Guidebook for Energy Efficiency in Municipalities

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«Training of Local Authorities Experts on the Identification, Development and Implementation of Energy Efficiency Projects in Municipalities – ENEFMUN»

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About this guidebook

The aim of this guidebook is to help reduce the energy consumption and costs through improving the energy efficiency of municipal operations. The focus explicitly lies on municipal activities that are of energy relevance directly or in directly – i.e., the role of a municipality as a consumer of energy is basically addressed by this guidebook. However, the aim is not to provide a guide to develop a comprehensive energy planning concept, rather the reader should be able to select single measures and implement them as a single project right away.

Clearly, municipalities also have the opportunity to improve the energy efficiency within the local community (in homes, offices, industries and transport) through legislative framework or any kind of incentives, however those opportunities are not covered by this guidebook. Additionally to the concrete organizational and technical suggestions for improving energy efficiency, the guidebook contains project management tools to support the implementation of the suggested measures.

It has been designed as a useful and informative guide to give the reader plenty of ideas and starting points rather than provide all the answers. However, the presented measures are detailed in order to put the reader in the position to realize them from the plan to the implementation and evaluation. The guide is especially configured for local energy managers, responsible for energy consumption related with the activities of the municipality itself. The modular structure of the guidebook allows to extend it by new information and to adjust the content individually.

Operation Instructions

In the section "Municipal Activities" all the fields of municipal activity are summarized and some motivating arguments and examples for the chances of a municipality engaging in energy efficiency projects are listed. Often it may not be obvious how municipal activities can be relevant for energy efficiency. Thus, in this section the impacts of typical municipal activities on energy use, as well as the energy saving opportunities for all of them are described.

It is really astonishing how many activities are relevant for the energy consumption of any municipality. For each activity (e.g. parks and gardens) the relevant technical fact sheets (e.g. lighting) and organizational measures (e.g. purchasing policies) are listed in a table. Following these links to the relevant fact sheets the reader will find detailed information for each kind of energy efficiency project.

The "Technical Fact Sheets" (T1 – T10) contain detailed information concerning technical issues within an energy efficiency project (e.g. heating and cooling buildings, street lighting). For each topic the reader will find a rubric with links to further information and best practice examples.

"Organizational Measures" (O1 – O6) provide suggestions for energy relevant "soft" measures concerning the organizational and administrative structure of a municipality (e.g. purchasing policies, monitoring and reporting).

In the section "Project Managing Tools" (P1 – P4) the reader will find useful information and tools for managing an energy efficiency project in the municipality. Starting from the definition of a project and the role of a project manager, a typical project life cycle is explained. As one of the most important aspects when deciding for a certain project, methods for the financial evaluation of a project are shown, and some possibilities for financing energy efficiency projects are discussed.

Sources used to develop the present guidebook

Sources for: Municipal activities and chances for energy savings (A1 – A4)

HANDBUCH KREP (german version), *Handbuch für kommunale und regionale Energieplanung, Joanneum Research Forschungsgesellschaft mbH,* 2000

MANAGING ENERGY IN LOCAL GOVERNMENT, *Community Partnerships – Australian Greenhouse Office*, Canberra 1999, http://www.greenhouse.gov.au/lgmodules/workbook/

Source for: Technical sheets (T1 - T7 and T9 - T10) and Organizational Measures (O1 - O6)

MANAGING ENERGY IN LOCAL GOVERNMENT, *Community Partnerships – Australian Greenhouse Office*, Canberra 1999, http://www.greenhouse.gov.au/lgmodules/workbook/

Source for: Technical sheet "District Heating" (T8) (except from the paragraph "Energy efficiency of DHC")

POLICY PAPER, *approved by the International Energy Agency Executive Committee for the Implementing Agreement on District Heating and Cooling including the Integration of CHP at its 38th meeting in Copenhagen,* 16 May 2002

Source for: T8 Technical Sheet: "District Heating" – the paragraph "Energy efficiency of DHC"

Energy efficiency improvement in district heating systems, *PHARE program (RO-0108.04)*, Romania, 2001

Source for: P1 (Introduction to Project Management), and P2 (The project life cycle)

Project Management Manual, Department for European Integration of the Government of Romania, 1997, www.projectmanagement.ro

MUNICIPALITIES AND ENERGY SAVING OPPORTUNITIES

Chances and roles for municipalities in managing energy

Why take action on energy efficiency?

Energy use is one not only one of the largest sources of greenhouse gas (GHG) emissions from municipal activities, it also causes significant costs for the budget of municipalities. To reduce energy costs, it is therefore important for municipalities to look at the ways in which they use energy. In many cases, they may be consuming more energy than they need, which is leading to unnecessary costs. By focusing on ways in which the municipalities can increase the efficiency of their energy use, they are likely to reduce their operating costs and will also set an example for the community by demonstrating ways in which activities can be done better.

What other benefits are there?

Apart from lowering the municipalities' energy bills and reducing GHG emissions, strategies to improve energy efficiency have many other benefits, including:

- Generating additional revenue: The energy use reduction initiatives and expertise developed can generate additional revenue for the municipality—through running training programs, offering new services, etc.
- Supporting new sustainable industries: Directly supporting energy efficiency through municipal policy and operations will help develop new markets and industries, providing local employment and business opportunities.
- Improving air quality: Relying less on fossil fuels for energy can reduce local air pollution and subsequent public health costs.
- Creating social benefits: Action on energy use reduction can also produce many other benefits such as reduced traffic congestion and more efficient and therefore competitive local industry.
- Demonstrating local leadership: Municipalities have a legitimate and vital role in articulating their communities' views and acting upon their concerns.
- Creating opportunities for partnerships with industry, community, and government at a local, regional, national and international level.

The citizens can experience right in front of their eyes the use of progressive technologies. Politics, administration, economics, and agriculture can reach together with all improvements concerned in the municipality and region.

The role of municipalities in managing energy

The Commission of the European Union has determined a very important role for municipalities in the future. This is underlined by the implementation of different programs which aim at the structure of regions and hence the municipalities as the organizational entities. The supply and consumption of energy is one of the key-issues in this context. The implementation of strategies of sustainability needs to be supported by municipalities as major players in the supply and consumption of energy.

The roles of municipalities can be summarized as follows:

- **municipality as consumer of energy** (e.g. heating, lighting, office equipment) for public buildings (e.g. schools, event locations, sports facilities, hospitals) and infrastructure (e.g. vehicle park, public transport, street maintenance and lighting)
- **municipality as producer and distributor of energy** (e.g. ownership of energy supply companies and power supply systems)

- municipality as the responsible institution for regional development (e.g. space- and energy planning, planning of road network)
- **municipality as supporter and motivator of energy relevant activities** (e.g. establishment of information centres, implementation of workshops, financing and implementation of pilot projects, membership in climate leagues)

This guidebook focuses on the role of a municipality as a consumer of energy. However in the next sections an overview of municipal activities of energy relevance will be given, to demonstrate the potential of a municipality in managing energy.

Municipal activities and energy relevance

The effective ranges in which the municipalities have to make decisions, which are of energy relevance directly or indirectly (consumption, production, distribution of energy etc.) are comprehensive. The effective ranges in which a municipality can take action and their energy relevance are:

- **Financial planning:** The energy costs for schools, municipal offices, sports facilities etc. must be included in the budget. The energy costs offer one of the few possibilities in the freely calculable budget portion for considerable savings by measures, which cause only small costs (e.g. energy bookkeeping). For projects that are more complex also alternative financing forms (e.g. contracting, leasing) can be applied.
- **Space planning:** Expulsion of building land can lead to housing sprawl and consequently conflict with a central energy supply (e.g., by district heating). The roof inclination and the geographical orientation of buildings influence the possibilities of passive (e.g., by south window, warmth insulation) and active (e.g., solar collector, Photovoltaic) solar use.
- **Promotion of the economy:** With company establishments, a new power demand is usually linked, which must be covered. For local-resident companies (e.g., plumbers, boiler manufacturers, property marketers, electric traders, agricultural companies) workplaces can be created or assured by a suitable energy policy.
- **Engineering infrastructure:** Among other things the streets and the street lighting, water supply, sewage and waste disposal, local vehicle park and participation in local energy supply enterprises belong to this category. In various regard decisions can be taken which affect the energy demand (e.g., substitute of old lamps, new vehicles).
- **Traffic:** The traffic influences decisively the noise load and environmental impact in the municipality. By more attractive public transport systems, the motorized individual traffic can be driven back. Sidewalks and cycle tracks or other traffic reassurances raise the quality of life and the attraction of the municipality.
- **Spare time and tourism:** The municipality pursues swimming pools, sport arenas, playing fields, etc. For these often a lot of energy is needed. A far-sighted energy planning is worthwhile (e.g. solar arrangements to the hot water preparation).
- **Social area:** This includes for instance hospitals, nursing homes, old people's homes, rescue and fire department. Common energy projects (e.g., solar self-construction groups, biomass district heating) can use existing social networks and can influence the social climate in a municipality positively (e.g. by strengthening regional identity).
- **Educational systems:** The local municipality pursues kindergartens and schools. Activities of information about energy can use this existing infrastructure which support raising of awareness and raise the state of information of the inhabitants about new energy technology in particular (e.g., by school projects).

Supporting roles of a municipality in managing energy

Obviously the municipal activities are very often of significant energy relevance directly or indirectly. Even if this guidebook focuses mainly on these activities, the other roles of a municipality in managing energy are briefly mentioned below:

- Being a model entity with its own activities (e.g. implementation of pilot projects, membership in climate leagues).
- Coordination of public activities (e.g. organization of car sharing, information centres for energy related issues).
- Support of private and commercial activities (e.g. initiatives for thermal insulation, industrial energy management programs).
- Energy consultations and information events (e.g. energy management courses, workshops for energy managers, information days for the public).
- Connection of space and energy planning (e.g. traffic calming, district heating).

Municipal activities and energy consumption

It may not be obvious at first how some municipal operations influence energy use. For example, a legal officer who drafts leases and contracts is not obviously consuming large amounts of energy, but the clauses in those leases and contracts can have long-term effects on levels of the use of energy by the activities covered. This section includes an overview and information for the various fields of activity found in most municipalities. It further contains ideas to help the reader identify major influences on energy consumption, and develop appropriate measures that can be implemented right away or incorporated into the municipality's energy management strategies and action plan.

The municipal energy manager may have to supply each operational group with the relevant information and then negotiate appropriate performance indicators and reporting procedures, so that the groups can play an appropriate role in the pursuit of improving energy efficiency. For each field of activity, the reader will find:

- a summary of ways the activity may influence patterns of energy use (note that although issues such as vehicle use and the effects of municipal activities on energy consumption in the local community are outside the scope of this guidebook, they are included for the sake of completeness);
- discussion of particular opportunities and problems related with developing and implementing energy efficiency measures;
- references to technical fact sheets and organizational measures, designed to help the reader to improve energy efficiency by offering detailed information.

What if municipal services are contracted out?

In this guidebook it is assumed that where municipal services are delivered by contractors the energy consumption generated by these contractors has to be included in the inventory of energy consumption of the municipality. After all, the municipality pays for energy used by contractors as part of the negotiated contract, and contractors are acting as agents of the municipality when they carry out activities. If this approach were not adopted, the picture of municipality's performance would be distorted, as energy consumption would be reduced by contracting out more services, or increased if previously contracted services were brought in-house.

An overview

The table below shows the fields of activity relevant to managing energy consumption. While the precise terminology and organizational structure may differ from municipality to municipality, groups with similar functions exist in most municipal organizations.

Municipal activities	Roles relevant to managing energy consumption
Property and facilities management	Purchase, lease, sale of properties; property management; operation and maintenance of buildings
Health services	Community health services, hygiene inspections
Parks and gardens	Developing and managing parks and/or gardens
Information systems	Information technology, communication systems, office equipment
Community facilities	Recreational facilities, libraries, childcare centres
Community services	For youth, aged, disabled, cultural groups; festivals, transport, grant schemes
Environmental services	Waste management, environmental policy, management of natural environment, air and water quality, hazardous sites
Infrastructure	Planning, design, construction and maintenance of roads, storm water, sewerage systems, etc.

Technical support	General construction and maintenance
Vehicle management	Purchase, operation, maintenance and resale of vehicles and mobile equipment (although transport energy issues are not considered herein)
Different kinds of offices	Using office equipment, using lighting and heating/cooling energy, using kitchen facilities
Financial management	Budgets, managing contracts, financial policy
Corporate support	Human resource management, governance community and corporate relations, legal support, catering/hospitality
Strategic planning	Long-term planning spanning economic, environmental and social issues, and covering urban development, transport and economic development
Statutory planning and building approvals	Development and building approvals, management of inspections etc.
Project management	Design and construction of new facilities, major refurbishments and infrastructure

Property and facilities management

The property and facilities management function has an important influence on energy consumption (apart from the office-based operations of the property management group, which use energy directly) resulting from municipal operations in ways that include:

- selection of facilities: location influences travel activity, while factors such as the energy efficiency of buildings leased, constructed and/or operated influence emissions due to heating/cooling and lighting;
- lease agreements: conditions such as energy performance targets can be included;
- maintenance practices: setting up standards of maintenance practices, including the extent to which energy management is integrated into practices;
- refurbishment programs which offer opportunities to incorporate energy upgrades.

Activity	**Relevant information sheets**
Setting criteria for the selection and development of facilities	All organizational measures
Preparation and negotiation of contracts, leases etc	O4. Leases and contracts
Building maintenance	O6. Building design and specification T1. Heating and cooling of buildings T3. Lighting (Office lighting) T6. Motors, drives, pumps and fans

Health services

The facilities operated for health services, such as health centres, often have significant energy requirements, especially for heating and lighting. Where these facilities are used intermittently, management for energy efficiency is often difficult. The way a municipality provides health services may also influence community's energy consumption, depending on how far clients have to travel and what transport modes they use.

In some cases, provision of municipal transport, such as a community bus, may increase municipality's own operational GHG emissions, but will reduce total emissions by avoiding use of less-efficient vehicles. The office-based operations of health services use energy directly. Health staff can also use significant amounts of transport fuel as they visit clients, attend local health centres and carry out inspections and consultations.

Activity	**Relevant information sheets**
Building management	T1. Heating and cooling of buildings, T3. Lighting, T4. Hot water production

Parks and gardens

Staff developing and maintaining parks and gardens can influence energy consumption in a number of significant ways:

- selection and operation of equipment and vehicles (type of fuel used, fuel-efficiency, maintenance, efficiency of operation);

- management of buildings in parks, such as the lighting of toilet blocks;
- tree and vegetation planting strategies, which not only affect the size of carbon sinks, but may affect building energy consumption by sheltering buildings from sun or wind or affecting the amount of daylight available to windows.

The office-based operations of parks and gardens staff also use energy directly. Vehicle use may also be an issue, as parks and gardens staff use trucks, mowers, mulchers and other motorized equipment, however these topics are not covered in this guidebook.

Activity	Relevant information sheets
Equipment selection	O3. Purchasing policies
Energy management in buildings and facilities	T3. Lighting
Management of green and other organic wastes	T9. Standby electricity generation (Cogeneration) T10. Renewable energy sources exploitation

Information systems

Information systems can consume substantial amounts of energy and resources, but using them effectively can save much greater amounts of them. The extent to which information flow and data storage occur in electronic form influences factors such as:
- the floor area required for document storage, which tends to be within air-conditioned spaces;
- ease of access to information, the need for re-typing documents and the energy used for these activities;
- paper use, and the resources and energy consumption associated with it (e.g. printing activity consumes energy and toner or ink, and involves investment in equipment).

Information technology staff can influence energy use through:
- specifications they establish for new IT equipment and software, including networks;
- the design and operation of computer centres and their associated air-conditioning; these facilities are often very energy-intensive;
- the extent to which they ensure that energy-saving features such as low-power 'sleep' modes are utilized; this involves specifying appropriate systems, making sure features are enabled, and training staff to use them.

Activity	Relevant information sheets
Developing purchasing specifications for equipment and software	O3. Purchasing policies T5. Office equipment
Design and operation of computer centre	T1. Heating and cooling of buildings T3. Lighting, T5. Office equipment
Staff training in energy-efficient computer operation	T5. Office equipment
Installation and maintenance of information systems and equipment	O4. Leases and contracts T5. Office equipment

Community facilities

Some of the community facilities, such as swimming/sports centres, are extremely energy-intensive, making them costly to operate and responsible for high levels of GHG emissions. In other cases, the facilities operate for long hours and comfortable conditions are a high priority; again, this results in significant energy consumption and high costs.

The selection of buildings and equipment within facilities, design of facilities, and patterns of operation can all influence energy efficiency. The input of ideas, requirements, and expectations by policymakers, managers and service delivery staff can therefore have long-term implications for energy use. Operational procedures are also important factors. Location can affect the level of emissions associated with client travel, while the office-based activities of community facilities staff also use energy directly.

Activity	Relevant information sheets
Input to design of facilities	O6. Building design and specification Depending on facilities being designed: T7. Refrigeration
Purchase of equipment and contracting services	O3. Purchasing policies, O4. Leases and contracts O5. Working with contractors
Facilities management (in conjunction with facilities management group)	T1. Heating and cooling buildings, T3. Lighting Depending on facilities managed: T7. Refrigeration, T4. Hot water production

Community services

Municipalities provide or contract many services to individuals and groups throughout their community, in some cases from dedicated facilities (libraries, recreation centres, childcare centres, etc.) and in others, such as meals-on-wheels or home help, purely as services. Those involved in developing strategies for the provision of services influence future energy consumption through the procedures and levels of activity planned. Taking environmental and energy issues into account when evaluating options for program delivery could provide useful insights into ways of minimizing energy consumption.

In managing activities such as festivals and community events, hiring out municipal facilities, or providing grants to community groups, there is scope to encourage the reduction of energy consumption within the community. For example, targets for recycling and energy performance may be included in arrangements with sporting groups using community facilities, or in contracts with festival organizers. In addition, staff may advise and assist users of these services to save energy, cut costs and reduce GHG emissions.

Activity	Relevant information sheets
Arrangements with contractors providing municipal services	O4. Leases and contracts O5. Working with contractors
Input to development of new services, and policies and strategies for implementation	O2. Monitoring and reporting program P3. Financial evaluation of projects
Catering services such as meals-on-wheels	T4. Hot water production

Environmental services

The environmental service activities play a key role in determining the scale of energy consumption associated with municipal activities, as well as the potential for sinks. This group may also influence community and business emissions (apart from their office-based operations, which also use energy directly) through programs and policies such as promotion of recycling and composting, or tree planting.

Significant activities may include:

- input to municipality's environmental policy and environmental management system, including the national and international programs and activities such as in-house energy-saving programs, paper recycling, etc.
- management of municipal wastes: recycling, minimizing the amount of material land filled, promotion of composting, production of energy from wastes (including landfill gas utilization) can all have significant effects;
- management of natural environment: activities such as tree-planting or reforestation of cleared areas, may involve significant energy use for vehicles and equipment;
- air quality programs: strategies for reducing air pollution may impact on local car usage, use of fuel wood, etc, as well as influencing municipal decisions on fuel selection and vehicle types;

Activity	Relevant information sheets
Policy development	All organizational measures
Energy from waste	T10. Renewable energy sources exploitation

Infrastructure

Where infrastructure involves ongoing use of energy – e.g. for lighting, pumping or other activities - it can be a major issue from both cost and environmental perspectives. For example, street lighting may comprise more than half the total electricity bill for many municipalities, and moving large volumes of water may require substantial amounts of energy for pumping. Much of the physical infrastructure of a city or prefecture needs modest amounts of energy for its maintenance and upkeep.

However, large amounts of energy and resources are incorporated into the infrastructure itself (the roads, drains, sewers, etc). Municipal staff can reduce the energy use embodied in infrastructure by specifying appropriate materials, designing to minimize material requirements, recycling, etc. Providing infrastructure also has significant greenhouse implications for the local community. For example, standards of road surfacing can influence car fuel consumption, as can traffic calming strategies.

Activity	**Relevant information sheets**
Infrastructure development	All organizational measures, T3. Lighting (Street lighting)
Infrastructure management	O4. Leases and contracts, O5. Working with contractors T3. Lighting (Street lighting)

Technical support

Technical support units play a critical role in ensuring that equipment and buildings operate correctly. Monitoring and maintenance are major areas for potential energy waste or improvements in energy efficiency. Technical staff may also be called upon to provide expert input to policy issues, including purchasing guidelines and building specifications. Apart from that, technical support groups may operate large workshops and depots, which are significant energy consumers. They also contribute to municipal consumption of energy through their travel and office-based activity.

Activity	**Relevant information sheets**
Input to policy issues	O3. Purchasing policies, O4. Leases and contracts, O5. Working with contractors, O6. Building design and specification
Energy management	T1. Heating and cooling of buildings, T3. Lighting, T6. Motors, drives, pumps and fans, T4. Hot water production, T8. Standby generation, T10. Renewable energy sources exploitation

Vehicle management

Although transport energy is beyond the scope of this guide, municipality's vehicle fleet is a major source of energy consumption and GHG emissions, as well as a major operating expense, so reference is made for the sake of completeness. Vehicle management may influence municipality's operational energy use in a variety of ways, including:

- the types and models of vehicles selected;
- provision or encouragement of other modes of travel (e.g. bicycles, public transport);
- extent of use of alternative fuels with lower greenhouse impacts
- monitoring and maintenance programs;
- energy use in buildings where vehicles are maintained or stored.

Activity	**Relevant information sheets**
Vehicle selection	P3. Financial evaluation of projects O3. Purchasing policies, O4. Leases and contracts

Office energy use

While heating and cooling might comprise up to two-thirds of energy consumption in an office, equipment used or controlled by occupants is responsible for the rest. This includes lighting, computers and other office equipment, boiling water units, etc. In some buildings, occupants also control heating and cooling systems.

Office energy use can lead to annual energy costs of up to €20 per square metre and between 50 and 500 kilograms of GHG emissions per year. As a building occupant a municipality can play an important role in saving energy, including:

- alerting building managers to problems and faults;
- switching off lights and equipment that are not needed;
- seeking training in energy efficiency issues relevant to the energy manager's work.

Activity	Relevant information sheets
Using office equipment	T5. Office equipment
Using lights and air-conditioning	T1. Heating and cooling of buildings, T3. Lighting
Using kitchen and coffee/tea-making facilities	T5. Office equipment, T7. Refrigeration

Financial management

Financial management creates a framework within which all municipal operations are carried out. The budget priorities set, the purchasing guidelines established, the cost-benefit criteria applied, and the contractual arrangements negotiated, all influence the kinds of buildings and equipment selected, and the behaviour of staff and contractors.

A particular challenge for financial management groups is the development of practical and effective mechanisms to facilitate increased up-front investment costs where future savings are increased. Most municipalities treat investment funds separately from recurrent funds, which mean that they fail to implement many cost-effective energy efficiency measures.

Activity	Relevant information sheets
Preparing and supervising purchasing guidelines	O3. Purchasing policies
Preparing and supervising leases, contracts, etc.	O4. Leases and service contracts O5. Working with contractors
Developing and implementing financial policy	O2. Monitoring and reporting P3. Financial evaluation of projects

Corporate support

Much of the corporate support function is office-based, so direct energy use by this area of activity is typical of that of many offices. Some corporate support activities may be fairly energy intensive, for example catering/hospitality often requires very energy intensive commercial catering equipment, and the equipment used to provide coffee and tea at meetings often consumes surprisingly large amounts of energy. Special events can also use large amounts of energy, depending on the venues and types of activities chosen.

Events provide an opportunity for a municipality to make a strong public statement about global warming, while investments in actions that normally would not be considered cost-effective can be justified on educational or promotional grounds. For example, human resources groups can include performance on energy efficiency job descriptions, and performance indicators that work against energy efficiency improvement can be modified (e.g., if a staff member's performance contract is based on the number of permits approved, this may discourage thorough scrutiny of the energy aspects of applications).

Activity	Relevant information sheets
Catering/hospitality	O3. Purchasing policies, O4. Leases and contracts T7. Refrigeration, T4. Hot water production

Special events	T3. Lighting, T8. Standby electricity generation T10. Renewable energy sources exploitation

Strategic planning

The nature of this field of activity means that the decisions it makes and the policies and guidelines it develops will significantly influence municipality's future energy efficiency and environmental impacts. For example, decisions about where municipal activities will be located will affect transport requirements of staff and their clients, while policies, specifications, guidelines and priorities developed to influence building design and equipment selection are major factors affecting ongoing energy use.

The priority placed on environmental factors, and the reflection of this prioritization in budget allocations, influence the extent of investments in projects to improve energy efficiency. In addition, through the incorporation of municipality's long-term plans into development policies and guidelines, this area of activity strongly influences long-term trends in energy consumption associated with local businesses and community activity. In terms of direct energy use, the strategic planning function is largely office-based and its energy consumption issues are typical of those of many offices.

Activity	Relevant information sheets
Policy development and implementation	All organizational measures

Statutory planning and building approvals

Most of the direct energy consumption from the statutory planning unit is likely to result from the use of office space and facilities, and travel to new constructions for field inspections. Where this unit makes input into policy development and is involved in specific municipal building projects, it may influence municipality's emissions for many years ahead. Staff can place emphasis on compliance with energy efficiency regulations in the national or international level (e.g. EU Directive on the energy performance of buildings), as well as providing advice and encouragement for applicants. The extent to which municipal policies and requirements create a context within which planning and building staff can encourage good environmental performance also influences outcomes.

Activity	Relevant information sheets
Policy input	O6. Building design and specification
Application of energy-efficiency skills when advising applicants	T1. Heating and cooling of buildings T2. Energy efficiency and the building envelope

Project management

When municipal facilities are being designed, constructed, commissioned or refurbished, the way the project is managed can play a crucial role in influencing long-term levels of energy consumption from the facilities. Major projects involve very complex processes, and many of the participants have limited perspectives on overall project objectives. Good project management can ensure that appropriate emphasis is placed on energy efficiency throughout the various stages of the project, in contractual arrangements, in supervision of performance and monitoring of outcomes. Project management staff also contributes to municipal energy consumption through their travel and office-based activity.

Activity	Relevant information sheets
Managing major projects	O2. Monitoring and reporting, O4. Leases and contracts, O5. Working with contractors, O6. Building design and specification, P3. Financial evaluation of projects

Objectives of municipal energy management

For municipalities energy relevant activities are triggered by very different factors. Some of them are set by legal liabilities or political commitments. For example the Commission of the EU has enacted guidelines concerning environmental and energy policies, which have to be transformed into national laws by all member states within a prescribed time limit. Furthermore, many national laws are in force that include regulations connected with necessary activities concerning energy supply, distribution and consumption.

A significant share of these activities has to be implemented by municipalities since they are, at least partially, responsible for energy supply, development planning, garbage collection and waste disposal, water supply, traffic management, etc. Often a concrete problem or project triggers a municipality to take action in the fields of energy supply, distribution and consumption.

Depending on the trigger, different objectives are pursued:

- Solving concrete energy problems (e.g. conflict because of emissions, energy supply for new private, industrial or public buildings)
- Cost reduction in public sector (e.g. vehicle park, street lighting, public buildings)
- Exploiting national or international funds for energy relevant projects (e.g. funds for thermal insulation, solar or biomass use)
- Getting an advantage over the neighboured municipality through better energy and environmental policy
- Getting benefits for the next election
- Stimulating the regional economy
- Creating jobs
- Improving the framework for tourism
- Supporting regional energy suppliers

Depending on the objectives and the available resources, the expected outcomes of such activities can be very different:

Primary expectations

- Reducing energy consumption and consequently obtaining a reduction in energy costs
- Sparing resources and environment
- Utilize regional resources
- Security of supply
- Sustainable development of the municipality

Secondary expectations

- Stimulation of regional economy
- Increasing quality of the region as a living space
- Increasing quality of the region concerning economical activities
- Contribution to the development of the region/municipality.

Suppositions and obstacles

The implementation of energy efficiency projects is very important for a community. However, often many obstacles endanger their successful implementation, and often it is simply the absence of some basic suppositions that impedes the successfulness of such projects.

Some of the **basic suppositions** are:
- technically experienced staff with sufficient resources of time and budget
- high motivation of staff by delegation of responsibility
- organized support and cooperation within the municipal administration
- well developed communication within the municipality

These suppositions should put the responsible staff into the position to:
- launch specific actions and procedures
- implement pilot projects
- organize regular information events
- participate in international projects
- respect actual arising problems
- integrate other groups in the municipal energy activities
- handle and integrate critics
- activate and motivate private households
- activate business and industrial enterprises
- acquire external experts for technical, ecological or economical issues

However, all these basic elements of municipal energy management can be impeded by a long list of negative factors, some of them being:
- the energy relevant issues are not important enough in the priority setting of the municipality
- lack of motivation
- lack of resources (time and budget)
- insufficient organizational structure (lack of explicit responsibilities)
- overestimation of the risks
- energy relevant activities are not considered spectacular enough
- lack of technical know-how
- protection of historical buildings and monuments
- protection of the view of the place
- conflict of political interests
- no regional movements for environmental issues
- lack of available data

Some of these obstacles can be considered while planning an energy project to find a solution, others impede energy related activities initially.

Energy planning concept versus single actions

There are different levels on which the energy relevant activities can be planned and implemented. On the one hand, there are comprehensive energy planning concepts (energy management action plans), which usually include the following parts:

- well defined objectives,
- analysis of the current situation,
- analysis of possible measures and scenarios,
- definition of actions and projects,
- implementation and evaluation.

Depending on the scope and degree of details, the literature differs between simple or standard energy planning concepts, climate protection plans, and programs for sustainability, which are the most comprehensive ones.

On the other hand, there is the possibility of implementing single measures that are not connected or embedded in a comprehensive energy planning concept. Experience has shown that often too much time and effort is spent in order to design a comprehensive, far-reaching, and complete energy efficiency action plan. Hence, a strategy characterized by the motto: “courage for the gap” is preferred then.

The idea is to identify and compare different measures only very rough without collecting a pile of comprehensive data and without designing a whole action plan. Rather only a single measure can be selected and implemented as a single project right away.

Energy management as a continuous process

It cannot be over-emphasized that energy management is a long-term commitment, not just something that is carried out once and then passes through. If the energy manager has implemented the review stage of the action plan properly, then a plan of continuous improvement has already been instituted. However, the need for continuous improvement is so overwhelming that it is presented separately here as well.

Policy

The Energy Manager should be involved in all capital works that affect energy use. These works include:

- Office refurbishment
- New buildings
- Relocation to new premises
- New equipment purchases
- Maintenance
- Operational decisions about the use of buildings

Each of these represents an opportunity to greatly improve efficiency at very little cost - or, on the other hand, a risk that a decision will be made that will significantly increase energy costs. The energy manager should ensure that processes are established in order to be able to provide input early in the decision making process. The later the energy manager’s involvement, the more likely it is that the decision will be treated as final, before he/she can change it.

Monitoring

The energy manager should follow his/her monitoring routine without fail, and indeed, be continuously thinking of new methods of gathering information to help identify further savings. While the energy manager needs to balance the amount of information available with the ability to process and comprehend that information, the converse situation of having no information is likely to cause the rapid failure of any energy management initiatives. If the monitoring data are not reviewed against the benchmarks, then all monitoring is wasted. Monitoring is a means to an end, and does not by itself save energy.

Review

The status of the energy management program must be reviewed informally every month and formally every quarter, as described in *section O2*. Thorough reassessments should occur six months after initial measures are implemented and thereafter approximately once every year.

Revival of benchmarks

The heart of continuous improvement is exactly that: continuous improvement. Thus, the target benchmark set after the first energy audit was performed is just the first step in the right direction, and should be redundant within 12 months if the energy manager wants to do his/her job well. Benchmarks should be reviewed and decreased no less often than once a year.

Action on information

It is essential that indications of energy use increase are acted on immediately. In any building there are thousands of things that can go wrong and increase energy use or decrease service levels. The role of the energy manager is to be vigilant in watching for these problems and fixing them as and when they occur.

Revolving procedure

Even detailed energy audits do not reveal every last detail of a building's operation. In order to really understand a building, the energy manager needs to work with it for years, not one or two months. Therefore, there is always a role for re-examining the energy efficiency opportunities. The energy manager or his/her consultant/energy performance contractor can do this. As part of the review process, the energy manager should re-examine the need and opportunity for further investigations and works once every year, or sooner if the need is pressing or the opportunities obvious.

TECHNICAL FACT SHEETS

Heating and cooling of buildings

A major part of energy consumption concerning office buildings result from heating, cooling, and ventilation. Since heating and cooling are major contributors to peak demand for energy, they also contribute disproportionately to energy bills, which increasingly include extra charges for high-energy demand. The capital investment in heating, ventilation and cooling (HVAC) equipment is enormous, as the equipment cost in a new high-rise building can often exceed 20% of the total building cost. Municipalities own and occupy a wide variety of buildings, which adds to the complexity of dealing with heating and cooling issues.

Opportunities for savings

Savings of between 20 and 70% can be achieved on both HVAC operating costs and energy consumption depending on the circumstances. Further, as electricity suppliers charge more for peak demand, operating costs could rise as HVAC is often the major component of peak demand. Therefore, the financial benefits of reducing HVAC energy consumption are likely to increase.

Considering both the building and the system

Commercial buildings and their HVAC systems vary widely in scale and complexity. However, there are basic elements in every case and it is important to make sure each works properly. The main elements are:

Building envelope: The design of the building's envelope (walls, floors, roofs, glazing etc.) determines the rate of heat flowing into or out of the building, and the transfer of air between indoors and outdoors. Flows of heat are usually largest through glazing, but the other elements (walls, floors, etc.) can be important too, especially in smaller buildings. Energy-efficient building design can cut total HVAC energy requirements and peak demand, in turn reducing the capital cost of HVAC equipment (as long as the HVAC designer takes the improvements into account). For small buildings, the characteristics of the building envelope are more important than in larger buildings, because the surface area of the building (and thus the heat flow through the surface) is much higher relative to the floor area than for a large multi-storey building.

Internal heat loads: Lights, office equipment and people generate heat, which has to be removed by cooling equipment (although in cold weather it can reduce heating demands). Reducing the energy consumption of lighting and equipment within a building reduces the amount of heat generated within it and, hence, air-conditioning costs. It is important to put measures in place to minimise internal heat loads before addressing the heating/cooling system, otherwise the full benefits of a more efficient system could not be achieved. In cool/moderate climates, an economy cycle (using cool outside air instead of refrigerative cooling) can remove internally generated excess heat when outdoor temperature is lower than the indoor temperature. This can save large amounts of energy.

Ventilation loads: Outside air is used in air-conditioning systems to control air quality (e.g., to remove odours, CO_2 and contaminants, such as plasticizers released by some building materials). However, ventilation often increases the amount of heating or cooling required, so outside airflow rates should match what is actually required, based on floor area and occupancy level. Modern control systems allow the ventilation rate to be varied with building occupancy. It also makes sense to run a start-up cycle with very low outside air supply at the beginning of each winter day, to warm-up the building at maximum efficiency.

Energy distribution systems: Pumps circulating chilled or heated water, as well as fans blowing air through ducts, often consume as much energy as is used to heat and cool the building. Furthermore, ducts and pipes are often inadequately insulated, so much of the cooling or heating energy may be wasted during distribution. In large buildings, both heating and cooling systems often operate at the same time because of variations in temperature throughout the building. This further increases distribution energy losses.

Control systems monitor the heating and cooling requirements of the building and vary the operation of the HVAC system to maintain comfort. At its most basic, a system may have a simple thermostat. Sophisticated systems involve time controls, humidity sensors, CO_2 sensors and optimisation systems, and may be part of a complex Building Automation System (BAS). In large buildings, control systems may operate heating and cooling systems at the same time, in response to conditions in different parts of the building; these systems often work against each other.

Heating and/or cooling equipment varies in scale and complexity from a simple wall-mounted air-conditioner, through standard ‘packaged’ modular units, to large and complex systems with boilers to provide heat, and chillers and cooling towers to provide cooling. The more complex the system, the larger the energy losses from the associated equipment, such as fans and pumps, and from the distribution system will be.

Ensure that the system is maintained properly

Even if the HVAC equipment in a building is properly commissioned after construction, performance deteriorates over time. Thorough maintenance programs can therefore bring substantial, cost-effective savings. Where maintenance is carried out under contract, make sure the contract is sufficiently detailed and supervision is adequate to ensure that maintenance is done properly.

In smaller buildings, maintenance activities might include:
- checking thermostat settings, calibration and correct operation, including sensors and controllers away from the plant room;
- checking the setting of controls including time switches and selector switches;
- checking the operation and settings of economy cooling dampers and controls;
- regular cleaning or replacement of filters in air-conditioners;
- checking for leaks or deterioration in insulation of ducting;
- sealing of air leaks around doors and windows.

Optimise the operation of pumps and fans

Large savings can be achieved by installing variable-speed motor drives, so pump and fan speeds can be matched to requirements. The savings are disproportionately large: halving the flow rate in moderate weather theoretically cuts pump or fan energy requirements to one-eighth.

Further savings can be achieved by:
- cleaning filters, fans and dampers regularly;
- checking and lubricating or replacing bearings;
- ensuring that drive belts are in good condition, evenly matched and correctly adjusted;
- installing high-efficiency, appropriately sized motors when replacement is needed, and installing variable-speed drives where loads on motors vary;
- fitting time switches or more sophisticated controls and using them to shut down cooling/heating in areas and at times when it is not needed.

Optimisation of control systems

Time controls

Air-conditioning systems in most commercial buildings are automatically started and stopped each day by a time switch. Operation could be optimised by ensuring that the time switch:

- is set to the correct time;
- has the latest start and earliest stop times consistent with building occupancy hours;
- cannot be permanently over-ridden by leaving a bypass switch in the wrong position.
- starts the plant later during mild weather (called 'optimal start'); this is usually able to reduce operating time by an average of 30 minutes each day, a saving of about 5 percent in a system previously operating for 10 hours each day;
- does not start the plant on user-programmed public holidays (saving 10 days out of 250 - a 4% saving).

Temperature controls

The savings from cooling system controls can be easily evaluated. Such controls:

- prevent cooling equipment from running in cold weather (in complex HVAC systems, controls may allow heating and cooling to operate simultaneously in different parts of a building, even if not really required),
- allow the temperature of chilled water to increase in cold weather; since only limited amounts of cooling are likely to be required in cold weather, less cold water can still provide enough cooling capability while reducing heat gain via pipe insulation (which is related to temperature differential) and improving chiller efficiency (which improves as temperature difference becomes smaller),

Similarly, savings may also be achieved with heating system controls which:

- prevent heating equipment from running in hot weather;
- allow the temperature of heating water to decrease in warm weather.

Choose the right equipment and install it properly

Small commercial buildings often use domestic air-conditioners and heating equipment. These carry appliance energy labels, so it is possible to select energy-efficient models. Where ducted or split systems are installed, it is extremely important to make sure that ducts or pipes are well suited. In general, it is more energy-efficient to distribute gas and electricity around a building than it is to pump heated or cooled air or water. Although large chillers are much more efficient at cooling than small modular units, the overall system efficiency is often much reduced when distribution losses and the additional 'parasitic' loads of cooling towers, pumps and fans are taken into account.

Features such as reheat systems (which reheat cold air to optimise comfort in each zone of a building) can further reduce overall efficiency. Trading-off efficiency of central plant against losses from distribution systems can be a challenging task. Many designers give inadequate consideration to these issues. The feasibility of 'economy cooling', a cooling mode which automatically uses outside air when cooling is required and the outside air is cooler than the air in the building, could be also investigated. Note, however, that many 'economy cycles' waste energy if they are inadequately maintained; for example, if dampers controlling the supply of outdoor air jam partly open, large amounts of energy can be wasted when heating or cooling excessive volumes of outside air.

The HVAC designers have to analyse heating and cooling loads in detail and optimise operational effectiveness and efficiency under the full range of likely conditions. This may require to specifically allocating part of the design budget to these tasks, but it will be money well spent. Structure contracts for design and commissioning so that part of the payment depends on the system performing to specified standards after the building is occupied. Designers might also be paid on the basis of system performance rather than a percentage of system cost.

In addition, the HVAC designer has to consult with the building designer to ensure that peak cooling and heating loads are minimised through good envelope design. This will cut the capital cost of the HVAC system, and the peak energy charges.

Building management systems

Building management systems (also called building automation systems or simply BASs) facilitate control and monitoring of equipment (especially air-conditioning and other mechanical equipment). Such systems can have the advantages of:

- improved control, comfort and security;
- reduced equipment operating times, energy consumption and GHG emissions, and reduced wear of the equipment;
- improved monitoring of building and equipment, including running times, electricity demand, temperatures, running costs, etc.

A BAS will have a capital cost of about € 120 per sensor or controlled point. The design of a system (depending on what the user want it to do now and in the future) will require a significant amount of time spent by staff and/or a consultant. BASs are sometimes oversold - when they are credited with savings that could have been achieved more economically by fixing existing simple controls.

When considering a BAS:

- make sure that existing controls are optimised and that low-cost rectifications are completed first;
- consider what equipment needs controlling and what inputs will be used to decide if and how the equipment will run;
- write a technical description of the required BAS (possibly with assistance from in-house technical staff or independent consultant); this will help in clarifying the requirements and communicate them to colleagues and potential suppliers.

When selecting a BAS it should be checked:

- that the system permits flexibility and later expansion;
- what happens to the system if some of the remote equipment fails;
- that the system can be easily interrogated and reprogrammed by the organization's technical staff/team (without needing to refer to the installer or manufacturer);
- that any new software or equipment introduced by the manufacturer will be made compatible with all previous versions of software and equipment (preventing premature obsolescence);
- that international data formats are supported.

Estimating energy consumption and greenhouse emissions

Ideally, the energy use for HVAC should be separately metered. If this is the case, this data can be easily converted to GHG emissions. If separate metered data are not available, 'house power' may be separately metered. This includes HVAC, lighting of common areas, lifts, etc. It may be possible to estimate electricity use for activities other than HVAC, and subtract this from the 'house power' to give an estimate of HVAC consumption. If only the whole building's energy use is metered, this at least gives some indication of HVAC energy consumption.

Possible indicators

- Total energy use or HVAC energy use (if available) in the building: trend over time
- Total energy use or HVAC energy use per square metre: monthly, seasonal and annual
- Energy use during and outside working hours (to identify scope for switching off equipment when not required)
- Energy use during peak and off-peak periods (to identify contributions to energy bills)
- Energy use in summer versus winter (to identify the extent of seasonal variation: where there is little variation, it is likely that significant energy is being wasted).

Further information

Seek out designers who have demonstrated expertise in achieving high levels of energy efficiency (and ask for evidence of expertise based on actual energy bills from buildings they have designed). Equipment manufacturers may also be helpful, but keep their advice in context as they are rewarded by bigger equipment purchases.

ES Guides (CRES, *in Greek)*
ENERGY SAVINGS IN HVAC SYSTEMS
ENERGY MANAGEMENT IN BUILDINGS
BUILDING ENERGY MANAGEMENT SYSTEMS

THERMIE maxi brochures
Centralised energy management in buildings
Energy efficiency in hospitals & clinics
Energy efficiency in office buildings
Natural and low energy cooling in buildings
Innovative energy saving technologies for social housing programs

CADDET Analyses Series No8
Learning from experiences with energy efficient retrofitting of office buildings
Energy Efficiency Office UK
“Energy efficiency in buildings: Health care buildings”
“Energy efficiency in buildings: Sports centers”

ETSU-AEA
“Introduction to energy efficiency in offices”
“Introduction to energy efficiency in further and higher education“

Best Practice Example

Energy efficiency and the building envelope

Apart from reducing energy consumption, the benefits of an energy-efficient building envelope include:

- lower cost of air-conditioning plant, as smaller quantities of heating and cooling are required at peak periods (often, the capital savings on HVAC plant can almost pay for the extra cost of insulation and other energy-efficient features—before the value of ongoing energy savings is even considered);
- lower charges for peak energy demand;
- improved occupant comfort.

The energy efficiency of an existing building envelope can be improved by a variety of measures. While this may not save on investment in heating and cooling plant, it can still cut peak energy demand charges, reduce operating costs and improve occupant comfort. For example, where air-conditioning equipment is being converted to eliminate the use of CFCs, the replacement refrigerants may have different properties, and this may reduce the cooling capacity of the plant. Rather than investing in extra equipment to compensate this, upgrading the energy efficiency of the building envelope is a good alternative, as this option also reduces peak capacity requirements and cuts ongoing energy costs as well.

Constraints to overcome

Efforts to improve the thermal performance of a building are often treated as a low priority for a number of reasons:

- Building design is the responsibility of the architect, while engineers look after HVAC design (including calculation of heating and cooling loads, which provides valuable information about which elements of the building envelope contribute most to heating and cooling energy consumption and peak demand). Often communication between the two is poor. Appropriate contractual arrangements and/or use of a project manager or coordinator can overcome this.
- HVAC designers are often paid a percentage of the cost of the HVAC system, so they have no incentive to help the architect reduce HVAC size and cost.
- Many designers believe that an energy-efficient building envelope may increase energy consumption by trapping heat generated by lights, equipment, and people inside the building.
- Energy efficient building design is perceived to be expensive, but the appropriate orientation, sizing, and selection of glazing can actually reduce envelope costs.

Opportunities for savings

Savings on HVAC operating costs (and greenhouse emissions) through energy-efficient building design can range from 20 to 50%.

Glazing

Up to a kilowatt of heat can enter a building through a square metre of clear glass exposed to direct sun, which is equivalent to switching on a single-bar electric heater at the hottest time of the day. Winter heat loss through each square metre of single glazing is three times that through uninsulated wall, and more than 10 times the loss through a square metre of insulated wall. This adds to peak electricity demand (often incurring extra demand charges), requires increased HVAC system capacity, and creates glare and occupant discomfort.

Ways of cutting energy flows through glass include:

- design the building with less glass (which also cuts capital cost, as wall materials are usually cheaper than glazing);
- if building or renovating, advanced glazing systems (which include double glazing and heat reflective coatings) are now available which allow much less heat flow and more daylight, improving occupant comfort compared with older types of glazing.
- install external shading (plants or constructed shading); in hot regions, consider shading the ground around buildings, as well as windows and walls exposed to sun;
- install reflective internal blinds such as reflective pleated blinds;
- install heat-reflective window films (today's films are much improved on those of a few years ago: they allow in more light while rejecting heat more effectively);
- paint dark-coloured metal window frames with a light colour (they constitute disproportionately important paths for heat flow; painting them with light colours reduces heat flow markedly, because light colours reflect most radiant heat); metal window frames are also available with thermal breaks, which reduce heat flow through the frame;
- for display windows in information centres, consider separating the display area from the main shop area with insulated partitions or glass panels;
- insulating panels can be fitted over part of a large window area to cut heat flow; but this should be balanced against loss of daylight and visual access.

Solar building design (which may use large areas of north-facing glazing) can often reduce energy costs and improve amenity. However, in many office buildings, which require mainly cooling and little heating, solar gains can increase energy costs and create glare problems unless carefully integrated into the building design. Ideally, computer simulation should be used to optimise building design.

Insulation of ceilings, walls and floors

Insulation reduces heat flows through ceilings, walls, and floors. This can markedly improve occupant comfort and reduce the time HVAC systems take to reach comfort temperature at the start of the day.

Municipal buildings are generally poorly insulated for several reasons. Often, large community buildings are purchased after construction, or are designed to normal commercial building specifications, which tend to place low value on future running costs relative to up-front capital costs. This is an inappropriate approach for owner-occupied buildings with long lives. In many cases, buildings originally designed for one purpose are converted to other uses without sufficient consideration of building energy efficiency.

In addition, many HVAC consultants consider that insulation has little net energy or financial benefit because it traps heat generated within the building, thus increasing cooling loads. However, this argument is losing validity because:

- electricity tariffs are shifting emphasis to charges for *peak* demand, and insulation is particularly effective in reducing electricity consumption during peak periods; insulation also reduces the size of HVAC system required, which saves capital costs (savings on peak demand charges and offsets against capital savings are often ignored in cost–benefit analysis);
- 'economy cycles' are now more common, which means that, in moderate temperatures, heat generated internally can be removed using outdoor air instead of increasing cooling costs;
- improvements in office equipment and lighting energy efficiency mean internal heat loads are declining in many circumstances (contrary to beliefs), which means that there is less unwanted heat to be trapped by insulated walls, ceilings and floors, and the net economic benefit of insulation improves.

Insulation of ceilings, walls and floors is a more significant factor for smaller buildings with low internal heat loads than for large multi-storey buildings. For example, consider two buildings, one five storeys high and the other only single-storey, both with 1000 square metres of floor area per storey:

- the five-storey building has around *0.9* square metres of external surface per square metre of floor area;
- the single-storey building has *2.5* square metres of external surface area per square metre of floor area.

Energy flows through the roof, walls and floor are therefore a much larger proportion of total energy flows for the smaller building.

To summarise, under extreme conditions, an energy-efficient building envelope always reduces energy consumption and energy charges for peak demand. The smaller the building and/or the lower the internal heat loads, the more energy insulation will save. Since most municipal buildings have long lives and relatively long occupancy hours, and aim to provide a high standard of comfort, it makes sense to incorporate a high standard of insulation into all these buildings.

For existing buildings, it may be difficult to retrofit insulation into walls, but it is usually possible to insulate ceilings and under exposed floors (such as floors above car parks).

Air leaks

Air leaking at the rate of only 100 litres per second (about the rate of air removed by a domestic exhaust fan) creates a cooling or heating load of up to 2 kW under extreme climatic conditions. In a building housing 250 people, entry of outside air at twice the required rate could add up to 50 kW to the cooling or heating load—a substantial waste of energy, costing up to €3 per hour.

Problem areas and strategies to address them include:

- Ensure doors are closed where feasible; use self-closing doors, fit heavy plastic strips to limit air flow, or install windbreaks or airlocks at entrances.
- Large amounts of air-conditioned air may be removed by exhaust fans, particularly where a building includes a commercial kitchen (such as for Meals on Wheels). In such a situation, outside air could be ducted into the area near the exhaust fan, providing an alternative source of air for the fan and preventing it removing air-conditioned air.
- Gaps around doors and windows, and cracks in the building fabric can be weather stripped or sealed. Often there are serious air leaks around doors and hatches to un-air-conditioned areas; these depressurise the building and allow cold draughts to cause discomfort for staff near doors and windows.
- Open fireplaces and heater flues are large sources of air leaks in some municipal buildings converted from residential use. Open fireplaces can be blocked off or fitted with dampers. Not much can be done about existing heater flues, but new heaters can be chosen that isolate combustion air from the indoor air, so (warmed) indoor air is not lost.
- Evaporative coolers installed for summer cooling can allow large quantities of warm air to escape in winter; they should be fitted with automatic louvres to seal them closed when not in operation.

Further information

<u>ES Guides (CRES)</u>
ENERGY SAVINGS THROUGH THERMAL INSULATION

THERMIE maxi brochures
Less is more. Energy efficient buildings with less installation

Best practice example

Lighting overview

Lighting accounts for about a third of all electricity used in municipal buildings, while street lighting normally uses more energy than any other municipal activity. Lighting is also important to a municipality because illumination affects:

- the ability of staff and citizens to see accurately, affecting their ability to read, work and move safely;
- the appearance, ambience and functionality of a building and its fittings, affecting the mood and morale.

When looking for ways to cut energy use, probably the first action most people think of is switching off lights. This is of course very effective, but there are many other ways to reduce lighting energy use, some of which are described here. Opportunities particularly relevant to offices and street lighting are presented in the corresponding topics below.

Opportunities for savings

Use of daylight

Daylight is the most abundant and easily used form of free, renewable energy (solar energy). A daylight sensor can control outside lighting and lighting in atria. Some sensors have an adjustable light-level setting, making them suitable for areas which have access to natural lighting but which require a higher lighting level than the setting of standard sensors. Such areas could include glazed foyers, some depot buildings, indoor swimming pool halls, undercover parking, or childcare centres.

In some cases, modest changes to a building will permit better use of natural lighting—for example, skylights in a depot workshop or garage. Painting internal surfaces with light colours and trimming vegetation back so windows have greater access to the sky can improve the effectiveness of day lighting. Painting walls outside windows with light colours to reflect more light into the room can also make a remarkable difference to the amount of useful daylight.

Using daylight inside a building will improve the quality of the lighting in municipal buildings by improving colour rendering, eliminating flicker and giving people a link to the outside environment. However, too much daylight, especially direct sun, can create glare problems and excessive heat. For example, a square metre of clear roof glazing in direct sun delivers as much light as up to 40 standard 36-watt fluorescent lamps[1]. Good design of day-lighting systems is critical.

Use the right amount of light

People need more light to read than they do to walk down a corridor, but offices and other buildings are often lit with the same lighting intensity throughout. Over-lighting wastes energy and money without producing any benefit. There are national and international standards that recommend appropriate lighting levels for various tasks, and the following table provides a first orientation (but each time the national standards should be used.

[1] ‘Standard’ means a fluorescent lamp (tube) which is not a tri-phosphor lamp. Compared with a tri-phosphor lamp, a standard fluorescent lamp has a shorter life (i.e. 8,000 hours compared with 16,000-24,000 hours), lower efficacy (lower light output for the same electrical power draw), poorer light colour, and quicker performance degradation (aging).

Class of task	Recommended illuminance	Characteristics and examples
Movement and orientation	40 lux	Corridors, walkways.
Rough, intermittent	80 lux	Interiors used intermittently. Change rooms, live storage areas, loading bays, stairs.
Simple	140 lux	Coarse detail. Staff canteens, entrance halls, etc.
Ordinary or moderately easy	260 lux	Continuously occupied areas with easy visual tasks, such as blackboards and charts in training rooms, food preparation, transaction counters.
Moderately difficult	320 lux	Routine office tasks of reading, writing, typing, enquiry desks, libraries.
Difficult	600 lux	Drawing boards, town planning and enquiry counters dedicated to viewing paper plans.

Put light where it is necessary

A light switch could be provided for each separate work area such as an individual office, so that only those lights required are used (and ask staff to switch on only the lights they need). In addition, fittings appropriate to the area that needs to be lit could be used. For example, a desk-light can provide very good lighting where it is needed, but consumes a small fraction of the power required by standard ceiling-mounted lights. The desk-light can also be adjusted to suit individual preferences.

Operate lights only when required

Apart from the daylight sensors and manual switches already mentioned, ‘burning’ time can be reduced by:

Occupancy detectors: They detect people by detecting movement, and automatically switch lighting off after no movement has been detected for a period (normally adjustable). Models are available for offices (these detect the slight movements made while reading, using a telephone or operating a computer) and for areas where movement is more obvious (for example, passageways, change rooms or car parks). Occupancy detectors are especially useful in low-occupancy areas that are not the responsibility of any one person (for example, conference rooms, tearooms or corridors).

The investment required to install occupancy detector lighting controls may be:

- about € 60 for a simple detector which can be installed in less than one hour;
- about € 150 for a more sensitive detector for office applications and a control relay to switch power to the lights;
- more than € 180 for an installation requiring more than one sensor or a sensor to cover a large area (such as a gymnasium or hall).

Selection, siting and adjustment of occupancy sensors is best done by an expert. Note that it is cost-effective to switch off fluorescent lamps, even for short periods. Financial and energy analysis has shown that if a standard fluorescent lamp is switched off for more than two or three minutes, the energy and financial savings exceed the costs associated with restarting the lamp (including the cost of slightly reducing lamp life).

Time switches: These are not appropriate for lighting in offices, stairwells and similar situations, where switching the lights off could plunge occupants into darkness. However, they can be used to switch off ‘aesthetic’ or display lighting at night after the time most people could benefit from it. For example, automatically switching off the lighting for a building exterior, monument or fountain at midnight will slash electricity use but still provide illumination when most people will be passing by.

Use of an efficient light source

The following list informs about the most appropriate lamp type for most applications.

- *For many general applications*: Modern fluorescent lamps, especially the more efficient 'tri-phosphor' lamps, have low cost, high efficiency, good colour (unlike the blue hues of older lamps) and very long life (8,000-16,000 hours rated life compared with 1,000-2,000 for incandescent lamps). They are readily available in lengths of 300-1500 mm.
- *For situations where there are size or style constraints*: Compact fluorescent lamps have characteristics similar to full-sized fluorescent lamps but are suitable for applications where the size or appearance of normal fluorescents is unacceptable or the high lighting output is unnecessary (e.g. desk lights, downlights, wall washers).
- *For lighting large areas (e.g. indoor pools, depot garages)*: Metal halide lamps produce a crisp white light. They have efficiency about the same as the best fluorescent lamps but more light output, and so fewer fittings are needed.
- *For situations of infrequent use*: Incandescent lamps (including standard light 'bulbs', low-voltage and linear tungsten halogen lights) should only be used in fittings which will be operated for less than 500 hours per year, such as cleaners' rooms, or outside lights controlled by movement detectors.

Apart from lower energy consumption, energy-efficient light sources such as fluorescents have two significant benefits, namely increased reliability (and hence safety) and reduced maintenance costs (both lamps and labour). Low-voltage lighting is over-used in many office buildings, partly because of the misconception that it is energy-efficient. Its real advantages are:

- the ability to highlight a small area or object (e.g. a painting); and
- small size, which can be an issue in some lighting installations.

However, energy efficiency is not one of them, since low-voltage lights are not low-power or low-energy ones. Their efficacy is about 20 lumens per watt (compared with 90-110 lumens per watt for modern fluorescent lighting). The transformers supplying the low-voltage power also use energy (typically 10-20 watts per lamp) further reducing the efficiency of the lighting system, and this should be taken into account when calculating the energy use of low-voltage lighting systems. Low-voltage lighting should not be used for lighting large areas, such as entire foyers and reception areas.

Role of the fitting

A light fitting (or 'luminaire') should distribute the light produced by the lamp as efficiently as possible to where it is required, while minimising the total cost over the life of the unit (purchase price plus energy, maintenance and other operating costs). Some perform better than others do, as an efficient fitting can use half the power of an inefficient one to produce the same light output (even though they may both use the same kind of lamp). Traditional recessed fluorescent lamp fittings with acrylic plastic diffusers deliver about 50% of the light produced by the lamps into the room, while the best models, which incorporate carefully shaped reflectors, deliver more than 75% of the light produced.

Fluorescent fittings include a device called 'ballast', which controls lamp current. This unseen component consumes up to 10 watts per lamp, or more than a quarter of the power rating of the lamp itself. Modern electronic ballasts are available which:

- reduce the total power of the light fitting by about 25% while maintaining light output (compared with only an 8% reduction with 'low-loss' iron-core ballasts);
- eliminate flicker during start-up and normal operation; and
- extend lamp life.

'Low-loss' iron-core ballasts reduce electrical power by about 3 watts per lamp (reducing ballast energy use by one third compared with a standard ballast). Although the savings are much lower than those of an electronic ballast, they are suitable for the replacement of failed iron-core ballasts, and/or use in fluorescent lighting which will operate for fewer than 1,500 hours per year.

Importance of maintenance

Unless lighting systems are regularly maintained (cleaned and relamped), the lighting quality declines. Fluorescent lamps dim as they age. This dimming effect, combined with the build-up of dust on lamps, diffuser panels and reflectors, reduces the amount of light reaching the area to be lit. Although less light is provided, just as much electricity as is paid is used.

There is a natural tendency to keep fluorescent lamps until they die completely, by which time they could be producing only a third of the light they produced when new. A standard 36-watt fluorescent lamp costs about €1.5 to buy but about 10 times this amount to operate in an office building for just one year. Standard fluorescent lamps should be replaced in bulk after 8,000 hours operation (about three years in an office or one year with continuous operation) or 16,000 hours for the new long-life fluorescent lamps.

The lamps and light fittings should be cleaned once a year. The advantages of this planned maintenance include:
- the quality of the built environment is maintained;
- the tendency to add more light fittings because of falling light levels will be avoided;
- bulk lamp replacement minimises disruptions and facilitates lamp recycling through a special lamp crusher, whereas lamps replaced one at a time tend to end up in landfill - where the mercury they contain may contribute to environmental problems.

The amount of light entering through windows and roof lights can drop by up to 60% because of dirt build-up, so these also need regular cleaning.

Useful data

Lamp efficacy—light produced per unit of power

Lamps are labelled with their wattage. This tells how much electrical power the lamp will use but not how much light it will produce. The amount of light produced by a lamp is measured in *lumens* (lm). The amount of light produced for each unit of electricity consumed is expressed as the lamp's *lumens per watt* (lm/W). The table shows typical figures for common lamp types.

Lamp type	**Lamp efficacy** (lumens per watt)	**Lamp life** ('000 hrs)
Tungsten filament (standard incandescent light 'bulb')	10-15	1-2
Tungsten-halogen (including low-voltage lamps)[2]	15-20	1-4
Fluorescent	65-100	8-16
Compact fluorescent	50-80	8
Metal halide	70-105	6-10

Calculating energy consumption and greenhouse emissions

For each group of lights:
- Calculate the annual electricity use for one light in kilowatt hours (kWh) by multiplying the power of the lamp by the number of hours of operation; the table below gives sample values for a range of different lamp types and applications.

[2] The transformers used for low-voltage lamps waste up to 30% of the total energy used, reducing overall efficacy to little better than that of standard incandescent lamps

- Multiply by the number of lights to give the total energy use of the group of lights
- Then, use the greenhouse coefficients to convert the annual electricity use (kWh) to GHG emissions (tonnes of CO_2 equivalent)

Lighting application	Operating hrs/year	Annual energy use (kWh/year) by lamp type				
		Fluorescent		Incandescent		
		Single 1200 mm (45 W[1])	Twin 1200mm (90 W[1])	Low-voltage 50 watt (65 W[2])	Standard 'bulb' (75 W)	Tungsten (example) (250 W)
Office, individual	1,250	56	113	81	94	313
Office, open plan	2,000	90	180	130	150	500
Library	3,000	135	270	195	225	750
Depot office, two shifts	4,000	180	360	260	300	1,000
Gymnasium	5,000	225	450	325	375	1,250
Continuous running	8,760	394	788	569	657	2,190

[1] Including ballast
[2] Including transformer

Example

A Perth library has 150 fluorescent fittings, each with two 1200 mm lamps. These operate for 3,000 hours per year. The electricity supply contract includes 25 per cent Green Power. What is the amount of CO_2 emitted as a result of supplying lights with electricity?

1. Annual electricity use for one light	From table above	= 270 kWh/yr
2. Annual electricity use for all lights	270 kWh/yr x 150 lights	= 40,500 kWh/yr
3. Deduct proportion of Green Power	40,500 – (0.25 x 40,500)	= 30,375 kWh/yr
4. Greenhouse emissions from lighting	From CCP™ software[1]	= 33.4 tonnes CO_2/yr

[1] Factor for WA electricity is 1.10, so emissions are 30,375 kWh x 1.10 = 33,4125 kg CO_2 = 33.4 tonnes CO_2 per year

Possible indicators

- Total lighting energy use (if available) in the building: trend over time.
- Lighting energy use per square metre: monthly, seasonal and annual.
- Lighting energy use during and outside working hours (to identify scope for switching off lights when not required).

Office lighting

Opportunities for savings

Use of daylight

Daylight can often be used effectively by automatically dimming the two rows of lights adjacent to windows (daylight switching is not recommended in offices because of the distraction it can cause—although dimming can be used).

Avoid excess lighting

The building owner and the lighting designer usually provide office-standard lighting before the office space has a tenant and the usage of the space is known. This results in ceiling-mounted light fittings being used to provide an illumination level suitable for reading almost everywhere, even though only about 5–10% of the office space will require this lighting level (e.g., 1 m^2 of desk space per person).

A much better approach is to:

- use a combination of up-lights and standard fittings to provide background illumination suitable for moving around the office and for other general tasks which do not require prolonged, detailed reading;
- use compact fluorescent task lights (desk lamps) to provide the high level of illumination required for reading and writing text (low-voltage halogen or incandescent task lights can be cheaper to buy but are much inefficient than compact fluorescent).

The advantages of this approach are:

- the total lighting power is cut by more than half, which also reduces the load on cooling equipment;
- office staff have more control over their own lighting;
- the office will look better, and effective up-lighting will remove the gloom a dark ceiling creates;
- unwanted reflections in computer screens (from light fittings and overlit objects) will be significantly reduced;
- work areas will be abundantly lit without over-lighting other areas such as walkways.

How efficient is the lighting system

The energy efficiency of a lighting system is gauged by the 'lighting power density' (watts per square metre) for a given lighting level, and the flexibility and effectiveness of lighting controls (switches, dimmers, etc). The lighting level is expressed as the 'maintenance illuminance' (the minimum illuminance for particular tasks, below which maintenance is required - for example, lamp cleaning, or replacement).

For routine office tasks, the recommended maintenance illuminance on the work surface is 320 lux. This amount of light could be achieved in various ways, some using more power per square metre than others do. The options are described in the following table.

Lighting design and installation	Description	Power density (watts/m²)
Mediocre	Standard 'project' ceiling-mounted fluorescent fittings using standard fluorescent lamps and ballasts. Same lighting level throughout the office space.	25–35
Good	High-efficiency ceiling-mounted fluorescent fittings using tri-phosphor lamps and low-loss, iron ballasts. Same lighting level throughout the office space.	12
Excellent	High-efficiency, ceiling-mounted, fluorescent fittings and uplights with metal halide lamps used to provide background illumination of 80–160 lux. Individual task lights used to provide illuminance of at least 320 lux at each work station	4–7
State of the art	As above plus daylight integration (bringing daylight into the working areas and automatically dimming lights according to daylight).	2–5 (averaged over time)

Calculating the lighting power density

It is easy to get an idea of where the office lighting falls in the above scale of energy efficiency by estimating the lighting power density. This is simply the total lighting power divided by the floor area, and can be calculated for a small typical area. Here are some 'rules of thumb' that can help:

- Each 1200 mm fluorescent lamp uses about 45 watts (including its ballast) and most fittings have two lamps, giving a total of 90 watts. If the number of lamps per fitting is

not clearly identifiable, try switching the power off and then on; the lamps may 'strike' at different times so the number of lamps will be more obvious.
- If the floor area is difficult to measure because of obstructions, the ceiling tiles could be counted. Each rectangular tile has an area of 0.74 m^2 and each square tile 0.37 m^2.

Prospecting for savings in office lighting

Begin searching for lighting energy savings by checking for:
- **Old, dirty fluorescent lamps and fittings**: cleaning the fitting will help, and using new, efficient lamps will allow getting the same amount of light from fewer lamps. Fluorescent lamps dim as they age, so make sure the initial illuminance is sufficiently higher than the maintenance illuminance, although the extra quantity required can be minimised by using modern 'through-life' tri-phosphor lamps, which lose less than 10% of their initial light output over their rated life.
- **Lighting levels significantly above those required**: this is usually because the lighting has been designed assuming the space will be used for office work when it is actually a walkway or staff room.
- **Incandescent downlights**: each 100W incandescent downlight uses more electricity than a 2 x 36 W fluorescent fitting, although it delivers about 80% less light. Also, the downlight housing causes the lamp to overheat, shortening the already short lamp life and adding further to maintenance costs. Compact fluorescent downlights will reduce the power required by 70% and are available from €30 (plus installation). In a typical office, each incandescent down-light replaced will save €5 to €15 in electricity costs.

Street lighting

Electricity distribution companies normally and, to a lesser extent, state departments that administer arterial roads provide street lighting (equipment, maintenance, and energy) on behalf of municipality. Of all municipal services, street lighting is the one that uses the most energy. It is also an expensive activity. Good street lighting has an important role to play in the community. It contributes to people's quality of life by improving pedestrian and traffic safety, as well as making people feel safer; it also improves the appearance of the local environment.

A decade ago, the electricity industry consisted mainly of government monopolies, whose main concern was the integrity of the electricity supply system. Street lighting was a small additional task that accompanied the poles and wires asset, so it was not a high priority and the energy efficiency of the service was a small concern. During the 1990s, much of the electricity supply industry was divided into smaller parts, as generators separated from distributors and energy retailers. For distributors street lighting is a bigger issue than it was to vertically integrated utilities. Street lighting accounts for about 20% of the GHG emissions attributable to a distribution company, so there is as well an environmental incentive to improve its energy efficiency.

Opportunities for savings

An Australian investigation of street lighting from 1999 found that present street lighting systems are inefficient, in that the quality of illumination of both minor and major roads is much lower than can be achieved, and the energy efficiency is low. Apart from that, there is a basic mismatch between the light colour produced by many streetlights and the light colour that the human eye can use under typical street lighting conditions.

The study also found that the quality of street lighting could be significantly improved, and the energy consumption at least halved, by a combination of:

- more efficient lamps (e.g. metal halide and compact or tubular fluorescent);
- more efficient luminaires (reflector design, less light loss in the diffuser, more accurate light distribution without a refractor bowl);
- efficient ballasts[3]; 'low loss' ballasts and especially electronic ballasts;
- more accurate control of lighting times (electronic photo-switch rather than the existing cadmium sulphide cells, to reduce burning time by at least an hour per day and give additional energy savings of 9%);

The investigation report recommended field trials to demonstrate energy-efficient lighting strategies that meet the needs of local communities and road users. These trials should involve local government, electricity distributors, road authorities, and lighting equipment suppliers.

What can municipalities do

- Prepare an inventory of street lighting equipment. This can be used to minimise charges now, and help to prepare for tendering street lighting when it becomes a contestable service.
- Clarify how much does the municipality pay for power, maintenance, etc. in the existing contract.
- Inform the electricity distributor of the project, and explain that it will be expected to work with him to achieve substantial energy and financial savings.

Further information

ES Guides (CRES):
ENERGY SAVINGS IN LIGHTING

THERMIE maxi brochure:
Energy Efficient Lighting in Schools
Energy Efficient Lighting in Offices
Day-lighting in buildings
Summary guide: Energy efficient lighting practice
Energy efficient lighting in buildings
Financing equipment linked to energy

CADDET Analyses Series No6:
Learning from experiences with energy efficient lighting in commercial buildings

Best Practice Example

[3] A ballast is a device which controls the current in a discharge lamp (e.g. fluorescent, mercury or sodium). Without a ballast the current would increase rapidly as the lamp started and the lamp would explode. Most ballasts for fluorescent lamps use 10 watts each, and those for mercury lamps use 20 watts.

Hot water production

Supplying hot water in municipal facilities can be an expensive process. For example, supplying just 100 litres of hot water per day can cost €180 each year. In many cases, heat loss from tanks and pipes is greater than the amount of useful heat delivered. While providing hot water is an obvious task in healthcare and catering facilities, it is also significant in offices when the purchase and operating costs of the many boiling water units and hot water services throughout the building are considered.

Opportunities for savings

The key issues to consider in ensuring that costs and energy consumption for hot water preparation are as low as possible are:

- minimising hot water consumption;
- maintaining properly the system;
- choosing the right equipment, based on:
  - the *energy source* - gas and solar are preferable concerning cost and greenhouse intensity,
  - the *consumption patterns* - how much will be used (taking into account efficient water use), and what will be the peak requirements,
  - the *performance of the equipment*, taking both standby losses and hot water use into account.

Rationalize hot water consumption

Water-efficient shower and tap fittings can cut hot water requirements by up to half. For new buildings and refurbishments, they also offer the opportunity to install smaller diameter pipes, which are cheaper and hold less water (so less hot water is wasted by cooling between uses). When purchasing water-using equipment such as dishwashers or washing machines, select the models that use the least hot water. Many household products now carry water rating labels which can help choosing the most efficient model.

In facilities such as swimming pools or recreation centres, where multiple showers are likely to be in use, AAA-rated water-efficient showerheads can reduce the risk of running out of hot water, as well as save hot water overall. In many cases, hot water may not be needed at all or the thermostat of the system can be set to a lower temperature to reduce heat losses. However, the storage temperature for hot water systems should normally be set above 50°C to limit the risk of legionella infection.

Carry out maintenance

Maintenance tips include:

- fix dripping taps;
- check yearly the pressure/temperature valves fitted to mains pressure hot water units, as these can leak large quantities of hot water without this being noticed; if more than a bucket of water is released over 24 hours, the valve should be repaired or replaced;
- drain off sediment from the bottom of HWS tanks regularly; in gas units, sediment can significantly reduce heating efficiency;
- replace sacrificial anodes in glass-lined steel HWS tanks at recommended intervals to prolong tank life.

Use low greenhouse-impact energy sources

Solar energy, gas or electric heat pumps generate much lower GHG emissions (typically around a third as much) per litre of water heated than electric storage systems. However, where only small amounts of hot water are used, a small electric HWS may be acceptable, due to its lower heat losses (especially if additional insulation is wrapped around the tank).

Choose appropriate equipment

When use is intermittent (for example, sports facilities or little-used kitchenettes), ensure that the system installed loses as little heat as possible or that can easily be turned off (but can also recover to operating temperature quickly and can supply the peak demand). For example, one or more high-capacity instantaneous gas HWS units with electronic ignition may be a good option for a sports facility.

If it takes a long time for hot water to reach an outlet, there may be a case for a point-of-use HWS. Check by turning on the tap and seeing how much cold water is collected in a bucket before the water becomes hot. Calculate wastage based on likely patterns of use to see if a change is warranted.

Hot water services

Suppliers can be asked for data on heat loss, so the units with the lowest losses can be selected. Extra insulation would also be effective, for example, foil-backed 75mm fibre-glass or polyester blanket wrapped around tanks and (at least) 10mm thick insulation fitted to pipes within 2m of the tank. The pressure/temperature (p/t) valve should not drip excessively (no more than 5% of the volume of hot water used should be released). This may involve uncoupling the overflow pipe and placing a container under the overflow outlet. Ensure that new installations allow for easy monitoring of valve operation.

Consider removing or switching off unnecessary HWS units. For example, if a boiling water unit is installed above a sink, an outlet with a mixing valve could be fitted to supply the modest amounts of domestic hot water needed for washing dishes much more cheaply and efficiently than a separate HWS. In-line heating elements can be fitted to water pipes to supply warm or hot water at moderate rates, adequate for hand washing (if a water-efficient tap is fitted). These have no heat loss when not in use, and avoid ‘dead water’ losses—heat lost when hot water cools in the pipe between the HWS and the tap.

Large central systems

Where hot water is provided by a boiler, steam is produced at much higher temperatures than required for hot water, wasting up to 30% of the energy used. Replacement with a water heater will cut operating costs. If a boiler used predominantly for space heating is operated in warm weather to supply hot water, it is often economic to supply the hot water from a separate HWS all year round, to reduce boiler losses.

Where long lengths of pipe deliver hot water from a central boiler to points of use, large amounts of energy can be wasted, both through heat loss from the pipe, and through the need to flush out water remaining in the pipe that has cooled down since the previous use. For example, 4.4 metres of 19mm pipe holds a litre of water. Small water heaters near points of use are often much cheaper to operate.

Ring mains (a pipe loop through which hot water is pumped continuously so it is available to any user without a long wait) often lose large amounts of heat and consume substantial electricity for pumping. For example, 100 metres of 25mm pipe with 25mm thick insulation loses 1.3 kW of heat, equivalent to the heat lost from about 20 small electric HWS units. Energy used to run the circulation pump adds to this energy waste. Variable-speed control of pumps and upgraded insulation on pipes can bring large savings. Again, point-of-use water heaters may be appropriate, particularly if they are well insulated.

Boiling water units

A large boiling water unit can cost up to €600 to buy and install, and to up to €220 per year to run - 90% of which is wasted through heat loss. Urns are also very inefficient. Many boiling water units are oversized, so it is better to consider a small unit. In most cases, a 5-litre model is more than adequate. It can supply around 40 cups of boiling water as quickly as people can queue, and can recover temperature in a few minutes. And it is hundreds of Euros cheaper to buy a smaller model.

Ask the manufacturer for data on standby power consumption and the major operating cost. A difference of only 50W in standby power consumption equates to extra €30–45 in running cost every year. Over 10 years, that makes a difference of up to €420. Some models have integrated timers, so they can be programmed to switch off outside working hours (clear instructions for users on how to override the timer should exist; workers on overtime or participants in out-of-hours meetings may become grumpy if only lukewarm water is available).

Few portable urns are well-insulated, so they have very large heat losses. Insulated jugs or air-pots are a much more energy-efficient way of providing hot water for meetings.

Estimating energy use and greenhouse emissions

To calculate the energy required to heat water, multiply the number of litres by the temperature rise by 0.00116 to calculate energy in kilowatt hours. For gas heating, multiply by 0.0053 for energy in mega joules (assuming 80% efficient combustion). For example, heating 100 litres of water from 15°C to 65°C (a rise of 50 degrees) consumes:

- for electricity: 100 x 50 x 0.00116 = 5.8 kWh
- for gas: 100 x 50 x 0.0053 = 26.5 MJ

The **efficiency** of a hot water system can be calculated by comparing the energy content of the water (calculated as above) with the total energy consumption of the HWS. For example, if an electric HWS consumes 10 kWh per day to supply the 100 litres of hot water as above (energy content 5.8 kWh), the efficiency would be: 5.8 kWh / 10.0 kWh x 100 = 58%

Possible indicators

- Total hot water energy use in the building: trend over time;
- Hot water energy use per unit of activity (e.g. number of staff, or number of customers): monthly, seasonal and annual;
- Trend in efficiency over time;
- Hot water energy use during and outside working hours (to identify wastage).

Further information

Technical consultants can carry out appropriate tests and calculations to compare options. However, make sure that they use realistic demand profiles (based on water-efficient taps and showers) and consider a wide range of options.

Equipment suppliers can provide useful information: comparing data from two different suppliers may highlight each one's assumptions and allow asking the right questions. Often the staff itself can highlight areas of hot water wastage.

Best Practice Example

Office equipment

The total energy use by office equipment each year produces millions of tonnes of GHG, of which:

- around a third is due to modular office equipment, including desktop computers, printers, copiers and fax machines;
- a third is due to mainframe computers; and
- the remaining third is due to PABXs, cash registers, EFTPOS units and other retail systems.

The electricity that powers office equipment is a direct cost to municipality, but there are indirect costs too. Waste heat from office equipment increases air-conditioning energy consumption, typically by 10 to 25%, and increases peak energy demand. This impact is often ignored, but it adds to operational costs.

Computers, copiers, printers, fax machines

Typically, at least two-thirds (and up to 90%) of the energy used by office equipment occurs when it is switched on but doing nothing useful. New equipment is generally much more energy-efficient than the equipment it replaces—although increases in screen size are outstripping efficiency improvements for computer monitors. For example, 17-inch monitors typically consume 100 to 130W, while 15-inch models use around 70W.

Efficient use of equipment

- Train staff to **switch off equipment** when it is not needed.
- **Activate energy-saving features**. Many modern PCs, printers, faxes, and copiers comply with the *Energy Star* program, originally developed by the US EPA but now promoted by energy agencies all over the world. These are fitted with 'sleep' modes (some functions are automatically shut down after set periods of inactivity). Activating these features saves energy and prolongs component life (in some cases), but they are sometimes complicated to set up. Consult the manual or equipment supplier. Use IT staff to set up energy-saving features on all equipment in an office and train staff to work with these features - to minimise staff confusion and highlight the benefits. Check regularly to make sure energy-saving features are not disabled. In some cases, energy-saving features can interfere with the operation of computer networks or software, but it is usually possible to enable at least some of them.
- **Consider fitting timer switches to photocopiers,** but make sure there are instructions showing staff how to override the timer outside working hours, or that the timer has not been removed by frustrated staff.
- **If computers must be left on to remain connected to a network, turn off the monitor**; this uses half to three-quarters less energy without disconnecting the computer. In these circumstances, using a notebook computer instead of a desktop unit will lead to large energy savings.

It is OK to turn it off: According to major equipment manufacturers, switching off electronic office equipment does not shorten its life. In fact, since hard disk failure is linked to the total number of hours of operation, shutting computers down reduces risk of catastrophic disk failure. Monitor brightness also declines as operating hours increase (screensavers *do not* save energy) so switching off monitors extends usable life. There are also security reasons for shutting down computers when they are not in use. Most municipal computers are linked to sensitive internal information, which may not be secure if unattended computers are left on.

Purchase energy-efficient equipment

Request information on energy use

When requesting purchasing documentation from suppliers, specifically ask for:

- power consumption in normal standby mode, in low-energy standby ('sleep') mode and while printing/copying etc.;
- time taken to change from 'sleep' and 'off' modes to full active mode (as it can be annoying if it takes three minutes for a copier to wake up and make its first copy!);
- compliance with the *Energy Star* program, which requires equipment to achieve low energy consumption in 'sleep' modes (but aim for much lower consumption than *Energy Star* requirements);
- for computers and printers, confirmation that the equipment will interact appropriately with networks (for example, some computers can't receive e-mail if in 'sleep' mode);
- evidence that controls for power management are user-friendly;
- information on the range of acceptable operating temperatures and humidity.

Assess the real requirements

Regarding **monitors**, take into account:

- the larger the screen area, the more energy it uses (but there is up to 40% variation in energy consumption for different brands of the same screen size, so the most energy-efficient large monitor may use less power than an inefficient smaller unit);
- liquid crystal display (LCD) monitors use much less energy and desk space than standard units; they are much more costly, but prices are falling rapidly;
- energy consumption among colour monitors of the same size can vary by almost 40%, so check energy consumption before buying;
- while monochrome monitors are being used less often, they are still used for low-grade activities; monochrome units generally use much less power than colour ones of the same size.

One networked printer or central copier often uses much less energy than several smaller ones distributed around an office.

For **small offices**, multipurpose printer/fax/scanner products are now available, which use less energy and can be cheaper than separate items of equipment (but adding extra features to the basic configuration can actually increase energy consumption, so beware).

Use paper efficiently

- Make sure equipment can use recycled paper without voiding the warranty.
- Purchase printers and copiers with duplex (double-sided) and reduction copying capability.
- Encourage use of paperless options such as e-mail.

Mainframe computers

Computer room air-conditioning can generate a third or more of the GHG emissions associated with mainframe computers. For this purpose:

- **Check the power consumption** of the computing equipment and that of the computer room air-conditioning (including pumps, cooling towers and fans). Often the air-conditioning was designed for energy-wasteful old computers that have been replaced, and it may be inappropriate for today's demand.
- **Consider air-conditioning redesign**. The amount of energy used by the dedicated computer air-conditioning system is often greater than that consumed by the

computers themselves, so there may be a case for this system to be redesigned (for example, a simple domestic split-system air-conditioner may replace a complex system with chillers, cooling towers and pumps).

- **Necessity of a computer room**: Contact the computer manufacturer to find out what range of temperatures and humidity the equipment can operate in. Many modern computers can operate in a normal office environment, avoiding the need for separate air-conditioning systems.
- **Minimise unnecessary power use** within an air-conditioned computer room to reduce the amount of heat that has to be removed. For example, switch off lighting and monitors when they are not needed, and locate uninterruptible power supplies outside air-conditioned areas.
- **Do not set temperature and humidity band-settings too tightly** as this wastes energy. Maintaining precise temperature and humidity conditions often involves high energy use as plant may switch on and off frequently, creating high transient losses. Also, where the range of conditions is small, separate HVAC units may 'fight' each other - a heating unit running at the same time as a cooling unit, leading to energy waste - if thermostats and sensors are not constantly monitored and adjusted. Modern computers tolerate a much wider range of conditions, so this problem can be avoided.
- **Insulate the computer room from surrounding office space.** If the walls of the computer room are not insulated, running the computer room at, say, 18°C while the surrounding offices are 22°C can increase the cooling load by 1.5kW. Insulating the computer room's walls, floor and ceiling reduces cooling loads imposed by surrounding areas. Also, consider updating computers to modern ones with much reduced energy requirements. This can save space too, apart from reducing air-conditioning and computer maintenance costs.

Estimating energy consumption and greenhouse emissions

It is unlikely that centrally metered data will provide accurate information on the energy consumption of office equipment. Sometimes it may be possible to collect metered data using a plug-in meter costing about €350. Alternatively, one could seek information from relevant equipment suppliers; remember to ask for information on standby losses as well as on consumption during operation. It should be noted that the information printed on the appliance approval label is unlikely to accurately reflect the actual consumption. This usually indicates the maximum possible consumption.

Further information

Suppliers of equipment can usually provide information on their own products; it is recommended to ask them to contact head office, or talk to their technical staff.

Best Practice Example

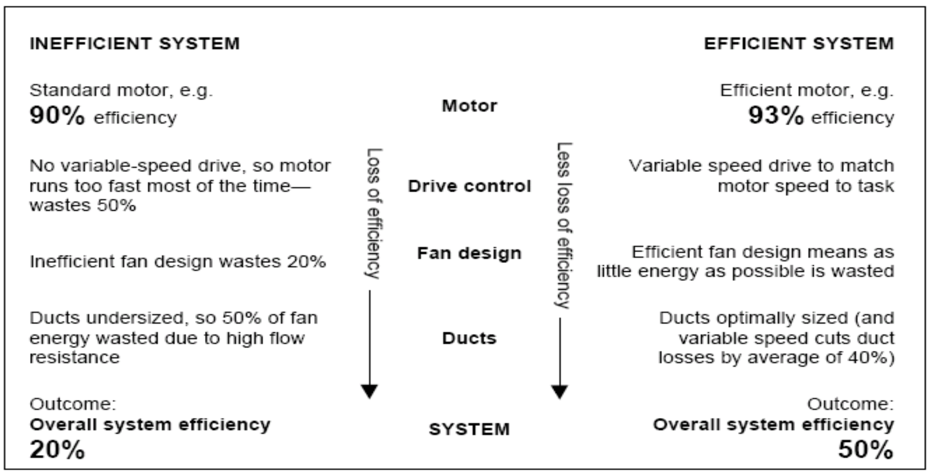
Motors, drives, pumps and fans

Opportunities for savings

The potential for savings in this area is great. Reductions in energy consumption of about 40% can be achieved, with a return on investment of about 40% per year. The first thing to consider is whether the motor is actually needed at all, since reassessing the motor's function sometimes means it can work without it. This is a very cheap energy-saving measure.

Considering the system as a whole

The greatest savings can be achieved by seeing the motor as part of a system. Although the difference in efficiency between a standard and an efficient motor may not be great by itself, the cumulative effect of all parts of the operating system can create a significant difference in overall efficiency. For example:



Reducing operating time

There are many ways to reduce the operating time of motors and these are usually cheap to implement. Examples include:

- a simple time-switch to restrict the hours of the day or week that the motor runs;
- a calendar time-switch will prevent a motor (in an air-conditioning system, for example) from running on public holidays;
- an ambient air temperature sensor can be used to prevent cooling equipment from running in cold weather.

Selection of the right motor for the job

Consider all the costs: The cost of an electric motor will usually be overtaken by electricity costs in the first one to four months of operation. Even without considering maintenance costs, the operating cost of a motor over a life of just 20 years can be up to 200 times the original purchase price. Factoring in all the costs and selecting the motor with the lowest cost over its full operating life will be better for the environment and for the organisation.

Size: Usually, motors are oversized. This is understandable, as erring on the small side would be more obvious than selecting a motor that is too large. However, there is a hidden cost in this conservative approach, because the efficiency of an electric motor is reduced as load is reduced. For example:

- while a 10kW motor driving a 10kW load may be 90% efficient, when driving a 4kW load it will have an efficiency of about 75%, so the electrical load will be 5.3kW;
- a 5kW motor driving the same 4kW load will have an efficiency of 90%, so the electrical load would be 4.4kW—a saving of 0.9kW or 17%.

An oversized motor is sometimes specified to allow for high load during motor start, but a variable-speed drive or a 'soft starter' device is a more appropriate way of handling this situation.

Efficiency: Not all electric motors are built in equal terms. Like most other products, quality and efficiency vary within and between brands, and some motors are designed and built to be more efficient. For example, a 10kW high-efficiency motor (HEM) will have an efficiency of 93%, compared with the standard electric motor's 88%—a saving of 4.3% in both energy and GHG emissions. The reduction in electricity costs will usually recoup the premium paid for a HEM in less than two years. The gap between standard and high-efficiency motors becomes increasingly wide as motor size decreases. Many small motors, such as those used in exhaust fans, may have efficiencies as low as 50%.

Replacement instead of rewinding

A burnt-out motor can be rewound, at least to its design efficiency, as long as energy efficiency best practice is observed by the rewinder. A poorly rewound motor can result in a loss of efficiency of up to 3%, which for a 30kW motor would add 2,500 kg CO_2 equivalent to greenhouse emissions and € 900 to the operating cost in just 10 years (based on 80% load, 3,000 operating hours per year, 6 cents per kWh). If the burnt-out motor cannot be rewound to its design efficiency then a preferred option is to replace it with a new motor. The new motors available now are more efficient than 20 years ago.

Use of variable speed

Most fans and pumps tend to run at constant speed, even though the flow they are required to deliver may vary. This means they are running too fast and using too much electricity most of the time. Large savings are possible since reducing the flow by 50% will reduce the power required by around 85%.

Variable speed can be achieved with a so-called *variable-speed drive* (VSD), an electrical device that controls power to the motor. Other advantages of a VSD include:

- it acts as a 'soft starter' which prevents the electrical system overloading (which can drop the voltage and affect other equipment) and avoids the cost of other starter controllers;
- the ability to control the speed often results in a higher quality of service (e.g., better comfort or process control);
- the ability to control speed allows the motor size to be matched more closely to the actual load, as the VSD can operate the motor at full or higher speed for short periods

Where a variable-speed drive is considered too expensive, it may be possible to use a multi-speed motor, or to install several smaller motors, with controls that switch on only enough motors for the required performance.

Avoid undersized piping or ductwork

Money saved by installing undersized piping or ductwork can be a very costly false saving, as it puts additional loads on the fans, pumps and motors. Ensure that the full effect of such additional loads is evaluated and included in the process of selecting system components.

Transmission efficiency

Getting the motor to turn is only the first step. The efficiency of belt drives can drop from 90 to 60% if poorly designed or maintained. In addition, all types of drives require regular maintenance to perform at optimum efficiency.

Maintenance

Check that drive belts, chains, and coupling are in good condition and adjusted in accordance with the equipment supplier's recommendations. Check for motors that are running hot, as this is a sign that energy is being lost. Use an infrared non-contact thermometer in preference to touching the casing. A motor casing temperature of 60°C or higher should be investigated. *Do not put hands near moving parts, couplings etc. even if the motor is stopped.*

Checking out the motors

An energy audit should identify significant electric motors and reveal opportunities to reduce electricity consumption. If an energy audit is not being conducted, a survey of the following data will often reveal motors running unnecessarily. For each motor, record:

- the motor's application or location - for example, main fan, air handling unit in pool hall;
- the purpose of the motor;
- the nominal power (in kW or horsepower) from the motor identification plate;
- how the motor is controlled (float switch, time switch, etc.);
- the motor's operating times;
- the actual power (preferably) or motor current. An electrician or other suitably qualified person can measure this by using a clamp-on meter. In some facilities, the motor power could be determined by running only this motor (possibly after hours), and timing the electricity.

Such a survey will often reveal clear opportunities to reduce motor energy use—for example, motors running when not required, or motors running at very light load (when the measured actual power is much lower than the nominal power), indicating that a smaller or slower motor, or a variable-speed drive, should be investigated.

Assessing a motor system example

For each motor:

1. Calculate the annual electricity use in kilowatt hours (kWh) by multiplying the average power of the motor by the number of hours of operation; the table below gives sample values for a range of different motors and applications.
2. Use the greenhouse coefficients (depending on the electricity mix in the region) to convert the annual electricity use (kWh) to GHG emissions (tonnes of CO_2 equivalent)

Application	Operating hrs/year	Annual energy use (MWh/year[1]) by average power of motor					
		1 kW	2 kW	5 kW	7.5 kW	15 kW	25 kW
Office cooling	1,000	1.0	2.0	5.0	7.5	15	25
Office heating pump	1,500	1.5	3.0	7.5	11.3	23	38
Office airconditioning fan	2,500	2.5	5.0	12.5	18.8	38	63
Depot (2 shifts)	4,000	4	8	20	30	60	100
Gymnasium fan	5,000	5	10	25	38	75	125
Continuous running	8,760	9	18	44	66	131	219

For example, a 20kW air-conditioning fan in the municipal offices operates for 2500 hours per year. The electricity supply contract includes a 25% Green Power component. What is the amount of CO_2 emitted as a result of supplying the motor with electricity?

In this case, the table does not give values for a 20kW motor, so one could use the figure for a 1kW motor operating for 2500 hours and multiply it by 20. Hence the steps of calculation are:

1. Annual electricity use for a 1 kW motor from table above = 2.5 MWh/yr
2. Annual electricity use for 20 kW motor 2.5 MWh/yr x 20 = 50 MWh/yr
3. Deduct proportion of Green Power: 50 – (0.25 x 50) = 37.5 MWh/yr
4. Greenhouse emissions with a specific regional emission factor of (for example) 1.02 tonnes CO_2 per MWh = 38.3 tonnes CO_2/yr

Further information

THERMIE maxi brochure:
Application of efficient technologies in motor drive systems

Best Practice Example

Refrigeration

For municipalities, refrigeration may be an issue:
- in community facilities and catering facilities, where commercial cold rooms and refrigeration units are installed;
- throughout offices and other facilities where domestic refrigerators and freezers may be used in kitchenettes;
- where refrigerated drink and food vending machines are installed for use by staff or visitors to facilities.

Existing refrigeration equipment may also contain large quantities of CFCs, which are powerful greenhouse gases as well as damaging the ozone layer. Issues related to CFCs are beyond the scope of this workbook, although using hydrocarbon refrigerants as replacement chemicals has the potential to improve energy efficiency.

Opportunities for savings

Domestic refrigerators

Domestic refrigerators are often used in staff rooms, kitchenettes, or small facilities. Decide on the smallest size that can meet the requirements and, within this size range, use energy labelling information to choose the model with the lower energy consumption. The energy label provides both a star rating (comparative efficiency for units of the same size) and an annual energy consumption number. Focus on this number rather than the star rating, as it gives a better indication of what the actual energy consumption is likely to be. Saving 200kWh every year can lead to savings of around €120 on running costs over the 10-year life of the fridge.

The refrigerator should not be in direct sun or placed against an uninsulated external wall exposed to sun, and plenty of ventilation should be provided over coils and around the cabinet. Installing a bar fridge in a timber cabinet without ventilation can increase running costs by 50%, impair its ability to cool its contents, and lead to premature failure. A 50mm deep opening should exist along the width of the fridge under the front of the cabinet, and at least the same area of venting at the top rear of the unit. If perishable items are not kept in a refrigerator, it can be switched off when not required (leave the door ajar to avoid stale smells).

Modular equipment

Modular equipment includes commercial refrigerators, freezers (often fitted with glass doors), display cabinets and cold rooms with integrated compressors. Most modular equipment uses fan-ventilated evaporators and condensers and display lighting, which increase energy consumption. Fans and lights are often fitted inside the refrigerated space, adding directly to energy consumption. In many cases, metal doorframes or structural components act as 'thermal bridges' across the insulation, increasing heat flow. This may lead to condensation problems on the outer cabinet—and extra heating elements designed to overcome this problem further increase energy consumption!

Tips for using the refrigeration energy as efficiently as possible

These include:

- use only as much refrigeration capacity as needed; in facilities that are used intermittently, shut down excess capacity when it is not needed;
- refrigerators and soft-drink vending machines can be switched off overnight if only non-perishable goods are kept in them (if the electricity tariff has a cheaper overnight rate, the unit can be switched back on at least an hour before the cheap rate period finishes); this can be achieved with a simple plug-in time-switch costing under €15;
- review freezer thermostat settings and set at the highest safe setting (e.g., in a high-volume catering facility where food is turned over in less than 2-3 days, freezers could be set to -10^{o}C instead of the usual -20^{o}C; this can cut freezer running costs by 30%); confirm the highest acceptable temperature setting with the health and safety staff;
- load non-perishable goods such as bottles or cans of drink into refrigerators when they are cool; cooling 20 two-litre bottles of drink from 30^{o}C to 4^{o}C uses 1kWh, but cooling them from 17^{o}C uses half as much energy;
- frozen food that is to be heated can be shifted to the refrigerator the day before; this reduces fridge running costs, and defrosted food reheats more quickly;
- consider fitting insulating covers over glass doors and open-top cabinets outside opening hours; flexible plastic strips, doors or sliding covers can be permanently fitted to open refrigeration units or to the doorways of walk-in cold rooms;
- ensure doors close and seal properly;
- defrost evaporators regularly;
- monitor operating temperature; too low a temperature increases running costs and emissions by 2–3% per degree;
- ensure airflow through condensers and evaporators is not obstructed; this is critical for efficient operation;
- avoid locating equipment against uninsulated external walls exposed to sun, in a hot area within the building, or in direct sun (this applies especially to open or glass-doored cabinets, which allow the sun to heat refrigerated contents directly);
- make sure the ceiling of the room is well insulated, particularly where open-top cabinets are installed; if the ceiling is warm, it radiates large amounts of heat into the refrigerated compartments;
- where lighting inside refrigerators or for associated displays is not needed, switch it off or disconnect it; for some equipment, such as drink vending machines, display lighting can comprise half the total energy consumption of the appliance;
- if anti-sweat heaters are fitted, use them only during operating hours or when condensation is visible; they use energy directly as well as adding to cooling loads;
- instead of having large numbers of vending machines scattered around buildings, locate them centrally and run a minimum number to satisfy demand; each refrigerated drink vending machine can consume up to 3,000 kWh per year, costing around €200, so rationalising the number in use makes financial sense.

When purchasing or leasing equipment:

- Where appropriate, a domestic refrigerator should be used instead of commercial equipment, as these units are cheaper to buy and often more energy-efficient (saving up to 80% compared to commercial equipment of similar capacity). Energy labels can then be used to select the most efficient model. Domestic models can also be more reliable, and have the advantage of different storage temperatures for different foods.
- Request energy consumption information (preferably under standard test conditions) from potential suppliers for comparison and use it to make a choice; a two-door drinks fridge can cost €200 to €300 per year to run, so significant savings are possible.
- Ask the supplier what energy-saving options they offer: for example, some suppliers of units with glass doors offer optional doors with improved glazing systems.
- Specify that switches should be installed to control lighting and anti-sweat heaters if fitted.
- Particularly if premises are air-conditioned, consider selecting a unit with a compressor that can be located outside (where it should be placed in a shaded, well-

ventilated location); then the waste heat will not increase cooling costs. Ensure that refrigerant pipes are insulated with durable insulation at least 25 mm thick.

- Consider refrigeration equipment that uses hydrocarbon refrigerants, as these have much reduced greenhouse impacts if they escape, cost less to buy than HFCs, and often allow equipment to run more efficiently. It should be noted that, hydrocarbon refrigerants are not yet well accepted by many in the refrigeration industry.

Possible indicators

- Refrigeration energy use (if available): trend over time
- Refrigeration energy use per unit of activity (e.g. number of meals distributed by a meals-on-wheels service): monthly, seasonal and annual

Further information

Best practice example

Standby electricity generation

Standby generators are often installed in municipal facilities, particularly where:
- the facility may be used in disaster relief coordination or as an emergency shelter, or when it provides essential community services (e.g. water pumping or sewage treatment);
- there are occasional high loads which do not justify the cost of upgrading the mains electrical supply (e.g. show-grounds).

A standby electricity generator normally operates only during grid power failures, during test runs or for special purposes. With such limited operating hours, the impact on energy consumption will probably be small. However, the perceived need for a standby generator presents an opportunity to evaluate alternatives that consume less energy.

Opportunities for savings

An electricity generation facility can be expensive to buy and maintain. Opportunities for saving energy costs arise from:
- assessing whether standby generation is really needed, or whether other strategies will fulfil the required functions just as well;
- minimising the size of generator needed;
- choosing the most efficient method of generation (including installing a cogeneration system if possible).

Some or all of the capital earmarked for a generator that normally lies idle can be diverted to an investment that will work to reduce energy consumption every day.

Necessity of standby generation

The risks of a power failure, which could range from a voltage dip of a few seconds that causes computers to reboot to a complete loss of supply lasting for hours, should be assessed. Consider the costs of alternatives, such as providing:
- a duplicate, alternative electricity feeder; sometimes it is possible to feed electricity to a site from two different parts of the supply network (for example, from lines in separate streets adjoining the property); this can overcome the problem of a single feeder being taken out of service by a vehicle impact, a pole fire, bird, tree or animal interfering with the pole, but it will not overcome the problem of a major grid failure, or if all the electricity to the area is supplied by a single feeder;
- facilities to enable connection to a mobile generator, taking into account the response time, standby charges, hire charges etc;
- equipment which does not need a permanent electricity supply; perhaps critical computer operations could be moved to a notebook computer with battery backup;
- small uninterruptible power supplies (battery systems) for critical items of equipment.

Replacing equipment that needs electricity with equipment that does not could also be considered, for example using equipment driven directly by a gas engine instead of an electric motor, or daylight instead of electric lighting (assuming daytime operation only).

Reduction of the size of generator needed

The strategies for minimising the amount of electricity used will also create savings by minimising the size of generator needed. There are many opportunities to reduce electrical demand, for example:

- updating central computers to more modern equivalents which require less power (and less cooling, less maintenance);
- increasing the efficiency of the lighting installation;
- replacing appliances that use electric elements for heating with, for example, gas appliances, heat pumps, or radiant heaters;
- installing intelligent controls to switch off some non-essential loads (for example, heating and cooling) for short periods when demand is high.

All the above actions will have the added benefits of:

- 'load levelling', or reducing the 'maximum demand' for electricity, which will reduce the electricity costs if the business is on a 'demand' electricity tariff;
- reducing the amount of electricity consumed in municipal facilities each year, reducing energy costs.

Also, consider providing uninterruptible power supplies (UPS) for vital computers and communications equipment (e.g., file servers, radio links, etc.). These will reduce the power and area of a building that a standby generator needs to serve. They also have the added benefit of protecting against power disturbances (less than a minute) and the first minute of blackouts, which a standby generator will not protect against.

Where standby power is required for only some equipment, the possibility to install a separate electricity supply so that the essential loads can be fed separately, reducing the size of the generator required, should be investigated. Where a generator is often required to meet a very small load (a few kW or less) which is much smaller than the capacity of the generator, installing a battery inverter system should be examined.

Considering cogeneration

If considering investing in a diesel-powered generator that will sit idle nearly all the time, it is a relatively small step to consider a generator that can work all year for about the same capital cost. The incremental cost will be more than justified by the cost savings. Cogeneration (or the combined heat and power – CHP – production) involves generating electricity on municipal premises all year – not just as standby – and putting the normally wasted in generating electricity heat for useful purposes such as water heating, space heating, pool heating or drying.

A typical coal-fired power station converts only a third of the energy from the coal into electricity; the remaining two-thirds is lost to the atmosphere as waste heat. A CHP system can reduce both energy consumption and fuel costs by utilising up to 80% of the energy contained in a fuel instead of wasting two-thirds of it. Such a system is often economically justified by energy savings alone, but it also has the advantage of providing an alternative electricity supply in the event of a grid failure. GHG emissions are reduced because of the intrinsic efficiency of getting more useful energy from the fuel used. Emissions may also be further reduced by using a less greenhouse-intensive fuel in the CHP system (e.g., natural gas or biomass) than is used in the power stations, which would otherwise supply the electricity.

Of course, cogeneration is only a benefit if the facilities have a year-round demand for heat, but many of them do, such as swimming pools, civic office buildings and plant hothouses. There may also be other municipal activities that could be economically converted to use heat from the generator once that cheap source of heat becomes available, including:

- absorption cooling (using hot water to produce cooling);
- desiccant dehumidification (using heat to recharge a desiccant [drying agent] used to dehumidify).

Alternatively, the heat (or the above derived cooling or drying resources) could be sold to nearby business or industry.

Types of cogeneration

Small to medium-sized cogeneration systems are usually natural-gas-fired, spark-ignition, reciprocating engines (usually derivatives of industrial diesel engines). These convert between 30 and 40% of the fuel energy to electricity and provide another 40% as useful heat (usually as hot water, but some of the heat can be provided as steam).

Small gas turbines (75 kW electrical capacity) may also prove suitable for a wide range of Council facilities, depending on price competitiveness. They are compact (about the size of a refrigerator) and quiet. Large cogeneration systems (above 1 MW) usually use gas turbines. A large system is much less likely to be suitable for municipal facilities, unless it is installed jointly with a major industrial plant, hospital or other major energy user.

Cogeneration energy sources

Some of the fuels used in cogeneration systems require conversion to gas (in a gasifier) or steam (in a boiler) as an intermediate step before electricity generation.

<u>Landfill gas</u>: Many municipalities have active and/or disused landfill sites, producing methane which unless captured will escape to the atmosphere, where it is a powerful greenhouse gas. However, it is possible to use this gas as a fuel in an engine, to generate electricity. This:

- converts a very active greenhouse gas (methane) to CO_2, which has less than 5% of the greenhouse impact;
- displaces the use of fossil fuels which would otherwise be used, saving more CO_2 emissions.

One of the signs that a disused tip site is producing methane is that grass is difficult to grow; it often appears very brown and dry. A specialist company that sells electricity to the grid normally operates projects converting landfill gas to energy on municipality's behalf. The waste heat may also be sold to adjacent properties, such as plant nursery hothouses. Many recently developed landfill gas projects generate electricity, but fail to utilise the waste heat from generation.

<u>Organic waste</u>: There may be waste products and by-products with energy potential within the municipal area, and municipality may be able to facilitate a regional waste-to-energy project. Candidate materials include waste wood from municipal collections and collection sites and, in some municipalities, **crop residues** (cotton, bagasse, etc.) and **product wastes** (tallow, sawdust, fabric, packaging, etc.).

These fuel sources can reduce GHG emissions by:

- displacing the use of fossil fuels;
- avoiding the waste material going to landfills where the breakdown process can generate methane.
- reducing the transport energy required to remove 'waste' and to deliver fuel or electricity.

<u>Natural gas, LPG</u>: The use of these fuels will generate lower GHG emissions than using the same amount of electricity produced from coal. Other processes also produce usable waste heat (electricity generation is not the only workplace process which generates potentially usable heat). Waste heat from engines, cooking, cooling and other equipment can be used to replace the use of some fossil fuels for 'low-temperature' heating.

Further information

Best Practice Example

District Heating (and Cooling)

District heating and/or cooling (DHC) is an integral technology that can make significant contributions to reducing energy consumption and air pollution and to increasing energy security. Because of myths and misconceptions, DH is often overlooked as a powerful measure within municipalities or other local units. These misconceptions cloud the real fact that DHC provide many opportunities to increase use of renewable energy sources.

The fundamental idea of DHC is simple but powerful, namely connecting multiple thermal energy users through a piping network to environmentally optimum energy sources, such as combined heat and power (CHP), industrial waste heat and renewable energy sources such as biomass, geothermal and natural sources of heating and cooling. The ability to assemble and connect thermal loads enables these environmentally optimum sources to be used in a cost-effective way.

Some countries, particularly in Scandinavia, show a significant penetration of district heating of over 50% of the heat market. However, DH has only a small fraction of the total heat market of the EU. Therefore, the potential is large and varies in each country depending on past national policies. DHC is no longer of importance only in northern latitude countries, since in many parts of the world the DHC concept is also being implemented for cooling, either through distribution of chilled water or by using the district heating network to deliver heat for heat-driven chillers. There is a variety of technologies for using waste heat to provide economical district cooling.

Myths and misconceptions

District heating is not competitive with distributed systems

DH systems are by their nature local solutions, and have limited ability to raise capital and to absorb early losses. National or regional gas and power networks can often forward-price or discount new gas or power developments and thus appear more competitive compared to district heating. There has been a tradition of national policies that also tend to favour large-scale energy supply alternatives, rather than local initiatives.

However, when examined on a consistent basis of total long-term costs, including environmental impacts, DHC is in many cases the most competitive alternative, and is essential for fully exploiting the potential for CHP. Building owners are receptive to a long-term energy supply system that is fuel flexible. This insulates them from the impact of market price shocks. Linking buildings together through DHC enables installation of CHP and other technologies that are technically and commercially proven, economically viable, and environmentally attractive.

District heating systems are yesterday’s technology

District heating has a long history. As a technology concept it has a significant presence in many countries and is implemented in many different forms, while it increasingly moves away from fossil fuels, toward recovery and use of waste from power plants, municipal waste, and biomass. Network systems are required for maximising the environmental benefit of new power technologies such as fuel cells and high efficiency gas turbines, as well as older technologies such as coal-fired power plants. The heat recovered through CHP or other energy sources can be converted to cooling, and worldwide implementation of district cooling is growing. In addition to integrating the best of new energy supply technologies, there has been and will continue to be progress in improving and reducing the cost of DHC pipe networks.

DH systems in Central-Eastern Europe are a sinkhole for investment

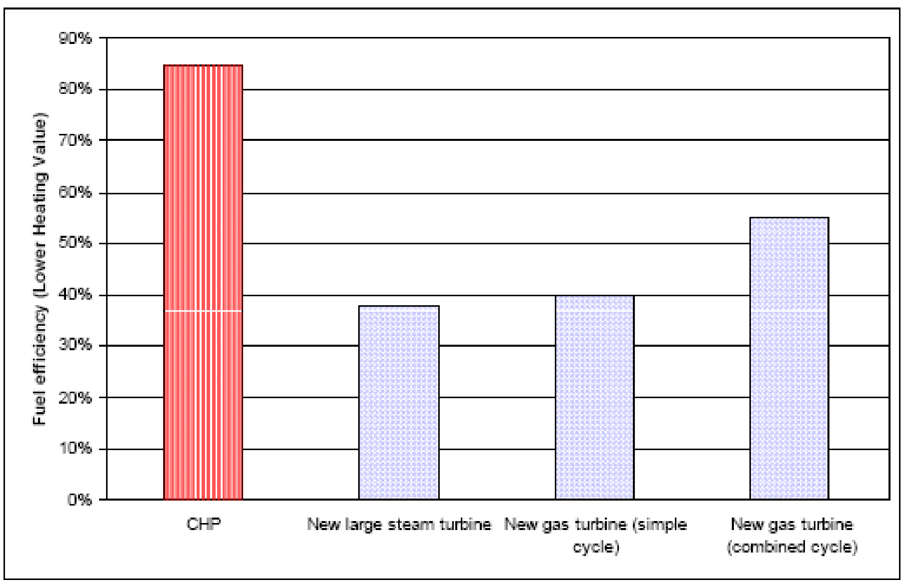
The poor performance of DH systems in the CEE countries is due to the centralized imposition of a single design concept. However, significant efforts are now being made by many parties to bring the networks up to the newest technical standard. The expansion of the gas system in some cases does not consider the full environmental advantage of using the premium fuel to first produce power, and then use the refurbished DH network to supply buildings with the rejected waste heat. It is important, that policy-makers need to recognise these networks as a **national environmental asset** rather than as liabilities.

Impact on key policy issues

Because DHC is an integrative and facilitative technology, it is relevant to many policy areas and should be considered in the preparation of national and regional policies.

CHP in the context of growing power demand

Electrical demand continues to grow worldwide, with corresponding requirements for new power plants. Power plants generate large quantities of low-grade heat that is normally wasted unless the plant is designed and operated as a CHP facility, as illustrated in the figure below.



DHC is important for implementing CHP because it expands the pool of potential users of recovered thermal energy beyond the industrial sector to include commercial, institutional, and residential buildings. The temperatures required by them are relatively low, allowing CHP to operate at higher efficiencies compared to plants producing higher temperature industrial process heat. In addition, as industry becomes more electrically intensive, large industrial heat sinks for low-grade energy are increasingly hard to find. Urban buildings, accessed through DHC, are a more stable long-term partner for CHP plants.

Reduction of greenhouse gas emissions

Greenhouse gas abatement will be among the most important policy goals in the next century. DHC and CHP have already made enormous contributions to controlling GHG emissions, and have the potential for significant additional contributions to this important international goal. About 11-12 ExaJoules (EJ) of heat are generated and delivered to DH systems in the world annually. The corresponding heat deliveries represent about 5% of the total final energy demand in the industrial, residential, public, and commercial sectors.

Avoided GHG emissions from the use of district heating (DH)[4] and combined heat and power (CHP) are significant (about half of the magnitude of CO_2 reduction presumed in the Kyoto protocol). Globally, DH and CHP (including industrial CHP) reduces existing CO_2 emissions from fuel combustion by 3-4%, corresponding to an annual reduction of 670-890 Mton compared to global emissions of 22,700 Mton during 1998. The highest CO_2 reductions from DH/CHP occur in Russia (15%), in the former USSR outside Russia (8%) and in the EU (5%).

CO_2 reductions from DH/CHP will decrease when the CO_2 emissions from alternative generation of electricity and heat are reduced. However, this is not a unique situation for DH/CHP; it will apply to all carbon-lean technologies, since the future competition will not come from carbon-rich technologies, but from other carbon-lean technologies. For the future, DHC/CHP can make further reductions of global CO_2 emissions by:

- increasing the market penetration of DHC through new and expanding existing systems;
- increasing the share of CHP in existing DHC generation, since only 48% is currently produced from CHP; and
- fuel substitution in existing DHC plants, since coal constitutes 38% of fuel supplied.

Transition to biomass

In the longer term, policy papers indicate that biomass fuels will have to play the major role in any renewable energy future. There is little recognition that district heating systems are already supplying urban centres with heat from CHP plants fired with municipal wastes, wood waste and other biomass materials. These are in fact prototypes of the kind of plants that would convert future fuel crops into low-grade heat. However, the crucial importance of network solutions appears missing from almost all present analysis of new and renewable technology solutions.

Urban quality of life

DHC is most effective in areas of high building density. The trend toward worldwide urbanisation offers a growing market, particularly in emerging economies and in the area of district cooling. Growing urbanisation presents significant energy and environmental challenges, and DHC can be an important part of a sustainable urban development policy. DHC network technology supports urban design that uses space well and can be served by energy efficient transit systems. DHC helps control urban air pollution, improving the quality of life and the vitality of city centers.

Energy market liberalisation

The trend toward transnational and regional electric and gas networks both hampers and assists DHC and CHP. It is important to recognize that with energy market liberalisation the focus on short-run financial performance works against implementation of capital-intensive sustainable technologies such as DHC and CHP. On the other hand, the trend towards distributed power will increase the focus on small-scale DHC systems that will be as efficient as large-scale electric power plants.

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[4] Only contributions from DH/CHP are considered. District Cooling (DC) is omitted, due to a relatively low market penetration and lack of relevant statistical information.

The transnational power market is depressing the value of power, priced on short-run marginal costs, with older coal-fired condensing plants increasing market share – often at the expense of highly efficient CHP plants. Volatile and generally high gas prices have squeezed the “spark spread” for gas-fired CHP, making it difficult to implement new schemes and putting some existing schemes out of business.

Gas networks are both a competitor and an ally of DHC. National and international gas distributors have much more market power than district heating systems that are by their nature local and often municipal in structure. On the other hand, availability of a clean burning fuel enables small scale CHP and small block central networks to be competitive, creating new markets for gas, particularly in district cooling applications.

Energy security

Energy security is an increasing important national and supranational policy issue. DHC and CHP can play a key role in increasing energy security by:

- Facilitating power generation in load centres. By generating power close to the load, CHP avoids or reduces power transmission and distribution constraints.
- Reducing cooling-related peak power demand. Air conditioning is a big contributor to peak power demands. By supplying cooling through highly efficient electric chillers and non-electric, heat-driven chillers, district cooling reduces peak power demand.
- Shifting demand to off-peak periods. DHC can shift power loads to off-peak periods through thermal energy storage systems that store hot water, chilled water or ice at night for use during the day, or by shifting loads seasonally through aquifer or other long-term storage.
- Increasing fuel flexibility. DHC systems boost reliability and energy security by providing flexibility to use a variety of domestic resources, thereby reducing the impact of supply and price variations.

Energy efficiency of DHC

Energy efficiency of DH supply, distribution, and end-use are often at a low level. Controls on boilers and burners are often manual. Heat exchangers are normally steel or copper pipe, rather than the modern plate heat exchange technology. Distribution networks are a source of losses because of heat and water losses from cracked or corroded pipes, and of high energy consumption from pumping due to over-extended distribution networks. Water losses are up to 30% in distribution on some systems (causing flooding and further damage to pipe insulation). At the level of consumers, few meters have yet been installed at the distribution/block interface, and even fewer controls exist in apartments.

Inefficient usage of heat

More than 90% of household energy consumption is used for heat and domestic hot water, and only a proportion of heating costs is being subsidised. Without thermostatic radiator valves and other controls consumers have no means of control heat consumption in their flats, and without heat cost allocators (or even in some cases metering at the level of a block) consumption is billed based on calculated rather than actual consumption. It is therefore necessary to equip a certain number of apartments with thermostatic radiator valves and heat meters, in order to allow households to control their heat consumption and pay according to it.

Experience in CEE countries demonstrated reductions in specific heat consumption of approximately 15-25% through the installation of thermostatic radiator valves and heat cost allocators, associated to an increase in prices to reflect economic costs. It has also shown that a reduction in subsidies of 20% can be realised through the reduction in end use consumption caused as a direct result of the introduction of heating controls and billing based on individual heat consumption. Other measures could include rebalancing of the hydraulic system of the blocks.

Training and public awareness

Experience with relevant projects in some CEE countries suggests that public awareness (i.e. flat owners fully understand the project) is a crucial element of success. A training and public awareness element will be important in order to:

- inform the public about the objectives of the project and to explain how to use the equipment installed;
- publicise the results of the project in order to realise a demonstration element; block administrators must be trained in the implementation of the new billing procedure.

Complementary measures

In addition, it may also include complementary measures where necessary to reduce the heat losses of the blocks where the controls and meters/ cost allocators are installed (e.g. sealing of windows and doors, and/or partial window replacement, and/or major heat losses through missing thermal insulation).

First steps to increase energy efficiency of DHC

1) **Technical assessment:** A first step would be the technical assessment and cost estimation. Consultants should undertake a technical assessment of the potential for energy efficiency improvements in DH in typical apartment block. The output should be a report setting out:

- A proposed list of measures to be installed in a typical apartment building (including individual metering or cost allocation devices, and thermostatic radiator valves).
- Estimated costs for the demonstration project including both equipment procurement, and installation.
- Estimated costs of monitoring and evaluation of the energy efficiency effects of the installations and measures.

2) A **demonstration project** could help: Based on the finalised list of measures to be installed and on the cost estimates, the consultants should proceed to the detailed project design. This will involve identification and selection of the sites for the demonstration project. Working with the DH companies, the consultants should identify, and make recommendations for representative sites for the demonstration project.

Selection of consultants

Consultants with the following experience should be proposed:

- Experience of energy efficiency related improvements at the end user level in DH
- Experience in the design and operation of secondary distribution systems of DH in multi-family housing
- Experience with energy efficiency related improvements and retrofits to DH
- Experience in preparing project design, including project scheduling, preparation of technical specifications, and terms of reference
- Knowledge of monitoring and evaluation methods for the evaluation of energy efficiency improvements in the multi-family housing sector

Conclusions and recommendations

Various policy initiatives, such as the EU's Cogeneration Directive, are essential to include strong and effective measures and DHC to become a key element in the solution. Although facilitation of CHP is currently the focus for these policy initiatives, the ability of DHC networks to use many heat sources including renewable energy is of great national and international value. The environmental and energy security benefits of DHC and CHP are not currently priced in the marketplace. Unfettered market forces tend to result in solutions that may be shorter-term than is optimum for society and discriminate against capital-intensive technologies such as DHC.

When a CO_2 emissions trading scheme is fully operational this will be an important step toward internalisation of environmental externalities. However, such a system will not be fully functioning until 2008 or later, and without action to address barriers the development of DHC and CHP potential will be seriously hampered. In addition, carbon dioxide emissions trading will not address the other environmental benefits of CHP resulting from reductions in emissions of air pollution, nor will it provide recognition of the energy security benefits.

Further information

<u>ES Guides (CRES):</u>
ENERGY SAVINGS IN STEAM NETWORKS

<u>THERMIE maxi brochures</u>
Less is more. Energy efficient buildings with less installations
Basic aspects of application of district heating
Development of district heating
Retrofitting of district heating networks

Best practice example

Renewable energy sources exploitation

This information sheet provides only a broad overview of renewable energy options. If it is possible to identify potential for applying any of these technologies, it is necessary to seek expert advice from appropriate energy agencies, industry associations, consultants or equipment suppliers. Renewable energy takes various forms, many of which do not fit into the stereotype of sun, wind or water. This summary outlines the technology options that could be utilised to supply energy for activities likely to be relevant to municipalities, including:

- electricity supply;
- lighting;
- ventilation and pumping;
- cooling;
- space and water heating;
- cooking; and
- miscellaneous tasks.

Opportunities for application

Electricity

For grid-connected facilities, the most convenient way to use renewable energy (RE) for electricity is probably by negotiating a Green Power electricity tariff, so that the electricity supplier deals with the technological details while the entity simply uses the renewable electricity. Where it is considered desirable to establish a grid-connected renewable generation system, this can now be achieved relatively easily, using off-the-shelf technology. For example, some municipalities now capture landfill gas and use it to generate electricity, which is fed into the electricity grid, and/or to supply heat to industry.

Off the grid, a variety of RE sources can supply electricity, including photovoltaic cells, wind generators, micro-hydroelectric generators, wood, organic wastes and solar thermal plants. It is critically important to use the most efficient technologies available to make the most of RE resources, and to minimise the overall cost of their application. For example, cutting energy waste by as little as 15 watts (continuous load) saves as much energy as that produced by a €500 solar cell panel.

Lighting

Lighting is directly responsible for more than a quarter of commercial-sector GHG emissions; and waste heat from lighting adds to air-conditioning loads. Street and outdoor lighting is also a major issue for municipalities. Much activity occurs during daytime, when daylight is available, so effective use of daylight can lead to very large reductions in energy consumption. Consider the following:

- sophisticated skylights, light tubes, light shelves and advanced glazing coatings (which exclude most heat but allow most light to pass through) are being developed rapidly, while computerised design programs are allowing these technologies to be used more effectively;
- using light colours and appropriate geometry for ceilings and walls makes the most of daylight;
- dimmable electronic ballasts are getting cheaper and improving in performance; this technology complements day-lighting, as it allows artificial lighting to be modulated with variations in daylight, to maximise savings.

It must be mentioned that, excessive areas of poorly designed and shaded glazing can increase cooling costs, create discomfort and cause glare problems. One square metre of clear glazing in direct sun can allow up to a kilowatt of heat to enter, while delivering as much light as up to 40 standard fluorescent lamps.

Solar-powered lighting systems are becoming more widely accepted. Even in suburban areas, they can be cost-effective where they avoid the cost of running electrical cable to toilet blocks, barbecue shelters, pathways or other points where relatively small amounts of electricity are required. Several specialist suppliers now manufacture solar lighting equipment for street and park lighting, indoor lighting, and even school crossing warning lights.

Ventilation and pumping

Pumps and fans generate consume a lot of energy as they move air and water around for cooling/heating, and water supply, and there is great scope to reduce this consumption through strategies such as variable-speed drives, efficient fans and motors, etc. Once the load is reduced, renewable electricity is more likely to be able to drive the motors. Some designers use natural principles to ventilate buildings: strategies such as effective cross ventilation or rooftop systems which draw air from a building have been used in traditional buildings. These techniques can be applied to even greater effect now.

Where water or other fluids must circulate, it is sometimes possible to use natural convection (warmer water, air or other fluids are less dense, so they rise) to assist or replace pumping. When mechanical systems assist natural ventilation or circulation, it is important to fit suitable controls and sensors, so that the mechanical systems do not operate unnecessarily. Solar-powered fans and pumps can also operate very effectively. Because they supply DC (direct current) electricity, they can drive DC motors; these are far more efficient than conventional AC motors, so overall results can be very impressive.

Cooling

A number of RE options can satisfy the demand for cooling. While renewable electricity can be used to power conventional air-conditioners, this can be an expensive solution unless the building is designed to be very energy-efficient. Rapid developments in photovoltaic cells mean it may be feasible in the near future to coat windows with solar-electric films that generate electricity for cooling and other purposes, but these are in the development phase at present.

Evaporative cooling provides comfort using the natural process of evaporation of water; in areas where the humidity is not too high, this can be an excellent solution. Indirect evaporative coolers can provide cooling without humidifying the indoor air. Where such coolers are installed, it is important to make sure they have automatic dampers fitted, so that they are sealed-off when not in use. Otherwise, large amounts of air may flow through the building at times when this is not wanted, such as on cold days!

Solar heat can be used to provide cooling in a number of ways. Absorption cooling (as used by the traditional kero fridge and more modern gas refrigerators) has been used widely. Desiccant cooling is also being developed. In one example of this approach, solar heat drives moisture from a moisture-absorbing substance (a desiccant), then air is dehumidified by the desiccant before being evaporatively cooled. This approach is relatively high in capital cost at present, but is useful for situations where a large amount of fresh air is required. Solar-powered fans can also be used to improve comfort.

Space and water heating

There is a long history of use of renewables to satisfy this requirement. Options include:

- **Passive solar** design of buildings (bioclimatic architecture), although this requires careful design if overheating and glare problems are to be avoided in office buildings; well-designed atria and conservatories can provide solar-tempered spaces which are very pleasant environments. Such spaces can be very valuable at childcare and community centres.
- **Wood-fired heating** - more practicable in country areas; advanced-technology chip and pellet heaters are being developed for automatic operation, and the emerging fuel-wood plantation industry could provide an increasing fuel resource. Open fires are not only very wasteful of wood, but create serious air pollution problems.
- **Landfill gas or biogas from waste organic material** - The landfill gas can be burned to generate heat, or waste heat from a landfill gas-fired cogeneration plant can be utilised.
- **Active solar** heating systems for swimming pools and hot water are well proven, and can be very cost-effective in many parts of Europe. Active solar space heating systems are relatively uncommon, as their capital cost has been high. Ongoing improvements in technology are reducing costs and improving performance.

Cooking

The traditional RE source for cooking is wood, but wood-fired cooking is usually very inefficient and polluting - although the traditional wood-fired barbecue may be a practicable solution in some parks. Biogas can be used in modified natural gas cookers. Solar thermal cookers use reflectors to concentrate the sun's heat, but most designs lack the flexibility required for commercial operations.

Miscellaneous tasks

Photovoltaic cells and small wind generators can be used to satisfy small electrical loads. Yachts, caravans and bushwalkers are making increasing use of these technologies to charge batteries, or to run refrigerators, lights etc. Solar panels for laptop computers are also available.

Solar-powered low-speed vehicles are also becoming practicable for use at resorts, and may have application for some municipalities, where local transport is required. However, it is generally more cost-effective to install the solar cells on a building, feeding into the electricity grid, and then charge the vehicle batteries overnight with cheap off-peak power. Renewable transport fuels such as alcohol and vegetable oils are now available, although they are more expensive than conventional fuels.

Applications of RE can also be used for public relations purposes. Solar powered advertising signs and hats or caps fitted with solar-powered cooling fans are just two examples of such applications. Some municipalities have established display centres and demonstration RE systems.

Further information

Best practice example

ORGANIZATIONAL MEASURES

Communicating with decision-makers

The Chief Executive has delegated to the energy manager responsibility for developing and implementing measures to improve energy efficiency. So far so good, but how can the attention of management and councillors be attracted and maintained? This strategy sheet provides some advice.

Five tips for improving communication

1. Brief management and councillors at key points in the process

Seek ‘live’ briefings with management and relevant councillors at key points in the development and implementation processes. Remember, the municipality is making a serious commitment on behalf of the community, so councillors and senior management need to be informed and involved. Focus the content of briefings on key findings (such as opportunities associated with new facilities), preliminary proposals for measures, and overviews of the inventory and action plan. Include specific recommendations for their consideration and identify emerging issues that require evaluation.

2. Report performance regularly

A regular reporting system is important in keeping informed about progress the energy manager himself, but it also gives a way of maintaining the attention of management. A simple, easy-to-interpret report (preferably simple graphs) of performance relative to key indicators should be sent to relevant managers and councillors each month or quarter. It should include dot points raising major successes and problems, and how they are being addressed. It can also flag key issues that will require management decisions in the near future. Organise publication of this regular report in internal and community newsletters and/or on bulletin boards in libraries and other high-visibility locations, for the information of all staff, councillors and the community. By negotiating regular reporting by key operational groups, their commitment can be encouraged and accountability achieved.

3. Present material for maximum impact

Most entities have standard formats for presenting information to decision-makers or to the city council. The energy manager must know exactly what is expected in the entity, and follow the guidelines. It is a good idea to talk to the accounting section about presenting the financial aspects of proposals: the manager should seek their assistance with draft proposals until feeling confident that he/she can follow the accepted approach.

Usually, a proposal will include:

- summary of proposed action;
- costs and benefits of the proposal;
- risks, added benefits and other considerations;
- implications for the municipality and the community;
- resources to be used;
- milestones and outcomes;
- recommendations for approval.

Project Management Sheet P3 *Financial evaluation of projects* can be helpful to make sure costs, benefits and risks are fully considered. Proposals should be brief. They should provide the right amount of information in a form that enables management or the city council to make clear and specific decisions to approve actions. It is a good practice to include no more than four recommendations in one proposal.

4. Get feedback on failures, then respond

When a proposal to management or to the city council fails to gain approval, the energy manager should actively follow-up to find out the reasons. Then a revised proposal that addresses the problems raised can be developed. The energy manager may have to discuss the details of a problem with the specific manager or councillor who raised the concern.

5. Develop alliances

Often other people in the entity can help in raising the priority of energy relevant projects. The energy manager's tasks involve efficiency improvement, quality assurance, organisational change, improved accountability, and continuous improvement, and other people in the entity may be pursuing similar objectives. Coordinating these activities and developing integrated strategies increases the chances of success.

Problems and opportunities that could be faced

Scepticism: Many people see energy saving programs as costly and likely to interfere with core activities. Make sure that the proposals for concrete measures and the overall action plan are business-like and clearly show opportunities to improve organisational performance as measured against recognised criteria. Benchmarking and performance indicators provide a basis to highlight where unusually high costs or significant opportunities for savings or other beneficial outcomes exist.

Crises: Often an equipment failure or other crisis creates an unexpected need for investment in equipment. The energy manager has to be ready to offer advice on how to make that investment help in reducing energy use. This is the time when the cost of an energy efficiency measure can be minimised, and some barriers to adoption can be at their lowest. It is also a time when quick, decisive action is essential, and this atmosphere of urgency can mean that simple solutions that can be quickly implemented to solve the obvious problem can tend to be bulldozed through. Such solutions often prove to be expensive or problematic in the long run.

New investments: It is important to take advantage of every opportunity when decisions are being made on new facilities or equipment. This is often the cheapest, easiest time to incorporate technologies and systems that reduce greenhouse emissions. Seek management approval to be involved in the decision-making processes, and ensure that sufficient budget exists to draw on expert advice. Each investment decision affects energy consumption for between five and 50 years, so it is important to get decisions right.

The Councillors and Council committees

Councillors are the elected representatives of the municipality. They shape Council policy and participate in major decisions through both formal committees and informal processes. Often, one or more councillors have a strong personal interest in environmental issues. Their involvement in developing and implementing policy, monitoring performance and influencing senior management can be pivotal. But there is also scope to demonstrate to councillors with interests in other areas, such as the local economic development or social justice, that energy efficiency can help achieve their objectives, too.

Monitoring and reporting

Indicators and benchmarks are important tools in monitoring the success of the action plan and reporting on progress.

Indicators are simply measures of performance, as e.g. the annual cost of energy purchased. By recording and reporting values of indicators, staff and managers can identify trends, make comparisons, and set targets against which performance can be assessed.

Use of appropriate performance indicators is a common management tool – e.g., most organisations monitor expenditures against budgets. Using indicators to monitor the performance of the organisation's strategies for reducing energy consumption will help to:

- identify areas where good results are being achieved, in order to learn from successes;
- focus on areas where emissions are high or increasing, in order to identify problem areas and address them early;

Benchmarks are reference points against which performance may be measured. Typical benchmarks include:

- performance of similar facilities;
- performance of the same facility in the past;
- an earlier forecast or estimate of performance—a target;
- 'best practice', as identified from international literature or technical analysis;
- best theoretically feasible performance.

Selecting indicators

The most appropriate indicators will vary from organisation to organisation and may even differ between sections of an organisation. Indicators to monitor the performance of particular programs or activities (an energy management program, for example), as well as the performance of the organisation as a whole, can be developed.

Key criteria for selecting indicators are:

- Can the information be collected relatively easily?
- Is the information of reasonably consistent accuracy?
- Is the indicator meaningful to management and staff?
- Does the indicator provide early warning of problems or opportunities?

Indicators of **participation**, **process** or **impact** may be used:

Participation indicators: These indicators reflect the extent of participation within an organisation, for example:

- number or percentage of sites reporting energy consumption to management quarterly;
- percentage of total annual energy consumption being addressed by efficiency strategies.

Process indicators: These indicators chart the progress through the process of implementing the energy efficiency projects—progress not necessarily visible using *impact* indicators. Often, these indicators reflect milestones. Some examples are:

- regular reporting of energy consumption is in place;

- organisational change has occurred which facilitates implementation of the energy efficiency project (e.g., establishment or expansion of an energy management team);
- staff have been trained in relevant issues (the indicator could measure the proportion of staff trained);
- energy efficiency criteria are incorporated in purchasing criteria for equipment, buildings, etc.;
- requirements have been developed for suppliers to provide data on energy use and GHG emissions related to, for example, goods purchased or facilities designed;
- benchmarks have been established for performance comparisons.

Impact indicators: These indicators document actual outcomes - the effects of measures and action plans. For example:

- levels of energy use;
- number and/or size of new energy-saving actions identified and/or implemented;
- energy use relative to baselines, targets or forecasts;
- energy efficiency of new equipment compared with that of existing equipment.

They are often related to the level of an organisation's activity or the size of the community - for example, energy consumption:

- per thousand Euros of turnover or expenditure;
- per capita;
- per square metre of floor area;
- per client, child cared for, etc.

Presenting indicators

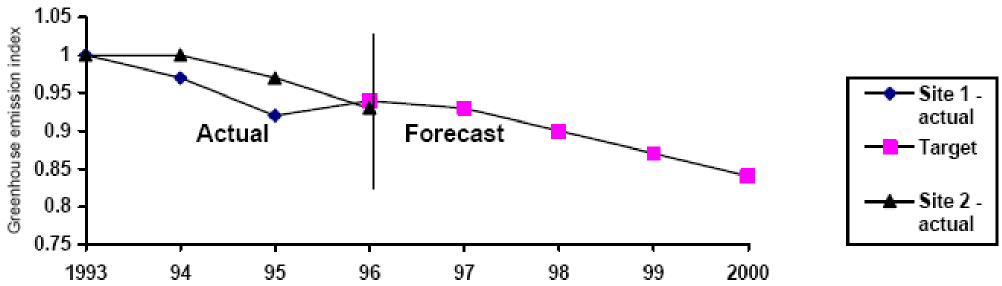
A single value of an indicator is of little use. Indicators are tools for comparison, for example:

- between different types of activity (annual energy use due to heating and cooling compared with annual emissions due to running lighting); different strategies (using gas or electricity for cooking); or different sites;
- against targets;
- over time (e.g., trends in energy consumption per thousand Euros of expenditure on an activity).

The value of an indicator may vary for reasons that are not related to the energy efficiency projects (because of the limitations of measuring equipment, or due to seasonal variations). In cases like these, the figures might have to be adjusted in some way so they can be effectively compared. This is risky as it can distort the picture rather than clarifying it, so seek expert advice before start manipulating indicator values. Data might also have to be collected for some time before meaningful trends are obvious or useful comparisons can be made. For example, winter gas consumption might decrease because of unusually warm weather, rather than because of any change in behaviour.

Performance can also be compared by creating an **'index'**—expressing the value of an indicator as a proportion of a reference value—as shown in the figure below. Because actual values aren't represented, using an index can also protect confidentiality of data while still showing trends or relative values.

Figure - Using an index to compare trends: In the example, values of an indicator for two different sites are 'indexed' against 1993 levels. The 1993 values are represented as '1' for both sites, even though the actual values may be different; the levels in subsequent years are then expressed as proportions of the 1993 levels



Reporting progress

Good reporting within the organisation is critical to the effectiveness of the energy consumption reduction strategies (see Strategy sheet O1 *Communicating with decision-makers*).

Useful techniques for monitoring progress

Annual repeat of the inventory

The initial inventory informed about the emissions in a recent year before measures on energy efficiency have been enrolled. Preparing this initial inventory will have highlighted a number of areas where data collection was inadequate. Repeating the inventory at yearly intervals will provide feedback on improvements in data collection, as well as showing how the actions have affected the GHG emissions.

Review of a technical audit

If energy and waste audits were undertaken when developing the action plan, the energy manager can conduct brief review audits every year to compare the ongoing performance with that of the earlier time. The review audit, which need not be as detailed as an original baseline audit, will reveal how the action plan is working. It is also likely to reveal additional opportunities that have arisen.

Track each project

The most direct and important mean for many organisations to demonstrate their reduction in energy consumption, hence their improvements in energy efficiency, is to document projects implemented and savings achieved. Use of appropriate performance indicators will help in this process. Documentation of all major projects will help the energy manager to track the progress and remain on target. It will also provide the information needed to substantiate the claims of savings made under the program.

Purchasing policies

Buying new equipment or services provides a very cost-effective opportunity to reduce long-term operating costs, energy use and GHG emissions. A purchasing policy sets out the criteria that will be used to choose which product or supplies to buy.

Tips for energy-aware purchasing

1. Look beyond up-front cost

Often, purchase decisions are based on up-front purchase cost alone, not overall cost to the entity over the life of the equipment or service contract. Indeed, some entities allow staff to make purchases below a specified threshold (for example, €1000) without further approval. Such a focus on up-front cost may discourage staff from minimising overall cost to the entity. Ongoing costs are often larger than purchase costs over the life of an item of equipment, so it is false economy to ignore them.

As an example, consider a purchase of a 100-watt light-globe costing €0.6 compared with a 20-watt compact fluorescent lamp costing €12, which delivers a similar amount of light. Over its life, the compact fluorescent lamp will cost less than a third as much to own and operate, due to its energy savings (enhanced by further savings on lamp replacement and maintenance costs, as well as reduced air-conditioning loads), but it would have been rejected if up-front cost had been the only consideration.

⇒ *Refer to: Sheet P3* Financial evaluation of projects

2. Buy what is really needed

Often it is in a supplier's interest to sell larger, more expensive and less efficient equipment than it is really needed, or to skimp on some features to trim purchase cost. Thus, the clear specification of the requirements is critical. For example, many entities buy 25-litre boiling water units for their kitchenettes. In practice, a much smaller unit of 1.5 to 5-litre capacity is usually quite adequate—it costs several hundred Euros less up-front and is around €100 cheaper every year to run.

3. Seek expert advice when developing purchasing guidelines

Purchasing guidelines shape operating costs for long periods, so the development of high quality guidelines is an investment in organisational success. Seek input from users of the equipment as well as from technical experts. By linking fees paid for advice to savings achieved, it is possible to create an incentive for advisers to help cutting costs, energy consumption, and GHG emissions. The kind of issues that should be taken into account are listed below.

4. Provide appropriate support for decision-making

Purchasing guidelines and specifications by themselves are often not enough to support high-quality decision-making by non-specialist staff. Computer networks can now make centralised purchasing support tools available throughout the organisation. For example, a simple computer-based checklist and form covering all costs, energy use, and GHG emissions for office equipment can be developed for use by non-specialist staff when seeking quotes. Data can be entered and calculations done automatically for comparison. The data collected can also be automatically added to a database, to save other purchasers time and effort.

Staff training in application of energy efficient purchasing policies is essential, and backup to assist staff in interpreting information provided by suppliers will also be needed. Clear instructions are also important. In one case, purchasing staff considered themselves legally liable for damages if a supplier of a less energy-efficient product complained about rejection on the grounds of energy efficiency. The problem was solved when the head of the organisation issued a formal written instruction to consider energy efficiency in purchasing decisions.

5. Ensure suppliers adopt appropriate purchasing criteria

Where a supplier provides a service (such as providing drink vending machines) or is responsible for selecting equipment which will be used by the entity (for example, lighting installed in a leased office), ensure appropriate criteria for selection of energy efficient equipment are used. Since the municipality will pay the operating costs, this is important for financial performance as well as GHG emissions. An incentive in the form of a bonus commission where a supplier achieves savings on the municipality's behalf could be included.

6. Ensure staff are trained to operate equipment

Some features designed to save money and reduce GHG emissions rely on using equipment appropriately. For example, the energy savings from buying *Energy Star* compliant computers and office equipment will not be achieved if staff does not make use of the energy saving features. Training and information programs may be needed.

Energy issues to consider

When **buying equipment** consider:

- the direct use of energy (usually electricity) **during operation** (*see also sheets*: T5 Office equipment; T6 Motors, drives, pumps, fans);
- the indirect use of energy from **reduced cooling loads** in air-conditioned buildings; reducing electricity use by equipment in an air-conditioned building is considered to reduce energy consumption by 10 to 25% beyond the direct energy saving (*see also sheets*: T1 Heating and cooling of buildings; T5 Office equipment);
- contribution to the greenhouse effect from **CFCs, HFCs** or **solvents** in products (*see also sheets*: T1 Heating and cooling of buildings, T7 Refrigeration).

The following issues are also relevant (although they are beyond the scope of this guide):

- energy consumption relating to **producing materials** for, and **manufacturing**, the product;
- energy consumption relating to delivering the product, especially packaging;
- energy consumption associated with **consumable materials** (especially paper) used during the operating life of the equipment.

When **buying electricity, gas and other fuels** consider that, as competitive markets open up, more electricity suppliers are offering 'green' electricity tariffs. For a small increase in the unit price, the supplier will guarantee that the electricity used is from renewable energy sources and has zero GHG emissions. If switching to a green tariff is accompanied by efforts to improve energy efficiency, the energy savings can offset the extra cost of the 'green' electricity.

When **negotiating contracts to purchase energy**, aim for a pricing structure with lower fixed supply charges and greater emphasis on demand-related charges and marginal unit price. These costs can be influenced by energy management strategies, while fixed supply charges cannot.

When **evaluating the potential savings** from energy-efficiency measures, do not just use today's energy prices as the basis for cost-benefit analysis. Indications are that prices for contestable customers (those who are eligible to negotiate contracts directly with suppliers) have been unsustainably low in the early stages of the competitive energy market. It is false economy to make equipment purchases on the assumption that such low energy prices will continue. The likelihood that greenhouse emissions trading and even carbon taxes will be introduced also means energy prices may be driven upwards in the near future.

When **buying services** consider that arrangements with consultants and contractors are an excellent opportunity to help the municipality reduce its own GHG emissions or influence suppliers to reduce their emissions. For example, in tender documentation, service providers can be asked to detail their energy performance.

⇒ *Refer to: Strategy sheet* O4 Leases and contracts

Further information

Equipment suppliers

Sample request to suppliers for information about a photocopier

Forms that itemise all relevant features and costs can be sent to tenderers to fill in. The process may need to be voluntary initially, to give suppliers time to collect the necessary data. *Note that this example includes issues that are beyond the scope of this guidebook, but should still be considered in a purchase decision.*

Model		______________________
Purchase cost	€	______________________
Cost of maintenance contract, 5 years	€	______________________
Cost of paper (4,000 reams @ €6 ea)	€	______________________
Duplex fitted (30% credit on paper cost)	–€	______________________
Duplex easy to use (user to test)	Rate 1 to 5	______________________
Cost of toner (for 2 million copies)	€	______________________
Energy Star compliance	Yes/no	______________________
Estimated energy consumption (5 years)	kWh	______________________
Cost of energy consumption (5 years at xx cents/kWh assumed)	€	______________________
Time to start copying from 'sleep' mode (30 sec or less preferable)	Seconds	______________________
Recommend or approve use of recycled paper?	Yes/no	______________________
Max. recycled content recommended %		
Packaging recyclable or returnable?	Yes/no	______________________
<u>Disposal arrangements:</u>		
a) designed for disassembly to facilitate recycling of components?	Yes/no	______________________
b) does the manufacturer arrange recovery for remanufacture/recycling?	Yes/no	______________________

Leases and contracts

Ensuring that leases and service contracts provide clear and appropriate signals and rewards is a very powerful way of improving energy efficiency. The right contract can help the municipality reduce its own energy consumption as well as influence suppliers to reduce theirs.

Contracts are widely used to specify the relationship between a municipality and service providers, consultants or contractors. These parties may provide municipal services to the community, design or specify buildings, equipment, or materials. They may install, commission or maintain equipment, or provide other services. The decisions they make often have long-lasting impacts on energy use.

Municipalities may lease some of the buildings they occupy and some of the equipment they operate. If lease agreements do not adequately specify performance in areas that affect energy efficiency—such as maintenance or regular upgrading—the municipality can be locked into higher levels of energy (and operating) costs for years or decades.

Service contracts

Where **municipality contracts a third party to provide community services** (rubbish collection, for example, or the operation of a leisure centre, library or other facility):

- Ensure that the contract provides feedback and incentives to the people who have the power to control energy consumption. This power is often shared between the municipality as the property owner (with control over purchasing, modification and replacement of major equipment, buildings etc) and the service provider (with control of daily operation, maintenance and minor equipment). If municipality does not have total control over energy consumption, the service contract should not specify that municipality pays all energy costs, otherwise those actually using the energy have no financial incentive to reduce their consumption.
- Consider sub-metering to accurately apportion energy (and water) consumption and costs, rather than relying on arbitrary percentages or floor area, etc.

For contracts relating to the design or purchase of equipment or buildings:

- Negotiate target energy performance levels to be confirmed by monitoring after commissioning, with penalties for failing to achieve targets.
- Establish incentive arrangements for the consultant that come into effect if the building or equipment exceeds specified targets while maintaining quality of service.
- Specifically allocate time and resources for analysing the performance of the design and exploring options which may reduce energy consumption—and require formal presentation of the findings of these studies to the municipality as client as well as to selected independent experts (e.g., an energy consultant or someone from a relevant government agency).
- Ensure that appropriate arrangements for convenient and comprehensive maintenance, such as proper access and adequate metering, are included in the design, and that maintenance programs are put in place during commissioning.
- Consider alternative types of contract which are more likely to encourage energy efficiency, including:
  - **performance contracting** (where the capital for an energy-saving measure is provided by a contractor, and some of the savings are used to repay the capital as well as to provide a profit for the performance contractor);
  - **build-own-operate** (where an external entity funds construction and operation over a specified period, after which ownership reverts to the client. In this case, any

reduction in operating cost over the period of ownership and operation accrues to the builder, so more emphasis is placed on minimising lifecycle costs—as long as the contract period is at least 10 years);
- **delivered services** (where an external organisation is responsible for the delivery of a service, for example, conditioned air, heating or compressed air. Municipalities contract the service at a set rate, and the service provider must deliver the service—within the agreed parameters—for the best commercial return).

⇒ *See also Organizational measure* O6 Building design and specification

> **When considering a performance contract:**
> - check that any easily implemented energy savings measures have already been put in place;
> - check that the property will be used by the municipality, in a similar role as at present for at least the next five years;
> - decide on the length of agreement acceptable to municipality (normally 5 to 7 years where the contractor pays for capital improvements).

Equipment and maintenance leases

- Ensure that the equipment leased is efficient—in terms of energy use and consumables, such as paper—by requiring the leasing agency to provide comparative information on running costs of a range of options (see also Organizational measure O3 *Purchasing policies*).
- Include a clause that requires regular checking and re-setting of energy-saving modes fitted to equipment.
- Require regular checking of energy consumption and corrective maintenance when consumption varies from specification.
- Allow for possible upgrading or replacement of equipment before the end of the lease where technological change would lead to net savings.
- Where practicable, specify equipment with remanufactured components or recycled material content.

Building leases

Municipalities normally own the buildings and facilities used in providing community services, but may also lease facilities, especially generic buildings such as offices. A municipality may also lease out facilities it owns, ranging from sporting ground club-houses to offices, halls or car parks. Normally, a building owner or manager will operate and maintain a building, as well as pay energy bills for central services, in exchange for a regular payment for 'outgoings'. Often, this arrangement does not even include provision for regular reporting of energy costs to tenants, so there is no accountability—other than the level of complaints about discomfort or failed lights. Since most leases run for at least three years and can apply to around half of the total energy consumption from activities in the building, it is very important to get them right.

Where **the municipality is the tenant**, negotiate a lease including specific clauses which will cut its costs and energy use (and often those of the building owner as well). Clauses could include:

- requirements for regular reporting (preferably monthly, but quarterly is adequate) of building energy costs and consumption, allocated pro rata among occupants and benchmarked against previous consumption and 'good practice';
- requirements for a once-off comprehensive energy audit to be followed by annual review audits, with reports to tenants covering findings, recommendations and progress on implementation of recommendations;
- provision for building owner and tenants to share energy savings beyond agreed levels as well as the costs of agreed actions to improve energy efficiency;

- requirement that the landlord move to a 'green' electricity tariff; when combined with an effective energy efficiency program, this will cut both costs.
- opportunities for incorporating all energy in leased buildings (including base building components) in a municipal buying group when negotiating an energy contract (where contestable markets exist).

A comprehensive building maintenance contract should also be required, including:
- a building-specific program of work showing the dates when each activity is scheduled, addressing the particular equipment in the building, and including standard sheets to be filled in by maintenance workers;
- monitoring and adjustment of times of operation of equipment and lighting;
- regular cleaning of equipment and filters;
- regular checking and maintenance of dampers, economy cycle controls, valves, etc.;
- regular calibration of thermostats and controls, including those not being in the plant room;
- regular cleaning of light fittings and programmed replacement of the lamps;
- formal reporting of the work done;
- opportunity for the tenants and/or their representative to review and require revision of the maintenance program at specified intervals.

Where the city council is the proprietor:
- negotiate a lease which includes the provision of the services and benefits described above;
- ensure that energy-efficiency upgrades can be undertaken with appropriate sharing of investments and benefits between municipality and the tenant.
- when refurbishing, ensure that energy efficiency (and materials efficiency) options are fully evaluated.

Working with contractors

When local governments think about energy efficiency, they generally focus on activities that occur within their own offices. Increasingly, however, municipalities contract out a wide range of services. Some of these, like the operation of swimming pools and recreation centres, provision of food services, building management and construction, either use large amounts of energy or significantly affect future energy consumption (e.g. when a new building goes into operation).

When a municipality contracts for a service, it does not give up the opportunity (or responsibility) to use energy efficiently. In addition to the financial and environmental benefits that can be achieved, the performance of contractors can also contribute to the image the municipality presents to the public. The public face includes not only the activities carried out by municipality's staff, but also those functions performed on the municipality's behalf by contractors.

Formulating partnerships for energy efficiency

Although the basic requirements can be included in the specifications for contracts, greater and more innovative efforts could be achieved when working closely with the contractors. After all, contractors may be in a much better position than others to identify the changes in their activities that would improve energy efficiency. Contractors are usually quite willing to work on reducing energy use so long as they are not put at a competitive disadvantage. In the requirements for periodic reporting, it should be specified that contractors include progress on agreed upon improvements in energy efficiency. Additional actions beyond those specified by municipality should also be included in such reports.

Make contractors aware of the municipality's policies

The first step in putting energy efficiency into the service contracts is letting current and potential contractors know about the municipality's efforts to reduce energy use. The energy manager can send out letters to contractors and suppliers to notify them of the adoption of policies and ask for information about the types of energy saving strategies they currently use. This step lets contractors know about the municipality's intentions well before the actual preparation of tender documents. It also provides all basic information needed for formulating the municipality's requirements, which should also be included in the specifications for tenders (see Strategy sheet O4 *Leases and contracts*).

Working for 'win-to-win' solutions

If a contractor delivering a service on behalf of the municipality needs to make additional financial investments to achieve energy efficiency improvements, it is critical the municipality to recognise the risks involved for that contractor. There is scope for the municipality to reduce the level of perceived risk by actions such as:

- **Joint financial arrangements that guarantee recovery of the investment:** This may require a longer-term contract, or an arrangement whereby municipality will take over financial liabilities for the investment if the contractor fails to win future contracts. Spreading cost recovery over a longer period reduces the annual cost, making it more affordable for both municipality and contractor.
- **Commitment** by municipality **to include in future competitive tendering new provisions,** which require a standard of performance consistent with that achieved by

the new investment. This would require competing tenderers to invest in equipment of similar standard, so a contractor offering inferior performance on energy efficiency could not undercut the contractor who has invested.

Building design and specification

The process of designing a building and its systems influences energy consumption now and for decades to come. It is a critical opportunity to lock-in efficient use of energy - and to improve the quality of working environments.

Opportunities for savings

During the design process

Communication failures between key interest groups, consultants, and contractors often lead to inefficiencies, over-design, and waste of energy. Ensuring effective consultation and cooperation can make a big difference. For example, the heating, ventilation and air-conditioning (HVAC) system designer must estimate the heating and cooling loads of a building in order to design the HVAC system. This information should be:

- **Cross-checked by experts** in lighting and office equipment to make sure excessive allowances have not been made for internal heat loads. For example, modern lighting systems are now often rated at 10 to 12 watts per square metre (and best practice is 6 to 8 watts). If the HVAC designer allows for 20 watts per square metre, this would lead to installation of an extra 100 kW of cooling system capacity in a 10,000 m^2 building - at the municipality's cost.
- **Used in detailed discussions with the architect**, as a basis for reviewing the building design. The load analysis will identify the major elements of the building which contribute to peak heating and cooling loads, and hence determine HVAC equipment capacity and capital cost (and peak electricity demand charges), as well as annual operating costs. In many cases, an architect can use this information to make minor modifications, such as changing areas of glazing, incorporating shading or adding insulation in critical areas. Regular project team meetings provide an opportunity to facilitate this kind of communication.

⇒ *See also Technical sheets:* T1 Heating and cooling of buildings, T2 Energy efficiency and the building envelope

Through appropriate costing methods

It is critical that all costs and benefits of each element of the building over its life are considered. Since municipality is usually an owner-occupant or long-term tenant, it can take advantage of such analysis to maximise life-cycle savings for itself. Many other organisations can expect to have short-term leases only, which makes it more difficult to place full weight on future operational costs when making choices, as someone else may benefit from their investment. The example above illustrates how investing in a more expensive energy-efficient lighting system can reduce HVAC cost.

This also applies to use of advanced glazing systems, improved duct insulation and many other features. Typically, the HVAC system costs over €120 per square metre, so measures that reduce cooling loads (and hence HVAC costs) often reduce the net capital cost of the building. Effective liaison between consultants is necessary to achieve optimum results, and such liaison must be allowed for in their budgets and specified in their contracts.

⇒ *See also Sheet* P3 Financial evaluation of projects

Through carefully structured contracts and contract supervision

Often, tough negotiation on contract prices leads to contractors cutting corners on design time, comparison of options, financial analysis, consultation with other contractors and consultants, and commissioning of plant and equipment. Contracts should require these processes to be carried out to specified levels and should allocate itemised funds for their implementation. A few hours of design or analysis time can save thousands of Euros in building costs.

Clear guidelines on rate of return criteria for evaluation of energy efficiency measures should be provided. Consultants should also be required to present estimates used for selecting equipment and material for review by the client. It is important for the client to be actively involved in decisions on issues affecting energy consumption. Consultants may be nervous about choosing an option with low energy consumption, because it is not the 'standard' solution.

Contractual frameworks can be designed to provide incentives for success in improving energy efficiency. For example, a bonus can be paid if the building exceeds a targeted level of energy efficiency—and/or part of the fee withheld until performance meets agreed targets based on actual energy bills. New types of contracts are also emerging - such as **performance contracting** or '**build-own-operate**' arrangements - that are more likely to encourage energy efficiency.

PROJECT MANAGEMENT TOOLS

Introduction to Project Management

Every described activity in this guidebook can be understood as a single project (e.g. increasing the energy efficiency in street lighting). Apart from identifying all the possible activities in the various fields of municipal activity, the tools for implementing such a project are of importance as well. Financial evaluation and cost planning is presented as an issue of particular importance for realizing energy relevant projects in municipalities.

Before going further, it should be very generally defined what is usually understood by a "project". The easiest possibility to get an idea is to define a list of characteristics a project usually has, namely:

- a start and a finish date
- a budget
- activities which are essentially unique and not repetitive
- roles and relationships which are subject to change and need to be developed, defined and established
- a life cycle (which will be examined in more details later) .

Managing a project – What does it means

One definition of project management could be: "Project Management" is a dynamic process, conducted within a defined set of constraints, which organizes and utilizes appropriate resources in a controlled and structured manner in order to achieve some clearly defined objectives. Alternatively, in order to be more concise, Project Management is making the project happen.

As with projects, it may be clearer to define some of the characteristics of project management rather than trying to provide a single definition. So, project management should be:

- objectives-orientated
- changes-orientated
- multi-disciplined
- innovative (seeking new ideas and solving new problems)
- control-orientated (to ensure it actually finishes)
- performance-orientated
- flexible (quickly adapted to changes)

This requires a variety of management and personal skills. Key areas to consider when looking at project management are management of time, people, and other resources. In general terms, these activities are described in the following.

Management of time

- Ensuring that the project completes its work on time
- Scheduling use of resources
- Rescheduling the project in the light of experience
- Predicting problems before they arise

Management of people

- Ensuring that people are available at the right time
- Ensuring that personnel know their roles and can perform their functions properly
- Managing peoples' expectations
- Resolving conflicts between people

- Changing peoples’ roles in the light of experience

Management of other resources
- Ensuring that appropriate resources are allocated
- Ensuring that the appropriate resources are available at the right time
- Reallocating resources in the light of experience
- Tailoring activities to limited resources
- Making maximum impact with available resources

Difference between project and organizational management

Of course there are many similarities between project and organizational management, but the nature of projects means that there are some differences of approach as well. These include:
- the lack of permanence of staff: people might be employed on a temporary basis or as consultants,
- the lack of permanence of roles of staff: people involved in the project may play very different roles at different times; the hierarchy is not so clearly set.

These two points mean that management of people and personal skills are very important. Too often project management is seen as a purely technical subject connected with planning techniques, but in order to be effective skills in dealing with people are just as important. In concluding:
- There is a clear plan, time frame, and budget for the project and therefore planning within this is important in organizational management; the constraints are frequently not so clearly set.
- There are clear overall objectives and a time frame in which to achieve them; success will be measured against the ability to meet objectives.
- Stakeholders play a more important and direct role; a project manager should take into account the specific desires and interests of donors, target groups, and all institutions co-operating in the implementation, whereas a manager in an organization is primarily interested only in direct clients and shareholders.

The role of a project manager

The project manager has to devote him-/herself to maintaining a balance between the demands and needs of:
- the project and all its ultimate beneficiaries;
- the Project Management Unit;
- any outside support (technical assistance, external experts);
- administrative units in the municipality tangent to the project;
- the Ministry responsible for local government and/or energy related issues, the European Union, or other organizations if it is a project in a wider context.

This produces very wide expectations from all the actors above which will require the project manager to demonstrate:
- ability to use project management tools and techniques;
- effective team leadership skills;
- ability to conform to established procedures, even when the project is new and experimental;
- ability to maintain control in a situation subject to great risks and where all kinds of unpredictable issues can arise.

A major part of project management is related to dealing with "stakeholders" by which someone who has an interest in the project is meant. This is a much wider set of actors than the immediate beneficiaries of the project. An absolute definition is difficult to make, but one can say that “stakeholder” is **any person, group of people or organization who has a vested interest in the project now or in the future** or, in more general terms, anybody who is affected by or can affect the project. It should be noted that stakeholders’ attitude can be both positive (supporting a successful outcome) or negative (trying to stop the project).

Importance of stakeholders

Stakeholders are important to a project because:

- they can be critical in its success or failure
- they can have a much better understanding of the feasibility of different actions and the resources required to reach certain objectives than an outsider to the project
- their expectations need to be managed
- they can provide important information on the progress of the project.

Therefore, a project manager needs to:

- manage the team of people who will be part of the project for its whole duration
- identify and manage stakeholders of all descriptions
- manage the risks involved in the project and plan the project in an appropriate way
- resolve problems as they occur
- ensure an acceptable outcome of the project.

The project life-cycle

Every project has a life-cycle or, in other words, very different types of activities take place at different times during its execution. Clearly, every project is different. In the following, an attempt to break down the project life-cycle into different phases will be made very generally. This model is in some ways too simple, since there is some interaction between these phases (for example, the preparation phase may cause the identification of new projects or redesign of the existing one).

Identification, analysis and formulation

This section includes background information on the first phase of the project life cycle, which is the one of identifying the problems that need to be addressed and analysing the ways in which they can be addressed. Therefore, this phase consists of:

- analysis of existing situation
- problem/needs identification
- problem analysis
- prioritization of issues
- decision on whether a project is appropriate
- definition of the project idea
- consultation with stakeholders and, finally,
- establishment of overall objectives.

Setting objectives and analyzing the real needs is an essential part of project design, particularly since it is at this stage that alternative designs and formulations are considered.

Preparation, appraisal and commitment

This phase is the one of defining more clearly the actual project, who will do it, what resources are available, and how it will be divided into different tasks. This would include:

- specification of objectives and results
- identifying resources available for the project
- identifying resources needed for the project
- design of the project
- packaging and planning of the project

This includes producing initial Terms of Reference (ToRs) and organizing the tendering procedure, and as a final step launching the project.

Implementation, monitoring and reporting

This phase is the one of actually performing the project and ensuring that the objectives are met and the outputs made, inasmuch as this is possible. This includes:

- mobilization of resources for each task and objective
- project marketing
- ongoing monitoring and reporting arrangements
- identifying problems
- addressing failures
- modification of the planned results and project objectives as appropriate

This phase leads to the production of successive strategic plans and work programmes as well as other reports on the implementation of the project.

Evaluation

Evaluation of the results of a project is important for several reasons, including:

- assessing whether the contractor has truly completed the task
- identifying best practice for further projects
- identifying what resources are required for the future (if something goes wrong this may mean that more resources are required rather than that the project has failed)
- identifying the need for future projects

Evaluation should be a natural part of the process and not seen as a “punishment” for a project that has failed to perform. The procedures used for evaluation can include financial reporting, independent evaluations and/or auditing.

Financial evaluation of projects

In planning energy relevant projects, potential measures should be thoroughly and fairly evaluated. For municipalities, many actions are aimed at delivering social or other non-financial outcomes, so it should be remembered that financial evaluation is only one part of a comprehensive evaluation of an option. However, if an energy efficiency measure meets financial as well as social criteria, this creates a strong case for adoption. It is important that clear and fair financial criteria are applied to measures. Seek advice from the financial section about the criteria applied in normal investment decisions, so that comparable criteria in evaluating measures to reduce energy consumption can be used.

Note that different financial thresholds may be applied to different kinds of decisions, and make sure to apply the criteria usually applied to core municipal activities, as tougher criteria are often applied to non-core activities. Many opportunities for reducing energy consumption are missed because their financial attractiveness is hidden by:

- not considering all the costs, and basing decisions on purchase price alone;
- not considering all the benefits;
- expecting investments to pay for themselves too quickly;
- ignoring the low risk of investments in waste and energy minimisation, which makes actions with even a moderate return very attractive.

Consideration of all costs

Initial cost is often the prime consideration when investing in new equipment, but a choice made on this basis alone can commit the municipality to paying too much every month for many, many years. This can be a particular problem where the capital budget and future operational budgets are treated separately, which can occur with anything from the purchase of a small printer to large building projects. A measure that increases the capital cost beyond the budget limit may be rejected, regardless of the potential for future savings.

Running costs: Consider all the likely running costs over the life of the equipment or process. These could include:

- energy consumption (e.g. electricity, gas, transport fuel);
- materials (e.g. consumables, maintenance, water, waste disposal);
- labour for operation, maintenance, administration, etc.

Both energy and materials use have implications for energy use as well as for the financial bottom line. Since many investments in reducing energy consumption involve an up-front expenditure balanced by future savings in operational costs, it is extremely important to specify an appropriate lifetime over which to calculate the savings. Failure to fully consider future savings could lead to rejection of a worthwhile energy efficiency measure.

'True' capital costs: While adopting a more energy-efficient solution may increase direct capital costs, it will usually create capital savings elsewhere. For example, a more efficient lighting system will reduce the load on the electrical and cooling systems, and so will reduce the capital cost of these items—if the designers of these systems will be asked to make appropriate adjustments to their calculations. The true capital cost can only be assessed when all 'avoided' capital costs are subtracted from the more obvious purchase price.

Count all the benefits

Energy and waste management actions often have benefits other than the obvious reductions in direct costs. For example, converting from incandescent (including low-voltage) lamps to fluorescent, compact fluorescent, and/or metal-halide light sources:

- increases lamp life, and so reduces the cost of ordering, purchasing, storing and installing replacement lamps; and
- improves lighting reliability.

Some of these ‘flow-on’ benefits are easy to evaluate, while others will be hard to quantify but may help to get the investment approved. Product and equipment suppliers should be able to identify these additional savings.

Allow projects enough time to pay for themselves

Energy management initiatives are often expected to pay for themselves in just one or two years (achieve a one- or two-year ‘payback period’). Some organisations consider an eight-year period to be very satisfactory, while for systems with long lives much longer payback periods can be justified. Short payback periods may be justified for investments where opportunities for increased revenue or reduced costs will be created for a limited time only, and management must be confident it will recoup its money quickly.

For example, advertising expenditures must repay their costs over a short period. However, waste and energy efficiency projects often have a life of 10–50 years, so longer payback periods are acceptable. Indeed, to apply a short payback criterion to a long-lasting measure is false economy, as options with much larger life-cycle savings may be rejected. The term ‘payback’ doesn’t tell the whole story anyway. ‘Return on investment’ (discussed below) is a better concept as it acknowledges that the financial benefits start flowing immediately, rather than only after the ‘payback period’ has elapsed.

Calculating return on investment

The return is the net benefit resulting each year from the investment. This is expressed as a percentage of the real amount invested (the purchase price minus any ‘avoided’ capital costs). This return can be compared with the cost of capital, or the return that could be gained from alternative investments. For example, a municipality may gain a return of 6% per annum (or 4% real return after subtracting 2% inflation) by investing funds in banks. In principle, investment in an energy-saving measure that achieves higher than 4% p.a. real rate of return on investment over its life would bring a greater return than the standard investment strategy. It is clear that applying a two-year payback period (requiring roughly a 50% rate of return) is a very stringent investment criterion that may lead to rejection of measures with very attractive financial returns far above those available from traditional investments.

For example, a compact fluorescent light fitting may have a purchase price (including lamps) of $80, which is $40 more than an equivalent incandescent light fitting. The incandescent fitting uses a 75 watt lamp, and the compact fluorescent version uses two 9 watt lamps (total power 25 watts, including the ballast). The light operates for 3,000 hours per year. Replacing lamps costs $5 for labour. The incandescent lamps have a life of 1,000 hours and the compact fluorescent lamps 8,000 hours.

The **maintenance costs** of the two fittings are:

Lamp type	Life (hours)	No. changes per year	Cost per lamp change			Cost per year
			Lamp	Labour	Total	
Incandescent	1,000	3.0	$1	$5	$6	$18.00
Compact fluorescent	8,000	0.75*	$4	$9	$13	$9.75
Maintenance saving						*$8.25*

* The fitting has two lamps; a similar fitting using one lamp would require half the number of lamp changes

The **energy costs** of each lighting fitting are:

Lamp type	Total power (watts)	Energy per year (kWh)	Energy price (cents/kWh)	Energy cost per year
Incandescent	75	225	8	$18.00
Compact fluorescent	25	75	8	$6.00
Energy saving		*150*		*$12.00*

The **return on the investment** for the compact fluorescent compared to a standard lamp fitting is:

$$\frac{\text{Net savings}}{\text{Net investment}} = \frac{(\$8.25 + \$12)}{\$40} = \frac{\$20.25}{\$40} = 50.5\% \text{ pa}$$

More sophisticated methods of calculating rates of return on investment can also be used, which can include factors for depreciation of equipment value, inflation, etc. Liaise with the financial section to find out the methods they use and, if they place insufficient emphasis on operating costs, work with them to revise their methods.

Considering risks

What the municipality regards as an acceptable rate of return (sometimes called an investment 'hurdle rate') generally depends on the riskiness of the investment—the higher the risk, the higher the return needed to justify the investment. With energy-efficiency projects the risk is normally very low because it is realistic to:

- be relatively confident about the return (as long as the building or equipment continues to operate, the savings will be realised); and
- calculate the potential savings relatively accurately (based on projected energy prices and past experience of energy savings potential).

This low risk means that energy management programs can be considered attractive investments even with a modest return. Decision makers might therefore consider implementing such programs wherever the annual return on funds invested is appreciably above the cost of capital—which could range from the 'lost opportunity' cost of not receiving interest on a bank deposit (say 5% p.a.) to the overdraft rate (say 15% p.a.).

The 'Net Present Value'

The concept of 'Net Present Value' or NPV can sometimes be useful in evaluating potential projects. NPV converts into today's prices the value of all cash flows (in and out) over the life of a project, including the effects of price rises, inflation and the cost of capital. The NPV for a range of different options (including doing nothing) can be calculated, and the option with the highest NPV chosen. The effort of working out an NPV is probably not justified for initiatives where the return on investment has been calculated as relatively high (say, over 25% p.a.), because in such cases the NPV will always be higher than the 'do-nothing' option. NPV calculations are probably not necessary for small investments either (say, less than €1,500). However, the Net Present Value can be useful where:

- the return on investment is close to the organisation's 'hurdle rate'; or
- future cash flows will be uneven (for example, equipment will be replaced or overhauled); or
- the prices of inputs (labour, electricity, gas, liquid fuels, spare parts) are increasing at different annual rates.

What needs attention is that calculating a NPV involves specifying an annual 'discount rate' for the estimation of future savings—the rate at which the value of future savings is reduced. This discounting is meant to offset the returns that could be gained by investing the same money in alternative investments. However, applying a high discount rate can heavily reduce the value placed on future savings. For example, at a discount rate of 5% p.a., a Euro saved 15 years from now is valued at 48 Cents, but at a rate of 20%, that Euro saved is valued at only 6.5 Cents. When calculating the NPV of proposed measures to increase energy efficiency, ensure that NPVs are calculated for a range of discount rates, so informed judgements can be made. It is sometimes said that whoever specifies the discount rate determines the outcome of the decision, and there is some truth in this.

Further information

SEVEN, The Energy Efficiency Center
Financial Manual for Municipalities in Central and Eastern Europe:
How to Develop Municipal Energy Projects

Jiri Zeman, Martina Diduskova
Vladimir Sochor, Miroslav Votapek

Developing a program for energy efficiency

The benefits of a well planned and managed energy efficiency program include:

- lower energy consumption and costs;
- greater control over energy costs and greater confidence in estimating future energy costs;
- lower non-energy costs (for example, of consumables such as fluorescent lamps, due to their extended life);
- higher quality of energy services delivered, such as lighting and air-conditioning (and hence a better working environment for staff and clients);
- higher productivity and reduced capital costs.

A program is more than an audit

Many people think an energy efficiency program starts and ends with an energy audit. Such a belief puts a municipality at risk of:

- not capturing the potential benefits which a good energy efficiency program will deliver;
- wasting the time and money spent on the energy audit.

The main steps in establishing an energy management program are:

1. **Get management support**, including:
   - seed funding;
   - a commitment to reinvest all energy efficiency savings and a percentage of energy price savings in further improvements;
   - formal commitment to an energy management policy,
   - appointment of an energy manager for the municipality and for each site or group of facilities.

2. **Develop a simple and concise reporting system** to keep management informed of progress.

3. **Perform a desktop study** to compare the energy consumption of each municipal facility with similar facilities, and assign priorities for energy investigation and efficiency improvement.

4. **Introduce a method of gathering energy consumption and cost data** from bills as they are received.

Understand that investment will be necessary

A well-designed and executed program should reduce the municipality's energy costs by around 40%. To achieve these savings it may be necessary to:

- invest around 3–5% of a year's energy costs in initial energy audits (which may focus on individual facilities);
- invest between 50 and 100% of a year's energy costs in implementing remedial maintenance and capital improvements to equipment (this investment does not all have to occur in a single year);
- put in place systems for ongoing monitoring and carry out more targeted audits and studies over time;
- establish an effective in-house management system with ongoing responsibility for energy management.

The energy manager should not commit to an energy audit unless the municipality is prepared to either commit the funds to invest in energy-efficiency improvements, or enter into an agreement with a company that will finance those improvements.

In the past, some municipalities' officers have had the authority to organise an energy audit but not the authority to find the capital funds to implement its recommendations, or have not had the line authority to organise works that had to be coordinated with municipal core activities. This is shortsighted because, although the audit is a key step, it is by no means the only step in an energy efficiency program. Implementing an energy audit's recommendations requires persistent management over a period of years; and this will pay dividends that will increase every year.

Decide on the aims of the program

Apart from the obvious goal of finding ways of cutting energy costs, the following issues have to be clarified before proceeding to an energy audit:

- What the program is trying to achieve?
- What are the municipality's short- and medium-term goals and plans?
- Are there any significant concerns about the operation, maintenance or quality of service of the energy-using equipment in the municipality?
- What will the energy auditor be briefed to do?
- How will recommendations be implemented (this will influence the kind of contract the municipality will enter into with the energy auditor)?

Select an energy auditor

Select an energy auditor who:

- has proven experience in the areas of energy use relevant to the municipal facilities to be audited;
- can demonstrate a history of energy audits where the recommendations have actually been implemented—because recommendations have been practical and the auditor has continued to work with the client organisation after submitting the report. This is important as there will often be issues which need to be resolved or misconceptions and misunderstandings clarified in order to achieve implementation. Many studies have shown that a major weakness of most energy audits is that few or none of their recommendations are implemented.

Commission the audit

The energy audit will look at the broad energy picture and formulate a coherent plan. It should identify:

- major issues which will affect subsequent opportunities to reduce consumption and costs, including such issues as choice of fuel, selection of major plant or the decision to reduce demand rather than increase supply;
- opportunities which can be implemented with little or no capital cost and time;
- other energy-efficiency opportunities which require a significant capital investment;
- potential energy-efficiency improvements which require further investigation and evaluation;
- opportunities to improve service quality or reduce costs in areas other than energy.

Options for financing an energy efficiency program

Contractual arrangements with energy management consultants will affect the way proposed measures are implemented.

Description	Best points	Possible drawbacks
Traditional The municipality contracts an energy management consultant to provide an energy audit investigation and report. The energy manager then reads and understands the report, obtains finance, and organises implementation (possibly including plans and specifications, tenders etc. although the consultant often handles this).	It's a system that most managers are familiar with. The contract for each stage is fairly simple.	The process can fall over at any stage. The municipality must find the funds for implementation. The municipality must have suitably qualified staff with the time to brief service providers.
Performance contracting Also called 'shared savings'. Similar to the Traditional method except that the hired consultant is paid partly or wholly according to achieved energy savings. See O4 *Leases and contracts* for more information about arranging performance contracts.	Lower risk for the municipality. Consultant will be motivated to achieve savings.	Contract may be more complicated. Some effort will be needed to calculate savings. Consultant may apply a conservative approach to maximise profitability instead of maximising cost-effective savings.
Lease Similar to the Traditional method, except that the municipality leases major items of equipment or possibly even leases major modifications.	Leases are a familiar instrument. The municipality can conserve capital for core activities.	May be limited to purchasing equipment and this may not be the most cost-effective solution to the municipality's energy needs.
Energy Services Contract An Energy Services Contractor (ESCO) agrees to provide the energy services which the municipality now receives (such as thermal comfort, illumination, etc.) for a fixed annual fee which is less than it is now paid for energy and maintenance. The ESCO can only profit by investing in the business to improve the energy efficiency of the municipality's plant. The ESCO provides the capital required and recovers this investment by sharing in the savings for a fixed period (normally around 7 years).	Contractor is motivated to achieve savings. There is a single point of contact for energy services. The agreement, once signed, is stable. No capital needed by the municipality. Demands on energy manager's time are minimised. Budgeting is easier as future energy costs are known. New technology can be incorporated during the life of contract.	The initial contract is more involved than those in the Traditional method (but there is only one contract). Some effort will be needed to calculate savings. ESCO may apply a conservative approach to maximise profitability instead of maximising cost-effective savings.