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Efficiency analysis in a domestic biogas programme

Domestic biogas plants have a direct positive effect on rural peoples' energy supply, environment, health and agricultural production. Therefore, the Netherlands Development Organization (SNV) supports the formulation and implementation of national programmes on domestic biogas in some developing countries. In these programmes, multiple actors at different levels cooperate on the basis of proper institutional arrangements to provide access to sustainable energy for households raising livestock. SNV advises these actors in developing a commercially viable and market-oriented biogas sector. This case explains how to analyse efficiency in domestic biogas project.

The Partos Efficiency Lab, November 2017

This case is one of a series of ten that was produced in the framework of the Partos Efficiency Lab. See back cover for more information.

Project at-a-glance[1]

- Project type: Domestic biogas programme
- Geographic intervention area: Rwanda
- Project budget: US$ 15 million[2]
- Budgeted for end-of-project evaluation: US$ ..
- Project Duration: 5 years

In Rwanda households depend on biomass, in the form of wood, charcoal or agricultural residues, as the main energy source for cooking purposes, both in rural and urban areas. The use of gas and electricity for cooking is negligible. The country relies on imports for all its petroleum related products which makes them expensive and inaccessible for the bulk of the population. Against this background, the Rwanda invests in developing the biogas sector along with other initiatives that focus on diversification of energy sources, reduction the reliance on firewood consumption and at the same time helping to preserve forests/the environment.

Project objective

The overall objective of the programme is 'to develop a commercially viable and environmentally sustainable market-oriented biogas sector, resulting in the reduction of biomass resource depletion while providing a significant improvement in the quality of life of the families concerned'.
It is expected that the project will generate the following results[3] at impact level:

- Significant reduction of the workload of 13 500 households (10 % failure rate), mainly for women and children;
- Annual savings on fuelwood of 36 450 ton;
- Annual savings on charcoal of 1 296 ton;
- Annual reduction in CO_2 emissions of 53 865 ton (based on a 90 % success rate and preliminary calculations indicating that domestic biogas plants reduce GHG emissions to the tune of 4 tons CO_2 equivalent per year);
- Use of bio-slurry resulting in significant annual savings on plant nutrients (NPK) and organic matter available in the soil to improve fertility;
- Significant improvement of health by the reduction of indoor air pollution and smoke exposure and in the future by the use of toilet attachments, benefiting especially women and children;
- Generation of employment in the rural areas

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[1] The text for writing this case has been copied from two sources. These are:

- Dekelver, G., Ndahimana, A., Ruzigana, S. (2006). Implementation Plan National Programme on
- Domestic Biogas in Rwanda, SNV/MININFRA, Rwanda.
- Bedia, A.S., Pellegrinia, L., Tasciottia, L., (2013). Impact evaluation of Netherlands supported programmes in the area of Energy and Development Cooperation in Rwanda, International Institute of Social Studies, Erasmus University Rotterdam, The Netherlands

[2] Total budget: 14 943 630 US$:

- Government of Rwanda (GoR) - subsidy (25 %): 1 113 750 US$
- Donor (to be identified) - subsidy (75 %): 3 341 250 US$
- Donor (to be identified) - programme cost: 1 447 480 US$
- Netherlands Development Organization (SNV) - technical assistance: 740 000 US$
- Farmers, via revolving fund of 5 494 500 US$ provided by a donor (to be identified) to a credit institute – credit: 7 024 050 US$
- Farmers - cash/labour contribution: 1 277 100 US$

[3] Some of the costs and many of the benefits of the programme are in the non-market sphere and this makes it difficult to determine financial and economical values. Furthermore, the programme has a number of social benefits which are difficult to quantify and/or value.

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Project approach

This impact will be achieved through four specific objectives, contributing to the overall objective:

- To develop, strengthen and facilitate a commercially viable and market oriented Rwandan biogas sector;
- To increase the number of family sized, quality biogas plants with 15 000 in the country;
- To ensure the continued operation of all biogas plants installed under the NDBP;
- To maximise the benefits of the operated biogas plants, in particular the optimum use of digester effluent..

Assumptions and risks

The programme is based on the assumptions that:

- There is effective demand for biogas plants;
- Sufficient companies and masons willing to engage in the construction of bio-digesters can be found
- Financial institutions in the programme area are willing to participate in the NDBP

The NDBP runs a number of risks which have been incorporated in the design of the programme including:

- Lack of firm data makes it difficult to arrive at reliable predictions on effective demand;
- Little information available on the presence of companies and masons that fulfil the conditions to participate in bio-digester construction trainings. The NDBP might have to actively recruit technicians from the artisan sector, to form trained mason teams and build-up production capacity;
- High material and transport costs;
- Uncertainty about the willingness and ability of farmers to accept the high interest rates.

Recommended approaches for assessing efficiency

Notes on applicable tools and methods, Antonie de Kemp
This note summarizes tools and methods that can be applied to assess efficiency in the Domestic biogas programme (case #10).
We discern two levels of analysis: level 1, focusing on the operational level of an intervention and level 2, an analysis of the main benefits and costs, in order to be able to compare the project with alternatives. After several remarks on the case (Section 1), the note discusses applicable tools and methods first for level 2 (Section 2), and then for level 1 (Section 3).

1. Remarks on the case

The overall objective of the programme is 'to develop a commercially viable and environmentally sustainable market-oriented biogas sector, resulting in the reduction of biomass resource depletion while providing a significant improvement in the quality of life of the families concerned'. The project expects to realise the following outcomes and impacts:

- significant reduction of the workload of 13 500 households;
- annual savings on fuelwood of 36 450 ton;
- annual savings on charcoal of 1 296 ton;
- annual reduction in CO_2 emissions of 53 865 ton;
- use of bio-slurry resulting in significant annual savings on plant nutrients (NPK) and organic matter available in the soil to improve fertility;
- significant improvement of health by the reduction of indoor air pollution and smoke exposure;
- generation of employment in the rural areas.

The project has a budget of USD 15 million, including a contribution (investment and annual expenses) of farmers of USD 7 million.

As a rough indication, an evaluation budget of 1-2% of the projects costs is realistic (USD 150,000 - 300,000). The uncertainties (about demand and supply) also mean that a rigorous evaluation, including efficiency analysis, is warranted.

2. Level 2 tools and methods

Level 2 tools and methods compare the efficiency of entire aid interventions with alternatives or benchmarks with the purpose of selecting those interventions producing the largest net benefit with available resources. Methods in this group can be applied ex-post for accountability and learning purposes.

Before suggesting such an approach, we're interested in the direct benefits for the farmers. Knowing that the uptake was low, we may analyse why. An analysis of the willingness to pay in advance would have provided more information on the potential uptake. We limit this analysis to the expected cost savings.[4]

[4] For 85% of the households, a reduction in energy related expenditure was the main motive for purchasing a digester.

Profitability for the farmers

The farmers had to pay REF 500,000 for a 6m3 digester. Annual costs of fossil alternatives were about RWF 58,000. The expected life span of digester is 20 years. A question is the right discount rate. Farmers could have earned an interest rate of about 6 percent on a long-term savings deposits. However, the market rate for getting credit was about 17%. So, it the farmer has the money and has no alternative investments, he may reckon with a discount rate of 6%. However, if he must borrow the money, he would need to reckon with a discount rate of 17%. This makes a lot of difference. In the first case the net present value (NPV) of an annuity of RWF 58,000 over 20 years =

NPV= [(1-(1+0.06)-10)/ 0.06] * 58,000 = RWF 665,000, suggesting a profitable investment.

In this case, the payback period would be 12.5 years[5]. However, if we use the market rate for getting credit, the NPV= 325,000.

In addition, a main impediment for the farmers were the high cash outlays. For the average farmer, the investment would cost twice the annual per capita expenditure of his household. Late in the process credits were offered for 3 years at an interest rate of 13% (with a maximum of RWF 300,000 and a monthly repayment of RWF 11,000 or 53% of the annual per capita consumption expenditure).

Overall Cost-Benefit Analysis

In this case it seems to be possible to apply cost-benefit analysis, as it may be possible to calculate the monetary value of the main impacts:

- Energy savings by farmers: Assuming that 90% of the 15,000 farmers on average reduce their annual expenditure with USD 70 (RWF 58,000), this includes annual savings of 0.9 * 15,000 * 70 = USD 945,000.
- An annual reduction in CO_2 emissions of 53 865 ton (as measured by savings on fuelwood and charcoal). Without trying here to calculate the real impact on the environment, we could use the price in the European market (about USD 9.0 per ton) = USD 485,000.
- Health improvement: here we include the estimated costs of advanced cookstoves. Using biogas may be more effective, so it is probably an underestimation of the benefits. HAPI gives an investment of USD 1.9 million for 25,000 households and annual costs of USD 190,000. For 13,500 households this would be about an investment of USD 1,0 million and annual costs of USD 100,000.

Health effects may be huge. In 2002, 8,100 deaths were attributable to indoor air pollution in Rwanda, with over ninety percent of those deaths occurring in children under the age of five due to respiratory infections and lung diseases. For that same year, 262,300 Rwandan DALYs were lost due to indoor air pollution exposure.

We do not include the impact on the workload or employment effects. The project only mentioned a reduction in workload but did not consider the work related to the biogas digester (such as taking manure from the shed to the house, fetching water to feed the digester and transporting the slurry from the house back to the field). This had an impact on the effectiveness of the project. The same holds for the employment effects: the project expected increased employment due to the construction and repair of digesters, as well as the transportation and sale of bio-slurry, but did not include negative employment effects of reduced business for firewood vendors.

[5] The formula for calculating the discounted payback period is ln(1/(1-(I*i)/A))/ln(1+i), where I=the value of the investment, A= the Annuity en i= the discount rate.

On the costs side, we assume that 5% of the investment will be needed annually for maintenance and repair.

Calculating the NPV, using a discount rate of 6% and a life span of 20 years, the NPV of the benefits is: 10.8 + 5.6 + 2.2= USD 18.6 million. The NPV of the total costs= 15 + 8.6= USD 23.6 million.

Of course, there many uncertainties, as the CBA hinges on many assumptions, such as on the discount rate, assumptions about the economic value of reducing CO_2, etcetera. A good practice for CBA is to conduct sensitivity analyses that demonstrate how CBA results change if underlying key assumptions change. Moreover, in this specific case the analysis took about 2 hours (including finding the relevant information on the internet) and therefore may be erroneous. However, the example shows the importance of such an analysis as it gives an impression how (investment) costs relate to potential benefits, rather than just assuming that the benefits "speak for themselves".

Conducting a CBA usually takes several to many weeks and requires advanced economic analysis skills.

Ex post analysis:
An ex post analysis may be conducted the same way, with the advantage of having more information, for instance on the actual uptake, actual functioning of the digesters, and assumed health and employment effects.

3. Applicable level 1 tools and methods

Level 1 analysis focuses on the operational efficiency of a single intervention. Level 1 tools and methods are often conducted ex-post.

Level 1 methods that may be applicable to this project include:

Benchmarking of unit costs
In this specific case, it would be possible to compare the unit costs of the project with other biogas projects or with comparable interventions, such as the costs of connecting the households to the electricity grid.

If CO_2 reduction is the main motive, the project may be compared with other investments, aiming at a reduction of greenhouse gases. And for realising the health effects, there are also other instruments.

In addition, it would be possible to compare the costs of the biogas digesters with other biogas digesters. The project evaluation concluded that in Rwanda these digesters were relatively expensive in comparison to other countries.

It should be noted that a benchmark only makes sense if intervention and context are comparable. As mentioned in the other cases, a principal caveat with unit costs benchmarking is that it does not allow straightforward conclusions about outcome/impact-level effectiveness and efficiency. Cost differences may be related to differences in quality and context. However, large differences may indicate inefficiencies and therefore an argument for further (qualitative) analysis. One could try to make a more qualitative analysis of why these costs diverge (different price levels, different geographic circumstances, differences in approach, etc.). In this specific case, a problem was that many households did not have at least two cows, the minimum needed for the functioning of the digesters.

Benchmarking of unit costs can usually be done in a matter of days (provided required information is available) and does only require basic analytical and quantitative skills.

Follow the money

This approach systematically screens all project expenses (including costs of inputs (staff, consultants, material costs) with the objective of identifying potential cost savings. When applying it, the evaluator systematically disaggregates total project expenditures and, for each budget or expense category, conducts additional analysis to determine whether there is cost-saving (or yield increase) potential. The analysis focuses on inputs (economy) as well as the conversion of inputs into outputs. It will be helpful to complement the financial analysis with a more qualitative analysis of the operational processes.

In this specific case, the analysis may focus on:

- the costs of the biogas digesters and the energy efficiency of the digesters
- the implementation process
- coordination costs.

4. Conclusions

In this example we assessed the efficiency of a biogas project in Rwanda. While it was a project with many different objectives, the analysis focused on three main benefits:

- reduction of energy costs for the farmers
- CO_2 reduction
- health effects

We compared the costs of each element with the costs of alternatives (i.e. the costs of using firewood and charcoal, the (market) price of carbon emissions and the realisation of health effects with advanced cookstoves. Here, it is a quick and dirty approach, just to provide an example. It may contain errors. A more serious analysis usually takes several weeks, as well as the possibility to calculate the monetary value of benefits and the availability of information.
There are also simpler ways of analysing efficiency by focusing on costs and the process of transforming inputs into outputs or outcomes. These approaches have the highest value if outputs or outcomes are homogeneous.

The Partos Efficiency Lab

This case is one of a series of ten that was produced in the framework of the Partos Efficiency Lab. The Efficiency Lab was established mid-2017, in response to the finding from the MFS II evaluation that development organisations in the North and the South, as well as evaluators, struggle with the concept of efficiency, and with how to measure and analyse efficiency.

The aim of the efficiency lab is twofold:

- To develop a common understanding among Partos members about the concept of efficiency, the various methods for assessing efficiency, including their advantages and disadvantages.
- To identify and/or develop a recommended repertoire of appropriate policies, methods and tools for addressing the efficiency question in development interventions.

On 23 November 2017 Partos organised a conference on efficiency. Important insights shared by a panel of experts include that efficiency analysis is often of very poor quality in project setups and evaluations. This is because there is a lot of confusion about the concept of efficiency.

- First, definitions used by influential bodies such as OECD suggest that efficiency is about the relation between costs of inputs and outputs. According to these definitions even a project that has no, or even negative, outcomes or impact, can still be efficient. A definition that can lead to such conclusions is not helpful for innovation and the improvement of interventions. A useful definition must be based on the premise that effectiveness is a prerequisite for efficiency. In other words, without effectiveness there can be no efficiency.
- Second, the purpose of conducting an efficiency analysis should be made explicit, because the purpose has consequences for the choice of methods and tools used. Two important types of purposes need to be distinguished: 1. comparing the efficiency of an intervention with alternatives or benchmarks, and 2. improving the efficiency of individual interventions.

The experts also looked into ten typical cases of development interventions drawn from the practice of member organisations of Partos. For each of the cases they have provided recommended methods and tools for analysing efficiency. This paper presents one of these ten cases.

The participants of the Efficiency Lab are: Mark Kirkels (War Child), Margriet Poel (SNV), Jeroen Bolhuis (Plan Nederland), Marieke de Vries (CNV International), Arnold van Willigen (Woord en Daad), Erik Boonstoppel (Oxfam Novib), Simon Bailey (Aflatoun), Kees Kolsteeg (GPPAC), Julio C. García Martínez (ZOA), Agnès Marsan (Simavi) Anita van der Laan (Akvo), Jan de Vries (Pax).

Facilitators of the Efficiency Lab are: Anne-Marie Heemskerk (Partos) and Heinz Greijn (L4D)

The panel of experts is composed of:

- **Markus Palenberg**, CEO of the Institute for Development Strategy in Munich, Germany and author of what is considered standard literature in this field: "Tools and Methods for Evaluating the Efficiency of Development Interventions. Evaluation Working Papers. Bonn: Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (2011)
- **Pol de Greve**, Development Economist at Context, international cooperation, with experience an assessing the efficiency of development projects
- **Antonie de Kemp** who worked as a researcher for the Netherlands Court of Audit, the Netherlands Institute for Social Research (SCP) and the Institute for Research on Public Expenditure (IOO). He joined the Ministry of Foreign Affairs in 1997, and since 2005 has been an evaluator at IOB.