Impact evaluation of Netherlands supported programmes in the area of Energy and Development Cooperation in Indonesia

Impact Evaluation of Indonesia's Domestic Biogas Programme

Arjun S. Bedi[a1], Robert Sparrow[b] and Luca Tasciotti[c]

This report is part of an evaluation commissioned by the Policy and Operations Evaluation Department (IOB) of the Netherlands Ministry of Foreign Affairs. It belongs to a series of impact evaluations of renewable energy and development programmes supported by the Netherlands, with a focus on the medium and long term effects of these programmes on end-users or final beneficiaries. A characteristic of these studies is the use of mixed methods, that is, quantitative research techniques in combination with qualitative techniques. The purpose of the impact evaluations is to account for assistance provided and to draw policy lessons. The results of these evaluations will serve as inputs to a policy evaluation of the "Promoting Renewable Energy Programme" (PREP) to be concluded in 2014.

[a] International Institute of Social Studies, Erasmus University Rotterdam, The Netherlands and Georgetown University. [b] Crawford School of Public Policy, Australian National University. [c] International Institute of Social Studies, Erasmus University Rotterdam, The Netherlands.

[1] Corresponding author, address for correspondence: Kortenaerkade 12, 2518 AX The Hague, The Netherlands, Phone +31-70-4260 493, E-mail: bedi@iss.nl. We thank BIRU staff for their co-operation and acknowledge the contributions of Gunther Bensch, Rebecca Niemann and Jörg Peters.

Table of Contents

Tables and figures

List of abbreviations

BATAMAS: Community Livestock Biogas Programme
BIRU: Biogas Rumah (Biogas for the Home)
BSM: Bank Syariah Mandiri
CPO: Construction Partner Organizations
DGNREEC: Directorate General of New Renewable Energy and Energy Conservation
DID: Difference in differences
ESDM: Ministry of Energy and Mineral Resources
HIVOS: Humanistisch Instituut voor Ontwikkelingssamenwerking (International Humanist Institute for Cooperation with Developing Countries)
IDR: Indonesian Rupiah
IOB: Policy and Operations Evaluation Department of the Netherlands Ministry of Foreign Affairs
ISS: International Institute of Social Studies
JRI: Jasa Risetindo
LIPI: Indonesian Institute of Science
LPG: Liquid Propane Gas
MEMR: Ministry of Energy and Mineral Resources
NGO: Non-Governmental Organization
PSM: Propensity Score Matching
SNV: Stichting Nederlandse Vrijwilligers (Netherlands Development Organization
RWI: Rheinisch-Westfälisches Institut für Wirtschaftsforschung
UNRAM: University of Mataram
USD: United States Dollars

1. Introduction

The BIRU programme (*Programme Biogas Rumah* – Household Biogas Programme), which commenced in 2009, is designed to facilitate household access to biogas in Indonesia and is supported by the Dutch Ministry of Foreign Affairs. It is managed and implemented by the Dutch development organisation Hivos with the technical assistance of SNV Netherlands in cooperation with Indonesian stakeholders. While the BIRU programme has provided digesters to rural households in seven provinces, its activities focus heavily on East Java and Lombok. A key objective of the programme was to disseminate 8,000 digesters by the end of 2012 and to generate benefits to farm households in the form of monetary and time savings, increased agricultural output and better health conditions.

Despite the existence of several initiatives, worldwide, to promote the use of biogas, systematic analyses of the effects of access to biogas on socio-economic outcomes are limited.[2] The aim of this report is to provide such an analysis. This report deals with a series of questions - as outlined in the terms of reference, however, the main objective is to assess the impact of access to biogas provided through BIRU (section 3.3.1 of terms of reference) on various indicators of household welfare.[3] These indicators include household energy expenditures, consumption of traditional fuels such as firewood and charcoal, time-use patterns, indoor air pollution and health effects and the use of bio-slurry and its effect on crop revenues/yields.[4]

To meet its objectives this evaluation relies on both quantitative household survey data and qualitative information. The quantitative analysis draws on a baseline and follow-up survey, conducted in May-June 2011 and 2012, respectively, in East Java province.[5] East Java was purposively selected as it is a region where the programme is most active and accounted for, at the end of 2012, 62 percent of the digesters that had been disseminated by BIRU. The sample for the quantitative analysis consists of 677 dairy farmers that are observed in both survey waves, of which 97 farmers already operated a biogas digester in 2011. 216 farmers had a biogas digester installed after the baseline survey was conducted and in operation by the time of the follow-up survey, and 364 farmers that do not have a digester. These data allow us to compare households with digesters to those without digesters, before and after the digesters were installed. Access to such panel data is

[2] Exceptions are Katuwal *et al*. (2009) and Gautam *et al*. (2009) who provide analyses for Nepal and show that access to biogas leads to time-savings especially for women and children which in turn may lead to an increase in recreational and income-generating activities. Arthur *et al*. (2011) provide similar evidence from Ghana and according to the Africa Development Fund (2008) in Ghana, access to biogas and the reduction in time spent on gathering firewood has been associated with an increase in child school attendance.

[3] See Terms of reference, dated 2nd February 2011.

[4] Effluents generated by the combustion of firewood are among the main reasons for eye infections and acute respiratory infections. The use of biogas which is smokeless may be expected to reduce the incidence of such diseases especially for those spending more time in the kitchen. In addition to these immediate effects, in rural Nepal, Bajgain *et al.* (2005) argue that as a consequence of improved hygiene, the use of digesters has worked towards decreasing the occurrence of contagious diseases such as cholera, diarrhoea and tuberculosis.

[5] For the implementation of the survey we contracted the Jakarta based research institute JRI Research, an experienced organization in the field of socio-economic surveys that has already worked for Columbia University and World Bank, for example. JRI was responsible for the logistics of the survey including the recruitment and supervision of enumerators as well as ensuring the quality of the collected data, of the sampling and the data entry. They also conducted the enumerator training together with two team members of ISS/RWI and provided input on the preparation of the questionnaire. Throughout the survey implementation, JRI was supported by an ISS/RWI team member.

expected to enhance the credibility of the analysis as it allows us to eliminate confounding unobserved characteristics that may generate misleading estimates.

With regard to the qualitative information, the report draws upon focus group discussions, key informant interviews with a range of stakeholders conducted in June-July 2011 in Lombok and in May 2012 in Malang (East Java). While details are provided later, the interviews involved staff of Hivos Indonesia, SNV Indonesia, staff of BIRU, heads and other staff members of dairy cooperatives located in Malang and private companies involved in different aspects of programme. While the study focuses mainly on the situation in East Java, in order to gauge programme effects in other contexts it relies on qualitative methods to provide an assessment of the situation in Lombok.[6]

The report is structured as follows. Section 2 describes the BIRU programme and the context in which it operates. Section 3 sets out the methodology. Section 4 describes the data, survey tools and sampling method. Section 5 contains information on the adoption and use of digesters and presents estimates of the effect of access to a digester on a range of outcomes. Section 6 provides an assessment of the programme in Lombok. Section 7 summarizes the report and contains concluding observations.

2. The context and the intervention

2.1. Regional context

Indonesia, with a population of 222 million people, is the fourth most populated country in the world. Administratively, Indonesia consists of 33 provinces, five of which have special autonomous status. The provinces are subdivided into rural districts (*kabupaten*) and municipalities (*kotamadya*), which are further divided into subdistricts (*kecamatan*), and villages and urban precincts (*desa* or *kelurahan*, respectively).

The study area consists of five rural districts located in the province of East Java, which is the most populated province of the country, with a population of 36 million people and slightly less than 10 million households. Although Java in its entirety is the most developed region of Indonesia, East Java is a fairly poor province and was ranked 18th out of 33 Indonesian provinces in the 2009 HDI ranking and 8th in terms of the MDG-Index ranking (BPS 2009, UNNDPA 2007). The Indonesian Socioeconomic Survey 2008 shows that agriculture is the main activity in East Java, with 38 percent of the active labour force engaged in agricultural activities (Table 1), which is slightly higher than the national average. In particular the poorer households in the study area are more likely to be farmers (43 percent). The occupational structure in the study area is quite similar to the rest of East Java and is comparable to the national occupational distribution.

Table 1 shows that the literacy rate of around 90 percent among adults in East Java is also very similar to the Indonesian average. However, the level of education is lower compared to the national average. The differences are particularly pronounced at the senior secondary and higher levels of education. Within the study area there are large differences in educational attainment between the bottom and top 50 percent, with the first group clearly showing a higher level of education.

[6] Lombok/Bali accounts for the second largest concentration of BIRU digesters and accounts for about 17 percent of all digesters installed by BIRU up to the end of 2012.

Table 1: Socio-economic and labour market characteristics in the sampled districts in East Java

Socio-economic group	Sampled districts			East Java	National
	Total	Bottom 50%	Top 50%		
Agricultural sector	35.12	42.26	23.12	37.79	34.16
Livestock sector	6.46	7.82	4.18	6.43	2.49
Self-employed without workers	19.02	18.66	19.63	16.54	18.25
Self-employed with workers	18.07	17.04	19.78	19.27	17.82
Workers/employees	31.80	26.84	40.15	33.93	38.89
Freelance/casual	18.24	24.02	88.10	15.07	11.23
Unpaid workers	12.86	13.44	11.90	15.19	13.81
Inactive	27.45	28.57	25.46	26.57	28.37
Education level					
No primary school completed	28.13	33.87	17.19	30.56	24.88
Primary school	33.34	35.79	28.68	29.68	29.48
Junior secondary school	21.32	21.31	21.34	19.50	19.89
Senior secondary school	12.28	7.49	21.37	13.29	17.46
Higher	4.93	1.53	11.42	6.98	8.29
Literacy	89.97	87.24	95.00	86.64	91.71

Notes: Labour market characteristics relate to the age group 16-60 years, while education attainment and literacy is reported for individuals aged 18 and older. Inactivity is defined as adults aged 16-60 years who are not working, looking for work or temporarily not working but otherwise do work. The bottom/top 50% refers to the position in the distribution of total household expenditure per capita.

Source: Own computations based on Indonesian Socioeconomic survey 2011.

2.2 Energy sector

Indonesia lags behind most other Asian countries in terms of its electrification rate and even when compared to other less developed economies. For 2009, the electrification rate in Indonesia was 64 percent, compared to 90 percent in the Philippines, 77 percent in Sri Lanka and 75 percent in India (IEA, 2011). At the moment the energy sector in Indonesia faces supply constraints as demand for energy is expected to grow at six percent per year and the government has plans to further increase the electrification rate with rural areas and the eastern part of Indonesia representing the main target regions. Power supply shortages have already begun to show in areas outside Java and Bali (IEA, 2008). International investors, who are needed to fill the substantial funding gap, have been reluctant to invest due to a less than attractive investment climate resulting from legal risks, subsidised pricing, unclear tendering processes and a lack of transparency, among other factors (IEA, 2008).

While the energy sector accounts for nearly 30 percent of total Indonesian exports (IEA 2008) and generates substantial revenues for local and national government, large scale national energy subsidies are a burden on the government's budget.[7] In the 2008 national budget, an amount of approximately USD 13.5 billion was allocated to fuel subsidies with the subsidy for kerosene accounting for about USD 3.2 billion (SNV 2009). Over the last decade, subsidies have been reduced, leading to price hikes. At the same time, to encourage the use of a more efficient fuel, a kerosene-to-LPG conversion programme was launched in 2007. Since then, kerosene subsidies have been significantly reduced but have been replaced by subsidies for LPG (for details see Beaton and Lontoh, 2010).

[7] In 2011, Indonesia was the third-largest exporter of liquefied natural gas and in 2006, Indonesia surpassed Australia to become the world's largest exporter of steam coal (IAE, 2008).

Although the majority of the population does have access to electricity for lighting, biomass – mostly wood – still represents an important source of energy for cooking (Table 2). While approximately 20 percent of Indonesian households use firewood, around 58 percent of households in East Java use firewood as a primary cooking fuel. The use of kerosene and LPG is also quite widespread with more than 41 percent of households using these fuel sources in East Java. In light of the relative abundance of firewood at no cost, the share of charcoal lies below 1 percent.

Table 2: Access to electricity and energy for cooking in sampled districts in East Java, in percent

	Sampled districts	East Java	National
Use electricity for lighting	99.24	99.49	95.43
Energy source for cooking			
Electricity	0.85	0.82	0.92
LPG	52.28	39.88	76.10
Kerosene	1.30	0.62	2.60
Firewood	44.92	58.10	19.60
Other	0.64	0.57	0.77

Source: Indonesian Socioeconomic survey 2011, own computation.

Table 3: Socio-economic structure and monthly energy expenditure in sampled districts in East Java, in thousands of Indonesian Rupiah

Type of expenditure	Sampled districts			East Java	National
	Total	Bottom 50%	Top 50%		
Household expenditure	1,753	1,212	2,792	1,990	2,630
Household energy expenditure					
Electricity	42	33	59	52	58
LPG	32	20	57	30	31
City gas	0.1	0.0	0.3	0.2	0.2
Kerosene	2	1	4	5	12
Total expenditure for energy	77	54	121	88	105
Share energy expenditure	4.4%	4.5%	4.3%	4.4%	4.0%
Per capita expenditure	424	276	708	487	596
Per capita energy expenditure	19	13	31	22	24
Household size	4.28	4.47	3.92	4.22	4.62

Notes: The bottom/top 50% refers to the position in the distribution of total household expenditure per capita.
Source: Own computations based on Indonesian Socioeconomic survey 2011.

Table 3 shows household expenditures for energy. As displayed, households in Indonesia spend approximately four percent of their budget on energy.[8] Electricity, mainly used for lighting purposes, is the most important item in East Java, accounting for more than 50 percent of the total energy expenditure. The second most important item with a share of 30 percent is kerosene, which is used both for lighting and cooking purposes. The energy share of total expenditures is about the same in the bottom 50 percent of the income distribution compared to the top 50 percent. However, in absolute per capita terms, energy expenditures for the top 50 percent of the population in the sampled districts are more than twice as high compared to the bottom 50 percent.

In recent years, due to the expected increase in energy demand and the associated environmental costs, promoting efficient use of energy and developing alternative energy sources and technologies has become a policy priority.[9] In particular, with regard to biogas, although knowledge of the energy

[8] Bacon et al. (2010) provide information on energy expenditure from a range of developing countries including Indonesia. Household expenditure on modern energy in Indonesia is higher than in India and Pakistan but lower as compared to Vietnam and Thailand.

[9] See, for example, the Indonesian Economic Development Masterplan MP3EI (Ministry For Economic Affairs, 2011).

potential of biogas is not new, dissemination of this technology proceeded quite slowly until 2000. According to SNV (2009), firewood was readily available and kerosene was still heavily subsidised, factors which hindered investments in biogas. After kerosene prices increased in 2002, various institutions and organizations began developing activities to disseminate biogas digesters. Most prominently, in order to promote the use of renewable cooking fuels and to reduce the consumption of kerosene and wood the Indonesian government launched a national biogas programme in 2006 through BATAMAS (Community Livestock Biogas Programme) and Rural Bio-Energy Programme.[10] Through this programme, at the end of 2007, almost a thousand units had been installed involving 1,693 families spread over 121 districts in 26 provinces (SNV, 2009). Other prominent initiatives include the development and installation of digesters by Padjajaran University, a biogas programme implemented by the Department of Agriculture and a programme implemented by LIPI, the Indonesian Institute of Science. In total, at the end of 2009, through fifteen initiatives about 6,000 digesters had been installed for domestic use (SNV, 2009). The principal problems of the biogas sector seem to be the lack of standardization and lack of information on uptake and use of biogas as the various initiatives tended to operate in isolation.

In this context, the BIRU programme with its envisaged output of 8,000 digesters over a four-year period is clearly designed to provide a large fillip to the use of biogas in Indonesia. Among others, the innovative aspects of the BIRU programme are its co-operation with international private sector dairy companies (for example, Nestle), which makes it easier for (dairy) farmers to access credit, training of masons and provisions for quality control. Details on the intervention are provided in the succeeding sub-section.

2.3 Institutional context and description of the BIRU intervention

Following the roll-out and apparent success of biogas use and spread in a number of Asian countries such as Nepal and Vietnam, China, India and Cambodia, in 2008, Indonesia's Directorate General for Electricity and Energy Utilization of the Ministry of Energy and Mineral Resources requested the Royal Netherlands Embassy to study the potential for biogas in Indonesia.[11] The Directorate General for Electricity and Energy Utilization, working under the supervision of the Ministry of Energy and Mineral resources, operates: i) to develop the ministry's policy in term of energy and electricity ii) to implement policies regarding energy and electricity iii) to set up standards, norms, criteria and procedures related to the use of electricity and energy iv) to conduct technical assistance, technical supervision and evaluation.

Following the request from the directorate, The Royal Netherlands Embassy commissioned SNV to conduct a feasibility study. Briefly, taking into account a number of technical, social and financial factors the study concluded that there was substantial potential to launch a biogas programme in the country. The study highlighted the favourable climatic conditions in the country which provide a favourable environment for the production of biogas as temperatures are high throughout the year.

[10] This program promoted the use of three types of plants for household use: 'Masonry fixed dome' for communal use (10, 25, 50 and 100 cubic meters); plastic bag (9 cubic meters) and glass-fibre fixed dome (from 5 to 10 cubic meters).

[11] Until October 2010, the Directorate General for Electricity and Energy Utilization was the organization responsible for the BIRU program. However, since the establishment of the Directorate General of New Renewable Energy and Energy Conservation (DGNREEC), this new Directorate has become the organization responsible for the BIRU program. This directorate deals with 'rural energy programs, rural electrification, development of new and renewable strategy and energy conservation programs' (BIRU, 2010). For the organizational structure of DGNREEC, please see Annex 1.

Although accurate data on the number of dairy farmers with 2 or more heads of cattle was not available, it was assumed that the market potential exceeded one million households in Java and Bali, where zero grazing is widely practised. Furthermore, the availability of water is not a concern in Indonesia (SNV, 2009). In terms of potential benefits, according to the feasibility study, the use of digesters may be expected to contribute to improved living conditions in rural households, especially for children and women. Other important benefits included time savings in core household activities as well as reduced use of firewood, coal and fossil fuels and the use of the by product (bio-slurry) as a fertiliser which may be expected to result in greater agricultural revenues/yields. In addition, the programme was expected to create employment opportunities by supporting the creation of new business activities (SNV, 2009).

Based on the positive outcome of the feasibility study, the Indonesia Domestic Biogas Programme, called BIRU was launched in 2009. It is a four-year programme funded by the Royal Netherlands Embassy and implemented by Hivos with the Ministry of Energy and Mineral Resources (MEMR) of the Republic of Indonesia and with the technical assistance of SNV. Amongst other tasks, Hivos and SNV are responsible for effective knowledge exchange and transfer during the implementation of the programme.[12] The overall objective of BIRU is the dissemination of domestic digesters as a local, sustainable energy source through the development of a commercial, market oriented sector in eight Indonesian provinces (East Java, DIY Yogyakarta, Central Java, West Java, Bali, West Nusa Tenggara, South Sulawesi and Lampung).

The BIRU biogas programme started its activities in 2009. In May 2009, after the completion of feasibility studies in several districts, sub-districts in three districts, Bandung (Western Java), Yogyakarta (Central Java), and Malang (Eastern Java) (see BIRU 2011), were selected for programme roll out. In addition to Java, the programme was rolled out in Lombok/Bali in 2010, South Sulawesi and Sumba in 2011 and Lampung in 2012. Although the programme had a slow start, initially failing to achieve its targets for 2009, it soon picked up momentum. By May 2011 the target for 2011 had already been achieved, with over 2,700 installed digesters and over 900 applicants awaiting construction of a digester. By the end of 2012, it had met its target of disseminating about 8,000 biogas digesters (see Table 4). While the overall target has been met, the refraction between province specific targets and installed digesters is quite high. The activities of the BIRU programme concentrate on East Java (62 percent of all digesters), followed by Lombok/Bali (17 percent), West Java (10 percent) and Central Java (9.6 percent) while a more even distribution across provinces had been envisaged (see Table 5).

The chart below summarizes some of the milestones in the implementation of the programme.

[12] Information available from http://www.biru.or.id/en/index.php/biru-program/ , last accessed on March 25th, 2013.

2009	2009	2010	2011	2012
SNV conducts a feasibility study which highlights the potential for biogas in Indonesia.	Hivos – with the technical support of SNV, in co-operation with MEMR, launches the biogas programme (BIRU). The target is to install 8,000 digesters in 8 Indonesian provinces by 2012. The target for 2009 is to build 150 digesters.	Nestlé Indonesia, Bank Mandiri Syariah and Rabobank Foundation join the programme as credit providers. A technical assessment led by an international team of biogas specialists raises the issues of increasing i) user training and ii) motivating users to use bio-slurry in agriculture. The target for 2010 is to build 1,150 digesters.	BIRU commissions Jember University in East Java and Mataram University in Lombok to study the properties and content of bio-slurry. The target for 2011 is to build 2,600 digesters.	The target for 2012 is to build 4,100 digesters. At the end of March 2012, 4,933 digesters had been completed and 5,862 were in the pre-construction phase.

Table 4: BIRU's annual budget and targeted and installed digesters

Year	2009	2010	2011	2012	Total
Annual budget (in thousand IDR)	222,802	1,041,509	1,554,962	1,759,125	4,578,398
Number of installed digesters (target)	150	1,150	2,600	4,100	8,000
Number of installed digesters	66	1,577	2,990	3,350	7,983
Share of the target (in %)	41	137	115	81	99

Source: BIRU (2013)

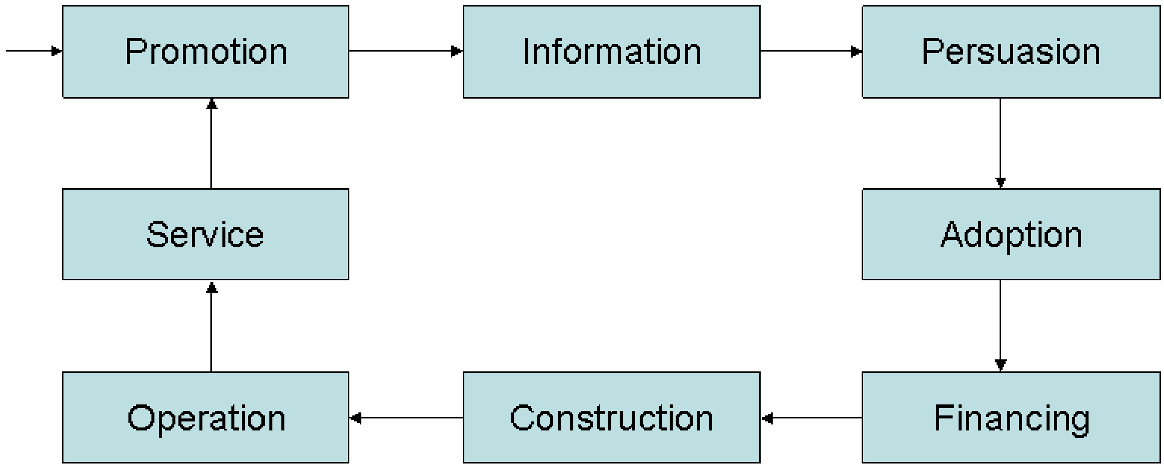
Table 5: Number of installed and targeted digesters, by year and province

	2009	2010	2011	2012	Total	Targeted 2009-2012
West Java	4	114	259	435	**812**	**2,000**
Central Java and Yogyakarta	9	133	226	397	**765**	**2,000**
East Java	53	1,248	2,190	1,460	**4,951**	**2,000**
Lombok/Bali	0	82	279	948	**1,309**	**1,000**
South Sulawesi	0	0	25	29	**54**	**1,000**
Sumba	0	0	11	79	**90**	**0**
Lampung	0	0	0	2	**2**	**0**
Total	**66**	**1,577**	**2,990**	**3,350**	**7,983**	**8,000**

Source: BIRU (2013)

The main intermediaries in the BIRU programme are so-called Construction Partner Organizations (CPOs) and biogas supervisors. The CPOs are operated by one or several cooperatives or by local NGOs. On the island of Java, the programme focuses on dairy farmers, as this sector has a large production potential for biogas. Thus, dairy cooperatives are a pivotal partner in the BIRU programme and help disseminate the biogas concept among dairy farmers. The BIRU CPOs raise awareness about the BIRU biogas digesters among their members in their regular meetings or in special gatherings explicitly for the purpose of discussing the digesters. If members show interest, the CPO carries out a farm eligibility assessment of the farm, which is based on criteria such as having at least two cows, a positive cash flow from milk revenues supplied to the cooperative, and the farmer's debt history. In addition, the CPO verifies whether the farm plot is large enough to install a digester. If the farmer qualifies, financial arrangements are negotiated and subsequently masons especially trained by BIRU are deployed to construct the digesters.[13] After the digester has been installed, the mason fills a completion report, which is submitted to BIRU. BIRU's quality assurance agent in the respective district controls the quality of the work delivered. Users are trained on the proper usage of digesters through targeted training provided by BIRU. They receive a user manual and a mason is present during initial plant feeding. BIRU guarantees an after sale service of two years.[14] A chart showing the programme's business cycle, including financing and construction, is given below.

Figure 1: Business cycle of the digester project



Source: SNV (2011).

The total investment costs per digester may amount to € 450-700, depending on the size. The programme provides a subsidy of € 160 (see Table 6). The remainder is paid by the farmer, usually through a loan obtained from credit schemes offered by the cooperative. The instalments are financed by deductions from the payments the farmer receives for the delivery of milk. Interest rates differ across cooperatives, depending on the source of the loan. A range of partners have made resources available for the credit schemes, and while there is no interest on 2-3 year loans provided by Nestlé, other partners such as Rabobank or Bank Syariah Mandiri (BSM) charge interest rates of 8 to 11 percent with repayment periods of 3 to 5 years.

[13] By October 2010, around 200 masons had been trained. The intention is that the training will be taken over by local institutions such as technical and vocational schools. To select masons BIRU requires that they should: i) be from the area where the digesters are to be constructed ii) have sufficient experience in brick laying, plastering iii) be able to read, write and to understand drawings.

[14] For a comprehensive list of promotional documentation, please refer to Annex 2.

Table 6: Size of digester, its costs and the subsidy provided (in IDR)

Size of the digester plant	Cost of the plant for the user	Subsidy provided
4 cubic metres	3,700,000	2,000,000
6 cubic metres	4,300,000	2,000,000
8 cubic metres	5,000,000	2,000,000
10 cubic metres	6,000,000	2,000,000
12 cubic meters	6,800,000	2,000,000

Source: BIRU (2013).[15]

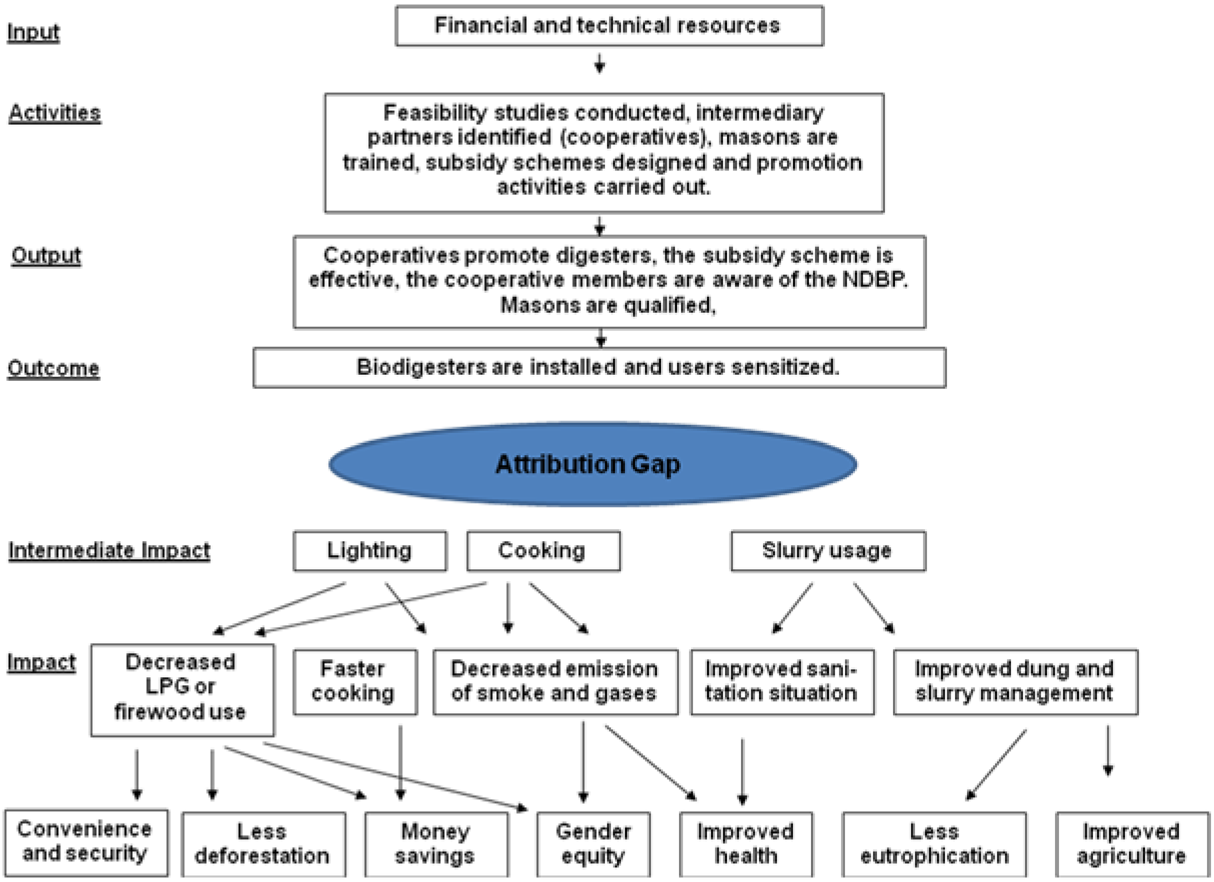
3. Impact evaluation

3.1. Evaluation objectives

The main aim of this evaluation is to identify the effect of access to biogas provided through the BIRU programme on a range of household level outcomes. A stylized result chain linking inputs and activities to outputs and outcomes subsequently to impacts is provided in the figure below:

Figure 2 provides a depiction of the intervention and the results chain.

Figure 2: BIRU biogas results chain



Source: Own illustration

15 From http://www.biru.or.id/en/index.php/download/10/biru-brochure-turn-waste-into-benefit.html , accessed on April 5 2013.

The evaluation of the digester programme will address the following research questions:

Output:

- Which socio-economic groups have applied for a digester?
- Have households made use of credit schemes or other loans to obtain a digester? What percentage of the total investment cost was financed through such means?
- Were users properly informed on how to use the digester (e.g. plant initial feeding, presence of user manual)?
- How many of the applicants (or actual biogas users) were using LPG, kerosene, electricity or firewood prior to the intervention?

Outcomes:

- As compared to the applicants, which socio-economic groups obtained digesters?
- Which household member/s decided on purchasing a digester, disaggregated by gender?
- How reliable is the gas supply?
- How many digesters have been installed and how many are being used?

Impacts:

- To what extent have the installed biogas plants actually been used for gas production? If they are not being used, why?
- Which expenditures did the household reduce in order to finance investment in the digester?
- For what purposes is biogas used (cooking, lighting, other)?
- What is the relative share of the various sources of energy for cooking and lighting? (biogas, LPG, kerosene, electricity, candles, charcoal, firewood, others)?
- To what extent are traditional stoves still used?
- How much is saved in total (per week or month) on 'traditional' energy sources (LPG, kerosene, firewood, candles)? How have expenditures for energy changed over time?
- How have cooking and lighting habits changed due to the use of biogas?
- Has there been any change in time/ workload, disaggregated by gender?
- For what purposes has the saved time been used, disaggregated by gender?
- To what extent did indoor air pollution reduce (perception of users only)?
- To what extent have health conditions (in particular respiratory illnesses) changed, specifically among women and children?
- Does the household use the slurry as fertiliser? How did the households use/dispose the dung before the intervention?
- What is the effect of digester slurry on agriculture (use and sale of fertiliser, expenditure on fertiliser, frequency of manure collection, crop yields)?
- To what extent has comfort/convenience changed, disaggregated by gender? What monetary value do households attribute to this increased convenience?
- To what extent have activities during evenings changed due to improved lighting usage? Have study hours/reading time of children changed?
- Have additional jobs been created in the biogas business sector (contractors, masons, input supply), disaggregated by gender?
- Has the availability of biogas triggered new economic activities or displaced old ones?
- What (if any) are the un-intended or negative impacts?
- Are there more or less accidents (explosions etc.) as compared to LPG usage?

Sustainability:

- Notwithstanding the short experience with the HIVOS-SNV biogas installations, what observations can be made about the technical sustainability of the equipment, for example when it comes to availability of materials for repairs, special cooking and lighting equipment?

- What is the financial sustainability of the BIRU programme from a) the perspective of the biogas client; b) from the perspective of the mason and small construction enterprises that install and maintain the biogas installations and c) from the perspective of a public sector support programme as far as it concerns the incentives, the advertisement and other dissemination activities.

- To what extent do the biogas installations exert an influence on environmental sustainability?

3.2 Identification strategy

The key challenge of the impact evaluation is to identify to what extent changes in outcomes of interest may be attributed to the BIRU programme. This is not straightforward, as there may be systematic differences in outcomes between digester owners and non-owners, which may not have occurred due to the programme and may therefore confound estimates of the impact of the programme. First, there is an element of self-selection, as households need to take the initiative to apply. This application decision may be partly determined by the financial commitment needed and the potential future benefits of installing a biogas digester. Hence, the (latent) ability and productivity of household members, their risk taking ability, their willingness to adopt modern technology and other unobserved factors may affect the probability of applying. At the same time, these factors may also affect the outcomes of interest. Second, conditional on application, programme beneficiaries are not selected at random but need to fulfil certain criteria such as ownership of at least one productive cow and a regular record of delivering milk to a cooperative. In addition to these observed criteria there may be other selection criteria that determine beneficiary status but which cannot be observed by a researcher. In short, it is important to account for factors (observed and unobserved) that determine beneficiary status and which may also be correlated with outcomes of interest. Not accounting for such factors may result in biased estimates of the effect of the BIRU programme.

To account for the challenges highlighted in the preceding paragraph and to deliver credible estimates of the impact of the programme, the study relies on a number of different evaluation approaches. These include a difference-in-differences (DID) analysis, a difference-in-difference analysis combined with propensity score matching (DID-PSM) and a pipeline comparison design.

Difference-in-differences analysis (DID)

As mentioned briefly in the introduction, the DID analysis is based on measuring and comparing outcomes for both participants (treatment group) and non-participants (control group) before and after implementation of the programme. The differences in outcomes over time (before and after programme implementation) between participants and non-participants will be interpreted as the causal effect of the BIRU programme. The approach is based on the assumption that the changes in outcomes recorded by the non-participants are the changes in outcomes that would have been recorded by the programme participants had they not had a biogas digester installed. By comparing differences in trends across treatment and control groups, rather than differences in levels, this approach eliminates time-invariant unobserved differences such as the latent ability and productivity of farmers which may have a bearing on digester uptake and outcomes.

In order to enhance the credibility of the basic DID analysis and to ensure comparability of the treatment and control group in terms of observed characteristics we combine the basic DID analysis with propensity score matching. Using this approach, each unit in the participant group is matched to an observationally similar unit from the non-participant group. This procedure implies that the control group is re-weighted such that it appears identical to the treatment group in terms of observed characteristics.[16] Subsequently, DID analysis is conducted on the treated units and the matched controls.

While the combination of PSM and DID allows us to control for differences in observed characteristics between the treatment and control groups as well as to control for time-invariant differences in unobserved characteristics that may be correlated with programme uptake and outcomes, some risks and caveats to this evaluation strategy remain. The key threat is that the credibility of the estimates is based on the so-called parallel trends assumption. To reiterate, the assumption that the changes in outcomes recorded by the non-participants are the changes in outcomes that would have been recorded by the programme participants had they had not had a biogas digester installed. This assumption may not hold. Typically, this assumption may break down if participation in – or targeting of – a programme is determined by shocks to the outcome variables (for example, poverty and social safety net programmes), or it is possible that due to inherent time-variant unobserved differences between treatment and control groups they may experience different outcome trajectories in the absence of the programme.

While it is possible that the parallel trends assumption does not hold, the nature of the BIRU programme greatly reduces this threat. First, participation in the BIRU programme is not driven by shocks or unexpected events, rather, these are carefully considered long term investment decisions by farm households, with assistance from BIRU CPOs. Second, the study focuses on a relatively homogeneous group of farmers who operate in a similar production and institutional context. This supports the credibility of the parallel trends assumption and provides a setting that is suitable for difference-in-difference analysis.

Pipeline comparison

Nevertheless, in addition to the DID analyses we also consider a cross-section based pipeline comparison approach. This method exploits a particular feature of the BIRU programme, in particular, that the programme has been rolled out gradually over a 4-year period. This means that during the baseline survey, some farmers without a digester had already applied for a digester and were awaiting delivery. That is, in 2011 they were in the pipeline to be treated in 2012. These farmers can be readily identified in the survey waves as the new users of biogas digesters in 2012. To

[16] We examine whether the treatment and control group are identical in terms of their observed characteristics by using a t-test to check for statistically significant differences in each characteristic.

implement the pipeline evaluation design we use these digester applicants and future users as a control group in the baseline year and compare them with farmers that were already participating in the BIRU programme in 2011. This approach bypasses potential bias due to eligibility or self-selection as both the groups have shown a desire to purchase a digester. In addition, this approach is not reliant on the parallel trends assumption or threatened by potential control group contamination, problems that are typical for longitudinal analysis. However, the cross-sectional approach of pipeline comparison introduces other problems. For example, there may be systematic differences between early and late adopters of an innovative technology, a problem that difference-in-difference analysis can deal with more effectively. Thus, while this approach is not a substitute for the difference-in-difference approach, it does provide an alternative evaluation methodology. The use of both approaches allows us to evaluate the robustness of the results. Similar to the difference-in-difference analysis, we combine the cross-section based pipeline comparison approach with propensity score matching in order to enhance comparability of the treatment and control groups.

For clarity, Table 7 summarises the choice of treatment and control groups for the different evaluation strategies. For the difference-in-difference evaluation, two groups of households are compared. First, the treatment group consists of households that did not have a biogas digester in 2011 but did have one in 2012. We refer to them as *new users* in the following. Second, the control group consists of farm households with comparable features (e.g. cooperative members, the same villages, similar number of productive cows) but those who have never obtained a biogas digester. We refer to them as *never users* in the following. For the cross-sectional pipeline comparison approach, a second treatment group is defined as consisting of households which were already using biogas digesters, which we refer to as *always users*. In this approach, the *new users* (i.e., the first treatment group) serve as a cross-sectional control group.

Table 7: Treatment and control groups, by evaluation strategy

Sample	**Definition**	**Pipeline comparison Cross section 2011**	**Difference-in-differences Panel 2011-2012**
Always users	Have fully operational biogas digester installed at the time of baseline survey in 2011	Treatment group 2011	
New users	Have fully operational biogas digester installed at the time of follow-up survey in 2012, but had no biogas digester (installed or under construction) in 2011	Control group	Treatment group 2012
Never users	Do not have a biogas digester in 2011 or 2012		Control group

4. Data

Data and information needed to respond to the terms of reference have been gathered from a range of sources. The quantitative part of the evaluation is based on two survey rounds of the same households conducted in May-June 2011 and May-June 2012 in East Java province. This particular province was chosen as at the time of the first survey it contained more than 75 percent of the total digesters installed through the BIRU programme. While details are provided below, the first round of data collection covered 695 households of which 677 households were also surveyed during the second round. The qualitative information base draws upon existing studies and project documents, focus group discussions, key informant interviews and a structured survey canvassed in 61 villages. Two rounds of qualitative work were undertaken. In June-July 2011 the focus of the qualitative work was on Lombok while during the second round of field work (May-June 2012) the qualitative work focused on East Java. This section of the report provides details on the survey tools and implementation and details on the data gathering process for both the quantitative and qualitative information bases.

4.1 Survey tools and implementation

Prior to the first round of the survey in May 2011, two survey instruments, a household and village questionnaire, were designed by ISS/RWI. The household questionnaire was designed to gather information on a wide-range of socio-economic aspects and in particular on cooking behaviour, energy use and energy related expenses (see Annex 3 for details). Given the purpose of the evaluation the questionnaire contained a detailed section on the reasons for (not) purchasing a digester, financing of the digester, its functioning and various other aspects. The head of the household, who is usually in charge of running the dairy business and a member of the dairy cooperative, provided responses to the bulk of the questionnaire. For the section on cooking habits and time spent on cooking, responses were provided by the household member in charge of cooking, which in most cases was the spouse of the household head. The village questionnaires were designed to gather information on the creation of new economic activities and job creation which may have occurred due to the development of the biogas sector.

Drafts of the questionnaire were shared with JRI research our Jakarta-based research partner. Based on their inputs, the questionnaires were adjusted prior to the mission. During the mission, the revised questionnaires were shared, discussed and refined in order to better reflect the context and the manner in which the project operates. Since the instrument had been discussed prior to the mission no major adjustments were needed. After finalization the questionnaires were translated into *Bahasa Indonesia*. The preparation mission for the baseline survey was undertaken by ISS/RWI researchers in May 2011 while the preparation mission for the follow-up survey took place in April-May 2012. For both survey rounds a four-day training workshop was conducted by JRI, and included two ISS/RWI researchers. 30 enumerators were trained to canvass the survey while eight operators were trained to carry out data entry. Following a one day pre-test the first round of the survey was canvassed between May 31st and June 14th 2011 while the second round was canvassed between May 1st and May 15th 2012. In the case of both survey rounds, data entry took place at the JRI office in Jakarta. The final version of the first round data was handed over to ISS/RWI researchers at the beginning of August 2011 while the final version of the second round data was handed over to ISS/RWI in late August 2012.

4.2 Sampling method

Households – identifying treatment and control

Dairy farmers that participate in the cooperatives covered by the BIRU programme form the natural sampling frame from which to sample treatment and control groups. In East Java, the BIRU programme is active in nine rural districts and involves 11 CPOs. These CPOs are in charge of the construction of digesters and each serves one to three dairy cooperatives. Each of the 19 involved cooperatives has a biogas supervisor who disseminates information about the BIRU programme and the eligibility criteria. The supervisor also manages the credit schemes. These services are only accessible to farmers who are members of the cooperative, underlining the need to restrict the survey sample to members of the cooperative.

The key challenge for the sampling strategy was to identify, in 2011, the cooperative members who would have a biogas digester in 2012. We selected these "potential" *new users* from the cooperative members that had applied for a BIRU digester by May 2011 but who had not yet had a digester installed. Since the treatment groups of *always users* and *new users* are by programme design confined to the members of the cooperatives, the *never users* who serve as controls were also recruited from the same cooperatives.

There were two potential problems that had to be considered during the baseline survey, both relating to "non-compliance" regarding the designated treatment status: (i) the designated control group *(never users)* could apply for – and receive – a biogas digester during the period between the baseline and follow up survey, and (ii) the designated treatment group – the applicants *(new users)* – may decide to resign from the BIRU programme and not install a biogas digester before the follow-up survey. To address the first threat, we oversampled the control group. In response to the second potential problem, we also adopted a pipeline comparison approach as a fall back option.

Given budgetary considerations the overall sample size was set at 700 households, consisting of 250 BIRU applicants (*new users*), 100 households with a digester (*always users*) and 350 households that had not yet applied for a digester (the potential *never users*). Power calculations (setting alpha = 0.05 and beta = 0.8) suggest that this sample size (treatment and control samples of 350 and 250 households) is sufficient to detect reasonable effect sizes (standardized effect size of 0.25) for the main outcome variables (firewood/charcoal consumption, energy expenditures and time use).

The first step in the sampling procedure involved the selection of CPOs to be included in the survey. Two CPOs, the cooperatives Kud Sri Sedono and Kud Tani Makmur were dropped, as they only had a small number of installed digesters and applicants among their members and are located relatively far from the Malang area. At a later stage of the sampling process, one of the three cooperatives served by the CPO LPKP had to be dropped due to unavailability of information on the cooperative's members. This left us with the 9 CPOs listed below in Table 8, covering 11 cooperatives in 30 sub-districts and 5 districts.

In the second step, the applicant group to be sampled was randomly drawn from a list of all applicants which was obtained from each of the 11 cooperatives. In total, the lists included 497 applicants (Table 8). After 250 applicants had been randomly selected, sub-districts with less than two selected farms were dropped for logistical reasons. The random selection was then repeated for the remaining sub-districts. The 250 sampled applicants are drawn from all five districts and include 13 sub-districts.

The non-applicants were sampled from the lists of members of the cooperative. In order to serve as suitable controls for our applicants, non-applicants had to comply with three criteria. First, they were supposed to – in principle – qualify to obtain a digester by keeping at least one productive cow and regularly delivering milk to the cooperative. Second, members who already owned a digester provided through a different programme or had applied for one through the BIRU programme were excluded. The third criterion was that control farmers live in villages from which treatment farms had already been selected in order to retain homogeneity in village characteristics. A total of 18,321 active members were selected as potential controls for this study.

From each cooperative, control farms were randomly sampled from the list of farms that met the above mentioned criteria. In order to achieve similar sample composition among treatment and control households, the number of control farms drawn from each cooperative was proportional to the share of applicants drawn from the respective cooperative. Before each interview, enumerators verified whether these criteria were actually met and, if needed, replaced the control.

Finally, the biogas users that had already installed a BIRU digester were randomly sampled from each CPO from the official BIRU list which only includes households with functioning digesters for which a completion report has been submitted. The users were selected only from villages in which applicants had been selected to be surveyed. In order to obtain a sample of users that are representative of the programme, the number of users drawn from each CPO was proportional to the number of BIRU biogas digesters installed in the respective CPO.

The distribution of the applicants, non-applicants and existing users among the 9 CPOs and 11 cooperatives is given in Table 9.

Table 8: Total number of BIRU applicants, installed digesters and active cooperative members, by districts and CPO

District	CPO	Cooperative*	Applicants	Digesters installed	Active members
Kab. Malang	KAN Jabung		14	164	453
	LPKP	DAU Kud Karang Ploso	47	184	900
	Sumber Makmur Ngantang		41	299	6,740
	Sae Pujon		115	441	4,126
Kab. Pasuruan	KUD Dadi Jaya		30	93	747
	Setia Kawan		175	457	4,050
Kab. Kediri and	KPUB Sapi Jaya		34	51	199
Kab. Jombang	Sami Mandiri	Sami Mandiri Karta Jaya	28	249	761
Kab. Blitar	KUD Semen		13	148	345
Total	9	11	497	2,086	18,321

Note: The cooperative names are given for those cases where the CPO is not a single cooperative.
Source: BIRU project data; Cooperative members' lists.

Table 9: Number of BIRU farmers sampled for the three groups, by CPO

CPO	Cooperative*	Applicants	Non-applicants	Current users	Total
KAN Jabung		4	5	8	17
LPKP	DAU	11	15	4	30
	Kud Karang Ploso	12	17	5	34
Sumber Makmur Ngantang		21	29	14	64
KPUB Sapi Jaya		15	21	2	38
Sami Mandiri	Sami Mandiri	7	10	4	21
	Karta Jaya	7	10	8	25
SAE Pujon		65	87	21	173
KUD Dadi Jaya		13	18	5	36
Setia Kawan		86	119	22	227
KUD Semen		9	13	8	30
Total	11	250	344	101	695

Note: The cooperative names are given for those cases where the CPO is not a single cooperative.
Source: BIRU project data; Cooperative members' lists.

Villages (Desa)

To assess the wider economic impact of the development of the biogas sector, village level information has also been gathered. In total, 61 villages from which the households are drawn were visited in the second round of the survey and the head of the village provided responses, among others, on issues such as the economic activities including employment that may have been triggered by the development of the biogas sector.

Table 10: Total number of BIRU users, by districts, CPO and cooperative

District	CPO	Cooperative	Number of user households
Kab. Malang	KAN Jabung		8
	LPKP	DAU	9
		Kud Karang Ploso	15
	Sumber Makmur Ngantang		38
	Sae Pujon		84
Kab. Pasuruan	KUD Dadi Jaya		18
	Setia Kawan		83
Kab. Kediri and	KPUB Sapi Jaya		18
Kab. Jombang	Sami Mandiri	Sami Mandiri	11
		Karta Jaya	14
Kab. Blitar	KUD Semen		15
Total			313

Notes: The 'number of user households' refers to both always user and new user households.
Source: Indonesian biogas survey, 2012.

4.3 Qualitative data and desk research

The qualitative databases underlying this report were put together over two rounds of field work conducted in June-July 2011, mainly in Lombok province and in April-May 2012, mainly in East Java.

In 2011, two weeks after the data collection in East Java had ended; a field visit was undertaken by ISS/RWI researchers to Lombok Island. To obtain an overview of the study regions and of issues relevant for biogas, the field work began with focus group discussions and was followed by semi-structured household interviews. Focus group discussions were conducted in three (East, Central and West Lombok) of the four districts of the island.[17] Household interviews and focus group discussions included topics related to energy usage and attitudes, in particular concerning biogas. In total, 37 semi-structured interviews were conducted with households and village heads in all four districts of the island. In addition, 5 interviews were conducted with masons working for the three CPOs active on the island. Key informant interviews included BIRU staff, representatives of the provincial and regional branches of the Ministry of Energy and Mineral Resources (ESDM), the Ministry for Environment, researchers from the University of Mataram (UNRAM), and a researcher involved in the Dutch capacity development programme Casindo.[18] These interviews provided information on the energy sector in Lombok, the provincial government's overall energy strategy,

[17] The focus group discussions involved five to ten households. Groups were mixed and included users, applicants and non-users. We selected the villages for this study in such a way that in each district one to four villages were included. In Central Lombok four villages were visited, in North Lombok only one and in East and West Lombok three villages each. The plan was to select villages based on the number of biogas users and socio-economic criteria. In this context we tried to select at least one wealthier and one poorer village in each district. However this procedure only worked out well in the case of Central Lombok and East Lombok where it was possible to select villages according to both criteria. The selection was based on information obtained from BIRU, village heads or the CPOs. In the other districts, the implementation of this procedure was difficult as the program was not very advanced and we lacked information on the socio-economic status of villages. Furthermore, some regions were difficult to access. In West Lombok there was no village with more than two digesters, and in North Lombok the program was just starting and was only active in one village with two users.

[18] Casindo aims at strengthening capacities for energy policy formation and the implementation of sustainable energy projects in West Nusa Tenggara and four other Indonesian provinces.

other energy initiatives and development programmes in the region as well as on the potential for and obstacles facing biogas development.

In 2012, the focus of the field work was on conducting key informant interviews with programme stakeholders in East Java. Based on the existing secondary information and the issues to be analysed a list of potential stakeholders that should be visited was drafted. This list included:

- Hivos and SNV in Jakarta
- Representatives from the BIRU project in Malang
- BIRU - Field technicians responsible for marketing, implementing and monitoring the programme
- Representatives from Nestle
- Representatives of business enterprises emerging as a consequence of the biogas project
- Dairy cooperatives
- Masons
- Digester owners

Semi-structured interviews were conducted with each of these key informants. The questions raised during the interviews closely followed the kind of information needed to respond to the terms of reference. Responses were noted and summaries of each interview are available.

The table below (Table 11) provides a list of the organizations and individuals with whom interviews were conducted in 2012.

Table 11: List and role of the interviewed organizations

Name of the organization / institution – Location	Persons interviewed
Hivos/SNV	• Mr. Robert de Groot, Programme Manager Hivos/SNV, BIRU programme
SNV – Jakarta	• Mr. Sundar Bajgain, SNV Senior Biogas Advisor
BIRU representatives – Malang	• Mr. Wasis Sasmito, Provincial Coordinator BIRU – East Java • Ms. Christina Haryanto Putri, Manure Management, BIRU – East Java
Government of Malang	• Mr. Nehruddin, Head of Planning and his team
Cooperatives– Malang	• Kan Jabung • Karangploso • Sae Pujon
Masons	• 1 mason associated with Karangploso cooperative and 3 masons associated with Sae Pujon cooperative
Nestle Indonesia – Malang	• Mr. Manu Scharer, Milk procurement and dairy development manager – Kejayan Factory
Bio-slurry business [19] – Malang	• Mr. Rianto
Households	• 3 digester owning households in different villages in Karangploso sub-district

Source: Own elaboration.

[19] The business consists of buying bio-slurry from digester owners and selling it to farmers who use it as a fertiliser.

4.3 Data quality, sample attrition and non-compliance

The household questionnaire covered a number of areas and given the level of detail requested from each household took between 1.5 and 2 hours to complete, although increasing familiarity did lead to a reduction in the time required to complete the form. Overall, the quality of the survey data, for both survey rounds, seems to be good in terms of the completeness of the data and consistency with other sources of information. The paragraphs below provide an assessment of the quality of the information.

One metric for judging the quality and completeness of the data is the non-response rate for various questions. For both survey rounds information on demographic composition of the household (household size, gender, age, and household composition) is complete and the number of missing values is negligible. Similarly information on the education and occupation of the household head is complete as is information on the educational attainment and the primary and secondary occupation of all household members over 6. Information on household assets such as house ownership, material of roof, floor, and space outside the dwelling and on the ownership of household consumer durables is also complete.

Information pertaining to a household's agricultural activities and livestock ownership is well covered by the survey. Depending on the variable, at most, the number of missing observations for variables such as amount of land owned, crops grown, crop output, amount sold and total revenue generated through agricultural activities is less than 1 percent. With regard to the number of cows and the number of other livestock, which is crucial information to assess whether the household can properly feed a digester, the non-response rate is less than 1 percent.

The detailed module on digesters (about 50 questions) contains comprehensive information and while there are some missing values (few households do not remember the application date or when construction was completed; other households could not recall the interest rate paid over the loan) there appear to be no major reasons for concern. Similarly, questions pertaining to energy use and expenditure and cooking and lighting patterns are quite well covered.

Information on health conditions and time-use is perhaps not as well-covered as other parts of the survey, although there does not seem to be any systematic pattern in the missing values. At most, for some of the questions in this section, 10 percent of the values are missing.

Information on expenditure was canvassed through a series of questions consisting of 20 categories (13 categories deal with household expenditures while the remaining 7 deal with expenditure related to agricultural activities). Enumerators were free to choose whether to record this information on a weekly, monthly or yearly basis in order to allow the respondent to choose the most convenient recall period. Given our past experience on other projects, the enumerators paid extra attention to minimizing the number of missing values and 'do not know' answers. This is important as incomplete information on any one of the expenditure categories makes it difficult to compute total expenditure for that given household and limits its use in the analysis. For both survey rounds the non-response rate for the expenditure questions was less than 1 percent.

The village level questionnaires were directed to the village chiefs. As compared to the household data the questionnaire is relatively short and consists of 21 questions. The data is complete and there are no missing values.

Household panel: attrition and non-compliance

While the quality of the information in terms of non-response rates and consistency across the two data rounds is satisfactory, there are still two issues which need attention. First, the baseline survey covered 695 households while during the follow-up survey 18 of the previously surveyed households could not be located as they had moved from their recorded place of residence. We were unable to locate them through their mobile phone numbers. Hence, sample attrition is about 2.6 percent. While this is not a large figure it is important to check whether the households that have dropped out from the sample are systematically different from households that remain in the sample. Our statistical assessment shows that there is no systematic difference between the two categories and that sample attrition may be treated as random and hence should not have a bearing on the credibility of the impact estimates.[20]

Perhaps a greater source of concern is non-compliance with designated status. The designated control group could apply for and receive a digester during the period between the baseline and follow-up survey. As Table 12 shows, this did take place and after accounting for attrition, of the 335 individuals who were designated as controls, 32 secured a digester between the baseline and follow-up period. Similarly, after accounting for attrition, of the 245 applicants, 61 had their applications rejected by BIRU and remained in the *never user* category. For the analysis in this report we have assigned households to the different groups as we find them in 2012, that is, 97 *always users*, 216 *new users* and 364 *never-users*.

A pertinent question is the consequence of this non-compliance for the evaluation strategy outlined in Section 3. To guard against the possibility that the control group may not retain its control status we had purposively oversampled the control group and despite the movement of 32 controls the overall sample size of 364 never-users lies in the same range as anticipated during the baseline (344 versus 364). In terms of the applicant group there is a larger reduction but the number of *new users* is not much smaller than anticipated (216 versus 250). In short, sample size issues are unlikely to be a concern.

In terms of the pipeline comparison design which is based on comparing *always users* with applicants the analysis focuses on the 97 *always users* and the 216 *new users* who were either applicants or part of the control group in 2011. Since the *always users* and the *new users* have both been accepted by the BIRU programme, a comparison of these two groups is appropriate as both sets satisfy the observed and unobserved criteria used by BIRU to determine programme entry. Indeed, it may be argued that by dropping the non-eligible applicants and focusing on *always users* and *new users* (who displayed an interest and have been deemed eligible) works towards enhancing the credibility of the pipeline comparison design.

With regard to the difference-in-difference analyses, the focus is on comparing *never users* and *new users*. Since we have panel data and can control for time-invariant observed and unobserved traits which may be associated with programme entry (obtaining a digester) there is no reason to expect that non-compliance should compromise the analysis. In any case we provide estimates based on

[20] A probit model for dropping out does not reveal that any systematic differences in the characteristics of those remaining in the sample and dropping out. The overall regression is statistically insignificant (p-value of 0.83).

both the DID and pipeline comparison designs and tend to focus on the most conservative estimates.[21]

Table 12: Composition of 2012 treated and controls

Status in 2012	Sampling group in 2011			Total sample
	User	Applicant	Control	
Always-users	97			97
New-users		184	32	216
Never-users		61	303	364
Total sample	97	245	335	677
Attrition	4	5	9	18

5. Assessment

We begin our assessment of the BIRU programme by first examining the comparability of the treated and control groups (section 5.1). This is followed by an examination of various issues related to installation and use of biogas such as reliability of gas supply, decision-making related to digester purchase and other related questions (section 5.2). Section 5.3 deals with livestock, dung management and bio-slurry, section 5.4 deals with cooking and lighting habits, section 5.5 examines time-use patterns. Section 5.6 presents econometric estimates. Section 5.7 deals with village-level effects. On the basis of the econometric assessment, section 5.8 provides a payback analysis.

5.1 Descriptive statistics: comparing treatment and control groups

Prior to discussing differences between treatment and control groups a few remarks on the entire sample and its relative socio-economic status are in order. Based on comparisons between the nationally representative Indonesian economic survey of 2011 and the 2011 round of the data collected for this study, average annual per capita spending by the sampled households is similar to average spending by Indonesian households in East Java who are engaged in the livestock sector. On average, the dairy farmers in the sample lie between decile 4 and decile 5 of the national per capita expenditure distribution.[22]

Profiles of the interviewed households are provided in Table 13. Most households are headed by a male (97 percent), with the average age of the head of household slightly below 50 years. The average household consists of about 4 members. On average, both the household head and his/her spouse have obtained between 6 and 7 years of schooling, while almost all children in the age group 6-12 attend school.

In terms of indicators of household wealth, all households in the sample own the plot of land on which their farm is located. The construction materials of the house vary: walls are mostly made of clay, roofs of tiles, and floors are made of ceramics and concrete. Most households have an account

[21] To elaborate we could have dropped the 61 rejected households from the entire analysis. However, this is costly. To use these data effectively we did the following (i) We provide estimates ***without including*** such households – the pipeline comparison design estimates which are based on 97 always users and the 216 new users who were accepted into the programme and (ii) Use PSM to match households and then provide PSM-DID estimates. If the 61 rejected households are very different they would be excluded from the estimates. Also, it is likely that the rejected applicants failed eligibility criteria or were not deemed credit worthy. Such unobserved time-fixed characteristics are controlled for in the PSM-DID estimates. In any case, as it turns out these households do not seem to be very different from households who are never users. Differences in means are only statistically significant for 5 out of about 40 variables. See table in Annex 4.

[22] Annex 4 contains a detailed table.

at a bank or saving association. On average 92 percent of the interviewed households have 2 or more cows, which is typically the minimum requirement for joining most of the cooperatives in the surveyed area, and also an eligibility requirement to obtain a digester. Access to electricity is very high, with almost 90 percent of the households reporting access. Per capita annual expenditure (excluding consumption of own produce) is 4.5 million Indonesian Rupiah.

Differences in some of the observed characteristics across the two treatment groups (new and always users) and the 364 households without a digester (never users) seem to be minor. Characteristics such as household size, age of household head and main occupation of the household head do not differ substantially across the three categories. Similarly, household demographic composition and incidence of land ownership are similar across all three groups. The main differences across the three groups lies in educational status with household heads (and spouse of household heads) amongst *always users* displaying a higher educational attainment as compared to the two other groups and the higher per capita annual expenditure amongst the *always users*. Consistent with these differences we also note that the number of cows owned and the amount of land owned is also higher for the *always* and *new* users as compared to the *never users*. Overall, there are observable differences across the three groups and digester users tend to be wealthier than non-users.

To examine whether the three groups are similar in terms of the probability of owning a digester we estimate logit models of digester ownership as a function of various socio-demographic characteristics (Table 16). For the pipeline comparison sample we dropped variables that are potentially affected by having a biogas digester, such as the cleanliness of the kitchen or having access electricity. For the difference-in-difference sample these variable do not pose a problem, as the dependent variables reflects having a biogas digester in 2012 while the explanatory variables are all taken at their 2011 values. The models have limited explanatory power (10 to 13 percent) and especially in the case of the pipeline comparison design sample the model is not able to discriminate very clearly between the treatment and control group (very few characteristics are statistically significant). In other words the two groups are similar in terms of the probability of owning a digester. Differences between treatment and control groups in the difference-in-difference sample seem more pronounced with households associated with some cooperatives far more likely to have a digester as compared to others.

Overall, the main point emerging from this section is that the profile of the three sets of households is not remarkably different. Nevertheless, in the forthcoming empirical work we use propensity score matching to ensure that the three groups are observationally equivalent in terms of the traits that determine ownership of a digester.

Table 13: Main characteristics of treatment and control groups (standard errors in brackets)

Variable	Total	Always users	New users	Never users
Household size	3.97	4.08	4.05	3.89
	(1.19)	(1.18)	(1.16)	(1.20)
Male head of household (%)	96.60	97.64	97.22	95.88
Age of the head of household	47.75	46.94	49.06	47.18
	(11.48)	(9.11)	(11.25)	(12.12)
Main activity head of household (%)				
Farmer	89.66	84.54	91.20	90.11
Civil servant retired	0.30	0.00	0.46	0.27
Other activity	10.04	15.46	8.80	9.89
Number of years schooling head of household	6.22	7.23	5.92	6.14
	(2.51)	(2.87)	(2.44)	(2.39)
Highest level of education (%)				
None	2.67	1.04	4.19	2.21
Literate	0.15	0.00	0.00	0.28
Primary school	76.52	65.63	80.47	77.07
Junior high school	13.37	15.63	9.77	14.92
Senior high school/vocational training or higher	7.29	17.71	5.69	5.53
Main activity head of household's spouse (%)				
Farmer	20.53	13.04	20.00	22.87
Unpaid family worker	17.87	19.57	18.05	17.30
Housewife	54.08	58.70	55.61	51.91
Other activity	7.52	8.70	6.34	7.92
Number of years schooling head of household' spouse	6.45	7.38	6.20	6.36
	(2.55)	(2.75)	(2.54)	(2.45)
Highest level of education (%)				
None	2.50	0.00	3.90	2.33
Literate	0.16	0.00	0.00	0.29
Primary school	73.75	60.87	77.07	75.22
Junior high school	15.00	23.91	11.71	14.58
Senior high school/vocational training or higher	8.60	15.22	7.32	7.58
Share of children aged 0-15 (%)	22.64	20.62	22.09	23.50
Share of children aged 6-12 attending school (%)	81.78	81.39	82.05	81.75
Share of household members aged 65 or more (%)	3.27	2.42	2.95	3.69
Plot of land ownership (%)	99.40	1.00	99.53	99.17
Material of walls (%)				
Clay	80.94	86.59	81.48	79.12
Cement	6.79	7.21	9.25	5.21
Wood	6.64	2.06	6.01	8.24
Other	5.61	4.12	3.24	7.41
Material of the roof (%)				
Tiles	80.35	88.65	79.16	78.84
Asbestos	11.81	7.21	12.03	12.91
Wood	3.24	2.06	1.85	4.39
Other	4.57	2.06	6.94	3.84
Material of the floor (%)				
Ceramics	59.67	68.04	59.25	57.69
Concrete	30.13	26.80	32.40	29.67
Soil	9.60	4.12	7.87	12.08
Other	0.59	1.03	0.46	0.54
Electricity available in the house (%)	88.77	94.84	92.59	84.89
Household has a bank account at bank or saving association (%)	86.70	88.65	91.20	83.51
Households has 2 or more cows (%)	92.91	96.91	97.69	89.01
Per capita annual expenditure (**IDR**)	4,488,021	5,515,895	4,453,455	4,234,621
	(3,213,236)	(5,004,113)	(2,997,159)	(2,633,865)
Number of households	677	97	216	364

Source: Indonesian biogas survey, 2012.

Table 14: Households involved in agricultural activities, size of their land and the number of the cultivated crops (standard deviation in parenthesis)

	Always users	New users	Never users
Household cultivating land	96.91	94.91	91.76
Size of cultivated land (ha)	0.74	0.68	0.50
	(0.78)	(1.87)	(1.46)
Number of locations	3	2.30	2.11
	(2.23)	(1.72)	(1.51)
Number of cultivated crops	2.87	2.88	2.87
	(1.36)	(1.54)	(1.72)

Notes: the household questionnaire gathers information on 32 different crops.
Source: Indonesian biogas survey, 2012.

Table 15: Livestock ownership (standard deviation in parentheses)

	Always users	**New users**	**Never users**
Cows	6.27	5.19	3.93
	(4.59)	(3.57)	(2.99)
Small ruminants	0.15	0.09	0.21
	(0.88)	(0.85)	(2.06)
Poultry and rabbit	10.95	5.21	4.96
	(52.18)	(20.96)	(17.43)

Notes: the category 'cows' includes milking and non-milking cows and buffaloes and 'small ruminants' includes sheep and goats.
Source: Indonesian biogas survey, 2012.

Table 16: Propensity score functions for the pipeline comparison and difference-in-difference samples

	Pipeline comparison (Probability of having a biogas digester in 2011)	Difference-in-difference (Probability of having a biogas digester in 2012)
Farming main activity of household head	0.0590	-0.1139
	[0.4482]	[0.3141]
Highest level of education (ref: none/primary)		
Junior secondary	0.3201	-0.0833
	[0.3490]	[0.2303]
Senior secondary	0.7607+	-0.6047*
	[0.3963]	[0.2867]
Vocational training	-1.0803	0.4543
	[1.1565]	[0.6406]
University	1.0918	-0.6610
	[0.6679]	[0.5647]
Number of children under 6 years	0.1283	-0.3725+
	[0.2825]	[0.2023]
Household size	-0.0570	0.1759+
	[0.1405]	[0.0924]
Has certified property rights to plot	-0.5126	0.5017*
	[0.3552]	[0.2336]
Size cultivated land (ha)	0.0785	0.0921
	[0.1384]	[0.1154]
Number of cows kept	0.0277	0.1214**
	[0.0318]	[0.0370]
Number of rooms in the house	0.2639**	-0.0532
	[0.0954]	[0.0687]
Cement or clay brick walls	-0.1754	0.3274
	[0.5795]	[0.3241]
Solid floor (concrete, brick, stone, ceramic)	0.5812	0.0818
	[0.6996]	[0.3610]
Roof made of concrete or tiles	0.1146	-0.3060
	[0.3954]	[0.2572]
Window fitted with glass	-0.1371	0.5715*
	[0.3844]	[0.2424]
PLN electricity connection		1.0380*
		[0.4336]
Household has bank account		0.2261
		[0.2093]
Kitchen wall slightly dirty (ref: clean)		-0.0730
		[0.2721]
Kitchen wall quite dirty (ref: clean)		-0.0648
		[0.3888]
Kitchen ventilation satisfactory (ref: good)		0.0371
		[0.2894]
Kitchen ventilation poor (ref: good)		-0.1312
		[0.4506]
Kitchen equipment satisfactory (ref: good)		0.7617*
		[0.3235]
Kitchen equipment poor (ref: good)		0.9195*
		[0.4683]
Cooperative (ref: Sae Pujon)		
Kan Jabung	3.5393**	-1.8310
	[1.1725]	[1.1290]
Sami Mandiri	0.9692	0.2520
	[0.7481]	[0.5761]
Karta Jaya	1.5838*	-0.2378
	[0.6872]	[0.5924]
Sapi Jaya	-1.2288	-0.0071
	[0.8469]	[0.4187]
Sumber Makmur Ngantang	0.3351	0.0770
	[0.4791]	[0.3782]
KUD Semen	0.9561	-0.1022
	[0.6687]	[0.5186]
Setia Kawan	0.0594	-0.6412*
	[0.3992]	[0.2669]
KUD Dau	0.7669	-1.3254*
	[0.8405]	[0.5837]
Dadi Jaya	0.2316	-0.2485

	[0.6500]	[0.4647]
Karang Ploso	0.2292	-0.4252
	[0.6577]	[0.4735]
Constant	-3.4773**	-3.1798**
	[1.0736]	[0.8137]
Treatment group	Always user (n=97)	New user (n=216)
Control group	New user (n=216)	Never user (n=364)
Pseudo R squared	0.135	0.100
Observations	313	580

Note: The tables reports logit coefficients with standard errors in square brackets. All explanatory variables are taken at their 2011 values. Significance levels: + 10%, * 5%, ** 1%.
Source: Indonesian biogas survey, 2012.

5.2 Knowledge, use, purchase and functioning of digesters

This section provides a range of details on source of knowledge about digesters, decision-making process regarding the purchase of a digester, financing digester purchases, as well as on the use and reliability of digesters.

A majority of households stated that they first heard about digesters and the potential of using biogas from representatives of the cooperatives (88 percent), while about 10 percent heard about digesters either from other cooperative members or neighbours. Television, radio and brochures do not appear to play a major role in disseminating information about digesters.

As shown in Table 17, for a majority of households (58 percent) the digester purchase is viewed as a collective decision. The head of the household is the main decision maker in about a third of households while the spouse of the household head appears to play a limited role. With regard to plant size, the head of the household makes the decision in about 41 percent of the cases while amongst another 40 percent of households it is considered a collective decision. Once again, the spouse of the household head does not play a dominant role.

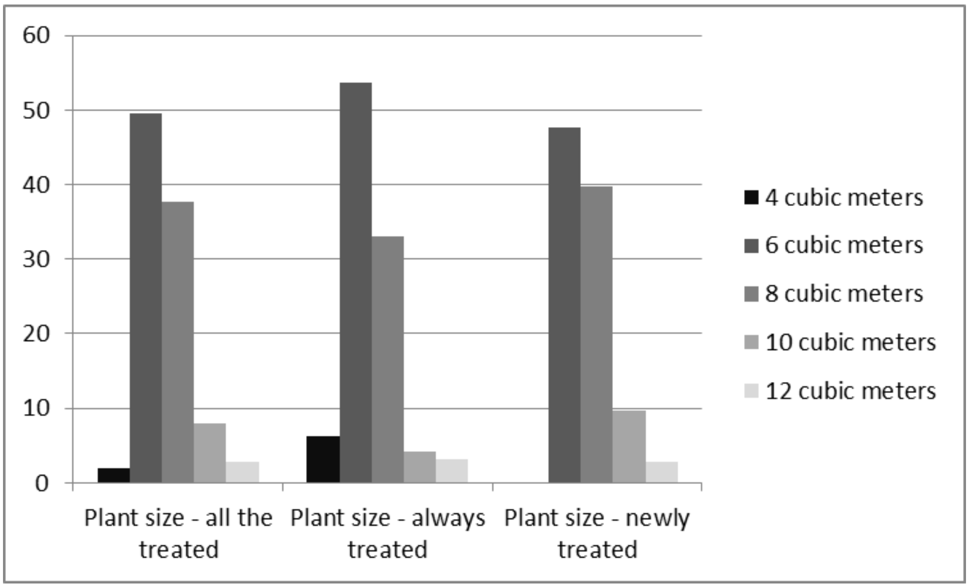
Table 17: Decision making regarding digester purchase and plant size

	Who decided on …	
	Digester purchase	**Plant size**
Collective decision with other households	1.92	2.24
Collective decision within the household	58.47	40.58
Head of the household	33.55	41.21
Spouse of the head of the household	3.83	3.51
Different household members	2.24	12.47

Source: Indonesian biogas survey, 2012

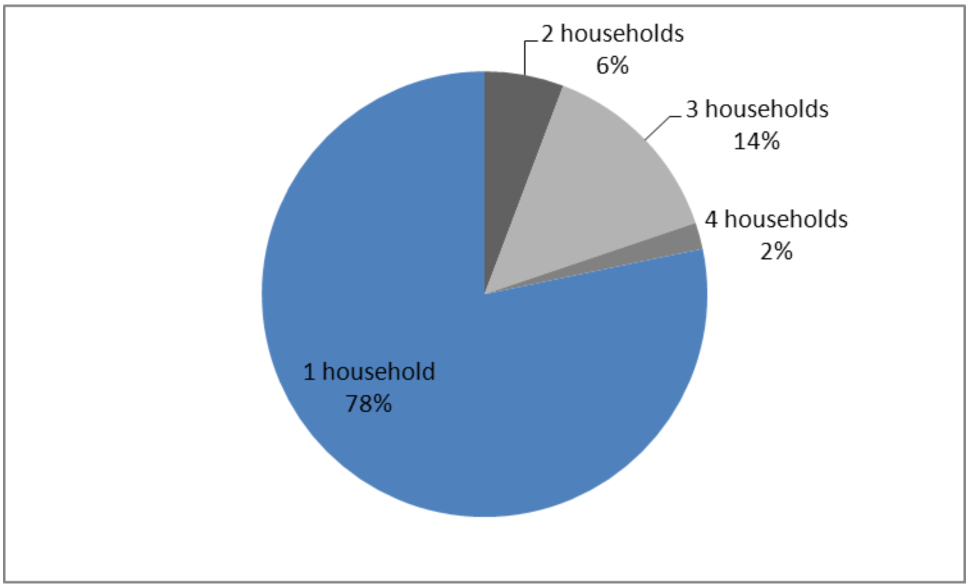
The $6m^3$ digester is the most popular plant size (50 percent), followed by the 10 m^3 plant (38 percent) (Figure 3). While digesters are typically intended for a single-household we found that digesters were being shared in about 22 percent of cases (see Figure 4).

Figure 3: Plant size for all the treated, the always treated and newly treated households



Source: Indonesian biogas survey, 2012.

Figure 4: Share of digester plants used by one or more households



Source: Indonesian biogas survey, 2012.

The bulk of the digesters are financed entirely through loans/credit (93 percent) while a minority of digester owners have drawn on their savings or sold cows to finance their digester purchase (Table 18). The main source of loan/credit as far as households are concerned is the cooperative to which they belong. This is a little misleading as almost all the cooperatives that are included in the survey sell their milk mainly to Nestle which in turn provides credit to cooperatives at 0 percent interest rate in order to enable digester purchases. Based on the field visits we found that cooperatives in turn offer their members loan/credit at interest rates ranging from 0 to 6 percent which they are expected to repay in 2 to 3 years. The terms of re-payment differ across cooperatives but the amounts are deducted periodically (usually every 10 to 12 days) and automatically from the money owed by the cooperative to the individual member for milk sales. During field work we saw the manner in which the system worked. While most farmers (75 percent) were unable to provide information on the interest rate that they were being charged or the amount of the outstanding loans they did have records on the total proceeds from milk sales, the deduction for repayment of the digester loan and the outstanding loan balance. None of the respondents expressed concerns about the repayment burden.

Table 18: How treated households finance plant construction, in percent

	All the treated	Always users	New users
Loan / credit	92.97	84.54	96.76
Saving and loan / credit	2.88	7.22	0.93
Selling cows and loan / credit	2.24	3.09	1.85
Other	1.91	5.15	0.46

Notes: the category 'other' includes disposable income and sale of agricultural products.
Source: Indonesian biogas survey, 2012.

Table 19: Where did the household get the loan/credit, in percent

	All the treated	Always users	New users
Cooperative	99.67	98.91	100
Cooperative and rentenir (loan shark)	0.33	1.09	0

Source: Indonesian biogas survey, 2012.

Table 20: Interest rate charged, in percent

	All the treated	Always users	New users
Respondent does not know	74.9	69.6	77.2
0%	23.6	28.2	21.4
2%	0.3	0.0	0.5
2.5%	0.6	0.0	0.9
6%	0.3	1.1	0.0

Source: Indonesian biogas survey, 2012.

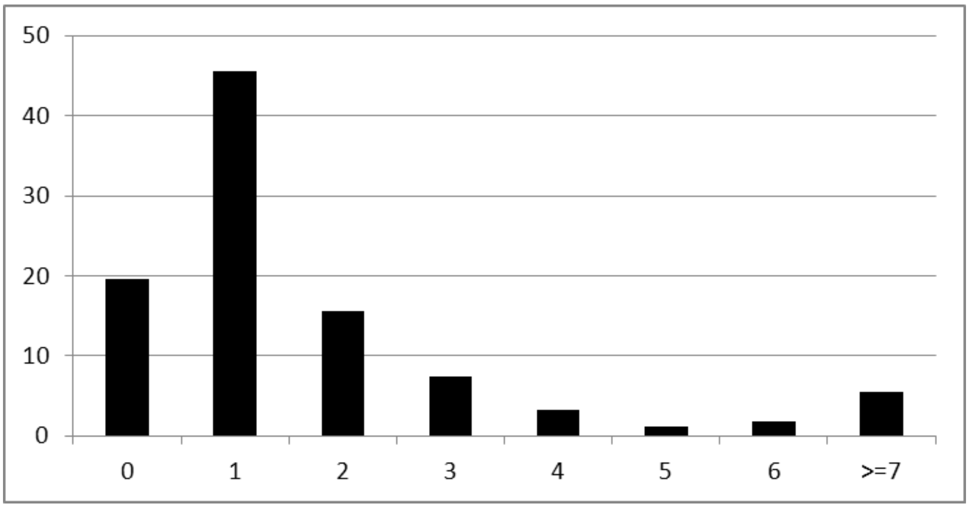
Table 21: Repayment by frequency (in IDR)

	All the treated	Always users	New users
Every 7 days	75,000	0	75,00
	[0]	[0]	[0]
	(1)	(0)	(1)
Every 10 days	58,763	55,037	60,230
	[31,831]	[23,363]	[34,603]
	(132)	(38)	(94)
Every 12 days	87,435	87,425	87,438
	[20,872]	[16,675]	[22,199]
	(81)	(20)	(61)
Every month	301,862	329,863	286,862
	[91,162]	[64,633]	[99,920]
	(86)	(30)	(56)

Notes: Among the 313 users, 9 households do not remember the terms of the repayment, 1 household has not yet started repaying, and 3 households have already finished repaying. Standard deviation in square brackets, number of households in parentheses.
Source: Indonesian biogas survey, 2012.

The process for obtaining a digester seems to run efficiently, as in 90 percent of the cases it has taken only four months from submitting the application form to having a completely operational digester (Figure 5).

Figure 5: Number of months between application and digester completion



Notes: The number of months is reported on the 'x' axis while the share of users (%) is reported on the 'y' axis. For 43 households we do not have information on the either the date of the application or the date when construction was completed.
Source: Indonesian biogas survey, 2012.

Among the treated households, 96 percent reported that their digester was producing gas as expected while the remainder pointed out that their plant was producing less gas than expected. In terms of their overall levels of satisfaction with the digester, 47 percent of the respondents reported that they were "very satisfied" while 52 percent reported that they were "rather satisfied". Only 1 percent of the treated households stated that they were "rather unsatisfied" with the digester.[23] The qualitative interviews confirmed that digester owners are very satisfied with the functioning of the digesters. There were few complaints, mostly regarding corrosion of stove knobs which need to be replaced every six months.

Consistent with the satisfactory remarks on gas production, there seem to be limited reports on the need for fixing or replacing parts of the digester.[24] About 6 percent of digester owners (19 households) reported that they have had to repair/replace parts since the time their digesters became operational. In 7 of the 19 households that experienced a problem, BIRU has stepped in to help and deal with the problem. About 3 percent (10 households) mentioned that they had experienced unexpected effects, including issues such as a bad smell due to gas leaks, a non-working stove or problems with the thermometer. The satisfaction with the construction and the limited need for repair may be linked to the attention paid to building digesters. SNV regularly organizes 8-day training courses for masons and provides instructions on how to build durable digesters. At the end of the training, each mason who has passed the course receives an 'ID code'. Through this code masons may be linked to the digesters that they have built which allows project implementers to check on the quality of the construction.

In addition to the role of good construction in ensuring adequate gas flow the satisfactory flow of gas suggests that the availability of water and cow dung, which are necessary for the proper

[23] There is no difference in overall levels of satisfaction between households that share their digester as compared to those who do not share digesters. For those sharing digesters 44 percent reported they were 'very satisfied' while 52 percent reported they were 'rather satisfied'.

[24] At the time of the survey the average age of a digester was 13 months.

functioning of digesters is not a major issue. The recommended link between digester size and cow ownership is provided in Table 22 while Table 23 shows the distribution of digesters conditional on size of cow holding and digester size. The recommended figures may be compared with the actual distribution to gauge whether households will potentially have enough cow dung to feed their digesters. Comparisons show that about a third of digester owning households do not have the recommended cow-digester size ratio. In terms of water availability, only 8 percent of the treated households stated that they faced water shortages. Notwithstanding the gap between recommended and actual ratios it does not seem that this aspect has a negative effect on gas production.

Table 22: Digester sizes and recommended number of cows

Size of digester	4	6	8	10	12
Number of cows	3	4-5	6	7-8	9

Source: http://sfiles.biru.or.id/uploads/files/1279109047.pdf

Table 23: Number of digesters conditional on cow ownership and digester size

	Always users					
	Less than 2 cows	*2 cows*	*3 cows*	*4 cows*	*5 cows*	*6 or more cows*
4 cubic meters	0	4	2	0	0	0
6 cubic meters	3	2	8	8	12	19
8 cubic meters	0	1	4	6	3	18
10 cubic meters	0	0	0	0	1	3
12 cubic meters	0	0	0	0	0	3
	New users					
	Less than 2 cows	*2 cows*	*3 cows*	*4 cows*	*5 cows*	*6 or more cows*
4 cubic meters	0	0	0	0	0	0
6 cubic meters	4	15	20	22	15	27
8 cubic meters	1	6	14	15	17	33
10 cubic meters	0	3	3	4	4	7
12 cubic meters	0	0	1	0	0	5

Source: Indonesian biogas survey, 2012.

Table 24 provides a first look at the expected effects of access to biogas. The table provides information on the main motivations for buying a digester which may be contrasted with the perceived benefits of owning a digester. There are interesting differences. The main motivations for buying a digester are a reduced need for firewood (44 percent), faster cooking (33 percent) and a smokeless kitchen (26 percent). However, *ex post* the percentage of households who perceive benefits in terms of reduced need for firewood collection, faster cooking, and smokeless kitchens is at least more than 90 percent. Indeed, along almost all dimensions listed in the table, more than 90 percent of household indicate that they experience benefits. The patterns are the same for longer-term users as well as new users. Based on these perceptions it is clear that households are very positive about the benefits of owning a digester.

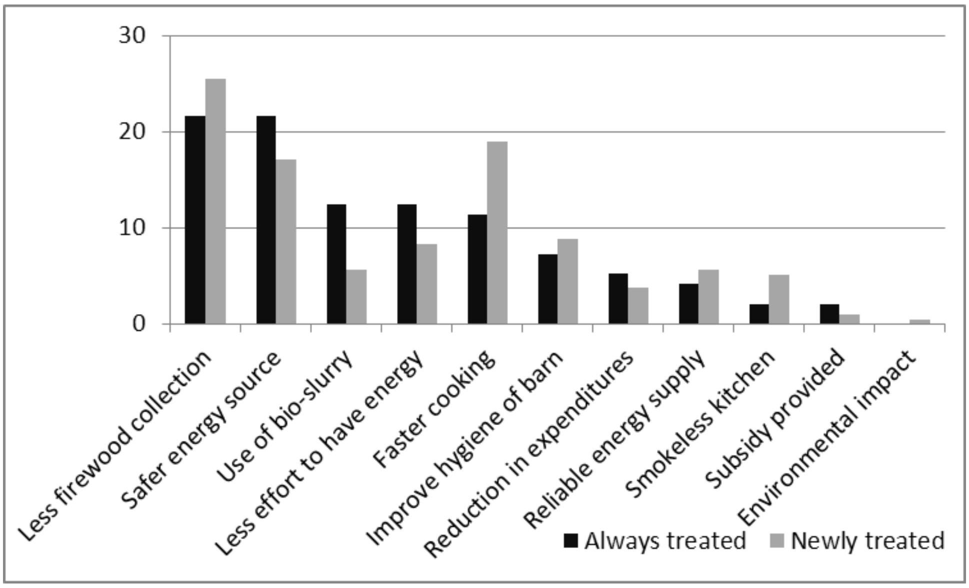
Table 24: Main advantages ex-ante and ex-post of having a digester, in percent

	Always users		New users	
	Main motivations ex-ante	*Perceived benefits ex-post*	*Main motivations ex-ante*	*Perceived benefits ex-post*
Reduced need for firewood	44.33	91.75	51.85	93.06
Reduction in expenditures	10.31	95.88	14.81	95.83
Smokeless kitchen	25.77	96.91	33.80	96.30
Faster cooking	32.99	91.75	22.69	88.89
Safety	22.68	95.88	16.67	95.83
Use of bio-slurry	14.43	94.85	14.35	87.96
Improve hygiene of the barn	19.59	95.88	20.83	94.91
Less effort to have energy	14.43	95.88	13.89	99.07
Reliable energy supply	10.31	96.91	4.63	96.30
Environmental impact	9.28	95.88	3.70	96.30
Subsidy provided	1.03	n/a	0.93	n/a

Notes: Numbers do not sum up to 100 as multiple answers are possible.
Source: Indonesian biogas survey, 2012.

While there are a range of benefits that households perceive, the most important benefit is reduced need for firewood followed by "safe energy source" (Figure 6).

Figure 6: Most important perceived advantage of having a digester, in percent



Notes: Numbers sum up to 100 as each interviewee can choose only one option.
Source: Indonesian biogas survey, 2012.

Despite the fact that less than 10 percent of the treated households mention 'reduction in expenditures' as the most important advantage of having a digester, the perceived saving in terms of energy related expenditures is quite high (Table 25). On average, users indicate that they save about IDR 59,000 per month on energy which translates into between 3 to 4 percent of their annual expenditure.

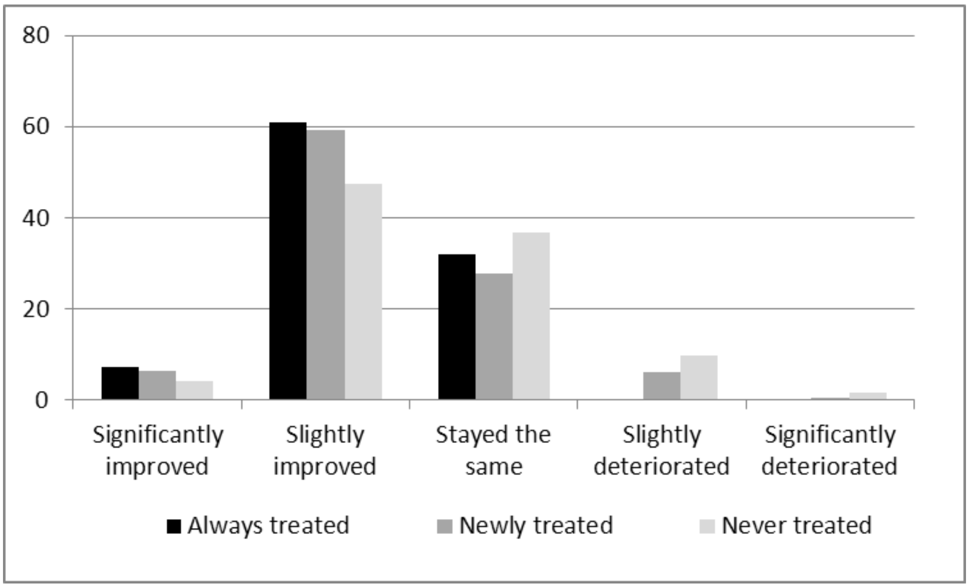
Table 25: Perceived saving in terms of energy related expenditures per month in IDR

	All the users	Always treated	Newly treated
Money saved due to the use of a digester	58,648.5	64,994.2	55,564.2
	(57,229.4)	(73,230.9)	(47,494.8)
	[266]	[87]	[179]

Notes: Number in square brackets refer to the number of households for which the statistics are computed, while the numbers in parentheses are standard deviations.
Source: Indonesian biogas survey, 2012.

In addition to the various benefits and the monetary savings, digester owners are more likely to report that they have seen an improvement in their living conditions in the last 3 years (see Figure 7).

Figure 7: Household living condition compared to 3 years ago



Source: Indonesian biogas survey, 2012.

About three quarters of the treated households have taken part in training organized by BIRU or by the cooperatives under the supervision of BIRU employees. This training covered topics such as how digesters work, how digesters need to be operated and fed, benefits of bio-slurry and how to read the manometer (Table 26). This training is offered to individuals but can also consist of a group course. The part of the training considered most useful relates to the general explanation on the use and maintenance of the digester. The quality of the training is considered good or adequate by 85 percent of those who have been trained. 8 percent of the treated say they are still in need of additional training. Of these, the topics where additional training is needed are proper advice on the use of bio-slurry and on how to fix or replace broken parts of the plant.

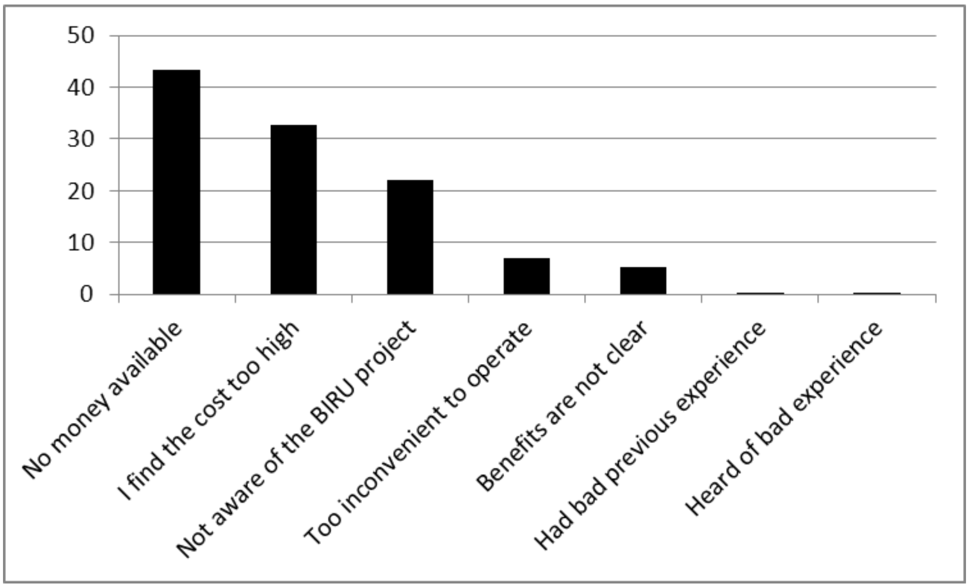
Table 26: Share of households who have received training, in need of additional training, most useful topics and additional training needs

Households received training (%)	77.00	Household in need of additional training (%)	7.88
Most useful topics (%)	How to use, keep and maintain the digester (65.40) How to stir the digester (10.83)	Topics where additional training is needed (%)	How to use bio-slurry properly (36.84) How to fix/repairs broken parts (36.84) How to control gas flow (5.26)

Source: Indonesian biogas survey, 2012.

A pertinent issue, given the high perceived benefits and the overall quality of the functioning of digesters, is why non-users do not apply for digesters? According to 75 percent of the respondents, the main reasons for not purchasing a digester are financial – either they do not have the resources or the cost is too high. About a fifth (22 percent) are not aware of the programme and about 12 percent consider digesters inconvenient to operate and/or do not see the benefits of owning a digester (Figure 8).

Figure 8: Reason for not applying for a BIRU digester



Notes: The share of never-users (%) is reported on the 'y' axis.
Source: Indonesian biogas survey, 2012.

5.3 Livestock, dung management and bio-slurry

This section provides an assessment of the difference in livestock ownership, dung collection and use practices and the use of bio-slurry. Table 27 provides an overview of the number of each type of livestock owned by the three groups. As displayed, while differences in cow ownership between the two users groups is not particularly pronounced, the never users are clearly less well-endowed in terms of the number of cows that they own.

Table 27: Livestock ownership (standard deviation in parentheses)

	Always users	New users	Never users
Cows	6.27	5.19	3.93
	(4.59)	(3.57)	(2.99)
Small ruminants	0.15	0.09	0.21
	(0.88)	(0.85)	(2.06)
Poultry and rabbit	10.95	5.21	4.96
	(52.18)	(20.96)	(17.43)

Notes: The category 'cows' includes milking and non-milking cows and buffaloes and 'small ruminants' includes sheep and goats.
Source: Indonesian biogas survey, 2012.

Practically all households keep their cattle in stables (Table 28) and the amount of cow-dung collected daily is a reflection of the differences in cow ownership patterns. The main use of cow dung in user households is to feed the digester followed by its use as a fertiliser, while in the case of the control group the main use is as a fertiliser followed by disposal of the cow dung in drains and lakes/rivers.

Table 28: Cattle and manure management (standard deviation in parentheses)

	Always users	New users	Never users
Cattle kept in stable (%)	100	99.1	99.7
Amount of cow-dung collected daily	85.74 (120.87)	60.22 (82.53)	35.45 (51.90)
Main use of cow-dung	Used for digester (30.21%) Used as a fertiliser (21.88%) For digester and for fertiliser (16.67%)	Used for digester (35.21%) Used as a fertiliser (13.62%) For digester and for fertiliser (22.07%)	Used as a fertiliser (44.51%) Dumped into open drain (19.36%) Dump into lake/river (11.56%)

Source: Indonesian biogas survey, 2012.

Bio-slurry, the residue after the fermentation of cow dung in the digester, is used by 72 percent of user households as a fertiliser (

Table 29).[25] The main reason for not using it is the lack of a place to dry the bio-slurry (62.5 percent), followed by the statement that using the bio-slurry is not worth the effort (13.9 percent) or does not make any difference compared to other fertilisers. About 8 percent of the newly treated households claim that they still do not know how or in what quantities bio-slurry should be applied to crops, and whether it needs to be mixed with other fertilisers.

There was considerable evidence of the promotion of bio-slurry during the field visits as well as instances where businesses were buying bio-slurry and selling it to other households. At the same time there was evidence of farmers experimenting with bio-slurry on their own. For instance, a digester-owning household living in the village of Tawanargo, Karangploso sub-district (semi-structured interview, conducted on April 25, 2012) expressed lack of awareness in terms of the bio-slurry needed for each crop but based on his experiments he has concluded that there is an increase in the yield of tomatoes due to application of bio-slurry. Similarly, a digester-owning household living in Bocek, Karangploso sub-district (semi-structured interview, conducted on April 25, 2012) believes that bio-slurry increases yields of vegetables and fruits but not rice and wheat.

In addition to these individual experiments, based on their own analysis, the Indonesian Government and Hivos have started a promotion campaign on the use of bio-slurry and associated benefits. Brochures and fliers have been developed and distributed.[26] Individual cooperatives have also started examining the benefits of bio-slurry independently. For instance, Kan Jabung cooperative in Malang (semi-structured interview, April 26, 2012) conducted an experiment with sugar cane where one hectare of land was exclusively fertilized using bio-slurry and another hectare only with chemical fertiliser. Based on their assessment, the output on the plot fertilized with bio-slurry was 102 tons versus 70 tons produced on the chemically fertilized plot. Similarly, Sae Pujon cooperative in Malang (semi-structured interview, April 27, 2012), conducted an experiment on the effects of bio-slurry on grass. On 1/8th hectare only bio-slurry was used while on 1/8th hectare urea

[25] Bio-slurry, which is the residue remaining after fermentation of the mixture of dung and water (undigested slurry) in the digester and the release of biogas is an organic fertilizer and may have an effect on crop yields and other agricultural activities. For details on the composition of bio-slurry and its properties see http://www.biru.or.id/en/index.php/bio-slurry/. Accessed on February 25, 2013.

[26] Source: Interview on April 25, 2012, with Head of the Planning, Government of Malang.

was used. According to members of the cooperative, the grass on the bio-slurry allotment took two months to be ready, compared to three months on the urea-fertilized allotment. They mentioned that the bio-slurry fertilized grass was 25 centimeters longer and that it was more nutritious.

Table 29: Main use of bio-slurry and reasons for not using it as a fertiliser, in percent

	Always users	
Main use of the bio-slurry (%)	Reasons for not using the bio-slurry (%)	Main use of the bio-slurry (%) [if not used as a fertiliser]
Used as a fertiliser (72.16)	Absence of a place to collect/dry it (62.96)	Dump into open drain (44.44)
Not used (27.84)	Not worth the effort (18.52)	Dump into lake/river (37.04)
	Not aware/convinced of its value as a fertiliser (14.81)	Dump into the irrigation system (11.11)
	New users	
Main use of the bio-slurry (%)	Reasons for not using the bio-slurry (%)	Main use of the bio-slurry (%) [if not used as a fertiliser]
Used as a fertiliser (63.89)	Absence of a place to collect/dry it (62.5)	Dump into open drain (58.33)
Not used (33.33)	Not worth the effort (13.9)	Dump into lake/river (13.89)
Other (2.78)	Do not know the application method (8.33)	Give it away for free (5.56)

Notes: The other reasons for not using the bio-slurry are: 'quantity is too little'. The other uses of bio-slurry, if not used as a fertiliser, are: 'sell it', 'leave it where it is', 'dump it into the forest' and 'bury it in soil'.
Source: Indonesian biogas survey, 2012.

Whether there is indeed a link between the use of bio-slurry and crop revenues based on the household data is an issue that we investigate in a forthcoming section.

5.4 Cooking and lighting habits: comparing treatment and control group

To examine patterns of energy use across the various groups we begin by examining cooking behaviour followed by lighting use. Mainly due to their ownership of a biogas stove, digester users own more cooking devices. Amongst users, despite universal ownership of a biogas stove and high ownership rates of other types of stoves, households still maintain a wood fuel stove. As far as the control group is concerned a higher proportion has a wood fuel stove and an LPG stove (Table 30). The differences across the two groups suggest that owning a digester is associated with reduced ownership of wood fuel and LPG stoves.

Table 30: Households owning different types of cooking devices, in percent

Type of stove owned	Always users	New users	Never users
Wood fuel stove	72.16	77.78	90.93
Kerosene run stove	8.25	8.80	7.97
Biogas stove	100	100	0.00
Biogas water boiler	0.00	1.85	0.00
Gas (LPG) stove	49.48	39.35	79.12
Electric stove	1.03	0.00	0.82
Electric boiler	0.00	0.93	0.27
Rice cooker	13.40	3.70	6.04
Magic jar	23.71	12.96	19.78
Magic com	63.92	54.63	54.67
Other	0.00	0.46	0.82

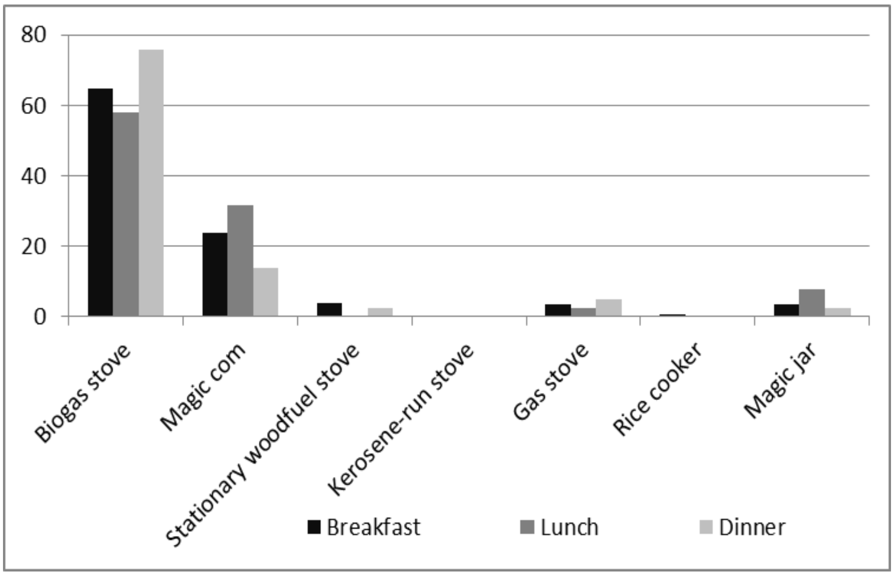
Average number of stove owned	4.7	4.3	3.8

Source: Indonesian biogas survey, 2012.

Most households cook three times a day, for breakfast, lunch and dinner. A comparison of stoves used for different meals, for the two treated groups and the never treated is provided in Figure 9. The cooking profile of the newly and always treated households is quite similar - regardless of the type of meal being prepared, the biogas stove dominates, followed by the Magic Com.[27] For breakfast and lunch, the biogas stove is the main stove used by approximately 60 percent of digester owning households, while for dinner this share is almost 80 percent. Magic coms are used by 20 percent of treated households, although their use is more common for preparing lunch. The predominant use of the biogas stove as opposed to the intensive use of the wood fuel and gas stove by households without a biogas digester indicates a clear pattern of substitution driven by access to biogas.

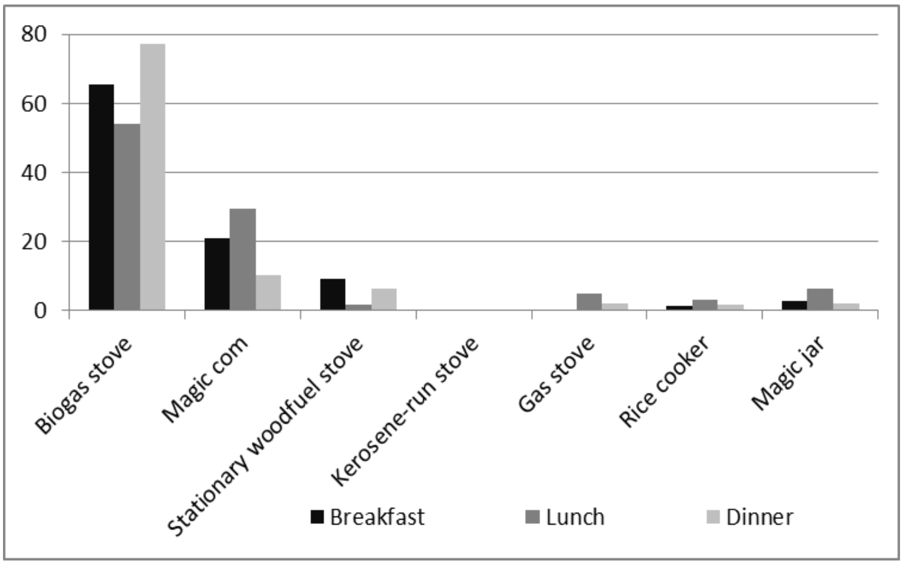
Figure 9: Main stoves used by always users, new users and never users for breakfast, lunch and dinner, in percent

Always users

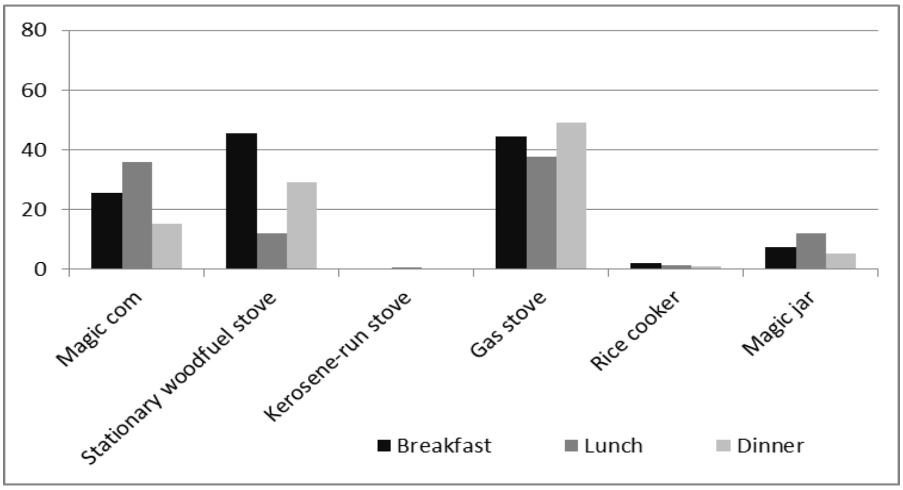


New users

[27] Magic Com and magic jars run on electricity. Magic jars are used to warm rice; Magic Coms are used for cooking and warming rice.


80
60
40
20
0
Biogas stove
Magic com
Stationary woodfuel stove
Kerosene-run stove
Gas stove
Rice cooker
Magic jar
Breakfast
Lunch
Dinner

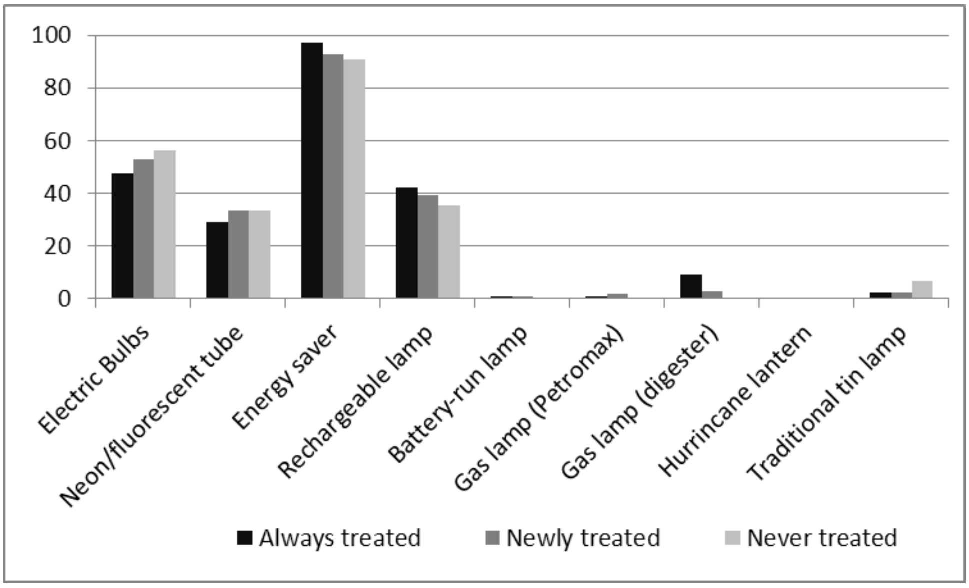
Never users



Notes: 'biogas stove' has been removed from the last figure as no household in the 'never treated' group uses it for cooking.
Source: Indonesian biogas survey, 2012.

While biogas is primarily used for cooking, a small proportion of households use it for lighting purposes. As shown in Figure 10, apart from the use of biogas lamps (for 9 and 3 percent of the always and new biogas users, respectively) the utilization of other sources of lighting does not display much variation across the three groups (see Table 31). This is not unexpected as most digester owners use electricity for lighting. On average biogas lamps are used for 0.66 and 1.83 hours a day by the always users and new users, respectively. Energy savers are the most commonly used types of bulbs, followed by electric bulbs and neon/fluorescent tubes. The field visits confirmed the limited use of biogas for lighting. Typically, electricity is used for lighting the house and in a few cases treated households were using biogas for lighting their barns.

Figure 10: Usage of different type of lighting devices, in percent



Source: Indonesian biogas survey, 2012.

Table 31: Number of lamps used per household (standard deviation in parenthesis)

	Number of lamps used per households			Lighting hours per day		
	Always users	New users	Never users	Always users	New users	Never users
Electric Bulbs	2.52	2.92	2.52	10.82	11.07	10.82
	(1.6)	(1.74)	(1.60)	(5.84)	(6.17)	(5.84)
Neon/fluorescent tube	1.71	2	1.73	6.67	8.46	7.77
	(1.08)	(1.65)	(1.14)	(4.09)	(5.34)	(5.72)
Energy saver	7.35	5.82	5.41	14.12	12.90	13.27
	(3.96)	(3.55)	(2.93)	(5.66)	(6.66)	(8.81)
Rechargeable lamp	0.8	0.75	1	0.22	1.08	0.26
	(0.9)	(0.69)	(1.00)	(1.08)	(3.55)	(1.11)
Gas lamp (digester)	0.07	0.01	0.00	0.66	1.83	0.00
	(0.3)	(0.03)	(0.00)	(2)	(4.49)	(0.00)

Notes: 'battery run lamp', 'gas lamp (Petromax)', 'hurricane lantern' and 'traditional tin lamp' have been removed from the table as households did not report ownership of such types of lamps.
Source: Indonesian biogas survey, 2012.

5.5 Time use patterns

The use of digesters may affect time allocation of household members through several channels. For instance, access to digesters may reduce the time spent gathering/buying firewood and the time spent on collecting/buying fertilisers and also reduce time spent on cooking activities. Time saved on these activities may be used elsewhere.

Time spent on different activities which are closely linked to digester access is provided below. On average, time spent by household members on gathering/acquiring firewood (affects household head) is substantially lower for digester owners. There is also a reduction in time spent cooking (affects mainly spouse of household head) although it is not as substantial. Differences in terms of time spent on gathering/buying fertiliser and on buying other energy sources (i.e. candles, LPG, kerosene and batteries) are not pronounced. While digesters appear to be associated with some time-savings there is also an increase in time spent on operating the digester (mainly for household heads). On average, households spend about 2 hours a week operating a digester. On balance, despite the additional time spent on operating a digester a household seems to save about 2 hours a week through a reduction in time spent cooking and on gathering/acquiring firewood.

Table 32: Time used for gathering firewood (standard deviation in parentheses), fertilisers and cooking

	Always users	New users	Never users
Time spent on collecting/buying fertiliser	72	98	97
(minutes per week)	(104)	(146)	(162)
Time spent on gathering/acquiring	36	95	316
firewood (minutes per week)	(165)	(225)	(606)
Time spent buying other energy sources	2	1	4
(minutes per week)	(3)	(3)	(6)
Time spent on cooking (minutes per week)	317	308	349
	(333)	(352)	(336)
Time spent operating the digester (minutes	114	112	n/a
per week)	(153)	(167)	(n/a)

Source: Indonesian biogas survey, 2012.

Table 33: Household member in charge of running the digester, in percent

Household member generally in charge of running the digester (filling it with water/dung, mixing it, checking it)	All users	Always users	New users
Head of the household	78.2	79.4	77.7
Spouse	11.5	12.4	11.2
Other household member	10.3	8.2	11.1

Source: Indonesian biogas survey, 2012.

Table 34: Household member in charge of cooking, in percent

Main household member in charge of cooking	All the households	Always users	Never users
Spouse	86.6	86.0	88.7
Head of the household	2.8	2.7	3.1
Daughter	7.4	8.1	5.1
Other household members	3.2	3.2	3.1

Source: Indonesian biogas survey, 2011.

Table 35: Household member collecting firewood, in percent

Main household member in charge of collecting firewood	All the households	Always users	Newly users	Never treated
Head of the household	82.5	87.5	76.5	84.0
Spouse	10.4	12.5	14.1	8.9
Daughter/son	5.3	0.0	5.9	5.1
Other household member	1.8	0.0	3.5	2.0

Source: Indonesian biogas survey, 2012.

To address whether these differences in specific activities translate into any changes in time use across users and non-users we examine how male and female household members in different age groups use their time. Across the three groups, we find (Table 36) minor differences in the manner in which household heads and spouses of household heads use their time on income generating activities and household duties.

Table 36: Time spent on different activities by the head of the household and his/her spouse, in hours per day (standard deviation)

	Always users	New users	Never users
		Head of the household	
Exercise income generating activities	6.31	7.1	6.52
	(2.34)	(2.33)	(6.33)
	[97]	[216]	[364]
Do household duties	0.30	0.12	0.11
	(0.22)	(0.52)	(0.40)
	[97]	[216]	[364]
		Spouse of the head of the household	
Exercise income generating activities	2.09	2.40	2.08
	(2.38)	(2.50)	(2.25)
	[97]	[216]	[364]
Do household duties	3.49	3.04	3.15
	(2.38)	(2.16)	(2.27)
	[97]	[216]	[364]

Source: Indonesian biogas survey, 2012.

Across the three groups, there are some differences in time allocation for the three categories of children in the household (Table 37), but the patterns do not reveal a clear story. For instance, children of always users in the age group 6-11 tend to study less at home after school and are less likely to do household duties. However, in such families, male children in the age group 12 to 17 tend to study more at home after school while for female children aged 12 to 17 there are no differences. In short, it does not seem that access to digesters has a clear impact on allocation of time to various activities.

Table 37: Time spent for activities by the children aged 6-11 and sons/daughters aged 12-17, in hours per day

	Always users	New users	Never users
		Children aged 6-11	
Study at home after school	0.58	1.04	1.03
	(0.36)	(0.51)	(0.58)
	[35]	[65]	[118]
Study outside the house after school	1.07	1.40	1.15
	(0.35)	(1.51)	(1.32)
	[8]	[9]	[28]
Do household duties	0.03	0.08	0.05
	(13)	(0.25)	(0.20)
	[35]	[65]	[118]
		Male children aged 12-17	
Study at home after school	1.23	0.58	1.01
	(1.31)	(1.10)	(1.16)
	[17]	[51]	[60]
Study outside the house after school	1	2.17	1.22
	(.)	(1.55)	(2.09)
	[1]	[8]	[18]
Do household duties	0.04	0.31	0.09
	(0.14)	(1.16)	(0.25)
	[17]	[51]	[60]
		Female children aged 12-17	
Study at home after school	0.50	0.46	0.53
	(0.36)	(0.37)	(0.49)
	[19]	[35]	[60]
Study outside the house after school	1	2.4	0.58
	(0.30)	(1.59)	(0.27)
	[8]	[12]	[23]
Do household duties	0.02	5	.
	(0.05)	(3)	(.)
	[19]	[35]	[.]

Source: Indonesian biogas survey, 2012.

5.6 Econometric identifications of impacts

This section presents difference-in-difference and pipeline comparison estimates on a range of outcome variables. The DID estimates are based on a comparison of *never-users* and *new-users* (those who acquired a digester between baseline and follow-up) and the pipeline comparison estimates are based on *always-users* and the *new-users*. The bulk of the DID estimates are based on 97 *always-users*, 216 *new-users* and *364* never-users. The PSM-DID estimates are based on 206 *new-users* and 364 *never-users*, that is, 10 *new-users* who could not be matched were removed from the analysis. The pipeline estimates are based on 93 *always-users* and 216 *new-users*, that is, 4 *always-users* could not be matched. The detailed estimates of the propensity score functions are presented in Table 16 and diagnostics regarding the distribution of the estimated propensity score balancing properties of the matched samples are reported in Annex 4.

Use of traditional fuels, energy and other expenditure

This sub-section begins by examining the effect of access to digesters on the probability of purchasing a range of energy sources (Table 38). There are two clear effects. First, digester access leads to a sharp reduction in the probability of purchasing LPG. Regardless of the estimation method used we find that users are about 60 percentage points less likely to purchase LPG. The second effect is a reduction in the probability of purchasing firewood. Although the effect is not as large as the LPG effect, access to a digester is associated with a 7-11 percent reduction in the probability of purchasing fire wood. In terms of quantities (Table 39) access to digesters lead to a reduction in the monthly use of LPG by 6-7 kilograms. We also see a reduction in the number of bundles of fire wood purchased but the effect is not statistically significant.

Table 38: Non-electric energy source purchased last month

	Year	Always users (T1)	New users (T2)	Never users (C)	DID (T2-C)	DID -PSM (T2-C)	Pipeline -PSM (T1-T2)
Candles	2011	0.536	0.653	0.624	-0.038	0.009	-0.082
	2012	0.464	0.491	0.500	(0.520)	(0.891)	(0.268)
LPG	2011	0.124	0.676	0.665	-0.605**	-0.622**	-0.583**
	2012	0.206	0.106	0.701	(0.000)	(0.000)	(0.000)
Kerosene	2011	0.041	0.042	0.077	0.020	0.014	0.024
	2012	0.000	0.009	0.025	(0.410)	(0.602)	(0.438)
Fire wood	2011	0.093	0.185	0.104	-0.115**	-0.070+	-0.075
	2012	0.041	0.065	0.099	(0.002)	(0.092)	(0.141)
Batteries	2011	0.113	0.051	0.044	0.018	0.017	0.049
	2012	0.041	0.042	0.016	(0.422)	(0.537)	(0.245)

Source: Indonesian biogas survey, 2012. *Notes:* Significance levels: + 10%, * 5%, ** 1%. p-values in parentheses.

Table 39: Quantity of non-electric source purchased last month

	Year	Always users (T1)	New users (T2)	Never users (C)	DID (T2-C)	DID -PSM (T2-C)	Pipeline -PSM (T1-T2)
Candles	2011	2.866	4.162	3.901	-0.432	-0.068	-1.895**
	2012	2.701	2.843	3.014	(0.382)	(0.893)	(0.002)
LPG (kg)	2011	0.495	6.236	4.907	-6.188**	-5.940**	-7.172**
	2012	1.144	0.667	5.525	(0.000)	(0.000)	(0.000)
Kerosene (litres)	2011	0.041	0.060	0.179	0.092	0.096	0.024
	2012	0.000	0.009	0.036	(0.163)	(0.184)	(0.438)
Fire wood	2011	0.392	1.380	0.536	-0.718	-0.390	-1.355
(bundles)	2012	0.082	0.648	0.522	(0.149)	(0.533)	(0.126)
Batteries	2011	0.216	0.097	0.093	0.049	0.063	0.047
	2012	0.062	0.083	0.030	(0.328)	(0.313)	(0.608)

Source: Indonesian biogas survey, 2012. *Notes:* Significance levels: + 10%, * 5%, ** 1%. p-values in parentheses.

The reduction in the purchase of LPG and firewood is also reflected in terms of energy spending (Table 40). Consistent with the estimates displayed earlier, digester owners experience a reduction in monthly spending on LPG of between IDR 28,000 to IDR 36,000 and a reduction in expenditure on firewood of between IDR 17,000 and IDR 26,305, although the effect is not always statistically significant. Overall, digester owning household experience a reduction in energy expenditure of between IDR 46,000 to IDR 72,000 a month. Based on the most conservative estimate (DID-PSM) this translates into a 40 percent reduction in energy expenditures for new users as compared to their expenditures in 2011. As compared to household expenditure the savings amount to about 3-5 percent of annual household expenditure. Interestingly, the average effect of digesters on energy expenditures lies in the same range as the perceived savings reported by households in section 5.2.

Table 40: Household spending on energy last month (IDR)

	Year	Always users (T1)	New users (T2)	Never users (C)	DID (T2-C)	DID -PSM (T2-C)	Pipeline -PSM (T1-T2)
Candles	2011	2485	3402	3259	12	-521	-1501*
	2012	2456	2831	2677	(0.986)	(0.456)	(0.019)
LPG	2011	2281	32955	26479	-29076**	-28824**	-37566**
	2012	5391	3199	25799	(0.000)	(0.000)	(0.000)
Kerosene	2011	371	531	1630	838	872	211
	2012	0	102	364	(0.185)	(0.207)	(0.447)
Fire wood	2011	4660	29125	5723	-19202**	-16691	-31768
	2012	902	8991	4790	(.0097)	(0.283)	(0.203)
Batteries	2011	380	215	195	39	107	14
	2012	268	174	114	(0.769)	(0.517)	(0.941)
PLN electricity	2011	44758	43358	37956	-145	-472	-4134
	2012	49641	42227	36970	(0.961)	(0.819)	(0.373)
Total expenditure	2011	54935	109587	75243	-47478**	-44720**	-74772**
	2012	58616	57672	70806	(0.000)	(0.005)	(0.004)

Source: Indonesian biogas survey, 2012. *Notes:* Significance levels: + 10%, * 5%, ** 1%. p-values in parentheses.

While the use of digesters leads to a reduction in energy expenditure we also examine whether this has an effect on other expenditure items. Per capita household spending in the last week on food, telecommunications, water, transport and cigarettes is given in Table 41. Spending for a more extensive list of items is reported for the last month and year in Table 42 and Table 43, respectively. There are no clear patterns and for the most part the estimates are not statistically significant. The only dimension along which there is an effect is a reduction in monthly transport costs. This may be due to reduced transportation needs for acquiring LPG/firewood and fertilisers. Regardless of this effect the main point is that while there is a clear reduction in energy costs this does not translate systematically into a change in terms of expenditure on other items.

Table 41: Per capita household spending last week (IDR)

	Year	Always users (T1)	New users (T2)	Never users (C)	DID (T2-C)	DID -PSM (T2-C)	Pipeline -PSM (T1-T2)
Food	2011	36188	37217	35662	-494	832	-5367
	2012	45232	41198	40138	(0.876)	(0.803)	(0.209)
Telecommuni-	2011	3520	3308	2477	-428	-97	-291
cations	2012	5964	4424	4022	(0.564)	(0.902)	(0.765)
Water	2011	546	405	1152	479	-419	119
	2012	370	547	815	(0.613)	(0.707)	(0.577)
Transport	2011	15141	13238	9251	-3972+	-4389+	-1276
	2012	15660	11833	11818	(0.069)	(0.061)	(0.682)
Cigarettes	2011	6185	7886	7456	225	-49	-2677+
	2012	9521	8675	8020	(0.882)	(0.968)	(0.053)

Source: Indonesian biogas survey, 2012. *Notes:* Significance levels: + 10%, * 5%, ** 1%. p-values in parentheses.

Table 42: Per capita household spending last month (IDR)

	Year	Always users (T1)	New users (T2)	Never users (C)	DID (T2-C)	DID -PSM (T2-C)	Pipeline -PSM (T1-T2)
Food	2011	159281	158950	15158	-2406	-3517	-8366
	2012	183513	168335	163371	(0.870)	(0.821)	(0.718)
Telecommuni-cations	2011	18101	13722	11928	-159	3285	2791
	2012	23948	17938	16302	(0.961)	(0.344)	(0.618)
Water	2011	2252	1724	1908	-426	-2531	512
	2012	1782	2275	2884	(0.760)	(0.121)	(0.563)
Transport	2011	72603	57013	36261	-20175*	-21953*	6839
	2012	56544	48188	47612	(0.026)	(0.025)	(0.646)
Cigarettes	2011	32684	35551	30164	-1912	1033	-5926
	2012	38231	36582	33108	(0.759)	(0.860)	(0.463)
Rent	2011	766	330	365	1759	2233	260
	2012	1526	3510	1785	(0.240)	(0.228)	(0.657)
Clothes	2011	23854	33611	15460	-16742+	-18180	3575
	2012	17224	12820	11411	(0.075)	(0.152)	(0.565)
Medical expenses	2011	2156	3932	2208	822	2249	-214
	2012	5700	7075	4529	(0.649)	(0.288)	(0.898)
Schooling	2011	41868	21595	30924	14008	11085	12279
	2012	38149	25791	21111	(0.194)	(0.344)	(0.158)
Crop transfor-mation	2011	22255	20738	10153	-10986	-13551	-27309+
	2012	5130	1752	2153	(0.116)	(0.142)	(0.092)
Other productive activities	2011	17269	12309	4676	-5956	-5656	14844
	2012	15043	3377	1700	(0.368)	(0.385)	(0.335)
Family/religious ceremonies	2011	11082	9745	11475	2966	10974+	1636
	2012	35561	16542	15306	(0.561)	(0.070)	(0.657)
Remittance	2011	3082	891	2355	1849	1147	1601
	2012	6586	2214	1828	(0.328)	(0.586)	(0.535)

Source: Indonesian biogas survey, 2012. *Notes:* Significance levels: + 10%, * 5%, ** 1%. p-values in parentheses.

Table 43: Per capita household spending last year (IDR)

	Year	Always users (T1)	New users (T2)	Never users (C)	DID (T2-C)	DID -PSM (T2-C)	Pipeline -PSM (T1-T2)
Food	2011	1892773	1889558	1827968	20327	-5745	-99936
	2012	2163546	2016673	1934756	(0.912)	(0.976)	(0.720)
Telecommuni-cations	2011	289635	165946	136223	-7035	48293	109051
	2012	284956	207354	184666	(0.844)	(0.202)	(0.312)
Water	2011	26898	19170	23682	-1483	-209	6670
	2012	17875	24719	30715	(0.880)	(0.985)	(0.515)
Transport	2011	868638	624248	460722	-174733	-191154	201392
	2012	699642	576765	587972	(0.123)	(0.117)	(0.250)
Cigarettes	2011	391529	407055	382244	20231	58473	-62201
	2012	453627	438711	393669	(0.789)	(0.416)	(0.506)
Rent	2011	9192	5703	4384	19408	24990	3115
	2012	18324	42133	21407	(0.282)	(0.253)	(0.657)
Clothes	2011	232097	333261	162384	-151877	-155452	9176
	2012	210594	162236	143236	(0.150)	(0.277)	(0.852)
Medical expenses	2011	29391	46420	26242	21926	27514	1092
	2012	68436	94725	52622	(0.408)	(0.284)	(0.958)
Schooling	2011	502420	259251	265761	61570	53424	145760
	2012	457781	309536	254476	(0.413)	(0.426)	(0.163)
Crop transfor-mation	2011	267090	229417	122088	-110447	-140920	-237874
	2012	61560	21026	24145	(0.180)	(0.195)	(0.212)
Other productive activities	2011	207870	147700	56273	-59130	-56384	178804
	2012	180515	52642	20346	(0.466)	(0.492)	(0.333)
Family/religious Ceremonies	2011	133283	125717	114368	4717	80517	10147
	2012	339133	196566	180500	(0.936)	(0.256)	(0.839)
Remittance	2011	36979	10694	28260	22185	13759	19217
	2012	79032	26559	21939	(0.328)	(0.586)	(0.535)

Source: Indonesian biogas survey, 2012. *Notes:* Significance levels: + 10%, * 5%, ** 1%. p-values in parentheses.

Cooking and lighting

Consistent with the patterns discussed earlier the impact estimates display that the use of digesters is associated with a displacement of LPG and wood fuel stoves (see Table 44). The average number of wood fuel stoves owned by new users declines by more than 20 percent and ownership of LPG stoves declines by about 50 percent. As may be expected, there is a sharp decline in the probability of using wood fuel and LPG stoves and a reduction in the frequency of use (see Table 45 and

Table 46, respectively). Indeed as shown in Table 40 the decline in the usage frequency of the wood fuel and LPG stoves is matched by an increase in the use of the biogas stoves.

Table 44: Cooking devices owned by households

	Year	Always users (T1)	New users (T2)	Never users (C)	DID (T2-C)	DID -PSM (T2-C)	Pipeline -PSM (T1-T2)
Wood fuel stove	2011	1.082	1.745	1.690	-0.395**	-0.371**	-0.596**
	2012	1.196	1.343	1.681	(0.000)	(0.001)	(0.000)
Kerosene stove	2011	0.062	0.037	0.060	0.035	0.048	0.037
	2012	0.093	0.097	0.085	(0.320)	(0.209)	(0.337)
Biogas stove	2011	1.856	0.000	0.000	1.552**	1.539**	1.860**
	2012	1.619	1.560	0.008	(0.000)	(0.000)	(0.000)
Gas stove	2011	0.536	1.088	1.159	-0.532**	-0.487**	-0.725**
	2012	0.732	0.583	1.187	(0.000)	(0.000)	(0.000)
Electric stove	2011	0.010	0.000	0.000	-0.008	-0.005	0.011
	2012	0.010	0.000	0.008	(0.181)	(0.502)	(0.317)
Electric boiler	2011	0.000	0.000	0.000	0.007	0.007	0.000
	2012	0.000	0.009	0.003	(0.291)	(0.397)	(n.a.)
Rice cooker	2011	0.103	0.097	0.091	-0.030	0.003	-0.026
	2012	0.134	0.037	0.060	(0.358)	(0.937)	(0.578)
Magic jar	2011	0.186	0.134	0.151	-0.051	-0.046	-0.009
	2012	0.237	0.130	0.198	(0.253)	(0.304)	(0.878)
Magic com	2011	0.495	0.421	0.440	0.006	-0.001	0.084
	2012	0.660	0.551	0.563	(0.923)	(0.986)	(0.278)
Open fire	2011	0.000	0.000	0.003	0.009	0.010	0.000
	2012	0.000	0.009	0.003	(0.194)	(0.284)	(n.a.)

Source: Indonesian biogas survey, 2012. *Notes:* Significance levels: + 10%, * 5%, ** 1%. p-values in parentheses.

Table 45: Cooking devices used by households in last week

	Year	Always users (T1)	New users (T2)	Never users (C)	DID (T2-C)	DID -PSM (T2-C)	Pipeline -PSM (T1-T2)
Wood fuel stove	2011	0.072	0.634	0.657	-0.471**	-0.485**	-0.553**
	2012	0.082	0.125	0.618	(0.000)	(0.000)	(0.000)
Kerosene stove	2011	0.000	0.000	0.003	0.005	0.011	0.000
	2012	0.000	0.005	0.003	(0.454)	(0.164)	(n.a.)
Biogas stove	2011	0.856	0.000	0.000	0.826**	0.829**	0.849**
	2012	0.918	0.843	0.016	(0.000)	(0.000)	(0.000)
Gas stove	2011	0.041	0.310	0.305	-0.343**	-0.333**	-0.267**
	2012	0.000	0.014	0.352	(0.000)	(0.000)	(0.000)
Rice cooker	2011	0.000	0.005	0.000	-0.005	-0.005	-0.009+
	2012	0.000	0.000	0.000	(0.194)	(0.317)	(0.309)
Magic jar	2011	0.000	0.005	0.000	-0.005	-0.005	-0.004
	2012	0.000	0.000	0.000	(0.194)	(0.317)	(0.611)
Magic com	2011	0.031	0.046	0.036	-0.005	0.012	-0.017
	2012	0.000	0.014	0.008	(0.794)	(0.612)	(0.531)

Source: Indonesian biogas survey, 2012. *Notes:* Significance levels: + 10%, * 5%, ** 1%. p-values in parentheses.

Table 46: Frequency of cooking devices used by households in last week

	Year	Always users (T1)	New users (T2)	Never users (C)	DID (T2-C)	DID -PSM (T2-C)	Pipeline -PSM (T1-T2)
Wood fuel stove	2011	1.89	12.43	12.90	-11.19**	-10.90**	-10.63**
	2012	2.31	3.60	15.27	(0.000)	(0.000)	(0.000)
Kerosene stove	2011	0.00	0.00	0.04	0.03	0.150	0.00
	2012	0.00	0.13	0.14	(0.872)	(0.555)	(n.a.)
Biogas stove	2011	14.41	0.00	0.00	17.97**	17.61**	14.36**
	2012	20.90	18.37	0.40	(0.000)	(0.000)	(0.000)
Gas stove	2011	0.72	6.05	5.75	-8.28**	-8.01**	-6.46**
	2012	0.00	0.40	8.39	(0.000)	(0.000)	(0.000)
Rice cooker	2011	0.00	0.10	0.00	-0.10	-0.10	-0.18
	2012	0.00	0.00	0.00	(0.194)	(0.317)	(0.309)
Magic jar	2011	0.00	0.10	0.00	-0.10	-0.10	-0.09
	2012	0.00	0.00	0.00	(0.194)	(0.317)	(0.611)
Magic com	2011	0.51	0.88	0.69	-0.16	-0.42	-0.35
	2012	0.00	0.29	0.27	(0.701)	(0.403)	(0.480)

Source: Indonesian biogas survey, 2012. *Notes:* Significance levels: + 10%, * 5%, ** 1%. p-values in parentheses.

Consistent with earlier discussions, except for a slight increase in the probability (incidence) of using biogas lamps there is no effect of access to digesters on household lighting habits. This is not surprising as biogas is used mainly for cooking and the bulk of households in the sample have access to grid electricity (see Table 47, Table 48, Table 49, Table 50). Overall, given the low uptake of biogas lamps there is little impact on the availability or use of conventional sources of lighting.

Table 47: Source of lighting available in household

	Year	**Always users (T1)**	**New users (T2)**	**Never users (C)**	**DID (T2-C)**	**DID -PSM (T2-C)**	**Pipeline -PSM (T1-T2)**
Normal electric bulb	2011	0.577	0.634	0.651	-0.016	0.051	-0.017
	2012	0.474	0.528	0.560	(0.790)	(0.392)	(0.815)
Neon tube	2011	0.474	0.472	0.470	-0.004	-0.041	0.0
	2012	0.289	0.333	0.335	(0.942)	(0.429)	(0.795)
Energy saver	2011	0.959	0.935	0.907	-0.009	-0.022	0.013
	2012	0.969	0.926	0.907	(0.784)	(0.471)	(0.685)
Rechargeable	2011	0.124	0.125	0.091	-0.011	0.035	-0.045
	2012	0.320	0.259	0.236	(0.802)	(0.481)	(0.364)
Battery-run lamp	2011	0.021	0.037	0.022	-0.010	-0.004	-0.004
	2012	0.010	0.019	0.014	(0.560)	(0.851)	(0.872)
Gas lamp (Petromax)	2011	0.031	0.005	0.003	0.021	0.023+	0.024
	2012	0.021	0.037	0.014	(0.117)	(0.095)	(0.243)
Gas lamp (digester)	2011	0.103	0.005	0.000	0.030**	0.032*	0.101**
	2012	0.113	0.037	0.003	(0.008)	(0.033)	(0.002)
Hurricane lantern	2011	0.000	0.000	0.003	0.002	0.011	0.000
	2012	0.010	0.005	0.005	(0.792)	(0.164)	(n.a.)
Traditional tin lamp	2011	0.113	0.088	0.088	-0.052	-0.049	0.043
	2012	0.082	0.042	0.093	(.118)	(0.174)	(0.356)
Candles	2011	0.804	0.907	0.904	-0.020	-0.017	-0.118*
	2012	0.856	0.880	0.896	(0.597)	(0.658)	(0.022)

Source: Indonesian biogas survey, 2012. *Notes:* Significance levels: + 10%, * 5%, ** 1%. p-values in parentheses.

Table 48: Use of lighting source inside and outside the house

	Year	Always users (T1)	New users (T2)	Never users (C)	DID (T2-C)	DID -PSM (T2-C)	Pipeline -PSM (T1-T2)
Electric bulb	2011	0.371	0.444	0.401	-0.067	0.029	-0.073
Outside	2012	0.433	0.407	0.431	(0.437)	(0.760)	(0.495)
Electric bulb	2011	1.000	1.227	1.335	0.411	0.490	-0.254
Inside	2012	0.753	1.542	1.239	(0.291)	(0.322)	(0.252)
Neon tube	2011	0.186	0.134	0.173	0.068	0.039	0.054
Outside	2012	0.124	0.167	0.137	(0.288)	(0.579)	(0.400)
Neon tube	2011	0.732	0.653	0.596	0.042	0.115	0.099
Inside	2012	0.371	0.560	0.462	(0.729)	(0.331)	(0.504)
Energy saver	2011	1.433	0.995	0.824	0.006	-0.053	0.417*
Outside	2012	1.536	1.097	0.920	(967)	(0.652)	(0.031)
Energy saver	2011	4.577	3.579	3.580	0.363	0.048	0.606+
Inside	2012	5.371	4.241	3.879	(0.222)	(0.856)	(0.097)

Source: Indonesian biogas survey, 2012. *Notes:* Significance levels: + 10%, * 5%, ** 1%. p-values in parentheses.

Table 49: Hours of lighting source inside and outside the house

	Year	Always users (T1)	New users (T2)	Never users (C)	DID (T2-C)	DID -PSM (T2-C)	Pipeline -PSM (T1-T2)
Electric bulb	2011	2.629	2.764	3.011	0.249	0.825	-0.235
Outside	2012	2.990	2.890	2.888	(0.249)	(0.203)	(0.742)
Electric bulb	2011	3.029	3.227	3.061	-0.456	-0.073	0.181
Inside	2012	2.144	2.957	3.248	(0.366)	(0.892)	(0.783)
Neon tube	2011	1.691	1.016	1.440	0.629	0.373	0.657
Outside	2012	0.794	1.083	0.878	(0.119)	(0.372)	(0.225)
Neon tube	2011	1.959	2.428	2.093	-0.326	0.273	-0.318
Inside	2012	1.132	1.738	1.729	(0.439)	(0.511)	(0.518)
Energy saver	2011	7.167	5.808	5.363	-0.130	-0.639	1.068
Outside	2012	7.385	5.902	5.587	(0.850)	(0.330)	(0.205)
Energy saver	2011	5.868	5.501	4.869	-1.034	-0.896	-1.194
Inside	2012	6.308	6.051	6.452	(0.105)	(0.237)	(0.139)

Source: Indonesian biogas survey, 2012. *Notes:* Significance levels: + 10%, * 5%, ** 1%. p-values in parentheses.

Table 50: Use of lighting source to illuminate rooms and cost of replacing lamps

	Year	Always users (T1)	New users (T2)	Never users (C)	DID (T2-C)	DID -PSM (T2-C)	Pipeline -PSM (T1-T2)
Number of rooms	2011	6.907	5.721	5.852	0.468+	0.225	0.534+
illuminated	2012	6.948	6.411	6.074	(0.066)	(0.352)	(0.096)
Cost of replacing	2011	35026	37980	35704	2547	5689	-14239*
Lamps (IDR)	2012	27791	32593	27770	(0.608)	(0.312)	(0.031)

Source: Indonesian biogas survey, 2012. *Notes:* Significance levels: + 10%, * 5%, ** 1%. p-values in parentheses.

Air pollution and health effects

There are sharp differences in the self-assessed quality of air in kitchens across treatment and control groups. Based on the DID estimates the likelihood of reporting that air quality is good is 21 to 24 percentage points higher for the treated as compared to the controls. The source of the poor air quality is attributed mainly to pollution from the burning of wood (Table 51).

Table 51: Air quality (%)

	Year	Always users (T1)	New users (T2)	Never users (C)	DID (T2-C)	DID -PSM (T2-C)	Pipeline -PSM (T1-T2)
Air quality good	2011	0.979	0.727	0.780	0.235**	0.216**	0.226**
	2012	0.887	0.745	0.563	(0.000)	(0.000)	(0.000)
Bad air from wood fire	2011	0.010	0.222	0.176	-0.313**	-0.287**	-0.200**
	2012	0.041	0.074	0.341	(0.000)	(0.000)	(0.000)
Bad air from Kerosene	2011	0.000	0.000	0.000	0.009	0.048+	0.000
	2012	0.031	0.097	0.088	(0.707)	(0.093)	(n.a.)

Source: Indonesian biogas survey, 2012. *Notes:* Significance levels: + 10%, * 5%, ** 1%. p-values in parentheses.

We analyse the effect of owning a digester on a variety of health outcomes for different household members. These estimates are reported in Tables 52-57. While there is some evidence of a reduction in self-reported symptoms of respiratory diseases for both men and women, the estimates are not robust. Similarly the results suggest that owning a digester is associated with a reduction in eye-related conditions and incidence of headaches. However, these estimates are not precise, as the standard errors are often too large to infer causal effects. We also estimated a full set of health effects for children but these are not reported as there was no evidence that access to digesters is associated with any positive health effects. Overall, while there is a clear improvement in the quality of air in the kitchen this has not yet translated into clear-cut health effects.

Table 52: Symptoms of respiratory disease for women older than 12

	Year	Always users (T1)	New users (T2)	Never users (C)	DID (T2-C)	DID -PSM (T2-C)	Pipeline -PSM (T1-T2)
Breathing difficulty	2011	0.000	0.023	0.025	-0.013	0.000	-0.017
	2012	0.000	0.005	0.019	(0.432)	(1.000)	(0.304)
Cough	2011	0.041	0.069	0.055	-0.028	0.000	-0.028
	2012	0.021	0.014	0.027	(0.244)	(1.000)	(0.439)
Cold	2011	0.000	0.023	0.014	-0.016	-0.017	-0.017
	2012	0.010	0.005	0.011	(0.251)	(0.339)	(0.304)
Sinusitis	2011	0.000	0.000	0.000	0.002	0.003	0.000
	2012	0.000	0.005	0.003	(0.709)	(0.650)	(n.a.)
Asthma	2011	0.000	0.005	0.005	0.001	-0.002	-0.024**
	2012	0.000	0.000	0.000	(0.889)	(0.800)	(0.005)
Days disrupted	2011	0.093	0.181	0.126	-0.061	-0.089	-0.062
	2012	0.000	0.009	0.016	(0.468)	(0.379)	(0.717)

Source: Indonesian biogas survey, 2012. *Notes:* Significance levels: + 10%, * 5%, ** 1%. p-values in parentheses.

Table 53: Symptoms of eye disease for women older than 12

	Year	Always users (T1)	New users (T2)	Never users (C)	DID (T2-C)	DID -PSM (T2-C)	Pipeline -PSM (T1-T2)
Itch	2011	0.010	0.005	0.005	-0.005	-0.004	-0.013
	2012	0.000	0.000	0.005	(0.561)	(0.612)	(0.345)
Redness	2011	0.010	0.009	0.011	-0.002	-0.001	0.004
	2012	0.021	0.005	0.008	(0.867)	(0.939)	(0.789)
Tears	2011	0.000	0.009	0.005	-0.009	-0.013	-0.009
	2012	0.010	0.000	0.005	(0.288)	(0.206)	(0.470)
Days disrupted	2011	0.000	0.028	0.003	-0.031	-0.029	-0.026
	2012	0.031	0.000	0.005	(0.181)	(0.341)	(0.611)

Source: Indonesian biogas survey, 2012. *Notes:* Significance levels: + 10%, * 5%, ** 1%. p-values in parentheses.

Table 54: Headache occurrence for women older than 12

	Year	Always users (T1)	New users (T2)	Never users (C)	DID (T2-C)	DID -PSM (T2-C)	Pipeline -PSM (T1-T2)
Headache	2011	0.289	0.301	0.269	-0.035	-0.075	-0.080
	2012	0.144	0.194	0.198	(0.497)	(0.231)	(0.241)
Days disrupted	2011	0.093	0.551	0.099	-0.437	-0.452	0.034
	2012	0.124	0.125	0.110	(0.200)	(0.326)	(0.659

Source: Indonesian biogas survey, 2012. *Notes:* Significance levels: + 10%, * 5%, ** 1%. p-values in parentheses.

Table 55: Symptoms of respiratory disease for men older than 12

	Year	Always users (T1)	New users (T2)	Never users (C)	DID (T2-C)	DID -PSM (T2-C)	Pipeline -PSM (T1-T2)
Breathing	2011	0.021	0.060	0.022	-0.036+	-0.020	-0.056+
difficulty	2012	0.010	0.019	0.016	(0.064)	(0.345)	(0.081)
Cough	2011	0.062	0.088	0.069	-0.021	0.022	-0.017
	2012	0.010	0.023	0.025	(0.428)	(0.477)	(0.660)
Cold	2011	0.031	0.023	0.005	-0.031*	-0.035+	0.017
	2012	0.041	0.014	0.027	(0.048)	(0.070)	(0.489)
Sinusitis	2011	0.000	0.000	0.000	0.000	0.000	0.000
	2012	0.000	0.000	0.000	(n.a.)	(n.a.)	(n.a.)
Asthma	2011	0.000	0.005	0.005	-0.005	-0.007	0.000
	2012	0.000	0.005	0.011	(0.585)	(0.582)	(n.a.)
Days disrupted	2011	0.072	0.667	0.151	-0.532	-0.518	-0.340
	2012	0.000	0.014	0.030	(0.117)	(0.257)	(0.662)

Source: Indonesian biogas survey, 2012. *Notes:* Significance levels: + 10%, * 5%, ** 1%. p-values in parentheses.

Table 56: Symptoms of eye disease for men older than 12

	Year	Always users (T1)	New users (T2)	Never users (C)	DID (T2-C)	DID -PSM (T2-C)	Pipeline -PSM (T1-T2)
Itch	2011	0.000	0.009	0.005	-0.012	-0.017	-0.006
	2012	0.021	0.000	0.008	(0.202)	(0.132)	(0.588)
Redness	2011	0.000	0.014	0.014	-0.000	0.005	-0.015
	2012	0.010	0.000	0.000	(0.998)	(0.653)	(0.206)
Tears	2011	0.000	0.000	0.000	-0.005	-0.012*	0.000
	2012	0.000	0.000	0.005	(0.275)	(0.049)	(n.a.)
Days disrupted	2011	0.000	0.000	0.000	-0.011	-0.006	0.000
	2012	0.000	0.000	0.011	(.275)	(0.622)	(n.a.)

Source: Indonesian biogas survey, 2012. *Notes:* Significance levels: + 10%, * 5%, ** 1%. p-values in parentheses.

Table 57: Headache occurrence for men older than 12

	Year	Always users (T1)	New users (T2)	Never users (C)	DID (T2-C)	DID -PSM (T2-C)	Pipeline -PSM (T1-T2)
Headache	2011	0.330	0.319	0.275	-0.104*	-0.071	-0.065
	2012	0.216	0.171	0.231	(0.047)	(0.249)	(0.363)
Days disrupted	2011	1.216	0.593	0.610	0.086	-0.155	0.933
	2012	0.103	0.204	0.135	(0.882)	(0.798)	(0.464)

Source: Indonesian biogas survey, 2012. *Notes:* Significance levels: + 10%, * 5%, ** 1%. p-values in parentheses.

Time effects

The effect of access to a digester on various time variables is provided in Table 58 to Table 61. Consistent with the descriptive statistics provided earlier we see a sharp reduction in the time spent on gathering firewood (more than 3 hours per week). There are no time savings with regard to time spent acquiring fertiliser, or time spent acquiring other energy sources. With regard to cooking, digesters do seem to be associated with a reduction in time spent cooking but the effect is not statistically significant.

Table 58: Fertiliser use: time spent on collecting/buying fertiliser last week (minutes)

	Year	Always users (T1)	New users (T2)	Never users (C)	DID (T2-C)	DID -PSM (T2-C)	Pipeline -PSM (T1-T2)
Non chemical fertiliser	2011	45	40	37	-9.6	-3.3	7.0
	2012	47	48	55	(0.379)	(0.781)	(0.628)
Chemical fertiliser	2011	34	31	27	4.7	7.8	8.7
	2012	25	51	42	(0.600)	(0.396)	(0.126)
Total	2011	79	70	64	-4.9	4.6	15.8
	2012	72	98	97	(0.745)	(0.777)	(0.324)

Source: Indonesian biogas survey, 2012. *Notes:* Significance levels: + 10%, * 5%, ** 1%. p-values in parentheses.

Table 59: Gathering fire wood last week

	Year	Always users (T1)	New users (T2)	Never users (C)	DID (T2-C)	DID -PSM (T2-C)	Pipeline -PSM (T1-T2)
Collect wood last week	2011	0.258	0.662	0.706	-0.269**	-0.324**	-0.387
	2012	0.247	0.394	0.706	(0.000)	(0.000)	(0.000)
Minutes per week	2011	72	265	264	-223**	-253.573**	-183.742**
	2012	36	95	316	(0.000)	(0.000)	(0.000)
Bundles per month	2011	3.031	12.120	12.420	-7.699**	-8.486**	-8.923**
	2012	2.546	4.644	12.643	(0.000)	(0.000)	(0.000)

Source: Indonesian biogas survey, 2012. *Notes:* Significance levels: + 10%, * 5%, ** 1%. p-values in parentheses.

Table 60: Energy use: time spent on buying energy last week (minutes)

	Year	Always users (T1)	New users (T2)	Never users (C)	DID (T2-C)	DID -PSM (T2-C)	Pipeline -PSM (T1-T2)
Candles	2011	0.776	1.071	1.035	-0.020	-0.027	-0.165
	2012	0.915	0.775	0.760	(0.924)	(0.909)	(0.395)
LPG	2011	0.430	3.690	3.185	-3.181**	-2.758**	-3.604**
	2012	0.619	0.347	3.023	(0.000)	(0.000)	(0.000)
Kerosene	2011	0.031	0.063	0.310	0.293+	0.250	0.006
	2012	0.000	0.069	0.024	(0.056)	(0.167)	(0.868)
Fire wood	2011	0.554	0.903	0.620	-0.613	-0.307	-1.319+
	2012	0.113	0.128	0.458	(0.111)	(0.439)	(0.068)
Batteries	2011	0.057	0.108	0.030	-0.021	-0.004	-0.109
	2012	0.039	0.072	0.015	(0.670)	(0.945)	(0.123)
All energy sources	2011	1.848	5.833	5.179	-3.542**	-2.847**	-5.191**
	2012	1.686	1.392	4.280	(0.000)	(0.000)	(0.000)

Source: Indonesian biogas survey, 2012. *Notes:* Significance levels: + 10%, * 5%, ** 1%. p-values in parentheses.

Table 61: Time used for cooking last week (minutes)

	Year	Always users (T1)	New users (T2)	Never users (C)	DID (T2-C)	DID -PSM (T2-C)	Pipeline -PSM (T1-T2)
Morning	2011	358	362	361	-19.3	-17.8	-2.5
	2012	215	207	225	(0.699)	(0.756)	(0.973)
Noon	2011	8	4	2	-14.8	-11.6	3.7
	2012	45	39	52	(0.119)	(0.283)	(0.595)
Afternoon/evening	2011	36	26	27	-8.6	1.0	11.7+
	2012	57	61	71	(0.404)	(0.932)	(0.069)
Total	2011	402	392	390	-42.6	-28.4	12.8
	2012	317	308	349	(0.438)	(0.634)	(0.864)

Source: Indonesian biogas survey, 2012. *Notes:* Significance levels: + 10%, * 5%, ** 1%. p-values in parentheses.

Fertiliser expenditure and crop yield

Despite the use of bio-slurry as a fertiliser and, thus, in principle, a reduced need for other fertilisers we do not find that access to digesters is systematically related to reduced expenditure on fertiliser. While there is evidence that access to a digester is associated with a reduction of at most IDR 3,500 a month on chemical fertilisers, the effect is not statistically significant (Table 62). Similarly, with regard to the effect of bio-slurry on agricultural revenues, we find that digester ownership leads to a large increase in revenues from agricultural output, however, the effect is not statistically significant (Table 63). The reduction in expenditure on fertiliser and the increase in crop revenues, albeit not precise, suggests that that there is substantial variation across treated households in the extent to which they substitute bio-slurry for fertilisers and the manner in which they apply bio-slurry to their land. Perhaps over time with increased spread of knowledge on the manner (proportion) in which bio-slurry should be applied a clear statistical effect will be noticeable.

Table 62: Household expenditure on fertiliser last month (IDR)

	Year	Always users (T1)	New users (T2)	Never users (C)	DID (T2-C)	DID -PSM (T2-C)	Pipeline -PSM (T1-T2)
Organic matter	2011	325	227	164	-60	-97	146
	2012	37	72	68	(0.705)	(0.609)	(0.649)
Cow dung	2011	5	18	8	0	8	-8
	2012	7	18	8	(0.997)	(0.682)	(0.622)
Other dung	2011	56	180	74	-107+	-37	-26
	2012	19	15	17	(0.064)	(0.624)	(0.769)
Bio slurry	2011	0	0	0	9	10	0
	2012	0	9	0	(0.192)	(0.317)	(n.a.)
Chemical fertiliser: Urea	2011	3060	5113	2942	-2212	-898	-620
	2012	1561	2573	2613	(0.363)	(0.777)	(0.892)
Chemical fertiliser: ZA	2011	788	1312	514	-413	-407	-94
	2012	576	1201	817	(0.473)	(0.586)	(0.816)
Chemical fertiliser: TS	2011	590	1252	367	-689	-833	-300
	2012	621	771	576	(0.131)	(0.173)	(0.764)
Chemical fertiliser: total	2011	4407	7677	3813	-3324	-2154	-400
	2012	2735	4545	4005	(0.264)	(0.583)	(0.941)
Total fertiliser Spending	2011	4793	8098	4058	-3479	-2286	-510
	2012	2798	4659	4098	(0.245)	(0.563)	(0.926)

Source: Indonesian biogas survey, 2012. *Notes:* Significance levels: + 10%, * 5%, ** 1%. p-values in parentheses.

Table 63: Revenue from agriculture in the last 12 months (IDR)

	Year	Always users (T1)	New users (T2)	Never users (C)	DID (T2-C)	DID -PSM (T2-C)	Pipeline -PSM (T1-T2)
Non-processed	2011	6276268	5428801	5868578	1684096	2250325	1325996
	2012	6348866	8102190	6857872	(0.481)	(0.239)	(0.583)
Processed	2011	1569206	629815	563113	2270	173227	754355
	2012	627320	293958	224986	(0.992)	(0.501)	(0.332)
Total revenue	2011	7845474	6058616	6431691	1686366	2423551	2080351
	2012	6976186	8396149	7082858	(0.481)	(0.207)	(0.404)

Source: Indonesian biogas survey, 2012. *Notes:* Significance levels: + 10%, * 5%, ** 1%. p-values in parentheses.

5.7 Impact at community level

In order to assess the effects of the development of the biogas business at a more macro level, we conducted interviews with the chiefs of 62 villages located in 5 districts – Blitar, Jombang, Kediri, Malang and Pasuruan. The community questionnaires gathered data on the main infrastructure available in the villages (that is, presence of schools, health centres), the main income generating activities in the village, main sources of energy and most importantly from the perspective of this study, a series of questions on economic activities which may have been triggered by the development of the biogas sector.

Briefly, we find that villages are similar in terms of a number of their observable characteristics. All the villages receive radio and mobile signals and while a majority also receive television and internet signals (with the exception of Kediri district where only 40 percent of the villages have access to an internet signal). Differences in terms of availability of financial services are minimal as more than 80 percent of the villages have a microcredit institution or a bank. In most villages dairy farming and agricultural activities were the main economic activities while the third most important business activity was manufacturing.

In over half the villages (33 villages) the village head reported that the biogas business had led to the development of some new economic activities. The new activities vary across districts but can be grouped into technical services (jobs for handymen/technicians to repair/service digesters in 11 villages), increase in production and petty trading of food products such as cassava chips and banana fritters as fuel costs are now cheaper (9), husbandry and agricultural related activities in 5 and 3 villages, respectively (see Table 64). On the other hand, in two villages there seem to be signs of diminished business for firewood vendors.

Table 64: Activities triggered by the biogas business and number of villages where the new activity manifested

District	Number of interviewed villages in the district	Activity triggered by the biogas sector	Number of villages in which the activity have been triggered
Blitar	1	--------	--------
Jombang	10	Trading	1
		Handyman	1
Kediri	5	Handyman	3
Malang	31	Agriculture	2
		Husbandry	3
		Trading	11
		Handyman	1
		Technician	1
Pasuruan	15	Agriculture	1
		Husbandry	2
		Handyman	6
		Stove business	1

Source: Indonesian biogas survey, 2012.

According to the village heads, in 60 percent of the villages the biogas sector has led to the creation of new jobs for both men and women (65 percent). While men are mainly involved in the technical jobs that have been created, women are responsible for opening food-related businesses. These comments on job creation were also echoed by cooperative representatives. For instance, during the interview at Kan Janbung cooperative (26th April 2012) it was pointed out that 6 women had opened small bakeries mainly due to the cheap/free biogas that was now available and a number of new jobs for masons (men) had been created.

Bio-slurry entrepreneur, Ngancar village, Kediri district, East Java
(Interviewed on 25th April 2012)

Of particular interest is the story of an entrepreneur (Pak Aditya) who has started a bio-slurry business. He started his business a year before the follow-up survey and was inspired by his brother, a digester owner, who was throwing away bio-slurry. Pak Aditya had heard about the potential role of bio-slurry as a fertiliser and after trying out the slurry on his own land and seeing its results he decided to start a business. In promoting his business he has received support from Hivos/BIRU.

Pak Aditya buys the bio-slurry for IDR 10,000 for 1,000 litres and sells it for IDR 125,000. He transports and spreads the slurry on the field of the buyer. Daily, he collects and distributes slurry 3 to 4 times (each delivery is 1,000 litres). This is the maximum capacity as he has only one vehicle and one container. He has two full-time employees. He usually buys bio-slurry from digester owners who have covered permanent (concrete) pits so that rainwater does not dilute the slurry.

He pointed out that initially, it was difficult to convince farmers to use slurry but, in part, due to the demonstrated effects of bio-slurry on his own fields he was able to convince sceptical farmers. His clients are farmers who do not have digesters and peak demand is in July, after harvest, till January.

At the time of the interview he stated that he did not face any competition although he expected that this would emerge. He hopes to expand his business in the near future and buy a bigger vehicle to transport bio-slurry.

Note: ***Pak Aditya is a pseudonym.***

5.8 Benefits and payback period

Based on the analysis presented in the previous section we see that the main financial benefit for digester owners is the close to 40 percent reduction in energy costs for digester owners. In absolute terms, at least, this is a reduction of IDR 46,000 per month or IDR 552,000 per year. There are no statistically significant effects of digester ownership on fertiliser expenditure and nor can we confirm evidence of an increase in farm revenue. The majority of households (about 60 percent) obtain financing for their digesters through their cooperative at zero interest rate. We assume that they could have earned an interest rate of about 6 percent on a long-term savings deposit (in April 2013, Bank Negara Indonesia offered an interest rate of 6 percent on term deposits). Based on the energy savings, the costs incurred by a household to acquire a digester and the opportunity cost of capital we provide a payback analysis for the most commonly installed digester (50 percent of households have a 6 cubic metre digester). The analysis presents payback periods with and without discounting future benefit streams and with and without the subsidy (see Table 65). We do not attempt to quantify the effect of cooking in a less smoky environment or the externalities associated with the reduction in the use of firewood.

For the most popular digester the payback period without discounting and without a subsidy is close to 11 years. Adjusting these estimates for the opportunity cost of capital (6 percent) leads to a lengthening of the "without subsidy" payback period to 19 years (the expected lifetime of a digester is 15-20 years). The subsidy shortens the payback period to about 8 years if future flows are not discounted while the discounted payback period is about 11 years (Table 65).

Table 65: Payback analysis for a 6 cubic metre digester

Without discounting			**Including financing costs**
Cost without subsidy (IDR)	6,300,000		
Cost with subsidy (IDR)	4,300,000		
Benefit - annual reduction in energy expenditure (IDR)		552,000	
Payback period without subsidy		11 years	14 years
Payback period with subsidy		8 years	10 years
With discounting			
Cost without subsidy (IDR)	6,300,000		
Cost with subsidy (IDR)	4,300,000		
Benefit - annual reduction in energy expenditure (IDR)		552,000	
Payback period without subsidy		19 years	32 years
Payback period with subsidy		11 years	15 years

Notes: The analysis is based on a 6 cubic metre digester as 50 percent of households have a digester of this size. Calculations do not include the costs of servicing loans as bulk of households finance the purchase at zero interest rate and maintenance costs are assumed to be zero. The inclusion of servicing and maintenance costs would lengthen the payback period. Energy savings are assumed to remain the same over time. Additional benefits such as reductions in expenditure on fertiliser and increase in crop output are not included as there is no statistically significant evidence that these are being realised at the moment. The discount rate is set at 6 percent, assuming that households are able to earn this rate on a long-term savings account. In April 2013, Bank Negara Indonesia offered an interest rate of 6 percent on term deposits. The formula used for calculating the discounted payback period without subsidy is generally Ln(1/(1-(cost of investment*discount rate)/savings))/Ln(1+discount rate). Financing costs are based on borrowing at 8 percent for 3 years.

6. The Intervention in a Different Context – BIRU Lombok compared to BIRU East Java[28]

A qualitative evaluation in the BIRU intervention region in Lombok was conducted in order to place the survey results from East Java in perspective and to assess how far usage and impacts may differ across regions. In general, the province of West Nusa Tenggara (NTB – Nusa Tenggara Barat) is less developed than East Java. This is reflected by the low ranking of the province in the 2009 HDI ranking for Indonesia, 32nd of 33 provinces, and 27th in the 2007 MDG-Index ranking and has a poverty rate of 28 percent (as compared to East Java which ranked 18th and 7th, respectively, and has a poverty rate of 11 percent; BPS 2009, 2011; BPS et al. 2004 and UNNDPA 2007).

The fact that there is no dairy sector in Lombok is a crucial obstacle hampering the diffusion of digesters, along with financial constraints and lack of access to credit. Differences in attitudes and culture also play a role. Additional factors that affect the development of a biogas sector are the low level of education, a lack of a well-functioning infrastructure (including energy infrastructure, water and sanitation infrastructure and roads), a low level of integration in the national and global economy, physical conditions (e.g. dependency on rain due to the lack of rivers), and factors linked to farming and livestock practices.

[28] Taken from Bedi et al. (2012).

The BIRU biogas programme is active in 30 villages in the region and is spread across all four districts of Lombok. Activities in Lombok started in July 2010, following a market study. The first digesters were installed in Central Lombok in Gapura village, in the district of Pujut, which is also the site of almost half the 107 BIRU digesters installed in total in Lombok.

The evaluation of the programme in Lombok was conducted two weeks after the data collection in East Java had ended and was based on qualitative methods, including semi-structured interviews, focus group discussions and field observations. Interviews were conducted with households, biogas masons, village heads, BIRU staff and other key informants such as representatives of the provincial and regional branches of the Ministry of Energy and Mineral Resources (ESDM), the Ministry for Environment, researchers from the University of Mataram (UNRAM), and a researcher involved in the Dutch capacity development programme Casindo.[29] These interviews provided valuable information on the energy sector in Lombok, the provincial government's overall energy strategy, other energy initiatives and development programmes in the region as well as on potential and obstacles for biogas development.

To get an overview of the study regions and of issues relevant for biogas, the field work began with focus group discussions and was followed by semi-structured household interviews. These discussions were conducted in three of the four districts. Household interviews and focus group discussions included topics related to energy usage and attitudes, in particular concerning biogas. The interviews also gathered information on some demographic issues. In total, 37 semi-structured interviews were conducted with households and village heads in all four districts of the island. In addition, 5 interviews were conducted with masons working for all three CPOs.

The villages for this study were selected in such a way that in each district one to four villages were included. In Gapura village, where the highest number of digesters had been built at the time of the field work about twice as many households as in the other villages were interviewed, along with several key informants.

6.1 Findings

The following summarises the most important findings. At the time of the field work a total of 107 digesters had been installed, of which eleven were demonstration digester financed completely by BIRU. Seven of these are located in East Lombok where the CPO obtained money from the local government. At the time of the study BIRU was working with three CPOs, all of which are local NGOs. There are plans for another NGO and another cooperative to become CPOs. Although there have been talks with several banks and cooperatives, so far, there has been no agreement on a credit scheme for the financing of the digesters.

When comparing the outcomes of the BIRU programme in East Java and in Lombok, it becomes obvious that the programme in East Java is more advanced in terms of the number of digesters built, as well as the development and institutionalisation of a biogas sector which is likely to ensure the continued usage of biogas after the end of the BIRU programme. The successful institutionalisation becomes manifest in the infrastructure provided by the dairy cooperatives in East Java, private sector support by Nestlé, the involvement of vocational schools and the national animal husbandry

[29] Casindo aims at strengthening capacities for energy policy formation and the implementation of sustainable energy projects in West Nusa Tenggara and four other Indonesian provinces.

training centre BBPP in Batu near Malang. Furthermore, local production of biogas equipment in Surabaya has been established and a local fertiliser producer is planning to market organic fertiliser based on bio-slurry to palm oil plantations throughout Indonesia. The conditions in Lombok are different. So far, there is no support for the programme through the private sector or financial institutions. Organisations and companies interested in the development of a biogas sector are lacking – except for government institutions and the University of Mataram. However, both in Bali and in Lombok there are plans to integrate bio-slurry in the development of organic agriculture, which may increase the attractiveness of biogas usage. Based on the development of the programme in Lombok to date, it seems that it will be hard to meet the initial target of 1500 units by the end of 2012.

At the same time, the pre-conditions (space and ownership of cows) for the success of biogas as a technology do prevail in Lombok, especially in light of the provincial government's programme of subsidizing cows (Bumi Sejuta Sapi (BSS) – "Land of one Million Cows Programme") and the fact that most livestock keepers are also farmers and can use the slurry. The incentives for households to apply for a digester seem to be higher than in East Java, as LPG and electricity are much more difficult to access. Most households use firewood, so that the potential for time and monetary savings and, hence, socio-economic benefits are higher. Biogas lamps may additionally produce larger impacts on households' life in Lombok compared to East Java given that households in more remote areas still use kerosene for lighting.

The BIRU programme in Lombok started a year later than it did in East Java. While this has to be factored in while making comparisons, the qualitative interviews and field observations reveal that there are several obstacles which may hinder the dissemination of digesters. First, at the household level, there are stark differences between the two regions. On the institutional level, the CPOs differ very much in terms of size, biogas experience, human resources, and budget. These differences between Lombok and East Java will be summarised in the following.

A) Obstacles linked to regional conditions and household characteristics

Physical conditions and infrastructure provision: Many regions in Lombok face water scarcity in the dry season and changes in rainfall have led to lower harvests for many farmers. This is a factor of insecurity which may make farmers less likely to make an investment. Some farmers stated that they did not have enough water for the cows, which may also keep them from investing in a technology that is dependent on cow dung. Lack of water might also represent a problem for the filling process and, as a consequence, time for fetching water has to be included in the process. Bad road conditions and a lack of accessibility of some regions make it more difficult and expensive for the CPOs to promote and construct digesters in certain areas. In most areas firewood is still available, even if the gathering process takes a lot of time. This combined with the fact that many households are not accustomed to cooking with gas, as LPG is not widely available, may reduce the incentives to apply for a digester.

Degree of cooperative organization: Households are not organised in one institution like a cooperative with a common interest and fairly hierarchical structures as is the case in East Java, making it harder to successfully promote the programme.

Financial constraints and lack of access to credit: The general income level in NTB is lower than in East Java and, therefore, the cost of the digester relative to household income is higher. At the time of the field work, no credit scheme had been established, which posed a major obstacle for many households. Large parts of the yearly household income stems from the rice harvest. This implies that households are most likely to be able to finance a digester right after the harvest season. This also means that in most cases there is no regular monthly income, making it harder for households to plan ahead and make long term financial decisions. Banks and other credit institutions are reluctant to provide loans to households.

Animal husbandry: Households keep cows in order to produce beef, not milk. Therefore, cows are sold every couple of years and do not yield a regular income. Households do not know for how long they will have their cows making it risky to invest in a digester. Furthermore, all cows in a village are kept in a communal stable from where the dung has to be fetched. Likewise, water has to be obtained from a shared well or spring. This was also mentioned as one of the reasons, why some biogas users only fill their digester once or twice a week.

Lack of private sector support: So far in Lombok there are no private sector stakeholders who are interested in supporting the programme. Cows are usually sold at the local market and there are no powerful stakeholders with an interest in promoting the biogas technology such as Nestlé in East Java.

Cultural factors and perception of biogas: Especially in the first stage of the programme people perceived biogas as being *haram* (unclean/ forbidden by Islamic law), since it is produced on the basis of dung. Some untreated households stated that they thought biogas was disgusting or impractical because of the filling process. In some regions previous biogas projects have failed, which has led to a negative image of biogas.

B) Obstacles linked to the CPO's capacities

Problems that the CPOs face: All three CPOs are small local NGOs without much experience in implementing a programme which has the scope of the BIRU programme. They have limited personnel and financial capacities. They are also not familiar with all of the regions where they are implementing the programme and have to find a way to identify target households, build trust among the local population and build structures to disseminate and construct the digesters, as well as ensuring payment. This is especially difficult, as they are often seen as organizations coming from outside the village. Building the digesters is only profitable once a certain number has been reached, meaning that at the beginning, the programme can lead to financial losses for some of these small organizations. Two of the three CPOs have financial difficulties and have not reached the stage yet at which building digesters becomes profitable. While the CPOs in Lombok only have a few part-time employees, the dairy cooperatives in East Java have a larger overhead and better qualified staff.

While in Lombok the CPOs follow ideological and humanitarian goals, the cooperatives in East Java seek to improve business opportunities of their members and to bind their members to the cooperative. They can use the structures that are in place for collecting and processing milk for the dissemination, construction, and payment of the digesters, which reduces the cost of running the programme, while the CPOs in Lombok have to create these structures first and build up trust in the local community. In East Java, the target households and many of the masons are cooperative members, so the CPOs are very well informed on the households' needs, but also on their financial situation. Biogas can be promoted at regular cooperative meetings and households trust the institution they are dealing with. In Lombok, however, it is a lot more difficult for the CPOs to find potential target households and in some villages in West Lombok there was great mistrust towards the CPO. Success of the programme in Lombok heavily depends on whether the CPO had already been active in the respective biogas target region and has established trust in the community prior to the BIRU intervention.

Problems resulting from the CPOs' limitations: Some problems are linked to the implementation of the programme, and include issues such as a lack of transparency, miscommunication with households, masons and with BIRU staff, and a lack of standardised procedures for the construction process and the payment of the digesters. Masons received different payments for the same work from the same CPO and households had to pay different amounts of money for the same plant size due to variations in material and transport costs. This has led to conflicts between households, masons and the CPO or BIRU. In general, the NGO YSLPP seemed overstrained with the role as CPO.

Selection of target regions: The CPOs did not seem to have a clear system of selecting target regions based for example on potentials for biogas development. As a consequence, there were only one or two digester in one village, and households were very spread out which lead to logistic problems and increased transportation costs.

Selection of and communication with households: While in Central Lombok the programme is running quite well and the CPO is quite familiar with the target population, especially in West Lombok, there seemed to be a lack of pre-selection criteria for households, based, for e.g., on financial criteria. In several cases, households received a loan from someone connected to the CPO although they actually could not afford to build a digester and already had a substantial amount of debt. They turned out to be unable to buy the materials and to pay the masons for their labour. In one case the digester was never finished and was not functioning at the time of the study, implying a substantial financial burden for both the masons and the households. In one village in West Lombok several applicants also resigned because they had not been adequately informed of the costs of building a digester prior to registration. These aspects led to a negative image of the programme in the region, making it hard to convince households to apply for a digester.

7. Summary and sustainability

This report has provided an assessment of Indonesia's Domestic Biogas Programme (BIRU). To meet its objectives the study relied on a two-round panel data (May 2011 and May 2012) and two rounds of qualitative data collection (June 2011 and May 2012). The analysis focused mainly on East Java province, which at the end of 2012 accounted for about 62 percent of all BIRU digesters. In order to probe regional differences the study also provided an assessment of the programme in Lombok, albeit the assessment in Lombok relied drew only on qualitative methods.

In order to identify the impact of the intervention the analysis exploited the panel data and changes in digester ownership between the two data collection rounds to provide difference-in-difference estimates of the impact of using a digester, that is, comparing new digester users with a control group of those who don't own a digester. In addition, the evaluation exploited the phased roll out of the programme to provide pipeline comparison estimates which were based on comparing those households who have applied for a digester with existing users. The evaluation and sampling strategies appear to have delivered credible control groups and in the case of a number of key outcomes the estimates were not sensitive to the empirical approach.

The report commenced by providing a brief contextual background, then went on to describe and analyse the functioning of the BIRU programme. This was followed by examination of the effect of the programme on various outcomes, including, patterns of energy expenditure and use of traditional fuels, time-use, air pollution and health outcomes, crop yield and fertiliser use.

By the end of December 2012 the programme had achieved its target of installing 8,000 digesters over a four-year period. Our analysis of the survey data showed that the process to obtain a digester runs efficiently, as in 90 percent of cases it took only four months between submitting an application and having a completely operational digester. Among the treated households, 96 percent reported that their digester was producing gas as expected. In terms of their overall levels of satisfaction, 47 percent of the respondents reported that they were "very satisfied" while 52 percent reported that they were "rather satisfied". Although, on average a digester has been operating only for 13 months, consistent with the satisfactory remarks on gas production, there were limited reports on the need for fixing or replacing digester parts. About 6 percent of digester owners reported that they have had to repair/replace parts and in about 40 percent of these cases BIRU stepped in to deal with the problem. The main concern raised by about 3 percent of users and also corroborated during field work were issues to do with leaky pipes, non-working stoves and/or corrosion of stove parts.

Since programme inception, a large number of masons (about 675) and supervisors (124) have been trained, and BIRU has a system of linking masons to the digesters built, which allows project staff to maintain construction quality. The quality of digesters built by BIRU seems to be well-appreciated and during each of the three interviews with cooperatives positive remarks about the quality of BIRU digesters versus those supplied by other programmes were made by respondents. For instance, as of April 2012, 330 members of Kan Jabung cooperative had digesters of which 194 were BIRU digesters and the remainder from other programmes. Staff of the cooperative argued that the BIRU digesters are better as they produce more gas and feeding is easier. While they expressed their satisfaction with the technical quality of the BIRU digesters their main complaint was about the stoves and lighting fixtures.[30] Similarly, as of April 2012, 907 members of Sae Pujon cooperative had a digester of which 757 were from BIRU and the rest from Brawijaya University. Respondents argued that while the technology of the two digesters is the same, BIRU digesters are simpler to use and are cheaper.

About three quarters of the treated households have received training on how to use and maintain digesters and while respondents expressed a need for additional training especially on the use of bio-slurry and on how to fix or replace broken parts, the bulk of them (85 percent) expressed their satisfaction with the quality of the training.

Overall, with regard to the technical aspects of the programme and/or technical feasibility there seem to be no major concerns. The quality of BIRU digesters is well-appreciated, a large number of masons have been trained, a majority of users have been trained and a quality control system which

[30] The cooperative sources stoves and lighting fixtures from a company called Metalindo but was considering a switch to a company called Butterfly.

ensures digester construction quality and which is reflected in respondents' assessment of the programme is in place. Some factors which need attention are the quality of the biogas stoves, an assessment of whether it is possible to store biogas and customised training on the use and proper application of bio-slurry.

With regard to the financial aspects of the programme, the bulk of the digesters are financed through loans/credit (93 percent) provided by the cooperatives to which farmers belong. In East Java, Nestle is the main credit provider and provides credit to households through cooperatives at 0 percent interest rate. The amounts to be repaid are deducted periodically (usually every 10 to 12 days) and automatically from the money owed by the cooperative to the individual member for milk sales. In no instance were there concerns about the repayment burden and households expect to repay their loans within two to three years. In terms of the returns on digesters the analysis showed that, on average, digester owning households experience a reduction in energy expenditure of between IDR 46,000 to IDR 72,000 a month. Based on the most conservative estimate this translates into a 40 percent reduction in energy expenditures for the treated versus control households or about 3 to 5 percent of annual household expenditure. While we also detected a reduction in expenditure on fertiliser as well as an increase in farm revenue for digester owning households these effects were not statistically significant.

Combining the information on the effects of bio-slurry on crop yields as indicated by cooperatives and households on the basis of the semi-structured interviews versus the lack of statistical significance based on the quantitative analysis suggests that the use of bio-slurry is not yet widespread enough or not customized to local conditions to translate into statistically precise effects. Nevertheless, the current model, at least in East Java with interest free loans, the prevailing subsidy and based only a cost reduction of IDR 46,000 per month or IDR 552,000 per year translates into a payback period of about 8 years. If there were no subsidy the payback period lengthens to 11 years. Set against the expected lifetime of a digester (15 to 20 years), even without any other financial benefits and without a subsidy, investing in a digester seems worthwhile at least from an individual's perspective.[31] Based on the current financial returns, without a subsidy and with interest rates of 8 percent (as in other parts of the country) the payback period lengthens to about 14 years and makes the investment worthwhile if a digester lasts towards the upper end of its expected life-span. While we cannot be certain about the net effect of accounting for additional adjustments, ignoring these issues for the time being, it does seem that from an individual perspective even without a subsidy and at an interest rate of 8 percent investing in a digester is worthwhile.[32] Clearly, an alternative way to enhance the appeal of the investment is to pay greater attention to realizing the potential effects of digesters/bio-slurry on reducing fertiliser costs and more importantly on enhancing agricultural revenues.

From the perspective of masons, according to SNV there are about 675 trained masons in the country. Each mason can build about 3 digesters a month and earn about IDR 1 million per

[31] BIRU digesters have an expected lifetime of 15 years although during field interviews it was pointed out that digesters may last for about 30 years.

[32] These calculations are relatively conservative as they do not account for the benefits of cooking in cleaner kitchens, the externalities associated with reduced firewood use and a cleaner environment. At the same time these calculations do not discount future benefits.

completed plant. However, most masons engage in a number of other activities and do not dedicate themselves only to digester construction due to lack of sufficient demand. Based on interviews with about 4-6 masons we found a high degree of appreciation for the BIRU training course and masons asserted that they are confident about building digesters without supervision. Thus, while technical knowledge and sustainability regarding ability to construct and maintain digesters seems to have been developed, as stated by the masons, relying only on digester construction as a source of income is not an option.

As indicated in the payback calculations above, even without a subsidy and at 8 percent interest rate and based on current cost savings, at least from an individual perspective investing in a digester seems to make economic sense. However, this does not imply that discontinuing the subsidy would have no negative consequences. The single most important reason for not acquiring a digester and mentioned by 75 percent of non-users, is related to its cost. Indeed, related to the financial aspects, one of the main reasons for the focus of the programme on East Java has been the supply of credit from Nestle. It is hard to conclude that without the subsidy *and* without credit from Nestle the programme would have been able to reach its expected targets.[33] Given the financing model whereby loan repayments are deducted at source it is possible that as long as Nestle is committed to providing credit at zero interest a subsidy may not be essential. However, given the potential externalities such as reduction in the negative environmental effects of indiscriminate dumping of cow dung it may well be argued that a subsidy is justified. At the same time if the programme is to prosper without any public subsidies and based on credit at market rates then there is a clear need to realize greater private benefits such as increased agricultural revenues and savings on fertiliser expenditure.

Turning to household environmental effects, there is a clear effect of access to digesters on air quality. Access to digesters is associated with a 22-23 percentage point increase in the probability that the air quality is rated as good. The effect may be attributed mainly to a reduction in fumes associated with burning wood. In terms of environmental issues related to dung management there are sharp differences across the treated and control households. The main use of cow dung in the case of digester owning households is for the digester, followed by its use as a fertiliser, while in the case of the control households the main use is as a fertiliser followed by dumping of cow dung in open drains and rivers. While there is clear evidence of better dung management in the case of digester owning households, the mitigating effects of the 8,000 digesters on the overall environmental consequences may be limited. Consider that while the approximately 4,000 digesters in East Java may be expected to lead to better dung management in the case of 20,000 cows (4000 x 5 cows per farm) the overall impact needs to be set against the current estimated population of 330,000 cows in Malang, East Java alone.

While the programme has met its overall target of building 8,000 digesters, has trained a number of masons, provided training to users, is highly rated by users, displays clear financial benefits and leads to better dung management, a clear concern regarding its future is whether it can also be equally successful outside East Java. Currently, 60 percent of programme activities focus on East Java which offers a number of favourable conditions such as a high concentration of cows, relatively richer dairy

[33]Indeed in two of the three cooperatives that were visited, respondents argued that at the moment the subsidy was more important than the technical support from BIRU.

farmers, support from Nestle which is developing its business in the region and the organization of farmers in cooperatives. Whether the programme can be scaled up and deliver benefits in other regions is still an open question. Indeed to emphasize, any generalization of the results obtained here should be restricted to the specific group that was the focus of this report. At the same time, in East Java itself, Nestle deals with 31 co-operatives or about 32,000 dairy farmers while about 4500 or so have digesters. Hence even though the external validity of the report is limited there seems to be ample scope for expansion.

8. Guide to reading: Responses to the evaluation questions

Output

Which socio-economic groups have applied for a digester?

See Section 5.1. Differences in some of the observed characteristics across the two treatment groups (new and always users) and the 364 households without a digester (never users) seem to be minor. Characteristics such as household size, age of household head and main occupation of the household head do not differ substantially across the three categories. Similarly, household demographic composition and incidence of land ownership are similar across all three groups. The main differences across the three groups lies in educational status with household heads (and spouse of household heads) amongst *always users* displaying a higher educational attainment as compared to the two other groups and the higher per capita annual expenditure amongst the *always users*. Consistent with these differences we also note that the number of cows owned and the amount of land owned is also higher for the *always* and *new* users as compared to the *never users*. Overall, there are observable differences across the three groups and digester users and applicants tend to be wealthier than non-users.

Have households made use of credit schemes or other loans to obtain a digester? What percentage of the total investment cost was financed through such means?

See Section 5.2. The bulk of the digesters are financed entirely through loans/credit (93 percent) while a minority of digester owners have drawn on their savings or sold cows to finance their digester purchase (Table 18). The main source of loan/credit as far as households are concerned is the cooperative to which they belong. This is a little misleading as almost all the cooperatives that are included in the survey sell their milk mainly to Nestle which in turn provides credit to cooperatives at 0 percent interest rate in order to enable digester purchases. Based on the field visits we found that cooperatives in turn offer their members loan/credit at interest rates ranging from 0 to 6 percent which they are expected to repay in 2 to 3 years. The terms of re-payment differ across cooperatives but the amounts are deducted periodically (usually every 10 to 12 days) and automatically from the money owed by the cooperative to the individual member for milk sales. During field work we saw the manner in which the system worked. While most farmers (75 percent) were unable to provide information on the interest rate that they were being charged or the amount of the outstanding loans they did have records on the total proceeds from milk sales, the deduction for repayment of the digester loan and the outstanding loan balance. None of the respondents expressed concerns about the repayment burden.

Were users properly informed on how to use the digester (e.g. plant initial feeding, presence of user manual)?

See Section 5.2. About 75 percent of the treated households did take part in training courses organized either by BIRU or by the cooperatives under the supervision of BIRU employees (Table 26). Training courses are normally organized for groups of households but can be arranged also for a single household. According to the interviewed households, general explanation on the use and maintenance of the digester were considered the most useful parts of the training. Even though the majority of households considered the quality of the training good or adequate, there are still few households (8 percent) in need of additional training on topics related to the use of bio-slurry and on how to fix/replace broken parts of the digester.

How many of the applicants (or actual biogas users) were using LPG, kerosene, electricity or firewood prior to the intervention?

See Section 5.4 'Cooking and lighting habits: comparing treatment and control group'. With regard to cooking behaviour, the biogas stove is the main stove used by approximately 60 percent of digester owning households; this share rises to 80 percent for cooking dinner (Figure 9). The predominant use of the biogas stove as opposed to the use of the wood fuel and gas stove by control households indicates a clear pattern of substitution driven by access to biogas. With regard to lighting habits, a small proportion of treated households use biogas for lighting purposes. Biogas lamps are used by 9 and 3 percent of the always and new biogas users while the utilization of other sources of lighting does not display much variation across the three groups (Figure 10).

Outcomes

As compared to the applicants, which socio-economic groups obtained digesters?

Out of 245 applicants surveyed in 2011 (Table 12), 75 percent received digesters in the period between May 2011 and May 2012. Descriptive statistics comparing new users and never users shows that in terms of observable characteristics the new users are relatively wealthier. Comparisons between applicants who were unable to obtain digesters and applicants who did obtain digesters does not show any systematic observable differences between the two groups.

Which household member/s decided on purchasing a digester, disaggregated by gender?

See Section 5.2 'Knowledge, use, purchase and functioning of digesters'. For the majority of households the digester purchase is a collective decision; the head of the household is the main decision maker in about a third of households while the spouse of the household head appears to play a major role in only 4 percent of the households. With regard to the plant size, the head of the household is reported to make the decision in about 41 percent of the cases while, for 40 percent of households, the choice of the digester size is a collective decision. Once again, the spouse of the household head plays a limited role.

How reliable is the gas supply?

See Section 5.2 'Knowledge, use, purchase and functioning of digesters'. Treated households reported that their digester was producing gas as expected in 96 percent of the cases; the remainder treated households pointed out that their plant was still producing gas but less than expected. The overall level of satisfaction with the digester is rather high, with 47 percent of the respondents being "very satisfied", 52 percent "rather satisfied" and only 1 percent "rather unsatisfied" with the digester. Few complaints regard the fact that stove knobs get easily corroded if not cleaned well and need to be replaced every six months.

How many digesters have been installed and how many are being used?

See Section 2.3 “Institutional context and description of the BIRU intervention”. By the end of 2012, BIRU had installed 7,983 digesters. While the overall target has been met, there are discrepancies between province specific targets and installed digesters disaggregated by provinces. The activities of the BIRU programme mostly concentrate on East Java (62 percent of all the installed digesters), followed by Lombok/Bali (17 percent), West Java (10 percent) and Central Java (9.6 percent) while a more even distribution across provinces had been envisaged (Table 5). All the interviewed user households reported that their digesters were in working condition and were being used.

Impacts

To what extent have the installed biogas plants actually been used for gas production? If they are not being used, why?

All the installed digester plants are being used and all of them are being used for gas production.

Which expenditures did the household reduce in order to finance investment in the digester?

See Section 5.2 ‘Knowledge, use, purchase and functioning of digesters’. The majority of the households, 93 percent, financed the digester purchase through loan/credit. No households mentioned reducing expenditures in order to finance the investment (Table 18). Qualitative interviews revealed that user households do not perceive a significant reduction in other expenditures to finance their digester.

For what purposes is biogas used (cooking, lighting, other)?

See Section 5.4 ‘Cooking and lighting habits: comparing treatment and control group’. Biogas is mainly used for cooking purposes. Even though it is possible to use biogas for lighting, only few households use biogas for this purpose. This is not surprising, as all households in East Java have electricity.

What is the relative share of the various sources of energy for cooking and lighting? (biogas, LPG, kerosene, electricity, candles, charcoal, firewood, others)?

See Section 5.4 ‘Cooking and lighting habits: comparing treatment and control group’. Household data pointed out that user households extensively use biogas for preparing breakfast, lunch and dinner in combination with magic coms (magic coms run on electricity and are used for cooking and warming rice). Very few user households still use wood-fuel stove (Figure 9). A small proportion of households use biogas for lighting purposes as well, although this use is restricted to 9 and 3 percent of the always and new biogas users, respectively. Overall, the use of other sources of lighting does not display much variation across the three groups (Figure 10).

To what extent are traditional stoves still used?

See Section 5.4 ‘Cooking and lighting habits: comparing treatment and control group’. Traditional stoves, such as stationary wood-fuel stoves, are still in use in about 5 to 10 percent of control treated households and about 40 percent of control households.

How much is saved in total (per week or month) on ‘traditional’ energy sources (LPG, kerosene, firewood, candles)? How have expenditures for energy changed over time?

See Section 5.2 'Knowledge, use, purchase and functioning of digesters' and Section 5.6 "Econometric identifications of impacts". Despite the fact that 'reduction in expenditures' is not reported as the most important advantage of having a digester, the perceived saving in terms of energy related expenditures is quite high. Users indicate a saving of 59,000 IDR per month on energy related expenditures, which translates into between 3 to 4 percent of their annual expenditure (Table 25). The impact evaluation analysis reveals savings in the same range as self- reported by households. The lower use of LPG and firewood translates into an overall experience reduction in energy expenditure of between 46,000 to 72,000 IDR a month (Table 40).

How have cooking and lighting habits changed due to the use of biogas?

Digester use leads to a sharp reduction in the probability of purchasing LPG in the sense that users are about 60 percentage *p*oints less likely to purchase LPG. In addition, the probability of purchasing firewood is lower for the users, even though this effect is not as large as the LPG effect (Table 39). Consistent with the previous findings, the use of digesters is associated with a displacement of LPG and wood fuel stoves. The average number of wood fuel stoves owned by new users declines by more than 20 percent while the ownership of LPG stoves declines by about 50 percent (Table 44). Digester use, except for a slight increase in the incidence of using biogas lamps, does not lead to remarkable effects in terms of household lighting habits.

Has there been any change in time/ workload, disaggregated by gender?

There is sharp reduction in the time spent on gathering firewood (more than 3 hours per week). There are no time savings with regard to time spent acquiring fertiliser, or time spent acquiring other energy sources. With regard to cooking, digesters do seem to be associated with a reduction in time spent cooking but the effect is not statistically significant.

For what purposes has the saved time been used, disaggregated by gender?

See Section 5.5 'Time use patterns'. Overall, there are no major differences in time allocations between users and non-users.

To what extent did indoor air pollution reduce (perception of users only)?

See Section 5.6 'Econometric identifications of impacts'. There are differences in the perceived quality of air in kitchens among treatment and control households. The DID estimates points out that the likelihood of reporting that the air quality in the kitchen is good is between 21 to 24 percentage points higher for the treated as compared to the controls (Table 51). Poor air quality is mainly attributed to the pollution due to the burning of firewood (Table 51)

To what extent have health conditions (in particular respiratory illnesses) changed, specifically among women and children?

See Section 5.6 'Econometric identifications of impacts'. Tables 52 to 57 report the effects of using the digester on a variety of health outcomes. Although there is evidence of a reduction in self-reported symptoms of respiratory diseases for both men and women, the estimates are seldom statistically significant. For the other health conditions, there is limited evidence that owning a digester is associated with a reduction in eye-related conditions and incidence of headaches for men. We also estimated a full set of health effects for children; these results have not been reported as there was no evidence that use of digesters is associated with a positive health effects. Overall, the clear improvement in the quality of air in the kitchen does not translate in a clear reduction of health conditions.

Does the household use the slurry as fertiliser? How did the households use/dispose the dung before the intervention?

See Section 5.3 'Livestock, dung management and bio-slurry'. User households mainly use cow dung to feed their digesters and as a fertiliser, while for control households the main use is as a fertiliser; 31 percent of the control households dispose cow dung in drains and lakes/rivers (Table 28).

What is the effect of digester slurry on agriculture (use and sale of fertiliser, expenditure on fertiliser, frequency of manure collection, crop yields)?

See Section 5.6 'Econometric identifications of impacts'. We do not find that access to digesters is systematically related to reduced expenditure on fertiliser (Table 62). While across all three econometric methods there is evidence that access to a digester leads to a reduction of at most 3,000 IDR a month on chemical fertilisers, the effect is not statistically significant (Table 62). Regarding the effect of bio-slurry on agricultural revenues, we find that digester ownership leads to an increase in revenues from agricultural yields; however, the effect is not statistically significant (Table 63).

To what extent has comfort/convenience changed, disaggregated by gender? What monetary value do households attribute to this increased convenience?

See Section 5.2 'Knowledge, use, purchase and functioning of digesters'. In addition to the various benefits and the monetary savings, previously mentioned, digester owners are more likely to report that they have seen an improvement in their living conditions in the last 3 years (Figure 7).

To what extent have activities during evenings changed due to improved lighting usage? Have study hours/reading time of children changed?

See Section 5.5 'Time use patterns'. Differences in time allocation arises when looking at the time allocation of the three categories of children in the household (Table 37), even though the patterns do not reveal a clear story. Most likely the amount of study hours/reading time for the children has not changed as rural households already used electricity for lighting purposes.

Have additional jobs been created in the biogas business sector (contractors, masons, input supply), disaggregated by gender?

See Section 5.7 'Impact at community level'. According to the village chiefs, in 60 percent of the villages the biogas sector has led to the creation of new jobs which have been enjoyed by both men and women (65 percent) and by only men (women), 33 percent (2 percent). While men get higher employment rate in the new technical related jobs, women are more responsible for opening food-related businesses. These comments on job creation were also confirmed by qualitative interviews with cooperative representatives. During the interview with some representatives of Kan Janbung cooperative (interviewed done on the 26th April 2012), it was pointed out that 6 women had opened small bakeries mainly due to the cheap/free biogas that was now available while men had found jobs in the masonry businesses.

Has the availability of biogas triggered new economic activities or displaced old ones?

See Section 5.7 'Impact at community level'. In 33 out of 62 interviewed villages, the chiefs reported that the biogas business had led to the development of some new economic activities. Although the new activities vary across districts, they can be grouped into technical services (jobs for handymen/technicians to repair/service digesters in 11 villages), increase in production and petty trading of food products such as cassava chips and banana fritters as a consequence of the fact that fuel costs are now cheaper (9) and husbandry and agricultural related activities in 5 and 3 villages, respectively (Table 64). On the other hand, two villages reported a diminished business for firewood vendors.

What (if any) are the un-intended or negative impacts?

See Section 5.2 'Knowledge, use, purchase and functioning of digesters'. Ten households mentioned that they had experienced some un-intended effects, including issues related to the bad smell as a consequence of the gas leaks, a non-working stove or problems with the thermometer. Furthermore, there seem to be limited reports on the need for fixing or replacing parts of the digester; 19 user households reported to have had to repair/replace parts of the plant since the time their digesters became operational. In 7 of the 19 households that experienced a problem, BIRU has stepped in to help and dealt with the problem. The overall satisfaction with the construction and the limited need for repair may be linked to the attention paid to building digesters and to the fact that SNV regularly organizes 8-day training courses for masons, providing masons with the necessary instructions on how to build durable digesters. At the end of the training, each mason who has passed the course receives an 'ID code' which will be linked to all the digesters they will be building so that project implementers are able to check on the quality of the construction.

Are there more or less accidents (explosions etc.) as compared to LPG usage?

Although this result has not been reported, the incidence of accidents with fire lamps and LPG bottles is already very low among households without biogas, and we cannot attribute any changes to biogas digesters.

Sustainability

Notwithstanding the short experience with the HIVOS-SNV biogas installations, what observations can be made about the technical sustainability of the equipment, for example when it comes to availability of materials for repairs, special cooking and lighting equipment?

Please see section 7.

What is the financial sustainability of the BIRU programme from a) the perspective of the biogas client; b) from the perspective of the mason and small construction enterprises that install and maintain the biogas installations and c) from the perspective of a public sector support programme as far as it concerns the incentives, the advertisement and other dissemination activities.

Please see section 7.

To what extent do the biogas installations exert an influence on environmental sustainability?

Please see section 7.

9. References

African Development Fund (2008). *Ghana country gender profile.* Human Development Department.

Arthur, R., Baidoo, M. F., Antwi, E. (2011), *Biogas as a potential renewable energy source: a Ghanaian case study*. Renewable Energy, vol. (36): 1510-1516.

Bacon, R., Bhattacharya, S. and Kojima, M. (2010), Expenditure of Low-Income Households on Energy: Evidence from Africa and Asia. Extractive Industries and Development Series # 16 Washington, DC: World Bank.

Beaton, C. and Lontoh, L. (2010), *Lessons Learned from Indonesia's Attempts to Reform Fossil-Fuel Subsidies*, International Institute for Sustainable Development, Trade, Investment and Climate Change Series.

Bedi, Arjun, G. Bensch, R. Niemann, J. Peters, R. Sparrow, L. Tasciotti (2012), Impact Evaluation of the Indonesia Domestic Biogas Programme: A Baseline Report. Mimeo.

BIRU (2010), *Annual Report 2010*.

BIRU (2011), *Indonesia Domestic Biogas Programme*, Annual Report 2010.

BIRU (2012), *Feasibility of the continuation of the Indonesia Domestic Biogas Programme beyond 2012*. Final Report.

BPS (Badan Pusat Statistik Republik Indonesia) (2009), *Human Development Index (HDI) by Province and National 1996 – 2009*, Available at http://dds.bps.go.id/eng/tab_sub/view.php? tabel=1&daftar=1&id_subyek=26&notab=2 .

IEA (International Energy Agency), (2008), Energy Policy Review of Indonesia. Paris.

IEA (International Energy Agency), (2011), World Energy Outlook. Paris.

Gautam, M. Bara, S., Herat, S. (2009). Biogas as a sustainable energy source in Nepal: present status and future challenges. Renewable and Sustainable Energy Reviews, vol. 13: 248-152.

Katuwal, H, Bohara, A. K. (2009). Biogas: a promising renewable technology and its impact on rural households in Nepal. Renewable and sustainable energy reviews, vol. (13): 2668-2674.

Ministry For Economic Affairs (2011), The Indonesian Economic Development Masterplan MP3EI.

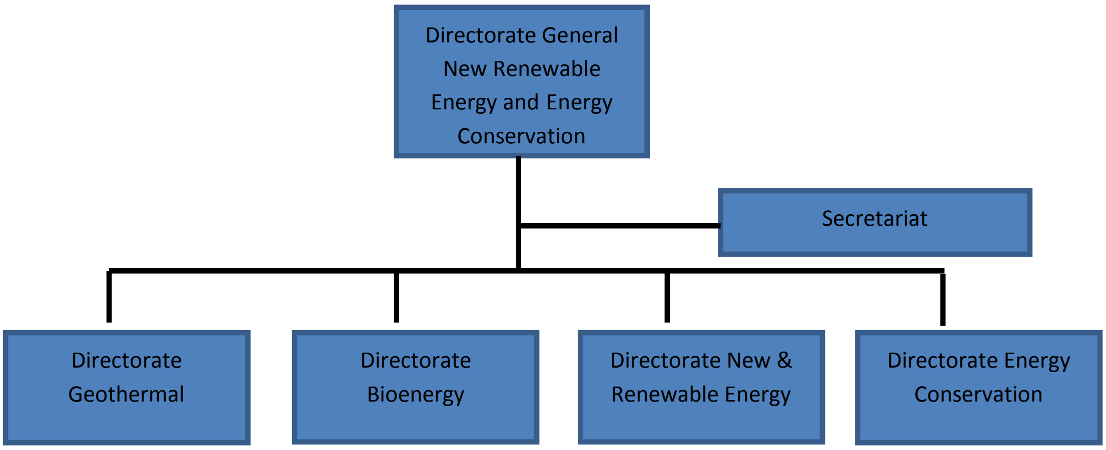
SNV (2009), *Feasibility of a national programme on domestic biogas in Indonesia*, SNV Netherlands Development Organization.

SNV (2011), *Domestic Biogas Compact Course. Technology and Mass Dissemination from Asia*, University of Oldenburg.

UNNDPA (United Nations National Development Planning Agency), 2007. Report on the Achievement of Millennium Development Goals Indonesia 2007.

10. Annex 1: Organizational structure

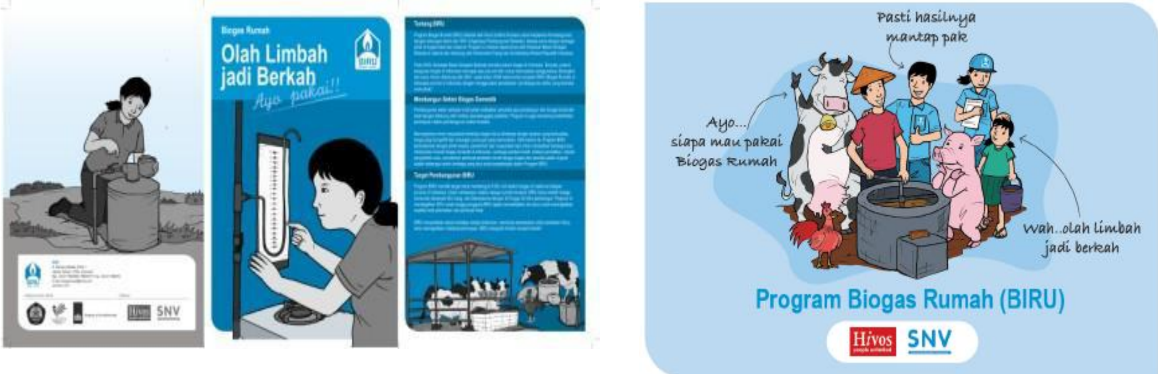
Figure 11: Organizational structure of the Directorate General of New Renewable Energy and Energy Conservation – Ministry of Energy and Mineral Resources



Source: BIRU (2012).

11. Annex 2: Promotion Documentation

Figure 12: BIRU brochure (on the left) and cards used to promote digesters to potential users



Source: BIRU (2010).

Figure 13: BIRU user manual (on the left) and BIRU user manual for slurry application

Source: BIRU (2010).

Figure 14: BIRU digester construction manual (on the left) and BIRU' s poster for exhibitions

Source: BIRU (2010).

12. Annex 3: Questionnaires

Household questionnaire (attached)

Community questionnaire (attached)

13. Annex 4: Technical appendix

Table 66: Distribution of annual per capita expenditure (at current prices)

	Mean	St.dev.	Min	Max
Susenas 2011				
Decile 1 (poorest)	2,079,072	306,324	868,824	2,488,284
Decile 2	2,763,648	155,532	2,488,284	3,026,904
Decile 3	3,304,224	162,324	3,027,312	3,600,120
Decile 4	3,906,048	181,788	3,600,120	4,227,708
Decile 5	4,604,376	221,244	4,227,708	4,996,200
Decile 6	5,463,600	285,012	4,996,200	5,977,548
Decile 7	6,588,000	374,400	5,977,548	7,266,516
Decile 8	8,176,992	565,500	7,266,684	9,257,124
Decile 9	10,972,152	1,145,268	9,257,124	13,267,836
Decile 10 (richest)	23,645,400	21,399,732	13,267,836	468,000,000
Agriculture	4,972,404	4,387,464	879,120	216,000,000
Agriculture East Java	4,112,568	2,788,584	1,036,020	69,785,436
Agriculture sampled districts	4,446,388	3,082,898	1,353,400	27,225,060
Livestock	4,700,880	3,912,144	1,033,404	100,331,148
Livestock East Java	3,918,120	2,923,068	1,231,608	41,332,740
Livestock sampled districts	4,229,148	2,970,900	1,490,232	27,225,060
BIRU sample 2012				
Full sample	4,488,021	3,213,236		
Always users	5,515,895	5,004,113		
New users	4,453,455	2,997,159		
Never users	4,234,621	2,633,865		
BIRU sample 2011				
Full sample	4,084,970	3,224,128		
Always users	4,331,904	2,606,140		
New users	4,160,645	2,899,138		
Never users	3,958,125	3,592,851		

Table 67: Differences in means between rejected applicants and never applicants

Variable	Never users – rejected applicants	New users – never applicants	H_0: $X_{DO} = X_{PA}$ *p*-values	Never users
Household size	3.88	3.89	0.95	3.89
	(1.00)	(1.24)		(1.20)
Male head of household (%)	100.00	95.04	0.08*	95.88
Age of the head of household	46.27	47.36	0.53	47.18
	(12.59)	(12.03)		(12.12)
Main activity head of household (%)				
Farmer	95.08	89.10	0.15	90.11
Civil servant retired	0.00	0.33	0.65	0.27
Other activity	4.91	10.56	0.17	9.89
Number of years schooling head of household	6.10	6.15	0.79	6.14
	(2.52)	(2.37)		(2.39)
Highest level of education (%)				
None	3.28	1.99	0.31	2.21
Literate	0.00	0.33	0.09*	0.28
Primary school	78.69	76.74	0.47	77.07
Junior high school	11.48	15.61	0.21	14.92
Senior high school/vocational training or higher	6.56	5.02	0.36	5.53
Main activity head of household's spouse (%)				
Farmer	28.33	21.70	0.26	22.87
Unpaid family worker	11.66	18.50	0.20	17.30
Retired	56.66	50.88	0.41	51.91
Other activity	3.33	8.89	0.14	7.92
Number of years schooling head of household' spouse	6.43	6.34	0.79	6.36
	(2.35)	(2.48)		(2.45)
Highest level of education (%)				
None	1.67	2.47	0.61	2.33
Literate	0	0.35	0.07*	0.29
Primary school	76.67	74.91	0.97	75.22
Junior high school	13.33	14.84	0.16	14.58
Senior high school/vocational training or higher	8.33	7.41	0.39	7.58
Share of children aged 0-15 (%)	24.01	23.40	0.08*	23.50
Share of children aged 6-12 attending school (%)	82.09	81.65	0.27	81.75
Share of household members aged 65 or more (%)	2.89	3.85	0.53	3.69
Plot of land ownership (%)	98.36	99.33	0.44	99.17
Material of walls (%)				
Clay	80.32	78.87	0.79	79.12
Cement	8.29	4.62	0.25	5.21
Wood	8.19	8.25	0.98	8.24
Other	3.27	8.25	0.17	7.41
Material of the roof (%)				
Tiles	78.68	78.87	0.97	78.84
Asbestos	13.11	12.87	0.95	12.91
Wood	4.91	4.29	0.82	4.39
Other	3.27	3.96	0.81	3.84
Material of the floor (%)				
Ceramics	67.21	55.77	0.10	57.69
Concrete	27.86	30.03	0.73	29.67
Soil	4.91	13.53	0.06*	12.08
Other	0.00	0.66	0.52	0.54
Electricity available in the house (%)	86.78	84.48	0.63	84.89
Household has a bank account at bank or saving association (%)	86.88	82.83	0.43	83.51
Households has 2 or more cows (%)	93.44	88.11	0.22	89.01
Per capita annual expenditure (IDR)	4,132,334	4,255,213	0.67	4,234,621
	(1,880,359)	(2,762,874)		(2,633,865)
Number of households	61	303		364

Table 68: Balancing properties of the matched samples for pipeline comparison

	Unmatched		Matched			
	Always users	**New users**	**Always users**	**New users**	**Δ**	**t-stat**
Farming main activity of household head	0.883	0.891	0.860	0.839	0.022	0.41
Highest level of education						
Junior secondary	0.344	0.363	0.355	0.376	-0.022	-0.30
Senior secondary	0.254	0.219	0.312	0.299	0.013	0.19
Vocational training	0.029	0.024	0.011	0.015	-0.004	-0.26
University	0.046	0.033	0.065	0.082	-0.017	-0.45
Nr of children under 6 years	0.329	0.376	0.376	0.359	0.017	0.21
Household size	4.076	3.974	4.172	4.256	-0.084	-0.47
Certified property rights to plot	0.302	0.236	0.247	0.232	0.015	0.24
Size cultivated land (ha)	0.715	0.549	0.770	0.871	-0.101	-0.61
Number of cows kept	5.849	4.560	6.817	7.269	-0.452	-0.50
Number of rooms in house	6.949	6.246	6.742	6.815	-0.073	-0.28
Cement or clay brick walls	0.922	0.854	0.935	0.938	-0.002	-0.06
Solid floor	0.939	0.878	0.957	0.951	0.006	0.21
Roof made of concrete or tiles	0.851	0.804	0.839	0.802	0.037	0.65
Window fitted with glass	0.707	0.665	0.710	0.710	0.000	0.00
Cooperative						
Kan Jabung	0.037	0.018	0.043	0.024	0.019	0.73
Sami Mandiri	0.037	0.029	0.043	0.037	0.006	0.22
Karta Jaya	0.054	0.030	0.075	0.062	0.013	0.35
Sapi Jaya	0.049	0.059	0.022	0.024	-0.002	-0.10
Sumber Makmur Ngantang	0.127	0.078	0.151	0.144	0.006	0.12
KUD Semen	0.054	0.038	0.075	0.062	0.013	0.35
Setia Kawan	0.254	0.347	0.226	0.262	-0.037	-0.58
KUD Dau	0.032	0.050	0.043	0.047	-0.004	-0.14
Dadi Jaya	0.056	0.052	0.054	0.065	-0.011	-0.31
Karang Ploso	0.049	0.051	0.054	0.071	-0.017	-0.48

Note: All variables are taken at their 2011 values.

Source: Indonesian biogas survey, 2012.

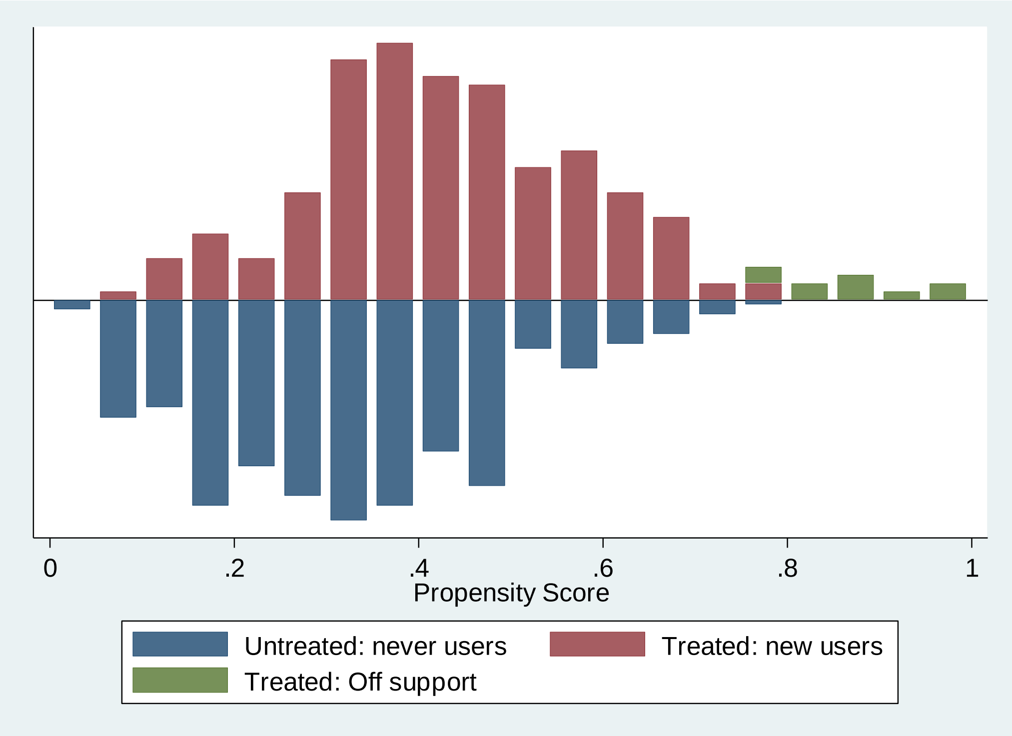
Table 69: Balancing properties of the matched samples for difference-in-difference analysis

	Unmatched		Matched			
	Always users	**New users**	**Always users**	**New users**	**Δ**	**t-stat**
Farming main activity of household head	0.875	0.885	0.903	0.910	-0.007	-0.24
Highest level of education						
Junior secondary	0.364	0.346	0.384	0.386	-0.003	-0.06
Senior secondary	0.233	0.223	0.189	0.201	-0.012	-0.30
Vocational training	0.026	0.019	0.034	0.038	-0.004	-0.21
University	0.045	0.041	0.029	0.023	0.006	0.37
Nr of children under 6 years	0.345	0.398	0.340	0.358	-0.018	-0.36
Household size	4.150	4.000	4.126	4.107	0.019	0.16
Certified property rights to plot	0.278	0.198	0.267	0.270	-0.003	-0.07
Size cultivated land (ha)	0.692	0.526	0.591	0.603	-0.012	-0.15
Number of cows kept	6.061	4.495	5.005	5.032	-0.027	-0.11
Number of rooms in house	6.294	6.063	6.044	6.132	-0.088	-0.60
Cement or clay brick walls	0.911	0.838	0.893	0.894	-0.001	-0.03
Solid floor	0.920	0.863	0.898	0.895	0.003	0.10
Roof made of concrete or tiles	0.799	0.816	0.782	0.784	-0.003	-0.07
Window fitted with glass	0.725	0.659	0.723	0.711	0.013	0.28
PLN electricity connection	0.971	0.896	0.961	0.957	0.004	0.20
Household has bank account	0.700	0.604	0.684	0.664	0.020	0.44
Kitchen wall slightly dirty	0.479	0.497	0.515	0.514	0.001	0.02
Kitchen wall quite dirty	0.131	0.159	0.189	0.186	0.003	0.08
Kitchen ventilation satisfactory	0.639	0.640	0.675	0.707	-0.032	-0.70
Kitchen ventilation poor	0.093	0.118	0.121	0.084	0.037	1.23
Kitchen equipment satisfactory	0.655	0.607	0.665	0.685	-0.020	-0.44
Kitchen equipment poor	0.115	0.137	0.155	0.131	0.024	0.70
Cooperative						
Kan Jabung	0.026	0.022	0.005	0.008	-0.003	-0.37
Sami Mandiri	0.035	0.027	0.034	0.048	-0.014	-0.70
Karta Jaya	0.045	0.030	0.029	0.037	-0.008	-0.44
Sapi Jaya	0.058	0.055	0.078	0.086	-0.009	-0.32
Sumber Makmur Ngantang	0.121	0.069	0.102	0.115	-0.013	-0.41
KUD Semen	0.048	0.038	0.039	0.045	-0.006	-0.29
Setia Kawan	0.265	0.365	0.296	0.250	0.046	1.04
KUD Dau	0.029	0.058	0.024	0.022	0.002	0.13
Dadi Jaya	0.058	0.049	0.058	0.058	0.000	0.00
Karang Ploso	0.048	0.052	0.049	0.060	-0.012	-0.52

Note: All variables are taken at their 2011 values.

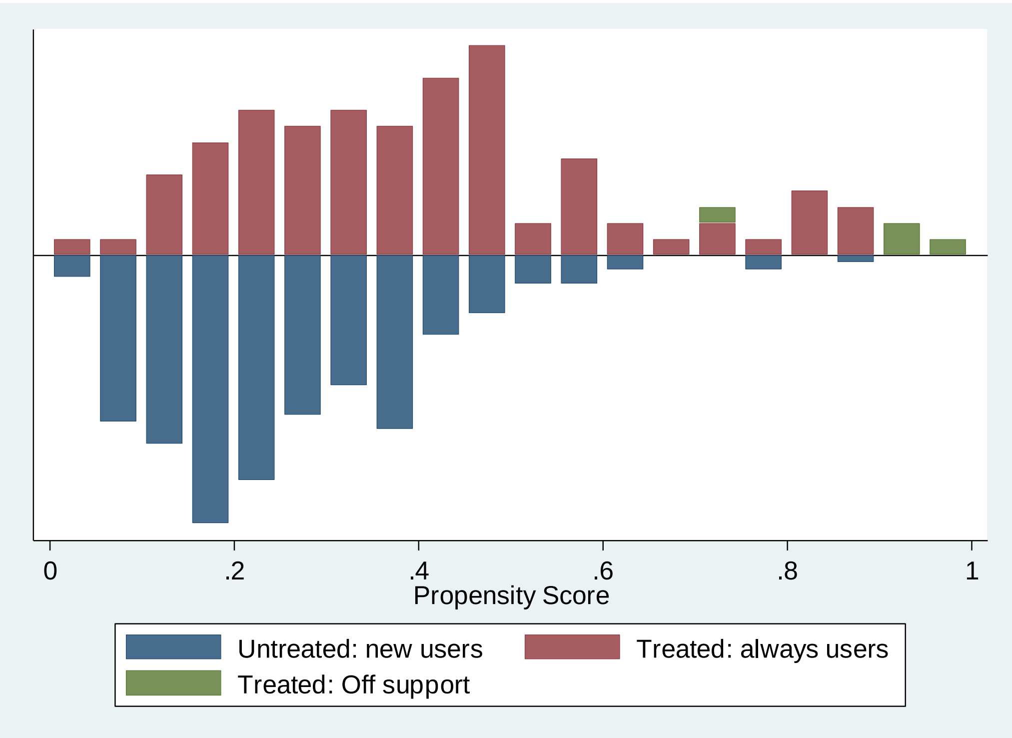
Source: Indonesian biogas survey, 2012.

Figure 15: Propensity score matching common support



Source: Indonesian biogas survey, 2012.

Figure 16: Cross-section pipeline analysis 2011: probability of having a biogas digester in 2011



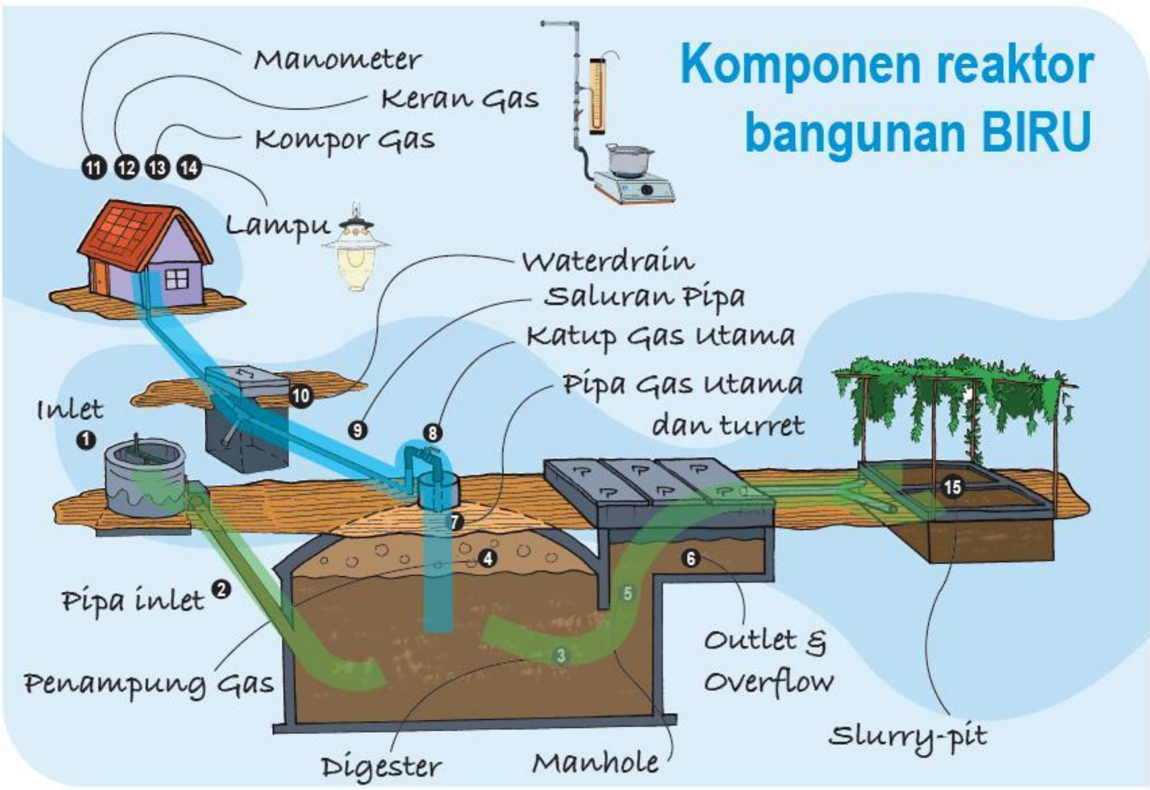
Source: Indonesian biogas survey, 2012.

14. Annex 5: Digester layout, construction and operation (pictures)

A combined mixture of cow dung and water/urine flows through the inlet (1) and inlet pipe (2) to the digester. The mixture produces gas through a process of anaerobic digestion which takes place in the digester (3), and is then stored in the gas storage chamber (4). After gas has been produced, the residue or bio-slurry flows out from the plant through the outlet (6) into the slurry pit (15). Gas is piped to kitchens through a gas pipeline (9).

A stylized sketch of a BIRU digester is provided below: 1. Inlet (mixing tank); 2. Inlet Pipe (adaptable to be connected to the toilet); 3. Digester; 4. Gas Storage (Dome); 5. Manhole; 6. Outlet & Overflow; 7. Main Gas Pipe and Turret; 8. Main Gas Valve; 9. Pipeline; 10. Water drain; 11. Pressure Gauge; 12. Gas Tap; 13. Gas Stove with a rubber hose pipe; 14. Lamp (optional); 15. Slurry Pit.

Figure 17: Diagram of a digester



Source: http://www.biru.or.id/en/index.php/digester/ (accessed on 26th March, 2013).

Finalizing the dome

A completed digester

The inlet

A biogas stove

A biogas lamp

A water heater running with biogas