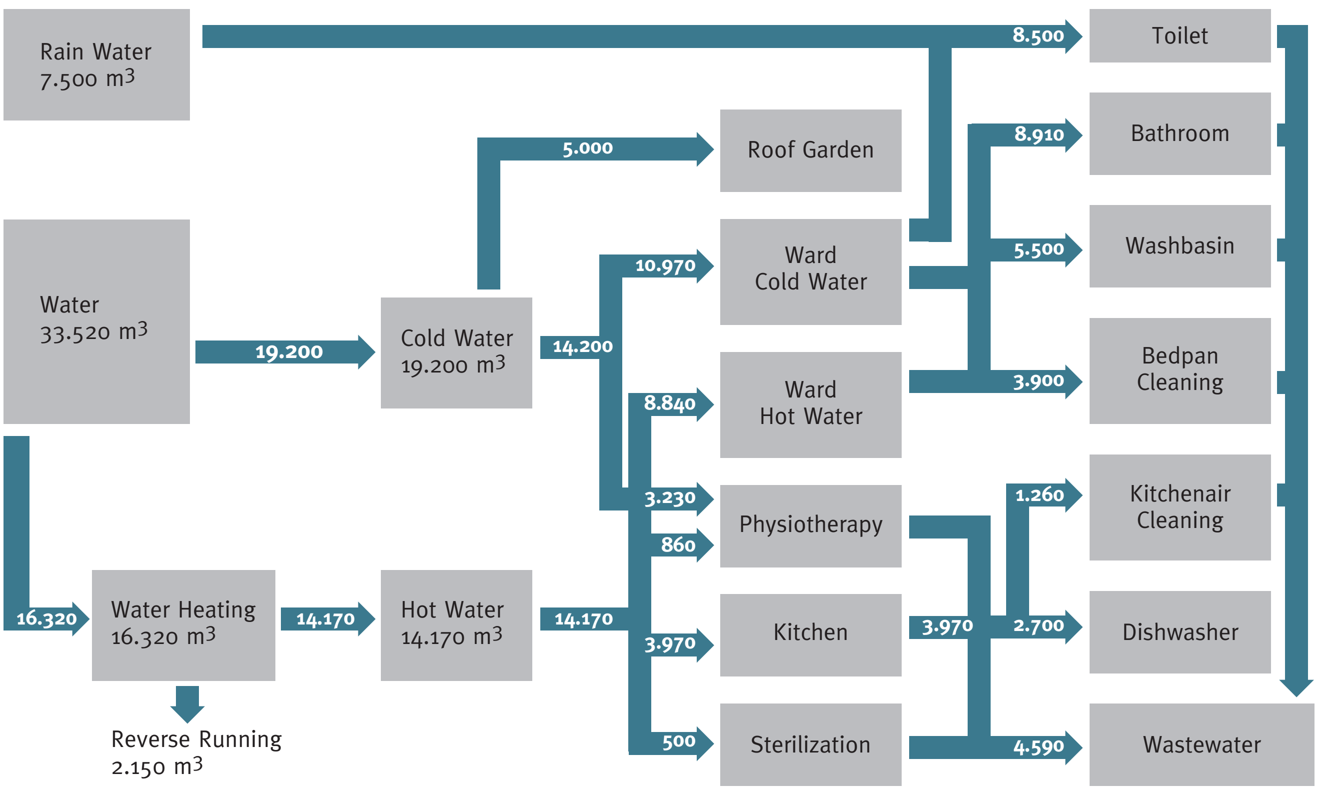


Figure 5.3 Water flows in a relatively small hospital [30]

[30] Hospital Tulln (1999), Austria

Wastewater sources should be determined, and potentially harmful substances identified that may contaminate the water (for example, disinfectants, cleaning agents, cytostatic and antibiotic agents) (see 5.1 Hazardous Substances). In hospitals with large radiological departments, at least 60 to 70 percent of organic halogen compounds in wastewater originate from X-ray contrast media containing iodine.

Potential chemical users should review material safety data sheets to identify hazardous substances prior to their purchase and delivery to the hospital.

A hospital's main wastewater discharge flow may not warrant pre-treatment (except neutralization or radioactive decontamination). However, partial flows from hospital functional areas (e.g., laboratories, oncology, and pathology) should be carefully evaluated for opportunities to reduce discharge and improve quality.

5.4.4. Reducing Pollutants in Hospital Wastewater

Organic halogen compounds:

Hospital wastewater, with respect to chemical oxygen demand (COD), biological oxygen demand (BOD), pH, and conductivity, resembles the household variety. However, it can differ greatly from domestic effluents with respect to organic halogen compounds, which have very low chemical and biological degradability, and often have high toxic and ecotoxic potential.

Organic halogen compounds in wastewater can originate from elementary chlorine ("active chlorine") or reagents that split off elementary chlorine (such as sodium hypochlorite). Opportunities for using less laundry chlorine bleach should be sought — perhaps by changing the wash cycles or by dosing at certain points in the cycle. It may also be feasible to use oxygen-based products, such as hydrogen peroxide ("perhydrol"), percarbonate or peracetic acid, that do not contribute to organic halogens.

Drugs containing halogens (fluorine, chlorine, bromide and iodine) usually have an insignificant environmental impact because they are not disposed of in wastewater. In contrast, organic iodine X-ray contrast media can be found in high concentrations in hospital effluents. Halogenated solvents (chloroform, methylene chloride, frigene), or reagents containing halogen from laboratories can raise organic halogen concentrations in wastewater as a result of creating a vacuum over the solvents using a water jet pump. A downstream cooling trap can help to lessen this effect. To completely eliminate solvent releases, a vacuum pump should be installed in place of a jet pump. Cooling traps also help to reduce emissions.

Heavy metals

- Copper, chromium, lead, nickel and zinc are toxic, do not degrade, and can be a significant issue in wastewater treatment systems.

- Zinc ointments can be replaced with zinc-free ones.
- Mercury-containing drugs, diagnostic agents (e.g., Thiomersal®), disinfectants (Merbromin®, Mercurochrome® and Nitromersol®), and diuretic agents (mercurophyllin) should be avoided. At a university in Germany, the skin disinfectant Mercurochrome, reportedly accounts for 1-1.5% of the slurry pollution in the local treatment plant. Mercury thermometers should be replaced with digital ones. Dental treatment units should be equipped with amalgam separators.
- Hospitals are one of the few known sources of the heavy metal gadolinium (from nuclear magnetic resonance imaging) in wastewater. Little is known about gadolinium's environmental impact.

Disinfectants:

Discharging concentrates of disinfecting and cleaning agents should be avoided — particularly chlorine, phenols, quaternary ammonium compounds, and products containing nonylphenol (potentially estrogenic effect) and strong cleaning ingredients. When possible, non-polluting, cost-saving, thermal disinfection should be used instead.

5.5. Air Emissions [31]

Hospitals contribute to air pollution indirectly by using electricity from fossil-fuel generating plants, and directly, by burning fuel for space heating and hot water.

5.5.1. Emissions from Power Generation and Consumption

Carbon dioxide (CO_2) emissions from power plants cause significant air pollution and are associated with global climate change. Table 5.5 shows CO_2 emissions in grams per kilowatt hour (g/kWh) generated by different energy sources.

CO2 Emissions per kWh Energy Consumption

Energy Type	CO2 in g/kWh
Natural Gas	200
Fuel Oil: light	260
Fuel Oil: heavy	280
External Supply of Electricity	492

Table 5.5 CO2 emissions [32]

In Germany, for example, hospitals release nearly four million tons of CO_2 annually from heat generation alone. They consume an average 26,000 kWh per/bed of thermal power each year — totaling an estimated 17 million megawatt hours (MWh) of energy for all hospitals.

See Section 5.3. for energy conservation tips that can help reduce the use of purchased energy.

5.5.2. Emissions Caused by Sterilizers for Thermally Unstable Materials

The use of toxic and mutagenic ethylene oxide gas as a “cold” sterilant should be minimized or eliminated. Sterilization using ethylene oxide gas, and formaldehyde gas is effective but environmentally hazardous, and a health risk for employees. Less hazardous alternatives, such as hydrogen peroxide or low-temperature plasma sterilization, are available and should be considered for use.

If ethylene oxide gas is used, precautions should be taken to protect employees from exposure. Several chemical engineering methods “detoxify” ethylene oxide gas emitted from sterilization processes. The most widely used is a catalytic reaction that converts ethylene oxide into CO_2 and H_2O. Another method, involving exhaust-gas scrubbing, uses sulfuric acid to convert ethylene oxide into the less harmful ethylene glycol, emitting only CO_2, H_2O, and low concentrations of H_2O_2 (max. 0.056 mg/m^3).

[31] Extracted from Daschner F.D./K. Kümmerer/M. Scherrer/P. Hubner/L. Metz: Handbuch Umweltmanagement
[32] Study Commission of the German Bundestag (1994), European Electricity Supply Network (UCPTE 93)

5.5.3. Emissions Caused by Anesthetic Gases

The most commonly used inhalative anesthetic agents are nitrous oxide, halothane, enflurane, sevoflurane and isoflurane.

Nitrous oxide (N_2O), a breakdown-stable compound, reacts in the stratosphere with atomic oxygen to form NOx which, in turn, breaks down ozone.

Halothane, isoflurane and enflurane are partially halogenated inhalation anesthetics with ozone breakdown potential, and atmospheric “life spans” of 0.7 years, 2.0 years, and 2.4 years, respectively. However, the life spans of these gases are much shorter than those of gases like chlorofluronated hydrocarbons (CFC) which may range from 76 years for CFC 11 to 140 years for CFC 12. A shorter atmospheric life span coupled with a chemical structure that results in substantial breakdown before reaching the stratosphere, means that halothane, enflurane, and isoflurane have a much lower ozone breakdown potential than CFC (e.g., CFC: 100 %, halothane: 36 %, enflurane: 2 %, isoflurane: 1 %).

Some practical measures for reducing anesthetic gas emissions include:

- using vacuum (local exhaust) systems
- using no-mask anesthesia; if masks are required, use double masks
- checking appliances and connections regularly for leaks
- checking the tightness of the anesthesia appliances after each cleaning and after changing of hoses
- measuring room concentrations regularly for excessive emissions
- monitoring technical air units regularly to make sure they are working properly

It is also very important that the potential for employee occupational exposures be thoroughly assessed by qualified EHS personnel.

5.5.4. Emissions Caused by Traffic

Employees, patients, and visitors should be encouraged to use public transportation, perhaps by offering various incentives. Fewer parking lots will be needed, and there will be a healthier environment with less auto emissions into the hospital ventilation system.

5.5.5. Other Atmospheric Emissions

Powder-based inhalers should be used instead of dosed aerosol dispensers with halogenated hydrocarbons. (Halogenated hydrocarbons are still used as propellants mainly in dispensers for broncholytic/antiasthmatic agents.)

5.5.6. Emissions Caused by Hospital Incinerators

Incineration may produce toxic air emissions by: 1) releasing the pollutants contained in the waste stream, such as mercury and other hazardous materials, and 2) creating new toxic compounds, such as dioxins, from the burning process itself. These toxic air emissions may potentially affect the local environment and, in some cases, the global environment. Incineration may also produce toxic ash residue as a by-product. The ash residue is often sent to landfills for disposal, where the pollutants can leach into groundwater. Waste treated by other methods and then landfilled may also produce potentially harmful leachate. Many, if not most, on-site medical waste incinerators not only burn infectious waste, but also readily recyclable items such as office paper and cardboard which could be profitably recycled.

Incineration plants should be designed according to local regulations, employ current technology, and be built by a competent contractor.

5.6. Environmentally Preferable Purchasing

Purchasing departments should be educated and trained on the procurement of environmentally "friendly" products. A procedure should be available that gives purchasing agents clear advice and requirements on preferred products and services. It is recommended that the life cycle of all products be evaluated to determine their impacts on the environment.

Hospitals should strive to purchase products that do not contain persistent (never degrade), bioaccumulative (are not excreted or metabolized) toxins, or PBTs. Some healthcare products contain PBTs, or can generate or release PBTs into the environment when they are manufactured, used, discarded, incinerated, or recycled. See table 5.6 below for PBT-free alternatives.

Product	PBT(s)	PBT-free Alternative
Batteries	Antimony, Cadmium, Lead, Mercury, Nickel	PBT-free batteries and other power sources (such as fuel cells) are available for some equipment. Set up a program in your facility. For more information about recycling or rechargeable batteries, see www.rbrc.org.
Blood-pressure equipment	Mercury	Mercury-free aneroid and electronic blood-pressure units (sphygmomanometers) are accurate, available, and widely used.

Product	PBT(s)	PBT-free Alternative
Diesel fuel used to power generators, vehicles (non-emergency) and other equipment	Antimony, Arsenic, Beryllium, Cadmium, Cyanide, Dibutyl phthalate, Di(2-ethylhexyl)-phthalate (DEHP), Dioxins, Lead, Mercury, Naphthalene, Nickel, Phenol, Polychlorinated dibenzofurons (PCDFs), Polycyclic aromatic hydrocarbons (PAHs), Selenium. Diesel exhaust contains all of the PBTs listed plus other cancer-causing substances.	Institutions that buy or lease shuttle buses and other vehicles should specify that they run on compressed natural gas (CNG) whenever feasible. For more information on the advantages of CNG, see INFORM's Bus Futures report (2000). For existing diesel-powered vehicles and equipment, consider adding biodiesel fuel. Some generators and other equipment may be able to be powered with hydrogen fuel cells or other energy source(s).
Fever and laboratory thermometers	Mercury	Electronic, gallium-tin, and other types of thermometers are available for most medical and laboratory uses. Avoid replacing mercury thermometers with instruments that contain mercury batteries or have PVC (vinyl) casing.
Gastrointestinal and feeding tubes	Mercury	Tubes weighted with tungsten or water are used in many hospitals today.
Laboratory chemicals	Mercury	Many laboratory reagents use mercury-based preservatives for calorimetric assays and tissue fixing. Mercury-free alternatives are available for almost all of these applications. Mercury can also be a contaminant in many reagents. Massachusetts has created a database listing the mercury content of chemicals used in hospitals (see www.masco.org/mercury).
Vinyl IV and feeding bags	Di(2-ethylhexyl) phthalate (DEHP), Dioxins plasticizers, which may potentially leach into bag contents.	When incinerated, vinyl (PVC plastic) may create dioxins that are released into the air. Vinyls also typically contain DEHP or other phthalate. Polyolefin plastic or other alternatives to PVC are available for many medical applications.

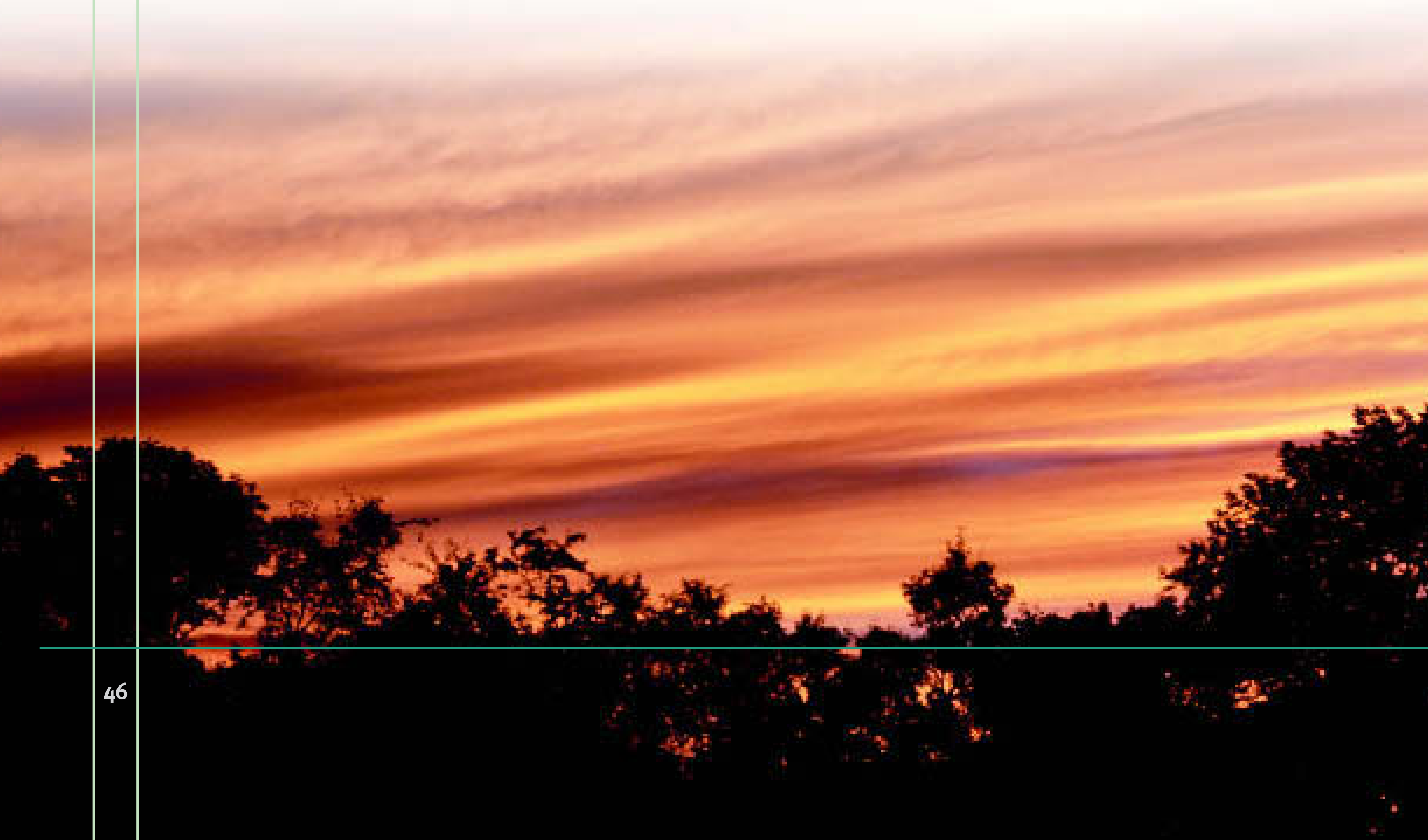
Table 5.6 PTB-free alternatives

5.6.1. Web Addresses: Environmentally Preferable Purchasing

Website Address	
www.geocities.com/EPP_How_To_Guide	How to Guide on Environmentally Preferable Purchasing
www.h2e-online.org/tools/epp.htm	Hospitals for a Healthy Environment
www.state.ma.us/ota/support/medspecs.htm	Environmental Specifications and Purchasing Policies used by Healthcare
www.sustainablehospitals.org	Sustainable Hospitals Project
www.hospitalconnect.com/ahrmm/products/HCEPT/index.html	The Healthcare Environmental Purchasing Tool

5.7. Future Planning

It is important that any new approach to environmental management include systems to ensure its continued success and that the effort is not perceived as a one-time program, but rather a continual process of refinement and improvement. The environmental management system should include objectives, timing, and persons responsible to follow through on projects and other opportunities that take time to implement. It should also include future environmental improvements within the institution's strategic planning process or other means of forecasting. In this way, the environmental management system can become part of the institution's broader objectives and will more likely be taken into consideration as new needs and challenges emerge going forward.



6. Environmental Checklist for Healthcare Facilities

This following checklist includes a number of elements of an environmental management system. By answering YES or NO to the various elements of the checklist, it is expected that you will become more knowledgeable about the current status of your environmental management system. A "YES" answer signifies that your facility's environmental management system already includes that particular element. A "NO" answer indicates that the element is not currently part of your environmental management system. The latter elements should be reviewed for applicability to your healthcare facility and incorporated into your environmental management system as appropriate.

Environmental Management System	
1. Does your healthcare facility have a set of principles or guidelines?	☐ Yes ☐ No
2. If yes, do these guidelines include environmental protection?	☐ Yes ☐ No
3. Are these guidelines communicated not only internally to staff but also externally to the public?	☐ Yes ☐ No
4. Are tasks and responsibilities relating to environmental protection clearly defined and assigned to medical staff, nursing staff, engineering staff and the hospital administration?	☐ Yes ☐ No
5. Has your healthcare facility appointed a person with special responsibility for: waste, hazardous substances, effluent, energy, pollutants and harmful emissions, radiation safety, hygiene, others?	☐ Yes ☐ No
6. Are all members of the staff aware of their specific responsibilities relating to environmental protection?	☐ Yes ☐ No
7. Do you have working groups concerned with special topics such as energy, water, pollution prevention, and environmentally responsible purchasing?	☐ Yes ☐ No
8. Does your organization have a program to routinely leverage the value of new building design or major renovations to incorporate green principles (for example, energy, and water conservation) into design, construction, and operations?	☐ Yes ☐ No
9. Have you implemented an environmental management system?	☐ Yes ☐ No
10. Has your organization developed measurable annual environmental objectives / goals?	☐ Yes ☐ No
11. Does your organization have a system in place to periodically evaluate your continued compliance with pertinent national, state or provincial and local environmental regulations?	☐ Yes ☐ No
12. Is appropriate training offered?	☐ Yes ☐ No
13. Are your contractors informed about your environmental requirements?	☐ Yes ☐ No
14. Are neighbourhood and community environmental questions and complaints documented and subsequently addressed?	☐ Yes ☐ No

Laboratory, Cleaning, Laundry, Kitchen

15. When purchasing chemical reagents for the laboratories, is consideration given to the question of their subsequent disposal (i.e., how they are disposed, possibilities for reducing the volume required, etc.)?	☐ Yes ☐ No
16. Are X-ray fixing trays made suitable for re-use by de-silvering, cleaning, and reconditioning?	☐ Yes ☐ No
17. When purchasing analysis equipment for the laboratories, is consideration given to the question of the disposal of rinsing water (for example, how it is disposed, possibilities for reducing the volume required, etc.)?	☐ Yes ☐ No
18. Does the in-house laundry use only as much detergent as needed?	☐ Yes ☐ No
19. Do the cleaning agents used in the laundry contain any of the following substances: phosphates, sodium hydrochloride, formaldehyde, chlorinated hydrocarbons (CHC), and cationic surfactants?	☐ Yes ☐ No
20. When purchasing cleaning and disinfecting agents, is consideration given to environmentally friendly products and alternatives?	☐ Yes ☐ No
21. Have the kitchen and cafeteria equipment been upgraded to include water efficient models?	☐ Yes ☐ No
22. Can the rinse water from the dishwasher be used as flush water in garbage disposals?	☐ Yes ☐ No
23. Have you addressed possibilities for reducing the consumption of detergents, or for substituting detergents with alternatives that are environmentally less damaging?	☐ Yes ☐ No
24. Are the dishwashing machines used in the kitchens regularly serviced and checked for their consumption of cleaning agent, water, and electricity?	☐ Yes ☐ No
25. Are collectors for fat, grease, starch, etc., used in the kitchens?	☐ Yes ☐ No
26. If so, are the contents of these collectors regularly emptied and are the collectors checked for proper functioning?	☐ Yes ☐ No
27. Are disinfectant procedures performed only as needed?	☐ Yes ☐ No

Waste Management

28. Does your organization have a written, comprehensive waste management program?	☐ Yes ☐ No
29. Is the amount of waste from various sections and departments individually measured?	☐ Yes ☐ No
30. Does your organization track the treatment and disposal costs of waste from individual sections and departments?	☐ Yes ☐ No
31. Is there an in-house chemical store to which leftover chemicals can be returned for subsequent re-use or recycling?	☐ Yes ☐ No
32. Are monthly and annual statistics kept for all waste produced?	☐ Yes ☐ No
33. Do you have a guideline for the collection, sorting, storage, and disposal of waste from all sections and departments?	☐ Yes ☐ No

34. Do you internally conduct waste audits to determine your compliance with this guideline?	☐ Yes ☐ No
35. Is there a central location where waste is collected, transported, labelled, and stored?	☐ Yes ☐ No
36. Is waste transported from the hospital to a recycling plant, incineration plant, or landfill by a private contractor?	☐ Yes ☐ No
Did you audit this contractor?	☐ Yes ☐ No
37. Does your organization have a written goal to reduce the overall volume of solid waste (hazardous and non-hazardous) that you generate?	☐ Yes ☐ No
Bathrooms / Restrooms	
38. Where applicable, are low flow and low volume fixtures being utilized?	☐ Yes ☐ No
39. Is the plumbing in all bathrooms and restrooms inspected regularly for leaks?	☐ Yes ☐ No
Energy Management	
40. Have you determined where the greatest amount of energy is consumed?	☐ Yes ☐ No
41. Is there a plan in place to reduce the consumption of energy?	☐ Yes ☐ No
42. Is there a method in place to recover thermal energy?	☐ Yes ☐ No
43. Are the power systems (e.g., heating oil, natural gas, etc.) adequately protected against leaks, fire, incorrect operation, sabotage, others?	☐ Yes ☐ No
44. Is the heating system regularly monitored and its power consumption optimized?	☐ Yes ☐ No
45. Is it possible to apportion quantified data for the consumption of materials, energy and heating, etc., to individual sections and departments?	☐ Yes ☐ No
46. Have ozone depleting refrigerants, such as chloroflurонated hydrocarbons or CFC's, and halogens been replaced by more environment friendly alternatives?	☐ Yes ☐ No
Hazardous Substances	
47. Have you identified sections or individual departments that consume hazardous substances (for example, toxic, caustic or corrosive, flammable, combustible, explosive, carcinogenic, reproductive toxic, mutagenic, irritating, environmentally damaging, others)?	☐ Yes ☐ No
48. If yes, is there a program in place to eliminate or substitute hazardous substances?	☐ Yes ☐ No
49. Have you determined which sections or individual departments consume the largest volume of hazardous substances?	☐ Yes ☐ No
50. Are all the local regulations for storing hazardous substances properly satisfied (containers, sealed floors, ventilation, spillage traps, fire prevention, others)?	☐ Yes ☐ No
51. Is personal protective equipment necessary for handling hazardous substances readily available for staff (respirators, gloves, goggles, others)?	☐ Yes ☐ No

52. Do staff members receive regular training in how to handle and store these hazardous substances?	☐ Yes ☐ No
53. Does your organization use mercury-containing devices?	☐ Yes ☐ No
If yes, do you have a labelling identification strategy for them?	☐ Yes ☐ No
If yes, do you have plans to phase out the use of these items?	☐ Yes ☐ No
54. Are there measures in place to minimize, eliminate, and improve the management of hazardous chemicals and persistent bio-accumulative toxins (PBTs) in your operations?	☐ Yes ☐ No
55. Does your organization have a written program to eliminate mercury-containing waste from your waste streams?	☐ Yes ☐ No
Water Management	
56. At present, can you determine how the consumption of water is distributed among the various sections and individual department's?	☐ Yes ☐ No
57. At present, do you know which sections or individual departments consume the greatest amount of water?	☐ Yes ☐ No
58. Is the system of water pipes and drains regularly checked for leaks?	☐ Yes ☐ No
59. Does this system of pipes and drains incorporate shutoff equipment?	☐ Yes ☐ No
60. Is drinking water regularly checked for compliance with local parameters?	☐ Yes ☐ No
61. Is rainwater collected for further use (for example, watering the lawns/gardens, used as general-purpose non-drinkable water for building services, etc.)?	☐ Yes ☐ No
Wastewater Management	
62. At present, do you know where your wastewater is discharged?	☐ Yes ☐ No
63. Is analysis of your wastewater required for compliance?	☐ Yes ☐ No
64. Does your hospital keep a record of all the substances it currently discharges into the public wastewater system?	☐ Yes ☐ No
65. Is any wastewater discharged into surface water (for example, streams, rivers, and lakes)?	☐ Yes ☐ No
66. Do you know all wastewater discharge points?	☐ Yes ☐ No
67. Is there any on-site pre-treatment prior to discharge?	☐ Yes ☐ No
68. Is the system of wastewater pipes and drains regularly checked for leaks?	☐ Yes ☐ No
69. Does this system of pipes and drains incorporate shutoff equipment?	☐ Yes ☐ No
70. Is your wastewater regularly checked for compliance with local regulations (e.g., chemical oxygen demand, biological oxygen demand, pH level, etc.)?	☐ Yes ☐ No
71. Is the analytical data reviewed?	☐ Yes ☐ No

72. Is there a radioactive decay system for wastewater coming from the nuclear medicine department?	☐ Yes ☐ No
73. Are the waste fluids from the dialysis ward discharged in accordance with the law?	☐ Yes ☐ No
74. Are photochemicals from X-ray equipment (for example, fixing agent, rinsing water, developer, etc.) discharged in accordance with the law?	☐ Yes ☐ No
75. Are chemicals from laboratory equipment (for example, reagent leftovers, rinsing water, etc.) discharged in accordance with the law?	☐ Yes ☐ No
Air Emissions	
76. Does your facility measure air emissions?	☐ Yes ☐ No
77. Are air emissions among the various sections and individual departments also measured (for example, heating, laboratory, and medical gases)?	☐ Yes ☐ No
78. Is there a plan in place to reduce air emissions?	☐ Yes ☐ No
79. Are air emissions monitored for compliance with applicable laws and regulations?	☐ Yes ☐ No
80. Are the results of the air emissions evaluated?	☐ Yes ☐ No
81. Are all buildings' fresh air intakes safely away and up wind from all sources of air emissions?	☐ Yes ☐ No
82. Is there an inventory of the medical gases (including quantity and type)?	☐ Yes ☐ No
83. Do you regularly measure workplace concentrations of harmful substances (for example, gases, vapors, and air-borne particles) to ensure that these values are in compliance with applicable regulations or consensus guidelines?	☐ Yes ☐ No
84. At present, do you measure potentially harmful air emissions that might occur in the operating rooms (for example, fluoroethane, fluothan, dinitrogen monoxide)?	☐ Yes ☐ No
85. Are operating rooms equipped with anaesthetic gas recovery systems and ventilation systems?	☐ Yes ☐ No
86. Are you currently collecting and analyzing emissions in the reanimation areas, intensive care wards, sterilizing department, and bed preparation or laundry area?	☐ Yes ☐ No
Outdoor Water Use	
87. Are contractors informed of water saving practices and policies?	☐ Yes ☐ No
88. Is there an automatic rain shut off on the sprinkler system?	☐ Yes ☐ No
89. Is the irrigation system checked regularly for leaks?	☐ Yes ☐ No
Environmental Preferable Purchasing and Material Management	
90. Does your organization have a written environmentally preferable purchasing program?	☐ Yes ☐ No

91. When purchasing medical products, is consideration given to environmental selection criteria?	☐ Yes ☐ No
92. Where possible, do you purchase reusable medical supplies?	☐ Yes ☐ No
93. Do you know how the consumption of medical products is distributed among the various sections and departments?	☐ Yes ☐ No
94. Is there a plan in place to eliminate the purchase of excess medical products?	☐ Yes ☐ No
95. Have you identified non-essential, highly hazardous substances that your healthcare facility is prohibited from purchasing?	☐ Yes ☐ No
96. Do you get feedback from departments when materials are no longer needed, or have been replaced by environmentally friendlier ones?	☐ Yes ☐ No

Wissenschaftszentrum Umwelt/WZU

The Wissenschaftszentrum Umwelt (Environment Science Center) at Augsburg University is an international meeting-place for selected high-ranking environmental experts and a center and 'crossroads' for international co-operative projects of interdisciplinary environmental research. Our aim is to stimulate cross-disciplinary, innovative research and technological developments in the field of Environmental Studies. To achieve this, we are focusing on the productive energy of interdisciplinary dialogue. Environmental topics can only be fittingly studied through the collaboration of researchers from different fields. The participation of scientists from other universities and from other countries will complement the potential of our own university staff. The exchange with scientists from other fields of study should lead to a questioning of the traditional academic divisions and field-specific working methods, which are usually taken for granted. Research groups are set up at Wissenschaftszentrum Umwelt to work for a specified period on topics within the context of our central theme - the sustainable handling of substances, materials and energy. Progress in environment science requires a thorough understanding of technical and industrial issues. Therefore, it is a major advantage for our work that the European office of the World Environment Center is located adjacent to the Wissenschaftszentrum Umwelt. The partnership with the WEC enables us to deal directly with decision-makers from various industry sectors, which is particularly useful for projects involving practical applications. Thus, innovation is possible.
For additional information on the Environmental Science Center please visit our website at www.wzu.uni-augsburg.de.

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ISBN 3-00-012582-5