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The Effects of Rwanda's Biogas Program on Energy Expenditure and Fuel Use

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Summary. — Dependence on biomass to meet domestic energy needs raises several socio-environmental concerns. In contrast, cattle manure, which may be used to generate biogas, is considered a cleaner and cheaper energy source. Despite several initiatives toyears of education promote biogas, systematic analyses of its effects are limited. This paper uses data from Rwanda to examine the effects of participating in a biogas program on energy-related expenditures and consumption of traditional fuels. We find evidence of substantial reductions in firewood use and large savings. However, the attractiveness of the program is hampered by a long payback period and low rates of return.

Key words — energy policy, renewable energy, biogas, Rwanda

1. INTRODUCTION

The bulk of Rwandese households rely on firewood to meet their domestic energy needs. According to the latest available figures, at the national level, 88% of households rely on wood and 8% rely on charcoal as their main source of energy (EUEI-PDF GTZ MARGE, 2009). Corresponding figures for rural areas are 95% and 1%, respectively (see Table 1). The continued consumption of traditional biomass and lack of alternative energy sources such as liquefied petroleum gas (LPG) or electricity has led to increased pressure on available forest resources (MININFRA, 2008; Ndayambaje & Mohren, 2011) and despite the lack of alternatives, recent legislation has attempted to restrict access to forests (Ndayambaje & Mohren, 2011).

In 2006, motivated by the challenges posed by household dependence on firewood, the Government of Rwanda with technical support from SNV Netherlands Development Organization (SNV) launched its National Domestic Biogas Program (NDBP).[1] Rwanda's NDBP, which is among the earliest domestic biogas programs in Sub-Saharan Africa, follows in the wake of programs established in several Asian countries such as Nepal, India, China and Vietnam.[2] These and other initiatives are expected to deliver a range of benefits to rural households in developing countries. The short-term benefits include a reduction in energy-related expenditures, a reduction in the use of traditional fuels and a reduction in time spent on gathering fuel and cooking. Longer-term benefits include enhanced agricultural productivity due to the use of bio-slurry, a by-product of biogas production which may be used as a fertilizer, improvements in indoor air quality and subsequent health benefits.[3] Notwithstanding these expectations and several years since project implementation, credible evidence on the actual impacts of these programs is limited.

One of the first examples is provided by Katuwal and Bohara (2009) who examine the effects of access to biogas plants in Nepal on a wide range of outcomes. Their study is based on 461 biogas users located in 15 districts and provides a before–after comparison. The authors reported a 53% reduction in the use of firewood and an 81% reduction in the time spent collecting firewood. A methodologically similar study, albeit based on a much smaller sample of 12 users, conducted in the Peruvian Andes (Garfí, Ferrer-Martí, Velo, & Ferrer, 2012) reports a 50–60% reduction in firewood consumption. While promising and informative, the lack of a control group in such before–after comparisons raises concerns about the credibility of the analysis.

Alternatively, attempts have been made to identify the effects of access to digesters using a treatment–control approach. One of the earliest such studies comes from India's Planning Commission (Program Evaluation Organisation, 2002) which examined the effect of India's National Biogas Development Project. The study, based on 615 biogas users and 740 non-users from 133 villages found that the majority of digesters (55%) were not operational.[4] Nevertheless, user households experienced a reduction in energy related expenditures (Rs. 188 a month) and a 10-kilogram reduction per month in the use of firewood. Based on data from three villages in Western China in 2006 (239 households; 183 users and 56 non-users), Groenendaal and Gehua (2010) concluded that despite working with a sample of relatively long-term digester users the many benefits attributed to the use of digesters have only partly been realized, if at all. They do not find strong fuel substitution effects (biogas replacing coal/firewood) and limited evidence of a reduction in energy related expenditures. For the bulk of the outcomes under scrutiny there were no statistically significant differences between users and non-users. In the case of both these studies, the authors do not provide evidence to support the validity of the control group and their assessments are based on simple differences in means, without controlling for variables which might influence uptake and outcomes.

Closest to the current context, Laramee and Davis (2013) work with a relatively small sample (40 households; 20 users and 20 non-users) drawn from seven communities located in

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Table 1. *Main source of energy for domestic purposes, Rwanda 1999–2000 and 2005–06*

	EICV1	EICV2	EICV1	EICV2	EICV1	EICV2	EICV1	EICV2
	City of Kigali		Other urban		Rural		National	
Wood	21.4	23.1	81.7	73.7	97.7	95.5	90.4	88.2
Charcoal	75.8	72.4	16.3	19.6	19.6	1.1	8.0	7.9
Gas	0.5	0.2	0.2	0.1	0.1	n/a	0.1	0.0
Electricity	0.5	0.2	0.2	0.3	0.3	0.0	0.2	0.1
Kerosene	0.3	0.8	0.1	0.3	0.3	0.0	0.1	0.1
Other	1.5	3.4	1.5	5.9	5.9	3.4	1.3	3.6

Source: EUEI-PDF GTZ MARGE (2009). Based on household surveys EICV1 (1999–2000) and EICV2 (2005–06).

Northern Tanzania. The authors find large effects and conclude that biogas almost completely replaces the use of firewood and kerosene in digester using households and energy-related expenditure in digester using households is only 15% of the amount spent by non-user households. While the large positive effects in Tanzania are striking as compared to the less sanguine outcomes in the papers on India and China, the credibility of the estimates is hindered by the small sample size. Furthermore, the control group was identified by asking adopter households to identify a neighbor with similar socio-economic characteristics rather than through an objective approach.

This study adds to the scant literature on the effects of access to digesters. We focus on Rwanda and attempt to provide credible evidence on the effects of the country's NDBP on two key outcomes, namely, whether access to digesters leads to a decline in energy-related expenditure and a reduction in the use of wood. In order to assess the viability of the intervention we provide an exploratory payback analysis and estimates of private and social rates of returns to investing in a digester. Methodologically, we rely on cross-section data and employ a treatment–control approach but, as is discussed later in the text, attempt to improve on the existing literature in several ways.

The paper is structured as follows. The next section provides a brief background of the program. Section 3 outlines the empirical approach while Section 4 discusses the sampling strategy and the data. Section 5 discusses the impact of the program while Section 6 provides a payback analysis and estimates of rates of returns. Section 7 contains concluding observations.

2. RWANDA'S NATIONAL DOMESTIC BIOGAS PROGRAM –A BRIEF SUMMARY

In 2006, motivated by the continued reliance on firewood as a domestic energy source and on the basis of feasibility studies which indicated a high biogas production potential, the Government of Rwanda launched a National Domestic Biogas Program.[5] In 2008, after training and sensitization, the program became operational. At inception, the program targeted the installation of 15,000 family sized (plant sizes of 4, 6, 8 and 10 m^3), high-quality biogas plants by the year 2011.[6] However, a mid-term review conducted in late 2009 led to a rescaling of the target to 5,000 digesters and in 2010 a new target of 3,000 digesters was proposed. By mid-2012, around 1,800 digesters spread over 30 districts had been built. Table 2 contains information on the original targets and the number of digesters actually built. The total expenditure incurred during this first phase of the program, which covered the period 2008–11 was Euro 1,633,000 of which 23% was provided by the Government of Rwanda and the remainder by the Governments of the Netherlands and Germany.[7]

The program has an integrated supply and demand approach. On the supply-side, NDBP with the support of SNV provides training on biogas technology and the construction of biogas plants and supports the establishment of digester construction companies. On the demand side, NDBP markets and promotes the use of digesters, provides a subsidy to cover part of the costs (see Table 3) and through Banque Populaire du Rwanda (BPR) has established a facility which provides loans at a favorable rate.[8] The procedure to apply for a digester involves the NDBP program (central office and field technician), a construction company and a bank (in case the beneficiary applies for a loan). After verifying that an applicant satisfies the eligibility criteria, which includes owning at least two cows and having a bank account, NDBP arranges construction.[9] The digester is covered by a '1 year warranty' and the construction company is expected to visit the plant three times during the first year to ensure proper functioning. Quality checks are also conducted by program field technicians and as part of the digester purchase package, NDBP offers a course to train users on plant feeding, small repairs and general maintenance.

3. IDENTIFYING THE IMPACT OF DIGESTERS

There are a variety of ways in which access to digesters may influence outcomes at the household level. Foremost among

Table 2. *Projected installation of digesters*

Year	2007	2008	2009	2010	2011	Total
Phase	Preparation phase			Implementation phase		
Number of digesters [a] (projected)	150	1,150	2,300	4,200	7,200	15,000
Year	2007–09	2010	2011	2012	Total	
Number of digesters [b] (installed)	366	627	755	699	2,447	

Source:
[a] Dekelver (2008).
[b] NDBP (data are current up to the end of November 2012).