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## Sustainable Development in Green Energies and the Environment

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### ARTICLE INFORMATION

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### ABSTRACT

The move towards a de-carbonized 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 stabilization 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 humans, livestock, and plants. This article presents a comprehensive review of energy sources, and the development of sustainable technologies to explore these energy sources. It also includes potential renewable energy technologies, efficient energy systems, energy savings techniques, and other mitigation measures necessary to reduce climate change. The article concludes with the technical status of the ground source heat pump (GSHP) technologies.

### INTRODUCTION

Over millions of years ago, plants have covered the earth converting the energy of sunlight into living plants and animals, some of which were buried in the depths of the earth to produce deposits of coal, oil, and natural gas (Cantrell and Wepfer; 1984; Ashrae; 1995; Kavanaugh and Rafferty, 1997). The past few decades, however, have experienced many valuable uses for these complex chemical substances and manufacturing from them plastics, textiles, fertilizer, and the various end products of the petrochemical industry. Indeed, each decade sees increasing uses for these products. Coal, oil, and gas, which will certainly be of great value to future generations, as they are to ours, are however non-renewable natural resources. The rapid depletion of these 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. Sunlight is not only inexhaustible but, moreover, it is the only energy source, which is completely non-polluting United Nations (2003).

Industry's use of fossil fuels has been largely 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 had 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. Notably, human activities that emit carbon dioxide (CO<sub>2</sub>), the most significant contributor to potential climate change, occur primarily from fossil fuel production. Consequently, efforts to control CO<sub>2</sub> emissions could have serious, negative consequences for economic growth, employment, investment, trade, and the standard of living of individuals everywhere.

### Energy Sources and Uses

#### Energy Sources

Scientifically, it is difficult to predict the relationship between global temperature and greenhouse gas (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 a 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 into account evolving scientific and technological knowledge while gaining experience in designing policies to address climate change United Nations (2003).

The World Summit on Sustainable Development in Johannesburg in 2002 United Nations (2003) 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, regulations, and information campaigns, can best stimulate innovation and investment to provide cleaner technology

The energy conservation scenarios include the rational use of energy policies in all economic sectors and the use of combined heat and power systems, which are able to add to energy savings from autonomous power plants. Electricity from renewable energy sources is by definition an environmentally 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 supporting 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. It is now universally accepted that 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 UNFCCC (2009). 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 policymakers tend to agree on UNFCCC (2009). However, reaching international agreements on climate change policies is no trivial task as the difficulty in ratifying the Kyoto Protocol and reaching an agreement at Copenhagen 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 only as much as 20% of the global energy supplies worldwide UNFCCC (2009). Over two-thirds of this comes from biomass use, mostly in developing countries, and some of this is unsustainable. However, 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. Nevertheless, the biggest problem with relying on renewables to deliver the necessary cuts in GHG emissions is more to do with political and policy issues than with technical ones Rees (1999). For example, the single most important step governments could take to promote and increase the use of renewables is to improve access to renewables in the energy market. This access to the market needs to be under favorable conditions and, possibly, under favorable 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 internalized 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 (Bos et al. 1994).

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 Duchin (1995). Hence, an approach is needed to integrate renewable energies in a way that meets the rising demand in a cost-effective way.

### **Role of Energy Efficiency Systems**

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 the 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 providing 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 fuel, and optimization of its operating conditions and service life leading to improved access to 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 programs 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 programs 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 Givoni (1998). New financing and implementation processes, which allow reallocating of financial resources and thus enable 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**

Buildings consume energy mainly for cooling, heating, and lighting. The energy consumption was based on the assumption that the building operates within the American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE) - thermal comfort zone during the cooling and heating periods ASHRAE (1993). Most of the buildings incorporate energy-efficient passive cooling, solar control, photovoltaic, lighting and daylighting, and integrated energy systems. It is well known that thermal mass with night ventilation can reduce the maximum indoor temperature in buildings in summer Kammerud, Ceballos, Curtis, Place, and Anderson (1984). Hence, comfort temperatures may be achieved by the proper application of passive cooling systems. However, energy can also be saved if an air conditioning unit is used Shaviv (1989). The reason for this is that in summer, heavy external walls delay the heat transfer from the outside into the inside spaces. Moreover, if the building has a lot of internal mass the increase in the air temperature is slow. This is because the penetrating heat raises the air temperature as well as the temperature of the heavy thermal mass. The result is a slow heating of the building in summer as the maximal inside temperature is reached only during the late hours when the outside air temperature is already low. The heat flowing from the inside heavy walls could be reduced with good ventilation in the evening and night. The capacity to store energy also helps in winter, since energy can be stored in walls from one sunny winter day to the next cloudy one. However, the admission of daylight into buildings alone does not guarantee that the design will be energy efficient in terms of lighting. In fact, the design for increased daylight can often raise concerns relating to visual comfort (glare) and thermal comfort (increased solar gain in the summer and heat losses in the winter from larger apertures). Such issues will clearly need to be addressed in the design of the window openings, blinds, shading devices, heating system, etc. In order for a building to benefit from daylight energy terms, it is a prerequisite that lights are switched off when sufficient daylight is available. The nature of the switching regime; manual or automated, centralized or local, switched,

stepped or dimmed, will determine the energy performance. Simple techniques can be implemented to increase the probability that lights are switched off Shaviv (1989). These include:

- Making switches conspicuous and switching banks of lights independently
- Loading switches appropriately in relation to the lights
- Switching banks of lights parallel to the main window wall

There are also a number of methods, which help reduce lighting energy use, which, in turn, relates to the type of occupancy pattern of the building Shaviv (1989). The light-switching options include:

- Centralized timed off (or stepped)/manual on
- Photoelectric off (or stepped)/manual on
- Photoelectric and on (or stepped), and photoelectric dimming
- Occupant sensor (stepped) on/off (movement or noise sensor)

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 the employment of a sustained program of energy consumption strategies and measures would have considerable benefits within the buildings sector. The perception is often given however 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 that encompasses 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:

- The application of environmental regulations and policy
- The application of environmental science and best practice
- Mathematical modeling and simulation
- Environmental design and engineering
- Construction and commissioning
- Management and modifications of environments in use

While the overriding intention of passive solar energy design of buildings is to achieve a reduction in purchased energy consumption, the attainment of significant savings is in doubt. The non-realization of potential energy benefits is mainly due to the neglect of the consideration of post-occupancy user and management

behavior by energy scientists and designers alike. Calculating energy inputs in agricultural production is more difficult in comparison to the industry sector due to the high number of factors affecting agricultural production. However, considerable studies have been conducted in different countries on energy use in agriculture (Singh, 2000; CAEEDAC, 2000; Yaldiz et al. 1993); Dutt, 1982; Baruah, 1995; Thakur and Mishra, 1993) in order to quantify the influence of these factors.

### **Sustainable Development**

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. It is an accepted fact that renewable energy is a sustainable form of energy, which has attracted more attention in recent years. Increasing environmental interest, as well as economic consideration of fossil fuel consumption and a high emphasis on sustainable development for the future, helped to bring the great potential of renewable energy into focus Wu, and Boggess (1999). Nearly a fifth of all global power is generated by renewable energy sources, according to a new book published by the Organisation for Economic Co-operation and Development (OECD) / International Energy Association (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 by 2010. Wind power grew fastest at 52% and will multiply seven times by 2010, overtaking biopower and hence helping reduce greenhouse gases, GHGs, and emissions to the environment.

## **RESULTS AND DISCUSSIONS**

The availability of data on solar radiation is a critical problem. Even in developed countries, very few weather stations have been recording detailed solar radiation data for a period of time long enough to have statistical significance. Solar radiation arriving on earth is the most fundamental renewable energy source in nature. It powers the bio-system, ocean, and the atmospheric current system and affects the global climate. Reliable radiation information is needed to provide input data in modeling solar energy devices and a good database is required in the work of energy planners, engineers, and agricultural scientists. In general, it is not easy to design solar energy conversion systems when they have to be

installed in remote locations. First, in most cases, solar radiation measurements are not available for these sites. Second, the radiation nature of solar radiation makes the computation of the size of such systems difficult. While solar energy data are recognized as very important, their acquisition is by no means straightforward. The measurement of solar radiation requires the use of costly equipment such as pyrheliometers and pyranometers. Consequently, adequate facilities are often not available in developing countries to mount viable monitoring programs. This is partly due to the equipment cost as well as the cost of technical manpower. Several attempts have, however, been made to estimate solar radiation through the use of meteorological and another physical parameter in order to avoid the use of an expensive network of measuring instruments.

A sustainable energy system includes energy efficiency, energy reliability, energy flexibility, fuel poverty, and environmental impacts. A sustainable biofuel has two favourable properties, which are the availability of renewable raw material, and its lower negative environmental impact than that of fossil fuels. Global warming, caused by CO<sub>2</sub> and other substances, has become an international concern in recent years. Protect forestry resources, which act as major absorbers of CO<sub>2</sub>, by controlling the ever-increasing deforestation and the increase in the consumption of wood fuels, such as firewood and charcoal, is, therefore, an urgent issue. Given this, the development of a substitute fuel for charcoal is necessary. Briquette production technology, a type of clean coal technology, can help prevent flooding and serve as a global warming countermeasure by conserving forestry resources through the provision of a stable supply of briquettes as a substitute for charcoal and firewood.

District Heating (DH), also known as community heating can be a key factor to achieve energy savings, reducing CO<sub>2</sub> emissions and at the same time providing consumers with a high-quality heat supply at a competitive price. Generally, DH should only be considered for areas where the heat density is sufficiently high to make DH economical. In countries like Denmark for example, 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.

Platinum is a catalyst for fuel cells and hydrogen-fuelled cars presently use about two ounces of the metal. There is currently no practicable alternative. Reserves are in South Africa (70%), and Russia (22%). Although there are sufficient accessible reserves in South Africa to increase supply by up to 5% per year for the next 50 years, there are significant environmental impacts associated with its

mining and refining, such as groundwater pollution and atmospheric emissions of sulfur dioxide ammonia, chlorine, and hydrogen chloride.

Hydrogen is now beginning to be accepted as a useful form for storing energy for reuse on, or for export off, the grid. Clean electrical power harvested from wind and wave power projects can be used to produce hydrogen by electrolysis of water. Electrolyzers split water molecules into their constituent parts: hydrogen and oxygen. These are collected as gases; hydrogen at the cathode and oxygen at the anode. The process is quite simple. Direct current is applied to the electrodes to initiate the electrolysis process. The production of hydrogen is an elegant environmental solution. Hydrogen is the most abundant element on the planet, it cannot be destroyed (unlike hydrocarbons) it simply changes state (water to hydrogen and back to water) during consumption. There is no CO or CO<sub>2</sub> generation in its production and consumption and, depending upon methods of consumption, even the production of oxides of nitrogen can be avoided too. However, the transition will be very messy and will take many technological paths to convert fossil fuels and methanol to hydrogen, build hybrid engines, and so on. Nevertheless, the future of hydrogen fuel cells is promising. Hydrogen can be used in internal combustion engines, fuel cells, turbines, cookers gas boilers, roadside emergency lighting, traffic lights, or signaling where noise and pollution can be a considerable nuisance, but where traffic and pedestrian safety cannot be compromised.

Water is the most natural commodity for the existence of life in remote desert areas. However, as a condition for settling and growing, the supply of energy is the close second priority. The high cost and the difficulties of mains power line extensions, especially to a low-populated region can focus attention on the utilization of different and more reliable and independent sources of energy like renewable wind energy. Accordingly, the utilization of wind energy, as a form of energy, is becoming increasingly attractive and is being widely used for the substitution of oil-produced energy, and eventually to minimize atmospheric degradation, particularly in remote areas. Indeed, the utilisation of renewables, such as wind energy, has gained considerable momentum since the oil crises of the 1970s. Wind energy, though site-dependent, is non-depleting, non-polluting, and a potential option of an alternative energy source. Wind power could supply 12% of global electricity demand by 2020, according to a report by the European Wind Energy Association and Greenpeace.

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 parts, 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. Diesel motors are associated with maintenance problems, high running costs, 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.

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## **CONCLUSION AND RECOMMENDATIONS**

### **Conclusion**

There is strong scientific evidence that the average temperature of the earth's surface is rising. This is a result of the increased concentration of carbon dioxide and other GHGs in the atmosphere as released by burning fossil fuels. This global warming will eventually lead to substantial changes in the world's climate, which will, in turn, have a major impact on human life and the built environment. Therefore, the effort has to be made to reduce fossil energy use and to promote green energy, particularly in the building sector. Energy use reductions can be achieved by minimizing the energy demand, rational energy use, recovering heat, and the use of more green energy. This study was a step towards achieving this goal. 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 CO<sub>2</sub>, 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 programs 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 the forest – plantation cover, a 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 non-technical issues, which have recently gained attention, include (1) Environmental and

ecological factors, e.g., carbon sequestration, reforestation, and revegetation. (2) Renewables as a CO<sub>2</sub>-neutral replacement for fossil fuels. (3) Greater recognition of the importance of renewable energy, particularly modern biomass energy carriers, at the policy and planning levels. (4) Greater recognition of the difficulties of gathering good and reliable renewable energy data, and efforts to improve it. (5) Studies on the detrimental health effects of biomass energy particularly from traditional energy users.

### **Recommendations**

The following are recommended:

- Launching of public awareness campaigns among local investors', particularly small-scale entrepreneurs and end users of RETs to highlight the importance and benefits of renewable, particularly solar, wind, and biomass energies.
- Amendment of the encouragement of investment act, to include further concessions, facilities, tax holidays, and preferential treatment to attract national and foreign capital investment.
- Allocation of a specific percentage of soft loans and grants obtained by governments to augment budgets of (R & D) related to the manufacturing and commercialization of RETs.
- Governments should give incentives to encourage the household sector to use renewable energy instead of conventional energy.
- Execute joint investments between the private sector and the financing entities to disseminate the renewable with technical support from the research and development entities.
- Availing of training opportunities to personnel at different levels in donor countries and other developing countries to make use of their wide experience in the application and commercialization of RETs, particularly renewable energy.
- The governments should play a leading role in adopting renewable energy devices in public institutions, e.g., schools, hospitals, government departments, police stations, etc., for lighting, water pumping, water heating, communication, and refrigeration.
- Encouraging the private sector to assemble, install, repair, and manufacture renewable energy devices via investment encouragement and more flexible licensing procedures.

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