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

The provision of electricity to rural communities through Micro-Hydro Power

Micro Hydro Power pilot programme
within the National Programme for Community Development (PNPM)
supported by the Netherlands through Energising Development

- Final Report -

FINAL VERSION

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This final 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 lessons from the findings for improvement of policy and policy implementation. The results of these impact evaluations will serve as inputs to a policy evaluation of the "Promoting Renewable Energy Programme" (PREP) to be concluded in 2014.

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1. Introduction

The Republic of Indonesia comprises more than 17,000 islands and is – with a population of around 240 million people – the world's fourth most populous country. Heterogeneity across the country is enormous with Java, the main island, being densely populated and well developed in terms of basic infrastructure access. Infrastructure development across the other islands is much more costly because of the lower population density and the mountainous topography. While the electrification rate averages at 73 percent across the country, it is close to 100 percent in Java, but goes down to 29 percent in Papua and even well below 10 percent in many rural areas. The Indonesian government has proclaimed rural access to electricity as one major objective and has set the target for the electrification rate at 95 percent for the year 2025 (DESDM 2005). At the same time, the promotion of renewable energies is high on the government's agenda and in particular the remote areas lend itself to decentralized electrification using solar or hydro power.

Against this background, the Micro Hydro Power pilot programme (MHP pilot in the following) strives to promote the development of micro hydro power fed mini-grids in remote areas. MHP pilot is part of the nationwide community development program PNPM. One component of PNPM, the Green PNPM, has a focus on natural resource management and micro hydro power development. Green PNPM is funded by a multi donor trust fund to which also the Netherlands contribute. Around 50 percent of the USD 51.9 million which the Green PNPM fund made available between 2007 and 2012 are earmarked for micro-hydro development.

MHP pilot extends the experiences of a predecessor intervention that, implemented between 2006 and 2009 by the GIZ Energising Development programme, established 96 micro-hydro power mini grids in Sumatra and Sulawesi. Energising Development as well is a multi-donor program that also receives funding from the Dutch Promoting Renewable Energies Programme (PREP). In a second phase of Energising Development, GIZ provides technical assistance to the MHP pilot in Sumatra and Sulawesi. MHP pilot pursues a community driven approach, i.e. communities apply for funding in order to establish a micro-hydro power mini grid. The community contributes in-kind to the construction of the power plants and the local distribution grids. After commissioning, the MHP is handed over completely to the community who operates and maintains the plants on its own. During the whole process, the community receives technical assistance via GIZ.

This report presents results of an evaluation that was conducted between January and March 2013. It is the major purpose of this evaluation to assess the impacts of micro-hydro power electrification has on the local population's welfare measured by various indicators including lighting usage, energy expenditures, activity patterns, and security aspects. The core of the underlying study is a household survey for which 520 households in 26 communities – 20 in Sulawesi and 6 in Sumatra – were canvassed. In addition to this, a survey undertaken among micro-enterprises as well as schools and health institutions serves to assess the effect electrification has on productive processes, firm performance and on the service provision of social institutions. Not least, the technical and economic sustainability of the mini-grids was examined based on interviews with community chiefs and MHP operators.

Methodologically, we used household data collected for a study conducted by GIZ in 2010 (GIZ 2011) and surveyed the same households again with a structured questionnaire. This allows for a simple before-after comparison. Since in 2010 no classical control group without access to electricity in the before and the after situation was included, a regular difference-in-differences approach is not applicable and we rather rely on a simple before-after comparison. One part of the sample, though, consists of households that had already been electrified some years before the baseline survey. These households serve to analyse long-term effects of electrification. In order to assess effects on micro-enterprises in the communities, a case study approach was applied for which a number of micro-entrepreneurs were interviewed in open interviews. Health centres, schools, community chiefs and MHP operators were interviewed using short structured questionnaires, complemented by an open interview if required.

The report unfolds by providing, in Section 2, a brief country background, a discussion of the Indonesian energy sector and a description of the main features of the MHP pilot programme under evaluation. Section 3 lists the evaluation questions and discusses the methodological approach. Section 4 presents some descriptive statistics on the plants and the communities. Section 5 presents the data and the results on the household level, while Section 6 examines the micro-enterprise sector as well as health institutions and schools. In Section 7, the sustainability of the MHP is analysed. Section 8 presents answers to the research questions formulated in the Terms of References, before Section 9 concludes the report.

2. The Intervention in its regional context

2.1. Regional context

As a former Dutch colony, Indonesia was declared independence in 1945, which was internationally acknowledged in 1949. From 1967 to 1998 Indonesia was ruled by the authoritarian leader Haji Mohamed Soeharto. The years after his fall were characterized by civil unrest and frequent changes of leadership. Meanwhile, continuity has returned under the current president, Susilo Bambang Yudhoyono, who came to power in 2004 and has been comfortably re-elected in 2009. Starting with an ambitious reformist policy agenda he has slowed down market reforms in the last years due to resistance within his governing coalition (EIU 2008, EIU 2011).

Table 1: Indonesia at a glance

Year	1998	2008	2011	2012
Land Surface (km^2)				1,811,570.00
Population (millions)	202.99	234.24	243.80	246.86
Population Density (per km^2)	112	129	135	
Ann. Pop. Growth Rate (%)	1.46	1.41	1.29	1.25
Urban Population (%)	39.42	48.33	50.69	51.45
Real GDP Growth Rate (%)	-13.1	6.0	6.5	6.2
Life Expectancy at Birth (y.)	65.0	68.1	69.3	
Population below poverty line (1.25 USD)	-	22.64	16.20	
Net Enrolment in 1^{ary} Schools (%)		116	118	

Source: World Development Indicators 2013

Indonesia achieved an average annual growth rate of 5.5 percent between 2008 and 2012 (World Development Indicators 2013). Furthermore, Indonesia's economy is not dominated by one sector only. While the industry sector is the largest contributor to GDP, services have expanded rapidly in recent years with agriculture remaining an important employer.

The agricultural sector is of vital importance to the Indonesian economy. Being the world's third-largest rice and the largest palm oil producer this sector is a source of export earnings and employment on which the majority of the rural population subsists (EIU 2010). The relatively strong economic performance is rewarded with increasing investment, especially in the commodity sector and by beginning of 2012 international rating agencies upgraded Indonesia's Sovereign Risk Rating to "investment grade" status (EIA 2013).

In spite of on-going economic growth, 16 percent of the population was living below the poverty line of 1.25 US$ per day in 2011. Poverty in Indonesia is marked by a significant difference between east and west. While the national poverty line of affording a diet of 2,100 calories a day amounts to 11.2 percent in the whole country, it exceeds 20 percent in several eastern provinces. While one of the target provinces of the intervention, Sulawesi Barat, has slightly more poor people than the national average (13 percent), the other target province Sumatra Barat reveals slightly fewer poor households, counting with a share of only 8 percent of the population living below the poverty line (BPS 2012).

2.2. Energy Sector

The electrification rate in Indonesia has been increasing at a steady pace within the last years, but the national average still only amounts to 73 percent in 2011 with big disparities between regions. The electrification rate ranges between 100 percent in Jakarta to only 29 percent in Papua. The surveyed province Sulawesi Barat and Sumatra Barat count with electrification rates of 64 and 78 percent, respectively (DGNREEC/MEMR 2012a). In particular the mountainous rural areas in Indonesia are in many cases difficult to access implying high investment costs for grid or road infrastructure extension.

The Indonesian government has made rural access to electricity a major objective and has set the target of 95 percent electrified households in 2025 (DESDM 2005). Effectively, the electrification rate has increased by almost 16 percent between 2006 and 2011 (DGNREEC/MEMR 2012a). However, legal and contractual uncertainties as well as low power tariffs have led to an underinvestment in power generation capacities. The bad financial situation of Indonesia´s state electricity company, Perusahaan Listrik Negara (PLN) aggravates the situation of the capacity shortage. PLN is responsible for the national provision of electricity. In order to solve this problem, the government designed a "fast track" plan in 2006 to add 20 GW to the grid by 2014, primarily through coal-based generation, but in a second phase also through natural gas as well as geothermal and other renewables. Subsequent delays slowed down the project and the commissioning of the first 10 GW foreseen in 2010 has been rescheduled towards 2013. In 2012, the installed capacity in Indonesia was 44 GW which is owned and operated by 90 percent through PLN and its subsidiaries. The vast majority of electricity is generated through conventional thermal sources (86 percent, more than half of it from coal), followed by hydroelectric (9 percent), geothermal (5 percent) and other renewable sources (EIA 2013).

It is the government's expressed goal, though, to increase the share of *new and renewable energy* (NRE) sources to 25 percent of primary energy in 2025 (known as *Vision 25/25*), reducing above all the share of oil in electricity generation. The term NRE also includes non-renewable energy sources like liquefied coal or nuclear energy. The main potential is seen in the development of geothermal energy, bioenergy and liquefied coal. The contribution of hydro power is not exactly specified. It is foreseen to cover 5% of total energy production together with biomass, nuclear, solar and wind power (DGNREEC/MEMR 2012b). Hydro power potentials are estimated to have a volume of 75 GW for large-scale hydro plants and 500 MW for mini- and micro hydro schemes. In 2010, only 17% of this micro hydro potential had been realized (U.S. Department of Commerce 2010).

While the targets of Vision 25/25 have already been defined years ago, a set of sound policy instruments to incentivize the inclusion of renewable sources is still missing. The main areas of discussion are fiscal incentives for renewable energy development, provision of funding arrangement including government assurances for NRE projects and pricing arrangement like feed-in tariffs for independent power producers and cuts in energy subsidies (DGNREEC/MEMR 2012b). In the past, a major market entry barrier for commercial independent power producers or off-grid projects were fixed electricity tariffs that are even below the average production costs of PLN. Moreover, subsidies for diesel fuel provided competitive advantages for diesel generators in contrast to non-subsidized hydro energy (YBUL 2002). Since these energy subsidies are posing a heavy burden on the national budget amounting to almost 29 percent of total public spending in 2011, the government committed itself to lowering energy subsidies and remove electricity subsidy completely by 2014 (IISD 2009, The Jakarta Post 2010). In 2013, the government effectively voted for an increase in fuel prices (rise of gasoline prices by 44 percent and diesel by 22 percent) and electricity prices are expected to rise by 15 percent in 2013 (Jakarta Globe 2013). Furthermore, the government has signed technology specific feed-in tariff for independent power producers of capacities of up to 10 MW (DGNREEC/MEMR 2013).

2.2. Project description: Micro Hydro Power pilot programme

The Micro Hydro Power pilot programme (*MHP pilot* in the following) is part of the National Programme for Community Empowerment (Program Nasional Pemberdayaan Masyarakat - PNPM), a programme for (urban and rural) community development that reaches about 30,000 communities and cities nationwide. It is the largest programme of its kind in the world. The PNPM provides funding and technical support for community driven projects in various sectors. Since the demand driven approach generated only a few environmental and natural resource management projects, the donor community, (and in particular Canada) established a separate financing line aimed at triggering the demand for natural resource management. This financing line is called the Green PNPM. Funds are made available through a multi donor Trust Fund deposited to and managed by the World Bank. The Netherlands participate in that Trust Fund and have earmarked its finance especially for activities concerning micro hydro power (MHP). In 2009 the Green PNPM Micro Hydro Power pilot programme started in eight provinces, equally spread over the islands of Sulawesi and Sumatra. About half of the Green PNPM funding of USD 51.9 million for the period 2007-2012 was planned to be allocated to the funding of MHP plants of the pilot scheme. The funds were made available for the hardware mainly.

Indonesia has a long history of using MHP for electricity generation that dates back to colonial times. Also during the last decades, the MHPs have been incentivised by the Government of Indonesia, mainly through providing funding for hardware components. Less attention has been paid to the sustainable operation of the MHP, which in many cases lead to poor operational performance or even the break-down of the plants (Puspa et al. 2013). Against this background, the MHP pilot builds on experiences from the Energising Development (EnDev) 1 programme, implemented by GIZ (with Dutch-BMZ core funding) from 2006-2009 and aimed at scaling up the construction and operation of MHP schemes in Indonesia. In total, EnDev 1 supported 96 MHP plants. In 2009, GIZ Indonesia started activities funded by a second phase of the EnDev programme (EnDev 2). Under EnDev 2, the GIZ support in Indonesia shifted focus to facilitating and supporting the community driven approach under the Green PNPM. By January 2013, 136 MHP plants had been supported whereof 90 were commissioned at that time.

In sum, the Dutch Programme *"Promoting Renewable Energy Programme"* (PREP) supports the MHP pilot in two ways:

1. The funding earmarked to micro hydro energy within the Green PNPM multi donor trust fund managed by the World Bank. The donors are Australia, Canada, Denmark and the Netherlands.

2. The BMZ-Dutch partnership EnDev 2 programme, implemented by GIZ, offers technical support and capacity development to the MHP pilot:

- Technical support is provided by the MHP Technical Support Unit (TSU);
- Capacity development at national level is supported through the Micro Hydro Power Project (MHPP2), focussing on establishing the sustainability of the sector.

The process of the community driven approach is that communities submit proposals for funding to finance small infrastructure projects at local level. The technical community workers of the PNPM assist in the formulation of the proposals and in the selection process. In principle, the PNPM design implies competition for block grants, based on the quality of proposals and prioritization between and within communities. In the case a community gives priority to the demand for an MHP plant, the GIZ TSU staff supports the local government in the assessment of the application by conducting site verification and realising feasibility studies. In the case the application leads to a technically and economically feasible proposal, the corresponding community is awarded a block grant (through government, but originating from the PNPM Green component earmarked for MHP) for the construction of a MHP plant. The MHP pilot grants are on top of the regular PNPM grants, and amount on average to USD 50,000 per scheme. Unlike the regular PNPM projects, there is no formal budget ceiling. Subsequently, the community makes manual labour and local material available and contracts a company to install the MHP plant. The quality control and quantity surveillance is done by the TSU.

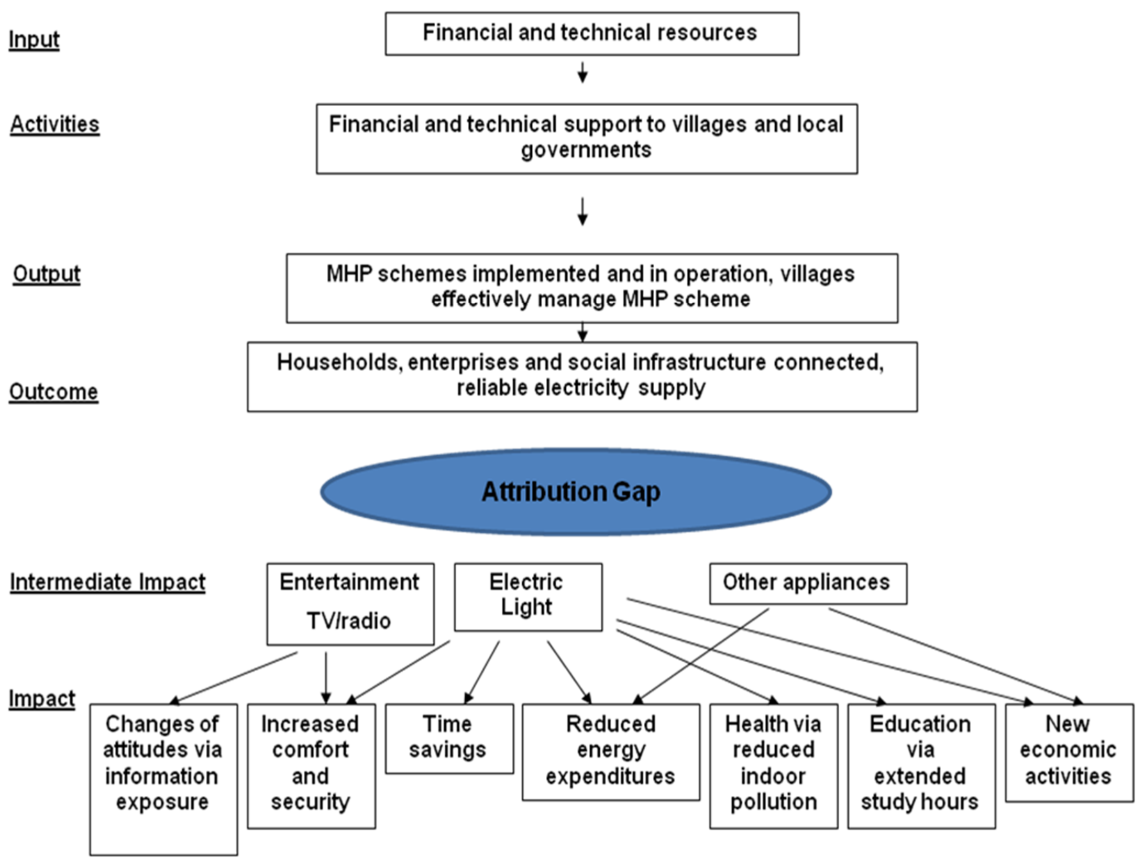
Selected communities are autonomously responsible for managing the block grant and for the implementation of the MHP projects. Since the proper operation and maintenance through the community was identified as crucial for a sustainable operation of the MHPs during the first phase of the programme (EnDev 1), technical support to the community on plant operation, book keeping, and accounting has been intensified during the second phase, EnDev 2. It is the newly created TSU that since 2009 organises management and operation trainings for the communities. TSU has also intensified quality control of the plants' construction. The combination of providing funding and technical support through a community development approach, as well as capacity development at national level is crucial for a sustainable implementation of MHP electrification projects.

3. Evaluation approach

3.1. Evaluation objective and study modules

This evaluation aims at assessing positive and negative impacts – intended or not – of electricity connections provided through the Green PNPM MHP pilot activities. The evaluation's major part focuses on households as the intervention's primary beneficiary and addresses questions related to the outcome and impact level as well as technical and economic sustainability of the MHP plants. Beyond the household level, the evaluation also assesses effects that evolve via health centres, schools and micro-enterprises. The research questions pursued by this evaluation follow the Theory of Change of the intervention, which is illustrated in the results chain in Figure 1.

Figure 1: Green PNPM MHP pilot program results chain



Source: Own illustration

At the output level, we address the question (i) how communities decide to apply for a micro hydro scheme, and who (gender specific) was involved in the decision and (ii) which socioeconomic groups (incl. poor/non-poor) applied for connection. On the outcome level, we address the following questions: (i) What is the connection rate of households, enterprises and social infrastructure institutions in the project area? (ii) How many households have been using electricity prior to the MHP electricity became available? (iii) How reliable is the electricity supply of the micro hydro plant (frequency of outages)? (iv) What are the main appliances using electricity used by households, enterprises and social infrastructure institutions? (v) How many hours per day or week is electricity being used? (vi) For what purpose and by whom in the household is electricity being used?

At the impact level: (i) How have expenditures for energy changed? (ii) To what extent has safety/protection changed? (iii) To what extent has comfort/convenience changed? What monetary value do households attribute to this increased convenience, disaggregated by gender? (iv) Has there been any change in time/ workload, disaggregated by gender? (v) For what purposes is the time saved been used, disaggregated by gender? (vi) To what extent have the household's activities during evening hours changed? Have study hours/reading time of children changed? Do women (and children) enjoy more or less rest for physical recuperation? (vii) To what extent has indoor air pollution been reduced (according to the perception of dwellers)? (viii) To what extent have health conditions (in particular respiratory illnesses) changed, specifically among women and children? (ix) How have, in response to the possibly increased media exposure, attitudes and behaviours, such as women's status, fertility, children's school enrolment changed? (x) How are these impacts distributed across different household members (women vs. men, children vs. adults)? (xi) Has the enrolment and school attendance, as well as student performance changed as a result of use electricity in the school? (xii) Has the availability of electricity triggered new economic activities or displaced old ones? (xiii) What (if any) are the un-intended or negative impacts?

At the **household level** we expect that the major impact is on 'softer' indicators such as increased convenience and comfort induced by using electric lighting and appliances such as radio, TV, or a mobile phone charger. The questionnaire we used for the survey covers several socio-economic aspects that characterise a household's living conditions with a particular focus on the use of appliances and energy expenditure. Convenience and comfort aspects are addressed by asking direct questions about satisfaction and perceived convenience. These questions are similar to those used in the happiness and subjective poverty literature and in the marketing/business school literature. A complementary approach would be to apply willingness-to-accept (WTA) methods, which have proven to be not implementable in the field in the specific context.[2]

Furthermore, we examine impacts on activities after nightfall, which might be affected thanks to increased usage of lighting and television. For instance, the time children dedicate to studying at home is an indicator. As the result chain shows, in principle, effects on health could be observed because of reduced household air pollution. However, even if this impact exists, it could only be rather small given that household air pollution is largely induced by cooking fuels. Cooking habits, in turn, can only be expected to be slightly affected by an electrification intervention. Households normally do not use electric cook stoves. Only the usage of electric rice cookers presents an exemption. However, the majority of meals are still cooked with biomass using stoves or gas and

[2] All households but one asked for the price at which they would accept to disconnect said they would not accept to lose their electricity connection no matter which price one would offer.

kerosene stoves for higher income households. For certain high exposure groups, though, kerosene smoke from lighting sources might nonetheless have health effects. School kids, for example, study in direct proximity to kerosene lamps (Epstein et al. 2013, Fullerton et al. 2009, Pokhrel et al. 2010, Schare and Smith 1995).

In addition, we study the impact on behaviour and attitudes resulting from increased media exposure, such as on women's status, and reproductive behaviour. Some studies suggest that the information and exposure provided by radio and in particular television can influence a wide range of attitudes and behaviour (see Grentzkow and Shapiro 2004, Olken 2006, La Ferrara, Chong and Duryea 2008, Chong and La Ferrara 2009, Peters and Vance 2011, Jensen and Oster 2008). A potential unintended negative effect could be the one of television on trust, social participation and social capital as observed in Olken (2009). Using Indonesia data, Olken finds that social interaction in various forms within communities is decreased with the introduction of television, since people stay at home to watch TV. New access to television is furthermore associated with lower levels of self-reported trust.

At the **micro-enterprise level**, various effects could be imagined. While manufacturing enterprises like carpenters or welders might use electricity to run new machinery, shops and service firms like hair cutters can use smaller appliances like TV, radios or electric haircutting machines to improve services or attract customers. Electric lighting can improve processes in all type of companies and might lead to an increase in operation hours. For **rural health centres**, the major impact is on the quality of health care provision through the use of appliances like electric lighting or diagnosis equipment as microscopes and centrifuges that are required to detect simple infectious diseases such as malaria. **Schools** can be expected to benefit most from lighting by offering courses during evening hours or by improving class quality during the (dark) rainy season. In exceptional cases, also computers might be acquired. It is also frequently argued that it is easier to recruit and keep qualified teachers for rural schools if the area is electrified, since usually teachers are displaced from urban to rural areas so they are used to urban infrastructure provision including electricity.

The question of **sustainability** of the intervention can be divided into technical and economic sustainability: Technical sustainability requires that MHP plants are operated and maintained properly in order to ensure a reliable electricity provision. Here, availability of spare parts and technical expertise for repairs of the power plant as well as electricity materials for repairs at household level play an important role. Economic sustainability requires that the MHP's revenues that are collected on the community level are sufficient to cover operation costs (including maintenance) and investments into spare parts. This depends on whether all households are able and willing to pay the electricity bill and what happens if they do not do so. The fact that the community itself is responsible for maintenance and operation of the plant is pivotal for both the technical and economic sustainability. The technical knowledge as well as the organisational and financial capacity to sustainably run the plant, does not necessarily exist in the communities. It is part of the intervention to enable the community to sustainably run and maintain the plant by using robust and easy to repair technology, organising trainings, and implementing rules and regulations that channel community dynamics in support of the MHP plant.

Table 2: Different Study Modules

Study module	Content	Sample Size	Interview Type
Household study			
Large household survey	Comprehensive Socio-economic questionnaire covering most household characteristics (revenues, expenditures, education, health issues, activities at night-time) with focus on energy and lighting usage.	450 in each wave	Structured questionnaire
Qualitative household survey	Open discussions about intended and unintended effects of electrification.	30	Open interviews
Micro-enterprise study			
Qualitative micro-enterprise survey	Energy usage, bottlenecks of firm development and role of electricity. Customer basis and market access.	52 during follow-up	Semi-structured interviews
Community study			
Community chief survey	Application process for MHP, connection rates, number of enterprises, community size, infrastructure and market access, availability of energy sources, major community particularities. etc.	all 26 communities	Structured questionnaire
Social infrastructure survey			
Qualitative health centre survey	Connection status, appliance usage, health care provision and role of electricity.	All HC in 26 communities	Semi-structured questionnaire
Qualitative school survey	Connection status, appliance usage, role of electricity in service provision.	All schools in 26 communities	Semi-structured questionnaire
Sustainability			
MHP management survey	Technical details and condition of plant, tariffs and sanctions, organization of operation and management, maintenance and capacities to provide maintenance services.	All 26 plants	Structured questionnaire

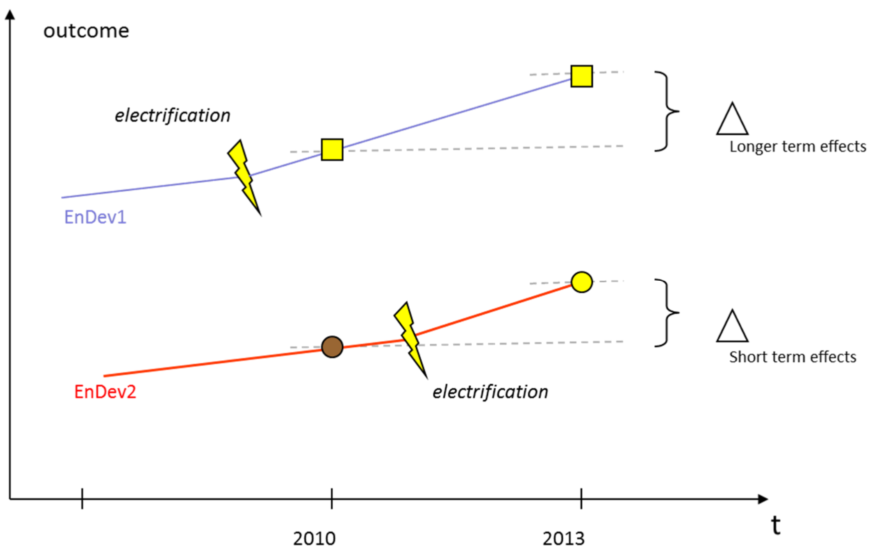
The different study modules employed to provide evidence on impacts on the different beneficiary levels are summarized in Table 2.

3.2. Identification strategy

The central attempt of this evaluation is the identification of effects of the electrification intervention – the treatment – on outcome and impact indicators on household level. For the purpose of determining the true effect, one would have to compare the impact variable after having received the treatment to the *counterfactual situation* of not having received it. Obviously, this is impossible, since we can never observe both situations: The household is either connected or not. To address this fundamental evaluation problem, we have to replace the unobservable and, hence, non-computable counterfactual situation.

The identification strategy of the present evaluation effort compares households after electrification through MHP to the same households before electrification through MHP. These households are part of the target group of the second phase of the Energising Development (EnDev 2) engagement in Indonesia. As baseline, a data set is used that was collected on behalf of GIZ in order to evaluate the first phase of the EnDev engagement in Indonesia in 2010. For that study, first EnDev 1 communities were surveyed that had been connected two to three years before and, second, EnDev 2 communities that were non-connected at that time.[3] The same households were visited again for the present evaluation endeavour in early 2013 and hence approximately two years after the baseline survey. In the meantime, EnDev 2 households had been connected to newly installed MHP.

Chart 1: Impact assessment: The before-after analysis



Source: Own illustration.

The EnDev 2 households are compared before and after electrification and the difference in a certain outcome variable (e.g. reading hours, expenditures) is assigned to the electrification. At the same time we compare EnDev 1 households in 2010 and 2013 and thereby can observe long term effects of electrification. In 2010, EnDev 1 communities had been using electricity from MHP for approximately three and a half years, but some communities had received the MHP only four month

[3] When commissioning the 2010 study, GIZ's idea was to use the collected data at the same time for a cross-sectional impact evaluation of EnDev 1 and as baseline for EnDev 2. Due to budget limitations no additional control group could be included. For the corresponding reports see (GIZ 2011).

prior to the survey. It is therefore quite likely that effects of electrification on many outcomes continued to unfold after the baseline data was collected. Especially concerning appliance usage it is plausible to assume that households do not invest into all appliances immediately after electrification, but for some bigger investments it might take time until households buy additional appliances. Also changes in lifestyle and economic growth may take more than just a few months to unfold.

The underlying assumption for this before-after comparison is that the households' outcome would not have changed between 2010 and 2013 if it had not been electrified. This assumption might be violated if external factors (improvements of general economic conditions, technological change, seasonality etc.) affect the households' behaviour with respect to the outcome over time. A growing economy, for example, might affect the household's income. One would then falsely ascribe an increase in an income dependent outcome variable (e.g. expenditures) to electrification although this increase would have taken place anyhow due to economic growth. Such external influences can be accounted for by including a control group that simulates how the households would behave without the electrification treatment. A regular control group would be untreated both at the time of the baseline and at the time of the follow-up survey in order to mimic the development in the EnDev 2 communities in the absence of the treatment. Such a control group was not surveyed in 2010 and is thus not available. Yet, the already electrified EnDev 1 communities might serve as a sort of control group for indicators we suspect to react very quickly to electrification. One example is the subjective assessment of the security situation: it can be expected that households that connect to the MHP switch to electric lighting sources very quickly and their assessment of security changes immediately – or never. For these indicators EnDev 1 households are not influenced through long-term effects of electrification, but can be expected to depict secular changes that would have materialized in the EnDev 2 communities if they were not electrified. For all other indicators we have to rely on qualitative observations and assessments of key resource persons on what has happened between baseline and follow-up.

The identification strategy for micro-enterprises, schools and health centres is restricted by the small sample size and thus case study based. We assess qualitatively the firm's behaviour in the counterfactual situation. The interviewer asked questions on the before and after situation as well as on the what-would-have-happened-scenario.

3.3. Sampling

Among the approximately 240 communities that were planned to be electrified in the course of the EnDev 2 project, 20 communities were selected in 2010 for the baseline: Ten in Sulawesi, ten in Sumatra (see Figure 2 for a comprehensive illustration of the sampling). All EnDev 2 communities had been non-electrified at that point of time. The selection of these 20 communities was driven by the implementation status of the projects and logistical considerations. In September 2010, EnDev 2 was only active in four kabupaten (regencies): Mamasa in Sulawesi and Pesisir Selatan, Solok Selatan, and Agam in Sumatra. Preference was given to EnDev 2 sites that were likely to be electrified in the near future. The six EnDev 2 sites in Mamasa/Sulawesi that were already under construction at the time of the baseline were surveyed. Additionally, four communities were surveyed for which the MHP installation was scheduled for 2011. In Sumatra, out of the total 13 possible EnDev 2 sites, those ten sites were selected for the survey that in 2010 were considered most probable to be electrified in 2011.

Moreover, another 20 communities - ten in Sulawesi, ten in Sumatra - were selected among 96 communities that already had been electrified under EnDev 1. Here, the selection was driven by comparability considerations in order to identify similar communities as the surveyed EnDev 2 communities. The applied criteria were above all the size of the community and proximity to the EnDev 2 regions.

The follow-up survey was initially scheduled to take place in late 2012, exactly two years after the baseline. However, the follow-up survey had to be postponed to January 2013 in accordance with our local partner institute JRI's assessment that the envisaged survey period is inappropriate due to Ramadan and Idul Fitri – religious festivities with profound implications for people's daily life that would have made a survey implementation difficult. Furthermore, it turned out that due to considerable delays in the project implementation in September 2012 only three out of the ten surveyed EnDev 2 plants in Sumatra had been installed. Five plants were still under construction and two plants had finally not been constructed and supported by EnDev 2. Since also the installed plants had only been operational for less than three month, we decided to postpone the follow-up survey to January 2013 in order to be able to observe more than only very early indicators of effects and possibly include some of the plants under construction. In January 2013 still only three EnDev 2 plants had been operational in Sumatra and we restricted the survey on these three communities. Accordingly, we also revisited only three of the ten EnDev 1 communities in Sumatra. Criteria for dropping EnDev 1 communities again were comparability criteria and whether the EnDev 1 plants were still operational. This decision was taken based on monitoring information of the MHP and short field visits. Information on non-operational EnDev 1 plants will still feed into our sustainability assessment, although household interviews have not been conducted in these communities. In Sulawesi all ten EnDev 2 plants were operational and thus both the ten EnDev 2 and the 10 EnDev 1 communities were revisited.[4]

For the sampling on the household level, we randomly selected approximately 20 households per community in the baseline and revisited them during follow-up. In the EnDev 2 communities, only those hamlets (dusun) that were expected to be connected to the planned MHP were surveyed. The hamlets to be connected were identified during a short interview with the community chief or with the PNPM facilitator. Accordingly, the total number of households surveyed in the baseline amounted to 800 out of which 520 households were revisited (with the remaining households being dropped in Sumatra). The attrition rate is modest at 13 percent, because 68 households could not be interviewed for the follow-up because of death, migration, or because they could not be retrieved.

For the micro-enterprise survey, we sampled enterprises from a comprehensive list that is officially available in each community. Selection criteria aimed at getting comprehensive information on each of the most frequent type of micro-enterprises: both electricity users and non-users in the most

[4] Visisted communities are:

EnDev 2 Sumatra: Taratak Paneh, Sungai Sirah, Sungai Keruh;

EnDev 1 Sumatra: Sungai Kalu, Karang Putih, Wonorejo;

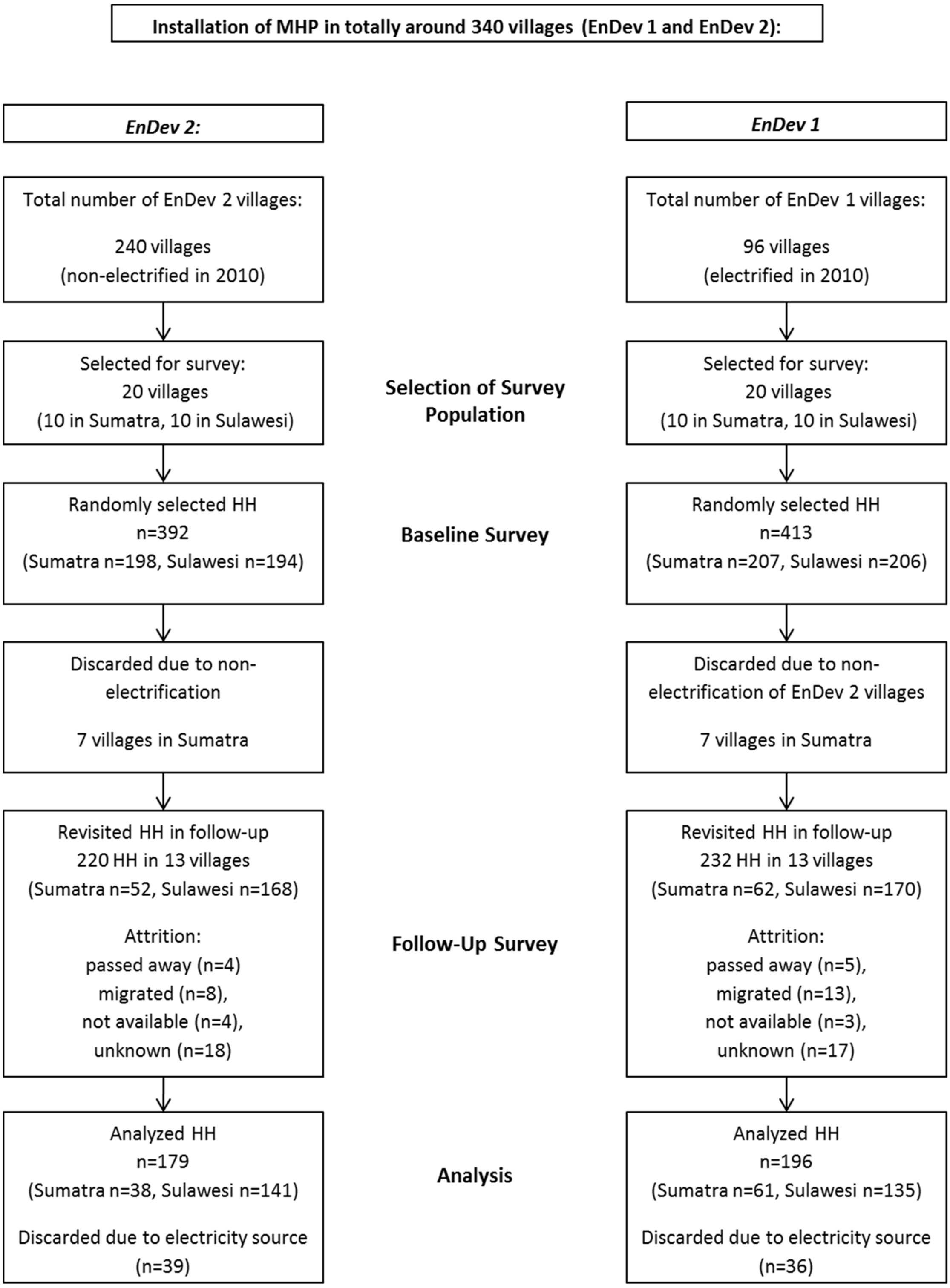
EnDev 2 Sulawesi: Orobua Selatan Salumokanan, Bumal, Salutambun barat, Limba dewata, Mambuliling, Osango, Bubun Batu, Lemsa, Tabang;

EnDev 1 Sulawesi: Lisuan ada, Lisuan ada (Sepang), Paladan, Rantepuang, Rante Tangnga, Satan Etang, Batanguru (Ratte), Batanguru (Minanga), Rippung, Sipai.

relevant crafts in the region. We strived for including both enterprises in which electricity was deemed to have a considerable effect on the production process and those where the effect was suspected to be rather subtle.

Information on schools and health stations was elicited in all communities in which these institutions exist.

Figure 2: Participants flow in survey



Source: Own illustration.

3.4. Survey Implementation

The baseline study was implemented by RWI in cooperation with graduate students from University of Makassar/Sulawesi and the Lampung/Sumatra based NGO RAGOM. The follow-up survey was initiated by a preparatory mission in January 2013 and implemented in cooperation with the Jakarta based institute *JRI Research*. JRI research was also involved in the ISS/RWI biogas study (Bedi et al. 2013) and was hence acquainted with the questionnaire and methodological requirements. All eight JRI enumerators conducted the survey in Sulawesi, six of them continued the survey in Sumatra. The enumerators were trained by JRI in an intensive two day course. The two supervisors had previously been involved in the ISS/RWI biogas study. Extensive pre-tests were conducted to verify the feasibility of the questionnaire.

During the whole follow-up survey, a RWI junior researcher stayed on the ground to supervise the implementation of the survey between January and February 2013. For the baseline RWI researchers conducted all semi-structured interviews, for the follow-up JRI performed part of these tasks and the RWI junior researcher concentrated on the micro-enterprise survey. The filled household questionnaires were checked every night for consistency and completeness by JRI and the RWI researchers in the field.

4. Modus operandi of MHP plants and community descriptives

The following section summarizes information from interviews with community chiefs, plant managers and plant operators in 26 communities, 20 located in Sulawesi and six in Sumatra. It concentrates on the MHPs, their modus operandi, household connection behaviour, and descriptive information on the surveyed communities.

4.1. Modus Operandi of MHP plants and household connection behaviour

In all 13 EnDev 2 communities the MHP scheme was installed between 2010 and 2012. On average the MHP plants had been in operation for 13.5 month at the moment of the follow-up, ranging from 5 to 25 month. In EnDev 1 communities the MHP plants had been in operation on average for 71 month, ranging between 30 and 91 month.

Even though the EnDev 2 communities in 2010 did not have an MHP plant, a considerable share of households had already been using electricity (see Table 3). In 2010, the most common electricity sources were traditional waterwheels, so called *kincir*, that supply various households in one community with electricity. These kincirs often only operate a few dim lighting devices and the service provided is mostly poor. They were especially prevalent in Sulawesi. In Sumatra, the most important sources were individual gensets.

In addition, some households were connected to the national PLN electricity grid illustrating that many of the communities are located in immediate vicinity of the national grid. Not all of these households are officially connected, but have simply extended the grid from their neighbour[5]. Another small number of households in the EnDev 2 communities was already connected to an MHP in 2010. This happened in communities where neighbouring hamlets already had had an MHP and occasionally households within the access area of the new MHP were able to connect to the existing MHPs.

At the time of the follow-up survey in 2013, the vast majority of households in the EnDev 2 communities is effectively connected to the MHP (90 percent). The main reason why households do not connect is that they are connected to the national PLN electricity grid.

For the following analysis we will drop all observations that had already have a PLN or MHP connection at the baseline stage (13 households) as well as households that have not connected to the MHP (7 households) or that have connected to the PLN grid in the meantime (3 households, see Table 3, observations in parentheses).

Table 3: Households' electricity sources, by wave and group of analysis

Electricity Source	**EnDev 2**		**EnDev 1**	
	2010 N= 218	**2013 N=218**	**2010 N= 232**	**2013 N=232**
Connected to MHP	0.04	0.85	0.97	0.86
Connected to MHP and additional electricity source	0	0.05	0.01	0.02
PLN (few with additional genset)	(0.06)	(0.07)	(0.01)	(0.01)
Genset	0.16	0	0	(0.01)
Connection to traditional water wheel	0.26	(0.01)	0	0
None	0.49	(0.03)	(0.02)	(0.10)

Note: Observations in parentheses will be excluded from the subsequent analysis.
Source: MHP household data set 2010/2013.

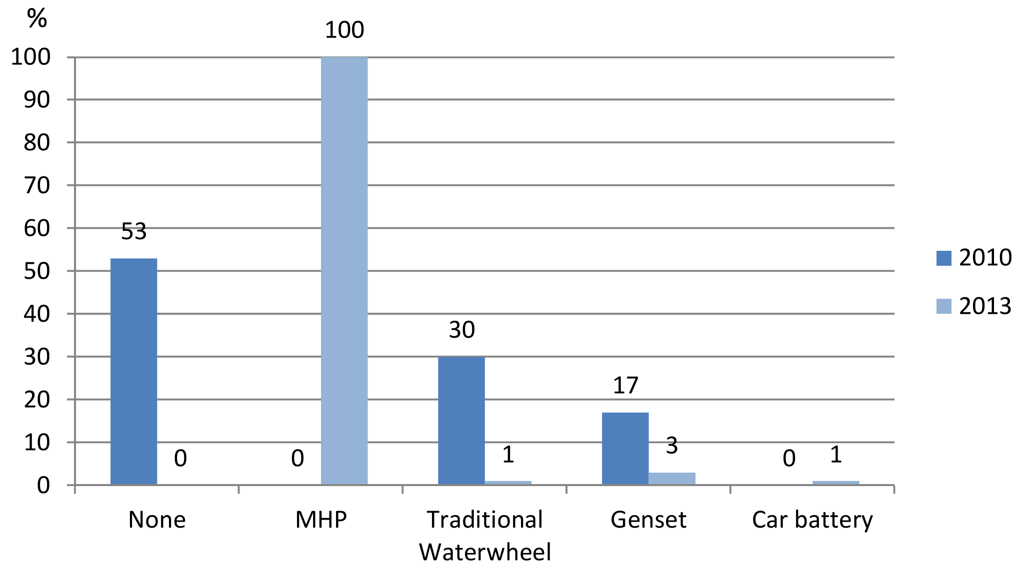
In EnDev 1 communities virtually all households were connected to the MHP at the baseline stage. At the follow-up stage a substantial part of the households does not use the MHP anymore. This is especially due to one community where the turbine had been broken four months prior to the survey and the community had been unable to re-establish the service[6]. For the following analysis we will only use those households as control group that had been connected to the MHP in 2010 and who are still using electricity from the MHP.

Accordingly our sample is reduced from 450 households to 374 households per wave, 178 living in EnDev 2 communities and 196 living in EnDev 1 communities.

[5] See Section 7 on sustainability for a discussion of the small distances between the MHP and PLN.

[6] Information on sustainability of EnDev 1 and EnDev 2 plants is provided in Section 7.

Table 4: Electricity sources in EnDev 2 communities 2010 vs. 2013



Source: MHP household data set 2010/2013.

The MHP plants have very different technical capacities (see Table 5). The smallest plant has a capacity of only 6 kW, the largest counts with 70 kW. On average, EnDev 2 plants are slightly smaller than EnDev 1 plants. The number of households connected to the MHP is slightly higher among EnDev 2 households and amounts to on average almost 100 households per community. The capacity available per household qualifies as a Tier 2 electricity connection according to the UN energy access tracking framework since peak capacity does not reach 2000 W per household.

Most plants are only switched on after nightfall and do not operate during daytime. The reason for this is that many of the EnDev 1 plants do not have electronic load control (ELC), which implies that a plant operator has to permanently monitor the load demand and to manually regulate water flows in the power house to balance voltage levels. In practice, the operator normally stays in the power house the first hours of the evening when households are using most appliances. Once the load is stable he goes home. He then returns only in the morning to switch off the system. Since electricity usage would be much more unstable during daytime and a continuous monitoring would be necessary, most plants are not switched on. Some plant manager furthermore indicated that they think the plant would deteriorate faster if they used it for too many hours. Besides these normal operation hours, many communities switch the plant on at daytime on Fridays when less people work in the fields and go to mosque or in case of special occasions like weddings or funerals. The implications arising from the operation schedule of the plants for productive usage of electricity is discussed more in detail in Section 6.1.2.

In most communities electricity consumption is not metered, but the households pay for electricity depending on the number of appliances they use (see Table 5). Typically, the lowest tariff is for households that only use electric lighting, for usage of radio, TV or further appliances households have to pay extra. Among EnDev 1 communities two communities also charge the usage fee according to the size of mini circuit breaker (MCB) used. In these communities MCB of 1, 2, 3 and 5 Ampere exist. One EnDev 2 community has exceptionally installed consumption meters at each household and households pay according to kWh consumed. The remaining EnDev 1 communities either apply flat tariffs for everybody or tariffs depending on socioeconomic characteristics of the households (poor vs. non-poor). One EnDev 1 community does not charge anything. This EnDev 1 community is located in Sulawesi and is the home community of the main turbine manufacturer, Pak Linggi, who maintains the turbine free of charge. The implication of the payment schedules and payment behaviour for the sustainability of the MHP will be discussed in Section 7. None of the plants apply special tariffs for social infrastructure or productive user as encouraged by TSU.

Table 5: Technical and Operational Details on MHP plants

	Treatment (EnDev 2)	Control (EnDev 1)
Cost for electricity connection (connection & inhouse wiring, In IDR)	226,310	374,607
Share of HH that paid connection fee		
Cash	89%	88%
Donation	8%	5%
Credit	3%	8%
Average Technical Capacity (kW)	21	26,2
Average Number of HH connected	103	93
Tariff system applied (number of communities)		
Based on number of appliances	12	9
Based on MCB used		2
Metered	1	
Flat tariff for everybody		1
Based on socio-economic characteristics		1
Electricity for free		1
Community applies special tariff for poorest	4	3
Community applies special tariff for social infrastructure	0	0
Community applies special tariff for productive use	0	0

Source: MHP household data set 2010/2013; Community data 2013.

The EnDev 2 households connected to the MHP plants paid on average 226,000 IDR for the electricity connection, including in-house wiring (see Table 5). This corresponds to only around 15 EUR. The low price is justified by an arrangement based on the in-kind contribution of villagers who participate in the construction and installation work. The connection fee was higher in EnDev 1 communities. Most households paid the fee in cash. The in-house installations were mainly done by the MHP operator (60 percent) or by a local electrician (34 percent).

4.2. Community characteristics

According to interviews with community chiefs, the average population per sampled community is around 1,250 persons or 265 households in 2013. While we generally do not observe many differences concerning community characteristics between EnDev 1 and EnDev 2 communities, quality and availability of basic infrastructure is generally better in Sumatra as compared to Sulawesi (see Table 6).

In Sumatra, more roads leading to the communities are paved or improved with gravel than in Sulawesi, where most roads leading to the EnDev communities are very low quality dirt roads. Although all community chiefs state that their community is accessible year-round with a four wheeled vehicle it is very demanding in rainy season to reach some of the communities in Sulawesi and only possible with a proper four wheel drive car (and a good driver). The distance from the communities to the nearest main road, i.e. a connecting road going through several communities and towns, is on average 3.8 km (but note that this number is not very meaningful in Sulawesi where cars have to drive at walking speed at best). We observe a pronounced difference for treatment communities in Sumatra where the mean value is highly skewed by one community that is located within a huge palm oil plantation, 23 km away from the next main road. However, due to the palm oil plantation and related commercial activities this community is actually very well connected to markets. Information on market activities confirms the obvious impression that the surveyed communities in Sulawesi are more remote than in Sumatra: less communities in Sulawesi have a market within their community and the distance to reach the nearest regional market is generally higher.

Virtually all communities count with health and educational infrastructure both in Sulawesi and Sumatra. In Sulawesi, health infrastructure in the communities are mainly very small health post, while in Sumatra some communities have bigger and better equipped health centres. The same is true for educational infrastructure; in Sulawesi most communities only have a primary school and in Sumatra more higher level schools can be found in the communities (for details on social infrastructure see Section 6).

Table 6: Community characteristics

		Average (total) N=26	Sulawesi		Sumatra	
			EnDev 2 N=10	EnDev 1 N=10	EnDev 2 N=3	EnDev 1 N=3
Average population per sampled community		1,250	1,248	1,144	1,202	1,323
Average number of households		265	268	246	332	248
Type of road leading to community (number of communities)	*asphalt*	7	2	2	2	1
	gravel	17	7	7	1	2
	earth	2	1	1	0	0
Distance to the nearest main road in km		3.75	2.25	3.4	11	2.67
Number of communities …						
accessible year-round with four-wheeled vehicles		26	10	10	3	3
	with schools	23	9	10	2	2
	with health station	25	10	9	3	3
	with market	6	3	2	0	1
Average distance to nearest market in km		2.6	2.4	3.3	1.5	1.7

Source: Community Interviews Follow-up Survey 2013

If we look at access to information, again, the communities in Sumatra are better off than in Sulawesi (see Table 7). Especially mobile phone reception and thereby internet availability is clearly better in Sumatra. Radio signal is available in all but two communities in Sulawesi. Television reception is not possible with a normal antenna- households need to use satellite receiver to watch TV. In all communities both in Sumatra and Sulawesi households use these satellite receivers.

Table 7: Access to information in surveyed communities (number of communities)

		Average (total) N=26	Sulawesi		Sumatra	
			EnDev 2 N=10	EnDev 1 N=10	EnDev 2 N=3	EnDev 1 N=3
Radio signal availability	Yes	24	8	10	3	3
Radio reception quality	Good	23	8	10	2	3
	Average	1	0	0	1	0
Mobile signal availability	Yes	18	6	6	3	3
Mobile reception quality	Good	4	0	0	2	2
	Average	10	5	3	1	1
	Bad	4	1	3	0	0
Television signal availability using normal antenna	Yes	0	0	0	0	0
Internet availability	Yes	5	0	0	3	2
Internet reception quality	Average	4			3	1
	Bad	1			0	1

Source: Community Interviews Follow-up Survey 2013

5. Impact assessment on household level

The following section assesses impacts of the electrification intervention on household level based on the 374 household interviews. First, we present descriptive statistics of the households, followed by a discussion of outcomes and impacts on the household level. We display differences in means in 2010 and 2013 and calculate the corresponding p-values for t-tests or chi-squared tests. P-values of up to around 0.1 are considered significant.

5.1 Household characteristics

The surveyed households consist on average of 4.6 members with around one fourth being children under 12 years and six percent being elderly over 64 years (see Table 8). The head of households is normally male, almost 50 years old and received primary school education only. We observe some statistically significant differences between EnDev 2 and EnDev 1 households for share of children and the sex of the head of household in Sumatra. The differences are not substantial, though.

Most households cultivate farming land (94 percent) and the most common primary occupation of the head of households is subsistence farming (73 percent). In Sulawesi, EnDev 2 households are slightly less engaged in subsistence farming and work more as public servants or stay at home because they are either unemployed, retired, study or are in charge of housework and children. In EnDev 1 households we see a relatively high share of head of households working as hired farmer. The reason is that two communities are located next to big commercial plantations (tea and palm oil) and many villagers work there.

Table 8: Household characteristics

	Average (N=374)	Sulawesi			Sumatra		
		EnDev 2 N=141	EnDev 1 N=135	p-value	EnDev 2 N=37	EnDev 1 N=61	p-value
Household size	4.6	4.8	4.6	0.278	4.5	4.2	0.368
	(1.9)	(1.9)	(2.1)		(1.4)	(1.9)	
Share of children < 6 years, in %	0.14	0.15	0.14	0.522	0.16	0.09	0.023
	(0.15)	(0.15)	(0.15)		(0.14)	(0.14)	
Share of children 6 - 12 years, in %	0.10	0.08	0.10	0.203	0.14	0.09	0.035
	(0.13)	(0.12)	(0.14)		(0.13)	(0.13)	
Share of elderly (> 64), in %	0.06	0.06	0.04	0.337	0.06	0.08	0.635
	(0.18)	(0.19)	(0.13)		(0.19)	(0.23)	
Head of Household is male	0.91	0.90	0.90	0.903	1.00	0.90	0.047
Age of Head of Household	48 (13)	49 (13)	48 (12)	0.752	44	48	0.138
Education of Head of Household				0.430			0.987
Without education	0.08	0.08	0.10		0.02	0.03	
Primary school	0.57	0.48	0.54		0.76	0.76	
Higher than primary school	0.35	0.44	0.36		0.22	0.21	
Household cultivates farming land	0.94	0.92	0.96	0.246	0.95	0.93	0.818
Household owns farming land	0.87	0.85	0.87	0.710	0.92	0.89	0.593
Hoh is subsistence farmer	0.73	0.65	0.78	0.015	0.86	0.72	0.099
Hoh is hired farmer	0.06	0.04	0.04	0.815	0.03	0.18	0.023
Hoh is public servant	0.05	0.08	0.04	0.145	0	0	
Hoh is unemployed, retired, studies or does housework	0.09	0.13	0.08	0.211	0.03	0.03	0.862
Number of rooms	3.2	3.1	3.2	0.337	3.2	3.5	0.220
	(1.2)	(1.3)	(1.1)		(1.24)	(1.2)	
Windows are fitted with glass	0.22	0.15	0.17	0.515	0.32	0.48	0.103
	(0.42)	(0.35)	(0.38)		(0.48)	(0.50)	
Building is plastered	0.16	0.13	0.05	0.018	0.24	0.43	0.067
Roofing is iron sheets or tiles	0.90	0.89	0.87	0.612	0.97	0.95	0.591
Outside wall is bamboo or wood	0.81	0.89	0.94	0.110	0.62	0.48	0.160
Flooring is bamboo, wood or earth	0.67	0.70	0.93	0.000	0.22	0.28	0.492

Source: MHP follow-up household data set 2013. HoH = head of household

The families live in houses with on average three rooms. Only one fourth of the households has windows fitted with glass and 16 percent of the buildings are plastered. Most houses have iron sheets or concrete as roofing (90 percent), walls made of bamboo or wood (81 percent) and flooring made of bamboo, wood or in rare cases earth (67 percent). In Sumatra more households than in Sulawesi use higher value construction material like bricks or stones for walls and concrete or tiles for flooring. Furthermore we observe statistically significant differences between the EnDev 2 and EnDev 1 communities for several housing characteristics indicating that in Sulawesi EnDev 2 households are slightly better off than EnDev 1 households. In Sumatra more EnDev 1 households have windows fitted with glass and plastered buildings than among EnDev 2 households. This difference again can be ascribed to the EnDev 1 communities near the commercial plantation where houses are built differently than in the rest of the region.

Table 9: Share of total expenditure spent for various expenditure aggregates, yearly expenditure

Expenditure aggregate	**Average (N=374)**	**Sulawesi**			**Sumatra**		
		EnDev 2 N=141	**EnDev 1 N=135**	**p-value**	**EnDev 2 N=37**	**EnDev 1 N=61**	**p-value**
Food	0.48	0.43	0.42	0.612	0.63	0.63	0.941
Cigarettes	0.13	0.14	0.13	0.394	0.08	0.11	0.249
Transportation	0.08	0.08	0.08	0.822	0.09	0.07	0.374
School	0.08	0.09	0.07	0.263	0.08	0.06	0.176
Energy	0.06	0.07	0.05	0.065	0.06	0.04	0.064
Family and Religious Ceremonies	0.08	0.09	0.07	0.262	0.08	0.06	0.176
Agriculture	0.04	0.04	0.05	0.326	0.04	0.03	0.456
Clothes	0.04	0.04	0.04	0.179	0.03	0.04	0.057
Total yearly per capita household expenditure **(in 1 000 IDR)**	12,300	11,900	8,749	0.001	19,100	16,700	0.231

Source: MHP follow-up household data set 2013.
Note: Expenditures without auto- consumption.

The same differences can be observed if we look at expenditure data (Table 9). Generally expenditure levels are higher in Sumatra than in Sulawesi and in Sulawesi we observe statistically significant differences between EnDev 2 and EnDev 1 households that are also quite substantial (almost 30 percent higher). These higher expenditures indicate that monetary incomes are also considerably higher among EnDev 2 households. Table 9 depicts furthermore the eight most important expenditures categories: The biggest share is spent on food, followed by expenditures for cigarettes, transport, school fees and equipment, energy, ceremonies, agriculture and clothes. The monthly fees for using MHP electricity vary between 10,000 and 32,000 IDR depending on consumption level and community. This accounts on average for around 2 percent of yearly expenditures.

5.2. Outcomes

In the following sections on outcomes and impacts of the MHP intervention, we compare mean values before and after the intervention among EnDev 2 and EnDev 1 communities separately.

5.2.1. Electricity and Traditional Energy Sources

After excluding households connected to the PLN electricity grid and those few households that abstained from getting connected to the MHP (see Section 4.1), all remaining EnDev 2 households use electricity from the MHP connection. Some few EnDev 2 households additionally use a traditional waterwheel (kincir), a generator or a car-battery (see Table 10). In contrast, in 2010, one third of the EnDev 2 households used a kincir. Some also used generators.

Among EnDev 1 communities, we only look at households that used MHP electricity in 2010 and still use it in 2013. We do not observe any significant changes in additional electricity sources.

Table 10: Electricity sources

Electricity source	EnDev 2			EnDev 1		
	2010 N=179	2013 N=179	p-value (before-after)	2010	2013	p-value
MHP electricity	0.00	1.00	0.00	1.00	1.00	0.00
Traditional waterwheel (kincir)	0.30	0.01	0.00	0.00	0.01	0.317
Generators	0.10	0.03	0.018	0.01	0.01	0.562
Car-Batteries	0.00	0.01	0.317	0.00	0.00	-

Source: MHP household data set 2010/2013.

Apart from electricity, the most commonly used traditional energy source in 2013 among EnDev 2 households is firewood used for cooking by around 96 percent (see Table 11). In comparison to 2010 the share of households using firewood has decreased slightly (in favour of gas). This decrease is statistically significant at the five percent level but, amounting to only three percent, rather small in size. Also among EnDev 1 households the share of firewood user has only slightly decreased. Looking at the consumed quantity of firewood we see that the amount of bundles consumed also decreased among both EnDev 2 and EnDev 1 households. This effect could be expected to be a result of electricity access, since we see that both among treatment and control households the share of households using rice cookers has increased since electrification (see Section 5.2.2). However, having a closer look at these households with newly acquired rice cookers, reduction of firewood is not higher than among households without rice cooker. Hence, the reduction seems to be due to some other factor, not the rice cooker adoption (e.g. seasonality)[7]. Apparently, households with rice cookers use the saved wood from rice cooking for other purposes, i.e. they might cook more or more wood consuming dishes.

Table 11: Consumption of traditional energy sources

Energy Source and consumption per month	EnDev 2			EnDev 1		
	2010 N=179	2013 N=179	p-value (before-after)	2010	2013	p-value
Firewood (share of HH using)	0.99	0.96	0.032	1.00	0.99	0.082
(Consumption in bundles)	27.35	19.51	0.000	25	22	0.050
Kerosene (share of HH using)	0.98	0.87	0.00	0.90	0.96	0.010
(Consumption in litres)	5.42	2.00	0.000	3.00	1.44	0.000
for lighting	4.62	1.43	0.000	2.8	1.2	0.000
for cooking	0.76	0.82	0.879	0.33	0.23	0.580
Batteries (share of HH using)	0.30	0.48	0.000	0.06	0.45	0.000
(Consumption in pieces)	0.93	0.71	0.193	0.14	0.56	0.000
for lighting	0.63	0.72	0.663	0.06	0.26	0.007
for radio	0.27	0.00	0.007	0.07	0.05	0.660
Candles (share of HH using)	0.05	0.13	0.009	0.08	0.08	0.852
(Consumption in pieces)	0.21	0.46	0.337	0.60	0.10	0.078
Gas (share of HH using)	0.01	0.14	0.000	0.01	0.02	0.177
(Consumption in kg)	0.10	1.10	0.000	0.06	0.17	0.335
Charcoal (share of HH using)	0.03	0.01	0.153	0.01	0.00	0.317
(Consumption in kg)	0.08	0.17	0.508	0.01	0.00	0.318

Source: MHP household data set 2010/2013.

We observe a clear decrease in kerosene usage, although the usage rate remains to be on a high level. While in 2010 almost every household used kerosene, in 2013 still 87 percent do so (see Table 11). The quantity of kerosene has decreased substantially, though. Also among EnDev 1 households the kerosene consumption decreased, but less than among EnDev 2 households. The decrease of kerosene consumption among EnDev 2 households is driven primarily by a reduction of kerosene consumption for lighting, which makes up around ¾ of the kerosene consumption. Kerosene consumption for cooking stays roughly the same. The observation that electrified households still use kerosene for lighting can have two possible reasons: first, only few communities have public lighting so the villagers still need portable lighting sources for moving around outside after nightfall. Second,

[7] The reduction in firewood consumption is neither induced through the increased usage of gas for cooking. If we exclude households from the analysis that switched between baseline and follow-up from firewood to gas, we still see a significant reduction in firewood consumption.

households resort to traditional lighting sources in case of blackouts that happen quite frequently in many communities (see section 7 for more details on blackouts).

For battery consumption we have to distinguish battery usage for lighting and for radio operation. While the average consumption of batteries for lighting has not changed significantly among EnDev 2 households, the consumption of batteries for radio has gone down significantly. Batteries for radio usage have been completely replaced by electricity. The overall share of households using batteries has increased among EnDev 2 households. Among EnDev 1 communities, the increase in battery usage has been even stronger. These consumption patterns have to be valuated against the background of the global trend of decreasing costs for battery driven LED lamps in the last years. This trend leads to an increase of battery driven lighting device usage in most parts of the developing world. This is why both in treatment and EnDev 1 community households use more battery driven lamps than before. In electrified areas these lamps are normally only used outside or in case of blackouts. Accordingly, intensity of usage decreased in treatment communities in comparison to the before situation. For candles we see an increase in the share of households consuming candles as well as an increase in the intensity of consumption among EnDev 2 households. Also among EnDev 1 households, more households use candles in 2013 than in 2010, but intensity has increased stronger among EnDev 2 households. Usage of gas has increased significantly among EnDev 2 households and not among EnDev 1 households. We do not find any effects on charcoal consumption that is anyhow hardly used at all.

5.2.2. Non-productive appliances and lighting usage

At the baseline stage, kerosene run tin lamps were the most common lighting device among EnDev 2 households, used by 79 percent of all households. In the follow-up study, energy savers have taken over this position being used by 100 percent of EnDev 2 households (see Table 12). Due to MHP electrification the share of households using energy savers nearly doubled. Tin lamps have not been replaced completely, though. They are still used by 87 percent of the EnDev 2 households at the follow-up (which is even more than at the baseline stage), but only occasionally for moving outside or in case of blackouts. Usage time decreased from around six hours per day before electrification to 0.1 hours after electrification. We furthermore observe a slight increase in battery driven torch ownership and in the number of torches per household. It increased from 0.64 torches per household to 0.76 torches per household (statistically significant at 10 percent level). Lighting hours have not been elicited, since these torches are normally used if household members go out after nightfall or also in case of blackouts and thus rather irregularly. The usage of all other non-energy-saver lighting devices decreased. Some devices like neon fluorescent tubes, hurricane lamps or gas lamps have vanished completely. Few households started to use rechargeable lamps, which had not been used before.

The daily lighting hours of energy savers and electric bulbs increased substantially. Whereas in the baseline study electric bulbs and energy savers outside the house were lit on average around three hours per day, the number doubled or even tripled in the follow-up. Energy savers are used almost seven hours, normal bulbs even ten hours. Inside lighting also increased substantially, although the increase is slightly smaller than for outside lighting. One reason for this might be that in some communities households are asked by the MHP management not to switch off lights in order to stabilize the load over the operation time of the plant. Furthermore, households normally do not have a financial incentive to turn off lights. In all but one community households pay flat rates.

Table 12: Lighting Devices (in % of total households: DiD and mean follow-up values)

	EnDev 2			*Hours lit per day (only HHs using respective lamp)*		EnDev 1			*Hours lit per day (only HHs using respective lamp)*	
	2010	**2013**	**p-value**	**2010**	**2013**	**2010**	**2013**	**p-value**	**2010**	**2013**
Energy Savers	0.44	1.00	0.000	Outside 2.99 Inside 9.48	6.89 12.65	0.79	0.86	0.062	Outside 4.03 Inside 10.92	5.68 12.69
Electric Bulbs	0.07	0.03	0.053	Outside 3.15 Inside 6.77	9.80 10.00	0.50	0.37	0.011	Outside 7.47 Inside 8.48	8.38 11.25
Neon/ Fluorescent	0.01	0.00	0.317	Outside 12.00 Inside 12.00		0.05	0.01	0.010	Outside 4.22 Inside 10.56	0 10
Tin Lamps	0.79	0.87	0.047	5.95	0.10	0.66	0.95	0.000	5.12	0
Battery driven torch	0.58	0.65	0.191	n.a.	n.a.	0.46	0.57	0.026	n.a.	n.a.
Hurricane Lamps	0.19	0.00	0.000	8.64	-	0.23	0.00	0.000	1.46	-
Candles	0.05	0.02	0.158	--	--	0.08	0.02	0.006	--	--
Rechargeabl e Lamps	0.00	0.03	0.024	0.00	0.00	0.00	0.00	-	0.00	0.00
Gas Lamps	0.02	0.00	0.082	3.66	-	0.01	0.01	0.562	2	7

Source: MHP household data set 2010/2013.

Also among EnDev 1 communities, the share of households having tin lamps and battery driven torches increased. It seems these lamps are used as back-up lighting sources, since usage time is very short. The usage of hurricane lamps between baseline and follow-up decreased substantially.

While the number of lighting devices has not increased, the average daily lighting hours per lamp have increased substantially in EnDev 2 communities. Whereas each lamp among the EnDev 2 communities was lit on average 3.67 hours in the baseline, in the follow-up they were lit on average 7.06 hours. In total, the total lighting hours consumed per day summed up over all lamps among EnDev 2 households amounts to 13 hours in the baseline and 22 hours in the follow-up (statistically clearly significant). Looking at lumen hours consumed, we also observe a significant increase. While EnDev 2 households in the baseline consumed almost 13,000 lumen hours, their consumption more than tripled in the follow-up to 42,000 lumen hours. This increase is straightforward: While traditional lighting sources like tin lamps or hurricane lamps only emit 11 and 32 lm respectively, an 18 W energy saver emits 1000 lm (O'Sullivan and Barnes 2006).

Table 13: Lighting hours and lumen hours consumed per day (DiD and mean follow-up values)

	EnDev 2			EnDev 1		
	2010	**2013**	**p-value (before-after)**	**2010**	**2013**	**p-value**
Number of lighting devices	4.31	4.22	0.673	5.50	4.15	0.000
Daily lighting hours per lamp (without torches)	3.76	7.06	0.000	5.21	7.55	0.000
Sum of Lighting hours	13.01	21.52	0.000	24.34	23.82	0.586
Lumen hours	12,694	41,934	0.000	32,208	38,356	0.003

Source: MHP household data set 2010/2013.

Among EnDev 1 households, the number of lighting devices decreased between baseline and follow-up. This seems to be a long term effect of the electrification: It took EnDev 1 households a while to remove their traditional lighting sources.

Box 1: Disposal of batteries and energy savers

The increased use of battery driven LED lamps and energy savers bring along a problem that so far has not received a lot of attention: the disposal of hazardous waste, i.e. empty batteries and broken energy savers. According to focus group discussions and community-chief surveys, in the communities there is little health or environmental awareness concerning the disposal of these products. In most communities batteries and energy savers are thrown into the garbage which is either burned or buried in the ground. Sometimes households throw this waste directly into the bushes or the river. Some carpenters stated that they open empty batteries and use the battery acid for marking woods. Also around 20 percent of the households specify that they dismantle broken energy savers to use parts of it for other purposes. Only in one community (Wonorejo), kiosks offer energy savers with a replacement guarantee of a certain period. If the energy saver breaks within this period, customers can bring back the broken energy saver and get a new one. The kiosks, in turn, can exchange the broken lamp at their wholesaler in a nearby community.

Apart from lighting, EnDev 2 households use electricity above all for charging mobile phones, watching television and listening to the radio or music (see Table 14). Usage of appliances like mobile phone, TV, satellite receiver, and CD/VCD player doubled between baseline and follow-up. Among EnDev 2 households, 64 percent possess at least one mobile phone, 59 percent possess at least one TV, 48 percent a satellite receiver and 38 percent a CD/VCD player. The usage of rice cookers substantially increased from virtually non-existence at the baseline stage to 22 percent during the follow-up study. This increase is perceivable both in Sulawesi and Sumatra, even though the share of households with rice cookers is substantially higher in Sumatra. At the follow-up, 41 percent of households in Sumatra use rice cooker, while in Sulawesi only 17 percent do so. Charcoal irons have likewise been replaced by electric irons in most cases. Radios, in particular battery and bivalent radio, are less prevalent among EnDev 2 households in the follow-up than baseline. The reason for this is that television usage crowds out radio usage. Some few households furthermore started to use electric refrigerators that replace all formerly used fuel-run refrigerators. Apart from these appliances, appliances like computers, fuel-run mills, or electric mills are sporadically used.

Appliance ownership among EnDev 1 households has also increased substantially between 2010 and 2013 and shows that households do not make all investments immediately after electrification but still increase in the mid-term. Ownership of mobile phones, television, satellite receiver, rice cookers, electric irons, electric refrigerators and water cookers have all increased significantly in EnDev 1 households.

Table 14: Appliance usage (in % of total households; DiD and mean follow-up values)

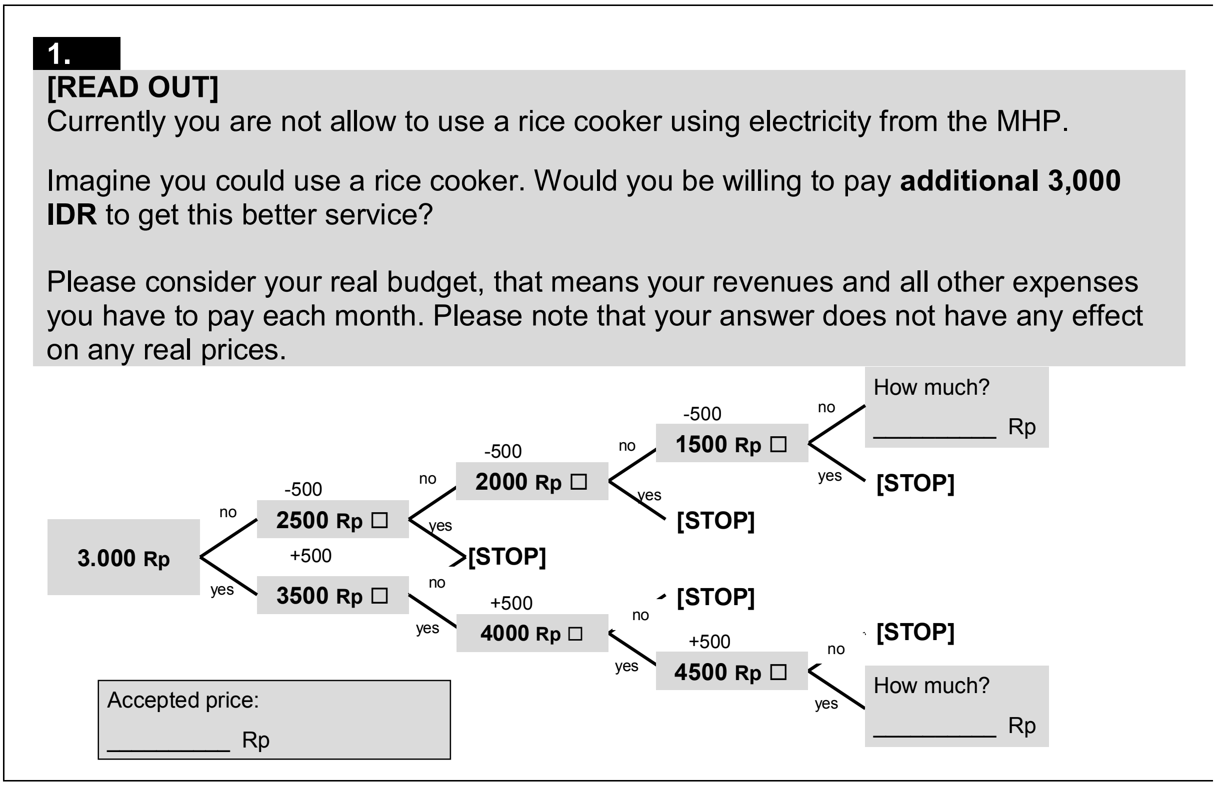
Share of HH using [*appliance*]	**EnDev 2**			**EnDev 1**		
	2010	**2013**	**p-value (before-after)**	**2010**	**2013**	**p-value (before-after)**
Mobile phone	0.31	0.64	0.000	0.49	0.64	0.002
Television	0.29	0.59	0.000	0.54	0.66	0.018
Satellite receiver	0.23	0.48	0.000	0.48	0.59	0.026
CD/VCD	0.18	0.38	0.000	0.38	0.41	0.470
Rice cooker	0.01	0.22	0.000	0.10	0.24	0.000
Magic Jar (keeping rice warm)	0.03	0.03	0.759	0.14	0.07	0.032
Electric Iron	0.04	0.16	0.000	0.20	0.27	0.120
Charcoal Iron	0.08	0.02	0.016	0.03	0.01	0.253
Radio:	0.27	0.14	0.002	0.17	0.16	0.589
(Line power only)	0.07	0.06	0.829	0.08	0.08	1.000
(Bivalent)	0.09	0.05	0.147	0.06	0.06	1.000
(Battery only)	0.11	0.02	0.001	0.04	0.02	0.359
Ventilator	0.02	0.06	0.102	0.01	0.01	0.562
Electric refrigerator	0.00	0.04	0.004	0.00	0.03	0.024
Fuel run refrigerator	0.02	0.00	0.082	0.01	0.00	0.317
Water cooker	0.02	0.02	0.703	0.02	0.09	0.001
Mechanical Sewing Machine	0.01	0.03	0.252	0.02	0.06	0.029
Electric Sewing Machine	0	0		0.01	0.00	0.317
Computers/ Laptop	0.00	0.06	0.001	0.00	0.02	0.044

Fuel run mill	0.00	0.01	0.156	0.01	0.04	0.032
Electric mill	0.00	0.01	0.317	0.00	0.00	-

Source: MHP household data set 2010/2013.

The substantial use of rice cookers both among EnDev 1 and EnDev 2 households (around 23 percent) comes as a surprise because in many communities it is officially forbidden to connect rice cookers. Rice cookers require between 500 and 1000 Watts and especially for MHP that do not have an electronic load control the usage might cause heavy voltage fluctuations. Nevertheless a substantial part of the households state that they use rice cookers. It can be suspected that real usage rates are even higher, since some users will not disclose the usage. The management teams of the different MHPs are widely aware of this but say that they are unable to stop households using rice cookers. In order to find out how much households would be willing to pay in order to be allowed to officially connect a rice cooker to the grid, we asked them for their willingness to pay to officially connect a rice cooker (see Figure 3). On average, both EnDev 1 and EnDev 2 households declared that they are willing to pay around 5,700 IDR more per month in order to be able to use rice cookers. Comparing this to monthly fees that are paid for usage of the MHP ranging between 5,000 and 20,000 IDR in most cases, this is a considerable amount.

Figure 3: Willingess to pay for usage of rice cooker



Note: The exercise does not imply any real time costs. Respondents are asked to give a hypothetical price.

5.2.3. Productive appliances

The productive usage of electricity in the communities is very low. In many cases the reason for this are the operation hours of the MHP that do not run during daytime when most productive activities are exercised. In this section we examine productive usage of electricity in households; electricity usage in micro-enterprises is under research in Section 6.1. The information is partly overlapping, since many of the micro-enterprises analysed in detail in Section 6.1 are home businesses.

Only very few appliances are used for productive purposes. The few existing ones are displayed in Table 15. The most frequently used appliances are non-electric appliances like fuel run mills and mechanical sewing machines (foot operated). The only electric machines are a rice cooker, electric carpentry appliances like sander or an electric saw, an electric brush, a coconut and chili grinding machine and a blender.

Table 15: Productive usage of appliances

Number of households using [*appliance*] productively	**EnDev 2**		**EnDev 1**	
	2010	**2013**	**2010**	**2013**
Fuel run mills	0	1	1	6
Mechanical sewing machine	0	1	1	2
Fuel-run refrigerator	0	0	1	0
Rice cooker	0	1	0	0
Electric carpentry equipment	1	1	1	0
Non-electric carpentry equipment	0	0	0	2
Electric brush	0	2	0	0
Coconut grinder	0	0	0	1
Chili grinding machine	0	0	0	1
Blender	0	1	0	0
Total HH with productive appliance	1	7	4	12

Source: MHP household data set 2010/2013.

5.3. Impacts

5.3.1 Energy expenditures

Energy expenditures are dominated by expenditures on electricity both before and after the MHP electrification. In 2010, EnDev 2 households spent on average 41,000 IDR on their pre-electrification sources and in 2013 they spend around 25,000 IDR per month for MHP electricity. The difference is close to statistical significance with a p-value of 0.128. While in 2013, all households use electricity and the standard deviation is relatively low, in 2010, only 40 percent of the households had expenditures for electricity. Accordingly, those who used to have an electricity source paid considerably more than in 2013. Here, especially genset users stand out with extremly high cost.

Electricity costs have also gone down among EnDev 1 households. Apparently, households in EnDev 1 communities pay less for electricity in 2013 than they did in 2010. This finding has been substantiated by interviews with community chiefs and MHP operators that show that contributions to the MHP have decreased in many of the communities (see further information in Section 7).

The second most important category are expenditures on kerosene. In line with expectations, these expenditures have gone down significantly among EnDev 2 households. We find that kerosene expenditures have also gone down among EnDev 1 households. This can be explained by the replacement of kerosene driven lamps by battery driven lamps. Here, the EnDev 1 communities contribute valuable information on general development trends: Only parts of the reduction on expenditures on kerosene can be ascribed to the electrification treatment. Another part is simply driven by general technological change that would also have happened without the electrification of the community. Among the EnDev 2 communities we furthermore observe a significant increase in expenditures for gas. This is due to the substantial increase in households using gas stoves.

Table 16: Monthly Energy Expenditures

Energy Expenditures per energy source	**EnDev 2**			**EnDev 1**		
	2010	**2013**	**p-value**	**2010**	**2013**	**p-value**
Electricity	41,057 (sd: 131,837)	25,444 (sd: 35,726)	0.128	18,396	16,071	0.059
Firewood	3,371	3,631	0.921	0	1,486	0.113
Kerosene	39,124	17,557	0.000	18,812	10,911	0.000
Batteries	1,854	2,456	0.337	242	1,982	0.001
Candles	320	1000	0.216	847	138	0.082
Gas	927	9,173	0.000	490	1,240	0.368
Charcoal	105	211	0.508	10	0	0.318
Total energy expenditures	86,758	59,471	0.014	38,797	31,827	0.009
Share of energy expenditures in total expenditures	0.09	0.07	0.019	0.05	0.05	0.484

Source: MHP household data set 2010/2013.

Looking at total energy expenditures in the EnDev 2 communities, we observe a significant decrease for EnDev 2 and EnDev 1 households. As discussed above, the reduction among EnDev 1 households is mainly due to the reduction in kerosene expenditures but also MHP contributions.

The low expenditures on firewood illustrate that most of the households do not buy firewood but collect it with strong implications for people's work load. In contrast to most African countries, collecting firewood in Indonesia is primarily exercised by adult men. At the time of the follow-up, only around 15 percent of the persons who collect firewood are women. The average age is 40 years and only ten percent of the persons searching firewood are younger than 16 years. The time households spend per week on collecting firewood amounts to around 6.5 hours and is not affected by electrification (see Table 17).

Table 17: Time used collecting for firewood

	EnDev 2			EnDev 1		
	2010	2013	p-value	2010	2013	p-value
Time spent per week in hours	6.6	6.4	0.655	6.0	6.3	0.497

Source: MHP household data set 2010/2013.

5.3.2. Access to information

The most important information source in EnDev 2 communities in 2010 used to be TV and informal communication channels like friends and neighbours (see Table 18). While the informal communication lines increased slightly over the time, especially the importance of TV grew extraordinary. In 2013, 84 percent of all EnDev 2 households indicate that TV is their main source of information. The importance of TV also grew among EnDev 1 households, even though this increase is not as big as among EnDev 2 households. In turn, the importance of friends and neighbours increased even stronger among EnDev 1 households. Radio and newspapers, the third and fourth most important information source are substantially less frequently named (around five percent).

Table 18: Main Source of Information (open question; multiple answers possible)

	EnDev 2			EnDev 1		
	2010	2013	p-value	2010	2013	p-value
TV	0.39	0.84	0.000	0.62	0.86	0.000
Friends and Neighbours	0.41	0.53	0.026	0.19	0.61	0.000
Radio	0.06	0.07	0.660	0.01	0.06	0.011
Newspaper	0.06	0.05	0.841	0.04	0.04	0.792

Source: MHP household data set 2010/2013.

The significant increase in TV usage can also be confirmed when looking at ownership of information technology (Table 19). Among EnDev 2 households, the share of households using TV has increased significantly from 29 percent to 59 percent. Furthermore, also mobile phone ownership has increased significantly even though nobody named mobile phone explicitly as the main source of information. Radio ownership has even decreased between 2010 and 2013. We observe the same pattern among EnDev 1 households for TVs and mobile phones. Only radio ownership decreased between 2010 and 2013 in these communities.

Table 19: Information technology used by households

	EnDev 2			EnDev 1		
	2010	2013	p-value	2010	2013	p-value

Share of households with TV	0.29	0.59	0.000	0.54	0.66	0.018
HH has mobile phone	0.32	0.64	0.000	0.49	0.64	0.002
Number of mobile phones	0.34	0.97	0.000	0.52	0.91	0.000
Share of mobile phone owners charging phone at home	0.65	0.99	0.000	1.00	1.00	-
Share of households with radio	0.27	0.14	0.002	0.18	0.16	0.589

Source: MHP household data set 2010/2013.

Asking the head of households and their spouses for the preferred programs they watch on TV it turns out that both name news as their preferred TV program. The question was asked openly and we did not propose any answers. The decision which program is watched is mostly decided by children under 18 years (in 45 percent), followed by the head of household (42 percent) and in some cases also by the spouse (14 percent).

Table 20: Preferred TV programme EnDev 2 households

	EnDev 2			**EnDev 1**		
	2010	**2013**	**p-value**	**2010**	**2013**	**p-value**
Preferred TV program of head of household						
News	0.82	0.95	0.001	0.78	0.93	0.000
Sports	0.53	0.59	0.434	0.51	0.60	0.143
Movies	0.15	0.35	0.006	0.08	0.27	0.000
Soap Operas	0.24	0.09	0.009	0.12	0.10	0.617
Preferred TV program of spouse						
News	0.46	0.80	0.000	0.50	0.79	0.000
Soap Operas	0.83	0.67	0.010	0.85	0.74	0.026
Movies	0.09	0.34	0.001	0.09	0.28	0.001
Sports	0.06	0.06	0.989	0.02	0.08	0.046

Source: MHP household data set 2010/2013.

The time household members watch TV (see Table 21) has increased significantly among EnDev 2 households. Also household members among EnDev 1 communities have more TVs and the average time they watch TV increased.

Table 21: Time household members watch TV

	EnDev 2			**EnDev 1**		
	2010	**2013**	**p-value**	**2010**	**2013**	**p-value**
Head of household	1h10	2h22	0.000	1h46	2h24	0.000
Spouse	0h49	1h59	0.000	1h22	2h00	0.000

Children 12-17 male	0h55	1h31	0.015	1h07	1h31	0.025
Children 12-17 female	0h50	2h01	0.000	1h10	1h34	0.092
Children 6-11	0h45	1h47	0.000	1h08	1h38	0.048

Source: MHP household data set 2010/2013.

In 2013 we asked households for different activities they might use their mobile phone for. Every households having at least one mobile phone had to answer whether or not they use their mobile phone for the specified activities. As to be expected, mobile phones are most of all used for communication, i.e. calling people outside the community or even province. The second most important activity is using the phone as torch for lighting or as a radio. Only 12 percent use the mobile phone as a source of information. Nobody transfers money with the mobile phone.

Table 22: Mobile phone usage pattern (all mobile phone owners, EnDev 1 and EnDev 2)

	2013
Uses mobile phone for	
Calling people outside the community	0.87
Calling people outside the province	0.63
Use as torch for lighting	0.47
Use as radio	0.22
Getting information on agricultural prices	0.12
Getting information on political news	0.02
Sending or receiving money	0

Source: MHP household data set 2010/2013.

In 2013 virtually all households charge their mobile phone at home, on average 4.3 times per week. In 2010, the distance to the charging place was on average 2.5 km and the median length 500 m. In the whole sample only one person used to pay for charging the telephone. The rest of mobile phone owners who did not have electricity at home could charge their phone for free at friends' houses or public institutions.

5.3.3 Gender and attitudes

Analysing the patterns of who decides over the household budget shows that both in 2010 and 2013 in around three forth of the households, women decide where and when to spend money. Looking at the EnDev 2 communities only, we observe that power over the household budget shifted from men towards a joint decision of men and women. The same trend can be observed in EnDev 1 communities. It is not clear whether this shift is rather a general development in the surveyed areas or an impact of electrification. The results could be driven by both and unfortunately we are not able to disentangle the two effects.

Table 23: Decision maker on household budget

	EnDev 2			EnDev 1		
	2010	**2013**	**p-value**	**2010**	**2013**	**p-value**
Woman decides alone	0.76	0.76	0.901	0.81	0.82	0.876
Woman decides together with man	0.05	0.17	0.000	0.00	0.13	0.000
Man decides alone	0.20	0.06	0.000	0.18	0.05	0.001
Pregnant woman in household	0.03	0.05	0.275	0.03	0.04	0.792

Source: MHP household data set 2010/2013.

The improved access to information as well as the wider variety of activities in the evening might have an effect on the fertility of women. During baseline and follow-up we asked whether any woman in the household is pregnant. In only three percent of the households a women was pregnant at the baseline stage. At the follow-up, the share is slightly higher at five percent. The difference however is statistically not significant and since the event is quite rare the difference has to be interpreted with care. We do not observe any differences between EnDev 1 and EnDev 2 communities. These results do not necessarily mean that electrification does not have an effect on fertility. Since it is probably a rather slow process of change that will only result in minor changes over such a short time period as two years it might be possible that we are unable to detect these changes given the relatively small sample size.

5.3.4. Time use and activities

The availability of electric lighting and an increased usage of television in the evening hours is often expected to influence the daily routine of the household members. When analysing the time use of household members, though, we have to bear in mind that baseline and follow-up data has not been conducted in the same season.

The baseline survey was conducted in September and October which is the end of the dry season. The follow-up survey was conducted in January and February which is plain rainy season. In rainy season, agricultural activities are more intense and, for example, drying crops in the sun – one of the regular agricultural activities household members are pursuing during the whole year - is more time-intense because household members have to cover or remove the crops several times a day in order to protect them from the rain and still make use of the scarce sunshine hours. Due to the more intense work during day-time, household members need more rest and sleep earlier. Furthermore, evening activities are less, since there is not so much to do in the communities if it is raining outside.

Table 28 displays the time at which the different household members get up in the morning, at what time they go to sleep and the total time they are awake. In fact, we see exactly the pattern described above. If we only look at the EnDev 2 communities, we observe a significant decrease in the time children are awake. In 2013, they are between 30 and 50 minutes less awake than in 2010. It is driven both by getting up later and going to bed earlier. Data on EnDev 1 households indicates that also the time awake of children in these households is lower in 2013 than in 2010. Given the existence of seasonal effects, we are unfortunately unable to draw any conclusion on the effect of electrification. If there was an effect of electrification it would point into the opposite direction and possibly some of the seasonally caused decrease in time awake might be weight off by an increase of time awake due to increased lighting and entertainment devices ownership.

For the head of household, though, we don't observe significant changes neither among the EnDev 2 communities nor among EnDev 1 communities. For spouses, we see a borderline significant increase (12 percent level) in time awake among EnDev 2 households while EnDev 1 households are slightly less time awake. Again, we are unable to disentangle the effects of seasonality from a possible effect of electrification here. One would expect that also adults are less time awake during rainy season and it might be electrification that counteracts this effect leading to the situation that we do not detect any effects.

Table 24: Time awake

		EnDev 2			**EnDev1**		
		2010	**2013**	**p-value**	**2010**	**2013**	**p-value**
Hoh	gets up	5h24	5h25	0.884	5h26	5h23	0.607
	goes to bed	21h25	21h20	0.478	21h32	21h06	0.000
	is awake	15h58	15h55	0.662	16h06	15h43	0.662
Spouse	gets up	5h05	4h58	0.125	5h05	5h04	0.742
	goes to bed	20h59	21h03	0.503	21h08	20h58	0.037
	is awake	15h55	16h04	0.125	16h03	15h54	0.125
Children 6-11	gets up	5h45	6h02	0.001	5h50	5h57	0.145
	goes to bed	20h44	20h17	0.000	20h51	20h20	0.000
	is awake	14h59	14h20	0.000	15h01	14h23	0.000
Male children 12-17	get up	5h34	5h46	0.112	5h30	5h46	0.024
	go to bed	21h14	20h37	0.000	21h21	20h42	0.000
	are awake	15h40	14h50	0.002	15h52	14h56	0.002
Female children 12-17	get up	5h38	5h36	0.919	5h43	5h23	0.221
	go to bed	21h04	20h52	0.181	21h11	20h37	0.000
	are awake	15h42	15h16	0.039	15h42	15h16	0.039

Source: MHP household data set 2010/2013.

Also, we suspect the time the head of household and the spouse spend on income generating activities (mostly agricultural activities, see Table 25) to be influenced by seasonal changes: Household members spend significantly more time working during the follow-up compared to the baseline. This increase in working time can be observed both among EnDev 2 and EnDev 1 household, most among spouses. Spouses work almost 2 hours more in income generating activities. The time they spent on housework is decreased respectively.

Table 25: Working time

	EnDev 2			Endev 1		
	2010	**2013**	**p-value**	**2010**	**2013**	**p-value**
Head of HH income generating activities	6h59	7h08	0.408	7h25	7h25	0.952
Spouse income generating activities	2h49	4h42	0.000	3h23	5h08	0.000
Head of HH housework	0h28	0h34	0.566	0h30	0h44	0.079
Spouse housework	5h23	3h29	0.000	4h58	3h17	0.000

Source: MHP household data set 2010/2013.

For children's study behaviour, we observe a general and often significant decrease in study time if we look at the EnDev 2 communities only, especially after nightfall. Again the DiD indicates no changes and accordingly also among EnDev 1 households children study less. This decrease could either be driven by seasonality or a general decrease in study time because both in EnDev 1 and EnDev 2 communities children experience more distraction, e.g. through the possibility of watching TV. However, since study time after nightfall of children who do not watch TV after nightfall also decreases significantly, we suspect the decrease to be driven by seasonality.

Table 26: Children Studying

	EnDev 2			EnDev 1		
	2010	**2013**	**p-value (before-after)**	**2010**	**2013**	**p-value**
Children between 6-11						
After nightfall	0h32	0h18	0.006	0h42	0h20	0.000
Total studytime	1h07	0h41	0.011	1h09	0h37	0.000
Male children between 12-17						
After nightfall	0h44	0h26	0.043	0h48	0h26	0.004
Total studytime	1h12	0h56	0.228	1h30	0h59	0.201
Female children between 12-17						
After nightfall	0h46	0h26	0.024	0h42	0h26	0.036

Total studytime	1h36	0h46	0.001	1h26	0h56	0.009
All children in households with children						
After nightfall	0h59	0h36	0.004	1h14	0h46	0.001
Total studytime	1h56	1h17	0.014	2h10	0h90	0.009

Source: MHP household data set 2010/2013.

Asking household members which other activities they pursue after nightfall shows that most of them read or pray after nightfall.

Table 27: Other activities after nightfall

	EnDev 2			EnDev 1		
	2010	**2013**	**p-value**	**2010**	**2013**	**p-value**
Head of household						
Praying	0.20	0.29	0.050	0.23	0.30	0.152
Reading	0.02	0.30	0.00	0.01	0.34	0.00
Listen to radio or music	0.02	0.05	0.265	0.01	0.03	0.280
Spouse						
Praying	0.19	0.34	0.003	0.21	0.36	0.001
Reading	0.00	0.30	0.000	0.01	0.37	0.000
Listen to radio or music	0.00	0.04	0.007	0.01	0.00	0.318

Source: MHP household data set 2010/2013.

5.3.5. Health

Both in EnDev 1 and EnDev 2 households many people report that indoor air quality has improved since the connection to the MHP. Among EnDev 1 households around 44 percent of households have noticed an improvement; among EnDev 2 households around 60 percent have done so. As the reason for improvement most households name that the air now is brighter and fresher. The second most frequent answer is that they feel warmer at night because of the lamp, which is a bit puzzling as energy savers hardly emit any heat.

Table 28: change in indoor air

	2013		
	EnDev 2	**EnDev 1**	**p-value**
Indoor air has improved	0.60	0.44	0.002
Indoor air has deteriorated	0.01	0.01	0.923
Reason for improvement			

Air became brighter and fresher	0.67	0.67	0.946
No smoke anymore	0.00	0.02	0.114
Feel warmer at night because of lamp	0.34	0.28	0.368

Source: MHP household data set 2010/2013.

This supposedly better indoor air quality does not translate into a measurably better health status of household members. First of all, for EnDev 2 households we see substantially more household members reporting headaches, respiratory diseases or eye infections in 2013 than in 2010. This, however, is probably again driven by seasonality: All of these diseases are generally more frequent in the rainy season. Similar effects can be observed among EnDev 1 households – which is in line with the seasonality suspicion.

Similar as for effects on fertility, these results do not necessarily mean that electrification does not have an effect on health. Improvements in health – if they existed – are probably rather small and possibly in the beginning not necessarily noticeable for household members. It is again quite likely that we are unable to detect these changes given the relatively small sample size and short study period using these self-reported indicators.

Table 29: Household members with health problems

	EnDev 2			**EnDev 1**		
	2010	**2013**	**p-value**	**2010**	**2013**	**p-value**
Headache						
Male adult suffers from [disease]	0.15	0.50	0.000	0.23	0.55	0.000
Female adult suffers from [disease]	0.16	0.54	0.000	0.26	0.60	0.000
Male child <18 suffers from [disease]	0.06	0.11	0.056	0.06	0.14	0.011
Female child <18 suffers from [disease]	0.06	0.14	0.012	0.06	0.13	0.025
Respiratory disease						
Male adult suffers from [disease]	0.03	0.28	0.000	0.04	0.33	0.000
Female adult suffers from [disease]	0.03	0.26	0.000	0.02	0.35	0.000
Male child <18 suffers from [disease]	0.02	0.14	0.000	0.01	0.19	0.000
Female child <18 suffers from [disease]	0.01	0.16	0.00	0.00	0.12	0.00
Eye disease						
Male adult suffers from [disease]	0.01	0.05	0.010	0.02	0.09	0.001
Female adult suffers from [disease]	0.02	0.11	0.000	0.01	0.08	0.001
Male child <18 suffers from [disease]	0.00	0.01	0.317	0.01	0.02	0.315
Female child <18 suffers from [disease]	0.00	0.02	0.082	0.00	0.03	0.024

Source: MHP household data set 2010/2013.

5.3.6. Security

For questions on security, we observe again differences among EnDev 2 households that are probably driven by seasonality. We detect a significant reduction of times children leave home after night – both among EnDev 2 and EnDev 1 households.

We find however significant effects on how EnDev 2 households judge different situations after nightfall. The number of respondents that state they are afraid when being outside after nightfall has decreased significantly, while we do not observe any change among EnDev 1 households. The same applies to respondents stating that they are afraid if their children are outside after nightfall. Surprisingly, the share of respondents that is afraid when being at home increased substantially at the same time.

Table 30: Security

	EnDev 2			EnDev 1		
	2010	**2013**	**p-value**	**2010**	**2013**	**p-value**
Times going out after nightfall per week						
Hoh	2.17	2.19	0.938	1.78	1.58	0.332
Spouse	1.48	1.08	0.144	0.92	0.72	0.253
Male children 12-17	1.29	0.77	0.154	1.10	0.78	0.292
Female children 12-17	1.03	0.28	0.00	1.00	0.31	0.003
Children 6-11	0.95	0.39	0.011	1.07	0.41	0.004
Respondent afraid when						
Being outside after nightfall	0.47	0.30	0.001	0.45	0.44	0.718
Children are outside after nightfall	0.99	0.70	0.000	0.99	0.79	0.000
Being at home at night	0.01	0.06	0.006	0.03	0.03	0.760
Respondent thinks darkness is dangerous	0.86	0.91	0.189	0.89	0.91	0.399

Source: MHP household data set 2010/2013.

6. Electricity in micro-enterprises, health infrastructure and schools

6.1. Micro-enterprises

6.1.1 Micro-enterprises in surveyed communities

The economy of the surveyed communities is dominated by agricultural activities. Beyond this, only few shops or other businesses exist. These businesses are very small and normally do not serve as the primary income source of their owners.

The most prevalent types of micro-enterprises are kiosks, carpenters – who primarily produce furniture-, joiners –who primarily produce houses -, tailors and agro-processors. The number of enterprises varies considerably among the communities, depending on the size and infrastructural endowment of the community. In an average community, there are 15 kiosks, 11 joiners, four agro-processors, two carpenters and two tailors per community (see Table 31). In addition, there are a few weavers (in Sulawesi), saw millers, beauty salons, few automotive workshops, as well as some welders and blacksmiths scattered in some communities.

Table 31: Number of most frequent micro-enterprise types and connection status

	EnDev 2	EnDev 1
Kiosks (# per community)	17.8	10.5
Number of communities with kiosk	13	13
Joiners (# per community)	10.9	11.3
Number of communities with joiners	12	13
Agro-Processors (# per community)	4.2	4.2
Number of communities with agro-processors	12	12
Tailors (# per community)	3.2	0.9
Number of communities with tailors	10	6
Carpentry (# per community)	1.9	2
Number of communities with carpenter	6	6

Source: Community data 2013.

In general, micro-enterprises run their business on demand only, since the lack of money for material and uncertainty of demand do not allow them to produce on stock. In fact, most micro-entrepreneurs pursue other income generating activities in times of deficient demand, which are mainly agricultural activities, but also motorcycle transportation services (‘*ojek*’), teaching, or helping out in other micro-enterprises. Micro-entrepreneurs usually do not have employees. They rather draw on unpaid family help if an order has to be finished on time. Virtually all produced goods are sold and consumed locally.

Within the surveyed communities, there are hardly any businesses without electricity connection, since most businesses are located on the owner’s compound, which normally has an MHP connection. While some micro-entrepreneurs have a constant additional cable to the working shed, some other micro-entrepreneurs switch their private cables to the working shed when needed. Nonetheless, electricity is only rarely used for operating appliances. Normally it is only used for lighting; if appliances are used this is done by generators or sometimes even electricity from the national PLN grid. The reason is that, first, in most communities the MHP is switched on only in the evening hours and most micro-entrepreneurs normally work only during day-time. Working at night is partly even depreciated by some communities from a cultural point of view. Second, the connection of heavier appliances is often forbidden by the MHP management, since MHP´s capacity is assumed not to be sufficient. Even if it is officially (i.e. based on TSU’s recommendation) not forbidden the technical installations are often not suitable for connecting heavy machines (i.e. no electronic load control) so many micro-entrepreneurs state that they do not dare to connect appliances because they fear they could damage the MHP or their appliances. They often fear to be held responsible if anything happens to the MHP. These concerns could in many cases be solved but in fact often preclude enterprises from connecting appliances. Some few communities operate the MHP during day time; some other communities are planning to do so. In exceptional cases MHPs also offer the possibility to switch on the MHP during daytime if needed. In one community this service is for free, in two communities users have to pay an extra-fee. This fee, though, is prohibitively high (around 100,000 Rp per day) and so far nobody has ever made use of this service.

6.1.2 Electricity Usage in most frequent enterprise types

Positive impacts of electrification on the business environment are expected to be either the emergence of new businesses or the improvement of existing ones. For an already existing business, impacts are expected to be money and/or time savings through better equipment, better quality or new products, higher productivity, longer operation hours and an increase in security leading possibly to higher owner income. The impacts on the community level could be employment creation, the availability of higher quality products or new products and price effects. Here it is of utmost importance to enquire at which markets products are sold and if other locally produced goods are crowded out in order to assess net benefits. Most positive net income effects on the community level can only materialise if products that used to be produced outside the community are now produced locally or if enterprises manage to serve markets outside the community.

Table 32 gives an overview on impacts of electrification on the most frequent enterprise types in the surveyed communities. In the annex each of the enterprise types is portrayed in more detail and effects are discussed for each of them. Generally, it becomes clear that only few enterprises have been able to generate additional income due to the MHPs. Impacts are rather on a softer level. Electric lighting at night increases the owner´s safety feeling, and particularly, his flexibility due to the possibility of exceptionally working at night if required. Expenditures for traditional lighting sources are reduced. This might of course positively affect the performance of the firm, but this effect can be expected to be rather subtle. Irrespective of whether a firm uses electricity for productive purposes, the lack of demand remains the main obstacle for micro-enterprises and prevents an increase in income. Only very few micro-enterprises, mostly carpenters, face a sufficiently strong demand that would allow them to augment sales by increasing their production. These enterprises, though, face a further major constraint: The non-availability of sufficient inputs, in this case: wood.

In a nutshell, the major bottleneck for firm expansion is the lack of demand, followed by non-availability of certain inputs. Micro-enterprises might extend opening hours or flexibility, perceived safety, convenience, and the product´s quality due to electricity in general and MHP in particular. This however, would only translate into an increase in income, if either the quantity could be expanded or the price increased. Both is not possible, since local markets for established products are already saturated before electrification.

If a micro-entrepreneur nevertheless achieves to increase his income, it is at another enterprise's expense and it hence usually does not increase the net community income. Since a micro-entrepreneur´s potential additional income is coming only from residents of the community, who have to reduce their expenditures elsewhere to increase spending at the aforementioned firm. The only net income effect on the community level is induced through the households' and micro-enterprises' savings of traditional energy expenditures, mostly for lighting or in few cases for generator usage. Since these energy sources like petrol and kerosene had formerly been bought outside the community, households and entrepreneurs now have more disposable income that they could spend locally, which thereby could increase the community's income if it is absorbed by local production.

Table 32: Effects of MHP electricity on most frequent enterprise types

	Kiosk	Joiner	Carpenter	Tailor	Agro-processing
Connection to MHP?	Virtually all connected	No, no permanent work place	Some	Virtually all connected	Virtually all connected
Other electricity sources?	Few with additional electricity sources	Mainly use gensets	Mainly use gensets	No	Many appliances run on fuel
MHP electricity used for					
…Electric Lighting	Yes	n.a.	Yes	Yes	Yes
..Operation of Equipment	Normally not. Very few TVs, refrigerators or blenders	n.a.	Normally not driven by MHP but by generator	Normally not. Still work with manual machines	Few appliances directly operated in power house, remaining appliances normally run on fuel
…Communication	Not used productively	n.a.	Not used productively	Not used productively	Not used productively
Impacts					
Longer opening hours	Yes	n.a.	No. Demand is too low	Demand is too low; shift into evening hours	occasionally
Safety / Security	Yes	n.a.	Yes	No	Yes
Higher product quality / new products	Exceptionally new products (ice-cream, cooling or fruit juices)	n.a.	No, appliances existed before and are mostly operated with generator	Only trough electric sewing machines (hardly used)	no
Money saving	yes	n.a.	Yes	yes	yes
Time saving	No	n.a.	Yes	no	Yes
Employment creation	No	n.a.	No	no	no
Firm creation?	Low	n.a.	No	no	no
Netto effects on community level	No income generation on community level since virtually all products are sold and consumed locally Only possible effect through more disposable income of HH through MHP	n.a.	Only for communities where carpenters serve demand from outside the region (exceptional cases) Only possible effect through more disposable	No income generation on community level since all products are sold and consumed locally Only possible effect through more disposable income of HH through MHP	No income generation on community level since all products are sold and consumed locally (except for coffee processor) Only possible

	electrification	income of HH through MHP electrification	electrification	effect through more disposable income of HH through MHP electrification

Source: Semi-Structured Interviews with micro-enterprises in surveyed communities 2013.

6.2. Electricity Usage in Social Infrastructures

6.2.1 Schools

Most of the surveyed communities have at least a primary school (see Table 33). These schools (Sekolah Dasar, or SD) offer six years of schooling for children at the age of six to twelve and are compulsory. Communities without a primary school are usually located in walking distance to another community with a primary school. The Indonesian educational system foresees additional three years of compulsory schooling at a junior high school (*Sekolah Menengah Pertama*, or SMP), which exists in around 30 percent of the surveyed communities. For continuing education children usually have to migrate, since there are rarely senior secondary schools *(Sekolah Menengah Atas, or SMA* and no vocational or pre-professional secondary schools (Sekolah Menengah Kejuruan, or SMK) in or around most communities. In treatment communities additional early childhood education for children under six years (*Pendidikan Anak Usia Dini*, PAUD) exist.

Table 33: Schools in surveyed communities

	Endev 2	Endev 1
Share of Communities with School	0.85	0.92
... primary school (SD)	0.85	0.92
… junior high school (SMP)	0.38	0.31
… senior high school (SMA)	0.23	0.00
… early childhood education (PAUD)	0.31	0.00
Share of schools connected to MHP	0.57	0.50

Source: Community data 2013.

More than 50 percent of all schools on the surveyed communities are connected to the MHP. However, electricity is hardly used: First of all, MHPs are usually only switched on during nighttime. Lectures, though, are held during daytime, lasting at most until 3 pm. Irrespective of MHP´s operating hours, electric lighting is seen by many teachers, parents and children as useless in schools, because they deem daylight to be sufficient. Occasionally, electric lighting is used for meetings of teachers or parents with teachers in the evening. No further evening activities exist. In those communities, where MHP is operating 24 hours daily or where the MHP runs occasionally on Fridays or for special occasions during daytime, some appliances are used. They are usually provided by the government or rented from other villagers. The most frequent appliance used are radios and speakers, which schools use for exercising sports. Some schools have microphones that they use for announcements or warnings. TV´s are rarely used for children´s education. Computers and Laptops are very rare and are rather used for administrative tasks of teacher`s for children´s education. One school offers typing lessons for children. Two schools that possess donated laptops and one that possesses a printer declared not to use them because they do not know how to use them.

The main reason for schools not to be connected is the location of many schools. Typically, the school building is located a bit outside of the community in order to facilitate access to school to as many neighbouring communities as possible. Accordingly, connecting the schools would require long cables, and thus high costs. Very few of these non-connected schools use a generator.

During several focus group discussions with teachers, head of schools and parents, participants mostly agreed that children show more enthusiasm to go to school and during lessons if there is electricity in school. In particular the radio, which supports sport exercises, is seen as attractive for children. Parents and teachers think that their children enjoy the lectures much more when there are electric appliances. This was confirmed by several primary school students, while junior high school students seem to partly even prefer the old fashioned way of teaching via books instead of animated videos on television. In general, however, teachers, parents and students agreed on the fact that children became smarter through electrification. Whereas the majority of parents and teachers explain this by increased studying hours at home, some parents argue that their children rather spent their time in front of the television or are heavily distracted by it.

Television and its contents are usually not suspected to positively influence the children´s education, since the TV series are rather regarded as funny nonsense for children. Few mothers rather claim that their children mimic aggressive behaviours of cartoon characters. Most parents thus ban their children from watching certain series, particularly series that contain fighting sequences.

A few head of schools claimed that in electrified communities it would be easier to attract better skilled teachers.

6.2.2 Health Centres

92 percent of the EnDev 1 communities and all of the EnDev 2 communities provide basic health infrastructure. In 85 percent of the communities there is a health service post (Posyandu), providing vaccinations and basic nutritional supplements among the community. In 77 percent of the EnDev 1 communities and in 46 percent of EnDev 2 communities, there are community health subcentres (Pustus). Pustus support units of the community health centres (Puskesmas) offering basic primary health service, but are much smaller and less equipped. These pustus are often very simple buildings located at some distance from the community centres or sometimes do not even have a permanent building. This is why Pustu services are often carried out in private houses of the nurse or others. Puskesmas exist only in 8 percent of the EnDev 1 communities and in 31 percent of the treatment communities. However, Puskesmas of surrounding communities usually are accessible within a short distance. Furthermore, there are usually regular health care visits within the communities, when health staff is looking after villagers or provide vaccinations.

Table 34: Health Infrastructure in surveyed communities

	Endev 2	Endev 1
Share of Communities with Health Centres	1.00	0.92
… health service post (Posyandu)	0.85	0.85

... community health subcentre (Pustu)	0.46	0.77
... community health center (Puskesmas)	0.31	0.08
... other health structure	0.15	0.08
Share of health centres connected to MHP	0.57	0.61

Source: Community data 2013.

Among all health centres in EnDev 2 communities, 57 percent are connected to MHP. The share is slightly higher among EnDev 1 communities and amounts to 61 percent. Similar to schools, benefits of MHP are low in health centres if MHP is not active during daytime. Low benefits in relation to often high connection costs, resulting from remote locations of some health centres, precludes health centres from connecting to the MHP. Additionally, appliances that require electricity are rarely available in health centres. Lighting is the most frequent appliance among connected health centres. Whereas it can usually not be used before evening, it is possible to shift certain jobs to evening hours, e.g. for using lighting when working with the non-electric microscope. Besides lighting, there are computers or laptops for administration in a small number of health centres. Electric fridges for the temporary storage of vaccinations face the problem of a cooling interruption if MHP is switched off during daytime. Whereas vaccinations get usually injected right after delivery, remaining vaccinations are stored in nearby fridges of households connected to PLN if possible. Furthermore, in very few cases, there are appliances for staff´s entertainment (TV and radio) and comfort (rice cooker). Health staff and several villagers agree that electricity, respectively lighting and particularly entertainment appliances, increased the attendance of staff in health centres. As a result, the number of health visits is supposed to have increased among the villagers, who now claim to feel better off, due to more reliable health service.

7. Sustainability of the intervention

The sustainability of the MHP schemes depends crucially on the management of the plants and the organisation of the respective community. We came across both strikingly well organized and maintained MHP schemes, while others exhibited worrying organisational and technical problems. The following section summarizes the results of the community visits in general and interviews with community chiefs and MHP operators both on EnDev 1 and EnDev 2 sites. In order to assess and compare the sustainability of the two project phases, it is important to remember the differences between the two phases:

- EnDev 1 had no technical support unit and building approaches (both material and procedure wise) differed strongly among individual sites. The lack of quality standards and the resulting poor operational performance of some EnDev 1 sites led to the stronger focus on technical supervision through TSU in the second phase.
- Budgets were generally lower for EnDev 1 plants compared to EnDev 2 plants. As a results, the project staff expect EnDev 2 plants to be constructed with higher quality material.

Furthermore, they claim the quality of components to have increased with time since most parts are manufactured in Indonesia and EnDev 2 could rely on capacity built during EnDev 1.

Overall, EnDev 2 plants seem to be designed in a more sustainable way than EnDev 1 plants, which does not only result from their shorter operation time.

Application process

The PNPM programme in general is omnipresent in the surveyed region. In virtually all communities PNPM has financed some small infrastructure project. Among the surveyed communities all but four communities have received also other funds from PNPM apart from the MHP funds. Most frequently financed projects are paving small roads, an irrigation systems or improvements of fresh water supply.

Accordingly, most community officials had already been in contact with PNPM facilitators on the local level and the application to the MHP funds in most cases has been initiated by community officials. More than 60 percent say that it was the community as a whole that applied for the MHP funds. In practice this means that the community decides in village assemblies and an official community committee manages the application. In the remaining cases it was normally the head of the community or in few cases other individuals from the community who initiated the application.

Management of MHP plants

The management team of the MHP plants normally consist of up to five persons: the head of management, the operator, the book keeper, and the secretary. For some plants, more than one operator exists. Generally, the management team is either paid a fixed amount or a percentage of the monthly revenues. While among EnDev 1 communities fixed payment prevail, for EnDev 2 communities it is the percentage of the monthly revenues.

During EnDev 2, one part of the activities of the Technical Support Unit TSU was to provide management and operation trainings to the management team. Accordingly, the share of communities that received training is substantially higher among EnDev 2 communities than among EnDev 1 communities. The reason why not all current members of the management teams have received such training is because the management team in some cases has changed since the beginning of the plant operation and new members are often not trained for their tasks. While the share of non-trained team members is substantially lower among EnDev 2 communities than among EnDev 1 communities, the share still seems high given that EnDev 2 plants are operational for a maximum of two years only. In 3 of 13 communities, members of the management team have already been replaced.

In EnDev 2 communities all management teams claim that they are properly documenting customer payments and cash flows. In most cases, this was verified during the field work by looking at the corresponding books. In some cases the book keepers had not been present during the interviews and it was impossible to check these books.

Table 35: Management of MHP (in percent of communities)

	EnDev 2	EnDev 1
Salary of management team paid as fixed amount	0.46	0.64

Salary of management team paid as percentage of revenues	0.54	0.36
Head of management received training	0.91	0.33
Operator received training	0.82	0.50
Book keeper received training	0.90	0.20
Secretary received training	0.88	0.33
Staff has been replaced since start of operation?	0.23	0.67
Management claims to document customer payment	1.00	0.91
Management was able to show properly documented customer payment	0.77	0.81
Management claims to document cash flows	1.00	0.64
Management was able to show properly documented cash flows	0.77	0.60
Management opened bank account	0.39	0.46

Source: Community data 2013.

In most communities the head of the community is not part of the MHP management team, but rather has an advisory role to facilitate in cases of discontent between the community and the management team.

Payment behaviour and financial sustainability

While the investment in the MHP as well as the distribution lines are completely covered by the Green PNPM subsidy, the operation of the MHP is supposed to be self-sustaining, this is, no further subsidies will be paid. The implication is that the tariffs paid by the connected households have to cover the operating costs and, in addition, costs for maintenance and spare parts. In reality though, the charged tariffs do not suffice to cover these costs. Compared to mini-grid tariffs in other countries the tariffs applied in the MHP pilot communities are very low. A monthly fee of 35,000 IDR as recommended by TSU can hardly be found and accordingly communities do often not have monetary resources to pay for repair services in case needed (see also next section on technical sustainability). In only three communities, households in the highest consumption class pay this amount. TSU furthermore advises to regularly increase tariffs, which also hardly happens. In several EnDev 1 plants, monthly fees have even been reduced since the beginning of operation (although this has come along a deterioration of service quality, see below).

In addition, while the share of households that does never pay the fees is negligible, the fees are not rigorously collected. A substantial share of households does not pay their contribution on time, but only very few households do not pay at all. The rate of non-payment is slightly higher in EnDev 1 households at 39 percent than in EnDev 2 communities where it is still at 28 percent. Asking the households why they did not pay on time, the most prominent reason is a lack of financial means (80 percent). Few households give other reasons like forgetting to pay. Also few households state that they are not satisfied with the service of the MHP plant or do not understand why they have to pay if electricity is generated “for free” as switching the plant on does not create any cost (apart from salaries for the operator).

Table 36: Payment habits of MHP customers

	EnDev 2	EnDev 1
Information from community interviews		
Share of HH that have never paid during last six month	0.01	0.01
Share of HH that normally do not pay on time	0.28	0.39
Share of communities in which sanctions are applied in case of non-payment	0.85	0.40
Share of communities who disconnected HH because of non-payment	0.15	0.40
Information from HH interviews		
Monthly contribution always paid on time during last year	86%	76%
What happens if not paying on time? nothing	36%	27%
Disconnection after several month of non-payment	20%	43%
Immediate disconnection	5%	2%
fine	36%	25%
Aware of household that does not pay the fee on time	7%	14%

Source: Community data 2013 and household data set 2013.

In a second question, we asked other households whether they are aware of households that do not pay their contribution on time (as an indicator for social cohesion). Only 10 percent say that they are aware of non-paying households (although our impression was that many households answered "no" since they did not want to peach on their neighbours). Asking what households think about this, one third has a pronounced understanding, as "villagers are poor". Another third state the opposite, i.e. that they are disappointed by these households and expressed a sense of injustice because these households still use the service of the MHP. The remaining households were unclear about their position.

In theory, all MHP plants apply sanctions for non-paying households that consist normally in fines and cutting the electricity connection after three month. In practice, though not all management teams apply these sanctions. In EnDev 2 communities these sanctions have been applied substantially more often than in EnDev 1 communities. The underlying reason for the lax interpretation and application of sanctions is straightforward: The management team members themselves are inhabitants of the community. It is very difficult for them – due to social relations between the villagers – to disconnect neighbours and friends, in particular, if they are encountering financial problems. Only if a strong consent exists between all households in the community and only if this consent is also outspoken repeatedly during community gatherings, the management can enforce the theoretical rules without marginalizing themselves socially.

While these rates of non-payment on the first sight seem rather manageable, they pose real problems for some of the communities. In some communities, non-payment reaches levels of around

50 percent (also in communities with stable electricity supply). Often the non-payment leads to a very bad electricity supply, because the management is unable to pay for repair work and households are unwilling to contribute as long as they do not get a stable electricity supply. In one of the EnDev 1 sites in Sumatra, the whole management team had been disbanded because the community accused them of misappropriating MHP funds. At the time of the survey, the MHP was not running (and therefore was excluded from the household survey sample). They finally decided to hand over the management of the MHP funds including the collection of money among MHP customers to a local savings and loan cooperative.

In a stylized way, this example is representative for two overall observations we made: First, organisational problems and non-payment are a severe threat to the sustainable operation of the MHP and it can by no means be taken for granted that the MHP's revenues effectively cover the operation and repair costs. On the other hand, most communities in the surveyed regions of the country are quite well organized and strive for solutions even in case of profound problems. Moreover, the increased attention of EnDev 2 to management and technical trainings improved some early indicators for sustainability. Whether the latter is sufficient to ensure a sustainable operation of the MHP in the long term remains to be seen.

Technical Sustainability

The electricity supply through the MHP plants is rather unstable. Especially during rainy season the vast majority of households report that they have experienced blackouts of more than one hour. Around one third of the households is unable to specify the exact number of blackouts and state that blackouts occur rarely. No difference exists among EnDev 1 and Endev 2 communities. The remaining households report blackouts to occur around 3 times per season with EnDev 2 communities reporting a slightly higher incidence than EnDev 1 communities. During dry season, blackouts are less frequent with only around half of the households reporting blackouts. Again, a substantial part of households that experienced blackouts states that they occur only rarely (46 percent among EnDev 1 and 64 among EnDev 2 communities). Those households reporting exact values, on average report again three blackouts to occur in dry season. Here, EnDev 1 communities report higher incidences than EnDev 2 communities. In case of blackouts, virtually all households switch back to traditional energy sources, most of all kerosene lamps and candles. Also voltage fluctuations are omnipresent; again, quality of electricity supply is worse during rainy season than during dry season. Two third of all households furthermore report that electric appliances have been damaged by voltage fluctuations. Most of all, light bulbs have been destroyed (65% of all households), but also TV sets (9% of all households).

Table 37: Service quality of MHP (based on household interviews)

	EnDev 2	EnDev 1
Cost for electricity connection (connection & inhouse wiring, In IDR)	226,310	374,607
Expenditure for repairing household connection to MHP last year (in IDR)	2,126	14,346
Share of HH that paid for repairing MHP last year	5%	19%

Experienced blackouts (more than one hour) in…	rainy season	91%	88%
	dry season	46%	62%
Experience blackouts rarely in…	rainy season	32%	35%
	dry season	64%	46%
Experience blackouts XX times per…	rainy season	3.2	2.7
	dry season	2.4	3.2
Experience brownouts **frequently** in …	rainy season	62%	46%
	dry season	37%	27%
Experience brownouts **every day** in …	rainy season	5%	8%
	dry season	11%	2%
In case of blackout, household…	uses back-up electricity source	1%	1%
	…uses traditional energy sources	97%	95%
	…waits until services is re-established	3%	4%

Source: Community data 2013.

In order to assess the capability of the management teams to handle technical problems we inquired about damages and technical issues of the plant and how they were solved. In many cases the plants have had some sort of severe technical problems leading to sometimes long service interruptions. The most frequent severe technical problems are damaged generators or turbines. Even among EnDev 2 communities that run on average for around one year only, each plant has experienced on average more than one severe technical problem.

For the first damage after installation, all communities managed to repair the plant. In around two thirds of the cases the management was able to buy spare parts and/or pay a technician. In one third of the cases they asked somebody for help, which either was a technician from the region or the government authorities. One person in Sulawesi plays a very central role: Pak Linggi. He has a turbine workshop and equipped most of the plants. Even in communities in Sulawesi where he has not built and installed the turbine, everybody knows him. Apart from building turbines he engages in local politics and ran for the position as head of the region Mamasa (*bupati*) in 2013. In many cases, he is the primary contact for the communities if they face technical problems. In several cases he also sent out his staff to repair turbines for free if communities are unable to pay. In virtually all cases he provided repair services at preferential prices or even for free.

Generally, most turbines and generators are covered by a sort of guarantee and the manufacturer offers to repair it free of charge in case it breaks due to regular usage. Still, the costs for transporting the broken part to the workshop or getting the technician to the site have to be borne by the community.

Table 38: Severe technical problems of plants

	EnDev 2	EnDev 1
Number of plants still in operation (out of the 30 MHP visited for the preparation of the survey)	13 out of 13	13 to 14* out of 17
Plants included in survey:		
Average number of severe technical problems since installation	1.2	2.6

Share of severe technical problem cases caused by		
… damaged generator	0.46	0.46
….damaged turbine	0.31	0.39
…damaged electronic load control	0.08	0.15
….damaged load ballast	0.08	0.00
… broken dam	0.08	0.00
…whole site destroyed	0.00	0.08
… damaged channel	0.00	0.08

Source: Community data 2013.

* one site had been in operation but due to the extremely unstable electricity supply, 20 out of originally 30 connected households had switched to the PLN grid

In communities that have experienced more than one bigger damage, this second damage brought the management into trouble, since repair funds have not recovered so rapidly. Two out of ten visited EnDev 1 plants in Sulawesi had not been running for months in January 2013, since the management was unable to repair the plant due to a lack of money. Also among EnDev 1 plants assessed to be included in the survey in Sumatra, two out of seven visited MHP schemes were not working or only barely working (which were consequently not included in the household survey). Technical assistance by TSU was only focussed on the construction phase of EnDev 2 plants. During that period, TSU staff also sporadically advised operational EnDev 1 plants if they were located closely to EnDev 2 plants under construction. After completion of these sites, though, neither for EnDev 1 nor EnDev 2 sites technical advisers to contact in case of problems exist.

The most common reason for voltage fluctuations, blackouts and shut down plants is the non-existence of electronic load controls (ELC) and frequent electric overloads that burn the generators. As described in Section 4.1 the disadvantage of not having ELCs is that the load of the system has to be regulated manually. In case of irregular consumption behaviour of households, this implies someone has to be in the powerhouse to control the consumption level and regulate the water inflow. If many people start using electricity, more water is needed to maintain the appropriate voltage level. In the evening, when people go to sleep and switch off their lamps and television, the water inflow has to be reduced to avoid excess voltage. In reality, though, most of the operators go to the power house, switch on the plant and maybe wait some minutes until most of the people started their electric appliances and the consumption level reaches a somewhat stable point. They only come back to the power house in the morning in order to switch off the plant. Some also only observe the voltage level when most of the households go to sleep and switch of their appliances. In the meantime, the load fluctuations are not balanced. Especially if household appliances that require high capacities such as electric irons or rice cookers are switched on, heavy voltage fluctuations can be caused.

Some other plants seem not to be well designed for the amount of water that is channelled into the plant. Especially among EnDev 1 plants the capacity of the plant is often too high compared to the available amount of water available and especially in dry season, water flows are too low to properly run the turbine. The problem has partly been aggravated by communities that bought new generators with a higher capacity than what had been officially foreseen during technical feasibility studies. Other communities still have the original generator but electricity consumption increased with the years and voltage does not reach the appropriate level of 210 Volt because too many appliances are connected at the same time.

EnDev 2 are better designed and plants run much smoother in terms of voltage fluctuations, since most of them are equipped with an ELC. As long as the ELC is working, at least the generator is protected against electric overloads. On the household level, voltage fluctuations and blackouts nonetheless are very frequent. Also, the ELCs of two EnDev 2 plants are already broken and have not been replaced.

Altogether, the technical sustainability in EnDev 1 communities seems to be quite worrisome. More than 20 percent of the visited MHPs are completely broken and many more exhibit severe problems. The inter-linkages with financial sustainability are obvious. While the technical set-up in EnDev 2 communities appears to be much better, problems remain and technical issues might occur more frequently as operation time increases. The ELC so far is the pivotal difference between EnDev 1 and EnDev 2 sites and seems to be the decisive factor for improved technical performance. Also training of management and technical operation staff and design of plants has improved in comparison to EnDev 1 sites. However, the fact that two (out of 13) of the ELCs have broken already after only one year and have not been replaced indicates that technical sustainability of EnDev 2 sites cannot be taken for granted either.

Competition between MHP and PLN electricity

Many of the communities are located in immediate vicinity of the national grid. Not all of these households are officially connected, but have simply extended the grid from their neighbour. In the beginning, TSU considered a community as eligible for application for a MHP scheme if the distance between the community and the PLN grid is at least 2.5 km, from 2010 onwards TSU even applied a 5 km minimum distance. This condition is not always fulfilled and several MHPs are in competition to PLN induced by the different conditions both grids offer. GIZ staff claims that on the one hand PLN grid has been extended much faster or differently from official grid extension plans and thereby eventually reached the MHP sites even though during feasibility studies it had been assessed that the PLN grid would not reach the sites. On the other hand, TSU had no mandate to refuse a site that was technically feasible for MHPs and therefore was forced to support all, even if they already were close to the PLN grid. Final decision for funding of the sites was with PNPM.

While the MHP grids are less reliable in terms of voltage fluctuations and blackouts, electricity fees are cheaper. This is why we observed some households that initially preferred to connect to the MHP grid (because it was cheaper), but eventually switched to PLN (because it was more reliable and they could connect more appliances). In one EnDev 1 community (where no household interviews have been done) a total of 20 households out of 30 originally connected households switched to PLN.

8. Research questions

Input and policy relevance:

- What attempts have been made to target and include women at all stages in the programme/project cycle?

The MHP pilot does not have any special approach towards women. It mainly relies on existing structures within the targeted communities which are in many cases headed by men.

- What are the financing mechanisms for the programme/project and does this include measures to ensure equity in access to energy (e.g. access to credit for women)?

The Green PNPM funds are disbursed based on a competitive procedure that does not especially consider women (see Section 2.2 with the project description). These funds are used to finance the investment into hardware of the MHP as well as the distribution lines. On the household connection level, no special financing arrangements exist, neither for women. Some communities apply special tariffs (and reduced connection fees) for poor households (see Section 4.1), though. These poor households are often widows living alone.

Output:

- Have specific measures been undertaken to enhance efficiency? If so, how and what have been the results?

Compared to the before situation – people are using kerosene, candles, or dry-cell batteries to meet their energy demands – electrification is efficiency enhancing in the sense that the same amount of energy can be produced at lower costs. Apart from this, MHP pilot has not implemented any specific measures to enhance efficiency.

- What have been the total (development and recurrent) costs and the costs per main output and beneficiary? To what extent are costs covered by contributions of the users/consumers?

About half of the Green PNPM funding of USD 51.9 million for the period 2007-2012 was planned to be allocated to the funding of MHP plants of the pilot scheme. The funds were made available for the hardware mainly. Operating costs have to be financed out of consumer contributions.

In order to calculate the cost per output and beneficiary we can resort to monitoring data of GIZ. They have supported since 2009 a total of 102 plants that were commissioned by beginning of 2013. Total funds for these 102 plants amount to USD 9.14 million. This is equal to almost 90,000 USD per plant. These plants serve a total of 18,600 households with almost 80,000 persons. Costs per connected household accordingly amounts to around 490 USD and 115 USD per person.

These calculations obviously do not include the TSU contribution and the management of PNPM funds. How much of these management cost can be attributed to the intervention is hard to tell since especially PNPM facilitators are normally in charge of all PNPM activities within one region.

- How cost-effective is the intervention, taking into consideration the financial inputs in terms of equipment, personnel, technical assistance as compared to the access to energy provided expressed by the number of households or beneficiaries ("value-for-money"). What benchmark can be used?

Given the immediate vicinity of the national electricity grid PLN (see Section 7 on sustainability) a straightforward benchmark would be costs incurred in case of grid connection. While officially the PLN connection does not cost anything, people interviewed in the field reported connection cost of between 2.1 Mio IDR (170 USD) and 15 Mio IDR (1,260 USD). These amounts obviously do not reflect actual cost but can rather be assumed to be unofficial income sources of local PLN employees.

As described above the set-up of the programme is very complex and it is difficult to calculate all financial inputs that would have to be attributed to each plant installed under EnDev 2. The sum of 490 USD per connected household can only be seen as the lower limit and real cost are definitely higher.

Answering this research question is therefore very difficult, since we lack the information to calculate the costs per connection. But even if we knew these costs, a benchmark to compare these actual costs with is not available given the very specific type of intervention (MHP in very remote and difficult-to-access areas).

- How do communities decide to apply for a micro hydro scheme, and who (gender specific) was involved in the decision?

The application process is detailed in Section 7.

- Which socio-economic groups (incl. poor/non-poor) applied for connection?

While one of the target provinces of the intervention, Sulawesi Barat, has slightly more poor people than the national average (13 percent), the other target province Sumatra Barat reveals slightly fewer poor households, counting with a share of only 8 percent of the population living below the poverty line. The MHP schemes were installed in very remote areas within these provinces and most of connected household will accordingly qualify as poor.

Outcomes:

- What is the connectivity rate of households, enterprises and social infrastructure institutions in the area studies?

The connectivity rate of households is specified in Section 4.1; connectivity rates for enterprises and social infrastructure in Section 6.1 and 6.2, respectively.

- How many households have been using electricity (either generated by an engine, solar energy or by an other source) prior to the MHP electricity became available?

Pre-electrification rates have been high among the treated communities and are specified in Section 4.1

- How reliable is the electricity supply of the micro hydro plant (frequency of outages)?

See Section 7 on Sustainability.

- What are the main appliances using electricity used by households, enterprises and social infrastructure institutions? How many hours per day or week is electricity being used?

For appliances usage in households see Section 5.2.2 on non-productive appliances and lighting and 5.2.3 on productive appliances. Usage pattern can furthermore be found in Section 5.3.2 and 5.3.4. Section 5 gives information on appliances usage in enterprises and social infrastructure.

- For what purpose and by whom in the household is electricity being used?

See section 5.2.2 on appliances usage, Section 5.3.2 on access to information and 5.4.4 on time use.

Impacts:

- What is the change in expenditure (per time interval) between the energy sources used prior to the arrival of electricity from the micro hydro plant (candles, kerosene, batteries) and current expenditures?

See Section 5.3.1 on energy expenditures.

- To what extent has (the perception of) safety/protection changed?

See Section 5.3.6 on security

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

See Section 5.3.6 on security and convenience. We furthermore tried to assess the monetary value people attribute to this increased convenience. Unfortunately, a Willingness to Accept approach turned out not to be feasible. 99 percent of all households state that they are not willing to accept to cut the electricity connection, no matter what one would pay. Only two households give a price which is 1,500,000 IDR and 5,000,000 IDR.

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

The most intense time burden for rural households related to energy is the collection of firewood which is hardly influenced by electrification interventions. We display time use for collection firewood in Table 17. We do not find any impacts.

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

Through increased lighting and entertainment appliances adult household members are longer awake than before electrification (see Table 24). Activities in evening hours are displayed in Table 27.

- To what extent have the household's activities during evening hours changed? Have study hours/reading time of children changed? Do women (and children) enjoy more or less rest for physical recuperation?

See Section 5.3.4 on time use.

- To what extent has indoor air pollution been reduced (according to the perception of dwellers)?

See Section 5.3.5 on health.

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

See Section 5.3.5. on health.

- How have, in response to the possibly increased media exposure, attitudes and behaviours, such as women's status, fertility, children's school enrolment changed?

For women's status and fertility, see Section 5.3.3 on gender.

According to qualitative interviews with teachers and parents school enrolment in Indonesia and in the surveyed areas in particular is close to 100 percent and no effect through electrification can be expected.

- How are these impacts distributed across different household members (women vs. men, children vs. adults)?

See Section 5.3.3 on gender

See Section 5.3.4 on time use, Section 5.3.5 on health and Section 5.3.6. on security and convenience where impacts are disentangled by gender and age.

- Has the enrolment and school attendance, as well as student performance changed as a result of use electricity in the school?

See Section 6.2 on electricity usage in Schools

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

See Section 6.1 on micro-enterprises in the surveyed villages.

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

The only unintended negative impact has been reported by two households who say they realized they have much more mosquitos inside the house since they have connected to the MHP.

Sustainability

- What observations can be made about the technical sustainability of the electricity generation equipment, for example when it comes to availability of spare parts or technical expertise for repairs of the generation and electricity materials at household level?

See Section 7 on technical sustainability.

- What is the financial sustainability of the MHP programme from a) the perspective of the electricity user; b) from the perspective of the small construction enterprises that install and maintain the installations and c) from the perspective of the public sector support programme as far as it concerns scaling down of currently provided incentives and subsidies.

a) For financial sustainability from the perspective of the electricity user see Section 7 on Sustainability.
b) Small construction enterprises are not particularly affected by the MHP programme, since the construction work is provided by villagers as in kind contribution to the installation costs.
c) The Green PNPM MHP pilot programme provides subsidies only for hardware during the construction phase. Afterwards the MHP schemes are handed over to the communities and do not receive any further subsidies or incentives. Accordingly, there is no need for a phasing out policy for commissioned plants.
   A further scaling up of micro-hydro activities in comparable remote areas without some sort of public sector support seems not realistic for the moment. The surveyed plants hardly are able to cover operation costs with users' contributions and won't be able to recover investment cost.

- To which extent the MHP installations affect –positively or negatively- the environmental sustainability?

The MHP are integrated in the local environment in a rather smooth way. The only adverse effect is that during dry seasons the MHP compete with irrigation systems for water supply. While this has brought up by villagers or community chiefs anecdotally, it does seem to be perceived as a severe or systematic problem.

On a global level, the MHP schemes will contribute to a modest abatement of CO_2 emissions by replacing kerosene usage.

9. Concluding remarks

This report has provided an assessment of the MHP pilot programme in terms of impacts on the level of households, enterprises and social institutions. It has furthermore assessed the sustainability of the MHP schemes that are operated by communities autonomously. To meet its objectives the report relied on a household survey, for which 520 households were visited in early 2013. In addition, qualitative and semi-structured interviews were conducted with micro-enterprises, health institutions, schools as well as community chiefs and MHP operators.

The identification strategy applied for household impacts is a simple before-after comparison. The before-information for the EnDev 2 households was obtained from a baseline study conducted by GIZ in 2010 (GIZ 2011). The original idea formulated in the ToR was to use a set of communities as control group that had been electrified already before the baseline survey (EnDev 1 communities). The analysis of the data has shown, though, that this group does not serve as a proper control group, since the observed trends are obviously affected by its electrification status for most impact indicators. For a few indicators, the behaviour of these EnDev 1 households nonetheless helped to grasp the overall development in the country that has to be netted out in order to obtain the pure effect of the electrification. In any case, the EnDev 1 group provides interesting insights into the long term effects of electrification.

The results for the EnDev 2 households show that the service is taken up by virtually all customers. Electrification rates in the communities are near 100 percent. While a considerable share of households had already been using electricity before, that was provided by water wheels or gensets, quality has increased substantially (compared to the water wheel) and costs have decreased (compared to the gensets). All households use electricity for lighting and have increased their lighting consumption tremendously after electrification. Many households furthermore also use TV sets, rice cookers, electric irons or CD player. In terms of energy expenditures we see a pronounced decrease in expenditures on kerosene and electricity and total energy expenditures went down by 30 percent. Increased usage of mobile phones and TV sets improved considerably the access to information in the surveyed communities. Furthermore, the availability of electric lighting leads to a shift in activities at least for the head of household who is longer awake than before MHP electrification.

The study of micro-enterprises has revealed that in many communities electricity cannot be used for most productive purposes, since the MHP is not running during day time when most activities are pursued. But it has also revealed that only in few cases electricity access in fact is a major bottleneck for firm performance. Most entrepreneurs are rather limited by the lack of access to markets. Demand for their products is by and large only coming from the community itself and thus already saturated. Accordingly, even if new products can be offered, it attracts local demand only that has to be retracted from other locally offered goods. Only in exceptional cases, enterprises have the opportunity to sell their products on markets beyond their own community. Productive use potentials are therefore very limited in such remote regions.

In terms of sustainability of the MHP schemes, the MHP pilot pursues a community based approach (as opposed to a private operator approach), i.e. the community itself is responsible for the management of the MHP including fee collection, maintenance and re-investments. On a national level, this approach is clearly innovative. In particular, the technical lessons learnt and the capacities built have the potential to contribute to the institutional knowledge in the country. According to statements of other donors in the sector, efforts to feed the experiences of the MHP pilot activities into the sector policy have been quite limited so far.

While the assessment of the intervention on this more national level was not part of this evaluation, this report has provided evidence with regards to the sustainability on the community level. Insights from the visited EnDev 1 sites (that have been running for between 2.5 and 7 years) suggest that a sustainable operation of the MHP schemes is more than critical. 4 out of 17 MHPs are not running anymore due to mostly technical breakdowns and formally it is the community itself that is in charge of solving these problems. While TSU had been active in nearby regions supervising construction work of EnDev 2 plants, they occasionally helped out giving assistance also to EnDev 1 communities.

Now that all EnDev 2 sites are operational, TSU is no longer active in these communities. Although the technical set-up in the EnDev 2 communities has been improved considerably, technical problems occur and the payment behaviour is not always ensuring that enough money can be accumulated by the management team to organize maintenance and invest in spare parts. Altogether, especially concerning the EnDev 1 intervention our assessment brings up strong doubts about sustainability and also for EnDev 2 it is by far too early to conclude that the provided access is is sustainable. But even if many of the connections fail, it might well be that the approaches developed for and lessons learned in this project will feed into the sector development in the country.

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Annex 1: Micro-Enterprises in surveyed communities

Description of most frequent enterprise types

Kiosks

Among the surveyed communities **kiosks** are the most common type of micro-enterprises and many of them have only opened in the last five years. Kiosks are usually small booths that are primarily selling cigarettes, candies, coffee powder, instant noodles and beverages. The product range is quite homogenous across different shops. Sometimes they are also selling bulbs, batteries and petrol. Larger sized kiosks that allow the customers to walk around are rare. Few kiosks are equipped with benches and tables, and offer occasionally services such as preparing coffee, tea or instant noodles. However, these services are rarely used. There are even kiosks that combine a kiosk with a small restaurant serving traditional food. However, these kiosks are very rare and can only be found in communities located close to a main road or in communities with a weekly market. In one community which is located in the region of Mamasa (Sulawesi), a kiosk also succeeded to attract customers from other communities and the city of Mamasa by serving a traditional liquor ('*bolo*'). In general, profit margin and demand for kiosks are low, including days without any income. Kiosk owners, which can be male or female, usually do not have employees, besides some unpaid help from their family. Kiosks usually open daily from 7am until 7 pm and occasionally until 9 or 10 pm. Since there is no continuous demand and kiosks are typically on the owner's compound, the owner can engage in other activities at the same time, such as housekeeping or child-caring. If the kiosk is not occupied the customers call for service, occasionally also after opening hours. Most customers are from the same community, but there are incidental exceptions if there is any event with guests in the community (e.g. wedding, funeral), and for kiosks next to a main road or a large weekly market in the community.

Nearly all kiosks of the surveyed communities are connected to MHP plants. In half of all surveyed communities even all kiosks are connected to MHP. Only some few kiosks get electricity occasionally from a generator or a nearby PLN connection if they use for example a refrigerator. Non-electrified kiosks are scarce, and are mostly located close to the fields and are only operating during harvest time *(seasonal kiosks).* Electricity in kiosks is mainly used for lighting in the afternoon and evening. In many cases lighting is not switched off when closing the kiosk and stays on until morning. Before MHP electrification, kiosk owners mainly had used tin lamps, torches or candles when opening the kiosk after nightfall. Accordingly, electricity reduces expenditures and as many kiosk owners state it increases the owner´s security feeling. Both leads to longer official opening hours and customers also pass by incidentally in the late evening to buy something. Many kiosk owners claim that the customer's attention is attracted by lighting, which makes the customers pass by the kiosk to chat while consuming some bought sweets, cigarettes or drinks in the evening. Furthermore, lighting in kiosks enhances product visibility and thus the owner´s and customer's convenience. According to some kiosk owners, the light also avoids losses by thievery or rats and gives owners the flexibility to shift some activities to night time such as filling small sacks of sugar for sale. Appliances usage beyond lighting in kiosks is rather exceptional. Very few kiosks have a TV, which is supposed to attract customers. Two kiosks that possess a refrigerator offer new products and services, most notably ice-cream, and cold drinks, but also ice (for cooling) and cooled (more perishable) vegetables. The very few kiosks equipped with a blender sell fruit juices.

It should be noted, that most of the owners have opened their kiosk after the installation of MHP. Methodologically this means that we cannot compare the situation today with the situation before electrification. The pivotal question is rather whether their creation can be ascribed to the availability of electricity. Generally, the MHPs could not be confirmed as a direct or indirect driver of the multitude of kiosk openings after it´s installation. The majority of new kiosks claim that they would still have opened a kiosk if there was no MHP, using traditional lighting sources. Some owners of bigger kiosks, though, report that they would have opened a smaller kiosk in the absence of MHP due to safety reasons.

Summing up, electricity usage in kiosk leads above all to higher convenience of customers: partly longer opening hours, more flexibility of customers and some new products. Even though customers effectively use the longer opening hours and buy after nightfall, these sales are not additional, but rather shifted from daytime to nighttime. Kiosk owners do not experience an increase in total sales but longer opening hours rather is an additional service meant to gain additional customers. Since all kiosks do so, though, and the number of customers is fix within the community, no kiosk effectively gains additional customers.[8] The lack of demand remains the kiosks' biggest obstacle. Apart from some savings in expenditure for kerosene, the income and cost structure of most kiosks has not changed since the installation of the MHPs. Sometimes kiosks invest the saved money in enlarging their product variety. Kiosk owners furthermore claim that electric lighting and thus increased safety feeling is a major driver for the opening of bigger kiosks with a wider product range. Some products that had been bought before outside the community accordingly can now be bought in the communities. This slightly increases the total community income since formerly "imported" goods can now be bought in the communities.

Selling new products, though, normally only causes a shift of income from one kiosk to another kiosk if customers are all from the community: For example one kiosk located close to a school achieved to increase her income by selling ice-cream to school children since she has a refrigerator. However, another kiosk complains about a decrease of sales since the school children do not by candies at his place anymore.

Joiners and carpenters

The jobs of **joiners** and **carpenters** are partly overlapping. According to the residents' categorization, a joiner builds houses and assists at the construction site, whereas a carpenter builds furniture. Often carpenter also work as joiner and vice versa. In general, however, the joiner´s job requires lower skills than the carpentry job, and thus more people work occasionally as joiners. In many communities, many **joiners** exist and their skills are rarely requested. They are usually organized in groups which are headed by a group leader who contacts a stable pool of workers when receiving an order. A team consists of two up to 40 usually male workers, depending upon the size of the house to be built, skills of the joiners, automation of work and timetable of the employer. Normally some experienced workers team up with less-skilled workers. The joiners usually get a daily salary, which depends on their skills. If workers bring own electrical appliances they get bonus payment. The usual working hours are from 7 am until 4 pm. Since the construction sites are often distant to the workers'

[8] *Considering opportunity costs, increased total daily opening hours lead to higher costs for the owner and – since sales are not increasing - a lower productivity. However, we are neglecting this fact here since kiosk owners often pursue other housework activities during the opening hours of the kiosk and generally it is questionable what kind of real opportunity costs exist in these small villages with basically no income generation potential.*

communities, they normally stay in the community or city of the construction sites for several days, weeks, or even months.

Carpenters predominantly build cupboards, tables, chairs, and bedsteads. Occasionally they also build window frames, doors and door frames. Some carpenters are also skilled in carving and refurbishing wood. Due to low and unstable demand and lack of capital for buying material carpenters do not produce in stock. They just produce if they get an order. In general, the demand for furniture is low and normally does not provide enough orders to keep the carpenter occupied during his regular daily working hours from around 7 am until 4 pm. Thus, the carpenter usually works alone and only in exceptional cases recruits workers or extends the operation hours. Only in Salumokanan (Sulawesi) a group of five carpenters has been working together for several years. In general, clients are all from the own community. Exceptions exist for carpenters who are close to a city or a big customer, like a palm-oil company, and have good road conditions.

Since **joiners** normally work on the construction site and thus their job is not affected by a MHP connection of their homes, we will exclude them from the following analysis. The majority of the **carpenter's** workplaces are connected to the MHP. For operating equipment they use electricity only occasionally, though. Some carpenters do not have a permanent connection, but rather switch the connection cables from their household connection to the working place when needed. Around half of the carpenters still work manually. Some carpenters use electric lighting even though it is not essential for exercising their activities because hardly any carpenter works at night. However, some few carpenters leave the light switched on during the night and claim to feel safer and to prevent thievery.

Because many MHPs do not work at daytime or do not allow carpenters to connect their appliances, most carpenters use a generator for operating appliances like grinder, chain saws, drillers, and sanding machines. Carpenters normally switch on the generator only for using appliances but then, once the generator is running also light electric lighting devices. In only two out of 26 communities the MHP can be switched on during daytime on demand and few carpenters occasionally connect smaller appliances of up to around 500W to the MHP. However, bigger appliances are still driven by a generator because of capacity problems.

Besides savings in expenditure, the connection of appliances to MHP instead of using a generator saves time and effort which was formerly spent on the procurement of petrol and activation of generator. The usage of electric appliances, however, is not caused by the installation of the MHP: Most of the available appliances had been bought before the installation of the MHP and had been operated with a generator. Manually working carpenters in general lack the money for buying appliances. They usually know about the possibility of microcredits, however they think not to be able to pay it back which might be realistic given the low demand. Working with electrical appliances instead of working manually saves around half of the carpenter´s working hours. Furthermore, appliances enables some carpenters to offer new products and working techniques, such as grinding wooden domes for window frames with a sanding machine. This new activity, which nobody performs manually, attracts customers and causes additional turnover for carpenters offering it. Furthermore, working with electrical appliances facilitates a more uniform production and can improve the quality of products. Few carpenters claim that this attracts customers, whereas a manually working carpenter claimed an increasing appreciation of his products since there is an incremental number of electrified carpenters and his manual work makes every piece of furniture unique.

Summing up, carpenters mainly benefit from time savings and convenience when using electrical appliances instead of working manually. However, these appliances had already been used before MHP electrification and today few connect them to the MHP. Accordingly, we observe only a small effect of saving energy expenditures formerly spent on generator fuel. Time savings furthermore do normally not have a significant effect on the carpenter`s income, since he usually either lacks demand or material for any additional production.

Tailors

Tailors primarily sew traditional clothes, uniforms for school or work, and occasionally some curtains. Modern daily clothes, however, are usually bought at markets, since industrially produced clothes are comparably cheaper and many villagers prefer them because they are more fashionably. Tailors also offer repair and alteration services for clothing. Demand is low and tailors normally do not spend the whole day working. If they work, they normally do it between 8 am and 4 pm, usually not in the evening. Also tailors, who are mainly women, usually work alone. In Salumokanan (Sulawesi) five tailors form a working group and distribute orders between each other. The vast majority of customers is from the same community and they either bring their own fabrics or pay in advance. Occasionally, guests from other places order products if they are in the community due to any event or a general visit.

Similar to carpenters, most **tailors** have an MHP connection or at least MHP access at their working places, because they mainly work at home. However, electricity is rarely consumed by tailors since they do not have electrical appliances and rarely use lighting, even though it improves the lighting quality while working and decreases expenditures. This is primarily because MHP is usually only operating in the evening. Whenever MHP is switched on during daytime, which is in some communities occasionally the case, e.g. on Fridays or for community events, tailors use lighting to illuminate their working places. Only few tailors occasionally shift their working hours to the evening because they believe they are able to produce a higher quality of products by using electric lighting. Strikingly, some tailors still use a tin lamp or candle, despite their MHP connection. They use it partly additional to MHP lighting in order to improve lighting conditions, partly because they would have to disconnect the cables from the home and connect the working place or due to the often unreliable electricity supply of the MHPs.

All but one tailor group use manual sewing machines. The exceptional tailor group (in Salumokanan, Sulawesi) that possesses and occasionally operates an electrical stitching and a sewing machine received this appliance from GIZ[9]. In Salumokanan, the MHP can be switched on during daytime if desired by the tailor or a carpenter group. By using a stitching machine, the tailors offer a new product that cannot be produced manually. Furthermore, stitching can upgrade textiles and increase

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[9] Within a GIZ initiative on the productive use of energy in mid-2012, electrical appliances were provided to selected village-based businesses with access to the MHP plant. In total, 53 businesses in 9 villages in regions of Sumatra and Sulawesi were comprised. Whereas it has initially been envisaged to provide the electric appliances at a loan basis for the duration of the project and subsequently return or purchase them at a reduced cost, the electric appliances were finally left for free. This is because the contracted NGOs (ProWater and Operation Wallacea Trust (OWT)) did not succeed in convincing the communities to purchase the appliances. Furthermore, many villagers claim they had not known that the electric appliances were only given on a loan basis. Most are confused of having to return or pay for a “present” that was given initially for free.

their prices. Textiles that are produced with an electrical sewing machine can be of higher quality than manually produced textiles due to a tighter and more regular seam, and a more uniform production. Working with an electrical sewing machine saves around half of the production time and is less exhausting. In spite of these advantages, there are only two women in the group who use the electric machines. Despite some instruction lessons and assistance, the other tailors of the group prefer manual machines. The tailor group claims to have a slightly higher demand since the possession of the electrical tools.

Except for the **tailor** group, which has electrical machines and can occasionally use MHP during daytime, the impacts of electrification on tailors are rather small. In general, the opportunity of additional or shifted working hours in the evening increases the tailor's time-flexibility, which can theoretically be used for other orders. However, also tailors usually do not have enough demand in order to profit from time-flexibility economically. Income usually does not change due to electrification. Even though MHP´s lighting is hardly used, expenditure savings from petrol can increase the tailor´s disposable income. The tailor group claims to have a slightly higher demand since using their electrical appliances. Time savings due to the electrical machines lead to a higher production rate, and thus additionally increased their income. However, another tailor in the respective community claims to have fewer orders since the tailor group uses the electrical appliances.

Agro-processing

Within the communities there are several **agro-processors**, whose services range from rice hulling to flour, coffee and coconut milling, and also include baking and coffee processing. The **rice hulling service** is operated by males who use an agricultural machine to automate the process of removing the chaff of rice grains. Compared to the manual way of pounding the rice by using a form of mortar and pestle, rice hulling service saves a lot of time and effort. However, in light of the small amount of harvested rice, which is usually only for the farmer's own consumption, and farmers trying to spend as few as possible, they rarely use the service. The rice hulling service is offered throughout the year, but primarily used in harvest time. The operator usually demands one tenth of the hulled amount as his payment, which is for his own consumption. The **millers** are in a similar situation. Even though their milling service of flour, coconut and coffee is effort- and time-saving, the residents usually process the harvest on their own. Just in case a bigger amount is needed, residents resort to the milling service. Millers charge around 2,000 Rp. per processed litre. Since usually every community has some grinding and hulling services, and in some places some mobile processing services are passing by on a car, the customers are from the same community only. **Bakeries** exist very rarely within the communities and are seldom operating. They are producing cakes and other traditional sweets, based on order. Demand does solely come from the own community. On average their monthly orders consist in two cakes and occasionally also some sweets. Depending on the customer´s order, the cakes and sweets are usually produced between 4 am and 7 am. There is a **coffee processor** in Ratte *(Sulawesi),* who buys coffee beans from other coffee traders or farmers. He roasts and grinds the beans during the morning and packs it into small sachets during the evening. He regularly employs two workers for several hours a day.

Most of the **agro-processor**´s workplaces are connected to MHP, or at least could be connected by switching cables. However, the electricity is rarely used productively. Agro-processors primarily work during daytime, and just extend working hours occasionally in harvest time, or for other events that are increasing demand. Most agro-processors do not use MHP´s electricity for their appliances. Depending on their work, this is mostly because they do not work with electric appliances, or because they do not work in the evening or the appliances are too energy intensive to be connected to the MHP. The hulling and milling machines are usually running on diesel and are normally not simply convertible to be driven by an electric engine. However, in some few communities a rice huller is installed in the powerhouse and can be operated directly using the mechanical energy of the turbine. Even though a baker possesses some appliances, like mostly blender and also an oven, he usually works manually because MHP´s connection is usually not sufficient for the **baker´s** appliances. The **coffee trader** roasts the beans on open fire and grinds them by a diesel-driven grinder. He packs the coffee into plastic sachets and closes them usually with the help of an electric sealing machine. Due to the restricted operation hours of MHP and low voltage he often has to close the sachets manually with a candle.

The impacts of electricity on **agro-processors'** income depend on their usage of the MHP. Those who use electric lighting benefit from more time-flexibility and convenience but this does not affect turnover. We observe partly savings on energy expenditures, which are considerable for the rice hulling machines which are connected directly to the turbine. The machines, though, are used only rarely.

Others

Besides the most prevalent occupational groups there are also some other businesses in some communities: **Saw millers** log wood in the forest and cut them according to the customer´s need. The customers, who are usually from the same community only, use the wood as fire wood or for construction work. W**elders** process metal products mainly for construction work, parts of motorcycles, and cooking stoves. **Motorcycle shops** repair motorcycles, the most commonly used means of transportation within the communities. In the Mamasa region *(Sulawesi)* there is a tradition of **weaving** manually. In some communities, around three fourth of all women are weaving. Whereas most weave only for their family´s private needs, some occasionally sell the woven blankets. The weavers do not only produce on demand, but also on stock and sell it at local markets or to guests within the community. **Beauty salons** primarily offer wedding styling, hair cutting and make-up. The customers are mainly from the community, but occasionally also comprise guests that pass by.

These small enterprises also consume electricity for lighting only and this only occasionally since they do not or seldom work at night time. Those who use appliances for their work run it with a generator or the appliances run on fuel. A **beauty salon** works with some electrical appliances (fan, hair straightener) that can occasionally be connected to MHP, however, the capacity is most of the time not sufficient so also the beauty salon mainly works manually or uses a generator.

Case studies of micro-enterprises in surveyed communities

Coffee Processor

Harta[10] has been running a coffee processing and trading business in Sulawesi since the year 2000. It is the only coffee trading business in his community and also with regard to his business size and customer structure his business is an exception. He employs two persons and sells his products to customers in the close-by city. His work place is in and around his house, which has been connected to an MHP since 2005. Around twice a month, Harta buys coffee beans from traders and processes them. This takes around three days and consists of roasting the beans on open fire, grinding them using a diesel-driven grinder and packaging into little sachets. While the first two steps are normally done during daytime, they pack the little sachets after nightfall. For packaging he uses an electric pressing-packaging machine – at least if the MHP plant is providing stable electricity running. This is only rarely the case. Most of the days the system is overloaded and voltage does not suffice to run the machine properly. In these cases, they seal the plastic sachets manually by using a candle. Harta acquired the electric machine in 2011 and theoretically saves one third of the time for packaging. In practice, though, he loses much of this time again because he always has to check whether the machine sealed the sachets properly and often has to re-seal the sachets manually.

Before MHP electrification Harta had been using a tin lamp for lighting or occasionally worked at a friend´s house that had electric lighting through the national grid PLN. He declares that he is now happy to use electric lighting when working after nightfall, which is brighter and cheaper. His employees are paid based on the amount produced when roasting (1,000 Rp. per litre) and they are paid per hour for grinding and packaging (5,000 Rp.- 6,000 Rp. per hour), no matter whether they work manually or use the electric packaging machine.

Harta sells the little plastic sachets of coffee to kiosks in a close-by city. He has several different customers and he does not see demand as his general problem for a further expansion of his business. In fact it is rather the time-consuming administration of each time having to ask each kiosk separately about the ordered quantity. Furthermore, he struggles with the lack of capital to buy coffee beans. He does not know how to overcome this problem and does not think that MHP is able to change these obstacles, since MHP just improves the lighting. His income, however, stayed the same.

Kiosk

Around two years ago, Aditya and her husband Menahen equipped a small room in their house with several sweets, cigarettes and drinks. They integrated a small gate into the open side of the room, which makes animals stay out and allows customers to come in. In front of the kiosk, there is a wooden bench, which is occasionally used by customers for chatting and consuming snacks and cigarettes. Whenever they sell something, they use the money to buy more and a wider range of products. In order to do so they drive by motorcycle to a market located ten kilometres away from their community. Their profit margin in rather low; selling basic products like small water bottles leaves them a profit of 500 Rp. and they earn 300-500 Rp by selling a box of cigarettes. Profit margins are slightly higher when selling machine oil or light bulbs. Aditya expanded her kiosk stepwise and today it is comparable to the nine other kiosks in the community. Many of them have also opened only recently. All kiosks offer more or less the same products at similar prices. Customers are virtually

[10] All names have been changed in order to assure anonymity of respondents.

all from the community and Aditya complains about a lack of demand. She works in the kiosk every day from 7 am until 9 pm, but sometimes gets help from her children or her husband. Since the kiosk is integrated in her house, Aditya is able to pursue house work if there are no customers around. The kiosk has been connected to the MHP since the very beginning. She uses electric lighting but does not connect any appliances. She says she feels saver using electric lighting than using a tin lamp and it provides a better visibility of her products, which helps her and the customers to find the right product. Furthermore, it saves expenditures on kerosene. The power supply is very unstable and many bulbs have already broken. This is why she does not want to connect any electric appliance. She knows about several appliances of her neighbours that broke. Irrespective of the unstable MHP connection, she thinks that a refrigerator and the selling of ice cream could theoretically increase her income. However, she lacks money for any investment and does not want to take up a micro-credit, since she is afraid that she could never pay it back. Furthermore, she claims that the bad roads, which are muddy and often flooded when it rains, prevent customers from coming to her kiosk, irrespective if she sells ice-cream. She argues that the bad road conditions after rainy days make people leaving their houses only for the most necessary purchases.

Group of tailors

The group of tailors consists of five women, who work together in a working shed that is connected to the MHP. Besides the tailoring group, additional ten tailors work in the community. All tailors produce only on demand, since they lack money to buy fabrics. They primarily sew traditional clothes, uniforms for school or work, and occasionally some curtains. Modern daily clothes however are usually bought at markets, since industrially produced clothes are comparably cheaper and many villagers prefer them because they are more fashionably. Tailors also offer repair and alteration services for clothing. Customers are mainly from the same community, but occasionally also from neighbouring communities.

The group of tailors usually works from 8 am until 3 pm. They usually meet in the working shed in the morning in order to divide the work between each other. Afterwards they either work in the working shed or at home. The working shed does not have electric lighting. If working after nightfall is required, they work in their private houses, using electric lighting from the MHP. They have an electric stitching and sewing machine that they received through a GIZ intervention[11]. These machines can be operated only during daytime if they ask the MHP management to switch on the plant. They do not have to pay for this extra-service. In the evening the machines do not work properly since the grid is overloaded due to demand from households. Furthermore, there are only two tailors who are able to operate the electrical machines. Even though these two tried to trained other tailors of the group and of the community to use the machines, these do not want to operate

[11] Within a GIZ initiative on the productive use of energy in mid-2012, electrical appliances were provided to selected village-based businesses with access to the MHP plant. In total, 53 businesses in 9 communities in regions of Sumatra and Sulawesi were comprised. Whereas it has initially been envisaged to provide the electric appliances at a loan basis for the duration of the project and subsequently return or purchase them at a reduced cost, the electric appliances were finally left for free. This is because the contracted NGOs (ProWater and Operation Wallacea Trust (OWT)) did not succeed in convincing the communities to purchase the appliances. Furthermore, many villagers claim they had not known that the electric appliances were only given on a loan basis. Most are confused of having to return or pay for a “present” that was given initially for free.

the electrical machines and prefer to work with manual machines. Accordingly, the electrical sewing machines are used only around three times in a week. During the last month, the tailor who operates the electrical sewing machine had to resort to using a manual machine for around one quarter of her orders, because the MHP was not working properly.

Altogether, the group of tailors has achieved to increase turnover since having MHP and electrical machines. This is quite exceptional because they are the only tailors in the surveyed communities who use an electric machine. However, the additional orders just come from inside the community and they have gained customers who before were ordering at other tailors in the community. Formerly imported goods could not be replaced, since modern clothes are still bought at markets outside the community. The chance to attract customers from outside the community is low, because each community has a sufficient number of tailors.

Carpenter

Setiawan works most of the time as a carpenter, but occasionally also works as a joiner, like most carpenters do. He additionally helps his wife in her kiosk. Setiawan has already started his carpenter business when he was in high school, more than 15 years ago. His business is similar to other carpenter shops in many regards but has an exceptional customer structure that goes beyond the local population of his community. He claims to have sufficient demand which is rare among carpenters in the surveyed area. Setiawan´s speciality is carving, a skill that few carpenters exercise. He has even once been commissioned by a trader to produce 100 handmade wooden statues and 1,000 wooden bracelets, which have partly been exported to the United States of America. Setiawan has been connected to the MHP since 2006 and uses MHP lighting when working. If required, he can work up to 12 hours. Before MHP electrification, he used to go to the neighbour´s house if he wanted to work after nightfall because the neighbour used to have a gas lamp. Setiawan recently bought a grinder, and also a generator, since the MHP management does not allow the connection of appliances. While he could produce two cupboards in a week when working manually, he produces five cupboards when working with electric appliances. He furthermore calculates that he could save a lot of money if he was allowed to connect the grinder to the MHP instead of buying petrol for the generator. He currently needs around three litres of petrol which cost around 18,000 Rp. for each produced cupboard. He tells us that if appliances were allowed to be connected to the MHP, he would also buy a small sawmill.

While he currently has sufficient demand, his main obstacle is the lack of wood. He often cannot execute orders because he does not have wood to work with. He claims that if he had a reliable supply of wood, he could increase his income. However, in most of the surveyed communities it is complicated to obtain wood. In order to avoid deforestation, Indonesia has strict regulations for logging. While an official logging license, which allows logging a certain amount of wood, is expensive, many people log illegally and pay bribes or fines which increases wood prices. Setiawan lacks the money to pay a higher price for wood and depends on saw millers who sell at a reasonable price. In order to cope with this, Setiawan sometimes requests his customers to pay him in kind. Instead of giving him money they have to bring twice as much wood as they needed for their order.

Rice huller

Ferdian and his son Imanuel opened a small rice hulling business around one year ago. They use a diesel driven mill, which is located in a stall next to their house. While the mill belongs to Ferdian, Imanuel operates it because he is physically stronger. They use electric lighting from the MHP and payed 65,000 Rp as connection cost. Lighting is used when working after nightfall, which is usually the case during harvest time. This is the time of the years with highest demand and Imanuel then has up to five customers each day. Beyond harvest time, it usually does not exceed one customer each week. Imanuel’s regular working hours during harvest time last from four to six o`clock in the afternoon. Imanuel is the only rice huller within his dusun (hamlet) and all his customers are from the same dusun. Within his community two more millers offer rice hulling services.

Imanuel is paid in-kind. He keeps around one tenth of the rice that he mills for the customers as payment. This amount is usually consumed by Ferdian’s and Imanuel’s family. Only if they need money to buy diesel, of which around one litre is needed for milling 4.5 kg of rice, they sell rice sometimes. In general, the revenues of their rice hulling service are rather small. Ferdian claims that farmers of his dusun often still hull the rice manually in order to avoid spending money on the hulling service. They usually bring only small amounts for hulling. Ferdian does not see any chance of changing this. He claims that agricultural fields are just very small, and thus keep the harvest low. Since their mill is diesel driven and lighting yields only advantages in harvest time, MHP is currently not of great importance for Ferdian´s and Imanuel`s business. However, they already proposed to the MHP administrators to install the mill in the MHP power-house and operate it directly with the mechanical energy of the turbine, in order to save expenditures from buying diesel for the mill. The MHP management approved the plans and claimed that these ideas are under planning.

Annex 2: Questionnaires

A3-1: Household Questionnaire 2013

A3-2: Community Questionnaire 2013

A3-3: Micro-enterprise Questionnaire 2013