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Impact Report on

Micro Hydro Power sites

Supported by EnDev I in Indonesia

May 2011

Gunther Bensch
Jörg Peters
Maximiliane Sievert
Coro Zimmermann

Contact details: Jörg Peters, Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI), Hohenzollernstrasse 1-3, 45128 Essen, Germany. Tel.: 0049(0)201-8149-247.
Email: peters@rwi-essen.de

Contents

List of Tables

List of Charts

Abbreviations

Endev	Energising Development; a Dutch-German Energy Partnership to promote sustainable access to modern energy services in developing countries
HH	Household
HoH	Head of Household
GDP	Gross Domestic Product
GIZ	Gesellschaft für Internationale Zusammenarbeit
GTZ	Gesellschaft für Technische Zusammenarbeit
IDR / Rp	Indonesian Rupiah
ILO	International Labour Organization
KDP	PNPM Kecamatan Development Program (kecamatan = sub district)
LPG	Liquefied Petroleum Gas
MHP	Mini / micro hydropower system
MHPP/ MHPP^2	Mini Hydropower Project Indonesia
NGO	Non-Governmental Organization
PLN	Perusahaan Listrik Negara, the Indonesian National electricity utility
PNPM	National Programme for Community Empowerment (Program Nasional Pemberdayaan Masyarakat)
TSU	Technical Support Unit
TV	Television Set
VCD	Video Compact Disc

Exchange rate as of 30th of September 2010: 10,000 IDR = 0.81597 EUR

Executive Summary

This report assesses the impacts of the rural electrification intervention Micro Hydro Power Project (MHPP) implemented by the Government of Indonesia and Gesellschaft für Internationale Zusammenarbeit (GIZ). MHPP supported between 2006 and 2009 the implementation of 96 micro hydro power (MHP) schemes in Sumatra and Sulawesi. These activities were funded as part of the first phase of the German-Dutch Energy Partnership *Energising Development* (EnDev), an output oriented program that aims at providing modern energy to 6.1 million people in 21 countries. The objective of this study is to examine the effective electricity usage of households that have connected to an MHP, i.e. what those households do with electricity and to what extent this changes the households' life.

For this purpose, 413 households that are connected to an MHP have been interviewed between September and November 2010 by RWI, the subcontractor Entec that carries out the implementation of the project, and local organizations. The household interviews are based on a structured questionnaire that covers virtually all socio-economic living conditions of the household and its members with a particular focus on energy usage. Additionally, qualitative interviews with key informants and village chiefs provide for background information. Out of 96 villages that have been electrified in total by MHPP, 20 were selected by the project for the impact evaluation. These 20 villages were electrified between 2006 and 2009.

The main challenge of any impact assessment is the identification of a valid reference scenario to which the evaluator can compare the electrified households to obtain an estimation for the impacts. A valid reference scenario is one that simulates the situation of the electrified households if they had not been electrified. For this purpose, we compare the MHPP-electrified households (EnDev 1 households in the following) to comparable households in villages that will be electrified by ongoing micro-hydro electrification interventions in the near future (EnDev 2 households in the following). The basic assumption of this approach is that the yet non-electrified EnDev 2 households are similar to the EnDev 1 households *before* they got electrified.

It turned out during the survey, though, that the EnDev 2 villages already exhibit a considerable share of pre-electrified households (approximately 50%)[1]. Among the EnDev 1 households, in contrast, only few households had been pre-electrified before getting the MHP-connection. Thereby, the pre-electrification rates in EnDev 2 villages violate the comparability assumption that is required to obtain a reasonable impact assessment. To respond to this, we can only take the non-electrified part of households form the EnDev 2 villages as a reference. In doing so, it has to be taken into account that these households have not been assigned to being non-electrified *by chance*. For example, poorer households are much less likely to buy a genset or a solar home system. More generally, one might refer to their status as *disadvantaged* (be it for financial, regional, or political reasons).

By identifying a corresponding subgroup of *disadvantaged* households among EnDev 1 households, we can at least perform an impact assessment for this subgroup. For the group of *advantaged*

[1] The results on the survey in EnDev 2 villages are presented in a separate report.

households we have no realistic simulation of their *before* situation, because among the EnDev 2 households the advantaged households are already using electricity. A comparison of *advantaged* EnDev 1 households with the pre-electrified EnDev 2 households only provides the lower boundary of the true impacts.

Generally, all MHP sites visited in EnDev 1 villages were found to be in operation. In few cases the service has been temporarily interrupted somewhere in the recent past, but all households interviewed are normally served with electricity from the MHP and had done so in the month prior to the interview. Virtually all households covered by the MHP mini-grids are connected indicating that the needs of the households are met. The MHP electrification enables a variety of services and activities, especially through a distinct increase in appliance usage. The households operate primarily lighting devices, but also TV sets and other information and entertainment devices like CD or VCD player or charge mobile phones. Almost half of the households use electric irons in Sumatra, whereas in Sulawesi only 6% use them. In Sumatra, more than half of the households use rice cookers. Generally, the number of electronic appliances is substantially higher in Sumatra than in Sulawesi. This might be due to the fact that households in Sumatra's target regions are wealthier than the target region in Sulawesi, but also due to notably higher available MHP capacities in Sumatra compared to the MHP schemes in Sulawesi. While the available capacity per household is at 145 W in Sulawesi, it is at 245 W in Sumatra.

The most important non-electric energy sources are kerosene and firewood. Virtually all EnDev 1 households use firewood for cooking. Yet, the considerable take-up of rice cookers indicates that some impacts on the level of cooking fuel usage can be expected – unlike experiences from rural Africa, where electricity is never used for cooking purposes. *Disadvantaged* EnDev 1 households use on average 5% less firewood than their non-electrified EnDev 2 counterparts. Among *advantaged* households the reduction is even roughly 15%. This implies rather a reduction in work load and exposure to smoke than in costs, as most of the surveyed households collect firewood and do not buy it.

Almost all households in Sumatra and Sulawesi use kerosene for lighting (Sumatra 98%; Sulawesi 89%) and/or candles and torches. This indicates that, although all households use electric lighting, traditional lighting sources are not completely replaced. Many households use kerosene lanterns in times of blackouts. This might also be an indication for the reliability of the electricity from the MHP and highlights further saving potentials for the households if they had a stable electricity supply. This fact is furthermore substantiated by the households assessment of the service quality provided by the MHP. 67% of the MHP users wish to have an improvement in the electricity supply, which mostly refers to a more reliable electricity supply (53% in Sumatra and 34% in Sulawesi). Asked for problems with the MHP mini-grid, some households complain about voltage fluctuations, by which 27% of the households state that some equipment has been damaged.

Assessing the consumption in lighting hours, we observe a 55% increase among disadvantaged EnDev 1 households in Sumatra if compared to their non-electrified counterparts. The amount of consumed lumen hours even rises by more than 20 times. In Sulawesi, the lighting hours have quadruplicated and lumen hours increased by almost 70 times. Also if we compare the advantaged EnDev 1 households to the electricity using EnDev 2 households, they consume distinctly more lighting hours

and lumen hours. This latter result is in line with expectation, because the quality of electricity provision will clearly improve for the pre-electrified EnDev 2 households as soon as they get connected to the MHP mini-grid.

A further indication for the improvement in electricity supply that EnDev 2 households will experience is the higher usage of traditional lighting devices among them. Although also the *advantaged* EnDev 1 households are still using kerosene and candles, they do so to a lesser extent. On average, EnDev 1 households light 3 rooms with their electric lighting devices and 1.6 rooms with the traditional lighting. This also illustrates the higher convenience of the lighting through MHP compared to electricity using EnDev 2 households, who only light 2.3 rooms with their electric devices. It can furthermore be seen that the MHP using EnDev 1 households are much more satisfied if asked directly how satisfied they are with their electric lighting sources than the electricity using people in EnDev 2 households.

The potentials to transform agricultural products by means of electricity is largely untapped. There are hardly any differences observable between EnDev 1 and EnDev 2 households and villages. Both in EnDev 1 and EnDev 2 villages most of the crop transformation is exercised by hand or with a manual tool. Only for grinding and hulling processes there are some households that employ motorized, mostly diesel driven appliances. Only in three EnDev 1 villages, rice hullers and threshers exist that are connected to the MHP-turbine in the power house.

Productive electricity usage is rather limited in the target region. In general, only few enterprises exist in the villages. Among the existing firms mainly shops get connected and use electricity for lighting and in some cases also for the operation of TVs and fridges. While some of the few tailors connect to the MHP, carpenters normally do not connect. This is mainly due to the fact that many of them are primarily subsistence farmers and only take up their carpentry work in case of demand. Accordingly, they do not have a fixed workshop and work with mobile generators at the place they are needed. On the supply side, the operation time of the MHPs hampers productive electricity usage. Most of the MHP only operate after nightfall (and fulltime only on Sundays and Fridays). Hence, the firms are not able to use electricity at daytime.

The comparison of energy expenditures between the *disadvantaged* EnDev 1 households and the non-electrified EnDev 2 households shows no clear reduction in Sumatra, where energy expenditures decrease by 3% only. In Sulawesi, the reduction is more accentuated at 35%. Assessing the possible reduction in expenditures for advantaged EnDev 2 households shows the enormous potential induced by a switch from pre-electrification sources to MHP electricity: Above all, the high reductions for generators users are striking. The EnDev 2 households pay 30% more for energy in Sumatra and 15% more in Sulawesi than comparable EnDev 1 households.

One part of the questionnaire was designed to examine if the daily routine of household members is affected by the availability of electricity. Persons living in electrified households on average are longer awake than persons in non-electrified households. The study time of children, though, is not higher among households with electricity; neither total study time nor study time after nightfall. According to open interviews with teachers, none of the schools in EnDev 1 villages offers evening courses or other activities after nightfall. As most of the MHPs do not operate during daytime, an

electricity connection is often not attractive for schools. If schools are connected at all, electricity is normally only used for sound systems, which are used for gymnastics courses.

Improved access to information could be one major impact of electrification. In fact, especially the ownership and usage of mobile phones is substantially higher among EnDev 1 households than in EnDev 2 villages. Likewise, more EnDev 1 households possess TV Sets and electrified households spend on average up to 90 minutes of their daily time on watching TV. The preferred TV programs in EnDev 1 households for fathers are news and sports (mostly boxing) – both in Sulawesi and Sumatra. Women like to watch soap operas, but also news. 81 % of households name TV as their major source of information. Only 9% state that they principally get news from friends or neighbors. Even among those households without TV at home 34% get their information mainly from TV, 33% from neighbors and friends.

Besides the partly severe reliability problems, the high connection rates and the strong usage of appliances indicates that considerable impacts on the life of the beneficiaries can be expected in the long run: modernization effects due to television, improved access to information through television and mobile phones, convenience, fuel and time savings, as well as improved air quality due to electric lighting and rice cookers. Income generating activities are also possible, although on the level of enterprises take up so far is modest.

The potential of rice cooker usage in Sulawesi, though, could be further exploited. Future research could follow up on these first results and examine the reasons for the usage and non-usage of rice cookers among the target households. Besides insufficient capacity provision per household, financial obstacles or a lack of awareness may be driving factors.

1. Micro Hydro Projects Indonesia

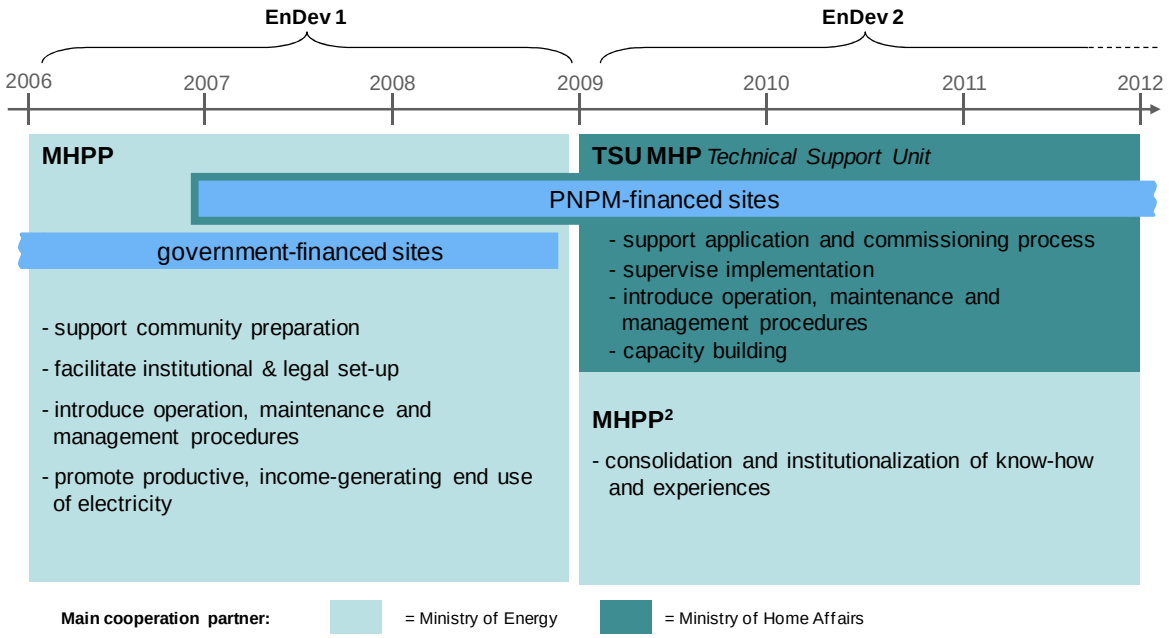
Since the end of dictatorship in 1998 Indonesia's economy has been growing on a persistently high rate of 4.6 %. Nevertheless, almost a third of its 240 million inhabitants is living in poverty (UNDP 2010).[2] In particular, in rural areas people are dependent on biomass and other traditional energy sources to meet their daily energy demands. The electrification rate is at 64.5 % - still leaving some 70 Mio. people without access to electricity who mainly live outside of the main island, Java. In 2008, 86% of total electricity consumption was derived from conventional sources (oil, natural gas, hard coal), 8% from hydroelectric sources and 5% from geothermal and other renewable sources (UNDP 2009). In particular in remote rural areas the water abundant and mountainous country bears huge potential for micro-hydro power (MHP) that is estimated at 500 MW. (U.S. Department of Commerce 2010).

Due to various reasons, this MHP potential to electrify further rural communities is largely untapped. In particular the mountainous rural areas are in many cases difficult to access implying high investment costs for grid infrastructure extension. The bad financial situation of the state electricity company Perusahaan Listrik Negara (PLN) aggravates the situation. Especially for commercial independent power producers or off-grid projects, the fixed electricity tariffs are a major barrier. These tariffs are even below the average production costs of PLN. Moreover, subsidies for diesel fuel provide competitive advantages for diesel generators in contrast to non-subsidized hydro energy (YBUL 2002).

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) has been active in the field of MHP for the last 20 years. In 2002, the Mini Hydro Power Project (MHPP), jointly implemented by the Indonesian Directorate General for Electricity and Energy Utilization (DGEEU) within the Indonesian Ministry of Energy and Mineral Resources and GIZ, was founded. Between 2006 and 2009, MHPP has supported the implementation of 96 MHP sites in Sulawesi and Sumatra with capacities ranging between 5 and 50 kW. These activities have been funded as part of the first phase of the German-Dutch Energy Partnership *Energising Development* (EnDev), an output oriented program that aims at providing modern energy to 6.1 million people in 21 countries. In the meantime, EnDev entered its second phase (EnDev 2) where activities are implemented via two complementary actors: The implementation oriented Micro Hydro Power Technical Support Unit (TSU) and the policy oriented Mini Hydro Power Project (MHPP[2]). Chart 1 summarizes the Micro Hydro activities of GIZ within the period 2006 to 2012.

[2] For a more detailed summary of the country's state of affairs refer to Section 1.3 in the BASELINE REPORT.

Chart 1: Micro Hydro Project activities of GIZ Indonesia, 2006-2012 (Endev 1 / EnDev 2)



In principle, it can be distinguished between two kinds of project sites supported under EnDev 1, while in exceptional cases a mix of the two exists: On the one hand, there are sites funded by the Indonesian government. On the other hand, a community driven development program, executed by the Government of Indonesia and financially supported by a World Bank multi-donor trust-fund (formerly KDP program, now PNPM) provides money for projects for community empowerment. Within this framework, communities can apply for funding for self-defined community development projects, which also include MHP, the so-called “Green PNPM”. The lead executive agency of the program is the Ministry of Home Affairs (MoHA). The community empowerment program already exists since the end of the 1990s. However, due to the lack of operational support and maintenance, many MHP sites did not perform properly. Since 2007, the GIZ cooperates with the community empowerment program via MHPP in order to improve the sustainability.

MHPP supported both the government and KDP financed sites during the implementation with the following activities:

- supporting community preparation and participation
- Facilitating suitable institutional & legal set-up
- Introducing operation, maintenance and management procedures
- Introducing principles of good business administration, tariff-setting, billing, savings, electricity customer relations
- Promoting productive, income-generating end use of electricity.

2. Evaluation Approach

2.1. Evaluation Objective

The impact assessment presented in this report is part of a broader evaluation effort of EnDev activities in Indonesia. Besides the assessment of impacts of the EnDev 1 intervention, the data serves as a baseline study for MHP TSU EnDev2 villages and therefore provides for data to be used in an ex-post evaluation. The objective related to the evaluation of EnDev 1 is to examine what the households that are connected to an MHP effectively do with electricity and to what extent it changes the households' behavior and, eventually the households' socio-economic situation. For this purpose, we compare the EnDev 1 households to comparable MHP TSU EnDev 2 households. Underlying challenges and caveats are extensively discussed in Section 3.4. Moreover, we predict impacts to be expected for EnDev 2 households.

2.2 Survey Implementation and Sampling

While in total 96 villages have been electrified under EnDev 1, 20 of them were selected by the project for the impact evaluation[3]. In total, 413 households were interviewed, 207 in Sumatra and 206 in Sulawesi. The selection of villages – ten in Sulawesi and ten in Sumatra – was driven by comparability considerations – in order to use the collected data for an impact assessment of the EnDev 1 intervention the surveyed EnDev 1 and EnDev 2 villages have to be comparable – and logistical considerations. The surveyed villages are concentrated in four *kabupaten* (regions): Mamasa in Sulawesi and Pesisir Selatan, Solok Selatan and Agam in Sumatra.

During a preparatory mission, the methodology including the questionnaire was finalized. For data collection in Sulawesi, 4 enumerators were recruited from the University of Makassar. All of the enumerators had recently graduated from the Faculty of Social and Political Sciences. Enumerators for Sumatra were recruited from RAGOM, an NGO based in Lampung, Sumatra, that is also contracted to support the institutional setup of MHP sites. The enumerators were trained by the RWI evaluation team in two four days courses, one in Sulawesi, one in Sumatra. Pre-tests were conducted to verify the feasibility of the questionnaire.

Two RWI researchers stayed on the ground to supervise the implementation of the survey between September and October 2010 with two survey teams working at the same time in Sumatra and Sulawesi. In each village, the hamlets (*dusun*) connected to the MHP were identified during a short interview with the village chief and an ad-hoc simple random sample of these hamlets was carried out. Thereby, all households in the access area of the MHP were included. Virtually all of these households are also effectively connected to the MHP, despite some few households that have been disconnected due to non-payment of the fees. A comprehensive list of households was obtained from the village chief or MHP management and 20 households per village were selected randomly. The four enumerators per team were subsequently assigned to the different hamlets.

The major survey tool is a structured questionnaire covering virtually all socio-economic dimensions that characterize the household's living conditions (see Annex 2). A particular focus of the

[3] For more details on the surveyed sites, please refer to Annex 1. Here, also some considerations concerning the site selection criteria are provided.

questionnaire is on energy and electricity usage. In addition, income sources, time use, and gender related issues are extensively covered. The household questionnaires have been checked every night for consistency and completeness by the two RWI researchers in the field. Semi-structured interviews with other beneficiaries like schools, health huts, administrative institutions, and micro-enterprises have been conducted. Qualitative interviews with other key informants complement the quantitative approach. This qualitative information provides for context that cannot always be captured in more structured interviews, not least to cross-check the household statements in the structured questionnaire.

3. Results from structured household interviews

3.1 Household Structure

The household structure in Sumatra and Sulawesi is similar (see Table 1). There are on average 4.2 people in one household including on average 1.3 children under 15 years. In three percent of the households there is a pregnant woman.

Table 1: Household Characteristics

	Sumatra	Sulawesi
Number of HH Member	4.3	4.1
Number of Children under 15	1.3	1.4
Number of Children under 11	1.2	1
Number of Children under 6	0.6	0.5
Share of HH with pregnant women	3.4%	3.4%
One parent is absent	11.6%	13.6%
Distribution of power		
Father is head of HH	88.9%	88.4%
Female is responsible for HH budget (together with male)	53.9% (15%)	86.4% (1%)
Female is responsible for buying fuel	42.2%	91.3%
Characteristics of Head of HH		
HoH did not receive education	5.8%	18.5%
HoH finished primary school	63.8%	48.1%
HoH finished junior high school	18.8%	14.6%
HoH finished senior high school	9.7%	13.1%
HoH went to university	1.5%	5.8%
Age of Hoh	45.6	47.1

What differs between the regions is the distribution of power between the mother and the father. Whereas in Sumatra in 69% of the households the mother alone or together with the father manages the household budget, in Sulawesi this share amounts to 87%. Also the share of women responsible for buying fuel is substantially higher in Sulawesi. This comes as a surprise as the majority of households in Sumatra follow a matrilineal tradition in contrast to Sulawesi where they live in patriarchal structures. The number of female head of households in both regions only totals approximately 11%. The primary reason for why women are head of household is the absence of the father. The share of household heads without education is higher in Sulawesi than in Sumatra (19% versus 6%). Those who obtained some sort of education, though, are better educated in Sulawesi (see Table 1).

3.2 Household Economy

3.2.1 Housing Conditions and Assets

The housing conditions in Sumatra are clearly better than in Sulawesi (see Table 2). This is illustrated by the higher share of houses constructed with high quality construction material in Sumatra and the bigger households with 3.8 room compared to Sulawesi with 3.1 rooms. The households in Sumatra have been living on the same plot of land for already 16.9 years. In Sumatra they have been doing so for 13.1 years.

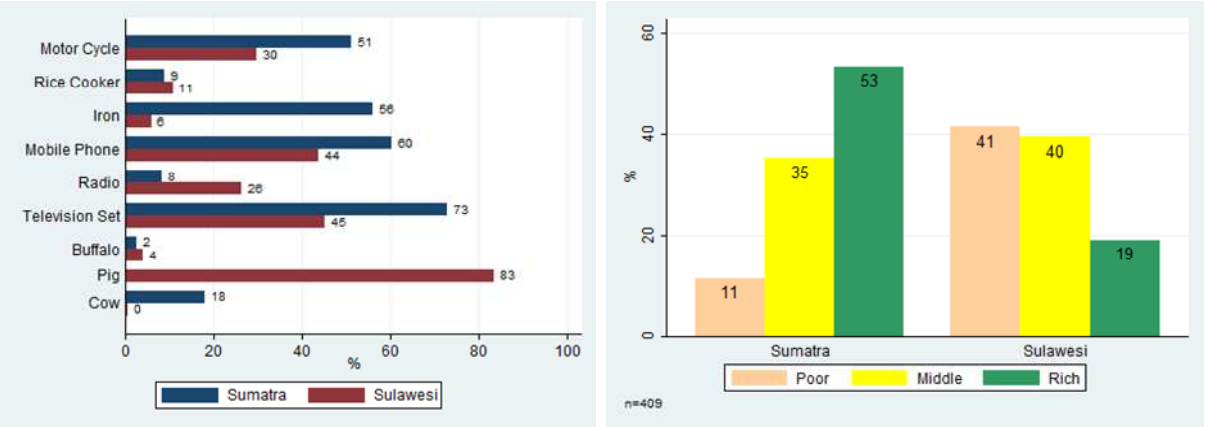
Table 2: Housing Conditions

	Number of rooms	Windows are fitted with glass	Roofing is palm leaves, ijuk[1] or wood	Building is plastered	Outside wall is stone, brick or zinc	Flooring material is…		
						soil only	bamboo or wood	concrete, bricks, ceramics
Sumatra	3.8	48.4%	2.9%	40.1%	50%	1.9%	31.8%	66.2%
Sulawesi	3.1	21.4%	13.6%	4.4%	2%	0.5%	91.8%	7.8%

[1] Palm fiber

Also looking at the households' assets shows that people in the Sumatra survey region are wealthier. 51% of the households in Sumatra and only 30% in Sulawesi own a motorcycle; owning a motorcycle is a typical dream of an Indonesian family in rural areas. Further assets like TV, irons, and mobile phones are much more common in Sumatra as well.

Chart 2: Assets and wealth indicator in Sulawesi and Sumatra



For the poverty analysis, a wealth indicator originally developed in Bensch and Peters (2010) is applied. Household data typically suffers from sporadic inaccuracies due to, for example, recall errors – in particular in rural areas of developing countries. Data on income and wealth is further biased, because people tend to state lower values in order not to give rise to jealousy. Therefore, a combined indicator has been created to reduce biases inherent in single variables and to incorporate different facets and proxies of wealth. These comprise assets, expenditures, and income elements (see Table 3). Income has been defined following the definition of the World Bank Living Standard Studies (WB 1992). The indicator takes on values between 0 and 24, which are categorized into "poor", "middle" and "rich".

Chart 2 shows that the percentage of poor households is clearly lower among Sumatra households and, accordingly, the share of rich households is higher.

Table 3: The Wealth Indicator

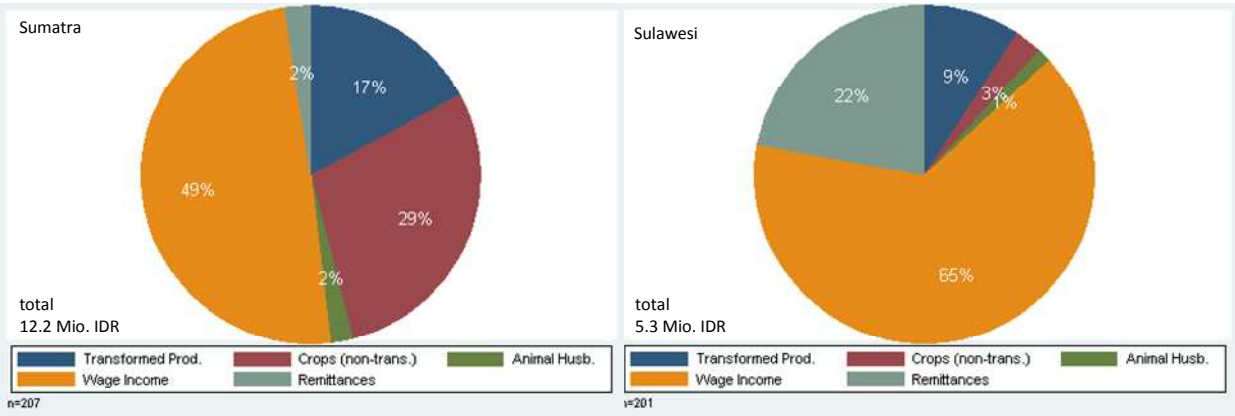
Criterion	Subindicator
ASSETS	
Dwelling Conditions	Construction Material of Outside Walls Flooring Material Roofing Material
Cattle	Quantity of Buffalos Owned
Savings	Ownership of a Bank Account Saving of Money
Mobility	Type of Means of Transportation
Education	Education Level of Head of Household
EXPENDITURE	
Nutrition	Food Expenditure per Adult Equivalent
Energy	Expenditure on Energy Sources per LogCapita
Health	Entitlement to governmental pro-poor health insurance
INCOME	
Income	HH Income per HH Member Able to Work excl. Consumption of Home Production

3. 2. 2 Income

The total monetary income comprises five different components: income from paid dependent employment (wage income), income from selling non-transformed agricultural product, income from selling transformed goods, income from animal husbandry, and from remittances. This total monetary income is substantially higher in Sumatra, where it amounts to approximately 12.2 Mio IDR (995 EUR[4]), while it is only 5.3 Mio IDR (432 EUR) in Sulawesi. Most of the working population in both regions works as subsistence farmers; only in Sumatra households generate remarkable cash income from agricultural sources. In Sulawesi, the most important income source is wage income that accounts for 65% of total revenues. The absolute value of these revenues, though, is not higher than in Sumatra. These revenues amount to 3.4 Mio IDR (278 EUR) per year in Sulawesi, compared to 6 Mio IDR (490 EUR) in Sumatra. The high revenues from non-transformed goods in Sumatra stem primarily from the cultivation of rubber.

[4] Exchange rate as of 30th of September 2010: 10,000 IDR = 0.81597 EUR

Chart 3: Composition of Annual Monetary Household Income in Sumatra and Sulawesi



The substantial difference in the total monetary incomes in Sumatra and Sulawesi can partly be ascribed to a high percentage of households in Sulawesi that do not have any cash income at all (21%). In Sumatra, 8 % of households do not have any monetary income. On the other hand, however, all of these households that do not declare any income nevertheless have expenditures that are on average only slightly lower than the average across all households. This might indicate that these households are just reluctant to disclose their monetary income – which does not come as a surprise, as income data in general is known to be prone to biases and inaccuracies. Because of the high sensitivity of income data it is advisable to use data on expenditure to approximate the level of income (Deaton 1997). The extensive information on expenditures elicited in our interviews allows us to proceed like this.

Table 4: Household Income

	Mean Annual Income	**Household budget is…**		
		sufficient	tight	not sufficient
Sumatra	12,200,000 IDR	29.1	42.2	28.6
Sulawesi	5,325,214 IDR	16.0	43.2	40.8

The lower revenues in Sulawesi are also reflected in the subjective estimation of the households concerning the adequacy of their households' budget (see Table 4). In Sumatra there are substantially more households that say their income is sufficient (29%) than in Sumatra (16%).

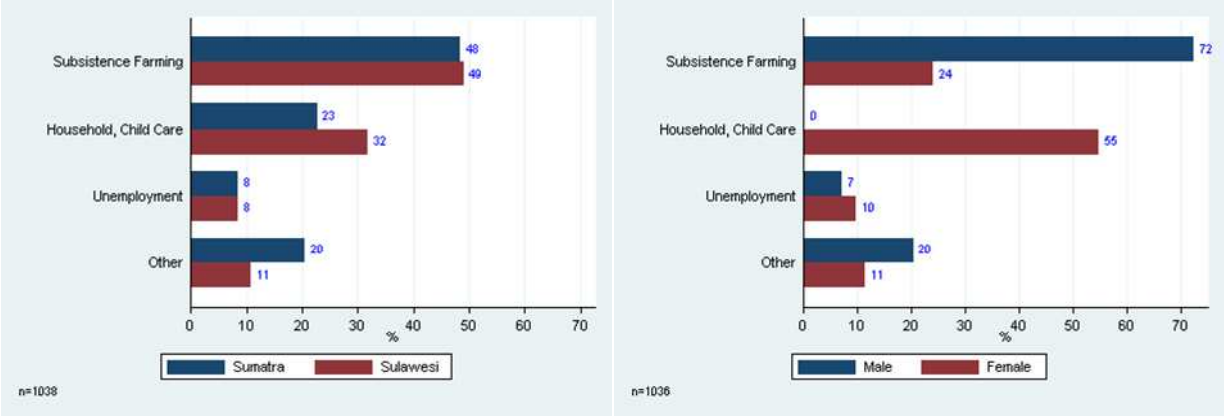
Main Occupation and Wage Income

Almost half of the population *able to work* both in Sumatra and Sulawesi are subsistence farmers (see Chart 4). Able to work is defined as being older than 14 and younger than 66, neither studying nor being retired. More than half of the women able to work are occupied with household duties and childcare. 8% are unemployed.

The activities subsumed as other activities in Sumatra amount to 20%. This includes first of all paid farm workers (48%), independent salespersons and traders (18%), and public servants (12%). In Sulawesi, where 11 % of the persons able to work are working in other activities, the biggest share works in the educational sector. 37% work as "honor teacher", which are teachers that are directly hired by the school and not employed by the government. Public servants make up a further 24%

and include besides teachers also nurses or policemen. Furthermore, there are some manufactures such as carpenters, mechanics, tailors and weavers (14%). In Sumatra, these occupations only account for 8 % of the activities that are subsumed as other occupations.

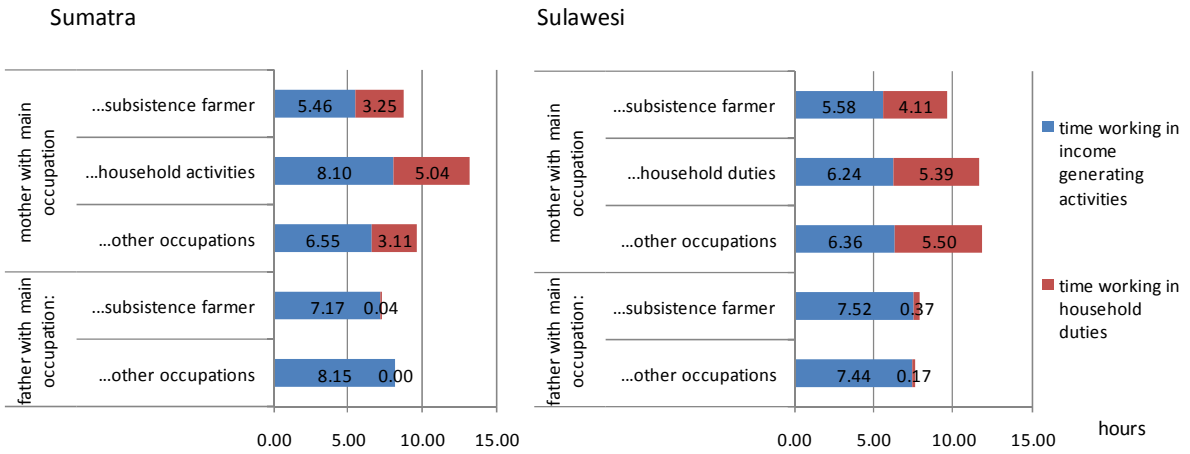
Chart 4: Main Occupation of population able to work distinguished by region and sex



The wage income earned by these activities is higher in Sumatra with 502,000 IDR (42 EUR) per month compared to 285,000 IDR (23 EUR) in Sulawesi.

Exercising a second occupation is more common in Sumatra among men (28%) than among women (12%); in Sulawesi it is vice versa (14% among men and 26% among women).

Chart 5: Time dedicated to work and household duties distinguished by main activity



If we look at the time household members spend on income generating activities and household duties, we observe differences between the sexes but also between the regions (see Chart 5). The wage income earned by these activities is higher in Sumatra with 502,000 IDR (42 EUR) per month compared to 285,000 IDR (23 EUR) in Sulawesi.

Exercising a second occupation is more common in Sumatra among men (28%) than among women (12%); in Sulawesi it is vice versa (14% among men and 26% among women).

Chart 5). For household duties, fathers do only participate to a very small extent in Sulawesi and not at all in Sumatra. The working hours for mothers in Sulawesi are slightly higher than in Sumatra. The generally higher work load for women in household duties does not translate into substantially lower working hours in income generating activities. Here, women only work few hours less than men. Accordingly, the total work load for women is much higher than for men.

Cultivation and Animal Husbandry

89% of households in Sumatra and 96% in Sulawesi are farmers (see Table 5). Around 80% cultivate their own land, whereas about 10% of households work under the *bagi hasil* system, which means that the farmer does not own the cultivated land. Instead of paying a rent, the harvest is shared between the owner and the farmer. While in Sumatra, farmers cultivate on average 0.9 ha land, it is 0.6 ha in Sulawesi.

Table 5: Agricultural activity

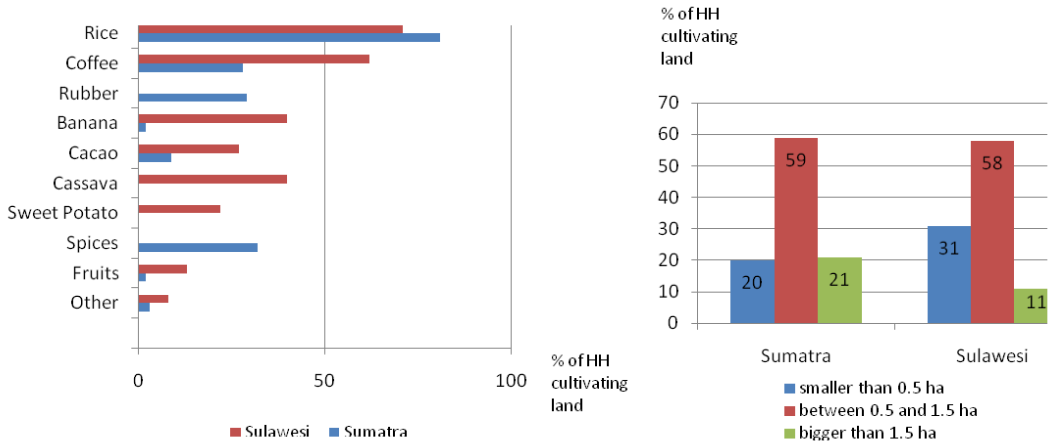
	Sumatra	Sulawesi
Share of HH cultivating land	89	96
Share of HH who sell non-transformed crops	37	22
Share of HH who transform crops	63	92
Share of HH who sell transformed crops	50	52
Land is own property	82	84
Land is cultivated under *bagi hasil*	13	11
Dimension of cultivated land (in ha)	0.9	0.6

Rice is the most important crop on both islands (see Chart 6) cultivated by around 70% of households in Sulawesi and 81% in Sumatra. The second most important crop in Sulawesi is coffee (62%), followed by banana and cassava with 40% each, and cacao with nearly 30%. More than 10% also cultivate several sorts of fruit (orange, mango, pineapple, and papaya) and nearly 10% cultivate other agricultural products (maize, pumpkin, peanut). In Sumatra, apart from rice, rubber, coffee, and spices (hot pepper, green pepper, Cardamom, Cinnamon) are the most important crops. The share of each amounts 30%.

The transformation of agricultural products is more common in Sulawesi. 63% transform agricultural products in Sumatra and 92% in Sulawesi. Half of households on both islands sell transformed products. 37% of households in Sumatra and 22% in Sulawesi sell agricultural products in a non-transformed way.

The average revenue per year from non-transformed products differs a lot between the two islands: It amounts to 3.700.000 IDR (301 Euros) in Sumatra and to 143.000 IDR (12 Euros) in Sulawesi. This difference is especially due to rubber cultivation in Sumatra that generates substantial parts of the income in Sumatra. Furthermore, the income in Sumatra derives from spices (green and hot peeper, cinnamon, and cardamom). In Sulawesi, the households sell coffee and cacao in a non-transformed way.

Chart 6: Most common crops and dimension of cultivated land



The revenues per year from transformed products also differ a lot between Sumatra and Sulawesi. Whereas farmers in Sumatra earn on average 2.100.000 IDR (171 Euros), in Sulawesi they earn just 481.000 IDR (39 Euros). The main transformed products sold are rice and coffee in both regions, cardamom and cinnamon in Sumatra as well as cacao in Sulawesi. The transformation of agricultural products will be analyzed more in details in 3.4.1 Energy sources and uses.

64% of the households in Sumatra and 94% in Sulawesi have domestic animals. Most important animals are poultry and cows in predominantly Muslim Sumatra, whereas pigs are most common in mainly Christian Sulawesi, followed by poultry.

Table 6: Most important animals

	Sumatra			**Sulawesi**		
	Animal	share of HH	average number	Animal	share of HH	average number
1.	poultry	73	8	pig	90	2.5
2.	cow	28	1.6	poultry	69	5
3.	goat	12	5	buffalo	4	2

Most households keep their animals exclusively for home consumption. Only 17% in Sumatra and 2% in Sulawesi gain revenue from their animal or animal products and services. The revenue from animal husbandry totals on average 253,000 IDR (21 EUR) per year in Sumatra and 68,000 IDR (5 EUR) in Sulawesi and stems mainly from pigs in Sulawesi and goats, cows and poultry in Sumatra.

Migration and Remittances

Migration is very common in both survey areas. In Sumatra, 43% of the households state that some former household member has migrated. In Sulawesi, it is even 50% of the households.

The most important reasons for migration are work and marriage. In Sumatra the latter is the most important (48%) followed by work (40%). In Sulawesi it is the other way round and 43% migrated in order to find work and 38% because they got married elsewhere. Household members that migrate to study are more frequent in Sulawesi (18%) than in Sumatra (10%).

Many of the migrants stay in the same *kabupaten*, if not even in the same *kecamatan*, especially in Sumatra. Further common destinations for migrants from Sumatra are the capital of the province, Padang (9%), and the capital of the neighboring province Jambi (9%). Only very few households leave Sumatra; 3% went to Jakarta and only 1% left the country to live in Malaysia. In Sulawesi, the province capitals Makassar (28%) and Mamuju (10%) attract most migrants. 10% went to other Indonesian islands, including 4% that went to Jakarta. 2% went to Malaysia.

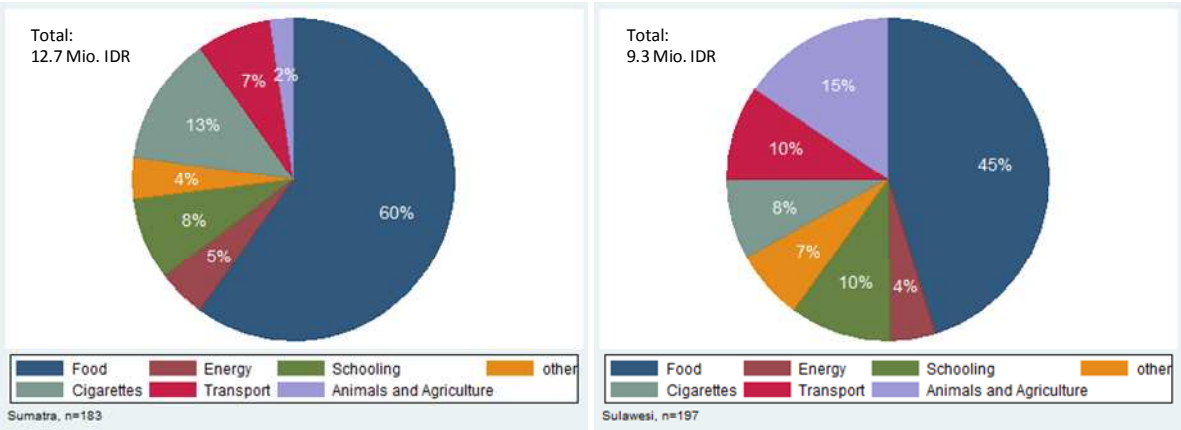
The number of migrants that send remittances to their family is substantially higher in Sulawesi (39%) than in Sumatra (19%). Also the amount of money these migrants send is higher in Sulawesi (450,000 IDR; 37 EUR) than in Sumatra (320,000 IDR; 26 EUR) if we exclude those that do not send any money at all.

The migrants' education level is higher than among all other household members between 15 and 60 years. 30% finished secondary school (19% among all household members) and even 11% went to university (4% among resident household members).

3.2.3 Expenditures and Financial Situation

Expenditures on food represent the biggest proportion of the households' total expenditures that amount to 12.7 Mio IDR (1,040 EUR) in Sumatra and 9.3 Mio IDR (759 EUR) in Sulawesi. In Sulawesi, the second most important category of expenditures is animal husbandry and agriculture. These expenditures amount to 1.4 Mio IDR (114 EUR). In Sumatra, they are substantially lower and only total 0.3 Mio IDR (25 EUR). What is striking, are the high expenditures for cigarettes that account for 13% of the expenditures in Sumatra and 8% in Sulawesi – in particular when compared to energy expenditures, which are at 8% in Sumatra and 10% in Sulawesi.

Chart 7: Expenditures per year by category, Sumatra and Sulawesi



Expenditures subsumed as "other" are telecommunications, remittances, and medical expenses. Besides these regular expenditures, households were asked about bigger investments (>200.000 IDR, >16 EUR) they made in the last 12 month. In Sumatra, almost 90 % of the households made bigger investments, whereas in Sulawesi only around 20% did. In Sumatra, these include especially expenditures for Idul Fitri, the Muslim celebrations at the end of Ramadan, when households spend much money on food and new clothes. In Sulawesi as well as in Sumatra, households invest in

children's education, investments related to animals or crop cultivation, mobile phones and TV, clothes, medicine, and furniture.

Having a bank account is both uncommon in Sumatra and Sulawesi (7%, see Table 7). Instead, in Sumatra, many households save money at home. In Sulawesi, saving is generally very rare. The rate of households that took up a loan in the last year, though, is higher in Sulawesi (24% versus 15%). However, these are primarily informal loans contracted with relatives and friends. Nobody contracted a loan with a commercial bank. In Sumatra, at least 17% of the loans were contracted with a commercial bank.

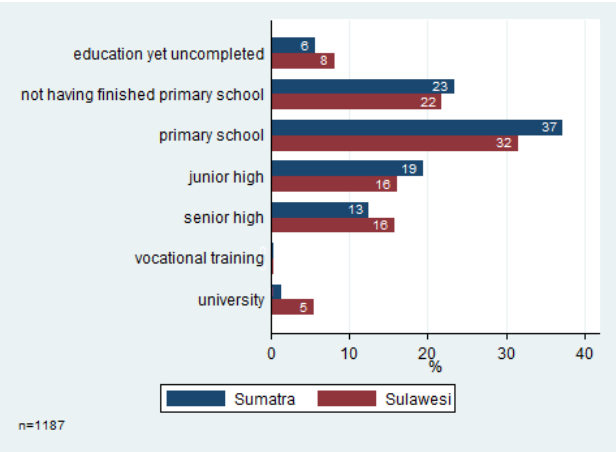
Table 7: Financial Situation

Percentage of HH that…	**…has a bank account**	**…saves money at home**	**…took up a loan last year**	**Loan was contracted with:**				
				relative, friend	commercial bank	microfinance association	cooperative	shop
Sumatra	7%	18%	15%	47%	17%	7%	23%	7%
Sulawesi	7%	3%	24%	86%	0%	8%	0%	2%

3.3 Education, Health and Infrastructure

3.3.1 Education

Chart 8: Educational level of household member



The number of household members older than 15 years that achieved secondary education is notably higher in Sulawesi than in Sumatra. 16% finished senior high school and even 5% visited university. In Sumatra, only 13% finished senior high school and only 1% visited university. The share of people that did not finish primary school is around 23% in both regions. The years of schooling total on average 7 years in Sumatra and 8.2 in Sulawesi.

3.3.2 Health

The share of households that have a health insurance in Sulawesi is substantially higher than in Sumatra. The reason is that 70% of the population in Sulawesi is covered by the pro-poor governmental health insurance *Jamkesmas*[5]. In Sumatra, only 21 % of the households are entitled to

[5] Refer also to Section 3.3.2 in the baseline report.

participate in this program due to their substantially higher living standard and, consequently, higher income figures.

Table 8: Health

Percentage of HH that…	HH that have health insurance	Health expenditures per year	Household is able to pay for medicine:			
			always	often	seldom	never
Sumatra	21%	76,396 IDR	52%	29%	17%	1%
Sulawesi	70%	250,117 IDR	9%	49%	24%	19%

The lower income figures in Sulawesi are also reflected in the households' self-assessment concerning their ability to pay for necessary medicine. While in Sumatra more than half of the households state that they are always able to pay for medicine, in Sulawesi the share only totals 9% and 19% state that they are never able to pay the medicine. The expenditures for medicine and medical treatment are substantially higher in Sulawesi, though.

All households both in Sulawesi and Sumatra boil the water before drinking it. About 20% in Sumatra and 50% in Sulawesi additionally filter sometimes or even always their drinking water.

It is sometimes argued that electricity might reduce respiratory diseases, headache, and eye problems through a reduction in indoor air pollution that is induced by traditional lighting sources. The households have been asked to indicate whether certain household members suffer from one of these diseases. The results are displayed in Table 9.

Table 9: Diseases suffered by household members in the last six months

		Sumatra		Sulawesi	
Disease	Age	male	female	Male	Female
Headache	≥18	58%	74%	6%	5%
	<18	15%	15%	2%	2%
Respiratory disease	≥18	8%	5%	2%	1%
	<18	1%	1%	1%	0%
Eye disease	≥18	6%	7%	1%	1%
	<18	1%	1%	1%	0%

3.3.3 Infrastructure

The quality of infrastructure is substantially different in Sumatra and Sulawesi. In Sumatra, most of the project villages can be accessed via at least good quality dirt roads also with a normal car. Only some villages (e.g. Sungai Kaluh, Sungai Sirah, or Limau Limau), are less accessible and require motorcycles or four wheel drive cars. In Sulawesi, basically all villages are only accessible with four wheel drive cars or motorcycles. Even these vehicles sometimes have difficulties during the rainy season when landslides frequently block the roads. Both in Sulawesi and Sumatra the public transport connection to other villages is difficult or non-existent. In most cases, only motorcycles can be hired if people do not have own means of transport.

In Sulawesi, 68% of the households do not have any means of transport. In Sumatra, the share only totals 44%. 51% in Sumatra and 30% in Sulawesi own a motorcycle – the most common private vehicle. Very few people have bicycles or chariots. Only 9 households in the sample own a car or a tractor.

Expenditures for transport amount to approximately 980,000 IDR (80 EUR) per year in Sumatra and 890,000 IDR (73 EUR) in Sulawesi.

The mobile network coverage is better in Sumatra. Among the interviewed household, 63 % are covered by the network. In Sulawesi, only 56 % are covered. Whereas some villages have always good reception, most of the surveyed regions only have connection sporadically or only in certain parts of the village. In Sumatra, in three villages all households have mobile phone reception and in the rest of the villages some have, some do not have. In Sulawesi, there are three villages without any reception and in the other villages only some households have reception.

There are no agricultural markets in the surveyed villages itself. However, at a maximum distance of one hour, all households can reach a village with a weekly market to sell their products. In Sumatra, traders regularly visit the villages to buy agricultural products, especially rubber.

3.4 Energy Usage and Impacts

The following section assesses the impacts of electricity usage from MHP. We examine what the households that are connected to an MHP effectively do with electricity and to what extent it changes the households' behavior and, eventually the households' socio-economic situation.

As a reference group for the MHP using EnDev 1 households it was intended to take the MHP TSU EnDev 2 villages that were surveyed at the same time for a baseline study of the EnDev 2 activities. Assuming that the MHP TSU EnDev 2 villages are comparable to the EnDev 1 villages – except for their electrification status – this would enable us to obtain an impact assessment by comparing the EnDev 1 villages to the EnDev 2 villages.[6] The comparability of the two groups in terms of road access, agricultural conditions, business environment, population size, market access, and, remoteness from regional hubs turned out to be satisfying. However, we encounter a major problem in realizing this impact identification strategy: While it had been expected before designing the study that the EnDev 2 villages are widely non-electrified, in fact around 50% of the EnDev 2 households are already using electricity from gensets, waterwheels, solar home systems, or the national grid. As retrospective questions in the household questionnaires as well as qualitative information of village chiefs and other key informants show the households in the EnDev 1 villages had not been using electricity before they were connected.[7] Hence, the EnDev 2 households cannot serve as their counterfactuals. In other words, the original impact assessment approach cannot be implemented, since half of the reference group does not look like the electrified group had looked before electrification.

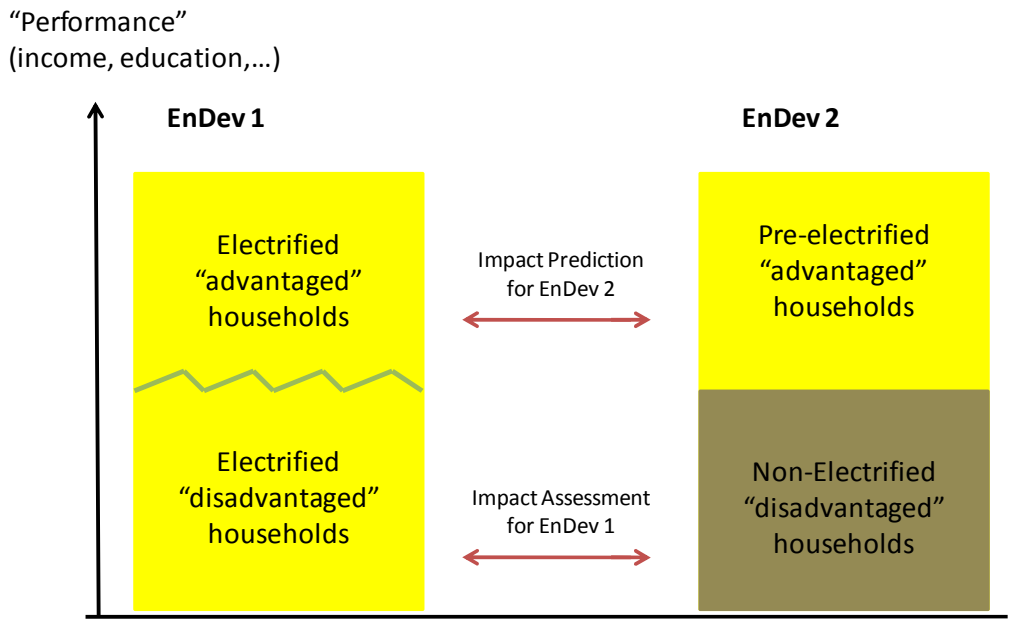
[6] For applications of this kind of cross-sectional comparison approach see Bensch and Peters (2010), Bensch, Kluve and Peters (2010), and Peters, Vance, and Harsdorff (2011).

[7] Contrary to the findings from individual household interviews, key informant and village chief interviews, some of the field project staff claims that pre-electrification rates have been comparably high in EnDev 1 villages before being connected to the MHP.

As an alternative, we take the non-electrified part of households form the EnDev 2 villages as a reference. Thereby, it has to be taken into account that these households have not been assigned to being non-electrified *by chance*. For example, poorer households are much less likely to buy a genset or a solar home system. More generally, one might refer to their status as *disadvantaged* (be it for monetary, regional, or political reasons and the like). If one now takes the average household from an EnDev 1 village and compares it to the disadvantaged households from the EnDev 2 region, this is a comparison of non-comparables. Taking again the example of wealth status one can easily imagine that poorer households also consume less (kerosene) lighting than richer ones. Assuming that the average household from the EnDev 1 region is richer than the disadvantaged EnDev 2 people, one would obtain an inflated impact in terms of lighting hours.

To avoid this apples and oranges comparison we try to identify the comparable households from both regions and obtain an impact assessment for them at least. The only reference group will still be the non-electrified households. We will use them to obtain an idea about why they did not "connect" to some electricity source. If we succeed in identifying these reasons, we will extrapolate this to the electrified EnDev 1 villages and isolate those households that would have been the electricity non-users before if there had been comparable access to electricity sources as in the EnDev 2 villages.[8] If an MHP-connected EnDev 1 household then proves to be comparable in terms of these characteristics (for example in the level of education or income), it will be included in the group of households for which we can assess the impact of the intervention We refer to them as the *disadvantaged* EnDev 1 households (see Chart 9). Comparing these two groups – "hypothetically" non-connected and effectively non-connected households – yields an assessment of impacts on the *disadvantaged* EnDev 1 beneficiaries.

Chart 9: *Advantaged* and *disadvantaged* households in EnDev 1 and EnDev 2 villages



[8] We acknowledge that the already hypothetical character of ordinary counterfactual thinking becomes even more hypothetical at this point.

For the remaining *advantaged* EnDev 1 households we are lacking a suitable reference group and cannot do a quantitative impact assessment. The already electrified EnDev 2 households cannot be used as they are pre-electrified before receiving the MHP treatment and the advantaged EnDev 1 households mostly did not have electricity when the MHP came. [9]

Alternatively, a comparison of the advantaged EnDev 1 households and the pre-electrified EnDev 2 households can be used to predict the impacts that can be expected if the pre-electrified EnDev 2 households switch from their often low-quality electricity source to higher quality electricity from the MHP. The *advantaged* EnDev 1 households serve to mimic their future electricity usage. Also, the impacts on micro-enterprises will be examined.

The crucial step in implementing this somewhat exotic evaluation strategy is the identification of comparable groups from both regions. While it is straightforward to separate the EnDev 2 villages into electricity using and non-using households, the task is more challenging for the EnDev 1 households, who are all using electricity. What we are basically are looking for are the counterparts to the electricity users and non-users from the EnDev 2 region. We therefore investigate the determinants of the decision to obtain an electricity source among EnDev 2 households and extrapolate this to the EnDev 1 sample.

More precisely, we estimate a binary decision model with the connection status as dependent variable in a probit regression. The possible outcomes are 1 “yes, HH connects” and 0 “no, HH does not connect”. The binary variable is regressed on different potential determinants – only using the sample of EnDev 2 households.[10] This means that we try to find out which households characteristics (*determinants*) influence the decision to obtain a pre-electrification source. The estimated coefficients for the determinants are then used to estimate a connection probability for EnDev 1 households. This probability tells us the likelihood of an EnDev 1 household to obtain an alternative electricity source – if there was no MHP mini-grid available. We thereby transfer the EnDev 1 households into a hypothetical situation that they would face if they were in lieu of the EnDev 2 people.

It is straightforward that the determinants that we include in the binary decision model have to approximate the determinants in such a hypothetical situation. This implies that we must not include potential determinants that are affected by the electrification treatment. For example, one might argue that lighting demand drives the decision to get an electricity source, which would advocate in favour of including lighting hours as a determinant in the model. However, lighting hours are definitely affected by an electricity connection, so that we cannot simulate the aforesaid hypothetical situation. Instead, we need determinants that can be expected to be non-responsive to electrification, but affect the decision to connect. In our data set we find the following variables to

[9] If one assumes that EnDev 1 households had been pre-electrified to the same extent as EnDev 2 villages are today, the comparison of advantaged EnDev 1 households and the pre-electrified EnDev 2 households would reflect the real impacts for these EnDev 1 households.

[10] This approach is an adaptation of so-called propensity score matching, which in turn is a widely applied and accepted method to overcome comparability problems in evaluations. See Bensch, Kluve, and Peters (2010) and Peters, Vance, and Harsdorff (2011) for comparable applications. For further readings on the selection of covariates or determinants see for example Harding (2003), Rosenbaum (1984), Schmidt and Augurzky (2001) and Caliendo and Kopeinig (2005).

fulfil this condition: the educational level of the head of household, the households expenditures excluding energy expenditures, housing characteristics (roof and floor material), possession of a bank account, savings, and the information whether the households obtains a pro-poor health insurance Jamkesmas[11].

Table 10: Results from binary decision model

	Sumatra	Sulawesi
Possesion of electricity source		
	Coefficients	
Edu_hoh	0.04* (0.08)	0.14** (0.00)
Exp_without_energy	0.001** (0.04)	0.001 (0.22)
Hind_saving	0.67** (0.02)	0.55 (0.33)
Hind_health	- 0.47** (0.04)	-0.75** (0.03)
Hind_bankacc	0.06 (0.79)	0.08 (0.74)
hdum_roof	0.45 (0.27)	0.33 (0.34)
hdum_floor	0.59** (0.02)	0.33 (0.29)
Number of obs.	184	150
Prob > chi2	0.0000	0.0000
R2	0.1804	0.259

Note: p-values in paretheses; *significant at the 10 percent level; **significant at the 5 percent level

If we regress the electrification status in the EnDev 2 villages – separated for Sulawesi and Sumatra – on these determinants using a probit model this yields us the influence of each respective variable.[12] As can be seen in Table 10 significant influences in Sumatra and Sulawesi can be found for the education level of the head of household and the entitlement to the health insurance Jamkesmas. In Sumatra, the households' expenditures, possession of savings and the material of the floor are additionally significant influences on the decision to get an electricity source.

While these coefficients have been estimated based on the EnDev 2 sample only, we now use them to predict the probabilities for the EnDev 1 households. This is, for each observed EnDev 1 household the values of the selected determinants are taken and multiplied with the coefficients. The sum of these products yields the probability with which the EnDev 1 household would obtain an electricity source if it was in the hypothetical situation that the EnDev 2 people are facing. This probability is now used to stratify the EnDev 1 sample into advantaged and disadvantaged households. The former could be expected to be connected in the hypothetical situation, the latter not.

Yet, first we verify the predictive quality of our model by also estimating the probability for the EnDev 2 households – for which we, obviously, know whether they have obtained an electricity source or not. For 71% of the EnDev 2 households we predict the decision to connect correctly. Furthermore, we use this prediction to obtain the stratification criterion for the EnDev 1 households: Since roughly 50% of the EnDev 2 households are using electricity we take the median value of the probability distribution as demarcation line. For Sumatra, this is at 0.47 and for Sulawesi at 0.25. In other words, every EnDev 1 household that exhibits a probability above 0.47/0.25 is assigned to the

[11] The governmental health insurance *Jamkesma* is designed to cover the costs of certain health services for the poor. Eligibility for this insurance depends on daily household consumption estimates.

[12] For this model we exclude two EnDev 2 villages in Sulawesi, Limba dewata and Bumal, where all households are connected to traditional waterwheels.

advantaged group, every EnDev 1 household that exhibits a probability below these values is assigned to the disadvantaged group.

3.4.1 Energy sources and uses

All surveyed households are connected to an MHP and, hence, use electricity (see Chart 10 and Table 11).[13] In Sumatra, there are three households that use gensets additionally to the MHP.

The electricity supplied by the MHPs has an average capacity available per household of 240 W. The minimum is 90 W and the maximum 710 W. Generally, the capacity is higher in Sumatra than in Sulawesi. The capacity per household is determined by the capacity of the whole MHP. Limiting factors for the capacity of the plant are the available potential (water flow, difference in altitude), and for EnDev 1 sites also the available budget from PNPM.

Chart 10: Energy Sources

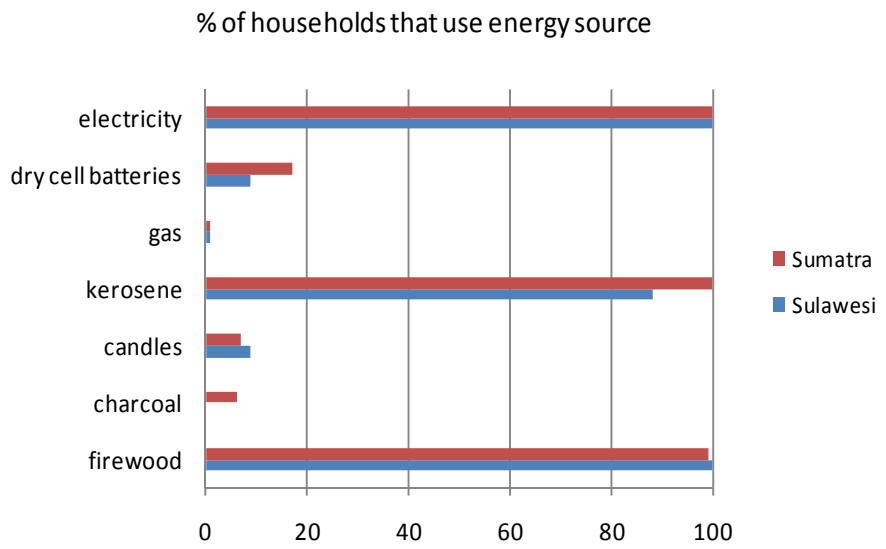


Table 11: Usage and Consumption of different energy sources

Percentage of HH that uses… (quantity per month)	Electricity	Dry cell batteries (pieces for lighting/radio)	gas (kg)	kerosene (liters for lighting/ cooking)	candles (pieces)	charcoal (kg)	firewood (bundles)
Sumatra	100%	17% (0.42/0.15)	1% (0.06)	100% (3.84/0.79)	7% (0.51)	6% (0.18)	99% (9.8)
Sulawesi	100%	9% (0.1/0.1)	1% (0.01)	88% (2/0.73)	9% (0.53)	0%	100% (31.3)

Next to electricity, the second most important energy source is kerosene with the vast majority being used for lighting. 3% in Sulawesi and 44% in Sumatra of the households use kerosene for cooking.

[13] There are four households in Sipai, Rippung, and SatanEtang that have been disconnected because they were not able to pay for the electricity. These households have been excluded from the following analysis.

Kerosene for lighting is used by 98% of the households in Sumatra and 89% in Sulawesi. This indicates that, although all households use electric lighting, traditional lighting sources are not completely replaced. Many households use kerosene lanterns in times of blackouts.

Nevertheless, if we compare the consumption level of kerosene for lighting in EnDev 1 villages with those in EnDev 2 villages, it is substantially lower (for exact data see Baseline Report). Looking at the group of *disadvantaged* EnDev 1 households, for which we can assess the impacts rigorously, we can observe a reduction in kerosene consumption for lighting of 57% (see Table 12). The relative reduction does not vary substantially between Sumatra and Sulawesi, only the initial consumption is higher in Sumatra. If we compare the usage levels of kerosene of those EnDev 2 households that already have some electricity source to the *advantaged* EnDev 1 households, we observe lower kerosene usage among Endev 1 households (-34%). Recall that the advantaged EnDev 1 households had not had any electricity sources before the MHPP came, so that probably for them the kerosene reduction has been even higher. Yet, this difference approximates the reduction in kerosene consumption for lighting for the EnDev 2 households if they switch from their pre-electrification source to an MHP connection. As described in the baseline report, most of the EnDev 2 electricity sources (e.g. traditional waterwheels, gensets, solar panels, etc.) only provide poor electricity and lighting quality and the households still have a high consumption of kerosene.

Table 12: Impacts on *disadvantaged* and *advantaged* households: Usage and Consumption of different energy sources

Percentage of HH that uses… (quantity per month in parentheses)		**dry cell batteries (pieces for lighting/radio)**	**gas (kg)**	**kerosene (liter for lighting/cooking)**	**Candles (pieces)**	**charcoal (kg)**	**firewood (bundles)**
„disadvantaged“	EnDev 2	32% (0.81/0.27)	0%	100% (6.1/0.28)	4% (0.14)	13% (0.26)	100% (22.9)
	EnDev 1	12% (0.23/0.09)	0%	94% (2.6/0.32)	6% (0.25)	2% (0.07)	100% (19.1)
„advantaged“	EnDev 2	27% (0.57/0.29)	2% (0.2)	97% (5/1.5)	5% (0.38)	6% (0.16)	98% (22)
	EnDev 1	16% (0.37/0.19)	1% (0.07)	97% (3.3/1.06)	10% (0.87)	6% (0.13)	99% (20)

Despite very few households that cook exclusively with kerosene, normally the households cook with firewood. The firewood is mainly collected and only 3% buy it. For rice cooking, the most important staple for Indonesian households and basic component of every meal, approximately half of the households in Sumatra and among 8% in Sulawesi use electric rice cookers. In particular, among the disadvantaged EnDev 1 households this can be completely ascribed to the MHP treatment: If we compare them to their disadvantaged counterparts in EnDev 2, we find that among the former now 24% are using a rice cooker, among the latter no one. But also among the advantaged households a substantially higher share is using these cooking devices in EnDev 1 households (39%) compared to EnDev 2 households (7%). At this point, the higher quality of MHP electricity (here in terms of power) becomes visible. Most of the users of rice cooker among EnDev 2 households are genset or MHP user. Few rice cookers are also driven by traditional water wheels, or PLN.

Table 13: Impact of using rice cookers on firewood consumption

	Usage of firewood		Firewood consumption in bundles per month	Reduction in %
Sumatra	„disadvantaged“	Without rice cooker (n=151)	9.75	3%
		With rice cooker (n=42)	9.45	
	„advantaged“	Without rice cooker (n=125)	11.9	13%
		With rice cooker (n=69)	10.4	
Sulawesi	„disadvantaged“	Without rice cooker (n=191)	32.2	7%
		With rice cooker (n=5)	30	
	„advantaged“	Without rice cooker (n=141)	33	17%
		With rice cooker (n=12)	27.4	

Accordingly, a reduction in firewood consumption can be expected. The reduction that can be assessed and ascribed to rice cooker usage varies between 3% and 17% (see

Table 13). The difference in consumption between Sumatra and Sulawesi partly derives in different bundle sizes in Sumatra and Sulawesi.

Table 14: Impact of using rice cookers on time for firewood collection

			Time spent on collecting firewood	Reduction in %
Sumatra	„disadvantaged“	Without rice cooker (n=151)	2.7	22%
		With rice cooker (n=42)	2.1	
	„advantaged“	Without rice cooker (n=125)	2.2	-14%
		With rice cooker (n=69)	2.5	
Sulawesi	„disadvantaged“	Without rice cooker (n=191)	5.5	9%
		With rice cooker (n=5)	5	
	„advantaged“	Without rice cooker (n=141)	5.8	3%
		With rice cooker (n=12)	5.6	

The persons who collect firewood are mainly men. Only 25% in Sumatra and 10% in Sulawesi are women. In Sulawesi they spend more time on firewood collection (5.2 hours per week) than in Sumatra (2.3 hours per week). The lower firewood consumption among households that use rice cookers does not translate into a reduction in the time spent on collecting firewood among all analyzed groups (see Table 14).

Charcoal is only used in Sumatra and here especially for ironing. Generally, households do not buy charcoal, but produce it themselves by collecting and drying coconut shells. The consumption is lower among EnDev 1 households than among EnDev 2 households as some EnDev 1 households use electric irons. Batteries are used especially for lighting (73% in Sumatra). In Sulawesi only 50% is used for lighting. The rest in used for operating radios. Compared to EnDev 2 households, the consumption level of batteries is lower among EnDev 1 households. The reduction in used batteries for lighting for the disadvantaged EnDev 1 households amounts to 85% and 70% for batteries for radio usage. Candles are only used in case of blackouts or fuel shortages. Interestingly, among the

disadvantaged households, households with electricity (EnDev 1) use more candles than those without (EnDev 2) – both on a very low level, though.

The number of electronic appliances is substantially higher in Sumatra than in Sulawesi. This difference is, besides the higher wealth level in Sumatra, possibly also linked to the notably higher available capacity of MHPs in Sumatra than in Sulawesi. While the available capacity per household is at 145 W in Sulawesi, it is at 245 W in Sumatra.

In both regions, the information and entertainment appliances are most prominently used among EnDev 1 households (see Table 15 and Table 16); most importantly TV sets and satellite receivers with electricity, followed by CD and VCD player. Generally, the usage of these appliances is much higher in Sumatra than in Sulawesi. In Sulawesi, an important appliance are radios that are used by 27% of the households, of which 19% still run on batteries. In Sumatra only very few households use radios.

Table 15: Appliance usage among *advantaged* households (electric appliances and *non-electric counterparts*)

	Sumatra		**Sulawesi**	
	Advantaged EnDev 1	**Advantaged EnDev 2**	**Advantaged EnDev 1**	**Advantaged EnDev 2**
Electric Lighting	100%	96%	100%	98%
TV	83%	50%	59%	49%
Satellite receiver	71%	42%	47%	38%
CD / VCD	71%	29%	24%	34%
Mobile phone	77%	51%	63%	41%
Electric Iron	54%	19%	10%	4%
Charcoal Iron	*13%*	*12%*	*5%*	*8%*
Rice Cooker with warm keeping mode (Magic Jar)	51%	7%	1%	0
Rice Cooker	10%	2%	11%	4%
Water cooker	11%	4%	1%	1%
Line powered radio	2%	2%	22%	11%
Bivalent radio	1%	1%	3%	14%
Battery radio	*5%*	*7%*	*7%*	*15%*
Ventilator	5%	6%	0	1%
Speaker	7%	2%	4%	7%
Electric refridgerator	3%	0	0	0
Fuel-run refrigerator	*3%*	*3%*	*0*	*0*
Electric Sewing Machine	1%	0	1%	0
Mechanical sewing machine	*4%*	*0*	*1%*	*3%*
Water pump	4%	0	0	0
Mixer/Blender	4%	2%	0	0
Coconut rasper	1%	2%	0	0
Washing machine and pump	0	2%	0	0
Computer	0	0	0	1%
Carpentry equipment	0	0	1%	1%

Table 16: Appliance usage among *disadvantaged* households (electric appliances and *non-electric counterparts*)

	Sumatra		Sulawesi	
	Disadvantaged EnDev 1	**Disadvantaged EnDev 2**	**Disadvantaged EnDev 1**	**Disadvantaged EnDev 2**
Electric Lighting	100%	0	100%	0
TV	62%	1%	28%	10%
Satellite receiver	52%	0	22%	6%
CD / VCD	52%	0%	21%	5%
Mobile phone	42%	21%	27%	34%
Electric Iron	40%	0%	3%	1%
Charcoal Iron	*5%*	*28%*	*1%*	*0%*
Rice Cooker with warm keeping mode (Magic Jar)	39%	0%	0%	0
Rice Cooker	6%	0%	5%	1%
Water cooker	8%	0%	0%	0%
Line powered radio	2%	1%	11%	7%
Bivalent radio	3%	0	10%	4%
Battery radio	*4%*	*17%*	*3%*	*12%*
Ventilator	1%	0%	0	1%
Speaker	2%	0	4%	0
Electric refridgerator	2%	0	0	0
Fuel-run refrigerator	*0*	*0*	*0*	*0*
Electric Sewing Machine	1%	0	1%	0
Mechanical sewing machine	*1%*	*1%*	*1%*	*1%*
Water pump	1%	0	0	0
Mixer/Blender	1%	0	0	0
Coconut rasper	1%	0	0	0
Washing machine and pump	0	0	0	0
Computer	0	0	0	0
Carpentry equipment	0	0	0	1%

Appliances like irons or rice cooker are much more common in Sumatra. For many households especially in Sulawesi it is simply not possible to use them because the capacity per household is not sufficient. Almost half of the households use electric irons (48%) in Sumatra, whereas in Sulawesi only 6% use them.

The already mentioned rice cookers are substantially more common in Sumatra. Here, 54% of the households have simple rice cookers or so called *magic jars*, i.e. rice cookers that are equipped with a mode to keep the rice warm. In Sulawesi, only 12% of the households have rice cooker and the majority of them are simple rice cookers without warm keeping mode.

If we distinguish between the *advantaged* and *disadvantaged* households (see Table 15 and Table 16), the higher appliances usage among advantaged EnDev 1 households becomes obvious. The comparison of the advantaged households among EnDev 1 villages with their electricity using counterparts in EnDev 2 villages, the higher quality and capacity of the electricity through MHP is illustrated. MHP users have substantially more appliances. Especially the high shares of households that use electric irons and rice cookers in Sumatra shows that it is a real upgrade to switch from a pre-electrification source to an MHP (see Table 16).

The EnDev 1 households have been asked if there are appliances they would like to use, but the capacity of the MHP does not allow to. The most frequent answers are displayed in Table 17. Whereas in Sulawesi many households ask for appliance like TV, rice cookers, or more lamps, which are already very common in Sumatra, in Sumatra the households give highest priority to refrigerators. Accordingly, the main bottleneck in electricity supply in Sulawesi seems to be the available capacity per households. Additionally, the interruption of the electricity supply during daytime causes complaints. The operation of refrigerators with the current electricity supply from the MHPs is difficult, as most systems only run half of the day and do not allow a continuous operation of the refrigerator. In both regions, more than half of the households are satisfied with the capacity of the electricity supply and do not desire any additional appliance. This can be interpreted as an indication that they are effectively already satisfied with the electricity supply they have. Additionally, households, especially in Sulawesi may not be able to connect more appliances as they are not able to buy them. Moreover, some appliances may also simply be beyond their imagination.

Table 17: Additional appliances wished to use (Multiple answers possible)

Appliance	**Sumatra**	**Sulawesi**
none	60%	52%
Refrigerator	16%	2%
TV	11%	22%
Rice Cooker	4%	8%
Satellite Receiver	3%	0%
Electric Iron	3%	3%
Water cooker	2%	0%
More lamps	1%	4%
CD Player	1%	2%
DVD	1%	0%
Computer	1%	1%
Washing machine	1%	0%
Speaker	1%	0%
Chicken / livestock breeder	1%	0%
Radio	0%	2%
Carpentry machine	0%	2%
Coconut Rasper	0%	0%
Mobile Phone	0%	1%

Lighting

The most common lighting devices are compact fluorescent lamps (CFL, commonly called “energy saver”). There are on average three bulbs per households in Sumatra and two bulbs in Sulawesi. Even if all households are connected to the MHP and use electric lighting, only 2% in Sumatra and 10% in Sulawesi replaced completely their traditional lighting sources with electric ones. The vast majority uses traditional devices as a backup.[14]

[14] For more details on used lighting devices and consumption pattern, please refer to Annex 3.

Table 18: Lighting devices and average lighting hours per day (EnDev 1)

Number of lamps per household (lighting hours per day)	Incandescent light bulb ("Normal electric bulb")		Neon/ fluorescent tube		Compact Fluorescent lamp ("Energy saver")		Rechargeable Bulbs	Hurri-cane lamp	Tin lamp	Gas lamp
	out-side	inside	out-side	inside	out-side	inside				
Sumatra	0.20 (12.3)	0.51 (11.9)	0.01 (12)	0.03 (1.7)	0.53 (12.2)	2.43 (11.8)	0.01	1.31 (1.07)	0.39 (0)	0.02 (0)
Sulawesi	0.37 (12.1)	0.77 (10.5)	0.03 (12.8)	0.12 (1.04)	0.29 (11.3)	1.73 (10.9)	0	0.01 (4)	1.45 (5.9)	0.03 (6.5)

Differentiating between advantaged and disadvantaged EnDev 1 households (see Table 19 and Table 20) shows that effectively those disadvantaged households possess less lighting sources and use them less than the advantaged households. By comparing the lighting sources of advantaged EnDev 1 one households to electrified EnDev 2 households shows that the EnDev 1 households use more electric lighting devices and use them also more hours. Concerning the most common electric lighting appliance, CFL,in Sumatra, EnDev 1 advantaged households use 25% more CFL outside and 27% more inside than pre-electrified EnDev 2 households. Also the higher lighting hours is striking. Lighting hours describes the hours the lamp is on average used per day by those households that use the corresponding ligting source. These lighting hours for CFL are more than twice as high among advantaged EnDev 1 households than among EnDev 2 households in Sumatra (see Table 20). In Sulawesi, the picture looks slightly different: electrified EnDev 2 households in Sulawesi use more CFL than the advantaged EnDev 1 households (2.1 CFL to 1.9). However, as extensively described in the baseline report, the bulbs connected to traditional waterwheel do not run at their full capacity and are not as bright as those connected to an MHP grid. A possible reason might be that, unlike the households connected to an MHP, the households connected to traditional waterwheels do not have any restriction in terms of used appliances. This might explain both the higher number of bulbs and the capacity problems of the – presumably overburdened waterwheels.

Table 19: Impact on *disadvantaged* households: Lighting devices and average lighting hours per day

Number of lamps per household (lighting hours per day)		Incandescent light bulb ("Normal electric bulb")		Neon/ fluorescent tube		Compact Fluorescent lamp ("Energy saver")		Rechargeable Bulbs	Hurri-cane lamp	Tin lamp	Gas lamp
		out-side	inside	out-side	inside	out-side	Inside				
Sumatra	EnDev 2	-	-	-	-	-	-	0	1.85 (10.12)	0.65 (11.7)	0.03 (12)
	EnDev 1	0.18 (11.7)	0.55 (11.8)	0.01 (12)	0.03 (4)	0.46 (12.1)	2.13 (12.1)	0.01	1.33 (1.3)	0.32 (0)	0
Sulawesi	EnDev 2	-	-	-	-	-	-	0	0	2.66 (5.4)	0.02 (4)
	EnDev 1	0.34 (12.8)	0.86 (10.3)	0.02 (13)	0.15 (0)	0.32 (10.9)	1.58 (11.1)	0	0.01 (4)	1.43 (5.6)	0

Table 20: Impact on *advantaged* households: Lighting devices and average lighting hours per day

Number of lamps per household (lighting hours per day)		Incandescent light bulb ("Normal electric bulb")		Neon/ fluorescent tube		Compact Fluorescent lamp ("Energy saver")		Rechargeable Bulbs	Hurri-cane lamp	Tin lamp	Gas lamp
		out-side	inside	out-side	inside	out-side	Inside				
Sumatra	EnDev 2	0.07 (5.3)	0.16 (5.8)	0.04 (7.25)	0.3 (1)	0.44 (5.6)	1.9 (5.3)	0.00	1.68 (7.75)	0.63 (7.1)	0.03 (6)
	EnDev 1	0.21 (12.7)	0.5 (12)	0	0.04 (0)	0.58 (12.3)	2.6 (11.7))	0.01	1.28 (0.87)	0.45 (0)	0.02 (0)
Sulawesi	EnDev 2	0.02 (13.5)	0.2 (12)	0.01 (12)	0.08 (2)	0.38 (10.3)	2.1 (10.2)	0	0	1.75 (6.5)	
	EnDev 1	0.42 (11.6)	0.7 (10.6)	0.03 (12.7)	0.11 (2.9)	0.27 (11.7)	1.9 (10.7)	0	0	1.5 (6.4)	0.05 (8)

A further indication for the improvement in electricity supply that EnDev 2 households will experience through the adoption of MHPs is that electrified EnDev 2 households use substantially more traditional lighting devices and also use them more hours than the *advantaged* EnDev 1 households.

On average, EnDev 1 households light 3 rooms with their electric lighting devices and 1.6 rooms with the traditional lighting. This also illustrates the higher convenience of the lighting through MHP compared to electricity using EnDev 2 households, who only light 2.3 rooms with their electric devices.

Chart 11: Satisfaction with lighting quality of traditional lighting sources

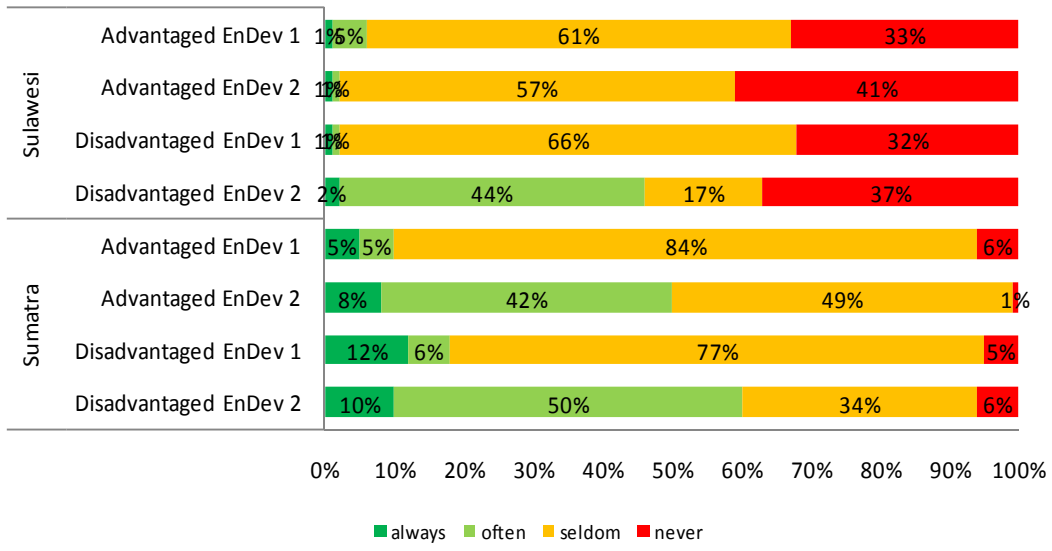
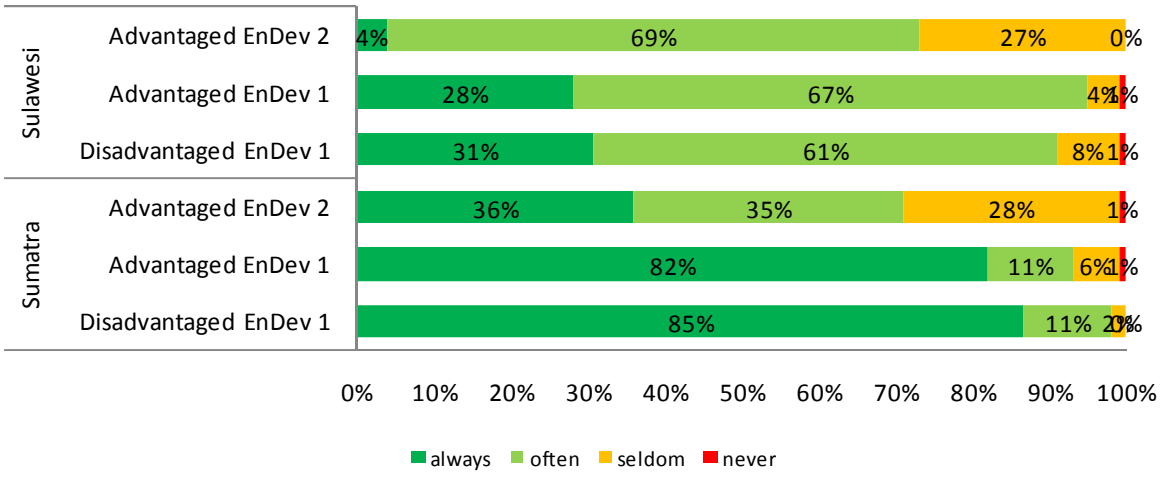


Chart 12: Satisfaction with lighting quality of electric lighting



The apparently higher quality of electric lighting also translates into higher satisfaction of consumers (see Chart 11 and 12). Most households are not satisfied with their traditional lighting source. Interestingly, those households that only use traditional lighting sources (disadvantaged EnDev 2) do not rate them as bad as those households that additionally use electric lighting. It can furthermore be seen that the MHP using EnDev 1 households are much more satisfied with their electric lighting than the electricity using people in EnDev 2 households.

If we look at the amount of lighting hours consumed by the households, they are slightly higher in Sumatra (see Table 21). Accordingly, also the consumption of lumen hours is higher in Sumatra. Lumen measures the lighting output of a lamp and varies substantially between the different lighting sources. The values are listed in Table 22.

Table 21: Daily consumption of lighting hours and lumen hours (per household)

Lighting hours and lumen hours consumed per day	lighting hours	lumen hours
Sumatra	45.14	27,510
Sulawesi	42.18	23,835

Table 22: Lumen per lighting device (O`Sullivan and Barnes (200))

	lm
Wick Lamp	11.4
Paraffin Candle	11.8
Hurriane Lamp (kerosene)	32.0
Gas lamp (“kerosene pressure”)	2,040.0
Incandescent Light Bulbs (60 W)	730.0
Fluorescent Tubes (40 W)	1,600.0
Energy Saving Bulbs (11 W)	600.0

For assessing the increase in lighting hours induced through the MHP, we look again at the group of *disadvantaged* EnDev 1 households. In Sumatra, they consume 55% more lighting hours than their non-electrified counterparts. The amount of lumen hours consumed even rises more than 20 times. In Sulawesi, the lighting hours have been quadruplicated and lumen hours increased by almost 70 times.

Also if we compare the advantaged EnDev 1 households to the electricity using EnDev 2 households, they consume distinctly more lighting hours and lumen hours. This comparison of lumen hours even

reflects the lower border of the difference because the lumen hours for EnDev 2 households have been calculated with the theoretical capacity of installed lighting appliances. As described above, most of the electric lighting devices in EnDev 2 households often yield in practice less than the theoretical capacity.

Table 23: Impact on *disadvantaged* and *advantaged* households: Consumption of lighting hours and lumen hours

Lighting hours and lumen hours consumed per day and household			lighting hours	lumen hours
Disadvantaged	Sumatra	EnDev 1	42.14	25,573
		EnDev 2	26.77	1,190
	Sulawesi	EnDev 1	43.59	22,948
		EnDev 2	14.79	328
Advantaged	Sumatra	EnDev 1	47.27	28,853
		EnDev 2	32.36	10,362
	Sulawesi	EnDev 1	45.91	24,810
		EnDev 2	39.62	17,790

Crop Transformation

The majority of households transform agricultural products. In Sumatra the share totals 63% and in Sulawesi even 92%. About half of the households sell transformed product. This value does not differ substantially between Sumatra (50%) and Sulawesi (52%).

The revenues from selling transformed crops generates much higher revenues in Sumatra (2.1 Mio IDR; 171 EUR) than in Sulawesi (0.4 Mio IDR; 34 EUR). The revenues in Sumatra stem especially from transforming rice, but also coffee, cardamom, and cinnamon. In Sulawesi, the revenues derive most importantly from coffee, but also from cocoa and rice.

Compared to the EnDev 2 villages, the share of households transforming agricultural products is higher among EnDev 1 villages (EnDev 2: 53% in Sumatra and 85% in Sulawesi). Also the share of households that sell transformed products is slightly higher (48% among EnDev 2 households and 51% among EnDev 1 households). However, concerning the transformation process, there are hardly any differences observable. Both in EnDev 1 and EnDev 2 villages most of the crop transformation is exercised by hand or with a manual tool. Only for grinding and hulling processes there are remarkable shares of households that employ motorized appliances. These are normally driven by diesel or petrol. Only in three EnDev 1 villages, rice hullers and threshers are used that are connected directly to the MHP-turbine in the power house. Yet, only in Lisuan Ada (Tandiallo) the appliances work and are also used by the population. In the two other villages, Batang Uru Minanga and Lisuan Ada (Sepang), the installations are not in operation as – according to statements of the villagers and the MHP management – they are broken.

In Sumatra, the households earn on average 2.100.000 IDR (171 Euros), in Sulawesi they earn just 481.000 IDR (39 Euros). This is substantially more money than the households in EnDev 2 villages earn in Sulawesi (300.000 IDR; 25 Euros), which is partly due to the higher share of households among EnDev 1 villages that cultivate land. But also if we exclude the households that do not cultivate land, the revenues are more than 50% higher among EnDev 1 households.

Table 24: Crop Transformation

		Number of HH cultivating basic product…	Number of HH transforming product	By which means?			Share of transforming HH that sells transformed product
				by hand / tool	motorized appliance (diesel or petrol)	electric appliance	
deshell rice	Sumatra	150	85 (57%)	24%	76%		100%
	Sulawesi	137	127 (93%)	45%	55%		19%
hull coffee	Sumatra	51	16 (31%)	37%	63%		100%
	Sulawesi	117	82 (70%)	94%	6%		87%
grind coffee	Sumatra	51	1 (2%)	100%			100%
	Sulawesi	117	31 (26%)	100%			19%
dry coffee	Sumatra	51	21 (41%)	78%	22%		41%
	Sulawesi	117	0				-
dry cardamom	Sumatra	36	27 (75%)	100%			100%
	Sulawesi	0	0				-
clean cinnemon	Sumatra	29	23 (79%)	100%			100%
	Sulawesi	0	0				-
dry cocoa	Sumatra	17	2 (12%)	100%			100%
	Sulawesi	53	48 (91%)	98%	2%		92%
hull cocoa	Sumatra	17	2 (12%)				100%
	Sulawesi	53	2 (4%)	100%			100%

For *disadvantaged* households that cultivate land, the difference amounts to 43% (370.000 IDR versus 530.000 IDR). Controlling for the also higher revenues from selling non-transformed crops and thereby approximating the total agricultural production, the differences is reduced to 39%. For *advantaged* households the difference even amounts to 58%. In Sumatra, an increase in the revenues from transformed products cannot be observed.

Productive Use

While the focus of the survey was on households as the ultimate beneficiaries of the electrification intervention, in qualitative interviews with village chiefs and other key informants a particular focus was put on enterprises and potential productive electricity uses.

Similar to the surveyed EnDev 2 villages, the EnDev 1 villages are clearly dominated by an agricultural economy. Micro-enterprises only exist to a limited extent and comprise especially kiosks, carpenters, tailors and weavers. In most cases, though, these businesses do not serve as the primary income source for their owners and are run more on a demand basis. Virtually all produced goods are sold and consumed locally. Table 25 depicts the existing businesses and distinguishes whether they are connected to the MHP or not. In all villages there are small kiosks that sell non-perishable food and beverages; often as a home business directly from their house or also from little huts. Most important products are sweets, instant noodles, and cigarettes, but also sandals or energy sources such as batteries, kerosene, or petrol are sold. All kiosks are connected to the MHP and mainly use the electricity for lighting. Additionally some kiosk owners in Sumatra also have fridges or TVs. Refrigerators can additionally be found in some private households, but used for income generation. For example, in Limau-Limau there is a household that produces ice cream and sells it to school children.

Mills and hullers exist that are used to transform rice and process coffee. Most of these appliances work with diesel or petrol, but in three villages in Sulawesi they are directly installed in the MHP powerhouse and driven directly by the mechanical energy of the turbine. However, as described above, only the rice huller and thrasher in Lisuan Ada Tandiallo are working well The inhabitants of villages without mills normally have to travel to neighboring villages to transform their rice. It is also common that after the harvesting period there are itinerant diesel mills that travel from village to village offering milling services for rice and coffee.

Most of the carpenters are not connected to the MHP. This has several reasons. First, many carpenters are primarily subsistence farmers and only take up their carpentry work in case of demand. Accordingly, they do not have a fixed workshop and work with gensets at the place they are needed. Second, many of the MHPs only operate after nightfall and fulltime only on Sundays and Fridays and, hence, the carpenters are not able to use electricity at daytime. Those workshops that are connected to an MHP work manually when the MHP is off and exercise those activities, for which they need electricity on Fridays or Sundays. Some also additionally use gensets.

Table 25: Businesses in EnDev 1 villages

	Kiosk	Mill/Huller		Carpenter		Other	
		Conn.	Non-conn.	Conn.	Non-conn.	Conn.	Non-conn.
Sulawesi							
Batanguru (Minanga)	2	1					
Batanguru (Ratte)	2		1		2		
Lisuan ada (Sepang)	1	1		1			1 blacksmith
Lisuan ada (Tandiallo)	1	2			1		
Paladan	5				1		
Rante Tangnga	2				8		
Rantepuang	3				9		1 tikar workshop, 4 weaver
Rippung	3						
Satanetean	1				4		
Sipai	2						
Sumatra							
Lambah Saiyo	1					2 tailor	
Limau-limau	5		1			2 fridge	
Muara Air	7		3	1			
Kampung Nan Lima	3						
Karang Putih	5		16		2	1 tailor	
Kubang Gajah	25		3		1	2 restaurants	2 tailor
Pidang	1					1 fridge	
Sapan Salak	10		2				
Sungai Kalu 1	4		1	2	3		
Wonorejo	8		5		Several*	14 fridges	

*These carpenters work on demand only

In Sulawesi there are some other businesses like a blacksmith who works on demand, a workshop for bamboo mats (*tikar*), and weavers. All of them work manually only and serve the local markets. In Sumatra, there is a number of tailors that are connected to the MHP, who also usually serve only the local demand. One exception are the tailors in Lambah Saiyo. This village is located near Bukittinggi, a quite touristic rural center. The tailors sew traditional clothes that are also sold there.

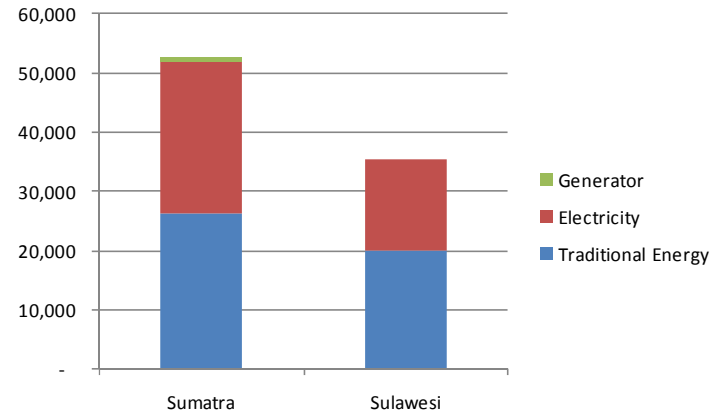
The households were asked explicitly if they had started to exercise a new activity with electricity: In Sumatra, 4% did; in Sulawesi even 10%. Most of these activities, though, are activities that had been pursued already but that are shifted after nightfall: Half of the new activities in Sumatra and Sulawesi are longer opening hours for existing kiosks. In Sulawesi, there are also households that started to weave at nighttime. In addition to these extended existing activities, further three households in Sumatra have started to produce furniture, to sew with electricity and to cook at night. In Sulawesi, there are also a new carpenter, two blacksmiths, a welder, and a household that installed heat lamps for breeding chicken.

The households have been asked if they improved their work due to electricity. In Sumatra, there are 76% who affirmed this and 52% in Sulawesi. The explanations how they improved their work mainly involved the aspects that the light facilitates their work especially after nightfall and that they can use electric appliances.

3.4.2 Energy expenditures

The expenditures on energy are clearly higher in Sumatra[15]. They total 53,000 IDR (4 EUR) and in Sulawesi only 35,000 IDR (3 EUR). The difference derives mostly from the higher electricity fees in Sumatra (see Chart 13). While in Sulawesi the households pay on average only 15,000 IDR (1,20 EUR) per month, the expenditures are 70% higher in Sumatra (25,500 IDR; 2 EUR). The expenditures on traditional energy sources are only 30% higher in Sumatra than in Sulawesi (20,000 IDR versus 26,000 IDR; 1,60 EUR versus 2,10 EUR).

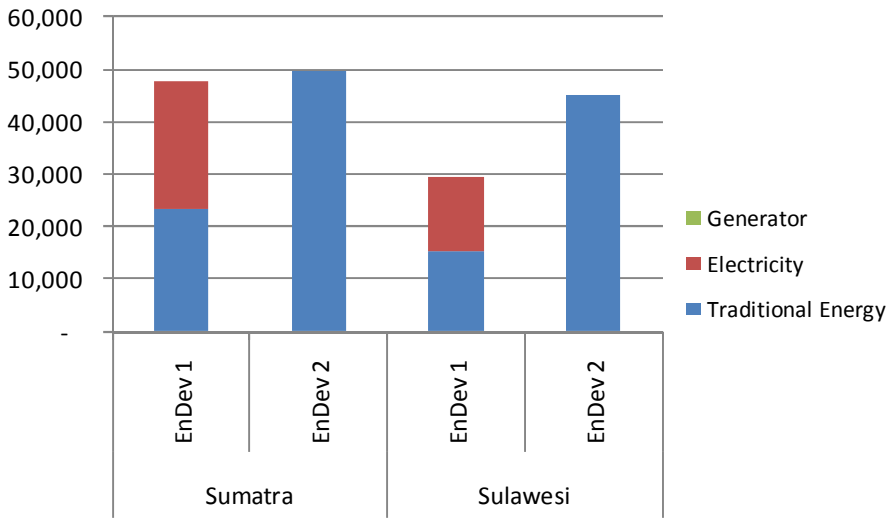
Chart 13: Energy expenditures per month by category (only EnDev 1)



[15] Energy Expenditures are displayed for total energy consumption. As consumption varies between the groups, higher expenditures are only partly induced through different prices or energy sources, but also through a different consumption level.

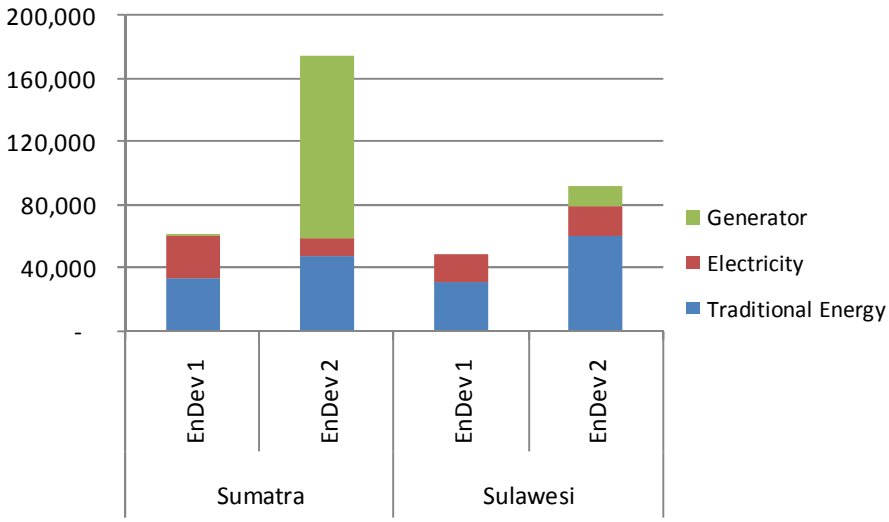
The comparison of expenditures on energy between the disadvantaged EnDev 1 households and the non-electrified EnDev 2 households shows that the energy expenditures are effectively reduced. In Sumatra, the non-electrified households in EnDev 2 villages spend on average 49,500 IDR (4 EUR) per month, while the disadvantaged EnDev 1 households only spend 47,800 IDR (3,90 EUR). In Sulawesi, the EnDev 2 households spend 44,900 IDR (3,70 EUR) and the low performing EnDev 1 households spend 29,300 IDR (2,40 EUR). The reduction in expenditures accordingly amounts to 3% in Sumatra and 35% in Sulawesi.

Chart 14: Impact on disadvantaged households: Energy Expenditures by Category



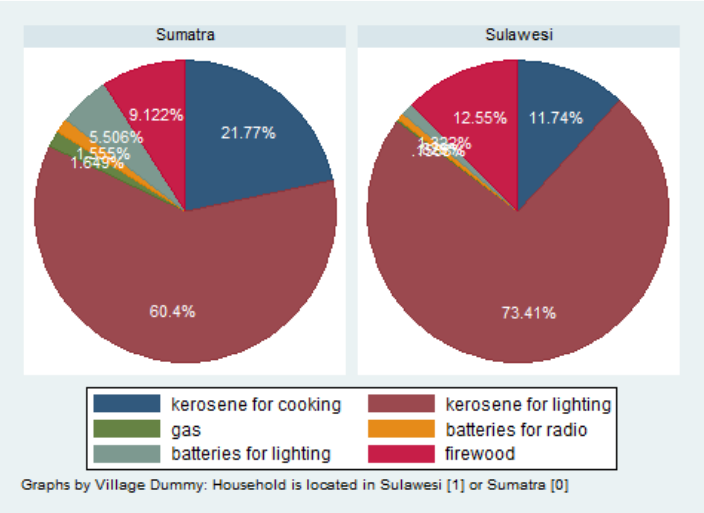
Assessing the possible reduction in expenditures for advantaged EnDev 2 households, Chart 15 shows the enormous potential induced by a switch from pre-electrification sources to MHP electricity. Above all, the high reductions for genset users are striking. The EnDev 2 households pay 30% more for energy in Sumatra and 15% more in Sulawesi than EnDev 1 households.

Chart 15: Impact on advantaged households: Energy Expenditures by Category



Despite the widespread usage of electric lighting, the most important part of the expenditures on traditional energy sources is spent on kerosene for lighting (see Chart 16). It might be an indication for the reliability of the electricity from the MHP and highlights further saving potentials for the households if they had a stable electricity supply. The second most important part are expenditures on kerosene for cooking and in Sulawesi also expenditures on firewood. In Sumatra, 5% of the expenditures are spent on batteries for lighting – also as backup for the MHP electricity.

Chart 16: Composition of expenditures on traditional energy sources (EnDev 1)



3.4.3 Activity Profile

The household members in Sumatra and Sulawesi are approximately 16 hours per day awake (see Table 26). There is a tendency perceivable that mothers get up slightly earlier than men and also go to bed earlier. Children normally get up later than their parents and stay awake longer than their mother but not as long as the father. Children between 12 and 17 years stay awake longer than their younger brothers and sister.

Table 26: Activity profile

Activity Profile	**Father**		**mother**		**children 6-11**		**male children 12- 17**		**female children 12-17**	
	get up	go to bed	get up	go to bed	get up	go to bed	get up	go to bed	get up	go to bed
	hours awake		hours awake		hours awake		hours awake		hours awake	
Sumatra	5.28	21.49	5.17	20.17	6.04	20.52	5.56	21.12	5.56	21.06
	16.20		16.01		14.59		15.16		15.10	
Sulawesi	5.25	21.28	5.00	21.07	5.56	21.12	5.14	21.29	5.25	20.48
	16.02		16.07		15.16		16.19		15.43	

Again, we assess the impact of MHP-usage by comparing the disadvantaged EnDev 1 households to the non-electrified EnDev 2 households (see Table 27). For the parents there is an increase in the time awake perceivable. Fathers and mothers stay awake on average 20 minutes longer than their

non-electrified counterparts. The reason is that electricity users go to bed later. For female children between 12 and 17 years the difference in the time awake even totals 49 minutes. Male children in the same age are 20 minutes longer awake. This effect is also induced by going to bed later. For younger children the difference only amounts to around 10 minutes.

Table 27: Impact on *disadvantaged* households: Hours awake per day

	father	**mother**	**children (6-11)**	**male children (12- 17)**	**female children (12-17)**
	hours awake	hours awake	hours awake	hours awake	hours awake
Non-user	15.47	15.38	14.42	15.28	14.50
User	16.05	15.58	14.51	15.47	15.39
Difference	0.18	0.19	0.09	0.19	0.49

If we compare the time awake of those households in EnDev 2 villages that already use some kind of electricity with the "advantaged" EnDev 1 households we can see that generally household members with an MHP are longer awake than those with other electricity sources.[16] The reason may be that the electricity sources in EnDev 2 villages are substantially more expensive in operation (especially gensets), are not available unlimitedly (small solar panels that only offer lighting for few hours) , or only offer low capacity that, for instance, does not allow for watching TV.

Table 28: Impact on *advantaged* households: Hours awake per day

	father	**mother**	**children (6-11)**	**male children (12- 17)**	**female children (12-17)**
	hours awake	hours awake	hours awake	hours awake	hours awake
EnDev 2	16.13	15.38	14.49	15.27	15.20
EnDev 1	16.19	16.10	14.57	15.48	15.15
Difference	0.05	0.32	0.08	0.20	-0.05

Time for Studying

In Sumatra, children dedicate on average more time to studying than in Sulawesi (see Table 29). Furthermore, older children between 12 and 17 years old study more time than their younger brothers and sisters between 6 and 11 years. In Sulawesi, the children study relatively more time during daytime than after nightfall. In Sumatra, it is the other way round.

Table 29: Time for studying

Studying time (in min/day)	**children 6-11**				**male children 12- 17**				**female children 12-17**			
	# of obs.	total	day	night	# of obs.	total	day	night	# of obs.	total	day	night
Sumatra	59	97	32	46	38	111	55	56	43	156	56	60
Sulawesi	62	65	38	28	40	102	59	44	41	99	60	40

[16] As outlined in Section 2.1 the impact on advantaged EnDev 1 households can be expected to be even bigger than this difference.

The important role of electricity for creating beneficial study conditions through improved lighting especially after nightfall are widely acknowledged. However, our data does not support this expectation (see Table 30). If we look at low performing households, children in households with MHP electricity do not necessarily study more after nightfall than their non-electrified counterparts. Children between 6 and 11 study on average 57 minutes in Sumatra and 37 minutes in Sulawesi after nightfall. No distinct difference between electrified and non-electrified households can be observed. For older children between 12 and 17 there is no difference between electrified and non-electrified households for male children and a slight increase for girls in Sumatra and even a negative difference in Sulawesi. The potential improvements through electric lighting apparently are not exploited. This is in line with qualitative findings from interviews with teachers: none of the schools in EnDev 1 villages offers evening courses or other activities after nightfall. If schools are connected at all, electricity is normally only used for sound systems used for gymnastics. As most of the MHPs do not operate during daytime, an electricity connection is often not attractive for schools.

Table 30: Impact on *disadvantaged* households: Time for studying

Studying time (in min/day)		**children 6-11**				**male children 12- 17**				**female children 12-17**			
		# of obs.	total	day	night	# of obs.	total	day	night	# of obs.	Total	day	night
Sumatra	Non-user	29	84	28	56	15	115	36	79	14	99	44	55
	User	26	95	36	59	13	116	37	79	17	113	53	60
Sulawesi	Non-user	31	69	31	38	28	103	45	58	26	104	58	46
	User	39	67	32	35	23	107	55	53	18	89	46	43

Television and mobile phones usage

60% of the households in Sumatra and 55% in Sulawesi own a mobile phone. These are substantially more households than among EnDev 2 households, where 37% in Sumatra and 32% in Sulawesi own mobile phones – even if the network coverage is similar among EnDev 1 and EnDev 2 households (cf. Section 3.3.3 Infrastructure). Obviously, this is due to a facilitation of charging the mobile phone among EnDev 1 households: Virtually all EnDev 1 households charge their mobile phone at home, while only 59% among EnDev 2 households do so. The interviewed EnDev 1 households use their mobile phones 4.7 times per week in Sumatra and 5.3 times in Sulawesi, which is slightly more often than among EnDev 2 households.

Table 31: TV usage in minutes per day

TV Usage (in min/day)		**father**	**mother**	**children 6-11**	**male children 12- 17**	**female children 12-17**
TV owner	Sumatra	121	105	31	74	75
	Sulawesi	139	139	61	132	103
no TV	Sumatra	18	17	11	90	55
	Sulawesi	77	58	38	54	75

TV ownership is significantly higher in Sumatra than in Sulawesi (83% versus 45%). However, the time household members watch TV is higher in Sulawesi (see Table 31). This applies to those households that have a TV and also those that do not have.

Comparing the television usage among the "disadvantaged" EnDev 1 households to the non-electrified EnDev 2 households in Table 32, the high TV usage rates among EnDev 2 households without electricity in Sulawesi are striking. All these households go to friends, neighbors, or kiosks with electricity to watch TV. In this case, these households cannot serve as a simulation of EnDev 1 households before electrification because EnDev 1 households had substantially less access to electricity because there were fewer households with electricity and accordingly TV sets in the villages. What can be recorded is that the electrified households spend considerable parts of their daily time on watching TV.

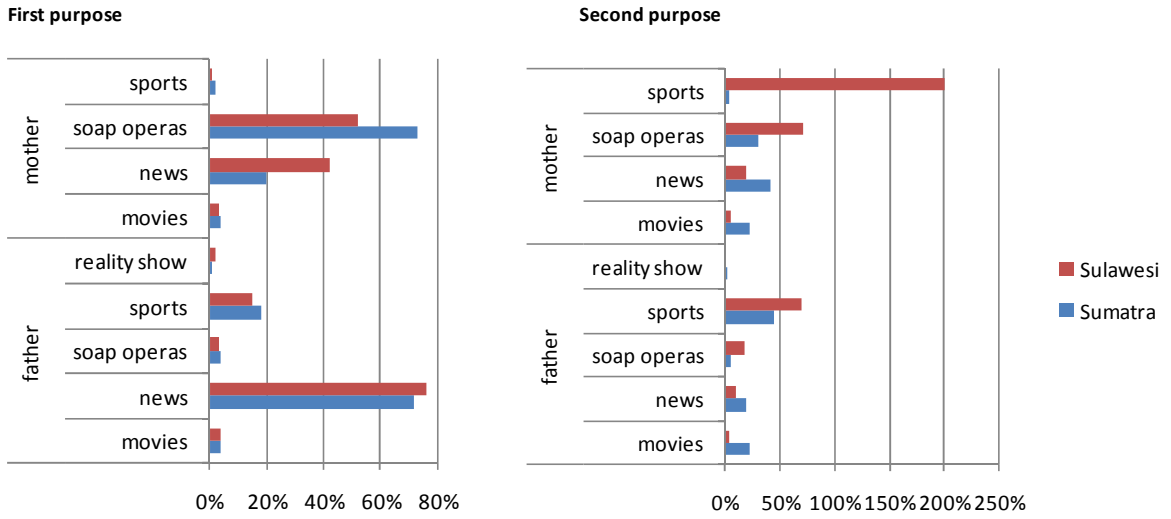
Table 32: Impact on *disadvantaged* households: TV usage in minutes per day

TV Usage (in min/day)		**father**	**mother**	**children 6-11**	**male children 12- 17**	**female children 12-17**
Sumatra	Non-user	2	2	2	5	0
	User	76	67	30	66	50
Sulawesi	Non-user	30	24	16	34	16
	User	89	74	43	43	77

The preferred TV programs in EnDev 1 households for fathers are news and sports (mostly boxing) – both in Sulawesi and Sumatra. Women like to watch soap operas, but the second most important purpose is also news. Consistently, 81 % of households name TV as their major source of information. Only 9% state that they get news from friends or neighbors. Even among those households without TV at home 34% get their information mainly from TV. Further 33% get their information from neighbors and friends. Compared to the non-TV using households in EnDev 2 villages, the importance of TV as an information source is higher among EnDev 1 villages. In EnDev 2 villages only 19% name TV as the most important source of information and 44% name neighbors and friends.

In qualitative discussions in Sulawesi, people highlighted the possibility to gain information through television from other parts of Indonesia or the world and to get in contact with ideas and topics that did not reach their villages before. With regard to publicity on television some stated that they want to work hard to be able to live a comfortable life like people on television, referring, for instance, to cooking equipment. As negative impacts, people mentioned the bad influence of erotic or pornographic content in international movies for their children. Another negative impact mentioned was the fact that people miss social obligations as for example church on Sunday when boxing is on TV or that parents watch sometime TV until late at night and do not get sufficient sleep. Some parents expressed also their concerns with regard to their children's study time, which is not extended thanks to electricity and lighting after nightfall, but even reduced because of the possibility to watch TV.

Chart 17: Purpose of TV usage



Social Commitment and Sense of Security

The affiliation to associations or political and social groups is more common in Sulawesi than in Sumatra (see Table 33). Whiles in Sulawesi almost 50% of the parents are member of an association in Sumatra approximately 25% are. In both regions, the most popular association are farmers associations. There is basically in all villages at least one farmer association. Their activities are the organization of mutual help at their fields, but also government subsidies for premium seeds or also fertilizer are allocated through these associations.

Table 33: Membership in groups

		Membership in association	frequency of participation per month
father	Sumatra	27%	1.8
	Sulawesi	54%	2.7
mother	Sumatra	23%	2.7
	Sulawesi	44%	3.1

Furthermore, in Sumatra also religious groups play an important role, especially for women. One fourth of the women who are active in some group or association participate in women's groups that offer religious activities, preparation of village celebrations, but also saving activities.

The perception of darkness among EnDev 1 villages is less negative than among EnDev 2 households. In EnDev 1 villages, only 39% of men and 66% of women are afraid of being outside after nightfall (see Table 34). Among EnDev 2 villages the respective shares amount to 71% and 77%. In Sulawesi and with regards to their children, EnDev 1 households are not less fearful. The shares are similar among EnDev 1 and EnDev 2 villages.

Table 34: Fear of going out after nightfall (in %)

Afraid when…	**Sumatra**		**Sulawesi**	
	m	f	m	f
… being outside after nightfall?	39%	66%	27%	67%
…children outside after nightfall	95%	92%	98%	96%
…at home after nightfall	1%	3%	3%	4%

3.4.4 Attitude towards Electricity

Half of the households state that they know how the MHP is managed. The vast majority of them (about 90%) think that it is managed well or very well. However, 67% of the MHP users wish to have an improvement in the electricity supply (see Table 35), which mostly refers to a more reliable electricity supply (53% in Sumatra and 34% in Sulawesi). Secondly, they name very specific problems about the civil works or the turbine, which in their opinion should be maintained more regularly (18% in Sumatra and 37% in Sulawesi). Only 9% in Sumatra and 4% in Sulawesi wish to have electricity 24 hours a day. Some households in Sulawesi explicitly state, that they do not need electricity during daytime. Further 10% in Sumatra and Sulawesi would like to have a higher capacity per household. Moreover, there are households that wish to have better in-house installation or better poles. They suggest concrete poles instead of bamboo poles, which they consider as dangerous in case they fall down (particularly for children).

Table 35: Suggestions for improvement of MHP-electricity supply

	Sumatra	**Sulawesi**
Share of households that wish improvement	67%	68%
Improvement		
More stable electricity supply	53%	34%
Repair of civil works or turbine to improve electricity supply	18%	37%
Electricity service 24h a day	9%	4%
Increase capacity	8%	11%
Better in-house installation	7%	5%
Better poles	2%	4%

Only seven percent of the households see negative impacts of electricity usage. The problems they name are that people, especially children, watch too much TV and go to bed too late, that electricity damages electric equipment and that electricity may cause house fires. Those households that are afraid of house fires and those that ask for better in-house installation mainly got their electric installation from the MHP operator. Accordingly, also the “official” installations partly seem deficient.

27% of the households state that some equipment has been damaged by voltage fluctuations. Affected appliances are mostly lamps (50%), TVs (23%), or CD, VCR, or video player (14%). For

detailed information on village level refer to Table 36. Moreover, the households complain that there are great fluctuations in the electricity supply depending on the season. Many plants especially in Sulawesi have problems with low water levels in dry season (most prominently Lisuan Ada, Batanguru Minanga, and Paladan; see Table 36), whereas there are also plants where in rainy season too much water hampers the smooth operation of the plant (especially Lisuan Ada (Sepang), Batanguru (Ratte), Kampung Nan Limo, and Limau Limau .

Table 36. Demand for improvement of electricity supply

	Site	% of HH that report…			
		…equipment damaged due to unstable electricity supply	… seasonally unstable electricity supply	Reason for seasonal variation:	
				… low water level in dry season	… too much water in rainy season
Sumatra	Kampung Nan Limo	55%	70%	0%	55%
	Karang Putih	6%	85%	5%	10%
	Kubang Gajah	45%	60%	0%	40%
	Lambah Saiyo	5%	20%	0%	10%
	Limau Limau	68%	47%	16%	53%
	Muara Air	58%	62%	0%	42%
	Pidang	10%	35%	0%	5%
	Sapan Salak	8%	70%	15%	35%
	Sungai Kalu	21%	71%	38%	29%
	Wonorejo	65%	65%	0%	30%
Sulawesi	Batanguru (Minanga)	14%	100%	91%	0%
	Batanguru (Ratte)	9%	67%	0%	61%
	Lisuan ada	0%	100%	100%	0%
	Lisuan ada (Sepang)	11%	84%	21%	63%
	Paladan	0%	95%	81%	5%
	Rante Tangnga	42%	74%	5%	40%
	Rantepuang	15%	95%	70%	15%
	Rippung	16%	74%	55%	5%
	Satan Etang	14%	24%	0%	23%
	Sipai	11%	56%	20%	20%

Both in Sumatra and Sulawesi, people value more that electricity is used for street lighting than lighting at primary schools (see **Fehler! Ungültiger Eigenverweis auf Textmarke.**). If they have to decide between electric appliance at health stations or at secondary schools, they opt for the former.

Table 37: Priority concerning lighting and electric appliances (in %)

	Sumatra	Sulawesi
Street lighting is more important than lighting at a primary school	76%	64%
Electric appliances at health stations are more important than at a secondary school	65%	82%

People in Sumatra give highest priority to street lighting, whereas electricity at health facilities is most important for households in Sulawesi. Electricity at administrative offices is considered less

important among the options displayed in Table 38. These perceptions are similar to those of EnDev 2 households.

Table 38: Importance of electricity provision in social infrastructure in the village (in %)

	Sumatra			**Sulawesi**		
	priority	desirable	Not necessary	priority	desirable	Not necessary
At school?	41%	58%	1%	34%	62%	3%
At health facility?	52%	47%	1%	59%	39%	2%
At administrative offices?	11%	84%	5%	12%	83%	5%
For street lighting?	88%	12%		50%	48%	3%

4. Financial and Technical Sustainability

In this section, we report our findings from the field work on the financial and technical sustainability of the MHPP in the surveyed villages. Although these questions were clearly not in the focus of our research, the various discussions with operators, villagers, and external experts have delivered insights that might be helpful for the implementation and potential upscaling of the project. For detailed information on the surveyed sites, please also refer to the Monitoring Report 2010 from Entec[17].

4.1 Financial Sustainability

While the investment in the MHPP as well as the distribution lines are completely covered by the Green PNPM subsidy, the operation of the MHPP is supposed to be self-sustaining, this is, no further subsidies will be paid. The implication is that the tariff that is collected from the connected households does not only have to cover the operating costs. In addition, reserves have to be created that are sufficient to come up for maintenance and spare parts. In reality though, most of the EnDev 1 villages do not manage to save this amount of money. This is mainly due to three factors:

First, compared to mini-grid tariffs in other countries the tariffs in EnDev 1 villages are very low. A monthly fee of 35,000 IDR as recommended by TSU can hardly be found. Only few households are paying this amount in 4 villages – but also only as highest consumption class. In Sulawesi, the highest observed fee is 25,000 IDR.

Second, the fees are not rigorously collected. In more than half of the surveyed EnDev 1 villages the documentation of the fee collection shows that not all households pay regularly the requested amount. The share of non-paying consumers varies between some few households in most cases and up to 70% in the worst case. Frequently, payments are delayed substantially, sometimes even for several months. Although in all surveyed EnDev 1 villages, in theory, households that do not pay for several months can be disconnected, this is hardly effectuated. The stated reasons can be summarized as follows: Operators themselves are inhabitants of the village. It is very difficult for them – due to social relations between the villagers – to disconnect neighbors and friends, in particular, if they are encountering financial problems. The close relations between households can easily lead to a subsequent problem, as we encountered in the village Sapan Salak: In 2009, virtually all households paid their fees on time. Then, after a change in management, one household stopped to pay because it was not satisfied with the service. As no sanctions were applied, a domino effect was induced and one household after the other refused the payment. In August 2010, only 30% of the households paid for electricity.

Third, bookkeeping and documentation of activities is deficient. None of the surveyed EnDev 1 MHP operators use all of the eight blue books that had been introduced to them during the MHPP training measures. The most commonly used book is the monthly payment registration book. The cash book for documenting the cash flow of incomes and expenditures is also used in some cases. However, often the villages do not use the provided blue books, but make notes in an ordinary notebook. Some of the cash book users record the cash flow, but do not calculate a saldo. Thereby, the principal

[17] Based on the information gathered by Entec and RWI during the survey, Entec prepared a monitoring report that describes technical and operational aspects of EnDev 1 sites in more detail.

objective of the book – to provide an overview on the cash position for both planning and transparency reasons – is not met.

Consequences of a lacking billing discipline of operators and customers are manifold: Funds are lacking to repair broken or damaged turbines, to maintain the distribution lines and, not least, to pay an adequate salary for the operators and book keepers. Anecdotally, this can be seen in Sapan Salak, where the MHP had been running smoothly and fees have been paid in time until the staff decided to give up their work because they found more profitable activities. From this moment on the operation deteriorated, partly due to a missing transfer of knowledge, partly due to the capacities of the following staff. Many conversations with operators and village chiefs have supported the hypothesis that the sustainable operation of the plants critically depends on the persons responsible for the operation and management.

For the future, it might be considered addressing these issues even more intensively in the TSU administration training events. Awareness among the participants to dedicate efforts to take the bookkeeping more serious can be further raised. The importance of the enforcement of monthly payments in order to be able to pay an adequate salary for the MHPP staff can be highlighted.

In addition to extending the administration training events, the villages could be supervised again after some months of operation in order to share the experiences gained and check if the trained knowledge is applied in practice. The low usage rates of the MHPP-provided blue books suggest that the total number of 8 books for book keeping and documentation of activities might be too high. The concentration on fewer books to document only indispensable information might improve the situation.

4.2 Technical Sustainability

This section addresses the question – given that funds are available – if spare parts and the know how to conduct maintenance work are available or accessible. In fact, a problem frequently mentioned by EnDev 1 MHP operators is that they do not know who to approach in case the MHP needs reparations. This indicates first, a lack of sufficient capacities among the technical service providers and, second, a lack of information on how to obtain technical support. More generally, there seems to be a need for improving the communication infrastructure between the villages, PNPM staff, TSU staff, and technical service providers, for example turbine manufacturer or other technicians. Actually, there are turbine suppliers both in the central Sulawesi area and West Sumatra who are able to repair broken turbines. In many cases, though, the MHP operators in the villages do not have the contact of any of the turbine technicians, especially in Sulawesi. Instead, the operators try to arrange themselves and, in fact, frequently manage to repair the MHP installation at least partly, so that restricted electricity supply is available in the village.

In addition to the lack of information among the operators, there is also a lack of well-trained technicians. An option to confront this problem could be that technicians are trained on *kecamatan*-level who observe and repair the MHP installations in their region.

Another crucial issue of technical sustainability is, as a matter of course, the quality of the installed hardware, particularly the turbines. It is normally foreseen that only turbines from certified turbine

suppliers are installed. The staff of these certified suppliers has been trained in Bandung. Such suppliers exist in both Sumatra and Sulawesi. However, at least in one case in Sulawesi (Rantettanga) the turbine was definitely not constructed by a trained turbine supplier and, consequently, the turbine frequently breaks down. Also in Muara Air, Sumatra, the village had problems with the turbine that has broken down already twice since the installation in mid 2009. It is, of course, difficult to say in both cases if the problems are due to a lower quality of the turbine or if it is rather due to bad maintenance. The turbines break easily, for example, if stones from the poorly cleaned channel enter. To reduce the risks of bad quality hardware, it could be a solution to oblige the manufacturers to issue warranties, which seemingly today do not exist.

For most of the visited sites the load management is done manually leading to high voltage fluctuations. This, in turn, endangers and occasionally destroys appliances in the households. Only some few sites in Sulawesi are equipped with an electronic load control (ELC) and a ballast – for financial reasons. While, in principle, an MHP is easy to operate and maintain, ELCs are comparatively sophisticated devices and if they breaks down, that can only repaired by experts.

The disadvantage of not having ELCs is that the load of the system has to be regulated manually. In case of irregular consumption behavior of households, this implies someone has to be in the powerhouse to control the consumption level and regulate the water inflow while the system is in operation. 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 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.

One approach to solve this problem was to instruct the households to keep their lights on so that the load does not vary. Obviously, this is not a satisfying solution and, as a consequence, more than 30% of the households complain about unstable electricity provision and report that equipment has been damaged by voltage fluctuations (lamps (50%), TVs (23%), and CD, VCR or video player (14%)).

A further implication of the lacking ELCs is that productive applications are hardly possible. If appliances that require much capacity like electric saws are used, the voltage level has to be readjusted manually. The same applies to household appliances that require high capacities such as electric irons (used by 25%), rice cookers (10%), or water cookers (5%). These appliances are particularly difficult to handle, since they are used occasionally and, thereby, induce load shocks to the system.

Nonetheless, some MHPs provide a relatively stable electricity supply, even in absence of an ELC. If the operator takes his job seriously and stays in the power house during the operation hours of the MHP, it is possible to control the load manually and reach a decent level of reliability.

5. Conclusion

This report has described the findings from an impact survey among the beneficiaries of the electrification intervention "Mini Hydro Power Project" (MHPP) in Indonesia, which is supported by the Dutch-German energy partnership *Energising Development* (EnDev). In 20 EnDev 1 villages in Sulawesi and Sumatra, 415 households were interviewed in September and October 2010; all of them connected to micro hydro power plants. In addition, a reference group of 392 households living in yet non-electrified EnDev 2 villages was surveyed. These villages will be electrified by MHPP mini-grids through the second wave of the project. However, due to high pre-electrification rates among these reference group households, a quantitative impact assessment could only been done for parts of the EnDev 1 households. Using a stratified matching approach we identified counterparts to the non-electrified EnDev 2 households among the EnDev 1 group and referred to them as the *disadvantaged* households. For them, an impact assessment is possible. The counterparts of the pre-electrified EnDev 2 households in EnDev 1 villages were called accordingly advantaged households. For them, we can only provide a lower boundary for impacts. Yet, the comparison of these two groups can be interpreted as a prediction of what can be expected to happen to the EnDev 2 households that are currently using lower quality pre-electrification sources and that will soon switch to a higher quality MHP mini-grid.

The take up rates in the MHPP project regions indicate that the needs of the households are met: Virtually all households in the access area of the MHP plants are connected to the MHP. Only some very poor household are not able to connect and to afford the monthly consumption fees. These do not present more than three percent of the population. Several sites even include them into the service by offering social tariffs.

Moreover, the electrification induces both the improvement of existing activities and services, and enables a wider variety of services and activities, especially through a distinct increase in appliance usage. The households' considerable adoption of different devices, most importantly TV, but also rice cookers, electric irons, and water cookers, distinguishes the MHPP project from many comparable electrification efforts, particularly in Africa.

First of all, the usage of TV is striking. More than 80% of the households in Sumatra and 45% of the households in Sulawesi possess a TV. Also those households that do not possess a TV spend several hours per week watching TV at their neighbors, friends, or kiosks. Next the entertainment momentum of watching TV people clearly also use it to access information. Also the increased usage of mobile phones demonstrates the linkage between electrification and better information and communication.

The usage of rice cookers is furthermore remarkable. More than half of the households in Sumatra and still more than 10% in Sulawesi use electric rice cooker and thereby reduce their firewood consumption. This implies rather a reduction in work load than in costs, as most of the surveyed households collect firewood and do not buy it. Depending on whether the firewood is extracted sustainably this can additionally reduce deforestation pressures. The potential of rice cooker usage in Sulawesi, though, could be further exploited. Future research could follow up on these first results

and examine the reasons for the usage and non-usage of rice cookers among the target households. Besides insufficient capacity provision per household, financial obstacles or a lack of awareness may be driving factors.

Altogether, the high connection rates and the strong usage of appliances indicates that considerable impacts on beneficiaries can be expected in the long run: modernization effects due to television, improved access to information through television and mobile phones, convenience, fuel and time savings, as well as improved air quality due to electric lighting and rice cookers. Income generating activities are also possible, although on the level of enterprises take up so far is modest.

In spite of the substantial take up of new appliances fuelled with electricity, energy expenditures are effectively reduced. Expenditures on traditional energy sources, especially for lighting are still considerable, though. Given that traditional lighting sources are only used in case of blackouts, the expenditures on kerosene hint at frequent blackouts and brownouts. This is in line with qualitative information that indicates that most of the surveyed sites have serious problems with both blackouts and voltage fluctuations. Also in structured interviews, households explicitly complain about the unreliable electricity supply and also state that many appliances are damaged. The usage of electronic load control (ELC) on the level of the MHPP counteracts these fluctuations and should be considered to tackle the problem.

Based on more anecdotal evidence, the financial and technical sustainability of the MHP schemes have been discussed. There are still some challenges to be met especially concerning book keeping, accrued reserves and proper maintenance to insure the sustainable operation of the MHP in the long run. In many cases, the operators do not collect enough money to cover all costs including the establishment of reserves for future maintenance or replacement costs. Further problems are the lacking access to technical support. Besides increase support from TSU/MHPP or PNPM, a further option to increase the technical ability of the villages is to support the exchange of experiences between them. A regular meeting on *kecamatan*-level would provide the framework to do so.

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Annex 1

Site Selection

For obvious reasons, site selection predetermines much of the potential of a sustainable operation of MHP. The scoring system applied by TSU within EnDev 2 encompasses main quantifiable aspects to be considered here such as the distance to the national grid, possible plant capacity, and the number of inhabitants. In terms of the latter two criteria, the EnDev 1 sites generally proved to be well chosen. Yet, concerning the distance to the PLN grid, some EnDev 1 villages were found to be less than 2 km away. Of course, in a few of these cases the grid only approached the villages recently and this development has not been foreseeable. Yet, it seems that the grid distance criteria – and thereby the alternative option of electrification by PLN grid extension – has not been rigorously considered in the site selection process.

Table 39: Estimated distance to PLN grid of sampled EnDev 1 villages

	Village	Distance to PLN grid		Village	Distance to PLN grid
	Batanguru (Minanga)	4 km		Lambah Saiyo	1,7 km
	Batanguru (Ratte)	4 km		Limau-limau	not in immediate vicinity
	Lisuan ada Sepang	3 km		Muara Air	not in immediate vicinity
Sulawesi	Lisuan ada Tandiallo	3 km	**Sumatra**	Kampung Nan Lima	1,5 km
	Paladan	4 km		Karang Putih	0 km
	Rante Tangnga	0 km		Kubang Gajah	0 km
	Rantepuang	0 km		Pidang	2 km
	Rippung	0 km		Sapan Salak	3 km
	Satanetean	2 km		Sungai Kalu 1	2 km
	Sipai	6 km		Wonorejo	2-3 km

This is, however, also an opportunity to think of alternative approaches, now that many MHPs are located in immediate vicinity of the PLN grid. The operators of these mini-grids could connect their MHPP to the central PLN grid and feed-in free capacities. Advantages for the consumers would be induced by overcoming capacity restrictions and also for the stability of the PLN grid it might be advantageous to connect decentralized generation capacity in order to counteract voltage losses due to huge distribution distances. However, these options depend, of course, essentially on the readiness of the PLN policy toward strategic cooperation like this.

Site description Sumatra

Lambah Saiyo

Kecamatan: Palupuh
Kabupaten: Agam
Distance to PLN: 1,7 km

Capacity of MHP: 20 kW

Connected

Households: 28
Productive Use: 2 tailor
Remarks: Village is located less than 2 km away from the main road to Bukittinggi, a quite touristic rural center.

Limau-limau

Kecamatan: 4 Nagari Bayang Utara
Kabupaten: Pesisir Selatan
Distance to PLN: not in immediate vicinity

Capacity of MHP: 60 kW

Connected

Households: 106
Schools: SD
Health Centers: Polindes
Religious Building: 3
Productive Use: 5 kiosk, 2 households have fridge and sell ice to children at school

Non-connected (in access-area)
Schools: SMP
Productive Use: 1 rice mill

Muara Air

Kecamatan: 4 Nagari Bayang Utara
Kabupaten: Pesisir Selatan
Distance to PLN: not in immediate vicinity

Capacity of MHP: 35 kW

Connected

Households: 75
Schools: SD
Religious Building: 1
Productive Use: 7 kiosk, 2 carpenter

Non-connected (in access-area)
Health Centers: Polindes
Productive Use: 3 mills
Remarks: The village has constantly problems with the channel (silting) and the turbine.

Kampung Nan Lima

Kecamatan: Sungi Pagu
Kabupaten: Solok Selatan
Distance to PLN: 1,5 km

Capacity of MHP: 9 kW

Connected

Households: 37
Religious Building: 1
Productive Use: 3 kiosk
Remarks: Many households started recently to plant rubber trees that do not yet yield.

Karang Putih

Kecamatan: Liki
Kabupaten: Solok Selatan
Distance to PLN: 0 km

Capacity of MHP: 50 kW

Connected

Households: 164
Schools: SD
Religious Building: 0
Productive Use: 5 kiosk

Non-connected (in access-area)
Productive Use: 2 carpenter, 1 tailor, 16 coffee and rice huller and mills
Remarks: Some households in the village have PLN connection. The households connected to the MHP preferred the MHP connection because the connection fee for PLN (2.500.000 IDR) was too high.

Kubang Gajah

Kecamatan: Sangir
Kabupaten: Solok Selatan
Distance to PLN: 0 km

Capacity of MHP: 64 kW

Connected

Households: 254
Schools: 2 SD, 1 Madrassar (religious)
Health Centers: 1 Pustu
Religious Building: 0
Productive Use: 25 kiosk, 2 restaurants

Non-connected (in access-area)
Productive Use: 3 rice huller, 1 carpenter, 2 tailor

Pidang

Kecamatan: Sangir Jujuhan
Kabupaten: Solok Selatan
Distance to PLN: 2 km

Capacity of MHP: 10 kW

Connected

Households: 33
Religious Building: 0
Productive Use: 1 kiosk, 1 fridge in household for commercial uses

Sapan Salak

Kecamatan: Koto Parik Gadang Diateh
Kabupaten: Solok Selatan
Distance to PLN: 3 km

Capacity of MHP: 32 kW

Connected

Households: 124
Health Centers: 2 Pustu
Religious Building: 2
Productive Use: 10 kiosk

Non-connected (in access-area)
Schools: SD
Productive Use: 1 rice huller, 1 coffee huller

Sungai Kalu 1

Kecamatan: Koto Parik Gadang Diateh
Kabupaten: Solok Selatan
Distance to PLN: 2 km

Capacity of MHP: 30 kW

Connected

Households: 104
Productive Use: 4 kiosk

Non-connected (in access-area)
Productive Use: 1 rice mill, 5 carpenter (on demand)

Wonorejo

Kecamatan: Sangir
Kabupaten: Solok Selatan
Distance to PLN: 2-3 km

Capacity of MHP: 40 kW

Connected

Households: 117
Religious Building: 0
Productive Use: 8 kiosk, 14 fridges in households for commercial uses, 50 planes and 30 drilling machines occasionally used for commercial uses

Non-connected (in access-area)
Schools: SD
Productive Use: 3 rice huller, 1 mill, 1 coffee huller
Remarks: There is an SD school newly constructed that has not yet been inaugurated. For the moment, children of classes 1-3 are taught in the musollah.

Site description Sulawesi

Batanguru (Minanga)

Kecamatan: Sumarorong
Kabupaten: Mamassa
Distance to PLN: 4 km

Capacity of MHP: 10 kW

Connected

Households: 46
Productive Use: 2 kiosk

Remarks: The day the village has been surveyed, the turbin broke down. The turbin manufacturer, who lives in the same village confirmed that the problem was temporary.

Batanguru (Ratte)

Kecamatan: Sumarorong
Kabupaten: Mamassa
Distance to PLN: 4 km

Capacity of MHP: 15 kW

Connected

Households: 90
Schools: 2
Health Centers: 1
Religious Building: 7
Productive Use: 2 kiosk

Non-connected (in access-area)
Productive Use: 2 carpenter, 1 coffee mill
Remarks: There are two MHPs in Ratte which are operating 24 hours since July 2010. One MHP serves exclusively as electricity source for the turbin workshop in the village.

Lisuan ada (Sepang)

Kecamatan: Sesena Padang
Kabupaten: Mamassa
Distance to PLN: 3 km
Distance to Main Road: 3 km

Capacity of MHP: 10 kW

Connected

Households: 63
Schools: SD, TK
Religious Building: 2
Productive Use: 1 kiosk, 1 mill, 1 carpenter

Non-connected (in access-area)
Productive Use: 1 blacksmith
Remarks: Mill is installed in the power house. Not in operation.

Lisuan ada (Tandiallo)

Kecamatan: Sesena Padang
Kabupaten: Mamassa
Distance to PLN: 3 km

Capacity of MHP: 8 kW

Connected

Households: 90
Schools: SD
Productive Use: 1 kiosk, 1 rice mill, 1 rice huller

Non-connected (in access-area)
Productive Use: 1 carpenter
Remarks: Mills are installed directly in the powerhouse.

Paladan

Kecamatan: Tawalian
Kabupaten: Mamassa
Distance to PLN: 4 km
Distance to Main Road: 4 km

Capacity of MHP: 9 kW

Connected

Households: 80
Productive Use: 5 kiosk

Non-connected (in access-area)
Productive Use: 1 carpenter

Rante Tangnga

Kecamatan: Sesena Padang
Kabupaten: Mamassa
Distance to PLN: 0 km
Distance to Main Road: 1 km

Capacity of MHP: 5 kW

Connected

Households: 46
Schools: SD, SMP
Productive Use: 2 kiosk

Non-connected (in access-area)
Schools: 3 TK
Productive Use: 8 carpenter
Remarks: The site is in a bad condition. The survey day the operator tried to repair the turbin, but he was not able. The turbin has been installed by a local turbin supplier who does not have the certificate from Bandung to construct MHP turbins. The site has serious problems with voltage fluctuations destroying many lightbulbs and electric appliances in the households.

Rantepuang

Kecamatan: Sesena Padang
Kabupaten: Mamassa
Distance to PLN: 0 km

Capacity of MHP: 6 kW

Connected

Households: 89
Schools: SMP
Religious Building: 6
Productive Use: 3 kiosk

Non-connected (in access-area)
Schools: 3
Productive Use: 9 carpenter, 1 workshop for mats from bast fibre (tikar), 4 weaver
Remarks: The main road is one hour walking away, the next Kecamatan Capital 2 hours (1 hour by moto.)

Rippung

Kecamatan: Messawa
Kabupaten: Mamassa
Distance to PLN: 0 km

Capacity of MHP: 5 kW

Connected

Households: 25
Religious Building: 3
Community Center: 4
Productive Use: 3 kiosk

Non-connected (in access-area)
Schools: 3 SD, 1 SMP
Health Centers: 1 (PLN connected)

Satanetean

Kecamatan: Orobua
Kabupaten: Mamassa
Distance to PLN: 2 km

Capacity of MHP: 12 kW

Connected

Households: 65
Schools: 1
Religious Building: 1
Productive Use: 1 kiosk

Non-connected (in access-area)
Productive Use: 4 carpenter
Remarks: Since June 2010 a new operater is managing the MHP. Before, many lightbulbs in households got broken.

Sipai

Kecamatan: Messawa
Kabupaten: Mamassa
Distance to PLN: 6 km

Capacity of MHP: 13 kW

Connected

Households:	71	Non-connected (in access-area)	
Productive Use:	2 kiosk	*Schools:*	1
		Health Centers:	1

Annex 2

Survey Tools

Soft copies of the following documents are available on request.

T 1 Household Questionnaire

T 2 Community Questionnaire

T 3 Health Center Questionnaire

T 4 School Questionnaire

Annex 3

Lighting Devices

Table A: Lighting devices and average lighting hours per day (EnDev 1)

Lighting devices		Sumatra	Sulawesi
Incandescent light bulb ("Normal electric bulb")	% (outside/ inside)	**19% / 28%**	**32% / 38%**
	# (outside/ inside)	1.05 / 1.86	1.16 / 2.03
	h (outside/ inside)	12.3 / 11.9	12.1 / 10.5
Neon/fluorescent Tube	% (outside/ inside)	**0.5% / 1.5%**	**3% / 7%**
	# (outside/ inside)	1 / 2.33	1 / 1.92
	h (outside/ inside)	12 / 1.7	12.8 / 1.04
Compact fluorescent lamp ("Energy saver")	% (outside/ inside)	**48% / 90%**	**25% / 74%**
	# (outside/ inside)	1.1 / 2.68	1.16 / 2.34
	h (outside/ inside)	12.2 / 11.8	11.3 / 10.9
Rechargeable Lamp	%	**2%**	**0%**
	#	1	-
	h	0	-
Candles	**%**	**7%**	**8%**
	# (consumption per month)	7.22	6.18
Hurricane Lanterns	%	**77%**	**1%**
	#	1.7	1
	h	1.07	4
Tin Lamps	**%**	**21%**	**86%**
	#	1.80	1.68
	h	0	5.9
Gas lamp	**%**	**2%**	**2%**
	#	1	1.25
	h	0	6.5

%= percentage of households using the device

= average number of devices per household (only device using households)

h= average lighting hours per lighting device

Table B: Impact on *disadvantaged* households: Lighting devices and average lighting hours per day

Lighting devices		Sumatra		Sulawesi	
		EnDev 1	EnDev 2	EnDev 1	EnDev 2
Incandescent light bulb ("Normal electric bulb")	% (outside/ inside)	**18% / 29%**		**31% / 39%**	
	# (outside/ inside)	1 / 1.86		1.09 / 2.19	
	h (outside/ inside)	11.67 / 11.81		12.78 / 10.34	
Neon/fluorescent Tube	% (outside/ inside)	**1% / 1%**		**2% / 8%**	
	# (outside/ inside)	1 / 3		1 / 1.78	
	h (outside/ inside)	12 / 4		13 / 0	
Compact fluorescent lamp ("Energy saver")	% (outside/ inside)	**42% / 88%**		**25% / 71%**	
	# (outside/ inside)	1.09 / 2.42		1.26 / 2.22	
	h (outside/ inside)	12.1 / 12.05		10.94 / 11.05	
Rechargeable Lamp	%	**1%**	**0%**	**0%**	**0%**
	#	1	-	-	-
	h	0	-	-	-
Candles	**%**	**3%**	**0%**	**8%**	**7%**
	# (consumption per month)	5.67	-	4	3.86
Hurricane Lanterns	%	**83%**	**76%**	**1%**	**0%**
	#	1.61	2.45	1	-
	h	1.32	10.2	4	-
Tin Lamps	**%**	**17%**	**22%**	**85%**	**100%**
	#	1.88	2.91	1.68	2.66
	h	0	11.7	5.6	5.4
Gas lamp	**%**	**0%**	**2%**	**0%**	**2%**
	#	-	1.5	-	1
	h	-	12	-	4

%= percentage of households using the device

= average number of devices per household (only device using households)

h= average lighting hours per lighting device

Table C: Impact on *advantaged* households: Lighting devices and average lighting hours per day

Lighting devices		Sumatra		Sulawesi	
		EnDev 1	EnDev 2	EnDev 1	EnDev 2
Incandescent light bulb ("Normal electric bulb")	% (outside/ inside)	**19% / 27%**	**7% / 10%**	**34% / 38%**	**3% / 11%**
	# (outside/ inside)	1.1 / 1.86	1.17 / 1.56	1.24 / 1.82	1.00 / 1.78
	h (outside/ inside)	12.68 / 12.04	5.29 / 5.79	11.64 / 10.62	13.5 / 12.00
Neon/fluorescent Tube	% (outside/ inside)	**0 / 2 %**	**4% / 16%**	**4% / 5%**	**1% / 1%**
	# (outside/ inside)	0 / 2.00	1.00 / 2.00	1.00 / 2.25	1.00 / 6.00
	h (outside/ inside)	0 / 2.00	7.25 / 1.04	12.67 / 2.89	12.00 / 2.00
Compact fluorescent lamp ("Energy saver")	% (outside/ inside)	**54% / 92%**	**44% / 81%**	**26% / 77%**	**32% / 90%**
	# (outside/ inside)	1.07 / 2.83	1.00 / 2.45	1.05 / 2.41	1.2 / 2.32
	h (outside/ inside)	12.25 / 11.68	5.58 / 5.31	11.70 / 10.67	10.3 / 10.22
Energy Saver	%	**1%**	**0%**	**0%**	**0%**
	#	-	1	-	-
	h	-	0	-	-
Candles	**%**	**11%**	**1%**	**9%**	**9%**
	# (consumption per month)	7.64	30	9	4.86
Hurricane Lanterns	%	**71%**	**70%**	**0%**	**0%**
	#	1.80	2.40		-
	h	0.87	7.75	-	-
Tin Lamps	**%**	**26%**	**26%**	**90%**	**94%**
	#	1.75	2.48	1.68	1.87
	h	0	7.1	6.4	6.5
Gas lamp	**%**	**3%**	**2%**	**5%**	**1%**
	#	1	1.5	1.25	1
	h		6	8	-

%= percentage of households using the device

= average number of devices per household (only device using households)

h= average lighting hours per lighting device