Biogas Beyond China:

first international training program for developing countries

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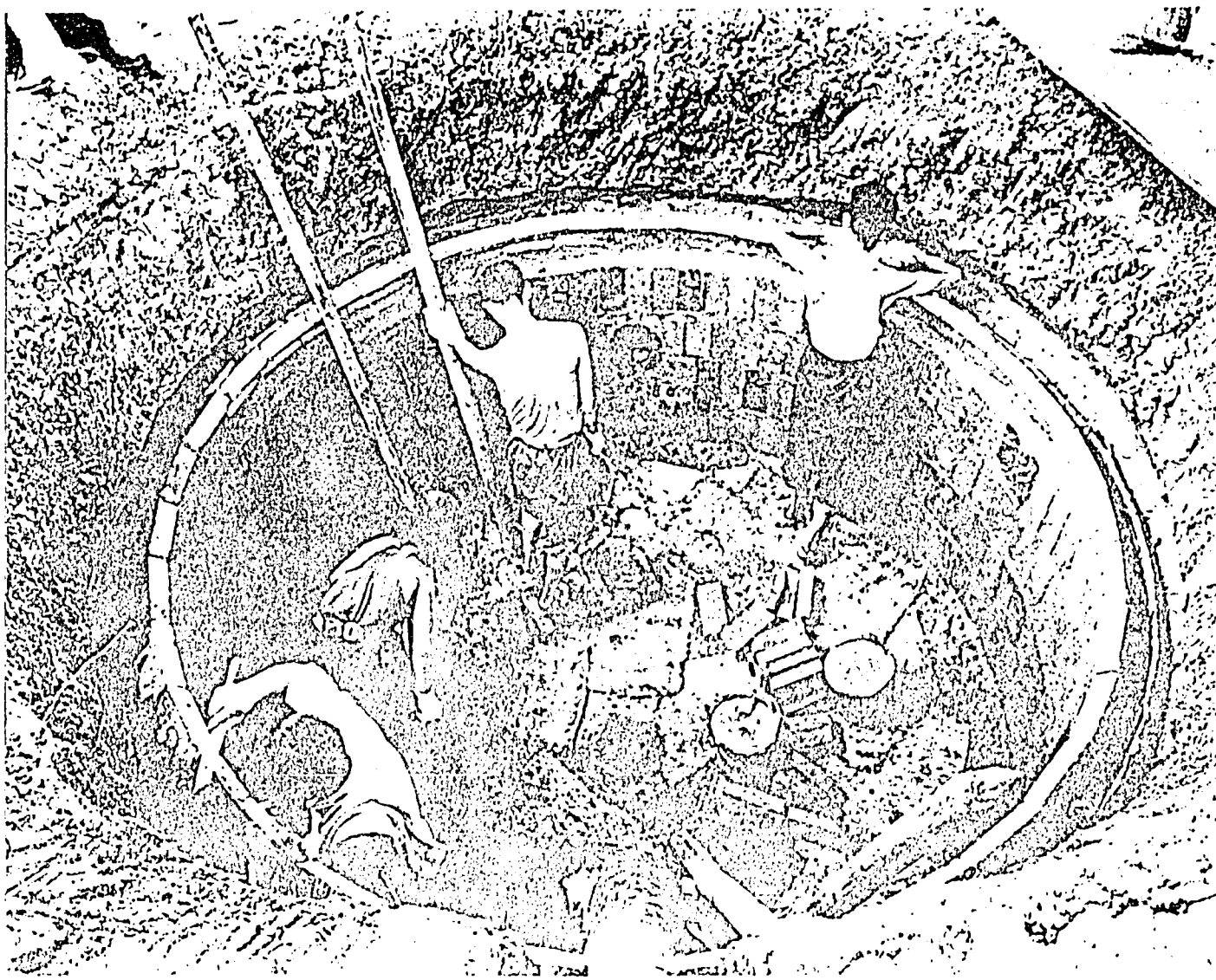
With over 7 million biogas digesters, the People's Republic of China is by far the most advanced country in the world when it comes to biogas production. Still, only 3.8 percent of the country's total population uses biogas technology and the province of Sichuan has launched a national campaign to encourage further development. Recently, Sichuan Province also hosted the first international biogas training program for developing countries in an effort to export its know-how in this increasingly important field of energy production.

Figure 1. A 10 m³ brick digester under construction. The workers are laying the base of the arch for the dome. Photo: UNEP/de Silva.



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even to those who know it well. In some areas of the county, 90 percent of the families have built digesters and are using the gas; and their cycles of agricultural production are planned in conjunction with the technology. Isolated attempts in other parts of the world to build, test, or sell single digesters cannot compare with the 7.2 million digesters built in China since 1970. In all of Latin America, for example, there is but one and that is merely a prototype. Even in India, the only other country that has developed biogas on a significant scale, the total number of digesters is only 1 percent of the Chinese level, for a population not much smaller.

In 1979 a first step was taken to extend Chinese biogas experience to other parts of the Third World. In the Province of Sichuan, where one quarter of the population of 97 million people use biogas, a biogas seminar was held. Eighteen people from developing countries attended the seminar which was sponsored by the United Nations Environment Program (UNEP) and the Environment Protection Office of China's State Council (1).

FIRST INTERNATIONAL BIOGAS TRAINING SEMINAR IN CHINA

Scientists from related research institutes (microbiology, architecture and engineering, agricultural engineering, soils science and parasitology) gave lectures at the seminar. The program also included site visits, opportunities to participate in construction, and exhaustive observation of how biogas is used: in domestic cooking and lighting, small-scale electricity generation, light agricultural processing industries, and even for motive power in recent experiments with small tractors. The seminar participants helped to build the 10 m^3 digester (Figure 1) which was completed in four days and producing gas a few days later. At the end of the training course presentations of biogas research were delivered by representatives from the developing countries which had attended the seminar.

The participants came from all corners of the globe: from India (which has subsidized the construction of 70 000 digesters) to Ethiopia and Cyprus which are just beginning to plan their research and experimentation. A middle position was represented by Egypt, which is already underway with a well-coordinated project to demonstrate the most economic and effective designs in selected villages, and Guatemala, which built the first prototype digester in Latin America as part of a rural development program. Most participants in the seminar were responsible for building their country's first digester. In some cases biogas programs were contingent on the outcome of the seminar.

Many of the participants were awed by the scale of biogas popularization in China and impressed with the simplicity of solutions to problems they had found intractable. But the Chinese say they still have a long way to go. The biogas development concentrated in Sichuan is not shared by the rest of the country. There are five million digesters in that one province compared with only 2 million for the rest of the country's population. If an the people use biogas.

THE EARLY YEARS

Chinese biogas development began in 1958, in the attempt to put to use all available resources for the Great Leap Forward. But at that time, technical support was insufficient for the movement to succeed.

In 1970 experimentation began again, prompted by acute shortages of firewood. Even with the advent of afforestation, a denuded landscape still persists in many areas. Outside the wooded hinterlands of the minority peoples, the main non-commercial cooking fuel traditionally consisted of crop residues, and still does today where neither biogas nor afforestation have taken root. More prosperous areas have access to coal distributed by the State, or to scarce firewood sold in local private markets.

Although their efficiency was not high, biogas digesters did provide fuel, without reducing the supply of organic fertilizer, as well as contributing to rural hygiene. The Communist Party is said to have been attracted by the popular initiative—within a couple of years, guidance and promotion were offered at various levels. Since 1972 biogas conferences have been held in Sichuan, attended by representatives from all over the country.

EXTENSION

Extensive dissemination began around 1974. In that year, material was collected for the first comprehensive and popular biogas manual. Published and nationally distributed in 1976, it has recently become available in English and will soon appear in French (2). While the original manual still provides the most comprehensive introduction, refinements in design, engineering and application were included in the international training course held in August, 1979.

The relevant microbiological, architectural, engineering, agricultural and parasitological research institutes have been mobilized for the deployment of biogas. Since the Great Leap Forward of the 1950s, conditions have changed. Now there is widespread technical competence in the rural areas; from barefoot medical care to the provision and standardization of spare parts and accessories. Coupled to this is an availability of materials and a coordination of services uncommon in the Third World. More and more biogas digesters have been built by peasants and are now being systematically studied and improved at the institutes. The technique has rapidly evolved into a sophisticated system of ecological engineering, linking the development of energy resources, rural health, agricultural production and environmental protection.

THE ONLY RENEWABLE HYDROCARBON FUEL

Biogas is produced by fermenting organic wastes such as animal dung, human excreta, crop residues, and effluent from food processing factories in an airtight digester. Optimal operation requires appropriate temperature, acidity, and sufficient water. The gas, synthesized by microorganisms in the waste, is 50–70 percent methane, and the

Figure 2. At the Biogas Research Station in Sichuan Province, charging of the digester occurs biannually and consists of a mixture of composted straw and dung, and night soil. When filled to within 60 cm from the top, the removable cover is inserted and sealed. Additional dung and night soil are washing in daily through the inlet pipe (covered hole at night). Photo: A van Buren/UNEP.

rest mainly carbon dioxide. It burns cleanly like natural gas and can be used in stoves, lamps, agro-industrial machinery, and for electricity generation.

When a diesel engine is converted to run on a dual fuel mixture, biogas can replace 75–85 percent of its fuel requirement. When biogas is used domestically, a 10 m^3 digester will normally supply enough gas to cook 3 meals and boil 15 liters of water daily for a family of five. While gas consumption and burner efficiency have not been measured, gas production has: the Chinese estimate that 0.15–0.20 m^3 of gas can be produced per m^3 of digester volume per day. In a commune near Shanghai, before they had biogas, 70 percent of the families needed to buy 1500 tons of coal for 3–4 months of the year. In 1978 with the development of biogas, they recorded savings of roughly 1.7 million kg of straw fuel, and 1000 tons of coal and charcoal, the cost of the latter amounting to the price of the materials necessary to build the digester. Therefore the payback period is one year.

ENVIRONMENTAL IMPACT

It is quite inappropriate to talk of the environmental impact of biogas production as though it were something imposed on the environment from the outside. Biogas production is a system by which all organic 'wastes' are fed into the digester (Figure 2), fermented to produce the gas, then returned to the fields as fertilizer. The extraction of gas removes little, if any, of the nitrogen, phosphorous, or other plant nutrients; on the contrary, it improves the quality of the fertilizer by preventing the evaporation of ammonia from the airtight digester. The end result is a closed circle where there are no wastes.

Another benefit of the system, vitally important for disease-ridden areas of the underdeveloped countries, is that prolonged storage of excreta causes the parasite content to settle on the bottom of the digester where they eventually die off. The liquid at the top is thus free of pathogens; and it is taken every week or two and safely sprayed on the growing crops. The sediment, removed only twice a year (at planting season) is stored for an additional 30 days with ammonium hydroxide in order to guarantee complete pathogen destruction, and is finally mixed with the soil prior to planting.

LOCAL BUILDING MATERIALS

The most important contribution the Chinese have made to the technology is that they have succeeded in designing and building airtight digesters without metal, plastic or other industrially advanced materials. They use cement and lime and non-commercial local materials such as clay, sand, pebbles, and cinders, which greatly reduces the cost. Most digesters are currently being made out of prefabricated slabs for which the grade of concrete is deliberately lowered by adding materials which allow one to economize on valuable cement.

Building three digesters during the recent seminar enabled the participants to scrutinize the construction of these airtight containers. The design now standardized is a cylinder 3 m across and 2 m deep with a shallow dome below and above (see Figure 3). While the wall width has been reduced to 4 cm to save on materials, the surrounding soil is used for structural support. Balancing the inside and outside pressures, already a complex problem in itself, becomes a feat of engineering and skillful masonry when accomplished with local materials. Thus, the Chinese citation that 40–70 work-days are required to complete a digester must be taken as a measure of skill as well as time. In particular, their techniques of dome construction are remarkable for their quality and simplicity. Domes are built out of brick with no support (Figure 4) or are cast onto the original soil, which first functions as a mould, then later is dug out from underneath the completed dome (Figure 5).

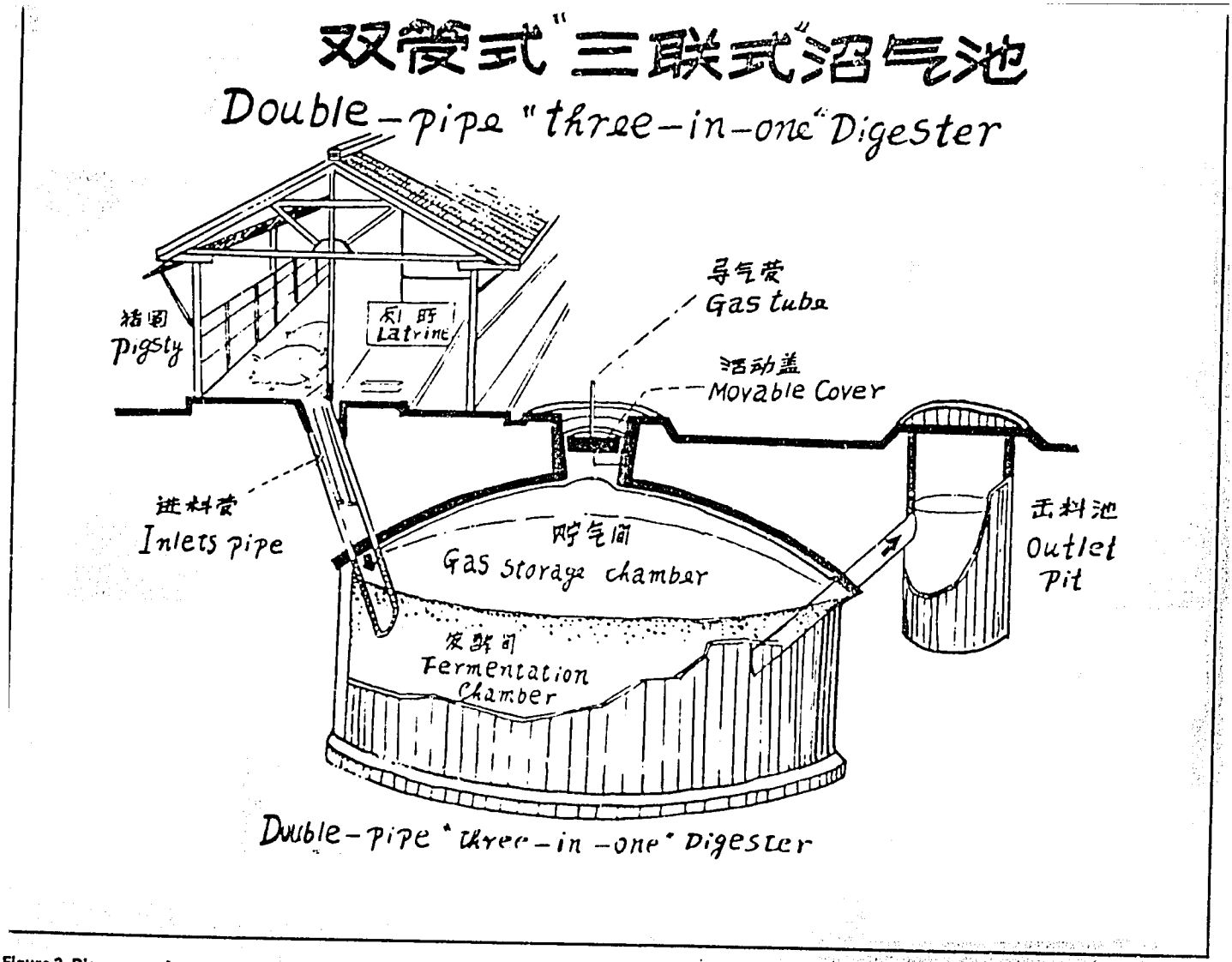

Figure 3. Diagrammatic cross-section of a Chinese biogas digester. Illustration: A van Buren.

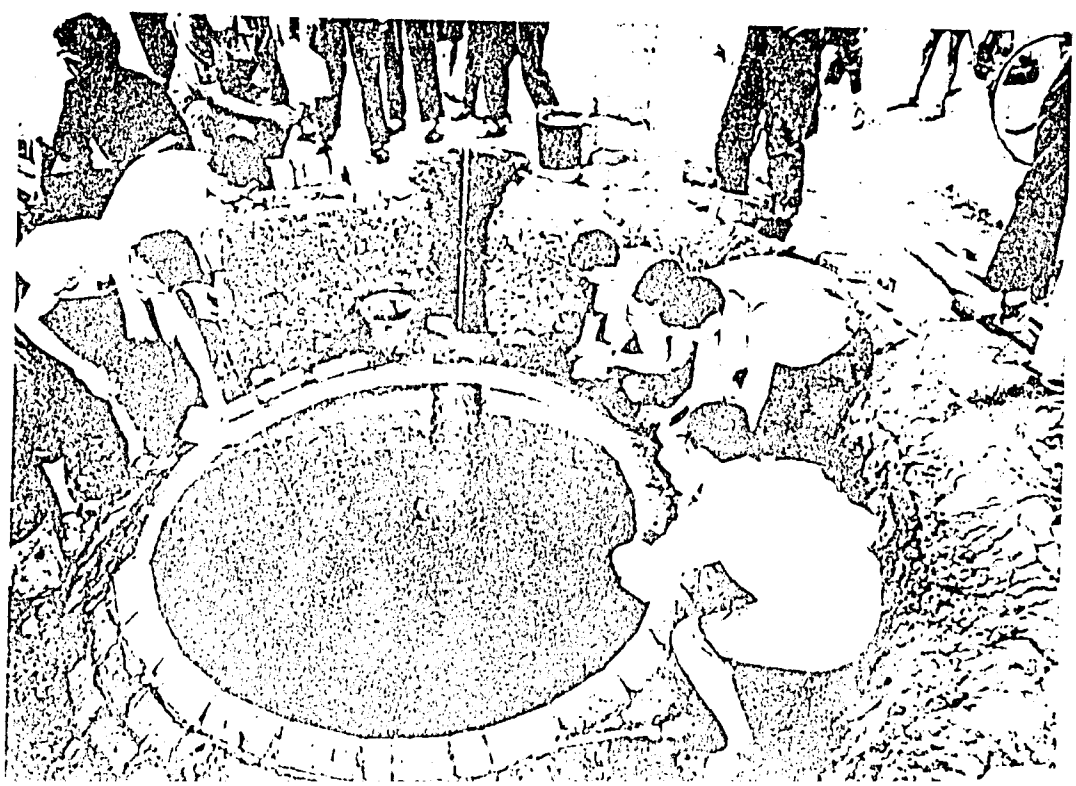

Figure 4. Here workers complete a brick dome without a support. The inlet pipe is suspended in place as the dome is formed around it. The dome radius is held constant by means of a measuring wire. Photo: A van Buren/UNEP.

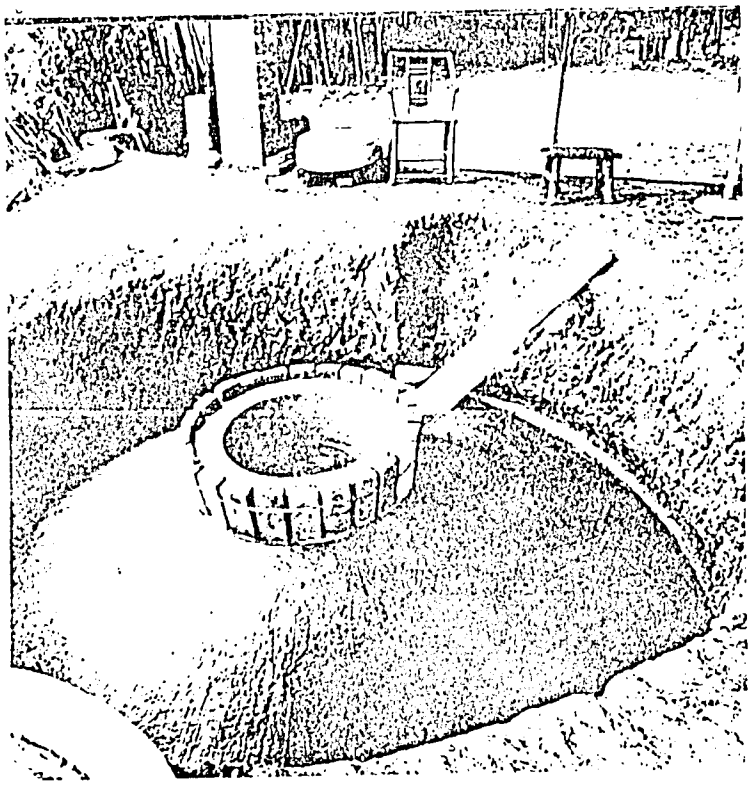

Figure 5. This is the completed dome of a concrete cast-in-place digester (10 m³). The original soil underneath the dome will be dug out through the mouth of the digester and a concrete floor laid inside. Photo: UNEP/de Silva.

Figure 6. Floating water cabbages on the puddle over the clay seal in the mouth of the digester marks the finish of this biogas plant. Photo: UNEP/de Silva.

Another impressive piece of common sense could be seen in the method of sealing a removable cover into the top of the digester. One participant in the seminar spent months trying to obtain an airtight seal with concrete, having to break and build it over and over again and finally giving up. The Chinese use clean clay as a gasket and then insert the cover into place in the mouth of the digester. A pool is formed inside the rim of the mouth, and filled with water to keep the clay from cracking as well as showing up any bubbles of gas leakage. Furthermore it is used for cultivation (Figure 6), a good example of the Chinese concern with productively utilizing all available surface area. The water cabbages and water hyacinths are fed to pigs whose manure is finally fermented in the digester. Our suggestion of putting the aquatic plants directly into the digester was greeted with surprise; the Chinese pointing out the inefficiency of by-passing a potential stage of nutrition in the cycle of resource use.

TRAINING

In the last five years, over 200 000 biogas technicians have been trained at various levels in Sichuan. After a one-month initial course at the provincial level, trainees return to their prefectures to serve as teachers. Their students then become teachers at the county level and extend the technology out to the communes, brigades, and teams.

In those production teams where biogas has been popularized, one to three members have now become technicians. Since these teams are small units of 20–30 families, the technicians cannot be professionally specialized and must continue to work in agricultural production. In their biogas work, they receive constant support and guidance from the specialized technicians in the commune (Figure 7). The range of skills begins with a simple, pragmatic dexterity at the team level, reaching detailed experimentation in the biogas laboratory of a more advanced commune. In research institutes at the province level there are groups responsible for the scientific research to support and promote further investigations and refinements.

Administrators are trained to understand the systems that overlap in biogas development, because it is they who must guide the work and support its position within the productive activities of the commune. It is they who will have to resolve potential conflicts of interest between the individual owner of the digester who needs the gas for domestic use and the collective which requires the residue as fertilizer and provides the bulk of the fermentation material.

The government of China supports biogas development through the establishment of Biogas Offices regionally and locally. The National Plan for economic development is adjusted to ensure that necessary materials are available for biogas construction, and a proportion of the country's cement resources are allocated to this task. State banks provide loans to builders of digesters at low interest rates of 0.18 percent per annum, to cover the cost of materials

Figure 7. Commune biogas technicians were specially chosen for the international biogas training seminar. Photo: UNEP/de Silva.

ILLUSORY CHEAPNESS

The quoted cost of a Chinese digester appears absurdly low when compared to the cost of all other versions developed elsewhere. The reason is that this figure includes only the commercially acquired materials. Labor is contributed by the family building the digester and is compensated in work points as part of the team's normal productive activity. But no account is taken of the extensive labor required to dig out local building materials and transport them, including commercial components, to the site. The creation of an infrastructure of training and support comparable to that offered by the State in China, would enormously escalate the cost of these digesters elsewhere.

POPULARIZATION

The methods by which such technology is being popularized could well be the focus of further study by Third World countries planning biogas development. Simple straightforward manuals are published and nationally distributed, reflecting the most recent advances and the range of experience. They are designed for use by technicians, teachers, and extension workers. Popular promotion is carried out primarily through the medium of radio broadcasts. Films and television programs have also been made, highlighting the initiative and innovation in different parts of the country.

THIRD WORLD EXTENSION

China's opening to the rest of the world has in most fields been for her own benefit. However, in biogas technology this aperture will work more to the advantage of other countries, because so little has been done elsewhere.

The report of the first international biogas training seminar in China will be published by UNEP early this year. It will describe the current status of biogas technology in China, discussing the feasibility of using Chinese technical training for people from other developing countries. It will also compare biogas development in the countries of the seminar participants. According to the last reports, a Chinese digester has already been completed in Sri Lanka and the groundwork for the Peruvian national program has been put in place. Reports of the seminar have also been prepared by each participant for their own governments.

It remains to be seen whether the momentum created by this promising experiment can be sustained and expanded into a network of biogas training programs throughout the Third World.

References and Notes

1. All material mentioned here is first hand, based on the 1979 International Training Program, discussions with the leaders of China's biogas development and on lectures prepared by the relevant research institutes. It will be published in book form in 1980 by UNEP.
2. *A Chinese Biogas Manual: Popularizing Technology in the Countryside*, A van Buren, *ed* (Intermediate Technology Publications and Commonwealth Science Council, London, 1979).

E Ariane van Buren was consultant to UNEP as Assistant Director of the first international biogas training seminar in China and author of the seminar report. She has arranged the translation and edited Chinese technical manuals for publication in English on biogas (2), rural water supply (to be published by the International Development Research Center in Canada), and plans the translation of several on afforestation, selected from a wide range collected in China over the last three years. Her other publications include a paper prepared for the Beijer Institute of the Royal Swedish Academy of Sciences on the feasibility of biogas use in East Africa. She is also co-author of the book entitled *A Low Energy Strategy for the United Kingdom*, co-editor of *Nuclear or Not? Choices for our Energy Future*, and co-author of a forthcoming book on the role of industrialized countries in Third World energy strategies. Currently she is a Research Associate at the International Institute for Environment and Development in London. Her address: IIED, 10 Percy Street, London W1P ODR, UK.