Production of biomass power, potable water, and value-added agricultural products through Surya Integrated Agro-processing System

Rajan Patel
CEO, Surya Ventures Corp

Background

Power production has always been a crucial input to sustained growth for all economies worldwide. The inexorable price rise of energy has put a severe strain on country resources. The limited reserves of fossil fuels and the recent increased demand from fast growing developing economies have squeezed sources of energy supply, which is reflected in the accelerated growth of energy prices. In addition, the global warming phenomenon is widely linked to the combustion of fossil fuels.

Renewable energy is seen as extending the energy supply base. Because by definition it does not contribute significantly to greenhouse gases and is carbon neutral, it is viewed with increasing favor as a preferred path for future sustainable energy supply. Biomass, biofuels (ethanol, biodiesel), solar, geothermal and wind are the main categories of renewable energy. A central challenge is how to make renewable energy pathways cost competitive with fossil fuels, on a scale comparable to the fossil fuel system.

Broadening the perspective to development in general, water is the other crucial infrastructural input. Water is a key input for human health and hygiene, as well as for industrial processes and production. Focusing on human needs, the universal availability of potable water supply is a highly desirable outcome.

Given that a large percentage of people in developing economies live in rural areas, these places need energy and potable water supply at affordable prices. Also given these very same areas largely account for the lowest income group in their countries, with relatively small clusters of population, it has been an immense challenge to provide the low cost energy and water infrastructure. These same areas are also often characterized by high unemployment, and low health standards.

Application of biomass energy within an integrated agro-processing system

Surya Ventures Corp[1], a private commercial enterprise based in Pickering, Ontario (Canada), has developed a simple but revolutionary system that provides an integrated solution to many of the problems outlined above in a cost effective manner.

The system (patents applied for) is specifically developed for rural areas in the developing world where resources are minimal, but there is a dire need for energy and water infrastructure, as well as economic agro-processing that allows rural based entrepreneurs to improve incomes through value added processing of their agricultural products.

System description

Simply described, the industrial plant is made up of 3 subsystems or modules: an agricultural processing unit, a power plant, and a water plant. The working model or prototype that is built and running at Surya Ventures' premises in Pickering, is built around the processing of peanuts, and a description follows.

The processing plant starts with raw unshelled peanuts and produces as its end products semi-refined peanut oil, and press cake, a high protein by-product. The peanut hulls produced when shelling the peanuts are separated and sent to the power module, where they are burnt in the furnace of a high pressure boiler to raise steam. The steam then goes to a reciprocating steam engine, which produces mechanical power. This engine drives a generator, which produces electrical power. This power is then fed back to the plant to provide all its energy needs, allowing the system to run 24 hours a day, six days a week. Seventh day is left free for mandatory maintenance.

After the steam exhausts the engine, it is condensed (turned into water) before being recycled to the boiler for reuse. The water requirements for the boiler are therefore kept to a minimum. Heat is recovered from the steam when it is condensed into water, and that heat is captured partly through a separate "cooling water " stream, and partly though an "air cooled " stream. The hot water is used to boil water in a water treatment plant, and the hot air is used for peanut drying or other hot air applications.. The water treatment plant consists of a pretreatment section, which prepares the water before boiling. Boiling is the disinfection step, and replaces chlorination which is normally used as the disinfection step. The water may be cooled and packaged for distribution as appropriate to the particular plant.

Benefits

The list of benefits is long and far reaching:

- Because the fuel is produced from the agricultural product being processed, the fuel is paid for in the raw material purchase price, making it effectively a low cost fuel.
- Because the plant does not need an outside (grid) supply of electricity, it is extremely flexible as it can be sited anywhere regardless of availability of grid electricity.
- Because the equipment is supplied from one source, it frees the client from having to match different pieces of equipment, and ensure they work together seamlessly and reliably.
- Not using diesel fuel, a widely used fossil fuel, yields its own set of benefits:
- Attain improved profitability of the biomass based energy system every time the price of diesel rises
- Based on net calorific values of fuel, every 3 tons of agricultural biomass residues replaces 1 ton of diesel.
- Displacing diesel fuel reduces the country's foreign exchange currency requirement allocated to importation of diesel.
- Because the potable water production system is integrated into a plant that also does other value added activities, (power production and agro-processing), it provides a lower cost entry point to establish potable water infrastructure in rural remote areas.

- Because the system is specifically designed to fit between the micro level and the industrial scale, it provides rural entrepreneurs (which include farmer groups, as well as individual and corporate investors) an entry point into the world of value added agricultural activities. which they are otherwise shut out of due to excessive capital requirements.
- Because the Surya system is designed in a modular fashion, it is extremely flexible in its configuration. It means, for example, organizations that already have a processing plant, can request an add-on package that provides the power and water modules only.

The system is also extremely scalable. Because the target market considered was for entry point systems for rural entrepreneurs, a specific size of power module was built. Recently, Surya Ventures has made a decision to make 2 more sizes of power modules, that will effectively cater for double and four times the size of the existing working model respectively.

System statistics

The existing working model is built to a size that will process approximately 6.5 ton of unshelled peanuts (groundnuts) a day. Typical outputs would be 1.7 ton of oil and 2 ton of press cake over a 24 hour period.

The average yield of biomass fuel in this system is about 1.6 tons per day, which fires a 17 boiler horsepower fire tube boiler, which operates at a design pressure of 200 psi. The boiler is certified by the Technical Standards & Safety Authority (TSSA) of Ontario , Canada, which has approved the design, construction and operation of the working model. The boiler code is based on the internationally known ASME code for power boilers. Surya Ventures will provide operator training for boiler operation as a mandatory feature of purchase of the systems.

The engine in this system produces about 30 horsepower, of which about 10 horsepower is used to mechanically drive the oil expeller unit, while the rest is converted into about 8 kW electrical , produced at 110 V and/or 220 Volt, single phase output. This is sufficient to power the entire plant, with enough additional power for lighting, and office power as well as for routine maintenance needs. A battery system allows for startup power, and is recharged once the system is running fully.

Applications

The concept is extremely powerful and versatile in scope. The Surya agro-processing system transposes across at least 3 main crops, i.e. paddy rice, timber and cotton. What follows is a more detailed explanation of how the system applies to these crops, as well as to different applications needs that can be met through the judicious design and construction of this system. Note , in all cases, the plant is completely self sufficient for power. In some cases, there is likelihood of surplus power availability, which may be an opportunity to provide local power supply.

Paddy rice

The processing plant cleans, shells and polishes the rice. Rice hulls produced from the shelling of paddy provide the biomass energy for the power module as explained earlier. The boiler is

adapted to meet the technical specifications for the combustion of rice hulls as against peanut shells.

Timber

The processing plant drives the sawmill and produces sawn lumber. The heat captured in the steam condensation process would be used to drive a lumber drying kiln. This would enable rural sawmills to produce high quality kiln dried lumber, which is much higher quality and more valuable than un-dried sawn lumber.

Cotton

The power drives a gin stand to separate lint from seed, together with ancillary operations such as seed cotton cleaning, lint cleaning and delinting. Gin trash would be used to power the boiler in this instance.

Crop drying

Rural areas rely largely on the sun's energy for crop drying. While that is an acceptable convention, there are clear commercial advantages to mechanical crop drying, which makes use of the hot air produced by the system:

Increased crop yields result from harvesting while the crop is not completely dry, and then drying down to 14% moisture content

By harvesting earlier and mechanically drying, one can often capture high market prices that are prevalent at the end of a crop season, and when the new season's crop has not yet entered the market

The quality is better, often resulting in better yields when the crop is processed (e.g. for rice), or in other ways that result in better prices.

Space heating

Where cold weather merits, space heating allows the air to be heated inside buildings

Hot water production for public baths

This interesting application would allow an entrepreneur to allocate some of the hot water production to setting up a public bath system.

Refrigeration

Refrigeration can be achieved using low pressure steam via absorption cooling instead of vapor compression cooling. This method can be used to sustain a small cold room for storage of meats and/or vegetables. It can also be used for ice production.

Community hospitals

This would be considered by the author to be the ultimate achievement, where hospital needs of power, hot water, laundry facilities, medical refrigeration, and sterilization would be met through a biomass powered facility. The biomass would either need to be brought in as an independent source of fuel, or be generated via an integrated agro-processing system, and the system would be run to toll mill for the local community, and the income would finance the power needs of the hospital.

Conclusion

Many of the applications described are familiar to industrial establishments. What is unique about our system is that it is specifically designed from the ground up to facilitate and empower the entry of rural entrepreneurs into the world of value added activities. In the process, it directly addresses many problems that have been largely intractable in their solution, especially when it came to being self sustaining.

With judicious matching of application needs and energy demand, this renewable energy based system meets a wide range of industrial processing needs. Surya Ventures will provide proposals for contracts to supply any of the systems upon request. It is important to note that system design requirements and energy limitations do limit the number of applications that can be matched from one system.

The economics of Surya Ventures' agro-processing system shows a high degree of profitability, which would make it consistently self sustaining. But a system by itself cannot guarantee success, unless other elements of required actions are also implemented. There needs to be in place a global strategy for financing qualified investors, recognizing that this is not simply a commercial venture, but it is also a pathway to creating a truly global rural energy and potable water infrastructure. The critical requirement of this infrastructure to catalyze rural development is well established.

In the absence of an initiative such as investment in Surya's integrated agro-processing system, rural infrastructure will continue to develop at a painstakingly slow pace, the rural poor will have to wait longer for the local installation of conventional infrastructure . Every developing country's policymakers need to ask themselves if they are prepared to wait decades for that goal to be achieved in the conventional way.

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[1] Website: http://www.surya-ventures.com

RAJAN PATEL
The author graduated in electrical engineering (1976) from King's College, University of London, England. He grew up in Malawi, Southern Africa, where his family ran an agro-processing business processing legumes, oilseeds and rice. His first hand business and market experience in developing economies, combined with the engineering training gave him the tools to develop the system under discussion in this paper.