ABSTRACT

Energy is the primary and most universal measure of all kinds of work by human beings & and the nature and the per capita energy consumption is considered as an important parameter to judge the standard of living, social and economic conditions, cultural values and degree of industrialization of a given area. The problem of energy shortages is aggravated by the fact that the available fossil fuels are limited and exhaustible and there is a strong need to initiate the search for non-conventional/renewable energy sources, which are not only the abundantly available but are also eco-friendly. In India, more than 80% population live in rural areas and meet their energy needs from traditional fuels. Large numbers of villages in the country are un-electrified due to inaccessibility of the grid supply. The basic impact of this scenario can be seen in rural areas facing the shortage of fossil fuel as well electricity due to their remoteness.

Since renewable energy can be produced in a decentralized manner, it can alleviate the problems of energy distribution associated with conventional sources of energy, especially, in remote rural areas. The significance of renewable energy can be judged from the fact that as many as 93,347 villages in India are un-electrified and 25,000 of these are considered economically non-viable for grid power. Moreover, the un-electrified villages, which had already lost their faith in conventional grid power, could find a ray of hope through non-conventional grid quality power. Since India has been implementing one of the largest renewable energy programmes in the world, it is therefore proposed to electrify all the 25,000 remote villages and hamlets through renewable energy options like solar photovoltaic (SPV), small hydro, biomass, wind and hybrid systems by year 2012.

Keeping this in view, the present study was proposed to optimally energise 12-unelectrified villages of *Jaunpur block* in the district of *Tehri Garhwal*, in the newly created state *of Uttaranchal (India)* through renewable energy. The 12-unelectrified villages of Zone 4 of Jaunpur block were finally chosen for the study. The study assessed the resource potential, demand estimation, sizing of the system and evaluation of unit cost of energy. The study area was surveyed for the collection of primary data and four renewable energy sources viz Micro Hydro Power (MHP), Biomass Energy (BES), Solar Photovoltaic Energy (SPV) and Wind Energy Sources (WECS) were identified for meeting the load for domestic (lighting, cooking, TV & Fan), agriculture (crop threshing) & small-scale industries (Flour mills, Rice huller) and cooking & heating energy needs. The MHP resources constitute the maximum potential followed by biomass, SPV and wind. The potential assessment of the resources (MHP, biomass, SPV and wind) has been done using the standard methods. The integrated renewable energy (IRES) models were formulated for the major end uses. The cooking model, being the single resources based system, could not be constructed.

A term "Effective Power Delivery Factor (EPDF)" known as optimizing power factor was used to account for the reduction in the total energy delivered by the MHP/SPV/WECS/BES, in order to improve life-cycle costs of the system, save power, save costs and reduce losses. The maximum value of EPDF is equal to 1. Based upon the resources assessed for the fulfillment of the demand, two types of models have been formulated, viz domestic and agriculture-industry. Linear Programming (LP) using LINDO software has been used for the optimization of IRES models.

On the basis of data collection, the potential of micro hydro power and biomass for electricity generation has been estimated as 236005 kWh/yr and 203525 kWh/yr respectively. A wind energy conversion system of 3 m rotor diameter of three-blade propeller type wind turbine having power coefficient as 0.45 has been considered to determine the unit cost of energy. About 300 W of power has been calculated to be available from one WECS for an average wind speed of 5.5 m/s. Ten number of such systems were considered for the study area with a total energy potential of 3600 kWh/yr. Similarly, a system of 1.0 kW SPV has also been sized to evaluate unit cost of SPV considering the solar insolation of the area.

It is worth mentioning that MHP and BES have the fixed potential, while the potential of WES is limited due to the poor wind regimes in the area. The potential of SPV is not limited due to its abundance availability. For the purpose of modelling, the MHP and BES resources were varied, while BES resources was kept fixed with respect to EPDF and any deficit in energy demand was shared by SPV. The demand of energy has been estimated as 385375 kWh/yr for domestic purposes (lighting, TV and fan), 412086 kWh/yr for agriculture and industry and 371673 kWh/yr for cooking and heating. The capacities/sizes of various renewable energy systems have been evaluated as 59 kW for MHP, 45 kW for BES, 3 kW for WECS, 1 kW for SPV and 155 kW for biogas. The unit cost of energy generation from each resource was found as Rs. 2.53/kWh for MHP, Rs. 3.68/kWh for BES, Rs. 7.18/ kWh for WECS, Rs. 20.50/ kWh for SPV and Rs.3.15/kWh for biogas. It is observed that the unit cost of energy from MHP and biogas are comparatively similar, while it is highest from SPV resource.

Based upon the above data, the two models i.e. Domestic and Agriculture-industry were formulated using demand and supply constraints. The MHP and BES resources were varied independently from EPDF from 1 to 0 keeping WECS as constant and taking the share of SPV for any deficit in demand of electricity. The results indicated that the unit cost of energy has been computed in the range of Rs. 3.62 to Rs. 18.53 /kWh in the case of MHP while the SPV was shared to the extent 30-90% to meet the deficit demand. Further, the cost of energy at EPDF value less than 0.25, becomes economically un-viable, and in case of BES, the unit cost vary in the viable range from 8.62 to Rs. 10.48/kWh and the energy deficit was shared by SPV from 33-44% with decrease in EPDF. The unit cost of energy in the above cases, has been found economically viable in comparison to independent Diesel generation. Further in one type of case, the two resource (MHP and BES) were varied simultaneously in two different mode i.e. decrease of MHP and increase of BES, while in another case, both the resources were decreased with decrease in EPDF. The results indicated that the unit cost of energy of Rs. 14.50/kWh at an EPDF of 0.5 has been found viable. The share of SPV has been from 33-99% as per the energy deficit. In another type of the case, the unit cost of energy of Rs. 16.00/kWh could be economically viable at an EPDF of 0.25 in case of MHP and EPDF of 0.75 in case of BES. The percentage contribution of SPV increased from 44-88%.

The biogas obtained from cattle dung has been considered to meet the cooking and heating energy demands, which is more than the biogas resources. The deficit of biogas has been proposed to be met from part of the biomass wastes available in the study area.

It is concluded that MHP and BES, being the major source, should be preferentially used for meeting the electricity needs of the area. Any deficit can be obtained from SPV resources, which is abundantly available. Though, its unit cost of energy is highest but it can be considered viable in the light of government incentives in the form of subsidies and tax & interest free loans.

Finally, it is recommended that the IRES models can be used to reliability meet the energy demands of the area in appropriate manner. The energization would definitely improve the living standard of the people of the area and check the deforestation presently occurring at a faster rate for want of fuelwood.