



Energy Savings in Cities

Issues, Strategies and Options for Local Governments



United Nations Environment Programme
Division of Technology, Industry and Economics

Urban
Management
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TECHNOLOGY CENTRE

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IETC Urban Management Series 1

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FOREWORD

Energy is one of the basest essentials of modern society. It provides the power needed to drive the economy but it also has adverse impacts on society and the environment. To obtain the maximum benefit from scarce resources energy use needs to be very carefully managed. Energy efficiency brings many benefits including cost savings, greenhouse gas reductions, fewer environmental impacts and increased local employment

Energy Savings in Cities was commissioned by the United Nations Environment Programme – International Environmental Technology Centre, Osaka, to provide information to city managers in developing countries on how they might reduce greenhouse gas emissions whilst saving much needed money.

Development and environmental issues, such as greenhouse gas emissions, go hand in hand and an understanding of them is crucial to developing nations on their transition to sustainable economies. This work is designed to assist in the process and to provide useful strategies for saving energy and case studies of international energy efficiency projects.

The publication was developed by a team of specialists from with expertise in the technical, social, planning and financial aspects of energy management, including Isabella Jennings, Katrina Lyon, Professor Philip Jennings, Dr Om Dubey, Duncan van der Merwe with assistance from Sue Taylor and Alix Rhodes.

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I. CITIES AND ENERGY USE

A. Background

Energy is the lifeblood of modern industrial society. Modern cities rely heavily on fossil fuels for the maintenance of essential services and for powering devices that are used in industry and commerce. Cities draw on their hinterland for primary produce and use human skills and energy to convert it into secondary products. Energy powers homes, transport systems, industry, infrastructure and commerce. The availability of abundant, cheap power has enabled societies to develop machines and systems that can enhance the quality of human life and increase the efficiency and productivity of our work. Industrialised societies have relied on cheap, abundant supplies of fossil fuels particularly oil and coal and their usage has increased steeply for most of the past century.

This pattern is being emulated by many developing nations. However, things are changing as the drawbacks of heavy reliance on fossil fuels become increasingly apparent. Concerns are growing about the environmental and social impacts of the consumption of fossil fuels which include air pollution, global warming, waste disposal problems, land degradation and the depletion of natural resources. Furthermore, cheap supplies of oil appear to be running out. These trends are likely to continue and even accelerate throughout the 21st century.

Due to the instability of fuel prices, energy intensive industries will find it increasingly difficult to maintain a competitive position. Householders and government agencies will experience budget over runs on items that are fossil fuel dependent.

As a consequence of these concerns, attention has been focused on ways of saving energy in both supply and use. Energy management offers the opportunity to stabilise prices and to reduce the adverse environmental and social impacts of energy use in cities. It provides opportunities to make substantial savings in energy bills across all sectors - domestic, commercial, industrial and government - through a various means, many of which require minimal investment of funds. By making such savings the energy costs of production can be reduced with consequent benefits for consumers.

B. Patterns of Energy Use

Majority of the world's primary energy comes from fossil fuels such as coal, oil and gas as well as uranium. Renewable energy sources at present account very small portion of total energy supply (Figure 1.1).

Energy is used in four major sectors in the economy:

- Industry ~ 30%
- Transport ~ 25%
- Domestic ~ 20%
- Commercial and others ~ 25%

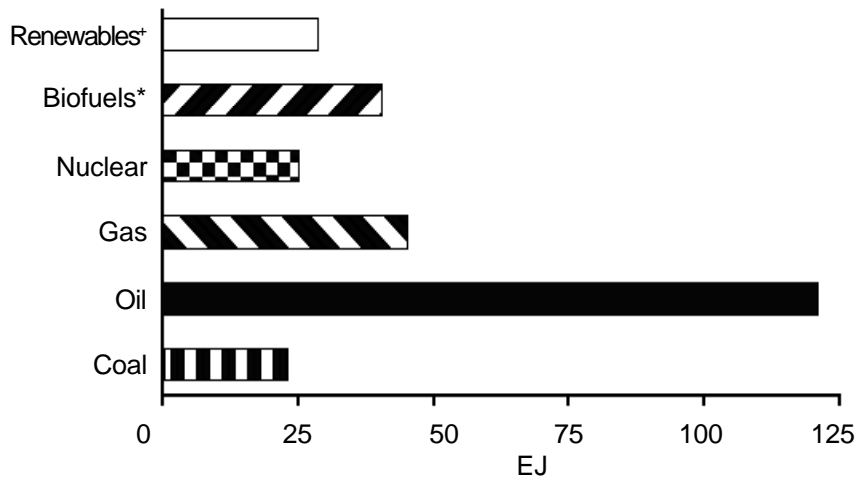


Figure 1.1: Worldwide pattern of primary energy use by fuel type (Year 1999).
 +Renewables include cogeneration, heat pumps, solar, wind, wave, ocean, geothermal and hydro energy.
 *Biofuels include biomass, wood waste, municipal waste, animal and agriculture waste etc.

Figure 1.2 shows worldwide pattern of energy use by major sectors. The patterns of energy use vary considerably within countries and particularly between industrialised and developing nations. For example, Figure 1.3 shows the pattern of primary energy use by sector for the United Kingdom and India.

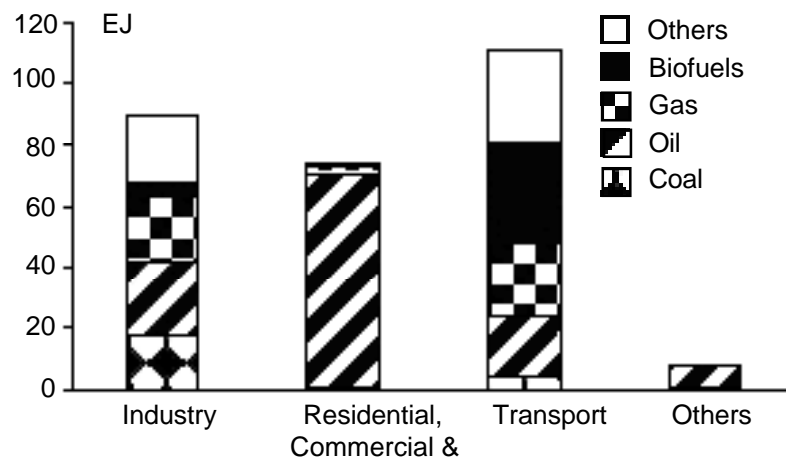


Figure 1.2: Worldwide pattern of primary energy use by sector (Year 1999).

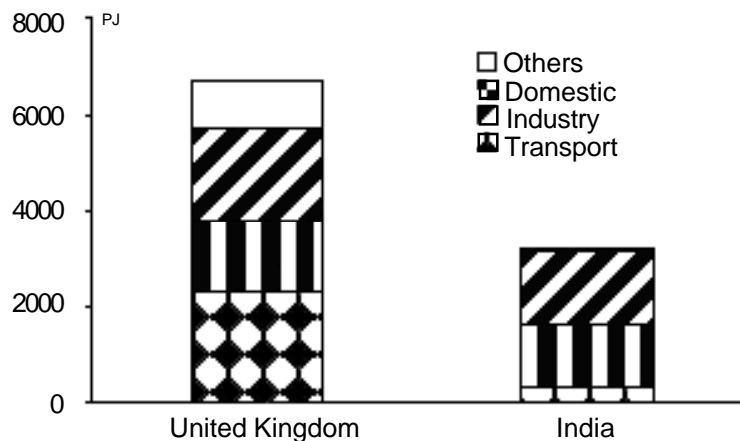


Figure 1.3: Comparison of primary energy use by sector for UK and India.
 *Others include services, agriculture, construction etc.

Worldwide, energy consumption has continuously been increasing during last three decades. Figure 1.4 shows total final energy consumption by region for Year 1973 as compared to the Year 1999. There have been overall 33% rise in the total final energy consumption during last 25 years. More of this data may be found on the International Energy Agency (IEA) website.

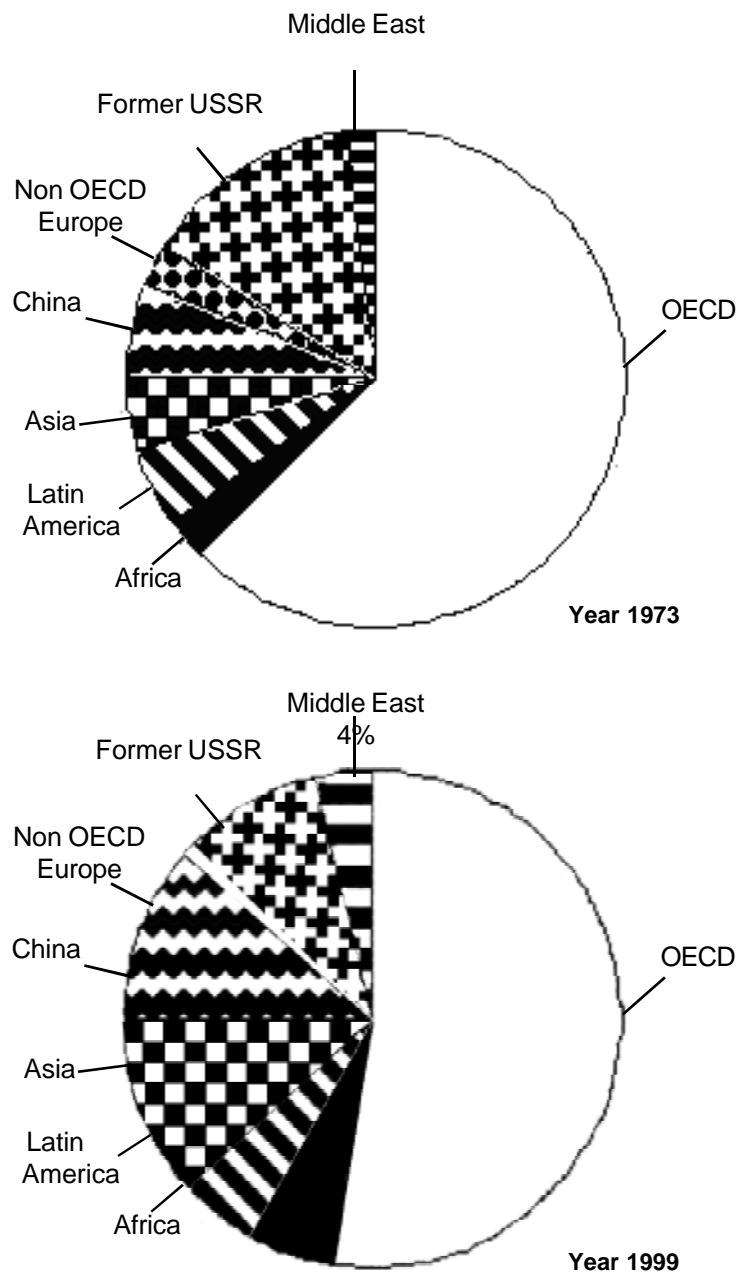


Figure 1.4: Comparison of total primary energy use by region for the Years 1973 and 1999.

Domestic

The domestic sector uses about 20% of the energy in cities and is one of the most promising areas for achieving energy savings. Consumers are usually willing to adopt measures that will save money and many options are available for saving energy and money in this sector. The major uses of energy in the home are for water heating, space heating and cooling, refrigeration, cooking and appliances. Local authorities can influence domestic energy use through building codes or by providing information and incentives to use energy efficient appliances. The measures available for energy savings in the home are discussed in more detail in Chapter 2.

Transport

In the transport sector strategies for saving energy range from technical solutions to full-scale urban planning solutions. The transport sector is a large user of energy and uses primarily liquid fuels, which are often imported and subject to price fluctuations. In industrialised countries private cars account for up to 80% of the passenger kilometres travelled. These vehicles use primarily gasoline and diesel fuel. Considerable scope exists for energy savings through the improvement of driver habits, better vehicle maintenance and improved vehicle design. Incentives to produce fuel efficient vehicles or to use public transport should also be considered. Public transport is a significant user of energy in cities, particularly in the developing world where there are considerable opportunities to save energy through improved vehicle design, fuel substitution and driver training. Chapter 3 addresses these issues in detail.

Commercial

The commercial sector uses energy for heating and cooling of buildings, running appliances such as computers and office machinery and for lighting and cooking. It has similarities to the domestic sector because efficient appliances and building design are key factors in achieving energy savings. There is some incentive in the domestic sector for modifying user behaviour with regard to use energy since the home occupier generally pays the energy bills. However, in commercial situations energy audits, incentives and employee training are often more effective ways to promote saving of energy. These matters are discussed in detail in Chapter 4.

Industry

The major area of primary energy, accounting for approximately 30% of total energy use, there are significant opportunities for energy savings is industry. Significant areas of industrial energy use are primary industries, such as agriculture and mining, which usually occur outside of cities. Power generation, construction, manufacturing and mineral and oil refining often take place within cities and there are large opportunities for energy savings through improved processes and operating procedures. Possible measures include supply side efficiency, cogeneration, demand management, fuel substitution, energy audits and operating procedures. There is considerable scope for industrial energy savings and these are addressed in Chapter 5.

Government

Local Government Authorities are major users of energy as their operations encompass a range of activities such as road construction, waste management, street lighting, park maintenance and operation of public buildings. Some activities have elements in common with the commercial sector while others are quite unique. Public authorities can influence community behaviour by setting an example or by regulation and incentives. There are many opportunities for local government agencies to save energy and money through energy efficiency and waste management practices which are discussed in Chapter 6.

For each sector, case studies have been provided to illustrate the use of different strategies. In many cases the information has been taken directly from the relevant sources such as the internet.

The establishment of the Global Environment Facility has resulted in a significant increase in the number of energy efficiency projects, particularly in areas such as commercial buildings, industrial projects and economic measures, including subsidies for energy efficiency equipment. At the time of print, few projects have reported on the evaluation of technical, social and economic benefits which provide a wealth of information on the lessons learned and should serve as an excellent background resource for organisations considering applying for this type of funding.

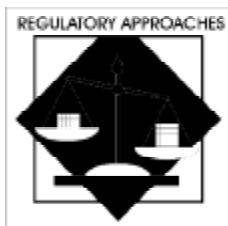
C. Approaches to Saving Energy

There are many opportunities for saving energy in cities and strategies can be classified by four major categories.



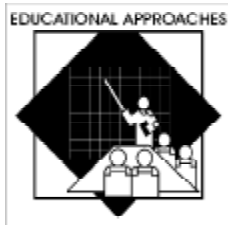
Technical Strategies

Technical strategies involve either new energy saving technologies or retrofitting existing technologies. Such changes often require considerable capital investment and can produce significant savings even in the short term. The implementation of technical strategies therefore is often limited by the availability of financial assistance such as grants or low interest loans.



Regulatory Strategies

Regulatory strategies are based on the introduction of local laws or regulations such as building codes or energy efficiency standards. These strategies pass most of the costs on to the users, but regulatory authorities must administer and enforce them.



Economic Strategies

Economic strategies involve incentives or penalties, which create a climate for energy efficiency. They can include 'no regrets' or voluntary measures as well as tax credits for energy efficiency and renewable energy research investment. These strategies are more costly for government, but they are generally more popular with industry and the public. In some cases economic strategies can generate considerable income by imposing taxes on fossil fuels or excessive energy use. Such taxes may be directed into the development of technical and education strategies for further energy savings.



Education Strategies

Education strategies involve the use of education, training and information to raise awareness about alternative energy systems and energy efficiency. It is a powerful agent of social change and can produce substantial energy savings for a minimal cost. Typical measures include driver training and raising public awareness of energy savings options. Education and training is also important for sales people, maintenance personnel and consumers.

D. Importance of Energy Planning

Considerable synergy is present between energy saving measures. Economic measures can generate income that may be used to implement educational, regulatory and technical measures and these can lead to further savings. In order to maximise energy savings some cities have adopted an energy plan which provides a comprehensive and integrated approach incorporating a range of measures and including implementation schedules and appropriate costings.

This energy plan may be part of a larger regional or national plan and it could be funded from national or international sources. It needs to be prepared carefully in consultation with stakeholders and implemented through an open process with support from local government authorities. The process of developing such a plan relies on identifying the major opportunities for energy savings, considering the methods of funding them and the possibilities of synergies between them, and the development of an implementation plan. The process is described in detail in Chapter 9.

E. Financing

Many opportunities for energy savings require some initial expenditure in order to realise the savings. Some measures produce a return on investment in the short term, whilst others are very cost effective in the long term. Finance is often available through national and international programs aimed at reducing pollution and greenhouse gas emissions. These opportunities will develop further in the years ahead as a result of the United Nations Framework Convention on Climate Change (UNFCCC) and the flexibility mechanisms it contains such as the Clean Development Mechanism. These are discussed in detail in Chapter 8.

F. Associated Benefits of Saving Energy

Although the emphasis in this publication is on energy savings in cities, there are many associated benefits from this approach. Power generation is a major source of air pollution, global warming and land degradation. Saving energy can help to reduce the severity of environmental and social problems. Energy efficiency planning is probably the most effective method of reducing greenhouse gas emissions and moving towards sustainability in the short term, some of these issues are discussed in Chapter 10. This publication also contains many examples of successful energy saving projects with web links and contact details to facilitate follow up. These are presented in Chapter 10.

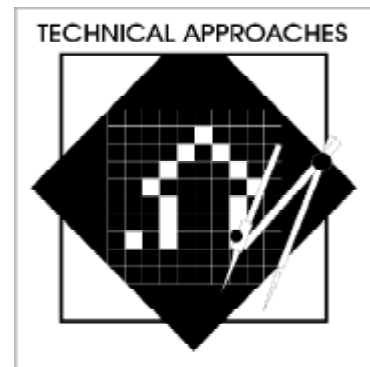
G. References and Resources

International Energy Agency (IEA). <http://www.iea.org/>

United Nations Framework Convention on Climate Change (UNFCCC)
<http://unfccc.int/>



Case Study 1 “Ki” nari House - Zero Energy Concept



Objective: To design a house which maximises the use of solar energy and natural ventilation.

Location: Okayama, Japan

Website: http://www.caddet-ee.org/nl_pdf/994_08.pdf

Description:

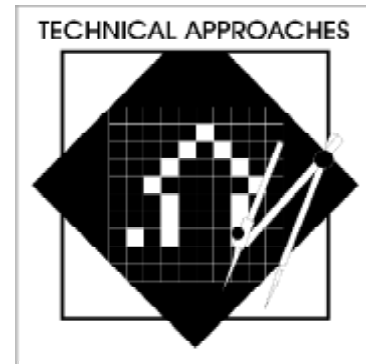
The “Ki” nari house is an experimental home built in the suburbs of Okayama. It is designed to harmonise with the environment and is geared towards a zero-energy concept by making maximum use of solar energy and natural ventilation. The wooden house has a roof covered by Sedum rock plants, large windows and doors on the south side, interior mud walls with mineral wool insulation, and floors heated by a solar collector. The thermal capacity of the building is enhanced by a concrete slab, which minimises the need for mechanical heating and cooling.

The simple gable roof has a green covering of small rock plants belonging to the “Sedum” family, which are rooted into mats. A series of solar collector panels are also mounted on the south-facing roof. A garden with a brook in front of the house is designed as a biotope (a self-supporting micro-habitat). Herb and vegetable gardens are located on the east side of the plot. The north-facing roof of the workshop, built on the southern side of the garden, is also covered with herbs.

To enable direct solar heat gain from the winter sunshine, the house has large windows and doors on the south side. Meanwhile, to reduce heat losses, the window area on the north side has been kept as small as possible. During the summer, deep eaves (1.5 m long) prevent the sun from shining directly onto the windows and wall. Deciduous Keyaki (*Zelcovas*) trees planted on the west side of the site also shade the house from the afternoon sun. Skylight windows on the south side are completely shaded by the deep eaves during summer, but allow the sun to reach the northern interior walls in winter.

To reduce heat loads in summer, in addition to the deep eaves, rooftop greenery and deciduous trees on the west side of the site, air vents are incorporated into the roof and the external walls. Wind blows through the house from the windows at ground level, flowing through the open ceiling in the northern part, to the skylight windows in the uppermost part of the north side. This makes mechanical cooling almost unnecessary. However, during the hot and humid Japanese summer there are some sultry days when natural cooling and ventilation are insufficient, and mechanical air conditioning is required. The house can also be ventilated by an auto-ventilation system.

Case Study 2 Second Generation Passive Solar Energy Houses in the Subsidised Housing Sector



Objective: To develop a demonstration project of low-cost passive solar housing.

Location: Spijkenisse; The Netherlands

Website: <http://www.opet.net.cn/energy/solar/Europe/innovative/case1.htm>
<http://www.opet.net.cn/energy/solar/Europe/innovative/>
<http://www.caddet-re.org/assets/no64.pdf>

Description:

In the summer of 1991, 66 sunspace homes were completed in the Dutch municipality of Spijkenisse.

The main focus was to achieve a simple low-cost second skin design with integrated sunshading/night insulation, suitable for mass production. This was done in co-operation with a Dutch producer of greenhouses for agriculture. Sunspaces and natural ventilation have been economically optimised in the sunspace houses in Spijkenisse. In the sunspace, ventilation air is pre-heated according to weather conditions and the supply of heat through the front facade between the sunspace and the house. Monitoring and evaluation took place during 1992 and 1993.

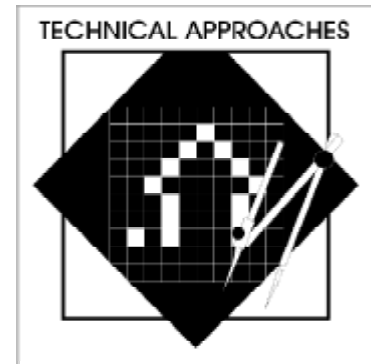
The sunspaces face south, are two storeys high and consist entirely of vertical single glazing. A separate kitchen, entrance hall and (internal) storeroom face north and have limited window areas.

The buildings are naturally ventilated by ducts in the kitchen, bathroom and toilet and by controlled air inlet openings operated by the occupants. Space heating is provided by a hot water radiator central heating system.

The indoor environment is kept balanced by the prevention of overheating in summer. The interior climate is maintained by keeping temperature gradients to below 2°C and by preventing cold draughts through the careful routing of the natural ventilation.

In wintertime, ventilation air is directed from the sunspace through tilting windows in the living room and bedrooms. This air having passed through the sunspace, is a lot warmer than the outside air. The air is exhausted through ventilation ducts in the kitchen, bathroom and toilet. To maintain good ventilation all inner doors have crevices. In summertime the tilting windows are shut during daytime.

Case Study 3 Solar Village



Objective: To provide energy-efficient housing.

Location: Ugie, South Africa

Websites: <http://www.sustainabledesign.com/ases98/usv-text.htm>,
<http://www.sustainabledesign.com/rsa-haus.htm>
<http://www.sustainabledesign.com/ases98/ases-pap01.htm>

Description:

The homes in Ugie are designed to replace the tin and mud shacks in which more than half of the people currently live. Since the majority of people in this community are unemployed and could not qualify for a mortgage, the basic home costs no more than the subsidy. The home is 570 square feet and contains two bedrooms, a kitchen, bath, and living room. The direct gain passive solar heating system provides 100% of the heating. Shading, coupled with good ventilation and thermal mass, keeps the home cool in the hot summer months. Cooking is done in a solar oven built into the north-facing wall. Passive solar heating and the solar oven helps reduce the need for traditional kerosene heaters and cook stoves, which emit dangerous levels of carbon monoxide. Optional passive solar water heating and PV systems are also available.

The insulation, mass, and solar window area were optimized using Energy-10 Version 1.2 energy analysis software, an 8760 hourly simulation programme. Since hourly weather data is not currently available for South Africa, ASHRAE design data (maximum and minimum temperature and relative humidity) were used for the location and compared to U.S. cities with the same latitude (north latitude) and the same design conditions.

Additional features of the house include:

Local materials used in construction as far as practicable. Candidate materials include soil cement blocks and bricks made on site and rammed earth.

Well-ventilated for indoor air quality

Passive solar heating - all homes are oriented to the north and have large windows on the north side so homes remain warm all winter with no supplemental heat.

Natural cooling - homes are well shaded in the summer with a combination of overhangs, arbors, trees, and other shade devices. Most of the lots around the houses are shaded in the summer to create cool islands around the homes. All rooms have flow-through ventilation to capture the summer breezes, so the homes remain comfortable all summer.

The house plan is easily expandable to adapt to growing family needs.

Case Study 4 Saving Energy Education Programme



Objective: To educate the public on ways to save energy.

Location: Ghana

Website: <http://www.ase.org/ghanaef/programmes.htm>

Description:

The success of any efficiency initiative depends on how information on the latest technologies and methods as well as the benefits of energy efficiency gets to energy consumers.

The Energy Foundation therefore has an elaborate plan of action to educate the public through seminars and workshops, print and electronic media adverts and campaigns, billboards, bumper stickers, calendars, newsletters, films, good practice case studies and various forms of greeting cards and an Internet website to highlight the activities of the Foundation.



Energy Efficiency & Environmental Conservation Club (EECHO Club) programmes in primary and secondary schools, polytechnics and colleges are organised to get information to the people through school children and students.

As a first step the Energy Foundation has organised a series of public education programmes. Notable among them are the 'Save a Watt' campaigns, which involve radio, TV and newspaper commercials on tid bits to improve efficiency of energy use in the home.

During a three-month campaign undertaken in 1998, consumers were encouraged to read their electricity meters daily, take steps to reduce consumption and also establish targets for their monthly consumption levels.

The results of the campaign have confirmed that given the right information at the right time, the Ghanaian consumer is capable of reducing electricity consumption by between 25 -75%.

The Foundation has also produced a brochure *EnergyWise* which includes easy tips and guides that will enable electricity consumers reduce electricity consumption and save money. Similar material is being developed for the transport sector.

Case Study 5 Energy Advice and Consultancy Programme



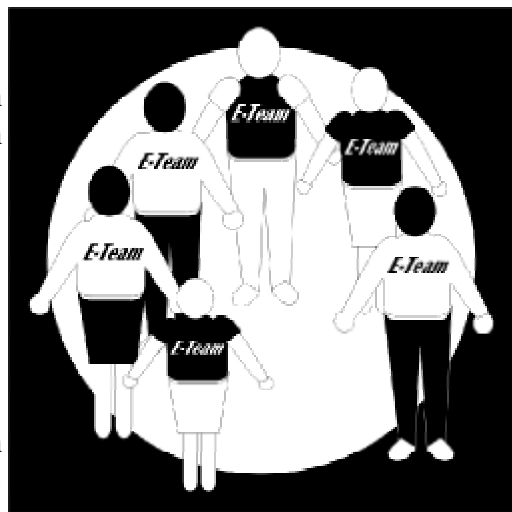
Objective: To reduce the energy consumption of low-income earners.

Location: Gouda, The Netherlands

Website: <http://www.eaue.de/winuwd/>

Description:

In 1991, the Gouda energy advice task force, the so-called E-Team, was set up in order to achieve two basic goals. Firstly to reduce the energy consumption of low-income earners through information provision and the implementation of simple, but effective energy saving measures (eg. installation of draught excluders and piping insulation). Secondly, the programme should help to create new employment chances for a group of long-term unemployed.



Since then E-team has become a permanent organisation which continues to deal with people on a personal basis, but which now fulfils a consultative rather than an executive role. In each district neighbourhood, residents are personally advised about the potential for energy saving at home. An energy saving report is provided to residents as part of this consultation.

An eco-team structure functions at the grassroots level. An eco-team consists of around six households, which, under an appointed guide, are encouraged to practice responsible eco-management at home. Energy saving is of course a vital element in all this. The first Eco-teams are already operational.

Case Study 6 Home Rating Scheme - The Austin Energy Green Building Programme



Objective: To rate homes according to the energy efficiency measures and other environmental criteria in order to encourage greater builder and consumer awareness.

Location: Austin, Texas, USA

Website: <http://www.ci.austin.tx.us/greenbuilder/suepaper.htm>

Description:

In 1991, the City of Austin, Texas recognised the direct local environmental impacts associated with residential building. This realisation and the need to protect dwindling natural resources prompted the City's efforts in establishing the Green Building Programme. To date, the programme has rated 1,800 homes, 1,400 apartment units, and 10 commercial buildings and has consulted on 85 other commercial projects.



The programme is based on a market-pull mechanism whereby the Green Building Programme promotes green building practices, rates buildings that feature these practices, thus creating more demand from the public because these buildings are perceived as more attractive products for people to buy. Technical staff provide design guidelines and rating systems in easy to understand language for each type of building construction. Staff also provide technical assistance to the public and participant building professionals, as well as assist in marketing and promoting green projects.

Green Building Membership

Membership in the programme allows technical, logistical, and marketing assistance for participating building professionals, as well as serving as a means to assure that building professionals are educated to a base level of expertise to practice sustainable building.

Rating System

A menu of sustainable options is available in an electronic spreadsheet for members. It self calculates a Green Building rating. In addition, the commercial building sector is offered a cash incentive and technical support for using a design checklist, which insures an integrated team approach.

The sustainable building movement is beginning to reach a critical mass in the United States. Currently, there are now eight green building programmes in the country, with new ones being planned.

Case Study 7 Mandatory Standards and Labeling



Objective: To lower energy consumption through compulsory standards and labeling of appliances.

Location: South Korea

Website: <http://www.clasponline.org/standard-label/general-info/success-stories/korea.php3>

Description:

For several years, South Korea has run one of Asia's most aggressive energy conservation programmes. Since the mid-1970s, there has been more than one hundred separate conservation initiatives across all energy end-use sectors in the country.

One of the most powerful programmes has been Korea's mandatory standards and labeling programmes.

By late 1993, the minimum efficiency levels had been reached by 91% of domestic products, and the 1995 target levels had been reached by 30% of products. Due to standards and labels, energy consumption for refrigerators and air conditioners dropped by 11% and 24%, respectively. The programme has reduced Korea's national energy consumption by 1.8% from 1992-1993.

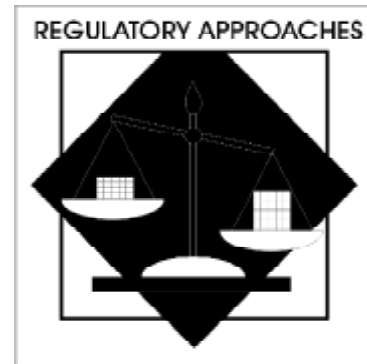


Additional information is available from the Collaborative Labelling and Appliance Standards Programme (CLASP) website on Australia, Europe, the US, Korea and the Philippines' mandatory standards and labeling at <http://www.clasponline.org/standard-label/general-info/success-stories/index.php3>.

Standards and labels are tools for transforming the market. Establishing a minimum efficiency standard "pushes" the market by eliminating the least efficient models. To maintain sales and revenue, manufacturers are forced to produce more of the models that pass the minimum energy performance standard. Setting a standard does not result in higher production of high efficiency models; most models will still be medium efficiency.

Energy labels encourage customers to purchase energy efficient products. This will indirectly encourage manufacturers to produce and market more efficient models, thus, "pulling" the market towards high efficiency. As a result, of the complementary market "pull" and market "push," the average energy performance of models on the market improves. Standards and labels can be used together to achieve significant market transformation.

Case Study 8 Energy Efficiency Building Codes



Objective: To improve the efficiency of new buildings through the application of energy efficiency building codes.

Location: Leichhardt, Australia

Website: <http://210.9.33.124/environ/energy.html>

Description:

Development Control Plan 17 (DCP17), Energy Efficient Housing, was adopted by Leichhardt Council on 24th May, 1994 and came into operation by public notification on 8th June 1994. Whilst the DCP relates specifically to the design and development of housing in Leichhardt, it reflects Council's broader concern for the conservation of the environment.

The Plan controls apply to development applications and building applications for new dwellings and for alterations and additions to existing dwellings, where the work involves new extensions; major internal renovations; minor internal renovations where the window area significantly increases, insulation measures apply, or timber framing is proposed.

An Energy Efficient Checklist must be completed for all applications to which DCP 17 applies.

Vision

Leichhardt Council supports energy efficient housing design and practices that reduce the use of non-renewable fossil fuels for energy, and minimise air pollution and carbon dioxide (CO₂) emissions.

Aims and Objectives

This DCP aims to:

- Encourage the design of energy efficient housing in Leichhardt

The Objectives of this DCP are:

- To encourage residential site planning and building design that optimises solar access to land and buildings.
- To reduce total energy use in residential buildings, by reducing heat loss, and energy consumption for heating and cooling purposes.
- To encourage the use of building materials and techniques that are energy efficient, non-harmful and environmentally sustainable.

Case Study 9 Energy-efficient Saarbrücken: Rate Structure of Energy Charges in Saarbrücken



Objective: To establish a rate structure that provides incentives for consumers to save energy.

Location: Saarbrücken, Germany

Website: <http://cities21.com/egpis/egpc-152.html>

Description:

Following the example of Wien, Austria and Zürich, Switzerland, the City of Saarbrücken introduced a linear and time-variable electricity charge in 1991.

Most rate structures for energy charges do not provide many price incentives for the client to save energy. This is because of high standing charges that have to be paid by the consumer, independent of the actual consumption levels. The utility of Saarbrücken recognised that this does not correspond with the principles of sustainable development and that there was a need to reform the rate structure. Their intention was to motivate people to save resources and money at the same time. Of course, any new tariff structure could not increase costs for the utility so this led to the introduction of a linear and time-variable rate structure.

The aim of a linear electricity charge is to influence consumer behaviour by offering financial incentives to save energy. Adjusted charges should support anybody who uses less energy or at non-peak-times and to charge more from large scale users using energy at peak times. Benefits may also be included in a comprehensive tariff system to reward those who provide renewable or highly efficient energy sources. Moreover, the linear tariff represents a simple system which can be introduced easily, because there is no need for new equipment or extra staff.

The utility initiated a model calculation for a new tariff system and investigated the possible social impacts. A working group with the utility, the municipality and other utilities in the region discussed all problems concerning the rate structure and decided to give it a try. The model project was successful and the linear time-variable tariff was implemented in full once it had been approved by the state government (being the authorising body for price control).

Results have shown that clients are reducing energy consumption in order to cut their bills. The policy is contributing to Saarbrücken's aim of staying independent of nuclear energy and, in the long term, relying exclusively on renewable energy.

Case Study 10 Energy Efficient Housing Grants



Objective: To provide grants for energy-efficient renovations

Location: Leicester, England

Website: <http://www.eaue.de/winuwd/>

Description:

Energy efficiency stock profiles have been prepared for the domestic sector. This has involved undertaking sample surveys of the entire housing stock of the City of Leicester, and calculating the National Home Energy Rating (NHER) using stock profile software. An NHER profile of the Council's housing stock has enabled the Housing Department to prioritise the measures needed to be undertaken to further improve the energy efficiency of its stock.

These measures have resulted in substantial improvements and have included insulating all the cavity-walled dwellings, loft insulation, boiler replacements, double-glazed windows and on a limited number of houses, external wall insulation. The NHER scale was also used to measure the energy performance of the Council's newly built housing. Originally a standard of a NHER of at least 8 was adopted and this was subsequently raised to an NHER of at least 9.

The same standards as those in House Renovation Grants are applied. The City Challenge housing is predominantly pre-war, solid brick wall housing with gas central heating. Homes in Renewal Areas are also solid brick wall construction. They typically achieve 1 to 3 on the NHER scale before any energy efficiency improvements. Following energy efficiency improvement measures they can reach up to 7 on the NHER scale, through a combination of loft insulation, heating control improvements and heating system improvements. Such a package of measures has been offered as discretionary grant to the mandatory housing renovation grant. These measures do not include wall insulation, because of its relatively high cost.

One of the initial problems encountered with the energy efficiency house renovation work was that building workers and heating technicians were unaware of the new advances in materials and components. They thus required training in these new methods, which was provided in training courses the City Council arranged. The trainees are also able to use the skills gained during the training to help them with other installation work within the city.

Case Study 11 Block-by-Block Weatherisation Programme



Objective: To provide or improve insulation in existing homes for low-income households.

Location: Portland, USA

Website: <http://www.sustainable.doe.gov/success/block.shtml>

<http://www.greenhouse.gov.au/yourhome/technical/fs16c.htm>

Description:

The Block-by-Block Weatherization Programme (BBB), administered by the City of Portland Energy Office, provides free basic weatherisation and energy-use education to needy, low-income households in Portland neighbourhoods. BBB targets households not already served by other low-income weatherisation programmes.

Many low-income individuals and families in the Portland area - those who can least afford high heating bills - live in older homes with little or no insulation and inefficient heating systems. In Portland, there are as many as 60,000 low-income residents living in 20,000 such homes. While local utilities and local, state and federal agencies have established programmes to serve this population, limited funds have historically restricted the scope of these programmes. State and federal programmes combined, for example, are only able to serve about 400 of these homes annually with free weatherization. Utility incentive programmes pay only 25% of weatherization costs and reach only a handful of low-income residents. BBB was created to bridge the gap between need and available resources for affordable, energy efficient homes.

Each year, about 120 homes are weatherized through the BBB programme. Recruitment for the BBB programme is performed in one of two ways. Representatives from a local nonprofit organization canvass neighborhoods, recruiting households for participation by going door-to-door. Direct recruitment has the added benefit of encouraging residents to become involved in neighborhood community groups and local projects that help improve the urban environment. Recruitment also occurs at the city's energy fairs held each autumn. Fair attendees who meet the programme's income requirements receive a visit from the weatherization crew that installs ceiling and wall insulation and seals all air leaks. To keep programme costs low, a complete overhaul is not performed at each location; only the most critical areas are attended to.

In addition to providing insulation, BBB gives each participant a weatherisation kit that includes low-flow fixtures, weather stripping, and storm window kits. Finally, the programme provides participants with in-home education in energy-efficient practices, such as lowering water heater and refrigerator thermostats, changing furnace filters, and drying clothes in the sun. One of the programme's main objectives is to motivate residents to develop their own energy action plans.

Case Study 12 Energy Smart Homes Programme - Rebates for Solar Hot Water Heaters



Objective: To encourage greater use of solar hot water heaters through a rebate system.

Location: New South Wales, Australia

Website: <http://www.energysmart.com.au>

Description:

The Energy Smart Homes Programme is a model energy efficient housing policy that Councils can voluntarily adopt to reduce the quantity of greenhouse gas emissions generated by local residents. It does this by ensuring that minimum energy performance requirements are met for all new residential developments.

Energy Smart Homes use the best combination of insulation, shading, ventilation, energy-efficient appliances and lighting, and solar, heat-pump or gas water heating to make them cheaper to run and greenhouse-friendly.

If you are building or renovating a home in an Energy Smart council area, you may be eligible for \$500 off a solar or heat pump hot water system. If you install a gas boosted solar, you may be eligible for a \$700 discount. The initiative, which is a joint effort between the Sustainable Energy Development Authority (SEDA) and participating manufacturers, aims to encourage development applicants to install Energy Smart water heaters.

Under SEDA's Energy Smart Homes Programme, the installation of low greenhouse gas emission water heaters is required for all new residential development approvals.

Water heaters that make the grade are:

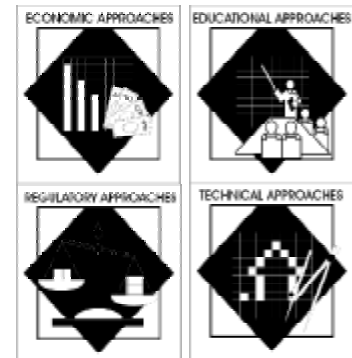
- Solar Water Heaters
- Heat Pump Water Heaters
- Natural Gas

The discount is available on presentation of a voucher for solar and heat pump water heaters which:

- meet technical equipment standards
- are made by participating manufacturers
- are sold by a participating hot water retailer
- are installed at private residences in respect of which a Development Approval has been obtained, as indicated by a number on a voucher, in an Eligible Local Council area. A maximum of ten vouchers may be presented with respect to any one Development Application.

The discount can only be claimed at point of sale. It is not a reimbursement.

Case Study 13 An Integrated Approach



Objective: To achieve energy savings by integrating a range of different energy savings strategies.

Location: Viernheim, Germany

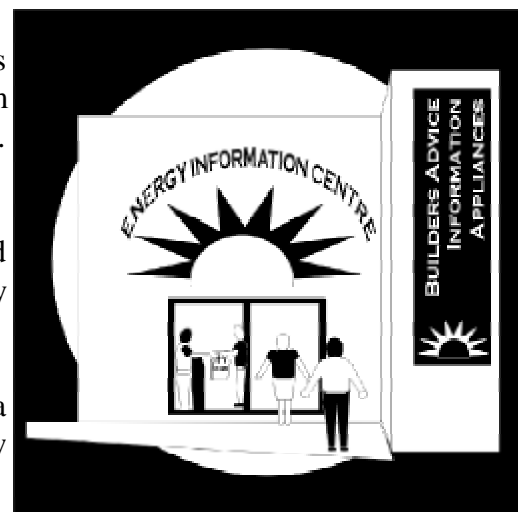
Website: <http://www.eaue.de/winuwd/62.htm>

Description:

In recent years a number of energy saving activities have been developed in Viernheim ranging from pilot projects to routine measures of energy savings. Examples include:

An ecological residential pilot project was created in the new residential area using low energy construction methods.

An old people's home was built with an useable area of some 12,000 m² and energy consumption below 50 kWh/m².



Five low energy houses were built as part of a support programme for the Viernheim Public Utilities. Two semi-detached houses, two residential and office buildings and a building with 32 local authority flats were granted subsidies as low energy houses.

Through the rational arrangement of buildings or central heating supply in the construction plan, influence was exerted on the energy needs in other new residential areas.

By introducing a linear electricity tariff, Viernheim Municipal Utilities has provided customers with an increased incentive to introduce electricity saving measures. In addition, an attractive night time use tariff was introduced.

An energy information office was opened by the Municipal Utilities providing information for all customers on energy saving measures. The information offered by the office ranges from advice for home builders to the best choice of electrical appliances.

II. DOMESTIC NEEDS

A. Major Domestic Uses of Energy in Cities

The domestic sector uses approximately 20% of the total final energy produced worldwide. Although it is a relatively small part of the total energy used, the domestic sector is a very promising area for energy savings.

The predominant fuel for domestic use in developing countries is biomass, which is sometimes firewood or in other cases animal or agricultural wastes. The use of these fuels causes many problems including deforestation, air pollution and loss of valuable fertilizers and nutrients. There is consequently a strong incentive for saving fuel in domestic situations in developing countries.

In the cities of industrialised countries gas and electricity are popular for domestic use because they are convenient. Coal and oil are used mainly for transport and industry or to produce electricity. The worldwide pattern of primary energy use was shown in Figure 1.1.

In most cities there are four distinct categories of domestic energy use:

- Electricity or gas for lighting and appliances
- High temperature heat for cooking
- Medium temperature heat for water heating
- Low temperature heat for space heating.

Figure 2.1, illustrates the major areas of domestic energy use in Western Australia - a typical temperate climate. This pattern will vary considerably between cultures and climatic regions. Further information may be found in the references given in Section D.

In temperate countries water heating and space heating usually require only low-grade heat and so it is wasteful to use high quality energy sources for these purposes. These applications use about 60% of domestic energy consumption. Cooking requires only about 10% of the total domestic energy supplied while appliances and lighting account for approximately 30% of use. There are clearly major savings possible by purchasing more efficient appliances and by educating people to use them efficiently.

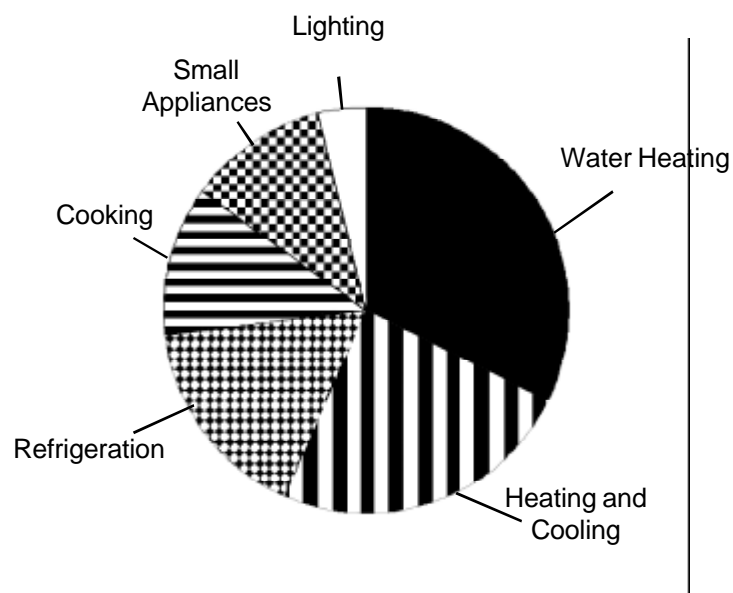


Figure 2.1: Domestic energy use in Western Australia.

Because domestic energy use impacts directly on the finances of the users there is a greater incentive to save energy in the home than in the workplace and it is in this sector that education, policy initiatives and regulations can be particularly effective.

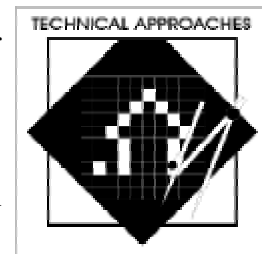
B. Approaches to Saving Energy in the Domestic Sector

A multitude of approaches are available to achieve energy and cost savings in the domestic sector, ranging from energy-saving technologies such as insulation and building design, as well as behaviours such as turning off lights to regulatory approaches including building design codes.

Case Studies illustrating these approaches are referred to in the following discussion and are presented in Section C. Additional Case Studies can be found through the websites of the following organisations; Centre for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET), the International Council for Local Environmental Initiatives (ICLEI) and the SURBAN database on sustainable urban development in Europe.

1. Technical Approaches

Energy and cost savings can be achieved by retrofitting existing homes or designing new houses and by using energy-efficient appliances.



Retrofitting Existing Homes

The rate of heat flow into or out of a building and the transfer of air between indoors and outdoors is determined by the design of the building's envelope. The building envelope consists of the walls, floors, attic/roofs, glazing and the basement of a home, - basically everything that surrounds the space you want to keep warm in the winter and cool in the summer. The aim is to address weaknesses in the design of the building envelope as much as possible to prevent heat gain in summer and reduce heat loss in winter.



Figure 2.2: Retrofitting existing homes with energy saving measures can save significant amounts of money.

Preventing Air Leakage

It is crucial that interior spaces are reasonably well sealed so that heat is not lost readily in winter or gained readily in summer. Basements need to be addressed first followed by other sites of loss including around doors and windows, electrical outlets and exterior wall openings. However, care needs to be taken to avoid eliminating healthy airflow which could lead to a build up of stale polluted air inside.

Insulation

Insulation is a material used to slow down the flow of heat through a building's envelope. Insulation helps to make homes more comfortable and energy efficient throughout the year. In winter it slows heat loss and helps prevent condensation build up while during the summer months, insulation reduces heat gain and helps keep homes cool.

Adding insulation to a home can reduce heating and cooling costs anywhere from 15% to 45% depending on such factors as, the original amount of insulation in the home, house size, air leaks, personal energy use and living habits. It can also be useful to insulate hot water tanks and hot water pipes to prevent heat loss.

Insulation is rated in terms of resistance to heat flow, referred to as the R-value, which indicates the resistance to heat flow. The greater the R-value, the greater the insulating effectiveness. The R-value of thermal insulation depends on the type of material, its thickness, and density.

Before installing insulation, you need to consider where it needs to be applied and the R-value required to determine the type of insulation you choose. Insulation is most commonly installed the roof and floor spaces of buildings (Figure 2.3).

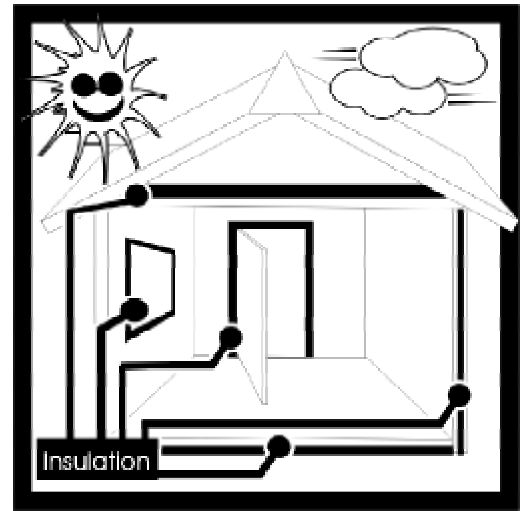


Figure 2.3: Buildings are able to be insulated in the roof, floor and wall spaces in addition to the weatherisation of window and door cavities.

However, wall insulation, should also be considered at the time of construction. Retrofitting of wall insulation is usually very costly, but should be investigated.

There are many types of insulation material available including fibreglass batts, cellulose loose fill and foil-faced plastic film.

Case Study 11 looks at a neighbourhood insulation programme in the United States for low-income families

Roof and Wall Colour

Dark surfaces absorb heat while white surfaces reflect heat. So dark roofs can contribute significantly to the heat gain of a building while white roofs reduce heat gain. Therefore, in hot climates it is beneficial to choose white or light-coloured roofs while in cooler climates darker roofs can assist in capturing heat. A study in Florida, USA revealed that by increasing heat reflectivity, home owners were able to save an average of 23% of their cooling costs. The best wall colour and material to reflect the sun is white paint on plywood, which absorbs only about 15% of the sun's heat.

Protecting windows

Windows are sites where heat flows are usually greatest. If a house is fully insulated, then the windows will be the weakest site for heat transfer in and out of the house.

In climates that experience cold weather, large north facing windows (*in the southern hemisphere, reverse for northern*) are required to allow the winter sun in during cold weather, and naturally their value will be diminished if they then allow that day's heat to escape at night. Close fitting heavy curtains or blinds with a pelmet will reduce heat transfer. Double glazing will reduce heat transfer by a similar amount to effective curtains, but will be more expensive. There are now readily available double glazing films that are cheap and easy to apply to most existing windows. Minimising the size and number of windows will also help to reduce heat loss.

In summer, each square metre of glass in direct sun can allow as much heat in as would be generated by a single bar radiator. For minimising heat gain from poorly placed windows, shading strategies such as awnings can be useful. Glazing is another option.

Glass is usually classified as either being reflective or absorbent. Tinted glass, which is the main sort of absorbent glass, reflects some heat and absorbs some heat, which is then radiated both inwards and outwards. In warm climates where cooling strategies are important, heat radiated inwards can reduce thermal comfort near the window. A double glazed unit (Figure 2.4) provides improved performance in this situation because the inner pane blocks some of the heat radiated inward by the outer pane.

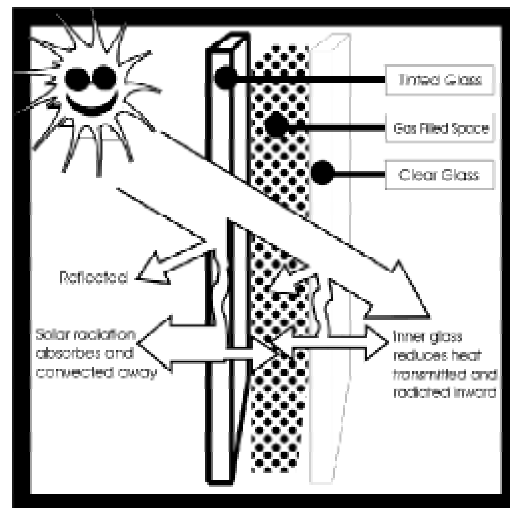


Figure 2.4: Double glazed windows can significantly reduce the thermal comfort of rooms.

The best performance is achieved by using a low-emissivity glass for the inner pane. Double-glazing also reduces infiltration of warm air from outside.

Shading

Careful selection and placement of trees can cut down energy use significantly by providing shade to buildings and particularly unprotected glass and also by cutting heat reflected off bitumen and pavements. Shading can block up to 90% of the heat generated by direct sunlight.

Evergreen plants are recommended for hot humid and some hot dry climates. In other regions, care needs to be taken with the placement and type of trees so that winter sun is not lost. Deciduous vines or trees should be used to the north in the southern hemisphere and to the south in the northern hemisphere. Deciduous or evergreen trees can be planted to the east and west.

Verandahs, balconies and pergolas can also be used to shade windows and walls. Awnings and other fixed shade structures can also be placed over windows that receive full summer sun.

Daylighting

Using natural sunlight to light buildings is a cost-effective form of lighting. Daylighting is best achieved by considering it in the overall design of buildings before construction, however it is also possible to retrofit existing homes. Installation of skylights can be very effective but some care needs to be taken to avoid excessive solar heat gain. Painting interior walls in light colours and also walls outside windows can increase the effectiveness of daylighting

Designing New Homes

Simple and careful design of new homes can ensure major energy savings as shown in the “Ki” nari House - Zero Energy Concept Case Study 1, which describes a Japanese experimental home that incorporates numerous energy saving features.

Passive solar design principles use the structure of buildings to provide heating and cooling and natural daylighting. All passive techniques use building elements such as walls, windows, floors and roofs, as well as external building elements and landscaping, to control heat generated by solar radiation.

There are a number of basic principles to consider:

Orientation

In hot humid climates and hot dry climates with no winter heating needs, houses should be orientated to exclude sun year round and maximise exposure to cooling breezes.

In all other climates houses will need to be designed using a combination of passive solar heating and passive cooling strategies. Essentially the aim is to maximise solar heat gain in winter during the day and minimise its loss at night. On the other hand, in summer the aim is to minimise solar heat gain during the day and maximise the effect of cooling breezes. Therefore the design will vary according to local conditions.

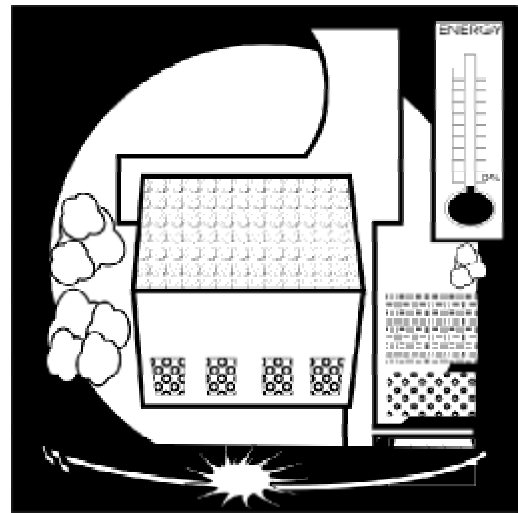


Figure 2.5: Building orientation is an important aspect when designing buildings for energy efficiency.

Daylighting

Well-designed and positioned windows, skylights and light tubes allow light in without adding to summer heat and winter cold. Light-coloured interior surfaces reflect more light and lessen the level of artificial lighting required.

Thermal mass

Thermal mass refers to the amount of potential heat storage capacity available in a material. In a building, materials with high thermal mass values include a concrete slab with a tiled floor, brick, stone or earthen walls, or even water tanks. When positioned correctly inside the house, thermal mass can store heat during the day in winter, and re-radiate it during the night. In summer the thermal mass is protected from direct solar radiation and can act as a heat sink (absorb heat) in hot weather to provide cooler indoor temperatures.

Ventilation

Optimising natural ventilation is a crucial passive cooling strategy. Knowing the direction of the prevailing winds is essential and as mentioned previously the house should be orientated so that the long façade of the building and the majority of the openings are positioned to capture the prevailing summer breezes. Windows should be able to be opened fully to let in summer breezes and interior doors and walls should be designed to maximise flow of these breezes through the house. In tropical climates, space should be left around and underneath the house to enable breezes to cool the external surfaces and enable cross-ventilation inside.

Additionally, the ideas mentioned in the retrofitting section such as insulation, shading etc also apply to new houses.

A summary of basic building and renovating measures is provided in *Global Warming Cool It! - A home guide to reducing energy costs and greenhouse gases* (2000).

See Case Study 2 Second Generation Passive Solar Energy Houses in the Subsidised Housing Sector and Case Study 3 Ugie Solar Village for examples.

Energy-Efficient Appliances

Energy-efficient fluorescent lights

Fluorescent lamps provide the most energy efficient form of lighting. While they are more expensive to buy than incandescent or halogen lights they are considerably cheaper to run and can last up to ten thousand hours. Fluorescent lamps use only about one quarter of the energy used by incandescent bulbs to provide the same light level. They come in two main types - compact and tubular.

Fluorescent lamps are best suited to areas where lighting is required for long periods of time, such as the living room and kitchen, and for security lighting. Another benefit is that they also produce less heat which assists in keeping homes cooler in summer.

Solar Hot Water Heating

Gas and electric water heaters are heavy energy users. A solar water heater can provide between 50% and 90% of a household's total hot water requirements, depending on the climate and the model of heater.

Solar water heaters use sunlight to heat water. Like most water heaters, they store the water to be heated in a tank but rather than heating the water with an electric element or a gas flame, the water flows through a solar collector panel, where sunlight heats it.

All solar water heaters come with some sort of backup boosting for periods of low sunshine, such as during cloudy days. Common boosting methods are electric, gas or a slow combustion wood stove. The amount of boosting needed will depend on the location. A gas-boosted solar water heater will probably bring the greatest savings in energy use and expenditure on energy.

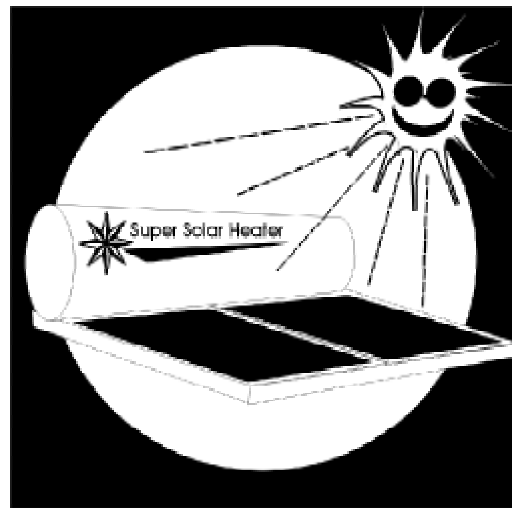


Figure 2.6: The sun can be used to heat water for applications which do not require boiling water, such as washing.

Space Heating and Cooling

In countries where heating and cooling is required for substantial parts of the year, care should be taken to choose energy efficient space heating and cooling systems. Although the initial purchase price of energy efficient systems may be slightly higher than less efficient models, the operating costs are much less and the payback period is relatively short.

The options available for cooling homes are similar to those of small commercial buildings, and are discussed at length in Chapter 4.

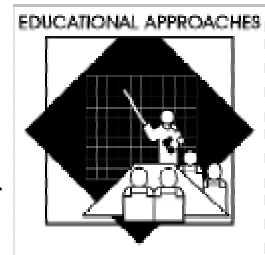
Fans, evaporative coolers and air conditioners are the three main methods of mechanical cooling. Fans are the cheapest to operate and have the least greenhouse impact. Evaporative coolers are the next best choice but they are suited best to low humidity situations as the air has greater potential to absorb water vapour. Air conditioners are the most expensive to operate and generate the highest greenhouse gas emissions.

Refrigerators and Freezers

These appliances are heavy users of electricity yet substantial savings can be made by purchasing efficient refrigerators and freezers. Many countries have developed rating systems to assist consumers in choosing efficient appliances.

2. Educational Approaches

Educational approaches are usually directed towards changing behaviour and informing people about energy saving options such as efficient appliances and retrofitting. Substantial energy savings may be made through changes in behaviour and where these changes also result in financial savings, householders are likely to embrace them once they are informed of their options.



Many national and local governments have produced information booklets or provide information websites on how householders can save energy and money by designing new homes for energy efficiency or by retrofitting existing homes and purchasing energy-efficient appliances as outlined in the previous section. Some also supply information on how to make savings by changing the householders' patterns of energy use.

Numerous basic lifestyle or behavioural measures can achieve considerable energy and cost savings.

Some of the measures include:

- Keeping lights and other appliances off during daylight hours as much as possible
- Closing doors and windows to keep heat in or out
- Avoiding cooking food in the oven during the hot part of the day
- Simmering pots gently with lids on or use a pressure cooker
- Washing clothes in cold water
- Keeping refrigerators well-maintained

See Case Study 4 Saving Energy Education Programme and Case Study 5 Energy Advice and Consultancy Programme. Also see Section D which lists websites that provide useful energy-saving information for householders.

There are many voluntary home rating schemes which provide an educational tool for both builders and customers, which help drive consumer demand for energy-efficient housing. In Austin, Texas, USA, new homes and remodels are rated under the residential Green Building Programme using "green" guidelines on a scale of one to five stars: the more stars the more green features in the home. Homes are rated in five areas: energy efficiency, water efficiency, materials efficiency, health and safety, and community.

See Case Study 6 Home Rating Scheme - the Austin Energy Green Building Programme.

3. Regulatory Approaches

Regulatory approaches are often the easiest method for local governments to implement new schemes. However, they do involve administration and enforcement costs and ratepayers may object if they are costly to implement. Some possible regulatory measures are listed below.

Standards and Labelling of Appliances

In the *Compendium on Energy Conservation Legislation in Countries of the Asia and Pacific Region* (1997) it is stated that “Minimum energy [efficiency] performance standards (MEPS) and energy labels for appliances are the two most frequently used tools of energy conservation programmes. Energy standards, if mandatory, aim at eliminating least efficient products from the market.

Energy labelling programmes aim to increase consumer awareness and to provide information for buyers/consumers on the otherwise invisible energy efficiency differentials. In some countries, energy labels have been designed to inform consumers of the different operating costs of an appliance, which may well be a parameter which ought to be considered in individual purchasing decisions”.



Figure 2.7: Energy labelling programmes, such as the Energy Star and Energy Rating schemes have made the purchase of energy efficient appliances easier for consumers.

In a recent report *Final Report: Accessing Overseas Markets: Energy Efficiency Standards and Appliance Labelling in Asia and Latin America* (1999) for the US National Center for Environmental Research it is stated that:

Environmental concerns and pressures of constrained capacity are stimulating the adoption of standards and labelling programmes in Asia and Latin America. In just five years, numerous standards and labelling efforts have developed into full-fledged, successful programmes which can serve as models for developing countries struggling with similar constraints and barriers.

See Case Study 7 Mandatory Standards and Labelling Information.

Building Codes

All municipalities have codes that builders must comply with, however a newer initiative is the development of building codes that incorporate energy efficiency principles. Most Councils that have adopted these have included guidelines which are voluntary rather than mandatory. Leichhardt City Council in NSW, Australia has introduced a Development Control Plan, which requires all applications for residential buildings to comply with certain energy-efficient design provisions. See Case Study 8 Energy Efficient Building Codes.

The International Code Council (ICC) was established in 1994 as a non-profit organisation committed to developing a single set of comprehensive and coordinated national model construction codes for the United States. The 2000 International Energy Conservation Code can be viewed at Building Codes Assistance Project website.

More information on the ICC and states that have adopted the International Energy Conservation Code can be found at the IECC website.

4. Economic Approaches

Domestic users can be encouraged to use energy-efficient appliances or retrofit their homes by Councils providing incentives. These can be in the form of:



- **Pricing policies** which encourage consumers to save energy. See Case Study 9 Energy Efficient Saarbrücken: Rate Structure of Energy Charges in Saarbrücken.
- **Grants** for the purchase of energy-efficient appliances or retrofitting homes. See Case Study 10 Energy Efficient Housing Grants.
- **Assistance to low-income households** to finance retrofits. See Case Study 11 Block-by-Block Weatherisation Programme.
- **Rebates** on purchasing of approved energy efficient appliances or retrofits. See Case Study 12 Energy Smart Homes Programme.

Financial incentives and programmes are discussed further in Chapter 8.

D. References and Resources

Centre for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET) <http://www.caddet-ee.org/>

International Council for Local Environmental Initiatives (ICLEI) <http://www.iclei.org/>

SURBAN database on sustainable urban development in Europe <http://www.eaue.de/winuwd/>

World Energy Efficiency Association <http://www.weea.org/>

Australian Greenhouse Office (2000) *Global Warming Cool It! - A home guide to reducing energy costs and greenhouse gases.* <http://www.greenhouse.gov.au/pubs/cool.pdf>

United Nations Economic and Social Commission for Asia and the Pacific. (1999) *Compendium on Energy Conservation Legislation in Countries of the Asia and Pacific Region.* <http://www.unescap.org/enrd/energy/compend/cecontents.htm>

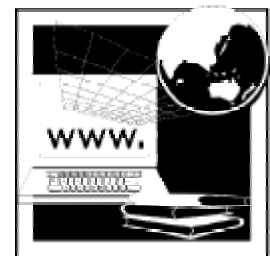
International Institute for Energy Conservation. (1997) *Final Report: Accessing Overseas Markets: Energy Efficiency Standards and Appliance Labeling in Asia and Latin America.* <http://es.epa.gov/ncer/final/grants/95/incentive/egan.html>

General Information on Energy Savings in the Home

Alliance to Save Energy PowerSmart <http://www.ase.org/powersmart/>

Austin Greenbuilder Fact Sheets http://www.ci.austin.tx.us/greenbuilder/fs_toc.htm

Australian Greenhouse Office - Your Home
<http://www.greenhouse.gov.au/yourhome/technical/index.htm>



Home Energy Saver <http://hes.lbl.gov/>

Home Energy Saving Tips <http://www.energyideas.org/library/residtips.cfm>

Oxford City Council - Search for Energy Saving <http://www.oxford.gov.uk/>

Sustainable Energy Development Authority, NSW, Australia <http://www.seda.nsw.gov.au/>

US Department of Energy http://www.eren.doe.gov/consumerinfo/energy_savers/

Buildings

National Renewable Energy Laboratory Passive Design
http://www.nrel.gov/clean_energy/home_passive.html

Building Codes Assistance Project <http://www.bcap-energy.org/2000IECC.pdf>

International Energy Conservation Code <http://www.intlcode.org/index.html>

Roof and Wall Colour <http://www.colormatters.com/energymatters.html> and
<http://www.fsec.ucf.edu/~bdac/pubs/CR904/oss.htm>

New Mexico Solar Energy Association
http://www.nmsea.org/Passive_Solar/Passive_Solar_Design.htm

Sustainable Building Industries Council <http://www.sbicouncil.org/>

Solar/Ecovillages

US Department of Energy green developments
<http://www.sustainable.doe.gov/greendev/stories.shtml#PC/S>

Global Ecovillage Network <http://www.gaia.org/>

Iowa Energy Center - Insulation
<http://www.energy.iastate.edu/efficiency/residential/homeseries/insulation/index.htm>

United States Department of Energy <http://www.ornl.gov/roofs+walls/insulation/>

ACRE REFile on Buildings <http://www.acre.murdoch.edu.au/refiles/built/>

Energy Efficient Appliances

Solar Water Heaters <http://www.acre.murdoch.edu.au/refiles/lowtemp/>

Lighting <http://www.greenhouse.gov.au/yourhome/technical/fs45.htm>

Appliance Labelling

Australian Energy Labelling <http://www.energyrating.gov.au/>

Energy Star (Australia) <http://www.energystar.gov.au/>

Energy Star (US) <http://www.energystar.gov/>

Case Study 14 Innovative Bicycles



Objective: Transport of goods in Penang

Location: Penang, Malaysia

Website: http://www.mobilityconsultant.com/brm/asia/meier/as_mei73.htm

Description:

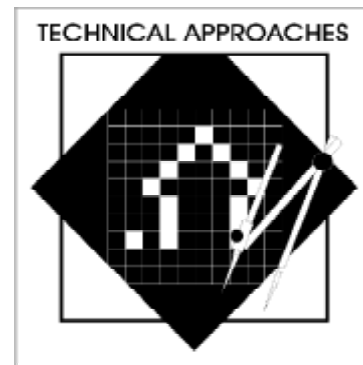
Bicycles are often used to carry freight. Virtually every freight bicycle has a rack built over the back wheel. Sometimes just a wicker basket is lashed on, but in the case of more specific uses a specially adapted rack is built. Bread delivery, for example, is usually done with a large box over the rear wheel. Similar trades are performed on motorcycles. Trishas are also an important freight vehicle. Trisha riders will often supplement passenger fares by carrying goods. They might, for example, arrange to make a regular delivery of some goods to a number of stores each morning. A common practice is to carry meat carcasses from the butchers in the market to their institutional customers like the hospitals and schools. If someone wants to move some goods, he merely hails a trisha, negotiates a fare, and loads up.

During World War II, a second form of trisha appeared. It was basically a bicycle with a sidecar attached to its left side. This form was used exclusively in Singapore - a few remain for tourist consumption - and partly in Kuala Lumpur. In Penang, however, the few that ever existed were converted to freight use. This is a very simple operation; the sidecar was designed so that the seat could quickly unscrew, leaving a flat, one and a half metre long, freight bed. The arrangement is ideal for odd shaped objects like glass or metal stock. Every glazier's shop, for example, has one of these tricycles. The most fascinating vehicle in Penang's transport mix is the freight tricycle. Although it has parallels in other Asian cities, no other place has exploited it so well as Penang. It closely resembles the trisha except that a large metal box is placed between the two front wheels instead of a seat. The rear half of the frame is identical to the trisha, though a lower gear ratio is sometimes used. Unlike the trisha, the tricycle's front kickstand is retractable, via a lever, from the rider's seat.

The steering bar is adjustable on the new models so that it will not knock the rider's knees. There are two models, medium duty and heavy duty. They differ only in the sturdiness of the front wheels. Recently, however, a new model has been introduced which uses a much smaller pair of front wheels, about the size of the smallest Honda motorcycle. They command a premium over the traditional tricycles because they can carry heavier loads and the tyres last several times as long. Since a tricycle lasts over twenty years, the accumulated savings on new tyres make the premium worthwhile.

Virtually every shop doing any sort of delivery or freight movement has a tricycle. Officially, there are just over 2,000 tricycles in Penang. In practice, there are probably closer to 3,000. The tricycles are ideally suited for Penang's narrow streets. They can efficiently carry loads of 5 to 200 kg. over distances of up to four kilometres. A number of tricycles travel much greater distances, leaving the city entirely to gather a crop of coconuts, sugar cane, or bananas, for use in the food stalls.

Case Study 15 An Electric Transit Vehicle Programme



Objective: To develop, build, test and operate electric buses as part of a sustainability initiative.

Location: Chattanooga, USA

Website: <http://www.sustainable.doe.gov/success/chattano.shtml>
<http://www.carta-bus.org/>

Description:

A prominent example of local sustainability initiatives, the transit authority for the city of Chattanooga and Hamilton County formed an innovative public-private partnership (Chattanooga Area Regional Transportation Authority - CARTA) to develop, build, test, and operate electric transit vehicles (ETVs) and ETV systems in downtown Chattanooga. Since 1991, 10 electric buses have gone into service on a downtown shuttle route,. a local non-profit (WHAT) has been launched to promote research and provide information, and a company has been formed to manufacture electric buses. The programme's *Living Laboratory* brings participants together to develop ETVs and share their discoveries worldwide. Programme benefits include reduced congestion on downtown streets, reduced air emissions, and over 30 new manufacturing jobs.

These organizations, along with the TVA's Electric Vehicle Test Facility, comprise an innovative public private partnership that has advanced ETV technology from troublesome prototypes to a practical and effective public-transit alternative. The ETV development partners accomplished this feat by establishing a process focused on the following objectives:

- *Bringing ETV technology into the public domain.*
In ETV development efforts elsewhere, private parties had claimed ownership of the technology. To avoid that experience, CARTA and its partners made public access to ETV research a principal goal.
- *Involving those who know transit best in the ETV design process.*
Owners and operators of transit vehicles have a unique understanding of operating conditions and rider concerns. From the outset CARTA strove to incorporate their perspective into the ETV design process.
- *Testing and improving ETV technology.*
CARTA recognized that real-world testing of components and systems would quickly advance ETV technology, paving the way to an electric-bus system that would define the state-of-the-art.
- *Developing ETV standards.*
Through research and testing, CARTA strove to establish consensus design and equipment standards for ETVs.
- *Disseminating ETV information.*
CARTA decided that other transit systems and operators interested in ETVs should benefit from Chattanooga's experience.

Case Study 16 Car-Free Day



Objective: To encourage people to use alternative transportation options.

Location: Bogotá, Colombia

Website: http://www.ecoplan.org/carfreeday/cf_index.htm

Description:

On Thursday February 24th 2000, the city of Bogotá in Colombia took a monumental step in promoting a reduced dependence on automobiles, by holding the world's largest Car-Free Day. From 6:30 a.m. to 7:30 p.m. private cars were banned from city streets (over the entire extended urban area). While some 850,000 private cars stayed home in their garages, city residents turned to public transport, bicycles, taxis, regional train, roller-skates and other modes of transit to get to their destinations.

One and a half million people cycled on the day, and 10% more people than average used public transport to get around. A substantial reduction in contaminants was reported for the day, with NO_x being reduced by 8%, carbon monoxide decreased by 22%, and particulates reduced by 21%. More lasting impacts included a sensitisation of the public to the impacts of the automobile on the city, and education on sustainable transportation. In one poll 30% of respondents reported having a change in their opinion towards public transport.

The car free day was the first day in more than three years that not one person died in a traffic accident compared to the daily average of 2-3 reported deaths. Although there were some reported crashes, and injuries, there were far less than an average day. Some hospital clinics reported a decrease of 20 to 30% in the emergency consultations. Such reductions save public costs in health care, police services and other associated costs. For car-free days to be implemented on a more regular basis, more work will have to be done with retailers, many of whom experienced losses in sales. One poll showed only 7% of retailers experiencing an increase in sales, while the remainder experienced either stable sales or decreases. In Bogotá, despite the lack of benefits for most retailers, 44% of retailers in one poll still believed the day was a success. Clearly however retailers must be closely involved with planning car free events so as to ensure that they too can benefit.

The success of the Day has led to local transportation, city planning and environmental teams in Bogotá working on plans to create an entirely new and innovative "alternative transportation system for Third World Megacities". The plan includes one of the world's most comprehensive bicycle transportation networks (more than 200 km of system built or under construction), stringent parking measures and major provisions for pedestrians taking trips within the city. Also under way is the strategic renovation and redeployment of a public transport system presently consisting of some 30,000 buses of various sizes and type and some 55,000 taxis.

Case Study 17 TravelSmart



Objective To provide information to transport system users to empower them to make informed choices about their travel behaviour.

Location: Perth, Australia

Website: <http://www.travelsmart.transport.wa.gov.au>
http://www.travelsmart.transport.wa.gov.au/pdfs/present_infra.pdf

Description:

TravelSmart is applied using a number of key principles to:

- Inform, motivate, facilitate and empower in order to achieve sustained behaviour change
- Examine the transport system from a user's perspective.
- Emphasise community learning about travel behaviour underpinning local community empowerment programmes.
- Ensure evaluation is based on behaviour change rather than just raising community awareness (eg. 50% remember the message).

TravelSmart is therefore designed to inform and motivate people to use alternative transport modes to the motor car, including car pooling and alternatives to transport (eg. Teleaccess). TravelSmart is helping local councils and their communities promote travel alternatives through:

- Local travel surveys providing information on how people travel
- Individualised marketing as an innovative way of promoting travel alternatives, and showing positive results where car use is reduced and walking, cycling and public transport use increased
- Local communities finding ways to reduce car use through TravelSmart Plans

Individualised Marketing is a particular type of dialogue marketing that has been developed and tested to facilitate travel behaviour change. The technique is built on a platform of informing people of their travel choices and encouraging self-help. It is not about telling people which trips to change or what modes to use. The design of the technique allows the information and dialogue to be related to each individual's or household's unique situation. The information, especially public transport, is tailored to each person's unique situation. h

“We telephone almost every household in an area to identify those interested. We ask them what information they would like about walking, cycling and public transport and deliver personalised packages of information specific to their situation, for example local bus service timetables and local cycling and walking maps. We may even visit their home, talk to them about using public transport, and offer new users trial use with free tickets. If they wish, we can arrange a personal visit by someone with practical skills and knowledge of walking and cycling (including local facilities). We can also provide discount vouchers from local bike shops, or give them a ‘Heart Movers’ Kit’ to encourage them to work more. Those people who are already using public transport or cycling or walking regularly are encouraged to continue by rewarding them with vouchers and small gifts (eg. sports drink bottle. We also give them additional information if they want it.”

Case Study 18 The Planned City



Objective: To plan and develop a city that avoids the transportation problems of car-based cities.

Location: Curitiba, Brazil

Website: http://www.solutions-site.org/cat7_sol110.htm
<http://www.dbj.go.jp/english/cooperat/hot/curitiba/02.html>

Description:

Curitiba's population started growing in the 1950's, a trend which was accentuated in the late 1960's as industrialization took off. The population has more than doubled in the past 30 years, from its 1970 level of 600,000. The city's mass transportation system, which was established in 1974 and 2 million people now use the city's integrated transit network every day. It has four elements: the direct line; an alternative 'speedy' system – buses which travel faster and have fewer stops; the inter-district line, which carries out trips between districts without crossing the centre of the city; and feeder buses, which connect terminals to the districts. It is integrated within the 12 municipalities of the metropolitan region, and is continually updated as the city and its population grow.

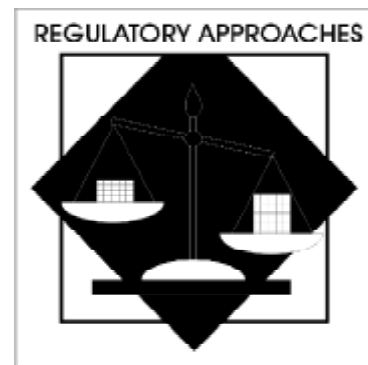
Curitiba has significant bus systems. "BI" buses run along dedicated bus lanes throughout the inner city, and "Inter-district" buses connect Curitiba directly with surrounding areas. In most cities, buses are prevented from becoming a high-volume, regular form of transport because of delays at stops due to fare collection and people negotiating steps in getting on and off buses, and also as a consequence of bus services not being smooth or reliable due to clashes with other forms of public transport. In Curitiba's case, however, these issues have been successfully resolved. Ironically the Curitiba bus system was originally set up as a desperate measure to develop a transport system with limited public finances. Nowadays, it is highly renowned both locally and abroad.

Public facilities have been built along arterial roads where buses run and citizen centers. There are a total of eight citizen centers in the inner city. Each center has public utilities such as water and electricity, as well as a range of public services including police, municipal branch offices, job centers, social security offices and libraries, and also a roofed multi-purpose sports ground, sports room and conference rooms; all of which can be utilized either free of charge or for next to nothing.

Due to ongoing increases in the city's population, Curitiba's bus system is expected to reach maximum capacity in the near future. The total cost of diversion of the highway and construction of the monorail is around US\$400 million. Well beyond the financial capabilities of the municipal government, the plan will be co-financed by the national government (60%), municipal Curitiba government (20%) and the private sector (20%).

The Centre of Excellence for Sustainable Development (<http://www.sustainable.doe.gov/transprt/maxchoice.shtml#Making>) for more information on making communities more pedestrian friendly.

Case Study 19 Integrated Public Transport Systems



Objective: To integrate fare, information and transit networks in order to create a quick and convenient public transport system.

Location: Singapore

Website: <http://www.transitlink.com.sg/>

Description:

Singapore has adopted an integrated public transport system which incorporates fare information and network integration so that travelling in the city is quick and convenient. Singapore's transport system is described in an article by Lim Swee Say, Singapore's Acting Minister for the Environment and Minister of State for Communications and Information Technology.

“There are at present two train networks in Singapore – the mass rapid transit (MRT) lines and the light rapid transit (LRT) system. The MRT links the main population centres north-south and east-west, while the LRT serves the intra-town and localized transport needs of the residents of satellite townships. Another 57 kilometres of MRT and LRT lines will be added to the existing 91 kilometre network over the next five years. By integrating the two networks, we are making travel by train a seamless and attractive mode of transport for commuters. There are also plans to improve bus and taxi services further. A ‘traveller information system’ is being introduced for the bus service. This will provide commuters with real-time information on bus movements, locations and expected arrival times, to help them plan their journeys better and cut down waiting time. At the same time, more and more taxis in Singapore are being equipped with a satellite global positioning system, allowing them to be directed to the nearest passenger pick-up points. The system has effectively cut down customers’ waiting time, while maximising the utilisation of the taxi fleet. All these are important features in making our public transport system attractive and appealing to commuters.”

A fully Integrated Public Transport System is one in which buses, the MRT and the LRT combine their services to provide a single planned network.

Information Integration

The Transit Link Guide gives commuters integrated information in just one book. Comprehensive information panels are put up at MRT stations and major bus stops for the ease of commuters making transfers.

Network Integration

Transit Link's central planning and coordination of the bus network, designed mindful of the MRT and LRT systems, reduces wasteful duplication of services and improves the use of transport resources.

Case Study 20 Urban Agriculture



Objective: To support the practise of agriculture in urban areas.

Location: Lima, Peru and various other places

Website: <http://www.cityfarmer.org/potatocentre.html>

Description:

Urban agriculture can be traced to the world's earliest civilizations. The Aztecs, Mayans, and Incas all produced food within the borders of their urban settlements. City farms were crucial to the development of Europe and the sites of many modern cities were selected because of their access to water and high-quality land. Today, an estimated 800 million people are engaged in some form of urban farming, whether tending home gardens or working in commercial livestock, aquaculture, forestry, or greenhouse operations.

For example, farmers in Cairo raise 80,000 head of livestock, while 1.7 million inhabitants of Mexico City rely on city dairy farmers for their milk. Ninety percent of the leafy vegetables sold in the public markets of Dar es Salaam are grown within the city limits. In Kampala, Uganda, about 30% of the population's need for meat and eggs is met by urban farmers. More than 16% of Harare's urban area is planted to crops. The shantytowns of Lima sprawl across one of the world's most barren deserts. Yet their resourceful inhabitants, many who are recent immigrants from the Andes, have found ways to produce everything from sweet potatoes and artichokes to chicken, fish, and pork. Their skills have been put to good use in this burgeoning city of 8 million providing critically needed food and income to some of the western hemisphere's most economically depressed neighbourhoods.

As urban populations grow at unprecedented rates here and around the globe, city farmers are becoming increasingly important. Under a new initiative launched by the Consultative Group on International Agricultural Research (CGIAR) in Washington, US, some of the world's leading agricultural scientists will be looking for ways to help those farmers play an even bigger role.

"Researchers have been working for years to make rural agriculture more productive and sustainable," said Hubert Zandstra, Director General of the Lima-based International Potato Center (CIP), which will spearhead the effort. In looking at the needs of urban farmers, we're pursuing the same goals as we are in the countryside - food security for developing countries, a way out of poverty for food producers, and better access to food for consumers."

The \$500,000 Global Strategic Initiative on Urban and Peri-Urban Agriculture will link several of the CGIAR's 16 research centers with international aid agencies, non-governmental organisations, and research networks in Latin America, Africa, and Asia. Among the sites to be considered for intensive study are Lima; Yaunde, Cameroon; Harare, Zimbabwe; Manila, Philippines; Accra, Ghana; Beijing, China; Dhaka, Bangladesh; Lusaka, Zambia; Dar es Salaam, Tanzania; Bogotá, Colombia; and Maputo, Mozambique.

Case Study 21 Vehicle Quotas



Objective: To restrict the growth of private car ownership.

Location: Singapore

Website: <http://www.ourplanet.com/imgversn/121/say.html>

<http://www.undp.org/tcdc/bestprac/social/cases/04-private%20vehicles.htm>

Description:

Under Singapore's vehicle quota system a certificate of entitlement (COE) must be acquired before a person can register a vehicle for use on the road. The price of a COE is determined by market demand through a public tendering system, and it is valid for ten years. By limiting the number of COEs issued each month, the quota system has served as an effective means to keep the growth of the vehicle population in Singapore at a level of 3% per year. The Vehicle Quota System (VQS) fixes an annual ceiling on the number of vehicles that can be bought. Thus, the government can directly control the vehicle population in Singapore in order to achieve its target vehicle population in line with road capacity and traffic conditions, instead of allowing the free market to dictate the number of vehicles. The target growth rate of the vehicle population is reviewed annually on the advice of the Public Works Department. This rate is the level at which traffic is able to flow smoothly given the current and projected expansion in infrastructure.

Every year, the government announces the number of vehicles that it is prepared to allow. This is decided by considering prevailing traffic conditions and the number of vehicles taken off the roads permanently. For each tender exercise, the government announces the number of Certificates of Entitlement (COEs) available in the various categories and would-be buyers bid for a COE for the particular category of vehicle which they wish to purchase monthly. Certain vehicles are exempt from this scheme, for example, buses, emergency vehicles, trailers, vehicles belonging to the disabled and diplomatic vehicles.

Each bidder is only allowed to submit one bid. Anyone found making more than one bid will find their applications rejected. Companies, however, are exempt from this ruling. The bid must be accompanied by a 50% deposit. On 1 November 1995, the bidding for COEs went fully electronic. Prospective buyers can now submit their bid through Automated Teller Machines of various banks.

Based on the quota available for a particular category that month, the highest bidders within that category will secure the COEs. The amount that the successful bidders will have to pay is the amount of the lowest successful bid in the particular category. Successful bidders for company registered cars and heavy goods vehicles are required to pay twice the amount in their respective categories.

The successful bidder now has the right to own a vehicle. Only COEs of goods vehicles and buses and the open category are transferable. Every COE is tagged to a vehicle and is valid for a period of 10 years from the date of the vehicle's registration.

Case Study 22 Employee Commute Options Rule (ECO Rule)



Objective: To reduce the number of car trips used for commuting.

Location: Oregon, USA

Website: <http://www.trimet.org/employers/ecorule.htm>

Description:

Why is there an ECO Rule?

The Employee Commute Options (ECO) Rule was developed by the Oregon Department of Environmental Quality (DEQ) to improve air quality in the region. Its goal is to reduce the number of auto trips used for commuting. The rule will become a part of DEQ's regional air quality maintenance plan needed for compliance with the Federal Clean Air Act. This region chose to focus on reducing commuter auto trips instead of increasing limits on industrial air pollution sources since over 50% of air pollution is caused by vehicle emissions.

Who is affected by the ECO Rule?

The ECO Rule affects employers located within the Portland Air Quality Maintenance Area (PAQMA) and with a total of 50 or more people at any one work site. The PAQMA encompasses most of Multnomah, Washington and Clackamas counties.

What does the ECO Rule do?

The ECO Rule requires affected employers to implement programmes that encourage their employees to use alternatives to driving alone. After implementing a programme, an employer has three years to achieve a 10% reduction in the number of commuter auto trips taken to work sites.

How do employers comply with the ECO Rule?

An employer has two options for complying - one is "prescriptive based," the other is "performance based." Under both options, the employer must conduct a baseline survey to document how employees commute before the programme begins. The employer then administers a follow-up survey each year to measure progress towards compliance.

Prescriptive Compliance- An employer who chooses this option will file a commute trip reduction plan with DEQ for approval. The plan outlines how the employer intends to meet its trip reduction target. Once approved, the employer implements the plan. DEQ will consider an employer in compliance with the rule as long as it submits and implements an approved plan, whether or not it fully achieves its trip reduction target.

Performance Based Compliance - An employer who chooses this option does not file a plan with DEQ. Instead, it implements a commute trip reduction programme which the employer feels will work for the site. If the employer is not able to meet its trip reduction target, it must demonstrate to DEQ that a "good faith effort" was made to do so. No evidence of "good faith effort" is needed if the employer meets its trip reduction target.

Case Study 23 Car-Sharing



Objective: To provide a car-sharing service to support people to not own cars and use alternative transportation wherever possible.

Location: Switzerland

Website: <http://www1.mobility.ch/e/index.htm>

Description:

Partnering With Transit

Mobility CarSharing Switzerland is already developing, testing, and evaluating several “mobility management” packages. Most of these are based on partnerships with public transit organisations and other businesses. While government institutions provided some start-up support, there have been no subsidies for actual operations.

Marketing Mobility

Mobility’s “zuri mobil” package is one successful mobility service initiative. For an annual fee of 80-EUR, zuri-mobil customers can: take a second person along with them on public transit at no extra charge; gain lower rates and preferred status for traditional car rentals; and, access over 450 shared-use vehicles at 220 stations in Zurich (and 1200 cars at 800 stations throughout Switzerland). In Zurich, these customers can access car-sharing on every third street, and most lots are closely linked to train and bus stations. Between 1996 and 1997 3,000 customers joined zuri-mobil capturing over 1% of the city’s population during its initial year of marketing.

Expanding Options

On a different front, Mobility recently launched a nationwide mobility package, called “mobility rail card 444” in collaboration with the Swiss National Railway System. With approximately half of all 700 Swiss train stations providing car-sharing lots, intermodal vacation trips or travel blending is now possible from most Swiss cities and towns. Mobility and Swiss Rail expect this programme to attract 20,000 to 30,000 new customers within the next year - a growth of 100% in the company’s car-sharing market. Success factors for linking private car-sharing initiatives with public transit through mobility management, include: the development of partnerships; the design of smooth interfaces and multimodal interchanges such as new technologies like smart cards and palm tops which can provide a market edge here; and, improvement of the customer’s subjective perception of service (e.g. convenience, comfort, prestige, and choice).

Conrad Wagner co-founded Mobility CarSharing Switzerland in 1987 and managed Strategy and Development for this growing corporation until 1999. He now works developing New Mobility Systems and Car Sharing Services at WestStart-CALSTART in the US.

Another similar business has been set up in Portland, USA. See FlexCar at <http://www.flexcar.com/>

Case Study 24 Transportation User Fee



Objective: To charge households based on their use of transport infrastructure.

Location: Austin, USA

Website: <http://www.ci.austin.tx.us>
<http://stratus.city.toronto.on.ca/inter/mte/mte.nsf/>

Description:

In the City of Austin, an innovative way of financing transportation infrastructure enables those who place a smaller burden on this resource to save money.

On every city utility bill is a charge for the Transportation User Fee (TUF). This figure is derived by calculations made by City Council on the average number of daily motor vehicle trips made per household. This calculation chiefly depends on the size and use of a property. Occupants are then charged according to which category they fit into.

Unlike an across the board property tax which applies equally to everyone, this charge takes into account the utility payer's contribution to the total cost of transportation infrastructure. The city has taken this to the extent of providing a total exemption from paying the fee for those who don't own a car. Residential properties may be exempted from these fees if the user does not own or regularly use a private motor vehicle for transportation, or if the user is 65 years of age or older. This exemption was authorised by Austin City Council in the mid-90s.

The monthly amount charged for the TUF varies depending on whether the ratepayer occupies a house, duplex or apartment, but savings generally are in the range of US\$30 to US\$40 per year.

Innovative financing mechanisms such as this can serve as a model to cities seeking to provide incentives for those who cycle, walk or use public transport to get around, while at the same time providing a way to lessen the financial burden on seniors and those in lower income brackets who are less likely to own a car.

Case Study 25 Shop and Ride Scheme



Objective: To provide shoppers and particularly low-income shoppers with free bus tickets.

Location: Knoxville, USA

Website: <http://www.grass-roots.org/usa/ktrans.shtml>

Description:

Anyone who rides the Knoxville Transit Authority's K-Trans buses at any time may ask the driver for a "Shop & Ride" coupon. The coupon is stamped following a purchase of \$10 or more at any of the region's Kroger, Food City or Cox & Wright groceries or Watson's department stores and is valid for a free bus ride home. The coupon provides up to US\$1.20 off a bus fare which is a significant boost to a low income earning person who has to rely on public transportation and who has to travel outside their inner-city neighbourhood to get away from small, poorly stocked and overpriced local markets to reach the large suburban supermarkets.

Although the transit authority presumes that most people who use the programme have limited incomes, the coupons are available to all, no questions asked, "...even if they make \$100,000 a year..." David White said. Further, no one minds if an individual picks up a coupon and passes it along to a friend. Costs of the programme are minimal. The transit authority prints the blue-and-orange coupons, collects used ones, and turns them over to the store management, which reimburses their full value, which rose to 2,286 bus rides in March 1993.

The grocery chains apparently consider the money well spent to get shoppers into their store, the transit authority gains riders, and the benefits to the people who use the coupons are obvious. "It's a win-win-win situation..." said White.

In theory at least, Shop & Ride has been on the books since before anyone now involved with the programme can recall. It may have originated as a device to get people into the downtown department stores during the early 1970s, when the rise of suburban malls was sucking the life blood out of Knoxville's downtown. But by 1990, only Watson's was participating, and only a few riders per month were taking advantage.

That all changed when several happy coincidences resurrected the programme in its new form, with the focus primarily on groceries. Financially disadvantaged people and local advocates held a demonstration calling for strategies to improve access to food for inner-city residents. In the informal discussions that followed among city officials, advocates, the Knoxville Food Policy Council and the transit authority, Kroger's Regional Manager Hunter McWilliams agreed to get the chain's nine Knoxville stores involved, and the programme took off. During the first full month of participation, just 25 Kroger shoppers got free rides. But within six months, publicised by advertising on buses, in stores and on radio and television, the number of Shop & Ride passengers rose to 1,100; and, a total of 1,640 Kroger shoppers got free rides in March 1993.

Case Study 26 RideShare Trust Fund



Objective: To reward employees who rideshare and penalise solo drivers.

Location: Los Angeles, USA

Website: <http://stratus.city.toronto.on.ca/inter/mte/mte.nsf>

Description:

In 1987 the City of Los Angeles and its employee bargaining units (labour unions) agreed to a unique arrangement regarding commuter benefits and employee parking. The initiative has worked very well, and could be used as a “benchmark” for other employers. In simple terms, it rewards the “good guys” (those who rideshare) and penalises the “bad guys” (solo drivers).

Parking Incentives

Employee parking in the City’s downtown Civic Center is very limited, and is assigned on a space available basis. The number of existing owned and leased spaces can accommodate only about 40% of City staff. Priorities have been established, with seniority being last in the “pecking order”. Carpools and vanpools are guaranteed spaces and park free. Employees driving personal vehicles or “home garaged” vehicles (fleet vehicles assigned to specific persons who have full time use of same) are charged parking fees. Charges vary, depending on proximity to the worksite and whether the space is inside the building or on a surface lot.

Self-Funding programmes

Collected fees are deposited into the Rideshare Trust Fund. Other revenues deposited into the Trust Fund include vanpool fares and a small (and fluctuating) amount from grants. Interest earned from such deposits also remains in the Trust Fund. Unlike typical use-it-or-lose-it budgets, unspent funds in one fiscal year are carried over into the following fiscal year. The Commuter Services Office (CSO) then applies these monies to its entire programme. Thus the initiative is relatively insulated from the effects of year to year tax revenue shortfalls in the General Fund. Trust Fund expenditures are primarily directed toward subsidising vanpool seats and employee purchases of transit passes. They also cover producing carpool matchlists, purchase and installation of bicycle lockers and paying office expenses.

The commuter programme is offered to approximately 38,000 City employees working at over 500 worksites ranging in size from 2-person neighbourhood parks to the 7,000+ employee Downtown Civic Center. Its budget is approximately US\$1.6 million a year - the CSO’s staff salaries, however are paid by the General Fund.

III. ENERGY SAVINGS IN TRANSPORT

A. Energy Use in Transport

The transport sector is the second largest area of energy use in society, accounting for more than 25% of total final energy use as shown in Figure 1.1.

In *Energy after Rio: Prospects and Challenges* (1997) it is stated that “Fossil fuel use for transport has increased dramatically over the past three decades. There has been a 3% annual growth rate in the world vehicle fleet leading in 1996 to some 800 million vehicles on the world’s roads. This growth rate is faster than that of either the world population or economy.”

Modes of transport in cities vary considerably between nations with a large proportion devoted to road transport in industrialised countries and a higher proportion devoted to rail and bus in developing countries.

The transport sector uses predominantly liquid fuels derived from petroleum. This is an imported item in many countries and a major drain on domestic capital. Hence there is a real incentive to replace imported liquid fuel with other options or to minimise the use of transport fuel. The use of liquid fuels for transport often causes serious air pollution in urban areas and this is another reason why efforts are being made to find alternative transport fuels. Some advances have been made in the use of Liquid Petroleum Gas (LPG) and Compressed Natural Gas (CNG) in road transport in recent years and research efforts are under way to use hydrogen as a transport fuel in the future.

While historically many cities of developing countries have been based on cycling and walking modes, in the last few decades car usage has started to grow as countries aspire to copy so-called ‘modern cities’ in the developed world. At the same time in recent years many modern cities are trying to reverse the stranglehold of the car. However, as A. Rahman Paul Barter and Tamim Raad in their publication *Taking Steps* (2000) point out “Many rich cities in Asia and elsewhere have successfully nurtured cycling and public transport. Some of the most modern and economically successful cities in Asia, such as Singapore, Tokyo, Hong Kong and Seoul, have placed public transport planning and development ahead of planning for cars.”

In cities where public transport is a major user of energy there may still be problems with reliance on fossil fuels. The use of electric powered transport in cities is one option for reducing the reliance of cities on imported oil and for saving energy through greater efficiency. However, electricity derived from coal can lead to serious air quality problems. Alternatively biofuels and solar-hydrogen systems may well be the favoured options in the future.

B. Strategies for Energy Savings in Transport

There are three major approaches to energy savings in transport:

- encouraging more people to use public transport
- purchasing more efficient vehicles
- educating people to use their vehicles more efficiently

Reducing automobile travel generates numerous benefits for local governments, and reduces air pollution, greenhouse gas emissions and traffic congestion, while improving economic development, public health and safety, and community livability (for further details see the ICLEI web site).

Local governments have significant powers to influence transportation sector energy use through land use, infrastructure, transit, parking, transportation demand management and other areas which essentially encourage people to use low-energy forms of transport such as walking, cycling and public transport

rather than the use a car. There are new cleaner transportation technologies such as fuel cells and electric vehicles. However, unless linked with solar technologies they do not reduce the overall consumption of fossil fuels.

Considerable savings can be made by using fuel efficient vehicles in cities and by fuel substitution to use cheaper, more efficient alternatives such as natural gas where possible. In all cases, further savings may be made by educating or requiring drivers to drive efficiently and to maintain their vehicles in good condition.

1. Technical Approaches

Technical approaches for saving energy in the transport sector range from fuel-efficient vehicles to the use of communications technologies to avoid the need for transportation altogether. Across the globe some innovative approaches have been developed.



Innovation in Non-Motorised Transportation

Many cities in developing nations have been embracing cars and other motorised forms of transport because they are seen as representing affluence and status. However, a key to sustainability is finding solutions that suit local conditions and sometimes appropriate technologies may not necessarily be the most high tech options.

Case Study 14 looks at the use of a range of different bicycle designs for the transport of freight and goods in Penang and illustrates the innovation that is possible in non-motorised transport technologies. The case study is taken from *Bicycle Reference Manual for Developing Countries* (1991). It explains the great diversity of intermediate freight and goods transport modes as partly a reflection of the lack of emphasis on status in freight transport with cost alone being the deciding factor.



Figure 3.1: Bicycles have long been used for the transportation of small items.

Telework or Telecommuting

Telework (also called telecommuting or teleaccess) is working at home, in a satellite office, or at a telework centre near home one or more days a week - rather than commuting to the main workplace. It involves use of a personal computer and possibly other telecommunication technologies and usually Internet access.

In a paper on *The Socio-Economic Impact of Telework on Developing Countries* (UNDP, 1998) the following examples are given of the types of telework:

- Home-based telework: an employee or contractor works at home instead of travelling to an employer's or a customer's premises
- Mobile telework: executives, professionals or service staff use ICTs (information and communications technologies) to continue their work while travelling
- Work in telecentres: employees work in local office facilities equipped with ICTs to avoid distant commuting to work
- Work in telecottages: provide local communities with access to skills development, high performance ICTs, and the networking and socialisation aspects of work that may be missed by a home-based worker

- Outsourcing: work in some sectors such as information-intensive services and software development can be done anywhere in the world and delivered across national borders, i.e. 'outsourced'

Businesses too can offer their customers services via the internet such as electronic banking and e-commerce, which reduces the need for customers to travel to an outlet of the business.

Teleworking raises many social and economic questions which need to be addressed to ensure that poor people are not further marginalised or labour standards further eroded.

The article also points out that "Teleworking may also help curb rural migration as the cities lose their exclusivity as centres of employment due to the growing opportunities for income-generation locally through remote channels. In addition to the retention of rural population there is a likelihood of migration of previously urban teleworkers to rural areas. This reverse migration is already occurring in Western countries triggering eventual growth of employment in the local services sector."

Additional references and case studies can be found in Section D.

Improving Facilities for Walkers and Cyclists

By adopting measures such as traffic calming, car-free zones, dedicated walking/cycling paths, facilities such as bike racks, showers and lockers, even undercover cycling and walking paths, the walking/cycling experience becomes much safer and more appealing.

Many cities have adopted or are preparing Bicycle Plans to promote cycling through improvements to facilities and also education initiatives. The City of Portland in Oregon, USA adopted a Bicycle Master Plan in 1996 and many of the goals have been realised.

Additional references and case studies can be found in Section D.

Purchase More Efficient Vehicles

Firms and agencies may make considerable savings in purchase costs and operational costs by buying fuel efficient vehicles. There are many modern vehicles that have high fuel efficiency and they often cost less to purchase than the larger less efficient vehicles.

Alternative Fuels

While petroleum is the main fuel used in vehicles, alternative fuels are gaining popularity. Alternative fuels include Liquefied Petroleum Gas (LPG) or Compressed Natural Gas (CNG), biofuels, methanol, ethanol, electric fuel, hydrogen and solar fuel which are cheaper and less polluting than gasoline or diesel fuel. Biofuels and hydrogen and solar fuels have the added benefit of being renewable. For more information on alternative fuels see the websites listed in Section D.

New vehicles may be purchased that are designed to run on alternative fuels or existing vehicles may be converted. The cost of conversion is often justified for taxis, delivery vehicles and buses. See Case Study 15 for An Electric Transit Vehicle programme in Chattanooga, USA.

It was reported in a Reuters article *Asia makes big push into clean, alternative fuels* (2001) that Asian countries are looking for fuel alternatives primarily because crude oil imports are very expensive but also because toxic emissions from vehicles were found to be the leading cause of air pollution in Asia. The article gives examples of the alternative fuels that are being taken up in various Asian countries.

Pakistan and Australia have turned to natural gas, in compressed or liquefied form, because of its relative abundance in those countries.

Resource-poor countries such as Singapore are pursuing fuel-cell technology. A fuel cell is an electrochemical device that combines hydrogen fuel and oxygen from the air to produce electricity, which can power a car.

Other countries such as China, India and Thailand are looking at biofuels. The two most common are ethanol and biodiesel, a diesel-engine fuel that can be made from vegetable oils, animal fat or algae.

In India, CNG is being used for original equipment and in converted buses, taxis, and three-wheelers. A biofuel LPG two-wheeler has been developed by an Indian company, TVS-Suzuki Ltd.

Estimates available in India and from experience worldwide show that an alternative fuels strategy is more cost effective in meeting tighter emission standards than improved conventional fuel technologies. New Delhi-based National Institute of Public Finance and Policy has confirmed in its study that the cost per weighted tonne of emission reduction with particulate trap on diesel vehicles is 60 times higher than the cost of a CNG retrofit.

A US General Accounting Office report on *Alternative Fuels Experiences of Brazil, Canada, and New Zealand in Using Alternative Motor Fuels* (1992) states that “Worldwide, ethanol, LPG (also known as propane), and CNG are the most commonly used alternative fuels. Ethanol and LPG are each currently used in about 4 million vehicles, and CNG in more than 400,000 vehicles.

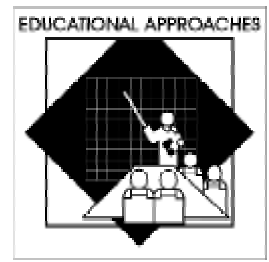
Our study focused on the alternative fuel programmes of Brazil, Canada, and New Zealand - countries that energy experts identified as leaders in encouraging the use of alternative fuels. In Brazil, ethanol is used in vehicles that are built to run only on that fuel. Brazil currently has about 4 million ethanol-powered vehicles, about 30 percent of its total number of vehicles. Also, almost all gasoline-powered vehicles in Brazil use a blend of gasoline and ethanol. In Canada and New Zealand, gasoline-powered vehicles are converted to run on CNG or on propane, and many of these vehicles can continue to use gasoline as well. Currently Canada has a total of 170,000 CNG and propane vehicles, or about 1 percent of its total number of vehicles, while New Zealand has a total of 105,000 CNG and propane vehicles, or about 6 percent of its total number of vehicles.”



Figure 3.2: Biofuels, including biodiesel, ethanol and methanol produced from agricultural sources are able to replace conventional fuel sources in many transport applications

1. Educational Approaches

Educational approaches involve informing people of the impact of using cars and encouraging people to use other modes of transport. Many different and creative approaches have been used to reduce people's dependence on the car and thus their travel costs, including:



Car-Free Days

The first Car-Free Day was organised in Bogotá, Colombia and its success has spawned many similar events around the world. The day provides a focal point for highlighting the impact of car usage and the other options which are available. By making the event entertaining and appealing people are encouraged to become more imaginative about their transportation options. See Case Study 16 Car-Free Day.

Information and Marketing Campaigns

Many cities have adopted campaigns to inform and motivate people to consider alternative transport modes to the private car. Western Australia has started the TravelSmart initiative which is featured in Case Study 17.



Figure 3.3: Car free days encourage the utilisation of non motorised transport, such as walking and cycling, but also public transport options including buses.

Boulder in the US has a GO Boulder campaign to encourage people to use alternative modes of transport using:

- Marketing brochures, pamphlets, posters, maps and lists
- A searchable database of businesses that home deliver
- Ads for events such as No Drive Days which are held monthly

Driver Training

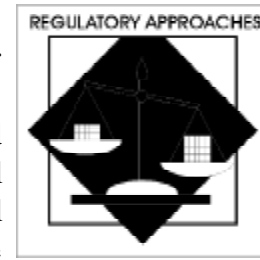
Where the use of cars cannot be avoided, energy and cost savings can be achieved by providing driver training and information like that provided in *Global Warming Cool It!: A home guide to reducing energy costs and greenhouse gases (2000)*, including:

- Information about the fuel efficiency of various motor vehicles to encourage people to purchase efficient vehicles
- Discouraging the use of four wheel drive vehicles in the city as they consume much more fuel than conventional vehicles
- The advantages of using LPG or CNG as a fuel
- Guidelines for sensible driving practices to reduce fuel use and pollution, such as smooth driving, driving at moderate speeds, avoiding short trips (walk or ride instead) and car pooling
- Discouraging the use of car air conditioning as much as possible as it can increase fuel bills by more than 10%

Encouraging car owners to keep their vehicles well-maintained, including keeping tyres at their optimal pressure to reduce rolling friction, in order to achieve much greater fuel efficiency and reduce pollution. Roof racks, sun visors and signs can increase air drag and waste fuel.

3. Planning and Regulatory Approaches

Innovative city planning can eliminate or greatly reduce the need for private car usage. This is obviously easier to do for new developments but retrofitting existing cities is also possible. Alongside planning initiatives some cities have adopted regulations to discourage private car usage. This approach is particularly crucial in large cities with serious air pollution problems. These methods are helpful especially in the short term but they need to work hand in hand with more positive long-term approaches which support transportation alternatives.



Integrated Planning

In many developed nations in the last 50 years, cities have grown based around the car. These sprawling cities are energy intensive and make the use of walking/cycling and public transport modes difficult or virtually impossible. By careful planning, walking/cycling and public transport modes can be made more convenient so that people can live easily without cars or use them much less frequently. This involves creating nodes of medium-high density mixed zoning developments. Curitiba in Brazil is an inspiring example of this and a great model for participatory, environmentally sensitive planning. See Case Study 18 The Planned City.

Integrated Public Transit Systems

Public transit options include light rail, trams, buses, mini-buses, and taxis. Public transit systems are more energy-efficient than private car usage when well-patronised which requires careful planning to ensure that public transport options are easy, safe and convenient to use. Singapore has developed an integrated transit network which provides a very fast and convenient public transport system. This has been achieved by integrating different parts of the system, making timetable information easily accessible and providing a simple ticketing system. See Case Study 19 Integrated Public Transport Systems.

Growing Food in the City

Cities are notorious for sucking in huge amounts of resources from beyond their boundaries. This involves lots of energy in transportation. By growing food in the city and even other materials such as timber, transportation needs are reduced and there are added benefits of cities being more self-sufficient and people maintaining contact with basic life-supporting systems. This approach requires planning and regulatory support.

Some 800 million people are engaged in urban agriculture worldwide, with the majority in Asian cities, according to United Nations Development Programme (2000) estimates. In the International Food Policy Research Institute report *Achieving Urban Food and Nutrition Security in the Developing World* it is quoted that “Urban agriculture provides an estimated 15 percent of all food consumed in urban areas and is likely to double that share in the next couple of decades. Cities with more advanced urban agriculture sectors, particularly in Asia, have become largely self-sufficient in higher-valued, nutritious perishables”. See Case Study 20 Urban Agriculture.

Quotas

Quotas can be used to limit the number of cars on the road and can be a fairer system than simply using pricing mechanisms. In Singapore a quota system has been introduced to control the growth of new cars on the road. See Case Study 21 Vehicle Quotas.

Employer Trip Reduction Schemes

Portland, US has introduced an ECO Rule which requires employers to adopt measures to reduce their employees' car usage. This may involve shorter working weeks, encouraging car pooling, incentives for the use of public transport, work from home options, flexible working hours, provision of better facilities for cyclists and workplace competitions and fitness programmes. See Case Study 22 Employee Commute Options Rule.

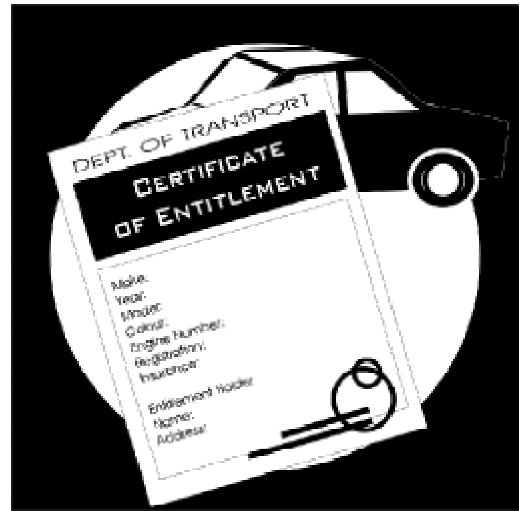


Figure 3.4: Quota systems can be very effective in limiting car ownership and use.

Parking

By regulating the number of parking spaces available and their usage, car usage can be discouraged especially for trips that could be serviced adequately by public transport.

Speed Limits

Speed limits should be enforced on urban streets for reasons of road safety and fuel efficiency. Fines can help to enforce this measure and they also generate funding for other road safety measures.

Vehicle Inspections

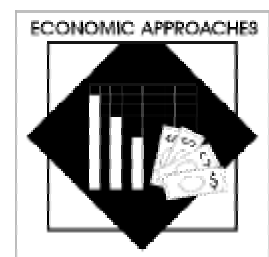
Compulsory annual vehicle inspections are used in many countries as road safety and efficiency measures. Well maintained vehicles use less fuel and are safer to drive. These programmes are self funding through inspection fees.

Alternative Fuel Regulations

Some State or local governments have introduced regulations to support the use of alternative fuels such as requiring their vehicle fleets to use alternative fuels.

4. Economic Approaches

Economic approaches encourage people to use alternative modes of transport by providing monetary incentives and disincentives for the use of the private car.



Car-Sharing

In many European cities car-sharing businesses have been established to enable residents in car-free communities to use neighbourhood car hire schemes instead of owning their own car. This initiative is gaining popularity in other countries around the world. See Case Study 23 Car Sharing.

Transportation Fee

Cars require significant amounts of infrastructure in the form of roads and parking. Often these costs are subsidised by the government. One way to encourage people to use their cars less or not at all is to adopt a user pays system where people who use this infrastructure more are charged more and so are aware of the true cost of car usage. See Case Study 24 Transportation User Fee.

Shop and Ride

A good example of corporate involvement is a novel scheme in the US which has been adopted by supermarkets whereby they offer their customers free public transport passes. See Case Study 25.

Parking Fees

Fee structures that encourage car pooling and use of parking only for short trips which may be hard to do by public transport, can act as powerful disincentives for single occupancy car use. See Case Study 26 on the Los Angeles Rideshare Trust Fund.

Fuel Levies

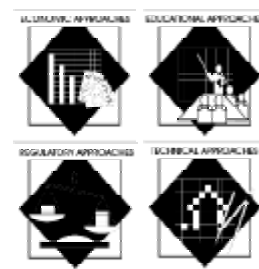
Many countries impose levies or taxes on fuel sales to finance road construction or road safety programmes. Such levies can also be applied selectively to influence consumer choice against leaded fuel or fuels that cause excessive pollution.



Figure 3.5: Case Study 12 details a successful Shop and Ride Scheme operating in the USA.

5. Integrated Strategies

Many developing cities are already experiencing serious air pollution problems from increased motorised transport use and this has prompted cities like Surabaya in Indonesia to embark on innovative integrated transportation programs to address these issues.

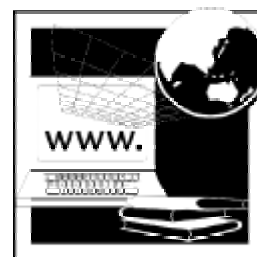


The Surabaya City Planning Board presented a paper titled *Efforts Toward Sustainable Urban Transport and Clean Air in Surabaya: An Integrated Approach*. The strategies that have been proposed or already undertaken cover improvements to public transport, measures to support non-motorised transport, technical measures, economic measures and reforms and education and public participation initiatives. This integrated approach is outlined in Surabaya's Strategic Plan which was developed through a long series of participatory meetings and incorporated input from a wide range of interested parties.

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Telework

Oregon Office of Energy. <http://www.energy.state.or.us/telework/telegas.htm>

You Can Work Anywhere <http://www.youcanworkfromanywhere.com/infocenter/casestudy.htm>

Washington State University Energy Programme Transportation and Telework Services

<http://www.energy.wsu.edu/index/telework.cfm>.

Facilities for Non Motorised Transport

Institute for Transportation and Development Policy. http://www.itdp.org/programs/programs_3.html.

Alternative Fuels

US Alternative Fuels Data Center <http://www.afdc.nrel.gov/>

Alternative-fuel Vehicle Directory <http://www.vwc.edu/~gnoe/avd.htm>

Clean Vehicles <http://www.clean-vehicles.com/>

Alternative Fuels for Fleet Vehicles, May 1999 US Report with numerous links

<http://www.pprc.org/pprc/pubs/topics/altfuels.html/#general>

Urban Agriculture

Feeding the City from the Back Forty: Case Studies in Regional and Urban Food Production.

<http://www.greenestcity.org/rap/>

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Sustainable Transportation

The City of Toronto

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Case Study 27 Energy Savings from Preventative Maintenance of Small to Medium Sized Ducted Air Conditioning Units



Objective: To reduce the energy consumption of ducted air conditioners through preventive maintenance

Location: Los Angeles, USA

Website: <http://www.caddet-ee.org/infostore/details.php?id=1197>

Description:

Preventative maintenance of air-conditioning units is known to restore performance capacity, improve comfort and perhaps lower utility costs. The Orleans Parish Extension Energy Advisory Committee conducted a series of result demonstrations in five small businesses. The aim was to determine the:

- servicing potential for restoration of capacity to the air-conditioning system
- servicing potential for lowering utility costs through preventative maintenance, and
- to estimate the need for air conditioner system servicing in the small business community.

The audit and analysis revealed that units with preseason services resulted in average monthly savings of US\$36.59 and a payback period of approximately two months. As with most systems, an additional benefit of extended operating life for the equipment is expected and hence, greater savings in the longer term.

Case Study 28 Re-evaluating Energy Efficient Buildings for Continuous Savings



Objective: To reduce the energy consumption in an existing energy efficient building

Location: Manila, Philippines

Website: http://www.iaeel.org/IAEEL/NEWSL/2000/Etttva2000/Case_1-2_00.html

Description:

The Asian Development Bank (ADB) headquarters building in Manila, the Philippines, is living proof of the potential for substantial energy savings in commercial buildings. When the building was designed in the 1980s, it received an energy-efficiency design award from the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE). However, despite the fact that the building was fairly modern, actions taken over the past six years reduced its energy use by nearly 40% and generated an internal rate of return of more than 25%.

In 1993, the electricity bill of the ADB headquarter building exceeded US \$2 million per year, and the monthly bill averaged around \$180 000. The two largest components of the bill were lighting (35%) and cooling (50-60%). Some of the other major end uses of electricity - all of which consumed less than 5% each - were computers, the restaurant, refrigeration, elevators and transformer losses.

Beginning in 1993, ADB began efforts to improve the use of energy in its headquarters. As part of this effort, the Building Maintenance Section undertook housekeeping measures and several projects to optimize the existing equipment. These efforts resulted in an 11% reduction in the building's energy consumption.

In 1994, ADB commissioned a detailed energy audit by the International Institute for Energy Conservation (IIEC) and Supersymmetry (of Singapore) to evaluate the potential savings of an additional set of more aggressive energy-saving measures. The measures considered in the study ranged from no-cost and low-cost measures to more significant retrofit investments.

Based on discussions with ADB staff, it was assumed that the Bank would only consider energy-saving opportunities with a return-on-investment (ROI) of greater than 12%. The measures analyzed in the study had ROIs ranging from 19% to 137%.

ADB budgeted \$3.5 million for the retrofit project. As of December 1999, committed expenditures were approximately \$3.3 million. The overall savings generated to date through the completed project components is more than 30000000kWh, or \$3.43 million in reduced electricity costs until December 1999.

Case Study 29 PowerSaver Energy Saving Device for Computers



Objective: To reduce energy consumption from computers without compromising availability or performance

Location: Canada

Website: <http://www.caddet-ee.org/infostore/details.php?id=2627>

Description:

This Case Study provides an alternate option to that presented later in Case Study 31 and examines the effect of installing a small, mouse sized hardware controller for powering down unused computer monitors. The PowerSaver device is connected in series with a monitor's power cord and consists of a small sensor attached to the keyboard to determine user activity. One major advantage of the device is it does not require connection to a computer's input devices (mouse and keyboard) and hence does not interact with the processing unit, hard disks, modem or network connections.

The organization spent approximately US\$8000 on installing 307 devices which resulted in an energy saving of approximately US\$13 000 in the first year, representing a return on investment of 168%.

Case Study 30 Awareness Raising and Motivation



Objective: To promote staff awareness of energy management issues

Location: United Kingdom

Website: <http://www.caddet-ee.org/infostore/details.php?id=2445>

Description:

The Sears Group plc is major group of companies with more than 2,000 retail outlets and employs over 40,000 staff. Each retail company within the Sears Group has full responsibility for its own financial performance, and each store manager is responsible for day-to-day operation and profitability. Historically, some of the retail companies undertook energy management initiatives, but many of those failed to achieve their full potential. Sears therefore decided to establish a full-time central energy team to provide an in-house service to all the group's retail companies.

In July 1994 a group energy manager was appointed who created a full-time energy team comprising an energy secretary, responsible for the processing of fuel and water data, an energy analyst, responsible for regular energy monitoring, the production of high-consumption reports, and tariff analysis, and an energy engineer, responsible for providing on-site technical support and assistance to individual store managers.

The team identified two main issues to address as part of a phased energy management strategy. These issues comprised the specification and adoption of standards for new and refurbished stores and the need for store manager training. These two initiatives were delivered as part of a broader energy and environmental campaign. The programme stressed the link between energy consumption and environmental benefits and was designed to be delivered in three phases. Advance flyers addressing a range of environmental issues were sent to all stores and were followed by an information pack containing posters, 'switch off' and other stickers, and a staff suggestion pad. Lastly, follow-up bulletins were distributed to provide feedback on the programme's success stories and maintain staff interest. The central team followed up poorly performing stores identified by its monitoring procedures, and provided a swift response to enquiries from the campaign publicity. The group energy manager used the interest created by the campaign to drive forward a ten point plan for the incorporation of energy-efficient technologies into new and refurbished store designs. Commitment was obtained from all the retail companies in the Group to adopt them as part of their design and refurbishment policies.

A few months after the launch of the program, a large colour poster illustrating success stories and including the photographs and telephone numbers of energy team members was sent to each store. The programme resulted in savings of approximately 7% across all stores, with maximum savings of up to 20% in some retail outlets. The payback period for the establishment of the energy team was two and a half months and resulted in average financial savings of £600 000. The cost of the program is £120 000.

Case Study 31 Computer Users Energy Management Behaviour



Objective: To reduce energy consumption from computers without compromising availability or performance

Location: Sweden

Website: <http://www.caddet-ee.org/infostore/details.php?id=1489>

Description:

Most computers and monitors today are EnergyStar compliant, meaning that they have reduced power modes which can be automatically initiated when computers are not in use.

Although most computer operating systems now include power saving features in the display settings, many of these features are not activated at the time of installation.

This Case Study examines the behaviour of staff who were asked to switch off computer equipment when not in use, without interfering with normal operations. A memo was sent out to staff after identifying that 40% of computer equipment was left on after hours and on weekends. Following the issue of the memo, non-productive equipment energy use dropped to 20% and resulted in energy savings equivalent to approximately US\$23 000.

Case Study 32 Funding Options for High Efficiency Lighting Programmes for Public Buildings



Objective: To improve the energy efficiency of lighting systems in public buildings

Location: New York, USA

Website: <http://www.caddet-ee.org/infostore/details.php?id=1738>

Description:

The New York Power Authority implemented a scheme of economic measures to promote the installation of energy efficient lighting systems in public buildings in New York State. Under the scheme, the New York Power Authority conducted an energy audit to determine lighting needs and fund the cost of the new more efficient lighting. Schemes like these are ideal for governments and government agencies that are able to provide attractive financing options to other government agencies.

The cost of the lighting installation is partly recovered through a surcharge on the monthly energy bill, with the total cost to the public building being only 53% of the value of the lighting installation. The scheme has resulted in annual savings in excess of US \$5.6M for the participants at an installed cost of US\$1650 / kW or approximately US\$ 0.03 / kWh with a payback period of 4.3 years.

**Case Study 33 Energy Savings from Equipment Replacements:
Water Chilled Air Conditioning Systems**



Objective: To reduce energy consumption due to HVAC through the replacement of split system cooling with water chilled central cooling

Location: Thailand

Website: <http://www.egat.or.th/dsm/GreenBuilding/casestudies/case.html>

Description:

The program was rolled out on 17 June 1998 as a joint initiative between the Port Authority of Thailand (PAT) and EGAT. The goals were:

1. To install air-conditioning systems with a 1,050 ton cooling capacity at the new head office of the Port Authority of Thailand. The investment cost was 56 million baht.

2. Redesign to use energy efficient water chiller instead of spilt type air-conditioners, which can yield a reduction of energy use from 1,470 kW to 871.5 kW, or a saving of 2.72 million baht per year.

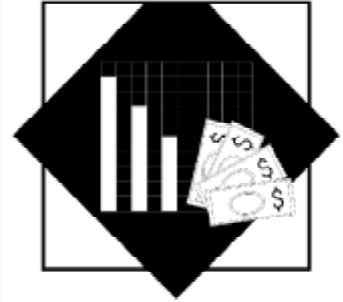
Designed by Plan Engineering Co., Ltd. the project was putted out to tender, and it was won by Siam Inter Air Supply Co., Ltd. Under close supervision of EGAT's Design and Construction Division, the project started on 28 September 1999 and was completed on 10 July 2001.

With upfront investment from the Electricity Generating Authority of Thailand (EGAT), the Port Authority of Thailand was able to install new air conditioning, which resulted in easier maintenance, longer service life and significant annual energy savings (598.5 kW), resulting in a US\$61 500 cost saving. However, the initial investment of US \$1.3 million dollars in this system, , results in a payback period longer than the life span of the new system.

Case Study 34 Motion Sensors Save 80% of Energy Costs



ECONOMIC APPROACHES



Objective: To reduce energy consumption through the use of motion sensors

Location: Sweden

Website: <http://www.caddet-ee.org/infostore/details.php?id=2808>

Description:

At the Swedish housing company Svenska Bostäder a cost of 22 million SEK (ca 2,5 million USD) was detected as a result of permanent - and, as it occurred, temporarily unnecessary - illumination in public areas like stairs and garages. Tests were made in an 11-storey building at Nybohovsbacken 65 in Liljeholmen just outside central Stockholm. The result was a fundamentally new system for illumination of public areas, based upon two different sources of light. This resulted in the development of "intelligent" luminaries that directs the level of light in relation to the physical presence of humans in the current area by means of thermal effect (IR) and motion, in combination. The PIR-system (passive infrared detection) turned out to save 80 - 90% of the electricity required for a conventional lighting system.

Especially in stairways there occurred to be a demand for a weak, basic illumination permanently being turned on. The installation of a dim, permanent light neutralises such negative experiences during the interval before the comfort light has reached its optimal level. When the installation was performed an energy analysis where made. The result of the measuring indicated a consumption of 58 kWh/year and flat, viz a decrease from 269 SEK to 48 SEK (from approx. 31 USD to 5,5 USD). The energy use in the stairways had diminished with some 84 percent, and this alteration had not affected the tenants in any way at all.

A hidden unit for detection registers movement and heat and sends a signal on to the luminaries. There are no circuits for controls or switches, which means that the installation becomes very flexible, simple and inexpensive. A PIR-luminaire located to the ceiling has an effective working area of about 6 m in diameter in a room of normal height (2,5 m) and has a detection area of 360 degrees. One single sensor can direct other luminaries up to 400 VA. The directing PIR-armature is equipped with a 11 W compact lighting tube or a 15 - 48 W standard tube.

The economic gain of these energy savings are estimated to be about 400,000 SEK/year (45,000 USD). The annual cost per flat decreased from 30 USD to 4,5 USD. The payback time is less than a year compared with installation of a conventional lighting system. The total potential of savings inside the concern Svenska Bostäder are in the magnitude of 4,5 million SEK/year (500,000 USD) by change of all luminaries located to the stairways.

IV. ENERGY SAVINGS IN COMMERCE

A. Energy Use in Commerce

The commercial sector uses less than 20% of the total final energy produced by society (see Figure 1.1). This is comprised of almost equal quantities of coal, gas, oil and electricity.

The primary uses of energy in commerce are:

- heating and cooling of buildings
- running appliances, particularly office machinery
- hot water
- lighting

Some of these uses resemble those in the domestic sector but the scale is often different and strategies need to account for the differences between home and work environments. Although the commercial sector is a relatively small user of total final energy it has been a leader in energy efficiency. Savings can often be made through changes to work practices or in conjunction with building renovations. Such changes can be cost effective in the short term. This is therefore a very attractive area for energy savings and one in which local government has a major role.

B. Strategies for Energy Savings in Commerce

For many businesses, environmental concerns such as global warming and air pollution are secondary to the financial benefits derived from reducing energy consumption. Substantial savings for both owners and occupiers of commercial buildings can be made through the introduction of energy management programmes involving some of the measures and approaches outlined in this Chapter.

1. Technical Approaches

There are a range of measures available to firms to reduce their energy consumption. Most of these have been discussed as they apply to the domestic sector in Chapter 2. The commercial sector is more diverse than the domestic sector and it is generally advisable to carry out an energy audit first to determine the major areas of energy use in the company and the opportunities for savings. This is discussed in Section C.

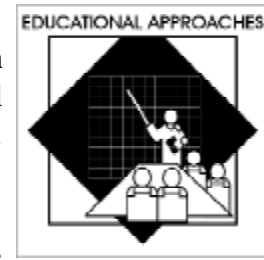


The technical options available to the commercial sector relate to the primary areas of use which are:

- climate sensitive building design
- retrofitting existing buildings with insulation, shading, day lighting (see Case Study 27 Energy Savings from Preventative Maintenance of small to medium sized ducted style air conditioner units)
- purchase of efficient lighting systems
- appropriate sizing and design of heavy use appliances such as air conditioners and water heating equipment (Case Study 28 Re-evaluating Energy Efficient Buildings for Continuous Savings)
- purchase of energy efficient office equipment (see Case Study 29 PowerSaver Energy Saving Device for Computers)
- the utilisation of energy management control systems

2. Educational Approaches

The largest potential for energy savings in commercial buildings is contained with its occupants. Technical solutions are usually only successful in producing financial savings where building occupants are an integral part of the energy management strategy.



For example, a building occupant who leaves the lights on all the time, regardless of whether the room is occupied, can quickly offset savings made through the installation of lower wattage lighting. In this situation, only awareness raising and behavioural change amongst the occupants will result in energy savings.

Essential to the success of any programme is the support of both management and employees. Management support can usually be obtained for the project champion, by highlighting the potential for cost savings to be made through the use of case studies or simple cost benefit analysis on one area, such as lighting. Employee support can be harder to obtain, particularly in businesses where staff are already overworked, or where there is no sense of ownership or responsibility for the energy conservation measures.

Two options for engaging employees or building occupants are available:

- staff training and incentives that encourage staff to be energy efficient through focussed conservation measures, such as 'switch off when you leave' stickers on light switches, and
- development of energy management teams with representation from all levels of the organisation and departments.

Whilst they are independent options, the greatest energy savings will arise from a combination of both methods.

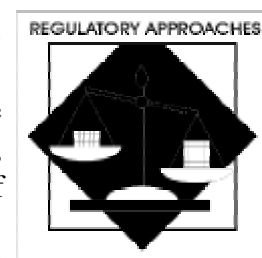
An awareness-raising exercise should be implemented at the start of the energy management programme to promote the project and keep building occupants informed about the project and potential benefits of the activities. This can help avoid negative attitudes about the project and highlight the benefits of improved lighting, heating or cooling as well as provide an avenue for feedback between the project team and building occupants.

See Case Study 30 Awareness Raising and Motivation and 31 Computer Users Energy Management Behaviour.

3. Regulatory Approaches

There are several regulatory measures that can produce energy savings in the commercial sector. These include:

- compulsory or voluntary appliance labelling. This assists purchasers exercise their right to choose energy efficient appliances. Some office equipment, especially PCs, printers and window air conditioners are heavy users of energy
- minimum energy performance standards. Some countries have introduced regulations requiring office equipment to meet minimum standards of energy efficiency
- building codes can be used to ensure that new buildings meet minimum standards for passive solar design in order to reduce energy use



See the Environmental Energy Technologies Division of the Lawrence Berkeley National Laboratory on <http://eetd.lbl.gov/EA/ecsw/ecsw.html>, for examples of regulatory measures in energy management.

4. Economic Approaches

Economic approaches are similar to those offered to industry and the domestic sector and they include

- time of use tariffs
- subsidies for substitute fuels
- subsidies for use of renewable energy
- tax relief for investment in energy efficiency equipment
- levies on energy use (see Case Study 32 Funding Options for High Efficiency Lighting Programme for Public Buildings)



C. Energy Audits for Buildings

Reduced consumption of energy and hence reduced operating costs for businesses can be achieved through an analysis and review of the areas of energy consumption, selection of appropriate appliances and education of building owners and occupiers.

Various definitions of energy auditing and the energy audit process exist. However, it is principally involved with the evaluation of an energy system to determine the energy use of that system (i.e. a building) and potential areas for energy savings to be made. For simplicity, consider the approach suggested by the Center for the Analysis and Dissemination of Demonstrated Energy Technologies (Aronsson & Nilsson, 1996), which identifies three levels of energy auditing.

Whilst it is often advantageous to engage a consultant who specialises in energy auditing in commercial buildings, initial energy conservation programmes can be undertaken, including level one and two auditing, without the need for a specialist. The advantage of this is that a relatively small investment can be made in a feasibility study to determine the commitment to energy management from the building owner and occupants, before engaging a consultant.

1. Level One Energy Auditing

Level one audits usually produce the lowest cost measures and typically result in only small energy savings. They are usually based on a combination of a screening survey (walk through audit) and historical energy use data from energy bills for the preceding year or more.

The purpose of this level of audit is to:

- determine the energy consumption of a building, and the cost of this consumption, and
- identify major consumers of energy and obvious or priority areas for energy conservation measures.

Source	Date of Bill	Units Consumed	Total Cost of Bill	Number of Days	Cost per Day	Tariff
Electricity						
Gas						
Oil						

Table 4.1: Summaries of energy use can easily be generated in spreadsheet programmes for analysis.

Energy Use Analysis

A historical analysis of energy consumption is important as it can be used to identify the daily consumption pattern, where time of use tariffs exist, as well as seasonal fluctuations in energy use.

This simple analysis can help to identify low cost solutions such as changing electricity tariffs, which can result in cost savings from little or no investment in energy saving initiatives.

When commencing a level one audit, you will require energy consumption and cost details for the organisation or location under analysis for at least one year, but two or more years is preferable. This information is usually contained in the bills from your energy (electricity and gas) supplier. When determining your total energy consumption, you will need to consider the electricity, gas, oil, coal or coke consumption as well as the physical amount of each unit consumed, if this is not specified on your bill.

For example, electricity is usually sold in units, and each unit is the equivalent of one kilowatt hour (kWh). Gas is usually purchased in units, where one unit is equal to one Mega Joule (MJ). This information can assist you to identify each of the energy sources utilised in your building or organisation as well as the quantities of each used. Where billing is more frequent than yearly (i.e. bi-monthly), seasonal and annual trends in energy consumption can be identified.

The bill should also contain information on the tariff or tariffs at which the energy was consumed. You should also obtain, prior to the audit, details of other tariff structures applicable to your organisation for your existing energy retailer as well as any other energy retailer providing energy services in your area.

Historical energy use data will also be used when evaluating the effectiveness of energy conservation initiatives once measures have been introduced. In organisations or buildings where energy consumption is sub metered and charged to the appropriate department or company level, an evaluation should be undertaken at both levels.

Collating Information for Analysis

Once the energy bills have been located and tariff information obtained, it is advisable to store the information in a spreadsheet programme, such as Microsoft Excel, Quattro Pro, or Lotus 1,2,3. Alternatively, information can be recorded in a table, either electronically or hard copy. When you have at least twelve months worth of data, analysis can commence.

Evaluating Tariff Structure

The first stage of the energy audit should examine whether the current tariff structure for your energy supplier(s) is the most appropriate, given your energy use, and whether there are alternative energy suppliers who could service your company at a lower cost. This is a relatively easy process, especially when you have collated the historical use information electronically. The evaluation can also be undertaken manually, and the results recorded in hard copy.

Simple or Flat Tariffs

Where your energy supply is not based on time or season of use, the following example is used: In this case, the existing supplier is the cheapest option.

Provider	Energy Consumption / Month	Tariff / kWh	Cost
Existing	1000 kWh	US \$0.25	US \$250
Option 1	1000 kWh	US \$0.20	US \$300
Option 2	1000 kWh	US \$0.27	US \$270

Example 1: Simple or flat tariff

Time of Use Tariff

Where energy consumption is based on the time or season (and occasionally both) a similar model can be used to evaluate the options.

Provider	Energy Consumption @ Tariff 1	Tariff / kWh	Cost	Energy Consumption @ Tariff 2	Tariff / kWh	Cost	Total Cost
Existing	750 kWh	\$0.32	\$240	250 kWh	\$0.18	\$45	\$285
Option 1	750 kWh	\$0.30	\$225	250 kWh	\$0.21	\$53	\$278
Option 2	1000 kWh	\$0.26	\$260				\$260

Example 2: Time of use tariff

In this second example, both alternate providers are cheaper than the existing energy supplier. However, the provider who has only one tariff applicable to your organisation, offers the best potential for savings.

Mixed Tariff Options

Where your current provider has a flat tariff and alternate energy suppliers have time of use tariffs the analysis is more complex, and requires an estimation of the consumption during each of the tariff periods. The easiest way to determine this information is to read the meter or sub meter at the start and finish of the tariff periods for at least one month. Once you have obtained this information, example two above can be applied.

Seasonal Analysis

In regions where distinct climatic changes occur between summer and winter or the wet and dry seasons, the energy consumption profile between seasons can assist in estimating the heating and cooling component of consumption. At the simplest level, the seasonal analysis can identify fuel substitution, for example, where gas, wood or kerosene heating is used during cool seasons.

Specialist energy management consultants can also use the results of seasonal analysis in combination with temperature information in simulation software to predict the ideal mix of energy sources.

2. Level Two Energy Audits

At this level, in-house energy champions are still able to undertake many aspects of energy auditing and develop strategies, which result in energy savings for the organisation. Level two audits usually consist of a detailed examination of major energy consumers, in terms of departments or building floors as well as energy systems, through the use of screening surveys.

Screening Surveys

Preliminary, or walk through evaluations of a building can be used to produce an initial list of large consuming items as well as areas of energy wastage. During the visual investigation of the site, the energy champion or auditor should look for those areas with the greatest opportunity for savings, which are usually (but not exclusively) those with the largest energy consumption. These are typically:

- space heating and cooling
- office equipment and appliances, and
- lighting.

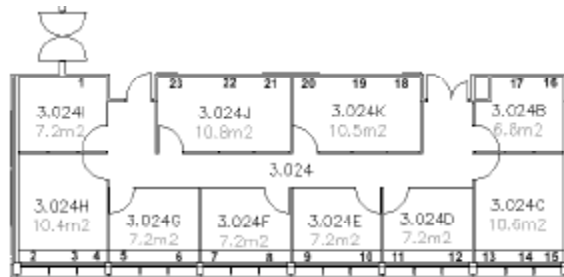


Figure 4.1: Floorplans can assist in the energy audit by providing a convenient reference to the building

When preparing for the screening survey, you will need to obtain an up-to-date floor plan for each floor of the building under investigation, which includes the locations of power and gas outlets as well as static energy appliances, such as water heating appliances, including hot water systems and urns. To commence your survey, locate the appropriate floor plan and begin walking through the floor, locating and identifying energy consuming items as shown in the example below. If possible you should also determine occupancy rates (ie used rarely or daily).

Appliances and Office Equipment

During your survey, you should identify the locations of power and gas outlets as this can provide information about the appliances and office equipment utilised in the building. Although the survey can be completed at any time of the day, an after hours survey will often provide the opportunity to uncover the greatest potential for savings in this area as a result of equipment left on after the user has gone home.

Number Description

- 1 Double power outlet: Double adapter: computer, printer, radio on second plug
- 2 Double power outlet: Computer and printer
- 3 Double power outlet: Computer and printer
- 4 Single power outlet: Reverse Cycle (R/C) Air conditioner (off, fitted with timer switch)
- 5 Single power outlet: R/C Air conditioner (off)
- 6 Double power outlet: Computer and cooling fan
- 7 Double power outlet: Computer and printer
- 8 Single power outlet: R/C Air conditioner (off)
- 9 Single power outlet: R/C Air conditioner (off)
- 10 Double power outlet: 2 Computers and 1 printer
- 11 Double power outlet: Computer and printer
- 12 Single power outlet: R/C Air conditioner (off)
- 13 Double power outlet: No appliances
- 14 Double power outlet: Computer and printer
- 15 Single power outlet: R/C Air conditioner (off)
- 16 Double power outlet: Computer and internet hub
- 17 Double power outlet: Computer and printer
- 18 Double power outlet: Cooling fan (off)
- 19 Double power outlet: Heater (off, fitted with delay switch)
- 20 Double power outlet: No appliances
- 21 Double power outlet: Computer and printer
- 22 Double power outlet: Computer and printer
- 23 Double power outlet: Computer and printer

Occupancy: each room is occupied by at least one person, who utilises the space from Monday to Friday during business hours.

From this example, it can be seen that almost every computer has a printer attached to it. Immediately, it should be obvious that one possible energy saving measure from the screening survey of this section of the building would be to install a shared printer. A simple calculation of the savings associated with energy consumption for this initiative would result in at least a 50W saving, or approximately 1.2kWh per day, where printers are left on all day.

10 Inkjet style printers (consumption of ~20W each) = 200W

1 Workgroup laser printer (consumption ~150W) = 150W

Saving = 200 - 150 W
= 50W

~~Consumption per day~~ = $\frac{\text{saving} \times 24 \text{ hrs}}{1000}$
= 1.2kWh

This represents a situation where only inkjet printers are utilised. In the above example, four of the printers were laser, thus increasing the potential for cost savings.

In most office environments, appliances are not utilised from about 7pm to 7am. Switching off computers, printers and other non-essential appliances and equipment can result in significant savings for the organisation. In the example above, switching each computer off when the user leaves for the day can represent an energy saving of around 2 kWh per machine per day. Whilst this does not sound like a significant amount, it can represent a considerable saving in organisations where there are large numbers of computers.

Where it is not practical, or possible to switch off computers, monitors should be switched off, as these represent the largest component of the energy consumed.

Although a voluntary programme, the energy efficient labelling system, known as EnergyStar, for computer equipment, introduced in 1992 has been widely accepted and now encompasses a variety of electronic equipment for both the home and small business. The EnergyStar website provides detailed information on the energy performance of common appliances and office equipment as well as a variety of tools for businesses and governments. Where possible, the purchase of energy efficient appliances that use less power for the same function should be encouraged. Higher initial costs for the capital purchase can usually be repaid in short time frames (compared with product life) and can represent considerable cost savings in the future.



Figure 4.3: Energy Star labelling scheme

Case studies 30 Computer Users Energy Management Behaviour and 31 PowerSaver Energy Saving Device for Computers provide details of energy management options for reducing energy consumption from personal computers.

Lighting

During the screening survey, you should also identify the lighting in the area under review, as savings can also be made in this area through the replacement of inefficient lighting and removal of unused fittings.

In this example, some cost savings have been implemented through the use of fluorescent lighting and the removal of the third fluorescent tube in most fittings. Lights numbered 2, 15 and 10 are on a separate switch and are usually switched off as sufficient lighting is provided in the corridor and the addition of a third tube in fitting 3 has provided enough light for the second occupant of the corner room.

Number	Description
1	Fluorescent 3 tube: Only 2 tubes fitted inner and outer.
2	Fluorescent 3 tube: Only 2 tubes fitted inner and outer.
3	Fluorescent 3 tube: All 3 tubes fitted.
4	Fluorescent 3 tube: Only 2 tubes fitted inner and outer.
5	Fluorescent 3 tube: Only 2 tubes fitted inner and outer.
6	Fluorescent 3 tube: Only 2 tubes fitted inner and outer.
7	Fluorescent 3 tube: Only 2 tubes fitted inner and outer.
8	Fluorescent 3 tube: Only 2 tubes fitted inner and outer.
9	Fluorescent 3 tube: Only 2 tubes fitted inner and outer.
10	Fluorescent 3 tube: Only 2 tubes fitted inner and outer.
11	Fluorescent 3 tube: Only 2 tubes fitted inner and outer.
12	Fluorescent 3 tube: Only 2 tubes fitted inner and outer.
13	Fluorescent 3 tube: Only 2 tubes fitted inner and outer.
14	Fluorescent 3 tube: Only 2 tubes fitted inner and outer.
15	Fluorescent 3 tube: Only 2 tubes fitted inner and outer.

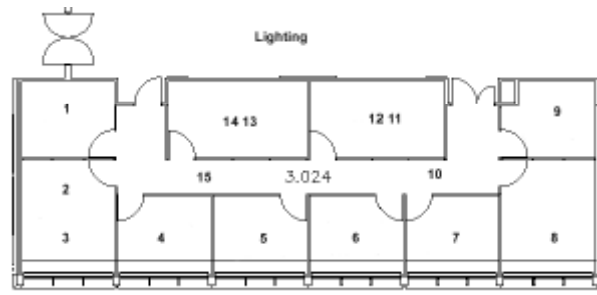


Figure 4.2: Floor plan of office area under audit

All fixtures are fitted hanging 50cm down from the ceiling

This example is similar to many commercial buildings, where incandescent lighting has been replaced by fluorescent lighting. In buildings where incandescent or filament type lighting still exists, consideration should be given to the installation of either compact fluorescent bulbs which can be fitted in existing sockets, or tube type fluorescent lighting. For example, for a given brightness of incandescent light, the compact fluorescent equivalent will typically use only 20% of the energy of the incandescent globe and will last approximately five to seven times longer.

Consideration should also be given to the fittings in fluorescent lights, especially the tube type as many are fitted with conventional electromagnetic ballasts. Replacement of this type of ballast with electronic ballast can represent a saving of 12 W per fitting (where only two lamps are fitted).

See Case Studies 32 and 33 on the New York Power Authority and the Asian Development Bank.

Space Heating and Cooling

In commercial buildings, the heating, ventilation and air conditioning (HVAC) systems will form the largest single component of energy consumption. HVAC systems can usually be characterised as:

- Air-conditioned: where air is distributed and exhausted either through a central ducted system, or a number of smaller, room sized conditioners. These systems can be refrigerative, absorptive or desiccant cooling, or reverse cycle systems where the unit can heat and cool the air.
- Mechanically ventilated: where air is exhausted through the use of fans.
- Naturally ventilated: where air is removed and supplied through the use of exhaust ducts (but not fans, except in toilets and food preparation areas), windows and doors.

Alternatives to Refrigerative Air Conditioning

When installing new cooling systems, careful consideration should be given to the selection of appliances, which are both suitable, and energy efficient as these will result in the greatest cost savings.

Refrigerative air conditioners are not suitable for use in all climates, and more appropriate alternatives include absorption, evaporative and desiccant cooling systems.

Absorption Cooling Systems

Very common in large commercial HVAC systems, absorption-cooling systems, in their simplest form, use chilled water, ice or other heat absorbent substance to remove heat from the circulated air.



Evaporative Cooling Systems

In hot dry climates, evaporative cooling systems, or Swamp coolers, can replace refrigerative systems, with energy savings of about 75%. In these systems, the evaporation of water into the hot dry air results in a cooling effect. Developments in evaporative technologies have resulted in both direct systems (where the humidity of the circulated air increases) and indirect systems (where the air remains dry).

Desiccant Cooling Systems

Ideal for humid climates, desiccant-cooling systems operate in three stages, they initially decrease the humidity of the air by passing it through a desiccant wheel which heats and dries the air. The dry air is then cooled by heat exchangers, where waste heat is exhausted. In the final stage, the air passes through an evaporative cooler prior to circulation.

HVAC in Large Buildings

In large commercial buildings, a central HVAC system will have been installed at the time of construction and is usually costly to replace with an energy efficient system, unless replacement is warranted. However, energy savings are still possible in these systems.

Savings from the operation of a HVAC system are most likely to occur by promoting the use of off peak power and thermal energy storage systems, such as ice, to cool the chiller water at times when power is cheapest. Although there are usually no energy savings, and it may result in slightly more energy being consumed, savings are made through the lower cost of electricity. Significant energy and cost savings are also more likely to be achieved where the system is maintained and serviced regularly. Consideration should also be given to recommissioning the HVAC system. The commissioning process will help to determine if the system is operating at optimal efficiency, whilst maintaining environmental conditions within the building envelope. Case Study XXX Re-evaluating Energy Efficient Buildings for Continuous Savings on the Asian Development Bank details their HVAC efficiency measures.

In buildings where split system air conditioning units have been installed, significant savings, through increased life span of equipment, easier maintenance and reduced energy consumption can be achieved through the retrofitting of central HVAC systems. Careful consideration and planning should be made as the retrofitting processes usually attracts a large capital cost associated with these solutions, and long payback periods, often longer than the life span of the new equipment. In these situations, the cost saving resulting from the easier maintenance should be included in the planning and evaluation prior to implementation.

Case Study 33 Energy Savings from Equipment Replacements: Water Chilled Air Conditioning Systems

In addition to these measures, consideration should be given to minimising the number of heat generating activities and processes. The three commonest areas, which are likely to result in savings through a reduced cooling load are:

Lighting

A significant amount of waste heat is generated by lighting, and reducing the lighting load as well as reducing the intensity of lighting can reduce the amount of waste heat generated and hence the cooling load.

Appliances

Reducing the heat generated by office equipment, through the selection of energy efficient devices or those which generate less heat as a result of technological innovation, such as inkjet printers and cost fusing photocopiers can significantly reduce the cooling load of HVAC systems.

Building Envelope

Reducing the amount of sunlight and external heat entering the building through windows, doors and open ductwork through shading, window treatments and insulation can also result in significant cost savings.

HVAC in Smaller Buildings

Buildings, which are not serviced by centrally ducted HVAC systems usually provide more opportunities for energy savings but tend to be more reliant on occupant behaviour for savings.

Air-conditioned Buildings

Buildings that are fitted with room-sized air conditioners (both single unit and split systems) can be difficult to manage, as the use of the system is usually the responsibility of the room occupant. In these cases, education and awareness raising activities with building occupants will provide the best savings potential.

Occupants can be encouraged to consider alternate heating and cooling methods, such as putting on, or removing layers of clothing to suit the conditions, prior to using the air conditioner.

From a technical perspective, the correct sizing of an air conditioning unit is an important aspect of overall energy management. As with other energy appliances, selection of energy efficient models will assist in reducing overall energy consumption as will ensuring that systems are serviced regularly - dust build up on the motor and heat pump reduces the efficiency of systems.

The financial savings of small business air conditioning is discussed in Case Study 37 Energy Savings from Preventative Maintenance of Small to Medium Sized Ducted Air Conditioning Units

Mechanically Ventilated Buildings

In small buildings where heat is extracted through the use of exhaust and ceiling fans, similar technical principles (selection, maintenance and operation) apply as to air-conditioned systems, although energy consumption is typically less than for a similarly sized air conditioned building.

The use of timer switches on exhaust fans can reduce the total overnight load of the building, for example the fan is switched off between the hours of 7pm and 3am. However, careful monitoring of the environmental conditions should be undertaken to ensure that this does not create an unpleasant environment for the building occupants.

As with any electric motor-based appliance, fans should be serviced and cleaned regularly by a qualified person to reduce dust build up and maintain efficiency. If units require replacing, consider energy efficient alternatives.

Naturally Ventilated Buildings

As these buildings do not rely on energy for the ventilation of the office space, only minor improvements to their energy efficiency can be made. These improvements usually focus around the draught proofing of windows and doors to prevent heat loss (or gain).

Water Heating

Water heating comprises only a minor component in commercial buildings unlike the domestic sector, where energy due to water heating is a large component of the total energy used. However, the heating of water for use in both hot and boiled water applications (ie washing versus drinking) is an additional area of potential energy savings.

In many commercial buildings, electric water heating units for supplying hot (not boiled) water are the only viable alternative. Although both gas (including natural and biogas) and solar offer the potential for cost savings, particularly in the case of solar heated units, they are often unsuitable either because gas is not distributed to the building or because access to the roof or other suitable location for solar water heating is unavailable. However, energy savings can be made through the selection of instantaneous electric water heating units, which heat the water at the time of supply, as opposed to storage systems which store pre heated water in a tank.

Units that supply boiled water, usually for consumption in hot drinks, such as coffee and tea, also offer energy savings. In rooms set aside for refreshments and breaks, water heating is usually by the use of an urn, or large capacity thermal element kettle. These appliances, especially portable types, are not fitted with timer switches and are frequently left on overnight, resulting in both energy consumption (at the rate of about 2 kW per hour) and potential damage to the appliance and fire.

Socket type timer devices, where available, offer a solution to both problems, although they themselves are small consumers of energy. In buildings where demand for boiled drinking water is low, an electric kettle may provide an alternate energy saving option to the large capacity urn.

3. Level Three Auditing

Level three energy auditing encompasses the systematic and detailed evaluation of energy consumption in buildings and building energy systems. Specialist energy management consultants usually undertake this level of audit using simulation software to determine minimum energy consumption for the building.

The simulation software usually incorporates thermal modelling of the building and energy services, occupancy and building use information and climatic information (or the ability to incorporate this type of information) to determine total energy consumption of the building. Energy management consultants should also be able to analyse components of the building environment such as the HVAC system and evaluate the energy performance of these systems.

Typically, the recommendations from energy management consultants are capital intensive and carry the greatest risk, due to their relatively long payback periods. Where level three auditing is utilised in a comprehensive energy management programme, incorporating levels one and two auditing, recommendations will usually involve detailed retrofitting of existing energy systems. This involves the replacement of HVAC and building wide lighting systems, appliance replacement and the upgrading of the thermal performance of the building envelope.

D. Energy Management Systems

In the last 25 years, much of the progress in energy management has been in the development and implementation of computer systems to control energy consuming devices, principally lighting and HVAC systems in commercial (and industrial) buildings, as a method for reducing energy consumption, and hence financial savings.

These systems are known by a variety of terms including:

- Energy Management Systems
- Energy Management Control Systems
- Building Energy Management Systems

Many Energy Management Systems are available commercially, and a valuable system will include the following aspects:

- Reporting of system parameters (including temperature, humidity and air flow associated with HVAC)
- Information summary of data at diurnal, weekly and monthly intervals, which are understandable to non-energy specialists
- Rapid response to changes within the system such as environmental conditions (i.e. sudden heat wave requiring lowering of temperature within the building envelope)

Advanced systems may also provide additional building services, such as smoke/fire detection.

When selecting systems, it is essential to consider the main goals for these systems:

- Reduced energy costs: with each additional component or feature, incremental cost savings should be achieved
- User friendliness: the system should not require extensive technical knowledge of the system in order to be utilised.

The system should be able to provide a variety of information for different levels of users. The Energy Manager/ Facilities Manager should be able to extract technical data from the system and use it to reprogram control features whereas the Area Manager or Night Staff should be aware of using override controls after hours should the system need temperature changes to HVAC or lighting.

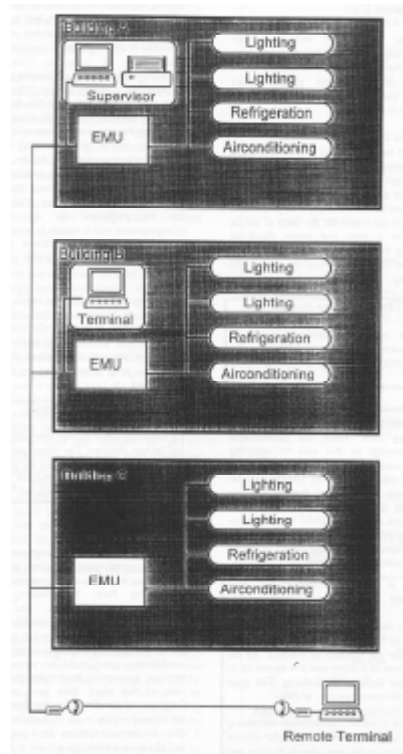


Figure 4.4: Schematic of an Energy Management Control System

1. Components of Energy Management Control Systems

Energy Management Systems have 5 principal components (and any number of inputs, such as lighting, refrigeration or air conditioning may be managed by the system). In small buildings, only one of each component may be required, whereas in larger installations, such as multi-storey office buildings may have many.

Data Link

Like all communication networks, such as telephones and computer networks, Energy Management Control Systems require a data link for the exchange of information between components.

As with other information networks either copper or fibre optic cables may be used. Many buildings utilise existing telecommunication infra structure, thus reducing the installation cost of the system, and allowing remote access to the system.

Energy Management Unit

At the heart of an Energy Management Control System is the Energy Management Unit. The main function of the Energy Management Unit is to provide a direct interaction with the input devices (i.e. air conditioning) being controlled by the Energy Management Control System.

A self-contained unit, the Energy Management Unit can be programmed (usually by the Energy Manager/ Building Manager) to perform the desired management functions. It should be capable of measuring the environmental conditions as well as maintaining conditions programmed into it, or those programmed from the Supervisor Console.

Supervisor Console

In large buildings, several Energy Management Units may be integrated into a supervisor console, which can control the programming of all of the individual units. It is possible to change operational parameters from this location and the Supervisor Console will produce summary reports so that changes to the system can be evaluated and quantified.

Terminal

In most systems, there is normally the capacity for terminals to be connected into the network. The prime reason for this is to allow building users to have access to the Energy Management Systems, principally to allow for equipment shut downs or modify performance during maintenance or emergencies.

Remote Terminals

Growth in the internet and communication technologies has seen the integration of Remote Terminals with Energy Management Control Systems to allow access to the system via direct access modem or internet connections. With these advances it has become possible for diagnostic work on systems to be performed remotely (i.e. external to the Energy Management Control Systems location). It has also provided the opportunity for rapid response to emergency situations from the home of Energy Managers. The installation of an appropriate computer system in their homes alleviates the need for the person to attend to the problem on site, and reducing the time taken to respond to these situations.

Simple Control Systems

In addition to Energy Management Control Systems, which operate on a large scale, a number of smaller alternatives exist.

Timer Controls

These simple analogue (dial) or digital (display) (Figure 4.5) devices are designed to turn appliances on and off at a set time each day. Sophisticated versions may allow for multiple set points to be programmed (i.e. Monday, Tuesday, and Wednesday on at 9am, Thursday, Friday on at 8.30am) or include battery back up in case of power failure.

Delay Switches

Delay switches are usually installed as override switches, and allow for appliances, including air conditioning to be turned on for a limited period of time, commonly for between 10 minutes and 3 hours.

After time has lapsed, the appliance is automatically turned off. To continue operation, the switch needs to be reactivated.

Motion Sensors/Light Detectors

Light and/or motion sensors have become commonplace in security applications where high wattage lamps are activated by motion in the sensor range. They incorporate light detectors to ensure that movement during daylight (as would usually be expected) does not trigger the light. The main advantage of these systems is in the cost saving potential, as it reduces the amount of time the globe is illuminated.

Case Study 34 examines the energy saving potential of motion sensors in lighting applications.

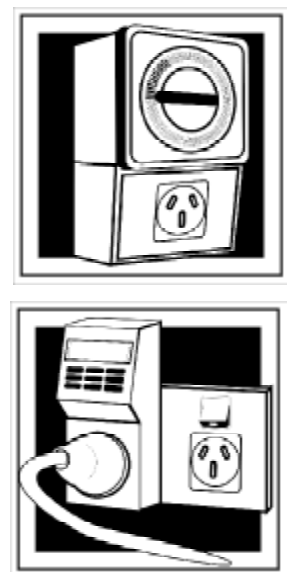


Figure 4.5: Analogue and Digital timer controls are suitable for small portable and fixed appliances.

E. References and Resources

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Alliance to Save Energy: Commercial Energy Efficiency
http://www.ase.org/programs/Buildings/commercial_energy_efficiency.htm



Canadian Office of Energy <http://oee.nrcan.gc.ca/infosource/businesses/index.cfm>

Energy Efficiency and Renewable Energy Network – Consumer Energy Information
<http://www.eren.doe.gov/consumerinfo/forbusiness.html>

Energy Efficiency and Renewable Energy Network - Commissioning for Energy Efficiency
http://www.eren.doe.gov/buildings/comm_energyeff.html

Roadmaps to Energy Efficiency
<http://www.energyroadmaps.org/road/roadmap1-resources.shtml#step1>

Turner W.C (2001) *Energy Management Handbook*. Fairmont Press, USA. ISBN: 0-13-092665-5 (4h Edition).

The handbook of Energy Management is a very comprehensive text on all aspects of energy management. Written from a technical perspective, it is ideal for managers with a science or engineering background. This text is available for purchase through many internet bookshops, and at time of print, the fourth edition was approximately US \$150.

Case Study 35 Energy Savings from Electric Motors



Objective: To reduce energy consumption from electric motors

Location: Australia

Website: <http://www.isr.gov.au/motors/meps/index.html>

Description:

From 1 October 2001, all three-phase electric motors from 0.73 kW to 185 kW supplied throughout Australia must meet minimum energy performance and 'high efficiency' standards. The new standards are set out in *Australian Standard AS/NZS 1359:2000*.

MEPS will remove from the market products deemed to be unacceptable because of the level of energy use required to deliver a given level of service.

The new uniform regulations will also set the Australian/New Zealand standard for minimum energy performance and for labelling of motors as 'high efficiency'. All products licensed for sale in Australia will have to be registered on a national database.

The data will be validated through targeted testing by independent laboratories, and significant penalties will apply for suppliers providing false or misleading information.

Saving the environment and saving money

The regulations will save four Mt CO₂ of greenhouse gas emissions through reduced power demands associated with more efficient motors—also saving motor users up to \$165 million through lower energy bills over the next 15 years.

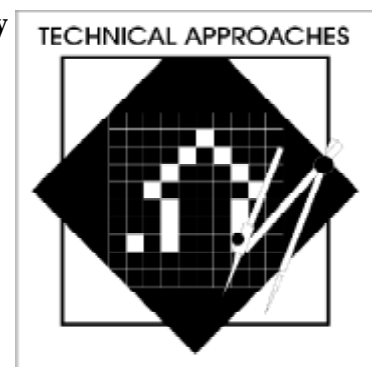
Consultative process

MEPS for motors were developed by the Australian Greenhouse Office Energy Efficiency Program, following a five-year Government/Industry/Stakeholder consultative process, and extensive economic and regulatory impact studies under the direction of the Australian and New Zealand Minerals and Energy Council.

The efficiency levels in the new regulations will be reviewed in four years, with a view to further raising the minimum efficiency levels.

Copies of the new Standard are available for purchase through Standards Australia <http://www.standards.com.au>.

Case Study 36 Variable Speed Drives Reduce Energy Consumption in HVAC Applications



Objective: To improve the ventilation systems energy efficiency

Location: California, USA

Website: <http://www.oit.doe.gov/bestpractices/motors/mc-cs07.shtml>

Description:

In an effort to improve ventilation system performance in its Fresno, California textile plant, Nisshinbo California, Inc. (NCI) working with ADI Control Techniques Drives (ADI-CT) of Hayward, retrofitted 15 of the system's fan motors with variable frequency drives (VFDs). This change enabled the fan control dampers to be fixed in a fully open position, and improved the system's air-flow control and energy efficiency.

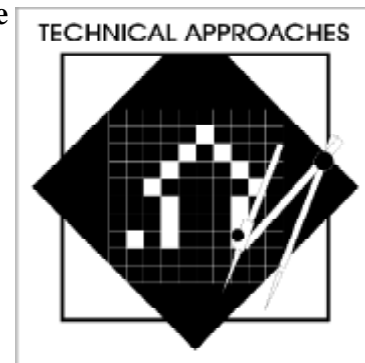
Installation of the VFDs reduced the ventilation system's total electricity demand from approximately 322 kW to 133 kW, a 59 percent drop. The total annual energy consumption for the fans similarly fell 59 percent from approximately 2,700,000 kWh to 1,100,000 kWh. The energy-efficiency gains were possible because the VFDs enabled plant personnel to fully open the fan control dampers and reduced fan speed. This results in a large drop in motor power consumption and allows the system to operate efficiently.

These electricity savings translated to annual energy cost savings of about \$101,000. When measured against the project's \$130,000 gross cost which included the cost of the feasibility study; base case evaluation; system engineering and design; VFDs and associated equipment; and installation, startup, and commissioning, the simple payback for the project was 1.3 years.

It should be noted, however, that NCI did not pay for any of the costs that the project incurred.

In addition to the energy savings, NCI also realized additional benefits that were difficult to financially measure. First, installation of the VFDs gave plant personnel more control over the plant's air flow. NCI estimated that 48 hours of labor per year were saved because the dampers and ceiling diffusers no longer required modulating. Second, air quality is now easier to control, as responses to minor variations in the ventilation requirements are now possible. Third, the amount of airborne lint in the plant decreased, improving product quality and reducing the number of equipment breakdowns. Finally, the VFDs slightly increased the plant's power factor, thus reducing the power factor penalty costs.

Case Study 37 Using Correctly Sized Motors to Reduce Energy Consumption in Wastewater Facilities



Objective: To improve sewerage pump performance

Location: Trumbull, USA

Website: <http://www.oit.doe.gov/bestpractices/motors/mc-cs08.shtml>

Description:

Located just north of Bridgeport in southwestern Connecticut, the Town of Trumbull has a population of 32,000 and, with ten sewage pumping stations, a total raw sewage handling capacity of 3.3 million gallons per day. Each of the stations pump sewage to a main lift station where it is then pumped to a sewage treatment plant in Bridgeport.

The Town of Trumbull was looking for a way to increase the energy and operating efficiency of its Reservoir Avenue sewage pump station. With the help of ITT Flygt Corporation, the town altered the existing pump system by adding a smaller pump and modifying the system control scheme.

Under normal conditions, the operating point for the new pump is 450 GPM at 40.7 TDH, compared to 850 GPM at 50.3 TDH for the pumps in the original system. The specific energy of the optimized system was measured at 325 kWh/MG, a 255 kWh/MG decrease from the original system. In addition to the 17,643 kWh of energy savings achieved by modifying the pump unit, significant energy savings also resulted from changes made to other energy use sources in the station.

Annual energy consumption by the lighting system was reduced from 5,256 kWh to 78 kWh, while energy consumption of the bubbler level control (7,300 kWh/yr) and the cooling water pumps (1,752 kWh) was entirely eliminated. In all, 31,875 kWh was saved, a reduction of almost 44 percent, resulting in \$2,614 in annual energy savings.

In addition to energy savings, the modifications reduced the system's cleaning and maintenance requirements as well as the control subsystem's maintenance requirements. Together, these reductions significantly decreased the labor needs of the station. Finally, the expected life of the operating equipment and electrical switch gear increased with the longer operating times and reduced power input of the new system.

Several lessons were learned from this Showcase Demonstration project which can be applied to other similar energy efficiency projects in the future: (1) rethinking the pump selection and operating methodology for pumping equipment can result in significant savings; (2) in systems with static head, stepping of pump sizes for variable flow rate applications can decrease energy consumption; (3) a "systems approach" can identify sources of energy consumption other than pumps that can be modified to save energy.

Case Study 38 Energy Savings in Compressed Air Systems



Objective: To reduce energy consumption in compressed air systems

Location: Various

Website: <http://www.knowpressure.org/content/library/casestudies.cfm>

Description:

The Compressed Air Challenge is a voluntary collaboration of industrial users; manufacturers, distributors and their associations; consultants; state research and development agencies; energy efficiency organizations; and utilities. They have a large number of case studies on their website including:

Michelin

In 1997, Michelin North America upgraded the compressed air system controls at its tire manufacturing plant in Spartanburg, South Carolina. In response to growing energy costs and the desire to remain competitive in the tire industry, Michelin performed an internal evaluation of its compressed air system to determine how it could improve the system's efficiency and energy use. The evaluation provided the basis for a project to install a new control system. The controls upgrade project at Michelin's plant enabled multiple compressor operation without blow-off during load swings. In addition, the plant has been able to stabilize and lower pressure levels, leading to estimated annual energy savings of \$75,000 and 2,143,000 kWh. The project's total cost was \$120,000, giving the plant a simple payback of approximately a year and a half.

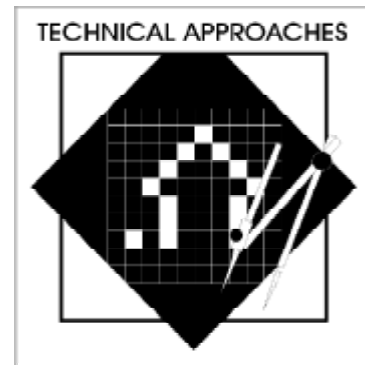
Visteon

The energy team at Visteon's Monroe plant, formerly owned by Ford Motor Company, implemented an ongoing compressed air system leak management program. The team developed an approach that combined a traditional "find and fix" effort with an innovative implementation and marketing program. As a result of the leak management program, compressed air system consumption was reduced by more than 50% on a per production unit basis. This represents savings of over \$560,000 per year and an 11.5% reduction in annual electricity costs.

Thomaston Mills

In 1997, a compressed air system improvement project was implemented at the Peerless Division of Thomaston Mills in Thomaston, Georgia. The compressed air system project was undertaken in conjunction with an effort aimed at modernizing some of the mill's production equipment. Once they were both completed, the mill was able to increase production by 2% per year while reducing annual compressed air energy costs by 4% (US\$109,000) and maintenance costs by 35% (US\$76,000). The project also improved the compressed air system's performance, resulting in a 90% reduction in compressor downtime and better product quality. Since the project's total cost was US\$528,000 and the annual savings are US\$185,000 per year, the simple payback is 2.9 years. The mill also avoided \$55,000 in costs by installing a more optimal arrangement of compressors.

Case Study 39 Performance Contracting Leads to Energy Savings in Steam Production



Objective: To improve the energy efficiency of the steam production system in two hospitals

Location: Czech Republic

Website: <http://www.weea.org/best/bulovka/>

Description:

Energy Performance Services Czech Republic (EPS CR) has completed implementation of two performance contracting projects to provide energy efficiency services to two hospitals in the Czech Republic. These are the Bulovka Teaching Hospital in Prague and the Jilemnice District Hospital in northeast Bohemia. Both hospitals needed a significant upgrade in their central heating systems and were facing a situation of no available funding and operating expenditures that were rising more rapidly than incoming revenues or government subsidies would cover.

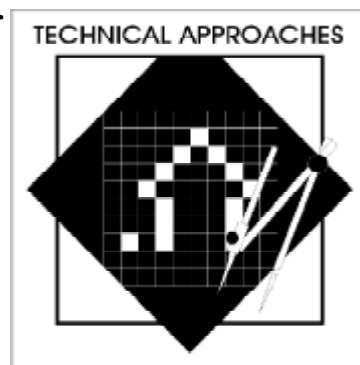
The performance contract with EPS CR provided long-term financing for the upgrade and generated savings that permitted the hospitals to reduce their operating costs without reducing the level of services. Both projects focused on modernizing heating systems, and did not include lighting renovations. Excluding construction time, the term of the performance contract for these projects is eight years.

There are four energy conservation measures in total project:

- switching the existing central steam system to district heating
- implementing a new energy management system
- installing a new air handler recovery system
- converting and upgrading to a new high efficiency natural gas boiler

Total installed cost of these measures was about US\$2.7 million. All of the measures operating together will produce an annual savings of about US\$700,000, resulting in a four-year simple payback. All four measures were put into operation in September 1995.

Case Study 40 Investment in Energy Efficient Equipment for Industrial Processes



Objective: Improving the energy performance in small scale glass production

Location: Firozabad, India

Website: <http://www.teriin.org/case/glass.htm>

Description:

It has been observed that small and medium enterprises in India are generally less efficient in material and energy use compared to larger enterprises and enterprises of similar scale in the developed countries. The poor energy and environmental performance is directly related to the lack of technical capacity in these enterprises to identify, access, and adopt better technologies and operating practices. Through detailed diagnostic studies carried out by TERI in various small and medium scale industrial clusters in 1995, it was found that there exists a tremendous scope for increasing energy efficiency in these units. Based on these studies, the small-scale glass industry cluster in Firozabad was identified for further intervention. The inadequacy of imported ready-made solutions for the small-scale glass making industry necessitated a dynamic design process in which the local industry played a central role. An important element of the intervention strategy to design and demonstrate an energy-efficient pot furnace was competence pooling, with synergies among the various actors resulting in an appropriate solution.

Though efficiencies of all furnaces were found to be low in general, it was decided to focus on pot and muffle furnaces in view of their low scale of operation, high share of coal use (48% for pot furnaces and 27% for muffle furnaces), very low operating efficiency and inability of the segment to mobilize support for technology upgradation. At this juncture, the Supreme Court of India passed a landmark judgement in response to a public interest litigation seeking protection of the Taj Mahal against pollution. Under this ruling, the apex court banned the use of coal /coke in the entire TTZ (Taj trapezium zone), an area of 10,400 sq. km. around the Taj. The court directed 292 specified industries located in the TTZ, which were using coke/coal as fuel, to switch over to natural gas, relocate outside the TTZ, or shut down. Gas Authority of India Limited (GAIL) was asked to supply gas to the industries in the TTZ. Since Firozabad also lies in the TTZ, it became mandatory for the industries in Firozabad to switch over to gas as a fuel. However, no off-the-shelf solutions were available to the industry to make this switch over.

The demonstration pot furnace, using natural gas as fuel, was commissioned in February 2000. There has been no deterioration in the plant performance, in terms of specific energy consumption. While specific energy consumption for the conventional furnaces was found to be about 5860 kcal/kg of glass, for TERI furnace it was found to be 2460 kcal/kg of glass, a reduction of nearly 60 %.

Case Study 41 Investment in Energy Efficient Equipment for Industrial Processes



Objective: Improve the energy performance of small scale foundries

Location: Howrah and Nagpur, India

Website: <http://www.teriin.org/case/foundry.htm>

Description:

The Indian small-scale sector has over 6000 cupola-based foundry units, located mostly in clusters. The energy intensity of these units is quite high as shown by the charged coke percentage. Further, after the strict imposition of emission standards, most small-scale foundry units found it extremely difficult to comply, primarily due to the lack of availability of any ready-made gas cleaning systems. This presents an ideal situation where both energy saving and pollution reduction could be achieved through technological upgradation.

The Howrah belt of West Bengal has the largest concentration of foundry units in India and accounts for over 20% of the country's output production of grey cast iron. TERI's Action Research Programme in the Foundry Sector was initiated with the support of the SDC (Swiss Agency for Development and Cooperation) to improve the energy and environmental performance of small-scale foundry units.

Energy audits of representative conventional cupolas and DBCs (divided blast cupola) were conducted in both Agra and Howrah foundry clusters prior to the designing of the demonstration plant. These audits revealed a very low operating efficiency of the cupolas, characterized by a very high charged coke percentage. The emissions and the particle size were measured before designing the new pollution control system.

As against the conventional cupolas used in most foundries, the DBC is an attractive option for increasing profitability by reducing coke consumption from a modest investment. Further, the lack of availability of any ready-made gas cleaning systems made it very difficult for the foundries to meet the stringent particulate emission norm of 150 mg /Nm³. Consequently, it was decided that a suitable flue gas cleaning system be designed along with a DBC. A DBC demonstration unit was set up, equipped with a flue gas cleaning system for controlling emissions. After optimization of control parameters, energy and environmental measurements were conducted to assess the cupola's performance.

Results indicated that, as against the conventional-cupola-based foundry units, the demonstration cupola was at least 33% more energy efficient than the 'best' unit audited by TERI. The extent of coke saving is even higher (nearly 65%) compared to the 'worst' cupolas audited. The degree of abatement in stack emissions was also substantial, with the SPM (suspended particulate matter) emission being only one third of the stringent norm. The sulphur dioxide emission from the demonstration cupola was also well below emission standards.

Case Study 42 Co-generation and the Confectionary Industry in Nigeria



Objective: To produce the power and steam needs as part of the manufacturing operations

Location: Nigeria

Website: http://www.jxj.com/magsandj/cospp/2001_01/winwin.html

Description:

The productivity of many manufacturing entities in Nigeria is seriously constrained by an unreliable supply of energy, in the form of power and petroleum products, which are the major energy carriers in manufacturing. Over many years of manufacturing operations, the food company Cadbury Nigeria Plc. has taken this bull by the horns, by maintaining in-house responsibility for providing its facilities with a reliable, high-quality energy supply.

To manufacture these products, the company requires an adequate, cost-effective and reliable supply of power and steam. The company generates sufficient power to meet all its requirements from generators with a total installed capacity of about 7.3 MW. Its manufacturing facilities are currently not connected to the national grid. In 1998 the company generated an average of about 23,000 MWh of electrical energy with a peak power demand of about 5 MW, using diesel as the fuel.

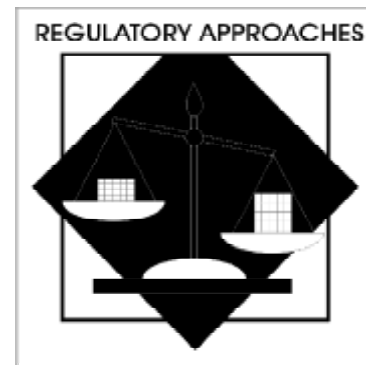
Its steam supply in the same year was supplied by seven boilers with a total installed capacity of about 54 tons/hour. In 1998, a peak demand of about 35 tons/hour was achieved, using low pour fuel oil (LPFO) as fuel to produce dry steam at pressure of about 10 bar. During this year, LPFO consumption totalled about 6.3 million litres.

The result is that the company generates 100% of its power and steam needs within the factory. By so doing over a period of years, its major energy security consideration has been the adequate, timely and reliable supply of diesel and fuel oil. Even then, it has not been completely shielded from unreliable petroleum product supplies.

The need to increase energy security (and hence productivity), coupled with better environmental performance and superior economics, recently influenced the management's decision to shift from the use of diesel and fuel oil to natural gas.

The factory has been able to obtain a 39.7% reduction in fuel requirement compared with the existing system and resulting in a large financial saving for the organization, with system efficiency in the cogeneration system of 90%.

Case Study 43 Cogeneration and the Privatisation of the Electricity Industry



Objective: To develop cogeneration as a method of energy efficiency

Location: Brazil

Website: http://www.jxj.com/magsandj/cospp/2000_02/cogeneration_for_brazil.html

Description:

With 162 million inhabitants in an area of 8.5 million square kilometres, Brazil's population density in many areas is very low. Per capita income is also low, yet Brazil ranks amongst the ten largest economies in the world. Industrialization is fairly advanced – the country's automobile industry, for example, produces over 2 million vehicles per year. Demand for power, which was 320 TWh in 1999, is growing rapidly. Over the last decade GNP grew by 21%, but demand for power increased by 79%. There are two main reasons for the rapid growth: the first is the intensive urbanization and development of basic industry and infrastructure that took place throughout the 1980s to meet the needs of many regions in Brazil; the second is an increase in the informal economy.

Brazil relies on large-scale hydroelectric plants to produce 95% of electric load. These plants, including the world's largest, Itaipu, are located in five river basins and are linked to the market by an extensive system of transmission lines. Cogeneration accounts for approximately 3% of total generated energy, the majority of which is based on seasonal production by the sugar-cane industry. The relatively low contribution of cogeneration to total power production is a direct result of the old power sector model. This model favoured large hydropower projects, encouraging them to take advantage of economies of scale and favourable locations along Brazilian rivers.

While cogeneration was not prohibited, the model lacked clear mechanisms for the sale of excess electricity to the grid. Another major barrier was the low price for electricity. Natural gas availability was very limited, supplying less than 3% of Brazil's primary needs. For these reasons investment in the development of on-site generation was very slight. The barriers that have inhibited development of on-site generation are diminishing as Brazil's energy sector is reformed. Most of the electric distribution utilities have now been privatized, and distribution gas utilities with private control are being organized.

Cogeneration is currently being developed in Brazil. The World Bank has recently given a loan to the Programa de Combate ao desperdicio de Energia Electrica (PROCEL) to focus on end-use energy conservation, and several industries are already using this technology (such as the President Vargas Steelworks with its 230 MW cogeneration thermoelectric power plant). Taking into account the existing power supplies and projected structures, the proportion of cogeneration in Brazil is likely to reach 10–15% by 2010. With demand expected to grow at a rate of 3–4% per year, demand for cogeneration could reach between 11 and 17 GW during the next decade, making Brazil one of the world's best markets for cogeneration and distributed generation.

Case Study 44 Cogeneration and District Heating



Objective: To replace coal fired cogeneration with natural gas

Location: China

Website: http://www.jxj.com/magsandj/cospp/2001_05/gas.html

Description:

China's energy needs are potentially enormous, and the challenge of supplying its vast population and rapidly growing economy is huge. Its environment is fragile in places, and the air quality in the larger cities already very poor. The country is also trying to find a balance between a centrally planned and a market economy. Greater use of natural gas is at the heart of the Chinese strategy for dealing with these potentially conflicting demands for energy supply.

Cogeneration has historically grown in step with other coal-fired plants, representing approximately 10-12% of coal-fired generating capacity since 1980. Large municipal steam systems and centralized cogeneration facilities in industrial parks are common. Nearly 45% of the cities in China have some form of centralized steam or hot water system. Population movements from rural areas to the cities and greater wealth have rapidly increased urban steam demand. State-run utilities and Chinese independent power producers have responded with the expansion of heating systems and new construction. The Beijing Municipal Heating Company, the largest in the country, increased its service area 15% in 2000.

After the capacity glut caused by the economic slowdown, the demand for electricity and steam in China is rebounding. The relatively steady pace of development in the country since the Asian financial collapse gives confidence in the stability of the country's financial system. In addition, many of the early problems, such as availability of foreign exchange and access to capital markets, have been worked out. However, there is still an uncertain regulatory environment which, while continually being reformed, also seems to have the potential for change on a continual basis.

For cogeneration developers, Chinese projects have almost solely involved coal-fired projects less than 100 MW, serving captive customers that were typically JV partners. Private power developer AES entered China with such a strategy, and more recently Alliant has announced it is taking a similar track.

Gas-fired projects have been less common, due to the extremely weak infrastructure. However, this infrastructure gap is being filled. Despite the many hurdles in the way of development, the high-profile West-East pipeline, the Guandong LNG terminal and further offshore gas production promise to provide substantial resources for gas-based cogeneration plants by 2008. The degree to which foreign participation will be realized in these projects will be due largely to the creativity in the financing and technology solutions offered to the Chinese market. While examples of early wins in the Chinese market are rare, there seems to be a consensus that the promise of the future will be worth the wait.

V. ENERGY SAVINGS IN INDUSTRY

A. Energy Use in Industry

Industry is the major user of energy in modern society, accounting for roughly 40% of final energy use. Coal or oil are heavily used, especially by primary industry and manufacturing and refining. Gas is being used increasingly to replace coal because it is a cleaner fuel producing less impact on the environment. Electricity is only a minor component of industrial energy use although its use in driving electric motors is very important.

The major sectors within industry can be categorised as follows:

Manufacturing – this includes the processing of primary resources into consumer products. Mineral refining, oil refining and chemical manufacturing are some areas of energy use where considerable savings could be made. Such activities often occur in the industrial zones of major cities.

Power Generation - the power generation industry is a massive user of fossil fuels and accounts for more than 50% of international greenhouse gas emissions. Many power stations are very inefficient and there are strong economic and environmental incentives to save energy in the power supply industry. Most cities have major power stations and these are often a cause of air pollution as well.

Mining – this is a primary industry which generally occurs outside cities, often in remote parts of the country. Energy intensity is high in most mining operations but there is an incentive to save energy because energy wastage is reflected in the cost of the minerals.

Agriculture – another major user of primary energy which takes place in rural areas and is largely beyond the scope of city governments to influence it.

Construction – is a modest user of energy, particularly liquid fuels because this activity often takes place at sites where electric power is not readily available. Considerable savings are available in this sector because there is often a large amount of wastage in construction activities

The main focus will therefore be on energy savings in manufacturing and power generation as these are the major users of industrial energy in cities.

B. Energy Auditing in Industry

Energy auditing in industry takes a similar approach to audits undertaken in the commercial sector (Chapter 4, Section C. and will generally involve:

- An analysis of existing energy consumption records to determine where, how and how much energy is being used in the plant. It will also seek to identify trends in consumption data
- A walk through audit that documents where the main areas of energy consumption exist within the plant. This phase will identify any obvious areas of wastage together with the most promising areas for potential savings
- A detailed analysis phase which will take the data obtained in the previous two phases and prepare detailed plans for energy savings options. These plans will include details on the energy use and cost of each stage of the production process as well as costings and expected payback periods of the various energy saving options proposed.

In the case of the industrial sector, the main focus should be level three auditing, where the individual processes are analysed, for example, the production of steam for use in commercial laundries. Although

level one auditing, which focuses on the analysis of energy use through and investigation of the tariff structure of existing energy purchases, should be undertaken, the greatest potential for savings in the industrial sector will usually revolve around the selection, operation and maintenance of efficient equipment in the process.

1. Planning for Energy Efficiency in Industrial Processes

Once an initial energy audit has been undertaken, it will provide an important first step in monitoring and achieving the progress towards energy efficiency goals. This information is the baseline energy consumption, or the energy usage associated with current practices in the factory as well as existing equipment. Known as T_0 , this is the energy consumption prior to any systematic energy efficiency measures being undertaken.

In conjunction with the result from the screening survey, the establishment of this baseline information allows energy managers to set targets for reduced energy consumption which can be achieved through changes in the management and operation of the industrial process as well as targets which would be possible through the implementation of energy efficient technologies.

Short Term Energy Efficiency Targets

Energy efficiency targets, which can be achieved in the short term, as a result of streamlined operation of the plant, are known as T_1 , or housekeeping targets. These energy savings will usually be the result of the efficient use of energy consuming equipment, a reduction in the amount of waste energy, timely maintenance of equipment and continual monitoring of the energy consumption of the industrial process. Specific examples of housekeeping targets for electric motors, compressed air systems, process heating, steam and heat recovery are covered later in this chapter, and are symbolised by (T_1).

Long Term Energy Efficiency Targets

Further reductions in energy consumption which can only be achieved through purchase with a high capital cost, are known as T_2 , or investment targets, and should ideally be based on the lowest energy consumption of best practice examples of similar industrial processes. As the purchase of expensive capital equipment is required to achieve these targets, careful modelling should be undertaken to ensure that the investment is sound, ie that the payback period of the equipment is not greater than the working life of the equipment.

The establishment of investment targets is a complex process, requiring a large amount of technical knowledge of similar industries, the options available for energy savings through the investment in new capital, as well as knowledge and skills in economic modelling. However, a large number of international best practice examples and case studies from industrialised nations, particularly in Europe and the United States, has increased the amount of information and data available on international best practice. Much of this information is available through CADDET – Energy Efficiency, the US Office of Industrial Technologies and the World Energy Efficiency Association, whose details are at the end of this chapter. Some examples are provided in Section D - Case Studies at the end of this chapter.

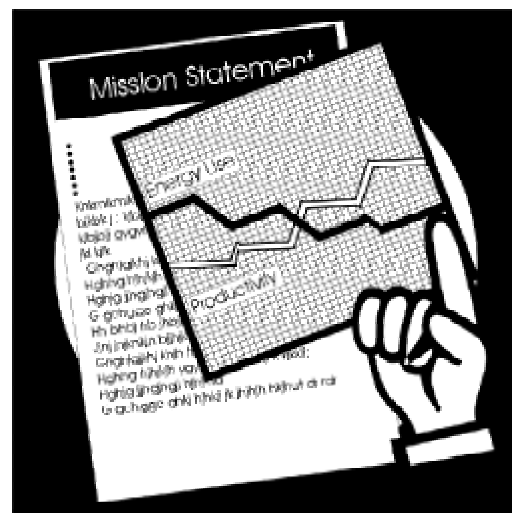


Figure 5.1: Energy efficiency targets in industry can help to focus resources to achieve the best results.

Innovation Energy Efficiency Targets

Energy efficiency is an area of increasing technological innovation and some consideration should also be given to setting T_3 , or innovation targets. These targets are based on the energy consumption of state of the art technologies, which are still economically viable. Innovation targets, whilst not immediately achievable, may become achievable in the medium to long term as a result of changes in the economic environment (i.e. greatly increased profitability of the industry), the production environment (i.e. the need for a higher quality or specialised product for niche markets) or regulatory changes (i.e. the introduction of legislation governing pollution control, energy consumption or the Kyoto protocol).

C. Strategies for Energy Savings in Industry

The strategies for achieving energy savings in industry are quite different to those for most other sectors. Industry is very diverse and is often controlled by very large multi-national corporations. In this context the appropriate approach needs to be carefully considered. Industry is generally receptive to efforts to cut its energy costs but it is less likely to be attracted to regulatory measures that increase its operating costs.

Technical Options

The technical options available for energy savings in the industrial sector are as diverse as the industries themselves. However, they principally revolve around the saving of energy in areas such as:

- Electric Motors
- Compressed Air
- Steam
- Furnaces
- Heat Recovery

The production of onsite power and heat (or steam) through Cogeneration systems, or Combined Heat and Power (CHP) systems can also result in energy savings, through the utilisation of waste energy associated with the production of power.

Opportunities for energy savings in relation to the operation and maintenance of industrial buildings also exist, although these are often similar to the commercial sector and are discussed in Chapter 4 of this publication.

1. Energy Savings and Electric Motors

Electric motors usually account for almost half of total industry energy consumption, and represent a significant opportunity for financial savings from energy consumption.

Four areas offer potential savings with regard to the selection and operation of electric motors:

- energy efficient motors (T_2)
- variable speed drives (T_2)
- correctly size motors (T_2)
- regular maintenance (T_1)

Energy Efficient Motors

By definition, one motor will be more efficient than another motor if it uses less energy to produce the same rated output. Most energy efficient motors are usually constructed with higher quality materials and advanced manufacturing techniques and result in less waste energy being produced through reduced vibration, noise and heat. Some countries have adopted minimum energy performance standards for new electric motors, many others have developed standards, which motors must meet in order to be

sold as energy efficient motors. These regulatory measures offer the potential for long-term savings, although are unlikely to result in wide scale energy reductions in the short term as they are rarely retroactive, relating only to future purchases, which may be made five to ten years in the future. Case Study 35 examines the minimum energy performance standards developed for electric motors sold in Australia.

Variable Speed Drives

Electric motors, which are able to operate at different speeds according to the amount of power supplied to the drive unit, are known by a variety of terms including, Variable or Adjustable Speed Drives and Adjustable or Variable Frequency Drives, as well as inverters (although not all inverters are variable speed drives). Variable speed drives are ideal for situations where a motor, or the device the motor drives, does not operate at full capacity during its entire operation, for example fans and pumps in HVAC systems and distribution systems in processes. In these situations, the variable flow rate of the fluid (i.e. air, water, acid etc.), is often obtained by physically restricting the system to achieve the lower flow rate, or installing vanes and throttles.

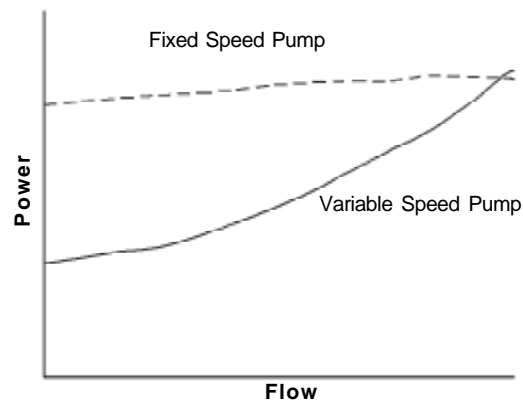


Figure 5.2: Pump flow rate comparison between fixed and variable speed drives.

Variable speed drives allow the speed of the drive, and hence the flow rate of the fluid, to be reduced by decreasing the amount of power supplied through the use of power control units. The main advantage of these drives is when the speed of the fluid fluctuates between low and high flow rates. For example the flow rate of conditioned air in a temperature controlled building, a smaller amount of power can be used to drive the unit, as compared to single speed drives (Figure 5.1).

Case Study 36 examines the effect of variable speed drives on HVAC applications in the textile industry.

Correctly Sized Motors

In many applications, the speed of a device powered by an electric motor is relatively constant. In these situations, high efficiency single speed motors are ideal as they are usually more efficient near the rated load of a motor than variable speed drives. However, careful attention should be paid to ensuring that the motor is not significantly oversized given the usual load. As with applications where the load fluctuates, motors, which are operated at less than full load, are operating far less efficiently than those at or near the rated load.

See Case Study 37 for an example of how downsizing an electric motor can reduce energy costs.

Maintenance of Electric Motors

As with other pieces of capital, electric motors and the devices they drive should be regularly serviced and maintained to:

- ensure components are clean and free from dust and oil.
- operating at peak performance as compared to the manufacturers specifications
- identify areas of wear or damage before the performance of the motor is degraded
- increase the operating life of the motor

Frequently, when electric motors fail, it is due to a fault in the stator wire. In this situation, rewinding the wire usually repairs the motors. Whilst motors can be rewound to have about the same level of efficiency,

some reduction in efficiency will usually occur. It is usually not practical, or cost effective, to have an electric motor of a lower efficiency rewound to a higher efficiency as the material used in the stator core and rotor will also influence the overall efficiency of the motor. However, a motor failure does represent an opportunity to upgrade to a higher efficiency motor.

2. Energy Savings and Compressed Air Systems

In many industrial processes, compressed air systems can consume a large component of energy use, and hence offer the potential for large financial savings from reduced energy consumption. The largest component of a compressed air system is the compressor unit. Compressors can utilise a variety of fuel sources, including diesel, petrol and electricity. Whilst this discussion will focus on electric compressors, the principles apply across all fuels, although predicting financial savings may be difficult where the fuel price, especially for oil based fuels, fluctuates rapidly.

Energy savings from compressed air systems will usually result from savings in two areas:

- compressor unit (T_2)
- distribution system (T_1/T_2)

Compressor Units

At the heart of all compressors, irrespective of fuel type, there are three areas that are essential for energy efficiency:

- Compressor Motor
- Compressor Element (also known as the Airend)
- Compressor Control System.

Compressor Motor

Energy savings for motors in general are discussed at length in the previous section. In addition to these, consideration should be given where feasible to replace electric motors with diesel fuels and vice versa, if energy, and hence financial savings are possible.

Compressor Element

The airend of the compressor is the component that is responsible for compressing the air in the compressor unit. The performance of compressor elements will depend largely on the type of element in the unit (rotary screw, rotary vane, reciprocating or centrifugal) and may vary by as much as 20% between the styles. The size of the element is also an important factor as larger, under utilised or poorly functioning compressors will use more energy than smaller units operating at full capacity. Reducing the operating pressure of the larger compressor may also result in energy savings.

Control Systems

The development of microprocessors has had an important effect on the efficiency of air compressors. Modern controls are able to match the air supply to the demand much more efficiently than is possible manually, and savings of up to 45% may be possible, through the installation of a number of smaller compressors which can be brought online automatically to match the demand for air.

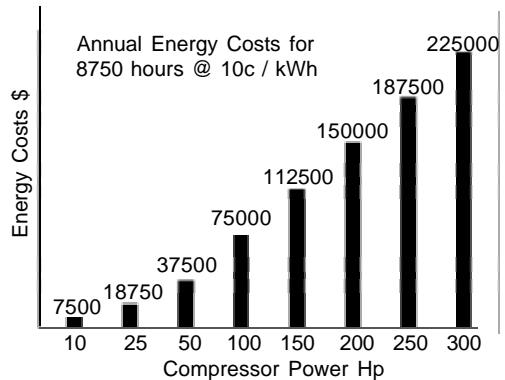


Figure 5. 3: Compressor Annual Energy Costs (Kaeser Compressors)

Aside from savings associated with energy consumption from the compressor components, financial savings will result from compressor units, which are appropriately located, correctly installed, maintained and serviced regularly as indicated in Table 5.1 (Kaeser Compressors, .

Component	Potential Saving through Maintenance
Oil Filter	1%
Inlet Filter	1%
Separator	2%
Cool running, synthetic oil	4%

Table 5.1: Energy savings through compressor maintenance
(Kaeser Compressors)

Typically, compressors are located out of sight in the factory and consideration should be given to ensure that they are not subjected to extremes of temperature and are appropriately ventilated, to prevent overheating. Reducing the compressor inlet air temperature by shading the location, or through increasing ventilation of this inlet can also offer significant savings. The correct installation and commissioning of new equipment as well as regular recommissioning of existing equipment after major services and repairs, should ensure that the system is operating efficiently.

Heat Recovery

One of the results of the process of compressing air is the generation of considerable amounts of heat. The use of a heat recovery system can increase the overall efficiency and cost-effectiveness of the operation. In many applications, the waste heat from compressed air systems, particularly from oil cooled rotary screw compressors, can be used in process and space heating applications. Water-cooled oil coolers can supply water for process heating applications at between 50°C to 70°C. Space heating is available from systems where cooling air is reticulated through pipes for distribution through buildings.

The Distribution System

After the compressor unit has compressed the air, it will need to be transported either through reticulated pipes or bottles to the location of the end use. Whilst some air leakage is almost unavoidable, care should be taken to eliminate audible air leaks, especially in reticulated compressed air systems. Audible leaks result in large amounts of energy being wasted, (between 25 and 35%), maintaining pressure to the compressed air tool or device. Thereby increasing the amount of air that must be compressed to complete the task.

Condensation in the distribution system should be minimised by eliminating its presence in the inlet air or providing systems for removing it from the distribution network. In reticulated systems, condensate traps, which collect and remove moisture from the distribution system, also pose as potential areas of energy loss. Traps which are not functioning correctly, or are manually controlled are especially prone to wasting energy. Filters should be regularly checked and cleaned as blocked or partially blocked filters will increase the pressure, and hence the energy, required to operate the system.

Case Study 38 examines how an evaluation of compressed air systems can result in financial savings through energy management.

3. Energy Savings and Steam Generation

Steam is used for a multitude of purposes in industrial plant. It can provide heat for chemical processing, hot water for cleaning purposes, steam for input to turbines for producing power and so on. Steam is generally produced by boilers. Boilers typically operate well below their optimum efficiency and savings of approximately 15% should be readily achievable.

As with all examples of industrial energy efficiency, it is important to consider the whole steam system from generation to recovery. Heat (and thus energy) losses in the steam generation and distribution systems will result in poor heating at the location of the end use.

4. Boilers

Energy savings in the generation side of steam use are usually the result of efficiency improvements in the operation of the boiler. In maximising the efficiency of boilers two key principles need to be addressed: first, the level of excess air (the extra air needed to ensure good combustion of the fuel in the boiler) and secondly the temperature of the flue gases needs to be kept as low as possible (otherwise a large part of the heat that was produced in the boiler will go up the chimney).

Good monitoring can be used to assist in achieving these outcomes. In addition, to these, the utilisation of high quality water, free from contaminants, ensures that the minimum amount of heat is required to produce steam.

In boiler plants, there are typically four areas of potential savings:

- Monitoring equipment (T_1/T_2)
- Load management (T_1)
- Condensate return (T_1/T_2)
- Fuel selection (T_1)

Monitoring Equipment

Boilers are a potential source of energy savings since they are frequently inadequately monitored, even at the simplest level, resulting in efficiency losses, and hence. Simple, but regular analysis of the flue gases, including chemical analysis of the gases and its temperature, will help determine if the boiler is operating efficiently. Care should be taken to ensure that the tests are conducted with load levels of at least 65 – 70% and that the load and gas (steam) pressures are constant. Once this level of analysis is well established, additional monitoring equipment which can determine the gross thermal efficiency of the boiler, may be required.

Case Study 39 and Chapter 8 demonstrate the potential for energy savings in boilers in a hospital environment, as well as options for financing energy efficiency projects.

Load Management

As with electric motors and air compressors, boilers do not run efficiently when they are operating at less than their recommended operating pressures. Significant cost savings can result where load management strategies, such as only operating the number of boilers to produce the required amount of gas/steam and advance warning of changes in the gas/steam load are given to boiler plant staff, are implemented.

Condensate Return

Unfortunately, there will always be some efficiency losses in process heating due to boilers as a result of condensate. Boilers and reticulation systems which are fitted with condensate return systems are far more efficient than those where the condensate enters a waste stream. The efficiency gains are largely

the result of chemical profile of the steam condensate, which is typically hot and free of oxygen. This liquid requires less energy to convert the already heated and deoxygenated liquid to gas (especially steam).

Fuel Selection

There are seven common types of fuels available for boilers:

- Coal
- Natural gas
- Liquefied petroleum gas (LPG)
- Furnace Oil
- Diesel
- Electricity
- Wood, or wood wastes (Biomass)

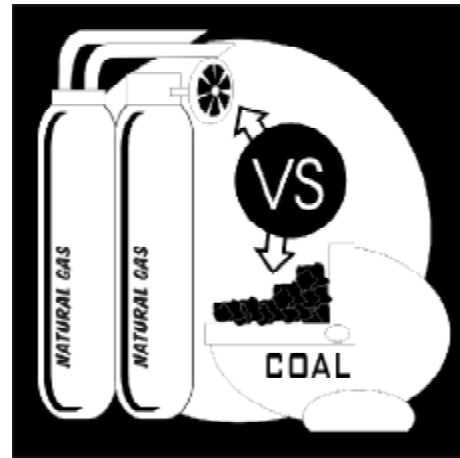


Figure 5.4: The selection of alternate fuel sources may result in financial savings

In many parts of the world, coal is used as a boiler fuel as it is usually the cheapest industrial fuel source. However, many countries are looking towards natural gas and biomass as alternatives due to the increasing cost of the traditional fossil fuels, diesel, coal and electricity as well as regulatory changes.

When selecting or reviewing the fuel selection for boilers, careful consideration should be given to ensure that the full cost of the fuel, including transportation cost, is considered. For example, a boiler in a pulp and paper mill may be more cost effective if it utilised the wood waste from the pulp process than coal or natural gas, despite a supply of both nearby.

Cogeneration, the simultaneous production of heat and power is also a potential area of energy savings, through the on site generation of heat / steam and electricity.

5. Energy Savings in Steam Distribution Systems

As with compressed air systems, the distribution of steam throughout an industrial facility is a potential area of energy loss, and hence increased operating costs. Steam traps are used in steam distribution systems to remove condensate as it forms. They often have the dual function of removing any entrapped air in the system. The presence of air and condensate in steam systems reduces the effectiveness of heat transfer in these systems as they tend to form insulating layers on heat transfer surfaces.

This means that temperatures have to be higher in order to achieve the same rate of heat transfer. Also the presence of air reduces the overall temperature of the system which is governed by the pressure of the steam. If part of the pressure of the system is caused by entrapped air, the net pressure of the steam is less than that read on the steam gauges and so the temperature will be lower than expected. Regular checking of steam traps and air vents is essential for the efficient operation of steam plant.

Energy is also wasted in steam distribution systems where heat is lost to the environment through inadequate insulation of the reticulation system. Care needs to be taken with valves and fittings that, if not properly insulated, lead to significant heat loss. Any heat lost in the distribution system means that additional fuel has to be consumed in the boiler to make up for this loss.

Condensate is an inevitable product of any steam system either as a result of heat loss or simply as a result of using the steam to transfer heat to a process. This condensate represents a source of hot, very pure water and so is an ideal feedstock for the boiler input. Assuming that the condensate has not been contaminated by the process, the use of condensate is a very effective example of using waste heat (or heat recovery).

6. Energy Savings and Furnaces

Furnaces are widely used in the manufacturing and mining industries. Although similar to boilers, they are usually used to melt metals for casting. Many of the potential areas for energy savings are the result of high capital cost, or require detailed changes in the current operation of the factory or smelter. These include rescheduling to reduce the occurrence of a furnace being heated with less than an optimum load, automatic control of furnaces, insulation of the furnace as well as modifications to the furnace. Although these items require large amounts of capital, consideration should be given to these issues, especially where the furnace is due to be replaced, or where a new furnace is to be purchased.

Cost effective, simple strategies for reducing the energy consumption of furnaces are very similar to those discussed in the section on boilers, and includes fuel selection, monitoring equipment (to ensure there is not excessive air in the melt) and load management.

Furnace systems often offer good potential for heat recovery systems where the very high temperatures in the exhaust air can be used to preheat the combustion air entering the system.

Case Studies 40 and 41 demonstrate the potential for energy savings from energy efficient furnaces in two common industries.

7. Energy Savings Through Heat Recovery

In many processes considerable amounts of waste heat are produced. Examples include the exhaust stacks of engines, boilers or furnaces, condensate in steam systems, and waste streams from washing, heating applications as well as compressed air systems.

Heat recovery involves the use of these waste heat streams to provide useful heat for another part of the plant. Heat exchangers are used to extract heat from the waste stream and transfer it to a second fluid flow. In many instances the waste heat from one part of the process can be used to preheat a fluid for use in that same process. For example the hot air in the exhaust of a furnace can be used to preheat the combustion air used in the same furnace.

Waste heat is usually best identified as part of an overall energy audit of the industrial process or facility. The audit should identify the fluid type (liquid or gas), the amount of fluid generated, either as a volume or flow rate, temperature of the fluid, the time of production (i.e. only between 10am and 2pm), its location as well as the location of heat using processes. From this information, the monetary value of the waste heat should also be determined.

Once the size and location of the waste heat product is known, a detailed analysis of the energy saving potential as well as the process of selecting an appropriate heat exchanger can be undertaken. Heat exchangers are devices which recover the waste heat from one process for use in another process.

There are a variety of heat exchangers available on the market, suitable for both batch and continuous feed operations. Recuperator type heat exchangers are able to work in continuous feed processes as the heat recovery from the fluid is steady. In regenerator type heat exchangers, heat recovery is delayed due to the storage period required for the release of heat from the fluid, and thus are best suited to batch processes. Careful consideration must also be given to the physical and mechanical performance of the proposed heat exchanger prior to purchase.

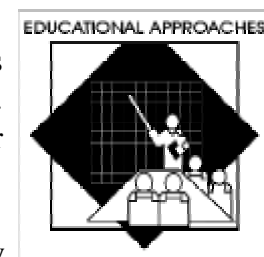
8. Energy Savings Through Cogeneration

Cogeneration is best explained by its alternate name of Combined Heat and Power (CHP). As it suggests useful process heat is generated simultaneously with power. Usually, electrical energy is produced through the combustion of fuel, generating heat as a by-product. Excess heat is recovered and used for process heat applications, including steam. Aside from increases in energy efficiency, CHP has the added advantage of increased reliability of supply for industry, especially where electricity supply is irregular or unreliable. Fuel substitution provides greater flexibility for CHP, where cheaper or renewable fuels are available to replace conventional fuels.

Cogeneration has been extensively used throughout the world in industry and non-industrial applications, such as district heating. However, regulated electricity industries pose significant institutional barriers for cogeneration projects. Case Study 42 examines cogeneration in a typical industrial process, whilst Case Studies 43 and 44 look at regulatory issues associated with the development of cogeneration projects.

9. Awareness Raising and Education

Awareness raising and education of the need and potential for energy savings is as important to the industrial sector as it is to the domestic and commercial sectors. Potential activities for encouraging energy savings are discussed at length in Chapter 4.

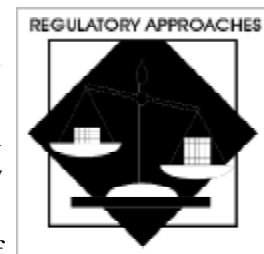


Operator behaviour can have a significant effect on the effectiveness of energy efficiency measures in industrial plant. Simply turning off equipment when it is not being used can provide an easy way of saving both energy and money. Education programs can provide considerable potential for energy savings.

10. Regulatory Measures

There are several regulatory measures that can produce energy savings in the industrial sector. These include:

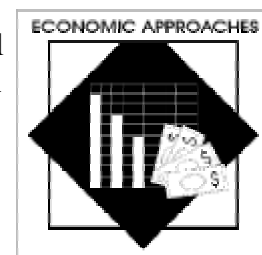
- minimum energy performance standards. Some countries have introduced regulations requiring office equipment to meet minimum standards of energy efficiency
- deregulation of the electricity industry to encourage the development of cogeneration
- building codes can be used to ensure that new buildings meet minimum standards for passive solar design in order to reduce energy use
- changes in the regulatory environment as a result of the control of emissions, such as carbon dioxide and international obligations, such as United Nations protocols



11. Economic Measures

The economic measures available to encourage energy efficiency in the industrial sector are similar to those offered to the commercial and domestic sectors and include:

- time of use tariffs
- subsidies for substitute fuels (including biofuels)
- subsidies for the use of renewable energy
- tax relief for investment in energy efficient equipment
- levies and penalties on energy use



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<http://www.cae.canterbury.ac.nz/energy.htm>



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WEEA Best Practices. <http://www.weea.org/best/>

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http://www.oit.doe.gov/bestpractices/case_studies.shtml

International Programs. <http://www.oit.doe.gov/international/>

Industrial Energy Management in Action. <http://www.oit.doe.gov/bestpractices/pdfs/plantprofiles.pdf>

Energy Efficiency in Small to Medium Sized Enterprises. Tata Energy Research Institute.

<http://www.teriin.org>

The Compressed Air Challenge. <http://www.knowpressure.org/>

Kaeser Compressors

Energy Savings in Compressed Air Systems — Achieving Significant Savings through Energy Management and Cost Savings with Compressed Air System Maintenance.

Available through <http://www.kaesercompressors.com/resource.html#aids>

Case Study 45 The Integrated Wetland System Project



Objective: To treat sewage and waste water by use of an integrated wetland system

Location: Various

Website: <http://info.tve.org/ho/doc.cfm?aid=572>

Description:

Wetlands in urban areas are natural receptacles for wastewater because they harness the nutrients available in waste through fisheries and agriculture. The integrated wetland system project aims to provide a low-cost, ecologically balanced and community linked sanitation option for the poorer cities of the world with ample sunshine. It is a system that frees the river from domestic contaminants and can at the same time recover the wastewater nutrients with remarkable efficiency to grow fish. The system costs less than other technologies for treating sewage and recycling waste.

There are two types of IWS - the flow-through system and the abstracted flow system. The primary objective of the flow-through system is the treatment of wastewater and for the abstracted flow system, it is resource recovery. In the flow-through system, the entire wastewater is transported through a pre-treatment system and is then detained in the recycling ponds for further treatment and for growing fish. Subsequently, the effluent from the recycling ponds is used for irrigation in downstream areas. The flow-through system needs less land to ensure adequate wastewater treatment and is particularly effective where cost of land is high.

The Mudiary Fishermen's Cooperative Society (MFCS)

Drawing support from the experience of the wetlands of eastern Calcutta, the MFCS have been successful in transforming a waterlogged area into a resource recovery eco-system in the south western fringe of the city of Calcutta and in demonstrating the sustainability of wetland option for wastewater treatment and resource recovery. There are 15 ponds of various sizes in the MCFS wetland area. Of these, 9 smaller ponds are used for improving the water quality before it enters the bigger ponds where the fish grow and further improvement of water quality takes place.

About 100 members of the MCFS produce about 5.6 tonnes of fish per hectare per year from about 50 hectares of water area which once was a wooded area. In the process about 23 million litres of composite sewage is treated each day in the wetlands. The entire eco-system has been built without any financial help. The money earned from the sale of fish has given a gross per capita income of about US\$3 per day which is more than three times the minimum daily agricultural wage in India. Municipal sanitation does not need to be a facility for which the government has to provide public money to run the system.

The information in this case study has been reproduced from the original manual on *Integrated wetland systems for wastewater treatment and recycling - for the poorer parts of the world with ample sunshine* prepared for RHUDO/New Delhi, USAID by Dr. Dhrubajyoti Ghosh.

Case Study 46 Energy Efficient Street Lighting



Objective: To improve the energy efficiency of street lighting to save energy and money.

Location: Sundsvall, Sweden

Website: <http://www.caddet-ee.org/infostore/details.php?id=2775>

Description:

Despite measures such as turning off the lighting in certain streets and complete turn off during summertime, expenditure would have had to decrease by 11,5 million SEK to maintain the budget for the Sundsvall municipality. The old street lighting, where it worked, did so poorly. In the technical office in Sundsvall the staff began investigating the possibility to run the street lighting in a more energy efficient way. However changing all electric fittings would demand a major investment. How should this investment fit in the municipal budget?

The answer was life cycle cost analysis (LCCA) and third party financing. With guidance from a methodology produced by the Swedish National Energy Administration, OPET and branch organisations, the LCCA for several options were calculated. The option of changing the fittings to more energy efficient ones had the lowest LCCA. Politicians were positive when they were informed about the possibilities of third party financing and the LCCA analysis. A procurement for 16,200 fittings was made. The evaluation did not only take the price and energy efficiency into account but also several other measures. After a detailed evaluation the choice fell on Thorn Lightings fitting "Streetus".

The Municipality of Sundsvall received several financing options but choose the municipal internal banks concept. Sundsvall is now installing energy efficient street lighting with lower energy and maintenance cost. A part of the energy savings covers the financing.

The energy use for street lighting before was 14,5 GWh/year. After it is 9,7 GWh which corresponds to energy savings of 4,8 GWh/ year or 33%.

The investment for the 16,200 street light fittings was 16,6 million Swedish crowns (SEK). 1 USD = 8,60 SEK. The cost for each fitting is 1,050 SEK.

The value of the 4,8 GWh annual energy savings is calculated to 2 million SEK/year. This gives a payback time of 8 years. The new fittings also demands less maintenance, the decreased cost however is not calculated.

The investment was made available by third party financing by the municipal internal bank. A part of the decreased cost for energy is financing the payment of the investment, interest rate and credits.

Case Study 47 Retrofitting Public Sector Buildings



Objective: To retrofit government buildings.

Location: Various in Australia and California

Websites: <http://www.ncc.nsw.gov.au/environ/index.cfm>

<http://www.lgc.org/freepub/energy/newsletter/jun2001/page04.html>

Description:

Newcastle City Council achieved a reduction of electrical usage by almost 40% at the major works depot by replacing inefficient compressed air systems and lighting systems, and by controlling its water and space heating systems. 400 downlights in City Hall were replaced with compact fluorescent lamps. Energy consumption for the lighting system was immediately cut by 75%, and a 30 kW heat load was removed from the building, thus reducing HVAC requirements. Refurbishment of the Council's Central Administration Centre involved provision of power factor correction equipment, installation of automatic lighting control for 14 toilet suites, and retrofitting 1200 fluorescent office light fittings with low energy ballasts which reduced the lighting system energy consumption by 47%.

Department of Transport and Regional Development Buildings, Australia

Department of Transport and Regional Development has four buildings in Civic, Canberra. The department has established a refurbishing program that as each floor is due for refurbishment:

- replaces existing lighting systems with better quality and more energy efficient light globes;
- establishes block lighting patterns that enable sections of each floor to be lit rather than the whole floor
- installs light sensors on conference and training rooms

The cost of changing over to more energy efficient systems should be repaid in approximately two years. Whilst savings have not been formally accounted for at this stage, as the refurbishment is still under way, it is estimated that the Department should save around 10% on its electricity bill over the next 12 months.

Cool Roofs Help Schools and Local Governments

The Local Government Commission is helping to coordinate the California Energy Commission's Cool Savings Program. The focus will be to help local governments, schools, colleges and universities install cool roofs this year. What's a cool roof? While most roofing materials absorb heat, a cool roof reflects at least 65% of the sunlight hitting it, significantly reducing the amount of heat penetrating the structure. Cooling energy savings resulting from a cool roof can be 20% or more. The amount of savings will depend upon your geographic location (hotter climates mean more savings) and the condition of your building (less efficient buildings will save more with a cool roof). Cool roof rebates are available for air conditioned spaces throughout most of California. Most approved cool roof products are for flat roofs, including coatings and membranes. For peaked roofs, there currently is only a clay tile, but a cement tile manufacturer is also seeking approval

Case Study 48 Electrical Energy Savings in a Government Ministry Building



Objective: To reduce energy costs in government buildings by a range of measures including no or low-cost strategies.

Location: Accra, Ghana

Website: <http://www.ase.org/ghanaef/MOME.PDF>

Description:

Electricity supply in Ghana suffered a serious decline in 1998 as a result of several factors but mainly due to the poor inflows of water into the Volta basin, which until then accounted for 95% of Ghana's electricity supply. The shortage also coincided with a period when the Public Utilities Regulatory Commission had initiated tariff adjustments aimed at removing priced subsidies to enable the utilities to meet the high cost of power production and distribution and also attract private investments into the Power Sector.

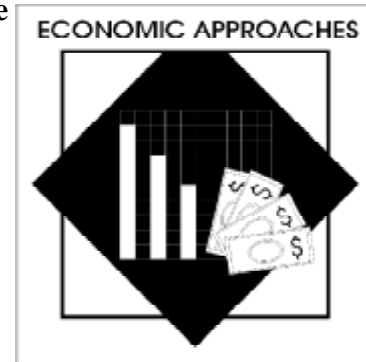
These recent electricity tariff adjustments and a high incidence of electrical energy waste have been identified as some of the primary causes of high government recurrent expenditure. Government Ministries, Departments and Agencies are making efforts aimed at reducing expenditure on utilities especially electricity. For this purpose, the Ministry for Mines and Energy has since February 1998, undertaken measures aimed at eliminating waste, improving efficiency and reducing electricity consumption in its building in Accra.

The measures included:

- Energy Auditing
- Educational Campaigns
- Power Factor Improvement
- Lighting Improvements
- Retrofitting of Windows for Draught Proofing
- Relocation of Air Conditioner
- Installation of Occupancy Sensors

These measures resulted in a reduction of electricity consumption in the building by 26,907kWh and maximum demand savings of 351kVA in 1999. The total cost saving in 1999 was c9.84million. The PIR sensors alone saved 14% of the total energy consumption or 21% of consumption due to air conditioning and internal lighting.

Case Study 49 Rooftop Gardens: Urban Heat Island Initiative



Objective: To reduce the urban heat island effect through the creation of rooftop gardens.

Location: Chicago, USA and Toyko, Japan

Websites: <http://w4.ci.chi.il.us/environment/AirToxPollution/oldUrbanIslands.html>
<http://www.cityofchicago.org/Environment/html/RooftopGarden.html>
http://jin.jcic.or.jp/trends/article/011003bus_r.html

Description:

Chicago's Urban Heat Island Initiative is designed to ameliorate the effects of dark surfaces and reduce pollution by:

- using alternative paving
- constructing light-colored roofs
- using alternative energy sources
- increasing greenspace
- installing rooftop gardens

The Chicago Department of Environment (DOE) is testing the benefits of rooftop gardens as part of its Urban Heat Island Initiative. Chicago is one of the few cities in the country to use rooftop gardens to reduce energy demand and lower area temperatures. The 20,300 square foot garden will started with 20,000 plants of more than 150 varieties including 100 shrubs, 40 vines and 2 trees. The plants were selected for their hardiness on a roof, where wind and watering are two challenges. The low-maintenance garden relies on a special blend of compost, mulch, and spongelike ingredients that weighs less than regular topsoil and retains more water. The rooftop garden will decrease City Hall's air conditioning and heating bills and also reduce ozone pollution and smog, and improve air quality. Temperature, stormwater run-off and other data will be measured against the adjoining Cook County building, which has a conventional black tar roof. Local high school students will get to participate in collecting and measuring data.

Many of Japan's leading general contractors are putting efforts into the development and sale of products related to rooftop greenery, which involves planting trees, flowers, and other plants on top of condominium and other buildings so as to absorb heat. And some home furnishing companies are selling rooftop-greenery systems for individual homes. It is hoped that rooftop greenery will lessen the "heat-island" effect, cut air-conditioning costs, and reduce noise pollution. The national and local governments are beginning to take up the challenge of encouraging the spread of this technology. The Tokyo metropolitan government passed a law requiring new buildings to make use of rooftop greenery beginning in April 2001.

Similar projects, some of which also incorporate food production, are listed below:

Roofwater Fish Farm (Australia) <http://www.cityfarmer.org/fishfarm.html#fishfarm>. An Urban Rooftop Integrated Microfarm For Mt.Gravatt's Commercial Buildings (Australia) <http://www.cityfarmer.org/rooftopmicrofarm.html#microfarms>. Singapore's Aero-Green Pioneers Tropical Aeroponics <http://www.cityfarmer.org/aeroponics.html#aeroponics>

Case Study 50 Employee Education Program



Objective: To save energy in municipal facilities by a range of measures including educating and involving employees in developing appropriate strategies.

Location: Saskatchewan, Canada

Website: <http://www.emtfsask.ca/studies/northbattleford.htm>

Description:

The North Battleford Energy Management project grew out of the successful Destination Conservation (DC) Project for schools run in Saskatchewan by the Saskatchewan Environmental Society (SES). The DC program combines education, practical energy savings measures, and innovative financing. Savings from one year's investment in energy management are re-invested in further retrofits. Limiting the first year measures to low cost/no cost measures, and running the program for three years means significant savings are achieved without any capital investment.

One major component of the programme was a survey. The purposes of the survey were to:

- Determine attitudes toward energy efficiency,
- Establish baseline measures of employee awareness and practice of energy savings activities
- Determine preferences for the type and sources of information, training and other tools and techniques to encourage and build awareness of energy savings options.

The result of the first questionnaire formed the basis of comparison for employee awareness, practices, and attitudes against which the results of the second questionnaire, distributed toward the end of the project, were compared. The second questionnaire was a slightly simplified version of the first questionnaire, so that the main focus would be on comparing employee attitudes, awareness and practices in regards to energy conservation. It was felt that it would be redundant to reassess preferences for types and sources of information and training at the end of the project.

The first self-administered questionnaire, which was distributed in August 1994, was responded to by 48 of 50 possible respondents. This represents a 95% return rate. 21 respondents returned the second questionnaire. Although the difference between the two sample sizes may be of some concern, it does appear that despite the smaller sample size, a good cross-section of employees was represented on the second questionnaire.

The first questionnaire found that there was quite high awareness of and positive attitude toward energy efficiency. The first questionnaire also found that energy conserving behaviour was well established at home.

The findings of the second questionnaire suggest that this high awareness, positive attitude, and active engagement has been modestly improved upon during the course of the project.

Case Study 51 City Energy Challenge



Objective: To motivate City operations to cut energy use and save money.

Location: Portland, Oregon, USA

Website: http://www.sustainableportland.org/energy_gov_challenge.html

Description:

It takes a lot of energy to run the City of Portland's parks, offices, sewage treatment plants, street lights, maintenance and repair vehicles, and much, much more costing the City several million dollars each year. In 1991, the City created the City Energy Challenge Program to cut energy use - and save money - in City operations. The program is a response to the City Energy Policy, which was adopted in August 1979 and updated in April 1990. The policy's goal is to: "Promote a sustainable energy future by increasing energy efficiency in all sectors by ten percent by the year 2010." The City has already exceeded that goal. Between July 1991 and July 2000, the program saved \$7.55 million. Currently, the savings equal \$1.38 million per year and, there are additional projects being considered that can save even more energy. By the end of 2001, we hope to have cut our annual energy use by nearly \$2 million per year - more than 15 %!

In 1995, the City signed an innovative contract with Portland General Electric (PGE) to purchase "green" power generated by wind or other renewable resources. The contract allowed the City to take advantage of wholesale rates for a 10 MWA minimum power purchase, and to require PGE to purchase five percent of that power from renewable resources. As a result, the City cut costs substantially for 95% of the purchase, and paid a premium for the five- percent of renewable power it received. Net savings: \$300,000 per year.

In July 1999, the City's Bureau of Environmental Services unveiled a methane-powered fuel cell at the Columbia Boulevard Wastewater Treatment Plant. The 200-kW fuel cell is one of only a handful of fuel cells in the U.S. that operates on a renewable fuel. It produces about 1.4 million kilowatt-hours a year.

Funding for this project was obtained through federal and state grants, including a \$200,000 grant from the U.S. Department of Defense. A rebate of \$247,000 from PGE in effect returned the green power premiums that the City had paid them earlier. The Oregon Office of Energy also provided a \$224,000 tax credit. Additional financing was provided by Western Bank, a subsidiary of Washington Mutual Savings Bank.

Just before Earth Day 2000, the City made another commitment to sustainable energy. City Commissioner Erik Sten announced that the City will buy electricity from renewable resources such as wind and solar (also known as "green power") through PGE and Pacific Power's green power programs. Today the City purchases over 600,000 kWh per year of green power for selected City facilities.

Case Study 52 Energy Management Programs



Objective: To assist local governments to reduce energy costs through appropriate energy management projects and practices.

Location: Victoria, Australia

Website: <http://www.sea.vic.gov.au/advice/government/local.html>

Description:

The Sustainable Energy Authority's Local Government Program is designed to assist councils to achieve reductions in recurrent energy costs through sound energy management projects and practices. The Sustainable Energy Authority provides a range of support and financial assistance programs to facilitate the implementation of cost efficient and greenhouse friendly energy technologies, renewable energy and energy management practices in all sectors of the Victorian community.

The Municipal Energy Management Support (MEMS) program consists of a series of workshops designed to help local governments gain an understanding of basic energy management principles. The aim of the MEMS program is to enable local governments develop and implement successful and sustainable energy management programs.

An easy to use Municipal Energy Management (MEM) Tool software package has been developed to assist Councils track and report their energy consumption and greenhouse performance. This information provides the means by which energy trends can be analysed, tariffs reviewed and improvements monitored. The MEM Tool also contains benchmark data which allows councils to compare their relative energy performance against other Council sites.

The most important step in developing a realistic and workable municipal energy management plan is to identify energy saving opportunities through energy audits. An energy audit establishes where and how energy is being consumed, and provides an accurate assessment of the potential for savings.

The only effective way to manage energy consumption and costs is by assigning responsibility to an internal "Energy Manager" as part of an energy management program.

Once energy savings and renewable energy opportunities have been identified, it is important to prioritise them and develop an implementation plan. The plan should take into account the findings of any relevant energy audit reports, and should have senior management endorsement. It should also include project time frames, responsibilities and budgets.

Implementing a Staff Awareness Program

Another key ingredient for the success of an energy management program is to maintain a high level of awareness amongst staff. Sustainable Energy Authority can provide material for newsletters, case studies and a range of energy efficiency and renewable energy literature for council staff to help them save energy and money at home.

Case Study 53 Life-Cycle Costing



Objective: To use life-cycle costing to assist make economic decisions and plan for new buildings or retrofit existing ones.

Location: Washington, USA

Website: http://www.eren.doe.gov/cities_counties/elecpro.html

Description:

The State of Washington has used Life Cycle Costing Analysis (LCCA) since 1975. In Washington, LCCA must be used in the building design for new construction or renovation of any public building with more than 25,000 square feet (2325 square meters) of useable space. Renovation projects include additions, alterations, or repairs that exceed 50% of the value of the building and that affect any energy system. The state's Superintendent of Public Instruction also requires that a school's LCCA be approved by the Washington State Energy Office (WSEO) before a school district receives state matching funds.

According to a report issued by the state, next to personnel costs, energy costs are schools' dominant operating expense. But the catch is that school districts have limited capital and operating funds. That's where LCCA offers some help. LCCA gives the school districts information that can be used for making long-term economic decisions.

LCCA is used primarily for building envelope design and for systems that use energy, such as heating, ventilating, and air-conditioning (HVAC) equipment, domestic hot water systems, and lighting systems. State staff members routinely use computerized energy simulation models for calculating energy use and cost of various options. The state also maintains information such as service life, energy performance standards, energy use indices, and LCCA spreadsheets on all types of equipment.

WSEO does not force public agencies to purchase items or materials with the lowest LCCA, but, in the case of schools, the school boards must vote not to implement the results of the LCCA. "The fact that the vote takes place in a public setting acts as a deterrent because it's a type of public pressure," Sheridan explains. "The public forum makes the boards accountable."

Free software is available that makes LCCA easy and inexpensive. The software, Building Life-Cycle Costing Computer Program, Version 4.14, was developed by the National Institute of Standards and Technology for the U.S. Department of Energy Federal Energy Management Program.

Case Study 54 Buy Recycled Campaign



Objective: To contribute to energy savings through the purchase of recycled products.

Location: California, USA and Victoria, Australia

Website: <http://www.ciwmb.ca.gov/BuyRecycled/StateAgency/Default.htm>
http://www.ecorecycle.vic.gov.au/buy/buy_index.asp

Description:

The State Agency Buy Recycled Campaign (SABRC) is a joint effort between the Department of General Services (DGS) and the California Integrated Waste Management Board to implement State law requiring State agencies and the Legislature to purchase products with recycled content. It compliments the efforts of the Integrated Waste Management Act which was enacted as an attempt to reduce the amount of waste going to California's landfills.

Under the State Agency Buy Recycled Campaign, every State department, board, commission, office, agency level office, and cabinet level office is required to:

- purchase products that contain recycled material
- certify the recycled content of all suppliers' products
- submit an annual report on products purchased in reportable product categories

The State Agency Buy Recycled Campaign requires that the California Department of General Services (DGS), in consultation with the California Integrated Waste Management Board:

- Submit a report to the Legislature every year on the State's progress in buying recycled products.
- Develop a uniform reporting procedure for agencies to follow.
- Make recommendations on revising the procurement policies of any agency that has not met the buy recycled requirements. These recommendations will go to both the individual agency and the Legislature.

Buy Recycled Campaign, Victoria, Australia

Each Victorian council has been given copies of the Buy Recycled Resource Kit. This is a comprehensive guide to understanding and planning how a council can implement a Buy Recycled Purchasing Program. Naturally, much of the information is relevant to many other organisations and for this reason the kit has been reproduced onto this site as PDF documents.

King County Recycled Product Procurement Policy, King County, Washington, USA , <http://www.metrokc.gov/procure/green/policy.htm>

Environmental Purchasing Policy

The Starter Kit includes program implementation strategies; case studies; model resolution and a resource list.<http://www.naco.org/programs/envirom/purchase.cfm> (form for purchasing, cannot be viewed online)

Case Study 55 Subsidies for Regional Energy Programs



Objective: To provide subsidies to local governments to assist them in implementing regional energy programs.

Location: Korea

Website: [http://wrweb.com/escap-ngo-profiles/ngo-profile-kemco.htm#Regional Energy Program](http://wrweb.com/escap-ngo-profiles/ngo-profile-kemco.htm#Regional%20Energy%20Program)

Description:

The Korea Energy Management Corporation (KEMCO) is a non-profit government agency in charge of implementing energy efficiency and conservation policies and programs.

Regional Energy Program

The Regional Energy Program supports various activities to stabilize demand and supply as well as the rationalization of energy by local government in the region. The Ministry of Commerce, Industry and Energy (MOCIE) provides local governments with subsidies to effectively implement the regional energy program. KEMCO provides education and training courses, technological consulting and information services for public servants charge of local governments' regional energy programs.

The Regional Energy Program consists of two sub-programs:

- Infra Build-up Program such as the establishment of regional energy planning, the feasibility study of unused and/or new renewable energy sources in the region, public relations and energy conservation education; and,
- Demo Project to invest in the facilities of energy conservation or the utilization of unused and/or new renewable energy.

Case Study 56 Performance Contracting



Objective: To save energy and use the cost savings to fund further improvements.

Location: USA

Website: http://www.eren.doe.gov/cities_counties/elecfin.html

Description:

A local government can increase energy efficiency without making any initial capital investment. A city or county can decrease energy costs and simultaneously reserve available capital for other projects.

This is called performance contracting, and it's a growing trend because it's a win-win situation. Everyone comes out ahead—business, government, and the taxpayer. Under such an agreement, a third party provides a city or county with a service package that typically includes the financing, installation, and maintenance of energy-saving capital improvements. The customer uses resulting energy savings to pay for the improvements. Performance contracts are often structured as a lease, but with a guarantee that payments will not exceed energy savings. This minimizes financial risk.

According to Ron Mutter, Director of Public Works for Redlands, California, that's exactly the type of arrangement that has worked for the city of Redlands. Honeywell, Inc., approached a city council member about replacing and updating the city's heating, ventilating, and air-conditioning (HVAC) equipment, wastewater pumps, lighting systems, irrigation systems, and sensors.

When everything is completed, improvements will have been made to 12 buildings and park irrigation systems.

In March of 1992, the city and Honeywell signed an agreement projected to save the city at least \$462,683 in energy and \$143,455 in labour and maintenance costs for the first year of operation. The equipment replacement project is financed with a municipal lease and a maintenance contract. Costs are covered by the energy savings and a Honeywell guarantee.

The city is already saving substantial amounts of money. "The city's energy use is about half what it was 2 years ago," says Mutter. In utility rebates alone, Redlands has received more than \$100,000 from Southern California Edison. "The wastewater treatment plant will be able to increase throughput without increased energy costs, while saving more than \$20,000 a year," Buckingham says.

For financing, a 7-year lease was structured; once it expires, savings will revert to either a city general fund or a utility fund. Although Honeywell guarantees the city that its savings will at least meet the sum of its lease payments and maintenance payments, the company anticipates that savings will exceed payments. If savings do exceed payments, the city keeps the extra money.

Case Study 57 Energy Management, Matching Grants and Budget Incentives



Objective: To fund energy management programs through matching grants and budget incentives.

Location: Arizona, USA

Website: <http://www.commerce.state.az.us/newenergy/outreach.html#memp>

Description:

The Municipal Energy Management Program encourages the development and utilization of energy management plans in Arizona municipalities with populations under 70,000. A limited number of \$10,000 matching grants are available for cost effective energy upgrade projects. The energy office provides a software package that enables municipalities to easily track energy use and costs through their utility bills.

You can motivate department heads and employees to save energy through effective energy management. This process usually involves all city departments and often relies on the expertise of existing staff. There are at least two financial components of effective energy management: accounting and budget incentives.

Tracking energy costs is the first essential step. In some municipalities, energy costs are totalled for each department. In others, energy costs are listed as a series of unrelated expenses for each department. If this last type of accounting is used, which is often the case, city managers and department heads may not even know how much they spend on energy. In that event, the first step in effective energy management is to begin to monitor consumption and costs.

Budget incentives can play a key role in effective energy management. With budget incentives, the departments or city agencies participating in the program keep all (or a predetermined part) of the money saved from using energy more efficiently. This arrangement is quite different from typical local government budgeting, where dollar savings often lead to smaller budget allocations the following year. Because it could reduce their available funds, local government agencies often do not have an incentive to save money on energy. Budget incentives, on the other hand, are effective because they encourage initiative and because they establish a permanent funding mechanism for energy efficiency. The incentives can take several forms. In some cities, part of the savings is returned to the departments involved in the program, such as the Los Angeles Fire Department or the Philadelphia public schools. In other cities with a centralized energy office, such as Phoenix, the savings return to the general fund. Whatever its form, the incentive is effective when dollar savings from energy projects are in turn used to establish a permanent fund for financing other energy conservation and energy efficiency projects.

The fund is used to help departments purchase new energy-conserving capital equipment. For example, if a department needs to buy new energy-consuming equipment, such as a chiller for air conditioning, the fund can pay for the difference between an energy-efficient model and a cheaper model that is less energy efficient.

Case Study 58 Iowa Energy Bank



Objective: To use energy cost savings to repay financing for energy management improvements

Location: Iowa, USA

Website: <http://www.state.ia.us/dnr/energy/programs/bem/ebank/index.htm>
<http://www.state.ia.us/dnr/energy/pubs/bem/EnergyBank.pdf>

Description:

The Iowa Energy Bank is an energy management program using energy cost savings to repay financing for energy management improvements which targets public and non-profit facilities (public schools, hospitals, private colleges, private schools, and local governments). The Iowa Energy Bank is expected to facilitate more than \$250 million in improvements using private funds in combination with minimal state and federal support.

Starting with an initial energy audit, the Iowa Energy Bank helps manage the energy efficiency improvements and financing process every step of the way. Experts will customize solutions that meet the specific needs of an organization, with the assurance of high technical quality and the potential for attractive cost savings. Financing is provided through area lending institutions that create budget-neutral, affordable financial packages.

The Iowa Energy Bank (the Bank) provides the necessary technical and financial assistance for creating energy management improvements. The program offers a three-step program:

- A preliminary energy assessment is completed for the facility. This assessment may be an extensive energy audit, or for small facilities, a simpler assessment of energy consumption and potential improvements by Energy Bank program staff.
- If necessary, an engineering analysis is completed for the facility by a qualified consultant. A six-month, interest-free loan is available to pay the up-front expense of the energy audit and engineering analysis.
- Full-term, municipal lease-purchase agreements or capital loan notes from private lending institutions are available at interest rates negotiated for the client by the Iowa DNR. All clients of the program are eligible for financing of cost-effective energy management improvements.

Examples of energy efficiency improvements include:

- fluorescent lamps and ballast replacements
- lighting controls
- exit sign replacement
- pipe insulation
- new heating and cooling equipment
- water heater blankets
- insulation
- doors
- low-flow shower heads and toilets
- ground-source heat pumps
- wind energy

VI. ENERGY SAVINGS IN THE PUBLIC SECTOR

A. Public Sector Energy Use

In many countries government authorities are responsible for a range of public services such as infrastructure provision including harbours, airports, roads, water supply, power generation, street lighting, waste disposal and sewerage. Other services include health and education services, public administration and social services. Many of these state or city-owned public services are heavy users of energy.

Public sector agencies are generally accountable to the public through a Council or a Parliament in a way that private sector agencies are not. The public generally expects the public sector to set an example to the community in the efficient use of public funds. Energy savings are an important aspect of this. As the public sector often generates power, supply side efficiency is as important as demand efficiency.

The major areas of energy use in the public sector depend on the local situation and the responsibilities of that sector in the national scheme of government which are generally:

- Lighting – particularly of public areas
- Heating and cooling of buildings
- Public transport
- Construction of roads and buildings
- Sewage treatment and waste disposal
- Management of reserves and public facilities

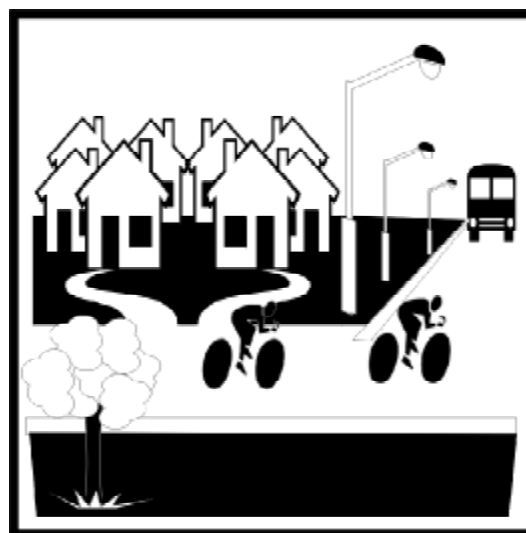


Figure 6.1: Energy use in the public sector is extremely diverse as illustrated in this figure.

These issues will be addressed in this Chapter although they are also covered in a different context in other Chapters.

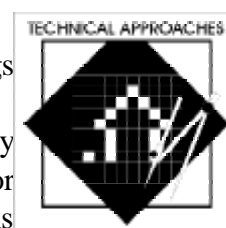
B. Strategies for Saving Energy in the Public Sector

Although energy bills only represent about 1-2% of a local Council's budget (ICLEI, Finance Department), Councils have an enormous capacity to influence energy efficiency on a local scale, and perhaps most importantly set an example to business and the community on the issue. Local governments can influence up to 50% of local greenhouse gas emissions through direct emissions from waste or in the more general urban planning issues of transport and energy efficiency.

1. Technical Strategies

Governments are responsible for most infrastructure provision and considerable savings can be achieved by:

- Choosing materials with low embodied energy. Embodied energy is the energy consumed by all of the processes associated with the production of buildings or infrastructure, from the acquisition of natural resources to product delivery. This includes the mining and manufacturing of materials and equipment, the transport of the materials and the administrative functions
- Installing energy-efficient technologies
- Using local renewable energy supplies (see Chapter 7 for more options)



Water Supply and Sewerage

Large amounts of energy and resources are incorporated into conventional water supply and sewerage infrastructure. Embodied energy needs to be considered at the planning stage. Savings can be made pumping water by adopting strategies such as using high-efficiency motors and pumping to the minimum pressure required. Other tips can be found in *Managing Energy in Local Government*.

In sewage treatment pumping is also a significant energy user along with the aeration process. Energy savings can be achieved in the aeration process by controlling the operation of the aeration fan through the use of dissolved oxygen sensors, reducing the pressure drop of air pipes and employing high-efficiency motors.

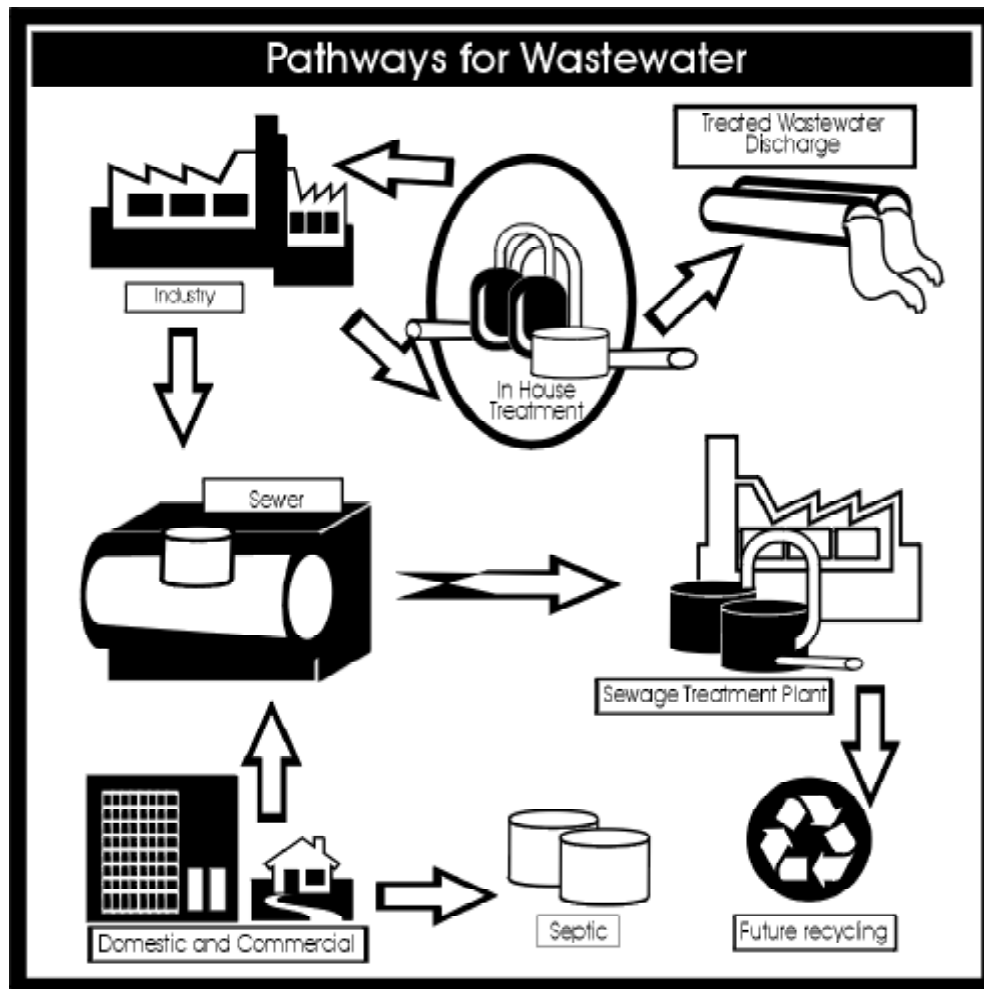


Figure 6.2: The options for the disposal of wastewater are varied as illustrated in this figure.

An alternative approach to the treatment of sewage is a constructed wetland system. In a report by Fujita Research on *Constructed Wetlands for Wastewater Treatment (Report 022)* it is stated that, "it is now recognized that constructed wetlands are an economic way of treating liquid effluent." The report points out that constructed wetlands are not widely used in developing, tropical countries which is the very environment in which such wetlands perform best as the continuous growing season means that the wetland biomass can also be harvested. These constructed wetlands can form an integrated part of the food production system in such climates. Water that has flowed through the wetland can be used to irrigate crops and/or be introduced to a fishpond. In this final stage, remaining nitrates and phosphates stimulate the growth of phytoplankton - the favorite food of the Tilapia (*Oreochromis niloticus* L.), a food fish becoming increasingly popular in Europe.

A US AID project is testing the development of Integrated Wetland Systems. See Case Study 45.

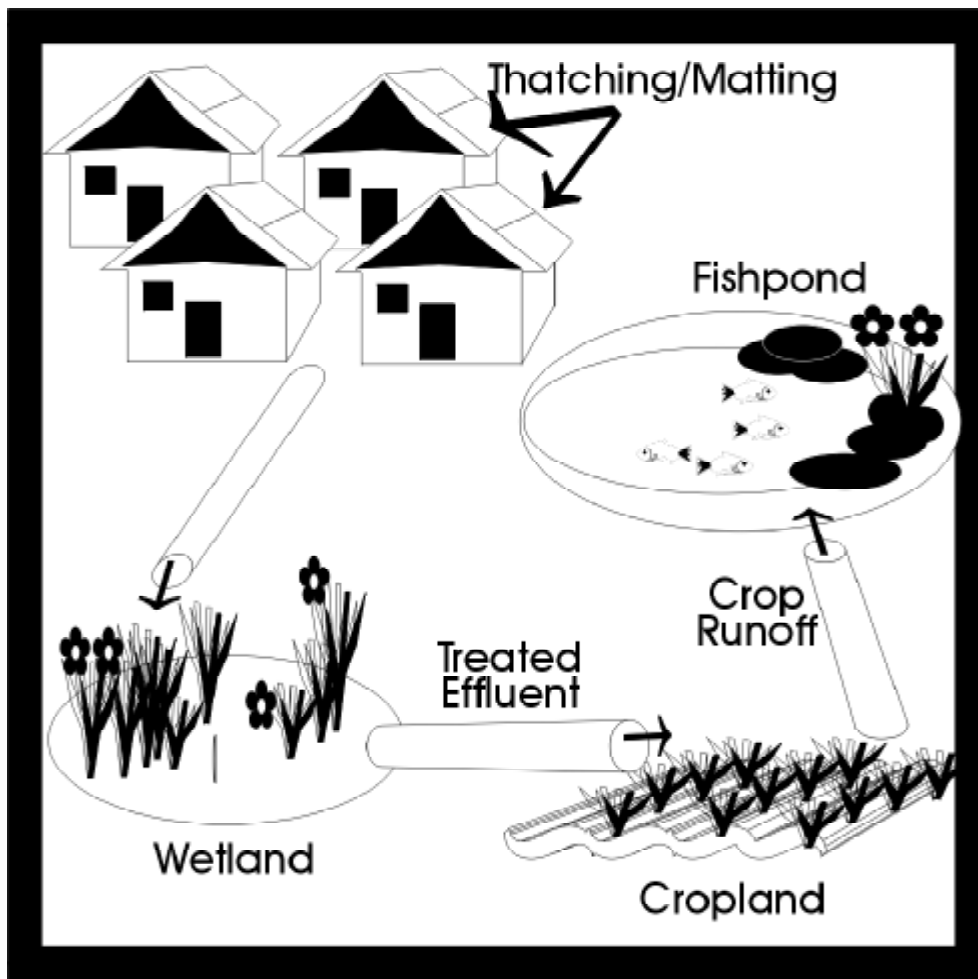


Figure 6.3: Wetlands Integrated Within a Village Food Production Cycle

Significant energy savings can also be made by using energy derived from sewage facilities to run the plants and to supply local industry (see Chapter 7 for more details on supply options).

Waste Management

Most local government authorities manage solid waste disposal facilities and much of this waste has value as recyclable resources or as a source of energy and soil conditioners. There are many different waste to energy schemes in operation or under consideration. This is a form of cogeneration which can yield considerable savings as well as social and environmental benefits. Some examples of this are provided in Chapter 7.

Street Lighting

Street lighting can be the most energy intensive service that local Councils provide and so there is significant scope for cost and energy savings by improving light efficiency. A 1999 Study by Energy Efficiency Victoria and the Sustainable Energy Development Authority found that the quality of street lighting could be improved considerably and energy consumption at least halved, by a combination of:

- More efficient lamps eg. metal halide, compact/tubular fluorescent
- More efficient luminaries which incorporates reflector design, reduced light loss in the diffuser and more accurate light distribution
- Efficient ballasts such as 'low loss' or electronic ballasts
- More accurate control of lighting times eg. by using an electronic photo-switch

See Case Study 46.

The Efficient Lighting Initiative (ELI) as mentioned previously aims to speed up the uptake of energy-efficient lighting technologies in emerging markets in developing countries. ELI is designed to lower market barriers to efficient lighting in Argentina, the Czech Republic, Hungary, Latvia, Peru, the Philippines and South Africa through a set of multi-country initiatives, local and global partnerships, and interventions suited to individual country conditions. ELI aims to motivate the government/public sector to carry out the retrofitting of street lamps to more energy-efficient versions. In the Philippines governments are being encouraged to install high-pressure sodium (HPS) lamps for street lighting, replacing the conventional mercury vapour lamps.

The electricity used to operate traffic signals has risen steadily with the growth in urban populations and motorised transport. Traffic signals are usually on 24 hours a day and the older technology normally uses high-intensity low-efficiency incandescent lamps with coloured lenses that further reduce the lamps efficiency. For traffic signals ELI's proposed specification is technology specific, specifying that to qualify for inclusion in ELI programs traffic signal systems must use light emitting diode (LED) - based products for at least the red signal. Traffic signals LEDs are energy efficient, durable and give out coloured light, removing the need for coloured lenses.

Building Design, Insulation and Air Conditioning

Significant energy savings can be achieved by careful building design or by retrofitting existing buildings. The AGO recommends that the single most important strategy in reducing the impact of embodied energy is to design long life, durable and adaptable buildings. Many of the ideas discussed previously can be applied to public buildings. Retrofitting is typically more difficult and expensive than building an energy efficient building in the first place.

Since most Council buildings have 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 Council buildings. The smaller the building, the more energy insulation will save. More than 60% of energy use in office buildings results from heating, cooling and ventilation.

Reverse cycle air conditioners are an energy efficient heating option for small offices, however on a larger scale this may not be the case. Opportunities for savings include: ensuring the system is maintained properly for example checking thermostat setting, sealing off air leaks around doors and windows. Blinds can be used as an aid to insulation. In the winter, closing blinds at the end of the day or on a cold winter's day, cuts down on heat loss.

See a series of short retrofitting examples in Case Study 47 and an example of electrical energy savings in a municipal building in Ghana as described in Case Study 48.

Interior Lighting

Numerous strategies are available for reducing energy from indoor lighting, many of which have been mentioned before in Chapter 2. These include:

1. Operate lights only when required - most Councils practice this policy, however it is doubtful that 'turning off' is practiced all the time. Occupancy sensors – which do not cost much and are mounted near doorways sense when a room is empty and automatically turn off the lights.
2. Use of an efficient light source.
Increasing daylight levels can reduce electrical lighting loads by up to 70%, providing that artificial lighting is controlled. Skylights are cost effective and improve user satisfaction within the workplace.

Compact fluorescent lights are more expensive but will reduce lighting bills by up to 80%. A standard 36-watt fluorescent lamp costs about \$2 to buy, but about 10 times this to operate in a building for just one year. In addition it has a shorter life, lower efficiency and poorer light colour and quicker performance degradation than a compact fluorescent. Traditional recessed fluorescent lamp fittings with acrylic plastic diffusers deliver about 50% of the light produced by the lamps.
4. Lighting systems require regular maintenance. There is a tendency to keep fluorescent lamps until they are no longer of use, by then they could be producing only a third of what they produce when new. Regular maintenance programs including cleaning of windows enables the following advantages:
 - light quality of the built environment is maintained
 - tendency to add more light fittings because of falling light levels will be avoided
 - bulk lamp replacement facilitates recycling through a special lamp crusher. Lamps that are replaced individually end up as landfill where the mercury they contain contributes to environmental contamination
5. 'Light' furnishings - Light coloured walls, ceilings and furnishings reflect more light to working areas and so need less artificial lighting to achieve required luminance. The walls in many government offices are painted white for this reason.

Office Equipment

Whilst computers and associated equipment are a smaller contribution to energy use, energy efficiency in this area will produce substantial savings. Energy use can be influenced through:

- specifications established for new equipment
- the extent to which energy saving features are utilised

Purchasing policies are important. "Energy Star" is an international standard for energy efficient equipment and can reduce energy consumption of individual products by over 50%. Printers and fax machines in this category can cut electricity use by over 65%, thus saving around \$20 per unit per year in electrical costs. However, energy features do need to be installed and used, for savings to be realized. 'Sleep mode' is one of these features, 'Screen savers' do not save electricity (*Energy Smart Schools Computer Related Equipment*). All electrical equipment should be turned off overnight or when it is not required on a regular basis.

In addition there are a number of other considerations when purchasing equipment. With photocopiers it is worth comparing the rated volume with actual copying volume before purchase in order to minimise wasted energy arising from the idle times. Considering different 'styles' of equipment such as laptop computers which run on 1/10th the energy required by desktop PC's. The extra cost of machines can be recovered very quickly through energy savings.

Kitchen Equipment and Hot Water Systems

Fridge location and maintenance are important in managing energy usage. In addition buying the right size fridge to suit needs and checking the energy labelling is important. Lower initial cost may not equate to ongoing low cost if the energy efficiency is low.

The installation of a solar hot water system with a booster may reduce hot water energy usage. Every 200L of hot water used from an electric water heater uses about 6 kWh of electricity and generates about ten kilograms of greenhouse gases. Reducing heat losses from an electric storage water heater by wrapping the tank with extra insulation may save up to half a tonne of greenhouse gases and save \$60 per year. In addition, many boiling water units are oversized. In most cases a five-litre unit is adequate, as it can supply 40 cups of hot water and recover temperature in a few minutes. Communal hot water systems should not be left on for 24 hours and over weekends.

Installing a timer, so that hot water systems are turned on early in the morning and off in the evening would result in reduced electricity consumption and will repay the cost of purchase quite quickly.

Streetscaping and Urban Forestry

As mentioned in Chapter 2, cities tend to heat up because of extensive heat-absorbing surfaces. Asphalt, concrete, and other building materials are very effective at absorbing light and reradiating it as infrared radiation (heat) that increases the temperature of the air. In turn this makes air conditioning systems work harder, even after sunset.

NASA scientists have found as part of the Urban Heat Island Pilot Project carried out in the 1990s that the evaporation of water absorbs a lot of heat. Plants and trees evaporate large quantities of water from their leaves. The energy needed to evaporate water is drawn from the air and from the sunlight intercepted by the leaves, thus cooling the air. Additionally, trees are very effective in shading the ground and so reduce the heating of the surface by sunlight.

Not only can people plant trees on their own properties but Councils can contribute by appropriate tree plantings along streets and public places. Trees can be used to shade buildings and pedestrian areas thus reducing the heat island effect. This could be combined with urban forestry programs which would have the added bonus of cutting transportation costs for timber.

The City of Toronto has initiated a Cool Toronto Project - Toronto's Urban Heat Island Mitigation and Adaptation Project. "Cities can be cooled by strategically placed vegetated areas.

Trees and other vegetation can shade buildings, pavements, parking lots and roofs, and naturally cool a city by releasing moisture into the air through evapotranspiration.



Figure 6.4: The electricity used by a two-door fridge may generate up to 1.5 tonnes of greenhouse gas and cost up to \$180 per year.

By protecting buildings from wind, trees can reduce heating costs in winter, and through direct shading and evaporative cooling, can contribute to reductions in air conditioning use in summer.

The use of reflective surfaces such as light-coloured roofs, roads, and parking lots are another way to cool cities. Light-coloured surfaces reflect rather than absorb heat. The more solar radiation a surface absorbs, the hotter it gets. The more radiation it reflects, the cooler it stays, and cooler surfaces can be achieved with little or no additional costs.

Strategically placed vegetation and the use of reflective surfaces will not only help cool cities during summer months, but also lower energy bills by reducing energy use (a hot roof translates into much higher air conditioning costs). This in turn reduces greenhouse gas emissions and ultimately improves air quality.”

A couple of rooftop garden projects are described in Case Study 49.

2. Educational Strategies

As mentioned in previous Chapters, education strategies can be implemented to inform government employees of ways to save energy in their departmental practices and adopt energy-saving behaviours in their travel to work and their use of office equipment.

Informing Government Employees

In government workplaces, there are numerous opportunities for saving energy. For example, the following measures could be taken to save energy in the office;

- Inkjet printers can be used for draft printing. Whilst laser printers produce higher quality images they use 5 – 10 times more energy when printing and idling.
- Turning a photocopier off when not in use reduces its annual electricity use by over 60%, which equates to approx \$90 per year. Making sure that computers, printers, fax machines and photocopiers are turned off at the power point during extended inactive periods of time can further reduce electrical consumption.

See Case Study 50 about an Employee Education Program in Saskatchewan, Canada.

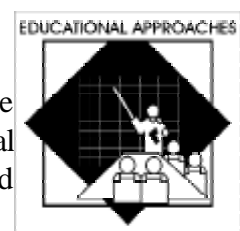
Reporting Successes

Another way to motivate changes in behaviour and practices can be by publicising and/or recognising best-practice or innovative projects. See City Energy Challenge Case Study 51

3. Regulatory, Policy and Planning Strategies

Energy Management Programs

Governments can save energy by careful planning. A popular approach is the development of an Energy Management Program which is often tied to some financial package (See Section 4.). Energy Audits, which identify energy usage patterns and ways to save energy, are usually a part of this process. See Case Study 52



Life-cycle Costing Analysis

Life-cycle costing is an accounting tool that cities and counties can use as part of decision making and energy planning. This method of economic analysis involves basing buying decisions not just on a product's purchase price, but also on the cost of operating the item during its projected life span. Often life-cycle cost analysis (LCCA) can identify energy-efficient items that are actually more cost effective than are less efficient products with a lower initial cost.

As LCCA considers inputs that might otherwise be ignored, it gives decision makers a full and complete assessment of the costs of using a particular item. Examples of inputs that LCCA examines include annual maintenance and energy costs, fuel price escalation and inflation, periodic equipment replacement costs, salvage or disposal costs, and useful economic life. Therefore, by using life-cycle cost analysis, cities and counties can make more informed choices about the allocation of scarce resources. See Case Study 53.

Policies/Regulations for Government Buildings

Governments can set high standards for the construction of their own buildings to reduce costs and greenhouse emissions. In this way they can provide demonstrations of energy-efficient buildings thereby providing leadership in innovative building design to the domestic, industrial and commercial sectors and stimulating private sector research and development.

Equipment and Materials Procurement Policies

Some State and Local Governments have adopted policies or regulations encouraging or requiring their departments to buy energy-efficient appliances and environmentally-sound materials such as recycled paper. See Case Study 54.

The Cities for Climate Protection Program

International programs such as Cities for Climate Protection (CCP) encourage local councils to take greenhouse action in those areas over which they have direct control, and in more difficult areas such as urban planning where there is a need for local, state and urban cooperation.

The Cities for Climate Protection (CCP) is a course of action for local governments to follow, with the overall goal of reducing greenhouse emissions and air pollution with the added benefit of improving community livability. Those councils that become part of the CCP program aim to achieve the following objectives (ICLEI *Cities for Climate Protection*):

1. Establishment of an inventory and identification of key sources of greenhouse emissions in the council and community
2. Setting of an emissions reduction goal – for the achievement of an emissions reduction target
3. Development and adoption of a local greenhouse action plan to achieve these reductions - the policies and measures to achieve the emissions goal
4. Implementation of the local greenhouse action plan
5. Monitoring and reporting on greenhouse emissions and actions and measures

See Chapter 9 for further information about this program.

Vehicle Fleet Purchasing Policies

Councils can implement purchasing policies for their vehicle fleets to ensure that vehicles are only purchased if they are really necessary and more fuel-efficient or alternative fuel vehicles are purchased or substituted for existing vehicles. Purchasing policies have been adopted in place such as Denver, USA, Helsinki Metropolitan Area, and Seattle, USA. For more information see Action 2.1 in *Local Government Greenhouse Reduction Measures Research Project*.

Some Councils such as in Utah, USA and Manningham, Victoria, Australia, have implemented a bicycle fleet program providing council staff with bicycles to use on the job such as to go to meetings, to go to lunch or to link up with public transport. These fleets could be electric bicycles which would be more suitable for rangers and parking inspectors who have to cover larger distances. See Actions 2.15 and 2.20 in *Local Government Greenhouse Reduction Measures Research Project*.

3. Economic Measures

Many financial measures are available which can support and encourage energy-conservation programs. They include:

- Subsidies from National or State Government to municipal governments to implement energy programs. See Case Study 55.
- Performance Contracting which enables savings to pay for ongoing energy efficiency investments - see Case Study 56.
- Matching Grants linked with Energy Management Programs - see Case Study 57.

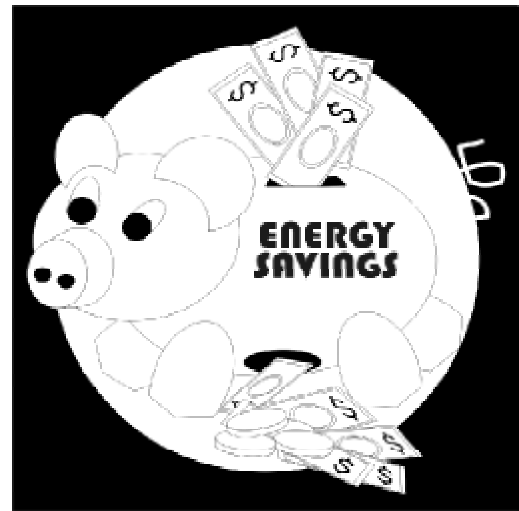


Figure 6.5: Energy banks, like piggy banks can generate savings. See Case Study 58.

4. Combined Approaches

Some Governments have initiated a range of different energy saving programs which include a combination of technical, educational, economic and regulatory strategies.

D. References and Resources

Australian Municipal Energy Improvement Facility
<http://www.ncc.nsw.gov.au/environ/ameif/>

CADDET Energy Efficiency. <http://caddet-ee.org/>

Cities for Climate Protection. <http://www.iclel.org/ccp/>

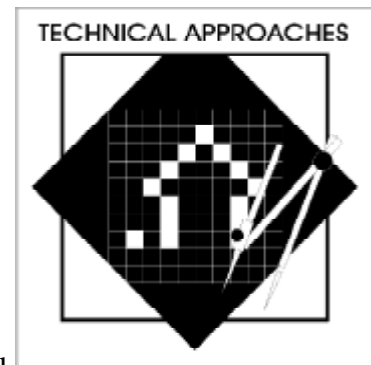
Saving Energy with Daylighting Systems: Maxi Brochure 14
<http://www.caddet-ee.org/brochures/display.php?id=1100>

Urban trees in arid landscapes: Multipurpose urban forestry for local needs in developing countries by Guido Kuchelmeister (1997) <http://ag.arizona.edu/OALS/ALN/aln42/kuchelmeister.html#addl>

Rooftop gardens <http://www.cityfarmer.org/rooftop59.html#rooftop>



Case Study 59 Anaerobic Digestion of Food Waste



Objective: Recovery of energy from food waste and solve landfill resource problem

Location: Anyang City, Kyunggido, Republic of Korea

Website: <http://www.caddet-ee.org/infostore/details.php?id=3234>

Description:

One of the major goals of the Korea Institute of Energy Research (KIER) is to develop and apply new technologies for the recovery of energy from various wastes including municipal solid wastes (MSW). The project dealing with the production of biogas and compost from large quantities of Korean food wastes is a co-operative effort between KIER, the Korea Ministry of Trade, Industry, Energy, and Halla Engineering and Heavy Industries, Ltd.

The project was first initiated to resolve the problem of food waste management in Korea. Problems of Korean food waste are caused first of all by its ever increasing volume and by its high moisture and salt content. Highly urbanised and populated towns in Korea do not have enough space for landfill and the high moisture and salt content of food waste hinders effective recycling for compost production or incineration for energy recovery.

The anaerobic process plant of this project, located at the Anyang City incinerator site, produces biogas and humus from the treatment of 5 tonnes/day MSW containing approximately 3 tonnes of food waste.

The major achievements of this project are;

- 1) development of a two-phase anaerobic process optimised for Korean food waste treatment and biogas (energy) recovery;
- 2) development of a sorting pre-treatment process suitable for Korean MSW collection systems;
- 3) demonstration of the feasibility of Korean food waste treatment as one component of an integrated waste management system including landfill and incineration.

In case of the 15 tonnes/day food waste treatment capacity, the operational cost of the plant was estimated to be \$25/tonne of food waste. Treatment and the construction costs were estimated to be \$435/tonne of MSW in Korea. However, no more landfill sites are available for the disposal of food waste in Korea because of environmental impacts such as leachate and bad odour etc.

The process was verified to be suitable for energy recovery from pre-sorted food waste in Korea. A plant sorting 15 tonnes/day of pre-sorted food waste using this process is under construction in Euiwang City for initial start-up in March 1997.

Case Study 60 Anaerobic Digestion of Industrial Waste Water



TECHNICAL APPROACHES



Objective: Production of electricity and heat from industrial waste water

Location: Wezep, The Netherlands

Website: <http://www.caddet-re.org/infostore/details.php?id=3198>

Description:

The Vita Company of Wezep in The Netherlands, produces vacuum-packed peeled potatoes. The process generates about 700 m³/day of waste water, which has to be cleaned prior to being discharged into the sewer.

The water treatment unit incorporates an anaerobic digestion stage, which produces biogas which was previously burned off. In this project, a new biogas-fired three-pass fire-tube steam boiler has been installed next to an existing natural gas fired boiler. The steam generated by this new boiler is fed to the existing steam grid. 325, 000 m³ of natural gas is saved every year and it is expected that the project will have recouped costs within 2.7 years.

Another project in the Netherlands has demonstrated substantial savings in operations costs by using biogas produced by a fermentation process. In this process, the sewage water is treated in three stages. In stage one waste water is led into a settling tank where particles are allowed to settle and the sediment, called primary sludge, is removed.

In the second stage, micro organisms digest organic components in an aerobic process, converting them to carbon dioxide, water and solids. The process takes place in an aeration basin through which outside air is blown. In the third stage, solid organic compounds are collected in a second settling tank. Collected sediment is mixed with the primary sludge and the mixture is heated in a heat exchanger to a temperature of 32.5°C and allowed to ferment in a fermentation tank. Gaseous fermentation products (containing methane) are collected and used in the gas engines driving the aeration blowers. Natural gas can be added to the fuel in case of a shortage; and surplus bio-gas is blown off.

Case Study 61 Fuel Cell Combined Heat and Power using Biogas from Brewery Effluent



Objective: Production of electricity and heat from industrial waste water

Location: Chiba, Japan

Website: <http://www.caddet-re.org/newsletter/display.php?id=1757>

Description:

The Chiba brewery in Japan has recently changed their waste treatment practice from an aerobic activated sludge process to an anaerobic pre-treatment process that simultaneously reduces the power required to treat the waste and also produces biogas. The company, Sapporo Breweries, decided to install a fuel cell combined heat and power system that can use 80% of the energy content of the biogas, rather than burning the biogas in steam boilers.

High concentration organic effluent from the brewery is pre-treated in an acid fermentation tank, neutralised and fed into an anaerobic digester which produces methane. Impurities such as sulfides can be harmful to the operation of fuel cells and these are removed from the biogas in a gas pre-treatment system. This pre-treatment process also absorbs carbon dioxide from the biogas improving the quality of the gas.

The system generates 1728 MWh/year of electrical energy and 1768MWh/year of thermal energy for use in the plant. The amount of power purchased from the grid for each bottle of beer has been reduced to one third and the energy savings are worth about 30 million Y a year.

Case Study 62 Use of Land Fill Gas in Brick Kilns



Objective: Production of heat for brick making from land fill gas

Location: Barnsley, United Kingdom

Website: <http://www.caddet-re.org/html/technical.htm>
<http://www.caddet-re.org/brochures/display.php?id=1883>

Description:

The kilns at the brickworks are fired using land fill gas from a landfill site situated adjacent to the clay quarries. There is an ongoing process of clay extraction and filling with refuse, and land fill gas is extracted by wells as the gas quality becomes useable.

The land fill gas is used in the medium temperature parts of the brickworks kiln at 870-960°C, and natural gas is used for higher temperature processing (up to 1050°C). All of the burners can be switched from one type of gas to the other with no interruption to the flame.

Land fill gas has been used by the brickworks for more than 12 years and the system has performed reliably, with little need for changing the gas supply to any particular burner. Gas pre-treatment consists of a simple moisture removal and filtration step. The kilns operate 24 hours a day, and land fill gas meets 20-30% of the gas requirements. Very little servicing has been required, and there have been no problems with contaminants or condensation.

By the end of 1995, use of land fill gas had saved the plant £1,330,000, from an initial investment of about £330,000. The payback period was longer than expected, as the land fill gas flow was smaller than expected, however the return on investment was achieved in 3 years.

Case Study 63 Anaerobic Digestion of Municipal Waste Water



Objective: Production of electricity and heat from municipal waste water

Location: Perth, Australia

Website: <http://www.watercorporation.com.au/environment/content-wastewater-woodman.asp>

Description:

The production of biogas by anaerobic digestion at the Woodman Point waste water treatment plant in Western Australia enables provision of the plant's power requirements for most of the day. Ninety-nine per cent of the waste water arriving at Woodman Point is from household kitchens, bathrooms, laundries and toilets. First the waste water is screened to remove any large objects (paper, rags etc) before passing through settling tanks to remove grit (sand etc). Next, the waste water spends several hours in large sedimentation tanks to remove settleable solids, or "sludge". The sludge is digested in one of two 38-metre tall anaerobic digesters.

Biogas produced by the digester is used on-site to provide electricity, and excess power is sold to the local electricity retailer, Western Power Corporation. A sludge is left after the digestion is complete and the gas is extracted. This bio-solid is dried then sold as a soil conditioner and fertilizer to the agricultural and landscaping industries. A significant future option for this plant is in providing an industrial water supply which is of great importance in the arid West Australian climate. Fittingly, the next by-product of Woodman Point could be water, for industry. Investment of \$100 million in a project based on a commercial partnership will amplify the Woodman Point plant to give wastewater 'secondary treatment'. This further refinement produces discharge water suitable for re-use in industry. Plant amplification is the cornerstone of the WaterLink Project, which will promote water efficiencies, provide a choice of water qualities for industry, and increase the proportion of groundwater and scheme water supplies available for the general community. Amplification will prepare Woodman Point for population growth in southern Perth, lifting throughput from today's 100 million litres daily, to 160 million litres.

At the Subiaco Wastewater Treatment Plant, the world's first *Oil From Sludge* (OFS) Plant has been developed. The OFS process is a patented thermochemical process called Enersludge in which the organic content of sludge is converted to an oil with properties similar to diesel oil. Raw sludge and excess activated sludge are pumped first to the sludge blending tank where they are mixed prior to dewatering. After drying, sludge is then heated in a reactor vessel in the absence of oxygen. During this process, almost half of the sludge is vaporised. In the second stage of the reactor, the vaporised sludge contacts with the sludge char, converting the organic molecules to principal components of crude oil, called *aliphatic hydrocarbons*.

This process will produce about 150 to 300 litres of oil per tonne of sludge processed, along with char, non-condensable gas and reaction water. These latter three are burned in a hot gas generator, which produces most, if not all, of the energy required for sludge drying and reactor heating.

Case Study 64 Incineration of MSW to Produce Combined Heat and Power



Objective: Production of local heating and electricity while mitigating landfill problem

Location: Seoul, Korea

Website: <http://www.caddet.org/infostore/details.php?id=2989>

Description:

There are several plants in Seoul that provide heat for industrial complexes and domestic units. In the Mok-Dong area, there is a large quantity of waste available from the local apartment blocks, which is being used to produce district heating and sell power to the electricity retailer. In addition to saving energy, the project reduces the volume of waste to land fill by 87%.

Waste is delivered by truck to a weighing station, and then deposited into a storage unit. A crane delivers the waste into the boiler for incineration. The plant has capacity for 150 tonnes/day of waste, while the boiler can incinerate 15 tonnes/hour. The average heating value of the waste is around 1,900 kcal/kg (7,950 kJ/kg).

The pollution control system includes an odour reduction system which involves high temperature dissolution (850-950°C) of refuse drainage. An electrostatic precipitator reduces dust emissions with 99% efficiency. Harmful emissions from the stack are reduced with a wet scrubber flue gas treatment system. Considerable effort has been made to minimise its environmental effect on those living nearby.

The project saves energy equivalent to 6.56 million Nm³ of liquid natural gas every year, at a saving of 1.3 billion Korean Won per year. The investment in the plant was 5.1 billion Won.

Case Study 65 Energy From Poultry Litter



Objective: Production of electricity from poultry litter

Location: Suffolk, U.K.

Website: <http://www.fibrowatt.com/UK-Eye/index.html>

Description:

This is the world's first commercial electricity generating plant using poultry litter as the fuel. The 12.7MW plant which started operation in 1992, generates sufficient electricity for 29,000 homes. The plant consumes over 150,000 tonnes of poultry litter per year.

The plant was the first project over 10MW to come on stream under the UK Government's Non-Fossil Fuel Obligation, which provides support for renewable electricity generation, as well as the first Small Generator to join the British Electricity Pool.

After transportation to the plant and storage, the fuel is conveyed into the boiler via a mechanical distribution system. Air from the storage hall is drawn into the furnace by fans and is used as the combustion air within the boiler. Here temperatures reach in excess of 850°C (1500°F), destroying any odour and bacteria.

The plant incorporates a single, conventional boiler design with a feed system and grate specifically designed to combust poultry litter and other biomass fuels. The boiler is equipped with a combustion chamber, a superheater, a generating bank and an economizer.

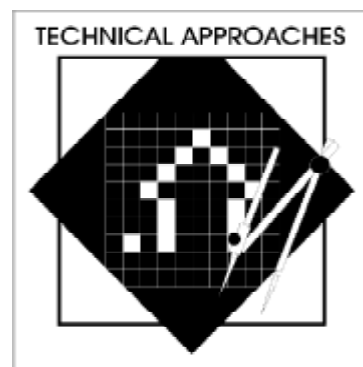
Boiler combustion air obtained from the fuel storage building is preheated for use as primary and secondary air. The preheated primary air is fed under the grate, and preheated secondary air is injected at strategic locations above the grate. The boiler combustion chamber or furnace is made up of water-wall tubes.

The plant was built under a turn-key contract by Aalborg Boilers A/S, the Danish turn-key contractor and boiler maker. The turbine was provided by NEI-Allen (W.H. Allen of Bedford). Foster Wheeler Energy Ltd acted as Owners' Engineer on the project throughout construction and commissioning. Third party finance was provided via a European Union grant and a £20 million Project Financed Senior Debt facility arranged by Bank of Tokyo-Mitsubishi.

The plant was architect-designed to be environmentally attractive. It consists of a low-key steel structure with a curved roof, partially sunk into the ground and surrounded by landscaped embankments to reduce its visual impact. The height of the building does not exceed typical heights of parish churches in the neighbourhood.

Eye is in the centre of one of the UK's largest poultry growing areas. The plant consumes over 150,000 tonnes of poultry litter per year, enough to fill 25 football pitches to a depth of 6 feet.

Case Study 66 Solid Waste to Energy Recycling Facility



Objective: Production of electricity, heat and recycled products from municipal solid waste

Location: Wollongong, Australia

Website: http://wollongong.nsw.gov.au/news/media/20010207_openswerf.html

Description:

Located at Woollongong City Council's Whytes Gully landfill site, this new Solid Waste-to-Energy Recycling Facility (SWERF) project includes:

- a pre-treatment process to separate recyclable products from the waste stream leaving the balance as a biomass feedstock or MGW (Municipal Green Waste)
- conversion of the MGW using a gasification process, and
- electricity generation using a high efficiency gas engine and generator.

Following the development of a synfuels gasifier in 1996, the SWERF concept using the gasifier evolved in 1997 and took 3 years to develop, evaluate and commercialise. The first project at Wollongong was opened in May 2000. Research and development has continued in parallel with developing the project so the gasifier that was originally installed does not incorporate all the latest technical advances. Handling difficulties of the MGW have been experienced due to its widely varying properties. Also the waste resource is often significantly contaminated with soil and foreign objects not always of organic origin.

Household green waste is received unsorted and sterilised at 140-150°C. It is then mechanically separated to remove any ferrous and non-ferrous metal materials which are then sold. Any other inert residues are taken to landfill or reprocessed and reused where feasible. The remaining organic fraction is floated off from the glass and grit contaminants and shredded. Clean shredded material is pelletised and stored ready for gasifying. The pellets are fed into the advance thermal gasifier. Primary gasification occurs at 900°C and the synthesis gas is used in gas engines (gensets) for power generation. The "green power" is sold to the grid.

Developments are under way to convert some of the organic fraction from possible future projects into "bio-fertiliser" if it shows a greater return on investment than if used for power generation. Future projects will depend on landfill charges, greenhouse issues, community issues and other available competing waste resource recovery processes. The financing of the project was difficult as an innovative process but should be overcome for future projects now that the first facility is operating successfully.

Case Study 67 Energy From Gasifier Based Power Plant



Objective: Production of electricity from wood and forest waste

Location: Sunderbans, West Bengal, India.

Website: <http://mnes1.delhi.nic.in/bionews/sep01/index.htm>

Description:

A 500 KW gasifier-based power plant was commissioned in the remote island of Chhotamollakhali in Sunderbans, West Bengal. On June 29, 2001, Mr M Kannappan, Minister of State (independent charge) for Non-conventional Energy Sources, Government of India inaugurated the plant.

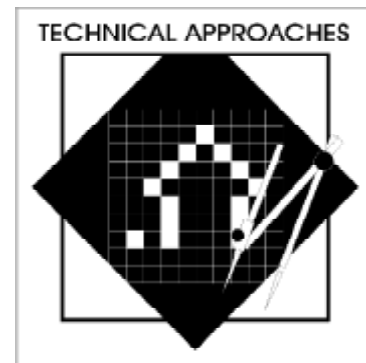
Prior to its commissioning, the region was bereft of electricity except for a privately owned 10 KW diesel generator that provided low voltage electricity at a very high price for only two hours a day.

The total power requirement of the Chhotamollakhali island is about 1 MW.

The power plant, installed by the West Bengal Renewable Energy Development Agency with financial support from the Ministry of Non-conventional Energy Sources, comprises 4 biomass gasifiers of 125 KW capacity, each connected to diesel generator sets. The gas produced from the gasifiers will enable upto 75 per cent diesel replacement. The power plant will be operated daily for seven hours. 800 connections will be provided and three villages are planned to be electrified this year.

Work has simultaneously been taken up to extend distribution lines for electrification of the remaining three villages on the island. About 3 million people inhabit the delta region of Sunderbans, 2 million of who do not have access to electricity. Power plants based on the non-conventional energy sources such as solar energy and biomass are already providing electricity to about 50,000 inhabitants.

Case Study 68 Energy From Recycling of Waste Plastic



Objective: Production of electricity from recycled waste plastic

Location: Hokkaido Island, Japan

Website: http://www.japancorp.net/Article.Asp?Art_ID=1047
http://www.sanix.co.jp/index_e.htm

Description:

Sanix Energy will operate the Tomakomai power plant in Hokkaido, northern Japan, which runs on fuel created from recycled plastic waste. The plant processes waste plastic to generate electricity using a gasification melting technology.

The plant operates at more than 850 degrees Celsius, generating energy from the naturally high calorific content of plastic and producing 74,000 kilowatts of electricity an hour, enough to power about 30,000 homes. Building on the success of the first venture, the company has plans to increase the number of similar power generation plants across Japan.

The recycled plastic is supplied by Sanix's Environmental Resources Development Division, which operates 11 plastic recycling plants across Japan that convert waste plastics into fuel. The division is currently constructing three more recycling plants.

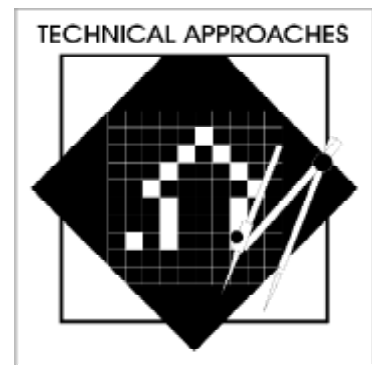
Social Value of Waste Plastic Power Generation

According to a Plastic Waste Management Institute survey, waste plastic disposal totaled 9.84 million tons (4.85 million tons from industrial sources, 4.99 million tons from household use) in 1998. Management at Sanix Inc. was convinced that this plastic waste could be used as a recycled resource and pursued the project fervently.

By using waste plastic, which would previously have been simply buried or incinerated, the company contributes to an extension of the remaining life of landfill sites and prevents dioxin pollution generated by inappropriate incineration. The recycling process also contributes to society by providing local retailers with low-cost, safe, electric power.

The plant will consume in-house about 15% of the electricity generated by the new power plant and the rest will be sold to industrial and commercial users. This will be the world's first power plant using recycled waste plastic as fuel. Company plans to build two more similar plants by year 2003.

Case Study 69 Solid Waste Management



Objective: Solve community and environmental problems associated with MSW management

Location: Bandung, Indonesia.

Reference: <http://www3.iclei.org/iclei/casestud.htm>

Description:

In response to a growing population, and therefore a growing amount of solid waste which it did not have the financial or land resources to manage, Bandung, Indonesia has developed, along with a non-governmental organization working in the city, the concept of a “module” of people who work to separate recyclables from the city’s waste stream, thereby providing a low-cost alternative to the landfill model of waste management services.

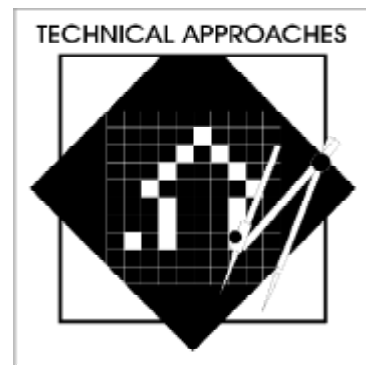
The recyclers working in the module are persons who previously survived as “scavengers;” that is, poor residents of the squatter’s settlements who make their living by collecting recoverable and recyclable materials from the waste stream. Historically, in Bandung and in cities with large poor populations throughout both the developing and the developed world, scavengers are considered to be a hindrance to the operation of efficient solid waste management rather than as an inexpensive and often entrepreneurial labor resource that can be supported and developed to collect and process recoverable materials. These people have been traditionally harassed and even jailed for their activities.

Through the Integrated Resource Recovery (IRR) program, these people have been given financial and technical support to improve their recoverable waste collection services, to compost organic wastes, and to create indigenous businesses and employment using waste products as raw material and “capital.”

Finally, the IRR program builds financial institutions which provide a financial base internal to the community, providing capital for other, non-recycling enterprises. IRR also has a significant impact on setting fair prices for the secondary materials from which the scavengers make their living, thereby supporting a fair living wage for these people who were heretofore considered an economic liability.

In the IRR concept, each module consists of a group of families. These families are given social system support in the form of evening schooling for children, health care, and assistance in the development of a savings and loan and a cooperative corporation. With this organizational infrastructure, these people then form businesses in resource recovery, composting, and seed farming which not only provide them with income, but reduce the amount of money which the city must spend on solid waste management in the form of landfill sites and the collection and transportation of waste.

Case Study 70 Participatory Solid Waste Management



Objective: To create an efficient and sustainable household waste management system

Location: Dakar, Senegal.

Reference: <http://www3.iclei.org/iclei/casestud.htm>

Description:

The Urban Community of Dakar (UCD) has a population of just under 2 million people. Only 27% of the households are connected to the sewer system, and until recently, less than 65% of the population had access to garbage collection services. To address both economic and social development, the UCD designed the New System for Household Waste, which involves local communities in the waste management process, and has provided an administrative and fiscal system for the oversight of MSW services. Small and medium sized companies that are staffed by local men women and young people contract to collect and transport waste from zones in the UCD.

Local groups are responsible for pre-collecting garbage from inaccessible areas, cleaning the streets, communicating information about the service and educating their communities in the benefits of sanitation.

By 1996 this project had demonstrated promising improvements in waste management and community employment. The New Management System for Household Solid Waste has promoted the emergence of local waste management industries and been of value to the Dakar economy.

The scheme has also benefited from international support. With an efficient and stable waste management system in place, the UCD is currently approaching the introduction of a recycling component, as well as a new agreement to compost organic waste and extract and use methane gas.

VII. SUPPLY OPTIONS USING LOCAL ENERGY RESOURCES

A. The Resource

Renewable energy sources and the use of domestic and industrial wastes can constitute viable energy supply solutions at a local level. The various issues that will be dealt with in this Chapter are evaluation of the local resource, production and distribution technologies, conditions necessary for market development, environmental and energetic impact.

Most cities throughout the world face similar problems with regard to the management of refuse. It is becoming increasingly costly to maintain existing land fill and waste water treatment methods, and inadequate waste treatment can present serious health and environmental problems. In some cities, the large volumes of domestic, commercial and industrial waste have been treated as a resource rather than a burden. New strategies have been adopted that use the energy generation potential of waste to simultaneously reduce environmental impact, reduce disposal costs and to create a new income stream.

Waste organic materials have an energy value and hence can be used as a source of renewable biomass. Biomass refers to organic matter which can be converted to energy. Some of the most common biomass fuels are wood, agricultural residues and crops grown specifically for energy. Biomass dominated global energy consumption until the middle of last century. It still remains an important energy source and contributes about 14% of the world's energy and 38% of the energy in developing countries.

Substantial energy content is dissipated in the form of discarded waste every year. Using conversion systems and techniques already commercially available or being demonstrated, a large component of this 'technical potential' can be economically exploited at current energy prices. Further technological development and the increasing costs of waste disposal will result in a dramatic increase in the generation of energy from waste.

Waste resources include Municipal Solid Waste (MSW), sewage sludge and effluent, food-processing residues, and industrial effluent. They are generally divided into two streams: *wet* and *dry* waste.

MSW is not an energy resource but the end stage of many very complex and ever changing production and consumption processes. It "contains nothing in particular and a bit of everything in general". Worldwide, the dominant methods of MSW disposal are to place it into landfills or on open rubbish tips. Although these disposal methods often have low initial costs, they may contribute to serious local air and water pollution, and in some instances have resulted in pest infestations and outbreaks of diseases in local communities. They also release methane, an explosive gas with a high global warming potential.

In many parts of the world, it is becoming increasingly difficult to locate suitable landfill sites. Recycling, incineration and waste-to-energy systems are increasing in popularity, particularly in the major population centres. Recycling programmes exist in many urban local government areas, particularly for paper, aluminium, steel, glass, plastics and to a lesser extent hazardous materials such as batteries (lead acid) and hydrocarbon products. These have gradually reduced the amount of solid waste going to landfill sites. As part of the transition towards more sustainable lifestyles, the processing of MSW is essentially and inherently a fractionation and refining process hopefully generating a range of commercial co-products, of which energy, in the form of heat, gas, oil, or power, is only one component.

Liquid by-products of effluents from industrial processes and sewage treatment usually have a high water content, hence the use of the term “waste water” to describe these products. Liquid waste streams are generated by washing meat, fruit and vegetables; blanching fruit and vegetables; pre-cooking meats, poultry and fish; wool scouring; dairy whey; grease traps; spent brewery wastes and wine making and, other cleaning and processing operations.. These effluents contain sugars, starches and other dissolved organic matter, but in a relatively dilute form. The potential exists for these industrial wastes to be anaerobically digested to produce biogas, or fermented to produce ethanol, and many commercial examples of these waste-to-energy conversion routes already exist. Liquid waste in the form of recycled frying oils collected from restaurants and other olefinic wastes such as low-grade beef tallow may also be used to produce diesel fuel, called bio-diesel.

Gaseous by-products of industries associated with the extraction and refining of fossil fuels are also used to produce energy, yielding both financial and environmental benefits. Heat, another by-product of many industrial processes, can also represent either a pollutant or a resource. In some instances there is the potential for some of this heat to be captured and recycled to increase process efficiency, or it may be profitably used for local heating needs, or even converted into electricity for on-site use. Distributed power generation with Combined Heat and Power systems enables the exploitation of waste heat resources.

B. Technical Approaches

Organic waste-to-energy technologies can be broadly classified as either bio-chemical or thermo-chemical processes, and will be individually discussed below.

1. Biochemical Conversion

Digestion is a bio-chemical process by which organic waste is broken down by the action of bacteria into simple molecules, either aerobically (with oxygen) or anaerobically (without oxygen). Aerobic digestion takes place where the waste is aerated, such as in the early stages of decomposition of municipal solid waste and during composting. Anaerobic digestion takes place where the waste has restricted aeration, such as in the later stages of the decomposition of MSW or in the digestion of sludges or waste water in enclosed digestion vessels. Aerobic digestion produces carbon dioxide and water, whereas anaerobic digestion produces methane and water, and some carbon dioxide and hydrogen sulfide. The gas produced by anaerobic digestion can be combusted and used to produce electricity or heat, thereby converting the methane gas to carbon dioxide (with a lower global warming potential).

Anaerobic Digestion

Anaerobic digestion is the decomposition of wet and green biomass through bacterial action in the absence of oxygen to produce a mixed gas output of methane and carbon dioxide known as ‘biogas’. Biogas can be used as a substitute for fossil fuels. Both liquid and solid wastes or green crops can be digested to produce biogas. The natural decomposition of organic wastes in the absence of oxygen (anaerobic decomposition) by mesophilic bacteria also occurs on the bottom of lakes and wetlands shown by gas bubbles rising, and is one of the major greenhouse gases resulting from hydropower installations when the surrounding land area is first flooded and the vegetation decomposes over fairly long periods of time.

The breakdown of organic materials involves a number of biological steps, each involving a defined class of bacteria. These bacteria absorb energy for their survival from the gradually decomposing biomass which is finally converted to methane, carbon dioxide and water. The process can be encouraged by placing the organic material in large airtight tanks known as digesters, and biogas produced is captured for use. Digesters range in size from around 1m³ for a small household unit to as large as 2000m³ for a large commercial installation. As a result, odours are removed and the pollution potential of the waste is reduced.

Biogas can be burnt directly in thermal applications displacing natural gas in cooking and space heating, or used as fuel in internal combustion engines to generate electricity. Some recent applications have used scrubbing techniques to upgrade the quality of the gas by removing carbon dioxide and hydrogen sulfide.

Case Studies 59 on the Anaerobic Digestion of Food Wastes, 60 on Industrial Food Wastes and 61 on the Utilisation of Biogas from Brewery Wastes.

Aerobic Digestion

Aerobic digestion, the bacterial decomposition of organics in the presence of oxygen, takes place during composting processes. Thus during the initial stages of the decomposition of landfill and during some waste water treatment processes.

Aeration is a very energy intensive operation, and does not have the potential for net energy gain that is possible by closed vessel anaerobic digestion. Where it is used for waste water treatment, aerobic digestion tends to produce greater quantities of sludge and have a greater overall environmental impact than comparable anaerobic processes. It is often argued that closed vessel anaerobic digestion involving methane capture and use is a more desirable process than aerobic composting. This is because aerobic composting may become poorly oxygenated, and under these circumstances will become anaerobic and produce methane that will escape into the atmosphere. This presents a higher greenhouse potential and a is potential flammable hazard.

Landfill Gas

Improved designs and management of landfill facilities can overcome litter, odour and leachate problems associated with landfill by lining and covering the tip, and by controlling access to trucks or rail wagons delivering wastes from local land transfer stations where recycling is encouraged. This cost is passed on to the users of the facility in terms of depositing the waste material.

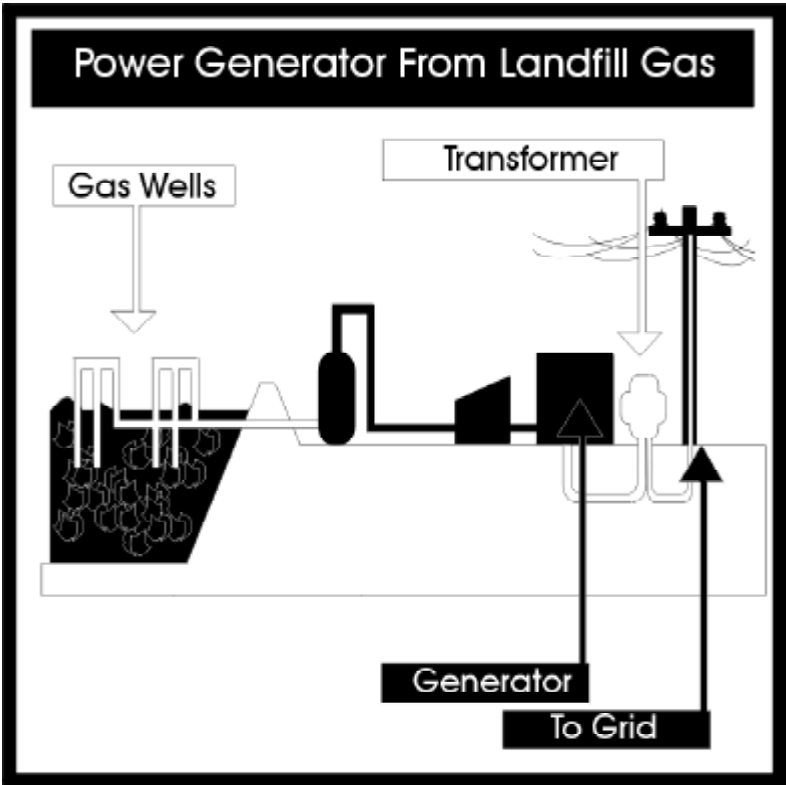


Figure 7.1: Schematic diagram of the generation of power from landfill sites.

Many communities aim to minimise the volume of materials going into landfills by encouraging the use of garden refuse for mulch and compost, recycling glass and metals, and utilising any combustibles for “waste-to-energy” projects. Regardless, at this point in time the majority of wastes end up in a landfill. The aim then should be to avoid methane emissions for both environmental and safety reasons, since the gas is flammable and has caused explosions in nearby buildings after seeping through the ground and accumulating.

Landfill gas is an adventitious fuel that is a by-product of current land filling practices and hence occurs only after MSW has been unsuitably disposed of. The anaerobic digestion of the buried solid organic waste produces the landfill gas naturally, as the bacterial decomposition of the organic matter continues over time. It is an extremely inefficient way of recovering energy from MSW.

Unless properly captured and extracted, methane produced in landfill sites normally escapes into the atmosphere contributing to greenhouse gas emissions and creating a potential combustion hazard. In the extraction process, the gas is removed via perforated pipes that have been inserted into the landfill. Landfill gas travels through the pipes under natural pressure or a slight vacuum, to be collected and used as an energy source, rather than simply escaping into the atmosphere. The burning of the methane to produce carbon dioxide and water also reduces the greenhouse impact of landfill, as carbon dioxide is a less potent greenhouse gas than methane.

In theory, up to 300m³ of biogas per tonne of waste can be extracted from a landfill gas site over a ten-year lifetime. This represents an energy content of about 5 GJ (gigajoules). In reality, because of the nature of landfill designs and construction, and the high component of non-putrescibles in the MSW, landfill gas projects produce only between 25 -50% of their theoretical gas potential. The assessment of landfill gas resources is discussed in Section D.

See Case Study 62 for an example of landfill gas projects.

Dedicated Anaerobic Digestion of Solid Organic Waste

Anaerobic digestion of MSW provides a more controlled and reliable means of extracting energy than by collecting landfill gas and is becoming a more common path for treatment of MSW in many cities.

The benefits of anaerobic digestion include:

- improving landfill management
- reducing the volume and odour of landfill
- avoiding production of methane in landfills
- enabling recyclable material to be reclaimed
- collecting all of the gas produced
- producing another useful end product – soil conditioner

The methods that have been developed for dedicated anaerobic digestion of solid organic waste include dry continuous digestion, dry batch digestion, leach bed processes, wet continuous digestion, and multi-stage wet digestion. Examples of these technologies are the Valorga process in France, the Dranco process in Belgium, Kompogas in Switzerland, Funnel Industries in the US, Biocel and Paques in The Netherlands, Avecom in Finland, Italba and Snamprogetti in Italy, Herning in Denmark, BTA and ANM in Germany.

Anaerobic Digestion of Waste Water

Methane recovery and use in the treatment of waste water can significantly reduce the amount of energy required to run the plant, and in some cases enable energy to be sold. Process changes that enable the capture of methane are also able to improve the environmental performance of the plant.

Biogas from waste water treatment plant sludge digestion is typically 60-70% methane, 30-40% carbon dioxide (CO₂), up to 0.5% hydrogen sulphide (H₂S), with some other inert gases and water vapour. Scrubbing systems, which remove H₂S and CO₂ are often used.

See Case Study 63 on the Anaerobic Digestion of Municipal Wastewater.

Assessment of the energy production potential of municipal waste water is described in a following section.

2. Thermochemical Conversion

Thermal processing of organic waste materials can produce heat or a number of liquid or gaseous fuels. The three main options for recovering energy from solid refuse are by:

- mass burn (combustion or direct incineration) of MSW without pre-treatment.
- production of more or less refined fuels out of the main waste stream either partially processed or highly processed refuse derived fuels (RDF) in the form of pellets for later combustion in incinerators (such as rotary kilns) or via new pyrolysis or gasification techniques.
- the development of new approaches involving the recovery of chemicals such as plastic monomers combined with gasification, pyrolysis, hydrogenation and/or reforming of the gases and oils produced.

Direct Combustion and Incineration

Also described as mass burn or direct incineration, direct combustion is the burning of waste to produce heat for cooking, space heating, industrial processes or electricity generation. Ash from the incineration process can also be sold to the construction and road building industry to further reduce the amount of material to be ultimately disposed. Dry wastes are required for direct combustion, and dried sludge from waste water can also be used as a feedstock.

Small-scale applications (such as domestic cooking and space heating) can be very inefficient, with heat transfer losses of 30 - 90% of the original energy contained in the waste. This problem can be addressed through the use of more efficient stove technology and the use of dry, compact biomass fuels, such as wood.

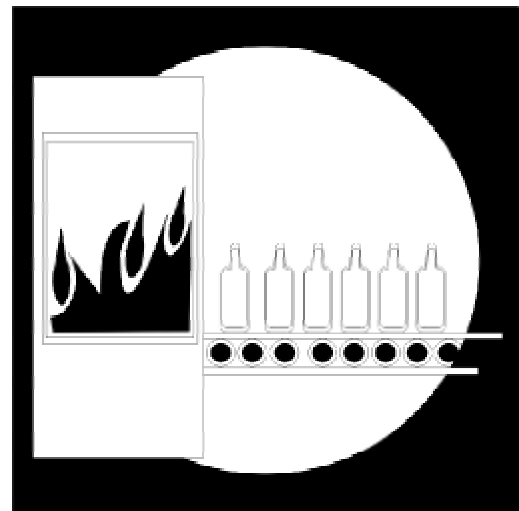


Figure 7.2: The burning of waste can produce significant amounts of heat and power for industrial and domestic applications.

On a larger scale, solid waste (including agricultural and forestry residues), can be combusted in furnaces to produce process heat to feed steam turbine generators. Power plant size is often constrained by the availability of local feedstock and is generally less than 25 - 40 MWe. However, by using dedicated feedstock supplies, such as the co-location of incinerators at waste disposal sites, the size can be increased to 50 -75 MWe, gaining significant economies of scale.

Mass burn technology involves the combustion of unprocessed or minimally processed refuse. The major components of a mass burn facility include:

- refuse receiving, handling and storage systems
- combustion and steam generation system (a boiler)
- flue gas cleaning system
- power generation equipment (steam turbine and generator)
- condenser cooling water system
- residue hauling and storage system

Early incinerators were characterised by a negative environmental image and poor performance. Concerns over direct combustion, particularly gas and smoke emissions as well as the disposal of ash means that direct combustion technologies are governed by more stringent government scrutiny and approvals, thereby increasing the establishment cost of these projects. Incinerators are often seen as a solution to the scarcity of urban landfill sites rather than as a means for efficient energy recovery from waste streams.

See Case Studies 64 and 65 on the use of incineration for electricity generation.

Refuse Derived Fuels

Using raw, unprocessed MSW as a fuel has its problems due to the heterogeneous nature of the material which varies from suburb to suburb and season to season. It also has a low heat value and high ash and moisture content. This makes it difficult for plant designers and operators to continuously provide acceptable pollution free levels of combustion. Processing of the waste to Refuse Derived Fuels (RDF) partially overcomes these problems. The fuel can then be used more successfully in either chain grate water-tube boilers or in circulating fluidised beds.

Waste with a high organic (carbon) content is suitable for briquetting and pelletising after non-combustible and recyclable materials have been separated. These processes involve the compaction of the waste at high temperatures and high pressures. The organic matter is compressed in a die to produce briquettes or pellets. It is important to note that using processed waste (where recyclable and non combustible components have been removed), for power generation will dramatically increase the efficiency of the waste-to-energy process, but at an increased cost due to the increased handling of the product.

Depending on the composition of the refuse, and the technology used, several types of RDFs can be made, such as coarse, fluffy, powdered or densified. Typically, after the removal of non-combustibles, MSW is comminuted by a flail mill. A magnetic separator then removes ferrous materials before screening out the larger particles. The remainder is shredded into small particles to make RDFs which are burnt in dedicated boilers or can be co-fired with another fuel such as coal, lignite, or increasingly biomass (wood or agricultural residues).

These products have a significantly smaller volume than the original waste and thus a higher volumetric energy density making them a more compact source of energy. They are also easier to transport and store than other forms of waste derived energy. The briquettes and pellets can be used directly on a large scale as direct combustion feed, or on a small scale in domestic stoves or wood heaters. They can also be used in charcoal production. RDF pellets have a heat value of around 60% of coal.

High temperature incineration of waste is common in the industrialised regions of Europe, Japan and the north eastern United States where space limitations, high land costs and political opposition to locating landfills in communities, limit land disposal. In other countries including developing nations, relatively low land and labour costs, lack of high heat value materials in the waste stream such as paper and plastics, and the high capital cost of incinerators have discouraged waste combustion as an option.

Gasification

This process of partial incineration with restricted air supply to create an air-deficient environment, can be used to convert biomass and plastic wastes into synthesis gas with a heating value 10-15% that of natural gas. When integrated with electricity production it can prove economically and environmentally attractive, though it appears better suited for clean biomass, such as wood wastes. The synthesis gas (CO + H₂) in turn can be converted to methanol, synthetic gasoline, or used directly as a natural gas substitute and even blended with natural gas in a gas supply line. Even at a larger scale (say >50MW), such processes are not usually cost effective compared with using natural gas.

In principle, gasification is the thermal decomposition of organic matter in an oxygen deficient atmosphere producing a gas composition containing combustible gases, liquids and tars, charcoal, and air, or inert fluidising gases. Typically, the term *gasification* refers to the production of gaseous components, whereas pyrolysis, or pyrolysis, is used to describe the production of liquid residues and charcoal. The latter normally occurs in the total absence of oxygen, while most gasification reactions take place in an oxygen-starved environment.

In a gasifier, the biomass or waste particle is exposed to high temperatures primarily generated from the partial oxidation of the carbon. As the particle is heated, the moisture is driven off. This could range from below 10% to over 50% of the incoming fuel weight. Further heating of the particle begins to drive off the volatile gases. For wood, this volatile content could be as much as 75 to 80% of the total dry weight. Discharge of these volatiles will generate a wide spectrum of hydrocarbons ranging from carbon monoxide (CO) and methane to long-chain hydrocarbons comprising tars, creosotes and heavy oils. After reaching about 900°F, the particle is reduced to ash and char. In most of the early gasification processes, this was the desired by-product. In gas generation, however, the char provides the necessary energy to effect the heating and drying previously cited. Typically, the char is contacted with air or oxygen and steam to generate CO and CO₂ and heat.

There have been some interesting and innovative ideas put forward for using small scale gasifiers to dispose of special wastes such as clinical waste by mixing it with other biomass sources such as cotton waste using an entrained flow, down draft gasifier.

The Texaco Gasification Process is an example of a proven large scale gasification technology being actively marketed for a wide range of applications, including MSW processing. The core of the process is a pressurised gasifier operating at 20 to 80 bar, 1,200 to 1,500 °C, and using an oxygen supply. The product is synthesis gas for which the potential use could be power generation, say in a combined cycle power plant, large scale cogeneration, or chemical synthesis of a new polymer.

In Germany, Veba-Oel uses a similar gasification approach to produce an oil substitute (40,000 t/y) followed by hydrogenation at 300 bar in its oil refinery. The process is apparently affected by a poor energy balance and negative public perception of it as an energy source rather than as a materials recovery operation. Texaco consider that a 100t/day plant (that is about 30,000t/y of pre-sorted waste) would cost about US \$40 million (without the ancillaries and downstream processing plant) and would be economical in the USA.

Gasifiers can utilise fluidised bed technology in order to increase efficiency, whilst treating a feedstock that varies in gasification properties. Fluidised bed gasifiers produce a combustible gas that can be fired in a boiler, kiln, gas turbine or other energy load. EPI produced the first fluidised bed gasifier power plant in the US and are currently introducing the gasifier approach as an add-on to utility coal-fired power plants to provide a means to convert a portion of the fuel supply to clean, renewable biomass fuel. In a fluidised bed gasifier, the bed material can either be sand or char, or a combination of these products.

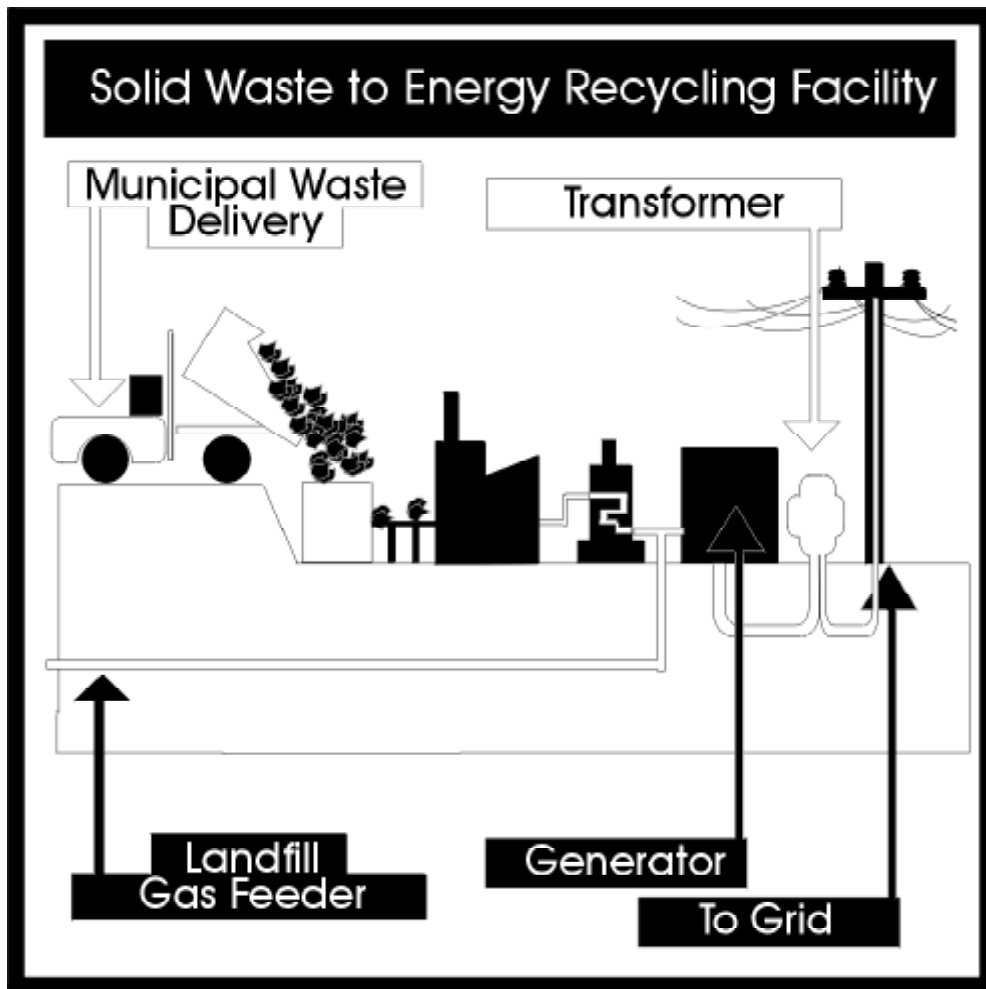


Figure 7.3: The SWERF process is an example of a gasification process which uses green wastes for power generation.

The fluidising medium is usually air, however oxygen and/or steam are also used. The fuel is fed into the system either above or directly into the bed, depending upon the size and density of the fuel and how it is affected by the bed air velocities. During normal operation, the bed media is maintained at a temperature between 1000°F and 1800°F. When a fuel particle is introduced into this environment, its drying and pyrolysing reactions proceed rapidly, driving off all gaseous portions of the fuel at relatively low temperatures.

The remaining char is oxidized within the bed to provide the heat source for the drying and de-volatilizing reactions to continue. In those systems using inert bed material, the wood particles are subjected to an intense abrasion action from fluidised sand. This etching action tends to remove any surface deposits (ash, char, etc.) from the particle and expose a clean reaction surface to the surrounding gases. As a result, the residence time of a particle in this system is on the order of only a few minutes, as opposed to hours in other types of gasifiers.

The large thermal capacity of inert bed material plus the intense mixing associated with the fluid bed enable this system to handle a much greater quantity and, normally, a much lower quality of fuel. Experience with EPI's fluidised bed gasifier has indicated the ability to utilize fuels with up to 55% moisture and high ash contents, in excess of 25%. Because the operating temperatures are lower in a fluidised bed than other gasifiers the potential for slagging and ash fusion at high temperatures is reduced, thereby increasing the ability to utilise high slagging fuels.

Case Study 66 on the Solid Waste to Energy Recycling Facility, Case Study 67 on the Energy from Gasifier Based Power Plant and Case Study 68 on the gasification of waste plastic.

Pyrolysis

Pyrolysis is a medium to high temperature process for converting solid feedstock into a mixture of solid, liquid and gaseous products. It is defined as incineration under anaerobic conditions, and is another option for waste-to-energy currently under investigation. Pilot projects using pyrolysis for plastic wastes and for mixed municipal solid waste potentially have very high energy efficiency. Combined pyrolysis and gasification systems as well as combined pyrolysis and combustion have also been developed and implemented.

A number of approaches treat organic waste less severely than the Texaco approach to produce what are effectively oil substitutes through various pyrolytic or cracking processes. Examples of such processes include the Conrad and Toshiba processes.

In the US the Conrad process was used to process urban waste to recover material from chemical polymers. This was a small-scale unit processing 5000 t/y through a rotary kiln and a liming stage to produce an oil-like product. The Conrad process has been banned because the oil substitute was considered by the authorities as an energy product and as such the overall process was not achieving the required level of material recovery.

The Toshiba pilot process has a capacity of 250 kg/h over an 11hour work day. It processes mixed plastics from Toshiba's factories in Japan to produce a range of oil substitutes. The process is essentially a series of cracking units. A high density alkaline solution is used to neutralise the chlorine (e.g. from PVC) and some of the additives that resist heat cracking.

A second high pressure cracking unit boosts reclamation further. Economic data is not yet available but other Japanese companies are pursuing similar routes.

Net greenhouse emissions from waste-to-energy facilities are usually low and comparable to those from biomass energy systems because the energy generated is largely from photosynthetically produced materials such as paper, MSW and organic wastes as opposed to fossil fuels. Only the combustion of fossil fuel based waste such as plastics and synthetic fabrics contribute to net greenhouse releases, but increased recycling of these materials will generally produce even lower emissions.

The promise of pyrolysis technologies lie in their ability to transform waste into gaseous and liquid chemical and fuel products, but the major disadvantage has been the unproven technical and economic feasibility of a large-scale facility. A full scale pyrolytic process has recently been instituted in Western Australia which offers an alternative to incineration or anaerobic digestion of sewage sludge or dumping it out at sea as is still often the case unfortunately. This is the innovative "Enersludge" process which converts sludge into useful bio-oil. The concept was first promulgated by Professor Bayer in Germany in the early 1980's but it is only recently that environmental pressures and the economics of other treatment options have made it competitive.

The process was commercialised by Environmental Solutions Ltd. and the first plant installed at a wastewater treatment plant in Australia. In essence this plant uses standard technology fairly common in Europe, to produce dry pellets from the raw sludge which have a soil fertiliser and conditioning value and are free of pathogens. The innovative part of the Enersludge process is the addition of a pyrolysis unit which produces gas, char and oil. The gas and char are used to heat the plant leaving the bio-oil for revenue earning activities - either for direct sale or for use on-site in an internal combustion engine to produce electricity and offset purchases. Prior to this the sludge was treated in one primary and two secondary covered anaerobic digesters and 12 aerobic digesters and the odours were cause for complaint by neighbouring properties.

Combustion Technologies

Technology for coal combustion has been adapted for combustion of biofuels and waste products. Combustion of biomass is more complex than coal combustion, due to the inhomogeneity, variation in moisture content and composition of the feedstock. Chain-grate boilers and fluidised beds are commonly used to improve the efficiency of combustion and heat transfer, whilst meeting environmental standards.

Fluidised bed combustion systems use a heated bed of sand-like material suspended (fluidised) within a rising column of air to burn many types and classes of fuel. This allows oxygen to reach the combustible material much more readily and increases the rate and efficiency of the combustion process. The technique results in a vast improvement in combustion efficiency of high moisture content fuels, and is adaptable to a variety of waste type fuels.

In a circulating fluidised bed boiler, a portion of air is introduced through the bottom of the bed. The bed material normally consists of fuel, limestone and ash. The bottom of the bed is supported by water cooled membrane walls with specially designed air nozzles which distribute the air uniformly. The fuel and limestone (for sulfur capture) are fed into the lower bed. In the presence of fluidising air, the fuel and limestone quickly and uniformly mix under the turbulent environment and behave like a fluid. Carbon particles in the fuel are exposed to the combustion air. The balance of combustion air is introduced at the top of the lower, dense bed. This staged combustion limits the formation of nitrogen oxides (NO_x).

The bed fluidising air velocity is greater than the terminal velocity of most of the particles in the bed and thus fluidising air elutriates the particles through the combustion chamber to the U-beam separators at the furnace exit. The captured solids, including any unburned carbon and partially oxidised carbon, are re-injected directly back into the combustion chamber without passing through an external recirculation. This internal solids circulation provides longer residence time for fuel and limestone, resulting in good combustion and improved sulfur capture.

Innovative cyclone combustors with integral ash removal designed into the system also have good potential for use with RDF and other bio-fuels.

New combustion technologies with higher efficiencies of energy production and lower emissions are currently being developed. Fluidised bed combustion is a very efficient and flexible system that can be used for intermittent operation, and can run with solid, liquid, or gaseous fuels. Despite high operating costs, this low pollution combustion technology is increasingly used in Japan and has also been used in Scandinavia and the USA.

Emerging Processes

Technology is moving fast in this area with a number of new approaches or renewed technologies. One example is the EnerTech SlurryCarb process currently being demonstrated in the US and based on a pre-treatment of MSW in water slurry form to facilitate the removal of recyclables. The slurry is then subjected to high pressure and temperature conditions and partial dewatering to turn it into a higher calorific value RDF amenable to gasification for combustion in a high pressure steam boiler or to power a gas turbine. If successfully demonstrated this process, albeit expensive, will have very low pollution levels and significantly higher thermal efficiency than mass burns.

Another example is a bio-thermal waste treatment developed by Ecoenergy Oy, Espoo, Finland called the WABIO process. Waste is pre-treated and divided into organic and combustion fractions. The organic fraction is degraded into biogas and compost matter. The RDF is burned in a specially designed fluidised bed boiler unit. The temperature is kept below 900°C to avoid the formation of thermal NO_x and dangerous slagging compounds that could threaten the life of the boiler. From 1t of municipal waste, 535kg of RDF is produced.

The VALORGA process, developed in France and recently adopted by Babcock-Borsig Power, uses a similar approach to WABIO. MSW is shredded and sorted mechanically (with manual polishing) to recover glass, metals, plastics, inerts such as sand and gravel, and to remove sources of toxic compounds such as batteries. The remaining fractions (including hospital waste) are separated into a dry RDF that is directed to a rocking kiln for steam raising and base load power generation. The fermentiscibles are sent to a proprietary, high solids (above 45% solids), computer controlled, high yield methane digester. The methane is used to produce peak load power. The organic residues are composted to produce a sterile high quality soil conditioner. A plant processing 120,000 t/y of fermentescibles could generate 31 GWh of power from the methane produced and 57,000t of soil conditioner. The trend in favour of such new energy technology integrated within an overall waste management strategy focusing on materials and energy recovery is illustrated further by the recently announced French government's plan to phase down landfills and develop up to 150 new MSW conversion facilities.

The CONVERTECH technology is directed at the processing of biomass into valuable products such as chemicals, reconstituted wood products like panel boards, heat and power. As such it is not specifically designed to handle mixed waste. In the long run, in the field of waste management, its main application is in the treatment of MSW to produce a dry, cleaner burning RDF.

In this context and from a long-term perspective, mention must be made of current trends in R&D in both biomass and MSW processing which show a renewed interest in fast pyrolysis and solvolysis approaches. Fast pyrolysis refers to the heat treatment of particulate organic matter at 300°C to 1300°C under steam or other non-oxidising gases at pressures ranging from atmospheric to above 30 bar to produce pyrolytic oils and/or medium to high energy value gases. Solvolysis refers to the use of organic solvents at 200°C to 300°C to dissolve the solids into an oil-like product (bio-oil). Such products offer the prospect of gas turbine firing with thermal efficiencies of over 40% which are substantially higher than those presently achieved with steam turbines powered with current RDF combustors/boilers (typically 25%).

4. Other Local Sources

Solar Power

The sun may be a local resource suitable for some applications within a city environment. It is highly desirable to optimise the use of this resource for heating needs. Designing buildings to make optimal use of passive solar heating and use of solar hot water systems are discussed in Chapter 2 of this book. Use of solar energy to produce power may be another option worth considering. The technologies that produce power from the sun use either the heat of the sun – solar thermal power – or use the energy of the sun to create a photocurrent in a solar panel – photovoltaic (PV) power.

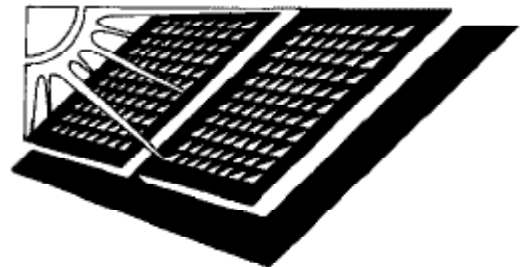


Figure 7.4: Photovoltaic power systems can produce reliable power for a wide variety of applications.

Currently, the costs of photovoltaic generation are greater than fossil fuel based technologies and there are many arguments that suggest that it has little prospect as a large scale power generation source in the near future. On the other hand, the economic performance of photovoltaic power is rapidly improving and it is already a viable source for remote and stand-alone operations, where the costs of grid connection outweigh the additional costs associated with PV. This source is well worth considering for applications such as cathodic protection of structures, motorway signs, street lighting and telephones. One of the benefits of photovoltaic power is that, once in place, it requires very little maintenance.

Wind Power

Wind energy, a source also derived from the sun, can present an economically viable option in locations with sufficient wind strengths. The technology has progressed rapidly since the 1980s, and is now widely considered as a serious option for large-scale generation.

C. Benefits and Limitations of Waste-to-Energy Projects

Wastes generally have a low energy density, can be difficult to handle and process and are often some distance away from the energy market. These are important factors in the project feasibility equation. Other constraints are due to existing cost structures and historical impediments. Existing power pricing structures typically do not reflect externalities such as environmental or social costs of traditional power generation. In addition, cost of waste disposal frequently omits the external environmental and social costs that often persist well beyond the useful lifetime of the operation. Historical impediments include factors such as pre-existence of plant infrastructure and equipment. This is often the case with existing municipal waste water treatment plants. Nevertheless, a thorough investigation of existing processes and practises is likely to reveal profitable energy saving strategies, even if the full implementation of a waste-to-energy scheme is not found to be financially competitive.

Treatment of these wastes and their management can also affect the release of greenhouse gases by:

- reducing emissions of methane from land filling and decomposition of wastes
- reducing fossil fuel use by substituting energy recovery from waste combustion
- reducing energy consumption and process gas releases in mining and manufacturing industries due to recycling
- maintaining carbon stocks in forests due to decreased demand for virgin paper as a result of recycling,
- reducing the energy used in the transport of wastes for disposal or recycling. Except for the long-range transport of glass for reuse or recycling, emissions from transport of waste materials are usually one or two orders of magnitude smaller than emissions from the other four factors listed above

See Case Studies 69 and 70 on the management of wastes.

There are four main issues, which have raised concerns by local communities and environmental groups and have therefore prevented wide scale adoption of waste-to-energy technologies to date:

- Waste-to-energy schemes promote the generation of rubbish and discourage the philosophy of *Reduce, Reuse and Recycle*.
- Combustion of waste products for direct generation of power is perceived as environmentally unsound, particularly the management of emissions, ash and smoke.
- ❖ Communities have heard the concerns about waste incinerators in other localities, and think these are older inefficient designs rather than state-of-the-art technologies.
- Good communication, careful planning and public education relating to overseas experiences and the performance of modern conversion equipment are needed to overcome these concerns.

D. Project Evaluation

1. Land fill Gas Projects

The two main drivers for land fill gas (LFG) recovery are the need to control methane emissions and the potential for creating a new revenue stream.

Key questions in assessing the potential of a landfill site are:

- How much will the additional infrastructure cost?
- How large is the revenue stream that will be received from the sale of LFG or energy?
- Is there a gas user in close proximity to the landfill, or will additional expenditure be required in transporting the gas?
- If electricity is to be produced, will the local utility buy from you?
- What are the buy-back rates?

It is important to gain a good estimate of the:

- quantity of gas that can be supplied
- reliability of supply
- period of time over which the supply can be guaranteed.

The factors that influence the methane production of a landfill are:

- Fraction of Degradable Organic Carbon (DOC). Commercial and industrial waste tends to have a high DOC fraction due to a high paper content. The DOC fraction in MSW varies widely depending upon the relative proportions of food, garden waste, paper etc.
- Moisture content and pH. Methane production exhibits an upward trend with moisture content, regardless of age, refuse density and composition. The optimum pH for methane production is between 6.8 and 7.4. Methane production rates decrease rapidly below 6.5 and carboxylic acid formed during decomposition can retard the onset of methane production by months and potentially years.
- Density and particle size of waste. Methane production tends to increase with density and increase with decreasing particle size.
- Filling practises affect the density of decomposable material in a landfill. Anaerobic digestion commences more quickly if the waste is frequently covered, but the covering material may decrease the proportion of decomposable material in the landfill.

These factors are influenced by the amount and type of waste and are directly related to population growth, per capita waste generation, waste segregation practises, recycling, composting and other methods of waste treatment, including co-disposing of other liquid and solid waste. The yield of land fill gas varies widely between landfills.

Methane production potential can be found by one of several ways:

- performing theoretical calculations using stoichiometric calculations some of which are given below
- conducting laboratory tests and simulating the landfill behaviour, and
- conducting field tests of actual landfills

There is a lag-time between the deposition of waste and the onset of methane generation. This is usually of the order of one year. Once methane generation is established, emissions continue for several decades as the waste decays. The amount of methane produced can be estimated with a knowledge of the quantity of cellulose and hemicellulose in the waste. Using this approach, methane production from cellulose is approximately 415 litres per dry kilogram and 424 litres per dry kilogram of hemicellulose. Another method

is to perform a Biochemical Methane Potential (BMP) test by measuring the anaerobic biodegradation of a sample of refuse in a small batch reactor. This will indicate a lower value than the stoichiometric estimation. Significant variations in the yield and production rate have been found by this method, ranging from 42 to 120 litres per kg of dry refuse. Field studies have measured values of 38.6 to 92.2 litres per kilogram of dry refuse and suggest that some regions may not produce significant volumes of methane. A figure commonly used to estimate the methane production in field scale landfill is 0.0067 cubic metres of methane per kilogram of wet refuse per year, which corresponds to a yield of approximately 8.4 litres of methane per dry kilogram of refuse. When the LFG flow has been estimated, a comparison of the discounted present value of the gas and the cost of implementing the project will indicate whether the project is worthy of progression.

As well as for electricity production, land fill gas can be used in thermal applications, where the gas is burnt to provide heating for buildings and industrial processes. Whilst this application can be less economic than electricity production, due to transmission costs associated with taking the gas to the desired location, use of gas on-site (such as the construction of facilities on reclaimed landfill sites) increases viability. LFG can also be processed to extract a gas that is almost 100% methane - chemically equivalent to natural gas. This process is only economically viable at very large landfills due to the upfront costs associated with the refining technology.

2. Dedicated Anaerobic Digestion of Solid Organic Waste

The use of anaerobic digesters for the processing of organic solid waste is a potentially efficient alternative to land fill. Waste managers need to consider a number of variables such as composition of the waste, total quantities, rate of refuse supply, gas production potential of the waste and environmental impacts of waste practices. Calculation of the carbon available for biogas formation allows an estimate of the energy production potential of the waste.

3. Anaerobic Digestion of Waste Water

Financial viability of these projects depends upon the proximity of the biogas user to the production facility, quantities that can be supplied, reliability of the supply and duration of the supply. Where the option to generate electricity on-site is under consideration, electricity buy-back rates for supplying electricity into the grid will be important. Additional considerations include the:

- extent to which any existing plant can be adapted to maximise biogas recovery
- reduction in energy required for the process
- reduction in the amount of sludge requiring disposal
- value of the land that can be freed for other purposes

Where industrial waste water is to be disposed there may be an additional advantage to using anaerobic treatment with biogas recovery, by a reduction in trade waste charges.

Income, and avoided costs, will comprise:

- reduction in trade waste charges
- revenues from sale of gas
- revenues from sale of electricity
- revenues from sale of compost-like residue
- reduction in greenhouse emissions
- reductions in local disamenity due to odour etc.
- reductions in local disamenity due to effluent discharge

In order to assess the feasibility of a biogas production plant, the amount of methane that could be produced and the value of corresponding energy production should be determined first. The energy content of one

cubic metre of methane is around 33, 810kJ therefore the potential for biogas energy production by the facility can be estimated accordingly.

4. Incineration

“Incineration” is a generic term that encompasses a wide range of options that differ markedly in technology, economics and environmental impact. In the USA, New Zealand, and Australia where there is land available, a number of incineration schemes have been considered over the last decade but so far few, have found economic acceptance relative to land filling.

Present trends indicate a move away from single solutions (such as mass burn or land fill) towards the integration of more advanced incineration technologies within overall waste management strategies. Based on setting priorities for waste treatment methods, these strategies include waste minimisation, recycling, materials recovery, composting, biogas production, energy recovery through RDFs, and residual land filling. This approach favours the integration of incineration within a range of complementary approaches. In the process, mass burn incineration tends to be replaced by more specific and efficient techniques such as RDF incineration, gasification or pyrolysis.

The incinerators required by different waste-energy combustion routes (mass burn, RDF, incineration, gasification, pyrolysis) are markedly different and so are their costs and environmental impacts. Mass burn is typically a low efficiency approach. While it eliminates large amounts of refuse, little energy is recovered. Typically, MSW has an average heat value of 8 to 12 MJ/kg compared with 19 MJ/kg for dry wood, 15 MJ/kg for lignite or 22 MJ/kg for steaming coal. Mixed plastics have an average heat value of 33 MJ/kg. Wet compostable material is in the range of 4 to 6 MJ/kg compared to natural gas which has a value of about 39 MJ/Nm³ (56 MJ/kg). In its modern versions the mass burn process is costly as substantial “end of pipe” technology must be applied for environmental control of emissions. New technology, however, is being developed that improves performance and reduces costs.

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Case Study 71 Poland: Efficient Lighting Project



Objective: This pilot project is designed to reduce greenhouse gas emissions in the electricity sector by building demand in the Polish market for CFLs and other lighting products. The goal is to rapidly replace 1 150 000 incandescent bulbs with CFLs over two lighting seasons.

Location: Poland

Website: <http://www.ifc.org/enviro/EPU/EEfficiency/PELP/pelp.htm>

Description:

Key Stakeholders: International Finance Corporation (IFC), Global Environment Facility (GEF), Netherlands Energy Company B.V., Polish Power Grid Company (PSE), Gliwice (GZE) and Warsaw Power Distribution Companies (WZE), Polish manufacturers of CFLs, (1995 - Present)

Financing Mechanism: A \$5 million GEF grant channelled through the IFC will enable a manufacturer's wholesale cost reduction designed to increase residential consumer purchases of CFLs. The full incentive must be passed on to the retailers, and further "pass-throughs" will be maximized. By targeting domestic manufacturers of CFLs, import duties of 15% are avoided.

Lessons Learned:

The direct manufacturer subsidy is a critical tool for lowering the retail price of CFLs to a level that will induce consumer purchases.

The IFC/GEF Poland Efficient Lighting Project is a utility DSM program funded by a \$5 million grant from the GEF to provide financial incentives through Polish manufacturers of lighting products to residential and commercial end-users. The program is administered by the Netherlands Energy Company B.V. for the IFC. One important aspect of the project is to build the capacity of selected Polish electric distribution companies to implement DSM programs.

The level of price discount was preliminarily determined to be \$3.05/unit for integral CFLs. The program utilizes several distribution channels, including established manufacturers' distribution systems, retail sales shops, bill payment locations for GZE and WZE, and emerging CFL manufacturers' networks.

Case Study 72 Magyar Hitel Bank Energy Savings Office



Objective: Using German coal aid funds earmarked for an energy efficiency revolving fund, the Magyar Hitel Bank Energy Office makes loans to various energy end-users for energy efficiency investments.

Location: Hungary

Website: <http://www.ecee.org/pubs/hungary.htm>
<http://www.mkb.hu/english>

Description:

Key Organizations: Magyar Hitel Bank (MHB) and Energy end-users, (1991 - Present).

Financing Mechanism: A revolving fund established with assistance from the German Coal Aid Fund (this also complied with a restriction of the provision of aid). In 1991, the fund was valued at approximately \$13.4 million; it has subsequently grown to almost \$29.6 million.

Lessons Learned:

- A revolving fund can be a very effective strategy for promoting energy efficiency.
- Cooperation among technical and financial experts improves the quality and cost-effectiveness of loan review.
- Restrictions established by bilateral donors can provide critical direction to local programs.
- Training for MHB personnel was essential in developing the capacity within the bank to administer the fund.

MHB administers an energy efficiency loan program funded from German coal aid to Hungary. Sixty percent of these funds, or almost \$13.4 million, were earmarked to establish a mechanism that would finance energy efficiency investments. Since its inception in August 1991, 430 applications were processed by MHB, resulting in loans totalling \$40 million. There have been only two defaults to date. One of the unique features of the MHB revolving fund is a loan review process that puts loan applications through parallel technical and credit reviews. The technical review is conducted by a jury of specialists drawn from several institutions in Hungary, including several engineering institutions. Their activities are funded by a 0.5% fee assessed on each loan.

The most significant aspect of the lending criteria is that the savings have to be demonstrated in the form of lower energy usage. Specifically, a prospective borrower needs to demonstrate to the bank that its project would save 500 GigaJoules for each HUF 1 million (\$6,500 at current rates) lent, and that at least one half of the funds will be applied in pursuit of energy savings. There is no concession made to monetary savings alone.

The maximum lending limit is HUF 50 million and the bank will allow an 85:15 debt-to-equity ratio. Money can be lent for a maximum of eight years on a term loan basis, with a two-year grace period.

Case Study 73 Proven Alternatives Capital Corporation / Banque Paribas Fund



Objective: Proven Alternatives Capital Corporation (PACC) developed a \$30 million fund with Banque Paribas to finance performance contracts. Target investments are commercial, industrial, and institutional energy efficiency programs and projects.

Location: USA

Website: <http://www.weea.org/worldwide/reports/html/053/Chapter4.htm>

Description:

Key Stakeholders: Proven Alternatives Capital Corporation, Banque Paribas (1994 - Present).

Financing Mechanism: The \$30 million PACC/Banque Paribas Fund, underwritten by Banque Paribas, provides financing structured on a non-recourse basis, with the collateral security for each project's financing limited to the physical assets, contracts, and cash flow of the project.

Lessons Learned:

- Establishing criteria for automatic approval is an important goal, but the process is still more cumbersome than necessary
- Firm agreement of approval turn around time (with penalties) is critical
- The originator of the project must have sufficient internal resources to support the required analyses
- The fund should have a flexible funding mechanism for non-standard approvals and streamlined documentation requirements

In 1993 Proven Alternative Capital Corporation, a merchant banking organization, organized a non-recourse financing pool for energy efficiency projects. This fund, currently performing above projections, pools many projects into one portfolio, thereby increasing the credit strength of the overall portfolio and reducing the interest rate. PACC's role includes fund administration, loan documentation, structuring customer contracts and negotiating non-standard approvals. The target investments for the PACC/Banque Paribas Fund include commercial, industrial, and institutional energy efficiency programs and projects. The minimum project size is \$1 million, although smaller programs have been approved where additional considerations existed (e.g., it was the first project in the development of an overall program). To maintain the balance of the portfolio, \$5 million is the maximum project size. Loan maturities range from 5 to 10 years.

Specific credit and technical criteria were established to create a relatively automatic and smooth approval mechanism. Programs that meet the pre-approved criteria are not required to go through a detailed approval process. This mechanism enables a rapid turn around time and also helps to maintain a low overall cost of capital. PACC first reviews the structure for pending investment opportunities; this ensures that projects submitted for financing will be approved either through the automatic mechanism or with as little additional review as possible. PACC has developed a thorough underwriting and review process that identifies all key risks and eliminates or prices for these risks.

Case Study 74 Mexico: Industrial Motors Pilot Project



Objective: To demonstrate the technical and economic feasibility of optimizing industrial motor and drive systems.

Location: Mexico

Website: <http://www.nrel.gov/tcapp/mexico.html>

Description:

Key Stakeholders: Equipment vendors, Medium-sized industries in central Mexico, FIDE, CFE, USAID, (1993 - Present).

Financing Mechanism: Two forms of financing are being utilized in this pilot project: vendor financing for industrial motors and adjustable-speed drives, and a revolving fund to offer attractive packages for longer-term efficiency measures.

Lessons Learned:

- Although this project has been slowed by the general financial difficulties in Mexico, it does represent a creative use of development support to harness vendor lending programs.
- Organizing the market makes traditional vendor financing part of an overall efficiency program.

The project considers all types of energy efficiency measures related to these systems, including maintenance and the purchase and installation of motor control systems, high-efficiency motors, high-efficiency transmission systems, and adjustable-speed drives. As part of the pilot project, vendor financing packages are being developed for the end-user as an incentive to implement energy efficiency measures with longer payback periods.

The Industrial Motors Pilot Project is an innovative initiative between USAID's Energy Efficiency Project and Fideicomiso de Apoyo al PAESE (FIDE). The core of the program consists of motor system audits conducted in 20 medium-sized plants (with monthly maximum demand ranging from 750 kW to 2,000 kW) in the central region of Mexico. The audits are performed by local consultants, paid for by the pilot project budget, and are performed at no cost to the industries. However, prior to the audit, the end-user signs a contract with FIDE agreeing to implement all measures with a payback of less than 6 months or reimburse the cost of the audit.

The project involves equipment manufacturers and vendors in its promotional and technical activities. Participating industries either applied directly for the audits or were recommended by industrial associations or groups. The selected plants represent a cross-section of industries; the majority of the participants come from the food, chemicals, textile, and mechanical assembly industries. As part of the project, financing packages are being developed as incentives for the industrial plants to implement the longer-payback measures.

VIII. TOOLS FOR FINANCING ENERGY EFFICIENCY

A. Introduction

The lack of financing is an often cited constraint to the widespread implementation of energy efficiency. In many instances, however, the problem is not only the lack of available capital but also market imperfections. The most obvious example of this is where energy prices do not reflect the real costs of energy production. If energy prices are low, rates of return on energy efficiency investments will be unattractive and the demand for financing will be too low to interest financial institutions. This is an example of a market barrier, not a financial barrier.

One resolution to this dilemma is to adopt an approach that considers market conditions, financing structures, and policies at the same time. Thus, this chapter:

- describes some of the key the market conditions and barriers that restrict making energy efficiency an attractive investment
- identifies financing structures that are applicable to energy efficiency investments
- recommends financing strategies for all stakeholders attempting to increase energy efficiency financing.



There are generally two types of stakeholders interested in financing energy efficiency: those who view energy efficiency financing from a “macro” perspective (i.e., governments, non-governmental organizations, and bilateral donor agencies) and those who view it from a “micro” perspective (i.e., energy end-users, equipment and service providers, and financial institutions).

Figure 8.1: Financing energy efficiency projects often requires the energy champion to think of novel ways of finding investor.

Some stakeholders such as utilities and multilateral development banks act as both micro and macro players. Much can be gained by stakeholders understanding both perspectives. The emphasis of this Chapter is on developing countries and emerging market nations. Although market and financing barriers clearly exist in these countries, the potential for energy efficiency is great. Electric and thermal energy end-users are emphasized, because this is where some of the most serious barriers to financing exist and the need for developing financing strategies in these sectors is critical.

1. Approach

To compile this chapter an extensive Internet based search of international public and private websites was carried out, publications and conference notes were reviewed (general government guidelines, journals, policy statements, technical notes, case studies, governmental acts and white papers) and some industry experts were interviewed. However, this Chapter is predominately a summary from two sources of information that were found to be the most comprehensive and accurate from all the research completed, as described below.

- A 77 page report for the United States Agency for International Development 1996 “Business Focus Series: Strategies for Financing Energy Efficiency”, prepared for the USA Office of Energy Environment and Technology, by Hagler Bailly Consulting, Inc.
- The US Office of Energy Efficiency and Renewable Energy (EERE) web site that provides useful links to energy efficiency and renewable energy financing resources in the USA and overseas.

2. Market Fundamentals

Before capital for energy efficiency investments can be secured, markets must be developed, projects identified, partners selected, engineering and economic analyses conducted, and the decision to invest made. However, all of these actions hinge on the ability to obtain financing. Where the market fundamentals are not strong, the likelihood of obtaining financing will not be high. A strategy that never loses sight of fundamentals - favourable market conditions, motivated stakeholders, and compelling economics - is the best one for obtaining much-needed financing for energy efficiency projects.

The four types of market conditions which have the strongest influence on energy efficiency investments are discussed in the following sections:

Market Opportunities

In each country, market opportunities will differ in terms of the technologies demanded (lighting, motors, cogeneration etc.) and the types of investments (retrofit, new construction, services). Most investments in energy efficiency involve the installation of new systems or technologies or the retrofit of existing equipment, either through a direct investment by an end-user or through the provision of energy services by a third party. Retrofit markets for energy efficiency technologies exist in most countries. Estimates of the current market size for energy efficiency products and services vary across sectors, technologies and countries, making it difficult to accurately value the total market. Market size estimates by region show that the largest markets are in the United States and Canada (40%), followed by OECD Europe, Asia, Eastern Europe, South America and Mexico, and the Middle East and Africa. Non-OECD markets are estimated to be 25% of the current market. Overall, market growth worldwide is expected to be a modest 6% annually through the year 2015 based on the market constraints that continue to exist. However, in developing countries, growth is anticipated to be more than twice as high (10% per year) than growth in industrialized countries (4% per year).

Because no single market structure encompasses all energy efficiency products or services, market opportunities will vary among countries. Identifying market opportunities that lend themselves to financing is a challenge for energy efficiency because of the complex market structure and the barriers that exist. Namely the market consists of a diverse group of finished goods, components, engineered systems and energy service companies that provide engineering, project management, finance, and software development expertise to deliver savings to energy users. The industry encompasses both end-use and supply-side applications. Distribution channels vary widely, both by product/service and by country. Energy efficiency projects may vary from a few hundred dollars for steam traps to thousands of dollars for motor retrofits, and to several million dollars for cogeneration systems and more extensive industrial system retrofits.

This is important for two reasons:

- a financing strategy that is applicable to a project of high value may have no application for the purchase of an inexpensive, individual technology
- the fixed transaction costs associated with small projects are high relative to total cost, negatively impacting a project's economics.

Energy Sector Conditions

Energy prices, industry structure, and power availability are the three most important energy sector conditions driving energy efficiency investments. Low energy prices give rise to excessive demand for energy. By raising energy prices, the return on an energy efficiency investment rises proportionately.

Ownership, regulatory environment, and market competition are key determinants of the industry structure. In countries with limited power availability and that experience power shortages, energy efficiency may provide additional financial and economic benefits.

Host Government Policies

Government policies that support investment in energy efficiency can make an important difference in the level of these investments. Governments stimulate energy conservation through regulation, incentive structures, and specific programs. Such policies are pursued for the societal benefits that improved energy efficiency can bring: minimization of power shortages, decreased environmental degradation and overall economic efficiency.

Economic and Business Conditions

The most important economic and business conditions affecting the attractiveness of energy efficiency investments are economic reforms, the level of capital market development, availability and rates for conversion of local currency into foreign exchange, the institutional and legal framework for investments, and internal corporate barriers.

3. Motivated Stakeholders

The key entities at the micro-level include energy end-users, energy suppliers (utilities), financial institutions, banks, and energy-related services or equipment providers. Macro-level stakeholders include host government entities (e.g., national energy agencies, regulatory commissions, energy conservation centres), multilateral development banks or other donor/bilateral aid agencies, and non-governmental organizations and associations. In some instances macro-level entities are parties to energy efficiency projects, thus acting at the micro level.

Likewise, energy suppliers, utilities and multilateral development banks are sometimes macro players. One challenge is to coordinate, and in some instances, merge the diverse motivations of stakeholders. This is especially true in the case of energy efficiency projects where the economic incentives are insufficient to induce the private sector to act. In the many cases presented throughout this Chapter, public sector entities played a critical role in either developing the project or providing financial support; most of the programs have received some type of financial support from a macro player.

4. Compelling Economics

Energy efficiency investments must provide acceptable returns for those who are making the investment. The payback period is the measure most often used when evaluating the returns on energy efficiency projects as is net present value (NPV), internal rate of return (IRR) and annualized life cycle costs. The allocation of risks among the parties is central to the decision to invest and the available financing options. The amount and nature of risks that a party is asked to bear determines the party's required return.

5. Barriers to Energy Efficiency Investments

The fact that huge potentials for energy efficiency improvements exist but remain unused obviously indicates that there are barriers to the implementation of such measures.

The main barriers are the following:

- Pay-back period criterion
- Subsidized energy prices
- Capital availability, capital costs, uncertainty and risks
- Information, transaction costs and limitations in access to foreign currency
- Possible disruption of production and the related "transition costs"
- Unstable economy with high inflation and unstable exchange rates and taxation
- Lack of skilled personnel or energy managers
- "Invisibility" of the impacts of energy efficiency measures
- General aversion of perceived risks

B. Financing Options

1. Commercial Sources of Finance

Commercial financial institutions represent an important source of untapped funds for energy efficiency projects; nearly half of all capital market activity worldwide in all sectors involves commercial loans and leasing.

Commercial sources of financing may be obtained for new investments as well as energy efficiency retrofits. Commercial financing sources include:

1 Leasing

Leasing gives the lessee use of the project in return for regular payments to the lessor, who remains the legal owner. Leasing has proven to be particularly adaptable to energy efficiency projects.

2 Third Party Financing or Performance Contracting

Often a developer or company does not have both the technical and the financial means to implement a project. In this case, recourse to a third party, usually in the form of an Energy Service Company (ESCO), may be appropriate. The ESCO provides the means and skills to finance, install, operate and maintain a project, and is usually financed directly from the energy savings or the energy generated by it. Thus, no up-front capital is required by the developer.

3 Project Financing

Whereby bank loans are secured largely against future cash flows rather than just the physical assets of the project.

4 Personal Reserves

On-balance sheet, whereby the costs of the project are met from the cash reserves of an individual or a small company.

5 Joint Venture

Many smaller energy project developers do not have the reserves to finance projects using the on-balance sheet route, or the time and skills to set up a limited recourse project-financing package. In this case, co-development (joint venture) with a stronger partner able to raise the necessary finance (perhaps an electricity utility) may be suitable.

6 Funds

Occasionally, recourse to pension funds, ethical/"green" investment funds, local community/co-operative support etc. may be possible, although these schemes are not common and there will be an element of competition for the limited funds available.

7 Vendor Financing / Corporate Financing

The involvement of private investors who accept all the risk from a new project on their balance sheet may also be a possible financing route. Investors could include large corporates, investment banks and institutional investors etc.

8 Venture, Seed and Development Capital

Certain projects may be attractive to the venture, seed and development capital industry, although the nature of the return expected and the investment criteria used may not be suitable for energy efficiency projects.

Local Financial Institutions

The most important sources of commercial financing for energy efficiency investments are local financial institutions: commercial banks, non-bank financial institutions such as leasing companies, and government- and privately-owned development banks that lend to commercial enterprises.

Since many energy efficiency investments are small (under \$1 million), local financial institutions play a very important role as retail distribution agents. Several examples of how local financial institutions are successfully acting as intermediaries for energy efficiency projects are described below.

India

In India, the Industrial Credit and Investment Corporation of India, Ltd. (ICICI) has been working with the Asian Development Bank (ADB) and the US Agency for International Development for over five years to strengthen its management's ability to support energy efficiency projects and to act as an agent bank for ADB in the development and commercialization of energy-efficient technologies. For example, ICICI is financing a waste heat recovery project in the cement industry. The project has a total power capacity of 2.2 MW at a cost of \$3.5 million. Of the 2.2 MW, 1.6 MW will be generated from recovered heat.

Poland

In Poland, Landis & Gyr is in the final stages of obtaining commercial bank financing with the support of EBRD for a district heating project in a town with a population of 38,000, of whom 20,000 are connected to district heat. The project will upgrade boilers and heat exchangers, install a full metering system, and shut down polluting local boilers. The efficiency gained will allow a further 8,000 consumers to be connected to the system, generating additional revenues, which will repay the financing. The atmosphere of the town will benefit by substantial reductions in CO₂, SO_x and NO_x emissions. The construction will take about 18 months and the benefits will accrue over approximately 8 years. The financing, structured for this time frame, is sourced from commercial banks, with support from the industrial partners and EBRD. Landis & Gyr has stated that "the management time committed to this project was not proportional to the commercial benefits, but was considered justified in an early stage of market development".

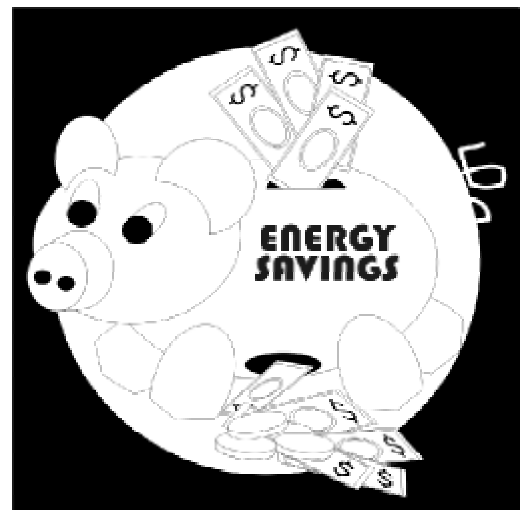


Figure 8.2: In Case Study 71, a revolving fund proved to be an effective strategy for promoting energy efficiency.

Hungary

In Hungary, the Energy Savings Office of the Magyar Hitel Bank has been making energy efficiency loans since 1987 with funding from the German "coal aid" fund (see Case Study 72.)

Thailand

In Thailand, the Energy Conservation Promotion Act (the Act) was approved by the Government of Thailand in March 1992 with mandates to promote energy conservation and energy conservation investment in factories and buildings. The Act is seen as innovative as it blends incentives with mandatory regulations to facilitate the implementation of mandated energy-efficiency measures.

National policies and programmes for the promotion of investments in energy efficiency in countries with economies in transition (EITs) like Kazakhstan, Kyrgyzstan and Tajikistan can be found at <http://www.unescap.org/enrd/energy/finance>.

In each of the examples mentioned, a local commercial financial institution was responsible for playing a different and important role in delivering financing for energy efficiency. A major barrier to increasing the use of commercial sources of financing for energy efficiency financing is posed by weak end-user creditworthiness. The end-user is the primary payor on most financing for energy efficiency investments. Even where performance contracts are used so that payments are based on measured savings, the end-user credit is material. Unlike power projects, which generate energy sales revenues, energy efficiency projects generate a stream of savings. The ability to secure financing still derives from an end-user's ability and willingness to pay. End-user credit can pose challenges of access to capital and transactions costs. Strategies to manage end-use credit risk must address both of these issues.

2. Leasing

Leasing is an important financing structure that is comparable to borrowing money. It allows the user of a leased asset (the *lessee*) to avoid using capital up-front to acquire the asset. A typical structure for leasing equipment is the finance lease, also referred to as a "capital lease" or instalment purchase agreement. Under a finance lease, repayments for up to 100% of the equipment and/or project costs are spread out over the lease term. The lessee usually has an option to take title to the equipment at the end of the term. There are many advantages to leasing:

- the lessee's requirements for initial cash are minimal or none
- the lease may be structured so that cost savings will be greater than the lease payments, thus generating a positive cashflow for the lessee
- lease contracts can be structured flexibly to be combined with other financing sources or to provide up to 100% of the total financing

Leasing can be used to finance virtually all types of energy efficiency equipment over the full range of project sizes that energy efficiency presents in various sectors, from large industrial projects such as heat recovery or cogeneration, to small, mass-market programs such as compact florescent lighting or power factor correction capacitor installations. Leasing can be used for residential appliances, building control systems, or HVAC systems. Despite growth in lease financing, leasing remains largely untapped as a source of financing for energy efficiency projects, particularly in the developing world. But this is likely to change.

There are at least four reasons for pursuing lease financing for energy efficiency transactions and programs. The first is that lease financing is a useful financial mechanism for accommodating the credit issues related to smaller-size investments and small businesses. Second, lease-financing structures can be included as part of energy efficiency programs involving other players, such as energy service companies, vendors, or electric utilities. Third, lease financing represents a potentially large source of funding. Fourth, lease financing structures are being used successfully for energy efficiency in the US and existing models can be replicated or adapted to other countries.

Today, such companies as detailed below aggressively market lease-financing services for energy efficiency equipment. US energy efficiency companies often use leasing to sell their equipment and turnkey project services both in the US and internationally.

3. Third Party Financing

Third Party Financing (European term) or Performance Contracting (US term) is frequently employed in the financing of energy efficiency projects. It has been widely used in the US and Europe, but is relatively new in developing countries and emerging market economies. In Third Party Financing, an end-user (such as an industry, institution, or utility), seeking to improve its energy efficiency, contracts with an energy service company (ESCO) for energy efficiency services and financing. Several contract and financing structures can be used and are described in this Chapter.

Energy efficiency projects generate incremental cost savings as opposed to incremental revenues from the sale of outputs. The energy cost savings can be turned into incremental cash flows to the lender or ESCO based on the commitment of the energy user (and in some cases, a utility) to pay for the savings. The essence of Third Party Financing is that some part of the contract is based on the ESCO's performance in achieving energy savings. Contracting based on performance does not necessarily have to be undertaken by an ESCO, but in practice, ESCOs have been the pioneers and major users of Third Party Financing for energy efficiency projects. Third Party Financing represents one of the ways to address several of the most frequently mentioned barriers to investment. Third Party Financing through an ESCO transfers the technology and management risks away from the end-user to the ESCO. For energy users reluctant to invest in energy efficiency, a performance contract can be a powerful incentive to implement a project. Third Party Financing also minimizes or eliminates the up-front cash outlay required by the end-user. Payments are made over time as the energy savings are realized.

Efforts to apply the ESCO model of Third Party Financing in developing countries are still relatively new and perhaps it is too soon to predict this model's long-term applicability and replicability. Over the short term, the results have been mixed. Several companies have committed to investments only to pull out of them at a later date. Other ESCOs have conducted initial business development and concluded that the development costs were too high, the financing unavailable, or the risks unmanageable. Some companies have been successful and have executed multiple performance contracts.

Two examples are EPS in the Czech Republic and Intesco in India; both are US ESCOs operating overseas with joint venture partners. A description of one of EPS' projects using Third Party Financing in the Czech Republic is described in Case Study 39.

One hypothesis for why the success stories are few is the mismatch between the skill mix and resources of US ESCOs and the requirements of doing business in developing countries and emerging economies. Many US ESCOs are small and medium-sized business with relatively short track records operating outside of the United States, and as small businesses, many of them lack the financial resources to sustain high market-entry costs. Another reason that Third Party Financing is not widespread outside of a few countries is that the fundamental concepts behind Third Party Financing are new and will take time to learn. In addition, most of the time, the contracts need to be adapted to conform with country's legal requirements.

The Role of Energy Service Companies

ESCOs have long been active participants in the US market for energy efficiency by acting as both project developers and marketers. However, US ESCOs have only begun to undertake business development activities in emerging market countries in the last several years. ESCOs have identified the lack of financing, especially for terms of 5 to 10 years, as a major barrier to implementing projects outside the United States. They are also finding that the sales, marketing and project development costs are quite high, due in part to the high risk of project cancellations and delays, and the lack of familiarity among energy users with the concepts of performance contracting.

In some cases ESCOs provide financing for projects from their own funds; however, they are generally only able to finance the initial stages of a project. More often, the ESCO's role is to arrange financing for its customers with leasing companies, institutional investors and commercial banks. In doing so, ESCOs assume certain risks for system performance and energy savings via extended warranties, guarantees or performance-based compensation arrangements where the end-user's payments are a function of verified energy savings.

ESCOs have been most effective in delivering energy efficiency services to larger commercial, industrial and governmental/institutional end-users, and to end-users with large and stable energy loads. Generally if the ESCO is to be profitable, it must develop projects of a minimum size. The minimum size will vary, but typically ranges from US \$250,000 to \$1 million in total project capital costs. However, some ESCOs have been effective in implementing small commercial, industrial and residential projects for utilities where the utility has organized the market or acts as the payor. This allows the ESCO to achieve economies of scale in service delivery on small projects.

Some ESCOs market their services by undertaking projects for low-cost or no-cost (operations and maintenance) types of efficiency measures that have quick paybacks. This allows the ESCO and the end-user to move directly into implementation by taking advantage of immediate energy savings opportunities that require little financing.

Types of Contracts Used by ESCOs

For ESCOs, projects are typically implemented using two general forms of contracting, both of which are performance-based:

- Performance based contracting for energy services only
- Performance-based contracting for energy services and financing

Several types of performance-based contracting are commonly used: guaranteed savings, shared savings contracts, paid-from-savings contracts, utility DSM contracts, energy/output sales agreements, and performance leases. The guaranteed savings contract is the most popular type of performance-based agreement.

Financing for Performance-Based Projects

ESCOs seeking to use performance contracting must develop sources of debt and equity to finance their projects. Most ESCOs do not have adequate credit to secure financing for their customers without pledging the project's assets. Therefore, most financing for projects developed by ESCOs in the US has been guaranteed savings, where financing is provided by financial institutions on a corporate financing basis with full recourse to the ESCO's customers. Sometimes financial institutions providing credit to ESCO customers receive guaranties of repayment from the ESCO or the ESCO's owners. Commercial banks and leasing companies in the US have experience in this type of lending. Few banks outside of the US and Europe have experience with energy services projects involving ESCOs. However, where the credit risk is that of the customer, it is often not necessary to undertake an in-depth credit analysis of the energy services project since the financing is not a non-recourse financing.

This allows ESCOs and customers to develop projects that are much larger than their net worth. Although non-recourse financing has important advantages, it also introduces significant business risks into the financing, and only a limited number of institutions provide this type of project financing. Structuring a non-recourse or limited-recourse project financing for any investment is a time-intensive process, requiring extensive evaluation and comprehensive documentation.

An example of a creative approach to securing adequate non-recourse financing is described in the Case Study 73. below. A special \$30 million fund was created, Proven Alternatives Capital Corporation and Banque Paribas were able to develop projects that qualify for non-recourse project finance. Although each specific project must be approved by the bank, underwriting criteria have been established that serve to create a faster and less costly approval process.

4. Vendor Finance Programs

Vendor finance programs offer a set of commercial finance techniques that can address some of the challenges of energy efficiency financing. Vendor financing works best in mass-market applications to finance sales of common equipment with large numbers of end-users (e.g., industrial motors, commercial lighting). Sometimes, vendors form their own finance companies to serve these purposes.

A vendor finance program is a programmatic relationship between an equipment marketer (the “vendor”) and a financial services company to provide financing at the point of sale. An equipment marketer may be the manufacturer, but may also be a distributor or retailer. The vendor becomes the motivated stakeholder behind the marketing effort, marketing financing in conjunction with equipment. The vendor assumes the responsibility for documentation and other administrative tasks, and shares in transaction costs. The vendor is also the “aggregator” of capital demand. The vendor may provide certain credit enhancements and, if sufficient numbers of transactions are pooled, credit can be evaluated based on the portfolio as a whole, saving in transaction costs and allowing credit to be extended to more end-users.

The Vendor/Financier Agreement

The goals of the vendor/financier agreement are to create a creditworthy program, enhance the security structure to allow credit to be extended to more customers, manage transaction costs, and create a volume of business for the financier. Obviously, the development of vendor financing requires the participation of a motivated vendor.

The Vendor/Customer Agreement

A key objective of the agreement between the vendor and the customer is to achieve an attractive financial arrangement for the customer. This is usually accomplished by achieving a positive cashflow for the customer, i.e., the savings resulting from the project will be greater than the finance payments and incremental project operating costs. A primary technique used to achieve a positive cashflow is to lengthen the finance terms: financing terms of three to seven years are most common, although terms of up to ten years are needed in some cases. In some emerging market countries, financing beyond a three-year term is unavailable for any purpose.

A good example of the use of vendor financing for energy efficiency is in Mexico in connection with a pilot industrial motors project implemented by the Fideicomiso de Apoyo al Programa de Ahorro de Energia del Sector Electrico (FIDE), a portion of the financing for the purchase and installation of the motors will come from General Electric, the motors’ manufacturer. See Case Study 74.

Use of Trade Finance in Vendor Finance Programs

Many countries do not manufacture important energy efficiency equipment (e.g., heat exchangers, high-efficiency boilers, heat distribution controls, steam optimization technologies, air conditioner and chiller equipment, low-energy lamps and reflectors, advanced motors and drives) and must import all or some of the equipment to meet their needs. Trade in services (design engineering, management or technical services) may also be desired.

Imported equipment and services are traditionally financed using trade finance mechanisms or through a competitive bidding process tied to a multilateral development bank loan. These individual procurements of goods and services require vendors to have access to trade financing mechanisms such as letters of credit confirmed through the commercial banking sector, medium and long-term buyer’s credits, trade insurance policies and relationships with financial intermediaries that work alongside commercial banks and export credit agencies.

Developed countries' export credit agencies can play a role in energy efficiency financing, especially in connection with vendor programs. Programs exist to provide vendor and equipment finance for projects in a range of sizes. For example, the Export-Import Bank of the United States offers credit insurance for terms of between 180 days and 7 years, and medium- and long-term loans and guarantees for terms of up to 10 years. The bank's credit guarantee facilities program is a medium-term line of credit extended by a bank in the United States to a foreign bank. The line of credit is guaranteed by Ex-Im Bank. This may be a suitable vehicle for vendor financing programs. The bank already offers some special programs for environmental goods and services, and energy efficiency falls into this group. Under these programs the maximum repayment terms allowed under OECD consensus guidelines can be extended.

5. Utility Finance Programs

Utilities can play a very powerful role in financing energy efficiency projects. In many countries, utilities have implemented or are considering implementing demand-side management (DSM) programs. Demand-side management programs are utility activities that encourage customers to modify their electricity or gas consumption with respect to both the timing and level of electricity or gas demand. Financing may be a feature of DSM programs. Utilities in the United States and Canada have had DSM programs in place since the late 1970s. Table 8.1 shows the types of activities included in typical DSM programs.

Sector	Program
Industrial	Time-of-use tariffs Interruptible and curtailable tariffs Motor efficiency Variable speed drive programs
Commercial	Ventilation and air conditioning efficiency programs Lighting efficiency Residential Refrigerator efficiency Lighting efficiency

Table 8.1: Typical DSM programs

Utility Incentives to Promote Energy Efficiency

As a precondition to undertaking an energy efficiency/DSM financing program, the utility must have an incentive to save energy. This incentive may be provided or enhanced by regulation, but must have a sound economic basis. Although there may be societal gains as a result of end-use efficiency efforts, financial incentives provide the clearest and strongest motivation for a utility's management to continually pursue energy efficiency as a resource.

Many utilities' efficiency efforts are undertaken primarily on the supply side (the reduction of transmission and distribution losses, for example). Such efforts translate into additional revenue for the utility. Financial incentives for energy efficiency are frequently less transparent or are negative. Although end-users benefit from energy efficiency projects through reduced energy bills or lower energy costs, the utility frequently realizes lower unit sales and revenues from that customer, thus providing a financial disincentive to promote end-use efficiency. Thus, the utility must realize benefits from end-use energy efficiency elsewhere in its system or be compensated for its lost revenue.

The extent of a utility's motivation is often a function of its operating environment. For many utilities in developing countries, there is a shortage of power capacity; this is the case in India, China, Columbia, Thailand, Brazil and other nations. In these circumstances, a utility has an economic motivation to promote energy efficiency to reduce or avoid capital costs for new generation and/or transmission and distribution capacity. Demand-side management through end-use energy efficiency can be an effective means for delaying capital expenditures for several years.

Another condition common in developing countries and emerging market economies is the cross-subsidization of utility tariffs, where certain customer classes (typically residential, agricultural, or municipal customers) pay rates that are below the utility's cost of service. In this case, the utility has a financial incentive to promote and invest in end-use energy efficiency for these classes as a way to reduce losses and to free up power that can be sold elsewhere, sometimes at a higher tariff, thereby increasing revenues. For example, in India, agricultural end-users receive subsidized rates for electricity.

The State Electricity Board and the State Government share in the cost of the subsidy, and both are motivated to increase efficiency. Many nations are also undergoing power sector restructuring, breaking up generation, transmission and distribution functions among separate companies and allowing open retail access. In this type of competitive environment, the utility's provision of value-added efficiency and financing services can be part of a customer retention strategy.

The provision of energy efficiency/DSM or financial services may also constitute a new utility profit centre. The sale of power can be combined with the delivery of end-use equipment and efficiency services. Energy efficiency also becomes a vehicle to meet the growth in demand for energy services. In the future, the utility may obtain benefits via pollution reductions or Joint Implementation greenhouse gas emissions credits.

Utility Roles in Financing Energy Efficiency

The utility can assume four roles in financing energy efficiency: facilitator, collection agent, financial services provider, or payor/buyer.

These roles are outlined below:

- **Facilitator**
Acting to organise the market for stakeholders
- **Collection Agent**
Method of aggregating capital demand and addressing credit risk
- **Financial Service Provider**
The utility is a vehicle to access financing for its customers
- **Payor/Buyer**
Direct payment (rebates) and credit support
Organizer and informer of the energy end-user
Billing and collection of finance payments
- **Project implementor**
Procurer of efficient products and services
Conductor of energy efficient procurements for customers
Financial service provider
Purchaser of efficiency resources
Stimulating the interest of financial institutions
Lowering transaction costs by pooling a number of energy efficiency projects

Utility Design Considerations for the Financing Program

Utilities that want to promote energy efficiency must also consider how customers will finance projects. Customers may be capital-constrained, or they may have higher priorities for using their capital. Providing or arranging financing may thus be essential for a utility to achieve its efficiency implementation goals. The general themes of program design include assuring that the program is attractive and marketable to customers, that services will be delivered effectively, that appropriate roles will be assumed by third-party contractors, and that utility costs are measured against the value of energy efficiency and DSM goals.

6. The Profitability of Energy Efficiency Upgrades

Application of the 10 energy efficiency measures described below in a typical home yields nearly US\$600 in annual bill savings, and an impressive 16% overall return on investment. The diagram below provides a representative view of the high profitability of energy efficiency upgrades. Note that the home evaluated here is located in an average US climate and has a heat pump, electric water heater, clothes washer, clothes dryer, and dishwasher. By adjusting the figures below by using foreign exchange rate and domestic buying power and other domestic economic assumptions, one can make comparisons with developing countries.

Upgrade	Purchase Price	Annual Savings	Simple Payback	Rate of Return
Fluorescent Lamps & Fixtures	\$200	\$80	2.5 yrs	41%
Duct Sealing	\$250	\$95	2.6 yrs	41%
EnergyStar Clothes Washer	\$194	\$66	2.9 yrs	37%
EnergyStar Programmable Thermostat	\$107	\$29	3.7 yrs	30%
Water Heater Tank Wrap (R12)	\$85	\$23	3.7 yrs	28%
EnergyStar Refrigerator	\$97	\$23	4.2 yrs	27%
EnergyStar Heat Pump	\$692	\$126	5.5 yrs	19%
EnergyStar Dishwasher	\$29	\$5	5.5 yrs	18%
Air Sealing (0.5 changes / hour)	\$522	\$38	13.7 yrs	9%
Increase wall and roof insulation	\$1784	\$111	16.1 yrs	8%
Total	\$3960	\$597	6.6 yrs	16%
Total Bill Savings as % of Baseline Bill¹				36%

Table 8.2: Potential energy savings for homes.

NOTES:

Assumes typical house with air-source heat pump, electric water heating, clothes washer, clothes dryer, dishwasher. Purchase prices and annual bill savings for efficiency measures are in nominal 1997 dollars. The rate of return assumes 3% annual inflation in residential electricity prices. After-tax rates of return assume a 28% marginal income tax rate.

¹Purchase price of clothes washer, dishwasher, thermostat, and heat pump measures is incremental to the price of existing "NAECA" appliance standards. All other prices reflect the full cost of the measure, including installation.

² Bill savings assume average electricity cost of 8.8¢ per kilowatt-hour. Bill savings of equipment measures are relative to a NAECA standard unit.

³ Heating and cooling consumption values are from LBNL energy modelling using DOE-2; other end-use consumptions are from the US Department of Energy's Residential Energy Consumption Survey (RECS).

The example cost-effectively surpasses the 30% savings target for existing homes under PATH (The Partnership for Advancing Technology in Housing). In fact, all of these measures yield a higher return on investment than an ordinary bank account, and most are as or even more profitable than the stock market has been in recent years! The efficiency savings shown above include the effect of income taxes. This makes the savings even more attractive, because you can keep all the money you save on your energy bills, but have to pay hefty taxes on most ordinary investment income.

7. Special Purpose Funds – Grants, Loans, Funds

The history of using special-purpose funds as a way to promote energy efficiency projects is a mixed one. There are examples where such funds have been very successful, and have been a useful tool in conjunction with program and project development. But in general, the creation of special-purpose funds for private sector energy efficiency investments has not been successful in instances where market opportunities are absent (many successful funds were able to offer below market-rate financing). The key is properly structuring these funds before they are implemented and then ensuring that they are utilized. To the extent that special-purpose funds are expected to earn a return, it is also critical that they be used within a certain period of time, usually several years or less.

Types of Special Purpose Funds

In the broadest sense, special-purpose funds are monies that are directed and limited to a specific use, country, region, sector, or type of investment. Many different types of funds exist and the term “fund” encompasses various financial structures.

Any of the types of funds described below can be used for energy efficiency:

- **Restricted Accounts**
Fully-funded trust or account restricted to specific purposes and administered by an agency or financial institution, usually under an agreement.
- **Line of Credit**
This is a dedicated line of credit at a commercial or development bank, or government agency, that is made available on a commitment basis, but is returned if not used.
- **Revolving Loan Fund**
This fund is structured to become self-sustaining after the fund’s initial capitalization.
- **Investment Fund**
This fund can be closed-end, open-ended, capitalized with equity, or leveraged with equity and debt. Its main purpose is to obtain an acceptable return for its investors/owners, although multiple developmental objectives often may be achieved.
- **Guaranty Fund**
This is an aggregation of commitments to cover the obligations of other parties, usually guaranties of loans.
- **Component of a Broader-Purpose Fund**
Energy efficiency funds have been coupled with funds for environmental improvements, industrial productivity, municipal housing, renewable energy, or an all-energy fund.
- **Tax-, Contractual, or Legal-driven Fund**
A fund can be structured as the most practical way to channel funds to a particular recipient, for legal, contractual or tax reasons.
- **Blocked Funds**
These are sometimes set aside as a way to limit losses and recover monies spent. For example, where investors or governments find themselves in possession of funds in inconvertible currencies, they may establish a fund to re-invest the local currency in projects that will eventually allow the funds to be recovered.

Depending on the structure of the fund, recipients receive grants, loans (interest-free, subsidized, or at market rates), equity, debt (term, convertible, subordinated), guaranties, or any combination of the above. Governments often capitalize these funds with tax receipts, surcharges or user charges (pollution charges), or penalties. Non-profit organizations may capitalize funds with voluntary contributions or membership fees.

Application to Energy Efficiency

Organizations find it useful to develop special-purpose funds for a variety of reasons. Government agencies develop these funds to further such policy objectives as environmental improvement, productivity gains, energy conservation, and energy security. Multilateral development banks often commit to special-purpose funds as a way to retail their funds and reach multiple smaller borrowers, as well as to further development objectives, such as capital market development. Individual and institutional investors find these funds to be a useful mechanism for diversifying their portfolios and for meeting their investment objectives. Equipment manufacturers, utilities, and energy service companies may find such funds to be a useful component of their marketing programs.

The stakeholders most likely to participate in special-purpose energy efficiency funds and the types of funds they might create are shown in Table 7 below. As this table indicates, nearly any stakeholder can be involved in the development, financing or administration of a special-purpose energy efficiency fund. Multilateral development banks, foreign assistance agencies such as USAID, and local government agencies have had the most experience with energy efficiency funds.

Multilateral Development Banks

Restricted accounts, line of credit, revolving fund, guaranty fund, small and medium-size enterprise funds

World Bank	http://www.worldbank.org
EBRD	http://www.ebrd.com/
ADB	http://www.adb.org/
Inter-American DB	http://www.iadb.org/
African DB	http://www.afdb.org/

Foreign Assistance Agencies

Guaranty fund, credit enhancement, seed capital for investment fund, grants, and subsidized loan funds

USAID	http://www.usaid.gov/
ODA	http://www.mofa.go.jp/policy/oda/
CIDA	http://www.acdi-cida.gc.ca/index.htm

Investment Finance Agencies

Investment fund, guaranty fund, insurance fund, all-energy regional funds

IFC	http://www.ifc.org/
IIC	http://iic.nic.in/
OPIC	http://www.opic.gov/
KFW	http://www.kfw.de/EN/inhalt.jsp

Export Credit Agencies

Lines of credits

USEXIM	http://www.exim.gov/
JEXIM	http://www.foejapan.org/en/aid/jbic01/jexim_cmt.html
EDC	http://www.edc.ca/
COFACE	http://www.coface.fr/anglais/indexe.htm
ECGD	http://www.ecgd.gov.uk/

Private Sector

Investment funds, grant funds, revolving funds

Foundations Institutional investors Individuals

Complete web source in the relevant country

Table 8.3: Likely foreign organizations / participants for energy efficiency funds and the type of fund.

Governments

Subsidized loan funds, grant fund, revolving loan funds, credit lines, restricted accounts
Environment agencies
Energy agencies
Municipalities
Development Banks
Complete web source in the relevant country

Utilities

Still early stages of development in developing countries
Electric utilities
District heating utilities
Water utilities
Complete web source in the relevant country

Private Sector

Leasing fund, lines of credit, revolving funds, investment funds.
Equipment vendors
Commercial banks
Industry associations
Foundations
Complete web source in the relevant country

Table 8.4: Likely local organizations / participants for energy efficiency funds

Multilateral Financial Agencies

Since the 1992 UNCED Conference in Rio de Janeiro, lending for environmental purposes has gained a high priority. Today, all major multilateral agencies are incorporating environmental consideration in their programmes. Although the share of financial assistance from the institutions is not as big as bilateral aid or private sector investment, they can play a pivotal role in promoting international cooperation in the new emerging mechanism. Multilateral financing agreements can promote models for private sector cooperation in financing of energy efficiency investments.

World Bank

The World Bank has increased its share in energy efficiency financing, including Activities Implemented Jointly (AIJ) activities, co-financing operations with the Global Environmental Facility (GEF) and through encouraging client countries to improve energy efficiency under its “country-policy dialogue”. The World Bank group also assists projects indirectly through the cooperation with relevant co-financers. As major implementation agency of the Global Environmental Facility, the World Bank has also mobilized private capital and bilateral cofinancing for the GEF funded renewable energy and energy efficiency projects.

During recent years, the World Bank has initiated new, innovative programmes for supporting energy efficiency projects. The objective of Prototype Carbon Fund (PCF) is to supply high quality carbon offsets to industrialized countries through investments in emissions reduction activities in developing countries and economies in transition at prices which are fair to both buyers and sellers.

Another activity of the World Bank is the Joint United Nations Development Programme (UNDP)/World Bank Energy Sector Management Assistance Programme (ESMAP) funded initiative *Energy Efficiency Operational Exchanges Programme*. This is not an activity related to financial activities but can be helpful for developing country hosts to share knowledge and practical lessons on energy efficiency issues.

The national strategies studies programme was launched in 1997 to assist potential host country governments of AIJ and JI in exploring the opportunities and potential benefits and in formulating their own positions.

With the need of an independent financial institution to fund mitigation and response strategies in eligible developing countries and countries in transition, UNFCCC designated the GEF as an interim financial mechanism with three agencies for implementation of projects: United Nations Development Programme, United Nations Environment Programme, the World Bank. From 1991 to mid-1999, GEF approved grants totaling US\$706 million for 72 energy efficiency and renewable energy projects in 45 countries.

Asian Development Bank (ADB)

The Asian Development Bank (ADB) also has undertaken several trial projects in the area of climate change. Since 1995, ADB has been implementing the Asia Least Cost Greenhouse Gas Abatement Strategy (ALGAS) in 12 Asian countries with funding provided by UNDP. Until 1999, selected projects in 11 countries have been identified. The total budget of the project was about 10 million dollars, of which about 8 million dollars came from the GEF through UNDP.

Experience with Special Purpose Energy Efficiency Funds

There are several reasons why funds are useful to energy efficiency projects, but not all of them apply in every instance. Energy efficiency lending requires specialized skills and expertise that are not ordinarily possessed by many financial institutions. Special Purpose funds provide extra market development and project preparation assistance, as well as acting as a vehicle to finance smaller projects and a way to lower transaction costs by replicating and standardisation.

8. Future Financing Structures

The previous financing options described above have discussed financing mechanisms and sources of capital that are well tested, if not in the field of energy efficiency, then elsewhere. Looking forward, there are three concepts that are emerging as potential avenues to finance energy efficiency investments:

Linking IPP Financing with Energy Efficiency Financing

Many developing countries are seeking funding for new capacity through independent power projects (IPPs). But in many nations there is also a role for energy efficiency to meet rising energy demand. Linking energy efficiency financing to an IPP financing can act as a “catalyst” for further energy efficiency funding.

Financial Assistance under the United Nations Framework Convention on Climate Change

Financial assistance to developing countries has been one of main issues in the international debate during recent years. In 1992, the United Nations Framework Convention on Climate Change (UNFCCC) agreed on the principle that international cooperation is needed to finance development needs. Since then Article 6 Activities Implemented Jointly/Joint Implementation (AIJ/JI); Article 12: Clean Development Mechanism (CDM) and Article 17 International Emission Trading (IET) have financing potential for developing countries. As detailed in the report commissioned by the United Nations Economic and Social Commission for the Asia and the Pacific “Promotion of Energy Efficiency in Industry and Financing of Investment” there are 143 AIJ projects which were implemented in 27 host countries and by 9 investor countries with a total of approximately 170 million tons (Mt) of emissions reduced at a total cost of approximately US\$ 640 million. See <http://www.unescap.org/enrd/energy/finance>.

In particular, looking at the share of private sector funding in the figures below, it would appear that there is a surprisingly large participation of private investment (US\$ 140 million), which compares to US\$46 million of public investment in AIJ projects. In 2000, seven parties (Japan, Canada, Denmark, Iceland, Netherlands, Norway, Sweden, and USA) have actively supported the pilot phase of AIJ and most of the private funding was from US investors. Schwarze (2000) considered the active participation of US private sector as a result of the US Initiative on Joint Implementation.

Tapping Secondary Financial Markets for Energy Efficiency Financing

Accessing secondary financial markets for energy efficiency financing is beginning to occur in the United States, and could be a mechanism for financing energy efficiency in other countries. The US Department of Energy is leading the effort to create a secondary market for energy efficiency and their efforts may be applicable to other countries in the future.

There are at least three applications that are being pursued:

- financing for energy efficiency building retrofits
- refinancing of utility demand-side management investments
- securitization of utility customer credits

C. Conclusions and Recommendations

1. Financing Strategies

While most of the strategies are specifically for financing, policy recommendations and a market strategy are also included since the issues of financing, policy and marketing are closely related.

The strategies combine traditional and innovative approaches. While nearly all of the financing strategies can be pursued over the short and medium-term, it should be acknowledged that the policy recommendations and market strategies can take longer to implement. Pursuing the strategies listed below cannot guarantee increased financing for energy efficiency. They are, however, a combination of strategies that have worked in the past.

Funding Strategies

1 *Groups of End-Users by Type and Locate Financing.* Strategies that aggregate the market by type of end-user or type of investment are a valuable way to address critical issues common to groups of energy consumers such as end-user creditworthiness, the small size of the investment, and the lack of collateral value. End-users can be aggregated by type of institution (municipality, industrial, institutional, or agricultural) to take advantage of the similarities in end-user credits. Where programs and projects can be aggregated, packaged, or bundled to reach amounts between \$1 million and \$50 million, financing can be more readily obtained from local financial institutions, and where appropriate, international financial institutions. Aggregating projects may also be a useful approach for Joint Implementation projects.

2 *Increase the Participation of Commercial Credit Providers.* These traditional providers of credit are a large and nearly un-utilized source of credit for energy efficiency, and actions should be taken to involve them. Important sources of financing are leasing companies and local commercial banks. Leasing is a growing business in many developing countries which lends itself well to some of the specifics of energy efficiency financing: large numbers of small credits and end-user creditworthiness. Local financial institutions may not have capital to lend from their own resources, but are in a good position to play other important roles in energy efficiency financing.

3 *Increase the Amount of Vendor Financing Available.* Accessing export credit financing and pursuing vendor-supported financing programs is another under-utilized source of financing for energy efficiency. In some countries, vendors are the most “motivated” stakeholders and are thus in the best position to drive the financing. In addition, some of the energy efficiency equipment vendors are large multinational corporations with access to attractive rates and innovative financial products. In addition, export credit financing programs are often well established and operating smoothly, but to date have limited applications to energy efficiency.

- 4 Obtain Funding for ESCOs.** ESCOs traditionally need access to financing as a tool to market their services, but have found that access to financing is a significant barrier in developing countries and emerging markets. ESCOs play an important role in project identification, development, implementation and evaluation. Most ESCOs work on a project-specific basis, seeking to develop a portfolio of projects. For ESCOs to be effective, they need both debt financing for their customers, and equity financing for their own marketing and project development needs.
- 5 Promote Utility Involvement in Energy Efficiency Financing.** Electric utilities can be powerful players in energy efficiency. Demand-side management programs can save utilities money, provide benefits for end-users, and act as a market pull for vendors and service companies. Utilities can provide direct credits, subsidized credits and rebates; act as collection agents with their customers; and offer a wide variety of credit enhancements for projects. For these reasons, involving a utility in an energy efficiency financing makes good sense wherever possible. Many utilities in North America have experience in program design and thus are good partners to act programmatically.
- 6 Establish Country- and Region-Specific Energy Efficiency Funds.** Special-purpose funds can be a good strategy provided they are well structured, their uses fairly well planned, and they are targeted to where demand is known. Funds are a good way to access both private and public sector sources of financing, as well as to lower the overall cost of financing. In the development of special-purpose funds, it is important to select a structure and management team that will ensure the fund's utilization. Given the specialized nature of energy efficiency project evaluation, a technical assistance component may be desirable.
- 7 Develop Innovative Financing Mechanisms for the Future.** It is not too soon to be looking to the future for new, innovative structures and sources of financing. Three types of financing mechanisms are discussed in the body of this Chapter: emissions credits through joint implementation, linking energy efficiency financing to independent power project financing, and tapping into secondary markets to access new sources of energy efficiency financing. However, these are just three mechanisms and there are many more.
- 8 Build Management, Technical, and Institutional Capability.** While building these capacities is not directly a strategy for financing, it is often a critical prerequisite in countries where the energy efficiency industry is not well developed. Capacity building actions that would more directly support financing include:
- enhancing engineering capabilities for energy efficiency project design and evaluation
 - providing project development and loan packaging support for financial institutions and energy conservations agencies
 - training financial institutions in energy efficiency project evaluation
 - building the organizational capabilities of government policy makers, conservation agencies and associations.
- 9 Continue Energy Sector and Market Reforms.** Government policies that support economic reforms and growth in general will be beneficial for energy efficiency financing. Specific energy sector reforms and direct incentives for energy efficiency can have a much more direct impact. The removal of price subsidies and the incorporation of environmental costs in energy prices are two important policy actions. Trade and investment liberalization has also proven to be helpful for energy efficiency, as have investment incentives. Since every country is different, it is not possible to recommend specific reforms; however, it is important to identify known market failures and develop policies that specifically address these market failures.

10 Increase Market Penetration of Energy Efficiency Goods and Services. Increase the energy efficiency component of investment in new plant and equipment. This is important in countries with high economic growth where the market for new investment significantly exceeds the market for energy retrofits. Various types of financing are likely to be available for new investments, and the energy efficiency component may be able to easily obtain financing as part of the overall purchase or investment. Increase the local availability of energy efficiency products through local manufacturing and distribution. Increased product availability, after-sales service and equipment warranties, and a reduction in foreign exchange requirements will help bring about the increased use of energy efficiency products.

Many opportunities exist for stakeholders to pursue the strategies described above. Each stakeholder can take concrete steps to ensure that more financing is made available for energy efficiency in the future. Bilateral donor agencies should take a lead role in keeping the topic of energy efficiency financing on the policy agenda. Local government agencies must actively support policies that create favourable market conditions and provide incentives for private sector development of the energy efficiency market.

Multilateral development banks and electric utilities, many of whom have long-standing relationships, are urged to work together to implement utility incentives for energy efficiency, to develop new loans for energy efficiency and to find ways to leverage utility-financed programs with private sources of financing. Lastly, all types of financial institutions - commercial banks, export credit agencies, international financing agencies, and leasing companies should learn about energy efficiency investments and be encouraged to become active participants in the market.

E. References and Resources

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Companies offering their own vendor finance

General Motors Acceptance Corporation. <http://www.gmacfs.com/>

Caterpillar Credit Corporation. <http://www.caterpillar.com/>

Lease-Financing Service Companies

GE Capital. <http://www.ge.com/>

Honeywell.<http://www.honeywell.com>

CIT Financial. <http://www.cit.com/>

BankOne. <http://www.bankone.com/>

Citicorp. <http://www.citibank.com/>

Energy Efficiency Funds

Korea - KEMCO. <http://www.kemco.or.kr/english/index.html>

United States - Proven Alternatives/Bank Paribas

<http://www.weea.org/worldwide/reports/html/053/Chapter4.htm>

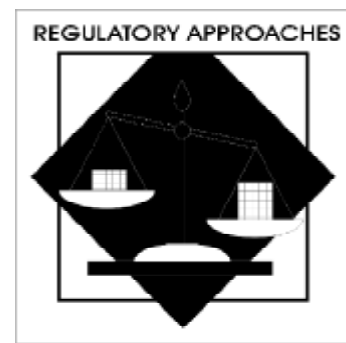
Hungary - Magyar Hitel Bank. <http://www.mkb.hu/english/>

Philippines -TTEM <http://www.gtz.de/em-home/phil/emphil2.htm>

India - Industrial Development Bank of India. <http://www.idbi.com/>

Pakistan - ENERCON<http://www.peemac.sdnpk.org>

Case Study 75 Cities for Climate Protection: Australia



Objective: To reduce greenhouse gas emissions through energy planning

Location: Australia

Website: <http://www.greenhouse.gov.au/lgmodules/>

Description:

It has been estimated that through their planning powers, building codes and spending policies, Municipal Councils have a strong influence over the production of as much as 50% of Australia's greenhouse gas (GHG) emissions (OCH, 2000). As part of an overall package to reduce greenhouse gas emissions, the Federal Government is, through the Australian Greenhouse Office (AGO), providing \$13 million in funding over five years to support the Cities for Climate Protection Australia Program (CCPAP). The CCPAP was initiated in 1998 and is delivered in partnership with the International Council for Local Environmental Initiatives (ICLEI), a worldwide membership association of local governments and national and regional local government associations that are committed to promoting sustainable development (ICLEI, 2001).

CCP Australia is a joint initiative of the International Council for Local Environmental Initiatives (ICLEI) and the Australian Greenhouse Office (AGO). As at 20th April 2001, 130 Australian councils were participating in the CCPA program; 43 had passed a Council resolution, 24 had reached milestone 1, 27 had reached milestone 2, 22 had reached milestone 3, and 11 had reached milestone 4, representing 56% of Australia's population (ICLEI, 2001a). It has been estimated that by 2008-2012 the CCPA program may have achieved almost 13 million tonnes of CO₂-equivalent (CO₂-e) reductions.

Assistance provided to CCP-Australia Participants

Before greenhouse gas reduction technologies can be implemented (which occurs at Milestone 4), Milestones 1, 2, and 3 must be reached. CCP-Australia provides relevant information and training, as well as the assistance of a recruitment manager who helps identify the most appropriate steps for councils to take in achieving the five CCP milestones. Training is offered for reaching each milestone as well as in media, community consultation, and the relationship between budget cycles and CCP.

The Australian Greenhouse Office has developed Greenhouse Action Modules which help councils implement effective greenhouse gas reduction activities. They encourage networking between councils, and range from workshops and technical assistance to software, workbooks and booklets.

Modules and Assistance Programs Provided by Either CCP-Australia or the AGO

Milestone 1: Conduct an emissions inventory and estimate emissions growth

Milestone 1 Assistance Program; provides assistance in completing emissions inventories and forecasts. The AGO provides \$4,000 funding to employ temporary staff to assist with the completion of Milestone 1.

cont...

Greenhouse Gas Emissions Software; allows quantification of greenhouse gas emissions from, for example, electricity production and waste operations, and includes default emissions coefficients consistent with the Australian National Greenhouse Gas Inventory. Training in quantification of greenhouse gas emissions is provided by CCP-Australia.

Data Management Sheets; help councils calculate greenhouse gas emissions and are fully integrated with the Greenhouse Gas Emissions Software.

They cover the following areas.

- Council buildings
- Council vehicle fleet information management
- Corporate green waste and recyclable organics
- The art of forecasting for the CCP™ campaign
- Water and sewage data management
- Driving the alternatives: alternative fuels and how to use the CCP™ software
- Specialised vehicles and equipment
- Street lighting
- How are we travelling?
- Increasing public transport options

Milestone 2: Establish an emissions reduction goal

Energy Management Advisory Service and forums; assists councils on a range of issues especially developing energy management systems for council buildings.

Green Energy Learning Program (GELP); illustrates how Newcastle City Council has made greenhouse gas reductions action self funding through energy efficiency and energy management programs. Three participants from each council are funded by the AGO.

Measures Sheets; are used to quantify emissions from a variety of areas as below.:

- solar lighting
- light emitting diodes
- alternative fuel options for the community
- corporate water supply and sewage treatment
- seeing the light: how changing streetlights can reduce emissions
- green waste - home composting
- hot water energy conservation
- photovoltaic panels and BIPV
- making the most of heating ventilation and cooling systems
- opportunities for measures in the residential sector

Milestone 3: Develop a Local Action Plan

Office Lighting Retrofit; provides in-house technical expertise to assist councils in identifying, developing and implementing lighting upgrades in their city council facilities.

Managing Energy in Local Government; a free workbook to help councils and businesses implement energy efficiency and energy management programs.

Greenhouse Homes; helps councils implement appropriate residential planning and energy efficiency measures for home buyers, home renovators and builders.

CITY Green; enables councils to measure and model the ability of trees to reduce heat islands and thereby improve residential and commercial energy efficiency.

Technical support materials; assist councils identify their capacity to take action on greenhouse emissions. They cover what councils can do to promote greenhouse gas reduction in the transport, industrial, commercial and residential sectors. In particular: high and low-emission transport, cleaner production, waste management, non-residential building design, partnerships with energy suppliers, greenfield developments, and medium-density housing developments.

Milestone 4: Implement the Local Action Plan

Emissions Reduction Incentive Program (ERIP) Module Round 1; provides 50% of the costs of actions that result in significant sustained greenhouse gas reductions beyond the council's core activities across a wide range of sectors, eg transport, waste and buildings. Round 1 closed on the January 25, 2001.

Case Study 76 City of Melbourne Greenhouse Action Plan



Objective: To develop and implement an action plan to reduce greenhouse gas emissions from the city.

Location: Melbourne, Victoria, Australia

Website: <http://www.melbourne.vic.gov.au/greenhouse/>

Description:

The Council's list of projects include:

1. Buildings
 - Energy Audits and Retrofits
 - Renewable Energy Generation
 - Renewable Energy Purchase
2. Public Lighting
 - Audits/Upgrades
 - Renewable Energy
3. Vehicle Fleet
 - Greenfleet
 - Alternative Fuel Passenger Vehicles
 - Transporting Staff
4. Waste
 - Waste Wise
5. Strategic Initiatives
 - Sustainability Assessments
 - Environment Champions
 - Environmentally Responsible Procurement

A list of community action plans has also been developed in projects include:

- Commercial Building Partnerships
- Renewable Energy (including solar hot water and Green Power Schemes)
- Energy Efficient Developments in the Residential Sector
- Rooftop Greening and Water Harvesting
- Integrated Transport Systems
- Waste Wise Businesses and Organisations
- Organic Waste Processing
- LFG Extraction and Electricity Generation
- Carbon Sequestration (Tree Planting)
- CNG Waste Trucks and Public Refuelling Sites

Case Study 77 Portland Energy Plan



Objective: To save energy via a local energy efficiency program

Location: Portland, Oregon, USA

Website: US Department of Energy case study

http://www.eren.doe.gov/cities_counties/enrgyuse.html

Portland Energy Policy 1990

<http://www.sustainableportland.org/energypolicy.pdf>

Description:

Portland, Oregon, provides one of the nation's best examples of how energy planning can become an integral part of comprehensive urban planning. The benefits to Portland include energy dollar savings, air pollution and traffic congestion reductions, quality of life enhancements, and local economic stimulation.

Portland's approach to energy planning is the broad-ranging 1990 Portland Energy Policy. Under this policy, the city is improving energy efficiency in municipal buildings, residential buildings, commercial and industrial facilities, transportation, and energy supply. The policy also requires increased recycling, decreased waste, and the development of telecommunications as an energy-efficiency strategy.

Why Portland's Policy Succeeds

Portland's policy has clear goals: Overall, Portland has set a goal of increasing energy efficiency citywide by 10% by 2000. In dollars, Portland expects its total energy consumption in all sectors to reach \$1 billion by 2000, so the energy-efficiency increase means that \$100 million will be retained within the local economy. To achieve this energy-efficiency goal, the energy policy sets forth 53 two-year objectives and 36 long-term objectives.

Portland's policy has authority. The Portland Energy Office manages the day-to-day implementation of the policy. "The policy has given us credibility, a way of merging energy with other issues," says Energy Office Director Susan Anderson. "That's key, because people may not care about energy. But they do care about keeping their houses warm, getting to work, traffic congestion, affordable housing, air and water pollution, and economic development for business. Energy ties all of those individual issues together."

The energy policy was adopted as official city policy by a vote of the Portland City Council and was incorporated into the city's general plan. The Portland Energy Commission, made up of citizen volunteers appointed by the mayor and city council, actively oversees implementation and updating of the policy.

Converting Policy into Results

Merging energy into other issues, the Portland Energy Office plays a variety of roles. It identifies opportunities for energy-efficiency improvement and sources of funds to pursue these opportunities. The energy office is also an energy-related information clearinghouse. Its staff members provide consultations throughout the community. Sometimes the consulting is free. In other cases, energy office staff members are consultants for hire on projects affecting the city's energy consumption. In fact, the Portland Energy Office brings in three dollars' worth of grants and contracts for every dollar it draws from the city's general fund.

However, most of the energy policy implementation is not done by the energy office, according to Ms. Anderson. "Our primary role is to be the facilitator," she says. "We found some funds to convert seven city vehicles to natural gas, for example. Our job was to get other departments excited about it and up to speed on it, and then we got out of it." Through such efforts, most of the 53 two-year objectives were implemented by the end of 1992, with considerable progress toward many of the 36 long-term objectives.

Portland's City Government Is Involved

The City Energy Challenge program was launched in July 1992. The goal of this program was to identify and implement energy-efficiency projects that would cut \$1 million from the city's annual energy bill by 1997. Based on energy costs to city facilities in 1991, which totalled \$9.14 million, the \$1 million reduction represents an 11% reduction in energy bills. To achieve this goal, the city imposed a 1% fee on all city government energy bills. Totalling about \$70,000 per year, these fees were used to hire an energy management coordinator for city facilities. Result: by the end of 1992, Portland had already implemented measures or identified opportunities to save more than \$775,000 annually.

Portland's Citizens Are Involved

The energy policy included plans to facilitate the weatherisation of 8000 units in low-income, multi-family housing complexes by 1992 and 20,000 such units by 2000. By October 1992, Portland apartment owners had spent more than \$6 million weatherising some 8300 apartments. Working under contract with three local utilities and the Oregon Department of Energy, The Portland Energy Office recruited apartment owners for the program and helped them to apply for more than \$2.9 million in utility and state cash rebates and tax credits. Buildings weatherised through this program achieved average energy savings of at least 26% on space heating. Also during this period, another 4000 apartments received energy audits and had weatherising work in progress, and an additional 1300 apartments had energy audits pending.

Portland's Businesses Are Involved

The Portland Energy Office's BEST (Business for an Environmentally Sustainable Tomorrow) program provides consultants to help local businesses save energy, conserve water, reduce waste generation, and promote clean and efficient transportation. The program, begun in January 1992, was intended to help 50 businesses during its first year. By the end of 1992, it had help 63. Through the BEST program, the Portland Energy Office helps businesses:

- obtain energy design assistance
- apply for state tax credits
- obtain rebates and incentives offered by local utilities
- select appropriate and energy-efficient technologies
- get long-term, fixed-rate financing for energy projects
- recycle construction waste
- use water more efficiently
- find transportation alternatives for employees
- receive recognition as energy and environmental leaders.

Case Study 78 Energy Plan as Part of Environment Plan for Newcastle, Australia



Objective: To develop an energy management plan for a city

Website: <http://www.ncc.nsw.gov.au/enviro/eenergy.htm>

Description:

General Strategies

- Engage an energy conservation officer for 2 years to coordinate a self funding energy conservation program within Council operations.
- Carry out assessments of new major developments undertaken by Council during the design phase to ensure the most efficient use of energy is achieved.
- Document and regularly publish Council's continual improvement in energy conservation.
- Lobby for implementation of true cost energy pricing as a demand management tool and seek a fixed proportion of revenue raised be returned to:
 - 1) local government energy conservation education programs;
 - 2) University research and development of alternative renewable technology.
- Publish a record of domestic energy consumption for the City quarterly in local newspapers and compare to community based goals.
- In cooperation with the Roads and Traffic Authority and the NRMA (*National Roads and Motorists' Association*), publicise energy consumption rating for vehicles to assist consumers to make informed choices when purchasing vehicles.
- Promote, demonstrate and facilitate diversification of energy sources encouraging the increase of the proportion and use of renewable energy supplies such as solar, biogas and wind power.
- Implement strategies to encourage urban development which reduces the need to use private vehicles for routine travel.
- Approach the University of Newcastle to develop an alternative energy technology and energy conservation research and development focus.
- Participate in national, state and regional programs to achieve sustainable energy use.
- Introduce energy conservation awards to recognise innovations in energy conservation locally and assist successful candidates to enter national and state competitions.
- Pool resources with energy utilities to conduct a citywide energy conservation promotion.

Suburban Strategies

- ¹ Produce energy efficient design guidelines applicable to subdivisions, construction of new homes and major renovation of existing homes.
- ¹ In cooperation with relevant industry associations, maintain a list of architects, landscape architects, planners, surveyors, builders and designers who specialise in energy efficient design.
- ¹ Carry out the House Energy Rating System (HERS) assessment for all dwellings approved recording the equivalent star ratings attained in building approvals, building certificates and property files; and review in 1997 the necessity for implementing a mandatory minimum rating.

Industrial/Commercial Strategies

- Require professional energy efficiency assessments be prepared for all developments valued at over \$500,000 and any significant energy consuming development under that value.
- Pilot in cooperation with local suppliers an energy labelling scheme for commercial appliances which will assist small business.
- Liaise with government and private sector training providers to offer accredited courses in Newcastle to develop skills of energy officers and auditors.
- Promote through education and grantsmanship the appointment of energy officers in industry.
- Encourage business to prepare energy conservation plans.
- Make available to industrial and commercial enterprises the Institution of Engineers, Australia, register of accredited energy auditors.
- In conjunction with energy utilities and petroleum companies, pursue the inclusion of NCC energy conservation goals into cooperative agreements with industry and commercial businesses.

Case Study 79 City of Toronto Sustainable Energy Plan



Objective: To create an urban sustainable energy plan

Location: Toronto, Canada

Website: http://www.city.toronto.on.ca/council/environtf_sustainable_energy.htm, <http://www.city.toronto.on.ca/council/oct209.pdf>

Description:

Recommendations from Part A of the City of Toronto Sustainable Energy Plan

- Articulate the Goal
The City Council to adopt, as a long range goal, the development of a Sustainable Energy Infrastructure for the City.
- Create a Sustainable Energy Agency
- Pursue More Energy Efficiency Across the Corporation Immediately:
 - All Departments be requested to come forward with energy efficiency plans, reducing energy use in their operations by 15%.
 - The Corporation undertakes a further 15% reduction in energy use in all buildings and facilities.
 - City Council authorizes the Energy Efficiency Office with the mandate and role to coordinate the Corporation's new energy efficiency efforts and requests that the Office act as a technical support to all Departments in the implementation of energy efficiency projects.
- The Waste Management Department be requested to conduct a full embodied energy/ greenhouse gas inventory on Toronto's waste stream and waste management options.
- Promote Comprehensive Energy Analysis in all New City Projects.
- Invest in Green Power Purchases Immediately
- Improve Sustainable Design in the Building Sector Immediately
 - The Buildings Department as part of a side collateral agreement for the issuing of a building permit requires the federal government performance C2000 for all new commercial buildings.
- Create a City-wide Buildings Design

- The Energy Efficiency office implement the federal government's Energuide label for Housing in new and existing residential buildings. The Buildings Department be requested to offer priority to renovation permits on buildings with Energuide labels and plans for energy efficiency upgrades.
- Designate Model Energy Communities.
- Establish Green Enterprise Zones for Sustainable Energy Technology.
- Advocate Rate Structure that Encourages Efficiency and Renewables.

Other Case Studies at <http://www.city.toronto.on.ca/council/oct210.pdf>

Case Study 80 Chule Vista Energy Plan



Objective: To develop a plan to reduce urban greenhouse emissions

Location: Chule Vista, USA

Website: <http://www.ci.chula-vista.ca.us/co2.htm>, <http://www.ci.chula-vista.ca.us/environ.htm>

Description:

Chula Vista can lower its CO₂ emissions by diversifying its transportation system and using energy more efficiently in all sectors. These strategies not only save energy and CO₂, but they also increase personal and business savings, and create jobs. To focus City efforts in this direction, it is proposed that Chula Vista adopt the international CO₂ reduction goal of returning to pre-1990 levels by 2010.

In order to achieve this goal, the plan proposes a reduction strategy composed of the following eight elements:

1. To spur action, increase the public's awareness of the problem.
2. Reduce the long-term need for travel in the community through efficient land-use/transportation coordination and telecommunications technology.
3. Of the travel that does occur, provide for multi-modal choices.
4. Of the automobile driving that remains, work to make it as clean as possible.
5. Capture cost-effective building efficiency improvements in both new construction and remodeling through a mix of implementation approaches.
6. Lead the effort with municipal energy programs that can be showcased. Focus on encouraging personal and organizational (business, government, school districts, residential) actions.
7. Interlock the City's efforts with other regional programs in order to strengthen region-wide progress on climate protection (Air Pollution Control District, SANDAG programs). Examples include: the Telecenter effort, BECA, etc.
8. Focus initially on a few short-range actions to build visibility and results, and then periodically update and fine tune the strategy over time.

This strategy is to be implemented primarily through voluntary efforts with encouragement from a strong public information and advocacy effort.

When fully implemented in 2021, the action measures will save approximately 100,000 tons/yr of CO₂ emissions, which is roughly one quarter of the savings needed to achieve the international reduction goal. The capital and O&M costs represent a total outlay of roughly \$95 million, which will be shared by municipal government, businesses, homeowners, and other regional agencies. This outlay, however, is estimated to produce approximately \$130 million in savings to the community.

IX. URBAN ENERGY PLANNING

A. Introduction

In previous chapters many different measures have been presented to achieve energy and cost savings across domestic, public, commercial and industrial sectors. As stated on the US Department of Energy web site “Cities and counties looking for ways to cut energy use and save energy dollars can choose from a dizzying variety of alternatives. However, separate initiatives while important are not as effective as a comprehensive and integrated program.

By developing comprehensive energy plans, cities can maximise energy and cost savings and real, long term improvements can be made to the quality of life and sustainability of cities. This is especially crucial for cities which are growing rapidly. A concerted and comprehensive city energy plan may be the only way for these cities to avoid skyrocketing energy costs and even shortages.

Across the planet, there are a growing number of cities that have developed comprehensive and innovative energy plans to address current problems or avoid future problems. The global Cities for Climate Protection (CCP) campaign, which was developed by the International Council for Local Environmental Initiatives (ICLEI) in 1993 and currently has 401 participating municipalities worldwide, commits participating municipalities to the preparation of Local Action Plans. This Chapter will look at the CCP Program and development of Local Action Plans and energy planning generally.

B. The Energy Planning Process

1. Cities for Climate Protection Program

In order to become members of the CCP program, Councils must pass a resolution to commit to achieving five milestones. The milestones allow local governments to understand how municipal decisions influence energy use and how these decisions can be used to mitigate global climate change while enhancing community quality of life. Although Council operations are focused on first to develop procedures and familiarise staff, the main objective is the reduction of greenhouse gas emissions by the general community (residential, business and industry) as these comprise the greater proportion (approx. 99%) of total emissions.

The five milestones are outlined below.

Milestone 1:

Conduct an energy and emissions inventory and forecast.

The inventory profiles energy use and greenhouse gas (GHG) emissions for a base year (1990 or 1995), and estimates growth in emissions for a target year, typically 2010 or 2015, for:

1. municipal operations, including buildings, facilities, and waste streams;
2. the wider community, including residential and commercial buildings, transportation, and industry (if data is readily available).

Milestone 2:

Establish an emissions target.

Adopting a target and timetable for its achievement is essential to foster not only political will but also to create a framework that guides planning and implementation of measures. Many CCP participants are striving to adopt the “Toronto Target” to reduce GHG emissions by 20% from 1990 levels by the year 2005 or 2010. In developing country cities, however, stabilizing per capita emissions may be a more realistic or even ambitious target, in order to allow them the ability to develop economically.

Milestone 3:

Develop and obtain approval for the Local Action Plan.

A strategy to reduce GHG emissions is created by the Local Action Plan, which synthesizes the previous analysis, provides a rationale for the target and timetable, and outlines the policies and measures the local government will pursue to achieve the target. Ideally the Local Action Plan incorporates public awareness and education campaigns, as well as direct GHG reduction measures.

Milestone 4:

Implement policies and measures.

This stage involves implementation of individual measures to reduce GHG emissions. This may begin once the Local Action Plan is developed and approved or might begin concurrent with Action Plan development, since the CCP participant may choose to start measures before adoption of the formal plan.

Milestone 5:

Monitor and verify results.

Monitoring and verification of progress on the implementation of actions to reduce GHG emissions is an ongoing step that begins once measures are implemented and is formalized with the approval of the Local Action Plan. ICLEI's software tool assists in the quantification of emissions reductions and allows for uniform reporting of emissions reductions to ICLEI on a biennial basis.

Local governments which are participating in the CCP program include Bhavnagar, India; Belo Horizonte, Brazil; Cebu, Philippines; Entebbe, Uganda; Gweru, Zimbabwe; Hanoi, Vietnam; and Zomba, Malawi. Case Study 75 looks at Australian CCP Initiatives.

The City of Melbourne is the first local government authority in Australia to achieve all five milestones of the Cities for Climate Protection (CCP) program and to report back against its 2010 targets. The City has prepared a Sustainable Energy and Greenhouse Strategy, a Greenhouse Action Plan for 1999/2000 and more recently for 2001/2003. Elements of the comprehensive 2001/2003 plan are featured in Case Study 76.

2. Developing Local Energy Programs or Local Action Plans

The Sustainable Cities Project, a U.S. Department of Energy initiative, has produced a workbook, *Sustainable Energy: A Local Government Planning Guide for a Sustainable Future*, which summarizes the experiences of several cities such as Portland and San Francisco, in developing plans. The guide indicates that in general, an energy efficiency policy is first legislated by the local governing body and this is followed by the development of an energy program to support the policy by developing and implementing an action plan. Often the policy and plan will focus initially on how the local government agency uses energy. However, many local energy programs expand to incorporate energy use throughout the whole community (http://www.eren.doe.gov/cities_counties/basic.html).

The following is an extract from the workbook and provides suggestions for preparing an action plan:

Step 1: Determine how much you spend on energy.

Tracking your energy costs is a smart first step. How extensively you track data will depend on how far reaching your city's or county's program will be.

In some local governments, energy costs are totalled for each department. In others, energy costs are listed as a series of unrelated expenses for each department. If the latter type of accounting is used, managers and department heads may not even know how much they spend on energy. In that event, the

first step is to start monitoring consumption and costs. (You may need to develop and implement a system for tracking energy consumption and costs).

For still other local governments, energy costs are a budgetary line item. Government officials who have tried this approach have found that looking at energy costs as a line item often increases awareness of energy efficiency.

You can sometimes save a surprising amount of money just by checking your utility bills. For example, Phoenix monitors all municipal utility bills. The city checks individual bills for correct charges and ensures that the correct utility rate is applied. In a 2-year period, the city saved more than US \$100,000 in utility bills because of this monitoring.

Step 2: Designate or create a lead office.

Leadership must come from one office, whether it's the planning department, city or county manager's office, public works, environmental services, or a special energy office. This doesn't mean, however, that the lead office is the only department involved. All city or county departments need to be involved in planning and supporting the process. Forming a staff committee is a good idea, too, as it helps ensure broad participation.

Step 3: Link energy programs with community goals.

A critical component of this step is to identify major community issues and goals related to energy efficiency. The idea is to piggyback energy issues with existing community goals. Your community may already have a general plan that outlines goals concerning land use, transportation, housing, energy, and the environment. You can often link these goals through an energy efficiency program. For example, lower energy bills can make housing more affordable. In addition, energy efficiency programs create local jobs and benefit the local economy through the purchase of contractor services and materials.

You may not need to look far to discover your major community issues and goals. Often, research will already have been performed on these issues by the city council, a chamber of commerce, citizen groups, or community publications that highlight the issues. A good way to assess community issues is to invite leaders in business, education, and neighbourhood groups to give their input. Work with your local media—they can arouse public support.

Step 4: Build grassroots community support.

To carry out your goals and objectives, you will need community involvement. Building support establishes allies and a clear picture of the financial resources you need for a project, compared with what you have available. You can build support through task forces, meetings with citizens, informal networking, and meetings with business leaders, utilities, and interest groups. If you can demonstrate why the community should care about energy, your efforts will be more successful.

Leadership, credibility, and visibility can be attained by connecting with a known corporate or community citizen. A champion acts as an advocate. Your champion can be an individual or an entire office.

Step 5: Don't reinvent the wheel.

Find out what's working in other communities.

Step 6: Prioritize actions and develop a draft plan.

With community members and leaders, create a list of options. Next, determine each option's costs, benefits, environmental effects, economic and technological potential, funding resources, and political acceptability. Choose the tasks that will produce the greatest benefit; then prioritize them according to how well they apply to your community.

Step 7: Implement the plan.

It's important to start with realistic goals, but it's also essential to avoid short-term thinking. Concentrate on projects that will produce the greatest impact. You can look for grants or contracts from utilities, energy or health and social service departments, private foundations, or local corporations. See Financial Resources for a description of other financing options.

Step 8: Evaluate success and update the plan.

Your policy should be a living document, with short-term plans being reevaluated and updated every 2 or 3 years, and long-term plans every 5 years. An evaluation compares your objectives with your outcomes. And that means tracking and documenting savings. When you evaluate, look for a specific, measurable result, such as reduced vehicle miles traveled or reduced air or water emissions. Tracking ensures that you'll have a mechanism to continually report benefits and fine-tune your program.

Step 9: Publicise the benefits.

Fostering a clear appreciation of the new policy's benefits is critical. That entails marketing, public relations, and media events. These build trust and credibility, too.

See Case Study 77 on Portland in Oregon, USA which describes the reasons for the success of the Portland program.

Examples of other Action Plans are given in Case Studies 78, 79 and 80. Extracts are taken from the actual plans as given on the Council websites.

3. Green City

Another broader initiative is the Green City program led by the United Nations Development Programme, which looks not only at energy but the broader issues of sustainability. A "Model Green City" is defined as "a city where environmentally lasting solutions have been found for human activity, economic development and environmental management. The aim is to achieve development that is both pro-people and pro-nature, to protect the interests of future generations."

The concept incorporates integration of the following aspects of urban activity:

- water and wastewater management
- clean air by transportation/traffic control
- waste management/recycling
- green manufacturing
- green energy
- green farming
- green construction
- green shopping

D. References and Resources

MELG (2000) *Managing Energy In Local Government Workbook*, Australian Greenhouse Office, Commonwealth of Australia, Canberra.

Available from <http://www.greenhouse.gov.au/lgmodules/workbook/index.html>

Cities for Climate Protection <http://www.iclei.org/co2/>

Financial Options <http://www.city.toronto.on.ca/council/oct208.pdf>

Hannover Case Study. <http://solstice.crest.org/efficiency/irt/77.htm>

<http://www.iclei.org/aplans/hannsap.htm>

Local Action Plan for Sudbury, Ontario, Canada

<http://www.city.greatersudbury.on.ca/earthcare/about.html>

Portland Energy Efficiency Plan, 2001 <http://www.sustainableportland.org/eeplan.pdf>

Rocky Mountain Institute. Extract from *The Community Energy Workbook*

<http://www.rmi.org/sitepages/pid308.php>

Sustainable Cities <http://www.sustainable-cities.org/>



X. ASSOCIATED BENEFITS

A. Energy and Sustainable Development

The focus of this publication is on how to save money through saving energy in cities. We have considered strategies for reducing the cost of energy in the domestic, transport, commercial, industrial and administrative sectors of cities. Additionally we have looked at how to utilise local energy resources, such as wastes, solar power and biomass to generate power. Many of these strategies will pay for themselves within a few months or years. However, the best results will be obtained if the strategies are costed, prioritised and organised into a comprehensive and integrated local energy plan.

While the focus has been on cost savings, saving energy has many other important associated social and environmental benefits, some of which have already been pointed out. We will explore these associated benefits further in this chapter.

The integration of economic, social and environmental goals is the basis for sustainable development. This concept was brought to the fore in the *World Conservation Strategy* (1980). In this strategy it was emphasised that humanity, which exists as a part of nature, has no future unless nature and natural resources are conserved.

In 1987 the World Commission on Environment and Development published a report called *Our Common Future* which defined sustainable development as development that “meets the needs of the present without compromising the ability of future generations to meet their own needs.”

In 1991, the IUCN published *Caring For the Earth - A Strategy for Sustainable Living*. The IUCN states that “Most current development fails because it meets human needs incompletely and often destroys or degrades its resource base. We need development that is both people-centred, concentrating on improving the human condition and conservation-based, maintaining the variety and productivity of nature. We have to stop talking about conservation and development as if they were in opposition, and recognize that they are essential parts of one indispensable process.”

This was followed by the Earth Summit at Rio de Janeiro in 1992 where Agenda 21 and the Earth Charter were developed. These set goals and directions for sustainable development in all areas of society. Agenda 21 is now being taken up by local governments around the world (ICLEI). Many municipalities are producing or have produced local sustainability plans which outline strategies to address issues such as energy and resource usage.

The Earth Summit also produced the Framework Convention on Climate Change (UNFCCC) and this is gradually being implemented via the Conferences of the Participants. At a local level the Cities for Climate Protection Initiative is being implemented by local governments in many cities around the world. It involves energy audits and the preparation and implementation of a local energy plan as discussed in Chapter 9. Although the focus of this program is on climate change, it has much in common with energy efficiency strategies.

Increasingly, decision-makers are using “triple bottom line” accounting to assess the economic, social and environmental costs and benefits of the decisions they make. Such an approach is also relevant to energy savings.

There are many associated social and environmental benefits that can be obtained in addition to the economic benefits of taking action to save energy. However, some energy saving measures may be cost effective (such as switching from gas to coal for power generation) but will have undesirable social and environmental consequences.

The use of triple bottom line accounting allows us to distinguish between those measures that bring economic, social and environmental benefits and those that bring only limited benefits and have many drawbacks as well. “In many situations it is possible to find a “Win-Win-Win” solution to an energy supply problem in which the result provides cost savings while bringing social and environmental benefits. The search for such solutions is the essence of sustainable development” (UNDP).

The use of local, renewable energy sources and energy-efficiency measures can produce a range of social and environmental benefits. This list is illustrative only and is intended as a guide to the type of social benefits that may result from energy efficiency programs and the use of local energy resources. Each project should be carefully analysed to determine the specific social benefits associated with it. In many cases the value of these benefits can be expressed in economic terms, although some benefits such as improved quality of life are more intangible.

B. Social Benefits

There are many potential social benefits resulting from energy efficiency and the use of local energy resources. Two major ones are the opportunities for new jobs and greater national security.

1. New Jobs

In a recent paper published by the Worldwatch Institute, a Washington DC-based research organisation, author Michael Renner indicates that moves towards environmental sustainability have already generated an estimated 14 million jobs worldwide. He points out that numerous opportunities for job creation are emerging, ranging from recycling and remanufacturing of goods, to higher energy and materials efficiency and the development of renewable sources of energy.

In response to the Kyoto Protocol and concerns about climate change, many industrialised nations have undertaken assessments of the impact of climate policies on jobs. Renner indicates that these reports affirm the general conclusion that, “for each dollar invested, pursuing energy alternatives will generate far more jobs than the fossil fuel industries can.”

2. Improved National Security

By reducing fossil fuel usage and employing renewable technologies, nations can reduce their dependence on energy imports and so contribute to national security. Supplies of cheap fossil fuels are limited and rising fossil fuel prices or even supply shortages in the future could lead to conflicts as most economies are so dependent currently on secure supplies of cheap fossil fuels.

The use of local energy resources and the development of local industries can also improve the balance of payments in developing countries and lead to lower costs for essential services.

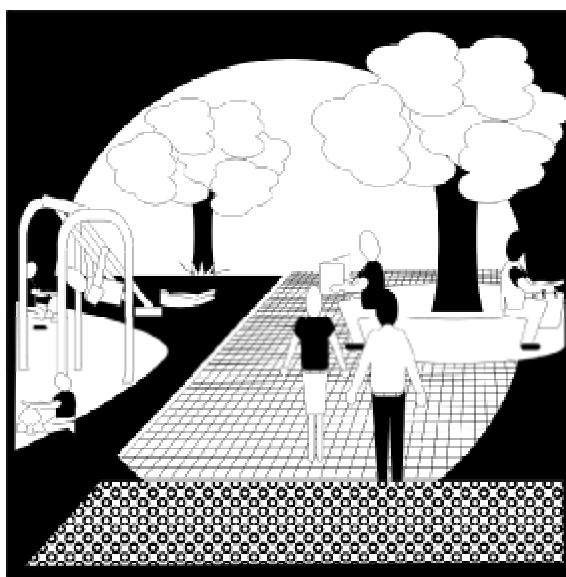


Figure 10.1: Pedestrianised space can offer safe environment for families.

3. Improved Quality of Life

By planning cities and buildings to be more energy-efficient, many improvements can be achieved in the overall quality of life of city dwellers, including:

- Fewer accidents and serious injuries in car-free or less car-dependent cities, and so safer neighbourhoods for children
- A greater sense of community is created in spaces that are based on walking and cycling transport modes, as they allow for more human interaction
- Daylighting and passive solar design have been shown to improve workplace efficiency and lead to greater job satisfaction and less absenteeism. They also bring other health and economic effects.
- Reduced motorised vehicle use cuts down on noise and vibration in residential areas.

C. Environmental Benefits

1. Air Pollution and Health Issues

The utilisation of fossil fuels has numerous negative implications for human health at all stages of the fuel cycle including extraction, processing, transportation and final usage. For instance, the typical coal fuel cycle is given in Figure 10.2.

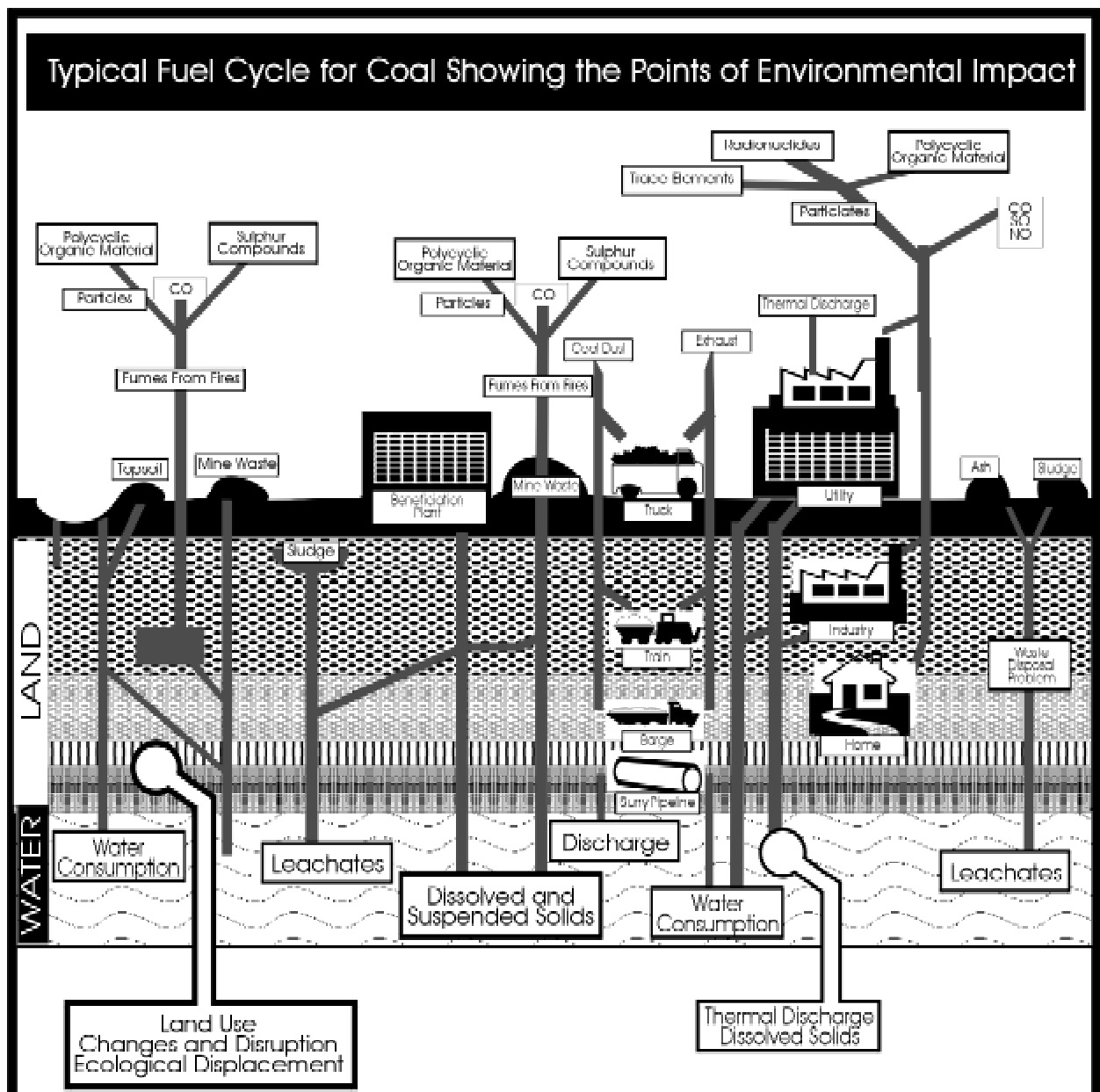


Figure 10.2: The Typical Fuel Cycle for Coal Showing the points of Environmental Impact.

Coal mining, particularly underground, results in accidents and health-related illnesses from the inhalation of coal dust. Processing of coal for the production of processed fuels and coke is also linked with occupational disease and risks.

Hazards associated with the petroleum and natural gas industry are less extensive than coal and exist mostly in the exploration and development phases of new oil fields.

Combustion of fossil fuels is the biggest contributor to atmospheric pollution. This process generates large quantities of sulphur and nitrogen oxides, heavy metals, hydrocarbons, particulates, and carbon monoxide, among other health-damaging pollutants. Such pollution results not only from fossil fuel combustion in power plants and industry, but also from motor vehicles and domestic use.

In the United Nations Development Program report *Energy after Rio: Prospects and Challenges* it is stated that “Considering six indicators of air quality: sulphur dioxide, solid particulate matter, lead, carbon monoxide, nitrous oxide, and ozone, the air pollution situation in twenty megacities (of which sixteen are in developing countries) is such that 38% of the indicators register as either “serious problems” or “moderate to heavy pollution”. In fact, most developing country megacities have air pollution levels well above WHO guidelines, and the situation is getting worse.”

The first study ever to look at the global short-term health impact of fossil fuel consumption - *The Hidden Benefits Of Climate Policy: Reducing Fossil Fuel Use Saves Lives Now* - projects serious consequences for people’s health and mortality worldwide. In this study it is stated that “Much of the debate over global climate policy misses one basic point: The same activities that will eventually threaten the earth’s climate also threaten human health today. The combustion of fossil fuels poses a double jeopardy. It produces carbon dioxide and other gases, which contribute to the gaseous greenhouse that warms the earth, and it releases fine air-borne particles, which can make people sick and damage their lungs.”

The authors point out that “polluted air can cause immediate or acute effects ranging from asthma attacks to death in those whose lungs are already weakened.” Additionally, there are other indirect health impacts that may be considerable. Climate change as mentioned in the previous section may have major impacts on human health because of changing temperatures, sea-levels, and disease-vector ecology. Damage to biodiversity through acid rain or local deforestation from fuel harvesting are other examples of energy-related environmental hazards with potentially grave health consequences.

The study by the Working Group on Public Health and Fossil-Fuel Combustion makes the following statements:

“The benefits of reducing CO₂ emissions go substantially beyond averting potential disruptions of the Earth’s climate. Even relatively small reductions in emissions worldwide could prevent 700,000 premature deaths a year by 2020.

The benefits of adopting climate policies extend to both developed and developing nations. Four out of every five of those who might otherwise die by 2020 are in developing countries. In the developed world, the number of lives potentially saved each year is also substantial, equalling the number projected to die from traffic injuries.

Implementing climate policies now will yield immediate benefits locally and globally by reducing particulate air pollution, by slowing the build-up of greenhouse gases, and by protecting public health. Over the next two decades, at least 8 million deaths could be avoided.”

The *Energy After Rio* report identifies the use of biomass in developing countries as having a negative impact on the health of household members, especially when it is burned indoors without either a proper stove to help control the generation of smoke, or a chimney to draw the smoke outside. A number of studies of the health effects of indoor air pollution show a positive correlation between indoor pollution generated by the use of traditional fuels and the incidence of respiratory illness or congestive heart failure. Often the users of biomass are people in poverty and so using cleaner, more efficient technologies will improve the health of poor people and consequently reduce health costs and improve work productivity. In energy plans, special consideration needs to be given to making new technologies available to the urban poor.

2. Climate Change

In the *Third Assessment Report* of the Intergovernmental Panel on Climate Change, titled *Climate Change 2001* it is stated:

“Human activities—primarily burning of fossil fuels and changes in land cover—are modifying the concentration of atmospheric constituents or properties of the Earth’s surface that absorb or scatter radiant energy. In particular, increases in the concentrations of greenhouse gases (GHGs) and aerosols are strongly implicated as contributors to climatic changes observed during the 20th century and are expected to contribute to further changes in climate in the 21st century and beyond. These changes in atmospheric composition are likely to alter temperatures, precipitation patterns, sea level, extreme events, and other aspects of climate on which the natural environment and human systems depend.”

The report identifies natural systems as being especially vulnerable to climate change because of limited adaptive capacity, and it is predicted that some of these systems may undergo significant and irreversible damage. Glaciers, coral reefs and atolls, mangroves, boreal and tropical forests, polar and alpine ecosystems, prairie wetlands, and remnant native grasslands are some of the natural systems most at risk.

Human systems that are sensitive to climate change include mainly water resources; agriculture (especially food security) and forestry; coastal zones and marine systems (fisheries); human settlements, energy, and industry; insurance and other financial services; and human health. The vulnerability of these systems varies with geographic location, time, and social, economic, and environmental conditions.

In *Climate Change 2001*, the following projected adverse impacts are given based on models and other studies:

- general reduction in potential crop yields in most tropical and sub-tropical regions for most projected increases in temperature
- general reduction in potential crop yields in most regions in mid-latitudes for increases in annual-average temperature of more than a few °C
- decreased water availability for populations in many water-scarce regions, particularly in the sub-tropics
- increasing numbers of people exposed to vector-borne (e.g., malaria) and water-borne diseases (e.g., cholera), and an increase in heat stress mortality
- widespread increase in the risk of flooding for many human settlements (tens of millions of inhabitants in settlements studied) from both increased heavy precipitation events and sea-level rise
- increased energy demand for space cooling due to higher summer temperatures

On the issue of severe weather events such as droughts, floods, heat waves, avalanches, and windstorms, while there are still uncertainties attached to estimates of such changes, some extreme events are projected to increase in frequency and/or severity during the 21st century due to changes in the mean and/or variability of climate, so it can be expected that the severity of their impacts will also increase in concert with global warming. Conversely, the frequency and magnitude of extreme low temperature events, such as cold

spells, is projected to decline in the future, with both positive and negative impacts. The report indicates that “the impacts of future changes in climate extremes are expected to fall disproportionately on the poor.”

By saving energy, emissions of greenhouse gases such as CO₂, CH₄ and NO_x are reduced thus helping to mitigate global climate change. All hydrocarbon fuels produce greenhouse gases when burnt while most renewable energy sources have minimal greenhouse impacts. Biomass and biogas utilisation can produce CO₂ but this is a less potent greenhouse gas than CH₄, which may have been produced if the biomass was left to rot. Often the full biomass cycle has a positive greenhouse benefit although parts of it do produce greenhouse emissions.

3. Acidification

Fossil fuel emissions can cause problems of acid rain. This issue came to media attention in Europe in the 1980s when forests started dying. It is stated in the *Energy After Rio* report that “Emissions are projected to increase in many parts of Asia, Africa, South and Central America, creating potential for serious damage in many parts of the world that have not experienced this type of pollution problem before.”

The report indicates that there is one important difference between the impacts on Europe and North America and on the developing countries, namely that in many areas agriculture is carried out on marginal soils which have a low buffering potential. Soil quality and yields could be affected significantly by anticipated depositions. In Europe, agricultural soils are limed and acidification of arable land does not represent a serious problem. However, liming is not carried out to any great extent in many countries of the developing world due to its high costs.

The recovery process for acidification is quite long and therefore, it is preferable to try to avoid damage at the outset rather than ameliorating it once it has occurred.

4. Land Reclamation

The *Energy After Rio* report concludes that, “While the unsustainable harvesting of biomass for energy purposes (e.g., fuel wood for cooking) has been one of many contributors to land degradation, the sustainable production of biomass via energy-efficient conversion processes for the production of modern energy carriers (electricity, liquid and gaseous fuels) can be a powerful mechanism for stemming and reversing land degradation.” Where the rainfall and soil quality are adequate to support high-yielding energy crops, this process can make it feasible to restore degraded lands for food production. Furthermore, biomass fuels grown sustainably are CO₂ neutral and low in sulphur, and returning the ashes created as a residue of biomass fuel processing to the land lessens the need for fertilisers in the growing of new biomass.

The report points out that carefully conceived and politically committed national programmes supported by policies and programmes at the international level could lead to significant biomass energy production on degraded land and thereby contribute positively towards improving farmers’ income and employment opportunities, promoting rural development, reducing urban migration, and reducing poverty and insecurity of food supplies, while rehabilitating abandoned and marginal lands

D. References and Resources

There are many excellent books and web sites that develop the theory and practice of sustainable development and apply it to energy supply and use. A few of the most important ones are:



Agenda 21

<http://www.un.org/esa/sustdev/agenda21.htm>

<http://www.igc.apc.org/habitat/agenda21/>

<http://www.igc.apc.org/habitat/agenda21/ch-09.html> (Energy section)

Caring for the Earth - A Strategy for Sustainable Living

<http://coombs.anu.edu.au/~vern/caring/care-earth1.txt>

The Earth Charter

<http://www.earthcharter.org/>

UNDP (1997) *Energy after Rio: Prospects and Challenges* <http://www.undp.org/seed/energy/#afterrio>

Energy, Environment and Security in North-East Asia <http://www.nautilus.org/papers/energy/ESENAfinalreport.pdf>

'The Hidden Benefits Of Climate Policy: Reducing Fossil Fuel Use Saves Lives Now' –

http://www.wri.org/climate/ghg_text.html

Interactive Learning about Sustainable Development

<http://iisd.ca/educate/learn.htm>

Intergovernmental Panel on Climate Change

<http://www.ipcc.ch>

Intergovernmental Panel on Climate Change (2001) Third Assessment Report - *'Climate Change 2001'* - has been published and consists of three books: *The Scientific Basis*; *Impacts, Adaptation and Vulnerability*; and *'Mitigation'*

International Council for Local Environmental Initiatives <http://www.iclei.org/>

ICLEI's Local Agenda 21 Campaign

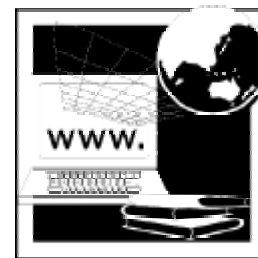
<http://www.iclei.org/iclei/la21.htm>

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