Mobilization **of** renewable energy sources **in** developing countries

The Biogas Programme **of** the Federal Government

by Uwe Lorenzen.

Few events **in** the last 30 years have resulted **in** such far-reaching economic upheavals as the end **of** mineral oil as a dependable and safe source **of** energy. The price explosion on the oil markets hit the developing countries, with their lack **of** foreign currency, especially hard, and plunged many nations into financial and economic hardship. An added factor is that wood is the primary source **of** energy for most developing countries and the increasing rape **of** the forests has led to a fuelwood crisis **of** immeasurable proportions. The search for solutions has resulted **in** cooperation with the developing countries **in** the field **of** energy becoming the Iynchpin **of** German development aid policy.

Conservation **of** energy, and the exploitation **of** renewable energy sources, has become the focal point, to which very great importance is attached.

In addition to the development pilot projects undertaken since 1975 the Federal Government, after the World Economic Summits **in** Bonn and Tokyo **in** 1978 and 1979 and following he recommendations **of** the conference on renewable energy **in** Nairobi **in** 1981, has introduced projects worldwide **in** the form **of** an integrated and coordinated programme set-up. These are known as the Special Energy Programme (SEP).

No separate budgetary item was created for the Special Energy Programme; i.e., this is not a financing programme. Rather, the nature **of** the programme is a conceptual one - the Special Energy Programme is financed from a variety **of** sources.

Test **of** the Special Energy Programme

The Biogas Programme is a separate, technology-oriented sub-programme **of** the Special Energy Programme. Like the Special Energy Programme, it is a concept-oriented programme and should not be degraded to a financing programme.

Satisfying energy requirements from renewable energy sources, above all by exploiting biomass, is **of** major importance for all developing countries. Commercial energy sources account for only 25 per cent **of** total energy consumption **in** these countries; 75 per cent **of** the energy used is produced from non-commercial energy sources such as firewood, charcoal, animal and vegetable waste produces, wind and water power, and animal and human muscle power. Two thousand million peopIe continue to rely almost entirely on wood and other traditional fuels. **In** many developing countries industry satisfies a high proportion **of** its energy requirements from firewood. **In** some countries, such as Mali, Burkina Faso, Tanzania, Nepal, Ethiopia, and Haiti, over 90 per cent **of** all energy needs are satisfied with traditional fuels. **In** **rural** regions up to 95 per cent **of** the energy consumed is provided by these kinds **of** fuel.

In many developing countries the **use** **of** biogas is still little known, despite the fact that conditions are more favourable than **in** the industrialized nations, because the gas is created by bacteria which are sufficiently active at temperatures **of** over 20°C; and because most **of** the developing countries are **in** tropical and subtropical zones they fulfil the necessary climatic requirements for biogas technology with unheated plants.

The Special Energy Programme has the following aims: energy conservation and the development and **use** **of** renewable energy sources, especially to supply the **rural** population living outside the urban centres. These aims are also the aims **of** the Biogas Programme.

With a comprehensive coordinated approach the following measures are to be taken **in** the Special Energy Programme: rational **use** **of** energy; identification and localization **of** renewable energy sources; development, adaptation, and dissemination **of** systems for economic **use** **of** renewable energy sources such as small-scale water power, wind energy, biomass, solar energy, and human and muscle power. Over and above this, the setting up or reinforcement **of** local counterparts for utilization, production, distribution, and maintenance **of** the systems; scientific, technical, and administrative training, and the development **of** regional supply concepts.

Measures to be taken **in** the Biogas Programme:

1. Identification **of** locations where it is possible to **use** biogas;

2. development, adaptation, and dissemination **of** biogas technology with the aim **of** economic utilization;

3. setting up or support **of** local counterparts that can carry out the production, dissemination, and maintenance **of** the technology and supervise utilization;

4. mobilization **of** scientific, technical, and organizational knowledge about the **use** **of** biogas;

5. development **of** concepts and strategies for decentral supply **of** biogas to the population at suitable locations.

The Biogas Programme is intended to make a practicable contribution to the development policy objectives laid down by the Federal Government, i.e.:

• assuring an appropriate and lasting development;

• strengthening the technological capabilities **of** the developing countries **in** the energy sector;

• reducing the dependence **of** the developing countries on imported sources **of** energy;

• improving the employment situation;

• raising incomes and living standards, especially **in** less-developed regions.

Mobilization **of** local resources

Since the 1970s the energy situation **in** the developing countries has deteriorated further. Oil prices have temporarily dropped, but the environmental damage caused by consumption **of** fuelwood has increased dramatically. The development **of** local energy-producing potential continues to be an urgent task for most developing countries. For a number **of** them renewable forms **of** energy, and above all biomass, represent the only energy sources locally available. But it is precisely here that there is a great potential for supplying **rural** regions. A programme for exploiting renewable energy sources, including the Biogas Programme, is **in** line with national and international discussion on development policy. It helps to reduce the economic and political dependence **of** the developing countries and to mobilize their own resources. The Biogas Programme can make a major contribution towards improving the energy situation **in** **rural** areas, conserving natural resources, and meeting basic needs.

Even if, quantitatively speaking, the Biogas Programme is only small, and its contribution to resolving the problems **of** energy supply, balance **of** payments, environmental damage, and unemployment is correspondingly small, the exploitation **of** local potential and mobilization **of** local resources is **of** such fundamental economic and political importance for the developing countries that the Biogas Programme is highly appreciated both nationally and internationally. The Biogas Programme is one **of** the projects **in** which local potential can be exploited and local resources mobilized successfully **in** the developing countries, by sector-specific measures and with relatively modest means.

Permanent adaptation and continuing development are required for the Biogas Programme concept, i. e., with regard to the technology **of** the plants, the management-related and overall economic assessment and evaluation **of** the socioeconomic effectiveness **of** the biogas systems, as well as the work **of** organizations, institutions, and target groups. The organization and efficiency **of** the Biogas Programme is exemplary as a typical sector programme **of** German development aid.

Abstract

The Biogas Program ist part **of** the Federal Government's Special Energy Program. The objective **of** this program is to identify and localize places where the exploitation **of** biogas is feasible, and to develop, adapt and promote this technology. A further objective is to establish and support local counterparts, and to develop concepts and strategies for decentralized supply **of** biogas to the population at appropriate points.

Résumé

Le programme relatif a l'utilisation du biogaz fait partie du programme spécial pour l'utilisation de sources d'énergies renouvables du gouvernement de la République fédérale d'Allemagne. Le but de ce programme réside dans l'identification et la localisation des lieux d'implantation sur lesquels l'utilisation du biogaz est possible, ainsi que le développement, l'adaptation et l'extension de cette technologie. Un autre but de ce programme est de constituer des organismes locaux et de leur apporter le soutien correspondent, de mettre au point des concepts et des stratégies permettant un approvisionnement décentralisé de la population en biogaz sur des sites appropries.

Extracto

El proyecto de biogas forma parte de/ programa especial para el aprovechamiento de fuentes de energia renovables del Gobierno Federal. Losfinesde este proyecto consisten en la identificacióny localización delugares, enlos que sea posible el aprovechamiento del biogas, asi como el desarrollo,

adaptación y popularización de esta tecnología. A estos fines . hay que anadir la creación y ayuda a entidades y organizaciones locales y e/ desarrollo de proyectos y estrategias pare una descentralización del abastecimiento de la problación con biogas en emplazemientos apropiados.

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Second biogas seminar in Oberreifenberg

by Martin Homola

The second GATE Biogas Seminar was held in Oberreifenberg from 26 to 30 August 1985. It was attended by almost all of the GTZ biogas experts from Third-World countries, members of the staff at GTZ headquarters, representatives from the BMZ (Federal Ministry for Economic Cooperation), and outside specialists from other institutions and consulting organizations.

The purpose of the seminar was to work out furtherreaching conceptual principles for the introduction and dissemination of biogas technology.

The emphasis was on interchange of information and experience, in particular in the following areas:

• refinement of the design of biogas plants;

• assessment of operating and overall economics;

• socioeconomic effects and acceptance by target groups;

• analysis and promotion of counterpart institutions.

In addition to "talking shop", the teams of the GATE Biogas Extension Service (projects in Burundi, Nicaragua, Tanzania, and the Caribbean), the workers on other GTZ biogas projects (Burkina Faso, Ivory Coast, Kenya, Columbia and Thailand), and the external participants took advantage of the opportunity to work out proposals for new concepts and strategies.

A detailed presentation of the projects currently in progress revealed the following picture: so far over 100 biogas plants have been built and countless others have been repaired. Additionally, gas-burning appliances adapted to local conditions have been developed and modified. A large number of specialiste (decision-makers, disseminators and artisans) have been trained and qualified. Last but not least, in some projects a start has been made on building up appropriate organization and counterpart structures.

In the total **of** 14 working groups, a very great deal **of** work was done; among other things, questions **of** plant and appliance technology, **use** **of** sludge, promotion **of** local skills, information and training, advisory work and acceptance were covered - and there was some lively debate.

The principal results **of** the work **of** the working groups are presented **in** brief **in** the following:

• Biogas technology has to be regarded as a complete system. As such, it includes target group-oriented identification **of** the location, the method **of** production **of** the substrate, especially **in** animal husbandry, the technology **of** the plant itself, the **use** **of** the gas, repair and advisory services, and financing procedures.

• The technology **of** family or respectively small-scale biogas plants has been developed into a system capable **of** being disseminated.

• The plants are economically viable if they can provide the user with a substitute for commercial sources **of** energy and commercial fertilizers, and if additional energy can be produced with them.

• The provision **of** light has advantages that cannot always be assessed **in** terms **of** money; effects which incidentally were judged to be very important were the improvement **in** hygiene, the reliability

of the energy supply, and the saving **in** labour.

• The energy produced is mainly used for cooking and lighting; many **of** the appliances developed have proved their suitability **in** practice. The gas produced **in** large biogas plants is distributed profitably.

Although the individual stages **of** development **in** the various projects differ widely, because local and infrastructural conditions are often completely different, it was possible to decide on the principal targets **of** future work:

• Further development or respectively consolidation **of** self-supporting national and regional dissemination structures, involving local manufacturing, distribution, and maintenance facilities, **in** particular those **of** the craft trades;

• Greater involvement **of** women **in** the biogas programmes (both local and foreign workers), since women represent a special target group **in** development aid policy, and the running **of** the plants and utilization **of** the gas are tasks which very often fall to them;

• The training **of** local specialists **in** the areas **of** planning, construction, and service, to assure continuation **of** the project **in** the long term, and thus to encourage independent identification **of** locations, developmeet, and **use** **of** their own sources **of** biogas;

• Intensification **of** the evaluation **of** sludge analyses both **in** the project and accompanying it, since the **use** **of** sludge as a fertilizer is **of** major importance for an economic appraisal **of** biogas plants, and not enough attention has so far been paid to this question **in** practical project work.

All **of** the participants agreed that the socioeconomic environment is every bit as important as the technical refinement and adaptation **of** biogas plants.

In Oberreifenberg it was also apparent that an intensification **of** information interchange **in** the context **of** a further training seminar **of** this kind can be **of** very considerable importance for the planning and conception **of** promising sector programmes **in** Technical Cooperation.

Abstract

Biogas technology must be considered as a complete system. This applies especially to identification **of** suitable locations, animal husbandry, installation technology, exploitation **of** the gas, and advisory and financial arrangements. **In** future, attention must be paid above all to the further development **of** self-sufficient national and regional bodies and to the training **of** local experts **in** the fields **of** planning, building and the provision **of** services.

Résumé

La technologie du biogaz doit être considérée en tant que système général. En particulier en ce qui concerne l'identification des sites, I'élevage d'animaux, la technologie de l'installation, I'utilisation du gaz ainsi que les modalités d'information et de financement. A l'avenir, une attention particulière devra être accordée a l'évolution des structures d'extension nationales et régionales ainsi qu'a la formation sur place d'un personnel qualifie dans le domaine de la planification, de la construction et de la maintenance.

Extracto

La tecnologia del biogas debe contemplarse como un sistema global, sobre todo en lo que respecta a la identificación del lugar de ubicación, explotación de ganado, tecnología de las instalaciones, uso y aprovechamiento del gas, asi como formas de asesoramiento y financiación. En el futuro deberá dedicarse especial atención al perfeccionamiento de extructuras de difusión autónomas nacionales y regionales, asi como a la formación y capacitación de expertos locales en los sectores de planificación, construcción y mantenimiento.

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Standardization **of** biogas units

by Alexander Schlusser

About a year ago we began a systematic study **of** the Arumeru District, which covers 3,000 sq.km. **In** the Arusha Region, where we work. This district itself can be subdivided Into tour small zones. One **of** them, known as the Coffee Banana Belt, covers 200 sq.km. and has a population density **of** 192 inhabitants per sq.km., which Is very high. There Is sufficient water all year round and agriculture is correspondingly Intensive (mainly coffee and bananas); livestock is usually kept inside. The majority **of** the 7,000 small-farming households have between two and six cows, and often a few pigs, goats, or sheep as well.

The average-sized family here has five to seven members, so that all **in** all one can speak **of** ideal conditions as far as biogas technology is concerned. As a realistic estimate **of** the potential, we believe that 700 plants have to be built without any financial assistance. Faced with such a large number we soon realized that we would first need an appropriate marketing strategy if we wanted even to begin to satisfy the demand for this potential market. So we would need many trained artisans familiar enough with construction methods to build a biogas unit with just a small subsidy. To negotiate with the customers and advise them we would also need technicians who knew everything about biogas technology, and who would assure the required construction quality. Last but not least we would need private contractors who would come **in** on this technology **in** order to earn money with it.

The second important point is that standardized units should be used rather than the custom-built models, which are admittedly optimized, but expensive and time-consuming.

However, before we could decide on standard sizes it was necessary to calculate mean values from the economic, ecological, logistical, agronomic, and sociocultural determining parameters. We finally opted for the low-priced dome-type unit **in** standard sizes **of** 8 m^3, 12 m^3, and 16 m^3.

What does the term "standardization" cover?

In Tanzania, transport and the procurement **of** materials are particularly expensive and time-consuming. To obtain a ½" elbow you may spend a whole day chasing around town and then pay about 20 DM. Cement is only available sporadically. So by the time we had built a few units it was clear to us that not only the size **of** the unit would have to be standardized.

We needed a strategy to get away from every kind **of** individual consideration, individual supply, and individual building - from the sale **of** a unit to the connection **of** the appliances.

On the technical side, this means that today, we only make the pipe system from ¾" pipes and accessories, and according to a precisely defined plan. Piping with the same bore is used for burners and lamps. All stopcocks for burners, lamps, and the unit are identical. **In** future the burners and lamps are to be made **of** materials that are readily available locally, e. g., for a lamp: a plate, a pot, a gas supply line **of** ¾" pipe, som wire, and the glass from a Petromax lamp, which is also available **in** Tanzania.

An example **of** standardization on the administrative side: we have worked out a graph from which the technician can read off the appropriate standard size immediately when the relationship **of** livestock owned to the size **of** the family and the way the gas is used is known. The materials ret quired can then be calculated immediately from a table. **In** this way all the building materials can be provided before building work is started.

Finally there is a special form the enables a quite accurate quotation to be prepared for the customer, taking into account any work he may do him self.

How it works **in** practice

1st step:

Either Chris, or I myself, or a counterpart go to a customer. There are already waiting lists; the basic details (size **of** the family, number **of** animals owned) are known. Agreement is reached with the customer on the location **of** the unit. **In** the folder we take with us we have the papers mentioned above, from which we can determine the standard size, materials required and the total cost **of** the unit.

Before building is started the customer makes a down-payment **of** 40% and before the unit is put into **use** a further 50%. The remaining 10% is paid when it has been established that the unit works properly.

2nd step:

The technician then tells the artisan which location has been chosen and where everything is. For his part, the artisan has a folder containing the standard drawings and when ail the building materials have been delivered he carries out all the work himself, from tying the plumbline to connecting the lamp and burner.

Ideally, the technician's only job is acceptance testing, i. e., checking the gas-tightness **of** the pipe system and the unit itself.

Advantages and prospects for the future with standardization

One only becomes aware **of** the huge advantages **of** standardization when one plans the practical work **in** complete conformity with it.

This can be shown by another example. Two **of** our units cracked immediately after being filled. But since all the units are similar thanks to standardization, the fault parameters can be analyzed relatively easily using a special matrix. If different degrees **of** importance are assigned to the individual parameters it is relatively easy to identify the possible causes. This is illustrated **in** much simplified terms **in** the following:

We built units **of** the various standard sizes **in** both the dry and the rainy season, and filled them immediately after completion. However, only units built **in** the rainy season cracked. We discovered that the two parameters 'rain' and 'initial filling' play an important role. After a thorough analysis **of** the cracks we came to the following conclusions: firstly, the initial filling technique would have to be changed, and secondly the design **of** the units was modified to prevent cracks from extending into the gaslight part.

This is just one example among many. What I want to point out with it is this: if you have standardized units you can develop technically perfected models, that is, you can

• adapt the unit exactly to requirements, from the stable to the gas consumers;

• specify tolerances to the artisan, because you know the units down to the last detail;

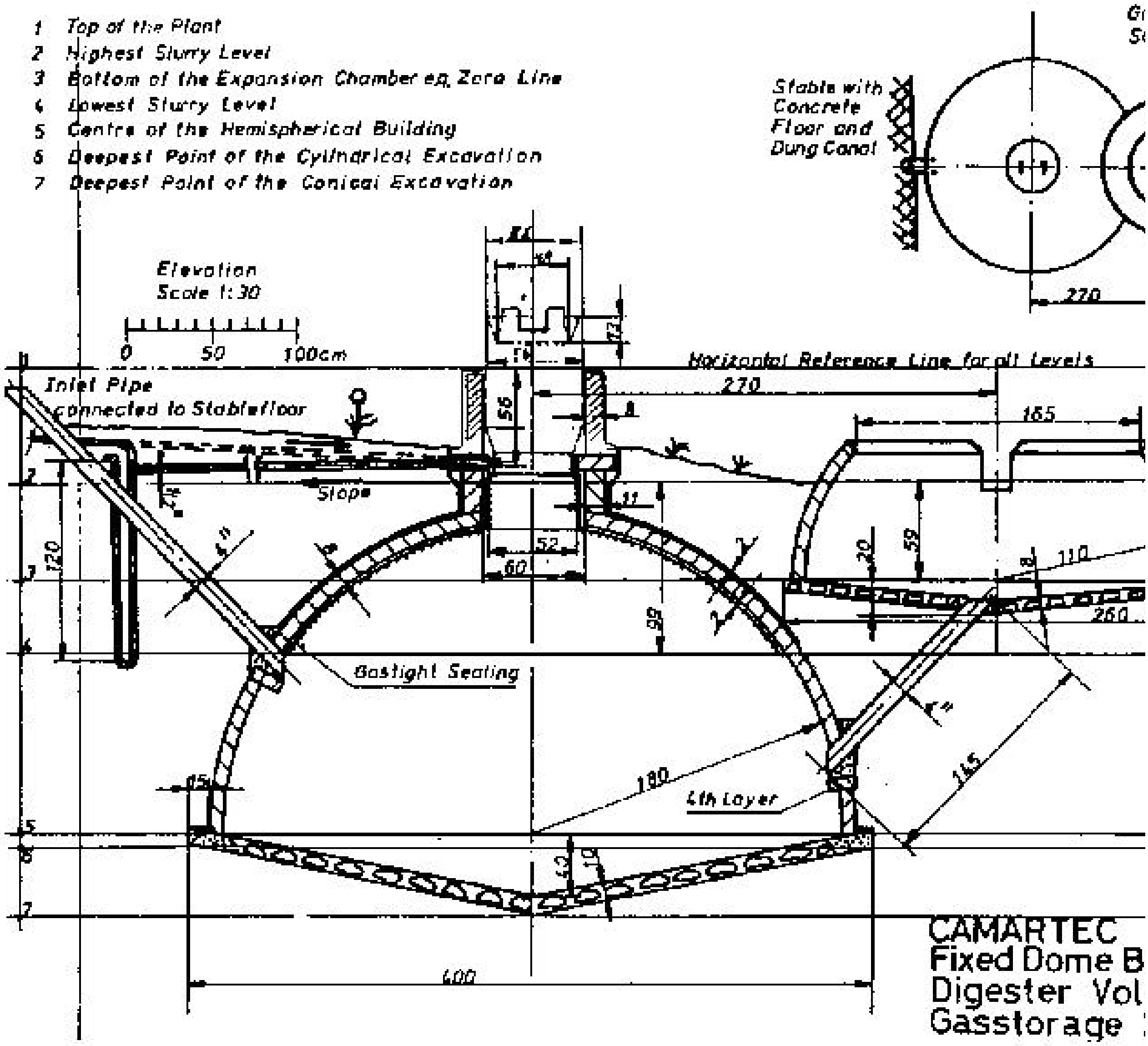
• develop standardized test methods and incorporate corresponding test points **in** the system;

• make fault-finding checklists (like the ones used for checking cars).

It is only by virtue **of** standardization that our dissemination strategy- via village artisans and private contractors - can become effective at all. Because the artisans do not have to be so highly qualified and can therefore be trained **in** a relatively short time. They can act as teachers **in** training programmes and teach the building method to other artisans. They can carry out servicing and repair work alone and, thanks to standardization, manage with a miminum **of** spare parts and tools.

And with perfected standards the technology also becomes profitable for private contractors, because calculations and design work are eliminated, supervision and administration are minimized, the transport costs - **in** fact all costs - can be calculated, and when serving several customers **in** one region they can be considerably reduced.

Our next article, which deals exclusively with the diffusion **of** family-sized biogas units, describes possible methods **of** selling standardized units **of** this kind.



Figure

Abstract

The basic aim **of** standardizing biogas units, which is now normal practice **in** Tanzania, is to save time and money. However, it a/so involves the training **of** suitable artisans, the setting-up **of** a service system, minimization **of** administrative procedures, and an attempt to interest contractors **in** building biogas units. To this extent, standardization means more than simply providing units **of** a certain size. And only with standardization is marketing possible on a large scale.

Résumé

Le but de la standardisation des installations au biogaz, telles qu'elles le vent entretemps couramment en Tanzanie, est une économic de temps et d'argent. Ceci dépendant évidemment aussi de la formation d'ouvriers qualifies; de la mise en place d'un selvice d'entretien, de la minimisation des démarches administratives ainsi que de la tentative d'intéresser les entreprises pour la construction d'installations au biogaz.

Dans cette mesure, la standardisation est plus que la simple mise a disposition d'installations de taille donnée. Par ailleurs, seule la standardisation permet un marketing a grande échelle.

Extracto

El objetivo perseguido con la standarización de las plantas de biogas, como las instaladas entretanto en gran numero en Tanzania, es, por una parte, el ahorro de tiempo y costes. Pero también esta relacionada con la formación y capacitación de personal adecuado, la organización de una red de servicios, la reducción a un mínimo imprescindible de los procesos y medidas administrativas, asi como despertar el interés de los empresarios en la construcción de estas plantas de biogas. En este sentido la standarización es algo mas que la puesta a disposición de plantas de un determinado tamano. Y edemas, la standarización es lo que permite un marketing a gran escala.

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The diffusion **of** familly-size unit biogas plants

by Christopher Kellner

In 1974, a first attempt was made **in** Tanzania to make biogas plants attractive to farmers. This first attempt failed because local conditions were not taken into account, because the plants were faulty **in** operation and because, last but not least, the technical knowledge required to operate such plants did not exist. Then last year CAMARTEC (Centre for Agricultural Mechanization and **Rural** Technology) took up the matter once more and is now trying to learn from the mistakes **of** the past.

For, to aid the breakthrough **of** biogas technology on a wide front, the corresponding basic prerequisites have first to be fulfilled. High density **of** population, the possibility **of** indoor stock-keeping all year round (zero-grazing is the key word here), intensive arable farming resulting **in** the need for manure containing nitrogen and, last but not least, the ability to handle the building materials concrete and brick.

The Tanzanian solution

But to be really successful meant more than just copying what had succeeded **in** other countries. What was required was a Tanzanian biogas plant that would satisfy the requirements **of** its future users. And this individual Tanzanian solution is the standardized biogas plant.

CAMARTEC developed three standardized fixed dome biogas plants dimensioned for 8, 12 and 16 cubic metres. The following table shows the material required and the costs involved. Costs which are bound to vary from farmer to farmer are the building costs for the necessary stable as, to keep work to a minimum, the biogas plant and the stable are directly linked to one another. It should also be said that the stable must have a concrete floor, for only this will guarantee that the entire faeces-urine mixture will reach the biogas plant unadulterated by foreign bodies.

Method **of** diffusion

In order to interest as many farmers as possible **in** the construction **of** a biogas plant, and **in** order to simultaneously train local artisans **in** the construction **of** such plants, a course **of** action that may, at first sight, seem somewhat complicated was chosen. So let me begin by describing it. First **of** all a survey is conducted to estimate the potential **of** farms suited to operate a BGP. With the help **of** a questionnaire the energy situation, the farming system, the availability **of** digestable material, the availability **of** water and the financial situation need to be established.

Then, if the results **of** the investigation show that a demand for BGPs can be expected, the technology will be introduced to the village administration and interested farmers. This will be done either by setting up a small transportable unit which supplies a small amount **of** gas or by a site visit to an operating BGP.

The third step is then the selection **of** a suitable site where the first unit **of** the particular village is installed. The construction is done by two artisans from the village and supervised by CAMARTEC Biogas Extension Service who will be conducting job training. Experience has shown that demand follows initial construction.

The farmer who has the required building material already at the premises will get the next plant built by the same artisans. The supervision input can be reduced after each plant. The village artisans are the main suppliers to satisfy the demand. To ease and accelerate for the individual farmer the process **of** purchasing the requested building material, CAMARTEC is establishing a material supply store.

It also supplies lamps and burners. A step **in** the future will be also to produce these **in** the country. The other task **of** CAMARTEC, within this strategy, is to advise on individual biogas problems e. 9. planning, construction, feeding, gas production, gas consumption, **use** **of** sludge, and maintenance.

The region **of** Tanzania **in** which we gathered our experience has already been described by my colleague Mr. Schlusser **in** his contribution, and our first findings show that ten percent **of** the farmers **in** the Coffee-Banana Belt are seriously interested **in** a biogas plant as well as having the necessary finance at their disposal.

Table: List of Requirements for the Three CAMARTEC Fixed Dome Standard Biogas Plants (BGP).

Item	**Unit small family BGP**	**Standard Digesters medium family BGP**					
			big family BGP				
	8 m^3	12 m^3	16 m^3				
	amount	costs	amount	costs	amount	costs	
	required	required	required				
Bricks 8×11×22	pieces	750	2250	1150	3450	1400	4200
Cement	50 kg bags	10	2000	14	2800	17	3400
Lime	25 kg bags	4	600	6	900	7	1050
Sand stones	kg	2500	1200	4000	1600	5000	2000
Plastic pipe >4"	6 m	1	500	1	500	1	500
Hole to be dug	cbm	20	400	26	520	33	660
Mason	Lump sum	1	1800	1	2500	1	3000
Helper	Lump sum	1	1400	1	1600	1	2000
Other material	400	500	600				
Total	10550 TSH	14370 TSH	17410 TSH				

1 All prices relate to 2/85

2 The price for sand can differ extremely

3 Other material e.g. kerosene and wax for gaslight sealing, clay for lid sealing, reinforced gas-outlet pipe, handles for lid.

Costs and benefits

Befor I describe why farmers request BGP, I will compare the costs with the benefits. There are many ways to calculate this. The crucial points arise when the benefits are mainly an increase **in** the quality **of** life. The traditional cooking fuel (wood) is unlikely to be commercialized yet and the supply **of** kerosene for lighting is very unreliable to obtain. But calculating the money saved on energy, the investment costs are comparatively high.

However, converting the produced and used amount **of** gas into commercial energies which finally represent the families' newly achieved standard **of** living, we come to a break-evenpoint **of** 3-4 years, including running costs and common interest.

However, the usual customer does not calculate this **in** advance. I did the same when I decided to buy a refrigerator - I did not consider whether it would save me money; I knew it would cost me money to run - but nevertheless I bought one. It has made my life easier and that makes it important enough to have it. The farmers and especially the farmers' wives who are demanding BGPs, react **in** a similar way, and arguments that were used for the decision were many.

- The increasing difficulty **of** getting firewood and kerosene,

- Quick and reliable preparation **of** small things like tea etc.

- Light **in** the evening.

We found that the farmers who are interested **in** obtaining BGPs are innovative and business oriented. This was our experience with the first four farmers who started to convert surplus energy **in** marketable food products e. 9. they brewed local beer, baked bread or pancakes or roasted their own coffee **in** order to sell it. It is apparent that the most feasible target group for BGPs are farmers who have more gas than they require, so that the surplus energy can be used for some business activity. The graph on this page shows what preconditions must exist to expect an excessive supply **of** gas with the various types **of** standardized plants CAMARTEC recommends.

The fertilizer

The overflowing sludge from the BGP is a very good fertilizer. It is not mentioned among the benefits **of** the biogas technology as it is a problematical material and its advantages are hardly utilized. These advantages can be described as follows.

- **In** no other stable system but zero-grazing on concrete floors are all the nutrients delivered by the animals collected.

- The overflowing sludge from the digester contains the same amount **of** nitrogen as the original manure, whereas the common way **of** storing manure before it is applied to the fields causes big losses **of** nitrogen.

- Digested manure can be applied to growing plants without any danger **of** chemical damage. The fertilizer is easily assimilated.

- The fertilizer does not smell and does not attract flies at all.

Nevertheless only the minority **of** BGP owners utilize this fertilizer **in** such a way that the advantages are brought to bear. It seems that the disadvantages are major:

- The liquid form **of** the material makes transportation on wheelbarrows or **in** buckets difficult.

- The material runs downhill and easily pollutes surface water.

- The fertilizer has its best effects if it is applied to the plant roots, under wet and cloudy conditions, **in** the stage **of** intensive plant growth. These preconditions occure on the farm only occasionally, while sludge is produced continuously.

A biogas extension programme has to incorporate the discovery **of** recommendations for practicable fertilizer application methods.

Steps **in** the future

A biogas extension programme which aims **in** spreading the technology requires a long term strategy. CAMARTEC has started **in** the Arumeru District and will extend its development activities to other suitable areas. For a success **of** the programme, the following aspects need further stress. Involvement **of** private entrepreneurs **in** plant and accessories construction. Surveys to estimate the potential number **of** farms suitable for biogas plant operation.

• Development **of** teaching aids for the further training **of** artisans and technicians.

• Regular training **of** artisans and technicians.

• Establishment **of** a maintenance team.

• Expert advice on all fields involved **in** the technology with the help **of** appropriate booklets and well equipped advisers.

• Continuous reassessment and improvement **of** standardized plants.

• Development **of** prefabricated building materials.

• Development **of** methods and instruments for the appropriate **use of** fertilizer.

Abstract

In the Arumeru District **in** Tanzania the procedure used for dissemination **of** biogas units is that requirements are first determined with a questionnaire. At the same time potential users are familiarized with the technology. They are not left to their own devices when it comes to building the units, either: they are advised by the CAMARTEC biogas specialists. Local artisans are also trained **in** the building **of** biogas units. All these things, plus the **use of** standardized units, are intended to help make ? success **of** the programme. The **use of** digested sludge as a fertilizer is one thing that has not yet been satisfactorily dealt with **in** all cases. **In** future, efforts should be concentrated on the advisory side and on developing accessories.

Résumé

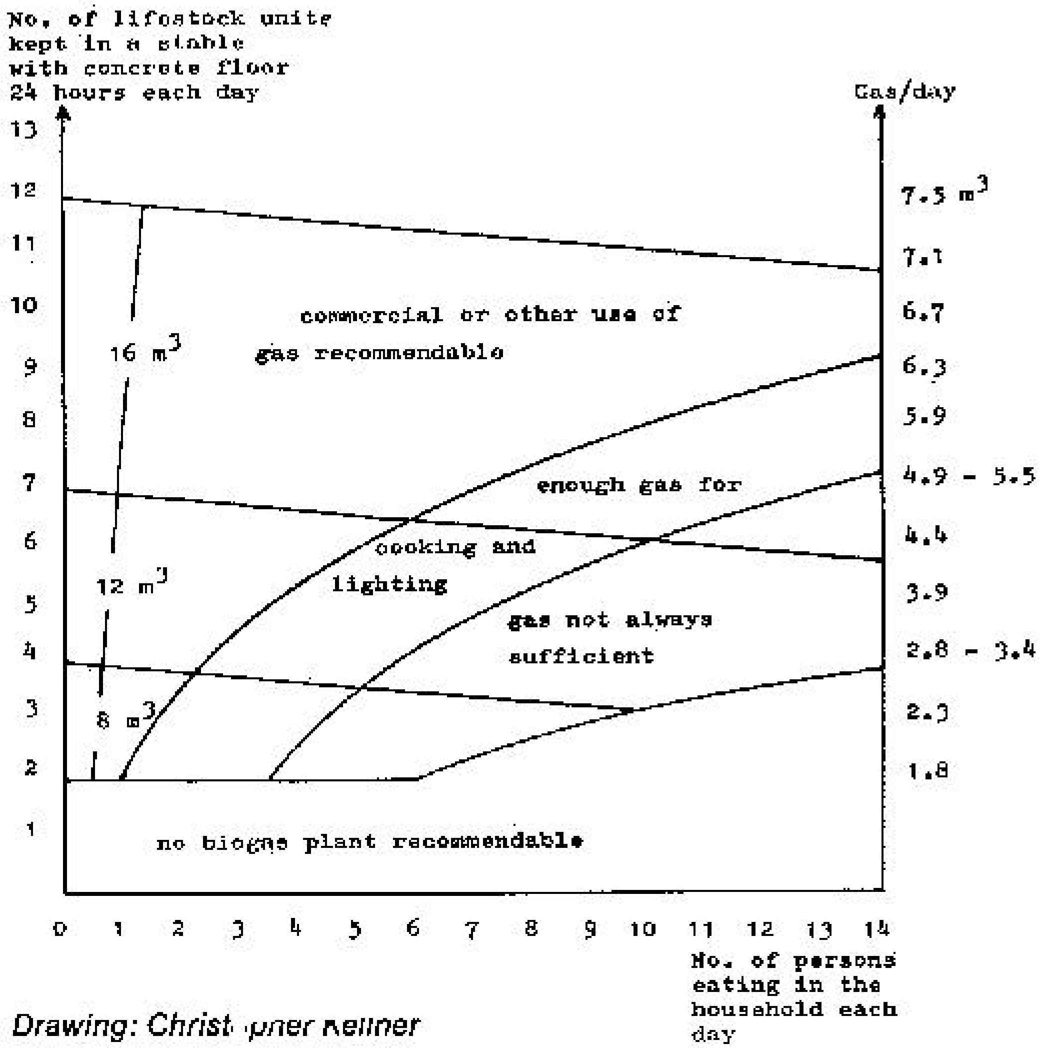
Dans le district tanzanien d'Arumeru, on procède a l'extension des installations au biogaz en établissant tout d'abord les besoins grâce a un questionnaire et en familiarisant simultanément les gens avec cette technologie. De même, ils ne vent pas livres a eux-memes lors de la construction, mais conseilles par les experts de CAMARTEC. Des ouvriers vent également formes sur place pour la construction d'installations au biogaz. Tous ces éléments doivent, outre ['utilisation d'installations standardisées, permettre d'aboutir a un succès du programme. L'utilisation du limon organique en tant qu'engrais n'a pas encore été résolue de facon satisfaisante dans tous les cas. A l'avenir, il faudra prêter une attention particulière a l'apports de conseils et a la mise au point d'accessoires.

Extracto

En el Distrito de Arumeru, en Tanzania, antes de instalar una planta de biogas se analizan primero las necesidades locales de una planta de estas características con ayuda de un cuestionario de preguntas, y al mismo tiempo se procure familiarizar a los futuros usuarios con esta tecnología. Luego, en la fase de construcción, tampoco se les deja solos, sino que se les asesora a través de los expertos de CAMARTEC. Asimismo los artesanos y pequenos industriales locales son instruidos en el manejo y

construcción de las plantas de biogas. Todas estas medidas, junto con la standarización de las instalaciones, contribuirán al éxito del proyecto.

Todavía no se ha resuelto satisfactoriamente e/ empleo del cieno de pudrición como fertilizante. En el futuro deberá prestarse especial atención al asesoramiento y la creación de accesorios.



Drawing: Christ· ,pner κeιιner

Means for first estimate to attach the appropriate standard unit to the given preconditions. All figures are related to the described unit and the cooking habits **of** the people **in** Arumeru District **of** Tanzania.

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Biogas technology and site-oriented agriculture

by Ulrich Hoesle

The aims **of** site-oriented agriculture under "low external output" conditions are to achieve high and sustained productivity while at the same time conserving or restoring balanced ecosystems, with active participation **of** the target groups.

From the many different measures that can be taken **in** the sphere **of** production technique, the following examples may be mentioned, directly or indirectly related to biogas technology: erosion prevention and watershed management; linking **of** animal husbandry and arable farming; compost and mulching; biological nitrogen fixation (cultivation **of** leguminous plants); and the **use** **of** locally available means **of** production.

The focal point **of** interest is the process within the target groups, which must develop from an improvement **in** decision-making to a sustained improvement **of** the group's social and economic status when an innovation (such as biogas technology) is offered.

This process is decisively influenced by ecology (soil, plants, animals, environment), the economy (market, land, finance, work), and the social sphere (health, education, religion, family, tradition, state); these are linked to one another by a variety **of** widely-differing flows **of** materials (foodstuffs etc.), energy, or money.

When the innovation offered is biogas technology, the factors **of** the system affected by it have to be identified and evaluated, by way **of** a partial analysis. With regard to production, and also ecological and economic considerations, both gas utilization and sludge utilization must be carefully analyzed to determine whether they might compete with and/ or complement each other.

Because this depends to a very large extent on the specific situation, ranging from the fodder the animals are given to the transport **of** the material, it is difficult to assess the effects **of** the sludge; it can only be done at the location **in** question, by appropriate tests and analyses.

On the basis **of** examples it can be proved that the fertilizing effect **of** digested sludge can certainly be inferior to untreated material and that the nitrogen losses during storage may be much higher

(Wenzlaff, 1982).

Since the feaces only contain about half **of** the total quantity **of** nitrogen, the animal's feaces and urine should be putrefied together if possible.

Although a biogas unit can also beregarded as a kind **of** fertilizer storage facility, subsequent storage **of** the sludge is often essential. It should therefore be investigated what techniques can be used to prevent further nitrogen losses during storage. One possibility would be a combination **of** compost and sludge storage. Since most **of** the nitrogen **in** the sludge is **in** dissolved form, drying should be avoided and attention concentrated on possibilities **of** extracting liquids. This often presents smaller farms, **in** particular, with unsolvable problems. **In** addition, a liquid fertilizer with quickly available nutrients should not be turned into the soil before sowing; the seedlings should already have roots if possible.

With regard to the problem **of** losses during storage, and bearing **in** mind the combination **of** measures **in** site-oriented agriculture mentioned above, it should also be pointed out that the cultivation **of** leguminous plants offers ways **of** fixing the nitrogen biologically.

Digested sludge is a nitrogen fertilizer with side-effects. On erosion-prone surfaces these side-effects, such as the improvement **of** soil structure, for example by increasing the humus content or encouraging soil life, can quickly become more important than the direct fertilizing effects. These long-term effects should not be ignored, either **in** studies relating to the utilization **of** sludge, nor **in** economic appraisals **of** the biogas unit as a whole. The **use** **of** digested sludge with its long-term effects, together with the saving **in** firewood, the reduction **in** over-grazing by stabling and cultivation **of** fodder, can make biogas units a valuable element **in** a site-oriented agricultural system.

Abstract

If biogas technology is used **in** site-oriented agriculture it should be borne **in** mind that it is particularly difficult to assess the effect **of** the sludge. Above all, the sludge should be removed while it is still liquid to obtain the full fertilizing effect **of** the nitrogen. Leguminous plants are especially suitable for fixing the quickly available nitrogen. However, the side-effects that can occur when digested sludge is used should always be taken into account.

Résumé

La mise en oeuvre de la technologie du biogaz dans le cadre d'une agriculture adaptée au site implique qu'il faudra tenir compte du fait que les effets du limon organique vent particulièrement difficiles a évaluer. Le limon organique doit surtout être en/eve dans sa phase liquide afin d'obtenir un engraissement maximal par l'azote. Les légumineux vent particulièrement appropries pour obtenir une fixation de l'azote rapidement disponible. Ce faisant, il faut toujours tenir compte des effets secondaires résultant éventuellement de l'utilisation de limon organique.

Extracto

Si la aplicación prática de la tecnología del biogas se realiza en el marco de una explotación agrícola en una ubicación apropiada, deberá tenerse en cuenta, sobre todo, que es difícil analizarlos efectos del cieno de pudrición. Sobre todo deberia esparcirse en su fase liquida, a fin de aprovechar todo el valor fertilizante del nitrógeno. Para la fijación del nitrógeno rápidamente disponible son muy apropiadas las leguminosas. En estas aplicaciones hay que tener siempre en cuenta los efectos secundarios que puede tener el empleo del cieno de pudrición.

Complements and Alternatives to the Biogas Unit

Gas	Sludge
wood from environment (forest)	fallow land mixed cultivation
- planted forest	mulch
- planting **of** wood	green manure
- living fence	fresh manure
- green manure	compost
petroleum or grass from the market	mineral fertilizer

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Fermentation **of** poultry excrement/rice chaff mixtures

A Report from Nicaragua

by Sofia Bonilla Garcia, Rolf Georg, Reimund Hoffmann and Günter Ullrich

Apart from the village 'Criollo' chickens, that run free **in** and around houses, poultry keeping is the most widespread form **of** intensive farming **in** Nicaragua. It is practiced **in** the following way: the empty coop is strewn with a 5-10 cm layer **of** rice husks, and then, according to the size **of** the coop, occupied by between 500 and 200 young hens **of** the same age. On average, laying hens remain **in** the coop for about 13 months, which is not cleaned during this period. **In** this way, a mixture **of** poultry excrement and rice chaff results. When laying capacity diminishes, the hens are sold to be slaughtered, more or less all at the same time. The stall is completely cleaned and disinfected. Up to the present, the resulting litter has, as a rule, been thrown away unused.

The authors were confronted with this situation **in** two schools with adjoining farms, which had asked for support **in** the construction **of** biogas units. After consultation with both headmasters it was decided to ferment the poultry excrement/rice chaff mixture. Because **of** the above-mentioned type and amount **of** biomass, it was decided to build two batch or respectively semi-batch units with a volume **of** 15 m^3 each.

The initial filling contained 16% dry matter: both digestors produced between 10 and 19 m^3 **of** good quality biogas (with a CO2 content **of** less than 30%) daily.

By contrast, the short decomposition period **of** between 45 and 60 days was unsatisfactory, especially as manual emptying with a bucket (1,500 buckets per digestor!) is very time-consuming.

An attempt was therefore made to prolong the decomposition period by increasing the proportion **of** dry matter to 33%. This attempt failed: gas production did not take place, and the unit evidently remained **in** an acid phase. It had to be emptied completely and refilled (proportion **of** dry matter: 13%).

Nevertheless, experiments were carried out **in** barrel units with varying proportions **of** dry matter: 8%, 10%, 12%,14%, 20%, 35%. Some results **of** these experiments are described here **in** brief:

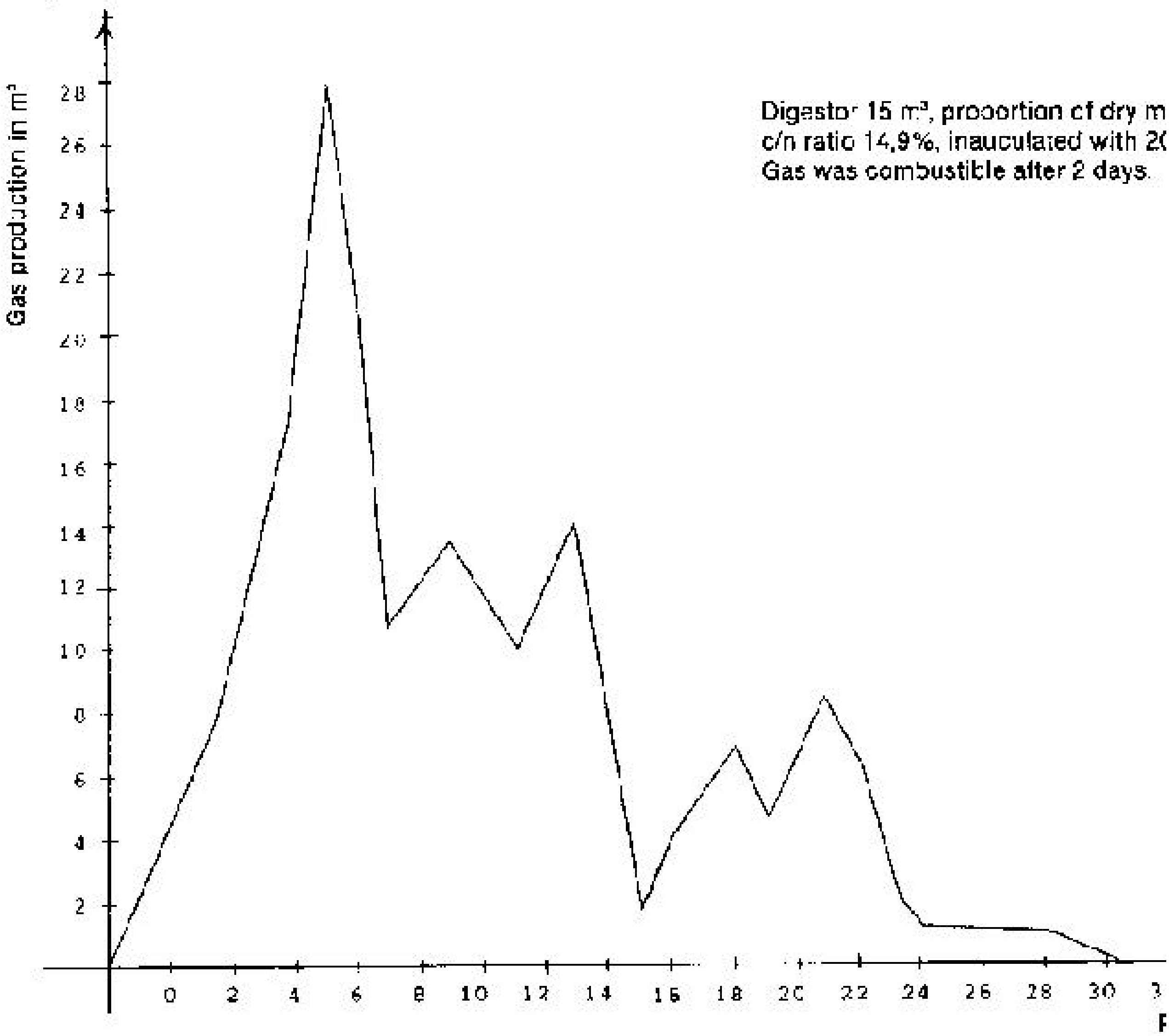
With a dry matter content **of** 10% the unit produced 0.18 m³ **of** biogas per kg **of** poultry excrement over a period **of** 24 days. At first, this gas contained 64% methane, increasing to 72% **in** the third week.

The quality **of** biogas is a direct function **of** the pH. With a pH **in** the acid region between 5 and 6, it is well possible that gas production will be very high but that gas quality, on the other hand, will be extremely poor with a methane content **of** only 20%. With improvement **in** pH, which came about automatically, gas quality also improved.

At present, one biogas unit is continuously being refilled with the poultry excrement/rice chaff mixture, thus slightly increasing the proportion **of** dry matter. The unit is functioning satisfactorily.

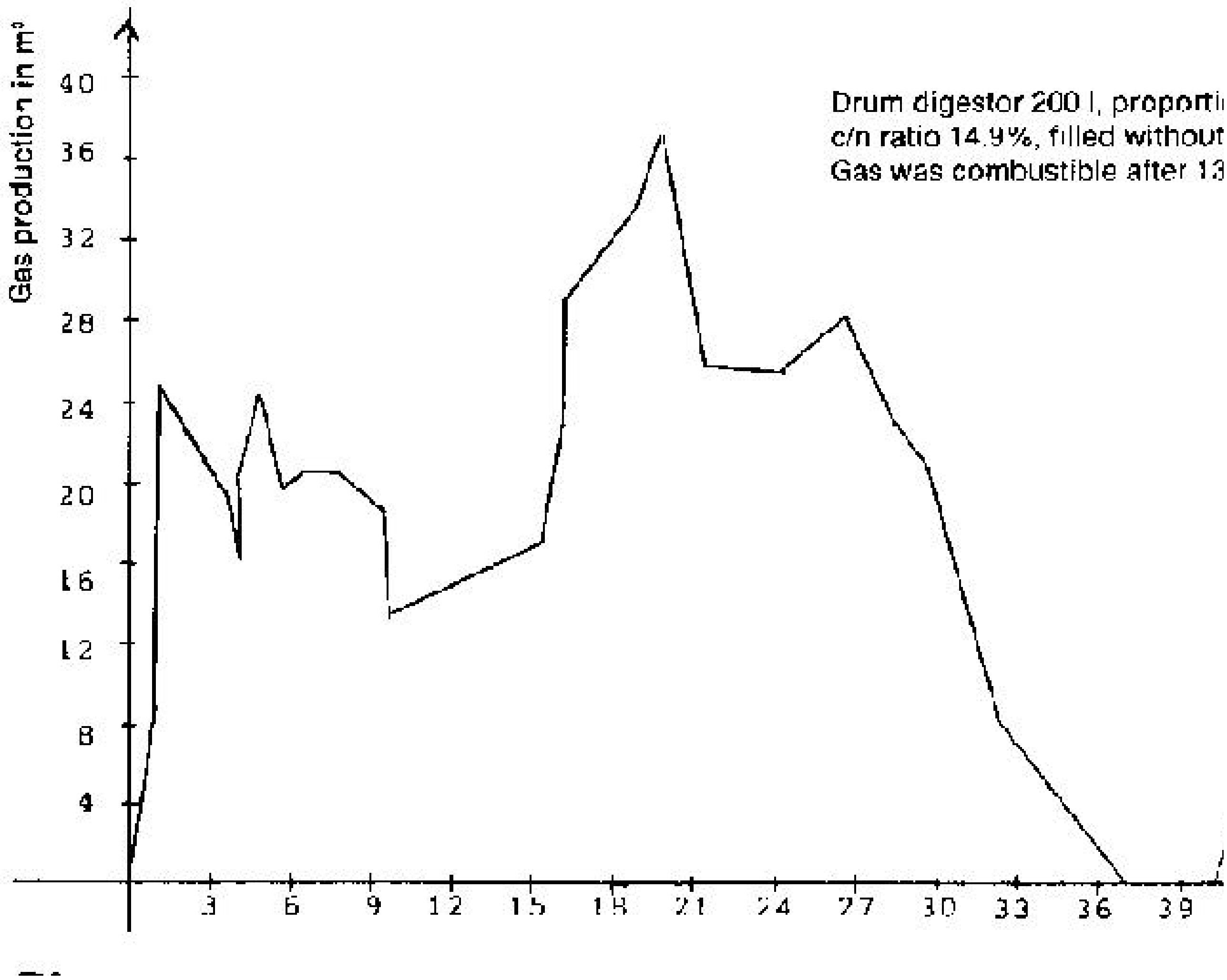
In conclusion, one can say that fermentation **of** these large amounts **of** biomass is feasible. Our experience has, however, shown that this is an extremely "sensitive" material and that the operator must always be **in** a position to interface **in** the process without too much trouble. On the other hand, this easily available and manageable **organic** material should not be ignored for fermentation **in** continuously operating biogas units.

Diagram 1: Production Graph



Figure

Diagram 2: Production Graph



Figure

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Biogas storage tanks **of** plastic sheet

by Gerhard Kopiske and Heinz Eggersglüss

At the "Biogas Workshop on Community Plants" **in** Bremen **in** May 1984 it became evident that **in** India **in** particular, transport and distribution **of** biogas present a problem. A need for portable gas storage tanks was thus identified and a search for new solutions was called for.

The company UTEC GmbH was commissioned by GTZ to collate the technical principles, experience **in** practice, and results from laboratory investigations into the **use** **of** sheet materials; also, to have prototype portable gas storage tanks with a capacity **of** 1.4 m³ each made, and to have them field-tested **in** cooperation with the Center **of** Science for Villages **in** Wardha. India. These gas bags are so designed that a day's supply **of** gas can be transported as if **in** a rucksack. The photo gives an impression **of** the size and appearance **of** these gas bags. No results **of** the field tests are available as yet.

Plastics as a gas storage material

Of the many possible plastics only those are considered which are thus far commonly used for producing sheets and coated fabrics. These are the thermoplastics polyvinyl chloride

(PVC), polyethylene (PER), chlorinated polyethylene (CPE) and the elastomers butyl (IIR), chlorosulphonated polyethylene (CSM), chloroprene rubber (CR) and ethylene-propylene-terpolymer (EPDM).

There is no standard governing the recipes for these plastics. The degree **of** freedom **in** the composition and production is so great that the different materials can only be described **in** general terms.

Long-term behaviour

One major criterion when selecting suitable sheet plastics is their long-term behaviour. The principal influences affecting the materials are atmospheric influences and the actions **of** chemicals, animals, and micro-organisms.

Of these influences, ultraviolet radiation and ozone loading have the greatest effect. The plastics undergo a chemical change and may become unusable, e. 9., as a result **of** a slow reduction **in** their ultimate tensile strength or sudden failure.

The resistance **of** thermoplastics to temperature is 65-70 °C, that **of** elastomers 90-120 °C.

In general it may be said that elastomers have better aging and temperature-resistance properties than thermoplastics.

In the application under consideration here, effects **of** chemicals only occur to a limited extent; resistance to methane, water, and to a limited extent also to hydrogen sulphide and **organic** acids. These criteria are satisfied by all materials; however, when PVC is used, biogas-resistant material should be chosen. This resistance is achieved by using special plasticizers which are not named here for reasons **of** commercial competition. If standard plasticizers are used the plastic is likely to become brittle after a certain time as a result **of** plasticizer migration.

Sheet material can be damaged by the actions **of** animals and micro-organisms. Rodents, **in** particular, may attack the material and make holes **in** the rolls. The susceptibility **of** the materials depends to a great extent on their physical properties, their outer form, the thickness **of** the material, and the chemical composition. Edges or tabs encourage gnawing, and the same effect results, for example, from the **use** **of** certain ingredients **in** PVC to which rodents seem almost addicted. One **of** these is red mud plastic (RMP), which has earned the nickname "rat mud plastic" because **of** its popularity with rodents. RMP is a PVC which has a bauxite extract and old oil as fillers and stabilizers.

If a mechanical stress is added to the above-mentioned effects the long-term durability is considerably reduced. For this reason, when, e.g., sheets are used, the limit load applied to them must be less than 10 per cent **of** their ultimate tensile stress.

Processing **of** plastics

Sheeting materials have to be treated very differently **in** processing than when being repaired. Among the possible methods are bonding, welding, and vulcanizing. The possible applications **of** these methods for producing and repairing gas bags are shown **in** the table on page

Risk to health and the environment

Plastics may constitute a danger during production, processing, and disposal, e.g., burning, due to the liberation **of** constituents.

While the plastic product causes no risk **in** normal **use** , a certain risk potential does exist **in** production, processing and disposal. Individual constituents, some **of** which may be liberated by decomposition, are toxic, cancerogenous, or represent a nuisance.

In processing, for example, these include the solvents **of** the bonding agents; **in** welding, evaporating ingredients **of** the plasticizer and vinyls. **In** disposal, cadmium, lead, and sulphur **in** the plastics may give rise to problems.

Gas permeability

In all **of** the materials studied, the gas permeability **of** the sheeting and coated fabrics is satisfactory, provided the following points are observed when selecting and processing them:

• the coating **of** coated fabrics must be thick (more than 0.8 mm on PVC); the coating thickness **of** cheap truck tilts is not sufficient;

• the coating must be protected from damage, because the fabric is very permeable to gases;

• **in** making the gas bags care must be taken to ensure that no open layers **of** fabric extend into the gasholding space on one side;

• with sheeting and coated fabrics the joining method used must not weaken or damage the material cross-section.

Since there is a very great increase **in** gas permeability as the temperature rises, it is advisable to keep the bags **in** the shade. The daily gas losses calculated for the above-mentioned gas bags are around 0.5-3 per cent **of** the bag's capacity. For this reason, gas storage bags made **of** sheeting must always be stored **in** a well-ventilated place.

Assessment

The various sheeting materials were assessed on the basis **of** a list **of** criteria. A subjective appraisal **of** their behaviour was required **in** many cases, since the stresses to which they would be subjected **in** practice could only be simulated.

It was found that with regard to the raw materials, elastomers were superior to the thermoplastics. **In** particular, the aging and temperature-resistance properties are better. If weight is an important criteria rubberized fabrics (CR, CSM) are preferable to pure sheets; the material strength is also considerably higher when artificial-fiber fabrics are used.

IIR and EPDM sheets are very labour-intensive and expensive to make up into bags. This is also true **in** respect **of** vulcanizing **of** coated fabrics, though **in** the latter case bonding with two-component cement is also possible.

In view **of** their lower resistance to aging and temperature, the thermoplastics are regarded as less satisfactory. PVC-coated fabric is the best among them. It can be processed easily and **in** many different ways and it is relatively cheap. The probable thermal load can be reduced by opting for a light colour and incorporating a shading device **in** the design. Biogas-resistant PVC is available **in** the FRG, though **in** other countries recourse will probably have to be made to the standard-quality product.

Because **of** its poor mechanical properties, PE was found to be unsuitable for the application under study. Bags made **of** PE tend to require very frequent repair. And this is complicated because simple bonding is not possible.

As a raw mateial CPE exhibits good resistance, but joints which can be subjected to loads cannot be made with it because **of** its tendency to yield. Gas bags **of** CPE can only be used completely unpressurized.

Summary

Of the many possible plastics for sheeting and coating fabrics, rubberized fabrics are most suitable for making portable gas bags. Pure rubber sheeting, on the other hand, is considerably heavier and also more laborious to process.

PVC-coated fabric was found to be suitable to a certain extent. Its resistance to aging and biogas depends to a great extent on the recipe. PVC can be processed very simply **in** many different ways.

However, locally, i.e., **in** the country **in** question, the criteria are different from those applicable **in** Europe. Questions **of** availability, local production, and repair methods are **of** paramount importance, while the theoretical suitability **of** a material becomes less significant because there is no choice.

The **use** **of** plastic sheeting for making portable gas storage tanks is certainly a suitable and interesting solution to the problem. The technical possibilities are known; the question **of** social considerations remains unresolved. The field test, which is still **in** progress, will provide some answers to this, too.

UTEC GmbH will be glad to answer your questions on this topic. **In** order to complete our documentation we would ask you to send us details **of** the experience you have gathered, literature, samples **of** materials, etc. This will be collected and kept **in** readiness for answering queries.

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Abstract

The **use** **of** plastic foil **in** the production **of** transportable gasholders is a very interesting and suitable solution. Field tests with these gas sacks have not yet been concluded, however, so that final results have yet to be published. At this stage, so much can be said: the material must not be too sensitive to ozone and ultraviolet radiation, and must be proof against micro-organisms and rodents. Up to the present, an tested materials have proved to be sufficiently safeguarded against gas permeability. As regards materials, elastomers are to be preferred to thermoplastics.

Résumé

L'utilisation de feuilles synthétiques pour la réalisation de réservoirs a gaz mobiles apparait comme étant une solution intéressante et appropriée. Les séries de tests réalisés sur place avec de tels ballons a gaz ne vent certes pas encore terminées, de sorte que l'on ne dispose pas encore de résultats définitifs. Cependant, on peut déjà dire que les matériaux ne doivent pas être trop sensible a l'ozone et aux rayons ultra-violets et doivent pouvoir résister a l'attaque des micro-organismes et des rongeurs. Il s'est avéré jusqu'a présent que la perméabilité au gaz de tous les matériaux testes est suffisamment assurée. Pour ce qui est des matériaux eux-memes, les élastomères vent supérieurs aux thermoplastes.

Extracto

El empleo de hojas de plástico pare la construcción de depósitos de gas transportables es, desde luego, una solución interesante y apropiada. Las pruebas practicas con estos ,,sacos de gas" no han concluido aun y no se dispone, por lo tanto, todavia de resultados definitivos. No obstante ya se sabe que el material no debe ser demasiado sensible al ozón y a los rayos ultravioletas y debe ser resistente a los microorganismos y los roedores. Hasta el momento ha quedado demostrado que todos los materiales comprobados ofrecen suficientes garantias en cuanto a la permeabilidad a los gases y que los elastómeros y termoplásticos son los materiales mas apropiados.

UK Farmers Support Practical Aid

Famers throughout England and Wales are rallying behind a new scheme that will bring practical agricultural help and know-how to their counterparts **in** the Third World.

The campaign is being organized by Britain's biggest agricultural organization : the NFU-(National Farmers' Union), **in** conjunction with Voluntary Services Overseas (VSO), the UK charity which sends people with specific skills to work **in** the developing world.

Each county **in** England and Wales has its own localised branch **of** the NFU, and 14 **of** these county branches have pledged to support VSO candidates working on two-year agricultural projects **in** such countries as Kenya, Nepal, Nigeria, Papua New Guinea, Tanzania, Thailand, Tuvalu and Uganda.

These VSO volunteers, all **of** whom win be working for subsistence wages only, will work **in** individual **communities** **in** local schools and institutes or on projects-funded by aid agencies, with the aim **of** training colleagues **in** basic agricultural skills relevant to conditions **in** the area.

Among the specific areas **of** agriculture **of** which they have specialist knowledge are food crop production, seed multiplication, forestry, fisheries, livestock production, ox traction, irrigation and soil conservation, and farm management. (LPS)

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Economic and socio-economic evaluation of biogas units from the users' point of view

by Ulrich Stöhr and Uli Werner

The majority of biogas units in developing countries are integrated in small and medium-sized agricultural enterprises. The following is intended to help advise farmers with small and medium-sized farms looking for an analysis of the cost/benefit effects of a biogas unit appropriate for their farming situation. For this purpose a useful life of 10-15 years for a biogas unit is generally assumed.

The analysis which follows, which is intended for unit operators, does not take overall economic effects of biogas units into consideration, such as effects on regional development, promotion and diversification of local craft trades, the net effect on employment, the conservation of natural resources, especially by reducing deafforestation and/or sewage, and savings in foreign currency expenditure on imported energy and mineral fertilizer. Seen realistically these secondary effects are only relevant when there is global dissemination, and in most countries this will not be achieved in the forseeable future.

Problems of determining benefit and evaluation at the user-oriented level

It is usually easy to put a figure on the cost of building and operating a biogas unit. The capital investment and the costs of spares are mainly money expenses. Operation and maintenance are primarily a question of working time.

Determining the benefits of a biogas unit is more difficult. Apart from clearly quantifiable effects, some of which can also be expressed in terms of money, there are a number of non-quantifiable factors. Economic appraisals based on cash flow only cover some of the factors which are important for unit operators in reaching a decision regarding the investment.

Because on the one hand it is also important to take the effects in the socio-economic and consumer sector into account when evaluating the benefits of biogas units, such as smoke-free cooking, increased prestige, or being able to read in the evenings. On the other, the problems of carrying out an economic appraisal on the basis **of** the flow **of** payments are all the greater, the less the small farm is integrated **in** the monetary economy and commercial energy markets.

Therefore, an appraisal **of** biogas technology that takes both business management and socio-economic considerations into account have three levels **of** evaluation, which are **of** corresponding importance **in** advising small and medium farmers. They have to be regarded as analyses which complement each other. The order **of** their importance and their individual importance may vary depending on the region or locality **in** question.

1. Monetary economic appraisal

All the outlay/income flows connected with the biogas unit as an investment object are taken into account. On the expense side these flows are, **in** particular, all investment expenses, the costs **of** spare parts, e.g., for the metal gas dome. Then there are repair and maintenance costs and possibly the costs **of** raising capital, as well as wage and ancillary wage costs.

On the income side there are:

• cash savings due to the substitution **of** commercial energy, the net sales proceeds from the production **of** superfluous energy or respectively the goods produced with it;

• cash savings due to the substitution **of** mineral fertilizer previously bought, the net sales proceeds from digested sludge fertilizer or respectively the net sales proceeds from increased agricultural yields;

• real income gains from savings **in** working hours due to the biogas unit enabling the users to do paid work or increase the output **of** marketable produce on their farms.

At the individual economic level the economic appraisal gives the investor an aid **in** deciding whether the project will bring advantages, or what relative advantages it offers compared to other farm investments. For direct information and advice for small and medium farmers a calculation **of** the investment amortization time and a simple profitability calculation are likely to be particularly relevant.

The calculation **of** the amortization time tells the potential unit operator whether he can recover the capital he will have to invest within the technically feasible working life **of** the unit. Small farmers operating with little personal capital, and **in** many cases with uncertain economic prospects, are justifiably interested **in** minimizing the risk, i.e., keeping the amortization time as short as possible. The static profitability calculation gives a rough idea **of** the likely interest on the invested capital per unit **of** time. By abiding by certain rules about methods it is also possible to choose the investment alternative - among several - which is likely to be the most favourable.

The two investment calculation methods outlined here, and their results, have the advantage that they can be communicated to the target group relatively easily. This applies especially to static calculation methods.

However, the biogas adviser should check the statements he makes on the basis **of** static calculations against the complicated dynamic methods, which take the uncertainties **of** future development into account. This is necessary because payments for biogas units extend a relatively long period **of** time.

2. Working time accounts

Keeping comparative working time accounts, expressed **in** hours and relating to family members and employees, is especially important for small and medium-scale farmers. This balancing also includes the monetary effects associated with expenditure or respectively savings **in** working time on the farm.

Additional work caused by the biogas unit on the farm and **in** the household includes:

• the work involved **in** building the unit;

• continual filling **of** the unit and collection **of** the dung;

• transport and removal **of** the digested sludge;

• the time spent by the operator on repairs and maintenance.

As a rule the biggest saving **in** working time is **in** cooking, because it is not necessary to gather and chop wood, cooking times are shorter, and it is no longer necessary to clear out or remove fresh and liquid manure.

It is not only advisable to keep working time accounts for the farm and household because they bring clarity; there are other reasons, too, because **in** many cases there is no real opportunity locally for the members **of** the family to do paid work. A further reason is that it does not always lead to additional yields which can be measured **in** monetary terms, even if the working time thus saved is invested **in** the farm. However, subsistence production can be increased. It could also happen that an excessive emphasis on the possible reallocation **of** saved working time, e.g., **of** women, to other agricultural work, associated with corresponding expectations **of** a higher yield, would lead to overwork for the women (this has also been found **in** practice).

3. Non-quantifiable effects

The third level **of** an analysis for unit operators is that **of** the numerous secondary effects **of** the biogas unit, which cannot be expressed **in** terms **of** money, but which are also hardly or not at all quantifiable.

These include, for example, the fact that the soil structure is generally improved by fertilization with digested sludge, without it being possible to prove this quantitatively. Or that the condition **of** the livestock improves as a result **of** improved housing conditions. **In** the consumer or respectively socio-economic area the benefits are above all **in** the improved reliability **of** the energy supply, the prestige value and the convenience **of** lighting **in** the evening, as well as **in** the general improvement **in** health and hygiene.

On the other hand, a negative factor that can hardly be quantified is the aversion **of** unit loaders to handling faeces and excrement.

None **of** the three levels **of** assessment alone will be decisive **in** the investment decision for or against a biogas unit, or the final assessment **of** it **in** everyday **use**. However, **in** practice they recur **in** ail packages **of** reasons for exploiting biogas technology, with varying degrees **of** importance attached to them, independent **of** local conditions. This is also shown by the examples **of** two family units.

Mascoll's Farm, St. Vincent, Caribbean

Static amortization calculation

The 11 cubic-metre family unit on a 20-acre farm with 4 head **of** cattle cost the family, who built it themselves, $ EC 2,730 (for materials only). The annual costs **of** materials for repairs and maintenance amount to about $ EC 200. On the credit side there is an annual saving **of** $ EC 400 for kerosene and fertilizer. With a static calculation this results **in** an amortization period **of** almost 14 years.

Working time accounts

The actual advantage **of** the unit for the Mascoll family is **in** the considerable saving **in** working time for gathering and preparing wood and **in** shorter cooking times (at least 3 hours a day); altogether, the saving **in** working time amounts to 120 days a year. This compares with time spent for filling the unit and removal **of** digested sludge amounting to about 20 minutes a day. Together with the time spent on repairs and maintenance this amounts to about 27 days a year.

If the members **of** the farm communitiy could reap the full benefit **in** cash from the considerable net savings **in** working hours, by doing paid work for average local wages, the amortization time would be considerably reduced, to about 2-½ years.

As benefits **of** the unit that are not or not yet - quantifiable the Mascoll family mention the reduced smoke nuisance when cooking and the relatively bright light **of** the biogas lamp, as well as the resulting more pleasant evenings. **In** addition, the family have plans to become advisers and unit builders, and thus to tap new sources **of** income.

Zakaria Family, Miovaro,

Tanzania

This family cultivates coffee and bananas and owns three cows, two calves, and eight sheep and goats.

Static amortization time

The investment cost **of** the "turnkey" unit (including gas-utilization apparatus, paving **of** the stable floor and connection to the biogas unit) was 11,000 THS. To this must be added the replacement **of** the burning-points, necessary every three to four years, costing 400 TSH. The unit supplies cooking energy for a 1 2-headed family; previously, "free" wood was used. The only tangible monetary benefit for the operators is the baking **of** about 100 flat loaves a week with superfluous biogas, and selling them. This is a completely new field **of** activity for the family, yielding a net profit **of** approx. 200 TSH a week. The amortization time (static) **of** the unit is thus about 1¼ years.

Working time accounts

The family statistics are similar to those **of** the Mascoll family: the net annual saving **in** working time is also between 90 and 100 days.

Additional beneficial effects **of** the biogas unit **in** the family's opinion are that the stable floor is kept clean, so that flies are less **of** a nuisance to both people and animals, and the greater taken **of** the animals; furthermore, obvious - though not quantified - fertilization successes **in** the coffee plantations. And at the same time vegetable fields are being laid out near the biogas unit.

These two examples **of** family biogas units make it clear that especially when "freely" cut wood, i.e., wood that costs nothing, is replaced by biogas the amortization **of** the biogas unit can hardly be guaranteed during its economic life. Only by turning savings **in** working time into money (Mascoll) or commercial activities (Zakaria) - on the basis **of** using superfluous biogas - can result **in** a favourable amortization period for the capital invested **in** these two cases.

However, both unit operators consider the saving **in** working time, even without any money income, very important; they usually invest the time saved **in** their farms. The other non-quantifiable benefits are similarly appreciated.

Abstract

Economic appraisals help users to estimate the value **of** individual biogas units correctly. They are therefore a valuable advisory tool- and can be applied **in** various ways: as a monetary economic appraisal or, e.g., **in** the form **of** working time accounts. **In** contrast, it is difficult, or completely impossible, to quantify the effects **of** a biogas unit **in** the area **of** consumption.

Résumé

Des calculs de rentabilité permettent une évaluation exacte de la valeur de chaque installation au biogaz. Ils vent done un instrument précieux pour l'apport de conseils. Il y a la plusieurs possibilités: d'une part, le calcul de rentabilité monétaire, d'autre part, I'établissement du bilan du temps de travail. Par contre, les répercussions d'une installation au biogaz dans le domaine de la consommation vent difficilement quantifiables, voire pas quantifiables du tout

Extracto

Los cálculos de rentabilidad son una ayuda pare analizar correctamente el valor individual de las instalaciones de una planta de biogás. Constituyen, por lo tanto, un instrumento de asesoramiento muy valioso.

Existen varias posibilidades; por una parte, el calculo de la rentabilidad económica y, por otra, el balance de las horas de trabajo. En cambio, es difícilo, incluso, imposible cuantificar Ias repercusiones de una planta de biogas en el sector del consumo.

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