Journal of Agricultural Extension and Rural Development Vol. 2(1). pp. 001-021, January, 2010
Available online http://www.academicjournals.org/jaerd

Full Length Research Paper

Environmental and socio-economic aspects of possible development in renewable energy use

Abdeen Mustafa Omer

17 Juniper Court, Forest Road West, Nottingham NG7 4EU, United Kingdom. E-mail: abdeenomer2@yahoo.co.uk

Accepted 12 October, 2009

The use of renewable energy sources is a fundamental factor for a possible energy policy in the future. Taking into account the sustainable character of the majority of renewable energy technologies, they are able to preserve resources and to provide security, diversity of energy supply and services, virtually without environmental impact. Sustainability has acquired great importance due to the negative impact of various developments on environment. The rapid growth during the last decade has been accompanied by active construction, which in some instances neglected the impact on the environment and human activities. Policies to promote the rational use of electric energy and to preserve natural non-renewable resources are of paramount importance. Low energy design of urban environment and buildings in densely populated areas requires consideration of wide range of factors, including urban setting, transport planning, energy system design and architectural and engineering details. The focus of the world's attention on environmental issues in recent years has stimulated response in many countries, which have led to a closer examination of energy conservation strategies for conventional fossil fuels. One way of reducing building energy consumption is to design buildings, which are more economical in their use of energy for heating, lighting, cooling, ventilation and hot water supply. Passive measures, particularly natural or hybrid ventilation rather than air-conditioning, can dramatically reduce primary energy consumption. However, exploitation of renewable energy in buildings and agricultural greenhouses can, also, significantly contribute towards reducing dependency on fossil fuels. Therefore, promoting innovative renewable applications and reinforcing the renewable energy market will contribute to preservation of the ecosystem by reducing emissions at local and global levels. This will also contribute to the amelioration of environmental conditions by replacing conventional fuels with renewable energies that produce no air pollution or greenhouse gases. This article presents review of energy sources, environment and sustainable development. This includes all the renewable energy technologies, energy savings, energy efficiency systems and measures necessary to reduce climate change.

Key word: Renewable energies, wind power, solar energy, environment, sustainable development.

INTRODUCTION

Spaces without northerly orientations have an impact on the energy behaviour of a building. For sustainable development, the adverse impacts of energy production and consumption can be mitigated either by reducing consumption or by increasing the use of renewable or clean energy sources (Reddy et al., 2006). Bioclimatic design of buildings is one strategy for sustainable development as it contributes to reducing energy consumption and therefore, ultimately, air pollution and greenhouse gas emissions (GHG) from conventional energy generation. Bioclimatic design involves the application of energy conservation techniques in building construction and the use of renewable energy such as solar energy and the utilisation of clean fossil fuel technologies. Most businesses could make savings of up to 20% by introducing basic improvements in energy efficiency. Meeting the target of a 60% reduction in carbon dioxide (CO_2) emissions on environmental pollution is both technologically feasible and financially viable. A genuine investment of energy and resources to meet the environmental challenges the world at equity for a small planet. One compelling reason why businesses should reduce emissions:

- It is right to reduce emissions and to use energy efficiency. There are inevitably concerned about costs. They want to provide goods and services at prices their customers can afford and without a competitive detriment.
- To reduce emissions in businesses is that customers care about the environment and would give a choice and support environmentally conscious business.

Renewable energy markets, industry and investment have never grown faster than they did in 2007. Countries with the largest amounts of new capacity investment were Germany, China, the United States, Spain, Japan and India. Sources of finance and investment now come from a diverse array of private and public institutions. From private sources, mainstream and venture capital investment is accelerating, for both proven and developing technologies.

Between 1980 and 2000 governmental awareness of wind energy mainly concentrated in Denmark and Germany, where a large number of wind turbines were manufactured and installed. Nowadays, most European governments are well aware of the potential of wind energy. Generally, the development and operation of a wind farm can be subdivided into four phases:

- Initiation and feasibility.
- Pre-building (conducted by go/no-go).
- Building.
- Operation and maintenance.

RENEWABLE ENERGY

In the majority of cities that have installed significant amounts of renewable energy over the last 10 years. The local municipal government has played a key role in stimulating projects. When it comes to the installation of large amounts of renewables, these cities have several important factors in common. These factors include:

- Information provision about the possibilities of renewables.
- The presence of municipal departments or offices dedicated to the environment, sustainability or renewable energy.
- A strong local political commitment to the environment and sustainability.
- Obligations that some or all building include renewable energy.

Energy efficiency is the most cost-effective way of cutting carbon dioxide emissions and improvements to households and businesses. It can also have many other additional social, economic and health benefits, such as warmer and healthier homes, lower fuel bills and company running costs and, indirectly, jobs. Britain wastes 20% of its fossil fuel and electricity use. This implies that it would be cost-effective to cut £10 billion a year off the collective fuel bill and reduce CO_2 emissions by some 120 million tones. Yet, due to lack of good information and advice on energy saving, along with the capital to finance energy efficiency improvements, this huge potential for reducing energy demand is not being realised. Traditionally, energy utilities have been essentially fuel providers and the industry has pursued profits from increased volume of sales. Institutional and market arrangements have favoured energy consumption rather than conservation. However, energy is at the centre of the sustainable development paradigm as few activities affect the environment as much as the continually increasing use of energy. Most of the used energy depends on finite resources, such as coal, oil, gas and uranium. In addition, more than three quarters of the world's consumption of these fuels is used, often inefficiently, by only one quarter of the world's population. Without even addressing these inequities or the precious, finite nature of these resources, the scale of environmental damage will force the reduction of the usage of these fuels long before they run out.

Throughout the energy generation process there are impacts on the environment on local, national and international levels, from opencast mining and oil exploration to emissions of the potent greenhouse gas carbon dioxide in ever increasing concentration. Recently, the world's leading climate scientists reached an agreement that human activities, such as burning fossil fuels for energy and transport, are causing the world's temperature to rise. The Intergovernmental Panel on Climate Change has concluded that ''the balance of evidence suggests a discernible human influence on global climate''. It predicts a rate of warming greater than any one seen in the last 10,000 years, in other words, throughout human history. The exact impact of climate change is difficult to predict and will vary regionally. It could, however, include sea level rise, disrupted agriculture and food supplies and the possibility of more freak weather events such as hurricanes and droughts. Indeed, people already are waking up to the financial and social, as well as the environmental, risks of unsustainable energy generation methods that represent the costs of the impacts of climate change, acid rain and oil spills. The insurance industry, for example, concerned about the billion dollar costs of hurricanes and floods, has joined sides with environmentalists to lobby for greenhouse gas emissions reduction. Friends of the earth are campaigning for a more sustainable energy policy, guided by the principal of environmental protection and with the objectives of sound natural resource management and long-term energy security. The key priorities of such an energy policy must be to reduce fossil fuel use, move away from nuclear power, improve the efficiency with which energy is used and increase the amount of energy obtainable from sustainable, renewable sources. Efficient energy use has never been more crucial than it is today, particularly with the prospect of the imminent introduction of the climate change levy (CCL). Establishing an energy use action plan is the essential foundation to the elimination of energy waste.

WATER RESOURCES

The world was blank, white and unformed. In the system of water, clouds are a bucket brigade, not storage. The atmosphere around the planet carries only about a ten day supply of fresh water - about one inch of rain. Each day on earth almost 250 cubic miles of water evaporates from the sea and the land. Its stay in the air is short; it is always seeking particles to stick to and fall with as rain or snow.

Climatic and environmental changes and a rising water demand have increased the competition over water resources and have made cooperation between countries that share a transboundary river an important issue in water resources management and hydropolitics. Yet in river basins around the world, international conflict and cooperation are influenced by different factors and general conclusions about forces driving conflict and cooperation have been difficult to draw. Rivers are an essential natural resource closely linked to a country's wellbeing and economic success. But rivers ignore political boundaries and competition over the water resources has lead to political tension between countries with Transboundary Rivers. Integrating international cooperation and conflict resolution into the water management of Transboundary Rivers has therefore become an important issue in water resources management and hydropolitics. The problem requires a good understanding of the history and patterns of conflict and cooperation among nations sharing international basins worldwide and of the different factors that have influenced their international relations.

Increasing water scarcity in the downstream areas of several river basins demands improved water management and conservation in upper reaches.

Improved management is impossible without proper monitoring at various levels. It is well known that all existing sewage treatment plants are overloaded. Hence, the treated effluents do not comply with international effluent quality guidelines. The main reasons behind this are:

- Weak management and absence of environmental awareness.
- Public-sector institutional problems.
- Failure in process design, construction and operation.
- Lack of skilled operating staff and insufficient monitoring programmes.
- Poor maintenance and weak financial resources.
- Low level of public involvement and lack of financial commitment.

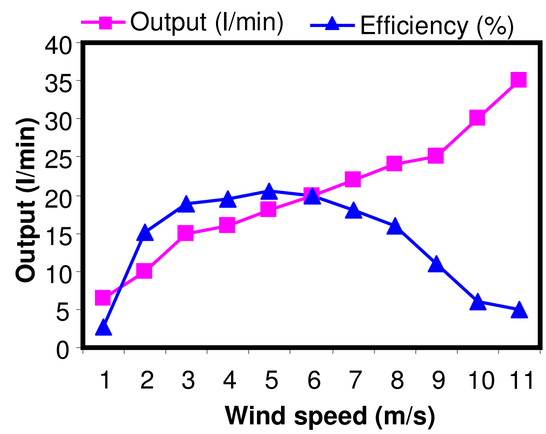

Figure 1. Performance of the wind pump.

WIND ENERGY

Wind energy is one of the fastest growing industries nowadays. The development in wind turbine (WT) technology is not limited to the significant increase in the size of the modern units, but also includes the high reliability and availability of the current machine. Therefore, a great competition among the manufactures established on the market and newcomers in the field is witnessed nowadays. A rapid development in the wind energy technology has made it alternative to conventional energy systems in recent years. Parallel to this development, wind energy systems (WES) have made a significant contribution to daily life in developing countries, where one third of the world's people live without electricity (Cavallo and Grubb, 1993).

Many developing nations need to expand their power systems to meet the demand in rural areas. However, extending central power systems to remote locations is too costly an option in most cases. Then, autonomous small-scale energy systems can meet the electricity demand in remote locations, even though they generate relatively little power. However, even little electricity would contribute greatly to the quality of life in some places of developing countries. Being one of the most promising autonomous power technologies, wind energy applications, in the power range from tens of Watts to kilowatts, are increasingly growing in rural areas of developing countries.

Technical and economical aspects of WESs should further be improved to sustain this growth. Techno-economically optimal designs are crucial for wind systems in competing with the conventional and more reliable power systems. High performance at the lowest possible cost will encourage the use of such systems and lead to more cost effective systems gradually (Figure 1). Design tools, allowing system performance assessment over a certain period of time, are therefore of great importance for sizing and optimization purposes.

Wind power now accounts for the dominant share of global investment in renewable energy. Total wind power capacity grew by 28% worldwide in 2007 to reach an estimated 95 GW. Annual capacity additions by market size increased even more: 40% higher in 2007 compared to 2006. Wind markets have also become geographically broad, with capacity in over 70 countries. Even as turbine prices remained high, due in part to materials costs and supply-chain troubles, the industry saw an increase in manufacturing facilities in the United States, India and China, broadening the manufacturing base away from Europe with the growth of more localized supply chains. India has been exporting components and turbines for many years and it appeared that 2006 and 2007 marked a turning point for China as well, with deals announced for the export of Chinese turbines and components. The annual energy yield is calculated by multiplying the wind turbine power curve with the wind distribution function at the site:

$$E_y = \sum_{i=1}^{i=n} f_{wi} P_{wi} \quad (1)$$

Where:

E_y is annual energy yield in kWh.
w is the wind speed in m/s.
n is the number of data bins converting the wind speed range of the turbine (0.5 or 1 m/s intervals).
f_{wi} is the number of hours per year for which wind speed is w m/s.
P_{wi} is the power resulting from a wind speed of w m/s.

Based on power curve from Figure 2 and the Weibull wind speed distribution, with a shape factor of 2, and the gross energy yield corresponding to 7 - 8.5 m/s is 10 MW.

Unchanging for all wind turbines- big or small- is a number of crucial factors that together determine the annual energy-generating potential in kWh/m^2 of rotor swept area. Key factors that impact potential energy yield and their physical relationships are expressed in the formula:

$$P = ½ \rho C_p \eta_{me} \eta_{el} V^3 A \quad (2)$$

Where:

P is the wind turbine power performance fed into the grid (Watts).
C_p is an aerodynamic efficiency of conversion of wind power into mechanical power, often called the power coefficient.
η_{me} is the conversion efficiency of mechanical power in the rotor axis into mechanical power in the generator axis. Encompasses all combined losses in the bearings, gearbox and so on.

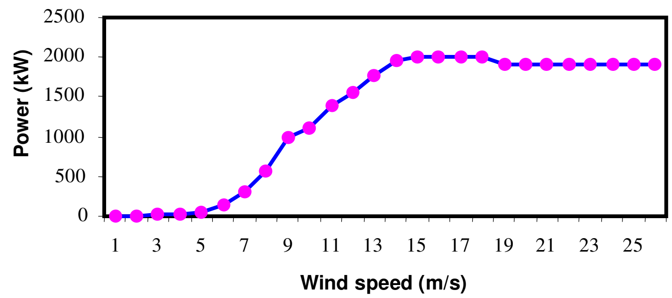

Figure 2. A power/wind speed curve.

η_{el} is the conversion efficiency of mechanical power into electric power fed into the grid, encompassing all combined losses in the generator, frequency converter, transformer, switches, etc.
ρ is the air density in kg/m^3 depends on environmental conditions.
V is the wind speed some three rotor diameters upwind from the rotor plane in m/s.
A is the rotor swept area in m^2.

Each of the elements of the performance formula has its own distinct contribution to total wind turbine power output and resulting yearly energy yield. Traditionally wind turbines applied in an open field are horizontal-axis designs fitted with an upwind rotor. In the operational output range, wind power generated increases with wind speed cubed. Rotor swept area is a function of the rotor diameter squared and is the second key wind turbine output variable. The Boyle-Gay-Laussac Law shows the impact of temperature and pressure on density, whereby density is proportional to pressure divided by temperature. The influence of air density on wind turbine performance is therefore limited.

ENERGY EFFICIENCY IN BUILDINGS

The world population is rising rapidly, notably in the developing countries. Historical trends suggest that increased annual energy use per capita is a good surrogate for the standard of living factors which promote a decrease in population growth rate. The term ‘low energy’ means achieving ‘zero energy’ requirements for a house or reduced energy consumption in an office (Figure 3). The main elements of energy concept are typical passive house components:

- Thermal bridges reduced to a minimum.
- Triple glazed windows with adequate frame and an optimised installation.
- A ventilation system with highly efficient heat recovery installed.
- Thermal solar collectors installed covering up 60% of the annual energy demand for domestic hot water.
- Excellent insulation level of opaque building elements:

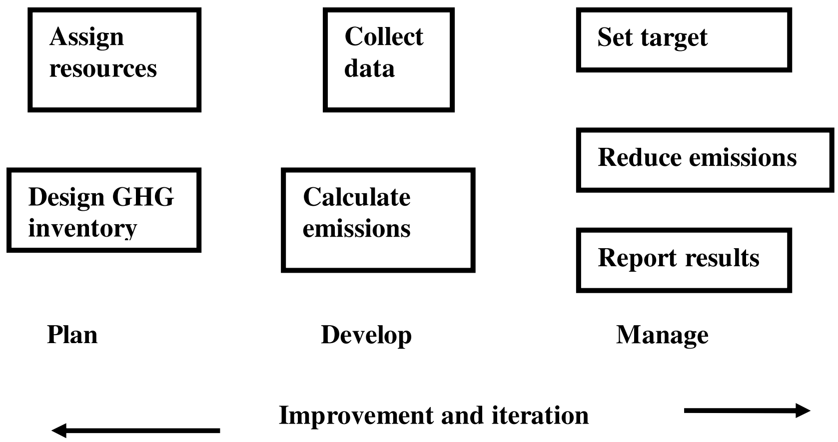

Figure 3. Shows office buildings can fight global warming.

u-values range from 0.10 W/m^{2}K for walls and roof to 0.18 W/m^{2}K for basement ceilings.
- Highly efficient condensing gas boilers were installed; where possible, ducts have been insulated to a very good level; in other projects biomass boilers have been successfully tested.
- The air-tightness was improved by a factor of 6 - 10; the limiting value for new passive houses was achieved.

Compact development patterns can reduce infrastructure demands and the need to travel by car. As population density increases, transportation options multiply and dependence areas, per capita fuel consumption is much lower in densely populated areas because people drive so much less. Few roads and commercially viable public transport are the major merits. On the other hand, urban density is a major factor that determines the urban ventilation conditions, as well as the urban temperature. Under given circumstances, an urban area with a high density of buildings can experience poor ventilation and strong heat island effect. In warm-humid regions these features would lead to a high level of thermal stress of the inhabitants and increased use of energy in air-conditioned buildings.

However, it is also possible that a high-density urban area, obtained by a mixture of high and low buildings, could have better ventilation conditions than an area with lower density but with buildings of the same height. Closely spaced or high-rise buildings are also affected by the use of natural lighting, natural ventilation and solar energy. If not properly planned, energy for electric lighting and mechanical cooling/ventilation may be increased and application of solar energy systems will be greatly limited. Table 1 gives a summary of the positive and negative effects of urban density. All in all, denser city models require more careful design in order to maximise energy efficiency and satisfy other social and development requirements. Low energy design should not be considered in isolation, and in fact, it is a measure, which should work in harmony with other environmental objectives. Hence, building energy study provides opportunities not only for identifying energy and cost savings, but also for examining the indoor and outdoor environment.

Energy efficiency and renewable energy programmes could be more sustainable and pilot studies more effective and pulse releasing if the entire policy and implementation process was considered and redesigned from the outset. New financing and implementation processes are needed which allow reallocating financial resources and thus enabling countries themselves to achieve a sustainable energy infrastructure. The links between the energy policy framework, financing and implementation of renewable energy and energy efficiency projects have to be strengthened and capacity building efforts are required.

SOLAR ENERGY

Policies for solar hot water have grown substantially in recent years. In particular, mandates for solar hot water in new construction represent a recent trend at both national and local levels. Large scale, conventional, power plant such as hydropower, has an important part to play in development. It does not, however, provide a complete solution. There is an important complementary role for the greater use of small scale, rural based, power plant. Such plant can be used to assist development since it can be made locally using local resources, enabling a rapid built-up in total equipment to be made without a corresponding and unacceptably large demand on central funds. Renewable resources are particularly suitable for providing the energy for such equipment and its use is also compatible with the long-term aims. It is possible with relatively simple flat plate solar collectors (Figure 4) to provide warmed water and enable some space heating for homes and offices which is particularly

Table 1. Effects of urban density on city's energy demand.

Positive effects	Negative effects
Transport: Promote public transport and reduce the need for, and length of, trips by private cars.	**Transport:** Congestion in urban areas reduces fuel efficiency of vehicles.
Infrastructure: Reduce street length needed to accommodate a given number of inhabitants. Shorten the length of infrastructure facilities such as water supply and sewage lines, reducing the energy needed for pumping.	**Vertical transportation:** High-rise buildings involve lifts, thus increasing the need for electricity for the vertical transportation.
Thermal performance: Multi-story, multiunit buildings could reduce the overall area of the building's envelope and heat loss from the buildings. Shading among buildings could reduce solar exposure of buildings during the summer period.	**Ventilation:** A concentration of high-rise and large buildings may impede the urban ventilation conditions.
Energy systems: District cooling and heating system, which is usually more energy efficiency, is more feasible as density is higher.	**Urban heat island:** Heat released and trapped in the urban areas may increase the need for air conditioning. The potential for natural lighting is generally reduced in high-density areas, increasing the need for electric lighting and the load on air conditioning to remove the heat resulting from the electric lighting.
Ventilation: A desirable flow pattern around buildings may be obtained by proper arrangement of high-rise building blocks.	**Use of solar energy:** Roof and exposed areas for collection of solar energy are limited.

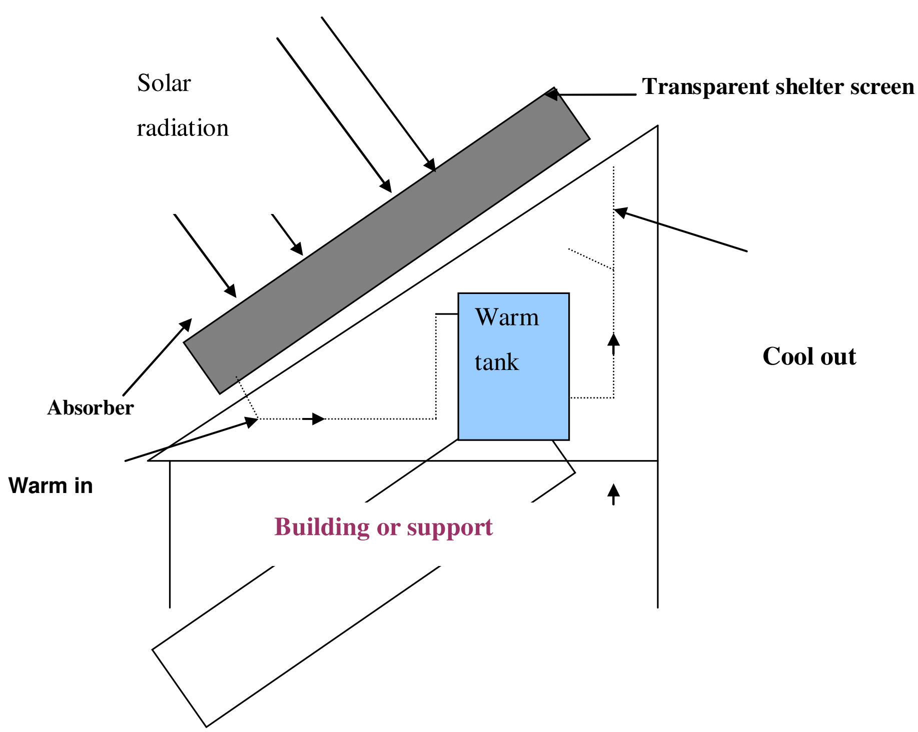

Figure 4. Solar thermal applications for hot water and space heating.

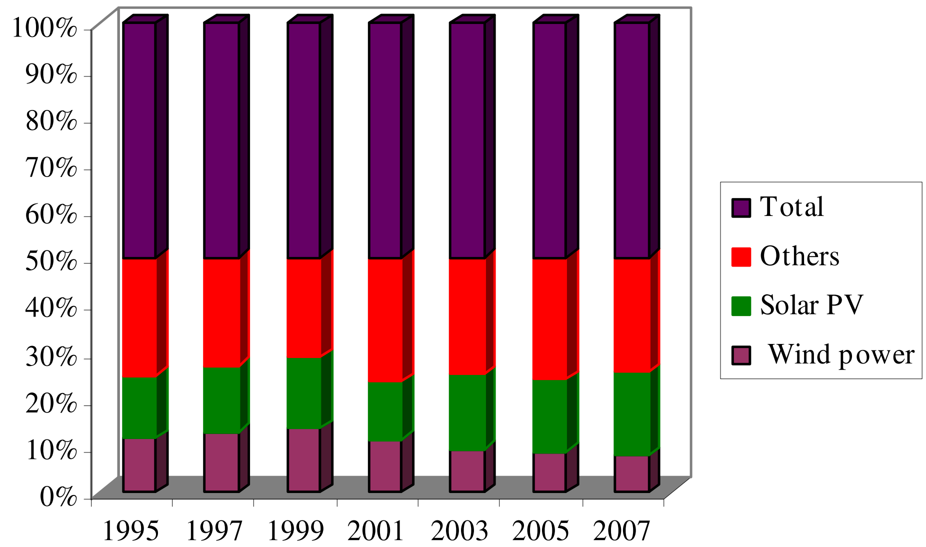

Figure 5. Annual investments in new renewable energy capacity 1995 - 2007 (REN21, 2007).

useful when the buildings are well insulated and thermal capacity sufficient for the carry over of energy from day to night is arranged. Energy efficiency is related to the provision of the desired environmental conditions while consuming the minimal quantity of energy.

The encouragement of greater energy use is an essential component of development. In the short term it requires mechanisms to enable the rapid increase in energy/capita, and in the long term we should be working towards a way of life, which makes use of energy efficiency and without the impairment of the environment or of causing safety problems. Such a programme should as far as possible be based on renewable energy resources. As with any market, the benefit of experience is invaluable in the successful implementation of a growth strategy (Figure 5). The large-scale uptake of photovoltaics in urban areas potentially represents a vast market area that could be developed under the right conditions. A wide range of countries, project stages and stakeholders have been involved and this has led to the collection of a comprehensive set of lessons learnt and successful methods of promoting the implementation of PV within the urban planning process:

- Setting the stage- the impact of planning policy on renewables within urban areas.
- Implementation- from financing to design to construction.
- Occupation- when the real success of otherwise of a project can be seen.

In many central European countries energy consumption for heating and domestic hot water causes around one third of national CO_2 emissions. For this reason the reduction of energy demand from buildings play an important role in efforts to control anthropogenic greenhouse gas emissions.

BIOMASS ENERGY

Biofuels are emerging in a world increasingly concerned by the converging global problems of rising energy demands, accelerating climate change, high priced fossil fuels, soil degradation, water scarcity and loss of biodiversity. For instance, the Intergovernmental Panel on Climate Change (IPCC) identified that in order to avoid more than an acceptable maximum 2 - 2.4°C rise in mean global temperature, greenhouse gas emissions will need to peak around 2015 and be reduced well below 50% of 2000 level by 2050. A lower figure is needed, which cannot be achieved by emissions reduction alone. Hence, there is a need for carbon removals, giving rise to enhanced supplies of biomass raw material and the potential of biofuels-related investments to show a profit from biofuels sales revenues. Many nations have the ability to produce their own biofuels derived both from agricultural and forest biomass and from urban wastes, subject to adequate capacity building, technology transfer and access to finance. Trade in biofuels surplus to local requirements can thus open up new markets and stimulate the investment needed to promote the full potential of many impoverished countries. Such a development also responds to the growing threat of passing a tipping point in climate system dynamics. The urgency and the scale of the problem are such that the capital investment requirements are massive and more typical of the energy sector than the land use sectors. The time line for action is decades, not centuries, to partially shift from fossil carbon to sustainable biomass. Figure 6 shows the contribution of biomass to global pri-

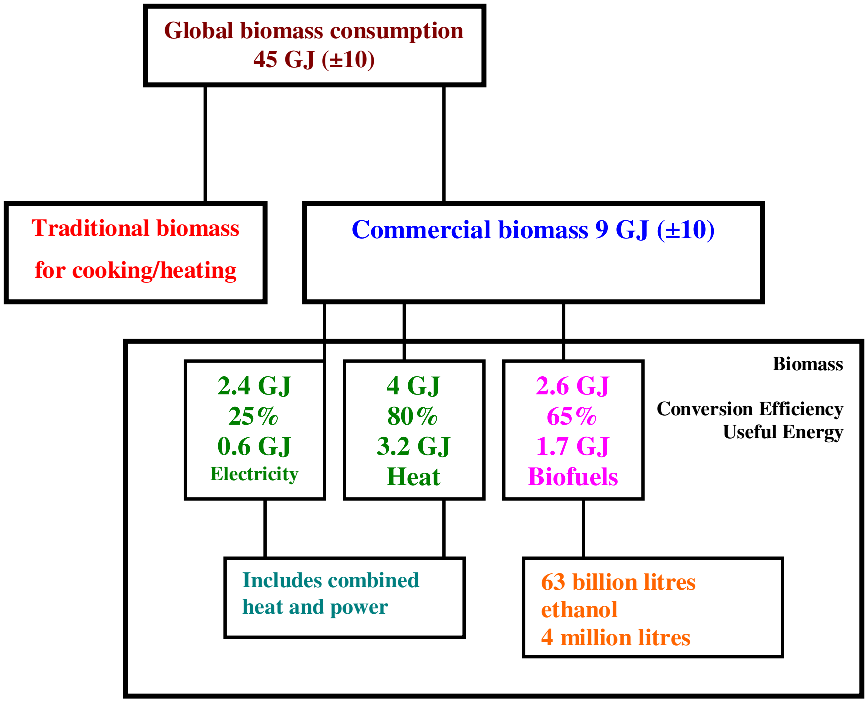

Figure 6. Contribution of biomass to global primary and consumer energy supplies.

primary and consumer energy supplies. Food and fodder availability is very closely related to energy availability.

APPLICATIONS

There are various successful applications of renewable technologies:

Water management

The current global usage of water identified to be 75% of an overall water consumption for agricultural purposes (Gilman, 1994). Excess heat and scarcity of water are the two major problems, which are usually encountered in irrigating land especially in the arid and semi-arid regions. It is predicted that a higher future demand on crops would take place as a result of a rapid increase in the world's population leading to a serious dilemma on the global water resources in the future. Furthermore, with the current environmental problems (that is, global warming), many plants and trees started to be exposed to additional amount of heat, which resulted in hindering their growth. The current global requirements for optimising water usage for the agricultural purposes especially in the arid and semi-arid regions, considered being the most demanding task. Irrigation in these lands, encounters two major obstacles, which are lack of water and access heat that could damage plants and prevent them from a healthy growth and attainment of a maximum production of crops. There are numerous advantages that could be associated with proper water and heat management of agricultural lands especially in the arid and semi-arid regions. Beside water is being conserved; optimum water usage for irrigation at different meteorological conditions could result in a healthy growth and optimum production of crops. The amount of heat the plant is exposed to, could play a major role in the plant's growth and sometimes proper shading could be necessary to maintain a productive land. In general, a greater economical saving could be achieved if appropriate steps are taken to manage heat and water in these lands in order to attain a better production of crops.

Greenhouses environment

Greenhouse cultivation is one of the most absorbing and rewarding forms of gardening for anyone who enjoys growing plants. The enthusiastic gardener can adapt the greenhouse climate to suit a particular group of plants, or raise flowers, fruit and vegetables out of their natural season. The greenhouse can also be used as an essential garden tool, enabling the keen amateur to expand the scope of plants grown in the garden, as well as save money by raising their own plants and vegetables. There was a decline in large private greenhouses during the two world wars due to a shortage of materials for their construction and fuel to heat them. However, in the 1950s mass-produced, small greenhouses became widely available at affordable prices and were used mainly for raising plants (John, 2001). Also, in recent years, the popularity of conservatories attached to the house has soared. Modern double-glazing panels can provide as much insulation as a brick wall to create a comfortable living space, as well as provide an ideal environment in which to grow and display tender plants.

The comfort in a greenhouse depends on many environmental parameters. These include temperature, relative humidity, air quality and lighting. Although greenhouse and conservatory originally both meant a place to house or conserve greens (variegated hollies, cirrus, myrtles and oleanders), a greenhouse today implies a place in which plants are raised while conservatory usually describes a glazed room where plants may or may not play a significant role. Indeed, a greenhouse can be used for so many different purposes. It is, therefore, difficult to decide how to group the information about the plants that can be grown inside it.

Throughout the world urban areas have increased in size during recent decades. About 50% of the world's population and approximately 76% in the more developed countries are urban dwellers (United Nations, 1999). Even though there is an evidence to suggest that in many 'advanced' industrialised countries there has been a reversal in the rural-to-urban shift of populations, virtually all population growth expected between 2000 and 2030 will be concentrated in urban areas of the world. With an expected annual growth of 1.8%, the world's urban population will double in 38 years (United Nations, 1999). This represents a serious contributing to the potential problem of maintaining the required food supply. Inappropriate land use and management, often driven by intensification resulting from high population pressure and market forces, is also a threat to food availability for domestic, livestock and wildlife use. Conversion to cropland and urban-industrial establishments is threatening their integrity. Improved productivity of peri-urban agriculture can, therefore, make a very large contribution to meeting food security needs of cities as well as providing income to the peri-urban farmers. Hence, greenhouses agriculture can become an engine of pro-poor 'trickle-up' growth because of the synergistic effects of agricultural growth such as (United Nations, 1999):

- Increased productivity increases wealth.
- Intensification by small farmers raises the demand for wage labour more than by larger farmers.
- Intensification drives rural non-farm enterprise and employment.
- Alleviation of rural and peri-urban poverty is likely to have a knock-on decrease of urban poverty.

Despite arguments for continued large-scale collective schemes there is now an increasingly compelling argument in favour of individual technologies for the development of controlled greenhouses. The main points constituting this argument are summarised by (United Nations, 1999) as follows:

- Individual technologies enable the poorest of the poor to engage in intensified agricultural production and to reduce their vulnerability.
- Development is encouraged where it is needed most and reaches many more poor households more quickly and at a lower cost.
- Farmer-controlled greenhouses enable farmers to avoid the difficulties of joint management.

Such development brings the following challenges:

- The need to provide farmers with ready access to these individual technologies, repair services and technical assistance.
- Access to markets with worthwhile commodity prices, so that sufficient profitability is realised.
- This type of technology could be a solution to food security problems. For example, in greenhouses, advances in biotechnology like the genetic engineering, tissue culture and market-aided selection have the potential to be applied for raising yields, reducing pesticide excesses and increasing the nutrient value of basic foods.

However, the overall goal is to improve the cities in accordance with the Brundtland Report (WCED, 1987) and the investigation into how urban green could be protected. Indeed, greenhouses can improve the urban environment in multitude of ways. They shape the character of the town and its neighborhoods, provide places for outdoor recreation, and have important environmental functions such as mitigating the heat island effect, reduce surface water runoff, and creating habitats for wildlife. Following analysis of social, cultural and ecological values of urban green, six criteria in order to evaluate the role of green urban in towns and cities were prescribed (WCED, 1987). These are as follows:

- Recreation, everyday life and public health.
- Maintenance of biodiversity - preserving diversity within species, between species, ecosystems, and of landscape types in the surrounding countryside.
- City structure - as an important element of urban structure and urban life.
- Cultural identity - enhancing awareness of the history of the city and its cultural traditions.
- Environmental quality of the urban sites - improvement of the local climate, air quality and noise reduction.
- Biological solutions to technical problems in urban areas - establishing close links between technical infrastructure and green-spaces of a city.

The main reasons why it is vital for greenhouses planners and designers to develop a better understanding of greenhouses in high-density housing can be summarised as follows (WCED, 1987):

- Pressures to return to a higher density form of housing.
- The requirement to provide more sustainable food.
- The urgent need to regenerate the existing, and often

decaying, houses built in the higher density, high-rise form, much of which is now suffering from technical problems.

The connection between technical change, economic policies and the environment is of primary importance as observed by most governments in developing countries, whose attempts to attain food self-sufficiency have led them to take the measures that provide incentives for adoption of the Green Revolution Technology (Herath, 1985). Since, the Green Revolution Technologies were introduced in many countries actively supported by irrigation development, subsidised credit, fertiliser programmes, self-sufficiency was found to be not economically efficient and often adopted for political reasons creating excessive damage to natural resources. Also, many developing countries governments provided direct assistance to farmers to adopt soil conservation measures. They found that high costs of establishment and maintenance and the loss of land to hedgerows are the major constraints to adoption (Herath, 1985). The soil erosion problem in developing countries reveals that a dynamic view of the problem is necessary to ensure that the important elements of the problem are understood for any remedial measures to be undertaken. The policy environment has, in the past, encouraged unsustainable use of land (Herath, 1985). In many regions, government policies such as provision of credit facilities, subsidies, price support for certain crops, subsidies for erosion control and tariff protection, have exacerbated the erosion problem. This is because technological approaches to control soil erosion have often been promoted to the exclusion of other effective approaches. However, adoption of conservation measures and the return to conservation depend on the specific agro-ecological conditions, the technologies used and the prices of inputs and outputs of production.

Heat balance: The greenhouse effect is one result of the differing properties of heat radiation generated at different temperatures. The high temperature sun emits radiation of short wavelength, which can pass through the atmosphere and through glass. Objects inside the greenhouse (or any other building), such as plants, absorb and then re-radiate this heat. Because the objects inside the greenhouse are at a lower temperature than the sun the radiated heat is of longer wavelengths and, hence, cannot re-penetrate the glass. This re-radiated heat is therefore trapped and causes the temperature inside the greenhouse to rise (BRECSU, 2000). It has been observed that there is a significant rise of between 2.5 and 15°C in the enclosed room air temperature of a controlled environment greenhouse as reported by various authors (Farm Energy Centre, 2000; Randall, 1998; Tiwari and Goyal, 1998; Santamouris et al., 1994; Santamouris et al., 1993; Mercier, 1982; Grafiadellis, 1987; Fotiades, 1987; Pacheco et al., 1987; Santamouris et al., 1996; Garzoli and Blackwell, 1981; Chandra and Albright, 1980). This leads to a thermal energy saving for heating a greenhouse and maintaining a favourable environment for crop production during the off-season of up to 75%.

At a certain prescribed depth an imposed temperature equal to a seasonal average ambient temperature, it is possible to identify the main parameters influencing the thermal behaviour of a greenhouse, which lead to a better understanding of the different processes inside the greenhouse.

Using the above concept with synthetic meteorological data (e.g., solar radiation, ambient temperature, wind speed, relative humidity, ground temperature, thermal and physical properties of the ground) will allow the prediction of energy consumption during a whole season in order to maintain the required inside air conditions for plant growth. Further modifications and introducing the more complex problem of plant growth, will allow programming the greenhouse for specific plants, thus improving the economic rentability of very specific types of solar collector.

Ventilation: Whereas heat loss in winter is a problem, it can be a positive advantage when greenhouse temperatures soar considerably above outside temperatures in summer. Table 2 illustrates typical greenhouse temperatures and gives an idea of temperature variation in a greenhouse. Therefore, ventilation is required to maintain the temperature at a level that plants can thrive, and to remove the still, humid air, which encourages the development of diseases. This can be achieved by natural ventilation, where warm air escapes and cool air enters through vents in the greenhouse roof (rigid vents), or by forced air ventilation, where a motorised fan designed specifically for greenhouses sucks warm air out of the greenhouse and pulling cool air in through openings on the opposite side.

The addition of side vents, which are optional extras on many small greenhouses, will, also, provide a more rapid movement of air. Cool air is drawn in from the side vents. As it heats up, it rises until it drawn out of the ridge vents. If only top ventilation is fitted, care needs to be taken not to open the vents too rapidly as rising warm air, particularly on cold days, will be quickly replaced by a block of cold air, which can prove a shock to plants. Where additional vents are available, these are best positioned on sidewalls. Table 3 gives typical ventilation space and vent numbers required for different greenhouses. Louvers will give adequate side ventilation and are less likely to cause draughts than standard ventilations (Anne, 1989). Further, the door opening can provide additional ventilation, which is particularly valuable in small greenhouses. However, this is not always desirable where security is a problem. Generally, ventilators should be provided on all sides of the greenhouse, so that on windy days the windward side can be closed to prevent draughts, while ventilation is opened on the leeward end side. The temperature in small greenhouses can rise rapidly, and

Table 2. Typical greenhouse temperatures.

Minimum winter temperature	Conditions
4°C	Frost-free
10°C	Temperate
15°C	Tropical

Table 3. Ventilation needs.

Greenhouse size	Ground area	Ridge ventilators space required	Number of 0.6 x 0.6 m ridge-vents required
1.8 x 2.5 m	4.5 m^2	0.9 m^2	3
2.5 x 3 m	7.5 m^2	1.5 m^2	4
3 x 3.7 m	11.1 m^2	2.2 m^2	6
3.7 x 4.3 m	15.9 m^2	3.2 m^2	9

and, hence, requires continuous monitoring and control. Note that manual control may lead to wide fluctuations in temperature. However, sufficient ventilation in greenhouse is essential for healthy plant growth. Hence, warm air gathering inside the roof may need to be released through a mop fan and replaced by cooler air.

Relative humidity: Air humidity is measured as a percentage of water vapour in the air on a scale from 0 - 100%, where 0% being dry and 100% being full saturation level. The main environmental control factor for dust mites is relative humidity. The followings are the practical methods of controlling measures available for reducing dust mite populations:

- Chemical control.
- Cleaning and vacuuming.
- Use of electric blankets, and
- Indoor humidity.

Indoor relative humidity control is one of the most effective long-term mite control measures. There are many ways in which the internal relative humidity can be controlled including the use of appropriate ventilation, the reduction of internal moisture production and maintenance of adequate internal temperatures through the use of efficient heating and insulation (Lynn, 1993). Plants, usually, require a humidity level of 50 - 60%, and succulents require 35 - 40% (Lynn, 1993). For small greenhouses, simple, automatic controls would create ideal conditions for plants and ensure that ventilation is provided only when required. This prevents the rapid fluctuations in temperature and higher fuel bills that can occur with manual control. For larger ones, however, more sophisticated controls may need to be implemented.

As the sun comes through the glass and gives the plants the energy they need to grow, it will, also, quickly raise the temperature. With no shade and inadequate ventilation, temperatures up to 35°C can be reached very quickly. This is uncomfortable for both plants and people, although plants can tolerate high temperatures, if provided with good ventilation. Also, to allow the carbon dioxide needed for photosynthesis into the plant, the small pores in the leaf, called stomata, must be open and so water will be lost into the air. Keeping the atmosphere humid will help, but eventually the plant will have to shut its stomata, and then growth will come to a stop. All plants have a minimum, optimum and maximum temperature for growth. During the time of the year when they are actively growing, a temperature as close as possible to the optimum is preferred.

The ideal living area: Most people would maintain a steady temperature between 15.5 and 21°C. For comfort, the level of atmospheric humidity should be low and indeed living areas should, generally, have a dry atomsphere (Lynn, 1993). Hence, artificial heating in autumn, winter and spring will, usually, be required.

Plants cannot live comfortably in an area of high humidity like human beings. Also, most plants do not like the combination of high temperatures and dry air. Tropical and sub-tropical plants, for instance, would make very poor growth in such environment and the leaves may shrive and dry up, or turn brown at the edges. Table 4, which is reproduced from (Lynn, 1993), classifies plants according to their climate preferences. The table, also, indicates that there are many plants that can be grown in a humid 'microclimate'. During the summer the greenhouse is generally warm and plants are sizzling. Good thermometers are good troubleshooters and enable the greenhouse operator to monitor the shifts in temperature and take appropriate action when necessary. Also, greenhouses can be very arid places in summer. Most greenhouse plants prefer a slightly humid atmosphere. A group of plants growing together will create heir own, more humid microclimate. Plants fro

Table 4. Atmospheric conditions for plants (Lynn, 1993).

Types/conditions	Warm conditions and high humidity	Warm conditions and thrive in a dry atmosphere	Cool
Shrubs	Aphelandra, Gardenia	Lantana, Cestrum	Acacia, Lantana
Climbers	Allamanda, Hoya	Plumbago	Jasminum, Plumbago
Flowering pot plants short-term	Capsicum, Celosia	Ipomoea	Solanum, Primula
Flowering pot plants long-term	Begonia, Euphorbia	Fuchsis, Cacti	Clivia, Erica
Foliage pot plants	Ferns, Ficus	Sansevieria	Coleus, Hedera
Bulbous and tuberous plants	Canna	Vallota, Gloriosa	Cyclamen, Lilium
Fruits	Citrus	-	Vitis Vinifera, Prunus Persica

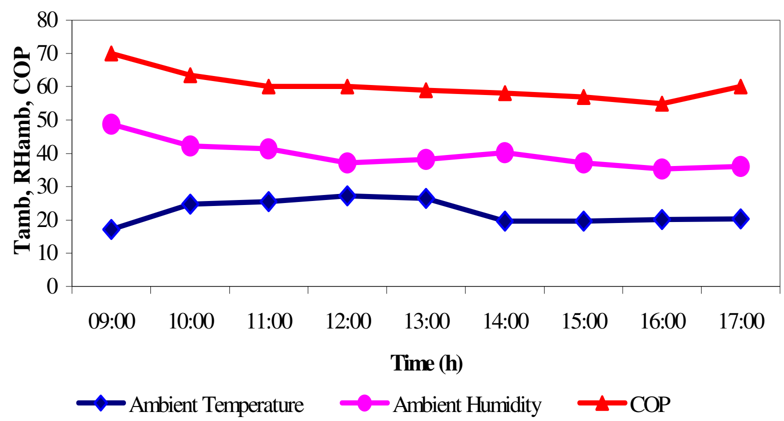

Figure 7. Ambient temperature, relative humidity and COP.

the Mediterranean are a good choice as they are naturally adapted to hot and dry summer.

Transpiration: Transpiration is a process used by plants to maintain their temperature when the environment is too warm. It serves the same functions as sweating in some animals. In order to cool the area around it, plants release water through the leaves. High rates of transpiretion will occur if temperature of the growing environment is too high, and this can seriously affect the nutrient solution. As a plant transpires, it will draw up more water from the solution to replace what has been lost. This will have an impact on the water ratio of the nutrient solution, which will affect both pH (potential of Hydrogen) and the level of conductivity of these nutrients from soil to the plant. Maintaining a basic nutrient solution of pH, which, in turn, affects how easy the plant, can take in the nutrient solution. In a good growing environment, the quantity of growth and yield primarily depends on the quality of the nutrient solution. A nutrient solution contains (Paul, 2001):

- Water
- A nutrient concentrate, which provides the basic food for plants.
- One or more nutrient additives, which provide supplementary nutrients, required to promoting specific processes within the plants development.
- Possibly pH solution.

Plants, like human beings, need tender loving care in the form of optimum settings of light, sunshine, nourishment, and water. Hence, the control of sunlight, air humidity and temperatures in greenhouses are the key to successful greenhouse gardening. The mop fan is a simple and novel air humidifier; which is capable of removing particulate and gaseous pollutants while providing ventilation. It is a device ideally suited to greenhouse applications, which require robustness, low cost, minimum maintenance and high efficiency. A device meeting these requirements is not yet available to the farming community. Hence, implementing mop fans aids sustainable development through using a clean, environmentally friendly device that decreases load in the greenhouse and reduces energy consumption. The effect of indoor (greenhouse) conditions and outdoor (ambient) conditions (temperature and relative humidity) on system performance is illustrated in Figure 7.

Heat transfer: The total rate of heat transfer on a surface

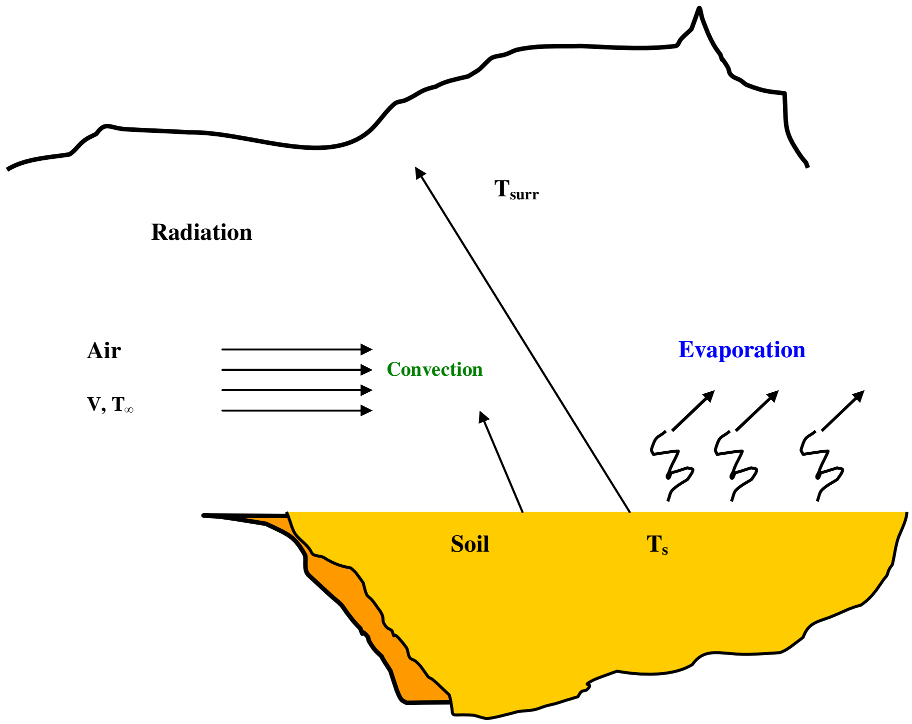

Figure 8. A combination of heat and mass transfer on the surface.

of a soil per unit area Q^n_{total}, shown in Figure 8, is a combination of radiation heat transfer Q^n_{rad}, convection heat transfer Q^n_{conv} and heat transfer sue to evaporation Q^n_{evap}, illustrated in the following equation:

$$Q^n_{total} = Q^n_{rad} + Q^n_{conv} + Q^n_{evap} \quad (3)$$

Where:

Q^n_{rad} Can be expressed in terms of emissive ε, surface temperature T_s and the surrounding temperature T_{surr}:

$$Q^n_{rad} = \varepsilon\ \delta\ (T_s - T_{surr}) \quad (4)$$

For the rate of convection heat transfer Q^n_{conv}, combinations of both natural and forced convection are considered especially for low air velocities. The vapour pressure of air far away from the watered-surface $P_{v,\infty}$, is a function of relative humidity φ and saturated water vapour pressure $P_{T\infty,\ sat}$ (Cengel, 1998):

$$P_{v,\infty} = \varphi\ P_{T\infty,\ sat} \quad (5)$$

Treating the water vapour and air an ideal gas, the densities of water vapour, dry air and their mixture at air-water interface and far from the surface are determined in the following equations:

At the surface:

$$\rho_{v,s} = P_{v,s}/R_v T_s \quad (6)$$

$$\rho_{a,s} = P_{a,s}/R_a T \quad (7)$$

$$\rho_s = \rho_{v,s} + \rho_{a,s} \quad (8)$$

And away from the surface:

$$\rho_{v,\infty} = P_{v,\infty}/R_v T_\infty \quad (9)$$

$$\rho_{a,\infty} = P_{a,\infty}/R_a T_\infty \quad (10)$$

$$\rho_\infty = \rho_{v,\infty} + \rho_{a,\infty} \quad (11)$$

$$\left\{ \begin{array}{ll} G_r/R_e^2 < 0.1 & \text{forced convection} \\ < G_r/R_e^2 < 10 & \text{mixed (forced + natural) convection} \\ 10 < G_r/R_e^2 & \text{natural convection} \end{array} \right\} \quad (12)$$

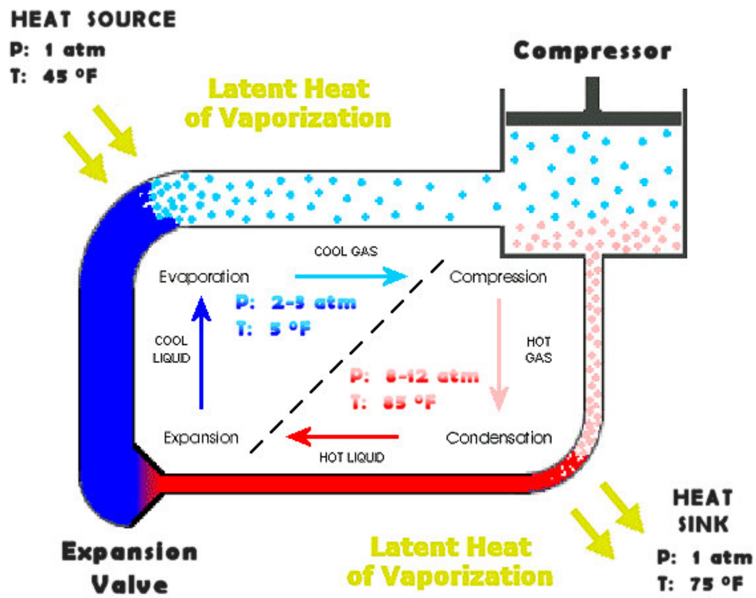

Figure 9. Heat pump works by promoting the evaporation and condensation of a refrigerant.

Where: G_r is Grash of number and R_e is Reynolds.

GROUND SOURCE HEAT PUMPS

Heat pumps function by moving (or pumping) heat from one place to another. Like a standard air-conditioner, a heat pump takes heat from inside a building and dumps it outside. The difference is that a heat pump can be reversed to take heat from a heat source outside and pump it inside. Heat pumps use electricity to operate pumps that alternately evaporate and condense a refrigerant fluid to move that heat. In the heating mode, heat pumps are far more "efficient" at converting electricity into usable heat because the electricity is used to move heat, not to generate it.

The most common type of heat pump-air-source heat pump-uses outside air as the heat source during the heating season and the heat sink during the air-conditioning season. Ground-source and water-source heat pumps work the same way, except that the heat source/sink is the ground, groundwater, or a body of surface water, such as a lake. For simplicity, water-source heat pumps are often lumped with ground-source heat pumps, as in this case.

The efficiency or coefficient of performance (COP) of ground-source heat pumps (GSHPs) is significantly higher than that of air-source heat pumps because the heat source is warmer during the heating season and the heat sink is cooler during the cooling season. GSHPs are also known as geothermal heat pumps.

GSHPs are environmentally attractive because they deliver so much heat or cooling energy per unit of electricity consumed. The COP is usually 3 or higher. The best GSHPs are more efficient than high-efficiency gas combustion, even when the source efficiency of the electricity is taken into account.

GSHPs are generally most appropriate for residential and small commercial buildings, such as small-town post offices. In residential and small (skin-dominated) commercial buildings, GSHPs make the most sense in mixed climates with significant heating and cooling loads because the high-cost heat pump replaces both the heating and air-conditioning system.

Because GSHPs are expensive to install in residential and small commercial buildings, it sometimes makes better economic sense to invest in energy efficiency measures that significantly reduce heating and cooling loads, and then install less expensive heating and cooling equipment. The savings in equipment may be able to pay for most of the envelope improvements. If a GSHP is to be used, planning the site work and project scheduling needed so carefully that the ground loop can be installed with minimum site disturbance or in an area that will be covered by a parking lot or driveway.

GSHPs are generally classified according to the type of loop used to exchange heat with the heat source/sink. Most common are closed-loop horizontal and closed-loop vertical systems (Figure 9). Using a body of water as the heat source/sink is very effective, but seldom available as an option. Open-loop systems are less common than closed-loop systems due to performance problems (if detritus gets into the heat pump) and risk of contaminating the water source or, in the case of well water, inadequately recharging the aquifer. GSHPs are complex. Basically, water or a nontoxic antifreeze-water mix is circulated through buried polyethylene or polybutylene piping. This water is then pumped through one of two heat exchangers in the heat pump. When used in the heating mode, this circulating water is pumped through the cold heat exchanger, where its heat is absorbed by evapouration of the refrigerant. The refrigerant is then pumped to the warm heat exchanger, where the refrigerant is condensed, releasing heat in the process. This sequence is reversed for operation in the cooling mode.

Direct-exchange GSHPs use copper ground-loop coils that are charged with refrigerant. This ground loop thus serves as one of the two heat exchangers in the heat pump. The overall efficiency is higher because one of the two separate heat exchangers is eliminated, but the risk of releasing the ozone-depleting refrigerant into the environment is greater. Direct-exchange systems have a small market share.

An attractive alternative to conventional heating, cooling, and water heating equipment is the GSHP. The higher initial cost of this equipment must be justified by operating cost savings. Therefore, it is necessary to predict energy use and demand. However, there are no seasonal ratings for this type of equipment. The ratings for GSHPs calculate performance at a single fluid temperature (32°F) for heating COP and a second for cooling energy efficiency rating (EER) (77°F). These ratings reflect temperatures for an assumed location and ground heat exchanger type, and are not ideal indicators of energy use.

This problem is compounded by the nature of ratings for conventional equipment. The complexity and many assumptions used in the procedures to calculate the seasonal efficiency for air-conditioners, furnaces, and heat pumps (SEER, AFUE, and HSPF) make it difficult to compare energy use with equipment rated under different standards. The accuracy of the results is highly uncertain, even when corrected for regional weather patterns. These values are not indicators for demand since they are seasonal averages and performance at severe conditions is not heavily weighted.

The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) recommends a weather driven energy calculation, like the bin method, in preference to single measure methods like SEER, HSPF, EER, COP, and AFUE. The bin method permits the energy use to be calculated based on local weather data and equipment performance over a wide range of temperatures (Heinonen et al., 1996). The bin method also calculates demand at the most severe conditions. This method was used to compare the energy use and demand of high efficiency equipment in Sacramento, California and Salt Lake City, Utah. The equipment considered was a high efficiency single speed air source, a variable speed air source heat pump and electric air-conditioner with a natural gas furnace, and a GSHP (Heinonen et al., 1996).

Heat pump principles

Heat flows naturally from a higher to a lower temperature. Heat pumps, however, are able to force the heat flow in the other direction, using a relatively small amount of high quality drive energy (electricity, fuel, or high-temperature waste heat). Heat pumps can transfer heat from natural heat sources such as the air, ground or water, to a building. By reversing the heat pump it can also be used for cooling. Heat is transferred in the opposite direction, from the application that is cooled, to surroundings at a higher temperature.

In order to transport heat external energy is needed to drive the heat pump. Theoretically, the total heat delivered by the heat pump is equal to the heat extracted from the heat source, plus the amount of drive energy supplied. Electrical powered heat pumps, for heating buildings, typically supply 100 kWh of heat with just 20 - 40 kWh of electricity. Because heat pumps consume less energy than conventional heating systems, there use will help to reduce the harmful emissions of carbon dioxide, Sulphur dioxide and nitrogen oxides. However, the over-all environmental impact of electric heat pumps depends very much on how the electricity is produced. Heat pumps driven by electricity generated by hydropower, wind power, photovoltaics or other renewable sources will reduce emissions more significantly than if the electricity is generated by coal, oil or gas-fired power plants.

The great majority of heat pumps work on the principle of the vapour compression cycle. The main components in such a heat pump are the compressor, the expansion valve and the two heat exchangers referred to as the evaporator and the condenser. A heat pump can take heat out of an interior space, or it can put heat into an interior space (Figures 10 - 11). A volatile liquid, known as the working fluid or refrigerant, circulates through the four components. In the evaporator the temperature of the refrigerant is kept lower than the temperature of the heat source. This allows heat to flow from the heat source (ground loops, air or loops in water e.g., rivers etc.) to the refrigerant. As the refrigerant warms up it evaporates. This vapour is then compressed by the com-pressor to a higher pressure and temperature. The hot vapour then enters the condenser, where it condenses and gives off useful heat. Finally, the high-pressure working fluid is expanded to the evaporator pressure and temperature in the expansion valve. The refrigerant is returned to its original state and once again enters the evaporator.

The compressor is driven by an electric motor and pumps circulate the water through (ground loops, or loops in water e.g., rivers etc.). The domestic fridge uses the same technology. When putting food and drink into

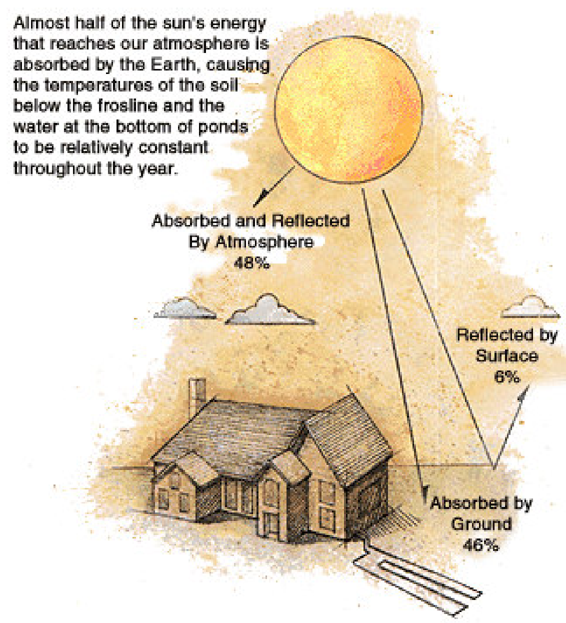

Figure 10. Earth heat.

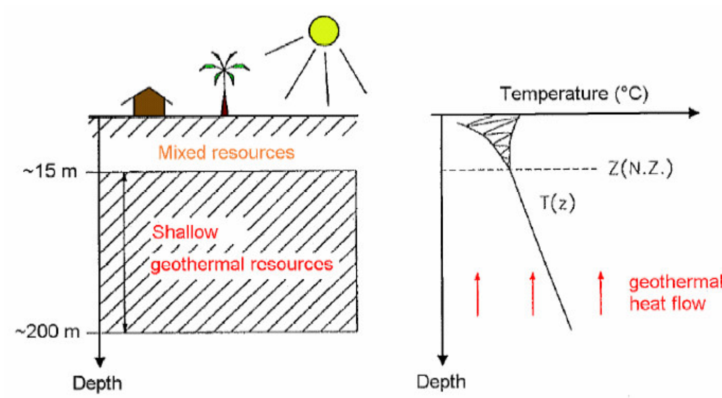

Figure 11. Geothermal energy, comprising geothermal and mixed resources in the shallow subsurface.

fridge the low-grade heat it carries (after all it is usually warmer than the inside of the fridge) is transferred from the icebox to the refrigerant in the unit. The refrigerant is then compressed and expanded to raise the heat; this high grade heat is then expelled from the back of the fridge. This is why the inside of the fridge remains cold whilst the back of the fridge gets hot.

In the cooling mode, cool vapour arrives at the compressor after absorbing heat from the building. The compressor compresses the cool vapour into a smaller volume, increasing its heat density. The refrigerant exits the compressor as a hot vapour, which then goes into the earth loop field. The loops act as a condenser condensing the vapour until it is virtually all-liquid. The refrigerant leaves the earth loops as a warm liquid. The flow control regulates the flow from the condenser such that only liquid refrigerant passes through the control. The refrigerant expands as it exits the flow control unit and becomes a cold liquid.

The term “ground source heat pump” has become an all-inclusive term to describe a heat pump system that uses the earth, ground water, or surface water as a heat source and/or sink. The GSHP systems consist of three loops or cycles as shown in Figure 12. The first loop is on the load side and is either air/water loop or a water/ water loop, depending on the application. The second loop is the refrigerant loop inside a water source heat pump. Thermodynamically, there is no difference between the well-known vapour-compression refrigeration cycle and the heat pump cycle; both systems absorb heat at a low

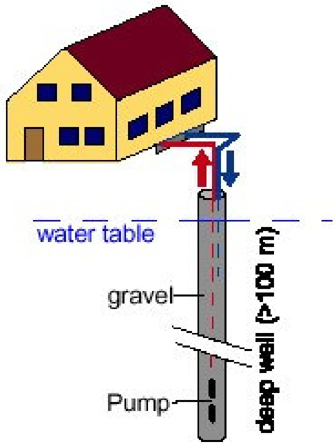

Figure 12. Standing column well.

Figure 13. A photograph showing the connection of heat pump to the ground source.

temperature level and reject it to a higher temperature level. The difference between the two systems is that a refrigeration application is only concerned with the low temperature effect produced at the evaporator, while a heat pump may be concerned with both the cooling effect produced at the evaporator as well as the heating effect produced at the condenser. In these dual-mode GSHP systems, a reversing valve is used to switch between heating and cooling modes by reversing the refrigerant flow direction. The third loop in the system is the ground loop in which water or an antifreeze solution exchanges heat with the refrigerant and the earth.

The GSHPs utilise the thermal energy stored in the earth through either vertical or horizontal closed loop heat exchange systems buried in the ground. Many geological factors impact directly on site characterisation and subsequently the design and cost of the system. The solid geology of the United Kingdom varies significantly. Furthermore there is an extensive and variable rock head cover. The geological prognosis for a site and its anticipated rock properties influence the drilling methods and therefore system costs. Other factors important to system design include predicted subsurface temperatures and the thermal and hydrological properties of strata. GSHP technology is well established in Sweden, Germany and North America, but has had minimal impact in the United Kingdom space heating and cooling market. Perceived barriers to uptake include geological uncertainty, concerns regarding performance and reliability, high capital costs and lack of infrastructure. System performance concerns relate mostly to uncertainty in design input parameters, especially the temperature and thermal properties of the source. These in turn can impact on the capital cost, much of which is associated with the installation of the external loop in horizontal trenches or vertical boreholes. The temperate United Kingdom climate means that the potential for heating in winter and cooling in summer from a ground source is less certain owing to the temperature ranges being narrower than those encountered in continental climates. This project will develop an impartial GSHP function on the site to make available information and data on site-specific temperatures and key geotechnical characteristics.

The GSHPs are receiving increasing interest because of their potential to reduce primary energy consumption and thus reduce emissions of greenhouse gases. The technology is well established in North Americas and parts of Europe, but is at the demonstration stage in the United Kingdom. The information will be delivered from digital geoscience's themes that have been developed from observed data held in corporate records. These data will be available to GSHP installers and designers to assist the design process, therefore reducing uncertainties. The research will also be used to help inform the public as to the potential benefits of this technology.

Geothermal energy use has a net positive environmental impact. Geothermal power plants have fewer and more easily controlled atmospheric emissions than either fossil fuel or nuclear plants. Direct heat uses are even cleaner and are practically non-polluting when compared to conventional heating. Another advantage, which differentiates geothermal energy from other renewables, is its continuous availability, 24 h a day all year round. While production costs are at times competitive and in other cases marginally higher than conventional energy, front-end investment is quite heavy and not easily funded.

Heat pumps

A heat pump can take low temperature heat and upgrade it to a higher and more useful temperature (Figure 13). If this heat comes from an ambient source, for example outside air or the ground, the use of a heat pump can result in savings in fossil fuel consumption and thus a reduction in the emission of the GHGs and other pollutants. The GSHPs in particular are receiving increasing interest and the technology is now well established with over

550,000 units (80% of which are domestic) installed worldwide and over 66,000 installed annually (Huttrer, 2001). Despite increasing use elsewhere, the GSHPs are a relatively unfamiliar technology in the UK although the performance of systems is now such that, properly designed and installed, they represent a very carbon-efficient form of space heating.

The GSHPs can be used to provide space and domestic water heating and, if required, space cooling to a wide range of building types and sizes. The provision of cooling, however, will result in increased energy consumption and the efficiently it is supplied. The GSHPs are particularly suitable for new build as the technology is most efficient when used to supply low temperature distribution systems such as underfloor heating. They can also be used for retrofit especially in conjunction with measures to reduce heat demand. They can be particularly cost effective in areas where mains gas is not available or for developments where there is an advantage in simplifying the infrastructure provided. This application will concentrate on the provision of space and water heating to individual dwellings but the technology can also be applied to blocks of flats or groups of houses (Omer, 2003; Lund et al., 2005; Brain and Mark, 2007; Federal Ministry for the Environment, 2005; WRAP, 2006).

BIOENERGY UTILISATION

The increased demand for gas and petroleum, food crops, fish and large sources of vegetative matter mean that the global harvesting of carbon has in turn intensified. It could be said that mankind is mining nearly everything except its waste piles. It is simply a matter of time until the significant carbon stream present in municipal solid waste is fully captured. In the meantime, the waste industry needs to continue on the pathway to increased awareness and better optimised biowaste resources. Optimisation of waste carbon may require widespread regulatory drivers (including strict limits on the land filling of organic materials), public acceptance of the benefits of waste carbon products for soil improvements/crop enhancements and more investment in capital facilities. In short, a significant effort will be required in order to capture a greater portion of the carbon stream and put it to beneficial use. From the standpoint of waste practitioners, further research and pilot programmes are necessary before the available carbon in the waste stream can be extracted in sufficient quality and quantities to create the desired end products. Other details need to be ironed out too, including measurement methods, diversion calculations, sequestration values and determination of acceptance contamination thresholds.

The internal combustion engine is a major contributor to rising CO_2 emissions worldwide and some pretty dramatic new thinking is needed if our planet is to counter the effects. With its use increasing in developing world economies, there is something to be said for the argument that the vehicles we use to help keep our inner-city environments free from waste, litter and grime should be at the forefront of developments in low-emissions technology. Materials handled by waste management companies are becoming increasingly valuable. Those responsible for the security of facilities that treat waste or manage scrap will testify to the precautions needed to fight an ongoing battle against unauthorised access by criminals and crucially, to prevent the damage they can cause through theft, vandalism or even arson. Of particular concern is the escalating level of metal theft, driven by various factors including the demand for metal in rapidly developing economies such as India and China.

Biogas technology

Anaerobic digestion (AD) has, for some time, been considered an important technology in the treatment of waste and in the development of energy recovery solutions. Historically, many anaerobic digestion plants have tended to specialise in the treatment of manure or sludge. In today's market, the latest AD plants have to handle more complex substances and varying volume streams. As a result, the demands placed on this technology in terms of reliability, stability and robustness are significant. Also, significant is the potential contribution AD could make to solving our most pressing environmental concern-namely a reduction in the anthropogenic emission of GHGs. AD technology can reduce unwanted and uncontrolled emissions of methane by tapping the energy potential of this gas while reducing the volume of waste going to landfill. Anaerobic digestion is a biochemical process where, in the absence of oxygen, bacteria break down organic matter to produce biogas plus liquor and a fibre.

The biogas consists of 55 - 70% methane (CH_4) and 30 - 45% carbon dioxide (CO_2) and can be used to generate energy through a generator. The energy content of biogas is 20 - 25 MJm^3. Alternatively; the gas can be cleaned and then either compressed for use in vehicle transport (compressed natural gas) or injected into the gas distribution network. An average CH_4 yield per metric ton of treated waste (sludge, manure) ranges from 50 - 90 Nm^3 per ton and for municipal solid waste (MSW) the yield increases to 75 - 120 Nm^3 per ton. The liquid fraction, with a high nutrient content and the fibre fraction can be used as a soil improver. More modern plants have been developed to process MSW, industrial solid wastes and industrial wastewaters, but impurities and the varying content of lipids, proteins and carbohydrates can cause problems. These wastes can be characterised according to their COD concentration. COD refers to the total quantity of oxygen required for oxidation to carbon dioxide and water and is a measure of the organic content of the waste. COD loading rate is the daily quantity of organic

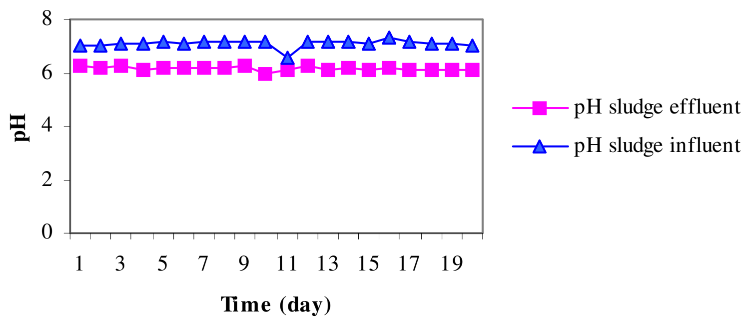

Figure 14. pH sludge before and after treatment in the digester

matter, expressed COD, feed per m^3 digester volume per day that is, kg COD/m^3/d. Some systems have been invented to process substrates with a minor COD concentration (<25 gO_2/litre raw material), for example:

- Up flow anaerobic sludge blanket (UASB).
- Expanded granular sludge blanket (EGSB).
- Internal circulation (IC).

With a loading rate of ≥15 kg COD/m^3 fermenter/d it possessed a sharp differentiation to traditional biogas plants. The advantages of the system are the following:
- Prevention of foam and floating layers- therefore high loading rates:

- No chemical requirement, no pH regulation- therefore cost savings.
- Low hydraulic retention time- therefore low demand for fermenter volume.
- Intense contact between substrate and microorganisms- therefore high degradation rates and rapid gas production.
- No accumulation of settling sediments (e.g., sand) in the system- thus supporting continuous operation.

The organic matter was biodegradable to produce biogas and the variation show a normal methanogene bacteria activity and good working biological process as shown in Figure 14. There are a number of factors that will give rise to greater interest in technologies such as AD. These include:

- Growing energy costs and import dependency within many countries.
- Decreasing capacity for landfill.
- Increasing world energy demand, in particular in China and India.
- Climate change needing urgent reactions and activities.
- 45% of European soils suffering from low organic matter content and reduced fertility.
- The most practical environmental solution will be deriving energy from waste, not only municipal solid waste but also the residues industry.

Anaerobic digestion has significant potential for industries with organic waste streams, such as food processing, the paper and textile industry, pharmaceutical industry and biofuels production. Anaerobic digestion combines several advantages. As a technology it can be regarded as being 'CO_2 neutral' because there is no net addition of CO_2 to the atmosphere. It degrades waste while producing biogas and a fertiliser product that contains a high nutrient content (nitrogen, phosphorous and potassium), but in order for the full potential of the waste/organic substrate/input to be realised, it is vital that the waste management industry is able to develop markets for all the by-products.

Sewage sludge

Sewage sludge is rich in nutrients such as nitrogen and phosphorous. It also contains valuable organic matter, useful for remediation of depleted or eroded soils. This is why untreated sludge has been used for many years as a soil fertiliser and for enhancing the organic matter of soil. A key concern is that treatment of sludge tends to concentrate heavy metals, poorly biodegradable trace organic compounds and potentially pathogenic organisms (viruses, bacteria and the like) present in wastewaters. These materials can pose a serious threat to the environment. When deposited in soils, heavy metals are passed through the food chain, first entering crops, and then animals that feed on the crops and eventually human beings, to whom they appear to be highly toxic. In addition they also leach from soils, getting into groundwater and further spreading contamination in an uncontrolled manner. European and American markets aiming to transform various organic wastes (animal farm wastes, industrial and municipal wastes) into two main by-products:

- A solution of humic substances (a liquid oxidate).
- A solid residue.

The key to successful future appears to lie with successful marketing of the treatment by products. There is also potential for using solid residue in the construction industry as a filling agent for concrete. Research suggests that the composition of the residue locks metals within the material, thus preventing their escape and any subsequent negative effect on the environment.

Conclusion

Newspapers, TV, schools, universities and politicians rant and rave about being 'green' and doing our bit for the environment, but can we as individuals change things? Energy efficiency brings health, productivity, safety, comfort and savings to homeowner, as well as local and global environmental benefits. The use of renewable energy resources could play an important role in this context, especially with regard to responsible and sustainable development. It represents an excellent opportunity to offer a higher standard of living to local people and will save local and regional resources. Implementation of greenhouses offers a chance for maintenance and repair services. It is expected that the pace of implementation will increase and the quality of work to improve in addition to building the capacity of the private and district staff in contracting procedures. The financial accountability is important and more transparent. Various passive techniques have been put in perspective, and energy saving passive strategies can be seen to reduce interior temperature and increase thermal comfort, reducing air conditioning loads. The scheme can also be employed to analyze the marginal contribution of each specific passive measure working under realistic conditions in combination with the other housing elements. In regions where heating is important during winter months, the use of top-light solar passive strategies for spaces without an equator-facing façade can efficiently reduce energy consumption for heating, lighting and ventilation.

Nomenclature: E_y; Annual energy yield in kWh, **w;** The wind speed in m/s, **n;** The number of data bins converting the wind speed range of the turbine (0.5 or 1 m/s intervals), f_{wi}; The number of hours per year for which wind speed is w m/s, P_{wi}; is the power resulting from a wind speed of w m/s, Q^n_{conv}; Rate of convection heat transfer per unit area, W/m^2, Q^n_{evap}; Rate of heat transfer per unit area due to evaporation, W/m^2, Q^n_{rad}; Rate of radiation heat transfer per unit area, W/m^2, Q^n_{total}; Total rate of heat transfer per unit area, W/m^2, T_s; Soil surface temperature, ℃, T_{surr}; Surrounding temperature, ℃, T_∞; Airflow temperature far from the surface, ℃, G_r; Grashof number, dimensionless, R_e; Reynolds number dimensionless, **DC;** Direct current, **HSPF;** Heating season performance factor, **SEER;** Seasonal energy efficiency ratio, **EER;** Energy efficiency rating, **DX;** Direct expansion, **GS**; Ground source, **EPA;** Environmental Protection Agency.

Greek letters: **ε;** Surface emissivity, dimensionless, **φ;** Relative humidity, dimensionless, **ρ;** Density, kg/m^3, **δ;** Stefan-Boltzmann constant, 5.67 x 10^{-8} W/m^{2}K

Subscripts: a; Air, **v;** Vapour, **sat;** Saturated, ∞; Far away from the surface, **s;** Surface.

REFERENCES

Reddy A, Williams R, Johansson T (2006). Energy after Rio: prospects and challenges. United Nations Development Programme (UNDP). http://www.undp.org/seed/energy/exec-en.html.

Cavallo AJ, Grubb MJ (1993). Renewable energy sources for fuels and electricity. London: Earthscan Publications. Pp. 15-21.

REN21 (2007). Renewables 2007 global status report. www.ren21.net.

Gilman K (1994). Water of wetland areas. In: Proceedings of a Conference on the Balance of Water – Present and Future. Dublin: Ireland, pp. 123-142.

John W (2001). The glasshouse garden. The Royal Horticultural Society Collection. UK. pp. 7-31.

United Nations (1987). World Urbanisation Prospect: The 1999 Revision. New York. The United Nations Population Division pp.10-25.

WCED (1987). Our common future. New York. Oxford University Press. pp. 20-25.

Herath G (1985). The Green Revolution in Asia: productivity, employment and the role of policies. Oxf. Agrarian Stud. 14: 52-71.

BRECSU (2000). Energy use in offices. Energy Consumption Guide 19. Watford: Building Research Energy Conservation Support Unit. Farm Energy Centre. Helping agriculture and horticulture through technology, energy efficiency and environmental protection. Warwickshire pp. 10-30.

Randall M (1998). Environmental Science in Building. Third Edition. pp. 6-14.

Tiwari GN, Goyal RK (1998). Greenhouse technology. New Delhi: Narosa Publishing House pp. 9-12.

Santamouris M, Balaras CA, Dascalaki E, Vallindras M (1994). Passive solar agricultural greenhouse; a worldwide classification evaluation of technologies and systems used for heating purpose. Solar Energy 53(5): 411-426.

Santamouris, M., Arigirious A, Vallindras M (1993). Design and operation of a low energy consumption passive greenhouse. Solar Energy 52(5): 371-8.

Mercier I (1982). Design and operation of a solar passive greenhouse in the South West France. In: Proceedings of the International Congress on Energy Conservation of Agriculture and Fishculture. London pp. 18-23.

Grafiadellis M (1987). Greenhouse heating with solar energy. In: Von Zabettitz C (Editor), FAO, Rome pp. 5-14.

Fotiades, I. Energy conservation and renewable energies. In: Von Zabettitz C (1987). (Editor), FAO, Rome pp. 16-25.

Pacheco M, Marreivos S, Rosa M (1987). Energy conservation and renewable energies for greenhouse heating. In: Von Zabettitz C (Editor), FAO, Rome pp. 10-19.

Santamouris M, Mihalakakow G, Belaras CA, Lewis JO, Vallindras, M, Argiriou A (1996). Energy conservation in greenhouses with buried pipes. Energy 21(5): 353-360.

Garzoli KV, Blackwell J (1981). An analysis of the nocturnal heat loss from a single skim plastic greenhouse. J. Agric. Eng. Res. 26: 203-214.

Chandra P, Albright LD (1980). Analytical determination of the effect on greenhouse heating requirements of using night curtains. Trans ASAE 23(4): 9994-1000.

Anne S (1989). A handbook of greenhouse and conservatory plants. Paston Press. London. pp. 8-21.

Lynn B (1993). The pleasure of gardening. ANAYA Publishers Limited. London pp. 8-16.
Paul F (2001). Indoor hydroponics: A guide to understanding and maintaining a hydroponic nutrient solution. UK pp. 5-13.
Cengel Y (1998). Heat Transfer-A Practical Approach. First ed. McGraw-Hill, Inc. pp. 15-27.
Heinonen EW, Tapscott RE, Wildin MW, Beall AN (1996). Assessment of anti-freeze solutions for ground-source heat pumps systems. New Mexico Engineering Research Institute NMERI 96/15/32580, p.156.
Huttrer G (2001). The status of world geothermal power generation 1995-2000. Geothermics 30: 1-27.
Omer A (2003). Low energy building materials: an overview. In: Proceedings of the Environment 2010: Situation and Perspectives for the European Union. Porto: Portugal pp. 16-21.
Lund JW, Freeston DH, Boyd TL (2005). Direct application of geothermal energy: 2005 Worldwide Review. Geothermics 34: 691-727.
Brain G, Mark S (2007). Garbage in, energy out: landfill gas opportunities for CHP projects. Cogeneration and On-Site Power 8(5): 37-45.
Federal Ministry for the Environment (2005). Nature conservation and nuclear safety. Waste incineration- a potential danger pp. 8-17.
WRAP (2006). Environmental benefits of recycling: an international review of life cycle comparisons for key materials in the UK recycling sector pp. 12-13.