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An Analysis on Various Resources of Renewable Energy

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Abstract – The potential of renewable energy sources is enormous as they can in principle meet many times the world's energy demand. Renewable energy sources such as biomass, wind, solar, hydropower, and geothermal can provide sustainable energy services, based on the use of routinely available, indigenous resources. A transition to renewables-based energy systems is looking increasingly likely as their costs decline while the price of oil and gas continue to fluctuate. It is becoming clear that future growth in the energy sector will be primarily in the new regime of renewable energy, and to some extent natural gas-based systems, not in conventional oil and coal sources. The development and use of renewable energy sources can enhance diversity in energy supply markets, contribute to securing long term sustainable energy supplies, help reduce local and global atmospheric emissions, and provide commercially attractive options to meet specific energy service needs, particularly in developing countries and rural areas helping to create new employment opportunities there.

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INTRODUCTION

Renewable energy can offer significant environmental and economic benefits. It is part of the energy hierarchy – the order in which energy saving and 'green' energy measures should be prioritised. The energy hierarchy was conceived in 1998 as part of the Local Government Position Statement on Energy. This states that organisations and individuals should pursue energy issues in the following order:

1. Reduce the need for energy
2. Use energy more efficiently
3. Use renewable energy
4. Any continuing use of fossil fuels should be clean and efficient.

Renewable energy refers to energy that occurs naturally and repeatedly in the environment. This can be energy from waves, wind, the sun and geothermal heat from the ground. Renewable energy can also be produced from plant sources such as wood or crops grown specifically as a fuel.

Producing your own renewable energy is not just a matter of 'environmental ideology'; it can offer a wide range of benefits to businesses including:

- Reduced reliance on fossil fuel, potentially lowering energy bills
- Providing possible backup if fossil fuel supply fails
- Improving businesses' 'green' credentials, leading to brand strengthening
- Providing the capacity to sell renewable electricity to an electricity distributor at a premium.

Businesses that can demonstrate that their energy supply comes from renewable sources will also be exempt from the Climate Change Levy (CCL) for that element of their energy use.

It is also useful to take into account the rising value of renewable energy in the market. The Renewables Obligation can make renewable energy generation schemes profitable for some owners where they can generate and sell electricity under attractive commercial terms.

The use of any of the renewable energy technologies requires considerable thought and planning. Renewable energy projects can also take a long time to implement due to the relatively immature nature of the market. However, as already discussed, they can make both environmental and economic sense in the long term.

The potential of renewable energy sources is enormous as they can in principle meet many times the world's energy demand. Renewable energy sources such as biomass, wind, solar, hydropower,

and geothermal can provide sustainable energy services, based on the use of routinely available, indigenous resources. A transition to renewables-based energy systems is looking increasingly likely as the costs of solar and wind power systems have dropped substantially in the past 30 years, and continue to decline, while the price of oil and gas continue to fluctuate. In fact, fossil fuel and renewable energy prices, social and environmental costs are heading in opposite directions. Furthermore, the economic and policy mechanisms needed to support the widespread dissemination and sustainable markets for renewable energy systems have also rapidly evolved. It is becoming clear that future growth in the energy sector is primarily in the new regime of renewable, and to some extent natural gas-based systems, and not in conventional oil and coal sources. Financial markets are awakening to the future growth potential of renewable and other new energy technologies, and this is a likely harbinger of the economic reality of truly competitive renewable energy systems.

Renewable energy sources currently supply somewhere between 15 percent and 20 percent of world's total energy demand. The supply is dominated by traditional biomass, mostly fuel wood used for cooking and heating, especially in developing countries in Africa, Asia and Latin America. A major contribution is also obtained from the use of large hydropower; with nearly 20 percent of the global electricity supply being provided by this source. New renewable energy sources (solar energy, wind energy, modern bio-energy, geothermal energy, and small hydropower) are currently contributing about two percent. A number of scenario studies have investigated the potential contribution of renewables to global energy supplies, indicating that in the second half of the 21st century their contribution might range from the present figure of nearly 20 percent to more than 50 percent with the right policies in place.

BIOMASS ENERGY

Biomass refers to the use of a wide variety of organic material such as wood, straw, dedicated energy crops, sewage sludge and animal litter for the generation of heat, electricity or motive power.

It can be viewed as a form of stored solar energy. The sun's energy is captured and stored via the process of photosynthesis in growing material. This energy is released by processes of conversion such as combustion (burning) or fermentation and distillation (to produce liquid transport fuels).

Biomass is a low carbon fuel source because the carbon dioxide released when biomass is converted for energy purposes is largely offset by that absorbed by the organic material during its growth. With the appropriate management this can be recaptured with new growth. However, other energy inputs may affect this carbon balance, for example via the energy used by vehicles harvesting or transporting the biomass to its point of use.

Combusting biomass fuels such as wood, straw or energy crops (for example, willow coppice or specific types of grasses) to raise heat or steam for space or process heating is one of the most cost-effective applications for biomass from a cost-of-carbon point of view at the present time.

Biomass heating plant can come in a wide range of sizes from a few kWs to many MW of heat. For biomass CHP (combined heat and power), sizes tend to range from around 1MW to many MW of electrical generation capacity. Biomass is a particularly attractive generation option for businesses that produce a by-product that can be used as a fuel, either alone or in combination with bought-in biomass fuels.

The capital cost of a biomass boiler is dependent on the size, fuel type used and level of automation of the system. The payback period for a biomass heating boiler also depends on the cost of fuel (which can be zero if a business produces a combustible by-product) and the cost saving of the displaced fuel.

WIND ENERGY

Wind has considerable potential as a global clean energy source, being both widely available, though diffuse, and producing no pollution during power generation. Wind energy has been one of humanity's primary energy sources for transporting goods, milling grain, and pumping water for several millennia. From windmills used in China, India and Persia over 2000 years ago to the generation of electricity in the early 20th century in Europe and North America wind energy has played an important part in our recorded history. As industrialization took place in Europe and then in America, wind power generation declined, first gradually as the use of petroleum and coal, both cheaper and more reliable energy sources, became widespread, and then more sharply as power transmission lines were extended into most rural areas of industrialized countries. The oil crises of the 70's, however, triggered renewed interest in wind energy technology for grid connected electricity production, water pumping, and power supply in remote areas, promoting the industry's rebirth. Wind energy is currently one of the most cost-competitive renewable energy technologies.

Worldwide, the cost of generating electricity from wind has fallen by more than 80 percent, from about 38 US cents in the early1980s to a current range of 3-6 UScents/kWh levelized over a plant's lifetime, and

analysts forecast that costs will drop an additional 20-30 percent in the next five years.

Wind technology does not have fuel requirements as do coal, gas, and petroleum generating technologies. However, both the equipment costs and the costs of accommodating special characteristics such as intermittence, resource variability, competing demands for land use, and transmission and distribution availability can add substantially to the costs of generating electricity from wind.

SOLAR PHOTOVOLTAIC AND SOLAR THERMAL TECHNOLOGIES

Solar Photovoltaic - Photovoltaic power has been one of the fastest growing renewable energy technologies: annual production of cells grew tenfold from about 50MW in 1990 to more than 500MW by 2003, with this growth continuing since. Demand has been driven by the modular character, standalone and grid-linked opportunities, reliability, ease of use, lack of noise and emissions, and reducing cost per unit energy produced.

Solar PV modules are solid-state semiconductor devices with no moving parts that convert sunlight into direct-current electricity. The basic principle underlying the operation of PV modules dates back more than 150 years, but significant development really began following Bell Labs' invention of the silicon solar cell in 1954. The first major application of PV technology was to power satellites in the late 1950s, and this was an application where simplicity and reliability were paramount and cost was a secondary concern. Since that time, enormous progress has been made in PV performance and cost reduction, driven at first by the U.S. space program's needs and more recently through private/public sector collaborative efforts in the U.S., Europe, and Japan.

Thus, PV systems are declining in cost, improving in efficiency, and increasing rapidly in sales. The cost of electricity produced from PV systems is still higher than from most other competing technologies, at about 30 cents per kWh, but these costs are expected to continue to decline steadily.

Solar Thermal Technologies - Solar heat can also be used to heat air for *drying crops* (Section 6.4). Much of the present world grain harvest is lost to fungal attack, which could be prevented by proper drying. Crop drying requires the transfer not only of heat but also of water vapour.

Heat *engines* convert heat into work (which may in turn be converted to electricity), and can be powered by solar radiation. Indeed, since the potential efficiency of heat engines increases with their working temperature, there are theoretical advantages in using solar radiation, which arrives at a thermodynamic temperature of 6000 K.

Solar thermal power systems use various techniques to focus sunlight to heat an intermediary fluid, known as heat transfer fluid that then is used to generate steam. The steam is then used in a conventional steam turbine to generate electricity. At present, there are three solar thermal power systems currently being developed: parabolic troughs, power towers, and dish/engine systems. Because these technologies involve a thermal intermediary, they can be readily hybridized with fossil fuels and in some cases adapted to utilize thermal storage. The primary advantage of hybridization and thermal storage is that the technologies can provide dispatchable power and operate during periods when solar energy is not available. Hybridization and thermal storage can enhance the economic value of the electricity produced, and reduce its average cost.

Power tower solar thermal systems are in the demonstration and scale-up phase. They use a circular array of heliostats (large individually-tracking mirrors) to focus sunlight onto a central receiver mounted on top of a tower. The first power tower, Solar One, was built in Southern California and operated in the mid-1980s. This initial plant used a water/steam system to generate 10 MW of power. In 1992, a consortium of U.S. utilities joined together to retrofit Solar One to demonstrate a molten-salt receiver and thermal storage system. The addition of this thermal storage capability makes power towers unique among solar technologies by allowing dispatchable power to be provided at load factors of up to 65 percent. In this system, molten-salt is pumped from a "cold" tank at 288° C. (550° F) and then cycled through the receiver where it is heated to 565° C. (1,049° F) and finally returned to a "hot" tank. The hot salt can then be used to generate electricity when needed. Current designs allow storage ranging from 3 to 13 hours.

HYDROPOWER

This technology is highly site-specific as it is dependent on being near a body of water that is both flowing and has a drop in level that can be exploited. Even at a suitable site, it will be necessary to undertake some development work to install the system.

Hydro-power is by far the most established and widely used renewable resource for electricity generation and commercial investment. The early generation of electricity from about 1880 often derived from hydroturbines, and the capacity of total worldwide installations has grown at about 5% per

year since. Hydro-power now accounts for about 20% of world's electric generation.

Hydropower continues to be the most efficient way to generate electricity. Modern hydro turbines can convert as much as 90 percent of the available energy into electricity. The best fossil fuel plants are only about 50 percent efficient. In the U.S., hydropower is produced for an average of 0.7 cents/kWh. This is about one-third the cost of using fossil fuel or nuclear and onesixth the cost of using natural gas. Hydro resources are also widely distributed compared with fossil and nuclear fuels and can help provide energy independence for countries without fossil fuel resources.

Small-scale hydro is mainly 'run of river,' so does not involve the construction of large dams and reservoirs. It also has the capacity to make a more immediate impact on the replacement of fossil fuels since, unlike other sources of renewable energy, it can generally produce some electricity on demand (at least at times of the year when an adequate flow of water is available) with no need for storage or backup systems. It is also in many cases cost competitive with fossil-fuel power stations, or for remote rural areas, diesel generated power.

GEOTHERMAL ENERGY

Geothermal heat is generally of low quality, and is best used directly for building or process heat at about 50–70 _C, or for preheating of conventional high temperature energy supplies. Such supplies are established in several parts of the world and many more projects are planned. Occasionally geothermal heat is available at temperatures above about 150 _C, so electrical power production from turbines can be contemplated. Several important geothermal electric power complexes are fully established, especially in Italy, New Zealand and the USA.

The amount of geothermal energy is enormous. Scientists estimate that just 1 percent of the heat contained in just the uppermost 10 kilometers of the earth's crust is equivalent to 500 times the energy contained in all of the earth's oil and gas resources. Yet, despite the fact that this heat is present in practically inexhaustible quantities, it is unevenly distributed, seldom concentrated and often at depths too great to be exploited industrially and economically.

Geothermal energy has been produced commercially for 70 years for both electricity generation and direct use. Its use has increased rapidly during the last three decades and from 1975 – 1995 the growth rate for electricity generation worldwide has been about 9 percent per year and for direct use of geothermal energy it has been about 6 percent per year. In 1997 geothermal resources had been identified in over 80 countries and there were quantified records of geothermal utilization in at least 46 countries.

CONCLUSION

In conclusion, we believe that the promise of renewable energy has now become a reality. Both solar photovoltaics and wind energy are experiencing rapid sales growth, declining capital costs and costs of electricity generated, and continued performance increases. Because of these developments, market opportunity exists now to both innovate and to take advantage of emerging markets, with the additional assistance of governmental and popular sentiment. The development and use of these sources can enhance diversity in energy supply markets, contribute to securing long term sustainable energy supplies, make a contribution to the reduction of local and global atmospheric emissions, provide commercially attractive options to meet specific needs for energy services particularly in developing countries and rural areas, and create new employment opportunities.

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