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A Micro Industry with Closed Energy and Water Cycles for Sustainable Rural Development

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Abstract

Sustainable development requires combining economic viability with energy and environment conservation and ensuring social benefits. It is conceptualized that for designing a micro industry for sustainable rural industrialization, all these aspects should be integrated right up front. The concept includes; (a) utilization of local produce for value addition in a cluster of villages and enhancing income of the target population; (b) use of renewable energy and total utilization of energy generated by co and trigeneration (combining electric power production with heat utilization for heating and cooling); (c) conservation of water and complete recycling of effluents; (d) total utilization of all wastes for achieving closure towards a zero waste system. *Enhanced economic viability and sustainability is achieved by integration of appropriate technologies into the industrial complex*.

To prove the concept, a model Micro Industrial Complex (MIC) has been set up in a semi arid desert region in Rajasthan, India at village Malunga in Jodhpur district. A biomass powered boiler and steam turbine system is used to generate 100-200 KVA of electric power and high energy steam for heating and cooling processes downstream. The unique feature of the equipment is a 100-150 kW back-pressure steam turbine, utilizing 3-4 tph (tonnes per hour) steam, developed by M/s IB Turbo. The biomass boiler raises steam at about 20 barg 3 tph, which is passed through a turbine to yield about 150 kW of electrical power. The steam let out at a back pressure of 1-3 barg has high exergy and this is passed on as thermal energy (about 2 MW), for use in various applications depending on the local produce and resources. The biomass fuel requirement for the boiler is 0.5-0.75 tph depending on its calorific value. In the current model, the electricity produced is used for running an oil expeller to extract castor oil and the

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castor cake is used as fuel in the boiler. The steam is used in a Multi Effect Distillation (MED) unit for drinking water production and in a Vapour Absorption Machine (VAM) for cooling, for banana ripening application. Additional steam is available for extraction of herbs such as mint and processing local vegetables.
In this paper, we discuss the financial and economic viability of the system and show how the energy, water and materials are completely recycled and how the benefits are directed to the weaker sections of the community.

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Keywords: Trigeneration; Micro-industry; Sustainable development

1. Introduction

It is now well recognized that economic growth alone does not lead to sustainable development. Besides techno-economic viability, we must simultaneously address energy, environment, water and social issues which are needed for sustainability. Conservation of human values and the ethical fabric of the society is an additional dimension. Industrialization must be planned within this framework assessing the technological system holistically.

Energy is a key input to mechanization. Ecofriendly and decentralized, renewable energy resources such as biomass and solar are most suitable for rural areas where there is good sunshine and conditions support agriculture. Generally, biomass is available and accessible in the form of residues from agriculture and various agro based industries besides dedicated energy plantations. Enterprises based on these resources may be developed at different scales from household to village clusters as shown in Figure 1.

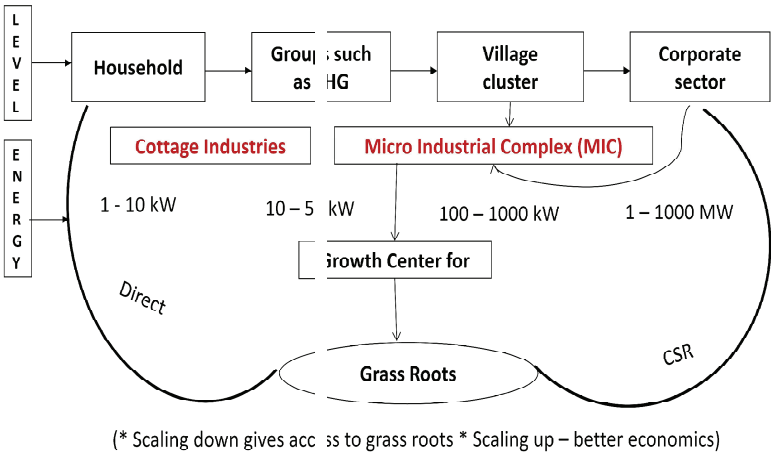

Fig. 1: Sustainable Enterprises at different scales

Both capital investment and energy requirements are scale specific. While, returns for investment would be higher at bigger scales of operation, at smaller scales there is a greater potential for local value addition and fostering employment and equity among the weaker sections. Hence, for achieving sustainability and spread effect, technologies and systems which are economically viable at small and intermediate scales have to be designed, developed and implemented at selected sites. Such scales are also suitable for designing closed energy, water and material cycles for environmental conservation.
Cogeneration and trigeneration help in the operation of closed-energy cycles. In the co and trigeneration mode, primary energy in the fuel is converted into electricity and thermal energy. The latter is used for heating and cooling in trigeneration. Thus, a broad range of energy services are made available at site. The systems can be configured and implemented in many ways, depending on the energy source, product and process requirements and the scale of