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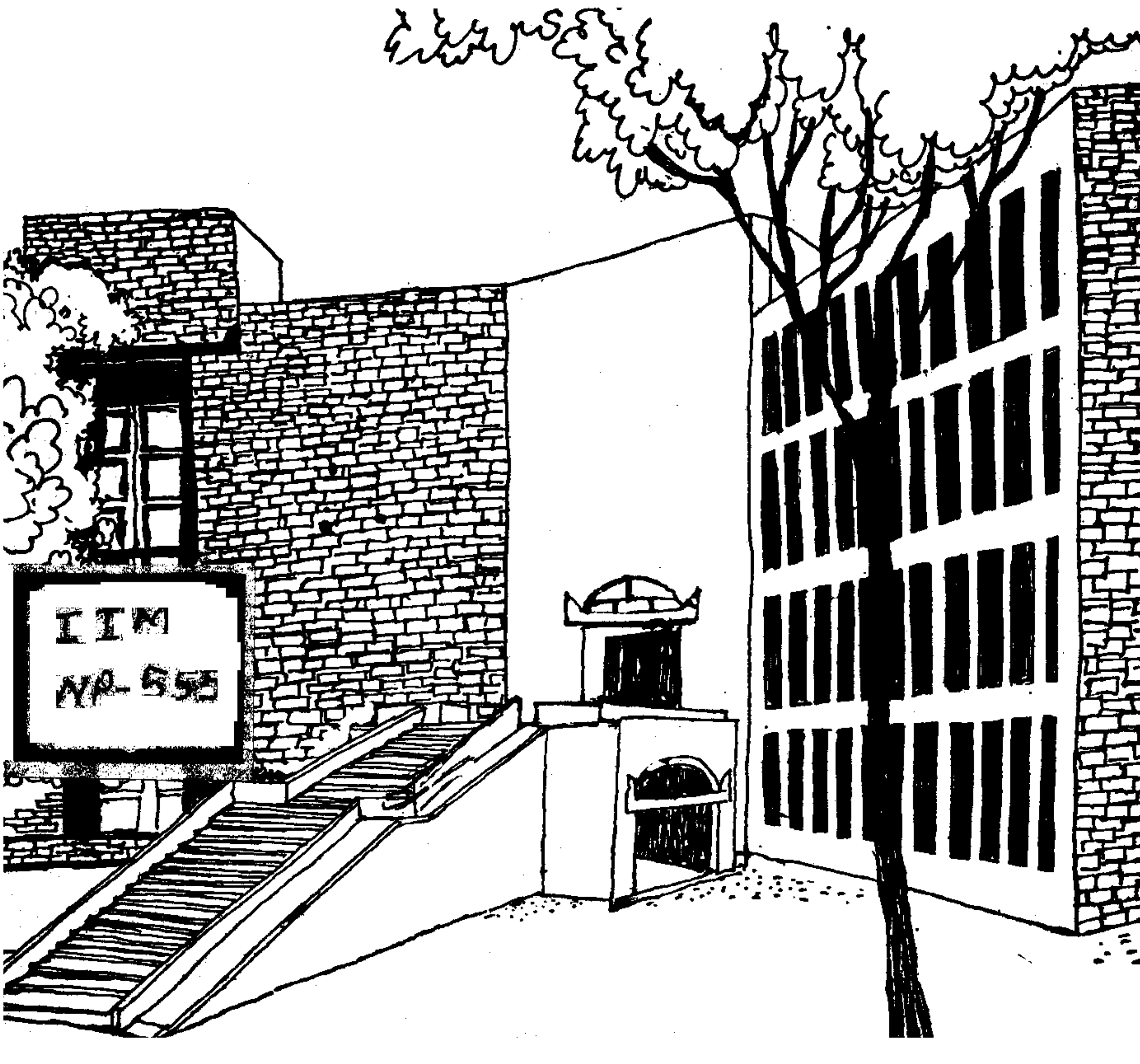

THE BIOGAS PROGRAM IN INDIA AND CHINA: A COMPARATIVE ANALYSIS OF EXPERIENCES

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Introduction

With over 7 million biogas plants serving 5.26% of the rural population, China's position in biogas technology is unique. It looks particularly unique when contrasted with India's 0.2 millionplants serving only about 0.08% of rural households. But what is still more glaringly evident is the fact that China achieved this target in half the time where official program started in 1972 as against 1962 in India. To some, this comparison and contrast between China and India becomes provokingly interesting in view of the claims often made that the small biodigester technology as it is being promoted in various parts of the world is basically an Indian invention. Whether or not this claim is true, the fact remains that the anaerobic digestion of biomass or organic wastes into basic essentials of energy, fertilizer and improved health is ecologically and technologically a relevant and promising technology for both India and China.

The relevance of biogas technology in these two countries can easily be understood in view of some quantitative estimates of the present level of biomass consumption as fuel. In rural India, for example, as high as 80% of energy consumption is presently met through biomass -- 133 million tonnes of firewood, 40 million tonnes of agricultural wastes, and 73 million tonnes of animal dung (cattle dung). In fact, the Indian peasants were reported to use a mere 15% to 20% of 260 million tonnes cattle dung as manure for agricultural production and the rest was either wasted or burnt, thus taking away the possibility of augmenting useful organic fertilizer.[1] China, on the other hand, having only a third as many large animals as India and the long tradition of importance given to organic recycling by the Chinese peasants, seems to be careful in not wasting large animal dung for other than fertilizer use. But it has been estimated that 400 to 500 million tonnes of firewood and straw are burnt up every year in China's countryside. Inspite of the tradition of use of nightsoil by the Chinese peasants, it has also been estimated that if only half of the nightsoil and stalks inthe countryside were collected and used to produce biogas, 68,300 million m^3 of biogas could be produced each year, which could provide 800 million peasants with gas for daily use, with a surplus of 6000 million m^3 gas. This surplus would be enough to generate 9000 million kwH of electricity per year.[2]

The above estimates are quoted merely toemphasize the relevance and potentialities of biogasification technologies in both India and China. Apart from direct benefits from the output of energy (in the form of biogas) and enriched manure, there are of course a host of indirect benefits, such as, checking deforestation and soil erosion, alternative gainful use of biomass, improving health and sanitation and a general ecological balance, - the benefits highly valued and immediately required by both China and India.

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[1] The World Bank Staff Estimates, 1983

[2] "Biogas Development in China", National Office for Biogas Development and Extension, Beijing, China, 1-19 July 1980.

Given the relevance and importance, the comparison of the biogas program between India and China is not only interesting for their differential rate of successes but also of tremendous experiential learning value. For, a number of cultural, religious, geographic and socio-politico-economic factors and processes seem to explain the differential levels of successes achieved in India and China. What follows here is a brief comparative account of history and processes of the biogas program implementation in India and China highlighting the factors in explaining the differential achievements.

Historical Background

It is striking to note the similarities and dissimilarities in the historical processes and perspectives in which the biogasification program has been introduced inIndia and China. The similarities lie in the fact that the experimentation with biogas digester dates back to 1930s in both the countries and the initial motivation for biogasification in both the cases has been the cheap source of energy and better quality manure. However, during the decades of development of the technology, there were conspicuous dissimilatities developed in emphasis, orientation and strategies between the two countries perhaps in consonance with widely varying socio-political background and historical processes.

Critical Steps in Historical Evolution of Biogas Program

A brief comparative picture of the critical landmarks in the History of biogas program in India and China is interesting.

INDIA

Time Period	Steps with Basic Thrust
Early 19th Century (1900–1920)	Historically referred early attempts
1938, at the Indian Agricl. Research Institute, Delhi.	Serious indigenous development attempt
1940–1950s, at various research institutes	Spurt of indigenous development research
1951, by JJ Patel	First standardized floating dome model developed
1954, by JJ Patel	Floating dome design improved
1955, when 500 installed with govt. support, but failed subsequently due to design defects	First govt. supported program
1960, first govt. sponsored programme	KVIC taking as one of its rural development programme
1960s, at various national institutes with setting up of biogas research station at Ajitmal, UP	Renewed interest in biogas research
1970, with fossil fuel energy Crisis	Importance of biogas as energy source
1975–80, national programme when Chinese type Janata model officially promoted and a large number of official and non-official agencies were involved apart from KVIC. Total plant 80,000	Biogas as major programme under Agricultural Ministry promoting multi-agency and multi-design programme
1975–80, by the Department of Science & Technology, GOI	All India Coordinated research and experiments with community biogas system

INDIA (contd.)

Time Period	Steps with Basic Thrust
1981, with a target of 0.4 million plants in the remaining 4 years of VI th plan and inclusion in 20-point programme	National Project for Biogas Development launched with enhanced target
1981, creation of the Commission of Additional Sources of Energy	Coordination of renewable energy programme
1982, setting up of the Department of Non-Conventional Energy Sources under the Ministry of Energy	Exclusive implementing organization for non-conventional energy sources
1984-85, crash programme with a target of 0.15 million plants and the proposed 1.5 million plants during the VII th plan period. Total plant installed 0.20 million plants.	Enhanced target

CHINA

Time Period	Steps with Basic Thrust
1930s, a Chinese Scientist built a digester in Jiangsu province in 1936 for lighting	Historical reference of interest of energy potential of biogas
1957-60, biogas in Great Leap Forward	Biogas technology transferred from Germany mainly for propulsion energy. Programme failed due to lack of experience.
1970-74, Renaissance of biogas programme	Fixed-dome Chinese design developed in Sichuan province and mass popularization of biogas, particularly in Sichuan. Village authorities took the responsibility of popularizing "small, local and operated by people" family size biogas plants.
1975, part of national development programme	First National Conference in Mianyang, Sichuan province

CHINA (CONTD.)

Time Period	Steps with Basic Thrust
1975-78, Enhanced pace of development and spread	From first to the second conference. The number of plants installed increased from 0.5 to 7 million. Massive drive for technical training.
1977, focus on research	Establishment of Nauhin Biogas Experiment Station, Shanghai.
1978, Organizational thrust	A national level biogas office in Beijing and separate offices for biogas development at provincial county and commune levels.
1978, (end), Rectification	Reported failure rate of 30 to 40 per cent. Central Committee proclaimed "search for truth in facts". 2 million plants rectified and professional training emphazied.
1979, reorganization of responsibility	Conference. Responsibility shifted from households to local authorities.
1980s, enhanced target	Professionalization and standardization target of 40 million plants in VIth Plan period.

Serious interest in indigenous development of biogas technology started at the Indian Agricultural Research Institute (IARI), Delhi around 1938. There were two factors which motivated the IARI scientists. Firstly, it was realized in early 1930s, that there was a loss of 40-60 per cent nitrogen in the standard aerobic composting of farm yard manure. With the experience of initial successes with the German "Edelmist" anaerobic process at the Indian Institute of Science, Bangalore, IARI started a large study for preparing cheap synthetic manure from town refuses and other waste materials. It was important to note that this initial interest in biogasification in India was primarily with manure and not with energy or gas. Neither was cowdung considered as the feedstock for biogasification at this stage.

The second factor, which in fact turned the focus to cowdung and gas, was the visit of the IARI scientists to the Sewage Purification Station at Dadar, Bombay in 1938. The Sewage plant had an anaerobic sludge digestor, out of which gas was used for running five tonne lorry for disposing garbage and the digested slurry was sold to the farmers near Bombay. This triggered off the research on small-scale anaerobic digestion of cowdung for gas and manure at IARI in 1939. The beginning was made.

If 1960s was the critical period in India's biogas programme, 1970s should be termed as the growth period. India by then was in full swing in her Green Revolution with emphasis on energy-intensive input uses (e.g. fertilizer and irrigation) in the agricultural system. On the other hand, the Fuel Policy Committee of the Government of India, in the wake of serious fossil fuel crisis of 1970s, in its analysis of serious commercial fuel situation in India, strongly recommended the popularization of gobar gas plants as alternative sources of energy.[3] Since biogas as alternative sources of energy also meant energy input in terms of fertilizer (biomanure) as per fuel Policy Committee's report, biogas was included as one of the major programmes under the Ministry of Agriculture during the 5th Plan Period (1975-80) as an integral part of its programme of development of local manurial resources. A target of 0.1 million plants was set for the 5th Plan Period. With a subsidy of 25% of the estimated cost of biogas plant from the National Government, about 70,000 new plants were set up in the country bringing the total number of plants around 80,000.

It was at this stage, the Ministry of Agriculture brought in two important changes in the biogas programme in India. Firstly, apart from KVIC, a host of government, semi-government and voluntary organizations were pressed into biogas popularizationprogramme. Secondly, purely from cost

[3]Government of India, Report of Fuel Policy Committee, Delhi: Manager of Publications, 1975.

considerations, the modified Chinese design, Janata, was officially promoted in the programme in addition to KVIC model. Thus, a multi-model-cum-multi-agency strategy was started in India's biogas programme. But it was interesting to observe that eventhough the biogas programme in the Ministry of Agriculture was identified withits ongoing manurial resource development programme, the emphasis continued to be on gas as alternative fuel for cooking. It seemed that the high priority of cooking fuel demand in rural India, the danger of serious deforestation and emphasis on chemical fertilizer input in India's agriculture had a bearing on its primary focus on biogas rather thanbiomanure.

DNES maintained the strategy of multi-model-cum-multi-agencyapproach in its biogas programme. It has initiated a crash programme with a target of 0.15 million plants in 1984-85 and a target of 1.5 million plants during the 7th Plan Period (1985-90). Simultaneously, at the State levels specific official model agencies were created to promote and implement the renewable energy programme in which biogas is by far the largest and most important component. Accordingly, the subsidy and other incentives were further enhanced in order to achieve the expanded targets.

For family size plants, the central subsidy from the government of India during proposed 7th Plan has been 50% of the cost for preferential categories (i.e. notified hill and desert districts and for scheduled castes, scheduled tribes, and small/marginal farmers and landless labourers) and 20% subsidy for the remaining categories. Apart from central subsidy, State Governments also provide additional subsidy ranging from 8% to 20% of the cost. For large size village community plant, the central subsidy has been 100% and 75% for institutional plants. For detection and rectification of the defective plants, a sum of Rs 1000 per plant is provided by the Central Government.

The biogas programme as we see today in China started in the political framework of a mass movement during Great Leap Forward of 1957-60. In an exhibition on Great Leap Forward held in Huuan, Mao Zedong was shown a biogas digester and a stove in operation.[4] In April 1958, Chairman Mao issued personal instructions to popularize biogas in China. Thus, we see a fundamental difference in the historical process in which Mao as the highest political authority actively and personally legitimizing the biogas technology as an important element in China's development strategy as early as in 1950s, while in India a similar process occurred in 1970s - almost two decades later.

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[4] A large part of the historical background and other following analysis on China's biogas programme documented in this paper are taken from, TK Moulik, "Mao's China: The Dilemma", Somaiya Publications Pvt.Ltd., Bombay, 1982.

At this stage it would be appropriate to digress into a brief analysis of the basic motivations for large scale popularization of biogas technology in China. The concept of "walking of two legs" as a developmental strategy is perhaps thekey motivating factor for reviving biogas programme in China. Following this concept, the Chinese have emphasizeddevelopment of small-scale, decentralized energy systems as well as the large-scale centralized and modern energy systems. Energy systems included under the decentralized small-scale 'leg' were small coal-mines, small-scale hydroelectric plants, biogas and local production of fuelwood.

Over the years, China has been experiencing severe shortages of traditional biomass fuels, abuse of forest resources by rural fuel gatherers resulting serious imbalances in the ecosystems and shortages in crop by-products for use as animal feed or fertilizer (composting) or other industrial products (e.g.paper)[5]. The Chinese felt that the development of decentralized energy systems like biogas presented the most practical means to solve problems associated with the traditional biomass fuels for rural household needs. For, apart from political factors, the decentralized biogas system in China was perceived to have the following specific economic rationals :

(i) Demand for energy from centralized sources like electricity might be relatively low and at varying levels in scattered communities and therefore most likely to be non-viable;

(ii) Small-scale biogas projects tended to have shorter lead times and therefore could provide necessary energy in a relatively short period.

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[5] As much as one-half of the available crop-byproducts was used as household fuel. See, Shangguan Changjun, "Ways Must be Found to Solve Energy Problems in Rural Areas", Nongya Jingji Wenti(Agricultural Economic Issues), 1980, No.4, pp. IV-56 to IV-58.

(iii) Biogas technology could be developed with a greater reliance on local finances, labour and construction materials, creating less financial burden to the State.

(iv) Biogas technology provided the opportunity to relieve the heavy financial and administrative burdento transport coal and oil to vast rural areas of China, for which rural people had to pay or State had to subsidize.

Besides the above mentioned economic rationals related to energy supply, there were two other important factors that influenced China's movement for biogas programme. Firstly, with their long tradition and experience in the collection and composting of all types of biomass for use as fertilizers, there has been increased demand for improved manure among the collectives. Unlike in India, the importance of organic manure in Chinese agriculture has been sustained, if not increased, in which the advantages of biogas system for production of better quality manure was significant. Secondly, biogas technology has been found to be an effective means to ensure rural sanitation, particularly, in controlling schistosmiasis - menacing disease in rural China.

Thus, in contrast to India, the biogas programme in China has been viewed as a particularly appropriate technology with equal emphasis of its advantages in relation to energy supply, better quality fertilizer production and rural sanitation. In fact, it was this equal emphasis on these three main advantages of biogas technology that setthe historical processes of Chinese biogas development programme in a particular direction.

While the primary emphasis in China's biogas programme, as in India, has been on family-size digesters, large community operated plants (about 30,000 in number) were also built with a capacity of 50 to 200 m^3. In rural areas community digesters are collectively owned and operated in conjunction with collective piggeries. Often large units were built at institutions such as schools, factories or hospitals. In urban areas, large biogas systems were usually built in conjunction with nightsoil treatment and disposal schemes.

With all available evidence, it seemed that China is committed to continued and aggressive promotion of bio-gas in the country. Biogas was declared as the "principal alternative" to cope with the fuel crisis of the Chinese villages. Even a target of 40 million plant units was announced as a medium term objective in 1980 to be set up mainly in the priority areas inhabited by 70 million rural families facing serious fuel problems. The development of 5 major research centres and budgetary allocations at all levels reflect this ambition of China. There are, however, some apprehension about the future of biogas programme in China mainly due to her recent political thrust on modernization and restructuring of the communes with 'responsibility system'[6]. In fact, as discussed

[6] The newly introduced 'responsibility system' means a contract between individual households and the commune stipulating that after the households have delivered and sold the assigned quotas of grain to the State, paid agricultural taxes, and put aside reserves for the commune, theyshall own the remainder of their products. In this arrangement, either a household may own part of their means of production and purchase the rest from the commune, or own all their means of production and are run independently, or may employ a small number of assistants or apprentices, according to government policies.

later in this paper, the success of Chinese biogas programme was largely contributed and facilitated by the socio-economic structure of the commune system. To many experts, therefore, the future of biogas programme in China would largely be determined by the impact of the 'responsibility system' in the relatively egalitarian socio-economic structure of the commune.

Technology Development

The historical parameters described above would obviously have a bearing in the whole processes of biogas technology development in both the countries. Just as socio-political history of a country determines the aims and strategies of development programmes, it equally influence the technology policies in relation to complexity, cost, acquisition, import and sophistication of a technology. This influence in its final and differential outcomes is perhaps relatively conspicuous in the case of biogas technology development in India and China.

It was interesting to observe that the starting point of biogas technology development in both India and China had been an external source, Germany. It was also equally interesting that apart from getting exposure and initial experiences, both the countries abandoned the external technology and embarked on indigenous technology development. The similarities between the two countries ended at this stage. The subsequent stages of indigenously developing biogas technology and its implementation or popularization programme differed widelybetween India and China.

Broadly, the biogas technology development programme in India can be characterized as elitist in its initiative and participation, whilethe Chinese process has been largely egalitarian in the sense that it was mass-based peoples' movement. In India, the initiative for biogas technology development came essentially from a group of highly aeducated scientists supported by R&D institutional infrastructure. Even Mr Patel, who was a graduate from the Poona Agricultural College became interested in anaerobic digestion while working with a reputed firm Mapara Parekh & Company in Bombay. Thus, from the very start, the major concern had been to evolve a technologically efficient biogas plant design without much concern about cost and construction materials. Scientists as they were, technological sophistication and scientific perfection were more important to them than the cost or the capability for building the digester locally by common people in the village. The fact that the biogas design development process started with a group of scientists and reputed research institutions, the initial objective of providing cheap fuel and manure had largely been sacrificed in favour of technological parameters. As a result, Patel's floating gas holder (made of steel) design(Gramalaxmi), which was ultimately adopted by KVIC for popularization in 1960s was technologically efficient but not economically for a vast majority of India's rural population. The steelgasholder alone accounted for about 40% of the total cost of the plant. Even the technological determinism in the sense of requiring 3 to 5 cattleheads automatically made biogas plant beyond the reach of a large majority.

It would, however, be wrong to suggest that there was no concern about the cost of biogas plant. There were evidences that even as early as in 1950s a number of individuals - again influential, high educated and institution based - made serious attempts for cost reduction by using cheap construction materials. Unfortunately, these attempts were not successful as compared to Patel's Gramalaxmi more on technological efficiency criterion than on economic basis. As a result, as soon as Patel's design was adopted by KVIC, there was a steady decline in cost reduction research in India. This lack of concern about the cost and cheaper construction materials was not only limited to the basic biogas plant but also equally to necessary accessories such as stoves, pipes, etc.

The fact that only the standardized floating dome Gramalaxmi model of biogas plant has been promoted in India for more than one and a half decade indicates several other dimensions of technology development process, apart from cost concern. Firstly, since no serious efforts were made to evolve a design suitable for diversified biomass feedstock other than cowdung, it seemed that there was a general acceptance of the limited market segment comprised of relatively large landowning and cattleowning households. Having accepted this limited market as the final demand, there was hardly any incentive for KVIC to look for an alternative cheap design. Secondly, there has been from the very beginning a pronounced tendency for standardization and professionalization of the whole process of technology development in India. As a result, production and installation of biogas plants and appliances were centralized with one or a very few professional institutions or firms. The process of centralization and professionalization has been so strong that, unlike China, there has been no published construction manual of biogas digester in India until recently. Since the development process remained concentrated with a few professionals and scientists, the necessity of construction manual was never felt in India till 1970s. In fact, India's construction manual appeared only after the introduction of Janata Model which necessitated training of a large number of village masons for development of specific skills to build fixed dome plant. In the process, there emerged in India the first organized efforts for creating grassroot level decentralized skilled manpower.

Thus, the scenario changed drastically in India in 1970s. With expanded target and national programme there had been serious search for cheaper designs. It was in this process of search, the modified Chinese design, Janata Model, was developed and popularized. The present multi-model-cum-multi-agency strategy of India was, in fact, the direct outcome of the search for alternative designs and processes. Since 1970s there was not only concern for the cost but also about utilization of biomass other then cattle dung (e.g. water hyacinth, bagasse, straws, green leaves, nightsoil etc.) as well as for alternative uses of gas other than cooking (e.g. water pumping, electricity generation etc.).

Although R&D efforts and experimentations are still largely done by research institutions and scientists in India, there has been a coordinated focus on the above mentioned issues and broad-based participation. There is also deliberate attempt to recognize individual private efforts. These are welcome changes. But the fact remains that India's biogas technology development process still remains far less than a mass-based people's movement.

The biogas technology development in China was almost a reverse process as compared to India. Not only the first successful initiative came from the peasants of Sichuan, but the deliberate policy was also for encouragi initiative, experimentation and creativity at the decentralized local levels in the commune structure. There were three important guiding factors in China's biogas technology development and promotion programme:

(i) It should be using easily available local construction materials such as brick, stones, lime, cement, etc.

(ii) Technology for construction of digesters should commensurate with locally available skills;

(iii) Cost of construction should below and maintenance easy.

The main advantage of the Chinese water pressure digester design is that it is relatively cheap and can be built easily with local skills. In fact, the Chinese emphasis on decentralized local initiative was evidenced right from the beginning in which skill-imparting training of large number of peasants had been the integral part of the programme. Since training and local level skill development was the emphasis, the detailed construction manual of Chinese design was brought out at the initial stages of the programme.

With rare exceptions, the Chinese have promoted the water pressure digester design. However, there was no standardization of the technology. Following guiding principles, it has been a deliberate strategy in China to actively involve the masses in local experimentation. As a result, keeping the principles of water pressure constant, the biogas digesters in China widely vary in shape, size, use of construction materials depending on soil conditions, water table, climate (particularly temperature) and locally available construction materials.

Still more striking was the fact that the decentralized local experimentation by the peasants were not limited only to biogas designs and construction of materials, but also extended to use of different biomass as feedstock, use of biofertilizers and its impact on soil and crop yield, various accessories and appliances (usually locally made) associated with biogas plant and different and uses of biogas.

In other words, local experiments were undertaken by a large number of peasants in the communes covering almost all aspects of biogas technology[7]. Not only these experiments were made locally but the results of the experiments were properly recorded and used in training and popularization programme.

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[7]For details of some of these experiments, see, Moulik, 1982, op.cit. and Sharidan, Mary, "Peasant Innovation and Diffusion of Agricultural Technology in China", Rural Development Committee, Center for International Studies, Cornell University, 1981.

With their equally strong emphasis on production of improved manure, Chinese were, from the very beginning, concerned about using a mix of biomass rather than any single one. Thus, a mixture of organic matter consisting of pig manure, nightsoil, crop byproducts, grasses, or leaves were commonly used in the digesters. Similarly, as compared to India, China started using biogas not only for cooking, but also for lighting, generating electricity, pumping water and as propulsion energy in transport and tractor operations in a much more extensive scale.

Thus, China's strategy for biogas technology development has been a mass-based decentralized programme characterised by a heavy involvement of local peasants in adaptive R&D and incremental innovations. The outcome of this strategy was the least expensive and locally adaptable technology of fixed dome water pressure biogas digester, which perhaps was not as technologically efficient and sophisticated as the expensive floating dome Indian design evolved by an elite group scientists. Comparatively, however, the Chinese strategy paid off more successfully not only in relation to rapid popularization in a massive scale, but also in creating a base of technically trained and experienced local manpower.

With the reported 30 to 50 per cent non-operating plants and their "seek the truth in the facts", there seemed to be in recent years (1980s) some rethinking about decentralized development programme. Apparently, in such a large scale decentralized development programme there were questions raised about quality control, supervision, multiplicity of efforts resulting waste, mistakes in design and construction, which might have contributed to operating problems of the digesters in such a large number.[8] The Chinese are making serious attempts to sum up and consolidate past experiences and move toward greater standardization and professionalization - a process with which India started and continued the programme for two decades. In fact, the office of the National Methane Production Leadership Group has recommended the establishment of a new methane research institute in the northern part of China.[9] Having already created a mass base of local technical manpower with relevant past experiences the Chinese policy hopes that the trade-offs between local innovation and standardization and between low-cost technology and efficient high quality technology would be beneficial to the biogas programme.

Pre-Existing Favourable & Constraining Factors

Having described the differential levels of biogas technology and its development processes, it is now possible to delineate factors which are likely to facilitate or constrain the dissimination of the technology. For, a technology and its development process are hardly "neutral" even if a particular technology is considered to be equallyrelevant for both India and China. The success or failure of a technology in a country is

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[8]Interestingly, the number of Indian digesters with serious operating problems was reported to be around 20% - not as low as it should be expected given the superiority of Indian floating dome design. The corresponding figure about Janata Plant in India seemed to be still higher.

[9]The Office of the National Methane Production Leadership Group, "Methane Production", pp. 27-28.

largely determined by a series of socio-economic, political and cultural factors that exist in a social milieu. It is also equally true that the introduction of a technology itself tends to change some of these factors in one way or the other. For the present, however, we will enlist some of the critical factors that existed in India and China before the introduction of biogas technology which are likely to have influence in the ultimate progress of the biogas programme.

The difference between India and China in relation to achievements in biogas programme has often been attributed to social organizations. This is quite expected and largely true. The existence of commune structure in rural China with its collective and socialized means of production (particularly land) and its highly organized work force presents a largely egalitarian and homogenous structure as compared to India's caste-class differentiated village structure. Of the 250 million pigs in China, 70% are privately reared. In fact, pig-rearing has been one of the most commonhousehold economic activities and, therefore, most of the Chinese rural households can be potential customers of biogas. In India, on the other hand, only 22 per cent of 85 million rural households have 5 or more cattle, which is technologically minimum requirement to meet the cooking fuel needs from biogas plant. Thus, the potential customers of family-size biogas plants is relatively small in India given the emphasis on cattledung as the biomass feedstock. Also it should be noted that the distribution of these potential users is widely scattered in India over a vast geographical area. As a result, not only it is difficult to reach the potential customers but also involves high administrative costs.

This brings us to the second important difference between India and China. Historically and traditionally organic matter recycling through composting into agricultural system has been welldeveloped in rural China. There is a tradition of collecting, transporting and composting of all kinds of biomass in China, the importance and significance of which in modern agricultural practices has been strengthened manifold. With this tradition, biogas plant fits in nicely with the Chinese peasants. Also biogas plant becomes particularly attractive in China in the absence of competing uses of pig manure. Eventhough China's 250 million pigs produce less digestible material than India's 260 million cattle, it could enhance the availability of total biomass feedstock for biogasification by utilizing a mix of organic matter including nightsoil.

Comparatively, India presents an almost diametrically opposite picture. With not so strong tradition and understanding about the importance of organic recycling as in China, the Indian peasants had been more keen on chemical fertilizer input, particularly, with the advent of Green Revolution. Neither was there any required amount of efforts in educating and training in this respect given the secondary role assigned to manure production in the biogas system. On the other hand, while traditionally China has been collecting and manuring nightsoil even before liberation, there are serious cultural and religious taboos about nightsoil in India. As a consequence, cattle, dung has been found to be the only acceptable and available feed-stock in India and in fact the technology was also designed accordingly.

But unlike China, where pigs and cattles are usually peuned within the household complex, it is seldom, done in India. Open grazing being the common practice, particularly, in day time there has been a considerable waste of dung due to non-collection. Additionally, cattle dung has many competing uses in India including direct combustion, which reduces the availability for biodigestion further. It should also be noted that with different breeds of cattle existing in India, the dung production also varies considerably meaning different herd-size requirements for meeting household fuel needs from biogas plant.

The Indian floating dome design requires some land space for installation. A $3m^3$ plant requires about 27 square meters of land for the plant and the slurry pits. In many villages in India dwellings are clustered so closely together that it is often rare to find a household who can spare the required land area near the homstead. In fact, this has been one of the reasons for popularizing Janata Plant in India, which, being underground does not exclusively occupy so much space. This means that the Chinese design has this specific advantage, eventhough the way most of the Chinese villages were restructured and relocated in a systemic geometric fashion along with a kitchen-garden for each household, the space requirement for biogas plant has never posed a serious problem in China. Similarly, given the consolidated collective land, slurry disposal is comparatively easier in China than in India with fragmented private landholdings.

Following from the above facts, it is obvious that distribution of biogas plants in rural India would necessarily be scattered and thin. Comparatively, the Chinese could easily concentrate biogas plant population in a production team or brigade/commune with maximum demonstration effects of its all primary and secondary benefits, apart from minimizing administrative costs. This is important given the relatively greater awareness among the Chinese about hygiene and sanitation brought out by research and education.

Like biogas programme, industries in India are largely urban based and centralized. Indian biogas programme has to depend on timely availability of two basic construction materials, cement and steel, from the centralized production units away from the villages. In contrast, with decentralized commune or district based industries, particularly, mini-cement works facilitate greatly the availability of the crucial construction inputs in China.

There are two motivational factors need to be mentioned. The level of fuelwood crisis as it existed in China has not been felt by most of the Indians. This certainly dampens the motivation for investing in biogas plant among many Indians. Also unlike in China where the programme has been designed in such a way that a net cash flow of income can easily be actualized by individual households,[10] there

[10] This aspect is discussed later in details.

is only notional cash benefits perceived by the Indian counterpart. But a still more serious cultural factor with likely inhibitive effects is the lowly status of women in decision-making as compared to relatively dominant status of the liberated Chinese women.

Lastly, but a very important dimension, is the actualized and readily perceptible nexus of benefits shared by the individual households, collectives and the state in the biogas programmes in China. In India, on the other hand, there is no such meeting point between micro and macro levels. In fact, most often there are serious divergence of interests.

It is thus clear that not only the pre-existing socio-economic factors favour China in relation to rapid popularization of biogas technology as compared to India, but the strategies and policies in China are also matched accordingly about which the discussion follows.

Programme Implementation

Favourable socio-economic preconditions alone cannot be sufficient to make a technology diffusion process a success. Equally important arethe matching implementation strategies and policies supported by appropriate administrative and institutional framework. At the outset it looks surprising to observe that eventhough given the existing socio-economic parameters the large collective/village scale digesters would appear to have a great future in China, the overwhelming preference has been small family digesters. In the Chinese context it does appear paradoxical. But a careful analysis will indicate the soundness of the strategy.

Apart from psychological advantage of the self-mobilizing required for good running of the digester, the choice of private household plants slots perfectly in the socio-economic structure of the commune system in China. Not only it minimizes the transport/handling of raw organic material from the pigsty and latrines, it offers an opportunity to neatly integrate the biogas system balancing the benefits of the State, collective and individual household. It is this convergence of interests between individual households, the community or collective and the State which is the fundamental basis of the institutional structure for implementing biogas programme in China. In this integrated process, the individual household benefits by saving fuel cost, free improved manure supply to kitchen garden, income from supply of biomass input (particularly human and pig waste) supplied to biogas plant and income earning opportunities for women due to saved cooking time. The incentive for the collective is in relation to increased improved manure supply, saving biomass for gainful use as fodder, manure and paper-making, saving commercial fuel cost through use of biogas for pumping irrigation and electricity generation, saving chemical fertilizer cost and increased productivity of crops. Lastly, the State gains in so far as the biogas programme relieves its duties and transport cost for energy supply, especially coal, and preserves forests and ecological-sanitation conditions.

To the extent there is convergence of interests between the three levels, the interests of different departments of the State Administration are similarly bundled up in China's biogas programme. As a result, in the Chinese biogas administration, this convergence of interest has found expression in the creation of biogas offices encroaching upon the various administrative departments.

The second important implementation strategy of the Chinese Programme has been a stage-wise process in which instead of diluting efforts and material resources over a large area, biogas has been popularized in some selected communes/teams/brigades having the most favourable agro-climatic and socio-economic conditions. This approach of concentrated popularisation has also the benefit of maximization of impact and demonstration effects.

Given the above mentioned implementation strategies, the Chinese policy has been for decentralized self-sustaining action by the rural collective units with minimum dependence on the hierarchy of the administration bureaucracy. Within this framework there are clearly four stages of action :

(i) Local experiments with local materials and designs suitable to local conditions

(ii) Enlarge gradually the number of experimental digesters within the collective

(iii) Peak year of popularization through concerted collective planning action; and

(iv) 'Basically popularized' meaning at least 70% of the households in a commune/brigade/team adopting digester.

In this whole process, the starting point has almost always been the local leader (mostly party cadre) setting up the first experimental digester. The initiative of the local leader of the commune system has been the crucial factor in the Chinese programme. The populari- zation programme, however, starts with a propaganda campaign using all media and methods, focussing mainly on the scientific basis of the technology and its benefits. One of the commonly used methods has been the collective organizing visits to successfully operating biogas digesters and sharing experiences with actual users in small group meetings. Apparently, Sichuan attracted people from different parts of the country. In some cases, even technical assistance was sought, to start with, from the nearby successful collectives.

Following the propaganda stage, local experiments are organized in which the local leader takes the first initiative. The data generated from these multiple local experiments are then extensively used in training-cum-exhibition programmes organized by the team/brigade/commune. The local leader takes the responsibility of convincing the masses and in arriving at a collective decision in favour of trying out the technology.

The third stage in the process is the biogas technician training programme. This is generally organized by the province, county, municipality, city, district or commune levels by the respective administrative units. It is the responsibility of the collective to select a specified number of members to participate in the training programme at collective's expenses. In some cases there are rigorous competitive tests developed for selection of the members. The state-administered biogas promotion offices play a crucial role in arranging technician training programme, arranging for the supply of necessary materials, the extension of bankloans, sponsoring biogas research and preparing technical literature. Usually only a few local people in a given collective receive training. This small group then trains others in management and construction techniques and the process is multiplied like a pyramid until a critical mass of required trained manpower is created. It is this trained manpower or biogas technicians who play the key role in supervising digester construction and management.

With the programme gaining momentum in a given collective, a biogas administration committee or group is formed with a few biogas technicians headed by the collective leader. Once the plan for the collective is finalised, the biogas technicians are assigned a target of biogas plants to be constructed within a specified period of time. Apart from the fact that the wage rate of the technicians is 10% above the normal agricultural labour, they are also given extra incentive if they surpass the target of plant construction. Similarly, there is disincentive for the technician if the constructed plant does not operate for a specified period of time.

The Chinese policy on financing biogas popularization programme has been to provide no direct subsidy to the collective. Normally the households are required to bear the whole expenses on construction materials and the collectives bear the cost of labour for construction, which is paid according to 'working points'. However, often the plant owner has to take care of the excavation of the pit with his own labour resource. This means that the popularization programme depends largely on the wealth of the collective and, therefore, the income level of the member households. The households either invest immediately or the collective arrange for the construction materials, the cost of which is realized at the year end. In addition, bank loan facilities for the household is available at a reduced rate of interest.

It has been theChinese strategy to meet the private demand for fuel first through small family digesters. Only after this, the medium and large size collective digesters are introduced for collective use in industries and farm machinery.

Obviously feeding and operating the digesters in China is the responsibility of the individual households. Major batches of feeding and removal of digested manure are done twice or thrice in a year, while there is smaller additional feeding and removal of slurry almost daily. Thus, gas production is interrupted when large batches are removed. In other words, gas production is continued for about 10 months or even less every year. This interruption of gas production is certainly to meet the manure requirements for agricultural production. The practice of interruption in gas production corresponding to agricultural seasons has often been taken as the proof of China's emphasis on manure production rather than energy-fuel objective. The Chinese experts, however, argue that on the contrary it indicates the equal emphasis on both the objectives, apart from technological necessity.

To sum up, the implementation strategy and institutional arrangements for biogas programme in China ensures a profitable investment by the individual households, collectives and the State, which is recoverable within a short period of time. Not only the investment cost for family-size biogas plants in China is reported to be extremely low (about US $ 100) given the almost exclusive use of locally available building materials, the cheap design and relatively low labour costs, the stream of perceptible monetized benefits make it worthwhile for individual household to invest in biogas system. The cost-benefit analysis of China's biogas programme shows that for the individual household the investment cost is recoverable within a year's time.[11] Comparatively, India's biogas programme does not seem to be as economically viable investment as in China. In India, the initial investment for family-size biogas plant ranges from $ 500 to $ 1000 depending on the designs and size of the plants. Added to this is the fact of indirect or notional benefits rather than any direct cash flow of income as in China. As a result, even with a high dose of subsidy and taking the monetized value of the notional benefits, the investment cost is found to be recoverable in not less than 4-5 years time.[12]

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[11] See Moulik, 1982, op.cit.

[12] See TK Moulik, Biogas System in India, Academic Book Centre, Ahmedabad 1982

The contrast or similarities between India and China in relation to implementation strategies and institutional arrangements are easy to identify in view of the foregoing description of the Chinese system. As mentioned earlier, the biogas programme implementation in India has been relatively centralized and operated through normal government bureaucracy. Secondly, almost from the very beginning, the biogas promotion in India has been intimately linked with direct subsidy and other cash incentives from the government. Like R&D in biogas technology, the initiative and administration of biogas promotion in India is largely a top-down process in which the concerned government departments (either KVIC till 1970s, Agriculture Ministry and DST during 1970s till 1980s and DNES from 1980s) take the load and responsibility for implementation. In other words, India emphasises transfer of biogas technology from an external system (e.g. research institutes, experimental stations, government department) to the beneficiaries through a network of official and non-official organized agencies which are basically external to the beneficiaries.

Apparently, in a system as it operates in India, it would require a network of institutional and administrative units at different levels of operation right from the national to the States/districts/villages. As mentioned earlier, till 1973-74, it has been the single model-single agency approach with KVIC as the only focal institution. KVIC has its network of recognised or affiliated network of institutional units throughout the country which has been utilized in implementing the programme.

By 1970s, when biogas became a part of the national programme, the institutional arrangements have gradually become relatively more structured on the one hand andbroad-based on the other. The monopoly of KVIC has been replaced by a multi-model-multi-agency approach in which a large number of official and non-official agencies/institutions have been involved in implementing the programme under a common fiscal arrangements in terms of subsidies and cash incentives. To the extent it was broad-based, there has been decentralization. However, unlike China, the initiative and responsibility still remained with the organized administrative units- official or non-official -external to the beneficiaries.

Just as the subsidies and cash incentives have been gradually raised to attract more customers in consonance with the urge for achieving expanded targets, administrative cost for staffing administrative units has also to be provided by the government. Similarly, a programme for cash incentives to private motivators at the local level for attracting prospective customers, fees for turn-key constructions by private contractors or entrepreneurs and easy bank loan facilities have also been initiated in India from 1970 onwards. In the early 1980s when NPBD was launched and Janata Model was introduced in a large scale, it became necessary to initiate a systematic training programme for the masons. This was again fully financed and promoted by the concerned government departments operated through a number of official and non-official organizations/institutions. But, perhaps this has been the first organized attempt for creating technical manpower at the local village level and thereby directly involving beneficiaries.

At this stage it would be worthwhile to briefly analyse the issue of subsidy and cash incentive system in India. In fact, this issue has been debated several times by the Indian policy-makers. As mentioned earlier, unlike in China, not only the market segment in India is relatively small, but the motivation for investing in biogas plant among the peasant households has been relatively low, particularly in the absence of any net cash flow of income from the biogas plant except notional. Given the situation, it is generally feared in India that the programme is likely to fail if the direct subsidy is withdrawn and, therefore, it has been continued. This subsidy may be compared to the cost contribution of the collectives in case of China.

There have been a number of organizational thrusts initiated in recent years in India. Firstly, in order to achieve the demonstration effect and multi-benefit impact of biogas programme and also to reduce the administrative costs, there has been deliberate plan to intensify popularization in a cluster of villages (cluster approach). This has a similarity with China's "basically popularized" strategy. Secondly, in order to expand the market segment, there has been a planned programme to popularize medium-size community or group biogas plants.[13] However, in a multi-caste multi-class village structure in India, there are organizational and management problems for community plants. Thirdly, the importance of manure production in biogas plant as equally important

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[13] See Moulik et al, 1983

objective has been revived in its popularization programme in India to the extent that a plan for national demonstration with biomanure has been under operation in collaboration with the Department of Agriculture.

Similarly, a vigorous R&D and promotional efforts have been initiated in relation to use of diversified organic matter as feedstock in order to reduce the dependence on cattledung, as well as for diversifying the end-use of gas mainly for propulsion-energy for pumping irrigation water and generating electricity. Fourthly, there has been a planned intensive publicity campaign on biogas technology using all kinds of media and methods during the last few years which has certainly made the Indian public relatively more aware about the biogas technology and the national programme than it was earlier. The actual fuel crisis particularly the increasing firewood crisis seems to be favourably contributing to attracting public attention to biogas alternative. Lastly, as in China, it has been increasingly felt necessary to integrate biogas programme in India with other ongoing developmental activities which has necessarily brought about close collaboration with and assistance from other government departments, such as , health, rural development, agriculture, environment, etc.

Thus, in the final analysis, the evolution of the institutional system for implementing biogas programme in India and China seems to be progressively shaping towards almost an identical framework. While China found it necessary to move towards relatively more centralization in the sense of standardization and professionalization, India with her expanded national programme had to initiate the process of devolution towards more and more decentralized programme initiatives. Similarly, the emphasis on manure production as objective, cost reduction of technology through promotion of Janata model, diversifying organic matter as feedstock, mass scale training programme for village masons, cash incentives to local motivators and finally integrating with other government departments' programme are some of the elements which India found necessary to initiate in recent years had been the starting strategies in China. In a similar context, China with her focus on standardization had to increase the State's direct financial contribution to the programme (rectification of 2 million non-operating plants were undertaken with full budgetory support from the State) - a process with which India started the programme.

Conclusion : Impact and Future Direction

Given the socio-economic preconditions and the implementation strategies, China has emerged as the leading country in the world in terms of popularization of biogas technology. As compared to India's 0.2 million plants, China's over 7 million family plants and 30,000 community plants in a relatively shorter time span appear to be a success beyond expectation.

Biogas is reported to be used by some 30 million commune members for cooking and lighting.[14] The foregoing discussion indicates the difference between India and China in terms of strategies, policies and institutional interventions for biogas development programme. It also highlights some of the critical limitations and constraints in relation to biogas technology in general and the differential implementation strategies followed by the two countries in particular. It is striking to observe how both the countries, as if through mutual sharing of experiences, are gradually evolving a similar institutional mechanism and strategies.

China's basic philosophy of "walking on two legs" and the strategy of decentralized development of biogas programme with emphasis on full participation and initiative at the rural collective units had certainly major advantages which contributed to her phenomenal success. Over a period of time, however, the same decentralized strategy appears to have caused weakness in planning, coordination and quality control. Thus, China's recent move towards centralization and standardization as compared to India's emphasis on decentralization perhaps indicate the necessity of a proper balance between the two for a programme of biogas development, irrespective of socio-economic factors.

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[14] Office of the National Methane Production Leadership Group, "Methane Production should be Energetically Developed in a Planned Manner", Guanoming Ribeo, 7 March 1980, p.3.

It is clear that the viability and usefulness of biogas technology need to be perceived and promoted with equal emphasis on multi-objective functions rather than focussing on any one. A combination of fuel-energy, manure and sanitation objectives, for example, is relatively more potent for popularization programme.

However, biogas technology in the present state, be it Chinese or Indian, has it serious technological limitations, such as reduction of gas production in winter. Just as serious scientific efforts are needed to solve these technological problems, clear government commitment in [illegible] terms of financial and administrative support are equally important in the diffusion programme.

In both India and China, some adverse social consequences have been attributed to biogas programme. In India, because of its emphasis on cooking energy cowdung as feedstock, there is a technological determinism in the sense that only a small relatively richer peasants have been benefitted by biogas programme. There is a serious limitation in terms of potential market segment for biogas technology in India. One way to solve this problem is large-size community plants, which are already being experimented with. The other ways could be diversifying biomass feedstock and more efficient microbial processes.

But a still more serious social consequence anticipated in India has been the deprivation of the poorer section from the access of free dung collection for fuel need, as it is presently practised widely. Such a possibility is anticipated if and when family digestor programme reaches cruising speed when large number of potential users (with 5 or more cattleheed) adopting biogas plant, importance of manure from biogas plant is highly valued to the extent that it assumes commercial market price and as a result the potential biogas users starting penning down cattle or collect dung from the open grazing field by themselves depriving the poor. This means a total revolution in their present practices including substantial investment in cattle-shed, digestor and labour. It is doubtful whether biogas could be a sufficient reason for such a revolution in India. Neither would it look worthwhile investment for the Indian peasants.

Similar problems are also raised in the case of China. The high concentration of biogas plants in Sichuan and China's policy of "basically popularized" in a relatively rich and climatically suitable communes bring the issue of adverse social consequences about discrimination between rich and poor. The diffusion of biogas technology in China corresponds to patterns of income accessibility, education and direct access to city leadership. As a result, there are conspicuous regional differences. Partly, this difference is due to the technological fact in the sense that areas, particularly, northern China are plagued with severe winter for a long period of time. Whatever might be the reasons, China has to address this problem appropriately in her future course of action. This is particularly important in view of China's recent policy on modernization and introduction of responsibility system in the commune structure.

In conclusion, it is important to note that inspite of limitations and constraints and despite changes in external factors and internal policies, both India and China seem to be committed for a larger and accelerated program in future. What is, however, important is sharing of experience and learning from each other.

It is in the spirit of experience-sharing, the following guidelines for future course of action are summarized in view of the transferability of the lessons learned from India and China.

1) Like many other development programmes, a widespread diffusion of biogas in a country seems to be largely dependent on a definite political commitment as a part of the broader national policy. The national political and government commitment in terms of financial and institutional support is particularly important for successful diffusion of biogas programme mainly due to :

(a) The economies of many developing countries are often characterized by extensive subsidies on conventional energy and fertilizers. As a result, the economic and financial viability of biogas is often marginal or even negative.

(b) On the other hand, biogas is associated with a number of non-monetized social benefits, which makes the biogas programme highly viable and profitable particularly, considering the broader macro level socio-economic justification.

(c) There is a considerable scope for improving the existing knowledge of biogas technology, relevant to varying country-specific situations. This means that there is a necessity for programme of coordinated indigenous R&D and field ex-experimentation - a programme which can and should be undertaken by the concerned government fully supported by the government resources.

2) Biogas programme in a country necessarily passes through two broadly defined phases : first, experimental and developmental stage in the sense that the technology is being tested and replicated in the field, second, extension and mass diffusion stage. In fact, the biogas programmes in different countries, particularly, developing countries can be classified into these two broad stages. The organizational and institutional requirements for the two different levels of programme are appropriately different. In the first stage, it is possible for an appropriate existing organization or institution to implement the programme as a part of its ongoing programmes, without burdening with unnecessary overhead and other infrastructural costs. In most cases, it could be the Agriculture Department. In the second stage, it is necessary to have a definite organizational and institutional identity exclusively for biogas programme, in the sense that an exclusive biogas organization becomes necessary or useful.

3) It should be noted that whether it is a part of the existing organization or institution's programme or a programme implemented by an exclusive organization/institution, by its very nature of the technology, it requires an interdisciplinary approach in order to maximize its multiplier impact. This suggests the necessity for strengthening the interface between the biogas programme and other developmental programmes (e.g. agriculture, rural development, forestry, animal husbandary etc.).

4) The interdisciplinary approach with strong interfaces with other developmental programmes is crucial for biogas programme in order to ensure the broadbasing of the beneficiaries across the socio-economic classes. Unlike many other programmes, technologically biogas is dependent on the local availability of basic raw material input and, therefore, the access or control or ownership of the raw material input determines the relevance of biogas to a particular section of the people. The importance of the existing socio-economic structure in terms of access to basic resources is perhaps not so crucial in many other technologies as in the case of biogas. Integrating biogas as a part of the overall developmental programme with suitable institutional interventions (community or institutional biogas plant as utility service facility) could be the answer for minimizing these constraints.

5) Operationally, the biogas programme requires two levels of organizational and institutional arrangements - centralized and decentralised. Centralized organisational functions may include, coordinated R&D activities, policies/strategy formulation, administrative and financial support delivery, manpower training, and information dissemination. On the other hand, implementation of biogas programme can best be done through decentralized operations which may include, pilot demonstrations, actual construction of plants, servicing/maintenance of the plants, motivating the beneficiaries, local level training and supervision. It is in this decentralized implementation programme a multi-agency approach including non-governmental organizations (NGO's e.g. voluntary organization and cooperatives) may be crucial. However, it should be noted that there cannot be a single blue-print about the balance between centralized and decentralized operations. The optimal and pragmatic balance would vary according to country-specific politico-economic-geographical situations.

6) It is mentioned earlier that a continuous R&D, both adaptive/developmental as well as basic is an important element for successful implementation of the biogas programme. This means creating a critical mass of scientific institutions and scientific manpower abreast with development of biogas technology in the world. Just as professionalizationans standardization are necessary, this should not be end by itself as island of scientific excellence and laboratory experience. All these scientific institutions and scientific manpower

should necessarily be linked with decentralized implementing agencies inorder to test and demonstrate the innovations in the field with the potential customers or users.

7) Lastly, the role of developmental assistance from various international AID agencies could be substantial in promoting biogas programme. The level and quantum of assistance will naturally differ according to country-specific situations. Broadly, the AID agencies may provide assistance in the following activities:

i) Provide continued assistance for research and development, with emphasis on technology and economic relevant to country-specific local conditions.

ii) Provide assistance in pilot demonstrations and evaluations.

iii) Assisting in manpower training and creating R&D institutions.

iv) Funding cross-country research on biogas programme in order to obtain the comparative perspectives between programmes in relation to technology, economics, social and institutional arrangements.

v) Creating information base to disseminate knowledge through network communication, workshop and seminar.

vi) Funding inter-country visits and consulting services.