Why Chinese Continue With Biogas Digesters?

by Bob Hamburg

Introduction

In this decade, Chinese government has emphasized rational integration of planned and market economies, administrative and economic controls, centralization as well as decentralization, collective sectors, etc. as a way to improve economy of the country. Communes were officially dropped in 1986 but many villages and production units still maintain communal aspects.

The State Energy Commission was established in 1980. Forests cover 12 % of the land and 80 to 90 % of the rural energy needs are met by biomass fuels. Primary sources of wood appear to be orchards, some small woodlots, trees planted in association with agriculture, and peripheral plantings around villages and roads.

Wood supply is far from sufficient and almost 50 % of the rural biomass energy comes from crop residues.

The second biggest producer of food, China has agricultural land under cultivation for centuries. The continual productivity of land could be attributed to careful husbandry and recycling of all organic matter. In the absence of anaerobic digestion systems, organic residues are still composted in piles or put in exposed pools to ferment before being taken to the fields.

Organic Matter in Soil

To properly appreciate the importance of Chinese biogas program, it is useful to briefly review the benefits of organic matter is soil. While situations may vary, an increase in the level of soil organic material generally includes the following effects:

— Soil color is darkened;

— Water infiltration, holding capacity and content are all increased;

— Drought susceptibility, erosion and resulting sedimentation, and nutrient runoff and leaching that causes pollution of water bodies is decreased;

— Aeration, permeability and pore size are increased and bulk density is decreased;

— Soil structure is improved through encouragement of granulation and aggregation while crusting, plasticity and cohesion are reduced;

—More plant nutrients are held in organic form, in rooting zones. More mineral elements are released by the action of humic acids;

The pH buffering capacity is increased;

— Soil biota increase in both number and variety, thus offering a greater opportunity for biological control of soil-borne pathogens;

— Due largely to increased moisture retention, soil temperatures tend to decrease. This decrease is somewhat mitigated by increased absorption of solar energy through darkened color and increased metabolic activity in the soil.

Why Biogas?

China's large population has always provided the labor force necessary for this recycling system. However, the population increases of the past few decades and associated increase in household energy requirements are taxing the traditional system. For example, the Yellow River's drainage area now experiences the greatest erosion problems in the world.

On the plains, often 70 to 80 % of the crop residues are now used as fuel and soil organic matter content is generally less than 0.8 %. In a three year study, it was observed that the yearly addition of only 750 Kg. of stalks per hectare increased production every year. This could have translated in an increase of 5 Billion Kg. of food production from the region.

Thus it should be clear that two of China's (and many other countries') most pressing needs are the supply of adequate household energy, especially for cooking in rural areas, and the build up and maintenance of organic matter levels in agricultural soils. Crop and animal residues could be recycled if external energy, largely coal, could be brought in. But there are numerous environmental and other costs. Composting of residues allows recycling of organic matter but the energy released by the process, while potentially useful, is not available for cooking purposes.

The residues could be processed thermochemically or burnt directly to produce energy, but essentially nothing would be left for return to the soil. While specific situations may vary, one metric tonne of dry dung contains about 16.7 Gigajoules (GJ) of potential energy. Direct burning at 10 to 20 % efficiency gives 1.67—3.34 GJ of useful energy and some ash for recycling.

Biogasification of the same amount of dung at 55 % efficiency results in a gas containing about 9.2 GJ plus much more organic material and plant nutrients for recycling. A burner giving 50 % efficiency (The widely used Bejing No. 4 model burner gives about 55 % efficiency.) results in about 4.6 GJ of useful energy. Terminal energy utilization efficiency of stalks through biogasification is about 30—40 % while direct burning would again be around 10—20 %!

Very simply, the only way to meet both of the aforementioned needs in a systematic, integrated (allocatively efficient) manner is to make use of the anaerobic decomposition process! Although some application of technology is necessary to utilize the process, digesters are far more biological than they are technological constructs; far more like a cow than like a car. Since humankind is now in the process of establishing a mutually beneficial relationship with digesters in general, the idea of domestication gives an excellent perspective on the situation.

The decomposition of organic materials and their preparation for reuse can follow two, often interwined, biological pathways. Through both pathways, organic materials are largely broken down by bacterial action and large amounts of carbon dioxide are released. The primary differences lie in:

The large oxygen requirements for the aerobic path and the requirement of the obligate anaerobes for no free oxygen;

The nitrogen transformations ending with mostly nitrates via the aerobic path and amonia via the anaerobic path; and

Solar energy, originally stored through photosysthesis, being released as heat through the aerobic path while it is largely contained in the combustible methane molecule formed through the anaerobic pathway.

Evaluation of Chinese Biogas Program

In the mid-seventies, Chinese built digesters at a rate of almost one million a year. In 1978, a total of 5.67 million digesters were reported; some accounts figured almost 7 million, including the ones in the planning stage. National plan at this time called for 20 million systems by 1980 and 70 million by 1985. It was expected that the latter figure would supply about 70 % of rural households!

By the late 1970's, it was becoming generally recognized that adaptation of digestion process to household use was not quite as easy as it first had appeared. Adequate digester functioning required a bit more attention to feed materials and practices than had been first recognized and publicized.

Construction had perhaps become a bit shoddy and many digesters were built so poorly as to never be used. Simple, locally available, traditional materials were proving inadequate for very long-term operation. Gas leakage was not the only problem. Water leaking out of the tank was another, but more important was leakage into the tanks from surrounding water table. The average digester lifetime was turning out to be only 3—4 years and systems were going out of operation nearly as quickly as they were built.

Re-evaluation of the national approach to diffusion of digester systems actually began in the late 1970's and it continued and became more more crystallized in the 1980's. Representatives from the various departments of the State Council

compose the State Leading Group on Biogas Construction. In 1979, the National Office on Biogas was firmly established within the Ministry of Agriculture and Forestry. The provincial, regional, county, and city levels of this ministry generally include a biogas component in their respective Rural Energy and Conservation Units.

Although there was a significant slowdown in construction of small-scale digesters in the late 70's, the sixth Five Year Plan for 1981-85 called for about 3.5 million new digesters nationwide. Also included were preliminary targets for 1990 of 20 million family digesters plus 10,000 larger systems for electrical generation supplying a total of about 5 % of rural household energy. Actual construction during the period fell a bit short of expectations, averaging a mere 500,000 new systems per year.

The leakage problems and other happenings of the big push of the 70's were accepted as a learning experience. Where possible, older digesters have been repaired and upgraded, but many hundreds of thousands have simply been crossed off.

Emphasis has shifted from extremely rapid diffusion using all locally available construction materials to slower, more careful diffusion with quality, concrete construction and systematic, scientific operation. National standards and designs have been established for concrete construction of systems for six to nearly sixty cu. meters. Interestingly, there appears to be decreasing "economies of scale" for these systems.

Well-designed digester construction tools and steel concrete forms and biogas appliances have become commercially available. Hanging gas mantle lamps equivalent to about a thirty watt bulb cost around $5 and the widely distributed Bejing No. 4 cooking burner cost about $6, and are available through out the country. Ultra-violet resistant, long-lasting red mud plastic tubing has become available for gas lines at a cost of less than 2 Yuan (about $0.60) for 30 meters.

With the improved quality, family-scale digestion system costs, now rose to around 200 Yuan (about $55), including labor, which is slightly more than the cost of a bicycle. Although digesters still received some priority in the allocation of materials and loan funds, direct subsidies have been largely phased out. With the economic reforms giving more individual and family freedom in financial matters, the continued spread of digesters has required emphasis to be placed on documentation of the financial benefits that accrue from biogas digestion. Considering only the values of the biogas, the effluents, labor saved, and yield improvements, researchers can still show a pay-back period of less than 2 years.

The cluster development approach has continued but villages must now be convinced rather than coerced. Also, as the peasants have become better off financially, they have also become more interested in convenience. Therefore, it was necessary to address some of the operational difficulties such as the emptying of digesters. Once this problem was addressed by the very large research and engineering community, numerous tools, pumps, and other devices have become available and continued to be refined. Training program for village volunteer biogas technicians has been refined and continues to receive government support. According to one source, there were over 200,000 of these trained extension workers by 1985.

At the same time, perhaps more emphasis has gone toward the development of large-scale systems for more industrial, food processing residue, and sewage applications. For example, the Nanyang Distillery constructed two new 5,000 cu. m. digesters which will supply gas to about 20,000 households in the surrounding city.

Research, development, and investigation is conducted in not only institutions of higher learning, but also provincial academies of science. Major site for development work is the Asian-Pacific Centre for Biogas Research and Training in Chengdu, Sichuan. The *Zhongguozhaoqi* (China Marsh Gas), a quarterly, began publication in 1983.

Conclusions

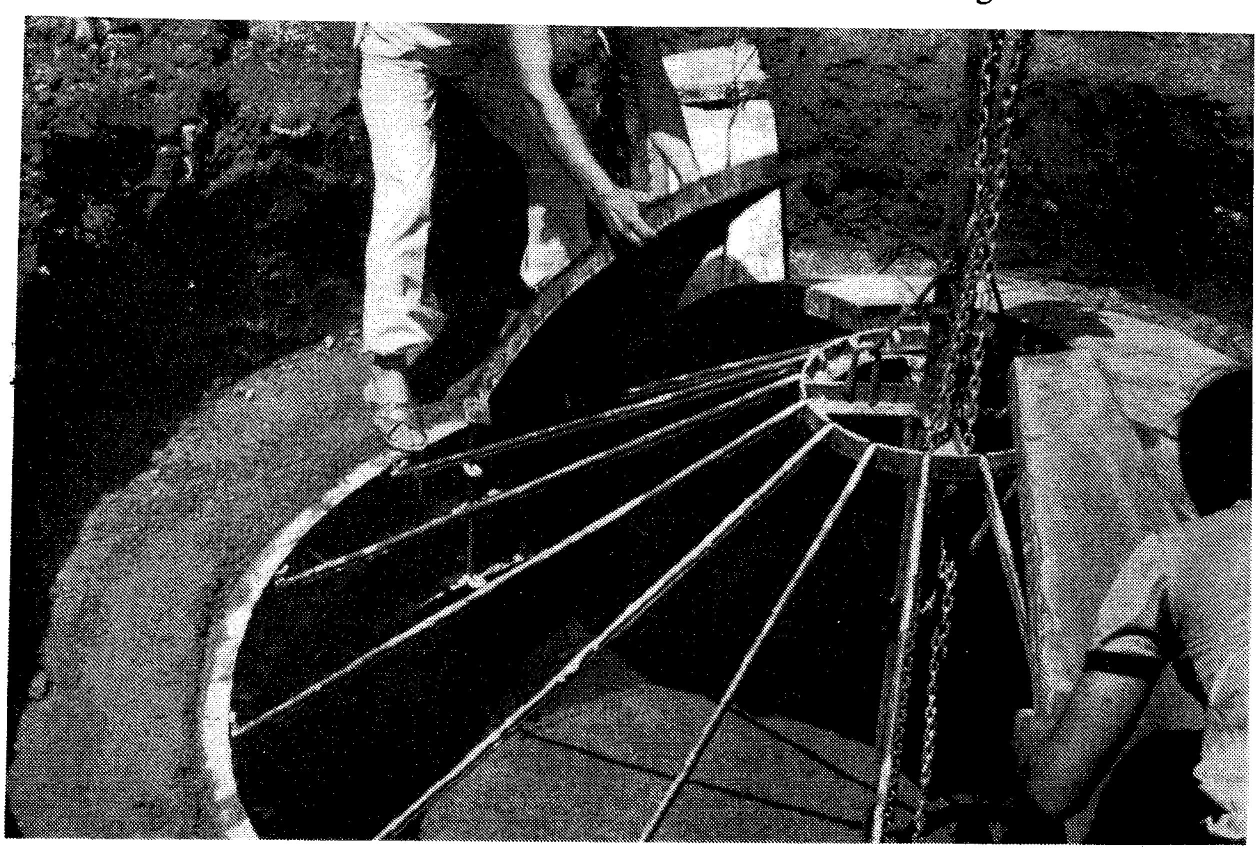
Although the euphoria of the mid-seventies is gone, the Chinese biogas program is on a very well practical, systematic, and scientific track. Biogas has become part of the national energy plan. The 500,000 new digester units per year dwarfs efforts in the rest of the world combined.

Biogas digestion offers a renewable, environmentally benign [in terms of both worldwide carbon dioxide levels and indoor air pollution levels (please see CN 8.1 on Indoor Air Pollution and Biogas discussion by the same author)] source of energy, potentially available to most of the world's population, especially those in the tropics, in a form which can directly fulfill all or a large part of one of their primary energy needs— the high heat requirements required for cooking food.

Biogas further offers a unique avenue for economically beneficial recycling technique for organic wastes.

It also offers greater control of human and livestock enteric diseases and their insect vectors, agricultural pests, and organic and chemical pollutants.

The applications for digestion around the world are fairly infinite and as long as animals must eat and the sun shines, never-ending. While constructing a functional digester does require a certain level of skill, operating a digester is very little harder than raising any type of livestock. Once economics gets the prices right for health and the environment and governments assume their rightful responsibility for maintenance of public welfare, one may expect a very broadly spread domestication effort to begin.



Please see the photo on the front cover.