Demand for Energy Efficient, Eco-Friendly Environment, Applications and Sustainable Development

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ABSTRACT

Energy conservation is a key goal of the world economy and will continue to be the one in future. The most effective way to reduce energy demand is to use energy more efficiently. People rely upon oil for primary energy and this for a few more decades. Other orthodox sources may be more enduring, but are not without serious disadvantages. This article gives some examples of small-scale energy converters, nevertheless it should be noted that small conventional, i.e., engines are currently the major source of power in rural areas and will continue to be so for a long time to come. There is a need for some further development to suit local conditions, to minimise spares holdings, to maximise interchangeability both of engine parts and of the engine application. The renewable energy resources are particularly suited for the provision of rural power supplies and a major advantage is that equipment such as flat plate solar driers, wind machines, etc., can be constructed using local resources and without the advantage results from the feasibility of local maintenance and the general encouragement such local manufacture gives to the build up of small scale rural based industry. The key factors to reducing and controlling CO$_2$, which is the major contributor to global warming, are the use of alternative approaches to energy generation and the exploration of how these alternatives are used today and may be used in the future as green energy sources. Emphasis should be placed on full local manufacture. This article discusses the potential for such integrated systems in the stationary and portable power market in response to the critical need for a cleaner energy technology. Throughout the theme several issues relating to renewable energies, environment and sustainable development are examined from both current and future perspectives.

Keywords: Renewable energy technologies, energy efficiency, sustainable development, emissions, environment

INTRODUCTION

Power from natural resources has always had great appeal. Coal is plentiful, though there is concern about despoliation in winning it and pollution in burning it. Nuclear power has been developed with remarkable timeliness, but is not universally welcomed, construction of the plant is energy-intensive and there is concern about the disposal of its long-lived active wastes. Barrels of oil, lumps of coal, even uranium come from nature but the possibilities of almost limitless power from the atmosphere and the oceans seem to have special attraction. The wind machine provided an early way of developing motive power. The massive increases in fuel prices over the last years have however, made any scheme not requiring fuel appear to be more attractive and to be worth reinvestigation. In considering the atmosphere and the oceans as energy sources the four main contenders are wind power, wave power, tidal and power from ocean thermal gradients. The renewable energy resources are particularly suited for the provision of rural power supplies and a major advantage is that equipment such as flat plate solar driers, greenhouses, wind machines, etc., can be constructed using local resources and without the advantage results from the feasibility of local maintenance and the general encouragement such local manufacture gives to the build up of small scale rural based industry. Several definitions of sustainable development have been put forth, including the following common one: development that meets the needs of the present without compromising the ability of future generations to meet their own needs. A recent World Energy Council (WEC) study found that without any change in our current practice, the world energy demand in 2020 would be 50-80% higher than 1990 levels. According to a recent USA Department of Energy (DoE) report, annual energy demand will increase from a current capacity of 363 million kilowatts to 750 million kilowatts by 2020. The world’s energy consumption today is estimated to 22 billion kWh per year, 53 billion kWh by 2020. Such ever-increasing demand could place significant strain on the current energy infrastructure and potentially damage world environmental health by CO, CO$_2$, SO$_2$, NO$_x$ effluent gas emissions and global warming. Achieving solutions to environmental problems that we face today requires long-term potential actions for sustainable development. In this regards, renewable energy resources
appear to be one of the most efficient and effective solutions since the intimate relationship between renewable energy and sustainable development. More rational use of energy is an important bridge to help transition from today’s fossil fuel dominated world to a world powered by non-polluting fuels and advanced technologies such as photovoltaic (PV) and fuel cells (FC) (WEO, 1995). An approach is needed to integrate renewable energies in a way to meet high building performance. However, because renewable energy sources are stochastic and geographically diffuse, their ability to match demand is determined by adoption of one of the following two approaches (EUO, 2000): the utilisation of a capture area greater than that occupied by the community to be supplied, or the reduction of the community’s energy demands to a level commensurate with the locally available renewable resources. For a northern European climate, which is characterised by an average annual solar irradiance of 150 Wm\(^{-2}\), the mean power production from a photovoltaic component of 13% conversion efficiency is approximately 20 Wm\(^{-2}\). For an average wind speed of 5 m\(\text{s}^{-1}\), the power produced by a micro wind turbine will be of a similar order of magnitude, though with a different profile shape. In the UK, for example, a typical office building will have a demand in the order of 300kWhm\(^{-2}\)yr\(^{-1}\). This translates into approximately 50 Wm\(^{-2}\) of façade, which is twice as much as the available renewable energies (DETR, 1994). Thus, the aim is to utilise energy efficiency measures in order to reduce the overall energy consumption and adjust the demand profiles to be met by renewable energies. For instance, this approach can be applied to greenhouses, which use solar energy to provide indoor environmental quality. The greenhouse effect is one result of the differing properties of heat radiation when it is generated at different temperatures. Objects inside the greenhouse, or any other building, such as plants, re-radiate the heat or absorb it. Because the objects inside the greenhouse are at a lower temperature than the sun, the re-radiated heat is of longer wavelengths, and cannot penetrate the glass. This re-radiated heat is trapped and causes the temperature inside the greenhouse to rise. Note that the atmosphere surrounding the earth, also, behaves as a large greenhouse around the world. Changes to the gases in the atmosphere, such as increased carbon dioxide content from the burning of fossil fuels, can act like a layer of glass and reduce the quantity of heat that the planet earth would otherwise radiate back into space. This particular greenhouse effect, therefore, contributes to global warming. The application of greenhouses for plants growth can be considered one of the measures in the success of solving this problem. Maximising the efficiency gained from a greenhouse can be achieved using various approaches, employing different techniques that could be applied at the design, construction and operational stages. The development of greenhouses could be a solution to farming industry and food security. Energy security, economic growth and environment protection are the national energy policy drivers of any country of the world. As world populations grow, many faster than the average 2%, the need for more and more energy is exacerbated (Figure 1). Enhanced lifestyle and energy demand rise together and the wealthy industrialised economics, which contain 25% of the world’s population, consume 75% of the world’s energy supply. The world’s energy consumption today is estimated to 22 billion kWh per year. About 6.6 billion metric tons carbon equivalent of greenhouse gas (GHG) emission are released in the atmosphere to meet this energy demand (Bos, My, Vu, and Bulatao, 1994). Approximately 80% is due to carbon emissions from the combustion of energy fuels.

**Figure 1. Annual and estimated world population and energy demand** (Million of barrels per day of oil equivalent (MBDOE))
Technological progress has dramatically changed the world in a variety of ways. It has, however, also led to developments, e.g., environmental problems, which threaten man and nature. Build-up of carbon dioxide and other GHGs is leading to global warming with unpredictable but potentially catastrophic consequences. When fossil fuels burn, they emit toxic pollutants that damage the environment and people’s health with over 700,000 deaths resulting each year, according to the World Bank review of 2000. At the current rate of usage, taking into consideration population increases and higher consumption of energy by developing countries, oil resources, natural gas and uranium will be depleted within a few decades, as shown in Figures 2, and 3. As for coal, it may take two centuries or so. One must therefore endeavour to take precautions today for a viable world for coming generations. Research into future alternatives has been and still being conducted aiming to solve the complex problems of this recent time, e.g., rising energy requirements of a rapidly and constantly growing world population and global environmental pollution. Therefore, options for a long-term and environmentally friendly energy supply have to be developed leading to the use of renewable sources (water, sun, wind, biomass, geothermal, hydrogen) and fuel cells.

Figure 2. World oil productions in the next 10-20 years

Renewables could shield a nation from the negative effect in the energy supply, price and related environment concerns. Hydrogen for fuel cells and the sun for PV have been considered for many years as a likely and eventual substitute for oil, gas, coal and uranium. They are the most abundant elements in the universe. The use of solar energy or PVs for the everyday electricity needs has distinct advantages: avoid consuming resources and degrading the environment through polluting emissions, oil spills and toxic by-products. A one-kilowatt PV system producing 150 kWh each month prevents 75 kg of fossil fuel from being mined. 150 kg of CO$_2$ from entering the atmosphere and keeps 473 litres of water from being consumed. Electricity from fuel cells can be used in the same way as grid power: to run appliances and light bulbs and even to power cars since each gallon of gasoline produced and used in an internal combustion engine releases roughly 12 kg of CO$_2$, a GHG that contributes to global warming.
People, Power and Pollution: Over millions of years ago plants covered the earth, converting the energy of sunlight into living tissue, some of which was buried in the depths of the earth to produce deposits of coal, oil and natural gas. The past few decades, however, have experienced many valuable uses for these complex chemical substances, manufacturing from them plastics, textiles, fertiliser and the various end products of the petrochemical industry. Indeed, each decade sees increasing uses for these products. Renewable energy is the term used to describe a wide range of naturally occurring, replenishing energy sources. Coal, oil and gas, which will certainly be of great value to future generations, as they are to ours, are non-renewable natural resources. The rapid depletion of non-renewable fossil resources need not continue. This is particularly true now as it is, or soon will be, technically and economically feasible to supply all of man's needs from the most abundant energy source of all, the sun. The sunlight is not only inexhaustible, but, moreover, it is the only energy source, which is completely non-polluting. Industry’s use of fossil fuels has been blamed for warming the climate. When coal, gas and oil are burnt, they release harmful gases, which trap heat in the atmosphere and cause global warming. However, there has been an ongoing debate on this subject, as scientists have struggled to distinguish between changes, which are human induced, and those, which could be put down to natural climate variability. Nevertheless, industrialised countries have the highest emission levels, and must shoulder the greatest responsibility for global warming. However, action must also be taken by developing countries to avoid future increases in emission levels as their economies develop and populations grow, as clearly captured by the Kyoto Protocol (DEFRA, 2002). Notably, human activities that emit carbon dioxide (CO₂), the most significant contributor to potential climate change, occur primarily from fossil fuel production. Consequently, efforts to control CO₂ emissions could have serious, negative consequences for economic growth, employment, investment, trade and the standard of living of individuals everywhere.

Scientifically, it is difficult to predict the relationship between global temperature and GHG concentrations. The climate system contains many processes that will change if warming occurs. Critical processes include heat transfer by winds and tides, the hydrological cycle involving evaporation, precipitation, runoff and groundwater and the formation of clouds, snow, and ice, all of which display enormous natural variability. The equipment and infrastructure for energy supply and use are designed with long lifetimes, and the premature turnover of capital stock involves significant costs. Economic benefits occur if capital stock is replaced with more efficient equipment in step with its normal replacement cycle. Likewise, if opportunities to reduce future emissions are taken in a timely manner, they should be less costly. Such a flexible approach would allow society to take account of evolving scientific and technological knowledge, while gaining experience in designing policies to address climate change. The World Summit on Sustainable Development in Johannesburg in 2002 committed itself to “encourage and promote the development of renewable energy sources to accelerate the shift towards sustainable consumption and production”. Accordingly, it aimed at breaking the link between resource use and productivity. This can be achieved by the following:

- Trying to ensure economic growth does not cause environmental pollution.
- Improving resource efficiency.
- Examining the whole life-cycle of a product.
- Enabling consumers to receive more information on products and services.
- Examining how taxes, voluntary agreements, subsidies, regulation and information campaigns, can best stimulate innovation and investment to provide cleaner technology. The energy conservation scenarios include rational use of energy policies in all economy sectors and the use of combined heat and power systems, which are able to add to energy savings from the autonomous power plants. Electricity from renewable energy sources is by definition the environmental green product. Hence, a renewable energy certificate system, as recommended by the World Summit, is an essential basis for all policy systems, independent of the renewable energy support scheme. It is, therefore, important that all parties involved support the renewable energy certificate system in place if it is to work as planned. Moreover, existing renewable energy technologies (RETs) could play a significant mitigating role, but the economic and political climate will have to change first. Climate change is real. It is happening now, and GHGs produced by human activities are significantly contributing to it. The predicted global temperature increase of between 1.5 and 4.5°C could lead to potentially catastrophic environmental impacts (DEFRA, 2002). These include sea level rise, increased frequency of extreme weather events, floods, droughts, disease migration from various places and possible stalling of the Gulf Stream. This has led scientists to argue that climate change issues are not ones that politicians can afford to ignore, and policy makers tend to agree (DEFRA, 2002). However, reaching international agreements on climate change policies is no trivial task as the difficulty in ratifying the Kyoto Protocol has proved.

Therefore, the use of renewable energy sources and the rational use of energy, in general, are the fundamental inputs for any responsible energy policy. However, the energy sector is encountering difficulties because increased production and consumption levels entail higher levels of pollution and eventually climate change, with possibly disastrous consequences. At the same time, it is important to secure energy at an acceptable cost in order to avoid negative impacts on economic growth. To date, renewable energy contributes as much as 20% of the global energy supplies worldwide.
Over two thirds of this comes from biomass use, mostly in developing countries, some of it unsustainable. Yet, the potential for energy from sustainable technologies is huge. On the technological side, renewables have an obvious role to play. In general, there is no problem in terms of the technical potential of renewables to deliver energy. Moreover, there are very good opportunities for RETs to play an important role in reducing emissions of GHGs into the atmosphere, certainly far more than have been exploited so far. However, there are still some technical issues to address in order to cope with the intermittency of some renewables, particularly wind and solar. Yet, the biggest problem with relying on renewables to deliver the necessary cuts in GHG emissions is more to do with politics and policy issues than with technical ones (DEFRA, 2002). For example, the single most important step governments could take to promote and increase the use of renewables is to improve access for renewables to the energy market. This access to the market needs to be under favourable conditions and, possibly, under favourable economic rates as well. One move that could help, or at least justify, better market access would be to acknowledge that there are environmental costs associated with other energy supply options and that these costs are not currently internalised within the market price of electricity or fuels. This could make a significant difference, particularly if appropriate subsidies were applied to renewable energy in recognition of the environmental benefits it offers. Similarly, cutting energy consumption through end-use efficiency is absolutely essential. This suggests that issues of end-use consumption of energy will have to come into the discussion in the foreseeable future (Levine, and Hirose, 1995). However, RETs have the benefit of being environmentally benign when developed in a sensitive and appropriate way with the full involvement of local communities. In addition, they are diverse, secure, locally based and abundant. In spite of the enormous potential and the multiple benefits, the contribution from renewable energy still lags behind the ambitious claims for it due to the initially high development costs, concerns about local impacts, lack of research funding and poor institutional and economic arrangements (IPCC, 2001).

Hence, an approach is needed to integrate renewable energies in a way that meets high building performance requirements. However, because renewable energy sources are stochastic and geographically diffuse, their ability to match demand is determined by adoption of one of the following two approaches (Parikn, Smith, and Laxmi, 1999): the utilisation of a capture area greater than that occupied by the community to be supplied, or the reduction of the community’s energy demands to a level commensurate with the locally available renewable resources.

Energy and Population Growth: Urban areas throughout the world have increased in size during recent decades. About 50% of the world’s population and approximately 7.6% in more developed countries are urban dwellers. Even though there is 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 (UNIDO, 1997). With increasing urbanisation in the world, cities are growing in number, population and complexity. At present, 2% of the world’s land surface is covered by cities, yet the people living in them consume 75% of the resources consumed by mankind (WRI, 1994). Indeed, the ecological footprint of cities is many times larger than the areas they physically occupy. Economic and social imperatives often dictate that cities must become more concentrated, making it necessary to increase the density to accommodate the people, to reduce the cost of public services, and to achieve required social cohesiveness. The reality of modern urbanisation inevitably leads to higher densities than in traditional settlements and this trend is particularly notable in developing countries.

Generally, the world population is rising rapidly, notably in the developing countries. Historical trends suggest that increased annual energy use per capita, which promotes a decrease in population growth rate, is a good surrogate for the standard of living factors. If these trends continue, the stabilisation of the world’s population will require the increased use of all sources of energy, particularly as cheap oil and gas are depleted. The improved efficiency of energy use and renewable energy sources will, therefore, be essential in stabilising population, while providing a decent standard of living all over the world. Moreover, energy is the vital input for economic and social development of any country. With an increase in industrial and agricultural activities the demand for energy is also rising. It is, however, a well-accepted fact that commercial energy use has to be minimised. This is because of the environmental effects and the availability problems. Consequently, the focus has now shifted to non-commercial energy resources, which are renewable in nature. This is bound to have less environmental effects and also the availability is guaranteed. However, even though the ideal situation will be to entice people to use renewable energy resources, there are many practical difficulties, which need to be tackled. The people groups who are using the non-commercial energy resources, like urban communities, are now becoming more demanding and wish to have commercial energy resources made available for their use. This is attributed to the increased awareness, improved literacy level and changing culture. The quality of life practiced by people is usually represented as being proportional to the per capita energy use of that particular country. It is not surprising that people want to improve their quality of life. Consequently, it is expected that the demand for commercial energy resources will increase at a greater rate in the years to come. Because of this emerging situation, the policy makers are left with two options: either to concentrate on renewable energy resources and have them as substitutes for commercial energy.
resources or to have a dual approach in which renewable energy resources will contribute to meet a significant portion of the demand whereas the conventional commercial energy resources would be used with caution whenever necessary. Even though the first option is the ideal one, the second approach will be more appropriate for a smooth transition (WRI, 1994).

**Energy and Environmental Problems**: Technological progress has dramatically changed the world in a variety of ways. It has, however, also led to developments of environmental problems, which threaten man and nature. During the past two decades the risk and reality of environmental degradation have become more apparent. Growing evidence of environmental problems is due to a combination of several factors since the environmental impact of human activities has grown dramatically because of the sheer increase of world population, consumption, industrial activity, etc., throughout the 1970s most environmental analysis and legal control instruments concentrated on conventional effluent gas pollutants such as SO$_2$, NO$_x$, CO$_2$, particulates, and CO (Table 1).

Table 1. EU criteria pollutant standards in the ambient air environment

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>EU limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>30 mg/m$^2$; 1h</td>
</tr>
<tr>
<td>NO$_2$</td>
<td>200 µg/m$^2$; 1h</td>
</tr>
<tr>
<td>O$_3$</td>
<td>235 µg/m$^2$; 1h</td>
</tr>
<tr>
<td>SO$_2$</td>
<td>250-350 µg/m$^2$; 24 h</td>
</tr>
<tr>
<td>PM$_{10}$</td>
<td>80-120 µg/m$^2$; annual</td>
</tr>
<tr>
<td>SO$<em>2$ + PM$</em>{10}$</td>
<td>250 µg/m$^2$; 24 h</td>
</tr>
<tr>
<td>Pb</td>
<td>80 µg/m$^2$; annual</td>
</tr>
<tr>
<td>Total suspended particulate (TSP)</td>
<td>100-150 µg/m$^2$; 24 h</td>
</tr>
<tr>
<td>HC</td>
<td>40-60 µg/m$^2$; annual</td>
</tr>
<tr>
<td></td>
<td>2 µg/m$^2$; annual</td>
</tr>
<tr>
<td></td>
<td>260 µg/m$^2$; 24 h</td>
</tr>
<tr>
<td></td>
<td>160 µg/m$^2$; 3 h</td>
</tr>
</tbody>
</table>

Recently, environmental concerns has extended to the control of micro or hazardous air pollutants, which are usually toxic chemical substances and harmful in small doses, as well to that of globally significant pollutants such as CO$_2$. Aside from advances in environmental science, developments in industrial processes and structures have led to new environmental problems. For example, in the energy sector, major shifts to the road transport of industrial goods and to individual travel by cars has led to an increase in road traffic and hence a shift in attention paid to the effects and sources of NOx and volatile organic compound (VOC) emissions. Environmental problems span a continuously growing range of pollutants, hazards and ecosystem degradation over wider areas. The main areas of environmental problems are: major environmental accidents, water pollution, maritime pollution, land use and sitting impact, radiation and radioactivity, solid waste disposal, hazardous air pollutants, ambient air quality, acid rain, stratospheric ozone depletion and global warming (greenhouse effect, global climatic change) (Table 2). The four more important types of harm from man’s activities are global warming gases, ozone destroying gases, gaseous pollutants and microbiological hazards (Table 3). The earth is some 30°C warmer due to the presence of gases but the global temperature is rising. This could lead to the sea level rising at the rate of 60 mm each decade with the growing risk of flooding in low-lying areas (Figure 4). At the United Nations Earth Summit at Rio in June 1992 some 153 countries agreed to pursue sustainable development (Boulet, 1987). A main aim was to reduce emission of carbon dioxide and other GHGs. Reduction of energy use in buildings is a major role in achieving this. Carbon dioxide targets are proposed to encourage designers to look at low energy designs and energy sources. Problems with energy supply and use are related not only to global warming that is taking place, due to effluent gas emission mainly CO$_2$, but also to such environmental concerns as air pollution, acid precipitation, ozone depletion, forest destruction and emission of radioactive substances. These issues must be taken into consideration simultaneously if humanity is to achieve a bright energy future with minimal environmental impacts. Much evidence exists, which suggests that the future will be negatively impacted if humans keep degrading the environment (Table 4). During the past century, global surface temperatures have increased at a rate near 0.6°C/century and the average temperature of the Atlantic, Pacific and Indian oceans (covering 72% of the earth surface) have risen by 0.06°C since 1995. Global temperatures in 2001 were 0.52°C above the long-term 1880-2000 average (the 1880-2000 annually averaged combined land and ocean temperature is 13.9°C).
### Table 2. Significant EU environmental directives in water, air and land environments.

<table>
<thead>
<tr>
<th>Environment</th>
<th>Directive name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>Surface water for drinking</td>
</tr>
<tr>
<td></td>
<td>Sampling surface water for drinking</td>
</tr>
<tr>
<td></td>
<td>Drinking water quality</td>
</tr>
<tr>
<td></td>
<td>Quality of freshwater supporting fish</td>
</tr>
<tr>
<td></td>
<td>Shellfish waters</td>
</tr>
<tr>
<td></td>
<td>Bathing waters</td>
</tr>
<tr>
<td></td>
<td>Dangerous substances in water</td>
</tr>
<tr>
<td></td>
<td>Groundwater</td>
</tr>
<tr>
<td></td>
<td>Urban wastewater</td>
</tr>
<tr>
<td></td>
<td>Nitrates from agricultural sources</td>
</tr>
<tr>
<td>Air</td>
<td>Smokes in air</td>
</tr>
<tr>
<td></td>
<td>Sulphur dioxide in air</td>
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<tr>
<td></td>
<td>Lead in air</td>
</tr>
<tr>
<td></td>
<td>Large combustion plants</td>
</tr>
<tr>
<td></td>
<td>Existing municipal incineration plants</td>
</tr>
<tr>
<td></td>
<td>New municipal incineration plants</td>
</tr>
<tr>
<td></td>
<td>Asbestos in air</td>
</tr>
<tr>
<td></td>
<td>Sulphur content of gas oil</td>
</tr>
<tr>
<td></td>
<td>Lead in petrol</td>
</tr>
<tr>
<td></td>
<td>Emissions from petrol engines</td>
</tr>
<tr>
<td></td>
<td>Air quality standards for NO₂</td>
</tr>
<tr>
<td></td>
<td>Emissions from diesel engines</td>
</tr>
<tr>
<td>Land</td>
<td>Protection of soil when sludge is applied</td>
</tr>
</tbody>
</table>

### Table 3. The external environment

<table>
<thead>
<tr>
<th>Damage</th>
<th>Manifestation</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOₓ, SOₓ</td>
<td>Irritant</td>
<td>Low NOₓ burners</td>
</tr>
<tr>
<td></td>
<td>Acid rain land damage</td>
<td>Low sulphur fuel</td>
</tr>
<tr>
<td></td>
<td>Acid rain fish damage</td>
<td>Sulphur removal</td>
</tr>
<tr>
<td></td>
<td>Global warming</td>
<td>Thermal insulation</td>
</tr>
<tr>
<td></td>
<td>Rising sea level</td>
<td>Heat recovery</td>
</tr>
<tr>
<td></td>
<td>Drought, storms</td>
<td>Heat pumps</td>
</tr>
<tr>
<td></td>
<td>Increased ultra violet</td>
<td>No CFC’s or HCFC’s</td>
</tr>
<tr>
<td></td>
<td>Skin cancer</td>
<td>Minimum air conditioning</td>
</tr>
<tr>
<td></td>
<td>Crop damage</td>
<td>Refrigerant collection</td>
</tr>
<tr>
<td></td>
<td>Pontiac fever</td>
<td>Careful maintenance</td>
</tr>
<tr>
<td></td>
<td>Legionnaires</td>
<td>Dry cooling towers</td>
</tr>
</tbody>
</table>

### Table 4. Global emissions of the top fourteen nations by total CO₂ volume (billion of tons)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Nation</th>
<th>CO₂</th>
<th>Rank</th>
<th>Nation</th>
<th>CO₂</th>
<th>Rank</th>
<th>Nation</th>
<th>CO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>USA</td>
<td>1.36</td>
<td>6</td>
<td>India</td>
<td>0.19</td>
<td>11</td>
<td>Mexico</td>
<td>0.09</td>
</tr>
<tr>
<td>2</td>
<td>Russia</td>
<td>0.98</td>
<td>7</td>
<td>UK</td>
<td>0.16</td>
<td>12</td>
<td>Poland</td>
<td>0.08</td>
</tr>
<tr>
<td>3</td>
<td>China</td>
<td>0.69</td>
<td>8</td>
<td>Canada</td>
<td>0.11</td>
<td>13</td>
<td>S. Africa</td>
<td>0.08</td>
</tr>
<tr>
<td>4</td>
<td>Japan</td>
<td>0.30</td>
<td>9</td>
<td>Italy</td>
<td>0.11</td>
<td>14</td>
<td>S. Korea</td>
<td>0.07</td>
</tr>
</tbody>
</table>
Also, according to the USA Department of Energy, world emissions of carbon are expected to increase by 54% above 1990 levels by 2015 making the earth likely to warm 1.7-4.9°C over the period 1990-2100, as shown in Figure 5. Such observation and others demonstrate that interests will likely increase regarding energy related environment concerns and that energy is one of the main factors that must be considered in discussions of sustainable development.

Environmental Transformations: In recent years a number of countries have adopted policies aimed at giving a greater role to private ownership in the natural resource sector. For example, in the UK the regional water companies have been privatised and have been given a considerable degree of control over the exploitation of the nation's regional water resources. Similar policies have been followed in France and other European countries. Typically, a whole range of new regulatory instruments such as technological standards accompanies such privatisation on water treatment plants, minimum standards on drinking water quality, price controls and maximum withdrawal quotas. While some of these instruments address problems of monopolistic behaviour and other forms of imperfect competition, the bulk of regulatory measures is concerned with establishing 'good practices' aimed at maintaining the quality of the newly privatised resources as a shorthand. Society has to meet the freshwater demands of its population and its industry by extracting water from the regional water resources that are provided by the natural environment (lakes, rivers, aquifers, etc.). These water resources are renewable but potentially destructible resources. While moderate amounts of human water extractions from a given regional water system can be sustained for indefinite periods. Excessive extractions will change the geographical and climatic conditions supporting the water cycle and will diminish the regenerative capacity of the regional water system, thereby reducing the potential for future withdrawals. Typically, recovery from any such resource degradation will be very slow and difficult, if not impossible; resource degradation is partially irreversible (Erreygers, 1996).
To make sustainable water extraction economically viable, the sustainable policy has to break even (all costs are covered by revenues) while unsustainable policy has to be unprofitable (costs exceed revenues):

\[(1+r) vt-1 = 5yt + vt\] (1)

Where: \(r\) is the interest rate, \(t\)=year, \(y\) is the revenue.

\[(1+r) vt-1 > 105yt\] (2)

\[(1+r) vt-1 < \left[\frac{105}{(105-5)}\right] vt\] (3)

The term \([105/ (105-5)]\) is to define the natural productivity factor of the water resource as \((1+g) = \frac{105}{105-5}\); \(g\) is the natural productivity rate. Rate \(g\) will be close to zero if the sustainable extraction level is much smaller than the unsustainable level. Using \(g\), the equation can be as follows:

\[vt > \frac{(1+r)}{(1+g)} vt-1\] (4)

Regulatory measures that prevent resource owners from adopting certain unsustainable extraction policies are a necessary pre-condition for the effective operation of a privatised natural resource sector. Unregulated water privatisation would result in an inflationary dynamics whose distributional effects would threaten the long-term viability of the economy. This inflationary dynamics is not due to any form of market imperfection but is a natural consequence of the competitive arbitrage behaviour of unregulated private resource owners.

**METHODS AND MATERIALS**

**Aims/Purpose:** The increased availability of reliable and efficient energy services stimulates new development alternatives. This article discusses the potential for such integrated systems in the stationary and portable power market in response to the critical need for a cleaner energy technology. Throughout the theme several issues relating to renewable energies, environment, and sustainable development are examined from both current and future perspectives. It is concluded that green energies like wind, solar, ground source heat pumps, and biomass must be promoted, implemented, and demonstrated from the economic and/or environmental point view. Biogas from biomass appears to have potential as an alternative energy source, which is potentially rich in biomass resources. This is an overview of some salient points and perspectives of biogas technology. The current literature is reviewed regarding the ecological, social, cultural and economic impacts of biogas technology. This article gives an overview of present and future use of biomass as an industrial feedstock for production of fuels, chemicals and other materials. However, to be truly competitive in an open market situation, higher value products are required. Results suggest that biogas technology must be encouraged, promoted, invested, implemented, and demonstrated, but especially in remote rural areas.

**Study Design:** Anticipated patterns of future energy use and consequent environmental impacts (acid precipitation, ozone depletion and the greenhouse effect or global warming) are comprehensively discussed in this article.

**Place and Duration of Study:** National Centre for Research, Energy Research Institute (ERI), between January 2012 and July 2012.

**Methodology/Approach:** An approach is needed to integrate renewable energies in a way to meet high building performance. However, because renewable energy sources are stochastic and geographically diffuse their ability to match demand is determined by adoption of one of the following two approaches: the utilisation of a capture area greater than that occupied by the community to be supplied, or the reduction of the community’s energy demands to a level commensurate with the locally available renewable resources.

**Results/Findings:** The adoption of green or sustainable approaches to the way in which society is run is seen as an important strategy in finding a solution to the energy problem. The key factors to reducing and controlling \(\text{CO}_2\), which is the major contributor to global warming, are the use of alternative approaches to energy generation and the exploration of how these alternatives are used today and may be used in the future as green energy sources.

**Originality/Value:** This study highlights the energy problem and the possible saving that can be achieved through the use of renewable energy technologies. Also, this study clarifies the background of the study, highlights the potential energy saving that could be achieved through use of renewable energy technologies and describes the objectives, approach and scope of the study. The move towards a de-carbonised world, driven partly by climate science and partly by the business opportunities it offers, will need the promotion of environmentally friendly alternatives, if an acceptable stabilisation level of atmospheric carbon dioxide is to be achieved. This requires the harnessing and use of natural resources that produce no air pollution or greenhouse gases and provides comfortable coexistence of human, livestock, and plants. The increased availability of reliable and efficient energy services stimulates new development alternatives. We present and focus a comprehensive review of energy sources, and the development of sustainable technologies to explore these energy sources. We conclude that using renewable energy technologies, efficient energy systems, energy savings techniques and other mitigation measures necessary to reduce climate changes.
DISCUSSION AND RESULTS

Role of Energy Efficiency System: The prospects for development in power engineering are, at present, closely related to ecological problems. Power engineering has harmful effects on the environment, as it discharges toxic gases into atmosphere and also oil-contaminated and saline waters into rivers, as well as polluting the soil with ash and slag and having adverse effects on living things on account of electromagnetic fields and so on. Thus there is an urgent need for new approaches to provide an ecologically safe strategy. Substantial economic and ecological effects for thermal power projects (TPPs) can be achieved by improvement, upgrading the efficiency of the existing equipment, reduction of electricity loss, saving of fuel, and optimisation of its operating conditions and service life leading to improved access for rural and urban low-income areas in developing countries through energy efficiency and renewable energies.

Sustainable energy is a prerequisite for development. Energy-based living standards in developing countries, however, are clearly below standards in developed countries. Low levels of access to affordable and environmentally sound energy in both rural and urban low-income areas are therefore a predominant issue in developing countries. In recent years many programmes for development aid or technical assistance have been focusing on improving access to sustainable energy, many of them with impressive results. Apart from success stories, however, experience also shows that positive appraisals of many projects evaporate after completion and vanishing of the implementation expert team. Altogether, the diffusion of sustainable technologies such as energy efficiency and renewable energy for cooking, heating, lighting, electrical appliances and building insulation in developing countries has been slow. 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 (CAEEDAC, 2000). New financing and implementation processes, which allow reallocating financial resources and thus enabling countries themselves to achieve a sustainable energy infrastructure, are also needed. The links between the energy policy framework, financing and implementation of renewable energy and energy efficiency projects have to be strengthened and as well as efforts made to increase people’s knowledge through training.

Renewable Energy Technologies: Sustainable energy is the energy that, in its production or consumption, has minimal negative impacts on human health and the healthy functioning of vital ecological systems, including the global environment (Pernille, 2004). It is an accepted fact that renewable energy is a sustainable form of energy, which has attracted more attention during recent years. Increasing environmental interest, as well as economic consideration of fossil fuel consumption and high emphasis of sustainable development for the future helped to bring the great potential of renewable energy into focus. Nearly a fifth of all global power is generated by renewable energy sources, according to a book published by the OECD/IEA (OECD/IEA, 2004). “Renewables for power generation: status and prospects” claims that, at approximately 20%, renewables are the second largest power source after coal (39%) and ahead of nuclear (17%), natural gas (17%) and oil (8%) respectively. From 1973-2000 renewables grew at 9.3% a year and it is predicted that this will increase by 10.4% a year to 2010. Wind power grew fastest at 52% and will multiply seven times by 2010, overtaking biopower and hence help reducing green house gases, GHGs, emissions to the environment.

Table 5 shows some applications of different renewable energy sources. The challenge is to match leadership in GHG reduction and production of renewable energy with developing a major research and manufacturing capacity in environmental technologies (wind, solar, fuel cells, etc.). More than 50% of the world’s area is classified as arid, representing the rural and desert part, which lack electricity and water networks. The inhabitants of such areas obtain water from borehole wells by means of water pumps, which are mostly driven by diesel engines. The diesel motors are associated with maintenance problems, high running cost, and environmental pollution. Alternative methods are pumping by photovoltaic (PV) or wind systems. At present, renewable sources of energy are regional and site specific. It has to be integrated in the regional development plans.

Energy from Waste: Measures to maximise the use of high-efficiency generation plants and on-site renewable energy resources are important for raising the overall level of energy efficiency. The world’s view of waste has changed dramatically in recent years and it is now seen as a source to feed the ever-growing demand for energy (Figure 6). The road from the initial concept to the production of the first kilowatt of power is long and has many challenges, not least the need for adequate funding. Scientific evidence, public awareness and increased levels of participation in environmental campaigning have led to governments’ worldwide implementing regulations and legislation. Examples include:

1. EU landfill diversion directive.
2. Recycling targets.
3. Climate change regulations.

The demand for nuclear power generation, wind farms, solar power and so on is now unstoppable and has created a whole new market, though each has its own challenges (Figure 7). The waste collection, transfer and landfill disposal business comprise a mature, slow-growth industry. Economic drivers to developing the waste and renewable energy sector have included:
Table 5. Sources of renewable energy

<table>
<thead>
<tr>
<th>Energy source</th>
<th>Technology</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar energy</td>
<td>Domestic solar water heaters</td>
<td>Small</td>
</tr>
<tr>
<td></td>
<td>Solar water heating for large demands</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>PV roofs: grid connected systems generating electric energy</td>
<td>Medium-large</td>
</tr>
<tr>
<td>Wind energy</td>
<td>Wind turbines (grid connected)</td>
<td>Medium-large</td>
</tr>
<tr>
<td>Hydraulic energy</td>
<td>Hydro plants in derivation schemes</td>
<td>Medium-small</td>
</tr>
<tr>
<td></td>
<td>Hydro plants in existing water distribution networks</td>
<td>Medium-small</td>
</tr>
<tr>
<td>Biomass</td>
<td>High efficiency wood boilers</td>
<td>Small</td>
</tr>
<tr>
<td></td>
<td>CHP plants fed by agricultural wastes or energy crops</td>
<td>Medium</td>
</tr>
<tr>
<td>Animal manure</td>
<td>CHP plants fed by biogas</td>
<td>Small</td>
</tr>
<tr>
<td>CHP</td>
<td>High efficiency lighting</td>
<td>Wide</td>
</tr>
<tr>
<td></td>
<td>High efficiency electric</td>
<td>Wide</td>
</tr>
<tr>
<td></td>
<td>Householders appliances</td>
<td>Wide</td>
</tr>
<tr>
<td></td>
<td>High efficiency boilers</td>
<td>Small-medium</td>
</tr>
<tr>
<td></td>
<td>Plants coupled with refrigerating absorption machines</td>
<td>Medium-large</td>
</tr>
</tbody>
</table>

1. Waste disposal and landfill gate fees/landfill tax.
2. Penalties/avoidance schemes (e.g., landfill allowance schemes and fines, carbon trading).
3. Energy prices.
4. Investments subsidies.

When considering the demand and opportunity in today’s marketplace these points are prevalent:
1. The demand for renewable energy is not going to go away.
2. The public feeling is that governments across the world are responsible.
3. The pressure caused by diminishing fossil fuel supplies is increasing.
4. Investment funds are increasingly available from traditional sources.
5. The needs for new technologies that can deliver carbon reduction and waste reduction outcomes are increasingly bankable which opens up the market for all.

Figure 6. Global fossil fuel consumption

Financial institutions across most global markets are gearing themselves up for the environmental revolution. Within the waste to renewable energy sector, history has shown a hesitancy to invest in projects not supported by four things:
1. Adequate independent technology due diligence.
2. Security of waste input and power off-take contracts.
3. A site with planning permission.

Reviewing the evolution of MSW management in general, waste collection has tended to progress from incomplete collection through to complete collection and finally to collection with separation into different waste streams. In turn, waste
treatment has progressed from ad-hoc decentralised disposal to a strategy more dependent on controlled treatment and disposal, including the use of sanitary landfilling accompanied by waste reduction strategies. In developed countries, this evolution has taken place over a period of about 30-40 years. The standard of liner design and construction standard are summarised in Table 6.

**Figure 7. Municipal waste management in the European Union**

![Figure 7: Municipal waste management in the European Union](image)

**Table 6. Comparison of basic requirements for bottom liners in MSW sanitary landfills**

<table>
<thead>
<tr>
<th>Liner system requirement</th>
<th>Leachate drainage layer</th>
<th>Geomembrane line</th>
<th>Compacted clay layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>US EPA Standard (40CFR258)</td>
<td>K &gt;1x10^{-4} ms^{-1} Thickness 0.3 m</td>
<td>Thickness ≥0.75 mm Recommended 1.5 mm HDPE</td>
<td>K ≤ 1x10^{-6} ms^{-1} Thickness ≈60 cm</td>
</tr>
<tr>
<td>EU Landfill Directive (1999/31/Dec)</td>
<td>Thickness 0.5 m</td>
<td>Not specified. Yet liner thickness should be 100 cm K≤ 1x10^{-6} ms^{-1}</td>
<td>With HDPE liner, thickness of clay layer &gt; 50 cm</td>
</tr>
<tr>
<td>German Standard (TASI 1993)</td>
<td>K &gt;1x10^{-6} ms^{-3} Thickness 0.3 m</td>
<td>Thickness ≥2.5 mm HDPE</td>
<td>K ≤ 5x10^{-10} ms^{-1} Thickness 3x25 cm</td>
</tr>
<tr>
<td>Chinese Standard (CJJ 113-2007)</td>
<td>K &gt;1x10^{-6} ms^{-3} Thickness &gt;0.3 m</td>
<td>Thickness ≥1.5 mm HDPE</td>
<td>K ≤ 1x10^{-6} ms^{-1} Thickness 75 cm</td>
</tr>
</tbody>
</table>

One of the negative results of growing prosperity worldwide has been an increase in waste generation from year to year. In response, policy-makers and researchers are examining how best to decouple waste growth and economic growth. In both developed and developing countries sanitary landfill sites can be operated in such a way that danger to residents and the environment, from Leachate, odours, fire and explosion is almost entirely eliminated. Table 7 summarised different parameters in waste compaction. Waste professionals use Cross Wrap machinery for its reliability and efficiency in storage and transport of waste materials.

**Waste Shredding:** With the demand for faster and more efficient recycling technologies showing no signs of abating, the market for faster, more efficient shredding equipment is of course on the up. To the man on the street the term shredding most likely brings to mind the transformation of business documents, bank and credit card statements into a bird’s nest of paper- a practice now relies on worldwide to prevent fraudsters accessing the personal financial data and sensitive information. It means big business, as shredding of waste is common practice across almost all areas of the waste industry. Far from focusing simply on paper, shredding is a disposal technique for everything from agriculture to household waste and electrical to industrial waste.

The overall trend in today’s market tends to be ‘shred first and sort later’. Shredding of waste material as a precursor to sorting is useful for two reasons. It reduces the size of the waste, allowing for greater ease of transportation, but perhaps, importantly – at a time when recycling as much materials as effectively as possible is paramount- it allows for more
Table 7. The different parameters in waste compaction

<table>
<thead>
<tr>
<th>Refuse</th>
<th>Item size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Organic components</td>
</tr>
<tr>
<td></td>
<td>Inert substances</td>
</tr>
<tr>
<td></td>
<td>Slurry</td>
</tr>
<tr>
<td></td>
<td>Application technique</td>
</tr>
<tr>
<td></td>
<td>Thin layer operation</td>
</tr>
<tr>
<td></td>
<td>Face operation</td>
</tr>
<tr>
<td></td>
<td>Pushing distance</td>
</tr>
<tr>
<td></td>
<td>Compaction machine</td>
</tr>
<tr>
<td></td>
<td>Compactor</td>
</tr>
<tr>
<td></td>
<td>Operating weight</td>
</tr>
<tr>
<td></td>
<td>Wheel design</td>
</tr>
<tr>
<td>Types of waste disposal site</td>
<td>Pit type waste disposal site</td>
</tr>
<tr>
<td></td>
<td>Raised refused disposal site</td>
</tr>
<tr>
<td></td>
<td>Height of the refuse disposal site</td>
</tr>
<tr>
<td></td>
<td>Refuse load</td>
</tr>
<tr>
<td>Weather conditions</td>
<td>Precipitation</td>
</tr>
<tr>
<td></td>
<td>Temperature</td>
</tr>
</tbody>
</table>

Effective sorting afterwards. And logically, effective sorting equals greater opportunity for recycling (Figure 8).

While every customer on the lookout for a shredder is interested in efficiency, one thing that will also attract a potential buyer is energy efficiency. With the large environmental challenges facing the world today, waste industry professionals are increasingly aware of the need to make sure their business are as kind to the environment as possible. The operation of large-scale equipment such as shredding machines naturally uses a large amount of power and machines which can run effectively on a lesser amount have an advantage over their competitors. Even with modest assumptions about the availability of land, comprehensive fuel-wood farming programmes offer significant energy, economic and environmental benefits. These benefits would be dispersed in rural areas where they are greatly needed and can serve as linkages for further rural economic development. The nations, as a whole would benefit from savings in foreign exchange, improved energy security, and socio-economic improvements. With a nine-fold increase in forest – plantation cover, the nation’s resource base would be greatly improved. The international community would benefit from pollution reduction, climate mitigation, and the increased trading opportunities that arise from new income sources. The aim of any modern biomass energy systems must be:

1. To maximise yields with minimum inputs.
2. Utilisation and selection of adequate plant materials and processes.
3. Optimum use of land, water, and fertiliser.
4. Create an adequate infrastructure and strong R & D base.

Figure 8 Monthly averages paper scraps

Biomass CHP: In addition to realising the economic potential identified by the National Energy Savings Programme, a long-term effort leading to a 3% reduction in specific electricity demand per year after 2020 is proposed. This will require: further improvements in building codes, and continued information on energy efficiency. The environmental Non
Governmental Organisations (NGOs) are urging the government to adopt sustainable development of the energy sector by:

1. Diversifying of primary energy sources to increase the contribution of renewable and local energy resources in the total energy balance.
2. Implementing measures for energy efficiency increase at the demand side and in the energy transformation sector.

Methane is a primary constituent of landfill gas (LFG) and a potent greenhouse gas (GHG) when released into the atmosphere. Globally, landfills are the third largest anthropogenic emission source, accounting for about 13% of methane emissions or over 818 million tones of carbon dioxide equivalent (MMTCO$_2$e) (Abdeen, 2009) as shown in Figures 9. The price of natural gas is set by a number of market and regulatory factors that include: Supply and demand balance and market fundamentals, weather, pipeline availability and deliverability, storage inventory, new supply sources, prices of other energy alternatives and regulatory issues and uncertainty (Brain, and Mark, 2007). Classic management approaches to risk are well documented and used in many industries. This includes the following four broad approaches to risk:

1. Avoidance includes not performing an activity that could carry risk. Avoidance may seem the answer to all risks, but avoiding risks also means losing out on potential gain.
2. Mitigation/reduction involves methods that reduce the severity of potential loss.
3. Retention/acceptance involves accepting the loss when it occurs. Risk retention is a viable strategy for small risks. All risks that are not avoided or transferred are retained by default.
4. Transfer means causing another party to accept the risk, typically by contract.

Figure 9. Distribution of industrial CHP capacity in the EU and USA

In addition to the drain on resources, such an increase in consumption consequences, together with the increased hazards of pollution and the safety problems associated with a large nuclear fission programmes. This is a disturbing prospect. It would be equally unacceptable to suggest that the difference in energy between the developed and developing countries and prudent for the developed countries to move towards a way of life which, whilst maintaining or even increasing quality of life, reduce significantly the energy consumption per capita. Such savings can be achieved in a number of ways:

1. Improved efficiency of energy use, for example better thermal insulation, energy recovery, and total energy.
2. Conservation of energy resources by design for long life and recycling rather than the short life throwaway product and systematic replanning of our way of life, for example in the field of transport.

Energy ratio is defined as the ratio of energy content of the food product/energy input to produce the food.

$$\text{Er} = \frac{\text{Ec}}{\text{Ei}}$$

Where Er is the energy ratio, Ec is the energy content of the food product, and Ei is the energy input to produce the food.

Economic importance of environmental issue is increasing, and new technologies are expected to reduce pollution derived both from productive processes and products, with costs that are still unknown. This is due to market uncertainty, weak appropriability regime, lack of a dominant design, and difficulties in reconfiguring organisational routines. The degradation of the global environment is one of the most serious energy issues. Various options are proposed and investigated to mitigate climate change, acid rain or other environmental problems. It is an accepted fact that renewable energy is a sustainable form of energy, which has attracted more attention during recent years.
**Combined Heat and Power (CHP):** Combined heat and power (CHP) installations are quite common in greenhouses, which grow high-energy, input crops (e.g., salad vegetables, pot plants, etc.). Scientific assumptions for a short-term energy strategy suggest that the most economically efficient way to replace the thermal plants is to modernise existing power plants to increase their energy efficiency and to improve their environmental performance (Omer, 2008). However, utilisation of wind power and the conversion of gas-fired CHP plants to biomass would significantly reduce the dependence on imported fossil fuels.

Although a lack of generating capacity is forecasted in the long-term, utilisation of the existing renewable energy potential and the huge possibilities for increasing energy efficiency are sufficient to meet future energy demands in the short-term. A total shift towards a sustainable energy system is a complex and long process, but is one that can be achieved within a period of about 20 years. Implementation will require initial investment, long-term national strategies and action plans. However, the changes will have a number of benefits including: a more stable energy supply than at present and major improvement in the environmental performance of the energy sector, and certain social benefits (Figure 10). A vision used a methodology and calculations based on computer modelling that utilised:

1. Data from existing governmental programmes.
2. Potential renewable energy sources and energy efficiency improvements.
3. Assumptions for future economy growth.
4. Information from studies and surveys on the recent situation in the energy sector.

The main advantages are related to energy, agriculture and environment problems, are foreseeable both at national level and at worldwide level and can be summarised as follows:

1. Reduction of dependence on import of energy and related products.
2. Reduction of environmental impact of energy production (greenhouse effect, air pollution, and waste degradation).
3. Substitution of food crops and reduction of food surpluses and of related economic burdens.
4. Utilisation of marginal lands and of set aside lands and reduction of related socio-economic and environmental problems (soil erosion, urbanisation, landscape deterioration, etc.).
5. Development of new know-how and production of technological innovation.

In some countries, a wide range of economic incentives and other measures are already helping to protect the environment. These include:

1. Taxes and user charges that reflect the costs of using the environment, e.g., pollution taxes and waste disposal charges.
2. Subsidies, credits and grants that encourage environmental protection.
3. Deposit-refund systems that prevent pollution on resource misuse and promote product reuse or recycling.
4. Financial enforcement incentives, e.g., fines for non-compliance with environmental regulations.
5. Tradable permits for activities that harm the environment.

District Heating (DH), also known as community heating can be a key factor to achieve energy savings, reduce CO₂ emissions and at the same time provide consumers with a high quality heat supply at a competitive price. DH should generally only be considered for areas where the heat density is sufficiently high to make DH economical. In countries like Denmark DH may today be economical even to new developments with lower density areas due to the high level of taxation on oil and gas fuels combined with the efficient production of DH. To improve the opportunity for DH local councils can adapt the following plan:

- Analyse the options for heat supply during local planning stage.
- In areas where DH is the least cost solution it should be made part of the infrastructure just like for instance water and sewage connecting all existing and new buildings.
- Where possible all public buildings should be connected to DH.
- The government provides low interest loans or funding to minimise conversion costs for its citizens.
- Use other powers, for instance national legislation to ensure the most economical development of the heat supply and enable an obligation to connect buildings to a DH scheme.

Denmark has broadly seen three scales of CHP which were largely implemented in the following chronological order (Cihan, Dursun, Bora, and Erkan, 2009):

1. Large-scale CHP in cities (>50 MWe).
2. Small (5 kWe – 5 MWe) and medium-scale (5-50 MWe).
3. Industrial and small-scale CHP.

Combined heat and power (CHP) installations are quite common in greenhouses, which grow high-energy, input crops (e.g., salad vegetables, pot plants, etc.). Most of the heat is produced by large CHP plants (gas-fired combined cycle plants using natural gas, biomass, waste or biogas). DH is energy efficient because of the way the heat is produced and the required temperature level is an important factor. Buildings can be heated to temperature of 21°C and...
domestic hot water (DHW) can be supplied with a temperature of 55°C using energy sources that are most efficient when producing low temperature levels (<95°C) for the DH water. Most of these heat sources are CO₂ neutral or emit low levels. Only a few of these sources are available to small individual systems at a reasonably cost, whereas DH schemes because of the plant’s size and location can have access to most of the heat sources and at a low cost. Low temperature DH, with return temperatures of around 30-40°C can utilise the following heat sources:

- Efficient use of CHP by extracting heat at low calorific value (CV).
- Efficient use of biomass or gas boilers by condensing heat in economisers (Table 8).
- Efficient utilisation of geothermal energy.
- Direct utilisation of excess low temperature heat from industrial processes.
- Efficient use of large-scale solar heating plants.

Heat tariffs may include a number of components such as: a connection charge, a fixed charge and a variable energy charge. Also, consumers may be incentivised to lower the return temperature. Hence, it is difficult to generalise but the heat practice for any DH company no matter what the ownership structure can be highlighted as follows:

- To develop and maintain a development plan for the connection of new consumers.
- To evaluate the options for least cost production of heat.
- To implement the most competitive solutions by signing agreements with other companies or by implementing own investment projects.
- To monitor all internal costs and with the help of benchmarking, and improve the efficiency of the company.
- To maintain a good relationship with the consumer and deliver heat supply services at a sufficient quality.

Installing DH should be pursued to meet the objectives for improving the environment through the improvement of energy efficiency in the heating sector. At the same time DH can serve the consumer with a reasonable quality of heat at the lowest possible cost. The variety of possible solutions combined with the collaboration between individual companies, the district heating association, the suppliers and consultants can, as it has been in Denmark, be the way forward for developing DH in the United Kingdom. Implementation will require initial investment, long-term national strategies and action plans. However, the changes will have a number of benefits including: a more stable energy supply than at present and major improvement in the environmental performance of the energy sector, and certain social benefits (Bhutto, Bazmi, and Zahwdi, 2011). A vision that used a methodologies and calculations based on computer modelling can utilised:

- Data from existing governmental programmes.
- Potential renewable energy sources and energy efficiency improvements.
- Assumptions for future economy growth, and information from studies and surveys on the recent situation in the energy sector.

Briquette: Charcoal stoves are very familiar to African society. As for the stove technology, the present charcoal stove can be used, and can be improved upon for better efficiency. This energy term will be of particular interest to both urban and rural households and all the income groups due to the simplicity, convenience, and lower air polluting...
characteristics. However, the market price of the fuel together with that of its end-use technology may not enhance its early high market penetration especially in the urban low income and rural households. 

Briquetting is the formation of a charcoal (an energy-dense solid fuel source) from otherwise wasted agricultural and forestry residues. One of the disadvantages of wood fuel is that it is bulky with a low energy density and is therefore enquire to transport. Briquette formation allows for a more energy-dense fuel to be delivered, thus reducing the transportation cost and making the resource more competitive. It also adds some uniformity, which makes the fuel more compatible with systems that are sensitive to the specific fuel input.

**Improved Cook Stoves:** Traditional wood stoves can be classified into four types: three stone, metal cylindrical shaped, metal tripod and clay type. Another area in which rural energy availability could be secured where woody fuels have become scarce, are the improvements of traditional cookers and ovens to raise the efficiency of fuel saving. Also, to provide a constant fuel supply by planting fast growing trees. The rural development is essential and economically important since it will eventually lead to better standards of living, people's settlement, and self sufficient in the following:

- Food and water supplies.
- Better services in education and health care.
- Good communication modes.

**Biogas Production:** Biogas technology cannot only provide fuel, but is also important for comprehensive utilisation of biomass forestry, animal husbandry, fishery, agricultural economy, protecting the environment, realising agricultural recycling, as well as improving the sanitary conditions, in rural areas. The introduction of biogas technology on wide scale has implications for macro planning such as the allocation of government investment and effects on the balance of payments. Factors that determine the rate of acceptance of biogas plants, such as credit facilities and technical backup services, are likely to have to be planned as part of general macro-policy, as do the allocation of research and development funds (Omer, 2006).

Biogas is a generic term for gases generated from the decomposition of organic material. As the material breaks down, methane (CH\textsubscript{4}) is produced as shown in Figure 11. Sources that generate biogas are numerous and varied. These include landfill sites, wastewater treatment plants and anaerobic digesters. Landfills and wastewater treatment plants emit biogas from decaying waste. To date, the waste industry has focused on controlling these emissions to our environment and in some cases, tapping this potential source of fuel to power gas turbines, thus generating electricity. The primary components of landfill gas are methane (CH\textsubscript{4}), carbon dioxide (CO\textsubscript{2}), and nitrogen (N\textsubscript{2}). The average concentration of methane is ~45%, CO\textsubscript{2} is ~36% and nitrogen is ~18%. Other components in the gas are oxygen (O\textsubscript{2}), water vapour and trace amounts of a wide range of non-methane organic compounds (NMOCs).

For hot water and heating, renewables contributions come from biomass power and heat, geothermal direct heat, ground source heat pumps, and rooftop solar hot water and space heating systems. Solar assisted cooling makes a very small but growing contribution. When it comes to the installation of large amounts of PV, the cities have several important factors in common. These factors include:

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

**Improved Forest and Tree Management:** Dry cell batteries are a practical but expensive form of mobile fuel that is used by rural people when moving around at night and for powering radios and other small appliances. The high cost of dry cell batteries is financially constraining for rural households, but their popularity gives a good indication of how valuable a versatile fuel like electricity is in rural area. Dry cell batteries can constitute an environmental hazard unless they are recycled in a proper fashion. Direct burning of fuel-wood and crop residues constitute the main usage of biomass, as is the case with many developing countries. However, the direct burning of biomass in an inefficient manner causes economic loss and adversely affects human health. In order to address the problem of inefficiency, research centres around the world have investigated the viability of converting the resource to a more useful form, namely solid briquettes and fuel gas (Figure 12).

Biomass resources play a significant role in energy supply in all developing countries. Biomass resources should be divided into residues or dedicated resources, the latter including firewood and charcoal can also be produced from forest residues (Table 8). Implementing measures for energy efficiency increase at the demand side and in the energy transformation sector is very important. It is common practice to dispose of this waste wood in landfill where it slowly degraded and takes up valuable void space. This wood is a good source of energy and is an alternative to energy crops. Agricultural wastes are abundantly available globally and can be converted to energy and useful chemicals by a number of microorganisms. The success of promoting any technology depends on careful planning, management, implementation, training and monitoring.
Main features of gasification project are:
- Networking and institutional development/strengthening.
- Promotion and extension.
- Construction of demonstration projects.
- Research and development, and training and monitoring.

**Figure 11. Biogas production processes**

**Gasification**: Gasification is based on the formation of a fuel gas (mostly CO and H₂) by partially oxidising raw solid fuel at high temperatures in the presence of steam or air. The technology can use wood chips, groundnut shells, sugarcane bagasse, and other similar fuels to generate capacities from 3 kW to 100 kW. Three types of gasifier designs have been developed to make use of the diversity of fuel inputs and to meet the requirements of the product gas output (degree of cleanliness, composition, heating value, etc.). The requirements of gas for various purposes, and a comparison between biogas and various commercial fuels in terms of calorific value, and thermal efficiency are presented in Table 9. 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.

Agricultural wastes are abundantly available globally and can be converted to energy and useful chemicals by a number of microorganisms. 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 Figures 13-14. The success of promoting any technology depends on careful planning, management, implementation, training and monitoring. Main features of gasification project are:

- Networking and institutional development/strengthening.
- Promotion and extension.
- Construction of demonstration projects.
- Research and development, and training and monitoring.

Biomass is a raw material that has been utilised for a wide variety of tasks since the dawn of civilisation. Important as a supply of fuel in the third world, biomass was also the first raw material in the production of textiles. The gasification of the carbon char with steam can make a large difference to the surface area of the carbon. The corresponding steam gasification reactions are endothermic and demonstrate how the steam reacts with the carbon charcoal (Omer, 2007; Robinson, 2007; Pernille, 2004; and Sims, 2007).

\[
\begin{align*}
\text{H}_2\text{O (g) + C}_x\text{ (s)} & \rightarrow \text{H}_2\text{ (g) + CO (g) + C}_{x-1}\text{ (s)} \ldots (6) \\
\text{CO (g) + H}_2\text{O (g)} & \rightarrow \text{CO}_2\text{ (g) + H}_2\text{ (g)} \ldots (7) \\
\text{CO}_2\text{ (g) + C}_x\text{ (s)} & \rightarrow 2 \text{ CO (g) + C}_{x-1}\text{ (s)} \ldots (8)
\end{align*}
\]
Table 8. Biomass residues and current use

<table>
<thead>
<tr>
<th>Type of residue</th>
<th>Current use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood industry waste</td>
<td>Residues available</td>
</tr>
<tr>
<td>Vegetable crop residues</td>
<td>Animal feed</td>
</tr>
<tr>
<td>Food processing residue</td>
<td>Energy needs</td>
</tr>
<tr>
<td>Sorghum, millet, and wheat</td>
<td>Fodder, and building materials</td>
</tr>
<tr>
<td>residues</td>
<td></td>
</tr>
<tr>
<td>Groundnut shells</td>
<td>Fodder, brick making, and direct</td>
</tr>
<tr>
<td>cotton stalks</td>
<td>fining oil mills</td>
</tr>
<tr>
<td>Sugar, bagasse, and molasses</td>
<td>Fodder, energy need, and ethanol</td>
</tr>
<tr>
<td></td>
<td>production (surplus available)</td>
</tr>
<tr>
<td>Manure</td>
<td>Fertiliser, brick making, and</td>
</tr>
<tr>
<td></td>
<td>plastering</td>
</tr>
</tbody>
</table>

Table 9. Comparison of various fuels

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Calorific value (kcal)</th>
<th>Burning mode</th>
<th>Thermal efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity, kWh</td>
<td>880</td>
<td>Hot plate</td>
<td>70</td>
</tr>
<tr>
<td>Coal gas, kg</td>
<td>4004</td>
<td>Standard burner</td>
<td>60</td>
</tr>
<tr>
<td>Biogas, m³</td>
<td>5373</td>
<td>Standard burner</td>
<td>60</td>
</tr>
<tr>
<td>Kerosene, l</td>
<td>9122</td>
<td>Pressure stove</td>
<td>50</td>
</tr>
<tr>
<td>Charcoal, kg</td>
<td>6930</td>
<td>Open stove</td>
<td>28</td>
</tr>
<tr>
<td>Soft coke, kg</td>
<td>6292</td>
<td>Open stove</td>
<td>28</td>
</tr>
<tr>
<td>Firewood, kg</td>
<td>3821</td>
<td>Open stove</td>
<td>17</td>
</tr>
<tr>
<td>Cow dung, kg</td>
<td>2092</td>
<td>Open stove</td>
<td>11</td>
</tr>
</tbody>
</table>

Figure 13. Organic matters before and after treatment in digester

The sources to alleviate the energy situation in the world are sufficient to supply all foreseeable needs. Conservation of energy and rationing in some form will however have to be practised by most countries, to reduce oil imports and redress balance of payments positions. Meanwhile development and application of nuclear power and some of the traditional solar, wind and water energy alternatives must be set in hand to supplement what remains of the fossil fuels. 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 (Bacaoui, Yaacoubi, Dahbi, Bennouna, and Mazet, 1998). Heat has a lower exergy, or quality of energy, compared with work. Therefore, heat cannot be converted into work by 100% efficiency.
Some examples of the difference between energy and exergy are shown in Table 10.

### Table 10. Qualities of various energy sources

<table>
<thead>
<tr>
<th>Source</th>
<th>Energy (J)</th>
<th>Exergy (J)</th>
<th>CQF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water at 80°C</td>
<td>100</td>
<td>16</td>
<td>0.16</td>
</tr>
<tr>
<td>Steam at 120°C</td>
<td>100</td>
<td>24</td>
<td>0.24</td>
</tr>
<tr>
<td>Natural gas</td>
<td>100</td>
<td>99</td>
<td>0.99</td>
</tr>
<tr>
<td>Electricity/work</td>
<td>100</td>
<td>100</td>
<td>1.00</td>
</tr>
</tbody>
</table>

The terms used in Table 10 have the following meanings:

\[
\text{Carnot Quality Factor (CQF)} = (1 - T_o/T_s) \ldots (9) \\
\text{Exergy} = \text{Energy (transferred)} \times \text{CQF} \ldots (10)
\]

Where \( T_o \) is the environment temperature (K) and \( T_s \) is the temperature of the stream (K).

Various parameters are essential to achieving sustainable development in a society. Some of them are as follows:

- Public awareness.
- Information.
- Environmental education and training.
- Innovative energy strategies.
- Renewable energy sources and cleaner technologies.
- Financing.
- Monitoring and evaluation tools.

**Wind Energy:** Since early-recorded history, people have been harnessing the energy of the wind. Wind energy propelled boats along the Nile River as early as 5000 B.C., by 200 B.C.; simple windmills in China were pumping water, while vertical-axis windmills with woven reed sails were grinding grain in Persia and the Middle East. New ways of using the energy of the wind eventually spread around the world. By the 11th century, people in the Middle East were using windmills extensively for food production; returning merchants and crusaders carried this idea back to Europe. The Dutch refined the windmill and adapted it for draining lakes and marshes in the Rhine River Delta. When settlers took this technology to the new world in the late 19th century, they began using windmills to pump water for farms and ranches; and later, to generate electricity for homes and industry.

Wind power is the conversion of wind energy into useful form, such as electricity, using wind turbines. In windmills, wind energy is directly used to crush grain or to pump water. At the end of 2007, worldwide capacity of wind-powered generators was 94.1 Giga-Watts. Although wind currently produces just over 1% of worldwide electricity use, it accounts for approximately 19% of electricity production in Denmark, 9% in Spain and Portugal; and 6% in Germany and the Republic of Ireland (2007 data). Globally, wind power generation increased more than fivefold between 2000 and 2007. The cost of the overall system increases as the complexity of the power electronic converter increases. The intricacy of the controller design also affects cost; for example, the use of MPPT techniques would cost more than a simple lookup table method. However, higher order control and converter designs may increase efficiency of the overall system. The inclusion of a DC-boost stage helps reduce the control complexity of the grid inverter at a small increase in cost.
Likewise, replacing the diode rectifier with a controlled rectifier allows for a wider range of control of both the generator and grid real and reactive power transfer. In order to maximise the benefits of the wind energy conversion system, a compromise between efficiency and cost must be obtained (Jamal, 2007; Barry, 2006; and VAN Schijndel, Den Boer, Janssen, Mrema, and Mwaba, 1998).

Wind is simple air in motion. It is caused by the uneven heating of the earth’s surface by the sun. Since the earth’s surface is made of very different types of land and water, it absorbs the sun’s heat at different rates. Today, wind energy is mainly used to generate electricity. Wind energy is also world’s fastest growing energy source and is a clean and renewable source that has been in use for centuries in Europe and more recently in the United States and other nations. Wind turbines, both large and small, produce electricity for utilities and homeowners and remote villages. Wind energy is a clean energy source as electricity generated by wind turbines do not pollute the air or emit pollutants like other energy sources. This means less smog, less acid rain and fewer greenhouse gas emissions. Every 10,000 MW of wind installed can reduce CO$_2$ emissions by approximately 33 MMT annually if it replaces coal-fired generating capacity, or 21 MMT if it replaces generation from average fuel mix. Many developing countries have little incentive to use wind energy technologies, to reduce their emissions despite the fact that the most rapid growth in CO$_2$ emissions is in the developing world. Two related activities could give both developed and developing countries incentives to develop wind projects. The first is joint implementation, a programme under which firms from the developed countries can earn carbon offsets by building clean energy projects in the developing world. Developed nations should endorse and push for joint implementation to move from its current status to full-scale implementation (Grabic, and Katic, 2004; Henderson, Roding, 2004; Chondrogiannis, Barnes, and Aten, 2006; Meier, Norrga, Nee, 2006).

The second activity is the World Bank’s Global Environmental Facility (GEF), which can cover the incremental cost of developing environmentally benign or beneficial projects in the developing world, such as building wind projects instead of an apparently cheaper coal projects. This incentive is particularly important for countries such as China and India, which have tremendous power needs and must build energy capacity quickly at the lowest possible cost. There are numerous factors that influence the overall prospects for the wind industry, though in the end, it is the economics that will be the deciding factor (Table 11). The most important issues identified:

- Assessment of previous patterns of market development in similar markets.
- Increased engagement of utilities and large energy companies.
- National energy plans and government support for renewable energy.
- Technical development.
- Growth in market and the present dynamics of the industry.
- Information about specific large projects.
- Assessment of wind resources and how they can be used.

Economic projections are difficult at the best of times, when economies are relatively stable and a reference ‘business as usual’ case can be used. However, there are numerous signals that the world faces very turbulent economic conditions for a while - a credit crunch may make some project finance difficult and the shortage of raw materials could lead to supply chain difficulties. However, the rapidly escalating price of oil is focusing a lot of attention on the price of energy and the hedge of electricity supply without a fuel cost is likely to become increasingly attractive to many companies and utilities. At some stage, rising fuel costs could lead to demand for wind energy becoming almost infinite. The main factors expected to influence the continuing growth of the wind sector are:

- The economies of the transition states (Russia and Central Asia) will start to grow and increasing energy demand in Asia and South America.
- Oil prices will continue to remain high as will demand for fossil fuels.
- Continuing competitiveness of wind with fossil fuels.
- Many countries may find they are well off their international CO$_2$ reduction commitments and need to install some new renewable capacity very quickly.
- Security of supply questions will continue to support wind power.
- Deregulated markets will remove excess conventional power capacity and new capacity is likely to be more expensive than wind.

Most of these factors are favourable for the industry at the moment. There is strong political support for wind energy, both as engineering and supply chain problems that have been associated with rapid growth in the past. While wind energy can still seem a small industry compared with conventional power generation, the achievement of 1% of world electricity generation is potentially significant. In individual markets such as Denmark, Germany and Spain reaching 1% has been a breakthrough figure, establishing a critical mass and being followed by further rapid growth in each year market. If the same pattern is seen with world wind energy demand and the industry continues to establish itself as a
Table 11. Market shares 2005-2007

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Country</th>
<th>Supplied</th>
<th>Share</th>
<th>Supplied</th>
<th>Share</th>
<th>Supplied</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vestas</td>
<td>Denmark</td>
<td>3186</td>
<td>27.6%</td>
<td>4239</td>
<td>28.2%</td>
<td>4503</td>
<td>22.8%</td>
</tr>
<tr>
<td>Ge Wind</td>
<td>USA</td>
<td>2025</td>
<td>17.5%</td>
<td>2326</td>
<td>15.5%</td>
<td>3283</td>
<td>16.6%</td>
</tr>
<tr>
<td>Gamesa</td>
<td>Spain</td>
<td>1474</td>
<td>12.8%</td>
<td>2346</td>
<td>15.6%</td>
<td>3047</td>
<td>15.4%</td>
</tr>
<tr>
<td>Enercon</td>
<td>Germany</td>
<td>1640</td>
<td>14.2%</td>
<td>2316</td>
<td>15.4%</td>
<td>2769</td>
<td>14.0%</td>
</tr>
<tr>
<td>Suzton</td>
<td>India</td>
<td>700</td>
<td>6.1%</td>
<td>1157</td>
<td>7.7%</td>
<td>2082</td>
<td>10.5%</td>
</tr>
<tr>
<td>Siemens</td>
<td>Denmark</td>
<td>629</td>
<td>5.4%</td>
<td>1103</td>
<td>7.3%</td>
<td>1397</td>
<td>7.1%</td>
</tr>
<tr>
<td>Acciona</td>
<td>Spain</td>
<td>224</td>
<td>1.9%</td>
<td>426</td>
<td>2.8%</td>
<td>873</td>
<td>4.4%</td>
</tr>
<tr>
<td>Goldwind</td>
<td>China</td>
<td>132</td>
<td>1.1%</td>
<td>416</td>
<td>2.8%</td>
<td>830</td>
<td>4.2%</td>
</tr>
<tr>
<td>Nordex</td>
<td>Germany</td>
<td>298</td>
<td>2.6%</td>
<td>505</td>
<td>3.4%</td>
<td>676</td>
<td>3.4%</td>
</tr>
<tr>
<td>Sinovel</td>
<td>China</td>
<td>3</td>
<td>0.0%</td>
<td>75</td>
<td>0.5%</td>
<td>671</td>
<td>3.4%</td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td>1032</td>
<td>8.9%</td>
<td>1094</td>
<td>7.3%</td>
<td>2076</td>
<td>10.5%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>11343</td>
<td>98%</td>
<td>16003</td>
<td>107%</td>
<td>22027</td>
<td>112%</td>
</tr>
</tbody>
</table>

Significant player in the energy sector and pushes on rapidly to 30% of world electricity demand and beyond, then the glass should be seen as half full. Wind energy is one of the low investments high yielding sources of power generation. The future of wind energy is extremely bright and there is no doubt that in the renewable energy sector, wind power would play a predominant role in adding to the national grids clean and non-polluting energy in the coming years (Table 12).

In recent years, demand for the micro wind turbines, of the output below 1 kW, is on the increase as monuments and educational materials. Most of the micro wind turbine that has a diameter less than 1.0 m is low blade tip speed ratio type on the market, by the problem of the frequency, the safety and the blade noise. In these circumstances, it would be necessary to develop the system characteristics of micro wind turbines for the purpose of much higher performance in spite of the low Reynolds number regions. Wind power generation is characterised by its stochastic nature, whereby supply and demand, in small grid systems in particular, mostly do not match. The combination of wind power with a second complementary power generation and/or direct/indirect storage technology therefore has, in principle, considerable potential. Wind-diesel, wind-water desalination and wind power in combination with hydrogen production are all potential options that have been high on the international renewable energy agenda for several years. A small-scale wind-PV hybrid power generator system for dairy farm is shown in Figure 15, to verify the possibilities to apply a power generating system and heating source for dairy farm. It is possible to apply the system for power supply and heat source to melt snow and process fertiliser.

Table 12. Installed capacity per year

<table>
<thead>
<tr>
<th>Year</th>
<th>Europe (MW)</th>
<th>World (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before 2000</td>
<td>9.413</td>
<td>13.954</td>
</tr>
<tr>
<td>2000</td>
<td>13.306</td>
<td>18.449</td>
</tr>
<tr>
<td>2001</td>
<td>17.812</td>
<td>24.927</td>
</tr>
<tr>
<td>2002</td>
<td>23.832</td>
<td>32.037</td>
</tr>
<tr>
<td>2003</td>
<td>29.301</td>
<td>40.301</td>
</tr>
<tr>
<td>2004</td>
<td>34.725</td>
<td>47.912</td>
</tr>
<tr>
<td>2005</td>
<td>40.897</td>
<td>59.320</td>
</tr>
<tr>
<td>2006</td>
<td>48.628</td>
<td>74.517</td>
</tr>
<tr>
<td>2007</td>
<td>57.136</td>
<td>94.593</td>
</tr>
<tr>
<td>2008</td>
<td>66.785</td>
<td>120.458</td>
</tr>
<tr>
<td>2009</td>
<td>78.514</td>
<td>151.753</td>
</tr>
<tr>
<td>2010</td>
<td>93.590</td>
<td>191.318</td>
</tr>
</tbody>
</table>

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 (Omer, 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.

**Figure 15. Wind-Photovoltaic hybrid generation systems**

![Wind-Photovoltaic hybrid generation systems diagram]

**Figure 16. Performance of the wind pump**

![Performance of the wind pump graph]

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 16). Design tools, allowing system performance assessment over a certain period of time, are therefore of great importance for sizing and optimisation 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 localised 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:

\[ E_y = \sum_{i=1}^{i=n} f_{wi} P_{wi} \]  

(11)

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 17 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.

**Figure 17. A power/wind speed curve**

Unchanging for all wind turbines- big or small- is a number of crucial factors that together determine the annual energy-generating potential in kWh/m² of rotor swept area. Key factors that impact potential energy yield and their physical relationships are expressed in the formula:

\[ P = \frac{1}{2} \rho C_p \eta_{me} \eta_{el} V^3 A \]  

(12)

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.
- \( \eta_{me} \) 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.
- \( \eta_{el} \) 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.
- \( \rho \) is the air density in kg/m³ 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 m².

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.

**Analysis and Assessment Methodologies:** Three basic methods have been used in wind energy resource assessments:

- Statistical and subjective analysis of existing wind measurements, other meteorological data and topographical information;
- Qualitative indicators of long-term wind speed levels; and
- Application of boundary layer similarity theory and the use of surface pressure observations.

In general, wind data in summarised or digitised formats are preferred. For stations having several different types of summarised wind data covering various time periods, one or two of the better summaries for those stations should be selected considering:

- The most suitable format for wind power assessment;
- The longest record;
- The least charge in anemometer evaluation and exposure; and
- The most frequent daily observations.

In many remote areas, wind data may be sparse or non-existent and evaluation of the wind data may have to rely on qualitative rather than quantitative methods. For example, there are topographic/meteorologic indicators of both high and low wind power classes. The following are some indicators of a potentially high wind power class:

1. Gaps, passes and gorges in areas of frequent strong pressure gradients.
2. Long valleys extending down from mountain ranges.
3. Plains and plateaus at high evaluations; and plains and valleys with persistent down slope winds associated with strong pressure gradients.
4. Exposed ridges and mountain summits in areas of strong upper-air winds.
5. Exposed coastal sites in areas of strong upper-air winds or strong thermal pressure gradients.

Features generally indicative of low mean wind speeds are as follows:

- Valleys perpendicular to the prevailing wind a lot.
- Sheltered basins.
- Short and/or narrow valleys and canyons.
- Areas of high surface roughness (e.g., forested hilly terrain).

**STATISTICAL DISTRIBUTION FOR WIND DATA**

**Methods of analysis:** Available wind data from the Meteorological Department must be used. The data must be subsequently stratified according to quality, based on the following factors:

- Accuracy of the recording equipment and techniques.
- Type of data collected.
- Exposure of the recording equipment.
- Recording period (year).
- Recording rate/interval.

**Adjustment of evaluation:** Due to the anemometers at different meteorological stations being set at different levels, the measurements, prior to analysis, have to be adjusted to the same height. The standard height, according to the World Meteorological Organisation (WMO), is 10 meters above ground level (WMO, 1994). This height is adopted in the following analysis. There are two methods that can be used to adjust the wind velocity at one level to another level. One of them is the application of power law; the other is to employ the logarithmic law.

**Power law:** Power law is a mathematical relation representing measured wind speed profile in turbulent boundary layer. This relation is expressed in the form:

\[ \frac{V_1}{V_2} = \left( \frac{h_1}{h_2} \right)^n \] \hspace{1cm} (13)

Where \( V_1 \) is wind speed at height \( h_1 \) in turbulent boundary layer; \( V_2 \) is free stream wind speed; \( h_2 \) is boundary layer thickness; and \( n \) is power law exponent.

Practically, the wind speed at any height \( Z \) is adjusted to the speed at \( Z \) reference. The equation, then, becomes:

\[ \frac{V_{\text{ref}}}{V_2} = \left( \frac{Z_{\text{ref}}}{Z} \right)^n \] \hspace{1cm} (14) \hspace{1cm} Or \hspace{1cm} V_{\text{ref}} = V_2 \left( \frac{Z_{\text{ref}}}{Z} \right)^n \] \hspace{1cm} (15)
Power law exponent varies depending on the surface roughness. It has a value of 0.14 for calm sea, 0.4 for town (Eldridge, 1980). In 1978, Smedman-Högström and Högström (Smedman-Högström, and Högström, 1978) proposed a relationship between the exponent \( n \) and the surface roughness \( Z_o \). Their proposed relation, deduced from the experimental results, also includes the stability of the atmosphere. This relationship can be mathematically written as:

\[
 n = C_o + C_1 \log Z_o + C_2 \log Z_o \ldots (16)
\]

Where \( C_o, C_1 \) and \( C_2 \) vary with the stability of the atmosphere, \( Z_o \) is the surface roughness length, which is shown in Tables (13) and (14).

A number of effects have to be considered:
1. Wind shear: The wind slows down, near the ground, to an extent determined by the surface roughness.
2. Turbulence: Behind buildings, trees, ridges, etc.
3. Acceleration: (Or retardation) on the top of hills, ridges, etc.

Wind flowing around buildings or over very rough surfaces exhibits rapid changes in speed and/or direction, called turbulence. This turbulence decreases the power output of the wind machine and can also lead to unwanted vibrations of the machine. Generally, the effect is stronger when the ridge is rather smooth and not too steep nor too flat. The orientation of the ridge should preferably by perpendicular to the prevailing wind direction. If the ridge is curved, it is best if the wind blows in the concave side of the ridge. A quantitative indication of acceleration is difficult to give, but increases of 10% to 20% in wind speed are easily attained. Isolated hills give less acceleration than ridges, because the air tends to flow around the hill. This means that in some cases the two hillsides, perpendicular to the prevailing wind, are better locations than top.

### Table 13. Roughness of height for different types of terrain

<table>
<thead>
<tr>
<th>Terrain</th>
<th>Types</th>
<th>Roughness height ( Z_o ) (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat</td>
<td>Ocean, landscape and beach</td>
<td>0.005</td>
</tr>
<tr>
<td>Open</td>
<td>Low grass, airports, high grass and</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>low crops</td>
<td></td>
</tr>
<tr>
<td>Rough</td>
<td>Tall row crops</td>
<td>0.25</td>
</tr>
<tr>
<td>Very rough</td>
<td>Forests</td>
<td>0.50</td>
</tr>
<tr>
<td>Closed</td>
<td>Villages</td>
<td>1.00</td>
</tr>
<tr>
<td>Towns</td>
<td>Town centre and open spaces in forests</td>
<td>&gt;2.0</td>
</tr>
</tbody>
</table>

The power output of wind rotor increases with the cube of the wind speed. This means that the site for a wind machine must be chosen very carefully to ensure that the location with highest wind speed in the area is selected. The site selection is rather easy in flat terrain but much more complicated in hilly or mountainous terrains. The manipulations are meant to facilitate the judgment to what extent a given location might be suitable for the utilisation of wind energy. In this respect, interest in the following:
1. The daily, monthly and annual wind pattern.
2. The duration of low wind speeds and high wind speeds.
3. The expected locations must be not too far from the place of measurements.
4. The maximum gust speed.
5. The wind energy produced per month and per year.

### Table 14. Values of the constants \( C_o, C_1 \) and \( C_2 \) of the equation (16) for \( n \) as a function of \( \log Z_o \).

<table>
<thead>
<tr>
<th>Stability class</th>
<th>( C_o )</th>
<th>( C_1 )</th>
<th>( C_2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2 Unstable</td>
<td>0.18</td>
<td>0.13</td>
<td>0.03</td>
</tr>
<tr>
<td>3 Near neutral</td>
<td>0.30</td>
<td>0.17</td>
<td>0.03</td>
</tr>
<tr>
<td>4 Slightly stable</td>
<td>0.52</td>
<td>0.20</td>
<td>0.03</td>
</tr>
<tr>
<td>5 Stable</td>
<td>0.80</td>
<td>0.25</td>
<td>0.03</td>
</tr>
<tr>
<td>6 Very stable</td>
<td>1.03</td>
<td>0.31</td>
<td>0.03</td>
</tr>
</tbody>
</table>
LOGARITHMIC LAW

Logarithmic law is the equation using physical arguments and experiment in analysis. This equation is:

\[ \frac{V_z}{V*} = \frac{1}{k} \ln \left( \frac{Z}{Z_o} \right) \]  \hspace{1cm} (17)

Where \( V* \) is friction velocity; \( V_z \) is the wind speed at height \( Z \); \( k \) is Von Karman constant, equals to 0.4; \( Z_o \) is the surface roughness length which can be found from (ESDU, 1972). (Monin and Obukov, 1954) modified equation (17) by including the stability of the atmosphere. Their modified equation becomes:

\[ V_z = \frac{V*}{k} \left[ \ln \frac{Z}{Z_o} - \Phi(Z/L) \right] \]  \hspace{1cm} (18)

Where \( \Phi(Z/L) \) is a function with value varying with the stability of the atmosphere. For examples:

**Stable condition:**
\[ \Phi(Z/L) = -4.7 \frac{Z}{L} \]  \hspace{1cm} (19)
Where \((1/L>0.003 \text{ m}^{-1})\)

**Neutral condition:**
\[ \Phi(Z/L) = 0 \]  \hspace{1cm} (20)
Where \((-0.003 < 1/L \leq 0.003 \text{ m}^{-1})\)

**Unstable condition:**
The determination of \( k \) and \( c \) was made in two steps (Wong, 1977). In the first step, the initial values are estimated by the moment method. In the second step, the maximum likelihood estimation is used to calculate the Weibull parameters. \( k \) and \( c \) are of course the solutions of the following system:

\[ \delta \ln L / \delta k = 0, \quad \delta \ln L / \delta c = 0 \]

\[ \sum_{i=1}^{N} \left( \frac{V_i}{C} \right)^k - \left( \frac{V_i}{C} \right)^c = 0 \]  \hspace{1cm} (21)

Where \( N \) is a set of an hourly data.

Determination of the position on the earth surface for evaluating the surface roughness: Equation (21) requires the value of surface roughness. However, in order to get the value of surface roughness, it is necessary to fix the area that has an influence on wind profile at the level to be adjusted. Smedman-Högström and Högström (Smedman-Högström, 1978) derived the relationship between the growth of the internal boundary layer, \( Z_X \) and the distance from the discontinuity, \( X \) from the analysis of (Pasquill, 1972):

\[ Z_X = aX^b \]  \hspace{1cm} (22)

In which \( a \) and \( b \) are constants which vary with stability and surface roughness.

**Available wind energy:** The power available \( (P_a) \) in cross sectional area \( A \) perpendicular to the wind stream moving at speed \( V \) is:

\[ P_a = 0.5 \rho A V^3 \]  \hspace{1cm} (23)

Where \( \rho \) is the air density.

Sometime available wind energy is expressed as power density:

\[ \frac{P_a}{A} = 0.5 \rho V^3 \]  \hspace{1cm} (24)

However, wind machines can utilise not all of this power. The amount of power, which can be extracted from the wind stream, depends on the available wind energy and on the operating characteristics of the wind energy extraction device. The power output \( P \) of a wind energy conversion system, which subtends area \( A \) of the wind speed \( V \), and density \( \rho \) is:

\[ P = 0.5 \eta C_p \rho A V^3 \]  \hspace{1cm} (25)

Where \( \eta \) is the power coefficient (is the ratio of the actual output compared to the theoretical available = Actual power/theoretical power) (Lysen, 1983), \( C_p \) (Betz) = 16/27 = (0.593) is the theoretical maximum efficiency of the Betz Limit (in other words, theoretical maximum fraction of extracted power). This maximum is called the Betz-maximum in honour of the wind pioneer who first derived its value (Stevens, and Smulders, 1979), \( \rho \) is the air density (kg m\(^{-3}\)); the density of the air depends on the temperature and on the altitude above sea level.

**Weibull distribution:** In recent years much efforts has been made to construct an adequate statistical model for describing the wind frequency distribution. Most attention has been focused on Weibull function, since this give a good fit to the experimental data (Justus, 1978). Weibull distribution is characterised by two parameters: shape parameter, \( K \) and scale parameter, \( C \). The probability density function is given by:

\[ F(V) = \frac{K}{C}(V/C)^{K-1} \exp\left(-\frac{V}{C}\right)^K \]  \hspace{1cm} (26)

Where \( V \) is the wind speed, \( K \) is the shape parameter and \( C \) is the scale parameter. In addition, the cumulative distribution functions by:

\[ F(V) = \exp\left[-\left(\frac{V}{C}\right)^K\right] \]  \hspace{1cm} (27)
The mean of the distribution, i.e., the mean wind speed, \( V \) is equal to: \( V = C \Gamma(1/K+1) \)...(28) Where \( \Gamma \) is the gamma function.

Defining a reduced wind speed,

\[
X = v/V...
\]

Where \( v \) is the average wind speed, and \( V \) is an accumulative wind speed parameter.

The probability density function can be rewritten as:

\[
F(X) = K \Gamma^K(1+1/K) X^{K-1} \exp[-\Gamma^K(1+1/K) X^K]...
\]

Moreover, the cumulative distribution functions as:

\[
F(X) = 1-\exp[-\Gamma^K(1+1/K) X^K]...
\]

There are several methods for determining the Weibull distribution parameters, for example, the method of moment, the method using the energy pattern factor, the method of maximum likelihood and the method of least square fit of the cumulative probabilities.

Wind is simple air in motion. It is caused by the uneven heating of the earth's surface by the sun. Since the earth's surface is made of very different types of land and water, it absorbs the sun's heat at different rates. Today, wind energy is mainly used to generate electricity. Wind energy is also world's fastest growing energy source and is a clean and renewable source that has been in use for centuries in Europe and more recently in the United States and other nations. Wind turbines, both large and small, produce electricity for utilities and homeowners and remote villages. Wind energy is a clean energy source as electricity generated by wind turbines do not pollute the air or emit pollutants like other energy sources. This means less smog, less acid rain and fewer greenhouse gas emissions. Every 10,000 mega Watt (MW) of wind installed can reduce \( \text{CO}_2 \) emissions by approximately 33 million metric tones (MMT) annually if it replaces coal-fired generating capacity or 21 MMT if it replaces generation from average fuel mix. Many developing countries have little incentive to use wind energy technologies, to reduce their emissions despite the fact that the most rapid growth in \( \text{CO}_2 \) emissions is in the developing world.

Two related activities could give both developed and developing countries incentives to develop wind projects. The first is joint implementation, a programme under which firms from the developed countries can earn carbon offsets by building clean energy projects in the developing world. Developed nations should endorse and push for joint implementation to move from its current status to full-scale implementation. The second activity is the World Bank's Global Environmental Facility (GEF), which can cover the incremental cost of developing environmentally benign or beneficial projects in the developing world, such as building a wind project instead of an apparently cheaper coal project. This incentive is particularly important for countries such as China and India, which have tremendous power needs and must build energy capacity quickly at the lowest possible cost. Without going into details, the materials can be ranked in terms of decreasing cost, e.g., titanium, aluminium, plastics (on average), iron and cement.

**Geothermal Energy:** Geothermal steam has been used in volcanic regions in many countries to generate electricity. The use of geothermal energy involves the extraction of heat from rocks in the outer part of the earth. It is relatively unusual for the rocks to be sufficiently hot at shallow depth for this to be economically attractive. Virtually all the areas of present geothermal interest are concentrated along the margins of the major tectonic plates, which form the surface of the earth. The forced or natural circulation of water through permeable hot rock conventionally extracts heat (Duchin, 1995). There are various practical difficulties and disadvantages associated with the use of geothermal power:

- **Transmission:** geothermal power has to be used where it is found. In Iceland it has proved feasible to pipe hot water 20 km in insulated pipes but much shorter distances are preferred. Environmental problems: these are somewhat variable and are usually not great. Perhaps the most serious is the disposal of warm high salinity water where it cannot be reinjected or purified. Dry steam plants tend to be very noisy and there is releases of small amounts of methane, hydrogen, nitrogen, amonia and hydrogen sulphide and of these the latter presents the main problem. The geothermal fluid is often highly chemically corrosive or physically abrasive as the result of the entrained solid matter it carries. This may entail special plant design problems and unusually short operational lives for both the holes and the installations serve.

- **Because the useful rate of heat extraction from a geothermal field is in nearly all cases much higher than the rate of conduction into the field from the underlying rocks, the mean temperatures of the field is likely to fall during exploitation. In some low rainfall areas there may also be a problem of fluid depletion. Ideally, as much as possible of the geothermal fluid should be reinjected into the field. However, this may involve the heavy capital costs of large condensation installations. Occasionally, the salinity of the fluid available for reinjection may be so high (as a result of concentration by boiling) that is unsuitable for reinjection into ground. Occasionally, the impurities can be precipitated and used but this has not generally proved commercially attractive.**

World capacity of geothermal energy is growing at a rate of 2.5% per year from a 2005 level of 28.3 GW (Rawlings, 1999). The GSHFPs account for approximately 54% of this capacity almost all of it in the North America and Europe. The involvement of the UK is minimal with less than 0.04% of world capacity and yet is committed to substantial reduction in
carbon emission beyond the 12.5% Kyoto obligation to be achieved by 2012. The GSHPs offer a significant potential for carbon reduction and it is therefore expected that the market for these systems will rise sharply in the UK in the immediate years ahead given to low capacity base at present. There are numerous ways of harnessing low-grade heat from the ground for use as a heat pump source or air conditioning sink. For small applications (residences and small commercial buildings) horizontal ground loop heat exchangers buried typically at between 1 m and 1.8 m below the surface can be used provided that a significant availability of land surrounding the building can be exploited which tends to limit these applications to rural settings. Heat generation within the earth is approximately 2700 GW, roughly an order of magnitude greater than the energy associated with the tides but about four orders less than that received by the earth from the sun (Oxburgh, 1975).

Temperature distributions within the earth depend on:

- The abundance and distribution of heat producing elements within the earth.
- The mean surface temperature (which is controlled by the ocean/atmosphere system).
- The thermal properties of the earth’s interior and their lateral and radial variation.
- Any movements of fluid or solid rock materials occurring at rates of more than a few millimetres per year.

Of these four factors the first two are of less importance from the point of view of geothermal energy. Mean surface temperatures range between 0-30°C and this variation has a small effect on the useable enthalpy of any flows of hot water. Although radiogenic heat production in rocks may vary by three orders of magnitude, there is much less variation from place to place in the integrated heat production with depth. The latter factors, however, are of great importance and show a wide range of variation. Their importance is clear from the relationship:

$$\beta = q/k... (32)$$

Where:

- $\beta$ is the thermal gradient for a steady state (°C/km), $q$ is the heat flux ($10^6$ cal cm$^{-2}$ sec$^{-1}$) and $k$ is the thermal conductivity (cal cm$^{-1}$ sec$^{-1}$ °C$^{-1}$).

The first requirement of any potential geothermal source region is that $\beta$ being large, i.e., that high rock temperatures occur at shallow depth. Beta will be large if either $q$ is large or $k$ is small or both. By comparison with most everyday materials, rocks are poor conductors of heat and values of conductivity may vary from $2 \times 10^{-6}$ to $10^2$ cal cm$^{-1}$ sec$^{-1}$ °C$^{-1}$. The mean surface heat flux from the earth is about 1.5 heat flow units (1 HFU = $10^{-6}$ cal cm$^{-2}$ sec$^{-1}$). Rocks are also very slow respond to any temperature change to which they are exposed, i.e., they have a low thermal diffusivity:

$$K = k/pC_p ... (33)$$

Where:

- $K$ is thermal diffusivity; $p$ and $C_p$ are density and specific heat respectively.

These values are simple intended to give a general idea of the normal range of geothermal parameters (Table 15). In volcanic regions, in particular, both $q$ and $\beta$ can vary considerably and the upper values given are somewhat nominal.

### Table 15. Values of geothermal parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Lower</th>
<th>Average</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>$q$ (HFU)</td>
<td>0.8</td>
<td>1.5</td>
<td>3.0 (non volcanic) ≈100 (volcanic)</td>
</tr>
<tr>
<td>$k$ = cal cm$^{-2}$ sec$^{-1}$ °C$^{-1}$</td>
<td>$2 \times 10^{-3}$</td>
<td>$6 \times 10^{-3}$</td>
<td>$12 \times 10^{-3}$</td>
</tr>
<tr>
<td>$\beta$ °C/km</td>
<td>8</td>
<td>20</td>
<td>60 (non volcanic) ≈300 (volcanic)</td>
</tr>
</tbody>
</table>

**Energy Extraction from Cold Water:** Climate change is a real threat to the planet’s future, and a major cause for it is the use of fossil fuels to power homes and businesses. Renewable energy, combined with energy efficiency, offers a viable and potent solution to countering the effects of global warming. By installing any of the available renewable energy technologies, one will be making a major personal contribution to the well-being of future generations and could also benefit from lower fuel bills. In heating applications, heat pumps save energy by extracting heat from a natural or waste source, using a mechanism similar to that found in a refrigerator. They can be used for any normal heating needs. However, this technology is not new. Several heat pumps were installed in the 1950's in a bid to save energy and fuel costs. One of the most famous of these was used to heat the Royal Festival Hall in London by extracting heat from the River Thames (Mortal, 2002).

Humans’ natural sense of heat is based more on instinct than science. Humans are warm-blooded and judge “heat” by comparing it to touch. Since the body temperature needs to be maintained to within a few degrees Celsius, the natural senses have evolved to make extremes of temperature uncomfortable. Hence, a hot summer’s day feels many times “hotter” than the freezing mid-winter. But in reality the earth’s surface does not vary in “heat energy” as much as one might imagine. Scientifically speaking, there is only 11% less energy in cold river water at 5°C (40°F) compared to...
hot bath water at 40°C (105°F). The most familiar form of heat pump is the domestic refrigerator. The heat is extracted from the cabinet to keep food fresh and the extracted heat is expelled through the radiator grill at the back of the unit. In this case, the heat is merely a waste product. The heat pump, utilises this heat, and put the "cold part" outside. To make this more understandable, imagine that the "ice box" of a refrigerator is immersed in a small garden stream and the hot grid from the back is placed inside a house. The "ice box" will attempt to freeze the stream and, if the stream stopped from flowing, freezing of the water would naturally occur. But the passing water will constantly warm up the very cold "ice box". Hence, the temperature of the stream will be reduced immeasurably. So, heat is extracted from the stream, which ends up as heat in the radiator grill, available to warm the house. In every case, the useful heat output will be greater than the energy required to drive the heat pump itself. Therefore, the heat was extracted from the stream for "free". Another way to think of it is as follows. If an electric kettle element was immersed in the stream, then water will rapidly absorb any warmth from the element. This would be a one-way loss of energy to the stream. If, conversely, the element is colder than the stream, then the stream will warm it up. Therefore, the surrounding will absorb, hence gaining energy. Swimming pool applications are very energy-efficient and fairly common. These are mostly air-source, taking heat from the air. An air source system, however, will be less effective in winter since the air temperature fluctuates and becomes very cold. For a year-round heating, a river, stream or spring is much more stable and better heat source, offering higher efficiency. The water source should ideally be close to the property. The water flow required is less than one litre per second for a 10 Watt output heat pump, so the smallest of streams can be utilised. Springs and boreholes can often deliver water at a steady 10 degrees Celsius (50°F) throughout the winter, making them excellent heat sources. Ground pipes, buried either vertically or horizontally, are good heat sources. This type is often referred to as geothermal. This system is particularly suited if cooling is also required since in cooling mode (air-conditioning), the energy efficiency is significantly better as compared to a conventional air cooled systems (Figure 18).

Figure 18. Schematic diagram of the GSHP

There are various types of heat pump with many different uses. Nearly all heat pumps use electricity as the form of energy input. Types using gas engines are almost unheard-of in the UK. These can save significant amounts of energy, and are a thing for the future. The heat pump usually delivers heat in the form of hot water. To maintain high-energy efficiency, the system should be designed so that the water temperature is not too high. For this reason, radiators with larger than average surface area (or more of them) should be used. Water temperatures within the pipes of an underfloor heating system can be as low as 35 Celsius (95°F); this gives a very high efficiency. Such systems are very comfortable, and are especially good when used in well-insulated houses.

Energy Source: The Grounds In the autumn of 2000, The British Engineering Council awarded an Environmental Engineering award to the GSHP project at Commerce Way, Surrey. This largest UK ground source project is a speculative built industrial building of about 3000 m² with both offices and warehouse facilities. It is known that during the normal life span of a building the surplus of heat would lead to higher ground temperatures. This leads to less efficient heat pump operation and may result in insufficient capacity during cooling and peak demands. As a solution, the project developed a hybrid system incorporating a dry-cooler (Shao, 2002). The principle idea was to use the dry-cooler to store cold in the wellfield during early spring, when the required summer peak load cold can be generated very efficiently and cheaply. A geothermal energy system uses the ground as a heat-source or heat sink, depending on whether the systems were used in a heating or cooling mode. The ground is principally suited for low temperature energy exchange. The usual operating temperature bandwidth is between –5°C and 40°C (not taking into account high
temperature energy stores). Different systems for exchanging energy with the ground are currently in use, such as direct use of groundwater, closed-loop ground heat exchangers or direct expansion (Yamakamika, 1998).

**Surface Soil Heat:** During the summer, solar heat is stored in the surface layer of the soil. Using this energy for heating is a practical approach for houses with a large plot (Figure 19). The amount of energy that can be extracted is greatest in soils with high water content. The heat is extracted from the soil by means of buried plastic tubing. An environment-friendly non-freezing liquid circulates in the tubing and delivers the collected heat to the heat pump. The heat pump converts the heat into high-grade heat for space heating and to produce hot water.

![Figure 19 Using the soil, bedrock or groundwater as the heat source](image)

There are various sources of energy in the form of stored solar energy, which can provide heat even if they have a low temperature. But, how can a few degrees above zero give enough energy to heat radiators and hot water? During the summer, solar heat is stored in the surface layer of the soil. Also, down in the bedrock there is a source of heat that stays at practically the same temperature all year round. With the help of the GSHPs one can use either or both of these energy sources, as explained below. 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.

**Heat from Bedrock:** Down in the bedrock there is a source of heat that stays at practically the same temperature all year round (Figure 20). Using heat from the rock is a secure, safe and environment-friendly way of heating all types of building, large and small, public and private. The capital cost is relatively high, but in return one gets a reliable, low-energy form of heating with an extremely long life. The coefficient of performance (COP) is generally good, as high as 4.8. The plant occupies little space and can even be installed on small plots. Very little reinstatement work is needed after drilling the borehole, so the effect on the nearby environment is minimal. The groundwater level is not affected, since no groundwater is used. The heat energy can be transferred to an existing, conventional, water-borne heating system and can also be used to produce hot water. The technical and economic performance of a heat pump is closely related to the characteristics of the heat source. An ideal heat source for heat pumps in buildings has a high and stable temperature during the heating season, is abundantly available, is not corrosive or polluted, has favourable thermophysical properties, and its utilisation requires low investment and operational costs. In most cases, however, the availability of the heat source is the key factor determining its use.

Ambient and exhaust air, soil and ground water are practical heat sources for small heat pump systems, while sea/lake/river water, rock (geothermal) and waste water are used for large heat pump systems.

![Figure 20. Ground source heat pumps](image)

Drilling for Energy: The heat is collected from the bedrock and the groundwater through a borehole 4.5 to 6.5 inches in diameter (Figure 21). The depth of the borehole is determined by the amount of energy needed for heating. If the energy demand is great, several boreholes can be connected together. Two lengths of tubing connected at the bottom are passed down into the borehole. Inside the collector tubing there is a frost-resistant liquid (cooling medium, and brine).
The system is completely sealed, so the cooling medium never makes contact with the groundwater. To ensure that the groundwater is not contaminated by surface water running down into the borehole, a steel liner or casing which extends a short distance down into the borehole is installed. Grouting or rubber rings should be used to form a seal between casing and bedrock.

Figure 21. Borehole specifications

Function of the Cooling Circuit: The collector liquid (cooling medium) is pumped up from the borehole in tubing and passed to the heat pump. Another fluid circulates in the heat pump in a closed system with the most important characteristic of having a low boiling point. This fluid is called a refrigerant. When the refrigerant reaches the evaporator, which has received energy from the borehole, the refrigerant evaporates. The vapour is fed to a compressor where it is compressed. This results in a high increase in temperature. The warm refrigerant is fed to the condenser, which is positioned in the boiler water. The refrigerant gives off its energy to the boiler water, so that its temperature drops and the refrigerant changes state from gas to liquid. The refrigerant then goes via filters to an expansion valve, where the pressure and temperature are further reduced. The refrigerant has now completed its circuit and is once more fed into the evaporator where it is evaporated yet again due to the effect of the energy that the collector has carried from the energy source.

The GSHPs come in 15 models from 4 kW up to 30 kW (even up to 300 kW when connected in parallel). At least 65% of the heating and hot water energy consumption of a house can be saved (65-75% of heating costs with a heat pump) as a result of using such a system. However, sizing of the heat pump and the ground loops is essential for the efficient operation of the system. If sized correctly, a GSHP can be designed to meet 100% of space heating requirements. The sizing of the system is very sensitive to heat loads and should therefore be installed into properties with high-energy efficiency standards, particularly new buildings. It is a good and practical idea to explore ways of minimising space heating and hot water demand by incorporating energy efficiency measures.

Free Cooling: The installation can additionally be fitted with fan convectors, for example, in order to allow connections for free cooling (Figure 22). To avoid condensation, pipes and other cold surfaces must be insulated with diffusion proof material. Where the cooling demand is high, fan convectors with drip tray and drain connection are needed. Ambient air is free and widely available, and it is the most common heat source for heat pumps. Air-source heat pumps, however, achieve on average 10-30% lower seasonal performance factor (SPF) than water-source heat pumps. This is mainly due to the rapid fall in capacity and performance with decreasing outdoor temperature, the relatively high temperature difference in the evaporator and the energy needed for defrosting the evaporator and to operate the fans. In mild and humid climates, frost will accumulate on the evaporator surface in the temperature range 0-6°C, leading to reduced capacity and performance of the heat pump system. Coil defrosting is achieved by reversing the heat pump cycle or by other, less energy-efficient means. Energy consumption increases and the overall coefficient of performance (COP) of the heat pump drops with increasing defrost frequency. Using demand defrosts control rather than time control can significantly improve overall efficiencies.

Ground water is available with stable temperatures (4-10°C) in many regions. Open or closed systems are used to tap into this heat source. Closed systems can either be direct expansion systems, with the working fluid evaporating in underground heat exchanger pipes, or brine loop systems. Due to the extra internal temperature difference,
Function of the cooling circuit

heat pump brine systems generally have a lower performance, but are easier to maintain. A major disadvantage of ground water heat pumps is the cost of installing the heat source. Additionally, local regulations may impose severe constraints regarding interference with the water table and the possibility of soil pollution.

**Performance and Costs:** The GSHPs energy cost savings vary with the electric rates, climate loads, soil conditions, and other factors. In residential building applications, typical annual energy savings are in the range of 30 to 60 percent compared to conventional HVAC equipment. Unlike air source units, GSHP systems do not need defrost cycles nor expensive backup electric resistance heat at low outdoor air temperatures. The stable temperature of a ground source is a tremendous benefit to the longevity and efficiency of the compressor.

A residential GSHP system is more expensive to install than a conventional heating system. It is most cost-effective when operated year-round for both heating and cooling. In such cases, the incremental payback period can be as short as 3–5 years. A GSHP for a new residence will cost around 9-12% of the home construction costs. A typical forced air furnace with flex ducting system will cost 5-6% of the home construction costs. Stated in an alternative form, the complete cost of a residential GSHP system is $3,500-$5,500 per ton (Horiuchi, 1997). Horizontal loop installations will generally cost less than vertical bores. For a heating dominated residence, figure around 550 square feet/ton to size the unit. A cooling dominated residence would be estimated around 450 square feet/ton. The table 16 below compares three types of systems.

**Table 16. Comparisons of central heating systems**

<table>
<thead>
<tr>
<th>Central system type</th>
<th>Concern for safety</th>
<th>Installation cost</th>
<th>Operating cost</th>
<th>Life-cycle cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combustion-based</td>
<td>Some concern</td>
<td>Moderate</td>
<td>Higher</td>
<td>Moderate</td>
</tr>
<tr>
<td>Heat pump</td>
<td>Less concern</td>
<td>Moderate</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>GSHP</td>
<td>Less concern</td>
<td>High</td>
<td>Lower</td>
<td>Moderate to low</td>
</tr>
</tbody>
</table>

Conserving natural resources will benefit everyone now and into the future. For homebuilders, green building means the resource-efficient design, construction, and operation of homes. It represents an approach to both building and marketing homes that highlights environmental quality (Roriz, 2001; and Witte, 2002). The GSHPs provide an effective and clean way of heating buildings worldwide. They make use of renewable energy stored in the ground, providing one of the most energy-efficient ways of heating buildings. They are suitable for a wide variety of building types and are particularly appropriate for low environmental impact projects. They do not require hot rocks (geothermal energy) and can be installed in most of the world, using a borehole or shallow trenches or, less commonly, by extracting heat from a pond or lake. Heat collecting pipes in a closed loop, containing water (with a little antifreeze) are used to extract this stored energy, which can then be used to provide space heating and domestic hot water. In some applications, the pump can be reversed in summer to provide an element of cooling. The only energy used by the GSHP systems is electricity to power the pumps. Typically, a GSHP will deliver three or four times as much thermal energy (heat) as is used in electrical energy to drive the system. For a particularly environmental solution, green electricity can be purchased. The GSHP systems have been widely used in other parts of the world, including North America and Europe,
for many years. Typically they cost more to install than conventional systems; however, they have very low maintenance costs and can be expected to provide reliable and environmentally friendly heating for in excess of 20 years. Ground source heat pumps work best with heating systems, which are optimised to run at a lower water temperature than is commonly used in the UK boiler and radiator systems. As such, they make an ideal partner for underfloor heating systems.

**Solar Energy:** In recent years, demand for the micro wind turbines, of the output below 1 kW, is on the increase as monuments and educational materials. Most of the micro wind turbine that has a diameter less than 1.0 m is low blade tip speed ratio type on the market, by the problem of the frequency, the safety and the blade noise. In these circumstances, it would be necessary to develop the system characteristics of micro wind turbines for the purpose of much higher performance in spite of the low Reynolds number regions. Wind power generation is characterised by its stochastic nature, whereby supply and demand, in small grid systems in particular, mostly do not match. The combination of wind power with a second complementary power generation and/or direct/indirect storage technology therefore has, in principle, considerable potential. Wind-diesel, wind-water desalination and wind power in combination with hydrogen production are all potential options that have been high on the international renewable energy agenda for several years. A small-scale wind-PV hybrid power generator system for dairy farm is shown in Figure 23, to verify the possibilities to apply a power generating system and heating source for dairy farm. It is possible to apply the system for power supply and heat source to melt snow and process fertiliser.

Global investment in renewables and energy efficiency now outpaces that for nuclear energy. Renewables also accounted for more than a fifth of new generation capacity built in 2007. The renewable energy and energy efficiency sectors seeing a level of commercial investment that most thought unattainable just a few years back. The risk factors pointing towards a ‘bust’ as identified and summed up in Figure 24.

**Figure 23. Wind-Photovoltaic hybrid generation systems**

Studies have been begun to estimate both the economic effects that climate change will have on global society as well as the costs of possible climate change mitigation and adaptation measures. Although the capacity to enact either a mitigation or adaptation strategy is based on country-specific conditions, technology and information availability, models have been used to calculate the approximate cost to stabilise atmospheric emissions at different levels. Wind power is far from the only clean energy sector on the rise and many of the technologies following in its tracks are much more decentralised, including roof-top systems like photovoltaics (PVs) or solar thermal and energy efficiency technologies on the demand side. Solar and energy efficiency were actually the two largest sectors in terms of venture capital investment, with solar bringing in 30% and efficiency 18% (Figure 25). Besides the high level of early stage investment, mostly focusted on new technology development, these two sectors also fared well on the public stock markets, ranking second and third after wind. Solar would have overtaken wind on the public markets. The potential of electric power generation from incorporating PVs in buildings is enormous. If the electrical power demand of many countries is to be supplemented by the use of PV, it is deemed necessary to integrate such systems into many of the building faces. Many larger structures such as superstores, public buildings and most houses use mass produced tiles on their roofs. Such areas lend themselves useful in contributing to the energy used in the building or to export to the electrical grid when active roof tiles (PV-tiles) are introduced as a part of the roof structure. The integration of PVs within both domestic and commercial roof offers the largest potential market for PV especially in the developed world. Numerous national programmes are attempting to stimulate this market using standard PV modules as a roof element. However, roofs are not static, uniform structures and so are not ideally suited to modules which require precise, planar
mounting structures. To date, attempts at producing a PV roof tile which accommodates current roof practice, in terms of both installation and aesthetics. The market for PV has historically been based on off-grid application where the relatively high cost of PV could be economically justified. In 2001 about 330 MWp of PV were produced and installed
around the world and the growth rate of the industry is over 30% per year-100% per year in some countries with aggressive implementation schemes (Figure 26).

**Figure 26. Cost increase for fossil primary energies and CO₂ emissions and continued technological development and economies of scale in renewables will improve competitiveness**

![Graph showing the growth of renewable energy technologies](image)

There have now been a number of successful large-scale programmes of systems deployed for basic power needs in rural households in developing and less developed countries. Remote applications servicing other applications such as tele-communications, cathodic protection, water pumping, etc., continue to grow as well. The PV market will continue to grow strongly for the next several years at least, driven by incentive programmes, cost reductions and greater market awareness. It is becoming evident, that the quality will be the key to the PV market (Figure 27). The European Commission’s Altener Programme a Training Manual was developed by the Global Approval Programme for PVs (PV GAP) to help manufactures of PV products to introduce quality management in their production. The manual contain important up-dates of the PV GAP Manuals for PV manufactures, published by the World Bank in 1999, including alignment with the 2000 edition of ISO 9001. This revised training manual was also translated from English into French, German and Spanish. Water pumping is one of PV modalities that are growing in rural areas, mainly in developing countries. Due to the importance for health and food production it may be regarded as one of the noblest solar PV uses in isolated areas (Figures 28-29). Reliability and autonomy or self-reliance is understood as main factors for this high growth rates.
Figure 27. Differences in predicted PV market volumes worldwide until 2010

Figure 28. PV distributions for different countries per person

Figure 29. Relative annual costs of the components of small PV stand alone system with a lead-acid battery
Hydropower Potential: This section discusses various aspects of hydropower including: harnessing ocean energy, hydrotelectric dams and micro hydropower systems. This section on hydropower explores the factors associated with utilising the actual potential of hydropower energy. The section covers all the technological details, along with issues and challenges faced during the utilisation of hydropower energy. Major projects, power plants, players in the industry, the major role of the United States in the global hydropower industry, and the various environmental benefits of using hydropower energy are all explored in depth in this section. The growing worldwide demand for renewable energy projects is being driven by ever increasing global energy consumption and the availability of carbon and renewable energy credits. Renewable energy is entering a new phase with additional funding becoming available from governments, from socially responsible equity funds, and from public capital raisings. Hydropower is the capture of the energy derived from moving water for some useful purpose. Prior to the widespread availability of commercial electric power, hydropower was used for irrigation, milling of grain, textile manufacture, and the operation of sawmills. Hydropower produces essentially no carbon dioxide or other harmful emissions. In contrast to burning fossil fuels, this energy is not a significant contributor to global warming through production of CO₂. Hydroelectric power can be far less expensive than the electricity generated from fossil fuel or nuclear energy. Areas with abundant hydroelectric power attract industry. Environmental concerns about the effects of reservoirs may prohibit development of economic hydropower sources in some areas.

Hydropower currently accounts for approximately 20% of the world’s electricity production, with about 650,000 MW installed and approximately 135,000 MW under construction or in the final planning stages. Notwithstanding this effort, there are large untapped resources on all continents, particularly in areas of the world that are likely to experience the greatest growth in power demand over the next century. It is estimated that only about a quarter of the economically exploitable water resources has been developed to date, leaving the potential for hydro to continue to play a large role in sustaining renewable global electricity production in the future.

Apart from a few countries with abundance, hydro power is normally applied to peak load demand because it can be readily stopped and started. Nevertheless, hydrotelectric power is probably not a major option for the future of energy production in the developed nations, however, because most major sites within these nations are either already being exploited or are unavailable for other reasons, such as environmental considerations.

Future hydropower energy programmes must be put into practice in conjunction with sound policies that restrict the use of fossil fuels and natural resources and contribute to the reduction of emissions into the environment. Such a strategy should be based in a sound scientific basis, without ideology, politics or financial interests. It should be implemented on a worldwide basis and not limited to industrialised countries. To achieve this goal, existing hydropower energy options must be evaluated for implementation, new strategies must be formulated and new, innovative solutions have to be found. All projects are required to have environmental impacts assessment conducted, covering all potential damage to the environment, mitigation and restoration, a reclamation plan including a resettlement programme for displaced residents, and the estimated implementation costs. All hydro projects are required to conduct an environmental impact study. Water is essential to industry for processes such as cooling, cleaning, diluting and sanitation. With increasingly stringent water abstraction limits, recent droughts and a growing interest in the environmental performance of businesses, there is a need for industry to reduce water use.

Wave Power Conversion Devices: The patent literature is full of devices for extracting energy from waves, i.e., floats, ramps, and flaps, covering channels (Swift-Hook, 1975). Small generators driven from air trapped by the rising and falling water in the chamber of a buoy are in use around the world. Wave power is one possibility that has been selected. Figure 30 shows the many other aspects that will need to be covered. A wave power programme would make a significant contribution to energy resources within a relatively short time and with existing technology.

Wave energy has also been in the news recently. There is about 140 megawatts per mile available round British coasts. It could make a useful contribution to people needs in the UK. Although very large amounts of power are available in the waves, it is important to consider how much power can be extracted. A few years ago only a few percent efficiency had been achieved. Recently, however, several devices have been studied which have very high efficiencies. Some form of storage will be essential on a second-to-second and minute-to-minute basis to smooth the fluctuations of individual waves and wave’s packets but storage from one day to the next will certainly not be economical. This is why provision must be made for adequate standby capacity.

The increased availability of reliable and efficient energy services stimulates new development alternatives. This study discusses the potential for such integrated systems in the stationary and portable power market in response to the critical need for a cleaner energy technology. Anticipated patterns of future energy use and consequent environmental impacts (acid precipitation, ozone depletion and the greenhouse effect or global warming) are comprehensively discussed in this theme. Throughout the theme several issues relating to renewable energies, environment and sustainable development are examined from both current and future perspectives. It is concluded that renewable environmentally friendly energy must be encouraged, promoted, implemented and demonstrated by full-scale plant.
(device) especially for use in remote rural areas. Globally, buildings are responsible for approximately 40% of the total world annual energy consumption. Most of this energy is for the provision of lighting, heating, cooling, and air conditioning. Increasing awareness of the environmental impact of CO\textsubscript{2} and NO\textsubscript{x} and CFCs emissions triggered a renewed interest in environmentally friendly cooling, and heating technologies. Under the 1997 Montreal Protocol, governments agreed to phase out chemicals used as refrigerants that have the potential to destroy stratospheric ozone. It was therefore considered desirable to reduce energy consumption and decrease the rate of depletion of world energy reserves and pollution of the environment. 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. The provision of good indoor environmental quality while achieving energy and cost efficient operation of the heating, ventilating and air-conditioning (HVAC) plants in buildings represents a multi variant problem. The comfort of building occupants is dependent on many environmental parameters including air speed, temperature, relative humidity and quality in addition to lighting and noise. The overall objective is to provide a high level of building performance (BP), which can be defined as indoor environmental quality (IEQ), energy efficiency (EE) and cost efficiency (CE).

Figure 30. Possible systems for exploiting wave power, each element represents an essential link in the chain from sea waves to consumer.
Nuclear Energy: Nuclear power is a type of nuclear technology involving the controlled use of nuclear reactions, usually nuclear fission, to release energy for work including propulsion, heat and the generation of electricity. Nuclear energy is produced by a controlled nuclear chain reaction and creates heat - which is used to boil water, produce steam and drive steam turbines (IEA, 2007).

A nuclear reactor is a device in which nuclear chain reactions are initiated, controlled, and sustained at a steady rate, as opposed to a nuclear bomb, in which the chain reaction occurs in a fraction of a second and is uncontrolled causing an explosion. The most significant use of nuclear reactors is as an energy source for the generation of electrical power and for the power in some ships. This is usually accomplished by methods that involve using heat from the nuclear reaction to power steam turbines. The United States produces the most nuclear energy, with nuclear power providing 20% of the electricity it consumes, while France produces the highest percentage of its electrical energy from nuclear reactors 80% as of 2006. In the European Union as a whole, nuclear energy provides 30% of the electricity. Nuclear energy policy differs between European Union countries and some, such as Austria and Ireland, have no active nuclear power stations. In comparison, France has a large number of these plants, with 16 multi-unit stations in current use. This process can often be a complex experience and therefore the most cost-effective approach is to employ an energy specialist to help. Improving access for rural and urban low-income areas in developing countries must be through energy efficiency and renewable energies. The future development of rural energy should be aimed at completely changing the current pattern of energy consumption, fully utilising abundant resources of hydropower, biomass, solar and wind energy, promoting economic growth through the development of rural energy and integrated utilisation of biomass.

ENERGY AND ENVIRONMENT

Today, renewable energy is some 20% of the world's annual energy use of about 9 x 10^9 tonnes of oil equivalent (Mtoe/a; 1 toe = 42 GJ) (UNEP, 2003). Fossil fuels account for the bulk; about 80% of the energy use. In the future, it is postulated that these roles will change as energy demand rises and cheap oil and gas are depleted; even without consideration of global warming effects. The changes will be driven mainly by the developing areas, which have relatively less of the fossil fuel reserves, but have a substantial potential to deploy renewable energies (Viktor, 2002). A substantial potential is believed to exist in the world for renewable energy sources. This is estimated as 4900 Mtoe/annually for biomass, 780 Mtoe/a (electric) for hydropower, and 4540 Mtoe/a (electric) for wind-power (Lam, 2000). Roughly half of these energy resources are in developing countries. The rest of the energy will have to be supplied by fossil, solar, geothermal and nuclear (fission and fusion) sources. An example distribution of world energy sources is shown in Figure 31. They are campaigning for sustainable development, which has been defined as development, which meets present needs without compromising the ability of future generation to meet their needs (D'Apote, 1998). It is, therefore, essential that energy efficiency improvements and all energy sources, particularly renewables, are developed and deployed rapidly in order to ensure that population stabilisation, with a decent standard of living for all, is realised. There is a need to move towards a sustainable energy policy with the objectives of environmental protection, sound natural resource management and energy security. Opportunities exist for the increased development of renewable energy and energy efficiency through regulation, changes to institutional and economic arrangements, and through liberalisation of the energy market, which offers the potential for the development of energy service companies and a market for green electricity. Friends of the Earth have been one of the leading environmental groups campaigning in support of renewable energy and energy efficiency over the last two decades. Industry’s use of fossil fuels has been blamed for our warming climate. When coal, gas and oil are burnt, they release harmful gases, which trap heat in the atmosphere and cause global warming. However, there has been an ongoing debate on this subject, as scientists have struggled to distinguish between changes, which are human induced, and those, which could be put down to natural climate variability. Industrialised countries have the highest emission levels, and must shoulder the greatest responsibility for global warming. However, action must also be taken by developing countries to avoid future increases in emission levels as their economies develop and population grows. Human activities that emit carbon dioxide (CO₂), the most significant contributor to potential climate change, occur primarily from fossil fuel production. Consequently, efforts to control CO₂ emissions could have serious, negative consequences for economic growth, employment, investment, trade and the standard of living of individuals everywhere. Scientifically, it is difficult to predict the relationship between global temperature and greenhouse gas concentrations. The climate system contains many processes that will change if warming occurs. Critical processes include heat transfer by winds and currents, the hydrological cycle involving evaporation, precipitation, runoff and groundwater and the formation of clouds, snow, and ice, all of which display enormous natural variability. The equipment and infrastructure for energy supply and use are designed with long lifetimes, and the premature turnover of capital stock involves significant costs. Economic benefits occur if capital stock is replaced.
Figure 31. Total energy uses for 2010-2300 with potential energy sources (added to give total). (a) Lower efficiency and developed countries take efficiency gains as increase in standard of living. (b) Higher efficiency gains and developed countries use gains to reduce energy use with more efficient equipment in step with its normal replacement cycle. Likewise, if opportunities to reduce future emissions are taken in a timely manner, they should be less costly. Such flexible approaches would allow society to take account of evolving scientific and technological knowledge, and to gain experience in designing policies to address climate change.

CONCLUSION

Many cities around the world are facing the problem of increasing urban density and energy demand. As cities represent a significant source of growth in global energy demand, their energy use, associated environmental impacts, and demand for transport services create great pressure to global energy resources. Low energy design of urban environment and buildings in densely populated areas requires consideration of a wide range of factors, including urban setting, transport planning, energy system design, and architectural and engineering details. It is found that densification of towns could have both positive and negative effects on the total energy demand. With suitable urban and building design details, population should and could be accommodated with minimum worsening of the environmental quality. Energy efficiency brings health, productivity, safety, comfort and savings to homeowners, 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 improve in addition to building the capacity of the private and district staff in contracting procedures. The financial accountability is important and should be made transparent.

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Urban Planning and Design


Appendix (1) solar Energy

Appendix (1.1) solar energy sources their final uses

Appendix (1.2) solar photovoltaic array

Appendix (1.3) solar photovoltaic
Appendix (1.4) Solar Chimney

Appendix (2) Wind Energy

Appendix (2.1) Wind generators

Appendix (2.2) Wind towers
Appendix (2.3) onshore wind generators

Appendix (2.4) Wind farm

Appendix (2.4) Wind generators
Appendix (3) Hydropower energy

Appendix (3.1) Hydropower

Appendix (4) Biomass energy

Appendix (4.1) Biomass resources

Appendix (4.2) Biogas production
Appendix (4.3) Gasifier system
Appendix (5) Ground source heat pump system

Appendix (5.1) shows the connections of the heat exchanger and expansion valve

Appendix (5.2) shows the connections of the heat exchanger, water pump, heat rejection fan and expansion valve
Appendix (6) Systems management

Appendix (6.1) Types of maintenance
Total productive maintenance (TPM) is widely known worldwide as a maintenance management technique. This technique, taken from the U.S. style of preventive maintenance (PM), was reconfigured by adding some elements of Japanese management style. TPM activities are performed based on a structure called "TPM 8 pillars", which include:
1. Individual improvement
2. Autonomous maintenance
3. Planned maintenance
4. Development management
5. Education and training
6. Office TPM
7. Quality maintenance
8. Safety, health and environment

Appendix (6.2) Outline of knowledge warehouse

Among the TPM 8 pillars, companies, especially small and medium-sized enterprises, put more effort into autonomous maintenance in addition to 5S.
Autonomous maintenance has seven phases or steps of activity, as listed below:
1. Performing an initial cleaning
2. Eliminating sources of contamination and inaccessible areas
3. Creation of cleaning and routine maintenance standards (checklist)
4. Conducting "standards and inspection" training
5. Carrying out an autonomous equipment inspection
6. Organisation and standardisation of the workplace
7. Continuous improvement of policies, standards and equipment
Appendix (6.3) Framework of maintenance performance benchmarking using data envelopment analysis (DEA)

- **Planning**: *identify what is to be evaluated*
- **Identification**: *identify the relevant data*
- **Assessment**: *conduct assessment*
- **Integration**: *analyse and share/transfer result*
- **Application**: *apply result to improve business*

*Acquisition from repository* -> *Store to repository*