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# REGION WISE FEASIBILITY ANALYSIS OF INSTALLING RENEWABLE AND SUSTAINABLE ENERGY SOURCES FOR OFF-GRID TELECOMMUNICATION TOWERS

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## ABSTRACT

In Sri Lanka, we can see rapid expansions in the telecommunication network due to the growth of the network traffic. Hence the energy consumption and emission of greenhouse gasses from the telecommunication towers are rising up. Especially in off-grid areas, where the power supply for the telecommunication towers are dependent on diesel generators have requirements of power generating systems with renewable energy sources. The purpose of this study is to assess the possible power generating systems for each region of the country among three different options: solar, wind and wind-solar systems in combination with diesel generators. The study shows that the generating high percentages of power demand by the renewable energy sources are convenient than generating less percentages of the power demand. And the suitable energy sources for each region were obtained at the end of this analysis.

**Keywords**: Solar power, Wind power, Renewable energy sources, Photovoltaic modules, Wind turbines.

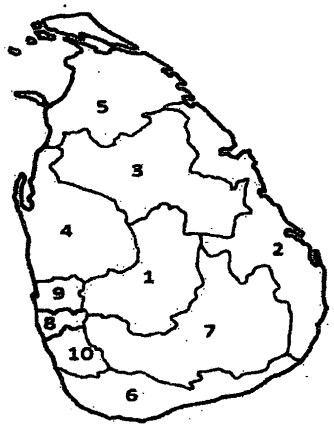
## 1. INTRODUCTION

With the expansion of telecommunication network over the country, they have to cover up rural areas as well as the urban areas. Most of the rural and distant sites are lack of electricity grid connectivity and they are running 24 hours with the use of diesel generators. Moreover with the increment of energy demand, significant bottle neck is occurring due to the rising up of diesel price. In addition, diesel transportation cost for the off-grid sites are somewhat high. Renewable energy sources can be taken as alternative for above mentioned problems.

Energy that is collected from resources which are naturally available is called as renewable energy. Among all other renewable energies, the solar and wind power can be considered as the dominant renewable energy sources due to the gradual reduction in price of solar modules, wind turbines, hybrid power systems and cost of system installations.[1]

But the feasibility of renewable energy sources is different over the different geographical locations.[2] A region wise feasibility analysis for installing renewable energy sources was not done so far according to the literature. Thus this type of analysis is worth-while not only for telecommunication industry but also for other industries as well.

## 2. EXPERIMENTAL




**1 - Central**
**2 - Eastern**
**3 - North Central**
**4 - North Western**
**5 – Northern**
**6 – Southern**
**7 – Uwa**
**8 – Western Central**
**9 – Western North**
**10 – Western South**

Figure 1: Ten regions considered for the analysis.

The analysis has been conducted for the off-grid sites which are running full time by the diesel generators. For that the accounted options are: Installing solar system, wind system or wind-solar system with combining the diesel generator system available. The total analysis has been conducted based on the ten regions which depicts in the Figure 1.

2.1 Determining the amount of energy to be produced by renewable energy source

At first, the average power demand of off-grid site which is full time running by the diesel generator was identified. Then the average cost per month was calculated for an off-grid site that full time running with diesel generator. The energy demand to be full filled with the renewable energy sources was determined for the cost saving of 50%, 75% and 100%.

2.2 Analysis for the installations

Number of solar modules or/and wind turbines required were calculated for each and every region according to the energy demands (50%, 75% and 100%) for the three options

considering (solar only, wind only, wind-solar). Payback period was calculated. The most suitable regions for installing solar only, wind only and wind-solar systems were obtained with considering each and every demand that was considering. Analysis was conducted for the installation of 250 W solar cell, 1kW and 2kW wind turbines. Temperature is a factor which effects for solar installation. So temperature based analysis was conducted for each region by considering the temperature variation with respect to the standard temperature of photovoltaic (PV) systems. Finally the most suitable system for each region was obtained by considering the pay back periods.

## 3. RESULTS AND DISCUSSION

### 3.1 Determining the energy demands

From the data of off-grid sites full time running with diesel generators, the average power demand was identified as 1.56 kW and the average cost per month was determined as Rs. 144, 218.50. The Table 1 shows the power demands which was considered for this analysis.

Table 1: Power demands accounted for the analysis

| Percentage of Saving | 50 % | 75 % | 100 % |
|---|---|---|---|
| Energy Demand (kWh) | 19.15 | 28.73 | 38.31 |

### 3.2 Analysis for PV system installation

The Figure 2 depicts the region wise irradiation variation and per day energy output variation from 250 W PV module. The both graphs obeys same pattern, because the energy output of PV module depends on the solar irradiation. In here worst average irradiation per month was concerned as average irradiation.

The Figure 3 shows the region wise variation of number of panel demand while Figure 4 depicts the payback period variation. Payback periods depend on the number of PV modules. Hence Figure 3 and Figure 4 show the same patterns.

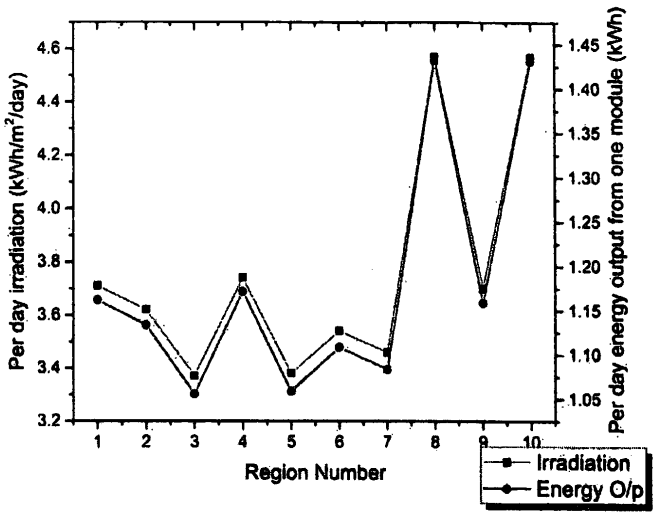



Figure 2: Region wise variation of per day irradiation and per day energy output.

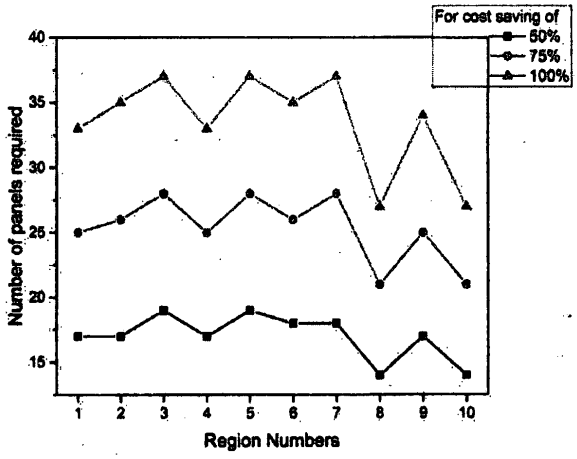



Figure 3: Region wise variation of number of solar panels requirement

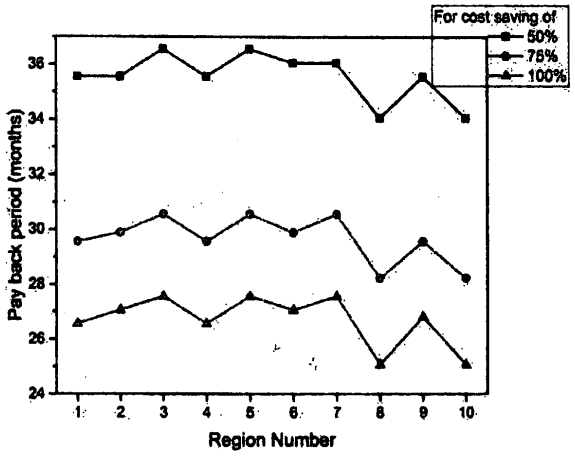



Figure 4: Region wise variation of payback period

According to the graphical analysis Western Central and Western North are the most suitable regions for installing PV systems due to the less payback period.

The Table 2 shows the region wise average temperature variation form the standard temperature of the PV module ( 25 $^0$C).

The temperature variance was calculated by the equation below,

$$Temperature\ Variance = (Average\ temperature - Standard\ temperature) \quad (1)$$

PV system installation is suitable for Central, North Western and Western North regions according to the temperature variation.

Table 2: Region wise temperature variation with respect to standard condition.

| Region | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Temperature variance | 2.4 | 3.5 | 3.0 | 2.4 | 3.0 | 2.9 | 2.8 | 3.0 | 2.4 | 3.0 |

3.3 Analysis for wind power system installation

Wind speed and air density are the factors that affects the output of wind turbine[1]. Air density has been calculated by using the equation below,

$$Air\ density = \frac{Air\ Pressure}{Specific\ Gas\ constant \times Air\ temperature\ in\ K} \quad (2)$$

where, gas constant = 287 J/kgK. Figure 5 shows the region wise variation of wind speed and per day energy output variation of wind turbine. From the calculations 1.15 kg/m$^3$ to 1.16 kg/m$^3$ was obtained as the air density all over the island. Hence the air density is averagely same for all over the island. Hence wind speed is the most effecting factor for the output of wind turbine the wind speed distribution and per day energy output obeys the same pattern.

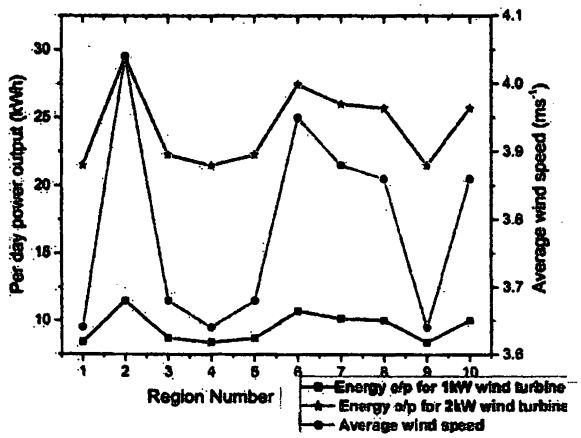



Figure 5: Region wise variation of wind speed and per day energy output of wind turbine

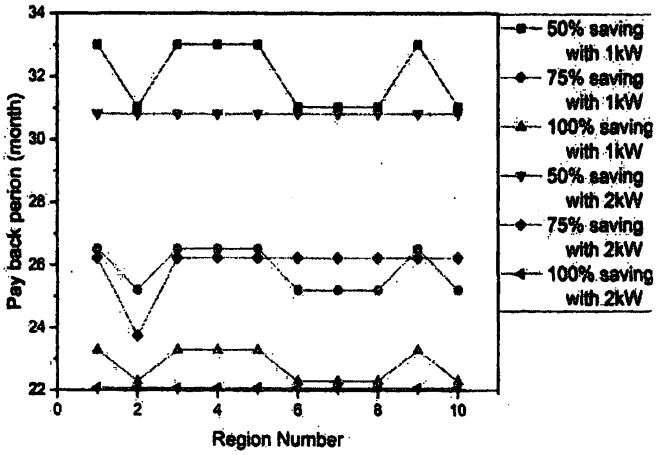



Figure 6: Region wise variation of payback periods

The Figure 6 shows the payback period variation for wind turbine installations. As the Eastern, Southern, Uwa and Western Central region have wind speed they have achieved the less payback period. Hence wind system installation is suitable for these regions.

The installation of 2 kW wind turbine have less payback period than the installation of 1kW wind turbine. Also wind installation for high demand is worthwhile than less demand.

3.4 Finding the most suitable system for the regions with the energy demand.

This analysis was conducted with considering the 250 W PV modules and 1kW wind turbines. The Table 3 shows the most suitable system for the each region with the demand.

Table 3: Analysis result of most suitable system for each region

| Region | Most Suitable system | | |
|---|---|---|---|
| | For 50% saving | For 75% saving | For 100% saving |
| Central | Wind-Soalr | Wind Only | Wind Only |
| Eastern | Wind Only | Wind Only | Wind Only |
| North Central | Wind-Soalr | Wind Only | Wind Only |
| North western | Wind-Soalr | Wind Only | Wind Only |
| Northern | Wind-Soalr | Wind Only | Wind Only |
| Southern | Wind Only | Wind Only | Wind Only |
| Uwa | Wind Only | Wind Only | Wind Only |
| Western Central | Wind Only | Wind Only | Wind Only |
| Western North | Wind-Soalr | Wind Only | Wind Only |
| Western South | Wind Only | Wind Only | Wind Only |

Wind is the most suitable power source. This is occurs due to the solar irradiation is available only 5 h per day while wind energy is available all over the day. But there are several other important factors to be considered while installing wind turbines such as analysis of terrain profile and geographical factors etc.

## 4. CONCLUSION

Installing renewable energy sources for saving high percentage of the energy demand is worthwhile. The PV system installation is cost effective for the Western Central and Western South regions and but Central, North Western and Western North region's temperature is appropriate for the PV installations. The Wind systems are suitable for the regions such as Eastern, Southern, Uwa and Western Central. According to the analysis wind systems are the most feasible to install among the country for the selected areas.

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