Energy efficiency - "Pick the low-hanging fruit"

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Energy efficiency - "Pick the low-hanging fruit"

Mounting energy prices and pressure on oil reserves are resulting in growing numbers of fuel-poor people, communities and countries. Energy efficiency is an essential part of the solution; it makes energy available to people whilst reducing the burden on the environment and the economy.

Energy efficiency is about minimising the input of energy resources per unit produced and at the same time optimising consumer utility. This can be achieved at any stage between energy source and end user.

Facts:

- Oil prices have more than doubled since 2002. Countries south of the Sahara paid about USD 1 billion more for their oil in 2005 than in 2002.
- At the G8 meeting held in the UK in July 2005, it was decided to give debt relief of USD 1.5 billion. However, this was cancelled out by the increase in oil prices.
- According to US EPA, energy-efficient solutions have reduced the energy bill for many homeowners and businesses by 20 to 30%.
- The European Commission's green paper on energy efficiency states that energy saving is the quickest, most effective and most cost-effective manner of reducing greenhouse gas emissions, as well as improving air quality.

The benefits of energy efficiency can be further enhanced by using renewable energy sources such as solar power or biofuels as well as cleaner and more efficient technology. This can enable countries with a weak economy or technological basis to implement more sustainable solutions by technological leapfrogging. In other words, they can move directly to the most modern and sustainable technologies, avoiding the path of industrial development pursued by industrialised countries. A modern and intelligent society is an energy-efficient society.

Energy efficiency makes sense

- It is cheaper to improve energy efficiency than to use more energy. For example, an energy-saving light bulb provides the same amount of light as an ordinary incandescent bulb, but uses only 20% of the energy.
- Cutting energy use has many direct and indirect beneficial effects, including lower greenhouse gas emissions, less formation of ground-level ozone, and better water quality and health.
- WWF and the Wuppertal Institute have identified ways for the EU countries to reduce their greenhouse gas emissions by 33% by 2020. Improvements in energy efficiency can play a central role in achieving this.
- Energy savings can improve the security of energy supply, and thus play an important role in improving access to energy services for the fuel-poor.

This booklet features 13 practical examples that are addressing the energy efficiency potentials and benefits to be gained from more sustainable consumer products and buildings. They include examples of technological innovation and of the use of known technology in new contexts. Contact details are provided for each example.

A life cycle perspective on design is essential for optimising the energy saving potentials of products and services, for example building construction, lighting, cooling, heating and insulation. Energy use at all stages of the product life cycle must be taken into account. Optimal energy efficiency is rarely achieved simply by using good technological alternatives. Environmentally-conscious consumers must put the technology to optimal use to achieve energy savings. Moreover, culture, lifestyle and personal habits play a key role in shaping consumption and production patterns. Thus, an integrated approach is needed to develop more energy-efficient and sustainable solutions.

Energy efficiency is important for rich and poor countries alike. In the North, it is primarily a means of reducing consumption and costs. In the South, it makes technological leapfrogging possible and improves access to energy services. The core message is that the technology is available, and that only relatively small adjustments are needed to improve energy efficiency, which often provides large economic benefits. We hope the readers would be encouraged to put energy efficiency into practice from picking the "low-hanging fruit" exemplified by the cases.

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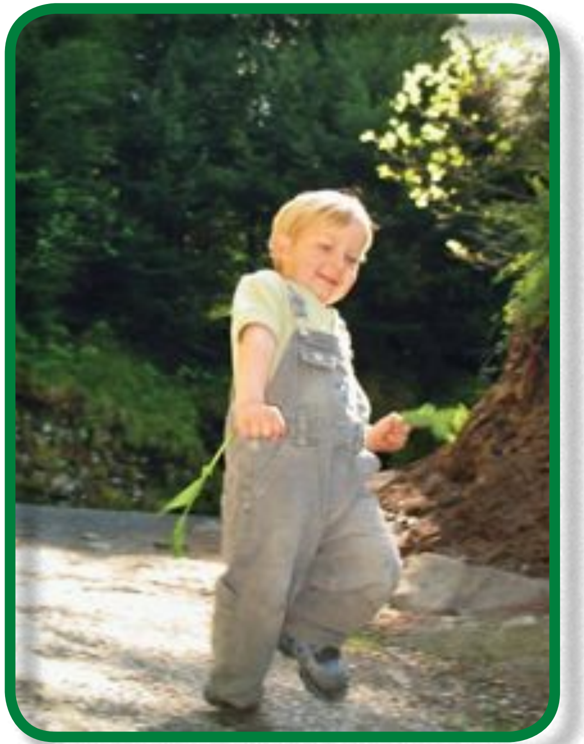

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"The best alternative energy is energy efficiency"… "There is too much wastage with energy. There are too many cars that are far bigger than what they need to be. In the home, there are often heating and air conditioners on unnecessarily".[1]

- Sadad Al-Husseini,
former head of exploration at Saudi Aramco

[1] *Financial Times, 27 Sept 2005*

Integrated biogas system for poverty reduction and nature conservation

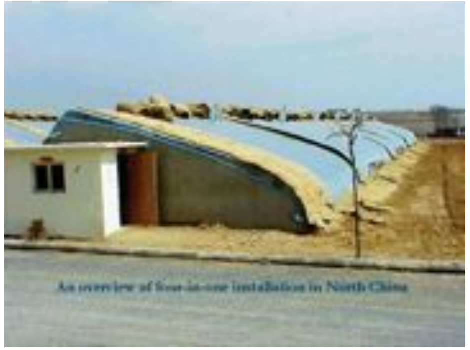
Baima Snow Mountain Nature Reserve, Deqin County, Yunnan Province, China (1999 – 2001)

Technology:

- Biogas digester with a latrine and pigsty
- Greenhouse

Performance:

- A biogas digester can produce sufficient methane gas for cooking, lighting, and space heating for a household.
- Biogas is a renewable form of energy and does not generate additional CO_2. CO_2 emissions generated by the use of firewood from unsustainable sources can thus be reduced, while the burden of obtaining 5-10 tonnes of firewood each year can also be diminished.
- It is estimated that the diffusion of biogas systems has the potential to reduce firewood use around the nature reserve by up to 50%.



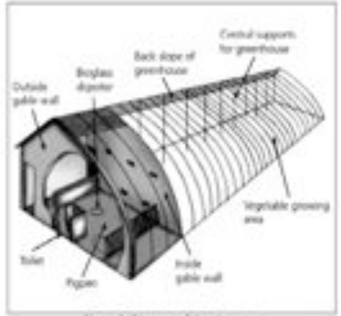


Figure 3: Diagram of 4-in-1 system

Description:

Biogas technology utilises agricultural residues and human and animal waste to provide an environmentally sound, high quality fuel in the form of methane that can be used for household cooking and lighting. A typical "four-in-one" biogas system consists of a biogas digester installed underground, a latrine and pigsty set above the digester, and a greenhouse. A "three-in-one" system is similar, but without the greenhouse. This forms an ecological cycle involving humans, animals and plants.

The villages of Tibetan origin around the nature reserve do not have electricity and homesteads are impoverished. A typical household keeps several yaks and pigs for their own consumption. The traditional way of raising animals is energy intensive. Firewood is collected from forests in and around the nature reserve. Moreover, firewood for indoor cooking may cause respiratory health problems and entail a risk of fire or carbon monoxide poisoning.

Adaptation to local conditions:

The local financial institutions provided micro-financing for poor farmers who installed biogas systems. The Beijing based NGO, South-North Institute for Sustainable Development, provided farmers with loans, and promised to cover the interest if the loans were paid back in time (effectively giving zero-interest loans). This strategy encouraged timely repayment of the loans and attracted local financial institutions. Farmers were trained in using the biogas system and in how to grow vegetables and raise pigs efficiently. To minimise cost, local household labour was used to install the systems.

Lessons learned and recommendations for replication:

The biogas system has been instrumental in reducing poverty among farmers, who can earn additional income from breeding pigs and growing vegetables. It also provides significant health benefits and saves time, especially for women who used to spend hours collecting firewood for cooking. Modern biogas stoves cook faster and are less polluting than open fires, thus reducing indoor air pollution. The success of the demonstration project resulted in the installation of more than 170 biogas systems in 2000-2001.

Biogas systems could be a viable solution for energy efficiency in rural farming communities in many developing countries where energy resources are scarce and agricultural productivity is low. However, the system is not necessarily inexpensive for the poor, so sound financial support schemes will be the key to success.

Many remote rural areas in China still lack access to electricity, and about 700 million people use biomass (crop stalks, animal dung, firewood and straw) for cooking and heating. Biogas programmes have been implemented throughout the country, and almost 7 million households already have biogas digesters. There are over 10 000 biogas offices across the country and more than 30 000 technicians have been trained.

When disseminating new efficient technologies, it is vital to build knowledge and capacity among local technicians through local partners. It is also important for project partners to be sensitive to the impact of new technologies on local culture and lifestyles. For example, introduction of biogas stoves may lead to losing the traditional communication place for rural families, with which conventional stoves have provided.

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Micro-hydropower for remote farming villages

Porcón Village, Cajamarca region, Peru (1989 – 1992)

Technology:

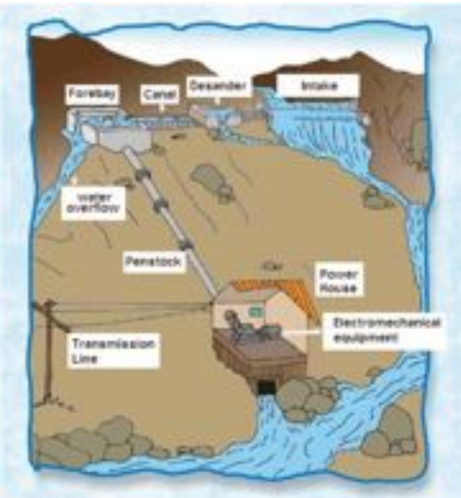
- Micro-hydro Pelton turbine with generator (35kW)

Performance:

- With 50 metres of gross head and three turbine injectors, this micro-hydro turbine can receive 135 litres per second of water flow and generate over 300 MWh of electricity per year. This amount of electricity has fed domestic uses of 46 families as well as industrial uses including carpentry workshops, a grain mill, and chicken incubators.
- The construction cost of the micro-hydro station was approximately EUR 60 000. As running costs, about EUR 1300 have been paid the operator and EUR 650 for preventive maintenance annually. The turbine's lifetime is estimated between 15-20 years.
- Compared with a diesel generator with the same output, CO_2 emissions can be reduced by approximately 260 tonnes per year since micro-hydro power generation does not create CO_2.

Description:

The aim of the project was to provide a permanent and reliable energy source for a farmers' co-operative. The co-operative previously relied on a small diesel generator (5kW), but operational costs were high and the electrical output was poor. A micro-hydropower plant was set up for domestic use and agro-industrial activities. The plant now provides households that are members of the co-operative with electricity for lighting, cooking, space heating, TVs and radios.



The existing carpentry workshop and milking and dairy unit have been able to generate earnings using the electricity generated. Both the members' living standards and community life as a whole have improved.

About 75% of the population in Peru have access to electricity. It is difficult to extend the conventional electricity grid system to rural communities in remote mountainous areas because of the lack of roads and the high costs involved.

The main energy sources in rural Peru are kerosene, firewood and animal dung. Diesel generators have also been used, mainly for domestic lighting for a few hours at night. The highland Cajamarca region has the largest number of people without access to appropriate health services, sewage systems and electricity (electrification rate 33% in 2002) in the country. It is located at the heart of a river basin where there are opportunities for hydropower generation.

Adaptation to local conditions:

The Peruvian government recognises decentralised micro-generation as a solution for rural electrification. This project was implemented as a pilot project by the Intermediate Technology Development Group (ITDG, now Practical Action) with grants and the co-operative's own contribution. A small price of EUR 0.13 per kWh (rate in 2005) has been charged for electricity consumed by agro-industrial activities. The price is based on the opportunity cost of the diesel generator. Electricity has been free of charge for households. The revenue from the charges and the surplus from industrial activities have been used for running and maintaining the micro-hydro station and subsidising domestic uses.

With financial support from the Inter-American Development Bank (IDB), ITDG introduced revolving funds that provide those who are willing to set up micro-hydro plants with soft loans for initial investment since 1992. To date, ITDG has provided 31 loans with a total of over EUR 700 000 in a revolving fund, which in turn generated complementary investments from other sources that amounted to more than EUR 1.6 million as a grant.

Lessons learned and recommendations for replication:

Micro-hydropower has good potential as a clean energy source in mountainous rural communities where energy use is limited to households and small-scale industry, and is now recognised by the Peruvian government as an alternative to rural electrification. Micro-hydro turbines can provide a continuous 24-hour energy supply. Depending on the amount of water in the river, a head of water of only a few metres can be sufficient. The main barriers to dissemination of this technology are a lack of awareness in rural communities and insufficient funding for initial investments. Introducing a sensible level of charges for electricity use can ensure loan repayment and appropriate maintenance and keep consumption levels below the generation capacity.

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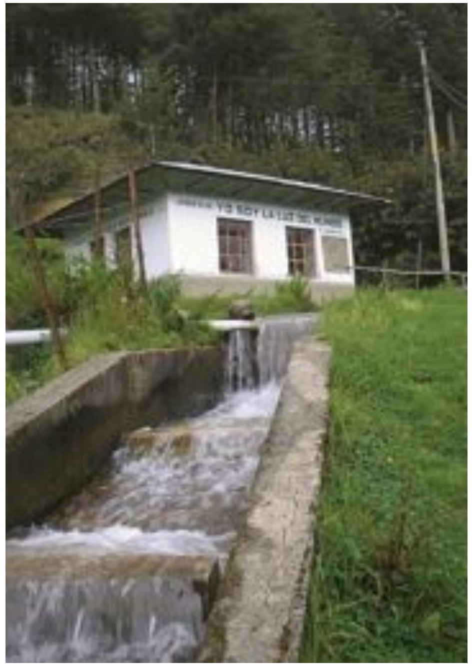

Promotion of energy-efficient light bulbs through the private sector

Poland (1995 – 1998)

Technology:

- Compact fluorescent lamps (CFLs)

Performance:

- Overall direct energy savings of 435.8 GWh and reduction of CO_2 emissions by 529 100 tonnes. Project cost per tonne CO_2 reduced was EUR 6.28.
- The total energy savings in the Polish market are estimated at 3 034 GWh, with a reduction of CO_2 emissions of 3.62 million tonnes.
- The life cycle cost savings (10 000 hours) from replacing a 60W incandescent lamp with a 13W CFL of equivalent brightness are approximately EUR 30. Electricity consumption can be reduced by 470 kWh per bulb (78% reduction), with an equivalent reduction in CO_2 emissions.
- It is estimated that the project accelerated the maturation of the CFL market in Poland towards saturation by around 3 years.

Description:

The Poland Efficient Lighting Project (PELP) was designed to reduce electricity consumption by stimulating the Polish consumer market for CFLs. It aimed to increase sales of CFLs during the project period and to stimulate a long-term increase in the demand for CFLs.

Unlike other CFL promotion projects that provide retail price subsidies to consumers, PELP chose to subsidise manufacturers in order to reduce the price of CFLs at the beginning of the product distribution chain. Subsidies were competitively awarded to manufacturers that were able to provide the greatest savings, in terms of projected avoided electricity use, at the lowest cost to the project. Providing the same amount of subsidy to consumers (e.g. by discount coupons) would have reduced the retail price of CFLs less because the sales tax and other mark-ups would already have been applied.

PELP achieved large increases in sales of CFLs at a lower cost per CFL than many other projects. About 1.2 million subsidised CFLs were sold to consumers through this project. By the end of the project, the retail price of CFLs had dropped by 34% in real terms relative to 1995. The rate of CFL ownership increased from one in ten Polish households to one in three a year after the project (1999).

Before the implementation of this project, consumer awareness of the environmental and economic benefits of CFLs was low. With low demand, manufacturers had little incentive to promote CFLs. Furthermore, Poland was facing the need to upgrade the electricity grid and power stations to meet increasing demand at peak periods. Approaches to demand side management were therefore also explored during the project.

Adaptation to local conditions:

To achieve its objectives, PELP involved the private sector, civil society, and the government. Firstly, manufacturers were encouraged to market CFLs to their wholesalers and retailers. They were discouraged from simply pocketing the subsidy by the introduction of recommended retail prices.

Secondly, a nationwide CFL campaign was co-ordinated by the Ministry of Education. Consumers were given comprehensive information on the advantages of energy-efficient light bulbs, and as a result, consumer awareness improved.

Lessons learned and recommendations for replication:

The project illustrates the need to offer energy-efficient products at competitive prices. Co-operation with the private sector and use of market mechanisms can help minimise project costs and maximise energy efficiency gains. An effective public awareness campaign is also vital to encourage consumer demand for energy-efficient products.

Based on the success of PELP, the International Finance Corporation (IFC) launched the Efficient Lighting Initiative (ELI) in 2000 to stimulate CFL markets and raise product quality in a number of transitional and developing countries.

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Low-cost air conditioning system in a concert hall

Rio de Janeiro, Brazil (2001 – 2004)

Technology:

- Bioclimatic air conditioning system

Performance:

- The costs of installing this system were EUR 20 000 (1% of the total construction costs), at least 96% lower compared to conventional air-conditioning systems.
- The total energy output of this system is only 5kW. The running costs are estimated to be 90% lower than the conventional systems. There is an equivalent reduction in CO_2 emissions.
- As a result, the initial investment was paid off very rapidly.

Description:

The Flying Circus is a famous concert hall in Rio de Janeiro. The main semi-open pavilion can hold up to 1 400 people and is equipped with stage lights, which cause a high thermal load. To create an economic and energy-efficient air-conditioning system, the original geometry was changed. The second step was to install a system of seven individually controlled ventilators in the re-designed opening close to the roof. The ventilators suck hot air out of the pavilion at individually controlled speeds to influence the direction of airflow and the noise level. Thirdly, a high-pressure pump with fog nozzles was planned to reduce the indoor temperature by dispersing superfine droplets.

The system has to provide comfortable temperatures for the audience under varying conditions had to be achieved: from classical concerts to rock concerts, from tropical summer nights to relatively low temperatures in winter. The pavilion is surrounded by granite rocks, which heat up during the day due to high solar radiation. The stored heat is emitted many hours after sunset, causing audience discomfort. A conventional air conditioning system was deemed too costly in terms of both installation and running costs.

Adaptation to local conditions:

The main obstacle was the hall owner's doubts about this simple but sophisticated system. The bioclimatic approach is highly resource-efficient, and takes into account climate and environmental conditions in achieving thermal comfort. Bioclimatic architecture is always adapted to the building in question and its surrounding climate. This approach is therefore ideal for providing comfort in tropical regions. The low maximum electricity input for the system used in this project also allows the use of photovoltaic panels as a back-up system in the event of power cuts.

Lessons learned and recommendations for replication:

To extend the application of bioclimatic systems, it will be necessary to communicate information on this approach to architects and planners in particular. Disseminating information about successful projects is key to persuading doubtful clients. If these obstacles can be overcome, this project can easily be replicated because of the simplicity of the basic concept.

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Providing solar cookers for households

Sabang Islands and Aceh Tenggara, Aceh Province, Indonesia (2006 – 2027)

Technology:

- Parabolic solar cookers
- Heat-retaining containers

Performance:

- Overall project cost is EUR 315 500 for installing, maintaining and monitoring 1 000 cookers and containers in the first phase, 2006-2013.
- Solar cookers and heat containers generate no CO_2 emissions or running costs apart from maintenance.
- The estimated annual mean CO_2 reduction is 3.5 tonnes per device, a 50% reduction from the current emissions of about 7 tonnes per household. The anticipated overall reduction during the first project phase is 24 500 tonnes.

Description:

The project is designed for households and small-scale fishing industry in Aceh. The aim is to reduce the use of firewood for cooking and water sterilisation, which is one of the main causes of deforestation. The parabolic solar cooker utilises the heat collected by a dish-type reflector (1.4m in diameter) that directs most of the intercepted solar radiation to a focal point. Cooking vessels are placed at the focal point, thus creating heating conditions very similar to traditional open-fire cooking. The heat-retaining container that comes with the cooker can keep food warm for a period of time. Using of solar cookers not only reduces deforestation and thus avoids greenhouse gas emissions, but also has health benefits, since households can avoid the respiratory problems caused by smoke from conventional cooking stoves.

Adaptation to local conditions:

Klimaschutz e.V. provides prefabricated solar cooker kits that are assembled locally under the supervision of local specialists. They also promote effective use of heat containers that make it possible to cook using retained heat (simmering) as an energy-saving measure. The project is expected to provide employment for about 10 people for assembling cookers, trained and supervised by PT Petromat Agrotech. It is expected that the cookers can be a source of additional income for households and local industry by saving expenses for fuel in processing and preserving food for trading.

Lessons learned and recommendations for replication:

Solar cookers cannot replace all use of firewood for cooking since they do not function at night. As local populations cannot afford the cost of the solar cookers, development aid is necessary to disseminate them in poor communities. Project partners can also consider innovative financing schemes using subsidies and micro-credit to replicate this project on a larger scale, while technology transfer is needed to make local production possible.

This project was realised as a Small Scale Project registered under the Clean Development Mechanism (CDM). Klimaschutz will receive all the Certified Emission Reductions (CERs) from the project in return for pre-financing. Thus, neither subsidies nor financial burdens on the users are necessary. The CDM could open up similar financing opportunities in the capital market for this kind of basic but effective technology. However, the accreditation of reduced CO_2 emissions by using non-renewable biomass, as in this project, was discontinued by the CDM in December 2005, and a new methodology is under consideration.

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Energy Star Product Labelling

USA

Performance:
In 2005 alone, the complete ENERGY STAR programme which covers products, buildings and private houses, led to energy savings of 150 billion kWh (about 4% of US electricity sales), resulting in utility bill savings of USD 12 billion. These savings prevented emissions of 35 million tonnes of carbon equivalent, equivalent to the emissions from 23 million vehicles.

Description:
Energy Star Product Labelling reduced greenhouse gas emissions equivalent to annual emissions of 23 million vehicles. With ENERGY STAR product labelling, the US government has set energy efficiency guidelines for more than 40 commonly purchased products for home and business use. These energy efficiency guidelines are above any minimum standards in place for products and employ agreed testing procedures for the measurement of energy use. Products that meet the specifications may display the ENERGY STAR. More than 2 billion ENERGY STAR qualified products have been purchased since the programme's inception in 1992.

Lessons learned and recommendations for replication:
Energy-performance improvements in consumer products and buildings are an essential element in any government's portfolio of energy-efficiency and climate change mitigation programmes. Governments need to develop balanced programmes, both voluntary and regulatory, that remove cost-ineffective, energy-wasting products from the marketplace and stimulate the development of cost-effective, energy-efficient technology. Energy-efficiency labels and standards for appliances, equipment, and lighting products deserve to be among the first policy tools considered by a country's energy policy makers. They fit well with most other energy policies and can play a role as the backbone of all countries' energy policy portfolios. Efficiency standards and labels can force a shift to energy-efficient technology and dramatically improve national energy efficiency. To assist implementation, the Collaborative Labeling and Appliance Standards Program (CLASP) has developed a Guidebook for Appliances, Equipment and Lighting.

Contact:
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Website: www.clasponline.org/main.php

ENERGY STAR

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Retrofitting low-cost urban housing

Khayelitsha, a township in Cape Town, South Africa (2004 – 2025)

Technology:
- Compact fluorescent lamps (CFLs)
- Ceiling insulation
- Solar water heaters

Performance:
- The cost of retrofitting a house during the demonstration phase was around EUR 1 000.
- Retrofitting allows the annual energy consumption to be reduced by approximately 2 700 kWh, and CO_2 emissions to be reduced by 2.8 tonnes per household (33% reduction).
- The living conditions in these households improve through the instalment of showers and hot water taps. It is estimated that annual health costs will be reduced by about EUR 90 through the disuse of conventional heating and lighting devices.

Description:

In South Africa, use of solar water heaters and CFLs is almost non-existent even in middle- to high-income households. Hot water is provided by storage boilers heated by kerosene, liquefied petroleum gas (LPG) or electricity.

Insulation is not part of the current low-cost housing delivery provided by public authorities. Low-income households give priority to extending their housing units when renovating. Income constraints mean that the poor tend to suppress their demand for heating and lighting. Conventional heating sources such as paraffin stoves are a fire risk, can cause carbon monoxide poisoning, and have negative respiratory health impacts.

This project involves retrofitting state-subsidised 30 m^2 housing units in Kuyasa, a low-cost housing settlement, to improve energy efficiency and use renewable energy. In the demonstration phase, a solar water heater (3kW input power), insulated ceiling (plasterboard, cardboard, and aluminium foil laminate) and two CFLs (11W and 16W) were installed in 10 units. The project will be continue for 21 years and will provide approximately 2300 households with opportunities for energy savings.

Adaptation to local conditions:

Most technologies applied in the project are available locally. The project also aims to increase local employment and build skills amongst local artisans, with a prediction of creating 139 man-years of employment every year for installation and maintenance during the 21-year period. All retrofitted houses are provided with showers, shower curtains, basins, hot and cold water taps, and pipes for wastewater, as they did not have showers before.

Lessons learned and recommendations for replication:

The City of Cape Town sold the first 10 000 Certified Emission Reductions (CERs) for EUR 15 each (CO_2 tonne) to the UK government to offset greenhouse gas emissions from the G8 summit held at Gleneagles in 2005. Over the project lifetime of 21 years, financial returns of approximately EUR 6.3 million in energy savings and EUR 500 000 in CERs are expected by 2012. This is more than four times the initial investment. However, as it was a CDM project and therefore generates tradable certificates, it was possible for it to be financed by the government, as it is not the government itself but the households that benefit from the energy cost savings.

To extend the applicability of retrofitting houses to other regions, it is important to devise innovative ways of financing the initial installation costs. In addition, governments and housing developers need to take the economic, environmental and health benefits of sustainable houses into account from the planning and construction stages.

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Solar power and energy saving initiative for schools

North Rhine-Westphalia (NRW), Germany (2000 – ongoing)

Technology:

- Photovoltaic panels
- Gas-fired combined heat and power (CHP) units
- Fluorescent light tubes (T5)
- Heating system optimisation and efficient circulation pumps
- Improved ventilation control systems with variable speed drives
- Water-saving devices

Performance:

- The total electricity consumption was reduced by 46% through efficient lighting and optimisation of the heating system by means of efficient circulation pumps. Gas consumption was reduced by 26% through heating optimisation, and water consumption was reduced by 16%.
- These results led to a reduction of CO_2 emissions by 30%, 118 tonnes per year, and reduced costs by EUR 21 000 a year.
- PV panels set up on the school roof generate approximately 43 000 kWh a year and the proceeds from selling this electricity amount to over EUR 15 000 a year.
- The initial investment of EUR 420 000 is expected to be paid back in 15 years through the savings in energy costs and the proceeds from solar energy sales.

Description:

The 100 000 Watts Solar Initiative aims to generate 50 watts of solar energy and save 50 watts through energy efficiency measures for each student. In an average school with 1 000 students, 100 000 watts of energy can be saved. To date, four schools participated in the project.

At each of the chosen schools, photovoltaic panels with an output of up to 50 kW were installed on the roof and the lighting system was refurbished using efficient T5 lamps. In addition, depending on conditions at the school, its heating and ventilation systems were renovated by optimising the control system and/or by installing a small natural gas-fired co-generation plant. Water-saving measures such as reducing water use for flushing toilets, maintaining showerheads, and constantly monitoring the total usage were introduced. The energy generated from the roof is fed into the electricity grid, not used directly by the school.

The schools chosen for the project were in need of renovation, which would normally require substantial investments by the municipalities. They were using old fluorescent lighting and conventional gas boilers for heating, which are less efficient than the latest technologies, and their ventilation systems were not optimal.

Adaptation to local conditions:

A large proportion of the funding was raised by individuals (parents, teachers, students and local residents). Investors could subscribe for shares of Solar & Spar Contract GmbH & Co. KG, a company specifically established for this project. This company receives the proceeds from selling energy generated by the solar power plant and the energy costs saved by the municipality. The minimum amounts for citizen investment were EUR 500 for those associated with a school and EUR 2 500 for others. The objective is for citizens to recover their investments within 20 years.

Lessons learned and recommendations for replication:

This project was designed to achieve several goals at once – raising funds for renovation through a citizen investment scheme, saving energy by modernising heating and lighting systems, and generating renewable energy. The project has great educational value as students gain hands-on experience of energy efficiency.

The project has great potential for replication. Local authorities and others can enjoy both environmental and financial benefits without a substantial initial investment. To realise the citizen financing, project partners need the capacity to arrange sound investment schemes and to ensure co-operation from citizens and utility companies. The country's energy policy must permit independent renewable energy plants to be connected to electricity grids and to sell electricity to utility companies

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Autonomous passive solar houses

Hockerton Village, Nottinghamshire, UK (1994 – 1998)

Technology:

- High thermal mass construction
- Conservatories for using passive solar energy
- Earth-covered roof
- Double and triple window glazing
- Mechanical ventilation and heat recovery system
- Water heating via a heat pump
- Rainwater collection including ultraviolet treatment
- Sewage treatment through a reed bed
- A reservoir (150 m^3)
- Two wind turbines (5kW each)
- Photovoltaic panels (7.65kW)

Performance:

- This passive solar house uses only 15% of the average UK household's energy consumption of 22 800 kWh per year. In terms of consumption in relation to space, it is estimated that 93% of the energy consumption in normal households can be saved.
- Wind turbines and PV panels generate most of the energy used in this building. Most of the CO_2 emissions from domestic energy consumption can thus be reduced.
- The annual saving on energy costs is 83%, approximately EUR 1 270 per household. This saving means that the higher construction costs of this type of house would be paid off over a period of time.

Description:

The Hockerton Housing Project aimed to provide a single-storey building accommodating five families that makes them as self-sufficient as possible in food, water, energy and waste management. The building was constructed to keep heat inside as far as possible with minimal additional energy input and maximum use of organic and recycled materials in construction. Most of the construction was done by the occupants, taking two years to complete.

Both walls and roof of the building are insulated with 30cm polystyrene before an earth covering with a minimum 40cm earth on the roof. Space heating relies on heat from passive solar gain and incidental gains from occupation with little extra input. The concrete fabric of the housing stores heat and releases it when the air temperature drops below that of the concrete. A ventilation and heat recovery system pre-warms incoming fresh air and keeps the inside temperature between 18 and 22 ^{0}C during the winter. Hot water is mostly produced by an air-to-water heat pump located to the conservatory, which is connected to an insulated storage cylinder. Drinking water is collected from rain on the roof and a floating reed bed treats sewage.

Adaptation to local conditions:

The building was built with exceptional planning permission on green belt land on the edge of an existing village. The sloppy nature of the site and the earth-covered roof made it possible not to disturb the landscape. A repeated modular bay system of 3.2 metres in width was used for simple construction of five houses. Each house is 6 metres deep with a 19-metre south-facing conservatory running the full width of each dwelling, which allows maximum winter solar gain.

Lessons learned and recommendations for replication:

This project shows that houses and buildings with innovative passive solar design can dramatically reduce energy consumption, and provide comfort without extra heating.

In Germany and Austria, for example, 'passive houses' are already realised in any design and size that conventional houses may have. Their construction costs are currently EUR 2 000-15 000 higher than conventional buildings. However, the saving in energy bills absorbs these costs in due course.

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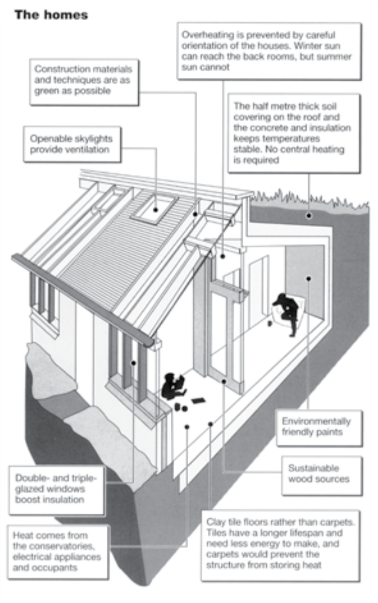

Installing a co-generation system financed by energy performance contracting

Griffith City, New South Wales Australia (2003 – 2010)

Technology:

- Gas-fired combined heat and power (CHP) unit

Performance:

- The total annual energy consumption increased by 470 MWh due to a rise in natural gas consumption for the CHP plant. Yet, as the electricity consumption from power grids (1 600 MWh per year) was significantly reduced, CO_2 emissions were reduced by over 1 000 tonnes a year.
- The cost of installing the CHP plant was approximately EUR 541 000. The savings from lower electricity bills and ease of maintenance amount to about EUR 63 000 per year. The internal rate of return is thus around 12%, which can be considered a low-risk investment.

Description:

The Griffith Base Hospital is a medium-sized facility with about 110 beds and buildings dating from the 1940s to 1970s. It had not undergone any major improvements or additions for 25 years and had a range of dysfunctional buildings and systems. Under the circumstances public spending for hearth had been tightened, investments in asset replacement and improvement was rather limited.

The co-generation system offers both economic and environmental benefits by producing both electricity and heat from a single fuel source without wasting heat from generators. After some parts of the buildings were closed down, the old, gas-fired steam boilers became too large for the hospital's needs. To meet the new, lower demand for electricity, hot tap water and space heat, a natural gas-fired CHP plant with a power output of 220 kW was installed. As a result of the greater efficiency, the hospital was able to cut its energy bills by half and reduce CO_2 emissions.

Adaptation to local conditions:

The funding for this project was delivered by a seven-year Energy Performance Contract (EPC). EPC enables money that will be saved as a result of introducing a new energy-efficient measure to be used to offset the cost of financing, installing and operating that measure. The contract was arranged between the hospital and an external energy performance contractor. The contractor operates the gas-fired combined heat and power (CHP) plant, and monitors the energy savings. This means that the hospital has not had to pay for the new CHP plant or take risks and responsibilities for operation and performance. The initial funding for EPC was provided by the Government of North South Wales in the form of a treasury loan.

Lessons learned and recommendations for replication:

The project shows the economic and environmental advantages of replacing old or under-utilised heating equipment with a co-generation system. Large establishments (e.g. schools, office buildings, factories, hotels, shopping malls, sport centres) are particularly likely to benefit from this system as they use large quantities of hot water, heat and electricity. EPC can be a viable means of raising initial investments when financial resources are limited. To promote energy efficiency through co-generation or renewable energy, governments need to facilitate sound financial arrangement such as EPC and remove barriers to decentralised energy production, whether this is connected to or independent from electricity grids.

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SEDA AGL case study 2001

GRIFFITH HOSPITAL INVESTIGATES COGENERATION

Griffith Hospital's central steam plant used to provide steam for the laundry and catering as well as hot water and space heating for the whole hospital. When the laundry and catering were closed down, the hospital was left with a steam plant working under capacity.

Stephen Butt, the Manager of Engineering and Biomedical Support decided that this was an ideal time to investigate cogeneration. He applied for a feasibility study under the SEDA/AGL Cogeneration Development Program and discovered that he could save $61,000 a year from the energy bill by installing a 250kVA plant to generate electricity onsite and provide space and water heating for the hospital.

The heating and domestic hot water plant at the hospital.

HIGHLIGHTS

- greater reliability of energy supply provides 92% of the site electrical requirements.
- $61,200 reduction in annual energy costs
- provides more flexibility in how buildings are run
- Saves 1380 tonnes of CO_2 emissions annually

BACKGROUND

Griffith Base Hospital is a small base hospital close to the centre of Griffith. The hospital provides Accident and Emergency; Maternity; Pathology; Operating Theatres; a Nursing School; beds for 110 patients and a children's ward. Most of these functions are carried out in double story buildings spread over a 10 hectare site.

Heating is provided via gas fired steam boilers. The boilers were designed to provide heat for the laundry as well as the hospital air conditioning, kitchen, heating, and domestic hot water systems. When the hospital decided to close the laundry and later the production kitchen, the boilers became too large for the hospital's needs.

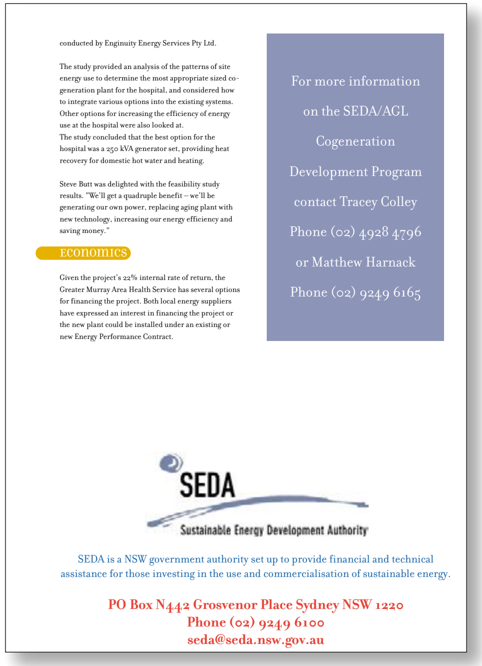
Heating and cooling of the hospital is carried out by an air-conditioning system nearing the end of its useful life, and by evaporative cooling and radiators. As well as replacing the boilers, the hospital wanted to replace the air-conditioners and extend the air-conditioning to cover parts of the building that are evaporatively cooled.

Any on site electricity the hospital can generate will decrease the need for the local energy suppliers to increase network capacity.

FEASIBILITY STUDY

Steve Butt contacted SEDA to investigate the possibility of cogeneration, and SEDA and AGL jointly funded a feasibility study for the hospital,

Griffith Base Hospital main entrance.



conducted by Enginuity Energy Services Pty Ltd.

The study provided an analysis of the patterns of site energy use to determine the most appropriate sized co-generation plant for the hospital, and considered how to integrate various options into the existing systems. Other options for increasing the efficiency of energy use at the hospital were also looked at.

The study concluded that the best option for the hospital was a 250 kVA generator set, providing heat recovery for domestic hot water and heating.

Steve Butt was delighted with the feasibility study results. "We'll get a quadruple benefit – we'll be generating our own power, replacing aging plant with new technology, increasing our energy efficiency and saving money."

ECONOMICS

Given the project's 22% internal rate of return, the Greater Murray Area Health Service has several options for financing the project. Both local energy suppliers have expressed an interest in financing the project or the new plant could be installed under an existing or new Energy Performance Contract.

For more information on the SEDA/AGL Cogeneration Development Program contact Tracey Colley Phone (02) 4928 4796 or Matthew Harnack Phone (02) 9249 6165

SEDA Sustainable Energy Development Authority

SEDA is a NSW government authority set up to provide financial and technical assistance for those investing in the use and commercialisation of sustainable energy.

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Nydalen Heating and Refrigeration Plant - Heat Storage in Bedrock

Oslo, Norway (2001 – 2003)

Technology:
Heat pump used for space heating and cooling.
Heat storage in bedrock with water circulating in boreholes.

Performance:
- Environmental benefit: 60-70% reduction in electricity use.
- The annual cost is reduced by EUR 0.5 million, or 55%.
- Efficiency/saving achieved by the project 8.9 GWh energy, representing a 75% reduction in energy use.

Description:
What is probably the largest heat storage plant of its kind in Europe has been built in connection with new offices, a hotel, a business school and apartment buildings in Oslo, Norway. The heating and refrigeration plant serves a total of 170 000 m^2, using heat from a total of 180 boreholes in the bedrock. The pipes are interconnected in collector wells and a separate pipeline brings water with a stable temperature to the heat pump. When the buildings need cooling in the summer, excess heat is removed by pumping water with a temperature of 25-40 °C into the boreholes and storing the heat energy in the bedrock.

Adaptation to local conditions:
Use of the technology was possible because it was included in new buildings in a newly built business park. The buildings were designed from the beginning to be equipped with heating systems based on circulating water at low temperature, thus reducing the overall cost of the project.

Lessons learned and recommendations for replication:
Low-temperature heating systems with circulating hot water have to be installed in order to use low-temperature heat sources facilitated by heat-pumps, solar heating systems, bioenergy boilers etc. The same applies to the use of heat storage in bedrock, such as the system in Nydalen. The actual choice of energy/heat source in new buildings, where this is needed, depends on the location and geographical distribution of low-temperature heat and cooling sources.

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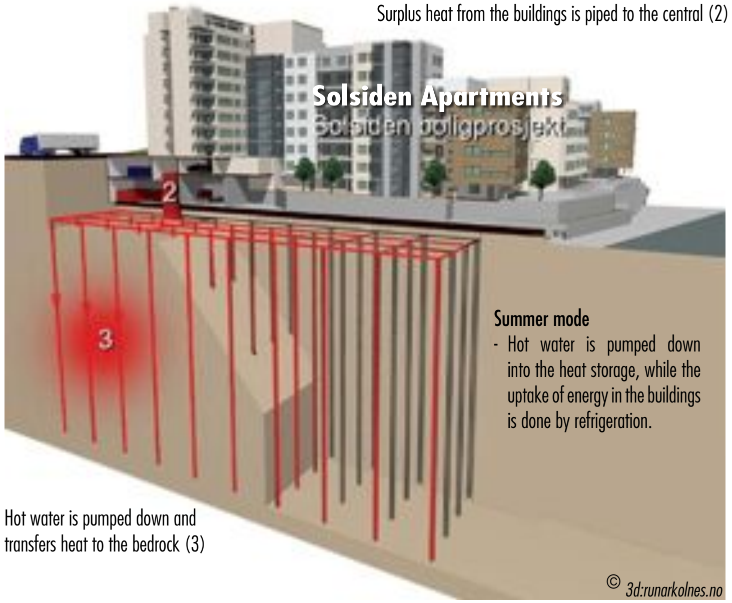
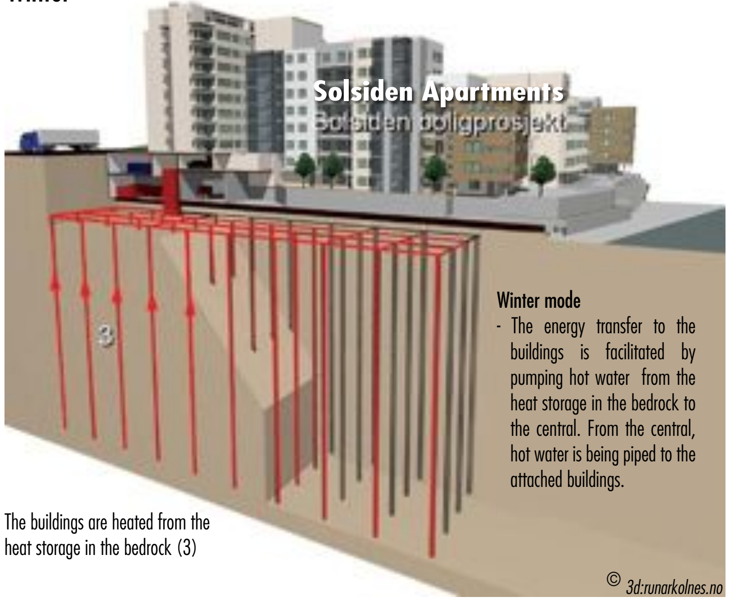
Summer



Hot water is pumped down and transfers heat to the bedrock (3)

Winter



The buildings are heated from the heat storage in the bedrock (3)

Simple energy efficiency measures in school buildings

Kola Peninsula, northwestern Russia (2003 – ongoing).

Technology:
- Silicone strips and silicone sealant for weatherisation of windows.

Performance:
- Typically, 15% reduction of energy use per building.

Description:
In this project, young people equipped with electrical hand tools are furnishing existing windows in schools, kindergartens and other public buildings with silicone weatherisation strips and silicone sealant. This reduces air leakage from the windows, reduces energy use for heating and increases indoor comfort in a region with very low outdoor temperatures in winter. Weatherisation is being carried out by volunteers, and they are instructed by people with previous practical experience.

The general attitude among the public towards energy use is conditioned by the prevailing technology for heating. Today there is no individual regulation of heating units. Lack of metering of heat use also induces little awareness of heating costs and no economic incentive to save energy. Poor maintenance leads to large heat losses from the district heating systems and the buildings. Weatherisation is a short-term measure. In the long term, total renovation of the district heating systems is required. This is of course more costly, and difficult to achieve under the present economic conditions in Russia.

Adaptation to local conditions:
Weatherisation can be a first step in reducing overall energy use, and more specifically energy use for heating purposes. Individual regulation of heating units (radiators) and metering of electricity consumption for heating each building would be important ways of raising consumer awareness and thus reducing energy waste in the region.

Lessons learned and recommendations for replication:
Weatherisation of the existing windows typically avoids a 5% increase in fuel use for each degree (°C) increase in indoor temperature. On average, this means a 15% reduction in energy need for heating in buildings that are weatherised. This is based on Ukrainian data.

Weatherisation of windows is a quick and very cheap measure, which increases indoor comfort without increasing fuel use. Silicone weather strips for windows have a life-time of up to 20-25 years.

The project served several purposes at low cost compared with more long-term solutions. The most important benefits are:

a) Greater indoor comfort without increased fuel and energy use, at very low cost.
b) Greater public awareness about energy use and increased energy efficiency.
c) Greater public support for public energy efficiency measures in general.
d) Greater environmental awareness.

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Traditional architecture – a premise for intelligent energy use, Punakha Hospital

Bhutan (1993 – 1997, 1999 and 2002 – 2003)

Technology:

Improved traditional building practices for natural ventilation and shading, low embodied energy, local materials, renewable energy (hydropower, wood stoves, a little solar water heating).

Performance:

- About 40% energy saving compared to conventional building methods and materials. 50% less wood used in modern roof construction compared to traditional methods. 250 000 Rupees saved by using locally produced roof tiles instead of imported galvanised iron sheets.

Description:

This project highlights the issue of cultural sustainability. Sensitivity to local tradition is integrated in an efficient and extremely economical project. It has become a model for subsequent hospitals in Bhutan – a sure mark of appropriate design. It was described by international health experts as the most successful in the country, and received a commendation in the international Ralph Erskine awards in 2000. The traditional decoration was emphasised as it has both religious and cultural significance. The project aimed to sustain and strengthen indigenous architecture. Not by imitation or pastiche – but real understanding of and careful improvements to the traditional architecture. It was essential for the project that the architect worked with the craftsmen.

The aim was a low-cost hospital to meet the medical needs of village people. The hospital has an inpatient capacity of 25-30 beds, and a full range of outpatient services including laboratory, pharmacy, X-ray, clinic, and sections for indigenous medicines, hostel and administration; as well as staff housing. Total 4000 m^2.

The project uses a maximum of local materials, reducing transport and embodied energy. Heating and power are electric since Bhutan produces hydropower. Some cooking is with wood, an abundant resource in Bhutan. There is an emergency diesel backup for the hospital since power supplies are not reliable. A small amount of solar water heating is used. However, the main energy strategy was to reduce the demand side, by careful planning, climatic adaptation and appropriate construction. The hospital thus needs no air conditioning, has good day lighting using natural light, simple ceiling fans, and probably uses about 60% of the energy in comparable buildings.

Adaptation to local conditions:

Punakha has a hot climate but it was also important to protect against winter winds. The buildings are oriented east-west to minimise solar gain. Large roof overhangs, verandas and trees increase shade. A fountain in a flower garden provides coolness. The main building has a three-storey high stairwell for natural ventilation. All rooms and corridors have cross ventilation and heavy building materials to keep the building cool. The roof is an open ventilated space following traditional solutions.

Paints are traditional earth- and plant-based pigments. Synthetic materials were avoided, reducing climate emissions and increasing use of local, natural resources. Locally produced roof tiles and use of modern trusses reduced cost of roof construction.

Lessons learned and recommendations:

This approach of bioclimatic or passive design, which reduces energy demand and all technology, is especially relevant in developing countries, where supply-side options and energy technologies may be inefficient and unreliable. Also, in developing countries there is often little money for maintenance so that energy technologies may quickly stop functioning. And good, energy-efficient design is free. It should always be the first priority.

Ecology, economy and community are the three pillars of sustainability. Whilst this project has many interesting ecological features, it is one of the few which puts great emphasis on the cultural and community part of sustainability – a reminder to energy and other specialists that all three aspects are equally important.

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The way forward

Energy efficiency must always come first in a comprehensive strategy for encouraging sustainable energy systems.

In the past, initiatives on energy and sustainable development have emphasised energy production rather than energy use. In contrast, this booklet focuses primarily on **energy efficiency and more sustainable patterns of consumption**. In future, more intelligent use of energy sources will be needed to meet a double challenge: we must combine providing adequate energy services for a growing population and alleviating poverty with protecting the natural environment. Just as we appreciate intelligence in our fellow human beings, we should welcome intelligence in societies, as demonstrated by the way they use the energy resources at their disposal. In future, the most energy-efficient society will also be viewed as the most intelligent and the most modern. Heating and cooling buildings in a way that wastes energy will be regarded as old-fashioned and irresponsible.

Energy efficiency and renewable energy solutions have been at the top of the international environmental sustainability agenda for a number of years. Improving efficiency makes it easier to phase out unsustainable energy supply options and phase in sustainable options. Some people would claim that energy systems worldwide can only be made sustainable by focusing on energy efficiency. This goal cannot be achieved simply by using renewable energy sources, particularly not if they are used in addition to rather than instead of the existing unsustainable energy options.

Globally, the necessary technology is available. Only relatively small adjustments are needed to make progress in energy efficiency in both North and South. The air-conditioning project in Brazil is an example of a project using comparatively cheap and simple yet sophisticated technology that would be applicable in buildings all over the tropical areas of the world

Understanding that technology must be suitable and applicable for the recipient, the industrialised countries have undertaken commitments under several UN conventions such as the Climate Change Convention to facilitate and promote technology transfer. Projects under the **Clean Development Mechanism (CDM)** are a means of implementing sustainable technology. They include two projects featured here; retrofitting of houses in Cape Town in South Africa and providing solar cookers for households in Indonesia. However, this mechanism alone is not enough. High-energy prices are putting many developing countries under tremendous financial strain, and forcing them to divert limited resources away from poverty alleviation to pay their fuel bills. Few countries are able to finance the necessary transformation of their energy systems by drawing on their own resources alone. Nor is financing the transformation by means of CDM projects alone a realistic option.

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As a result of the **increase in oil prices** over the last two years, the sub-Saharan countries (excluding South Africa) had to pay USD 1 billion more for their oil in 2005 than in 2002, an additional burden for already stretched economies. Reducing the amount they have to pay for energy would free resources that could be invested in more sustainable energy systems and in schools, hospitals and basic infrastructure. Reducing dependency on oil would make the international economy more predictable, since oil is the commodity that has fluctuated most in price in recent years.

Investing in efficiency in rural areas provides both direct and indirect **economic benefits for developing countries**. Improving living conditions in rural areas can keep people from migrating to cities, and thus reduce the need to invest in urban infrastructure. A healthier, more productive rural population can also produce more goods and services for the benefit of the whole country. The Punakha Hospital project in Bhutan is an example of how indigenous building materials, construction methods and know-how can be adapted to the needs of a modern society. Such projects can also help to increase self-reliance in traditional societies. This approach to construction is widely applicable in different climates and in many countries all over the world.

There is a great potential for developing countries to **leap-frog stages in technological and industrial development**. The fact that they have relatively few large, centralised fossil fuel power stations could prove to be a blessing in disguise, given today's high fuel prices and the constraints being put on carbon emissions. Leapfrogging must be encouraged by means of **priorities set by the international financial institutions**. However, today, most funding is provided for building large conventional power stations. The flow of money must be redirected towards energy efficiency and renewable energy technologies. Renewable energy solutions should be based on local adaptations so that more cost-effective and sustainable solutions are implemented.

© *Klimaschutz e. V.*

Energy-efficient equipment and renewable energy technologies may be more expensive than less efficient technologies, but this is often offset by lower running costs after a relatively short time. The energy-efficient light bulb project in Poland exemplifies the need in many cases to subsidise the introduction of energy-saving technologies. In this case, a time-limited subsidy to producers brought down the price of energy-efficient light bulbs to the consumer more than a subsidy on the sales price would have done. This made the product more attractive, and helped to increase the volume of sales. This project is an example of how **cooperating with the private sector** and using market mechanisms can minimise project costs and maximise energy efficiency gains. Public awareness campaigns are sometimes, as in the Polish case, designed to strengthen the effect of other policy measures.

In other cases, all that is needed is a **system for communicating information** about the technology. **Labelling and standards** can play an important role in encouraging public participation and changing consumption patterns. For example, the US Energy Star is a government-backed programme that helps businesses and individuals to purchase more energy-efficient products. US EPA states that in 2005 alone, the programme led to energy savings equivalent to the greenhouse gas emissions from 23 million cars, and savings of USD 12 billion on utility bills.

In the extremely cold climate of northwestern Russia, a **volunteer-based initiative** is achieving improvements in energy efficiency and indoor comfort by weatherstripping windows, thus reducing draughts and heat leaks. Best of all, this is being achieved with relatively simple tools and at negligible cost. In Russia, as in many countries in eastern and central Europe, buildings and heating systems waste large amounts of energy, and urgently need renovation to improve energy efficiency. Weatherisation can be the first step in this process.

Another possible approach is to make use of **innovative investment schemes** for energy efficiency, as in the schools project in Germany. Here, much of the funding needed for renovation to improve energy efficiency was raised from private citizens. **Energy performance contracting (EPC)**, as used for example in the co-generation system in Australia, which also uses EPC. Experience gained in this project shows how important it is to devise innovative ways of financing the initial installation costs if this approach is to be extended to other regions. In addition, governments and housing developers need to understand the economic, environmental and health benefits of sustainable housing and must take these into account in the planning and construction stages. EPC can be a viable means of raising the initial investment when financial resources are limited. To promote energy efficiency measures using co-generation or renewable energy, governments need to facilitate sound financial arrangements such as EPC and reduce the barriers to decentralised energy production, which may be either connected to or independent from the electricity grid.

Micro-financing schemes were pioneered by the Grameen Bank in Bangladesh, and the idea has since spread to other developing countries all round the world. In many cases, the small loans provide sufficient funds for villagers to invest in energy-efficient equipment to help them earn a living. This may involve the use of solar power as in the solar cooker project in Aceh in Indonesia. In this case, cookers were provided through a CDM project: otherwise, such projects need some form of micro-financing. The micro hydropower project in Peru illustrates the need for loans and grants to spread this technology. The biogas digester project in China is another example where the provision of sound financial schemes will be the key to extending the approach to other areas. This case demonstrates that even if full subsidies are not available, small-scale financial support such as **zero-interest loans** can provide a strong incentive for taking up energy efficient technologies.

The conservatory that allows maximum passive solar gains
© Hockerton Housing Project

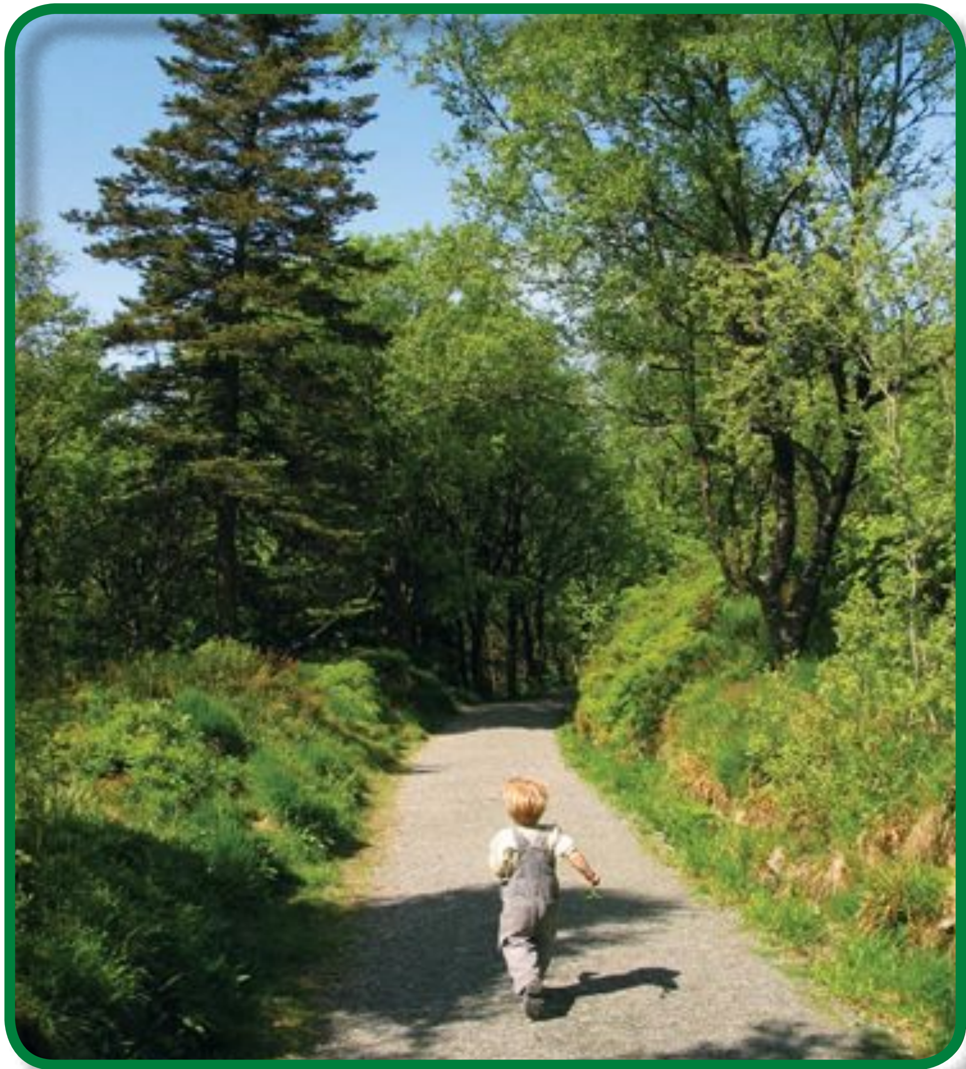
The UK housing project illustrates the importance of the many **environmental and social benefits of integrated projects** designed with a holistic approach. The project highlights the need to take a comprehensive approach to the design of living spaces, instead of focusing on one or a few isolated aspects. The systems designed to heat, cool and light the buildings reduce the need for external energy supplies drastically. Energy installations are also tightly integrated with water and waste management systems.

Public authorities should take responsibility for implementing standards for public buildings and procurement. This can encourage the development of markets for new technologies and also achieve long-term cost savings. The example from Norway shows that where conditions are suitable, geothermal energy can be a good alternative, coupled with solar heating systems, bioenergy boilers etc.

The choice of energy/heat source for new buildings depends on their location and the geographical distribution of low-temperature heat sources. Retrofitting of old buildings should be carried out in connection with major renovation. A mix of **building regulations and economic incentives** is needed to facilitate improved energy efficiency.

China has already installed more than 7 million biogas digesters, and has more than 30 000 trained technicians. When disseminating new efficient technologies, it is vital to build knowledge and capacity among local technicians through **local partners**. Projects on this scale are dependent on official support to provide the necessary political and financial framework for investment and project implementation and follow up.

To facilitate a **shift towards more sustainable energy solutions**, the focus should be on initiatives that combine improved energy efficiency with renewable energy technologies. Funding is generally needed to refurbish and promote efficient district heating and to raise public and institutional awareness. Using passive cooling systems (sun shading, natural ventilation etc.) in hot climates and energy-efficient passive and active heating/cooling systems in temperate and cold climates is a potentially powerful approach that should be encouraged through financial incentives and support mechanisms.



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