ABSTRACT

The economic progress of any country is reflected as an increase in its energy consumption within the population. Conversely, if economic progress is desired, then an increase in the per capita energy consumption is an inevitable consequence, which needs to be given due consideration by Planning Bodies. Developing nations like India are largely rural in composition. Much of the country's economic growth is thus dependent on the suitable growth and development of its rural segment vis-a -vis the urban segment. The oil crisis beginning in the 70's has necessitated the general policy that oil and petroleum imports be judiciously utilized for achieving productivity that is conducive to national growth and development. Much of the productivity related to the gross national product occurs in industrialized areas of urban sectors. By contrast, there is a low level of productivity in the rural sector due to the poor and often unstable agricultural practices currently adopted. It is therefore evident that the major supply of available commercial fuels imported at the cost of precious foreign exchange are more likely to be diverted to the urban than the rural sector, since better levels of productivity are assured in such areas. In view of this, the rural sector is unlikely to receive the required amount of commercial energy for its development. It must thus make up for this energy deficiency by augmenting its available energy reserves with alternative resources that are available locally on a renewable basis.

India is predominantly rural in composition, it is therefore clear that the overall development of the country will be benefited by improving the level of economic growth in its rural sector. The concept of integrating various energy resources for meeting the total energy requirements of a rural area is popular in developing countries. The commonly available renewable energy resources at the rural area can include: solar

energy, wind energy, biomass energy and energy of flowing/captive water reserves. These resources are supplemented with other conventional/commercial resources in the rural area.

The end use of the required energy demand in the rural areas ranges from basic and subsistence needs of cooking, heating and lighting to productive activities ranging from farm mechanization to rural industries, irrigation etc. For each end use, there could be a range of energy options viz. commercial/non-commercial/renewable, which can be used in a manner depending upon the resource endowment of the micro region, the annual resource availability, the energy needs and their priority for the given population. Since energy utilization scenario would differ from one micro region to another, it becomes necessary for rural planners to conduct independent studies for each micro region instead of generalizing for the whole region encompassing a cluster of micro regions.

Energy planning for different regions in the rural Indian segment is thus a challenging task. In the literature, several researchers have attempted to design and evaluate energy plans for different cluster of regions and thus provide in a piecewise manner a picture of the energy scenario in different pockets of the Indian sub-continent. Despite the numerous studies reported, several rural regions have yet to be explored in regard to their existing energy scenarios. The scope for extensions of the reported work is therefore encouraging.

For the present work, it was proposed to take up energy studies for a village in the district of *Pauri Garhwal*, in the newly created state of *Uttaranchal (India).* There are very few studies reported for this region, and, the present work was therefore directed to fill a part of this need. *Kanvashram*, a rural hilly village in the district was chosen for the purpose. This village has recently been identified by the *Garhwal Mandal Vikas Nigam*, a

planning body for the district, as a promising site for development into a tourist/pilgrimage centre. It is therefore expected that in view of this proposal, the village of *Kanvashram* is likely to experience rapid development in the near future. Hence the village appears to be ideally suited for the purpose of energy studies and planning. Accordingly, the present study attempts to address the objectives of assessment of the energy consumption trends of the rural population, estimation of the level of inequality in energy resource consumption in different segments, development of an integrated energy planning model involving the major energy end use applications, application of the developed energy planning model for subsequent simulated studies and evolving effective policy measures in relation to energy planning for the study area.

These objectives can be realized using appropriate methodology of analysis. The data needed for the study is by and large of a primary nature.

Detailed analysis relating to the energy consumption trends among the rural population was carried out using statistical measures. The energy consumption patterns were analyzed for three categories viz. *Joint households, Nuclear households and All households* in relation to the commonly used energy resources available in the study area.

Linear programming models were developed for the end uses of the area and an integrated model was designed that could be used for subsequent simulation studies. The integrated model was used to examine the impact of certain scenarios in the projected year 2005 A.D., for which the energy planning exercise is being carried out.

The findings of the study reveal that the energy consumption of the *Joint* family household differs from that of the *Nuclear* household in regard to magnitude, inequality levels and pattern of use for different decile groups. This was found to be true for the major energy resources i.e. electricity, kerosene, LPG and fuel wood. The implication of

these findings is that an energy plan based on extrapolation of current trends must make suitable provision while allocating energy resources for future energy demand in the region under planning.

The integrated energy planning model developed for arriving at the most suitable mix of energy resources needed for meeting the demands in the study area shows that the optimal solution cost obtained from the model is reduced in comparison to the cost employing the existing consumption pattern in the study area. The use of the optimization methodology for energy resource planning is therefore to be recommended. The projected energy allocation model for the year 2005 A. D. is accordingly prepared after allowing for changes in demand and supply constraints.

Hypothetical scenarios, introduced as outcome of policy moves, are also examined by the simulated application of the model for the projected year. The findings helped in deciding the effectiveness of the scenario as a policy measure for implementation. The results showed that certain policy moves are effective, some were break even, while others are to be rejected. Based on these and other major findings, recommendations are made for policy measures suitable for the study area and other areas sharing common characteristics.