Technical Report

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ECONOMICS OF GOBAR GAS PLANT

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July, 1974

T R No. 41

Indian Institute of Management
Ahmedabad

No. ER NO.41

To

Chairman (Research)
IIMA

Technical Report

Title of the report ....Economics of Gobar Gas Plant.................

Name of the Author ....D.K. Desai....................................

Under which area do you like to be classified? ....

ABSTRACT (within 250 words)

The oil crisis has led us to explore the alternative sources of nitrogen. One of the alternatives ~~to the~~ for nitrogen is cow dung (Gobar). Scientists have invented a gobar gas plant which gives methane gas for fuel and rich slurry with high content of nitrogen. Based on the data provided by the Khadi and Village Industries Commission, the cost-benefit analysis of the gobar gas plant shows that the investment in gas plant is economical both from the private and social points of view.

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Date .26.July.1974..

Signature of the Author

ECONOMICS OF GOBAR GAS PLANT

INTRODUCTION

The oil crisis has made all oil consuming countries seek for alternatives. In India among other things, the oil crisis is going to affect fertiliser production severely. Fertiliser consumption has started picking up in recent years and fertiliser industry has faced a problem of feed stock. In order to achieve the targets of agricultural production the minimum consumption of 4.0 million tonnes of N should be achieved by 1978-79. If difficulties in obtaining naptha and crude oil increase (and within foreseeable future it does not seem possible to augment our oil resources), it is going to be increasingly difficult to achieve the target of production of chemical fertilisers. It is, therefore, necessary to explore alternative sources of feed stocks. Because of this situation, attempts to develop coal-based fertiliser technology are seriously undertaken. One of the alternative sources of nitrogen is cow dung (gobar). Government and scientists have started exploring this alternative very seriously.

ALTERNATIVE OF GOBAR GAS PLANTS

The use of cow dung as manure is well known in India from time immemorial. The shortage of fuel in the rural areas has led to the use of dung as fuel. Many persons have considered this as a wasteful use. In the absence of alternative sources of fuel the use of dung as fuel seems to be quite rational because farmers can afford to purchase equivalent value of fertilisers which they lose by using dung as fuel.

The innovation of gobar gas plant promises to solve the difficulty of fuel and also save dung as manure. This innovation was thought of by Dr. S.V. Desai of Indian Agricultural Research Institute. This was developed by Prof. N.V. Joshi of Poona. Around 1951 Mr. Jashbhai Patel developed a design of the plant which was commercially viable. The work on improvements in the design of the gobar gas plant is in progress.

Indian Agricultural Research Institute, Gandhi Smarak Nidhi, Government of Bombay (Maharashtra), Planning Research and Action Institute at Lucknow and many organisations took great interest in this innovation and pushed it further.[1]

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[1] Directorate of Gobar Gas Scheme, Khadi and Village Industries Commission, Gobar Gas on the March. pp.2-3

In 1961, Khadi and Village Industries Commission (KVIC) included the development and extension of gobar gas plants as one of the important items in its programmes. It helped setting up gobar gas plants at farmers houses and institutions by way of grants and loans. The number of gas plants and the amounts disbursed through grants and loans for gas plants from 1962-63 to 1973 are given in exhibit 1. The average amount per plant varied from Rs.1477.8 to 5008.3.

It is learnt that the Planning Commission has approved a proposal of KVIC to set up 20,000 gobar gas plants in the country. The total investment on the project is estimated at Rs.7.81 crores. These plants will be located in 2000 blocks at the rate of ten in each block. In justification of this project it is claimed that these plants will produce 490 lakh cubic metres a year of methane gas (equivalent to 318.5 lakh litres of Kerosene valued at Rs.190 lakhs). The manure which would be produced per year would have a value of Rs.96 lakhs. It is also learnt that nationalised banks have decided to provide loans for setting up 6000 gobar gas plants during 1974-75.[1]

As the government was keen to explore the alternative source of gobar to supplement fertilisers, in October 1973 the Indian Council of Agricultural Research set up a Committee to assess the cost-benefit effects of cow dung gas plants.

As a member of the Committee, I thought it is advisable to analyse the data provided in the literature produced by KVIC on gobar gas plants and then modify this analysis in the light of the experience gained in field visits.

I have used an analytical model to understand the economics of gobar gas plants.

The Model:

The model uses the usual capital budgeting technique employed in cost-benefit analysis.

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[1] Indian Express, February 5, 1974.

Notations for the model are as follows:

K_i = Capacity of a gobar gas plant where i varies from 1 to 5

5 specific capacities were considered as follows: 60 cft, 100 cft, 150 cft, 200 cft, 250 cft.

I_i = Investment for a gas plant where i varies from 1 to 5 denoting the above specified capacities.

L_{1i} = Methane gas in cft. produced per year per plant where i denotes the capacity of a gobar gas plant.

L_{2i} = Fuel in kgs from the dung of equivalent quantity which is processed in the gobar gas plant, where i denotes the capacity of a gobar gas plant.

N_i = Number of animals required per plant where i denotes the capacity of a gobar gas plant.

X_j = Dung produced per day per animal where j varies from 1 to 6

1 = 4 kgs per day per animal
2 = 6 kgs per day per animal
3 = 8 kgs per day per animal
4 = 10 kgs per day per animal
5 = 12 kgs per day per animal
6 = 14 kgs per day per animal

C = Efficiency of gas production varying from 0 to 1

h = The proportion of cow dung used as fuel in the existing system. This varies from 0 to 1.

1-h = The proportion of cow dung used as manure in the existing system

M_i = Manure obtained from dung per year where i denotes the capacity of a gobar gas plant.

E_i = Difference in the value of gas and the value of fuel obtained from dung where i denotes the capacity of a gobar gas plant

F_i = Difference in the value of manure produced through a gobar gas plant and the existing system, where i denotes the capacity of a gobar gas plant.

Di	= Recurring expenditure for maintenance of a gas plant where i denotes the capacity
Ri	= Contribution per year for the investment in a gas plant where i denotes the capacity
I	= Rate of interest
t	= Economic life of a gobar gas plant
P_1	= Price of gas per one cubic foot
P_2	= Price of dung fuel per one kg
P_3	= Price of nitrogen per one kg

Assumptions

(1) It is assumed that dung would be collected from the required number of animals and used in the gobar gas plant. No additional expenditure is involved compared to the existing system.

(2) The average quantity of gas produced per 1 cft of wet dung is 1.3 cft.

(3) The proportion of manure to wet dung is assumed to be 40:73.

(4) The proportion of fuel to dung is assumed to be 25:73.

(5) Manure obtained from the gobar gas plant will have 1.5 per cent nitrogen.

(6) Manure in the existing system has .75 per cent nitrogen.

Equations:

(1) $Ni = \frac{Ki}{1.3 \quad X_j}$ where Ni is the smallest integer $\geq \frac{Ki}{1.3 \quad X_j}$

(2) $L1i = Ki \times 1.3 \times 365$

(3) $L2i = Ni \times X_j \times 365 \times \frac{40}{73}$

(4) $Ei = P_1 \times c \times L1i - P_2 \times h \times L2i$

(5) $Fi = P_3 \times .015 \times Mi - P_3 \times .0075 \times (1-h) \times Mi$

(6) $Ri = Ei + Fi - Di$

(7) $NPV = \sum \frac{Ri}{(1+I)^t} - Ii$

DATA

From KVIC the following data were obtained:

Capacity of the plant in cft	Investment Rs.
60	1575
100	2075
150	2475
200	2850
250	3275

The recurring expenditure on a 100 cft gobar gas plant was Rs.50 per year for painting. This was assumed to be the same for plants with varying capacities. The dung produced per animal was assumed to 10 kgs per day.

The price of gobar gas was Rs.10 per 1000 cft and the price of fuel was given as Rs.5.40 per quintal. The price of nitrogen was assumed to be Rs.2 per kg.

RESULTS

Net Present Value

With the help of IIMA Computer (HP 2000 A), the (NPV) was worked out for different sizes of gas plants assuming the economic life as 10 years and the effective rate of interest as 10 per cent.

The following conditions were stipulated:

(1) The gas plant is used most inefficiently and gas obtained is lost and only enriched manure is obtained.

(2) Only 50 per cent of gas capacity is utilised, and enriched manure is also obtained.

(3) The gas capacity is utilized upto 100 per cent. Enriched manure is also obtained.

The operation of a gas plant under these three conditions is compared with the alternative uses of dung in the existing system. These uses are stipulated as follows:

(1) All dung is used as manure and no fuel is obtained.

(2) 50 per cent of dung is used as manure and 50 per cent as fuel.

(3) All dung is used as fuel and no manure is obtained.

From the revenue obtained from the operation of a gas plant, the revenue obtained from the alternative use of dung in the existing system is deducted to obtain the contribution towards the investment in a gas plant.

When this net revenue is discounted for the economic life of the plant at the given rate of interest, the present value is obtained. When the investment is deducted from the present value, the net present value (NPV) is obtained. The NPV will indicate whether the investment is economically justifiable.

Results of Private Cost Benefit Analysis

Table 1 gives the results.

Table 1 : Net Present Value of Gobar Gas Plant

No. of animals	5	8	12	16	20
Conditions / Capacities in cft	60	100	150	200	250
1. No gas, full utilization of dung as manure	-960.55	-907.545	-570.205	-207.865	104.476
2. No gas, 50% cow dung used as fuel and 50% as manure	-1536.6	-1829.22	-1952.72	-2051.21	-2199.71
3. No gas, dung used as fuel	-2112.64	-2750.89	-3335.23	-3894.56	-4503.9
4. 50% gas utilization and dung used as manure in the existing system	-287.727	213.827	1111.85	2034.88	2907.9
5. 50% gas utilization and 50% dung used as fuel 50% as manure	-863.774	-707.848	-270.661	191.529	603.716
6. 50% gas utilization dung used as fuel	-1439.82	-1629.52	-1653.17	-1651.82	-1700.47
7. Full gas utilization and dung used as manure	385.096	1335.2	2793.91	4277.62	5711.33
8. Full gas utilization 50% dung used as fuel 50% as manure	-190.951	413.523	1411.4	2434.27	3407.15
9. Full gas utilization dung used as fule	-766.998	-508.152	28.8843	590.921	1102.96

If there is no utilization of gas and if the value of enriched manure <u>has</u> to meet the fuel cost of farmers' household upto the extent of the value of fuel obtained from the dung utilized in the plant the economics of the plant shows that it is not a viable proposition for the capacities of plants varying from 60 to 250 cft. There is a net loss varying from Rs. 2112.64 to Rs.4503.9 in the plants of 60 cft to 200 cft.

If farmers use dung as 50% fuel and 50% manure, and if gobar gas is not utilised, the value of enriched manure has to cover the value of 50 per cent dung used as fuel and other 50 per cent used as manure. Under this situation net losses decrease for all types of plants, the loss varying from Rs.1537 (60 cft) to Rs.2200 (250 cft).

When the farmers do not use dung for fuel in the existing system and use it as manure, if the value of this manure only is to be covered by the value of enriched manure of the gobar gas plant, it is observed that the plant with 250 cft capacity becomes economical but all other plants will incur losses varying from Rs.208 (200 cft plant) to Rs.961 (60 cft plant). This shows that there is economy of scale in the gobar gas plants.

It is unrealistic, however, to assume no utilisation of gas from a gas plant. Various complaints have been received from the existing gas plants mainly for low production and utilisation of gas and also stoppage of gas formation during certain periods. Therefore, a condition of 50 per cent gas utilisation was stipulated. This was then compared with the alternative uses of cow dung in the existing system.

Again, it is observed that the value of gas and the enriched manure does not cover the value of fuel obtained from the alternative use of dung. The losses vary from Rs.1440 (60 cft plant) to Rs.1700 (250 cft plant).

If the alternative use of dung is 50% fuel and 50% manure, the losses decline and the plants of 200 and 250 cft capacities become profitable giving Rs.192 and Rs.603 as net profits respectively. But other plants incur losses varying from Rs.271 (150 cft) to Rs.864 (60 cft).

If farmers use dung as manure in the alternative use, the value of gas and enriched manure covers the value of manure in the existing system and makes all types of plants profitable except a 60 cft plant. The profits vary from Rs.214 (100 cft) to Rs.2908 (250 cft).

If the operational difficulties of the gobar gas plant are overcome through improvement in design and management, it is possible to achieve 100 per cent efficiency in gas utilisation. If this situation is compared with the alternative uses of dung in the existing system, the picture about profitability of the gas plants changes. Even in the situation where the value of gas and enriched manure has to cover the fuel cost of dung, the plants over 150 cft capacity become profitable, the profits varying from Rs.29 (150 cft) to Rs.1103 (250 cft).

In the situation where the alternative use of dung is 50 per cent fuel and 50 per cent manure, the plants of 100 cft capacity and above become profitable, the profits varying from Rs.413 (100 cft) to Rs.5711 (250 cft).

In the situation where the alternative use of dung is manure only, plants of even 60 cft become profitable, profits varying from Rs.385 (60 cft) to Rs.5711 (250 cft).

Social Cost-Benefit Analysis

So far the analysis was done from the point of view of private firms. The investment in gobar gas plant can be viewed from the social angle. In social cost benefit analysis the important variables which we have to consider are (a) the materials used in investments and their social costs, (b) the shadow price of gas obtained from the gas plant, (c) the shadow price of fuel obtained from dung, (d) the shadow price of nitrogen obtained from manure, and (e) the interest rate representing the social cost.

<u>Investment</u>

The break-up of investment for $3m^3$ gas plant is as follows:

Gas Holder and frame		Rs. 701
Piping and Stopes		Rs. 260
Civil construction		Rs.1576
	Total	Rs.2537

In civil construction the material and labour costs are not separately given. We can assume a ratio of 60:40. Thus the labour component would cost Rs.630.4. The social cost of materials could be assumed as the same as the private cost of materials. So far as the cost of labour is concerned it could be assumed to cost less than the private cost if most of the labour used is family labour which may be costed at the maintenance rate rather than the going hire charges. However, as a substantial portion of this labour would be skilled labour, one can assume that the social cost of labour would be the same as the private cost of labour. Thus the social costs of investments in gobar gas plant would be more or less the same as the private costs of investment. In working out the social cost-benefit analysis the figures of investments are taken as the same as in the private cost-benefit analysis.

Shadow price of gas

In the private cost benefit analysis, the price of gas was assumed as Rs.10 per 1000 cft. Instead of this gobar gas can be priced in such a way that the value obtained from gas would equate the value of fuel obtained from the equivalent quantity of dung which is processed through the gas plant.

Shadow price of fuel

The shadow price of fuel obtained from dung should be calculated on the basis of the price of alternative source of thermal power which could replace dung fuel. These sources are (a) wood, (b) coal, and (c) kerosene. As all these sources are in short supply the best way to price dung fuel is the market price at which it is sold.

Shadow price of nitrogen

In view of the oil crisis there is a likelihood of prices of fertilisers going up. At present the farm gate price of nitrogen is Rs.2 per kilo gram. The nitrogen obtained from manure should be evaluated at least at the farm gate price of fertilisers. In case the manure is to be transported to the farms where it is not produced the cost of transport will have to be added to the farm gate price of nitrogen.

Interest rate representing the social cost

Looking to the overall shortage of capital and non-availability of credit from internal sources, a rate of 10 per cent seems to be quite reasonable.

The Model for Social Cost-benefit Analysis

The model would be more or less the same as that of private cost benefit analysis with the following modifications:

$$Ei = P_1 \times L1i - P_2\, h \times L2i \text{ but } P_1\, L1i = P_2\, L2i$$

$$Fi = P_3\, .015 \times Mi - P_3\, .0075 \times (1-h) \times Mi$$

$$Ri = Ei + Fi - Di$$

$$NPV = \sum \frac{Ri}{(1+I)^t} - Ii$$

As we had analysed the model for private cost-benefit analysis under 9 different conditions, we can stipulate the following conditions for social cost-benefit analysis:

(1) If all dung is used as fuel in the existing system the contribution from the gas plant would be as follows:

$$Ei = P_1 \times L1 - P_2 \times L2 = 0$$

$$Fi = P_3 \times .015 \times Mi$$

$$Ri = Ei + Fi - Di$$

$$= P_3 \times .015\, Mi - Di$$

(2) When cow dung is used as 50% fuel and 50% manure in the existing system the contribution would be as follows:

$$Ei = P_1\, L1 - .5\, P_2\, L2$$

$$\therefore \quad Ei = P_2 L2 - .5\, P_2 L2 = .5\, P_2\, L2$$

$$Fi = P_3 \times .015\, Mi = .5\, P_3 \times .0075\, Mi$$

$$Ri = Ei + Fi - Di$$

$$= .5P_2\, L2 + 1.5\, P_3 \times .0075\, Mi - Di$$

(3) When all dung is used as manure in the existing system the contribution of gas plant would be as follows:

$$Ei = P_1\, L1 - P_2\, L2$$

$$Fi = P_3 \times .015\, Mi - P_3 \times .0075\, Mi$$

$$Ri = Ei + Fi - Di$$

$$= P_2 L2 + P_3 \times .0075\, Mi - Di$$

Applying the values of P_2, P_3 and Di and Ii as the same as in private cost benefit analysis, the net present values obtained were as given in table 2.

From the social cost-benefit analysis investments in gobar gas plants seem to be more profitable than the private cost-benefit analysis. In the situation, when all dung is used as fuel in the existing system, the investments in gas plants are profitable for all capacities except the plants with 60 cft capacity. The net profits vary from Rs.567 in 100 cft to Rs.3791 in 250 cft gas plant.

In the situation where 50% of dung is used as fuel and 50% as manure, investments in gas plants of all sizes are profitable. The net profit varies from Rs.537 in 60 cft to Rs.6095 in 250 cft gas plant.

In the third situation when all cow dung is used as fuel investments in gas plant appear to be much more profitable from the social point of view. The profits vary from Rs.1130 in 60 cft plant to as high as Rs.8400 in 250 cft plant.

In the social cost-benefit analysis we had assumed 100% efficiency of gas utilisation. Because of operational difficulties if only 50% of gas is utilised and if this gas is priced as it was done in case of table 2, the net present values of investments for different types of gas plants would be as shown in table 3.

Under the situation when dung is used as fuel in the existing system investments in gas plants are not profitable and losses vary from Rs.356 in 250 cft to Rs.1076 in 60 cft gas plant.

In the situation where dung is used as 50% fuel and 50% manure investments in gas plants of 150 cft and above capacities are profitable. The profits vary from Rs.536 in 150 cft to Rs.1948 in 250 cft gas plant.

In the situation where dung is used as manure only investments in gas plants seem to be profitable for all capacities, the profits varying from Rs.76 in 60 cft to Rs.4252 in 250 cft gas plant.

If the gas plants are operated inefficiently and no gas is utilised investments in gas plants seem to be unprofitable in all the three situations of the utilization of dung in the existing system except in a gas plant of 250 cft capacity and in the situation when all dung is used as manure. The data of net present values are given in table 4.

Conclusions

1. The data of both private and social cost-benefit analysis show that unless the contribution from the production of gas is added to the contribution from the enriched manure the gas plants do not become profitable.

2. The large sized plants, particularly the plants of 250 cft capacity, are more economical than the smaller sized plants.

3. The investments in gas plants are more profitable from the social point of view than from the private point of view.

4. The limitations of the gas plants are as follows:

(1) As the large sized plants are more economical, it would be desirable to operate large sized plants. This operation requires collection of gobar from sizeable number of animals. This would require a kind of collective action rather than setting up the plant on individual ownership basis.

(2) As manure is bulky material it can supply nutrient elements only to the areas around the gas plant. For example, if nitrogen requirements of 10,000 acres (10 kg per acre) are to be met, we would need about 166 plants of 250 cft capacity and a population of about 3320 animals. It may be possible to have a bigger size plant of say 3000 cft. Then the number of plants would reduce but the management of operating these plants would become quite complex. To supply fertilisers to all farmers in the village on an equitable basis, it would be desirable to have larger size plants and manage properly than to have smaller plants on individual ownership. The latter would create the problems of income distribution also.

Table 2: Net Present Value at 100% utilization of gas

Capacity	60	100	150	200	250
1. All dung used as fuel	-38.8743	567.136	1641.82	2741.5	3791.18
2. 50% dung used as fuel and 50% as manure	537.172	1488.81	3024.33	4584.85	6095.37
3. All dung used as manure	1113.22	2410.49	4406.84	6428.2	8399.55

Table 3: Net present value at 50% utilisation of Gas

Capacity	60	100	150	200	250
1. All dung used as fuel	-1075.76	-1091.88	-846.707	-576.534	-356.361
2. 50% dung used as fuel and 50% as manure	-499.712	-170.204	535.806	1266.82	1947.83
3. All dung used as manure	76.3347	751.471	1918.32	3110.17	4252.01

Table 4: Net Present Value at Gobar Gas Plant used for producing manure only

Capacity	60	100	150	200	250
1. All dung used as fuel	-2112.64	-2750.39	-3335.23	-3894.56	-4503.9
2. 50% dung used as fuel and 50% as manure	-1538.6	-1829.22	-1952.72	-2051.21	-2199.71
3. All dung used as manure	-960.55	-907.545	-570.205	-207.865	104.476

Exhibit 1: Number of Gas Plants and Amount Disbursed per Plant

Year	No. of Plants	Disbursement in Rs. (lakhs)		Total	Average per plant
		Grant	Loan		
1962-63	315	0.87	1.27	2.14	679.3*
1963-64	203	1.21	1.79	3.00	1477.8
1964-65	230	0.75	1.10	1.85	804.5*
1965-66	204	2.03	2.96	4.99	2169.5
1966-67	313	1.58	3.38	4.96	1584.6
1967-68	436	3.94	5.64	9.58	2197.2
1968-69	664	5.41	15.45	20.86	3326.2
1969-70	720	6.13	29.93	36.06	5008.3
1970-71	811	9.76	29.92	39.68	4892.7
1971-72	1041	7.27	32.32	39.59	3803.0
1972-73	1065	9.17	31.20	40.37	3790.6
Total	6002	48.12	154.96	203.08	3383.5

* The average investment is much less than the cost of the smallest sized gas plant.

Source: Directorate of Gobar Gas Scheme, Khadi and Village Industries Commission, Gobar Gas on the March.