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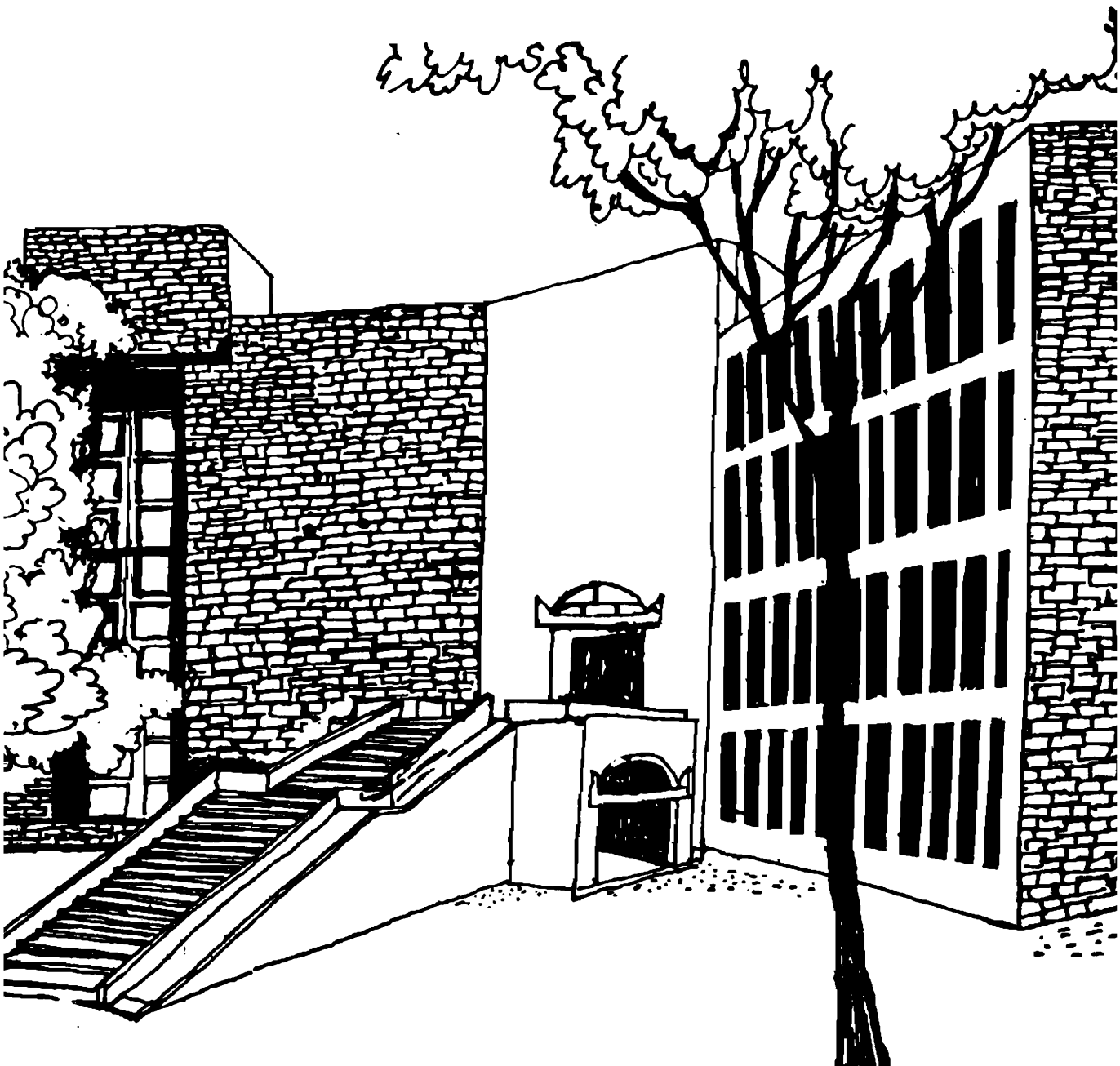

ROBUST DESIGN BUT INDIFFERENT MANNER OF USE: FAMILY BIO-GAS PLANTS IN GUJARAT

By

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Robust Design but Indifferent Manner of Use: Family Bio-gas Plants in Gujarat

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Introduction

The national program of bio-gas development started in 1981 in Gujarat, with the Gujarat Agro-Industries Corporation (GAIC) as the nodal agency. GAIC estimates the potential as 11 lakh units. Till 1993, two lakh units had been installed. In view of such a large potential yet to be tapped, a study was undertaken to identify factors that might lead to faster diffusion in future and help achieve the aims better.

In this paper we present a part of the findings that indicate that deenbandhu model, the most popular choice, is quite robust in design This is indicated by high reliability in the field. But the manner in which the owners use it, is rather indifferent. It is indicated by feed-rates with low mean and large variance. This will prevent the user from deriving full benefit, making him prone to develop adverse opinion.

Method and Data

A sample of 150 owners of family size bio-gas plants was selected. Sample was drawn from three districts--Mahesana (45), Jamnagar (49), and Valsad (56). Out of this total, 127 were of deenbandhu model, indicating that this is the most popular choice. Out of these 127, twenty one plants were found to be in disuse. Analysis presented here relates to 106 that were in use. Data was collected through home visit. Data consisted of various aspects of plants performance and users' experience.

Reliability

Reliability is the probability that a component, machine or system performs 'satisfactorily' over an interval of time say, (o,t). In the present case, satisfactory performance will mean uninterrupted supply of gas. When the biogas plant needs to be closed for an unscheduled repair a breakdown would be considered to have occurred. Thus,

$$R(t) = 1 - F(t) = \int_t^{\infty} f(y)\,dy \qquad (1)$$

where

R(t)	reliability or probability no breakdown occurs in (0,t)
F(t)	probability distribution of time-to-breakdown
f(t)	time-to-breakdown density

Time history of successive episodes of breakdown since installation were obtained from the users. Analysis revealed that time-to-breakdown can be described satisfactorily by log-normal distribution.

$$f(t) = \frac{1}{t\sqrt{2\pi\,\sigma 2}}\; e^{-\frac{(\ln t - \mu)^2}{2\sigma 2}} \qquad (2)$$

where

μ, σ parameters, whose estimates are given below.

Parameters	Mahesana	Valsad	Jamnagar
$\hat{\mu}$ (Months)	77	85	75
$\hat{\sigma}$ (Months)	4	8	6

Using the estimates, reliability, function **R(t)**, was evaluated. **Figure 1** shows the graph for samples in Mahesana and Valsad. Both the graphs are similar in form. It shows, for instance in Mahesana, that the probability the plant will incur no breakdown in the first 12 months since installation is 0.98, in 24 months 0.95, and on 48 months 0.78. This is quite high reliability.

Based on this it can be said the design is robust. Deenbandhu model has oval digester, with dome as integral part of the masonry structure. It has no moving parts. High reliability and long working life were expected from such a design.

Low Maintenance

Annual maintenance expenditure remains steady at a low level increasing significantly only by fourth or fifth year. This is usually for clean up and replastering. This cycle appears to repeat itself. Total expenditure in one cycle appeared to be about Rs.200 to 300.

Feeding Practice

Users were asked to state the amount of feed-stock (wet dung) put into the plant each day. The answers, often in terms of 'topalas', were converted to kilograms using 'fill-and-weigh' observations. Data showed unexpectedly large variation. Beta density function was found to describe the pattern satisfactorily.

$$f(x) = \frac{x^{\alpha_1 - 1} (1-x)^{\alpha_2 - 1}}{\beta(\alpha_1, \alpha_2)} \qquad (3)$$

where

$0 < x < 1$

$\beta(\alpha_1, \alpha_2)$ beta function

Figures 2 and 3 show the distribution function for 2 m^3 and 3 m^2 plants separately.

The stipulated daily feed-rate for 2 m^3 plant is 50 kg of dung. It is seen from figure 2 that only about 15 per cent of the sampled owners fed at or above this rate. Others fed widely varying amounts, some as low as just 15 kg. The mean, 30 kg, is much lower than the stipulated feed-rate.

The situation is worse in case of 3 m^3 plants (figure 3). The stipulated feed-rate is 75 kg. Again the mean was low, 40 kg. People fed widely varying amounts, some as low as just 5 kg. In fact practically no one fed above 60 kg.

Low feed-rates will lower the output. Low output, even though for reason of low feed, may make the user hold adverse opinion and convey it to others. This may deter others from adoption.

Reasons for Low Feed Unclear

Effort was made to identify factors that may be responsible for large variation in feed-rates. Factors that were considered plausible are listed below.

1. Stock of cattle owned - measure of dung supply,
2. Size of family - measure of demand for gas,
3. Distance of water source from the plant (measure of convenience),
4. Monthly expenditure on wood and other cooking fuel before installation of the plant - measure of value attached to biogas,
5. Educational level of family, and
6. Length of experience with the use of biogas plant.

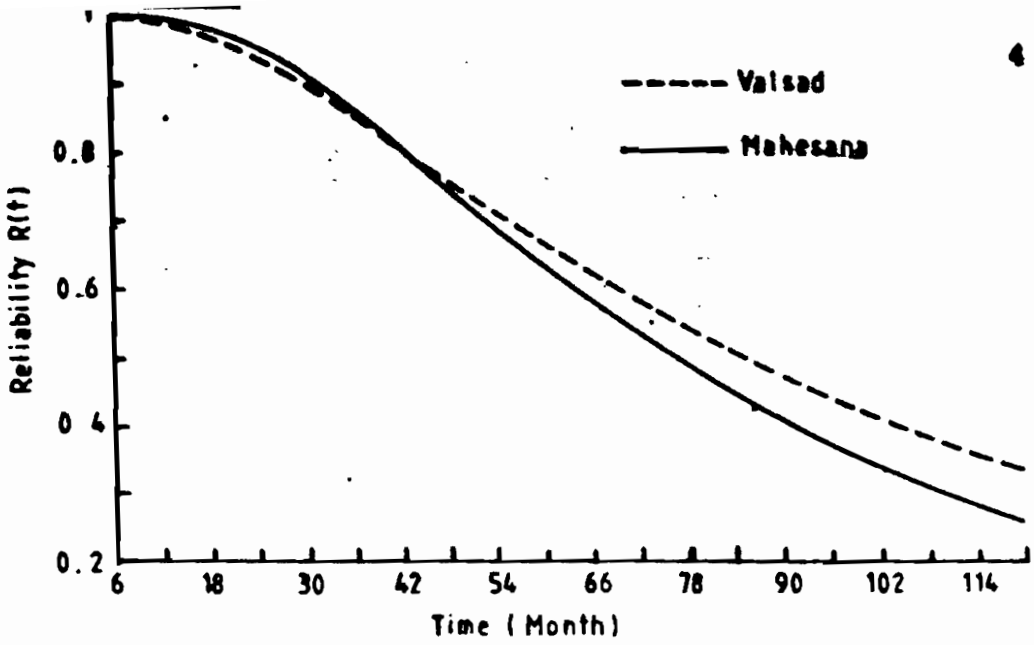


Fig 1: Reliability (Deenbandhu Model)

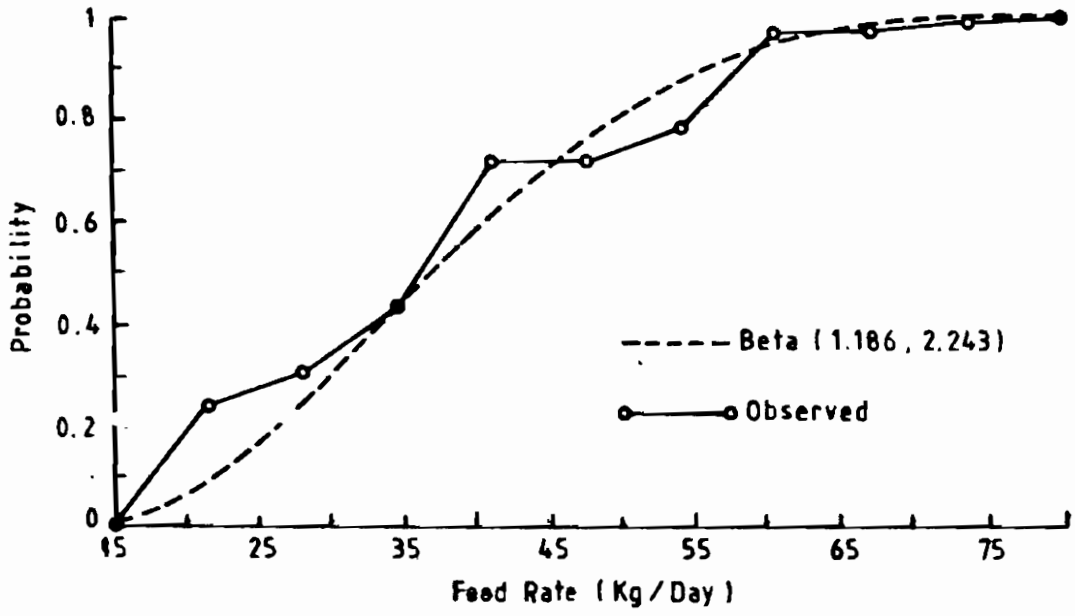
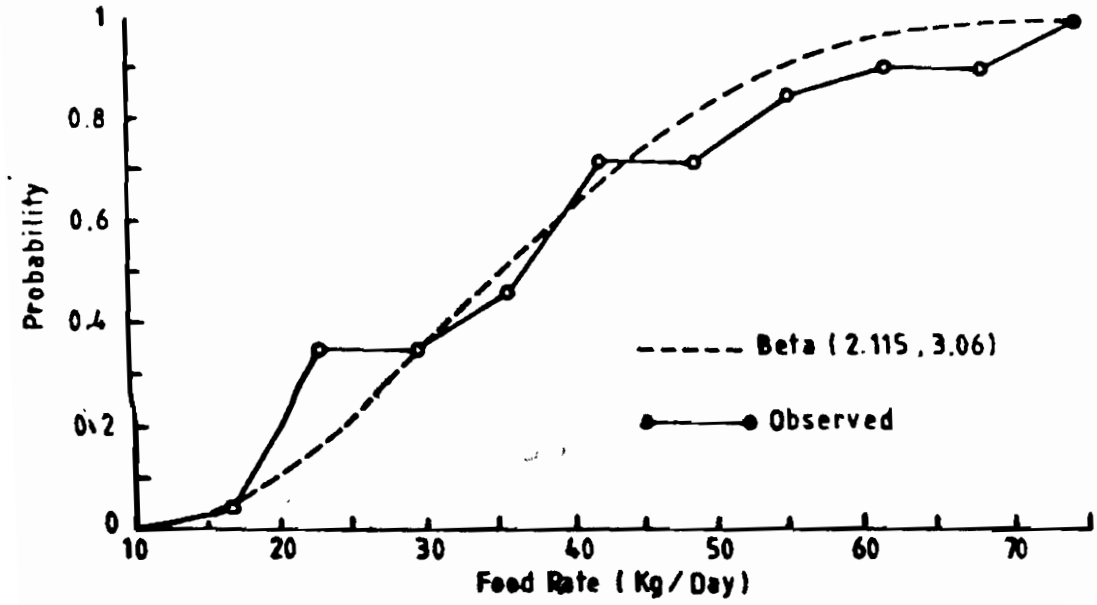


Fig 2: Distribution Function (Deenbandhu 2 m^3)



Each of the above was examined for its association with feed-rate separately. None were found to be consistently and strongly associated.

Separate analysis was then done of the small segment of sample, people who fed the plants adequately. It revealed that these users had three things in common--larger stock of cattle, larger families, and high monthly expenditure on cooking fuel before installation of plant.

Using this insight, one can suggest a conjecture. That the majority of others who showed indifference to the requirement of regular and adequate feeding, did not have an acute problem of fuel. They may have acquired the plant only because no great investment was called for.

Implication for Program Management

Basic criteria for identifying a potential biogas customer presently is requisite minimum stock of cattle. Above analysis suggests that this criterion will lead to a large list, many of whom will probably acquire but not use the plant rationally.

It would be appropriate to add to this two other factors--size of family, and actual monthly expenditure on cooking fuel presently. This will lead to a smaller list, but such people are likely to use the plant more rationally.

Conclusion

Deenbandhu biogas plants are robust in design, give long trouble-free service and require low maintenance expenditure. Despite this however, large proportion of owners tend to be indifferent to the requirement of feeding the plants regularly with adequate amount of feed-stock (dung).

Those who feed the plants regularly and properly are only about 15 per cent of the present owners. These people tend to have large cattle holdings (more than six heads), large families (over eight), and were incurring large expenditure on cooking fuel earlier (over Rs.700 per year).

Promoters of family size plant, need to take this into account. They need to target those who are more likely to use it properly. A composite criterion that gives weightage to family size, cattle holding and households fuel-wood expenditure needs to be built and used in identification of potential customers.

It is important also to help the present users improve the manner in which they feed and use the plant. It is suggested that along with the plant, each owner should be given a calibrated container to be used for dumping measured amount of feed-stock and water into the feed trough. This will enable the user to know accurately the amount being fed, with reference to the desired amount.

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