Cost Benefit Analysis of installing Renewable Energy

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Abstract: In this paper, we present a mathematical model for integrating renewable energy sources in order to meet an energetic demand in Nagapattinam district with a lowest cost. It would be beneficial to switch over to renewable energy sources like solar, wind, tide and biomass etc. This study focuses on making use renewable sources as an alternative source of energy. The study area is Nagapattinam district a south coastal region of Tamilnadu in India, and a generalized findings and suggestions have been given based on the secondary data obtained. The problem is formulated as an integer linear program where the objective function is to be minimizing the initial capital investment.

Key words: Renewable energy - Photovoltaic panel- Wind turbine- Mathematical model.

Introduction:

Rapid depletion of fossil fuel resources on a worldwide has necessitated an urgent search for alternative energy sources to cater to the present day's demand [1]. In India the development of remote rural areas could not take place even after more than 50 years of independence. In recent years, the remote areas facing a very big power crisis. Depending upon the topography of the area, energy resources available and type of energy needs, demand and socio economic status of remote areas, the energy models can be developed and optimized in order to meet the needs of the area. The capacity of renewable energy sources constantly increases world-wide due to governmental funding policies and technological advancements. Renewable energy sources like solar, wind and renewable energy due to its availability, continuity and cleanness. Solar energy is abundant in India. The government of India has decided to aid consumes choosing to invest in solar in hopes of supporting "green" or sustainability movement .Solar energy is clean and free of emission which is great for the environment, as it does not produce pollutants or harmful nature. Energy generated from wind is rapidly emerging as one of most important clean and renewable energy sources in the world. In order to efficiently and economically utilize the renewable energy resource, one optimum sizing method is necessary. The optimum sizing method can help to guarantee the lowest investment with full use of the PV array, wind turbine and battery bank. So that the hybrid system can work at the optimum conditions interms of investment and system power reliability [2].

Solar energy

Energy is derived from the sun through the form of solar radiation. Solar powered electrical generation relies on photovoltaic and heat engines. The photovoltaic system consists of solar modules, a control device, rechargeable batteries, a load or device and the associated electrical connections. The cells absorb sunlight and convert the solar energy into electrical energy which is then passed to the control unit. Since the electrical energy produced is Direct Current (DC), an inverter is occasionally needed to convert the electricity to AC. The entire system is relatively simple. A photovoltaic system is essentially pollution free. The PV system generates electricity approximately 60%.

Solar Energy in India

India has high population rate and solar radiation as well, providing an ideal combination for solar power in India. In solar energy sector some large projects have been proposed and a 35,000km^2 area of the Thar Desert has been set aside for solar power projects sufficient to generate 700 to 2100gigawatts.India is endowed with rich solar energy resource. The average intensity of solar radiation received on India is 200MW/Km square. India has 2.12 megawatts of grid-connected solar radiation capacity. As part of the National solar mission, the ministry aims to bolster the annual photovoltaic production to at least 1000 megawatts a year by 2017. With an installed capacity of 123GW, the country currently faces shortage of 8 percent and a peak demand of 11.6 percent. As of October 2009 India is currently ranked number one along with the

United States in terms of installed solar power generation capacity [3]. For the first time generation based incentives will be provided for grid interactive solar power generation. A maximum amount of Rs. 12per KWh will be provided as incentive for electricity generated from solar photovoltaic and Rs.10 per KWh for electricity generated through the solar thermal route and fed to the grid from a power plant of 1MW capacity and above [4].

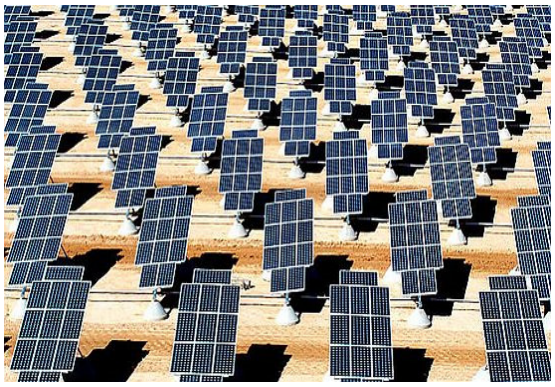


Fig:1 India's largest solar photovoltaic power plant in Kolar district of Karnataka

In Tamilnadu, totally 3522 domestic solar water heating systems and 419 industrial systems were installed under subsidy schemes of MNRE(upto 1992-93)and state government as on 31.03.2008 solar water heating systems have also been installed in 70 government buildings such as hospitals, hostels etc., with 100% funding by the state government. For the year 2007-08, the state government has sanctioned Rs.10.000lakhs for installation of solar water heating systems in government institutions. The most common and widely used outdoor lighting systems is the SPV street lighting systems with SPV module capacity of 74WP, a lead acid battery(12volt,75Ampere) and CFL of 11watt. It can operate from dust to dawn with automatic switch ON/OFF for 10-12 hours daily. The solar traffic signals are operative in five places in Chennai with a Government subsidy of Rs 1.5 lakhs for each signal. Solar vaccine Refrigerators are operating in five primary health centres which are in remote villages with a government subsidy Rs 10 lakhs per year [5].

Wind Energy

Wind behaviour is intermittent, that is the wind speed and directions vary with time and height. The wind speed increases with height and is influenced by the roughness class of the terrain and atmospheric stability.

Wind Energy in India

Wind energy has been the fastest growing renewable energy sector in the country. Commercial wind energy power generation in India began in 1986. The target of 15 percent of total power capacity through renewable energy for India by 2020 envisaged under the national action plan on climate change cannot be achieved without a substantial contribution of wind energy. India is the 3rd largest annual wind power market in the world [6]. India's wind sector has tremendous job creation potential as the domestic industry grows. India has the fifth largest installed wind power capacity in the world. Samana wind farm is the largest wind project at Gujarat. Suzlon, India's largest wind power company has risen to ranking 5th worldwide with 7.7% of the global market share in just over a decade. Suzlon holds some 52 percent of market share in India [3].

Fig: 2 Wind-powered turbines set up by Suzlon energy near Dhule, India.

Tamilnadu is the most dependent on outside sources. Own generation of the Tamilnadu Electricity Board is among the lowest of all the states considered. Tamilnadu is highly dependent on wind power generation; around 15 % of power availability is still expected to be supplied by this sector [7].

Features of study area

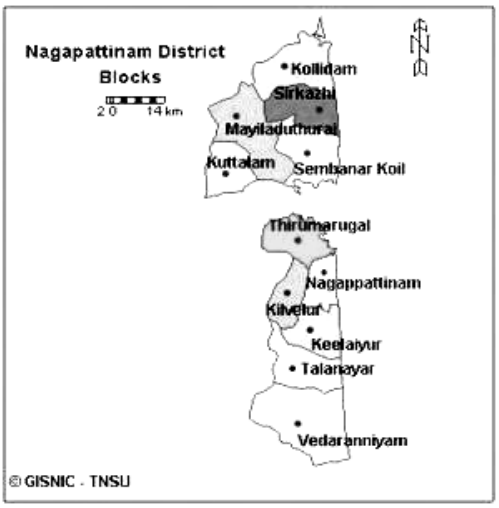
The district of Nagapattinam has been carved out as a separate district due to bifurcation of Thanjavur district. According to this division, 11taluks were detached from their parent district (Thanjavur) to form this new district. The earlier history of this district is more or less same as that of its parent district. Thanjavur is being a part of it till recently. Tamil and Telugu are the main languages spoken in the district.

The Nagapattinam district lies on the east coast to the south of Cuddalore district and another part of the Nagapattinam district lies to the

south of Karaikal and Tiruvarur districts. Its northern boundary is about 75km southwards from the head quarters of the Cuddalore district. Thanjavur district and Tiruvarur district flank it on the west and on the south and east it is bordered by the Bay of Bengal. The district lies between 10.25^0 and 11.40^0 North longitude and 76.49^0 and 80.01^0 east longitude. The general geological formation of the district is plain and coastal. The Cauvery and its offshoots are the principal rivers. The following figure shows the area chosen for the study. It shows the taluk and district boundaries. The total geographical area of the district is $2715.8km^2$.

Weather and climate

The average maximum temperature for the district (from 1991 to 2011) as a whole is about 32.46^0C and the average minimum temperature is 24.75^0C. Dust storms whirl winds and dusty winds blow from various quarters towards the end of M ay. The southwest winds sets in during April, it is the strongest in June and continues till September North east monsoon starts during the month of October and blow till January. Cyclonic storm with varying wind velocity affects once in 2 or 3 during the months of October, November and December. During southwest monsoon the air is calm and undisturbed.



Sources of power supply

There are five main sources of power in a state. They are their own generation, central allocation; power purchased from Independent Power Producers (IPP), short term power from the exchange and other sources (including wind mills). Tamilnadu is the most dependent on outside sources. Own power generation by Tamilnadu Electricity Board is the lowest among all the states considered. A large portion of power supply in the state (around 30%) is allocated to it from central generating stations (CGSs). Another significant portion of power (15%) comes from other sources which includes wind power generation. Further 6% of power coming from the power exchanges. The reason for the low generation by the state sector is the absence of investments by the state in stable internal sources. In 2015-16, it is estimated that Tamilnadu will have a power deficit of around11 percentage. The power consumption in Nagapattinam District is tabulated as below:

Power consumption	**Units(KWh)**	**Power consumption Needs**	**Percentage**
Day	21,26,200	Domestic	36%
Month	6,37,86,000	Commercial	28%
Year	76,54,32,000	Agriculture	16%
		Others	20%

Suggestions

The aim of our study is to satisfy the energy demands in the study area chosen by integrating in an economical way, the available renewable energetic sources. Since, Nagapattinam district is in the coastal belt of Bay of Bengal, both solar and wind energies are abundant in the places chosen for the study. The main occupation of the district is agriculture. For agriculture, Tamilnadu Government is providing electricity with free of cost. For this purpose, the Government is buying electricity from private sector for heavy amount. To avoid such things we can generate our own integrated renewable energy. It is important to find an alternative to minimize buying electricity from private sectors. The integration of solar and wind energies will reduce the burden of buying electricity which is very beneficial to the government. Moreover, agriculture consumes a large amount of non-renewable resources, specifically petrol and diesel; it would be beneficial to switch over to integrated renewable resources.

Mathematical Modelling

Nagapattinam district is covered by coastal areas. The maximum temperature is about 32.46C and the minimum temperature is 24.75C. To meet our energy demands we can make use of the available renewable energy sources such as solar and wind. To meet the energy demands with cost minimized, we can combine

photovoltaic panels and wind turbines with specific capacities. Here the two types of energy, say photovoltaic and wind turbine are considered. That is, now assume the variables as follows:

X_{pv}- Photovoltaic panel

L_{pv}- Limit

C_{pv}- Unit cost

X_{wt}- Wind turbine

S_{wt}- Limit

C_{wt}- Unit cost

D- Demand

The problem consists of determining the number of photovoltaic panel as well as number of wind turbines. Therefore the problem can be converted into an optimization program known as integer linear programming problem that requires pure integer solutions for decision variables N_1 and N_2. The general formulation consists of minimizing cost function Z while satisfying the demand D and the unit costs of each renewable unit is C_i and its annual energy production is E_i. This problem can be modelled mathematically as

Min $Z = \Sigma C_i N_i$

Subject to $\Sigma E_i N_i = D$, i=1,2,…..

$N_i >= 0$,

N_i's are integers.

In this analysis the investment for capital cost of the hybrid system may involve the number of PV panels (N_1) and the Number of wind turbine (N_2). Therefore the objective function is Min $Z= C_1N_1+C_2N_2$.

Moreover, we assume an electrical demand D (KWh/year) that has to meet this demand and it is required to use a certain number of PV panels and wind turbines. That is, the constraint $E_{pv}N_1+E_{wt}N_2=D$ has to be satisfied.

Conclusion:

We have studied and presented here in this paper the availability and utilization of renewable energy sources and also the sources of power supply in India. Power consumption of Nagapattinam district has been surveyed and few suggestions have been made. The purpose of this work aims at showing the application of integrated energy sources will be cost benefit as well as fulfil the energy needs without any interruption.

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