ASSESMENT OF RENEWABLE ENERGY TECHNOLOGIES (SOLAR THERMAL AND WINDMILS)

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ABSTRACT

The development of renewable energy technologies (RETs) has moved forward significantly; while the current environmental problems that some attribute to, among others, the combustion of fossil fuels to produce energy has contributed to the attractiveness these technologies. In some instances, governments support RETS and have put in place subsidies to encourage people and companies to implement or use them. Companies have responded to this as it not only brings monetary savings from using energy efficiently but can also be valuable for their image as more and more consumers are becoming environmentally conscious. Many companies have decided to take a similar route and is interested in using RETS and other environmentally friendly technologies to meet its energy requirements. The report has addressed the issue of looking at the technical and financial feasibility of installing some or all of the identified renewable energy technologies (wind energy and solar thermal), and has been structured in line with the following approach. In this report, the following approach/preliminary assessment method based on Investment Costs, O & M Costs, Operational hours/year, Ease of Installation, O&M Procedures, Social Acceptability, Greenness of technology.

Keywords: renewable energy technology; operation and maintenance.

1. INTRODUCTION TO TECHNOLOGICAL OPTIONS

The need to utilize renewable energy technologies (RET) like solar thermal, geothermal, wind energy, hydro energy, etc, for meeting electricity and heating requirements is becoming the norm in many establishments. This could be attributed, at least in part, to the heightened global interest in climate change. Increasingly, governments encourage and support the use of renewable energy technologies wherever possible to combat climate change. This is done for instance with the use of subsidies where some governments (like that of the Netherlands), indirectly reimburse consumers purchasing energy efficient equipment.

Using energy efficiently is the first step in reducing the demand for energy that is rising worldwide. A technology such as cogeneration is a good example of how energy can be used efficiently by capturing excess heat from electricity generation, and using it, where heat itself is required in different sections of an establishment. Wind energy and solar thermal alternatives are considered efficient and environmentally ‘green’ in that they use the sun’s free potential energy to generate sources of heat or electricity which thereby reduces the need for fossil fuel dependence.

Company has sought to identify areas where improvements to its energy consumption can be made. What better time to introduce renewable and energy efficient technologies at its facilities. It must be noted that using energy efficiently and minimizing heat loss from buildings can bring attractive monetary savings, where the use of renewable energy technology is good for relations with consumers who are becoming more environmentally conscious. Needless to say this is good for overall company profits.

2. TECHNOLOGICAL OPTIONS

2.1. Solar Thermal Technology

Generally speaking, solar thermal energy could be utilized for both heating and electricity generation purposes. The most direct application of solar energy is the direct conversion of sunlight radiation into low temperature heat which could be used for domestic/commercial/ industrial hot water production and/or space heating.

Tremendous progress has also been made into developing solar power to be used electricity generation. Such systems basically employ the technique of concentrating large amounts of sunlight (via mirrors and lenses) onto small areas to permit build up of high temperature heat which is converted into electricity in conventional heat engines.

Though there are 5 varieties of solar thermal electricity generators (parabolic troughs, central receivers, dish plants, solar ponds and solar chimneys), each of these have very significant disadvantages that prohibits them from further discussions (for Eco-camping purposes). The primary shortcoming concerns the issue of costs – these vary from one system to the other with the typical installation costs been in the region of $2,000-5,000 per kW output. Operations and maintenance figures are also in the range of $0.12-0.18 per kW. Other disadvantages surround the vast expanse of land space that must be available for installation (1 square kilometer per 60MW is not uncommon). They are also more operationally effective under most selective climatic conditions.

For these primary reasons, solar thermal technology for electricity generation would not be considered as a viable option for implementation at the Eco-camping site. Studies would therefore now focus on looking at how solar thermal technology could be used for providing hot water and space heating for camp facilities.

2.2. Solar Thermal Heating Technology

2.2.1. Functioning Principles. Solar technology for heating purposes (of which there are active and passive types) is achieved by embedding pipes for carrying circulating fluid (could be water, air) in panels (referred to as collectors of which the flat plate type is the most common). As fluid circulates through the solar collector, it absorbs radiant energy (from the sun), which heats it to about 65–80^{0}C and thereafter is transported for storage and/or distribution. To achieve such temperatures, collectors are designed to work on the greenhouse principle: radiated sunlight incidents and enters collector covers but part of that reflected from heated plate remains trapped within.

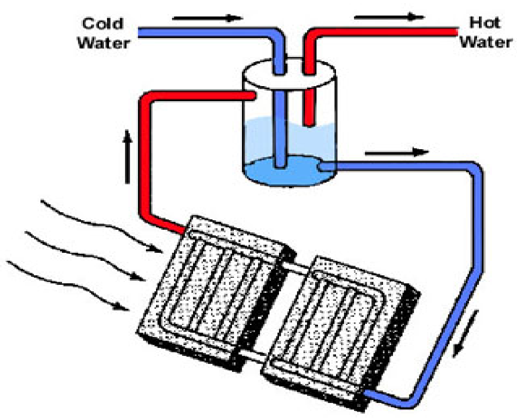


Figure 1. Solar Thermal Heat Principles

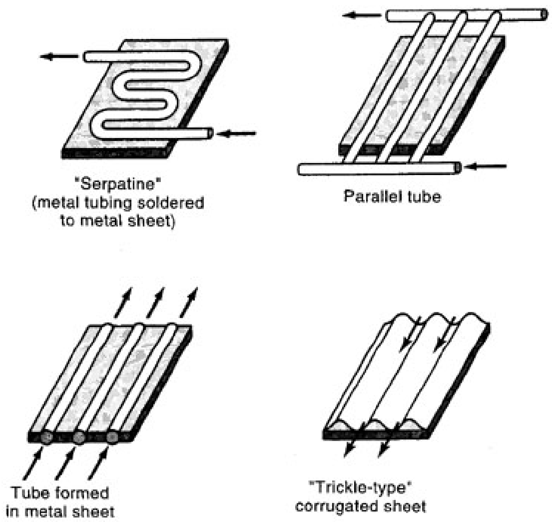


Figure 2. Types of Flat Plate Collector Arrangements

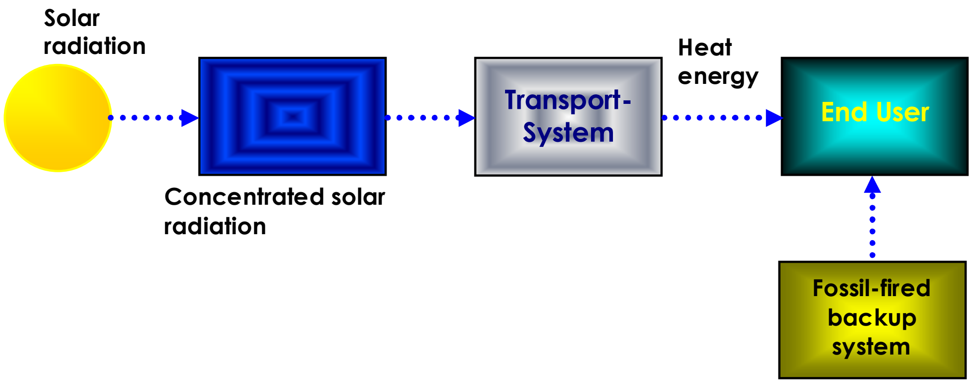


Figure 3. Schematic of Solar Thermal Heat Chain

2.2.2. Energy Output. The size of collector area per unit of installation however varies between 2-4 square meters (or an equivalent of about 2kW) for countries in the Mediterranean to about 3-6 square meters (representing output of about 3kW) for Central and Northern Europe.

The total installed capacity of solar thermal technologies for heating systems worldwide is estimated to be in the region of 30 million square meters of collector area. This can be expressed as an installed capacity of about 18,000MW (UNDP World Energy Assessment 2000). Of this, the European market has been said to account for about 5 million square meters (World Energy Assessment, 248).

2.2.3. Basic Parameters. Active types make use of pumps and controllers for forcing fluid through the tank collector. Size and efficiency of such pumps are therefore of paramount importance for successful operation.

On the other hand however, passive solar thermal units do not make use of mechanical pumps but rely on physical and chemical heat properties (conduction, convection etc) for transporting fluids for use or storage.

Other relevant parameters include the amount of sunlight incident on the collector as well as the efficiency of collector absorption.

2.2.4. Investment Costs. System costs for installation of large solar heating systems can range between $300-800 per square meter of collector area whilst operation and maintenance costs could range between $25-30 per year (World Energy Council).

2.2.5. Advantages, Disadvantages and Associated Risks. Advantages for solar thermal heating technology are:

- Solar radiation is plentiful and effective utilization offers long term cost-effective, reliable and insured forms of taking advantage of the sun's potential power.
- Solar thermal heating methods reduce the need for conventional (fossil-fuelled based) energy input for several months of the year (approximately only $2m^2$ of collector area is required to produce 80% of heating demands for typical domestic purposes).
- Solar heating systems could be expected to give almost trouble-free operations whilst maintenance and operating costs during a systems' lifetime are generally low.

The primary disadvantage of using solar systems for heating purposes is its initial installation costs (and their relatively long payback periods). These costs are influenced by factors such as maintaining temperature levels (fossil-fuelled back-up equipment may have to be used in maintaining storage heat during periods of low solar radiance), relationship between demand and availability (related to aspects of seasonal dependence) and status of technological maturity.

There are very few technical or environmental risks associated with implementation of solar thermal technologies for heating purposes though planning approval may have to be sought for very large projects.

2.2.6. Current Status and Expected Technological Developments. Solar thermal technologies for heating purposes have generally been tested and proved to be durable, reliable and fairly mature in their levels of technological developments. However, still more research is being done with regards systems design, sizing and maintenance issues for larger units.

2.2.7. Barriers to Implementation.

- Public awareness not well supported (even though much information are available to decision makers which could be used for investment decisions and other institutional and educational/social strengthening)
- Technology not adequately granted price bias it could receive given its CO_2 non-emission advantages. Conventional technologies are still therefore quite cheaper when compared to solar heating options. CO_2 taxes may even this balance

2.3. Wind Energy Technology (Wind Turbines)

2.3.1. Functioning Principles. Wind turbines come in two basic types, horizontal and vertical axis. Despite their different appearances, the basic mechanics of the two systems are very similar. Wind passing over the blades is converted into mechanical power, which is fed through a transmission to an electrical generator. The transmission is used to keep the generator operating efficiently throughout a range of different wind speeds. The electricity generated can be used directly, fed into a transmission grid or stored for later use.

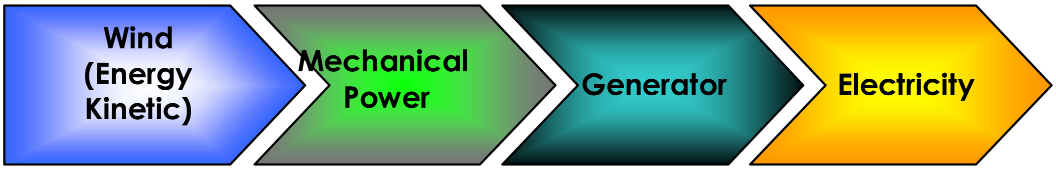


Figure 4. Function Principle of the Wind Energy Technology

Windmills are made up of component parts such as vanes, rotor blades, gearboxes, etc (Figure 4). Some of components' primary functions as follows:

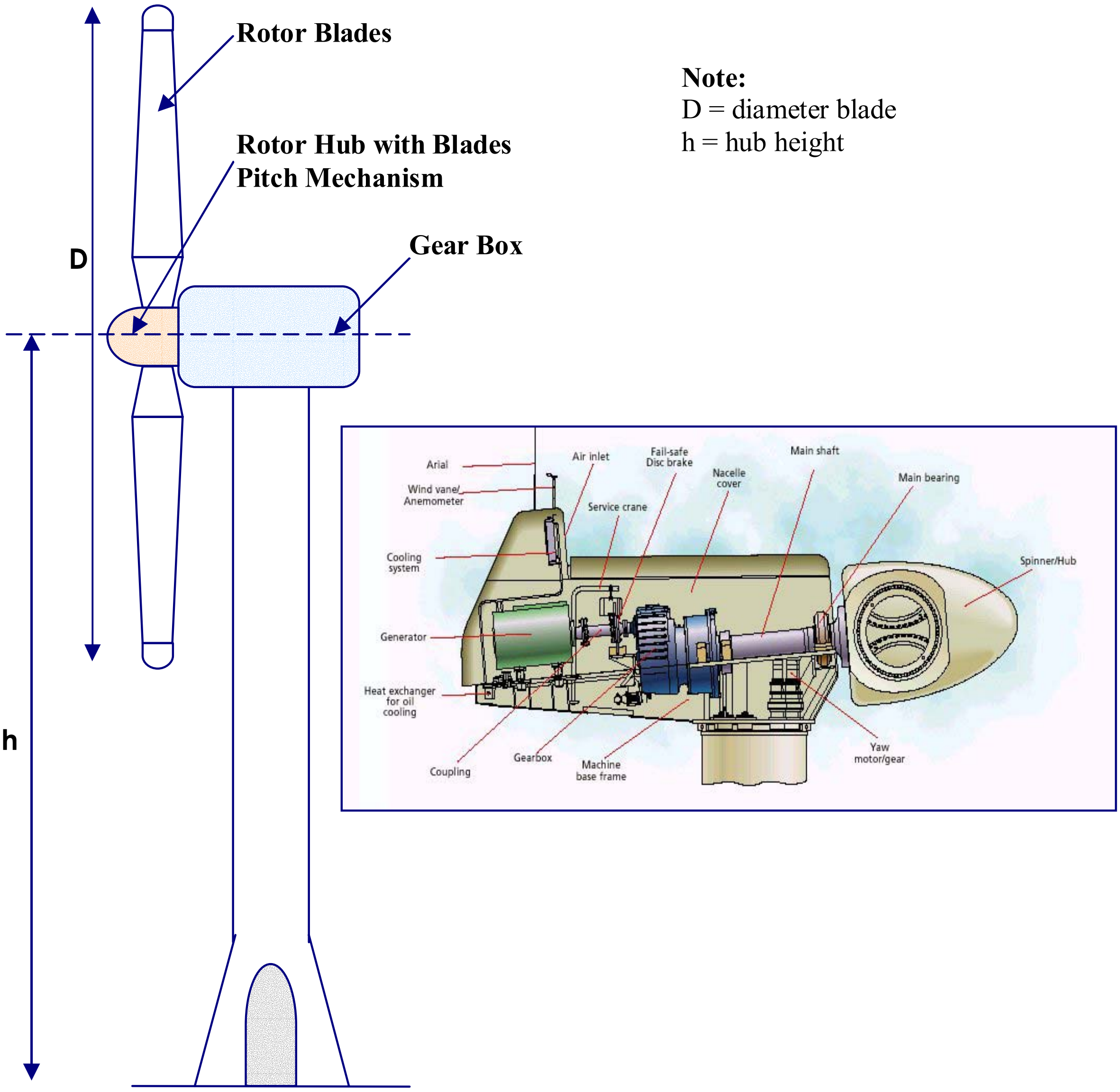
- Wind vanes ensure that equipment rotor remains oriented at all time into the wind
- Rotors capture the kinetic energy of the wind and convert it into rotary motion to drive the generator. The rotor turns (clockwise mostly) at constant speed of 4 -5 m/s and upon attaining the designed speed (rpm), signals for the unit's generator to switch into a grid (through a transformer) resulting in the wind turbine producing electricity. Production continues as long as the speed is above cut wind speed and below cut off speed (ranges typically 4 – 25 m/s). When wind speed goes beyond the cut-off value, the generator switches off the grid and installed brakes brings the rotor to stand still. If wind speeds decrease below cut-in values, the rotor will gradually go idle until stops (Wind Energy).

2.3.2. Energy Output. Windmills mainly deliver or produce energy output in electricity. The energy output of a wind turbine can be estimated by $E= b.V^3$ kWh per square meter, where E is the annual energy output, b is the performance factor and V is the average wind speed at hub height. The efficiency of modern wind turbine is around 30% – 35%. The factor b depends on the system efficiency of the wind turbine and the statistical distribution of wind speeds. In coastal climates (in Europe for example) a value of 3.15 for b is representative for modern wind turbines (World Energy Assessment, p.234).

2.3.3. Basic Parameters. The most important parameters determining wind turbine operations are wind distribution, turbulence intensity and surrounding terrain type. Wind plants must be located as close to supply premises as technically and socially acceptable so as to avoid potential voltage drops in the transmission lines of DC power generators. This could also avoid higher wiring and installation costs.

Further, plants must be free from physical interference (from trees and buildings) to make use of maximum winds. Installation towers must be strong, properly guyed with cables and grounded against lightning strikes.

In general, local average wind speeds should exceed 5 meters per second at heights of 10 meters to allow for economic exploitation of grid connected wind turbines. Most of the time however, technical availability of wind farms exceeds 96% with operational lifetimes been estimated to be between 15-20 years.



Note:
D = diameter blade
h = hub height

Figure 5. Wind Mill (HWT) and Detail of Gear Box

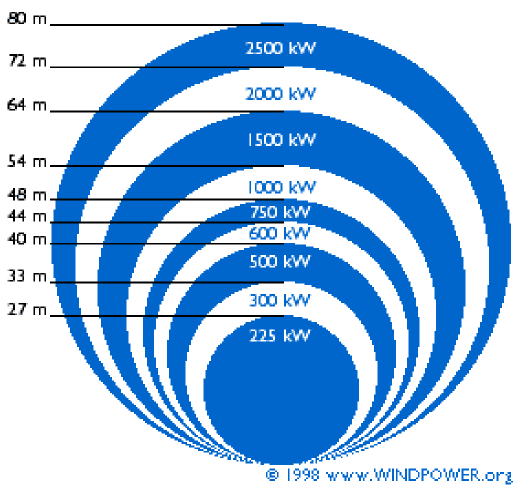


Figure 6. Power Output Increases with the Swept Rotor Area (Size of Wind Turbines)

2.3.4. Investment Costs. Cost per kWh produced by a wind turbine are influenced by several parameters such as wind regime (at place of installation), total investment costs (turbine and installation), efficiency of turbine, reliability expressed in availability (% of the time ready for operation) and other economic parameters (e.g. interest rates on capital investment loans) (Wind Energy).

However, typical figures for investment projects cost in Europe (for example) could be in the range of $460-660 per square meter or about $1000 per kW (What does a Wind Turbine Cost). This however does not include costs associated with such local factors as soil and road conditions and the availability of electrical substations. Operations and maintenance costs (during a plants' lifetime) averages $0.005 - $0.01/kWh (Operation and Maintenance Costs for Wind Turbines).

2.3.5. Advantages, Disadvantages and Associated Risks. Some advantages of wind turbine technologies include:

- Normal operation of wind turbines causes no carbon dioxide emissions
- Simple materials or manufacturing processes are required in producing a wind turbine or building the civil works
- Electricity from windmills is easy to distribute via existing infrastructure and has a high efficiency

However some of the disadvantages could be highlighted as follows:

- Fluctuations in velocity that occur short periods (referred to as turbulence) and can cause fatigue and failure of wind turbine components (blades, transmissions, and generators).
- As a power source, wind energy is less predictable than solar energy.
- Difficulty in estimating available power at specific times of day and may thus cause flickers (power quality problem, caused by variations in the main voltage and affecting lighting sources)
- Negative environmental and social aspects such as acoustic noise emission, visual impact on landscape, impact on bird life, moving shadows caused by the rotor and electromagnetic interference with radio, television and radar signals

Associated Risk:

- Human safety during the operation and maintenance

2.3.6. Current Status and Expectations of Technological Development. Wind turbines are a mature technology capable of providing large amounts of power at prices competitive with most other sources of electricity. Recent liberalization of European energy markets has also allowed for the choice of purchased sustainable energy. As a result, wind energy has proved to be among the most popular options. Long term forecast for the potential reduction in prices of electricity from wind turbine has also been accomplished from time to time. Wind power is a vast resource of clean, reliable cost effective electricity. Electricity generated from the wind does not contribute to global warming and acid rain.

In the last decade, the costs of wind generated electricity have decreased considerably, and the reliability of wind turbines has increased dramatically. During the 1980s the cost of wind generated electricity dropped from about 15 - 20 cents per kWh to the current costs of 7 - 9 cents per kWh. This is similar to the costs of generating electricity from fossil fuels and is cheaper than the cost of electricity from most recent nuclear power plants. The costs came down largely because of improvements in the reliability of wind turbines, the best of which are now available to operate 95 - 98% of the time.

Modern wind turbines are designed to work for some 120 000 hours of operation throughout their design lifetime of 20 years. That is far more than an automobile engine which will generally last for some 4 000 to 6 000 hours (Operation and Maintenance Costs for Wind Turbines).

2.3.7. Barriers to Technological Development. Manufacturers and project developers usually identify the following items as serious barriers for efficient implementation of wind turbine projects (World Energy Assessment, 234-235):

- Fluctuating demand for wind turbines as a result of changing national policies and support schemes
- Uncertainties leading to financing costs as a result of changing governmental policies
- Complicated, time consuming and expensive institutional procedures resulting from a lack of public acceptance, which varies considerably from country to country.
- Lack of sufficient international acceptance of certification procedures and common standards

3. CRITERIA FOR TECHNOLOGY ASESSMENT

Careful consideration needs to be put into selecting environmentally friendly energy technologies. These have to be based on criteria covering a broad range of issues, including technical, financial, ease of operation and maintenance and socio-economic.

Questions that could be asked include:

- Can proposed technology provide the form of energy desired
- Can the technology meet with the scale of energy supply required
- Is the technology easy to set up
- Are operations and maintenance procedures simple enough to be conducted with moderate ease
- Can operational hours be appropriately met by technological option
- Would capital investment, operation and maintenance expenses prove cost effective
- Would the technological option be financially viable
- Would the option be socially acceptable
- Is it "green technology"?

Specifically, the technological options discussed above could be assessed by answering these questions with the aid of information and data provided for the Eco camping site. These have to be evaluated and analyzed to determine the energy requirements and existing costs, etc so that suitable technology recommendations could be proposed. In other words, the selected criteria should enable us to distinguish clearly (in the next phase) between the different options and reach an informed decision as to which is most suitable given the specific circumstances of the project.

Table 1. Preliminary Assessment of Technologies

Assessment Criteria	Solar Thermal	Wind mill
Investment Costs	$ 300 – 1000 per square meter	+/- $ 1000/kW ($ 460 – 610 per square meter)
O & M Costs	$ 25 – 30 per annum	$ 0.005-0.01/kWh
Operational hours/year	Seasonal dependency, back up provided for night/cloudy days	+/- 6000 hrs/year
Ease of Installation, O&M Procedures	Fairly simple	Rather difficult (necessary skill required to install and maintain)
Social Acceptability	Good	Sometimes Tolerated
Greenness of technology	Green	Green

4. CONCLUSION

Renewable energy technologies as well as energy efficient technologies are becoming the order of the day and most companies wish for customers to be aware that the products and services they are receiving are environmentally friendly. Using energy efficiently does not only saves energy but money as well.

Most RETs may not provide all the energy required by a company but they offer enough to run major operations. Solar thermal heating are suitable for most hot water production and space heating. Windmills may also be fully exploited in regions where wind speeds average 4meters per second.

It therefore stands to reason that all the above are worth considering if efforts are to be made in reducing dependency on fossil-fuelled based supplies in favor of greener practices. Further analytical studies are to be done (in subsequent technical and financial appraisals) to determine which of these technologies may be most applicable for each consumers.

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