Cooking with Firewood
- The Burning Issue

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Preface

There are several dimensions to the firewood burning issue:

How to economise on its use

How to grow more fuel wood

How to develop substitutes

This preliminary paper is limited to a survey of what has been done or is being done with regard to the question of economical use of firewood through improved (cooking stoves) chulahs, what kind of improved chulahs have been developed, how they have been extended in the field and with what results.

Limitation of time and resources has restricted the coverage of the paper but it does provide enough material for starting a discussion on this neglected, albeit vital subject from the view point of energy, households, women and health.

Devaki Jain

An Effluent Chulah for the Rural Women

There is a growing realisation today among socic-ogists and development experts that mere economic growth and technical innovation do not by themselves constitute development. Urgent attention must also be paid to amoliorating the working and living conditions of the underdeveloped. Improved tachnology and a stronger economy must be harnessed to serve this end. Only thus can the people - the poor - truly benefit from the fruits of development and proceed towards that freedom of spirit and mind which is the ultimate human goal.

To the uninitiated and unquestioning mind, the cry for an improved chulah might sound irrelevant and almost esoteric. However, a closer, harder look soon reveals the important and far reaching significance of this issue.

The 'chulah' is that ubiquitous device which is tied up with the daily life of the family especially the women. Urban women now have electric ranges, gan or kerosene stoves to cook on. The rural women have almost no choice and no alternative. A vast majority of these women spend a large part of their time in procuring fuel, tending fires and cooking to nutture their families.

The cooking device that they normally use is the open-fire chulah made out of mud or bricks or stones, and fuel is usually fire wood or cowdung or agricultural residues. These smoky, primitive unhygenic and wasteful chulahs constitute a national problem, affecting health, housing, fuel economy and forest economy.

Therefore, providing an improved chulah, by doing away with some of its major draw backs, is as basic a need for the rural woman, as safe drinking-water, sanitary toilets, housing, primary health case and primary education. The attempt here is to study the dimensions of the problem, its socio-economic implications, the efforts at developing an improved model/design, the difficulties faced with extension programmes and finally suggestions as to possible lines of research and development for the future.

Draw backs of the Open-fire Chulah

Before talking of improvements, it would be a good idea to study the drawbacks of the commonly used open-fire chulah. The first thing that comes to mind is the smoke, which is irritating and injurious to the eyes. It also blackens the room, making it gloomy and stuffy. This and the open nature of the fire are hazardous to health and life since the risk of accidents is high.

Secondly, the constant blowing and fanning required for lighting and tending the fire, are tedious and consume and inordinate amount of time and energy.

Thirdly, cooking time itself is slow, the heat cannot be controlled or adjusted to suit different cooking needs.

Fourthly, in hot, damp climates, the intense direct heat of the open chulah causes profuse perspiration and severe prickly heat. For example, in West Bengal this is a common problem and often leads to serious skin ailments.

Next, one comes to the drawbacks with respect to fuel consumption. In the common chulah, there is great wastage of heat and therefore, of precious fuel. It is estimated that in open-fire cooking only 5-10 per cent of the potential energy in the fuel wood is utilised.

In view of the world wide fuel crisis, fuel economy and conservation, gains added importance. Shortage of fuel wood is a crisis of rural areas. With the depletion of forests, more and more time has to be spent in collecting fuel wood or substitutes for the hearth - e.g. the acute problem faced by the people of Chamoli district in Uttar Pradesh, a similar problem was heard from women of as far a place as Mizoram.

The use of cowdung cakes is uneconomical considering the labour and time required for collecting, dung making and drying the cakes and the low heat efficiency of this fuel. The dung would be far more valuable as organic fertilizer for the soil or to produce methane in a gobar-gas plant. Other fuels like kerosene, gas or coal are not feasible either, because apart from the expenses of processing and transportation the rural population has little access to them.

Research on biogas and solar energy for fuel is promising but achieving a breakthrough on a mass scale, is yet a long way-off. Simultaneous and serious research is required on simpler, intermediate technology, which would be applicable in the immediate future and practicable in the most primitive areas to reach the poorest of the poor.

What is needed is an efficient chulah which is safe smokeless, economical in terms of fuel and time and where the heat can be controlled and adjusted. Further, it should be portable and cheap to build and there should be scope for adaptation to the special needs of a particular region or community. This might sound like a tall order but it is surely not impossible in a world where such impressive advances have been made by science and technology.

Brief Review of Research

In India, efforts at improving the indigenous model started early enough. In the early fifties, the Magan chulah and the HERL (Hyderabad Engineering Research Laboratories) chulah were developed. The HERL chulah design was exported to various other countries and gained acceptance in a modified form in Egypt and Ghana.

The Magan chulah provided the prototype for the Lorena stove, which is being propagated vigorously in Gautemala and other South American countries.

Both these designs were tried out and publicis[illegible] in India in the fifties, but failed to achieve the expected success and acceptance. The reasons for this failure will be dealt with later.

Polytechnics and other technical institutions and universitites have experimented with chulah designs from time to time. The planning Research and Action Institute at Lucknow, developed and tried out a design at Bakshi-ka-Talab in U.P. in the fifties and early sixties. In 1970, the National Buildings Organization published a study on the efficiency of several chulah designs. Fifty five different chulah designs used in various parts of the country were collected; of these nine were selected for systomatic testing at the PRAI laboratories, to study their relative merits and efficiency. Out of these, the two most satisfactory models were tested in users homes and their opinion obtained. Finally, two designs were selected by PRAI-one for stoves using soft coke or coal and the other using firewood.

In more recent times, an improved chulah design has been suggested by Dr. Salariya of Punjab Agricultural University. The Central Mechanical Engineering Research Institute at Durgapur has also developed a new chulah model.

Interest and experimentation on an economically smokeless cookstove has been evident in other parts of the world too. An improved Rice - Hull stove has been developed in the Philippines and is gaining sider acceptance as other energy sources become scarce. International agencies like FAO (Food and Agricultural Organisation) and UNICEF have been aware of the importance and need for an efficient chulah and have collected and published designs and ideas from all over the world and have founded some extension programmes. Several international appropriate technology organisations are keenly interested in finding a suitable cookstove model specially for propagation in rurul areas.

Improved Models

HERL Chulah

Research on a "thermally efficient cooking stove which would be simple and cheap and could be built with earth and earth products by village craftsman and housewives themselves" - was started at the Hyderabad Engineering Research Laboratories in 1946. The chulah developed at HERL, was also known as the Raju chulah, after the Director of the Institute who showed keen interest in the project. The new design was quite a break-through innovation at that time.

It was designed "as a simple structure" built of only mud or brick and mud plastered with fine earth. It consisted of an 'L' shaped duct with one, two or three holes for cooking pots and an opening for the firewood. At the end of the duct was an arrangement for a big pot of water where the hot gases, before going out, would be further utilised, thus providing an automatic supply of hot water for the family. The gases would finally be taken out of the cooking range by means of a chimney which could be made of clay pipes, bricks, country tiles or metal. The thermal efficiency of this chulah was claimed to be far greater than the usual open chulah.

Lit in the usual way, the flame is maintained by a natural draught ensured by the design. Firewood, cowdung cakes or other combustible form of household waste can be used as fuel, all holes are to be covered or sealed while lighting the fire and cooking, otherwise back draught or smoke could occur. All three holes can be used at one time.

This design can also be adapted for burning coal or charcoal and enlarged for use in institutions. Later on, alternative design was evolved where the slopping fire was replaced by a straight one; the floor of the first holo where the fuel was burnt was kept while the floor of the ducts and remaining cooking holes were raised 3" above the floor, leaving an opening of 2" below the roof. The last duct before the water heater was tapered as before and provided with a damper suitably shaped for futher regulations of draught. A clay baffle 1" x 1" x 6" could also be placed in the centre of the second or third cooking hole and could serve as a hurdle for the gases to be lifted towards the pot and transmit more heat.

A mould was also developed at HERL to facilitate fabrication of this model.

<u>Magan chulah</u>

The Magan chulah, named after Shri Maganlal Bagri, was developed at Wardha at about the same time as the HERL model. The principles used were similar - an internal flue to connect the different holes to the fire hole, a chimney to carry away smoke and also to provide the necessary draught to light and maintain the fire.

However, the suggested method of building the chulah was different. For this, first a solid block wasto be made out of a mixture of mud-clay, fine-cut hay and cowdung. When this dried, the cooking holes were to be cut or dug out of the block so that their centres formed an equilateral triangle. Then the holes had to be joined by tunnelling through, to form an indirect slopping flue to the chimney. These could be made of pot tiles, old-tin, asbestos or zinc sheet. Iron grates were to be placed in all the cooking holes. The block was finally carved into a semi-circular shape.

Variations and modifications of these two stove designs have been experimented with over the years. "Typically, design modifications changed the outward shape or size of the stoves, altered the internal course and/or cross-sectional size of the flue channels, modified the fire-box size and/or shape, rearranged the location of dampers, and incorporated slightly different methods of and materials for construction of the stove, especially the chimney.

Bakshi Ka Talab Chulah (PRAI Design)

This design incorporated adjustments and modifications based on the observations made from different series of experiments. There was provision for providing 2 pots seats and two dampers, one horizontal and the other vertical. With this arrangement, it was possible to regulate heat in the first pot seat. A second damper provides retention of the heat in the second pot's seat and that the same time allows free movement of smoke because it is perforated and thus is not disturbed while cooking. This arrangement is useful as housewives often forget to regulate this damper.

This model with a dimension of 30" x 16" x 8" was more compact than the models designed earlier. The chulah could be made out of a mud and bhoora mixture, the chimney of locally made burnt clay pipes. First, the block was built up and then the pot-seats and flue were to be carved out, then the whole structure topped with mud-paste. A cowl covered the chimney top to prevent ontry of rain water. The cost was minimal as indigenous materials were used.

A mould was also designed to facilitate rapid construction according to technical specifications, in rural areas. The mould was made of iron, in several bits and the cost was about Rs.80 in the fifties.

New PRAI Model Selected in WBO Study

The new PRAI model for a firewood stove is a modified simplified version of the Bakshi-ka-Talab design. This consisted of a square mud block with one open-ended fire-hole cum main pot-seat, a second pot-seat just behind and a right-angled flue leading to a down cast chimney. The compactness of this design as compared to previous designs was a point in its favour. Another improvement was the open ended main pot-seat in which chapathis could be roasted on the tawa and puffed on the flame underneath in a continuous process. Thus one major complaint of earlier designs was eliminated. This design kept as close as possible to the traditional shape and design while introducing the crucial modifications.

Gujarat Chulah

The chulah design being propagated in Gujarat is also a two-hole type, the chimney with a cowl being in the same straight line as the pot-seats. The flue is flat and straight, the firehole is large and a damper is provided between the two pot-seats.

Ludhiana Design

According to Dr. Salariya of Punjab Agricultural University, Ludhiana, this model was designed "so that heat losses through the walls is utilised to heat water". The new chulah is similar to the common chulah except that its outer casing forms a double walled chamber which serves as a water-jacket. It's inside is lined with water through the funnel provided at the rear top of the chulah and the hot water can be drained out from the tap fitted at a lower level.

The water jacket is 5 cm thick all over and has a capacity of 30 litres. The chulah measures 62 cm is the length 40 cms is the breadth and 32 cms is the height. This design gives an economy of 9% which is achieved by heating water while cooking is going on. The cost would be about Rs.40.

The overall economy could be further improved by embedding it completely in mud, i.e. by covering it on all sides by a 10 cm. thick layer of clay or bricks and clay. This would insulate the water - jacket and reduce heat losses to a minimum, resulting in considerable economy of fuel.

FAO Approved Designs

The FAO Has collected wood-stove designs from all over the world. The ones selected for their series on Rural home techniques, are based on similar principals as the designs developed in India.

The suggested methods of construction are:

1. Either the stoves can be moulded directly from the clay-mix or

2. Built of bricks moulded from clay-mix which are then sun dried or burnt in an oven. A cooker moulded from clay would last approximately one year, while one of sun-dried bricks could be expected to last much longer.

Basic Guidelines for Proper Use of Improved Models

The designs recommended are both of the high platform and low platform type, with straight or indirect flues to the chimney, and with the number of pot-seats required by individual users.

Certain basic guidelines must be observed in order to obtain efficient functioning of all these chulah design as wood burns comparatively quickly with a very long flame, requiring little oxygen.

1. the hearth must be blocked, with limited air-intake to ensure controlled combustion

2. flues, for flames and fumes, must be built in to concentrate heat at the cooking-holes before it is carried out of the stove.

3. the chimney is essential to lead off fumes and provide a draught of air which is necessary for combustion.

4. for cleaning, all openings should be closed first and the ashes removed from the fire-box.

5. for laying the fire, a base of wood - shavings or other available tinder or crumpled paper should be made, then small pieces of wood added and topped by larger logs chopped to size.

6. to increase heat, the fuel door must be closed with the cover leaving open only the small hole in it. To lower the heat, the hole in the cover should be half closed. To extinguish the hole should be completely closed.

7. pots and pans should fit the cooking holes closely. The base of the cooking utensil should be 3-5 cm. (1-2") below the surface of the hole.

8. an unused cooking hole should always be covered. For smaller sized pans, rings or plate washers can be used.

9. the cooker should be cleaned regularly and all damaged pieces patched immediately.

10. the chimney must be maintained by cleaning and removal of all soot at least once in six months.

The use of wet or damp wood causes damage to the chimney through accumulation of pitch-resin leading to risk of fire. Heavily coted chimneys should be replaced.

Designs for Coal Stoves

Fire wood is the most commonly used fuel for the rural cookstove, but coal and charcoal are also used in some regions where they are easily available and comparatively cheaper as in West Bengal and Bihar. Hence, some improved models have been designed for coal stoves too.

The 'HERL' model could be adapted for burning coal. Two openings are provided adjacent to the two pot-seats for cleaning out the ash, and grates are placed on the pot-seats. The openings for the hot-water pot, the chimney and the flue, remain the same.

The NBO study also selected a coal stove with the two cooking holes with grates, an internal flue joining them to a chimney, with a damper and provision of 2 holes with covers in front, for cleaning out ash. The damper has to be manouvered to induce draught to light the fire quickly and to regulate it.

Extension Efforts and Their Results

Having discussed the various design and modifications of the chulah, that have been developed, one comes now to the extension in the field.

In the fifties, the project for an improved smokeless chulah was taken up at the government level and sought to be implemented by the Directorate of Extension. The scheme was one of several others for community development and social welfare, entrusted to the gram sevikas or village level workers, for propagation. Targets were fixed and the workers did what they could. Obviously, their efforts were not adequate in approach or in terms of perseverance and zeal. The scheme is supposed to have failed badly and backfired. So much so that, the new chulahs had to be destroyed to calm irate villagers whose houses had filled up with smoke from the smokeless chulah. The scheme was dropped and since then, considerable scepticism seems to have gripped concerned government officials, regarding the smokeless chulah.

In more recent times, the National Buildings Organisations has tried to propogate the improved and simplified model of the chulah (Now PRAI design). They build them in their demonstration Housing Clusters in nine Rural Housing Wings all over the country. They have also exhibited the model at Trade and Agro Industrial Fairs and at other sites. They too report poor response and poor acceptance of the smokeless chulah.

The reasons for this negative response are not too difficult to understand. When the early smokeless chulahs were tried out - the psychological and socio-economic climate in rural India was not ripe for it. Not enough research was done before advocating the new designs to the rural users. There was a gap between the research and the practical demonstration stage. For example, in the NBO study, only urban and not rural users were asked to try out and comment on the selected models.

The new chulahs were bulky, fixed to the floor and even too complicated for the illiterate villagers. These responsible for implementing the project didinot have the patience and time to explain the functioning properly to users For example, the importance of keeping all fire-holes covered while lighting the chulah and cooking, was not impressed on the users. Thus back draught was created, and caused smoke to flow back into the room. Also, quite often the design specifications were not followed accurately while constructing the chulah. Defects resulting from this could mean increased fuel consumption and other problems making the villagers wary of the chulah.

Recognizing the importance of correct construction, the voluntary organisation, AFPRO (Action for Food Production), includes construction of chulahs in their training programmes for masons from all over the country.

Although simple enough, the chulahs must be carefully constructed if the efficiency claimed for them by the research organisations is to be experienced by the village.

Another factor against existing designs is that of portability. Specially in northern India, women do not like to have fixed kitchens. They like to be able to move the chulah indoors or outdoors according to the season and to their convenience. Further south, these designs could find greater acceptability if properly introduced - as kitchen pride is strong among people of these regions.

Today, with a shortage of firewood and the energy crisis, the conditions of life has changed even in the rural areas. Greater awareness and expectation of the masses and especially arousing of women to some extent - the whole climate is very different from thirty years back. The time is ripe for serious efforts at development of appropriate models and sustained extension programmes. But projects must be carefully worked out and systematically introduced if acceptance by the people is to be gained. Experience in the field shows that where adequate ground work has preceded the introduction of the improved models and where care has been taken to communicate instructions, and guidelines regarding proper handling to users, these models have proved successful and have been accepted. Of course, further research on designs is called for, but more crucial is the formulation of the correct methodology for introduction and implementation of the programme.

The people must be persuaded and convinced of their efficiency in terms of fuel, time, convenience, elimination of smoke and other advantages. Only then will this improved smokeless fuel-saving cooking devices find wide acceptance among those for whom they are intended.

The extension schemes on the smokeless chulah are being implemented steadily in Gujarat. This seems to be the only State with a visible and encouraging programme.

Under the 'Gram Safai Scheme' and Rural House Reconstruction Schemes, 10,945 smokeless ovens were installed between 1976-79. In 1979-80, the State

Government provided Rs.12 lakhs for ventilations and smokeless ovens to some 8,000 houses in rural areas.

As in the case of sanitary latrines, the interest and inspiration of Sri Iswarbhai Patel and the good work of the Safai Vidyalaya has contributed largely to the effective implementation programme.

Agencies like UNICEF and CARE have disbursed funds to several States for rural development schemes which included installation of smokeless chulahs. One such scheme is the 'Composite Programme for Women and pre-school Children' (CPWPC) undertaken in Kerala, with UNICEF aid. However, there is no readily available data as to exactly how many chulahs have been installed and at what cost? In Punjab and Haryana too, some improved chulahs have been installed but there is no large scale or consistent programme.

With the new interest and awareness of the concept of social forestry, the related issue of the smokeless, fuel, saving chulah is beginning to draw the attention of the powers that be.

It is noted that fossil fuels are non-removable and are being depleted rapidly. In contrast, forests are renewable and if properly nurtured and managed, can meet to-morrow's energy needs. Mr. M.S. Swaminathan points out that "In the years to come, countries whose wealth depends mainly on renewable resources will be the ones who are economically strong".

Keeping this view point in focus, the twin projects of smokeless fuel saving ovens and village wood-lots to service their energy needs, emerge as very relevant solutions in the economics of development. These projects need to be taken up with vigour. Research on a realistic practical basis should go on side by side with effective implementation of viable schemes.

Some R&D organisations must come forward to pick up the challenge.

BIOGAS : SOME ISSUES

A Discussion Paper prepared by L C Jain and Alok Jha for the Gandhi Peace Centre and the Industrial Development Services

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CONTENTS

I Status

1 There are an estimated 100 million rural households in India. These households mainly depend on firewood and cowdung cakes as fuel for cooking their food and heating water. Their access to commercial fuels (electricity, coal, kerosene) is limited. Table 1 shows the pattern of energy consumption, by source, in India's rural and urban households.

2. Cowdung is likely to continue as an important source of fuel since India has a large livestock population - estimated at 366 million as per 1976 Livestock Census. In fact, the consumption of dung as fuel between 1961 and 1971 increased from 22.15 crmt to 26.91 crmt*.

3 There are, however, serious disadvantages/deficiencies in the present pattern of use of dung as fuel. The question is how to make the best use of dung, which is a renewable source of energy, for fuel and otherpurposes.

4. When dung (cakes) is burnt as fuel, the fertiliser potential of dung and the nutrients it could provide to the soil are lost. And when dung is used only as fertiliser - compost - its fuel value is lost. Besides, the prevalent manner of using dung as fuel is highly inefficient - the thermal efficiency obtained is less than ten per cent of its potential calorific value, 230 kcal per kg. against 209 koal per kg. Considerable losses are also observed in the prevalent method of composting without cover - time taken for maturing is between 120 to 150 days and losses upto 45%. It the mannure is composted under cover, the time taken for maturing is reduced to 90 to 100 days with losses upto 25%. However, if the dung is digested in a gas plant, the digested slurry takes only 7-1[illegible]%.

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* Coal Replacement Million Tonnes

Besides using dung in a gas-plant, the gases generated could be used as fuel.(1)

5 It is for these reasons that there is a world wide interest in developing bio gas plants, using dung as well as human excreta and agricultural wastes for fuel and fertilizer.

6. Many countries including India have been engaged in research on developing the most efficient and economical type of bio gas plants to suit individual households, communities and as energy suppliers for agricultural and industrial purposes.

7 The first biogas plant was constructed in 1946 in India long before any other country except Germany. By March 1980 only 80,113 gas plants had been set up in India.

8 The khadi and village Industries Commission is the principal agency in the country involved in R & D, extension and subsidisation of biogas plants. Planning Research and Development (PRAD) of U.P. Government is another agency which has notable contribution to R & D on bio gas generation and utilisation. A brief note of R & D work on biogas by important agencies is given in Appendix I.

9 An overview of the status of these efforts is provided by the Department of Science and Technology (DST) in its Annual Report 1979-80:

> BioGas Technology and Utilisation:
>
> Recognizing the importance of biogas systems as a source of fuel and fertilizer and for utilization of agricultural residues, a time bound, results oriented All India Coordinated programme covering this area involving several research centres, has been sponsored by the Department. The first phase of this project was over by March 1979. Considerable progress has been made during the first phase; and the work plan as envisaged at the time of formulation

(1) Bio gas Achievement and Challenges, M Sathinathan, AVARD.

of the project has almost been completed. The significant results achieved in this phase are: design and fabrication of a comparatively cheaper design namely 'Janata Biogas Plant'; development of ferro cement gas holders; development of cheaper and high capacity, industrial burners; optimisation of various parameters to use alternate feeds such as castor meal, water hyacinth, and other agricultural residues; effect of the addition of various additives like urea, urine, organic and inorganic salts for increased gas production etc.

As considerable work has already been done on the family size biogas plants, various aspects of community type biogas plants have been taken up in the second phase of the All India Coordinated project. Khadi and Village Industries Commission Bombay, Planning and Action Research Division Lucknow, Structural Engineering Research Centre, Roorkee and Central Building Research Institute, Roorkee are implementing the project in colse collaboration. Intensive and extensive sutdies on community type biogas plants from the socio economic administrative, management and technical aspects are being conducted. To evolve appropriate design data and suitable norms for wider application of biogas technology in different agroclimatic regions of the country and differing economic conditions, investigations on gas distribution system, anticorrosion paints, masonry structures, leakage problems, soil effect and permeability, etc are under progress. Six community plants of different designs and sizes are being installed; and for these plants the spade work relating to preliminary survey and study of the base line energy requirement of several villages has been completed.

Six regional centres in different parts of the country have also been established by KVIC to study and evaluate the performance of different designs of plants and to collect data on an yearly basis for comparative analysis. A programme in collaboration with State extension agencies has been started by PRAD, Lucknow to train masons/supervisors to improve the workmanship in the construction of the plants.

At two centres viz. Maharashtra Association for Cultivation of Science (MACS), Pune and Punjab

Agricultural University (PAU) Ludhiana R & D work on use of agricultural resideus and studies relating to digestion and Microbiological aspects, are in progress; the development of 'Kachra' biogas plant to utilise industrial agricultural, domestic wastes has been supported. At MACS, Pune promising results have been obtained on the digestion of dry cowdung cake, isolation of methano-bacteria and optimisation of fermentation parameters. At PAU, Ludhiana, the design of the Kachra gas plant is being perfected and data in respect of different types of biomass and the digestion parameters has been collected.

10 The procedure for installation of biogas plants is that a rural household has to apply on the preseribed form to either one of the 17 state offices of the KVIC or to the State Khadi Khadi and Village Industries Boards which exist in 21 states and Union Territories. The same network provides technical and financial assistance including (i) scrutiny of proposals and recommendations of financial assistance (ii) the survey of site for location of plant and (iii) supervising the construction and ensuring its satisfatory operation.

11 For subsidy, KVIC is not the only source now. The Ministry of Agriculture has also started to provide subsidy of 25 per cent to small and marginal farmers for biogas plants of 2-3 m^3 capacity; and 50 per cent for biogas plants installed in hill and notified tribal areas. A general subsidy of 20 per cent is provided for all household biogas plants not covered by above categories. KVIC also has a scheme to provide75 per cent subsidy for all gas plants constructed by Scheduled Castes and Scheduled Tribes households (inclusive of subsidy available from the Ministry of Agriculture).

In addition, loans can also be arranged from banks for the following purposes: (a) for latrines @ Rs. 400 per latrine, (b) loan for gas utilisation i.e. for fitting of additional pipe line, to be given according to the requirements and (c) in case sufficient gas is available and is to be used for generation of motive power, additional loan @ Rs. 1200 per H.P. of the engine.

12 A Statewise list of biogas plants installed upto 1979-80 is given in Table 2. Four States (Gujarat , Haryana Maharashtra, and UP) account for more than 50 per cent of the plants. Between 1976 and 1979 the number of plants increased from about 27,000 to 80,000.

II COMMENTS

13 Although the number of biogas plants in India is likely to go upto 85,000 by 1980-81, the progress is strikingly slow considering that (a) the first biogas plant was constructed in India in 1946 long before any other country except Germany (b) there are about 100 million rural households in India and even one per cent coverage means one million biogas plants; and (c) China which entered the field at a late stage, around 1973-74, has reportedly constructed 7 million plants - an impressive performance even in allowance is made for about 3 million plants which it is believed are not working.

14 The reasons for India's poor progress are partly technical and partly organisational.

15 There are undoubtedly some unresolved technical issues which several Indian R & D institutions are trying to tackle. But it is difficult to ascribe the slow progress entirely to this factor. The review by DST of India's R & D efforts in biogas technology for household biogas plants acknowledges that 'considerable progress has been made during the first phase ...... The significant results acheived in this phase are: design and fabrication of a comparatively cheaper design namely Janata Biogas Plant' But there is no visible push to instal them on any appreciable scale.

There is also a view that India's progress cannot and should not be compared with that of China. It is argued that the design problems related to biogas plants in China are relatively easy since the Chinese are interested primarily in fertilizer (and little in fuel) from biogas plants:

> At present, there is unnecessary controversy between two gobar gas models - one designed by KVIC(India) and the other by China

> People fail to understand that there is little ground for comparison between the two designs as the priorities of thesd two countries are entirely different. China is more pre-occupied with the manufacture of manure than bio-gas production. Consequently, even human excreta, piggery waste agricultural residues are used to produce maure. India on the other hand is more concerned with both manure production and fuel saving measures (2).

16 The available literature from China however points to the contrary:

> Solving the Fuel Problem: The development of biogas in an important route to the solution of the fuel problem in the coutryside, and therefore of concern to the entire rural populatiion. The use of biogas, a fuel obtained from inexhaustible biological sources, as a replacement for solid fuels like coal and firewood has brought about a radical change in the history of fuel for rural areas in China. It is an important technical innovation which not only solves the fuel problem for farmers and rural inhabitants, but also saves vast amounts of coal for the state. It thus plays a significant role in stimulating both industrial and agricultural production and in building up cooperation in the countryside. In Sichuan (Szechuan) province several hundreeds of thousands of commune members now have biogas They have transformed themselves from firewood-lacking families into firewood-surplus families.(3)

17 The organisational aspects of the problem therefore deserve greater attention. KVIC provides some clue to these problems:

> In the wake of energy crisis the government introduced Central Subsidy Scheme in the year 1974-75 and the Ministry of Agriculture fixed the responsibility of release of subsidy in some states to state governments and in some states to KVIC. KVIC, however, continue to implement the scheme in hill, border and tribal area under the liberalised pattern of

assistance for weaker sections of the community. In 1979-80 consequent upon the decision of the National Development Council, the subsidy component of the gobar gas scheme was transferred to the State Sector under the head 'development of local manurial resources'. The commission, therefore, had to implement its scheme within the available limited budetary resources.

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The State Government provides capital subsidy to the extent of 25 per cent after the completion certificate has been issued by KVIC's technician/supervisor. The banks usually charge interest at 12 per cent on the loan and the loan is repaid in a period of five years. In the past, the capital subsidy used to be paid by the Ministry of Agriculture, Government of India, through KVIC. Unfortunately, since 1978-79 the scheme of capital subsidy assistance has been passed on to the state governments. The state governments usually accord relatively lower priority to the construction of gobar gas plants and consequently the scheme has received a set back. KVIC has approached the government for bringing the capital subsidy scheme again at the centre so that the gobar gas activity could again gain the lost momentum.

* * *

Gobar gas plant has also received a set back due to unprecedented escalation in the cost of construction of critical raw materials viz. cement and steel. These are not available at controlled rates in a sizeable quantity.

* * *

In certain areas, due to haste, the quality of construction has not been upto the mark. This has adversely affected the gas generation. The supervision has to be improved, especially at the time of constuction and after construction.

18 The crux of the matter is that biogas plants cannot be installed on a large scale in a short period within the confines of the KVIC or the state governments. As Jyoti and Kirti Parikh have observed 'the introduction of such seemingly sensible new technology has failed in the past for want of appropriate management and organisational structures, and consequently, for want of social participation by persons of various income groups'(4). Ashok Khosla also observes that though 'in principle, biogas has much to offer to the poor ..... utilises waste materials to generate .... rich organic fertilizer for agriculture .... eliminates infections diseases and improves public health ..... yet in practice biogas technology has generally not been successful' and concludes with a proposal to establish a Corporation for manufactruing and marketing of biogas plants(5).

19 Action for Food Production (AFPRO) a non profit organisation which has rendered valuable services in developing minor irrigation has now entered the field of extension of biogas plants. It has set up demonstration-cum-training units consisting of a team of five persons each (an experienced technical supervisor, two skilled masons and two helpers) to train local masons while constructing the biogas plants. It also arranges training courses.

20 Under the Community Polytechnics Scheme of the Ministry of Education, 35, Polytechnics have entered the field of rural development since 1978. In one district in M.P., the community polytechnic is reported to have been delegated full authority by the Collector to implement the biogas plants extension programme including issue of cement permits etc.; and the farmers have been greatly enthused.

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(4) Mobilisation and impacts of Bio gas Technologies, Jyoti and Kirti Parikh, IIASA, 1977

(5) Technology Research and Development Enterprise, Ashok Khosla 1980

21 The disbursement of subsidy is reported to be so dilatory, and not free from mal-practices, that its contribution to obstructing the progress of the programme is not inconsiderable. No innovation has been attempted in this matter. If technical assistance is made available from independent sources like AFPRO, community polytechnics and other governmental and non-governmental agencies in rural development field, it should be possible to disburse the subsidy through banks themselves which provide the loan component. The banks in turn should be able to claim the refund of the subsidy amount from designated sources. This will eliminate the necessity ofthe individual farmers having to run from pillar to post.

22 An equally serious aspect of the problem is poor maintenance of the plants. Though no reliable figures are available, it is believed that quite a large number of the 80,000 odd plants installed in India are not functioning. It is necessary therefore to involve a large number of voluntary and other organisations in the essential task of helping the households to maintain the plants. This aspect is not on the agenda ofany official or non official organisations.

23 Special attention also needs to be given to the human excreta based plants. For example, inmany plantations there are workers' colonies including lattrines provided by the plantation management. A systematic programme could be undertaken to introduce biogas plants in all such areas. Similarly in urban or semi urban areas not connected with the sewage system, the workers colonies attached with public and private undertakeings could be fitted with biogas plants to meet both fuel and lighting needs.

24 Regional imbalance in the extension of biogas plants, noted in Table 2, also needs to be corrected. One method

would be to identify encourage and aid voluntary and other technical institutions, especially in the states lagging behind, to provide a shoulder.

25 The Department of Science and Technology should also publish a special six monthly report on the work of its Technical Committee and Design Extension for biogas technology for wider public knowledge

26 There is also need to learn more systematically from the field successes and failures. DST/KVIC/Ministry of Agriculture/AFPRO may therefore sponser some case studies of the biogas plants (in operation or dormant) for an authentic feed back to R & D institutions, funding and extension agencies.

27 For household biogas plants, training should be provided to atleast one male and one female member of the family.

28 For promotion of community size biogas plants on a significant scale and on an assured basis it is mecessary to give serious thought to the suggestion made by Jyoti and Kirti Parikh that 'a pricing poligy for purchase of farmwastes and distribution of gas and fertilizer' should be adopted 'as an essential tool to ensure that no one is worse of by the introduction ofbiogas plants and thus to motivate the required participation in the scheme'.

Table 1 Energy Consumption in Rural and Urban Households in India: Shares of Fuels and Sources of Supply

Energy	Rural per capita energy consumption: % share of energy forms	Rural: % share of source of supply of each form: Purchased	Collected	Home grown	Urban per capita energy consumption: % share of energy forms	Urban: % share source of supply of each form: Purchased	Collected	Home grown
Electricity	0.6	100.0	0.0	0.0	5.9	97.0	3.0	0.0
Oil products	16.9	100.0	0.0	0.0	30.2	100.0	0.0	0.0
Coal products	2.3	65.1	34.9	0.0	13.7	95.6	4.4	0-0
Firewood	68.5	12.7	64.2	23.1	45.5	73.7	14.8	11.5
Animal Dung	8.3	5.1	26.2	68.7	3.2	49.1	12.3	38.6
Others	3.4	8.9	61.0	30.1	1.5	71.2	28.8	0.0
Share of commercial fuels	20%				49%			
Share of non commercial fuel	80%				51%			

Source: Computed from National Sample Survey 28th Round 1975 by T.L. Sankar, in Energy Requirements and conservation in Human Settlements in the ESCAP Region-Nov. 1979

Table 2 Gobar Gas Plants, Statewise 1979-80

(1) States	1976	1979-80
Andhra Pradesh	1235	2756
Assam	29	116
Bihar	1310	6918
Gujarat	4080	10663
Haryana	8526	10521
Himachal Pradesh	10	17
Jammu & Kashmir	27	103
Karnataka	1678	6906
Kerala	490	1389
Madhya Pradesh	952	1883
Maharashtra	3204	10180
Manipur	7	28
Nagaland	-	14
Orissa	87	634
Punjab	1177	5185
Rajasthan	188	435
Tamil Nadu	1177	5439
Tripura	7	100
Uttar Pradesh	2207	14320
West Bdngal	472	2254
(2) Union Territories	125	252
Total	26984	80113

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17 Problems in Adoption of Bio-Gas - Alok B Guha, Specialist, AFPRO, Jan. 1981

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25 Ecodevelopment News, No. 11, December 1979

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36 NEERI-Annual Report 1978-79 and 1979-80

37 Energy Crisis and Gobar Gas-Y A Pandit Rao, 1980

38 Hemalata Dandekar: Gobar Gas Plants - How Appropriate are They? Economic and Political Weekly, Vol.XV, No.20 May 19, 1980

39 Proposal to establish a new development-promoting non-profit corporation to design, produce and market appropriate technologies-Ashok Khosla 1980 Technology Research and Development Enterprise

40 International Energy Studies-Edited by R K Pachauri (c) 1980 Wiley Eastern Limited

APPENDIX I

Institutions Engaged in Research and Development on Bio-gas in India.

KVIC

In 1960-61, the KVIC adopted a design of a biogas plant* In this plant the digester was divided into two chambers by a partition wall. The gas holder has a guide pipe erected in the centre of the digester. It was fed near the bottom of the first chamber. The slurry travelled over the partition wall and left from near the bottom of the second chamber. The gas holder had vertical members at intervals to stir the slurry when the holder was rotated to and fro. This arrangement effectively prevented the formation of matt on the surface of the slurry. This design worked so well that plants installed in 1953-54 were working without a break till 1975. The KVIC has not made any significant changes in the basic design of the plant since its adoption in 1960-61.

However, KVIC has carried out considerable amount of Research and Development work covering various aspects of biogas technology. They have developed atmospheric burners with high efficiency (55-60%). They have also developed gobar gas lamps and adapted diesel engines to work on gobar gas. In the diesel engine only about 10 to 15 per cent of the oil has to be used to fire each power stroke.

The KVIC Gas Plant

The fermentation tank or digester is made of brick and cement mortar. The gas holder is fabricated from mild steel sheets or form fibre glass reinforced polyester. The former though cheaper has to be scrubbed and painted before use. Once installed they have to be periodically protected from corrosion by painting at regular intervals adding to maintenance costs. The latter though expensive will not corrode leading to lesser maintenance costs. Pipes carrying gas are either of galvanised iron or black polythene with an internal diameter of not less than 32mm and wall thickness of 4.7 mm. Polythene pipes are cheap and easy to lay. Inside the house galvanised iron pipes are used. The use of specific construction material and accessories increase the cost

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* developed by J J Patel in 1951

of KVIC plants. It has been estimated that the gas holder and cement together account for 40% of the total cost of installation. The cost of the KVIC plant, and the use of difficult to procure construction material has been the major limitation in large scale adoption. The use of a steel gas holder leads to increased heat losses, resulting in low temperatures during the cold seasons. At low temperature, the methane producing bacteria are not able to function at their optimum level hence the quantity of gas produced is considerably reduced. Aslo a steel gas holder requires an equipped workshop to fabricate them, thereby limiting the extention capability of the plant.

The KVIC is now concentrating its R & D efforts:

1 to reduce the cost of construction of gobar gas plants;

2 to ensure successful functioning of gobar gas plants in cold regions or in high altitudes;

3 use of other alternative raw materials viz. other organic wastes as a substitute or to supplement cowdung.

4 improving the gas burners having a higher efficiency and developing a 100% gas engine by redesigning the existing petrol and diesel engine.

IARI

The IARI took up research of anaerobic fermentation of cowdung in 1939. In 1949, Desai set up a pilot plant with a separate digester and gas plant. A flat cover was bolted to the digester top and gases could not escape leading to bursting out of the digester. This plant was abandoned.

In 1952, Patel's design having the gas holder over the digester itself was incorporated in the IARI design. The chief advantages claimed for the IARI plant was that it is cheaper bot in cost and in scare materials. Unbiscuited bricks and mud mortar was used to build the digesters. Subsequently, biscuited bricks, mud mortar and cement pointing was used. A thinner guage of mild steel plates for the gas holder was also used.

The design was cheap, but, owing to the trouble they gave in use, the IARI design never became popular. Almost all of approximately 500 plants installed between 1955 and 1957 were abandoned in due course, because inexpensiveness was achieved at the cost of efficiency of performance.

PRAD

The Planning Research and Action Division of the State Planning Institute, U.P. has been interested in biogas technologies for nearly two decades since 1957. Through the Gobar Gas Research Centre at Ajmital it had been experimenting on a number of different plants which have been designed by Ram Bux Singh. These plants were designed with both stirring and heating arrangements and were suitable for those regions where the temperature goes below the optimum required for proper digestion. This of course made the initial costs very high. The following types of digesters were developed and their standard drawings prepared:

a. single stage digester
b. two stage digester
c. batch feed digester
d. digesters for cold climate areas

In August 1976, ESCAP news letter had brought out the design of the biogas plant widely prevalent in China. The PRAD got interested in the plant and the construction of the first plant based on the Chinese design was completed in April 1977. The constructed plant was then coated with two covers of enamel paint to avoid gas loss due to absorption in the cement plaster.

The PRAD Gas Plant or Janata Plant

The plant is made of bricks and cement. It is a sort of well, dung and built below the ground. A sloping outlet and inlet reach the bottom of the well on either side of the fermentation tank and have their openings at the ground level. The plant is fed daily and an equal quantity of spent slurry flows out through the outlet. There is no separate gas holder. The gas holder in this type of plant is a brick and reinforced concrete dome shaped structure or a flat slanting roof of the digester itself. The main difference is that the gas holders and the digester are combined in one unit. When the gas is formed, it ascends towards the top of the dome and pushes the effluent down. The displaced level of the effluent thus provides the necessary pressure for the gas.

The following conclusions emerged after working the pilot plant:

1 The cost of a 100 cubic ft. plant will be less than half the cost of a KVIC plant of the same size.

2 Local masons available in villages can do all the construction work

3 The rate of gas production compares favourably with conventional plants having a steel gas holder (0.04 M^3 per kg. of cattle dung at 24-27°C)

4 Life of the plant will be longer, because there is no steel drum hence no corosion.

5 Maintenance costs will be negligible

6 The effluent obtained from the Janata Plant is richer in phosphorus and potassium contents by 2.5. to 6.5% and 7.2 to 18.5 % respectively as compared to previous models.

7 The plant is less susceptible to temperature changes on account of being underground, hence a better yield of gas is obtained during winter months.

R & D Efforts

Successful experiments have also been carried out at Ajitmal to run international combustion engines with biogas. PARD have also developed a gas plant using water Hyacinthas as an input instead of cowdung.

ASTRA

Application of Science and Technology to Rural Areas which is a part of Indian Academy of Sciences, Bangalore, has done considerable research work covering the technical aspect of b iogas technology. Research covering Optimisation of Plant Dimensions was carried out by A K N Reddy etal and the results published in July 1979.[1] It was found that a minimisation of the cost of the cost of the gas holder alone leads to the narrow and deep digesters of the KVIC design. If instead, the total capital cost of the gas holder plus digester is minimised, the optimisation leads to wide and shallow digesters which are less expensive. Such plants were 25 to 40% cheaper and their performance was also slightly better than the conventional KVIC plant.

Other research carried out by ASTRA include 1

1. Performance of a conventional biogas plant
2. Thermal Analysis of biogas plants
3. A novel biogas plant incorporating a solar water heater and solar still.

NEERI

NEERI has done pioneering work with respect to digestion of night soil for gas production. From the parameters obtained from research, NEERI [1] designed a gas plant for the digestion of night soil and cowdung.

It was found that gas produced from 100 percent night soil was about four times the volume of that produced from 100 per cent cowdung on the basis of weight of volatile solids added and about twice time the volume on the basis of weight of volatile solids destroyed. It was therefore obvious that night soil is much better material to digest and gasify than cowdung, hence addition of night soil would increase gas production.

Escorts Scientific Research Centre

Research covering substitution of mineral oil by biogas has been carried out by Escorts Scientific Research Centre. Research was done on the following aspects of diesel engines:

1. Determining biogas introduction system and their metering;

2. Extent of possible replacement of diesel fuel by biogas;

3 Commercial methods of scrubbing the gas for hydrogen sulphide and carbon dioxide;

4 Effect of raw biogas on diesel engine life;

5 Methods of accelerating generation of biogas; and

6 Possibilities of biogas on mobile applications

Kirloskar Oil Engines Limited

Kirloskar has done research covering the use of biogas in diesel engines. The research started in 1976 and they developed an engine by 1977. They have been marketing these pumps since June 1977.

Basically, the Engines developed are based on dual fuel operations. The combustion chamber is filled with a homogeneous mixture of biogas which is ignited by a small quantity of diesel oil. The flame reaches from the spray tip to all parts of the combustion chamber. When the gas gets exhausted, the engine on its own switches over to diesel without the slightest interruption.

Engines from 5 to 12 HP are available. They can be either water or air cooled.

Punjab Agricultural University

The Soils Department of this University is carrying on research with respect to feeding materials. Use of materials like fruit and vegetable wastes and agricultural residues, like straw, are in progress.

The University is also carrying out research, comparing Biogas Plants of various designs, including

KVIC and Janata models.

Other Institutes who are carrying out research and development work on biogas technology in India are given below:

1. Agricultural Tools Research Centre
   Suruchi Campus
   P O Box 4
   Bardoli 394601
   Gujarat State

2. Central Salt & Marine Chemicals Research Instt.,
   Bhavnagar 364002
   Gujarat State

3. Centre of Sciences for Villages
   Department of Energy and Environment
   Maganwadi
   Wardha 442001

4. FAO/UN Regional Project RAS/75/004
   Improving Soil Fertility Through
   Organic Recycling,
   C/o UNDP, P O Box 3095
   New Delhi 110 003

5. Indian Institute of Technology
   Powai
   Bombay 400 076

6. Indian Institute of Technology
   Madras 600 036

7. Indian Institute of Technology
   Hauz Khas
   New Delhi 110 029

8. National Institute of Waste Recycling Technology
   A/18 Juhu Apartments
   Juhu Road
   Santa -Cruz(W)
   Bombay 400 049

9. National Sugar Institute
   Kalyanpur
   Kanpur 209017

10. P S G College of Technology
    Palamedu
    Coimbatore 641004

11 Resources Development Institute
1100 Quarters Area
Bhopal 462016

12 Shri AMM Murugappa Chettiar Research Centre
Tharamani
Madras 600 042

13 Sobic Industrial Consultants
5 V N G Road
Madhavaram Milk Colony
Madras 600051

14 Sri Parasakthi College for Women
Courtallam (via Tenkasi
Tamil Nadu 627802

APPENDIX

Organisations Involved in Extension of Biogas

KVIC

KVIC accepted the plant designed by Patel in 1960-61. From then till 1975 it had constructed about 15000 plants all over India. Because of the Energy crisis and the need to tap alternative sources of energy, a greater emphasis was given to their biogas programme and between 1975 to 1980, another 65000 plants were constructed.

KVIC has been the pioneering organisation carrying out large scale implementation work. They have a number of offices all over India, which provide technical and financial guidance. They help to arrange loans from the banks as well as provide manpower to construct these plants.

However, there are certain inherent limitations with the design which would impede large scale implementation. The use of steel to fabricate the gas holder is one. Steel is not available easily and to fabricate gas holders from it, equipped workshops with trained personnel are needed. Gas holders are fabricated where facilities are available and then transported to the site.

KVIC has developed the best infractructural facilities for large scale extention of bio gas. However, they are constructing plants which were adopted by them in 1960-61. They are not constructing Janata Model Plants as yet.

NEERI

NEERI is concerned mainly with waste utilisation and their safe disposal. A few plants that have been constructed by NEERI use night soil as the main input. NEERI has constructed a plant at theNagpur Central Jail which utilises the night soil of the inhabitants and the gas produced is used for cooking in the prison itself.

PRAD

PRAD is helping the extention of the Janata biogas plant developed by the Gobar Gas Research Station, Ajitmal. The Janata Biogas Plant is a proven and accepted technology.

The government of Uttar Pradesh decided to construct 10,000 Janata Plants in 1979-80. To construct a Janata Plant, it was felt that the first step should be to train masons and supervisors in construction techniques and training programmes were taken up at twenty one centres.

The Janata Plant besides being less expensive, does not use steel has lesser maintenance expenses and can be constructed completely underground.

However, one major problem exists in the Janata Plant. If the plant is not constructed propoerly, the possibility of leakages is very high. This is a major limitation in large scale implementation of such a Plant. Trained masons have to be available for the construction of such plants.

AFPRO

In 1978, AFPRO decided to get involved in the field of appropriate technology related to Agricultural and Rural Development. One of the technologies selected by AFPRO for Promotion and Extention was biogas.

AFPRO decided to systematically promote the Janata biogas plant through voluntary agencies operating at the grass root level. For the construction of successful Janata biogas plants, it was imperative that masons be trained in construction techniques. With this in mind, AFPRO organised several regional training workshops during 1980 and have planned many more for 1981. The masons are sponsored by various voluntary agencies. However, due to lack of manpower and financial resources, only 10 masons can be trained at one time.

AFPRO has also been retained to construct a number of plants for various organisations. They are also installing a Janata Plant which works using Night soil in West Bengal.

In the past AFPRO has been only connected with Extention work. However, during 1981, they plan to construct about 50 plants which would use a mixture of lime stone and surkhi instead of cement. If plants can be constructed using the above substitute, it would reduce the costs incurred for installation by a sizeable amount as well as improve the viability of large scale extention.

Steel and cement are difficult to procure as well as expensive. If a plant can be developed without using these, the promotional potential of such a plant is tremendous.

Agricultural Tools and Research Centre

Agricultural Tools and Research Centre, Bardoli has been constructing a number of gas plants for cooperatives, educational institutions as well as individuals. The plants constructed were based on the KVIC design. Lately, they have started constructing Janata biogas plants also

Centre of Science for Villages

Centre of sciences for villages is located in Wardha. This organisation has constructed 14 plants for small industries and bout 101 plants for individual users. The financial resources for their biogas programme has been given from Department of Science and Technology. Besides construction, they are also involved in Teaching and training of Masons.

Maharashtra Arogya Mandal

Based at Poona MAM is a voluntary organisation. They have constructed a number of plants for Industries, cooperatives and over 137 plants for individual farmers. They are also involved in teaching and training of masons for plant construction

Resources Development Institute

Situated in Bohpal, this Institute is a voluntary agency. They have constructed biogas plants for Industries -7 small industries - 15 cooperatives- 2, government institutions - 2, international bank - 1, and many individual farmers.

A number of other organisations and Institutes are involved in Training and Extension of biogas plants. Some of them are given below:

1. Shri AMM Murugappa Chettiar Research Centre
   Tharamani, Madras 600042
2. Sobic Industrial Consultants (Extention & Promotion)
   5 VNG Road, Madhavaram Milk Colony
   Madras 600051
3. Sri Parasakthi College for Women (Teaching and Training only) Courtallam (Via) Tenkasi, Tamil Nadu 627802
4. North Eastern Railway (Promotion and Extention)
   Gorakhpur 273001
5. National Institute of Waste Recycling Technology
   A/18, Juhu Apartments, Juhu Road,
   Santa Cruz (W)
   Bombay 400049

6. IIT Delhi - (Teaching and Training)
   Hauz Khas, New Delhi 1100029

7. IIT Madras (Teaching and Training)
   Madras 600036

8. IIT Bombay (Teaching and Training)
   Powai, Bombay 400076