International Journal of Modern Engineering Research (IJMER)
www.ijmer.com Vol.2, Issue.6, Nov-Dec. 2012 pp-4587-4590 ISSN: 2249-6645

Cost Analysis of Small Scale Solar and Wind Energy Systems

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Abstract: *The recent dramatic increase in the use of renewable energy systems leading towards competitive markets within the various individual renewable energy systems. The aim of this paper is to prove the hypothesis i.e. in next few years, when the cost of the solar PV modules come down below 1$ per Watt, small wind turbines become more costlier because of the cost of structures required to support the wind generator. And also if the threat from the market is not addressed both technically and commercially, small wind turbine manufactures will lose the competition to solar PV module manufactures in the near visible future. Objective of this paper is to do cost analysis on the industry data and prove hypothesis and to arrive at the cutoff point, where after the generating energy from the wind is not economically feasible. With this cost analysis, author here by alarm for the small scale wind turbine manufactures to take necessary measures to survive the competitive markets of small scale renewable energy systems.*

Keywords: *Renewable energy, Solar PV, Wind Turbine, Curve Fitting, Cost analysis.*

I. INTRODUCTION

1.1 Renewable energy system

A Renewable energy system uses any sources of energy that can be used without depleting its reserves. These resources include Sunlight or Solar energy and any other sources such as wind, wave, biomass, hydro energy and geothermal energy. These are replenished by nature rather than by man. Renewable energy systems help protects the environment since they usually do not release harmful byproducts into the atmosphere.

1.2 Industry Scenario of Solar Energy systems

Author have visited few industries related to Solar Power Plant Equipment Manufacturers in Hyderabad, Complete process of fabrication of a solar Photovoltaic module along with merits and demerits of various solar cells and Process techniques and Q/A methodologies had been studied, It was observed that very soon cost of production of solar photovoltaic module per peak watt is going to be as low as 1$/ watt. These are some of the factors responsible for the rapid down fall of solar panel costs.

- Shortage of silicon used in solar panels is almost over. Multi crystalline solar cells are being more efficient over mono crystalline solar cells which are considered to be at higher costs.
- Latest technologies in amorphous solar cells are also responsible for the reduction of solar PV module costs.

This rapid drop down of costs of solar panels became a problematic for small scale wind energy systems which may not be able to compete with small scale solar energy systems in the market.

1.3 Industry scenario of small scale wind Energy systems

As per the study conducted by author on small scale wind generator producer companies, in India, small scale wind turbines are installed by Nature lovers, self financing institutions, universities, government funded projects, energy parks etc. For any Renewable Energy System, presently there is 80% depreciation in first year, 20% in second year and results in 30% tax savings in India. Wind generator Customers are more worried about the work failure, quality of the product than on investment.

In 100% depreciation projects, industry gets direct benefits payback is 10 years. Supernova Technologies, Gujarat manufactures a patented design of small scale wind generator ranging from 700W to 5KW and had completed more than 100 installations for the past 10 years. Benefits of these designs are more service life, low noise level. SNT's nano model of Wind Turbine is claimed to be the world's smallest commercial Wind Turbine with cut in wind speed of 1.2 m/s.

II. Need for Cost Analysis

Solar and wind energy systems involve a significant initial investment, they can be competitive with conventional energy sources when accounted for a lifetime of reduced or avoided utility costs. The cost of the system itself—depends on the system chosen, resources on the site and electric costs in the area. So the entire solar and wind energy system is analyzed for subsystem costs. Objectively to get an optimized cost model for the best selection of the renewable energy system.

III. Methodology

The parameters required for the cost analysis of solar and wind energy systems are

Table1: Parameters of Evaluation for Solar Energy

1	Annual Average Daily Peak Sunshine Hours (h)
2	Daily solar Radiation Horizontal (KWh/m^2/day)

Table2: Parameters of Evaluation for Wind Energy

1	Mean Annual Hourly Wind Speed(m/sec)
2	Hub Height (m)

The cost analysis is done by evaluating the parameters for a Particular location. Example Hyderabad situated in Southern India, geographically located at Latitude 17^o 22'31" North of the equator and 78^o28'27" East of the Prime Meridian of the world map.

According to the Indian Metrological Department IMD, the daily solar radiation horizontal and Mean Annual Wind Speed at Hyderabad is shown in table3.

Table3

Parameter	Design Value
Annual Average Daily Peak Sunshine Hours (ADPS)	9.31
Daily solar Radiation Horizontal(KWh/m^2/day)	3.83
Mean Annual Hourly Wind Speed(m/sec)	3.277
Hub Height (m)	50

The above parameters of a particular location are used to compute and estimate the energy density.

IV. Description

The below graphs were developed to prove the hypothesis and to arrive at the cut-off point (Energy demand Vs. Cost of the system), where after generating energy from Wind is not economically feasible.

Graph #1 Energy demand (KWh) vs. Cost of the solar energy system (excluding structure costs).

Graph #2 Energy demand (KWh) vs. Cost of the Wind energy system (excluding structure costs).

Graph #3 Energy demand (KWh) vs. Cost of the solar energy system (including structure costs).

Graph #4 Energy demand (KWh) vs. Cost of the Wind energy system (including structure costs).

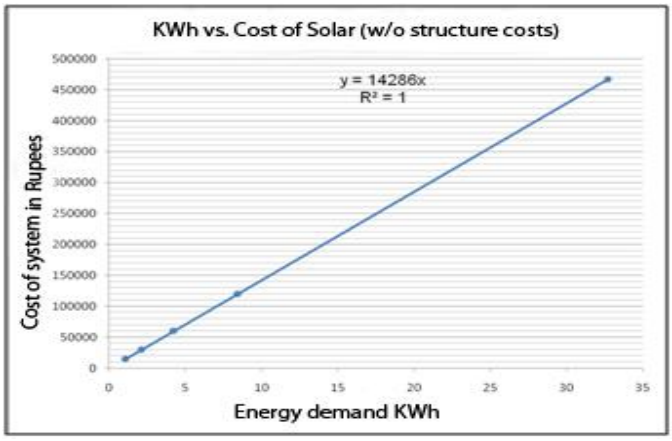
- The supporting structures are different for both the Solar PV modules and Wind turbine. Hence, their costs.
- Once, these graphs are developed on the same scale of Energy demand (KWh) vs. Cost of the energy system, and overlapped them to find the optimal region defined by the intersection of the curves.
- Assuming that without structure costs of the energy system, the slope of the graphs Cost/KWh does not vary much between solar and wind energies. But, there is a huge variation when structure costs are included.
- Building the graphs is to gather X, Y values (KWh vs. Cost) of Solar panels and Wind turbines with and without their respective structures.

Energy demand vs. Cost of system graph of solar and wind energy systems:

Graph #1: Energy demand (KWh) vs. Cost for solar energy system (excluding structure cost)

Data Points:

KWh	Cost
1.05	15000
2.1	30000
4.2	60000
8.4	120000
32.68	466866.5

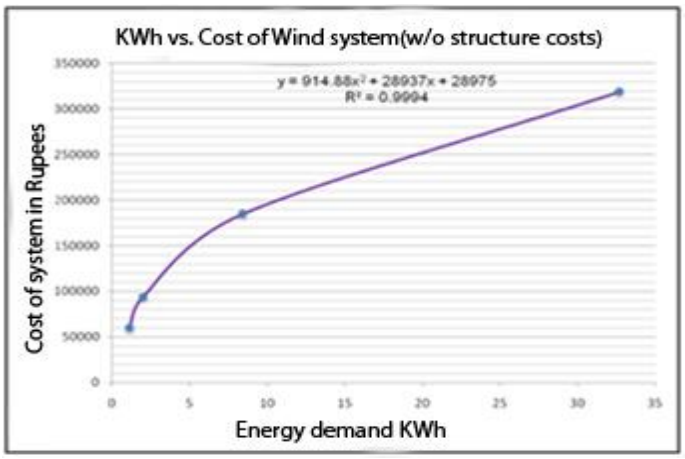


The graph shows a linear relationship between the energy deamnd and cost of the solar system (excluding the structure
cost) .Graph represented by the linear equation y=14286x.

Graph #2 Energy demand (KWh) vs. Cost for wind energy system (excluding structure cost).

Data points:

KWh	System Cost
1.12	60000
1.99	94000
8.4	185000
32.68	319000

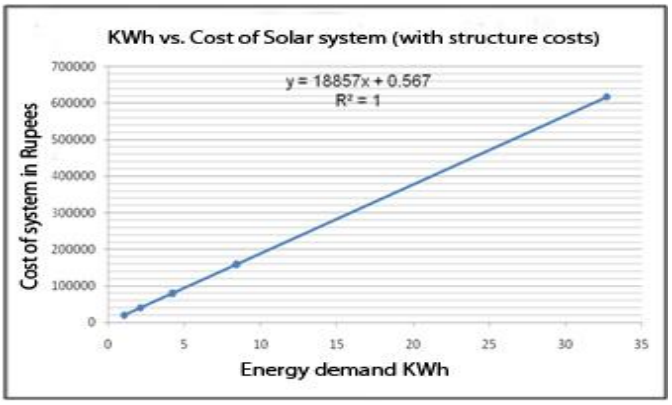


The above graph shows nonlinear relation between the energy demand and wind system cost (excluding the structure costs). Graph represented by the polynomial equation $y = 914.88x^2 + 28937x + 28975$ with a correlation coefficient of R^2=0.9994.

Graph #3 Energy demand (KWh) vs. Cost for solar energy system (including structure cost)

Data points:

KWh	System Cost
1.05	19800
2.1	39600
4.2	79200
8.4	158400
32.68	616246.8

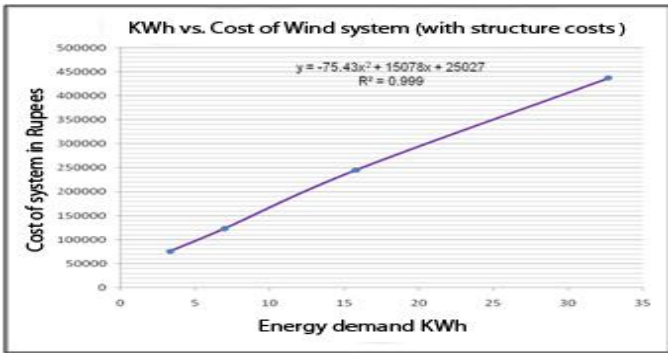


The above graph shows a linear relationship between the Energy deamnd and cost of the solar system (with structure cost).Graph represented by linear equation y=18857x+0.567

Graph #4 Energy demand (KWh) vs. Cost for Wind energy system (including structure cost)

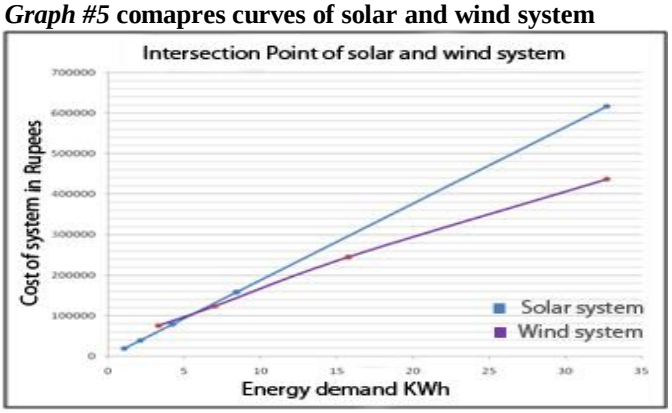
Data points:

KWh	System Cost
3.312	76000
6.96	123300
15.74	245000
32.68	437000



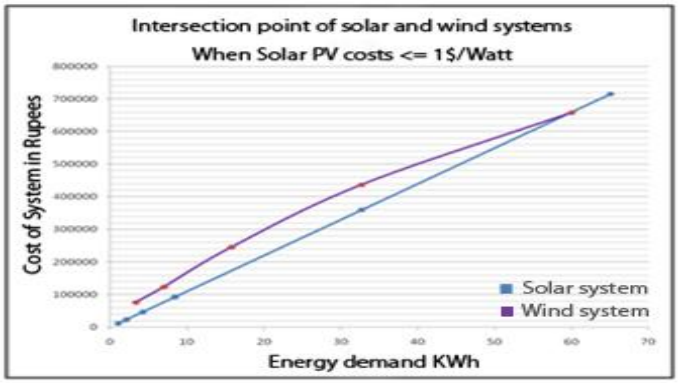
The graph shows a non linear relationship between the Energy deamnd and cost of the wind system (with structure cost).Graph represented by non lilnear equation $y=75.43x^2+15078x+25027$ with a Correlation coeffecient of $R^2=0.999$

Graph #5 **comapres curves of solar and wind system**



Graph #3 & Graph #4 were overlapped (i.e. energy demand vs. cost of solar system and wind system including their structures) to get the cutoff point where after generating energy from the wind is not economically feasible. And obtained cutoff point from the above graph as (KWh, Cost) = (6.96, 123300).

Graph #6 shows intersection point of solar and wind system (assuming solar PV module costs < 1$/peak watt)



When the graphs ,Energy demand vs. Cost of solar and wind systems (including the structures costs and aslo assuming the solar PV module costs < 1$/ peak watt) are compared and arrives at a cutoff ponit (KWh,Cost) = (59.604,655643.734) . From the graph generating energy from wind below this cutoff point is economically not feasible. This proves author's hypothesis i.e. when the cost of the solar PV modules comes down below 1$ per Watt small wind turbines become uneconomical because of the structures cost required to support the wind turbine and wind generator. And also if the threat from the market is not addressed both technically and commercially, small wind turbine manufactures will lose the competition to solar panel manufactures in the near visible feature.

V. Analysis

Graphs were developed between energy demands vs. the cost of renewable energy system. Projecting energy demand on x-axis and Cost on y-axis. For wind energy systems the data is acquired from the supernova technologies ltd. and the data for the solar photovoltaic modules is obtained from the Andromeda.

The following assumptions are made in the cost analysis of small scale solar and wind energy systems.

- The Mean Annual Hourly Wind Speed is 6.0m/s
- Annual Average Daily Peak Sunshine Hours is 9Hrs.

Graphs are developed using Microsoft Excel.

VI. Result and Discussions

From the above graphs it is clear that the cost of solar system follows a liner relation, whereas the cost for wind generators slightly varies at higher ratings. The comparison of the two curves in graph #5 gives an intersection point i.e. cost of both the systems at this point is same and the region below this point ,solar is preferable and wind is preferable above the intersection point as per cost analysis. In a couple of years, we can expect cost of solar photovoltaic modules may bring down to less than 1$/peak Watt, at this situation from graph #6 we can say

small scale wind generator manufacturers may lose their competition to solar market.

VII. Conclusion

Structure Costs are highly considered in case of total cost of the energy system either for solar or wind. Solar structure cost takes 20% to 25% of the total system cost while wind turbine structure cost is about the 40% to 60% of the total system cost.

So wind turbine structure cost is more than that of solar structure cost. Therefore some measures are to be taken in order to reduce the structure cost, so that small wind generators may survive in the market.

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