

---

## 4 TARGET TECHNOLOGIES

This section examines the technologies for which governments are likely to be responsible. It is divided into **Energy Supply**, **Buildings**, **Appliances** and **Vehicles**.

Under the **Energy Supply** section two renewable energy technologies are examined: solar thermal technologies and PV.

Under the **Buildings** section the following technologies are covered:

passive solar, high performance windows, combined heat and power (CHP), boilers and heating systems, heat pumps, electric motors, air conditioning, and lighting.

The **Office Appliances** section covers copiers and computers, with related information on printers and fax machines. Refrigerators are examined in the **Domestic Appliances** section because of their widespread use in public sector buildings such as residential care homes, hospitals and prisons.

The **Vehicle** technology section covers the use of alternative fuels for use in buses, vans and cars, and the deployment of electric vehicles.

### 4.1 Energy Supply

Today, solar energy can be a viable contributor to a building's total energy requirement, providing electricity for appliances, lighting, heating and cooling a building. Two solar powered technologies are mature and are widely used in some countries: PV and solar thermal. Both technologies are found to be most acceptable (aesthetically and practically in terms of space needed for the equipment) for small scale applications where they are integrated into the building's fabric as roof or wall panels. They are currently deployed across the range of climates which are experienced in IEA/OECD countries with widespread use in sunny (Greece, Australia) and not so sunny (Austria and Norway) countries, where they are used for water heating, and for heating swimming pools.

#### 4.1.1 Technological Opportunities : Solar Thermal (Active Solar) Design

##### *Status of the Technology*

Solar thermal technology for small-scale applications such as in government buildings, involves the use of components to capture solar radiation and apply the heat where it is needed, such as for space and water heating. A variety of systems are available for use on buildings, but the most practical for small-scale applications are relatively cheap solar panels which can be mounted on the roof or wall of a building. Due to the seasonal variation of solar radiation, most systems also include heat storage or supplementary heating.

In many situations active solar systems are not cost competitive with natural gas and other fossil-fuels, because of the relatively low price of these fuels compared with the cost of the technologies for utilising the solar resource. However when the environmental costs of using fossil-fuels are considered (as with all renewable energy sources) the economics of solar thermal become more favourable. Cheaper technologies which are emerging, such as

---

integrated solar hot water systems, should allow the technologies to become relatively cheap, and the market to remain buoyant and self-sustainable. The potential market for solar thermal technologies is huge, therefore any increases in the use of the technologies could offer a strong boost to the industry and enhance its prospects for becoming fully market competitive with fossil fuel technologies.

### *Deployment / Market Enhancement Activities*

Deployment of solar thermal technology in sunny countries such as Greece, Japan and Australia is 80-90% for domestic water heating, whereas this figure is 60-70% in cooler climates<sup>6</sup>. The remainder of the systems are usually used for heating swimming pools. In Luxembourg and Norway the governments have installed solar power in publicly owned swimming pools, which will improve public awareness of the technology and could act as a market enhancement measure if it causes replication elsewhere. The success of the technology in heating swimming pools in countries with a cooler climate demonstrates the usefulness of the technology in countries which are not usually noted for their hot, sunny weather, and could provide a useful model for countries with similar climatic conditions.

Australia has a programme for enhancing the market for solar energy, and is promoting it through the Solar Water Heater Programme (A\$6 M over 3 years) and has established the Perth International Centre for Applications for Solar Energy to disseminate information about the technologies.

In 1990 the Netherlands launched a targeted information campaign with the express aim of promoting the market for solar domestic hot water systems. The motto of the campaign is "Switch to the sun for a better environment", and it aims to install 300,000 solar hot water systems by the year 2010. In 1988 the government introduced subsidies for solar hot water installations but these failed to make a significant impact on the market, and large orders for the technology were not forthcoming, manufacturers were unwilling to make the investments needed for large-scale production, and therefore the capital costs of the technologies remained high. Since 1990 information campaigns coupled with easy access to the technologies has led to improved deployment of the technology, such that by 1997 40 Dutch power companies were offering the technology for rent, lease or sale, and 300 installers had been newly trained. Three-quarters of the installations have been made in new housing construction projects, and because these are on a relatively large scale this has lowered the price of the technology by about 20%. The remaining installations were made in private houses by utilities or by housing corporations. As a result of the widespread interest in the technology, solar thermal panels are now being marketed alongside fossil-fuel fired appliances by some suppliers which should open up further market interest. When the programme is completed in 1998, it is hoped that the technology will be at a price which private individuals could afford. However, the subsidies currently remain essential to the success of the programme, and it is expected to be a few more years before the industry will be self sustaining. Purchasing programmes for government premises could contribute to the market position of these technologies.

---

## **Austria**

### **Solar Heating Self-Build Technology**

*The market for solar collectors was encouraged by financial support and information programmes by the government which led to the formation of "self build" groups.*

*These "self build" groups enthusiastically adopted the technology, and formed co-operatives who were then able to make bulk purchases of the technology components. As these groups built their own systems, they have themselves been able to make minor repairs as necessary.*

#### **Effect on the Market:**

*In 1991 the number of such installations was 123,000 m<sup>2</sup>, but as a direct result of the "self build" policy the number of installations by 1995 had increased to 203,000 m<sup>2</sup>. In total there are about 1,241,000 m<sup>2</sup> throughout Austria (1997 figures), 35% for swimming pools (including pools operated by the public sector), and 65% for water heating. This is estimated to have made savings in electricity of around 415 Wh. by the end of 1995, corresponding to about 114,000 tonnes of oil<sup>4</sup>.*

### **4.1.2 Technological Opportunities - Photovoltaics (PV)**

#### *Status of the Technology*

Solar PV technology produces a flexible form of energy which can be integrated with other sources of electricity via local, regional and national networks. It is also very successfully used in off-grid applications where it can be more cost-effective than extending electricity cables to a remote location. Solar PV consists of manufactured materials, usually formed into small assemblies or cells, which are light-responsive semi-conductor devices which directly convert solar radiation into electricity. The PV unit can be made to the size most appropriate for its needs and is particularly well suited to roof top installations which are most likely to be practical in government owned premises<sup>21,6</sup>.

#### *Deployment/Market Enhancement*

The economics of PV are highly dependent on the location. Remote locations are currently those areas which are most likely to benefit from PV as the costs of connecting the area to the main grid are so high. PV is currently used quite extensively in remote locations in developing countries for lighting, refrigeration, and for operating radios and televisions. In OECD countries PV is found in individual or network-linked schemes in urban areas as well as in off-grid locations.

---

In Switzerland PV has been installed in school buildings, and as part of Canada's Green Power Procurement Initiative PV will be deployed and tested in Canadian government buildings. In the UK a consortium of the University of Northumberland, a building construction company, and two power companies installed 456 PV panels on a four-storey building at the University as part of an extensive refurbishment programme. In summer the electricity produced meets the building's entire daytime need for lighting, heating and powering computers and other appliances (30-40 kW). Surplus power is fed into the university's distribution system. In overcast conditions the panels provide less than 10% of the building's requirements. The PV panels and wiring added £800,000 to the cost of the refurbishment. The project acts as a demonstration of the visual acceptability of PV on large buildings, and is being used to assess the technical viability of such installations. It aims to improve prospects for the technology to be more widely adopted.

Roof and wall mounted systems are found to be most acceptable in the OECD region, and programmes in Japan and Germany have proved successful in encouraging private house owners to adopt the roof top technology. In Germany the "1000 Roofs" programme began in 1991, with financial support for the installation of 1000 roof mounted grid-connected PV systems. The aim is to gain information on the reliability and cost-effectiveness of roof-mounted systems in connection with the electricity grid. Forty-one different types of inverter and 25 different types of PV module have been installed. Government grants cover 70% of the cost, with participants paying between DM 7,000 and DM 40,000 depending on the size of the system. There has been enormous public interest in the programme with applications from more than 4,000 households. By 1997 2,500 installations had been made.

In the US the *Million Solar Roofs Initiative* was launched in 1997. The programme aims to have one million solar energy roofs in place by 2010. By 2010, when this will be achieved, annual emissions of carbon will have been reduced by the equivalent of 850,000 cars, and 70,000 new jobs will have been created in the PV and solar technology industries.

This programme includes two types of solar technologies: PV to produce electricity from sunlight, and solar thermal panels to produce heat for domestic hot water, space heating or swimming pools.

The programme will establish 25 major partnerships by September 1999, between the US Department of Energy, the building industry, other Federal agencies, utilities, the solar energy industry, financial institutions, state and local governments and non-governmental organisations. It aims to bring together the Federal government with key businesses, state and local government and organisations to focus them on building a strong market for solar energy applications in buildings. Access to financing for solar energy systems will be improved, and uniform loan regulations and a solar energy financing pool will be established in the secondary mortgage market. A network of State Renewable Energy Funds has been established to purchase, finance and/or buy-down the cost of solar energy systems. These Funds are expected to provide \$1 billion between 1997 and 2002 for renewable energy programmes. The Department of Energy is facilitating information sharing between those states implementing initiatives, such as California's \$450 million programme which includes a \$3 per watt buy-down fund for PV, Massachusetts's \$146 million renewable energy development fund, and Illinois' \$5 million per annum fund.

The *Million Solar Roofs Initiative* will reduce technical, regulatory and programmatic barriers, and organise training and technical assistance to enhance state Fund activities. A Tax Credit is being established as part of a \$6.3 billion package of Federal tax and research incentives for energy technologies to address climate change. Tax credits of up to \$2,000 will be available for

---

the installation of a rooftop solar energy system. The Department of Energy will work with partnerships, businesses and industry to integrate tax credits into their business plans.

Federal agencies are committed to installing 20,000 solar energy systems in their facilities by 2010, and 2,000 are already planned for the year 2,000. Work with relevant Federal departments will facilitate adoption of the technologies in a wide range of regional applications, and provide technical assistance, training, partnership development and disseminate information. Rapid changes in the electricity supply industry provide opportunities for the *Million Solar Roofs Initiative*, and proposals include net metering in all states, a renewable energy portfolio standard and a \$3 billion public benefit fund. Further proposals to reduce barriers to the use of solar energy systems include: establishing uniform interconnection standards to reduce barriers to connections to the utility grid; supporting net metering in all 50 states; and changing building codes to include solar electric and solar thermal energy systems. Support for research and development will continue particularly to expand reliability, in developing systems which last longer, are easier to maintain and meet consumer expectations.

By increasing the domestic market for solar energy, domestic technology production will increase and unit costs will fall, enabling the US industry to maintain its competitive edge in the world market.

### **Japan**

#### **Rooftop PV Programme**

*In 1992 Japan began a PV programme by subsidising installations in schools, community halls and museums. In 1994 the government launched a programme of subsidies for installations on the roofs of private houses aimed at installing 7,000 systems. Subsidies are available for up to 50% of the installation of the system, up to a limit of 5 kW per system. In exchange the owner is obliged to provide specified system monitoring data for the following three years. The intention is that this monitoring data will help the PV industry to develop cheaper PV equipment.*

#### **Effect on the Market**

*The budget for the programme rose by 65% between 1994 and 1995 which led to PV suppliers increasing their sales efforts by cutting prices by around 30% for a 3 kW system. In addition, as a result of the programme the network of distributors of PV who market, instal and service the systems has grown. This will help the industry to become self-sustaining after the programme has been completed.<sup>13</sup>*

### **Training**

One of the major disincentives for adopting PV technology on a wider scale is the lack of trained installers in many IEA countries. Take-up of this technology is unlikely to be widespread beyond the bounds of targeted government programmes, until there are readily available, well qualified installation and maintenance personnel<sup>9</sup>. In conjunction with practical demonstration

---

programmes such as those mentioned above, training programmes would go a long way in improving the widespread accessibility of this technology, and in enhancing the marketplace for the PV industry.

#### **4.1.3 PV for Telecommunications**

PV is increasingly being used in telecommunications facilities in several IEA countries. In France, for example, PV is used to power some emergency telephones on motorways, and in the US PV is commonly used to power traffic signals and traffic warning signs (with battery or other back-up). PV offers a cost effective option for the military as it is often cheaper to use individual PV technologies to power remote telecommunications facilities than it is to link those sites to the electricity grid.

In Canada PV is increasingly used to provide electric power for water pumping and purification, for remote monitoring and control, and in remote residential areas and in various coast-guard lighting/beacon systems. PV is increasingly being used for telecommunications in Australia:

#### **Australia**

##### ***PV Telecommunications in Rural Areas***

*Telecom Australia (Telstra) has installed more than 2 MW of PV capacity in 8,000 telecommunication units whose capacity ranges from 100 Watts to 8 kW. PV is installed wherever it is economically viable to do so.*

*The Australian government awarded Telstra a grant of A\$1 million in the early 1980s to establish a PV test facility and four field test sites. Following the results from these facilities, Telstra embarked on an A\$30 million installation programme.*

##### ***Effect on the Market***

*Telstra's programme has given an important boost to the PV industry, as it provided a commercial demonstration of the technology's capabilities. PV is now increasingly being used in other market sectors throughout the country, including domestic power supply and water pumping in rural areas.<sup>8</sup>*

#### **4.2 Buildings: Key Issues**

The heating and lighting of buildings provide governments with numerous opportunities for choosing climate friendly technologies. While this fact may not of itself have been recognised by governments in the past, governments did target their buildings for the first tranche of energy savings when they began their efforts in energy conservation. In the US in 1992 buildings accounted for 36% of primary energy consumption and energy used in homes accounts for 20% of all air pollution emissions<sup>25</sup>. In the UK in 1990 nearly £20 billion was spent on energy used

---

in building (out of a total energy spend of £49 billion). Energy used in buildings also accounted for around half of the total UK CO<sub>2</sub> emissions<sup>1</sup>.

Since the oil crises of the 1970s many IEA/OECD member governments have periodically conducted energy saving programmes in their own buildings, largely to reduce their fuel bills, but also to demonstrate the potential of some new technologies. More recently the motivation for making savings in energy has increased with the raised awareness of the environmental impact of the consumption of fossil-fuels and the resulting emissions of greenhouse gases. For government-owned buildings the potential for adopting climate friendly technologies is great. A mixed set of options are available for reducing CO<sub>2</sub> emissions from buildings. These range from renewable energy technologies such as passive solar, solar thermal and photovoltaics which are very attractive options as they produce no greenhouse gas emissions themselves, to other renewable energy sources such as biomass. Biomass can be used in small and large scale combined heat and power schemes, which are particularly well suited to hospitals, prisons and other institutions which produce waste and need space heating and hot water.

In general terms, improvements to the energy efficiency of building heating systems tend to be best carried out at the same time as other improvements. For example while upgrading the thermal insulation of the building fabric and reducing air infiltration with draught proofing, a smaller boiler can often be installed which will lead to savings in capital costs and in fuel efficiencies. In Sweden 55 ventilation projects run under the Department of Energy Efficiency's collective agreements have resulted in savings of 11 Gwh, and improved efficiency of 37%.

Government purchasing programmes, or even isolated demonstration projects of the least deployed technologies, can offer a significant boost to the market prospects of these technologies. At the same time, savings in energy consumption and CO<sub>2</sub> emissions will be realised. For some of these technologies the existing market is so limited that any increase in their deployment will be a welcome boost to the industry. However, a one-off stimulus to the climate friendly technology industry is often limited in effect if the industry fails to consolidate its market position to enable it to be fully market competitive and self sustaining, without the need for additional government support.

There are a number of issues relating to the use of energy in buildings, which have an impact on governments' programmes for reducing fossil fuel energy use and CO<sub>2</sub> emissions from buildings. These are divided into separate sections below covering:

- the importance of *targets* for achieving reductions of CO<sub>2</sub> emissions from buildings;
- the role of *building regulations*, and the impact of *building energy labels and auditing schemes* on encouraging the deployment of climate friendly technologies;
- the value of *demonstration projects* for stimulating replication of successful technologies.

#### **4.2.1 Targets**

In the last few years, with growing concern over the impact of emissions on the global environment from energy use, targets for reducing emissions have been adopted. Targets are often adopted by industries and institutions in conjunction with voluntary agreements with

---

government to achieve improvements in energy use. Following the Rio Conference in 1992 where all IEA member states except Turkey signed the UN Framework Convention on Climate Change, many governments declared targets for the reduction in energy use in their own buildings. There are a number of benefits for the climate friendly technology industry both in governments declaring a *national* target for reduced national emissions of CO<sub>2</sub>, and in *locally* applied targets set by governments for their own facilities, industry or other institutions:

- ◆ targets raise the profile of the energy and environment issues; renewable energy and energy efficient technologies can expect to benefit from wider public awareness of their environmental advantages;
- ◆ targets require high-level commitment, in this case by governments. With government backing, policies to increase the use of climate friendly technologies will be pursued in order to meet the target by the specified date.

In a number of IEA countries governments have found that policies to meet targets are most successful when the target is linked to locally held objectives. Likewise when the target setting is decentralised institutions are encouraged to implement their own measures which can contribute to the overall government target. A flexible structure for meeting the target (as in voluntary agreements) allows innovative solutions, which a more structured approach might inhibit. Public review of a government's achievements has also been identified as an important factor in the success, or otherwise, of reaching a declared target. All these factors can be expected to work towards increasing deployment of climate friendly technologies, and, as part of a package of policy measures, could lead the industry to become market competitive and self sustaining.

Of the IEA countries, 5 have declared a target for reducing CO<sub>2</sub> emissions from their own buildings, some by a percentage reduction from a specified base year (Australia, Canada, UK) and others (US and Japan) as a reduction in energy use per square foot or unit of office space by a specified year. All of these 5 countries have allowed themselves at least 5 years to implement measures which will enable them to meet the target, and some have projected further savings which they intend to achieve by a later date.

#### **4.2.2 Building Regulations**

Building Regulations can play an important role in encouraging the deployment of climate friendly technologies in new buildings. By requiring building developers to consider alternative energy options governments raise awareness of the characteristics and benefits of the available technologies. Building regulations impose restrictions on developments at the *design stage*, which is important if renewable energy technologies such as passive solar are to make inroads into the building market. Passive solar technology is most effectively adopted at the design stage, because issues such as siting, design, building orientation, layout and landscaping of the site affect the successful application of this technique.

In addition, the heating and/or cooling technology which is chosen for the building is intended to last for 15-20 years in many cases, and so the energy performance of a building is decided at the development stage. Most IEA countries have revised their building regulations in recent years to reflect increasing concerns about CO<sub>2</sub> emissions from energy use in buildings. These *revised regulations* have improved the thermal efficiency of new buildings, but not all countries have used the regulations to introduce the building industry to the potential opportunities for utilising renewable energy technologies.

---

In many countries architects, engineers and technical personnel who instal and maintain heating systems, are among the most conservative, and do not seek out innovative options for new building developments. Building regulations could be used more specifically for encouraging more widespread adoption of renewable energy technologies in buildings, to overcome *the information barrier* in the building sector which currently inhibits the increased adoption of these technologies.

Some countries have also adopted *energy labelling schemes* e.g. in July 1995 the UK revised its building regulations to require all new dwellings and conversions in England and Wales to obtain a Standard Assessment Procedure (SAP) home energy rating. In Spain from 1996-99 a mandatory energy certificate will require public housing to use adequate thermal insulation and building materials according to the region; and in France energy labelling for new buildings started in 1996, with mandatory energy efficiency audits introduced for existing buildings, and energy efficiency studies for new ones. In Europe the EU SAVE Directive (93/76/EEC) has been adopted by some member states which assesses the energy consumption of residential buildings. In Belgium energy labelling of buildings is required in compliance with the EC Directive, and in Finland energy auditing of public and residential buildings is being developed, and a new certificate (based on the EU SAVE Directive) is being developed. Voluntary agreements with industry on energy audits are in effect in Austria, Belgium, France, Greece, Ireland and the UK.

In addition to its building regulations, the US has an energy code for the construction of new Federal buildings, and requires life cycle cost analyses in Federal building decisions. The US is also working with builders through its *Energy Star Homes Program* to provide homes which are at least 30% more efficient than the national Model Energy Code. This is equivalent to a Home Energy Rating System Five-Star Home, as in the national HERS guidelines. As builders and developers incorporate better building practices, the Energy Star Homes Program provides them with a brand name label and preferred mortgage financing to distinguish their products in the market place. Monthly energy savings are expected to exceed the small increase in mortgage repayments which accrue from the higher capital costs for energy saving products. Features included in Energy Star Homes are advanced insulation, tight construction, high-performance windows, and high-efficiency heating and cooling systems which are likely to become state-of-the-art in the near future. The success of the Energy Star Homes is expected to reduce annual carbon emissions by around 4 million metric tons by 2010.

#### **4.2.3 Demonstration Projects**

Demonstration schemes can also be very influential in encouraging the deployment of climate friendly technologies. One of the barriers to the deployment of renewable energy technologies particularly, is *risk*, as purchasers are unwilling to choose a technology about whose performance they know very little. Demonstration projects can reassure potential purchasers of the reliability and performance of the technologies, of the energy delivery, power availability, maintainability and potential costs and savings. In addition, for government purchasers the fact that the building is a government facility may encourage them to follow the example, as they will not feel that they are breaking new ground.

In Canada in addition to the *Federal Buildings Initiative* for reducing energy use in government buildings (see *section 6.1.1* on financing) the government launched the *C-2000 Program*. This is a demonstration programme promoting environmentally sound design and construction principles, with very demanding performance requirements in newly constructed offices. Energy consumption in C-2000 buildings has been set at no more than 50% of conventional buildings.

---

The buildings are intended to demonstrate to industry that high environmental and energy efficiency standards can be reached without excessive costs or difficulty. Results by 1997 showed that the C-2000 buildings were meeting the performance requirements at lower-than-expected capital cost increments. This success is largely attributed to the clear design guidelines which have been developed.

In the US the 1994 *Executive Order 12902 on Energy Efficiency and Water Conservation at Federal Facilities* encourages the designation of one major building as a showcase for energy or water efficiency. Under *Executive Order 12902* the US programme for improving the energy performance of its buildings encourages departments to switch to less-polluting energy sources such as natural gas or solar and other renewable energy sources, and to conduct audits and prioritisation surveys on all facilities. The majority of the Environmental Protection Agency's (EPA) facilities have been assessed for energy conservation opportunities, and high efficiency central plant components, solar hot water and water source heat pumps are being installed in three or more EPA facilities. The *Executive Order* addresses the market stimulation issue by encouraging the Administrator of General Services to develop procurement techniques, and contracts which will speed-up the deployment of energy efficient and renewable energy technologies in Federal facilities. It includes performance contracting, and designer/builder incentives such as award fees and life-cycle-value engineering.

In Germany the major government offices have moved from Bonn to Berlin, and as the moves were implemented green design and construction principles and practices have been put into place. The German Parliament initiated a list of environmental performance criteria which had to be met, including: no air conditioning, energy via combined heat and power generation, solar energy, ecologically sound construction materials, and transport efficiency.

In Finland, demonstration schemes are a key part of the government's strategy for encouraging the deployment of renewable energy technologies. In Australia, Telecom Australia (Telstra) has installed more than 2MW of PV capacity in 8,000 telecommunication units. Telstra's programme has given an important boost to the PV industry, as it provided a commercial demonstration of the technology's capabilities. PV is now increasingly being used in other market sectors throughout the country, including domestic power supply and water pumping in rural areas. In both Australia (in the year 2000) and in the US (1996) the Olympic Games sites have been developed as high profile venues for demonstrating renewable energy technologies in operation.

In Switzerland individual metering of heating and hot water consumption in new and existing buildings has been introduced, as this was not standard previously, and new water heaters, hot water and storage heating systems have to meet specified efficiency standards. In 1995 Switzerland introduced stringent recommendations for the use of electricity in buildings which it expects will save between 10% and 50% of electricity consumption for ventilation, air conditioning and lighting.

### **4.3 Target Technologies in Buildings**

In addition to the renewable energy technologies covered in *section 4.1*, there are a range of applications where governments could introduce climate friendly technologies to replace existing less efficient and higher energy consuming technologies.

In many countries governments are one of the largest single actors in the economy, and their decisions in relation to technology purchases can be very important for the technology market. This section examines the range of technologies available for use in government buildings,

---

which will reduce energy consumption and CO<sub>2</sub> emissions when they are deployed. The technologies examined are: passive solar design in buildings; high performance windows; combined heat and power systems; air conditioning systems; the use of heat pumps and electric motors; and the use of energy efficient lighting.

#### **4.3.1 Technological Opportunities - Passive Solar Design**

##### *Status of the Technology*

The use of renewable energy technology is a very important factor in reducing CO<sub>2</sub> emissions from energy use in buildings. Increased deployment of renewable energy technologies in new and refurbished government-owned buildings could provide demonstration buildings showing the technology in action, which is a very effective way of encouraging technology replication.

Passive solar technology enables a building, through its design, to trap all naturally available heat for use in space heating or cooling. The basic principles of passive solar design are:

- ◆ *heating*: orienting buildings and distributing glazing in the direction which allows the interior to be heated by the maximum available solar radiation, while at the same time minimising heat loss from shaded facades;
- ◆ *cooling*: allowing solar-heated air to assist natural convection within a building, thus reducing or obviating the need for mechanical ventilation and cooling systems<sup>7</sup>;
- ◆ *lighting*: arranging glazing to allow natural daylight to light the interior.

Heating and cooling applications impose different requirements on passive solar design. The passive solar cooling of buildings relies on creating temperature differences which drive air movement through the building by convection. The greatest space heating requirements arise during the coldest period of the year, when the availability of solar power is at its lowest. Hence, passive solar designs for space heating require large collection areas, usually involving substantial glazing, which may cause problems with overheating in the summer. High performance building materials can considerably improve performance, for example: transparent, and aerogel insulation, advanced glazing (films and coatings, gas-filled insulation, transparent aerogels, evacuated glazings, “intelligent” windows which respond to light, heat or electricity, control systems for window shading) and devices which improve the uniformity of daylight, such as light shelves, light pipes, mirrored louvres, holographic glazing and prismatic glazing.

##### *Deployment / Market Enhancement Activities*

As passive solar is incorporated largely into newly constructed buildings, the rate at which it is adopted will be slow. Nevertheless governments in some countries do, from time to time, construct new buildings for their departments, or agencies, and consideration of passive solar design could be a useful contribution to limiting the energy use of the building, and in acting as a demonstration of the technology in operation. By raising awareness of the opportunities for adopting this design technique governments can do much towards making passive solar a first consideration for any new building project. In addition to the construction of new government

---

buildings measures could be taken to encourage passive solar design in commercial, industrial and residential buildings. Measures such as educational programmes for architects, collaborative programmes with architectural firms, and a rewrite of the tax codes to favour new passive solar developments would all help encourage passive solar construction projects.

Appropriate *building and planning regulations* are important for allowing the wider use of passive solar in buildings. Several IEA countries, such as Australia, Austria, France, Ireland, Norway, New Zealand, Spain, Turkey and the UK have recently tightened their Building Regulations to improve the energy efficiency requirements for new buildings. Such measures will improve the insulation levels of new buildings and should also improve prospects for more widespread use of passive solar methods, although specific demonstration projects probably do more to alert interest in the technologies.

Some IEA member countries have constructed publicly owned buildings with passive solar as a key element of the design, but these are relatively few in number. In Japan a passive solar system was used in a school whose climatic conditions would, on the face of it, appear unfavourable as there is limited daylight in the winter. However, a very effective system was devised which vastly improved the internal comfort levels of the building and cut energy costs dramatically<sup>12</sup>.

In Australia angular selective skylights were installed in a classroom which minimised the glare from the sun while at the same time providing natural light. Because of the extreme glare from the sun schools in Australia usually have heavy exterior shading which reduces the amount of light in the classrooms, thus electric lighting is used. The skylight was developed using a light deflecting material, known as a laser cut panel, which was formed into a pyramid in the skylight. These laser cut panels reject high-elevation sunlight but increase the penetration of low-elevation light, thus replacing the electric lighting which was previously used in the classrooms. These skylights led to savings of 8kWh of electric light per day, thus 8kg of CO<sub>2</sub> per day per classroom, at a cost of A\$3.2 for four skylights per classroom.

In Switzerland solar collectors have been installed in large apartment blocks. In the United Kingdom 500 houses and 100 non-domestic buildings were constructed following passive solar designs, which achieved estimated savings of around 1.5 GWh/year<sup>2</sup>. One such house was built in the city of Leicester to be a demonstration model, and included wall insulation, under-floor heating, loft insulation, and solar panels, and another *Energy Friendly Home* in Havering, UK, required an investment of £8,000 which halved the energy bill from £970 to £430 per year<sup>21</sup>.

In addition the US, as part of its greening of government strategy is installing solar hot water into three of the Environmental Protection Agency's facilities.

---

---

The **US** has its **Exemplary Buildings Program** which primarily focuses on residential buildings, but has extensive public building participation.

The **Objectives** of the Programme are to :

- create validated design and analysis tools for passive solar technologies;
- test and demonstrate the technologies;
- monitor and test data to enhance the design and analysis tools.

The Program helps building designers with energy simulations, and helps designers, owners, and occupants to monitor their building's energy use. The Programme publishes case studies, technical reports, articles and presentations to disseminate information about passive solar design.

An Exemplary Building meets at least one of the following criteria:

- solar technologies satisfy at least 75% of the building's energy demand;
- energy consumption is 70% less than an equivalent building which meets Federal Energy Code 10CFR435 or the Home Energy Rating System reference building.
- solar technologies reduce energy consumption by at least 30% for retrofit and renovation projects.

### 4.3.2 Technological Opportunities - Windows

#### *Status of the Technology*

Glazing is generally regarded as the point from which much of a building's energy might be lost. To combat heat loss, occupants will use additional energy for heating the building. High efficiency glazing in well fitting frames are climate friendly technologies by virtue of their contribution to minimising heat loss, maintaining the interior warmth of a building, reducing the need for increased heating and so reducing emissions of greenhouse gases from the energy source.

The thermal performance of windows is measured as a u-value. The lower the u-value (measured as  $\text{Btu/hr}\times\text{ft}^2\times\text{°F}$ ), the better the thermal performance and the lower the level of heat loss. There are a range of window options available to improve their performance, from double and triple glazing, to evacuated glazing, and a range of transparent insulation materials (although some of these have poor light penetration). If properly installed all of these windows should lead to a reduction in condensation and draughts, and should improve sound insulation compared with single glazing, depending on the size of the gap between the glazing sheets. The thermal performance of the window frame is also critically important for achieving maximum benefits. With a badly sealed window frame draughts will still penetrate, and however good the glazing, the overall performance will be significantly reduced. Where the frame is well fitting, durable and a reliable material, the u-value of the frame can be higher than that of the glazing.

---

Poorly designed glazing can lead to excessive heat gain inside the building from the sun in the summer. To counteract this, energy is often used in a building to operate mechanical ventilation, either with or without additional cooling. Heat-reflecting or absorbing glass and solar window films can be effective in deflecting excessive heat, and reducing the need for mechanical ventilation, but these technologies reduce light penetration, causing more artificial lighting to be used in offices, thus increasing the use of electricity. Various types of chromogenic glazing have been developed and some are controlled by electrical signals which allow significant cooling in the summer while not reducing the warmth of the winter sun.

### *Deployment / Market Deployment*

The potential for improving a building's energy performance by installing high efficiency glass is not fully understood in many IEA/OECD countries, and therefore the advanced technologies are not deployed as widely as they could be. Government purchasers are in a prime position to make use of such technologies when property refurbishments are being carried out. In conjunction with more widespread dissemination of information about high performance windows, governments could provide the necessary stimulus for this sector of the market, and could demonstrate the advantages of the technology to purchasers in the commercial and industrial sectors.

In Finland the government used a very effective mechanism for raising awareness about a technology while at the same time improving its technical potential: by launching a competition. The aim of the competition was to accelerate the market penetration of new window technologies in buildings. The current u-value required of new windows in Finland is 2.1 W/m<sup>2</sup>K, and as a result of the competition a U-value of 1.4 W/m<sup>2</sup>K was achieved. At the same time high efficiency windows were manufactured at an affordable market price. The competition was focussed so that windows were developed for both new and existing buildings. An important element of the competitive process was, of course, the benefit (prize) which would be awarded to the winners. In this case a buyer group of 60 home owners, schools and public buildings joined forces to guarantee that they would purchase the winning windows. The government subsidised some of the costs of the windows by exempting from tax 15% of the cost.

The competition has led to considerable market stimulation for the high performance windows. The buildings which installed the winning products (4 different window types) have made data available about the windows' performance, and their contribution to saving energy in buildings. With continued information dissemination it is expected that this improvement in the market penetration of these high performance windows will increase, and that these technologies will be able to establish themselves with a secure and competitive market share.

In Sweden a competition (see box) was launched with the aim of lowering the costs of technically advanced windows. A subsidy from the Swedish government attracted companies to join the consortium. This is one example where when the price of the technology is set at a reasonable level for the market, the subsidy need not necessarily be in place for longer than a couple of years for the market to be sufficiently influenced, and for the product to become competitively established.

---

## **Sweden**

### **Competition to develop high performance windows**

*Cold downdraughts from windows are caused by the contact of indoor air with the inner pane, thus causing the air to sink towards the floor, which is experienced as a draught. Radiators are therefore installed underneath windows to counteract this effect. In 1991 Sweden's Energy Administration (NUTEK) announced a competition for the development of a window whose energy loss would be less than half that from a triple glazed window. Other performance requirements were imposed relating to noise reduction, low weight, and maximum admission of daylight.*

*The competition was won jointly by a Swedish and a Norwegian company. In addition to the prize premiums, market stimulation was provided by a subsidy paid to the purchasers of the first 2,500 m<sup>2</sup> of windows of SEK 500/m<sup>2</sup>.*

*While the cost of the windows was higher than conventional windows, the heating system in a housing association building in Västerås was changed. Radiators were replaced by convector heaters in the hall and bathroom of each apartment. The building's heating energy requirements were reduced from 5,900 MWh/year to 3,300 MWh/year.*

#### **Effect on the Market**

*The competition persuaded nine window manufacturers to invest time and money on developing high-performance windows, and alerted the rest of the industry to the technical possibilities and availability of the technology<sup>19</sup>.*

In the US window labels awarded by the National Fenestration Ratings Council have proved very successful in providing information to consumers. These labels classify the manufacturer's name, the U-value of the window, the solar heat gain (measuring the sun-shielding properties, and the products ability to absorb or reflect solar heat), visible light transmittance, the designation by the Independent Certification Agency and a product description.

### **4.3.3 Technological Opportunities - Combined Heat and Power (CHP) / Cogeneration**

#### *Status of the Technology*

CHP refers to the simultaneous production (cogeneration) and exploitation of high quality energy (mechanical and/or electrical) and low-grade energy (thermal) from the same energy source. One of the most important aspects of CHP is its great economy of fuel-use compared to the usual combination of boiler plant for heating, and conventional thermal generation for electricity. CHP can be considered as an electrical generator incorporating a heat recovery system, and the generator can be driven by a number of prime movers running on a variety of fuels<sup>1</sup>. The different prime movers are generally available in sizes ranging from those suitable for small building units which will utilise all the energy, to those for district heating systems where

---

electricity will be exported to the grid. Conventional electricity generation in the UK, for example, has a conversion efficiency of approximately 35%, thus 65% of the primary energy input is rejected as low-grade heat. CHP utilises the heat, providing overall efficiency of 65-85%, and if it is used locally there will be negligible transmission and distribution losses. CHP is most effective when it is installed at the stage of a site's construction, and later conversions can significantly reduce the plant's efficiency. In addition the distance between the generation plant and the buildings receiving the heat and power, is also critical to its efficiency. Pipe insulation is essential for minimising heat losses. If the CHP plant is at some distance from the buildings it is serving, its efficiency can be little better than conventional electricity generation.

If the CHP plant is sited close to the buildings it is serving, there are significant environmental benefits from using CHP rather than conventional sources of heat and electricity. This is both in terms of energy conservation and reduced emissions of noxious and greenhouse gases. CO<sub>2</sub> emissions can be reduced by around 40% through the increased efficiency, and if the supply fuel is changed from coal to gas or biomass, the CO<sub>2</sub> emission reductions can be as high as 55%<sup>2</sup>. As CO<sub>2</sub> is the major greenhouse gas, an energy source which reduces emissions (such as CHP) can be considered a climate friendly technology.

#### *Deployment/Market Enhancement*

Seventy five percent of the cost of a *district heating CHP* system is accounted for by the construction of the network of piping which is necessary to distribute the heat and electricity, and only 25% is the cost of the fuel. CHP schemes offer a highly efficient technological option for providing heat and electricity to single buildings or networks of buildings, such as on hospital or further education sites. The choice of fuel used in a CHP system will depend on availability and relative costs. CHP can be either a large scale district heating system in a town or city, or it can be a small scale local system for industrial and commercial sites, or in public sector building and campuses.

Energy recovery from **organic waste** can be a very efficient source of fuel for providing power in public sector buildings such as hospitals, college campuses, military bases and other residential institutions which create a significant amount of waste, and require a means of disposing of it. By operating a CHP plant the heat recovery from the combustion will provide space heating, hot water and electricity for the buildings on the site while at the same time the waste will have been effectively disposed of.

In countries such as Finland, Austria and Sweden energy recovery from the forestry industry's **timber residues** is common, and Sweden provides financial support for installations of small boilers in buildings which are linked to biofuel-fired district heating systems.

CHP is found commonly in industrial applications in most IEA/OECD countries, but is found as district heating in towns most commonly in Austria, Denmark, Finland, Sweden, Switzerland and Germany. In some IEA/OECD countries the deployment of CHP is inhibited by unfavourable price structuring which creates barriers to the take-up of the technology. For example, in some countries sales of electricity to the grid are not based on full avoided costs, and are therefore unfavourable and in other countries tariffs for purchase of complementary power from the grid may not be the same for CHP operators as for other energy consumers. In addition in some countries restrictions are placed on cogenerators in relation to the eligible market for their electricity<sup>18</sup>. Until barriers such as these are lifted CHP will be unable to expand in these countries as it will not be sufficiently attractive for wide scale application. These considerations

---

are important barriers to the take-up of climate friendly technologies and Member countries would be advised to examine their price structure to identify such barriers to deployment.

However, a number of OECD/IEA countries actively promote the use of CHP. In the US, for example, utilities are obliged to purchase power from CHP schemes at the “avoided cost” rate. In Austria subsidies are provided to encourage the development of small district heating schemes, and Denmark offers subsidies of up to 50% of the installation costs of a CHP plant using biomass as the fuel. Denmark also offers grants to encourage the conversion of district systems to biomass or biogas CHP. Some municipalities (Elsinore and surrounds) have taken advantage of the support and converted existing waste incineration plants, to CHP plants offering district heating and electricity. Japan also offers subsidies for waste-generated CHP district heating and cooling systems. In the Netherlands CHP district heating is exempt from carbon and energy taxes, and in Sweden fuel for a CHP plant is taxed at 50% of the energy tax rate, and investment grants are offered up to 25-35% of the capital costs of biofuel CHP installations.

In addition to economic incentives to enhance the market for CHP information dissemination is necessary to encourage its wider application. In the UK, for example, the “Best Practice” information dissemination programme which targets industry and commerce emphasises the benefits of CHP in terms of the fuel efficiency, environmental, and cost benefits which it offers.

#### **4.3.4 Technological Opportunities - Boilers and Heating Systems**

##### *Status of the Technology*

Space and water heating dominate building energy use. The largest energy savings in buildings may be made from improvements in the energy efficiency of a boiler and heating system. Significant opportunities exist, therefore, for the deployment of technologies which will improve a buildings energy use and reduce greenhouse gas emissions. The main sources of space heating are currently boilers, air heaters, radiant heaters, electrical on-peak and storage heaters and room heaters. The more recent technologies include; condensing boilers, gas, oil, and air heaters, heat pumps, micro CHP, and solar thermal heating systems. All of these sources (except for air heaters) are also used for the provision of hot water either as part of the output of a single appliance, or as a separate system<sup>1</sup>.

Condensing boilers increase the frequency of condensing operation, which improves the efficiency of the boiler. For conventional gas boilers the average system efficiency falls off as the load decreases, from 70-75% to values of 65% or below for loads below 25% of the design maximum. Boilers designed to condense water vapour in the flue gases have a higher inherent efficiency, with peak load efficiencies of around 90%, which is as much as 30% higher than older conventional boilers, and 10% higher than modern conventional boilers<sup>1</sup>. Careful system monitoring and maintenance must also be carried out on fuel efficient technologies, as well as insulation to the hot water storage vessel and hot water pipework to achieve optimum results. Inefficiencies will swiftly reduce the effectiveness of a technology in reducing greenhouse gas emissions, leaving the technology’s definition as a climate-friendly one, in doubt.

Decentralisation of the heating and hot water system can avoid many system inefficiencies, as can a combination of technologies in dispersed buildings on a single site. For example a site’s requirements may be met as follows; part of the base load may be supplied by a CHP plant, sized to meet the electrical demand, with the remaining base load met by a condensing boiler.

---

The peak seasonal demand could be met by a conventional high efficiency boiler. The advantage of this system for the technology market would be that the purchasing choices would be more widely spread, benefitting more manufacturers.

### *Deployment / Market Enhancement*

The potential for improving the performance of boilers and heating systems in government properties in IEA member countries is enormous. The energy and CO<sub>2</sub> emissions savings which could be achieved by retrofitting or replacing inefficient technologies could make a very significant contribution to national goals for limiting CO<sub>2</sub> emissions. In addition central and local government action in upgrading their boilers and heating systems would, by virtue of the large numbers of appliances in operation, have an important impact on this branch of the technology industry. Given the number of appliances which would be involved in any retrofit or replacement programme, these would most likely be done in stages, so spreading the costs for governments over a number of years, and providing the industry with a steady demand for new energy efficient products. Governments who opt for renewable energy technologies as part of such a programme could provide a similar stimulus to the renewable energy technology industry. Before governments dismiss such a proposition as too costly, the financing mechanisms outlined in *section 5.1* could provide ideas for ways of sharing the financial burden with other interested parties. In Canada the *Federal Industrial Boiler Programme* has been launched (under its *FBI*) to retrofit old boilers, or instal new boilers which are more efficient, and reduce emissions of Nox (see *section 5.1.1*). Canada is funding its programme under a mechanism of energy performance contracting (3rd party financing) to involve private funding in the capital costs of the technology improvement programme.

In recognising the impact which boilers and heating systems have on the energy efficiency of a building and the level of CO<sub>2</sub> emissions, efforts have been made in many IEA/OECD countries to improve standards and regulations relating to these appliances. In the US the majority of EPA's facilities have been assessed for energy conservation opportunities and high efficiency central plant components will be installed in at least one of their sites.

In Switzerland individual metering of heating and hot water consumption in new and existing buildings has been introduced in contrast to traditional arrangements where metering was centralized, which discouraged individual efforts to reduce energy consumption. New water heaters, hot water and storage heating systems now have to meet efficiency standards in Switzerland. In Germany the 1994 *Ordinance on Heating Appliances* tightened the regulations on heating appliances, requiring them to be more efficient with improved insulation, and required the retrofitting and modernisation of old installations. In Austria and Belgium the EU directive 93/76/EEC on minimum energy efficiency standards for hot water devices and boilers has been adopted nationally and Regional Ministers for Energy launched campaigns on energy labelling for boilers, to increase awareness of the advantages of the appliances and stimulate market interest in them. In the Netherlands an energy certificate for hot water boilers is in force, and in France regional and national demand-side management (DSM) pilot programmes are promoting energy efficiency audits and efficient industrial motors.

One of the barriers to the deployment of technologies such as high efficiency condensing boilers (apart from the higher capital cost) is the lack of information about these technologies among installation and maintenance personnel. If central and local authorities initiated programmes of adopting such technologies, they would need to train their personnel to maintain the appliances at peak efficiency. The "snow-ball" effect of training and information can be a significant factor in encouraging technology deployment. As technical personnel become familiar with a

---

technology they are likely to disseminate information about it to other contacts thus make it more familiar as a viable option to other purchasers. This could lead to the technologies being more readily available in the boiler distribution network, and help make the purchase and use of such technologies the norm both within and outside the bounds of governments' own purchasing activities.

#### **4.3.5 Technological Opportunity - Air Conditioning**

##### *Status of the Technology*

Air conditioning can be a major source of energy consumption. Where air conditioning is required, there are three types of system each with many variations: centralized, where all heating and cooling is carried out in a central plant room, and conveyed to the rooms by duct work. partially centralized air/water, where centrally cooled or heated air is further heated or cooled at entry to the rooms, and decentralised where all operations are performed locally. Variations and combinations of these systems can be used in any application, and choices exist for each of the component parts. An alternative to full air conditioning is the "mixed mode" approach where some level of cooling is provided together with provision for natural ventilation. Different systems can then be operated at different times as internal and external loads change, and unnecessary energy use is avoided<sup>1</sup>.

An energy efficient air conditioning system would be one which fulfilled the following criteria:

- achieved just the required level of conditioning, dehumidification and condensate removal (an important environmental consideration in dry regions where moisture capture and reuse would be difficult) and no more;
- had large ducts in a compact distribution system with low velocity air movement allowing low energy use by fans;
- used variable speed compressors, fans and pumps; used free cooling where possible; reclaimed the most heat possible;
- avoided simultaneous heating and cooling;
- used the most efficient source of cooling with thermal storage as appropriate;
- was effectively maintained;
- had good controls which allowed the system to shut down when not needed<sup>1</sup>.

Over the last decade, district cooling systems have been introduced in major European cities such as Paris, Stockholm, Lyon and London and is prevalent in Japan. Such systems allow the user to link into an existing loop, which is more efficient than small scale individual building systems. District cooling systems allow greater flexibility in terms of capacity, lower operating costs, and provide the user with fully trained maintenance personnel managing the central plant. Modern sites use the cheap electricity of off-peak hours to store cooling for the following hours, days or weeks. During peak demand chillers in combination with ice stored in large storage tanks deliver chilled water to the distribution grid. The chillers used to chill water during the daytime then operate at night to make ice when electricity prices are lowest.<sup>15</sup>

---

### *Deployment / Market Enhancement*

Air conditioning is increasingly being used in commercial buildings, including government properties. Although governments in most IEA countries are probably not the major purchasers of new commercial premises, nevertheless governments do periodically require new premises, or require major refurbishments of existing buildings. In these cases the choices of whether or not to have air conditioning, and the potential for avoiding inefficiencies and utilising non-mechanical cooling sources should be carefully examined at the earliest stages.

In some countries where the climate does not demand sealed buildings for year round temperate controls, alternatives to air conditioning could be installed in buildings to improve the quality of the interior temperature during the hot summer months. These could involve the use of natural ventilation, and for cooling purposes, the use of high performance windows or exterior shading to limit the levels of the interior heat. In addition more widespread concentration by government buildings operators, and purchasers when the need for new equipment arises, on the technological possibilities for improvements in the operation of air conditioning units (as in the Australia case -see box), could make a clear contribution to governments' efforts in reducing national CO<sub>2</sub> emissions.

In the UK in 1990 around 55 million square metres of floor space, (and 50% of new office buildings) were air conditioned, and it is estimated that improvements in efficiency from what are now typical levels to good practice levels, would result in a reduction in energy use of about 7PJ/y with associated savings in greenhouse gas emissions<sup>1</sup>.

In Switzerland stringent recommendations for the use of electricity in buildings came into force in 1995, and is expected to save 30-50% of electricity consumption for air conditioning.

There is a clear need for the development, deployment and dissemination of information on the technological possibilities of improving energy efficiency in air conditioning systems. Significant improvements in the energy efficiency performance of air conditioning systems can be achieved by controls on the fan speeds of the air-handling units (such as in the Australian hospital example below). New air conditioning technology, such as scroll (screw-type) compressors, are now readily available in the US and these operate in 2-speed or variable speed mode in response to the air conditioning load demand. The efficiency of air conditioning systems will be slightly affected by the switch from ozone depleting to ozone friendly refrigerants. Installers and operators will need to be trained in the use of these newer refrigerants.

Governments as managers of a wide variety of buildings with different cooling requirements could themselves support the technological improvements in efficiency and promote the dissemination of information about the system developments. As has been found with other technologies, appropriate training for system operators and maintenance staff is essential, and government support for training programmes in conjunction with technology promotion programmes go a long way in giving the market the stimulation it needs to improve take-up of the high efficiency technologies on a sustained basis.

---

### **Australia**

*Variable frequency drives were installed in a hospital system on each of eight supply and return air fan motors, which had electrical ratings ranging from 7.5 kW to 45 kW. A number of other modifications were made to secure the correct controls and balances.*

*Since the variable fan speeds were introduced in 1994, monitoring has shown that average reduction in fan speed has ranged from 34% to 40%. The total cost of the project was A\$119,932 and direct electricity cost savings have been estimated at A\$129,000 per annum, and diesel fuel cost savings as a result of eliminating reheat was estimated at A\$181,000 per annum<sup>12</sup>.*

#### **4.3.6 Technological Opportunity - Heat Pumps**

##### *Status of the Technology*

The use of heat pumps in the commercial sector is, in IEA/OECD member countries, best established in the US and Japan, where about 12% of all the heat demand in commercial buildings is met by heat pumps. In terms of energy value, the electricity consumed by a heat pump is typically about 25% of the energy consumption of fossil-fuel equipment<sup>11</sup>. In appropriate climates heat pumps can be attractive in buildings such as those owned by central and local governments because they often have a cooling requirement in the summer and need heating in the winter. Reversible pumps are designed to meet these needs. Large premises enable a variety of technologies to be used, which reduces the price per installed kW.

The main barrier to the deployment of heat pumps is probably their initial capital cost which can be between 1.5 and 5 times higher than a gas or oil fired heater of the same capacity, and the price differential for electric resistance heating is even greater. Today's low oil and gas prices make the differential between heat pumps and fossil fuel systems even more unfavourable. However if a cooling system is required the cost differential is smaller and in new buildings the total cost of air conditioning and space and water heating will be considered, which makes heat pumps more attractive<sup>10,11</sup>.

Recent developments in the application of the technology may widen its appeal. For example, where heat pumps are combined with thermal storage, a warm water well is used as a heat source for an electric heat pump, and the warm water is transferred to a cold well (at 8°C), the water is then stored until the building requires cooling when it is used as the cooling source. The method is operated in reverse during the summer so that the warm well (at 17-20°C) is then able to meet the winter warming needs.

In the context of governments' needs, office buildings have a high level of office automation and modern buildings are generally well insulated, and both of these contribute to the need for space cooling in the summer, even in relatively cool countries. Reversible heat pumps are well placed to provide year round comfort as they provide heating for the winter and cooling for the summer. The added advantage of their high efficiency and their climate friendly status makes heat pumps an attractive option for governments' programmes to limit CO<sub>2</sub> emissions.

---

### *Deployment / Market Enhancement*

Some IEA/OECD member countries have fairly widespread deployment of heat pumps. In Japan, for example, around 70% of the total heating and cooling requirements of newly-built commercial buildings are met by heat pumps.

The main driving force for the large market for heat pumps in Japan and the US is the cooling demand, as most pumps sold are reversible systems. Other relatively hot countries such as Australia, Greece, Italy and Spain also have strong heat pump markets, for the same reason.

The market in northern and central Europe is fairly limited in many countries because the traditional heat distribution systems are high-temperature wet systems which are not suitable for use with heat pumps. Considerable effort is needed by the industry to overcome these traditions and encourage designers to install the low temperature systems favoured by heat pumps such as underfloor or forced-air heating systems. Information dissemination on a wide scale is needed to raise awareness of the environmental and energy benefits of this technology and member governments could help in this by installing heat pump systems in their buildings and making them high profile demonstration projects of how the technology works in practice.

The market for heat pumps in Germany was stimulated by the electric utility's (RWE) scheme which offered special tariffs, guarantees, and low interest loans for purchasing the technology, and helped the customer to arrange installation. This support was only given for heat pumps meeting minimum standards for seasonal performance factor (SPF) and safety, and when equipment installers and manufacturers meet a set of guidelines<sup>11</sup>.

Encouragement for heat pumps in Scandinavia has centred around competitions which have been held for residential heat pump designs, where the winners have received substantial subsidies to stimulate sales of their new equipment. In Norway 5% of all heat demand from buildings and industry is met by heat pumps, and because of their dual need for both heating and cooling, and for constant hot water, large heat pumps are commonly deployed in hospitals, office blocks, residential care homes, schools, and sports centres with swimming pools<sup>11</sup>. Sales in Norway have continued to be fairly steady largely as a result of a six year government supported information campaign plus a subsidy. Between 1989 and 1992 training courses were run for consultants, energy advisors and installers ranging from a basic introduction to heat pumps to detailed training on installation and fault finding. The subsidy for purchases of heat pumps started in 1992 at 40% of the price, was lowered to 20% in 1993 and was removed in 1994. The subsidy, combined with the information and training campaign encouraged the take-up of the technology, and allowed the market for heat pumps to establish itself competitively and become self sustaining.

Switzerland has provided support for R&D programmes, provided incentives for Pilot and Demonstration Projects, and marketing activities such as information dissemination, training programmes, basic marketing and lobbying.

In the Netherlands however, despite the availability of a 25% subsidy, readily available, low-cost gas boilers are the preferred option in most buildings. The market for heat pumps is small, at only around 100 units per annum and mostly in agricultural situations, thus the capital costs of the units remain much higher than could be achieved by larger sales. Problems with poor performance of some systems in the 1980s led to mistrust of the technology. This is a key hurdle in developing the heat pump market, as installers and maintenance staff who are inadequately trained will be unable to operate the technology at its optimum performance level and a few bad experiences can lead the market to collapse<sup>11</sup>. However the Dutch Heat Pump

---

Action Programme was launched in 1995 aiming to increase deployment in homes to 24,000 systems by the year 2000, establish 20 collective space heating systems for domestic houses, and 100,000 hot water systems by the same year.

In the US sales in heat pumps are strong. Of the 2,700 electric utilities in the US at least 100 offer rebate programmes to promote the use of heat pumps, and increasingly ground-coupled (“geothermal”) heat pump technology is being supported by rebate schemes. A consortium of utilities is aiming to increase annual sales of geothermal heat pumps from 40,000 (1995) to 400,000 by the year 2000, and the Consortium of Energy Efficiency is complementing this effort by its *Golden Carrot* initiative:

### **United States**

#### **“Golden Carrot” Initiative on Ground-Source Heat Pumps**

*Led by the Consortium for Energy Efficiency (CEE), whose members include utilities, government agencies, research institutions and public interest groups, the “Golden Carrot” initiative is a market-pull strategy for these technologies.*

*The CEE has established efficiency specifications on heating and cooling, with three tiers of standards. Utilities which participate in the scheme must offer their support for technologies which meet the lowest specification, and must offer financial incentives (loans, leasing, site-based tariffs or rebates and consumer rebates) for those which meet the higher standards. Credits are awarded for technologies which have variable speed operation and which heat water. They must offer basic advice on the correct system sizing for the property, and improvements in the building itself which can reduce the heating and cooling loads.*

#### **Effect on the Market**

*Other utility programmes such as this one have sometimes failed because they were not coordinated across the country, which resulted in a proliferation of different efficiency specifications, thus making it difficult for manufacturers to respond to the programmes. With the CEE lead, manufacturers have been given clear guidance of the energy performance requirements of their products.*

As mentioned above, in recent years a number of financial incentive schemes for heat-pumps have been introduced by utilities and governments from around the IEA/OECD region, which generally last a year or two. If the right level of support is set and if it is combined with a wide scale information campaign, such short term schemes can provide enough incentive for the market to establish itself and for it to become self sustaining. Incentives give manufacturers, installers and maintenance companies the confidence to enter the heat pump market. After the incentive is removed these companies will tend to stay in what has become a mature market, as more consumers are aware of the technology. Financial incentive schemes work best when they are coupled to stringent quality and performance requirements, which ensure that the technology will operate well if it is installed, operated and maintained properly. As with all new technologies governments who adopt this technology need to ensure that their maintenance staff are adequately trained to allow the equipment to operate at maximum potential.

---

### 4.3.7 Technological Opportunity - Electric Motors

#### *Status of the Technology*

Motive power is by far the largest user of electricity in the industrial sectors of OECD countries and is estimated to consume half of all electrical energy produced in industrialised countries for reconversion to mechanical forms of energy (and around 70% of industry's electricity use<sup>1</sup>). In the US alone 40 million electric motors are in operation, and industry spends over \$30 billion annually on electricity to drive the motors. The main applications of electric motors are: pumping, fans, compressors (compressed air supply and refrigeration), conveyer systems, and machinery drives.

Most electrical drives are of the constant speed type, but there are a number of technologies which improve the efficiency of the drives as follows:

- ◆ Variable speed drives are only applicable to AC motors and come in three types: mechanical and hydraulic coupling ( which preceded electronic systems and are largely ineffective for improving energy efficiency), fixed frequency variable voltage drives (inefficient at low speeds) and variable frequency invertors (efficient and easy to retrofit). For pumping and fan operations these can provide savings up to 35% of energy use, and for compressors and refrigeration up to 23%. Both these savings are likely to be achieved in larger scale applications.
- ◆ High efficiency motors are designed with energy efficiency in mind, and are up to 40% more expensive than a standard motor. Improvements to the range of high efficiency motors are being developed. Energy savings of around 4% are typical with this equipment.
- ◆ Soft starters are largely used to protect equipment from high voltage at the starting current, although soft starters with energy saving (optimisers) offer better efficiencies particularly if motors are lightly loaded or oversized for their normal duty. Automatic switch-off devices can be used with soft starters which would provide further opportunities for energy saving when the motor is not in operation. Energy savings of up to 7% are typical for around half of the machinery in use<sup>1</sup>.

In addition to these measures other factors influence the efficiency of motors in operation, such as optimal motor sizing, better repair and maintenance practices, use of induction motors, elimination of past rewind damage, correction of previous over sizing, use of DC and synchronous motors and drive-train lubrication and maintenance. All these factors contribute to a motor's ability to limit CO<sub>2</sub> emissions during its operation.

#### *Deployment / Market Enhancement*

Given the vast numbers of motors in operation worldwide, in a wide variety of applications, the potential for improving their performance is equally vast. With leadership from governments in a broad range of applications, industrial and commercial usage could also move towards the high efficiency products. Such a boost in sales of high efficiency motors would be enormously important to this technology industry.

---

Electric motors technologies are basically similar throughout IEA countries but patterns in electricity end use from motors differ widely between countries, because of the factors which influence demand, such as climate, prices, regulations and user behaviour. There are a number of barriers to the uptake of the technologies. For example, the decision to install a modification to a motor will usually be taken by someone with expertise in electrical matters, and often the operators of the machinery do not have this level of expertise and therefore see the effort of making assessments of the energy use and potential savings as a low priority. Even after the products have been bought, there can often be inadequate after-sales advice about the installation and operation of the technology, which can mean that it will not be properly used. Cost can be a barrier to further interest in this technology, and so can the complexity of installation. Although the financial return from investing in efficiency measures can offer paybacks of under two years, on peripheral equipment such as a motor, this return can be insufficient to motivate investment. For smaller units (below 10 kW capacity) the costs per unit of capacity of electronic controllers for variable speed drives are relatively high compared to larger units, and even though large savings can be made in some applications, very few small motors are fitted with variable speed drives.

A number of IEA countries have programmes to improve the efficiency of electric motors. In the US the scope for achieving improvements in the energy performance of electric motors has been recognised and a major programme for improving the energy efficiency of motors was launched in the Department of Energy's *Motor Challenge* programme. The programme is targeted to help industry capture 5 billion kilowatt hours per year of electricity savings by the year 2000 (translated into \$250 million in energy cost savings and 1.2 million metric tonnes of carbon equivalent). The *Motor Challenge* programme is an industry and government partnership which focusses on informing users of the technical possibilities of, and developing the market pull for, the technologies. It focusses on practical and unbiased advice, for example, on the implementation of management systems within thousands of companies which will help to create behavioural changes in the purchase and use of motors; the programme also provides an information clearinghouse which also includes case histories, and provides practical tools for calculating the costs and benefits of the energy efficiency technologies to particular applications.

In Canada federal *Energy Efficiency Regulations* for electric motors came into effect in 1995, which specify energy efficiency standards. These are currently being reviewed and may be tightened to the same level as the US, and Finland is currently leading a technology procurement project to form a buyer group for new, very efficient electric motors.

#### **4.3.8 Technological Opportunities - Lighting**

##### *Status of the Technology*

Lighting is a major energy consumer in buildings, and there is great potential for making energy savings and reducing CO<sub>2</sub> emissions. Many IEA/OECD countries have made improvement in their energy consumption from lighting by replacing inefficient lamps with high efficiency alternatives. Nevertheless there have continued to be improvements in the lamps on the market and governments could be advised to re-examine their lighting systems to identify further energy savings. In many cases, where efficient lamps have been installed there is still room for improvements in energy consumption with the use of motion sensors, time switches and dimmers.

---

Several types of lighting appliances are available and widely marketed:

- incandescent lamps;
- tungsten halogen lamps (which offer a 30-35% saving in energy over the incandescent);
- linear fluorescent lamps (which produce three to five times as much light and much less heat than incandescents), these require a ballast, which raises the initial cost;
- compact fluorescents which are energy efficient fluorescents but much smaller than standard fluorescents and consuming significantly less electricity than tungsten lamps for the same or slightly lower output. Compact fluorescents are available in lower wattages (7 to 26W) and offer savings of up to 80% when used to replace incandescents. Their average life expectancy is six times that of the incandescent;
- induction lamps have a considerably longer life than fluorescents but are very expensive and require a purpose-made fitting;
- high intensity discharge lamps are more efficient than tungsten halogen lamps. Sodium filled lamps are the most efficient option;
- ballasts which provide starting and operating voltage to discharge lamps and limit the amount of current during the operation of the lamp. Electronic ballasts have improved the energy efficiency of fluorescents by around 20%;
- luminaires which can contribute further to lamp efficiencies, but problems with glare have inhibited their deployment<sup>1</sup>.

Fluorescents do have other negative environmental impacts, however, as the mercury in the lamps requires proper disposal to avoid contamination.

In addition to the choice of the lamp, the use of lighting control systems can make a significant impact on the energy use of a building's lighting system. These systems range from simple manual switches and dimmer controls to automatic control systems based on time control, occupancy linking or photoelectric daylight linking. Such controls are not suitable for use with high pressure sodium lamps which require some minutes to warm up before reaching full light output. Maintenance of the lamps (cleaning) is also an important factor in achieving consistent performance, as the assessment of the lighting needs of a building. are made on the basis of the light output, thus the number of installations may be increased (and the energy use) if poorly maintained lamps are emitting insufficient light.

### *Deployment / Market Enhancement*

Energy efficient lighting technology is generally well demonstrated. In many cases the more energy efficient equipment has a higher initial cost, and this is often the reason why these lamps are not installed. Governments in their role as building managers have considerable scope for retrofitting their buildings to make improvements to their energy use and as landlords in the domestic housing sector they could make considerable improvements to the level of energy use

---

by their tenants, and to the level of CO<sub>2</sub> emissions from this sector. In the UK, lighting is estimated to account for around 8.6TWh of electricity per year, from 21 million premises, and it is estimated that 60% savings could be achieved by the use of compact fluorescents, bringing the level down to 3.44Twh per year<sup>1</sup>. In 1990, 97% of all the lamps sold in the UK domestic market were incandescents, and while there are some technical constraints to their use (for example in very small decorative lamps) there is no obvious reason other than the capital cost why high efficiency lamps such as compact fluorescents should not be deployed much more widely. It is estimated that wide scale use of compact fluorescent lamps leading to volume production, would lower the capital cost by around 40% to the consumer.

As mentioned above many IEA/OECD member countries have already implemented lighting replacement programmes in their buildings and in recent years Canada, Belgium, Denmark and the UK have adopted strategies for introducing high-efficiency lighting in government buildings. In Canada one building alone is expected to save 30% in energy, or \$200,000 per year. In the US the *Green Lights Programme* is a voluntary programme whereby an organisation (company, hospital, government agency, university, etc.) agrees to survey its domestic facilities and upgrade the lighting within 5 years, wherever it is profitable to do so. The Environmental Protection Agency (EPA) provides technological information, and guidance on financing options. By the end of 1995 the *Green Lights* system had been exploited in 500,000 square feet of space. In one public institution the lighting equipment was upgraded at a cost of \$85,446, and it achieved annual savings of \$102,150 and prevented 3,064,488lbs of CO<sub>2</sub> emissions per year.

The value of information campaigns to encourage the adoption of efficient lighting technologies has been recognised particularly in the Netherlands where it has been coupled with subsidies to allow low-energy light bulbs to be competitively priced on the market. This strategy has led to energy efficient light bulbs accounting for 68% of all light bulb purchases in the Netherlands. Ireland too recognises the need for information dissemination to encourage the uptake of efficient lighting technologies, and the Government supports conferences and workshops targeted at industrial and commercial applications.

In Italy and France regional and national demand side management (DSM) programmes have included the promotion of low-energy light-bulbs (see box).

---

### **Guadeloupe, West Indies : DSM Programme**

*Electricite de France (EDF) carried out a DSM programme in Guadeloupe (an administrative region of France), because French law requires EDF to sell electricity at a set price, which in Guadeloupe is less than half the cost of production.*

#### **The Programme:**

*Customers received coupons for up to 10 compact fluorescent lamps (CFLs) per household, which they exchanged at any of the 80 shops which had agreed to take part (EDF bought the lamps from the manufacturer and supplied the shops). With the use of TV advertisements demonstrating the running cost savings, customers were encouraged to use the coupons to buy the lamps. Payment for the lamps was included in the electricity bill and spread over 18 months.*

*The programme cost EDF around 2.4 million French Francs in advertising, extra staff in stores etc.*

#### **Effect on the Market:**

*Before the programme around 1000 CFLs were sold each year. When the programme was launched 100,000 CFLs were purchased with coupons in 1.5 days, and an additional 160,000 thereafter. Similar programmes were run in neighbouring islands of Martinique, where 360,000 CFLs were sold in 1993.*

The success of programmes such as these depends largely on the winning combination of information dissemination, readily available products and favourable financing arrangements which enable the products to be within the price range of the target purchasers. Financing arrangements such as that in Guadeloupe are not beyond the reach of governments, and several governments are adopting 3rd party financing techniques to enable them to make necessary capital purchases without suffering from capital cost constraints (see *section 5.1*).

In Sweden the widespread deployment of low-energy light bulbs is expected to achieve savings in electricity use of up to 60%. In 1991-93 NUTEK encouraged the establishment of a number of buyer groups aiming to improve the deployment of high-frequency lighting, and supported their activities with subsidies to lower the capital cost of the lamps. This encouraged the retail sector to stock the lamps and more than 200,000 outlets were selling the low-energy bulbs by 1993. As a result of the programme the rate of uptake of the lamps has increased 100% each year. Following the success of their programme NUTEK reviewed the effectiveness of their methods and found that the subsidy was necessary to provide the initial stimulus to the market to bring the cost of the lamps down to an affordable level, but once the market had taken off, the subsidy was no longer necessary as bulk production by the manufacturers enabled them to produce the lamps more cheaply. An essential accompaniment to this programme was the information dissemination which NUTEK employed. NUTEK found that videos, training brochures and demonstrations were most effective at the start of the campaign and had to be repeated at regular intervals thereafter.

The Department of Energy Efficiency in Sweden is implementing a programme of involving property administrators in *Collective Agreements*. The programme aims to make the normal

---

lighting requirement for rooms 10W/me. The Government offers training programmes for installation contractors to allow them to learn about the new high-frequency technologies. High-frequency lighting systems have been installed in half of all lighting refurbishments in schools and government offices and high-pressure sodium lamps (10% more efficient, contain no mercury, and fit existing fittings) are routinely installed for street lighting and large indoor areas such as sports halls. The use of high-frequency lighting improves not only the light output efficiency of fluorescent tubes by about 20%, but also eliminates flicker and allows the use of lighting sensor controls. Buildings where improvements have been made are used as demonstration examples to spread the word.

The effect of these collective agreements on the lighting market has been impressive: a technology procurement project run in 1991 resulted in a significant price reduction and the market share of the lamps doubled in one year, and by 1994 had increased by 500% and cornered 30% of the market. Twenty-four incentive agreements have been signed resulting in improvements in efficiency worth over 34 Gwh; 107 lighting projects have saved 14 Gwh, making an average improvement of 41% relative to the original lighting installations.

#### **4.4 Appliances: Office Equipment**

Central and local government departments use an increasing number of office appliances. In many countries, office equipment (computers, printers, copiers, document scanners, fax machines) is the fastest growing electricity load in the commercial sector. In OECD countries office equipment consumes nearly 80 Twh/year of electricity and in 1995 office equipment was responsible for nearly 30 million tonnes of CO<sub>2</sub><sup>23</sup>. Computer equipment alone accounts for 5% to 20% of commercial energy consumption<sup>23</sup> and this figure is expected to double by the year 2000. It is estimated that office equipment draw about 15-30% of a building's total building electricity. In view of the significant and rapidly growing contribution of these appliances to total energy consumption, measures to reduce the energy intensity of the equipment need to become more widely utilised across the OECD regions. Any government strategy to reduce greenhouse gas emissions must include an examination of office equipment. Purchasing programmes of low energy equipment by the public sector would significantly improve the market for these products, and encourage the adoption of low-energy equipment as the norm in the public and private sector.

Energy efficiency standards, and energy efficiency labelling are two promising methods of reducing the energy consumption of appliances. In the case of office appliances, standards for the energy consumption of the equipment tend to be adopted on a world-wide basis, because the market for these appliances is international. In addition, the market readily accepts improved standards of performance in these appliances, because so many aspects of the appliances have already changed very rapidly, and continue to do so. Given the enormous market for office appliances world wide there is obviously significant potential for increasing the market share of the most energy efficient models. The influence which governments can have in encouraging the increased deployment of high efficiency equipment has been well demonstrated by the influence of the US *Energy Star* programme. Because the US market is so vast, the requirements of this market for products with increased efficiency has pulled the standards of other products up to the *Energy Star* level. The overall market for high efficiency products therefore has grown enormously as a result of the pull by a large sector of the market. In other countries, governments can join buyer groups to increase the size of the demand for the climate friendly products, thus providing significant demand, and some market security, to the industry. If the government's lead is replicated in other sectors this can lead to a sustained improvement in the market position of the industry.

---

#### **4.4.1 Copiers**

In the United States alone there are about 6.6 million copiers in operation which are estimated to use 3.7 billion kWh directly (electricity use from the plug for operation), and even more energy, around 11.7 billion kWh, is consumed indirectly in the form of energy required to produce copier paper. Average energy use and costs per machine vary enormously across the OECD region, depending on the size and output rate: it ranges from about \$14/year to over \$260/year of direct electricity use. Indirect energy costs are about 3-4 times higher for a mid-range copier<sup>5</sup>.

##### *Status of the Technology*

The most important near-term opportunities for improving the energy efficiency of copiers are the use of controls for:

- automatically shutting-off machines during non-work hours;
- automatically switching them into low-power mode during idle periods (but with quick recovery time);
- making convenient, reliable and more rapid duplex (double sided) copying the default mode for all but the very small machines.

A recent study by the IEA Implementing Agreement on Demand-Side Management (DSM) has assessed that if all these measures were taken on all the copiers sold in the United States stock in one year, the energy savings could be as much as 190 kWh at the plug (25% saving), while extensive use of duplex copying could save another 700 million kWh (less 30%) of indirect energy embodied in paper<sup>5</sup>.

Substantial energy efficiency savings can be made from additional improvements such as low-power sleep mode with rapid recovery, or a modular power supply; new features such as automatic scanning of the original to make duplex copies where possible; use of new imaging and printing technologies; and the use of external switches to power-off an existing machine after a period while not in use based on a "smart" control or room occupancy sensor. One major contribution to cutting the energy consumption of office appliances is by switching the machines off overnight and on non-work days. Much equipment is left on, sometimes because users erroneously think it improves the appliance's efficiency but more often because of carelessness.

##### *Deployment / Market Enhancement*

Since 1991 Switzerland's Federal Office of Energy has worked with manufacturers to define target values for stand-by power levels of office equipment (see box). Target values work well as a clear signal to manufacturers, and to purchasers, of the direction in which further development is anticipated. Those copiers which meet the target values will carry the E-2000 label. Labels are a valuable tool for marketing energy efficient technologies, as products with efficiency labels will appear to best advantage against their competitor products, and for sales to government establishments in Switzerland the label is necessary. However as the label has not been adopted in neighbouring countries, it is debateable whether companies whose products do not carry the label will lose much of the market share, as they can concentrate their marketing efforts in other areas. If the label is more widely adopted in the region, or if it is adopted

---

internationally, then products with the label will gain a significant market advantage and could expect much increased sales.

The IEA Implementing Agreement on Demand Side Management (Annex III) is, in collaboration with the US, UK, Switzerland, the Netherlands, Korea and Finland, launching a procurement project for new generation copiers, *Copiers for the Future*. The project aims to accelerate the market introduction of these new copiers. It will entail a competition for a Zero Energy Standby Mode copier which will feature a recovery time of around 10 seconds. The prototype will be

### **Switzerland**

#### **Label E-2000 : Target Values for Appliances**

*The power levels for the 'stand-by' and 'off' modes of computers, screens, printers, fax machines, copiers, television sets and video recorders have been set for each year, so that 20-30% of products on the market will meet the requirements. The power levels have been adjusted each year until they meet the maximum consumption target values.*

#### **Target Values:**

**Computers:** Off mode - 5W by end 1997; 3W by end 1999  
Sleep mode - with integrated monitor: 15W by end 1997, 13W by end 1999;  
- without monitor: 10W by end 1997

**Screens:** Sleep mode - 5W by end 1997, 3W by end 1999.

**Printers:** Off mode - 1W by end 1996,  
Stand-by - 2W by end 1996.

**Copiers:** Off mode - 1W by end 1996,  
Stand-by - 27 + 3.23 copies per minute by end 1996.

**Telefaxes:** Stand-by - 2W by end 1997.

**Televisions:** Stand-by - 5W by end 1995, 3W by end 1997.

**Video recorders:** Stand-by - 6W by end 1996, 3W by end 1998

#### **Effect on the Market:**

*The target values give the manufacturers clear guidance on the level of improvements in energy efficiency which would be required for their products to gain an E-2000 label.*

*Those products which meet the criteria and are marketed with the E-2000 label will gain a market advantage in Switzerland for sales to government establishments (which require appliances to carry the label), but may not make a significant impact on the overall market for copiers if the standard is not adopted in the region, or on an international basis.*

developed over 2 years, and marketing will be during the following year when groups of buyers and supporters (including the public sector) will push the market.

---

#### 4.4.1 Computers

##### *Status of the Technology*

Personal Computers (PCs) and monitors each consume over 25% of the total office equipment energy use. The most important development for saving energy in PCs is in the use of technologies which slow or shut down various components after some user-defined idle time.

The US *Energy Star* is probably the most developed programme which sets efficiency targets for computers. It evolved as a result of the variety of state standards which were causing difficulties and confusion for manufacturers. The *Energy Star Programme* is a voluntary partnership between the Environmental Protection Agency and computer manufacturers. The specifications in force since 1995 are that computers, monitors and printers whose output is less than or equal to 14 pages per minute should use no more than 30W of power in the stand-by mode, and that larger and colour printers should use no more than 45W of power in the stand-by mode.

However one of the key uncertainties about the energy savings from *Energy Star* and other standards for office equipment is whether the power saving features are properly set to save energy. One estimate is that only 50% of PCs and 70% of monitors have their power management properly set in the US, and in Europe that only a small percentage of products sold with the energy saving features have them correctly set<sup>23</sup>. In addition, users should be encouraged to switch off their machines at night to save energy.

##### *Deployment / Market Enhancement*

In the US over 85% of the PC and monitor manufacturers, over 90% of the printer manufacturers, and over 130 components and software manufacturers participated in the programme (up to 1997). By the end of the first year of the programme, over 40% of PCs and 85% of printers sold carried the *Energy Star* label. Copiers, fax machines and combination copier/faxes are also now included in the programme. The programme was accompanied by widespread press coverage of the label and its requirements, which generated interest among purchasers, and among manufacturers who were afraid to lose their market place. In 1993 Executive Order 12845 *Requiring Agencies to Purchase Energy Efficient Computer Equipment* required all Federal purchases of computers, monitors and printers to carry the *Energy Star* label. This further enhanced the market for these products, as the US Federal government is such a large purchaser. The influence of the US standard on the world computer market has been very significant as, because the US is such a large market, it has improved the efficiency of computers sold world-wide.

Government purchasing can be a particularly powerful tool when the demand for high efficiency products is coordinated with other market enhancement activities such as information campaigns. Information campaigns raise awareness of the improvements in appliance technology and stimulate demand for new, more efficient products. International coordination can also be essential if small countries such as Switzerland are to have any impact on the technology market beyond its national borders. US activities are influential because of the size of its market, but regional coordination is necessary for energy efficiency standards to affect appliance specifications in the majority of appliances on the market.

---

## 4.5 Domestic Appliances

Governments in the wider sense use many “domestic” appliances. Hospitals, residential care homes, prisons, correction centres, public housing in some countries, military sites, and further education residences all provide domestic appliances from public funds. Items such as refrigerators, washing machines and driers are routinely purchased, and can make a substantial contribution to the energy load of a building. Domestic appliances in the UK, for example, account for 13% of total energy use, and 54% of electricity in the domestic sector<sup>2</sup>.

Energy consumption in domestic appliances is not generally a feature which is given a high priority by purchasers. In both domestic and commercial situations there is usually greater consideration given to features such as low noise, size, and speed (in the case of washing and drying machines). Because the majority of their consumers do not demand low energy use, manufacturers have little incentive for investing much effort into producing low energy appliances, especially if such appliances would cost more, and would thus appeal to a limited market. With careful consideration of the energy efficiency characteristics of appliances on the market, purchasers could opt for the most efficient products which do not necessarily have the highest capital cost, and which certainly have lower operating costs, energy use and therefore lower emissions of CO<sub>2</sub> the major greenhouse gas.

### 4.5.1 Refrigerators

#### *Status of the Technology*

Approximately 73 million refrigerators are manufactured and sold each year around the world. Refrigeration consumed more than 350 TWh of electricity in Annex I countries in 1995<sup>26</sup>, and is typically the largest domestic sector electricity end-use, representing about 20% of total domestic electricity consumption. New refrigerator efficiency has improved dramatically in major markets over the last 20 years but levels of, and specifications for, their energy efficiency vary widely across IEA/OECD regions, and between countries within those regions. There is a wide gap between the efficiency of the best available technology and average levels of efficiency of appliances on the market. The main reason for these wide variations is that, unlike office appliances, refrigerators are manufactured by companies focussing on the regional rather than the international markets, as consumers in different regions like very different product characteristics in their appliances.

Most domestic appliances are replaced only every decade or so, (fridges roughly every 9 years in Japan and every 19 years in the US) therefore purchasing decisions made now will affect the energy use of the appliance, and contribute to the overall energy load of the building for the following decades. Governments in all IEA/OECD regions could take a leadership role in encouraging awareness of the energy savings, and environmental advantages of energy efficient appliances, by coupling their own purchasing programmes with information dissemination on a wide basis to encourage replication in all sectors.

The technical improvements in refrigerator/freezer efficiency have been made in increasing the motor/compressor efficiency, improved thermal insulation, and better energy controls. These improvements have more than outweighed unit energy consumption increases which have resulted from increasing the size of refrigerator/freezers, and the additional features such as automatic defrost, ice-making, and low temperature compartments.<sup>23</sup>

---

The size of refrigerators varies enormously across the IEA/OECD region: the most common volume of North American refrigerators is around 500 litres (17.5cu.ft), Australian refrigerators average 336 litres, Canadian refrigerators 463 litres, Japanese refrigerators 320 litres and the European refrigerator averages 275 litres.<sup>23</sup>

### *Deployment / Market Enhancement*

The role of energy efficiency standards in improving the energy efficiency of refrigerators in the OECD region was examined by the OECD Secretariat in 1997<sup>23</sup>. Its findings suggest that in addition to savings which will be achieved through other means, *energy efficiency standards* could potentially achieve a saving of between 5% and 18% in CO<sub>2</sub> emissions from refrigerators by 2010 (depending on the level of stringency of the standards). Many IEA/OECD countries have set standards for energy efficiency in refrigerators. In the EU the German government reached a voluntarily agreement in January 1980 with German manufacturers to improve the average efficiency of refrigeration appliances by 15% to 20% by 1985<sup>23</sup>, but this was subsequently discontinued. Switzerland and Denmark are implementing energy efficiency targets for refrigerators/freezers and Australia plans to introduce mandatory minimum energy performance standards for refrigerators/freezers in 1999 (and has a mandatory labelling scheme). Both New Zealand and Australia are working to implement common standards for refrigerators. In Japan, there are relatively few formal environmental product standards. Public authorities rely heavily on self-regulation by industry. Industry generally first establishes standards or targets amongst themselves, and the Government sets standards when 60% to 80% of firms can meet the industry standard<sup>23</sup>.

In the US proposed refrigerator standards were agreed in October 1994, but the proposals have not yet been finalised, and some manufacturers have now reversed their position and oppose the standards. Through its *Energy Star* programme the US has encouraged volume purchase efforts for refrigerators. Also in the US the *Golden Carrot* programme stimulates *competition* among manufacturers. In the first scheme 24 utilities pooled \$30 million in the *Super Efficient Refrigerator Program (SERP)* and a competition was launched to find the manufacturer who could build the most efficient CFC-free refrigerator at the lowest costs. The winner received guaranteed rebates from the pool to offset the incremental product development cost. Fourteen manufacturers responded to the challenge by submitting proposals, and even though thirteen of these failed to win, several manufacturers have introduced efficiency improvements to their standard commercial models.

Winners of both the US and Swedish competitions have since agreed that the competitions encouraged them to develop more advanced technologies at a much faster rate than they had planned, to meet the competition's requirements. As a result these manufacturers have continued to improve the efficiency of some of their models on the market.

Until the market prospects for energy efficient fridges improves on a wider scale, these products will continue to account for a small percentage of the appliance market. Stimulation of this sector of the industry by government purchasing strategies could, in view of the large numbers of these appliances which are installed in publicly owned buildings, have an important impact on the market. Such a strategy would be particularly effective if it was coupled with information dissemination about the policy, and the energy and environmental advantages of the appliances. The use of energy labels can make the task of information dissemination easier as the products are already easily identified as energy efficient products.

---

## 4.6 Technological Opportunities - Vehicles

Emissions of CO<sub>2</sub> from vehicles have risen at the fastest rate of all emission sources over the last decade, and are set to continue to rise. With the trend in private car ownership continuing on its upward path, governments are considering a range of options for limiting greenhouse gas emissions. Unless major changes occur in the number of vehicles on the road (which appears unlikely) governments will continue to consider alternative approaches, aimed at encouraging industry and major vehicle users to participate in the development and demonstration of cleaner vehicle technology.

Some local authorities have concentrated efforts on devising alternative transport policies to discourage the use of the private car, and encourage the use of an integrated public transport system; other local authorities have introduced fuel switching from petroleum to alternative fuels in their own vehicle fleet. Local authorities (especially in cities) are in many ways best placed to experiment with new transport strategies which would be uneconomic and politically unacceptable in the national context. Local communities have traditionally been the chief motivators for change in local transport policies, largely because the environmental effects of road transport are most keenly experienced at the local level.

Some local transport strategies which involve discouraging traffic in central city or town areas will reduce local emissions of greenhouse gases and other pollutants, but may well increase emissions in out-of-town areas. The more widespread use of vehicles running on alternative fuels can reduce overall greenhouse gas emissions without this adverse effect elsewhere.

In addition to encouraging the use of alternative fuel vehicles, governments have a very prominent role in encouraging fuel efficiency in all their vehicles irrespective of the fuel used. Many IEA/OECD governments recognise this and have implemented policies to educate their vehicle drivers in fuel efficient driving habits, to organise their operations to minimise the vehicle usage, and in improving maintenance of the vehicles to avoid pollutant emissions. Some governments, such as Canada and Japan, have considerably reduced the size of their government vehicle fleets, as part of their review of environmental considerations in government activities. Another purchasing issue which governments need to consider, is the use of air conditioning in vehicles. The amount of fuel used by the vehicle increases significantly when air conditioning is in operation, and when vehicles are bought or leased, purchasers should give due consideration to the real need for this facility, against its environmental impacts and increased fuel use and costs.

### *Status of the Technology*

Several fuel technologies exist which provide an alternative to petroleum use in vehicles and which can achieve various levels of CO<sub>2</sub> emission reduction:

- ◆ methanol manufactured from natural gas, reformulated petroleum, ethanol from grain where the conversion process is fuelled by a fossil-fuel fired power station; each of these technologies offer little or no improvement in greenhouse gas emissions over conventional petrol;
- ◆ LPG, CNG and diesel: these fuels can offer reductions of up to 30% in greenhouse gas emissions, although in some circumstances (where gas leaks are high from CNG) the emissions could be higher than from petroleum. Some

---

biofuels such as ethanol produced from grain or sugarbeet using fossil fuels for processing, electric vehicles where the electricity is generated from a mix of fuels (coal, gas and renewable energy sources) may also achieve a 30% reduction.

Buses in a number of urban areas in some IEA countries are being operated commercially on LPG, CNG and LNG because they have low particulate emissions. However the fuel is used in spark ignition engines, which are less efficient than compression-ignition diesel engines and so there will be no net reduction in CO<sub>2</sub> emissions. If they are used in compression-ignition engines the particulate emissions will rise due to the introduction of diesel which helps them operate. The cost of converting a bus to operate on these fuels is high, at around \$6000-7000<sup>2</sup> and therefore it is likely that this option will be confined to buses in urban areas with concerns over particulate emissions from diesel vehicles;

- ◆ ethanol produced from grain or sugarbeet using agricultural biomass to power the process, and electric vehicles where the electricity source is mainly non-fossil fuels can achieve 50% reductions in greenhouse gas emissions, and even greater reductions can be achieved by the use of rapeseed oil methyl ester (RME);
- ◆ if the electricity source is mainly non-fossil fuels, electric vehicles may provide the most promising option for reducing CO<sub>2</sub> emissions. Batteries and fuel cells for powering vehicles still require considerable development before they will be considered viable for wide-scale adoption.

Many IEA/OECD countries have research programmes aimed at developing alternative fuel technologies. Japan, the EU and the United States are working on lightweight materials, alternative engine concepts, hybrid (ICE-electric) vehicles, fuel cells, and batteries. Several countries in all OECD regions have specialist expertise in particular technologies, including a company in Canada which is the world's main producer of solid polymer fuel cells.

#### *Deployment / Market Enhancement*

A number of other IEA/OECD countries have programmes for encouraging the use of AFVs: Australia, Canada, Italy, Japan the Netherlands, and the United States all market LPG and CNG at prices around one-third the price of petroleum. In both the UK and Denmark the local authorities (who have responsibility for public bus transportation) have started some voluntary trials of AFV buses; the City of Luxembourg has introduced hybrid electric buses in the city; and Sweden is currently testing ethanol and biogas in buses, trucks and private cars, and since 1993 a four year project has been running involving demonstrations of several hundred electric and hybrid buses.

Japan plans to reduce pollution and improve fuel consumption to approximately 90% of 1996 levels by the year 2000. To help implement this aim Japan is subsidising (at two-thirds of the cost) non-commercial refuelling facilities for AFVs. In 1996 the *Programme to Encourage Dissemination of Electric Vehicles* was launched which subsidises purchases of electric vehicles, at a rate of 50% of the price difference between an electric vehicle and a conventionally fuelled vehicle. In the first few months of operation around 1000 purchases were subsidised under the scheme, vastly increasing the uptake of these vehicles relative to previous sales figures.

---

The **US Energy Policy Act** (1992), and Executive Order 12844 *Federal Use of Alternative Fuelled Vehicles* (1993) requires state governments to purchase Alternative Fuel Vehicles (AFVs) for 10% of their fleet, rising to 75% by 2000. State government initiatives have been important for encouraging the market for AFVs e.g. The California Air Resources Board (CARB) introduced the *Clean Fuels and Vehicles Plan* in September 1990, whereby progressively lower emission standards are imposed on vehicles from 1994 onwards. Vehicles have been classified according to four levels of emissions, and manufacturers have limits on the number of vehicles they can sell each year, depending on the level of emissions from the vehicles. The Plan also required the establishment of at least 90 Southern California filling stations by 1994, rising to 400 by 1997. The target for sales of low-emission vehicles is 200,000 (about 10% of the state's new car fleet) from 1994. Tax exemptions and utility promotions for purchasing AFVs or converting cars to alternative fuels are also encouraging take-up. Electric vehicles were originally meant to make up 2% of new car sales by 1998, rising to 10% by 2003. However due to insufficient technological development of batteries and vehicles the 1998 target has been withdrawn but the 2003 maintained. New York and Massachusetts also adopted this plan.

In California the more widespread use of electric vehicles would make the most significant impact on the emissions of greenhouse gases from vehicles in the state, because most of the power generation is from non-fossil-fuel sources or natural gas.

---

Several countries have experience of encouraging motorists to make fuel changes, although most experience has been in encouraging the take-up of diesel and lead-free petrol. This experience can be a useful model for a strategy to enhance the market for AFVs. Essentially, increased deployment of diesel fuelled vehicles was achieved in France when:

- ◆ the manufacturers developed a large enough range of vehicle models for consumers to have the same specifications (size, power, performance, aesthetic appeal etc.) as in petrol engined cars;
- ◆ the price of diesel fuel was attractively lower than petroleum.

This experience was also reflected in the UK when lead-free petrol was encouraged. The market moved in favour of lead-free petrol when the technological options were available and when the price of the fuel was favourable. Similarly in Brazil the buoyant market for ethanol vehicles, which had been built up since 1979 (reaching 90% of new car sales in 1986), remained strong as long as the subsidies were in place which guaranteed that ethanol fuel would be no more than 65% of the price of petrol. As soon as the subsidies were withdrawn the market collapsed. These incentives were later restored to revive the ethanol vehicle market.

Governments' role in encouraging the market for AFV technologies appears, from these experiences, to lie in supporting the build-up of the infrastructure (in assuring the availability of alternative vehicles or easy access to technical conversions and guaranteed fuel supplies), and in subsidising the fuel to a level which is attractive to the customer. The appeal of climate-friendly technologies to the purchaser lies in the savings which can be achieved in terms of costs and environmental impacts. AFV vehicles therefore will need to provide cost savings throughout their operating life, before the initial purchases will be made.

When these criteria have been met there must certainly be a leadership role for governments. Information from government sources is generally considered more reliable and less biased than

---

from a vehicle manufacturing company, thus information campaigns and demonstration projects of alternative-fuel technologies in action are likely to reinforce the inducements of economic incentives, and persuade consumers to adopt such technologies.