Micro Renewable Energy Systems: Synergizing Technology, Economics and Policy

Narayanan Komerath[1] **, Vigneshwar Venkat**[2]**, Monica Halka**[3]
komerath@gatech.edu, Vignesh@gatech.edu, monica.halka@carnegie.gatech.edu

This paper studies the technological, economic and public policy issues and opportunities in developing a renewable energy economy based on 1KW to 3KW devices suitable for retail marketing. The research question is whether such systems can be popularized in the retail marketplace to the extent that families and non-governmental organizations will adopt them on a scale that substantially augments global renewable power generation.

If micro renewable energy devices become popular enough for people to buy, the effect on energy independence can be dramatic. Developing efficient, cost-effective renewable power generators at the level appropriate for a single family, is a challenge at the leading edge of technology. Examples of such devices are as diverse as the Mars rovers that use solar power for locomotion and communication, and the new Honda Home Energy Station hydrogen generator associated with the FCX hydrogen fuel cell car concept. Much more down-to-earth are concepts for small wind turbines, solar photovoltaic and thermal generators, biogas methane converters, thermocouple power generators, and clean-burning stoves integrated with LED lighting for mothers in slum dwellings to be able to supervise their kids' homework while staying healthy. In this paper we discuss five innovative concepts for micro renewable energy systems, along with the community features and public policy interplays involved in taking these to market success.

The first concept is a vertical axis micro wind turbine (Komerath 2006), built out of commonly-available materials adaptable to local labor and employment. The second is a solar thermal generator sized for a footprint compatible with roof terraces in the developing world – or an American urban high-rise balcony. The third is a hybrid wind-solar device that improves the usage factor of the electrical generator. The fourth is "EduKitchen", a device that improves the efficiency of a slum-dwelling kitchen woodstove, generates power to drive fresh air in and exhaust pollutants out of the kitchen, and LED lights to enable the kitchen to serve as a good educational environment for children. The fifth is a unique synergetic system that enables growth of food and biodiesel on a scale compatible with the space constraints of American apartment dwellers or of villagers in the developing world. The first four are under development in the Micro Renewable Energy Laboratory of the School of Aerospace Engineering (Komerath, 2009). The fifth has been developed into a testbed in collaboration with the Honors Program of Georgia Tech, and is discussed here to illustrate the interplay of economics, technology and policy issues.

The symbiotic solar algae farm will produce electricity, biodiesel and food in an extremely efficient method, utilizing the different components on the farm as inputs in some capacity. The farm will have 3 components –

- Solar Panels – to produce electricity and provide shade

[1] Professor, Aerospace Engineering. Director, Micro Renewable Energy Laboratory, GIT.
[2] Undergraduate Student, Aerospace Engineering, GIT
[3] Director, Honors Program, Georgia Tech

- Mushrooms – grown for food and to provide carbon dioxide
- Algae – grown to produce biodiesel by utilizing the carbon dioxide

In this synergistic system, the solar panels provide shade for the mushrooms to grow, and the mushrooms in turn produce carbon dioxide as they grow. This carbon dioxide is supplied to the algae, being required for algae growth. The algae are extracted from the water in which they grow, and oil is extracted, which is then converted to biodiesel. Since this system can be set up easily in even the most rural of areas, a host of jobs and increases in standard of living can be expected. Substituting the fuel producing algae with spirulina (an edible and extremely nutrient rich algae), could be influential in boosting local health standards while the electricity, fuel and mushrooms would improve the quality of life.

Biodiesel is a logical replacement for fossil petroleum since most of the transport infrastructure can remain almost completely unchanged. Pure biodiesel (B100) works in most present vehicles with a slight modification and a biodiesel blend (B20) can be used in all vehicles without that modification. Biodiesel is already making a large impact: Indian Railways, probably the world's largest railway system, has been cultivating the jatropha plant on its right-of-way, and using biodiesel extracted from it to power locomotives.

Our interest is in adapting the biodiesel-mushroom synergistic system to a micro-scale distributed cultivation template, for adoption in the developing world, as well as in the American urban environment. Both applications offer opportunities for policy initiatives to boost their adoption. The primary public policy initiatives required to make this a success deal with reducing the price of biodiesel and solar panels through subsidies. The costs in this system are primarily one-time capital costs associated with setting up the farm. While the cost of biodiesel will become cheaper that diesel in the long run, an initial subsidy or government investment will be required to offset the initial costs. The subsidy required by our system will be much lower than any other models out in the market since we would be producing our own CO2 and have a source of electricity for all farm based purposes. Public policy to boost such synergistic food-energy-biodiesel generation on a distributed microscale, includes support for facilities that house homeless or physically challenged individuals, to adopt such practices.

A yield of 4000-5000 gallons of oil per acre per year would be feasible. At those yields, it would take 12 million acres to produce enough biodiesel to replace all the diesel fuel consumed in the US in a year. To put this in context, this is about half the acreage used to grow enough corn to supply 10 billion gallons of ethanol in the US this year. However, this acreage can be carved out of urban rooftops, balconies, and backyards to a great extent, once the system is successfully adapted to the needs and resources of apartment dwellers and rural families.

References:
1. Komerath, N.M.,, and Komerath, P.P "Are Distributed Energy Systems Optimal In India? Proceedings of the WAVES Conference, Houston, TX, July 2006
2. Komerath, N., "A Campus-Wide Course on Micro Renewable Energy Systems". Proceedings of the ASEE National Conference, College Park, TX June 2009.