Journal of Soil Science and Environmental Management Vol. 1(7), pp. 127-154, September 2010
Available online at http://www.academicjournals.org/JSSEM
ISSN 2141-2391 ©2010 Academic Journals

Review

A review of non-conventional energy systems and environmental pollution control

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Accepted 30 August, 2010

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, 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. 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. Self-renewing resources such as wind, sun, plants and heat from the earth can provide clean abundant energy through the development of renewable technologies. Virtually all regions of the world have renewable resources of one type or another. Research and development investments in the past 25 years in renewable technologies development has lead to important advances in performance and resulting cost effectiveness. Renewable resources currently account for about 9%-10% of the energy consumed in the world; most of this is from hydropower and traditional biomass sources. Wind, solar, biomass and geothermal technologies are cost effective today in an increasing number of markets and are making important steps to broader commercialisation. The present situation is best characterised as one of very rapid growth for wind and solar technologies and of significant promise for biomass and geothermal technologies. Each of the renewable energy technologies is in a different stage of research, development and commercialisation and all have differences in current and future expected costs, current industrial base, resource availability and potential impact on energy supply. 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. 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 paper. Throughout the theme, several issues relating to renewable energies, environment and sustainable development are examined from both current and future perspectives.

Key words: Energy, renewable energy technologies, energy efficiency, environment, sustainable development, global warming, emissions.

INTRODUCTION

Energy has been a vital input into the economic and social development. However, one third of the world population, living in developing and threshold countries, has no access to electricity. These people mostly live in remote and rural areas with low population density, lacking even the basic infrastructure. Accordingly, utility grid extension is not a cost-effective option and sometimes technically not feasible. Therefore, it is imperative to look for sustainable (that is., cost-effective, environmentally benign and reliable) sources of energy for the development of these regions. Using locally available renewable energy sources (especially solar irradiation that is characterized by a sufficient availability on a daily basis) which are of high potential in most of these regions offers a strategic solution for their techno-economic development. From the point of view of technology, the design of system technology that meets electrification requirements and fulfils, if necessary, the requirements of integration into AC supply grids, has to be considered (Abdeen, 2008a).

The modernization of the system components and their power ranges which allow easy expandability of the supply structure, the standardization of interfaces and the hybridization by integration of different energy converters in order to increase the power availability, represent the most important measures from the point of view of system technology. Moreover, the use of renewable energy sources is essentially made easier if the existing reliable AC- technical standards of construction and extension of conventional electricity supply systems are adopted. Therefore, incompatibility cannot be taken as a reason to reduce the dissemination of renewable systems.

In the early years of PV history stand-alone as well as grid-connected PV-systems had been built as individual items or unique masterpieces. Until recent years the realization of PV-systems still was characterized by monolithic system concepts resulting in a costly design and engineering process. Consequently a large number of different PV system components (e.g., inverter) were developed each tailored for the use in the dedicated application with its specific parameters (e.g., input voltage/current).

The exploitation of the energetic potential (solar and wind) for the production of electricity proves to be an adequate solution in isolated regions where the extension of the grid network would be a financial constraint. The use of wind as alternative energy source is increasing and research and development about this clean and unlimited resource is being carried out on various levels (Abdeen, 2008b). Likewise, energy savings from the avoidance of air conditioning can be very substantial. Whilst day-lighting strategies need to be integrated with artificial lighting systems in order to become beneficial in terms of energy use, reductions in overall energy consumption levels by employment of a sustained programme of energy consumption strategies and measures would have considerable benefits within the buildings sector (Fordham, 2000). The perception often given however is that rigorous energy conservation as an end in itself imposes a style on building design resulting in a restricted aesthetic solution. It would perhaps be better to support a climate sensitive design approach, which encompassed some elements of the pure conservation strategy together with strategies, which work with the local ambient conditions making use of energy technology systems, such as solar energy, where feasible. In practice, low energy environments are achieved through a combination of measures that include:

(i) The application of environmental regulations and policy,
(ii) The application of environmental science and best practice,
(iii) Mathematical modelling and simulation,
(iv) Environmental design and engineering,
(v) Construction and commissioning, and
(vi) Management and modifications of environments in use.

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. 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 paper. 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 plan especially for use in remote rural areas.

ENERGY FROM WASTE

Measures to maximize 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 1). 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:

(i) EU landfill diversion directive.
(ii) Recycling targets.
(iii) 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 2). The waste collection, transfer an landfill disposal business comprise a mature, slow-growth

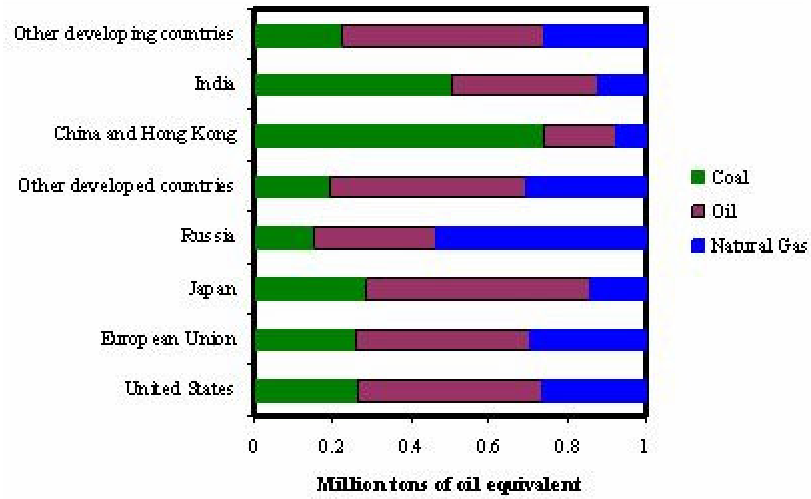

Figure 1. Global fossil fuel consumption.

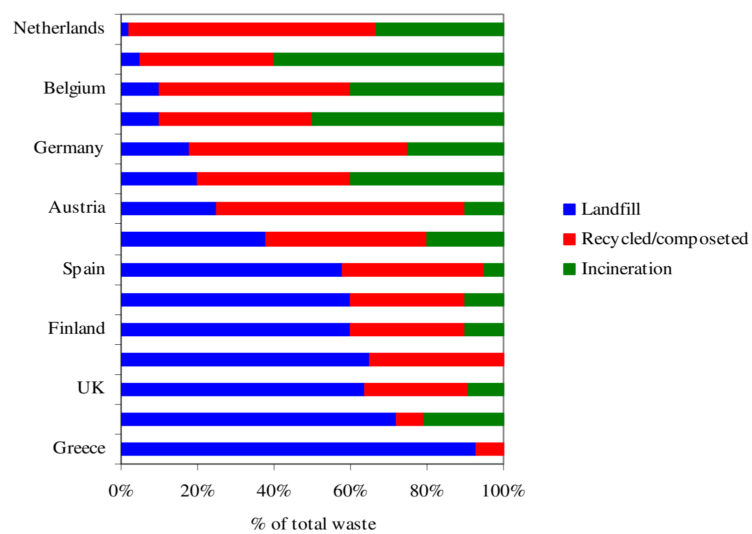

Figure 2. Municipal waste management in the European Union.

industry. Economic drivers to developing the waste and renewable energy sector have included: (i) Waste disposal and landfill gate fees/landfill tax,
(ii) Penalties/avoidance schemes (e.g., landfill allowance schemes and fines, carbon trading),
(iii) Energy prices, and
(iv) Investments subsidies.

When considering the demand and opportunity in today's marketplace these points are prevalent:

(i) The demand for renewable energy is not going to go away,
(ii) The public feeling is that governments across the world are responsible,
(iii) The pressure caused by diminishing fossil fuel supplies is increasing,
(iv) Investment funds are increasingly available from traditional sources, and
(v) The needs for new technologies that can deliver carbon reduction and waste reduction outcomes are increasingly bankable which opens up the market for all.

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:

(i) Adequate independent technology due diligence,

Table 1. Comparison of basic requirements for bottom liners in MSW sanitary landfills.

Liner system requirement	Leachate drainage layer	Geomembrane line	Compacted clay layer
US EPA Standard (40CFR258)	$K > 1 \times 10^{-4}$ ms^{-1} Thickness 0.3 m	Thickness ≥ 0.75 mm Recommended 1.5 mm HDPE	$K \leq 1 \times 10^{-6}$ ms^{-1} Thickness ≈60 cm
EU Landfill Directive (1999/31/Dec)	Thickness 0.5 m	Not specified. Yet liner thickness should be 100 cm $K \leq 1 \times 10^{-6}$ ms^{-1}	With HDPE liner, thickness of clay layer > 50 cm
German Standard (TASI 1993)	$K > 1 \times 10^{-3}$ ms^{-3} Thickness 0.3 m	Thickness ≥ 2.5 mm HDPE	$K \leq 5 \times 10^{-10}$ ms^{-1} Thickness 3 cm × 25 cm
Chinese Standard (CJJ 113-2007)	$K > 1 \times 10^{-3}$ ms^{-3} Thickness > 0.3 m	Thickness ≥ 1.5 mm HDPE	$K \leq 1\times 10^{-6}$ ms^{-1} Thickness 75 cm

Table 2. The different parameters in waste compaction.

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

(ii) Security of waste input and power off-take contracts,
(iii) A site with planning permission, and
(iv) A reference plant, preferably at scale.

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 decentralized 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 summarized in Table 1. 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 2 summarized different parameters in waste compaction. Waste professionals use Cross Wrap machinery for its

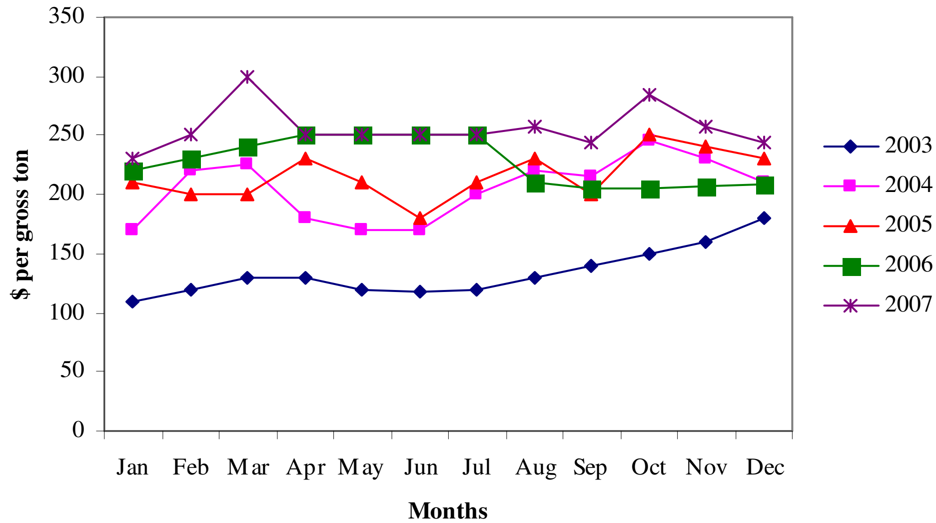

Figure 3. Monthly averages paper scraps.

reliability and efficiency in storage and transport of waste materials (Abdeen, 2008c).

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 more importantly – at a time when recycling as much materials as effectively as possible is paramount- it allows for more effective sorting afterwards. And logically, effective sorting equals greater opportunity for recycling (Figure 3). 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:

(i) To maximize yields with minimum inputs.
(ii) Utilization and selection of adequate plant materials and processes.
(iii) Optimum use of land, water, and fertilizer.
(iv) Create an adequate infrastructure and strong R&D base.

BIOMASS 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 modernize existing power plants to increase their energy efficiency and to improve their environmental performance. However, utilization of wind power and the conversion of gas-fired CHP plants to biomass would significantly reduce the dependence on

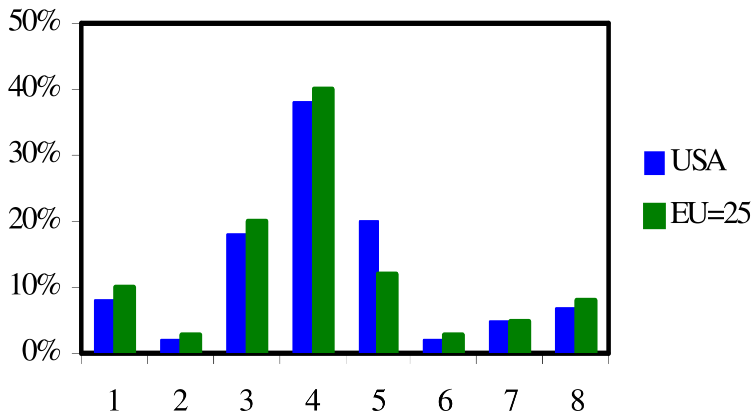

Figure 4. Distribution of industrial CHP capacity in the EU and USA (Abdeen, 2008c). 1 Food, 2 Textile, 3 Pulp and paper, 4 Chemicals, 5 Refining, 6 Minerals, 7 Primary metals, and 8 others.

imported fossil fuels. Although a lack of generating capacity is forecasted in the long-term, utilization 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. A vision used a methodology and calculations based on computer modelling that utilized:

(i) Data from existing governmental programmed,
(ii) Potential renewable energy sources and energy efficiency improvements,
(iii) Assumptions for future economy growth, and
(iv) Information from studies and surveys on the recent situation in the energy sector.

In addition to realizing 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 Organizations (NGOs) are urging the government to adopt sustainable development of the energy sector by:

(i) Diversifying of primary energy sources to increase the contribution of renewable and local energy resources in the total energy balance, and
(ii) 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 ($MMTCO_2e$) (Abdeen, 2008c) as shown in Figure 4. 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. Classic management approaches to risk are well documented and used in many industries. This includes the following four broad approaches to risk:

(i) 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,
(ii) Mitigation/reduction involves methods that reduce the severity of potential loss,
(iii) 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, and
(iv) Transfer means causing another party to accept the risk, typically by contract.

WIND ENERGY

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 3). The

Table 3. Market shares 2005 - 2007.

Year		2005		2006		2007	
Manufacturer	**Country**	**Supplied**	**Share%**	**Supplied**	**Share**	**Supplied**	**Share%**
Vestas	Denmark	3186	27.6	4239	28.2%	4503	22.8
Ge Wind	US	2025	17.5	2326	15.5	3283	16.6
Gamesa	Spain	1474	12.	2346	15.6	3047	15.4
Enercon	Germany	1640	14.2	2316	15.4	2769	14.0
Suzton	India	700	6.1	1157	7.7	2082	10.5
Siemens	Denmark	629	5.4	1103	7.3	1397	7.1
Acciona	Spain	224	1.9	426	2.8	873	4.4
Goldwind	China	132	1.1	416	2.8	830	4.2
Nordex	Germany	298	2.6	505	3.4	676	3.4
Sinovel	China	3	0.0	75	0.5	671	3.4
Others		1032	8.9	1094	7.3	2076	10.5
Total		11343	98	16003	107	22207	112

most important issues identified:

(i) Assessment of previous patterns of market development in similar markets.
(ii) Increased engagement of utilities and large energy companies, iii) National energy plans and government support for renewable energy,
(iv) Technical development,
(v) Growth in market and the present dynamics of the industry,
(vi) Information about specific large projects, and
(vii) Assessment of wind resources and how they can be used.

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. 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:

(i) The economies of the transition states (Russia and Central Asia) will start to grow,
(ii) Increasing energy demand in Asia and South America,
(iii) Oil prices will continue to remain high as will demand for fossil fuels,
(iv) Continuing competitiveness of wind with fossil fuels,
(v) Many countries may find they are well off their international CO_2 reduction commitments and need to install some new renewable capacity very quickly, (vi) Security of supply questions will continue to support wind power, and
(vii) Deregulated markets will remove excess conventional power capacity and new capacity is likely to be more expensive than wind.

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 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 4).

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 under 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

Table 4. Installed capacity per year (Abdeen et al., 2010).

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

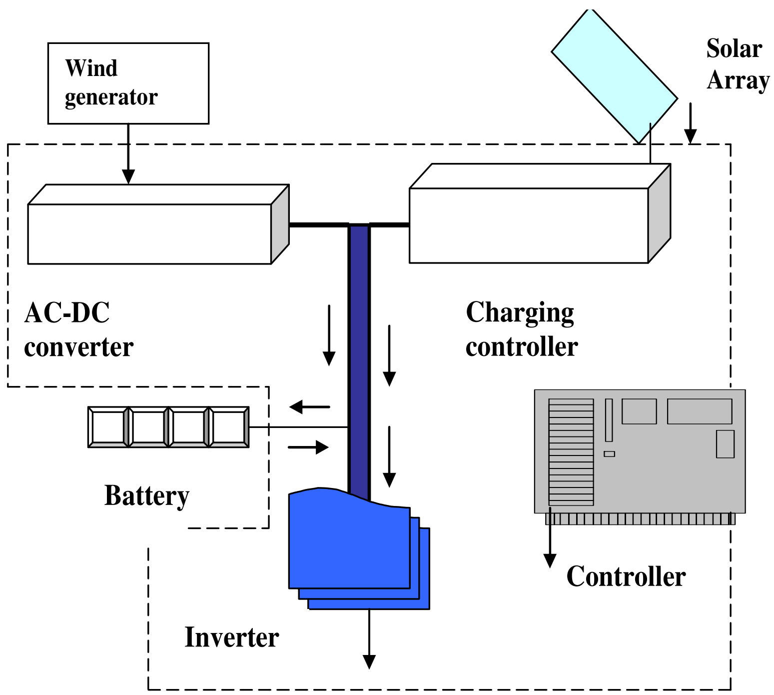

Figure 5. Wind-Photovoltaic hybrid generation systems (Abdeen, 2010).

purpose of much higher performance in spite of the low Reynolds number regions. Wind power generation is characterized 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 5, 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 fertilizer.

SOLAR ENERGY

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

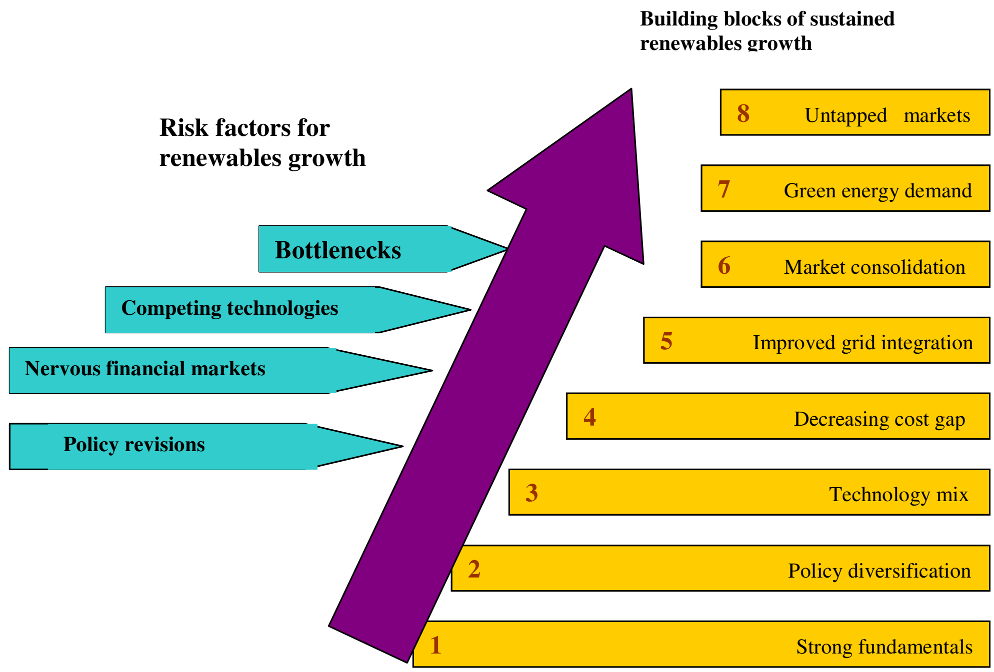

Figure 6. Summary of risk and risk mitigation factors (Abdeen, 2010).

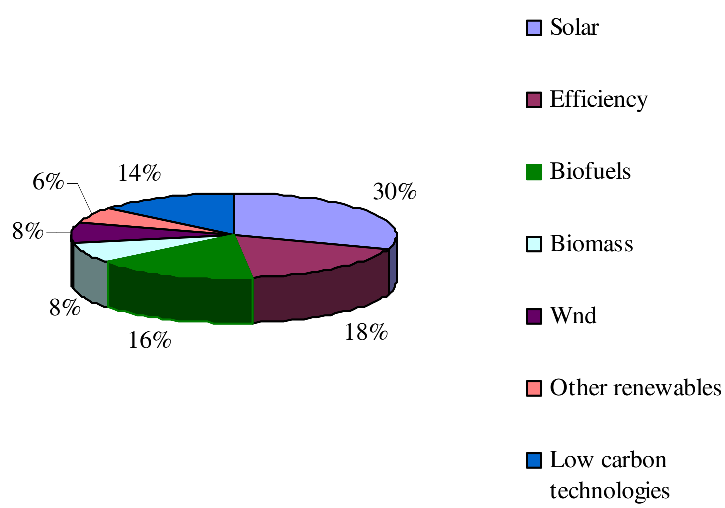

Figure 7. Investment in renewable and energy efficiency.

built in 2007 (Omer, 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 6. 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 7). Besides

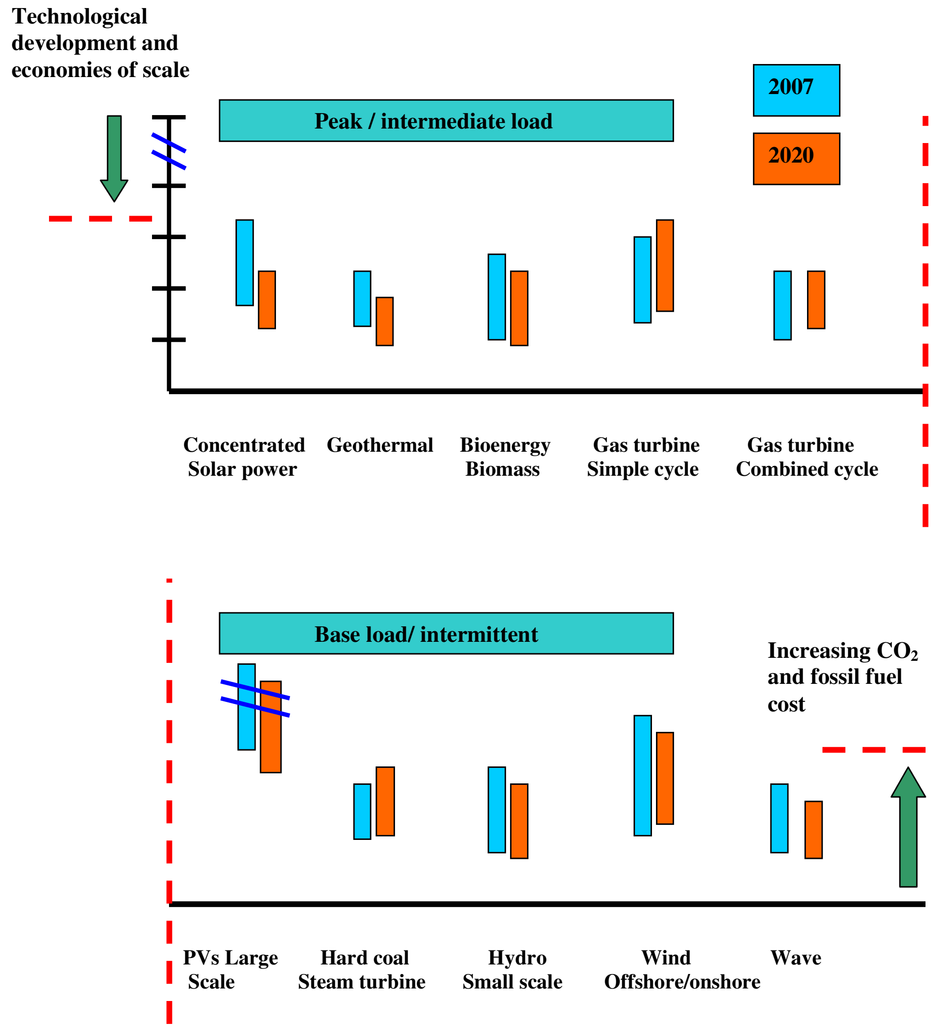

Figure 8. Cost increase for fossil primary energies and CO_2 emissions and continued technological development and economies of scale in renewables will improve competitiveness (Abdeen, 2010).

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 8).

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

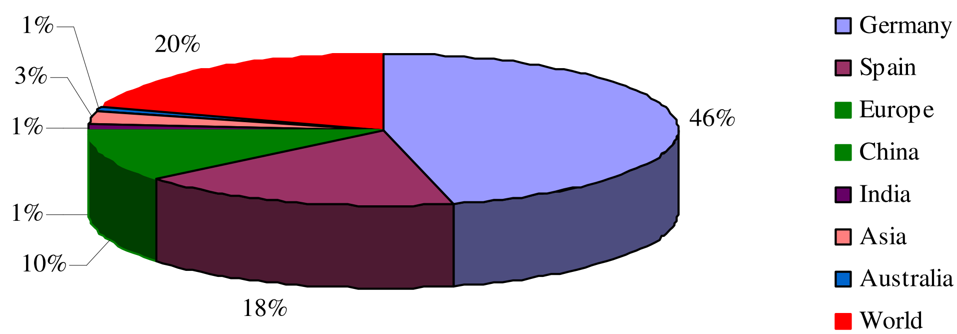

Figure 9. Differences in predicted PV market volumes worldwide until 2010.

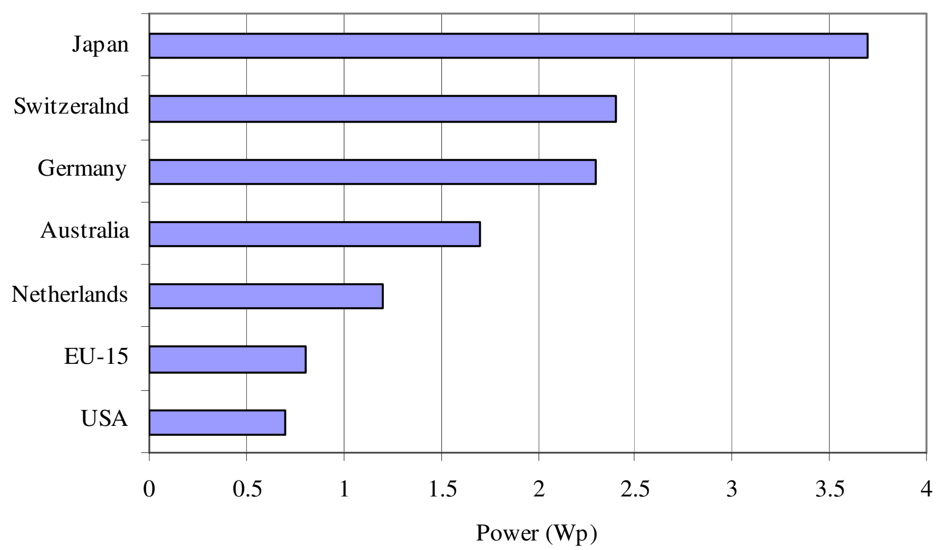

Figure 10. PV distributions for different countries per person.

countries. Remote applications servicing other applications such as telecommunications, catholic 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 9). 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 10 - 11). Reliability and autonomy or self-reliance is understood as main factors for this high growth rates.

HYDROPOWER POTENTIAL

This section discusses various aspects of hydropower including: harnessing ocean energy, hydroelectric dams and micro hydropower systems. This section on hydropower explores the factors associated with utilizing the actual potential of hydropower energy. The section covers all the technological details, along with issues and challenges faced during the utilization 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

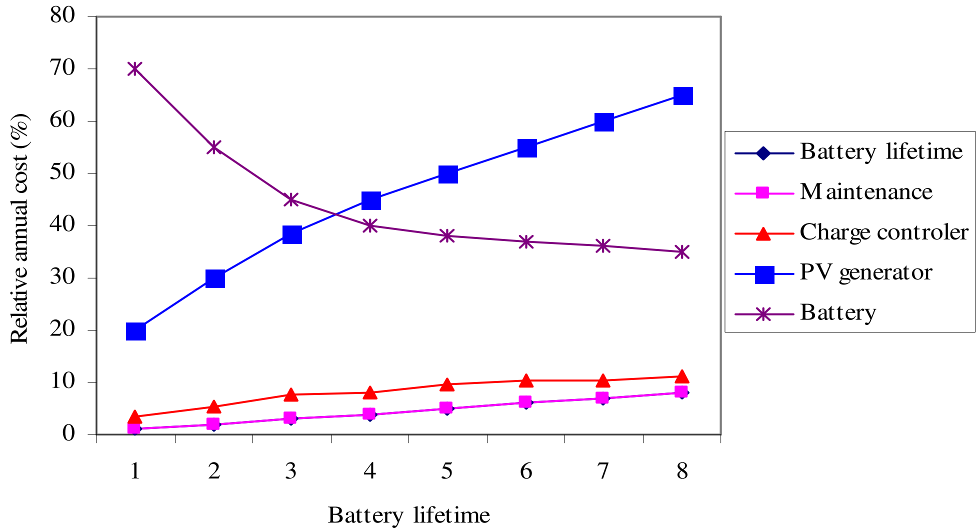

Figure 11. Relative annual costs of the components of small PV stand alone system with a lead-acid battery.

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 CO_2.

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, hydroelectric 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 industrialized 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.

GASIFICATION

An important consideration for operators of wastewater

Table 5. Energy recovery from WWTP sludge.

	Cement kiln	Coal-fired power plant	Mono-incinerator	Refuse incinerator
Dewatered sludge	No	Yes	Yes/No*	Yes
Fuel substitute	-	No	No	No
Thermal dry biosolids	Yes	Yes	Yes	Yes
Substitute for fuel	Yes	Yes	Yes/No	No
Substitute for minerals	Yes	No	No	No
Type of process	Residue-free process	Fuel substitution	Disposal	Disposal

*Depending on type of plant.

treatment plants (WWTPs) is how to handle the disposal of the residual sludge in a reliable, sustainable, legal and economical way. This by-product of wastewater treatment contains abundant organic material, including many kinds of bacteria. It also contains heavy metals and its composition is generally unknown. The benefits of drying sludge can be seen in two main treatment options:

(i) Use of the dewatered sludge as a fertilizer or in fertilizer blends, and
(ii) Incineration with energy recovery.

Use as a fertilizer option takes advantage of the high organic content 40 - 70% of the dewatered sludge and its high levels of phosphorous and other nutrients. However, there are a number of concerns about this route including:

(i) The chemical composition of the sludge (e.g., heavy metals, hormones and other pharmaceutical residues),
(ii) Pathogen risk (e.g., salmonella, Escherichia coli, prionic proteins, etc., and
(iii) Potential accumulation of heavy metals and other chemicals in the soil.

Sludge can be applied as a fertilizer in three forms:

(i) Liquid sludge,
(ii) Wet cake blended into compost, and
(iii) Dried granules.

Use as energy recovery option takes advantage of the energy available in the sludge's organic content. Drying the sludge reduces its water content, thus increasing its calorific value and making it easier to combust. It also reduces odours and improves handling, with lower transport and storage costs. Sludge from WWTPs is typically combusted in (Table 5):

(i) Cement kilns,
(ii) Coal-fired power plants,
(iii)Mono-incinerators, that is, plants burning refuse-derived fuel or a single waste stream, and
(iv) Mixed waste incinerators, e.g., municipal waste incinerator.

The recognized advantages of energy recovery from sludge include:

(i) The high calorific value (similar to lignite) of dewatered sludge,
(ii) The use of dewatered sludge as a carbon dioxide (CO_2) neutral substitute for primary fuels such as oil, gas and coal,
(iii) The use of dewatered sludge is a 'sink' for pollutants such as heavy metals, toxic organic compounds and pharmaceutical residues, thus offering a potential disposal route for these substances provided the combustion plant has adequate flue gas cleaning, and
(iv) The potential, under certain circumstances, to utilize the inorganic residue from sludge incineration (incinerator ash), such as in cement or gravel.

The demands placed on the drying system are therefore critical and include:

(i) High process stability,
(ii) High mechanical reliability,
(iii) High safety standards under all operating conditions,
(iv) Compliance with environmental legislation such as emission limits, and
(v) A product with properties suitable for a wide range of uses.

The energy efficiency formula takes into account the energy generated by the plant and puts it in relation to the calorific value of the municipal waste (FME, 2005). The energy introduced into the process from outside (such as fossil fuels or electricity) is subtracted. The energy efficiency can be improved by, for instance, reducing the input of fossil fuels. According to the European commission's formula, the energy efficiency for waste-to-energy (WTE) plants is calculated as follows:

$$\text{Energy efficiency} = Ep - (E_f+E_i) / 0.97(E_W+E_f) \qquad (1)$$

Where, E_p is the annual energy produced as heat or

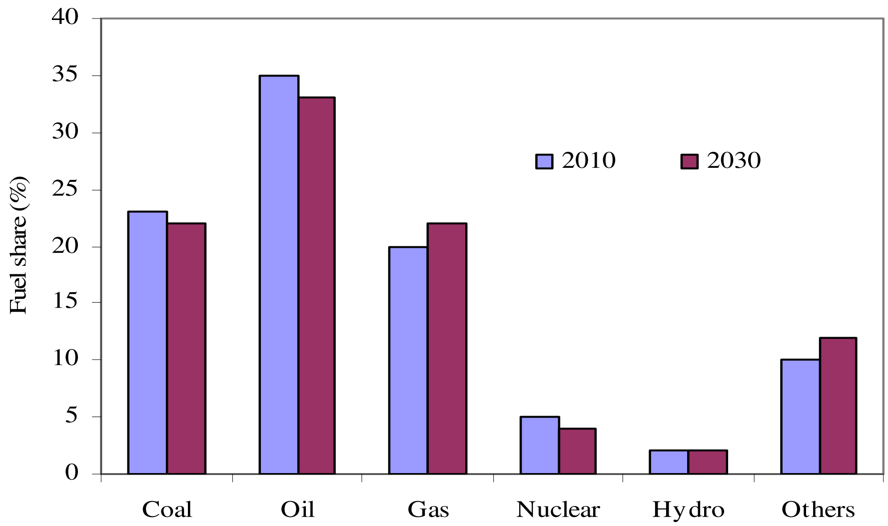

Figure 12. Outlook for world total primary energy supply. ('Others' includes combustible renewables and waste, geothermal, wind and tidal energy).

electricity in GJ/year. It is calculated with energy in the form of electricity multiplied by 2.6 and heat produced for commercial use multiplied by 1.1, E_f is the annual energy input to the system in GJ/year from fuels contributing to the production of steam, E_W is the annual energy in GJ/year contained in the treated waste calculated using the lowest net calorific value of the waste and E_i is the annual energy imported in GJ/year, excluding E_W and E_f. For thermodynamic reasons, E_f must be deleted in the nominator of the equation as it is included twice- in the nominator and the denominator.

An energy efficiency factor of 0.6, which has been proposed by commission, is too high for most existing plants. A threshold of 0.5 would be sufficient, with a further reduction of 0.1 for small plants and plants that produce electricity only due to a lack of demand for heat. A factor of 0.6 would disadvantage smaller plants as they generally need the same energy for operation as larger plants, but have a lower throughput. It should be noted, at this point, that the public tend to prefer smaller plants in order to reduce the distance waste is transported (Figures 12 - 13).

ENERGY RECOVERY

Mechanical-biological treatment (MBT) can be one option for improving the conservation of resources and energy in waste management systems. Mechanical-biological treatment enhances the conservation of embedded energy through recycling and allows potentially more efficient combustion or conversion of refuse-derived fuel (RDF). MBT encompasses a wide range of technologies aiming to process solid waste by a mixture of mechanical and biological separation. It also enables metals and other dry recyclables to be recovered (Figure 14). There are five main types of MBT process:

(i) Incorporating anaerobic digestion to generate biogas for electricity production. Anaerobic digestion also generates a digestate to be discharged or to be dewatered, producing a compost product,
(ii) Producing an RDF product,
(iii) Producing a compost product and/or a stabilized material for land filling as well as a RDF product,
(iv) Producing a compost product, and
(v) Stabilizing waste prior to landfill.

Gas production in the gasification system is controlled in two ways:

(i) The system analyses the gas produced and proprietary software feeds instructions back to a control system, delivering constant management of operating variables, and
(ii) A surge and mixing tank blends the gas flow.

Social and environmental will benefit to the community from the utilization of alternative energy and reduced fossil fuel consumption. Recycling is hugely beneficial, both from an economic and environmental perspective. The environment and economy will both benefit from an improved and more efficient reverse supply chain. This, in turn, would result in increased and optimized recycling of waste streams that reduce the depletion of scarce natural resources- water, oil and minerals- while at the same time protecting the environment by keeping these valuable materials in service. Figure 15 shows how the

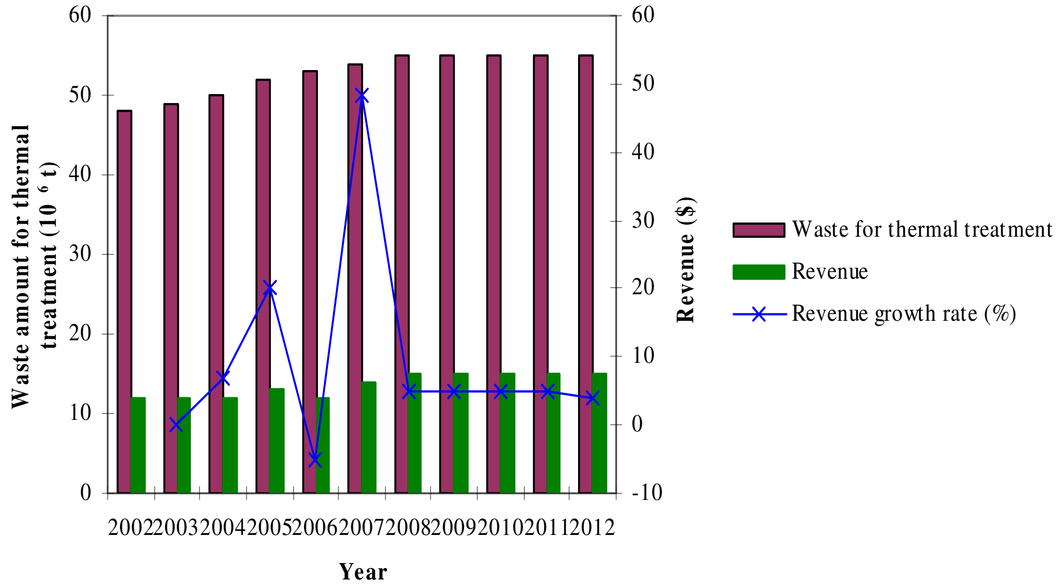

Figure 13. Volume shipments and revenue forecasts for the western European thermal waste treatment services.

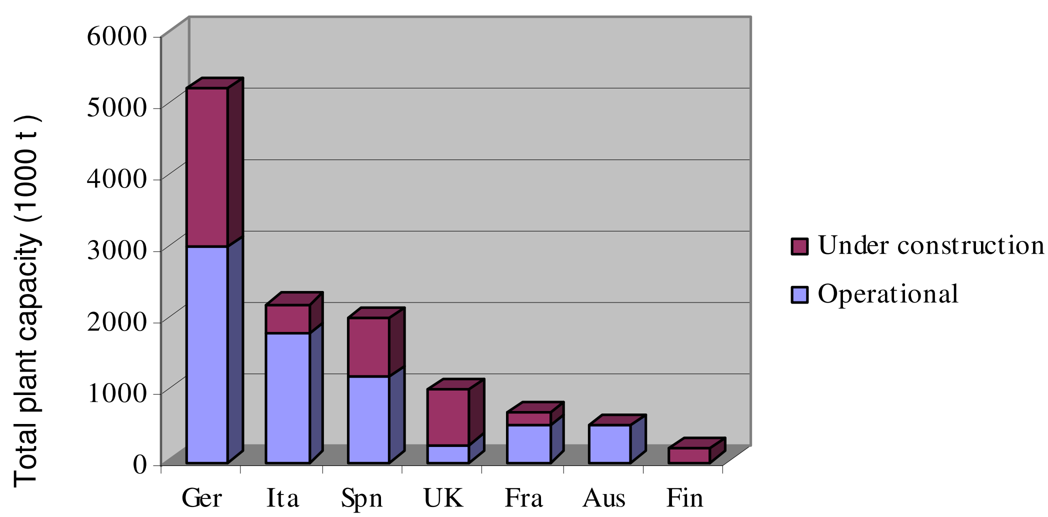

Figure 14. Capacity of plants in each country.

individual LCAs performed on avoided greenhouse gas emissions in CO_2 equivalent by material (WRAP, 2006). A cornerstone of recycling is effective waste collection and many local authorities are now looking to households and businesses to ensure this is in place. It is no longer sufficient to leave one or more bags of ‘rubbish’ at the end of a drive or back of a workplace.

Odorous emissions are a serious concern relating to biowaste treatment facilities and affect the likelihood of planning permission being granted particularly in urban areas. Research has shown odour is one of the prime concerns from urban residents where MBT plants are proposed. An often unrecognized aspect of the waste management field is the many examples of individuals giving back. A conventional biofilter operates by engineering the correct environment in a closed vessel, ensuring that the bacteria within it are cultivated to effectively biodegrade the compound in the air that passes through it. Recirculation of the airstreams improves the rate of degradation by the bacteria. This has several advantageous characteristics:

(i) A surfaces structure that is excellent for supporting bacteria and has the ability to retain moisture in the event

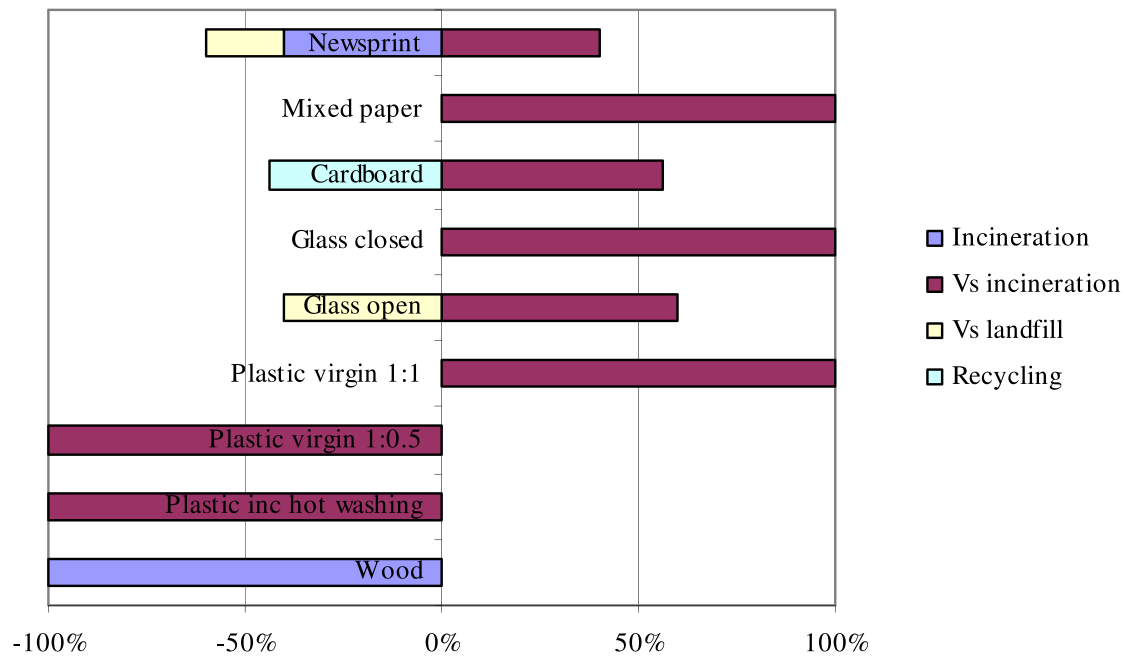

Figure 15. Performance of the life cycle analysis (LCA) on avoided greenhouse gas emissions.

of temporary water failure.
(ii) A self-supporting structure with good packing characteristics that ensure there is minimal pressure drop across the media bed (thus reducing running costs).
(iii) The right conditions to encourage bacteria to metabolize more than grow which minimizes sludge production and hence associated disposal.

GEOTHERMAL HEAT

This study explores the factors associated with utilising the actual potential of geothermal energy. It also covers all the technological details, along with issues and challenges faced during the utilisation of geothermal energy. Major projects, power plants, players in the industry, the major role of the United States in the global geothermal industry, the active role of the US Department of Energy, and the various environmental benefits of using geothermal energy are all explored in-depth in this study.

Geothermal power is the use of geothermal heat to generate electricity. Geothermal comes from the Greek words geo, meaning earth, and therme, meaning heat. The utilisation of geothermal energy for the production of electricity dates back to the early part of the twentieth century. For 50 years the generation of electricity from geothermal energy was confined to Italy and interest in this technology was slow to spread elsewhere. In 1943 the use of geothermal hot water was pioneered in Iceland. Estimates of exploitable worldwide geothermal energy resources vary considerably.

The largest dry steam field in the world is the Geysers, about 90 miles (145 km) north of San Francisco. The Geysers began in 1960 which has 1360 MW of installed capacity and produces about 1000 MW net. Calpine Corporation now owns 19 of the 21 plants in the Geysers and is currently the United States' largest producer of renewable geothermal energy. The other two plants are owned jointly by the Northern California Power Agency and Santa Clara Electric. Since the activities of one geothermal plant affects those nearby, the consolidation plant ownership at the Geysers has been beneficial because the plants operate cooperatively instead of in their own short-term interest. The Geysers is now recharged by injecting treated sewage effluent from the City of Santa Rosa and the Lake County sewage treatment plant. This sewage effluent used to be dumped into rivers and streams and is now piped to the geothermal field where it replenishes the steam produced for power generation.

Another major geothermal area is located in south central California, on the southeast side of the Salton Sea, near the cities of Niland and Calipatria, California. As of 2001, there were 15 geothermal plants producing electricity in the area. CalEnergy owns about half of them and the rest are owned by various companies. Combined the plants have a capacity of about 570 megawatts. Geothermal energy can be used as an efficient heat source in small end-use applications such as green-houses, but the consumers have to be located close to the source of heat. Geothermal energy has a major environmental benefit because it offsets air pollution that

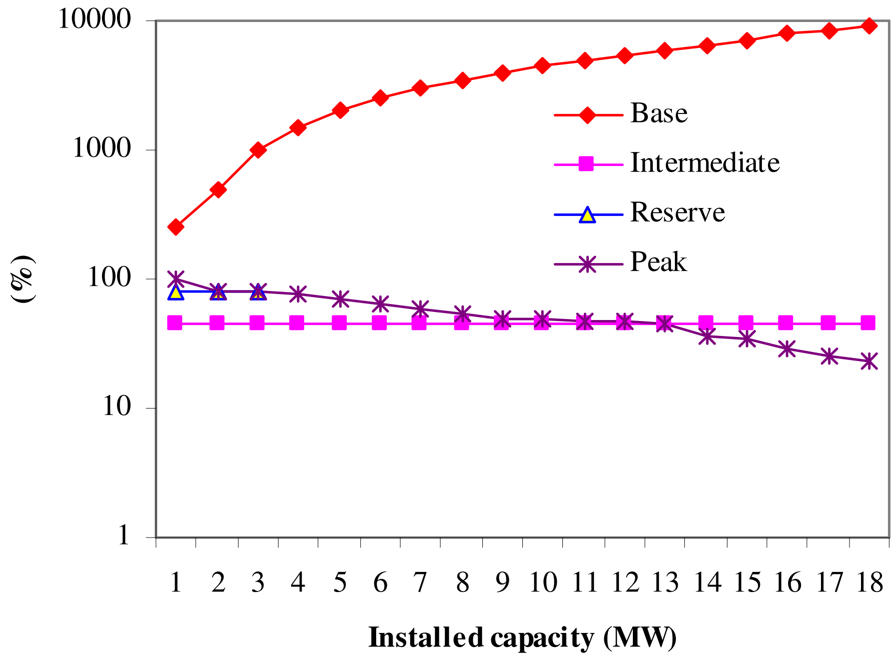

Figure 16. Load duration curve showing the base, intermediate, peaking load segments, and necessary contingency reserve.

pollution that would have been produced if fossil fuels were the energy source. Geothermal energy has a very minor impact on the soil - the few acres used look like a small light-industry building complex. Since the slightly cooler water is reinjected into the ground, there is only a minor impact, except if there is a natural geyser field closed by. The world's decentralised energy industry is right to look towards developing countries as potential markets for its wares. These countries have the opportunity to miss out the industrial development stage characterised by a single, centralised electricity transmission and distribution system, in favour of a hybrid of local grids liberally supplied by small-scale decentralised power generators.

GREENHOUSE GAS EMISSIONS

The typical challenge in the developing world is lack of everything, including electricity. When striving to feed the increasing power demand to enable social reform and industrial growth, local decision makers face the question of which route to take. Shall we copy the model of the rich countries, or could there be another, maybe better way? The need to reduce CO_2 emissions presents a new, additional challenge, difficult even for the richest of nations. Conventional, centralised electricity networks are the norm in the developed world. However, the present energy infrastructure of the developed countries was mainly created during the monopolistic utility era of the past. The utilities had the power to decide what kind of capacity to construct and how to construct the grid. There was practically no competition. The main challenge for many utilities was to get construction permits for building new generation capacity- the construction itself was practically risk free as they could turn their cost structure into a solid power tariff. Capital was easily available and cost competitiveness and overall system cost optimisation were not the main concerns.

Today the market situation and rules have permanently changed. Progressive modern utilities have left the past behind and are striving towards a modern, competitive energy system. However, one remainder of the past, still to some extent maintaining the economies of scale thinking, is to look at and calculate power plant and grid investments separately, as if they had nothing, or very little, to do with each other. Installing flexible, high-efficiency peaking and grid stability generation capacity closer to the load pockets of cities and industrial areas would be a natural way to go, but it does not fit the model of old, large-scale utility thinking (Figure 16). A typical electricity system built by a rich country monopoly utility 'wasted' capital in the following ways:

(i) Large, steam-fired power plants, running on part load, were used for frequency and load control (unless hydro non-dispatchable wind condition, but the problem has been solved with the very strong grid, which can transmit the wind power over long distances to remote countries.
(ii) Efficient peaking capacity was not constructed;

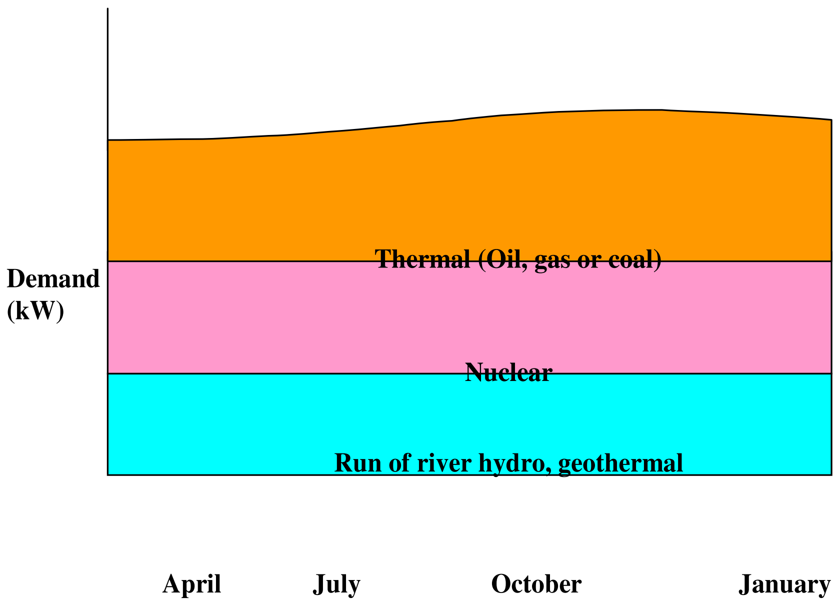

Figure 17. Image of annual load profile of power plants.

instead, the so-called peaking plants were typically based on largest possible simple cycle industrial gas turbines located in critical points in grid. This capacity functional mainly as an emergency reserve at grid nodes and was hardly ever used as it has such poor heat rate and relatively long starting time.
(iii) Excessive base-load capacity was constructed. This was possible as there was an ensured return on asset investments.
(iv) The grid has been sized to transmit the full peak power from large remote power plants to the consumption centres in cities.

Utilities in the developing world face a major challenge in developing their electricity systems (Figure 17). The parameters to optimise at the same time are:

(i) Reliability of supply.
(ii) System flexibility and preparedness for load growth.
(iii) Economical competitiveness that is., cost effectiveness, elimination of 'wastes'.
(iv) Access to power for the whole nation.
(v) Ensured access to fuels and fuel flexibility.

Combined heat and power (CHP) has been installed and used for many years as a highly efficient energy supply system to fulfil electricity and thermal energy needs in a range of applications around the world. As environmental issues, particularly those of climate change caused by greenhouse gases (GHGs), become as an effective means to reduce emissions is more pronounced than ever. However, despite CHP's significant contribution to the reduction of CO_2 emissions, calculation of its effects can result in preventing further dissemination of CHP. This is because, when an appropriate calculation method is used, there is a risk of under-estimating the effects of CHP and even, in some instances, estimating erroneously an increase in CO_2 emissions as a result of installing a CHP system. Proper estimation of the benefits of CHP will be vital in encouraging more businesses to install CHP systems.

Considerable debate surrounds the calculation of CO_2 emissions as a result of the use of the two emission factors (GHG Protocol, 2007; and Kyoto Protocol, 2008) .

(i) All fuels average emission factor (AEF) - used to calculate emissions from power consumption,
(ii) Marginal emission factor (MEF) - used to estimate reduced amount of CO_2 emissions as a result of lower power consumption and
(iii) CO_2 emission by consumption of a fuel is calculated as follows:

Emission amount (kg CO_2) = emission factor of a fuel (kg CO_2/MJ, kWh, etc.) × energy consumed (MJ, kWh, etc.) (2)

In the case of electricity, however, CO_2 is not emitted at the point of use. The power on the grid is usually generated by a mix of fuels – some CO_2 – emitting plants such as oil, coal and natural gas-based thermal power plants and non- CO_2 – emitting power sources such as nuclear, hydro and renewable. As a result, when calculating CO_2 emission by the use of grid power, the use of AEF or MEF is preferred. Therefore, CO_2 emission by an electricity user is estimated as follows:

CO_2 emission volume (kg CO_2) = AEF (kg CO_2/kWh) × power consumed (kWh) (3)

CO_2 emission of grid electricity is not accounted for on the demand side, rather on the generation side. AEF is obtained by dividing the total CO_2 emission volume from thermal power plants connected to the grid by the total power supplied through the grid including those that are free of emissions, indicating average CO_2 emission per kWh of power on grid.

AEF (kg CO_2/kWh) = total CO_2 emissions from all thermal plants on grid (kg/CO_2) /total power supplied to grid from all sources (kWh) (4)

To calculate the amount of CO_2 emissions reduced because of lower power consumption, the emission factor for these plants must be multiplied by the reduced power consumption. The factor used is called the marginal emission factor or MEF. The reduced emission amount is obtained by the following calculation:

Emission reduction (kg CO_2)=MEF (kg CO_2/kWh) × electricity conserved (kWh) (5)

ENERGY EFFICIENCY

Eventually renewable energies will dominate the world's energy supply system. There is no real alternative. Humankind cannot indefinitely continue to base its life on the consumption of finite energy resources. Today, the world's energy supply is largely based on fossil fuels and nuclear power. These sources of energy will not last forever and have proven to be contributors to our environmental problems. The environmental impacts of energy use are not new but they are increasingly well known; they range from deforestation to local and global pollution. In less than three centuries since the industrial revolution, humankind has already burned roughly half of the fossil fuels that accumulated under the earth's surface over hundreds of millions of years. Nuclear power is also based on a limited resource (uranium) and the use of nuclear power creates such incalculable risks that nuclear power plants cannot be insured.

Renewable sources of energy are an essential part of an overall strategy of sustainable development. They help reduce dependence of energy imports, thereby ensuring a sustainable supply. Furthermore renewable energy sources can help improve the competitiveness of industries over the long run and have a positive impact on regional development and employment. Renewable energy technologies are suitable for off-grid services, serving those in remote areas of the world without requiring expensive and complicated grid infrastructure. In 2007, the United States outlined plans to ease out of its foreign oil dependence through the use of renewable energy resources, and reduce gas usage by a full 20% in ten years through alternative fuels. Extending hope and opportunity depends on a stable supply of energy that keeps nation's economy running and environment clean. Many wind/solar farms are located in remote areas served by low capacity radial distribution networks. These networks often have insufficient capacity to ship the power to demand centres when the turbines are generating at full capacity.

The public awareness of the depletion of the ozone layer has increased since 1970s. The ozone layer in the stratosphere protects life on earth against the ultraviolet radiation from the sun. Scientists and politicians argued for some years on the reasons for the reduced ozone layer, which was recognised especially over the Antarctic. The fact is that the ozone is depleted by the presence of chlorine. Further, very low temperatures as well as sunlight are required for having the process running. Vapour compression refrigeration systems using fluorocarbons, hydrocarbons or ammonia represent the established technology for household, commercial and industrial refrigeration and air-conditioning (Omer, 2010a).

Understanding the earth and the processes that shape it is fundamental to the successful development and sustainable management of our planet. The evolution of the earth's crust over geological time has resulted in diverse, often beautiful, landscapes formed by earthquakes, oceans, fire and ice. These landscapes are also a source of mineral wealth and water, a base for engineering projects and a receptacle for the waste. Minerals are vital for manufacturing, construction, energy generation and agriculture. Some of the requirements can be met by increasing the use of recycled and renewable resources, but the need for new mineral resources continues. Minerals are important to maintaining the modern economy and lifestyle. Hence, everyone must make best use of these valuable assets whilst minimizing the impact of their extraction on the environment. Global energy use will rise dramatically but world oil and gas production will eventually decline. Geological hazards account for huge loss of life and damage to property. Poorer countries often suffer the most due to inappropriate land-use planning and in the future climate change may worsen these effects. Clean drinking water is a basic human need. The environmental sustainability of water resources, especially when balancing ecological and human needs with economic growth, is of major concern to governments worldwide. Increases in the world's population, the growth of cities, industrial development and ever-increasing waste and pollution can increase pressure on the environment. Understanding the effects of climate change is a key issue for society and researches focus on how to predict future climate change events and how to mitigate them.

Two essential components for economic development are a soundly based knowledge of a country's natural resources, such as groundwater, minerals and energy, and an understanding of the geological environment. The latter includes the potential effects of earthquakes, volcanic

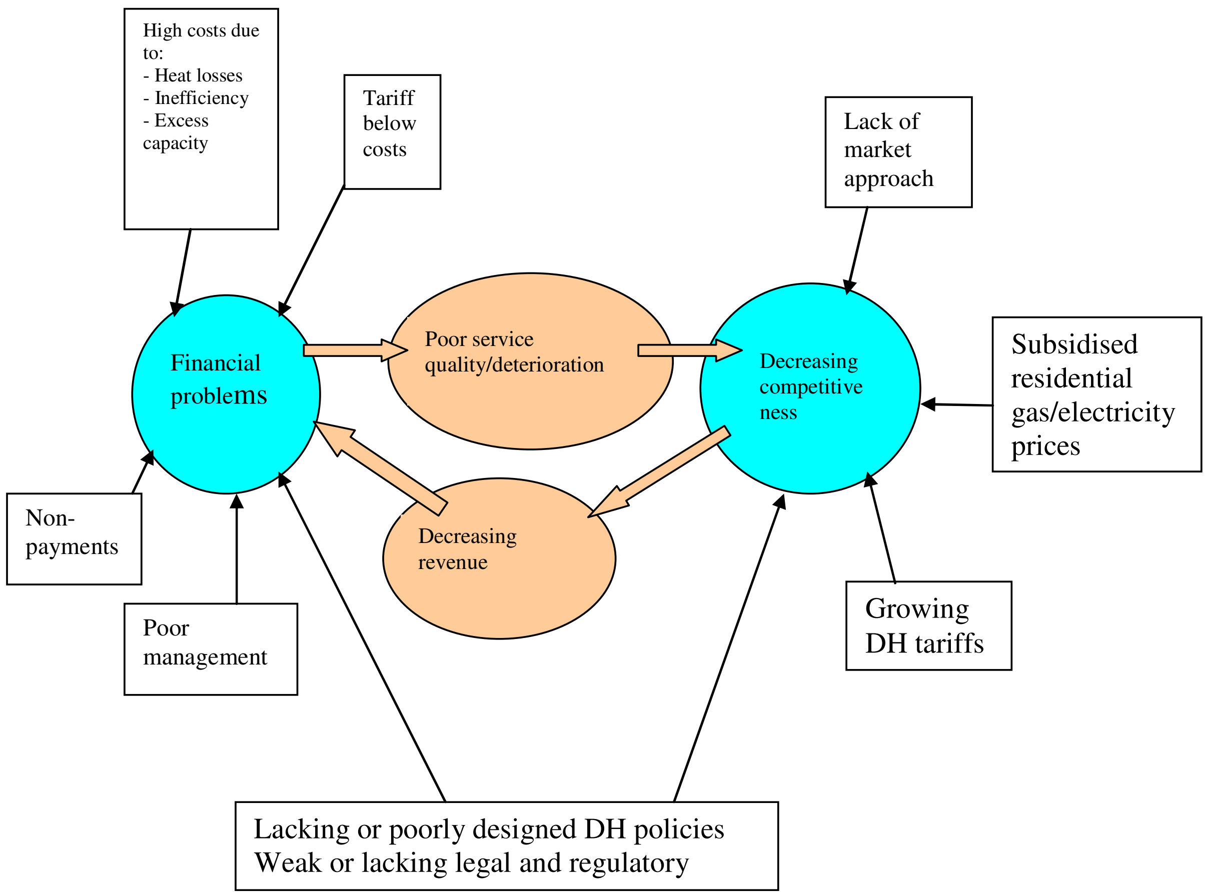

Figure 18. Key challenges for district heating systems in transition economies.

volcanic eruptions, landslides and the forces of erosion and deposition on rivers and coastlines. Helping developing countries acquire this knowledge and apply it to promote economic growth, sustainable livelihoods and the protection of people. Sustainable land use involves protection of the natural environment (viable agriculture, forestry, water resources, and soil functions), the quality and character of the countryside and existing communities. Groundwater is an essential source of drinking water (70%). Although commonly regarded as pure, it is often vulnerable to pollution or may contain natural concentrations of elements that can adversely affect health. Population growth, intensive agriculture, urbanization and higher standards of living have resulted in increasing, often unsustainable, demands on groundwater resources. These pressures and the likely effects of climate change mean that groundwater systems must be better understood so that they can be evaluated effectively, managed sustainably and protected securely.

District heating plays a very important role in transition economies. District heating systems in transition economies often face financial, technical or managerial problems largely created by an inadequate policy framework. These challenges include lack of customer focus, low efficiency, excess capacity, corruption and an uneven playing field. Figure 18 shows how these challenges are interrelated and create a vicious circle that undermines finances and competitiveness of district heating companies, jeopardizing their long-term sustainability.

ENERGY SUPPLY

The earth is believed to be close to a state of thermal equilibrium where the energy, which is received at the surface by solar radiation, is lost again at night and the much smaller amount of energy, which is generated by the decay of unstable isotopes of Uranium, Thorium and Potassium distributed within the earth is balanced by the small continuous heat flux from the earth's interior to the pecans and atmosphere. 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 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. Heat is conventionally extracted by the forced or natural circulation of water through permeable hot rock. There are various practical difficulties and disadvantages associated with the use of geothermal power:

(a) 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.
(b) 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 they 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. Ocasionally, the impurities can be precipitated and used but this has not generally proved commercially attractive (Omer, 2010b).

REFRIGERATION

The refrigeration industry has had to face environmental challenges. Regulation and behaviour related to the ozone layer differ from one country to another. Problems related to global warming are likely to cause similar problems in very different ways. These two kinds of problems may lead company managers to change/ modernize equipment. These environmental factors must not hide other important development factors such as those related to hygiene, organoleptic quality, control methods and equipment packaging, etc. All equipment change and investment projects must take all of them into consideration. The more developed a country, is the more widely refrigeration is used. Food preservation is still the main use of refrigeration, followed by air conditioning, energy savings and transport (heat pump and liquefied gases), industrial processes and medicine. When consumers demand more and more fresh products, fresh products, handling such products becomes increasingly difficult: cold stores, display cabinets, refrigerated trucks have to be much more effective. Difficulties are mostly related to:

(i) Very narrow ranges, in many cases, between temperatures involving microbial or chemical risk and temperatures that cause chilling injury or freezing,
(ii) No or little overlapping between temperature ranges permitted for different products,
(iii) No or little possibility for the consumer or the seller to evaluate the remaining life spans of the product or even to perceive any risk, and
(iv) Humidity control, vapour pressure differences have serious consequences, not only on the weight but also on the unit value of products.

The production and use of CFC refrigerants have been phased out in developed countries. HCFC refrigerants are now subject to regulation and are scheduled to be phased out in the twenty-first century. Recent developments in refrigeration technology and environment (climate) control have provided a better quality of life for mankind. As is known, refrigeration technology has played a key role in preserving the quality of food and eliminating waste (spoilage). The refrigerated transport of perishable products provides a critical link in the cold chain between the consumer and the producers, processors, shippers, distributors and retailers. The transport refrigeration industry incorporated mechanical vapour compression mechanisms into the first transport refrigeration units. Therefore, the physical, chemical and thermodynamic properties of these refrigerants had a major impact on the design on the compressors and refrigeration system components. Many refrigerants have excellent thermodynamic properties suitable for use in vapour compression refrigeration systems, but are limited by other properties such as toxicity, flammability and chemical stability within the refrigeration system (Omer, 2010c).

Most district heating systems in former planned economies are less efficient and oversized. In other words, their supply infrastructure is larger than necessary to meet current demand. This problem can be exacerbated when they lose customers. Reforms, particularly for tariffs, are needed to improve finances and break the vicious circle of deteriorating competitiveness. Yet policymakers need to design the reforms very carefully for them not to backfire and make matters worse, as illustrates in Figure 19.

TEMPERATURE DISTRIBUTIONS

World capacity of geothermal energy is growing at a rate of 2.5% per year from a 2005 level of 28.3 GW (Brain and Mark, 2007). GSHPs account for approximately 54% of this capacity almost all of it in North America and Europe

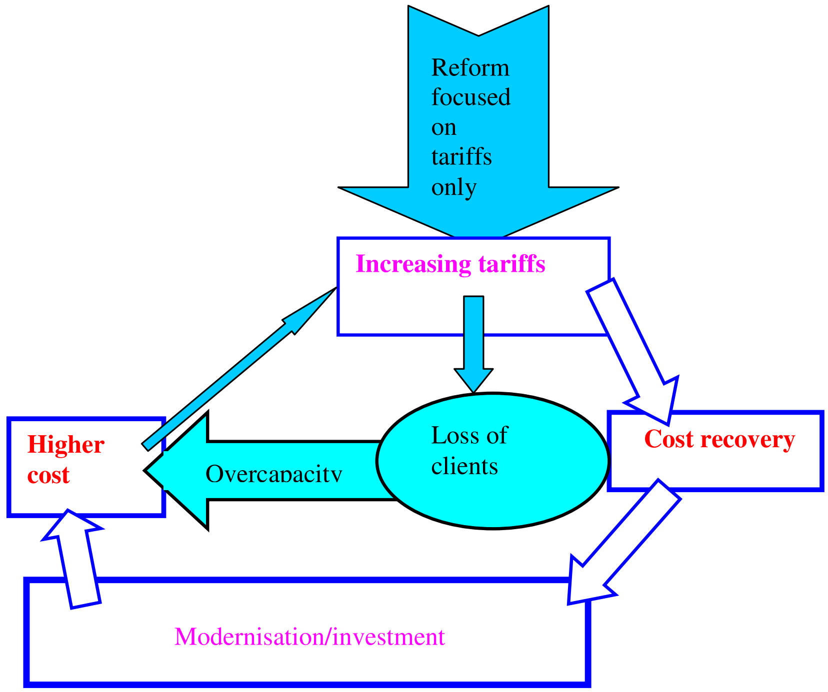

Figure 19. Unsustainable tariff growth.

(Lund et al., 2005). 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. 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. Horizontal ground loop heat exchangers can be used to circulate refrigerant (direct heat exchanger) or a water/antifreeze mixture (indirect heat exchange) and rely to some extent on solar input during summer for earth temperature recovery following winter heat extraction (Figures 20 - 21). For a more economical use of available land, a vertical ground loop heat exchange array or ‘‘borehole’’ array can be used typically involving a matrix of vertical borehole heat exchangers spaced at 5 m at depths of up to 180 m. high density plastic (typically high density polyethylene) tube of 20 - 40 mm nominal diameter is fed down to 100-150 mm diameter borehole to form a U-tube with the borehole subsequently grouted using a high conductivity hard-setting compound (usually bentonite). These and others methods of low grade-ground heat harvesting have been reviewed in details from the perspective of UK application by Rawlings (Rawlings, 1999). 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:

(i) The abundance and distribution of heat producing elements within the earth,
(ii) The mean surface temperature (which is controlled by the ocean/atmosphere system),
(iii) The thermal properties of the earth's interior and their lateral and radial variation, and
(iv) Any movements of fluid or solid rock materials occurring at rates of more than a few millimeters 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:

Figure 20. A photograph of a laying ground-loop heat exchanger (Abdeen Mustafa Omer, 2009).

Figure 21. A photograph shows the earth loop vapour and liquid (Abdeen et al., 2009).

B=q/k (6)

Where, β 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 β being large that is, 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 2×10^{-3} 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}) (Oxburgh, 1975). Rocks are also very slow respond to any temperature change to which they are exposed that is., they have a low thermal diffusivity:

$K = k/\rho C_p$ (7)

Where, K is thermal diffusivity; ρ 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 6). In volcanic regions, in particular, both q and β can vary considerably and the upper values given are somewhat nominal. In many geothermal areas natural heat exchangers exist in the form of large scale, sub-surface water circulation systems, which commonly give rise to hot springs

Table 6. Values of geothermal parameters.

Parameter	Lower	Average	Upper
q (HFU)	0.8	1.5	3.0 (non volcanic) ≈100 (volcanic)
k = cal cm^{-2} sec-1 $^{o}C^{-1}$	2×10^{-3}	6×10^{-3}	12×10^{-3}
β = ^{o}C/km	8	20	60 (non volcanic) ≈300 (volcanic)

Table 7. Selected comparative cost data for geothermal energy (Oxburgh, 1975).

Geothermal field	Geothermal production	Local average, other fuel
Electricity, US mills/kWh		
Iceland	2.5 - 3.5	-
Italy	4.8-6.0	~7.5
Japan	4.6	~6.0
Mexico	4.1 - 4.9	~8.0
Russia	7.2	~10.0
USA	5.0	7.0
Space heating, US$/Gcal energy		
Iceland	4.0	6.7
Hungary	3.0	11.0
Refrigeration, US$/Gcal		
New Zealand	0.12	2.40
Drying diatomite, US$/ton		
Iceland	~2	~12

hot springs or geyser activity at the surface (Table 7).

THERMODYNAMIC ANALYSIS OF REFRIGERATION CYCLES

Thermodynamics is the study of energy, its transformations and its relation to states of matter. A thermodynamic system is a region in space or a quantity of matter bounded by a closed surface. The surroundings include everything external to the system and the system is separated from the surroundings by the system boundaries. These boundaries can be movable or fixed, real or imaginary. Potential energy (PE) is caused by attractive forces existing between molecules, or the elevation of system.

$$PE = mgz \quad (8)$$

Where, m is the mass, g is local acceleration of gravity and z is the elevation above horizontal reference plane.

[Net amount of energy added to system] = [Net increase of stored energy in system] (9)

Or

[Energy in] – [Energy out] = [Increase of stored energy in system] (10)

Refrigeration cycles transfer thermal energy from a region of low temperature T_R to one of higher temperature. Usually the higher temperature heat sink is the ambient air or cooling water, at temperature T_o, the temperature of the surroundings. Performance of a refrigeration cycle is usually described by a coefficient of performance (COP), defined as the benefit of the cycle (amount of heat removed) divided by the required energy input to operate the cycle:

COP = useful refrigerating effect / Net energy supplied from external sources (11)

For a mechanical vapour compression system, the net energy supplied is usually in the form of work, mechanical or electrical and may include work to the compressor and fans or pumps. Thus,

$$COP = Qevap / Wnet \quad (12)$$

ENVIRONMENTAL CHALLENGE

The Montreal Protocol and its amendments (London, 1990; Copenhagen, 1992; Vienna, 1994) have given rise to the drawing up of regulation on the phase out the substances named Ozone Depleting Substances (ODS), including CFCs such as R12, R11 and HCFCs such as R22. Alternatives to CFCs include:

(i) Hydro Fluoro Carbons (HFCs) such as R134a and many mixtures,
(ii) Naturally occurring refrigerants such as NH_3, hydrocarbons, water, air CO_2, Some of them are flammable and/or toxic or should be limited to relatively small niches, and
(iii) For other technologies such as absorption, solid sorption, etc., there are also some very interesting niches. However, refrigeration as a whole is not likely to shift there very soon because of the many other challenges it has to face.

The United Nations Framework Convention on Climate Change came into effect on March 21, 1994 and the Kyoto Protocol on December 10, 1997. Global warming is mostly caused by the rising percentage of various substances in the atmosphere, particularly CO_2, CH_4 and many others including CFCs, Hydro Chlorofluorocarbons (HCFCs) and HFCs. Refrigeration is involved because of:

(i) Refrigerants themselves, if they are released into the atmosphere, this is the ‘direct effect’, and
(ii) CO_2 produced by energy consumption of the system throughout its lifespan, this is the ‘indirect effect’.

The Fifth Framework Programme (FP5) is designed to ensure that European research efforts are translated more effectively into practical and visible results. The programme includes four thematic and three horizontal programmes.

Thematic programmes are:

(i) Quality of life and management of living resources,
(ii) Users-friendly information society,
(iii) Competitive and sustainable growth, and
(iv) Energy, environment and sustainable development.

Horizontal programmes are:

(i) Confirming the international role of community research,
(ii) Promotion of innovation and encouragement of participation, and
(iii) Improving human research potential and the socio-economic knowledge base.

Research in agro-food industry, including refrigeration, has an important role, particularly under the key action ‘‘Food, Nutrition and Health’’.

NATURAL DISASTERS

The following is a detailed guide for communities and emergency operations team to develop and maintain a viable disaster management and recovery plan. In addition, it explains in details the concept of disaster management and various steps from planning to prepare against any disaster. It further highlights the role of government agencies and local authorities at the time of disaster as well as before and after it. It also discusses long and short-term goals for mitigation, planning and recovery from disaster along with initiatives that US government has taken in recent years. It also, has a special focus on management of energy infrastructure during the time of disaster and presents a checklist for emergency response and recovery (Figure 22). Every year, tornadoes, hurricanes and other natural disasters injure and kill thousands of people and damage billions of dollars worth of property in the United States. Most of the times, it is almost impossible to prevent the occurrence of these disasters and their damages. However, it is possible to reduce their impact by adopting suitable disaster management strategy. Disaster management is a systematic approach towards preparing for disaster before it happens and includes disaster response - emergency evacuation, quarantine, mass recontamination - as well as supporting and rebuilding society after natural disasters have occurred. Efficient disaster management relies on thorough integration of emergency plans at all levels of government and non-government involvement.

Disaster preparedness, emergency management and post disaster recovery is highly dependent on economic and social conditions local to the disaster. However, the basics steps for disaster management remain same in all scenarios. Preparedness is the first step to counter disaster, which involves developing plan of action and it, includes communication, chain of command development, proper maintenance and training of emergency services and development of emergency warning systems along with emergency shelters and evacuation plans. Next step is response, which includes mobilization of the necessary emergency services such as fire fighters, police, and ambulance that may be supported by a number of secondary emergency services, such as specialist rescue teams. Recovery from disaster involves restoration of the affected area including destroyed property, re-employment and redevelopment of essential infrastructure. Mitigation efforts attempt at preventing hazards from developing into disasters or reducing the

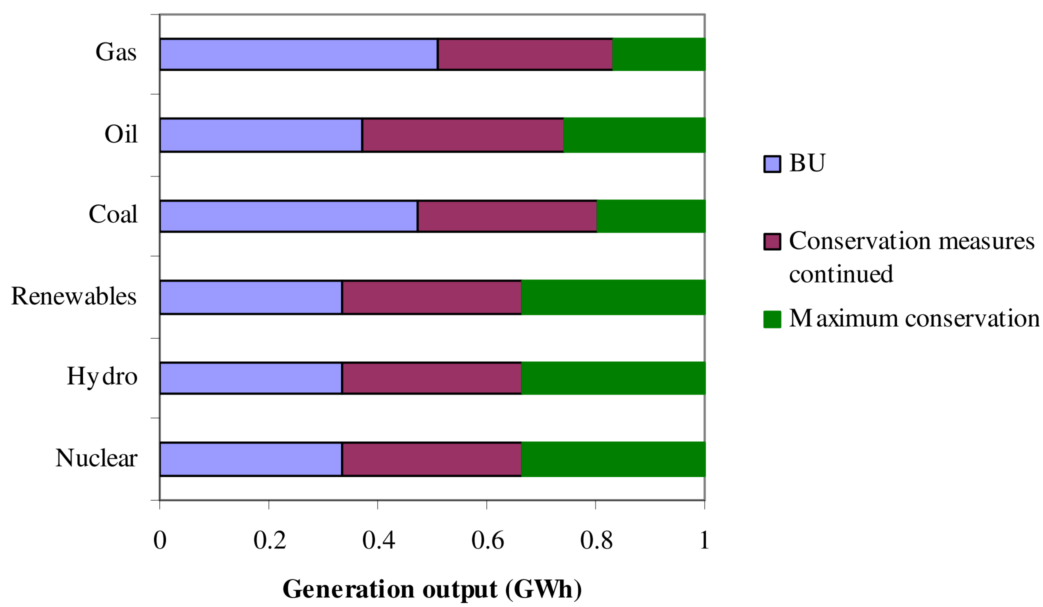

Figure 22. Energy conservation measures.

impact of disasters and it focuses on long-term measures for reducing or eliminating future risks. In summary, achieving low energy building requires comprehensive strategy that covers; not only building designs, but also considers the environment around them in an integral manner. Major elements for implementing such a strategy are as follows:

Efficiency use of energy

(i) Climate responsiveness of buildings,
(ii) Good urban planning and architectural design,
(iii) Good house keeping and design practices,
(iv) Passive design and natural ventilation.
(v) Use landscape as a means of thermal control,
(vi) Energy efficiency lighting,
(vii) Energy efficiency air conditioning,
(viii) Energy efficiency household and office appliances,
(ix) Heat pumps and energy recovery equipment,
(x) Combined cooling systems, and
(xi) Fuel cells development.

Utilize renewable energy

(i) Photovoltaics,
(ii) Wind energy,
(iii) Small hydros,
(iv) Waste-to-energy,
(v) Landfill gas,
(vi) Biomass energy, and
(vii) Biofuels.

Reduce transport energy

(i) Reduce the need to travel,
(ii) Reduce the level of car reliance,
(iii) Promote walking and cycling,
(iv) Use efficient public mass transport, and
(v) Alternative sources of energy and fuels.

Increase awareness

(i) Promote awareness and education,
(ii) Encourage good practices and environmentally sound technologies,
(iii) Overcome institutional and economic barriers, and
(iv) Stimulate energy efficiency and renewable energy markets.

CONCLUSIONS

The following are concluded:

(i) Promoting innovation and efficient use of applicable renewable energy technologies,
(ii) Identifying the most feasible and cost effective applications of renewable energy resources suitable for use,
(iii) Highlighting the local, regional and global environmental

benefits of renewable energy applications,
(iv) Ensuring the renewable energy takes its proper place in the sustainable developments, supply and use of energy for greatest benefit of all, taking due account of research requirements, energy efficiency, conservation and cost criteria,
(v) Ensuring the financing of and institutional support for economic renewable energy projects, and
(vi) Encouraging education, research and training in renewable energy technology in the region.

UTILIZATION OF RENEWABLE ENERGY

Developing and implementing the use of renewable energy sources.

Policy and environment

(i) Efficiency, conservation, and policies,
(ii) Renewable energy availability,
(iii) Local and environmental concerns,
(iv) Technology transfer,
(v) Financing requirements, and
(vi) Educational initiatives, legislative benchmarks.

Solar electrical technology

(i) PV technology manufacture, testing and certification,
(ii) PV Stand-alone systems and components,
(iii) PV for utility rural development and grid connection, and
(iv) PV Markets and commercialization, financing schemes and national programmes.

Solar thermal technology

(i) Solar radiation prediction and analysis,
(ii) Solar cooling, heating and rural applications,
(iii) Solar thermal applications for power generation, and
(iv) Collector technology developments.

Solar and low energy architecture

(i) External Environment,
(ii) Building, landscape design and urban communities and comfort productivity and health issues,
(iii) Sustainable policy and social issues,
(iv) Building simulation, material and design,
(v)Building refurbishment and integration of renewable energy; case studies,
(vi) Internal environment,
(vii) Thermal, ventilation and air movement, and
(viii) Lighting operation and control.

Wind energy technology and applications

(i) Small, micro-generation and hybrid systems.
(ii) Machines and wind farms,
(iii) Offshore wind power,
(iv) Wind resources and environmental issues,
(v) Connection and integration,
(vi) National and regional programmed, and
(vii) Economic and institutional issues.

Biomass conversion

(i) Heat and electricity generation,
(ii) Energy crops and residues,
(iii) Liquid fuels,
(iv) Socio-economics, case studies, and environmental impacts, and
(v) Gasification processes.

Fuel cells and hydrogen technology

(i) Fuel cells technology advances electricity generation,
(ii) Fuel cells technology advances for transportation,
(iii) Hydrogen production for fuel processing and systems, and
(iv) Proven commercialization reports including economic and policy issues.

Marine/ocean energy

(i) Wave and tidal energy resources and their characterization,
(ii) Device modeling, testing and development,
(iii) Device hydrodynamics, structural integrity and environmental analysis,
(iv) Environmental impact assessment and standards,
(v) Balance of system - power take-off, sensors, controls and grid integration,
(vi) Legislation, policy, finance and markets, and
(vii) Socio-economic assessment, education and training.

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