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Will investing in renewable energy pay off?: A case study in Florida

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Abstract

Environmental benefits are a major advantage of renewable energy. However, the deciding factor for the development of the industry is whether it pays off to invest in renewable energy. Because of climate and topography, only biomass and solar energy are potential sources of renewable energy available for application in Florida. One way to find out if investing in an enterprise pays off is to compare total cost of the final product with its competitors. The expected costs of energy from renewable sources must be competitive with the costs of energy from other sources before it can be considered as an investment option. This paper presents a comparison of the cost of energy from renewable sources in Florida (solar, biomass) with energy from fossil fuel sources. To date, there are two practicable systems for converting solar to usable energy: solar water heating, and photovoltaic electric systems. Biomass resources for conversion to energy can be available as dedicated energy crops, or various wood wastes that can be used as feedstocks.

Presently, cost of electricity from solar energy converted by photovoltaic technology is about \$0.22 per KWh. Cost of electricity from thermal solar is equivalent to \$0.04 to \$0.11 per KWh. Various studies on sugarcane, elephantgrass, *Leucaena*, and *Eucalyptus* as biomass crops have shown promising results under certain conditions. Biomass crops can be converted to ethanol and electricity. However, only sugarcane can be converted to ethanol by using the conventional, less expensive conversion methodology. The technology for conversion of other biomass crops (elephantgrass, *Leucaena*, and *Eucalyptus)* to ethanol using cellulosic conversion processes has not yet proven commercially economical. Energy value from direct combustion of various biomass crops, including sugarcane bagasse ranged from 17.8 to 19.3 MJ dry Mg^{-1} (7660 to 8300 Btu/lb.). Cost of producing electricity from various biomass crops ranged from \$0.068 to \$0.08 per KWh. These numbers are compared with cost of electricity of \$0.0437 per KWh for using fossil fuel (coal, natural gas). Considering all aspects of renewable energy in Florida, for the time being, investing in solar thermal energy for certain domestic application can be considered as the highest pay-off. Photovoltaic systems as a source of renewable energy have not yet proved economically feasible. Biomass can be considered a source of renewable energy only if the cost of biomass feedstocks can compete with other sources. Data shows that the fuel cost for a biomass power plant ranges from \$2.00/Mbtu to \$5.00 per MBtu compared with \$1.23 to \$1.25 per MBtu for coal.

Keywords: Investing; Renewable energy; Solar energy; Florida

1. Introduction

Renewable energy has long been considered to be a viable energy option. Solar, wind, hydro-power, wave energy, tidal power, geothermal energy, biomass crops, and municipal solid wastes are sources of renewable energy. Due to geographical and climatic conditions there are only certain types of renewable energy with potential for use in a given area. In Florida, biomass crops, and municipal solid wastes are potential sources of renewable energy that may be economically developed. Because of climate and topography, solar energy is the only other source of renewable energy that has potential in Florida. While some sources of renewable energy like sunlight are abundant, because of the high cost of collection and conversion to usable energy, so far, solar sources have been used to produce only limited amounts of energy. The environmental benefits of renewable energy have always been mentioned as a major advantage, however, the deciding factor will be the cost of producing renewable energy and whether it pays off to invest in this endeavor. The cost of renewable energy must compete with the cost of energy from other sources before renewable energy will be developed further. Over the past twenty years there have been various studies on feasibility of potential types of renewable energy in Florida. While most of these studies were focused on biomass-to-energy system, there were some studies on feasibility of solar as a source of renewable energy. Based on the results of these studies, economic aspects of these two available sources of renewable energy in Florida and the potential for investment in renewable energy sources was analyzed.

2. Solar energy potential

Considering climatic conditions, Florida has the potential to benefit from solar as a source of renewable energy. Data on the annual average daily direct normal solar radiation for the United States show Florida with 14 MJ/m^2 compared with up to 28 MJ/m^2 for other areas [1]. This data indicates that Florida is not in a preferred position when it comes to solar energy, however, solar radiation is high enough for Florida to be considered a potential place for taking advantage of solar as a renewable source of energy. While using solar energy systems has certain environmental benefits, it is the net monetary benefit that determines economic viability of a renewable energy system. "Sunshine may be free but collecting it is not" [2]. There have been studies on economic evaluation of solar energy systems. Some of the studies evaluated costs and benefits of different technologies for conversion of solar to energy in Florida.

The Florida Solar Energy Center has conducted several surveys on the application of various solar energy conversion technologies in Florida. At the present time there are two technologies for conversion of solar energy that appear to have potential: solar thermal collectors and solar photovoltaic (PV) cells [3,4]. Solar thermal energy technology uses the sun's energy to heat water and is usually applied to heat water for residential or commercial use. Solar photovoltaic technology converts solar energy to electricity by means of solar cells. Presently, each of these technologies has some drawbacks and limitations.

Most solar thermal systems heat water for residential use such as heating of swimming pools or household usage, or hot water for commercial use. The technology uses a solar collector to heat the water inside the collector. In Florida, three types of solar systems are used: pumped, integral collector storage (ICS), and thermo-siphon [5]. The ICS and thermo-siphon systems use no pump or controllers to circulate the water from the collector panel to the hot water-tank, therefore, these are less expensive systems, however, not as efficient as pumped systems. The advantage of solar thermal technology is the low initial capital outlay. The total cost of this system, for a house, ranges from $1,500 to $3,500 in Florida, depending on the size, type, manufacturer or installer, and other factors such as roof type, and building code [6].

A similar technology is used for heating swimming pools, however, the heat collector is different from solar hot water systems. Presently, solar pool heating (for residential use only) is one of the most economically attractive solar energy options in Florida. Cost of a solar heating system, including installation, for a swimming pool in Florida ranges from $2,000 to $4,000 depending upon many factors, and has a payback period of 1.5 to 7 years [7]. This can be compared to an average yearly cost of $1,450 for heating a residential pool in Florida using electricity or $1,080 using an electric pump plus natural gas [8]. It is estimated that solar pool heating comprises 70 to 80 percent of Florida's solar industry with about 18,000 installations per year [8].

One major limitation of a solar water heating system is shade from trees that can prevent full benefit of the sunshine. In Florida, however, tree shade is a source of energy conservation since energy needed for cooling is reduced. It has not yet been shown that the benefits of full sunshine for a solar water heating system outweigh the tree shade benefit for a residential building. A report on a solar water heating pilot program in central Florida compared its costs only to an electric water heater. However, comparing the cost to a natural gas water heater may yield different results. Natural gas water heaters are often a lower cost option than electricity. When cost of solar thermal system is converted to cents per KWh the report estimated the total cost of generating energy with a solar thermal system ranged from $0.035 to $0.116 per KWh, assuming an initial cost of $2,000 to $3,500 and annual electricity consumption of 3,000 to 6,000 KWh [9]. Average total cost of electricity from fossil fuel in the same area was estimated at $0.05 per KWh. In a comparative cost analysis by Southern Company, cost of solar thermal estimated at $0.11 per KWh and photovoltaic at $0.27 per KWh versus $0.04 to $0.11 per KWh for energy from biomass resources.

Photovoltaic technology uses solar cells to convert sunlight directly to electricity. Since photovoltaic modules and arrays produce direct current (DC), an inverter converts direct current to alternating current (AC)for use by electric appliances and equipments. The photovoltaic technology is relatively simple in design with no moving parts and very low maintenance, however, photovoltaic modules are too expensive at the present time to compete with other sources of energy. Currently, photovoltaic modules cost $4 to $10 per peak (bright sunlight) watt [10]. The U.S. Department of Energy estimated the cost for a 5-kilowatt solar photovoltaic system to be $30,000 to $40,000, which is about $6 to $8 per watt [11]. The cost of electricity from photovoltaic technology, assuming an installed cost of $7 per peak watt, is estimated at $0.22 per KWh. In some areas such as the U.S. desert Southwest, with higher annual average daily direct solar radiation, the cost of PV electricity is estimated at $0.18 per KWh [9].
In addition to the high cost of PV systems, the storage of excess electric power produced by photo cells is also a major issue for application of photovoltaic technology. Once photovoltaic

cells become economically competitive, the connection of a residential PV system to the utility grid, which is now available in Florida, would make it possible for the excess power to be used by the grid system. It is estimated that at a capital cost of $1.00 to $1.50 per peak watt, electricity produced by PV technology may be competitive with other sources of energy. The United States Department of Energy's goal is to reach $3.00 per peak watt by 2010 and $1.50 per peak watt cost of electricity produced by a photovoltaic system by 2020 [9].

3. Biomass energy potential

Favorable climatic conditions that make Florida a potential place to produce biomass as a source for renewable energy include yearly rainfall of 45 to 80 inches (various parts) and 280 to 365 frost-free days per year. There are more than twenty years of experience in research and development on various aspects of biomass crop production, including converting biomass to energy sources such as ethanol, methane, and electricity in Florida. There are three major factors contributing toward development of a biomass energy system: land availability, suitable crops, and favorable climatic conditions.

Availability of low opportunity cost land that can produce high yielding biomass crops is a necessity for establishing an economically competitive biomass energy system. A viable renewable energy system depends on the consistent feedstocks delivery to conversion facilities throughout the year. Energy conversion facilities using biomass cannot rely on one single crop that is harvested and made available only within a narrow harvesting season. A number of suitable biomass crops, with different harvesting periods, that can be grown and harvested throughout the year and provide a consistent flow of feedstocks are needed for a successful biomass-to-energy system. Some crops which have been evaluated include elephantgrass, sugarcane, *Leucaena*, various *Eucalyptus* species, and slash pine.

3.1. *Land availability and favorable climatic conditions*

Results from numerous studies in Florida have shown that there are a number of suitable sites for growing biomass crops. A Geographic Information System was used to study land availability for biomass production in Florida. Results show that there are more than 70 thousand parcels of forest, agricultural, reclaimed, or industrial land with a total area of 2.5 million ha (6.17 million acres) in peninsular Florida that could potentially be used for biomass production. Land-use and land-cover classifications show these parcels are being used as crop and pasture land, natural or developed forest, reclaimed land, power plants, waste treatment facilities, food processing, other processing facilities, and transportation terminals. The crop and pasture land-use type with an area of 877,000 hectares has the highest potential for biomass production. This area can produce up to five million metric tones of biomass feedstock per year. Potential biomass production for all types of land-use in peninsular Florida exceeds 13 million Mg per year [13]. In addition, there are 81,000 hectares (200,000 acres) of mined lands and more than 161,000 hectares (400,000 acres) of pastureland in Central Florida that are marginal lands with a very low opportunity cost, that have potential for biomass production [14].

3.2. *Suitable Crops*

There are several crops that can be grown as biomass feedstocks in Florida. Florida's weather conditions are favorable for growing many herbaceous crops as well as woody biomass crops. However, some of these biomass crops have higher yields and have fewer environmental problems. Results of numerous studies over the past 20 years have shown that elephantgrass, sugarcane, *Leucaena*, various *Eucalyptus* species, and slash pine (*pinus elliettii*) have higher yield potential than other biomass crops in the area. Since environmental concerns are an important factor in development of a renewable energy system, these biomass crops have a minimum of environmental problems compared with other potential biomass crops in the state. Sugarcane has been considered for production of ethanol as well as electricity. Yield estimates for some of these biomass crops are based on results of growing these crops in the test plots in Florida. Sugarcane is the highest yielding biomass crop in the state with yields ranging from 30 to 49 dry Mg/ha/year (14-22 ton/A/yr) on different soil types. Elephantgrass, *Leucaena*, various *Eucalyptus* species, and slash pine are estimated to yield from 20 to 40 dry Mg/ha/yr (9-18 ton/A/yr) on various soil types. Based on a four- year crop rotation period *Eucalyptus* yield is estimated at 29 to 40 dry Mg/ha/yr (13-18 ton/A). Based on an eight-year crop rotation period, the pine yield was estimated to average 21 dry Mg/ha/year (9 tons/A)[14]. Table 1 shows potential energy values per hectare for these crops that range from 126 to 187 GJ per hectar per year (264-390 Mbtu per acre per year). An important operational advantage of biomass crops in Florida is the wider harvesting window, extending up to 11 months in some cases. This helps to reduce the need for storage, allows efficient use of processing capital, and reduces total cost of biomass feedstock.

Table 1: Potential energy values from biomass crop in Florida

Biomass crops	GJ/ha/yr	MBtu/A/yr Table 2
Sugarcane (ethanol from juice+ steam from bagasse)	187	390
Elephantgrass	134	280
Leucaena	126	264
Eucalyptus species	132	276

Source: Stricker *et al.*, 1995 [14]; Rahmani *et al.* 2000 [12].

3.3. *Biomass Conversion to Energy*

Results of several surveys have shown that biomass crops grown in Florida can be converted to ethanol and electricity. However, only sugarcane can be converted to ethanol by using the conventional, less expensive conversion technology. The technology for conversion of other biomass crops (elephantgrass, *Leucaena*, and *Eucalyptus)* to ethanol has not yet proven to be commercially economical. Laboratory analysis of sugarcane presscake, elephantgrass, *Leucaena*, and *Eucalyptus* produced in central Florida indicated the energy value for these crops ranged from 17.8 to 19.3 MJ per dry Mg (7660 to 8300 Btu/dry lb.). Cost of producing electricity from various biomass crops in central Florida is estimated at $0.068 to $0.08 per KWh [15].

As with renewable energy from solar sources, renewable energy from biomass also has its limitations. There are a few technical problems that must be overcome to make investing in biomass to energy economically feasible. Drying biomass under Florida's humid weather conditions, and the associated cost is one of these concerns. Part of the data presented are the result of small plot studies, therefore, its reliability on a large scale of operation needs to be tested once biomass production and conversion enter into a commercial phase. The constraints of alternative land-uses, markets for biomass products, competing energy sources, and demand for energy would reduce the actual commercial potential of biomass production considerably. The land identified as having potential for growing biomass generally is being used for various economic activities at present. For these lands to be dedicated to biomass energy production, the new use will have to outbid the existing uses. If invasive, nonnative plants in some areas of Florida could be harvested for an economic use, this could help defray the cost of managing these lands. There may also be potential for biomass production to help reclaim lands that have been mined and environmentally disturbed, again helping to defray costs.

4. Analysis and conclusion

The information presented regarding investing in renewable energy suggests that in Florida biomass and solar sources may be considered as a potential investment opportunity only under certain conditions. There are serious limitations in using solar and biomass sources for producing energy on a large scale commercial operation. Low temperature solar water heating systems may be cost competitive only under certain conditions and mostly for domestic application. Solar hot water is not suitable and economical for every house, and it is not widely used. Initial capital cost of a solar to electric system (photovoltaic system) is still very high ($30,000 to $40,000 for a 5-kilowatt system) to be considered a viable choice at least for some time. It is estimated that a 4-kilowatt system can provide half the energy needs of a 2,000 square foot home [16].

Considering climatic advantages in Florida, biomass production and conversion to fuel grade ethanol and electricity seems a feasible option if the advantages of low opportunity cost land in central Florida are taken into account. Some realistic comparison will shed a light on the issue. A recent study has shown that agricultural residue (wheat straw and corn stover), energy crops, forestry residue, urban wood waste/mill residue are all viable if available at the price of $5.00 per million Btu. The study also indicates that by year 2020, the United States is estimated to have a maximum of 7.1 quadrillion Btu of biomass available at a price of $5.00 per million Btu or lower [17]. This is compared with $1.25 per million Btu for new coal [18]. In a study on cost of electricity in fossil fuel generation and 100 percent biomass fuel generation, total cost of generated electricity, from various biomass sources and by various boiler types, was estimated at $49 to $108 per 1000 KWh. This is compared with $44 per 1000 KWh. for new coal and new natural gas generation respectively [18].

Still there may be potential for biomass production to help reclaim lands that have been mined and environmentally disturbed, again helping to defray costs. Utilizing waste biomass feedstock and collecting tipping fee, such as the case with some power plants cofiring biomass with coal, presents a practical and economical way of using biomass to produce electricity. It is true, using biomass resources have certain environmental benefits. However, unless somebody (public sector or consumer) is ready to pay for this benefit to offset higher cost of energy from renewable sources, energy from renewable sources is going to have a tough time competing with other sources of energy, and so will the investment in this endeavor.

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