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Co-generation of energy and feed / food in integrated farming systems for socio-economic and environmental benefits

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Introduction

The world population is rising dramatically, particularly in Cambodia where the population is growing at a rate of 2.4 % per year. Eighty-five percent of the population is concentrated in rural areas, based on agriculture for livelihood. The country is rich in natural resources, of which forest serves as one of the most important, supplying wood fuels, timber and other forest products. The country faces a growing need for energy to support the economic growth and social development of the growing population (Sovanndara, 2004).

The US Department of Energy reported that increases in population and energy consumption, accompanied by growing concerns about global change and atmospheric pollution, will create a major opportunity for fibrous biomass to play a greater role in energy production (Skog and Rosen, 1997).

Energy drives the world economy. It is derived from oil, natural gas and other fossil fuels, hydro, wind, wave, solar power and biomass. In Cambodia, the energy use is based on wood 82 %, charcoal 1.2 %, other biomass 1.7 % and imported petroleum products (Sovanndara, 2004). In the Philippines, in 1996, annual biomass consumption for energy generation was estimated at the equivalent of 72 million barrels of fuel, of which about 65% consisted of fuel wood and charcoal used predominantly by households and small businesses for cooking (PRESSEA, 2000).

In 1998, it was predicted that fossil oil supplies were close to their peak and would soon decline (Campbell and Laherrère, 1998). It is now widely accepted that the peak in production will occur within the next 5 years, and that this will cause a crisis of energy consumption and will seriously affect world socio-economic development due to the high price of oil and the dependence on this commodity for all aspects of economic development. Many economists emphasize the need to prepare replacements for fossil fuels for energy consumption (see Preston and Leng 2004)

The other problem related to use of petroleum products is the effects on the environment, especially global warming (the green-house effect), pollution and incidence of natural disasters such as drought and flooding.

Biomass utilization for energy has the potential to be a sustainable system, as growing plants have the capacity and ability to capture power from the sun in order to transform carbon dioxide into biomass by a photosynthesis reaction,

$$CO_2 + 2H_2O \xleftarrow[\text{heat}]{\text{light}} ([CH_2O] + H_2O) + O_2$$

The two alternative ways to use biomass for energy are through conversion to ethanol and to a combustible gas (a mixture containing hydrogen and carbon monoxide). The former is by way of fermentation of sugar while hydrogen can be obtained by gasification. Ethanol production is criticized because it has been estimated that the fossil energy requirement to produce ethanol is higher than the energy that ethanol contains (Paztek, 2004). In any event the real (unsubsidized) price of ethanol is still above $1 per litre at present (Elaine, 2004).

Gasification seems to offer a moré sustainable pathway as a means to extract energy from renewable biomass. Gasification is the way to convert solid fibrous biomass by pyrolysis into producer gas which contains H_2 18-20 %, CO 18-20 %, CH_4 1-2 %, CO_2 12-14 %, and N_2 45-48 % with a calorific value of 4.5-4.8 MJ/m^3 (IISc, 2003).

The gas can be used as fuel for internal combustion engines and gas turbines, as well as a source of heat. Economic studies show that biomass gasification plants can be as economical as conventional coal-fired plants (Badin and Kirschner, 1998). Additional benefits are that the system is "carbon-neutral" (does not add to global warming), produces negligible amounts of sulphur compounds (the cause of "acid" rain), reduces waste disposal and has fewer negative environmental impacts.

The integrated use of biomass (for food/feed and energy) can be the basis of sustainable farming systems which support both socio-economic needs and a healthy environment. As such this approach is considered to be the key priority for successful development, especially in the developing world (Preston and Leng, 2004). An integrated farming system is a system that reuses and recycles, using plants and animals as partners, creating a tailor-made ecosystem, mimicking the way nature works (http://utafoundation.org). This concept is attracting the attention of young scientists encouraging them to think deeply about the benefits of this system with a broad vision, not just for this generation but for the next.

In Cambodia, the price of electricity is almost double compared with neighboring countries ($US 0.15/kw in Cambodia vs 0.10 in Vietnam). In the small towns of the rural areas of Cambodia, the price may be as high as $US 0.50/kw. However, in rural areas of Cambodia, there is a great potential for the development of rural electricity through gasification due to available fibrous materials including crop by-products and fibrous residues and tree branches around households. The development of rural electricity supply will in fact create more jobs and be a means to get access to information including marketing, which in return will create a better livelihood for the rural community.

2. Objective

- Determine yields of biomass from selected farming systems.
- Determine the feasibility of gasification of the fibrous residues from these systems
- Estimate the overall economic efficiency and environmental impact of the selected farming systems