Investigation of Renewable Energy Potential in Union Territory of Lakshadweep Islands

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***Abstract*— The Energy Supply of most islands depends mainly on expensive oil derivative importation; the others are linked by usually a week electricity grid connection to the main land. Due to high Energy Costs, the islands are proving to be excellent test beds for the introduction of new technologies, and some islands are trying to become so-called renewable Islands to satisfy their energy demand mainly or entirely from indigenous and renewable sources, thus increasing the security of supply, and employment opportunities, without increasing the cost significantly along with environmental pollution mitigation. A great deal of work has been carried out in this specific aspect of energy supply on different Islands in the world. Unfortunately due to Island specific energy use profile, resources and different kind of environmental conditions, study to One Island can't be applied to other islands. The main source of electricity in Lakshadweep Island is Diesel Generators even though there is an abundance of renewable energy sources such as solar, wind and biomass. In this paper an investigation has been made to find out total available potential of solar, wind and biomass in five islands of union territory of Lakshadweep (UTL).**

Keywords—biomass; wind; solar; pollution mitigation; renewable energy potential; Lakshadweep.

I. INTRODUCTION

The Lakshadweep Island group lies in the Arabian sea and consists of 36 small size islands scattered about 200-400 Km from the western coast of South India between latitude $81^0$15' N and $11^0$45' N and longitude $72^0$00 E and $74^0$00' E, of these 11 Islands are inhabited [1]. Out of these 36 Islands only Kavaratti and Androth Islands have area greater than 4 Km^2 and population greater than 10,000 persons and Kavaratti is the Capital of UTL. Lakshadweep has a tropical climate with summer's temperature ranging from 35^0C to 22^0C and winter temperatures lies between 32^0 to 20^0C. Humidity levels are high through the year and ranges from 70-80%. The Island experience moderately high rainfall of 1000 mm a year with the major share from the southwest monsoons [2]. The Lakshadweep islands are identical in structure and formation and their tops are built up of coral reefs. The soil has been derived from coral limestone. It is essentially coral sandy soil underlined by limestone and gravel of different shapes and size. The land has 85 to 98 percent calcium carbonate, which is totally unfavorable for any type of cultivation[3]. Thus the natural eco-structure of these islands is not conducive to agricultural development. However, it is suited for coconut plantation, which is done here to a great extent. The feudal character of land tenure that existed in the islands earlier was abolished in 1965 and ownership was transferred to the tenants of the land. The majority of land holdings (almost 90%) at present are thus less than 1.0 Ha in size. Limited land and the ownership of these small holdings, which mostly belongs to the local population, is a major constraint for the Administration for utilizing the land for other purposes[4].

Renewable Energy sources (RES) that can be tapped for electricity generation are mainly solar, wind and Biomass energy. Other sources lithe Ocean thermal energy is also available but the technology is yet to mature to levels where it can be applied commercially. Considering the energy demand and size of the Islands, The RES potential and its optimal use for five Islands namely Kavaratti, Kadmat, Kiltan, Androth and Agatti is investigated[5].

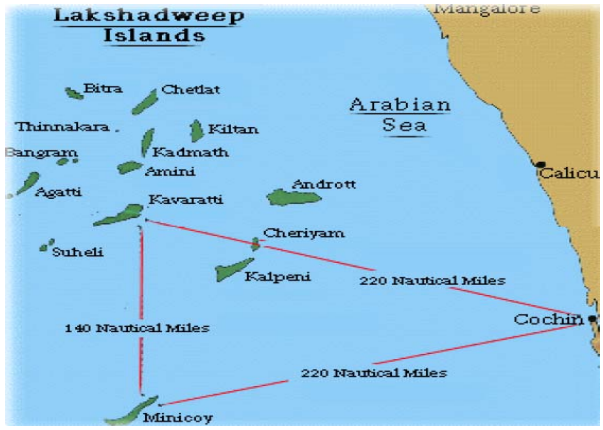

Fig.1. Location of different Islands of UTL

II. RENEWABL ENERGY POTENTIAL IN UTL

A. Solar energy potential

The average solar radiation over the islands is 4.032 KWh/m^2/day [1-2]. It indicates the vast potential offered by this source of energy. The SPV installations in the islands have been setup on land that has been leased from the local population for fix duration of 60 years. About 0.4 Ha of land has been leased and cleared of the coconut trees to setup 100 KWp systems which operate during day time for 5 to 6 hours satisfactorily [6]. In 1970, the installed PV peak watt costs $100, during 80's it fell to $10; at present the price is around $4 per installed peak watt. With massive production of PV modules, progress in research and development and inclusion of governmental financial support, future price drops are

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expected which will encourage the use of renewable energy resources [7-9].

Fig.2. 100 kW SPV Installation at Kavaratti Island

The main limitation of solar based RET in the Islands is the large land area required for setting up solar panels, and this problem is further aggravated by dense tree cover in the islands that shades the grounds over most parts of the islands. The rooftops of buildings are also shaded as the tree cover, mainly coconut trees, expends to a height of 10-15 meters. This necessitates clearing of trees around the installation to enable solar radiation to strike the panels, as shadowing of any part of PV array even for small period of time significantly affects the DG load resulting in overloading of DG set[13-14]. Considering the population growth and above constraint, not more the 2.0 Ha of land in Kavaratti Island will be available for further installation. Annual Solar PV energy potential for Kavaratti Island is estimated as 1211.06 MWh. Using the monthly solar radiation levels and taking into account the efficiencies of current system monthly solar energy generation potential for six islands are shown in table1.

Table 1: Solar Photo Voltaic energy potential in kWh for five islands of UTL

Islands/ Months	Kavaratti	Kiltan	Kadmat	Agatti	Androth
J	104898.4	40517.6	77555.2	96446.9	120310
F	117951.9	45559.6	87206.1	108448.7	135281.3
M	128284.2	49550.5	94845.2	117948.5	147131.6
A	123639.8	47756.6	91411.4	113678.3	141804.9
M	101927.6	39387.5	75392.1	93756.8	116954.4
J	80326.1	31026.4	59387.9	73854.2	92127.4
J	77318.3	29864.7	57164.3	71088.8	88677.9
A	87323.3	33729.1	64561.3	80287.8	100152.8
S	101195.2	39087.2	74817.3	93042.1	116062.7
O	95793.7	37000.9	70823.8	88075.6	109867.7
N	96714.4	37356.5	71504.5	88922.3	110923.6
D	95589.1	36921.9	70672.5	87887.6	109633.1
Total	11211007	467758.6	895341.6	1113437.6	1388927.4

B. Wind energy potential

Among renewable energy sources, wind energy has a good potential apart from solar PV system that can be tapped for electricity generation in Lakshadweep Islands. Wind speed and solar radiation for the island depicts that the solar and wind resources complement each other. The complementary nature of the monthly wind speed and solar radiation suggests that it would be better option to have a mix of solar and wind energy for greater reliability of the System [10].

However due to inadequate shipping and unloading facilities in the island, it is not permitted to unload more than 2 tones of equipment [15]. This limitation on the weight limits the maximum rating of wind generator to 80 KW, therefore necessitating larger number of generators to be installed. The area required for a wind farm would be correspondingly high which a limitation is again. Another important factor is the height of must, which needs to be higher than the height of the coconut trees for it to catch winds of sufficient speed. Operation and maintenance of wind generator was a major problem due to poor accessibility to the Islands for manufacturers and Suppliers to provide spares and servicing. Analyzing the above facts the wind generators is to be selected such that they have Low hub weight, Hub height greater than 20m and Low and Easy maintenance [16].

Moreover, a better utilization of wind power generation would occur if the wind power generator rated speed were close to site mean wind speed.

The spacing between wind turbines is typically 5 -9 rotor diameters apart in the prevailing wind direction and 3 -5 rotor diameters apart in the direction perpendicular to the prevailing winds. The rotor diameters for 60-100kW turbines would be in the range of 15-20m. The coastline length on the western side of Kavaratti is approximately 8 km (the island is linear in shape with its longer axis of about 6m in the north -south direction). It is assumed that only a fourth of this length is available for locating wind turbines and limits the number of turbines (of 20m diameter) to between 20 and 30. Similarly, the numbers of turbines that can be located in the other islands have proportionately been estimated roughly is came out to be 20 to 30[11].

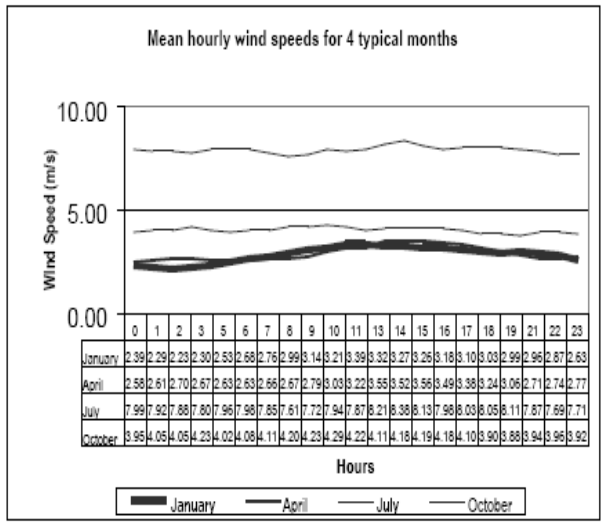

Fig.3. Wind speed characteristics at UTL

Due to a lack of information, it has also been assumed that the wind characteristics are the same in all the islands and the low wind speeds of Minicoy given above have been used for the analysis so as to be conservative in the estimate. Wind potential for five Islands of UTL, taking lower limit of number of turbines and considering the example of a French turbine-Vergent GEV 15/60, which fulfill the above criteria and over comes the limitation, are shown in table 2.

Table 2: Wind energy potential in kWh for five islands of UTL

Islands/ months	Kavaratti	Kiltan	Kadmat	Agatti	Androth
J	42134.8	14747.2	42134.8	31601.1	42134.8
F	35318.9	12361.6	35318.9	26489.2	35318.9
M	23422	8197.7	23422	17566.5	23422
A	34079.7	11927.9	34079.7	25559.7	34079.7
M	58988.8	20646.1	58988.8	44241.6	58988.8
J	281683.8	98589.3	281683.8	211262.8	281683.8
J	276850.7	96897.7	276850.7	207638	276850.7
A	246488.8	86271.7	246488.8	184886.6	246488.8
S	128139.5	44848.8	128139.5	96104.6	128139.5
O	40895.6	14313.5	40895.6	30671.7	40895.6
N	41639.1	14573.7	41639.1	31229.4	41639.1
D	29618.3	10366.4	29618.3	22213.7	29618.3
Total	1239260	433741	1239260	929445	1239260

C. Biomass energy potential

Coconut is the major economic crop of the territory with the annual production reaching 283 million nuts during 2001-11. Copra is produced from the coconuts and the dried husk is used for fiber extraction. There is however, a very large portion of the dried husk, leaves or cadjins, shells and sawmill biomass that is unused and the availability of biomass in the islands is such that its disposal is a major environmental problem. The biomass availability and the basis for proposing the 250kW gasifier at Kavaratti is given bellow[1-2]. Biomass availability & electricity generation proposed at Kavaratti island is given below-

1. No. of coconut trees at Kavaratti 1, 20,000
2. Average yield per tree per annum 40
3. Total coconuts per annum 48, 00,000
4. Total husk per annum (Nos) 48, 00,000
5. Biomass available from husk @ 0.32kg/husk (Tones) 1536
6. Total shells per annum 48, 00,000
7. Biomass available from shells @ 0.075kg/shell (tones) 360
8. Average cadjins per tree per annum 12
9. Total cadjins per annum (Nos.) 14, 40,000
10. Biomass available from cadjins per annum @ 2.0kg/cadjin (tones) 2880
11. Sawmill biomass available (tones) 50

A Total Biomass available (tones) 4776

Biomass requirement for 250kW plant for 6000hrs operation (250 days per year) 6000 x 350 kg = 2,100 tones (43.5% of total availability)

The above figures show a consumption of 350 kg per hour for the 250kW Gasifier, which corresponds to1.4 kg/kW. This is a realistic consumption as the fuel is a mix of loose and dense matter.

Fig.4. Biomass from Coconut Plantation

The kavaratti island of UTL has around 120000 coconut trees. Copra is produced from the coconuts and the dried husk is used for fiber extraction. The island have 4776 tons of estimated biomass consisting of dried husk, leaves, shells and sawmills[12]. However, if these biomass were properly not utilized, its disposal shall be a major environmental problem. The environmental problem of solid waste disposal can be solved to a large extent through gasification. The gas produced from the gasifiers will enable 75% Diesel replacement based on the study of 500KW gasifier installed at chhotanollakhali island Sunderban, West Bengal. At part load, the emission increases significantly in diesel as well as in dual fuel mode also. The biomass has the capacity to run a 250KW gasifier involves @350 Kg per hour. The estimated yearly biomass energy potential of five Islands is shown in the table3.

Table 3: Biomass energy potential in kWh for five islands of UTL

Island	Coconut harvested	Biomass available from Husk (tonnes)	Biomass available from candji (tonnes)	Biomass available from shells (tonnes)	Total biomass available (tonnes)	Approximate annual Electricity generation potential (KWh)
Agatti	2800000	896	1680	210	2786	796000
Androth	4390000	1405	2638	329	4368	1248000
Kadmat	3540000	1133	2124	266	3522	1006000
Kavaratti	3800000	1216	2280	285	3781	1080000
Kiltan	1770000	566	1062	133	1761	503000

III. COMPARATIVE ANALYSIS

Comparative analysis of renewable energy potential at different island from different sources i.e. solar, wind and biomass is shown in fig.5 to fig.9. Fig.5 shows the Renewable energy potential of Kavaratti Island. From these figures it is clearly shown that at all five islands maximum wind energy potential is available in the month of June and July and least wind energy potential is available in the month of December. At all five islands maximum solar energy potential is available in the month of March and April and least solar energy potential is available in the month of June and July. Total biomass energy potential is divided equally for each month.

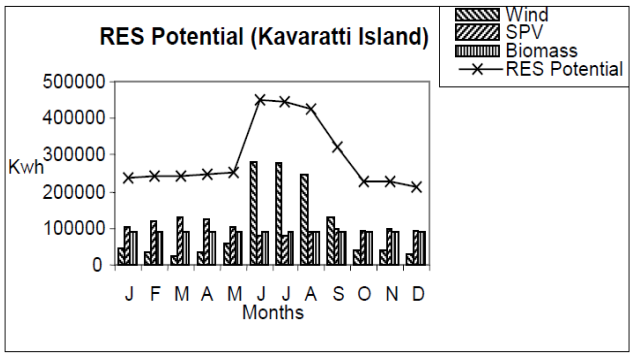

Fig.5. Renewable energy potential of Kavaratti Island

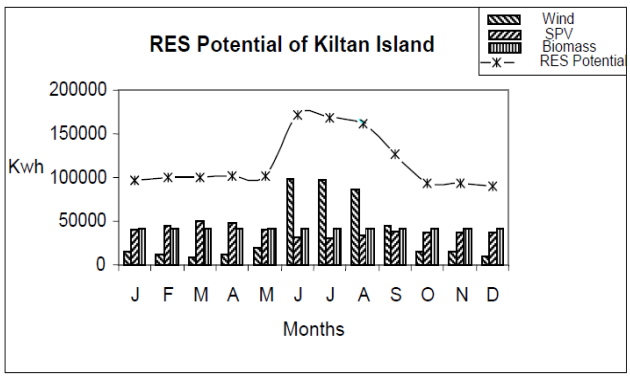

Fig.6. Renewable energy potential of Kitlan Island

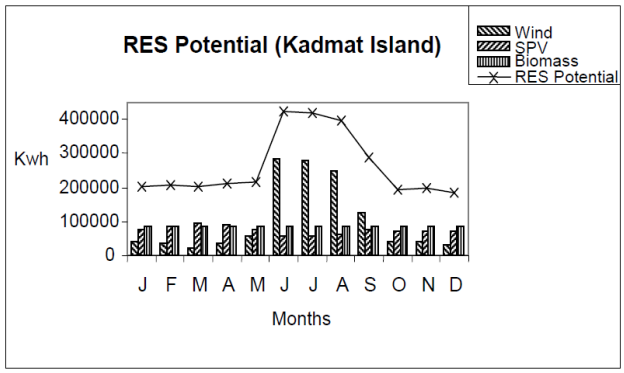

Fig.7. Renewable energy potential of Kadmat Island

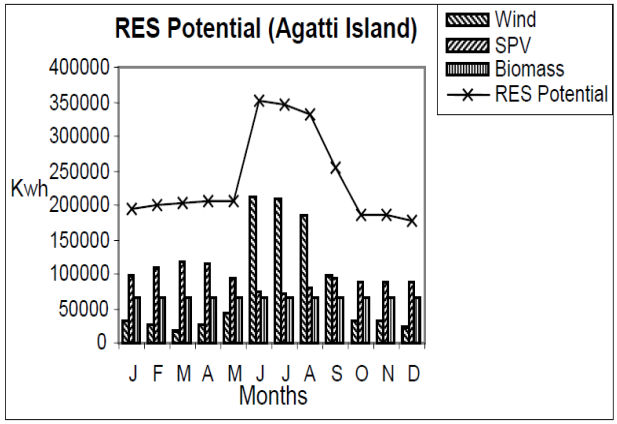

Fig.8. Renewable energy potential of Agatti Island

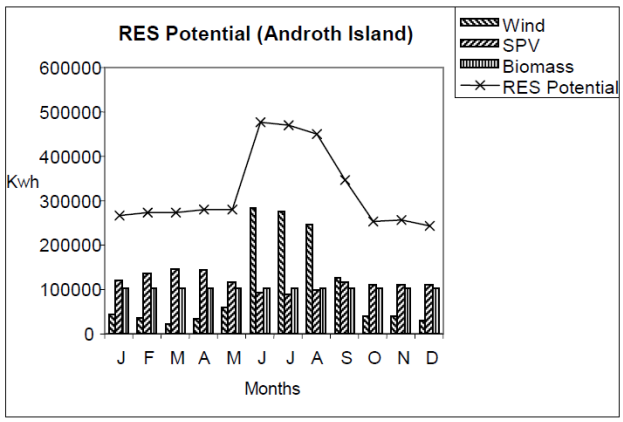

Fig.9. Renewable energy potential of Androth Island

IV. RESULT AND DISCUSSION

Table1 shows solar photo voltaic energy potential in kWh for five islands of UTL i.e. for Kavaratti, Kitlan, kadmath, Agatti and Androth. From Table1 it clear that maximum solar photo voltaic energy potential is available at Kavaratti Island and minimum solar photo voltaic energy potential is available at Kitlan Island. From table1 it is also clear that maximum solar potential is available in the month of March and April and minimum potential is available in the month of June and July.

Table2 shows wind energy potential in kWh for five islands of UTL i.e. for Kavaratti, Kitlan, kadmath, Agatti and Androth. From Table2 it is shown that the maximum wind energy potential is available in Kavaratti, Kadmat and Androth islands and is available in the month of June and July and minimum wind energy potential is available in Kitlan Island and is available in the month of December.

Table3 shows the biomass energy potential in kWh for five islands of UTL i.e. for Kavaratti, Kitlan, kadmath, Agatti and Androth. From Table3 it is clear that maximum biomass energy potential is available in Androth Island and minimum biomass energy potential is available in Kitlan Island.

V. CONCLUSION

From above investigations it is clear that the union territory of Lakshadweep island have vast potential of solar, wind and biomass energy. Till now the energy generation from these renewable energy sources is very less but if we start generating up to or very close to the available renewable energy potential then the use of diesel will be reduced to a great extent which reduces the cost of energy generation.

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