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.

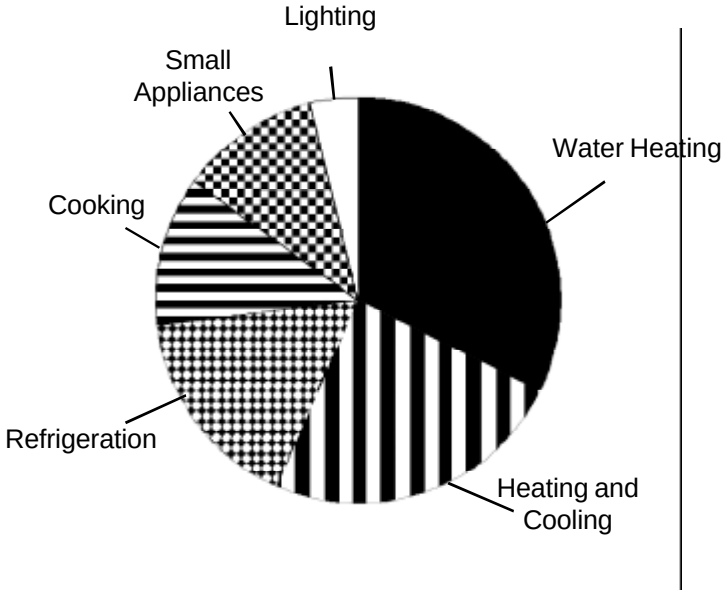


Figure 2.1: Domestic energy use in Western Australia.

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).

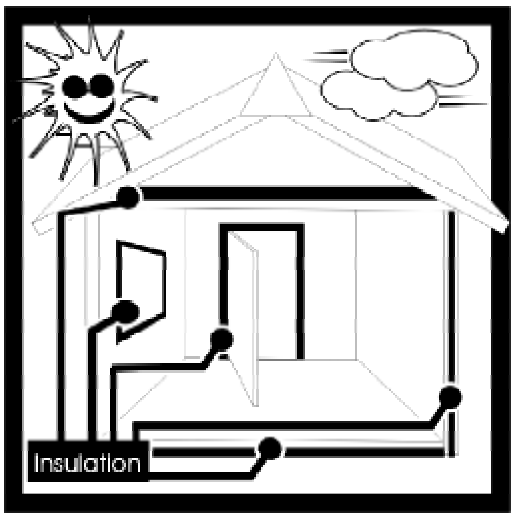


Figure 2.3: Buildings are able to be insulated in the roof, floor and wall spaces in addition to the weatherisation of window and door cavities.

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.

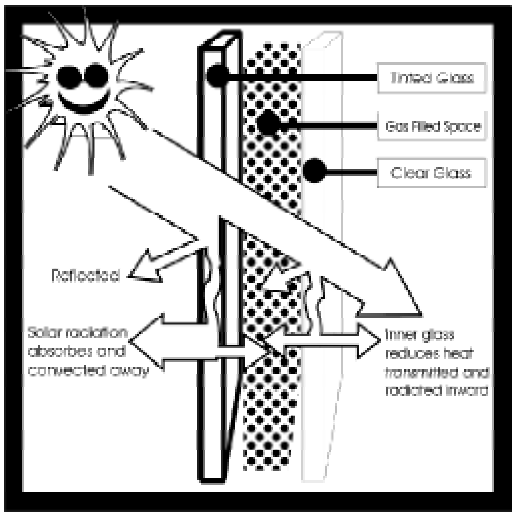


Figure 2.4: Double glazed windows can significantly reduce the thermal comfort of rooms.

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.

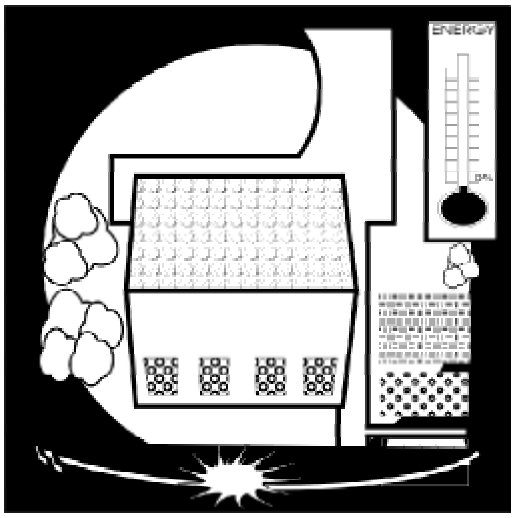


Figure 2.5: Building orientation is an important aspect when designing buildings for energy efficiency.

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.

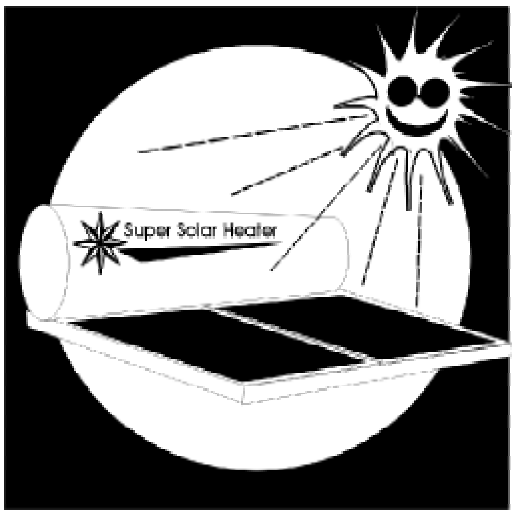


Figure 2.6: The sun can be used to heat water for applications which do not require boiling water, such as washing.

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.

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.

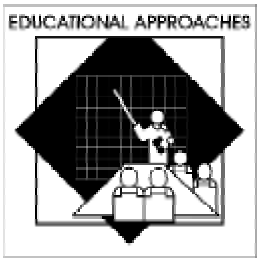
The options available for cooling homes are similar to those of small commercial buildings, and are discussed at length in Chapter 4.

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".

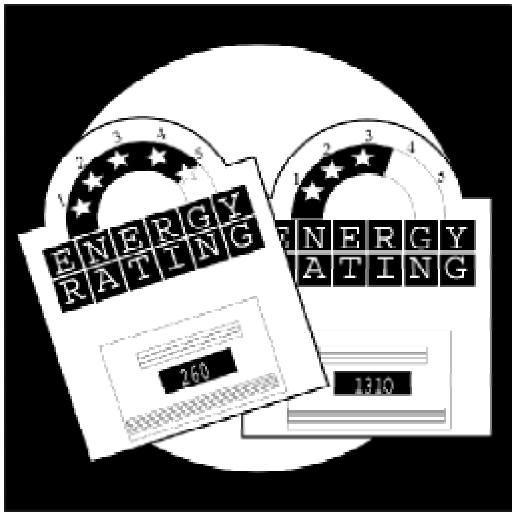


Figure 2.7: Energy labelling programmes, such as the Energy Star and Energy Rating schemes have made the purchase of energy efficient appliances easier for consumers.

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.

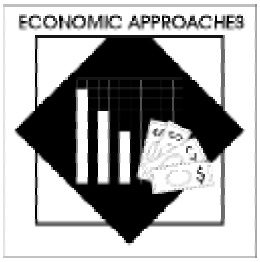
See Case Study 7 Mandatory Standards and Labelling Information.

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/ceccontents.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/