Tropentag 2011
University of Bonn, October 5 - 7, 2011
Conference on International Research on Food Security, Natural Resource Management and Rural Development

Biogas as Business – Biogas Transport Technology and Economic Concept for Developing Countries

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Introduction

Improved energy supply of the rural population in developing nations has the potential to accelerate the development from a bottom up direction. Not only the uneven distribution of fossil fuel resources, but also missing infrastructure for distribution and the people`s inability to pay currently limit a large-scale grid dissemination. In East Africa, about 90% of the energy needed for cooking, lighting and heating is generated from burning organic material. The resulting short term excessive wood consumption leads to widespread deforestation in the medium term and severe soil degradation through soil erosion in the long term. This causal interconnection between fuel shortage at rural household level and the shortage in fertilizer finally resulting in insufficient food supply lead to the assumption that supporting the rural poor in their energy needs means approaching the root of a complex of closely related problems. Within the framework of the Africa Biogas Initiative of 22 African countries, the dissemination of family-sized biogas plants is planned, feasibility studies have been undertaken and in some countries the first years of implementation have already been evaluated. These show that the installation of biogas plants at household level, each one big enough to theoretically supply one family with sufficient gas, is fraught with difficulties, especially regarding attainment of the poorest and sustainability of the subsidy driven activity. In Ethiopia the aim of providing poor rural households with an affordable source of energy in order to improve living conditions and to reduce environmental impact is approached as defined in the National Biogas Program Ethiopia (NBPE). It includes a highly subsidised (around ETB 5000/installation) implementation of domestic biogas for individual households and is designed to provide 14.000 (0.13%) out of 11.2 million households in 4 selected regions within a 5 year period until 2013 with domestic biogas plants (4-10m^3). Progress reports show a variety of discrepancies between goals and actual achievements. Until December 2010, a number of 860 digesters had been installed (Branden, C., Addis, Y., 2011). Major constraints of the NBPE are related to lacking financial attractiveness and to the conditions concerning cattle, funds and water to be met by households. Thus, the majority of households is excluded from the program due to their inability to meet these conditions.

In order to improve the accessibility of biogas for rural households in developing countries the subsidy driven domestic application should be transformed to an independent business opportunity for investors. The present paper sketches an alternative approach for biogas dissemination and presents a new biogas storage and transport technology.

Material and Methods

The status quo of biogas in different developing countries was investigated in a literature research. Reasons for failure of both, domestic and community biogas were evaluated and the findings were used as basis for the development of the biogas-as-business concept.

The biogas transport device was systematically designed according to VDI guidelines 2221(1993) and 2222 (1) (1997). The design problem referred to a “transportable storage device for biogas in developing countries”. The overall task was to develop a device for repeated fill up with biogas at the place of production to flexibly provide individual households with the daily required amount of energy for cooking and lighting. This task was divided into the three main sub tasks *refill, storage* and *release of biogas* with their appertaining sub functions: *connecting to biogas plant, safe transport* and *supply of stove or lamp*. The morphological matrices were used to systematically find design solutions for the storage device and its protection from external impacts.

The theoretically designed container was produced and prototypes were tested for further characteristics like gas transmission and pressure resistance. To determine transmission rates for methane and carbon dioxide the device was filled with artificial biogas (60.3% methane, 39.7% carbon dioxide) and stored in a climate temperature system (CTS, type C-20/1000). To analyze changes of air composition in the closed chamber over time, the air was circulated and measured by the Fourier Transformed Infrared (FTIR) spectrometer (Ansyco, Gasmet Dx 4000) at three different temperature-humidity-settings: 23°C/50%, 45°C/20% , and 70°C/5%. For pressure tests the container was equipped with a manometer and slowly inflated with compressed air.

Results and Discussion

The path laid through the morphological matrix as shown in… leads to the biogas storage and transport device, that was realised as prototype. It is equipped with compressor quick coupling to connect to the biogas plant via hose. Inflation is achieved by pressure equalisation between device and digester, which is possible, because it is made of a flexible (not elastic) and preferably light material (PE, EPDM or PVC). The device is equipped with straps to be transported as backpack. During storage it stands upright and the gas is forced out of the container by weighting down with external weights. There is no interconnection of individual parts required, because the device is designed as one unit. In order to control the flow in front of the stove a shut-off is provided.

Gas transmission generally increases with temperature for both gases, but CO_2 shows a much higher permeation rate of 4 to 7-fold higher than CH_4. The CO_2 permeation can be reduced to about 50% by using 2 layers of PE, while the permeation of methane is only slightly slowed down by an additional layer. Compared to the formerly measured suitability of butyl rubber for the storage of biogas, the PE inliner shows a much higher selectivity. Butyl rubber is more permeable for methane while the transmission of CO_2 is similar to the 2-layered PE material. The maximum pressure as found in Ethiopian biogas plants does not exceed 8 kPa. The pressure tests showed that the containers persist pressures above 11 kPa.

The designed container fulfills all requirements and its applicability could be approved in a first field test in Ethiopia.

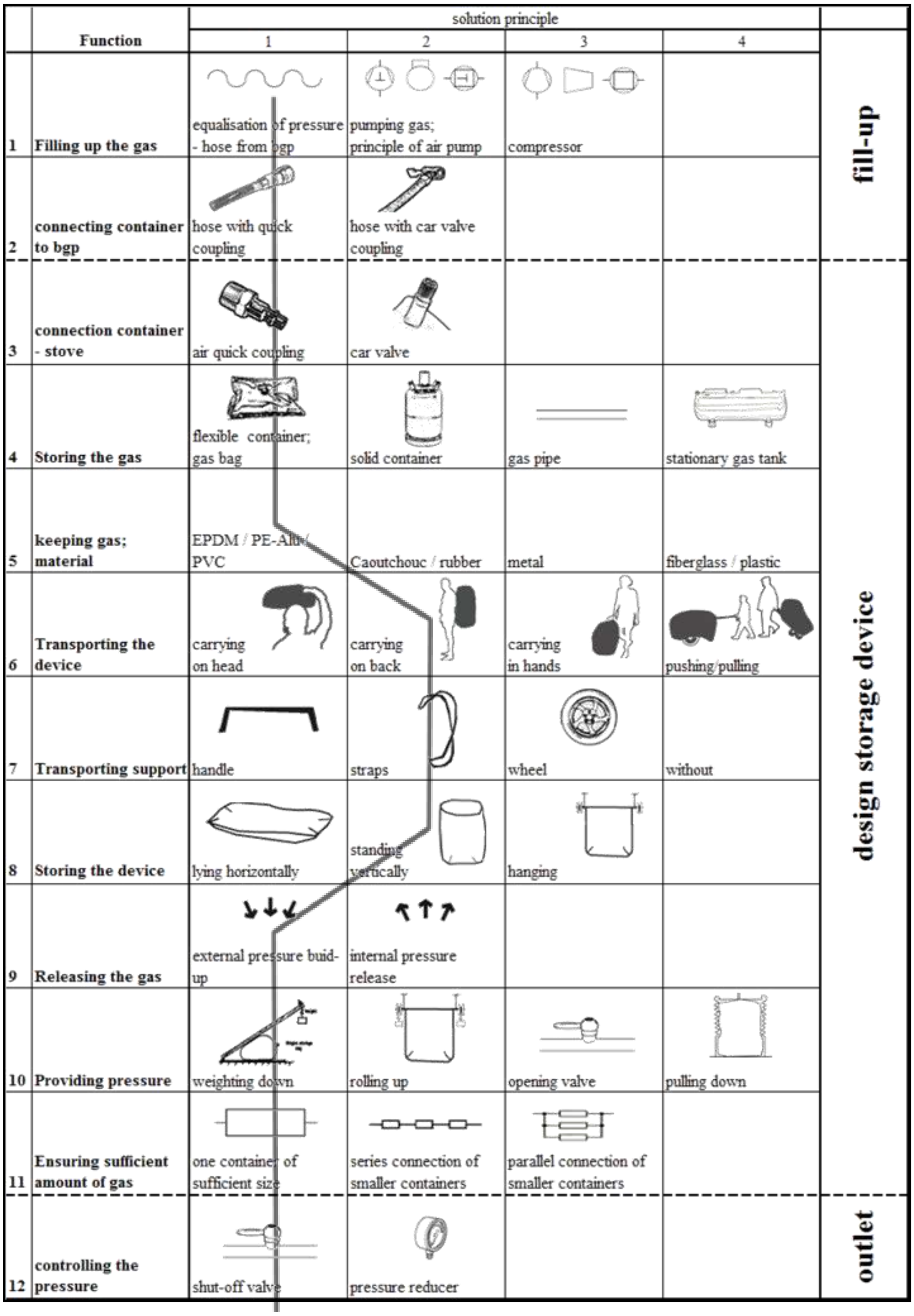

Fig. 2: Morphological Matrix: Biogas Storage device including refill and release technology

Conclusions and Outlook

The two currently followed approaches - domestic and community biogas – have different advantages and a variety of serious constraints to a successful implementation. What they have in common is that they are based on subsidies, thus lacking economical attractiveness for entrepreneurs. Without a higher motivation of the plant owners or operators the continuance of biogas production without foreign help and financing cannot be assured. Up to date the commercialisation of biogas was limited, because a technology for economical gas distribution was not available. Thus, the sale of biogas was practically impossible when not pipes were run or compressors were used to bottle the gas – both expensive solutions. The mobile biogas storage device now provides the opportunity to sell biogas on a low-tech basis. The transport of biogas facilitates the development from a subsidy driven, involuntary dissemination of biogas to a self-determined and commercial market for alternative energy. Potential producers for biogas in Ethiopia are commercial cattle or pig farmers. They can easily meet the conditions like substrate availability, possession of property and ideally also capital for investment. At this privately owned central biogas plant villagers can buy biogas by filling up their individual biogas backpack. In remote areas of developing countries, typically the areas where alternative sources of energy are needed the most, lack of income can be the decisive constraint to the above described approach. By sensibly embedding a larger scale biogas plant into the communities potential, that means including the potential of small scale farmers to contribute to biogas production and employing the funds of villagers with external income, the ability to pay for biogas can be created. The trading system that needs to be established around a central, privately run biogas plant, affiliated to a commercial animal farm, includes the purchase of substrate from small scale farmers and the sale of biogas and fertiliser to all villagers. The biogas investor has to size the plant big enough to process his own substrate as well as the substrate otherwise available in the area. This is preferably cow dung from small scale farmers who can gain additional income by delivering dung of their own cattle. Through conversion to biogas the initial value of dung is increased so that the profit from biogas sale is higher than the expenses on substrate. This is important in order to win back the awareness for the value of energy and to fight the “culture of non-payment”. Additional profit is gained by selling digestate as fertiliser. In this way, both, producer and user of biogas can financially profit, but only when input and output side are balanced. This requires a certain number of households, which only buy biogas and fertiliser without selling substrate. They typically have an income outside the agricultural sector and do neither have cattle/ substrate nor do they rely on the sale of it. The kind of substrate, its condition (size, water content) and price have to be specified in future research after close investigations of availability, way of transport, willingness of people to participate etc. The advantages towards the current approach of household biogas dissemination can be summarized as

- *financially more effective* due to economies of scale
- *creating independence* of long-term foreign help and finance due to profitability
- *sustainable* due to self-reliance, financial benefit and self-motivation
- *facilitating further development* for the area, because many benefit from the trading system
- *including small-scale farmers,* who can contribute to biogas production as substrate seller, even when possessing only one cow
- *exploiting full potential* of biogas production
- *teaching responsibility* to solve the own problems instead of creating dependencies.

References

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