

# Energizing Development Indonesia (EnDev Indonesia)



## Productive Use of Energy (PUE): Findings of the EnDev Indonesia Pilot Project

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## Abbreviations

ATS	Automatic transfer switch
EnDev	Energising Development; a Dutch-German Energy Partnership to promote sustainable access to modern energy services in developing countries
ELC	Electronic load control
EUR	Euro (EUR 1 = IDR 12,500)
Genset	Generator set
GIZ	Gesellschaft für Internationale Zusammenarbeit
HH	Household
IDR	Indonesian Rupiah
KPI	Key Performance Indicators
kW	Kilo Watt
kWh	Kilo Watt hour
MHP	Mini/micro Hydro Power
MHPP <sup>2</sup>	Mini Hydro Power Project for Capacity Development
NGO	Non-Governmental Organization
OWT	Operation Wallacea Trust
PUE	Productive use of energy
PUECA	Productive Use of Energy Centre Area
VMC	Village Management Committee
W	Watt

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## 1 Executive summary

In mid-2012, EnDev Indonesia initiated a proof-of-concept project to assess whether productive use of energy (PUE<sup>1</sup>) can enhance the sustainability of rural off-grid electrification infrastructure. In essence the project comprised the provision of electrical appliances to selected village-based businesses (small enterprises) with access to electricity from a community-operated micro-hydro power (MHP) plant. The project comprised a total of 53 businesses in 9 villages in regions of Sumatra and Sulawesi, Republic of Indonesia. The project's objective was to assess the following assumptions:

1. PUE will strengthen the sustainability of community-based MHPs by expanding the revenue potential (increased electricity sales) and improving overall MHP cost effectiveness (optimisation of capacity factor)
2. PUE appliances will improve production and income and reduce work load and overall expenditure of rural businesses
3. Numerous small-scale, off-the-shelf appliances spread across several businesses are more cost effective and less technically vulnerable than single specialised/customised large appliance.

The project was implemented from August to December 2012 by two different non-governmental organisations (NGO), ProWater and Operation Wallacea Trust (OWT), in Sumatra and Sulawesi respectively.

Table 1 Overview of PUE pilot scope

PUE Pilot Project (August - December 2012)		
Province	West Sumatra	South and West Sulawesi
NGO	ProWater	Operation Wallacea Trust (OWT)
Number of villages	6	3
Total number of households	401	210
Number of businesses	38	15
Number of appliances	63	49
Value of appliances	EUR 5,630	EUR 3,640
Average appliance cost	EUR 92/appliance	EUR 74/appliance
Average appliance power	563W	461W
Smallest appliance	10W egg incubator	100W sewing machine
Largest appliance	1,500W rice huller	900W circular wood saw

While findings for Sumatra lacked some key quantitative data, the results from Sulawesi conclusively suggest that the above assumptions are indeed plausible. The findings are most useful in terms of implementing and/or strengthening rural electrification initiatives and enhancing their sustainability through productive use of energy initiatives.

This report provides a combined overview of the project results for both Sumatra and Sulawesi in Chapter 2. More detailed findings for each region are compiled in Sections 3 and 4 for Sumatra and Sulawesi respectively. The report concludes with conclusions and recommendations in Chapter 5.

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<sup>1</sup> Within the project, PUE is defined as a small-scale activity, using a renewable energy-based electric energy source for providing a service or adding value to a product in order to sell the product and/or service to a willing market.

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## 2 Overview of pilot project findings

### 2.1 Methodology

EnDev Indonesia recruited two NGOs through a consulting contract, with a separate budget for purchase of PUE appliances. Bidding for this consulting contract included identifying pilot villages, participating businesses, and types and cost of PUE appliances required. Thus the NGOs undertook a needs assessment in their geographic area of activities prior to commencing with the project. This ensured that the project was demand-focused from the onset.

In essence, the NGOs' scope of work involved:

- Liaising with the participating businesses regarding suitable appliances
- Liaise with the Village Management Committee (VMC) responsible for MHP operation regarding the implications of this PUE initiative (MHP operating times, PUE tariff, etc.)
- Train and mentor both the businesses and the VMC on record keeping (through prepared record sheets) and conduct monthly follow-up
- Monitor and review all data jointly with EnDev Indonesia in order to address the following questions:
  1. Is a PUE tariff charged?
  2. Is the PUE tariff paid regularly?
  3. Has MHP operating time increased?
  4. Has MHP maintenance requirement increased?
  5. Has MHP operation been affected positively and negatively?
  6. Has monthly revenue from electricity sales increased?
  7. Have electrical appliances experienced technical failures?
  8. Have income and expenditure of rural businesses increased or decreased, compared to baseline?
  9. What is the general sentiment in the community regarding PUE initiatives?

The procured appliances were provided to the businesses at no cost, with the initial intent that they were provided on a loan basis for the duration of this project and subsequently returned or purchased at reduced cost. Unfortunately both NGOs were not successful in persuading the community regarding this approach. In the interest of project implementation it was decided to proceed nonetheless and provide the appliances without condition or payment. However, since the original approach has merit in terms of measuring "ownership", it is highly recommended for possible subsequent initiatives.



**Figure 1 Socialisation in Salumokanan, West Sulawesi**

*Group consultations, supplemented by individual meetings, were held with the villages' business community, MHP management committee and village authorities.*

## 2.2 PUE Appliances

The type and technical specifications of the appliances were determined by the rural businesses during one-on-one consultations. Table 2 provides an overview of the type of rural businesses engaged during this project, along with the appliances used, while Figure 2 reflects the appliance choice per region.

Table 2 Type of equipment for each business

Business	Electrical appliances
Blacksmith	Metal grinder, blower
Bread-making	Blender, mixer, sealer/laminator
Carpentry	Hand drill, sander, planer, trimmer, circular saw, metal grinder, compressor
Coffee grinding	Coffee grinder
Egg hatchery	Egg incubator
Rice milling	Rice huller
Tailor	Sewing machine, embroidery machine, lockstitch machine, seaming machine desk light
Warung (Kiosk)	Oven, freezer, water dispenser, blender, rice cooker, food mixer
Workshop	Compressor, bench drill, arc welder, metal grinder

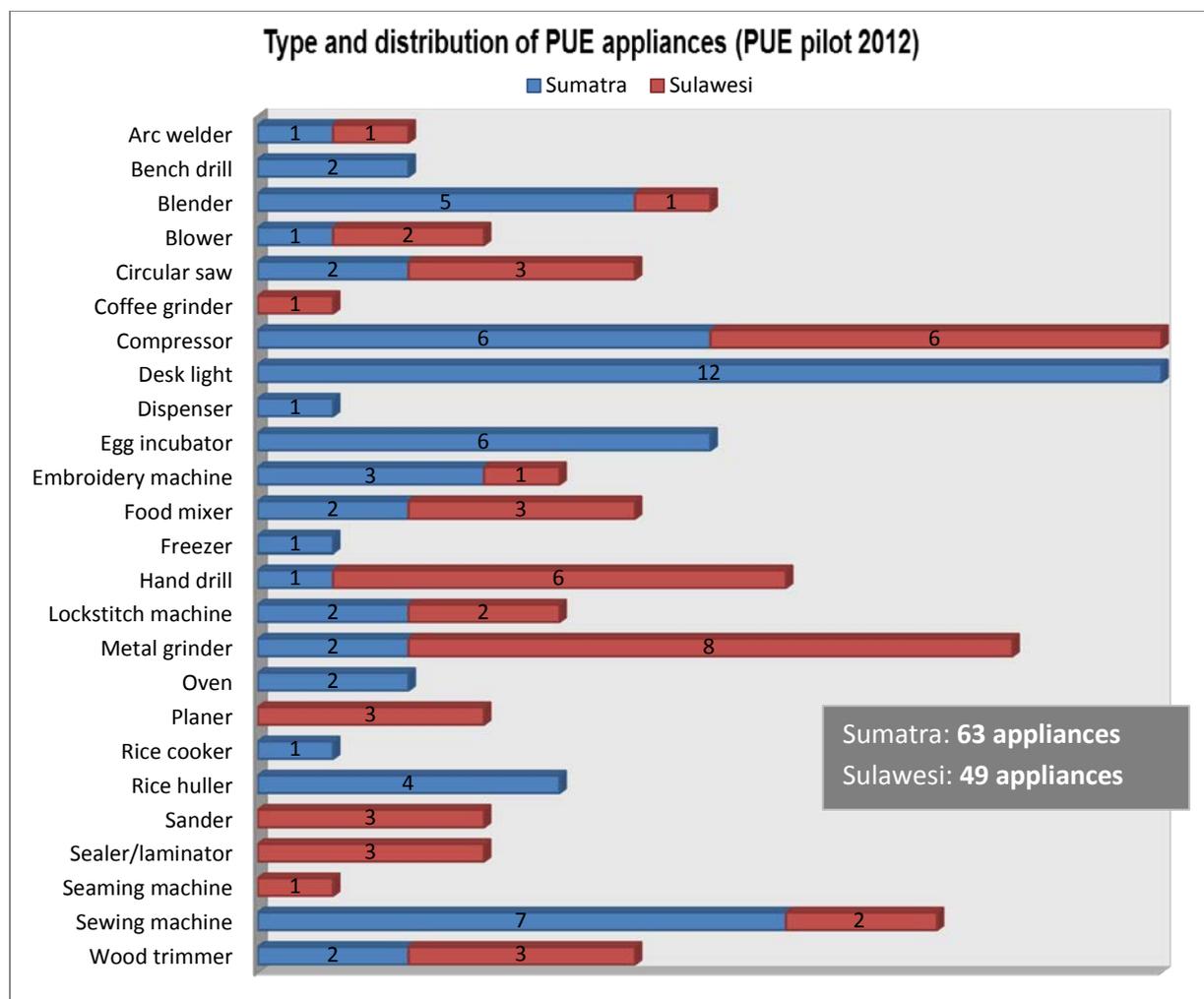


Figure 2 Type and distribution of PUE appliances

Appliance power consumption ranged from as little as 10 W to 20 W (egg hatchery, desk light) to as much as 1,500W (compressor, bench drill and rice huller), and cost ranged from EUR 11 (desk light) to EUR 266 (rice huller). The average power demand across all appliances is 533W, with an average cost of

EUR 83. The two figures below rank the appliances according to power demand (Watt) and capital cost (EUR) respectively.

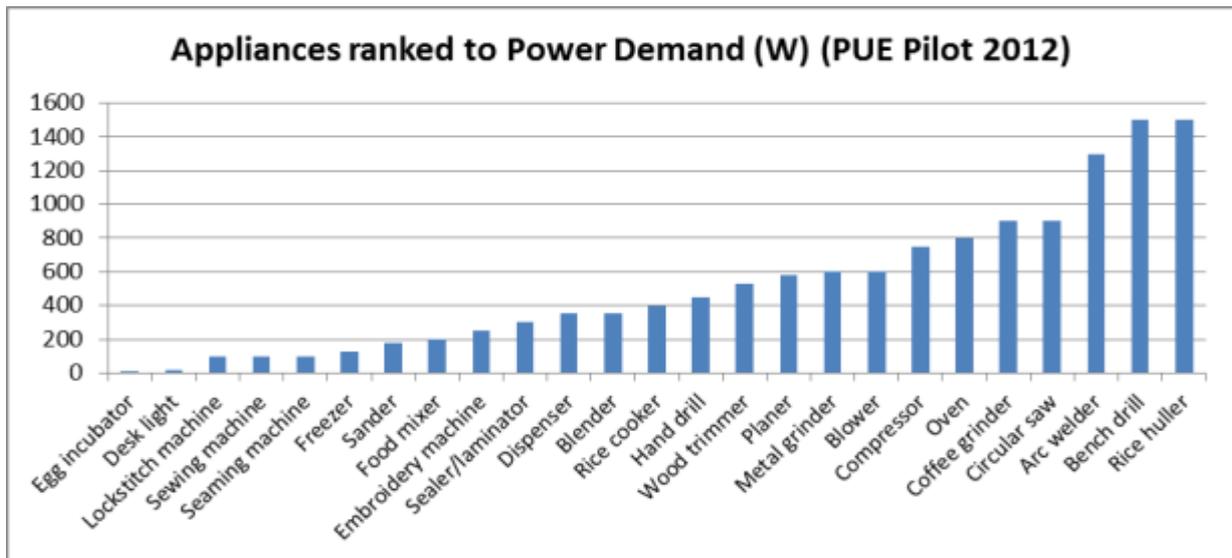


Figure 3 Appliances according to power demand (Watt)

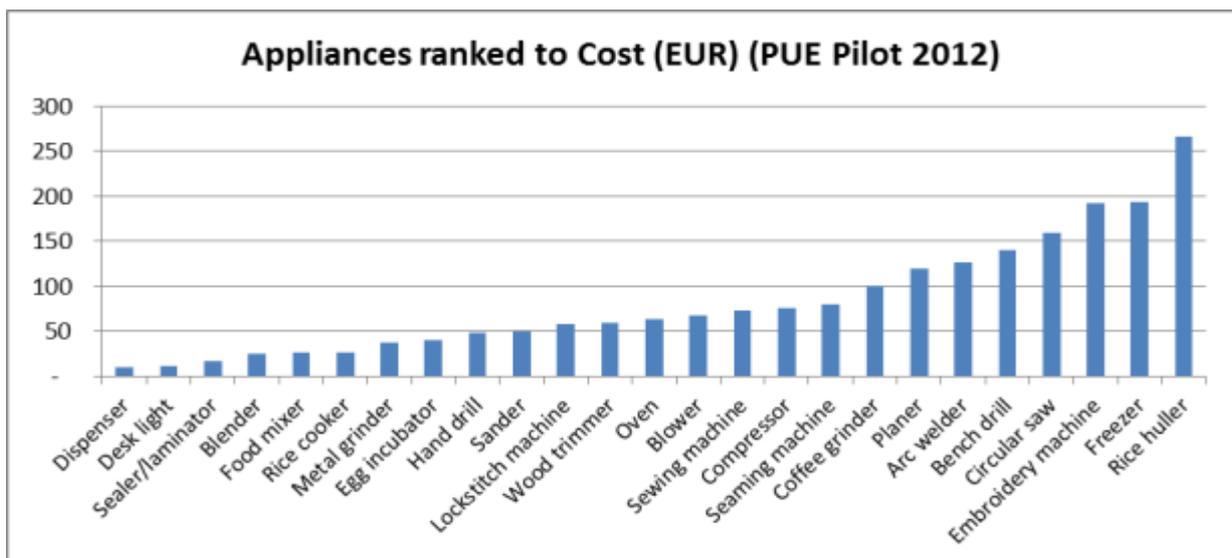


Figure 4 Appliances according to cost (EUR)



Figure 5 Petrol-operated rice huller

*These mobile units (about 5kW) have provided rice hulling services for a long time, at sufficient quantity and quality to remain a popular option.*

During the pilot period, the businesses reported no breakages of appliances except for the egg incubator. In fact, the egg incubator (along with the rice huller) was a specialised appliance (i.e. only available from specialised retailers), opposed to the other appliances which were off-the-shelf (i.e. available from ordinary hardware shops).

The community also faced difficulties in operating the rice hullers which could not produce quality de-hulled rice at sufficient quantity. The rice huller's 1.5kW power demand

strained the capacity of the MHP, to the point that it could only operate from the power house. This in turn made the delivery and collection of rice cumbersome and inconvenient. Villagers preferred the established petrol/diesel-operated rice hullers, mounted on a mobile carriage. Other than egg incubator and rice huller, all appliances satisfied the businesses' expectations.

## 2.3 Business performance

The pilot project assessed both monthly income generated and expense incurred by the 53 businesses. In the case of Sulawesi, this was compared to a 3-month baseline. As can be observed from the table below, the majority of businesses recorded a profit, with the profit accrued being sufficient to pay for the appliance in less than 6 months. The weakest performing businesses were egg hatchery and rice hulling.

Table 3 Profitability of businesses

Business	Sumatra (period 1-4months)	Sulawesi (period 5 months)
<b>Blacksmith</b>	<b>Profit</b> generated, but no baseline data (1 business, individual managed)	<b>Profit</b> increased by average 30% compared to baseline (2 businesses, group managed)
<b>Bread-making</b>	Not applicable	<b>Profit</b> increased by average 20% compared to baseline (3 businesses, group managed)
<b>Carpentry</b>	<b>Profit</b> generated, but no baseline data (4 businesses, individual managed)	<b>Profit</b> increased by average 30% compared to baseline (3 businesses, group managed)
<b>Coffee grinding</b>	Not applicable	<b>Profit</b> increased by average 30% compared to baseline (1 business, group managed)
<b>Egg hatchery</b>	<b>Loss</b> generated due to unreliable appliance (4 businesses, individual managed); no data available from 2 community-based businesses	Not applicable
<b>Rice milling</b>	<b>Loss</b> but not quantified as appliance proved inconvenient (4 business, community managed)	Not applicable
<b>Tailor</b>	<b>Profit</b> generated, but no baseline data (8 businesses, individual managed); <b>Loss</b> generated, but no baseline data available (1 business, individual managed)	<b>Profit</b> increased by average 33% compared to baseline (3 businesses, group managed)
<b>Warung (Kiosk)</b>	<b>Profit</b> generated, but no baseline data (4 businesses, individual managed); <b>Loss</b> generated, but no baseline data available (1 business, individual managed); no data available from 3 businesses, individual managed	Not applicable
<b>Workshop</b>	<b>Profit</b> generated, but no baseline data (5 businesses, individual managed); no data available from 1 business, individual managed	<b>Profit</b> increased by average 27% compared to baseline (3 businesses, group managed)

More detailed information regarding business profitability is contained in Chapter 3 (Sumatra Case Study) and Chapter 4 (Sulawesi Case Study). Capturing this data was an easier task for OWT (Sulawesi) than for ProWater (Sumatra) because of OWT's extensive experience in monitoring and evaluating field data and a deeper understanding of scientific analysis. It is also worth noting that OWT collaborated with businesses that were group managed (i.e. shared profit/loss responsibilities amongst members), while ProWater focused on individual-operated businesses and community-operated businesses (i.e.

the business satisfied a community need, where an exchange of money for service was not the core consideration).

## 2.4 MHP performance

One of the main objectives of the PUE pilot was to improve the performance of the MHP by extending daily operating times (most MHPs observed in Indonesia operate during evening and night time only<sup>2</sup>) and increasing the income from electricity sales (by charging a “PUE tariff” for businesses).

Operating times remained unchanged for five (5) of the nine (9) sites at between 16 and 24 hours daily operation. **For four (4) of the sites however, operating times increased by between 4 and 8 hours per day, specifically to cater for PUE activities.**

In terms of increased revenue from electricity sales, a “PUE tariff” was introduced by the MHP operating committee at the Sulawesi sites. Unfortunately Prowater (Sumatra) failed to institute this approach, with the consequence that improved financial performance in Sumatra could not be demonstrated. Also MHP operating expenses in Sumatra were significantly higher than in Sulawesi, and the reason for which could not be determined (but possibly includes inaccurate record keeping).

Table 4 Profitability of MHP

Description	Sumatra						Sulawesi		
	Lembah Derita	IMPP	Paninjauan	Paningsiran Bawah	Wonorejo	Sungai Keruh	Salumokanan	Tawalian Timur	Tandung
Income collected from households (EUR/month)	76	40	200	60	320	480	120	48	52
Income collected from PUE (EUR/month)	<b>No special tariff for PUE applied. The business owners pay only the household tariff.</b>						20	14	14
Expenses for salary (EUR/month)	No info	16	160	22	72	280	80	21	32
Expenses for maintenance (EUR/month)	36	5	22	24	20	20	8	4	4
Number of customers	23	42	99	28	139	70	90	51	70
Monthly tariff per HH (EUR)	4.00-6.00	0.80 - 2.40	2.40 - 3.20	2.00	2.40 - 2.70	0.08/ kWh	1.20 - 1.60	1.20	1.20
Difference (%) between pre- and post-PUE in profit/loss for MHP	0%	0%	0%	0%	0%	0%	<b>+63%</b>	<b>+60%</b>	<b>+88%</b>

Despite the data shortcomings in the project, **MHPs appear profitable for all nine (9) sites, with a profit increase of between 60% and 88% for the three (3) sites in Sulawesi.**

<sup>2</sup> For 47 MHP sites surveyed in September 2012, the average operating times were 15 hours/day, expressed in Availability Factor of 62% (source: Survey on Key Performance Indicators for Indonesian Micro-hydro Power Sites - EnDev Indonesia - December 2012).

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## 3 Sumatra case study

### 3.1 Methodology

For the pilot, ProWater selected 6 villages in West Sumatra comprising three districts i.e. Agam, Pasaman Barat, and Solok Selatan. The selection was based on the community and the MHP management team readiness as well as the feasibility to perform regular monitoring activities in these locations.

ProWater is technology supplier and manufacturer whose expertise lies on designing and producing turbines and other MHP components. ProWater has been active in assisting many rural communities especially in West Sumatra to develop a community-based MHP. The assistance is both in the form of technical support and providing credit scheme for purchasing MHP components.



**Figure 6 Tailor group in Paninggiran Bawah, West Sumatra**

*Working on clothes using manual sewing machines may take around 3 weeks. Through an electric sewing machine, the working day reduced to only 3 days. However, for some artwork, the villagers still prefer to use the manual appliance.*

Some existing businesses were supported to improve the production either by replacing or adding appliances. Some others were newly established businesses which were proposed by the community.

ProWater conducted identification, socialisation<sup>3</sup>, and monitoring on the rural businesses in six (6) pilot locations over a period of four (4) months which concluded in December 2012. Seven (7) staff members were assigned to mentor the businesses regularly and evaluate their performance. Socialisation and field monitoring were carried out for one to three days a week with a team of two or three people for each location. With these regular visits, it was expected that:

- The team can provide timely guidance, both technical and administrative, to the community.
- The beneficiaries will be skilled in operating the electrical appliances, but also in general business management and sufficient coaching to improve the production
- The MHP operating team's skill in MHP operation, maintenance and further development will be improved
- An empathetic socio-cultural approach in monitoring general community sentiment can be ensured

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<sup>3</sup> "Socialisation" describes the process of community liaison and mobilization. This typically includes briefing village elders, conducting community meetings, conducting focus group discussions, provide training and address any concerns any raised by the community at large.

Table 5 Overview of pilot sites in Sumatra

Village ID	Village Name	MHP Capacity (kW)	MHP Customers (HH)	# Business	# Appliances
SumBar150	Lembah Derita	16	23	4	8
SumBar151	IMPP	13	42	2	4
SumBar152	Paninjauan	35	99	14	20
SumBar153	Paninggiran Bawah	20	28	5	12
SumBar154	Wonorejo	45	139	6	8
SumBar065	Sungai Keruh	17	70	7	11
<b>Total</b>				<b>38</b>	<b>63</b>

The number of households mentioned above does not necessarily represent the number of customers for the businesses which actually is higher, as the businesses cater for a larger market.

### 3.2 PUE Appliances

The following table gives an overview on what appliances are in place for each business in the Sumatra project sites. From 6 types of business, 20 types of appliances are utilised with the total of 38 small businesses using 63 appliances.

Table 6 Appliances installed in each site in Sumatra

No	Type of Business	Appliances	Village					
			Lembah Derita	IMPP	Paninjauan	Paninggiran Bawah	Wonorejo	Sungai Keruh
1	Carpentry	Hand drill		1				
		Wood trimmer	1	1				
		Circular saw					1	1
		Compressor						1
2	Egg hatchery	Egg incubator	1		4			1
3	Rice milling	Rice huller			1	1	1	1
4	Tailor	Sewing machine		1	3	2	1	
		Embroidery machine				3		
		Lockstitch machine			1	1		
		Desk light	1	1	2	5	1	1
5	Warung	Oven						2
		Freezer			1			
		Dispenser			1			
		Blender	1		3		1	
		Rice cooker						1
		Food mixer						2
6	Workshop	Compressor	1		2		1	1
		Bench drill	1				1	
		Arc welder					1	
		Metal grinder	1		1			
		Blower			1			
		Desk light	1					
<b>Total</b>			<b>8</b>	<b>4</b>	<b>20</b>	<b>12</b>	<b>8</b>	<b>11</b>

Except for egg incubator and rice huller, all appliances installed are off-the-shelf items which can easily be purchased in local shops in Sumatra. These appliances are considered affordable with the price range of EUR 11 to EUR 266. ProWater purchased most the following items in Padang, Sumatra, and then transported them to the six districts of the project sites. The customised appliances were ordered from Bekasi, West Java. Table 6 below will give more insight on the power demand and price of each appliance.



Figure 7 Rice huller in Paninggiran Bawah (left) and egg incubator in Lembah Derita (right), West Sumatra

*The rice huller's high power demand and prolonged usage interfered with the MHP's performance, while the egg incubator failed to facilitate the hatching of eggs, most likely due to a design fault of the appliance.*

Table 7 Appliances wattage and price in Sumatra

No	Appliances	Wattage (W)	Unit Price (EUR)
<b>Carpentry, workshop</b>			
1	Blower	600	76
2	Hand drill	450	49
3	Trimmer	530	64
4	Wood cutting machine	1,050	76
5	Compressor	1,500	238
6	Bench drill	1,500	140
7	Arc welder	1,300	126
8	Metal grinder	200	76
<b>Hatchery</b>			
9	Egg incubator	10	40
<b>Tailoring</b>			
10	Sewing machine	120	76
11	Embroidery machine	150	192
12	Lockstitch machine	100	58
13	Desk light	20	11
<b>Food processing</b>			
14	Oven	800	64
15	Freezer	130	194
16	Dispenser	350	10
17	Blender	350	26
18	Rice cooker	400	27
19	Food mixer	200	27
20	Rice huller	1,500	266

### 3.3 Business performance

The monitoring activity on business performance in Sumatra was unsuccessful in capturing baseline data before the project was implemented. Therefore pre- and post-project business performance could not be compared, nor how the community obtained some services which were not available before.

ProWater only record profit (income minus expense) earned by each business, over different time periods, and the average monthly profit is presented in the table below.

Table 8 Financial performance of the businesses in Sumatra

No	Business	Village	Average Monthly Profit (EUR)	Period (months)
1	<b>Blacksmith</b>	Paninjauan (Aswan)	48	3
2	<b>Carpentry</b>	Lembah Derita (Abu Bakar)	195	1
3		IMPP (Burhanas)	11	4
4		Wonorejo (Jasmi/Eben)	30	2
5		Sungai Keruh (Tagor)	1,967	2
6	<b>Egg hatchery</b>	Lembah Derita (Abu Bakar)	-5	2
7		Paninjauan (Dodi)	-6	1
8		Paninjauan (Aguspardi)	-5	1
9		Paninjauan (Afriko)	-6	1
10		Paninjauan (Epi)	NA	NA
11		Sungai Keruh (Mughtar)	NA	NA
12	<b>Rice milling</b>	Paninjauan (MHP VMC)	NO	NA
13		Paninggiran Bawah (MHP VMC)	NO	NA
14		Wonorejo (MHP VMC)	NO	NA
15		Sungai Keruh (MHP VMC)	NO	NA
16	<b>Tailor</b>	IMPP (Siti Halimah)	8	3
17		Paninjauan (Wendra)	36	3
18		Paninjauan (Jasma)	26	3
19		Paninggiran Bawah (Risa)	25	3
20		Paninggiran Bawah (Ratnis)	42	3
21		Paninggiran Bawah (Yesi)	146	3
22		Paninggiran Bawah (Erlianis)	63	3
23		Wonorejo (Puja)	-17	2
24		Sungai Keruh	6	2
25	<b>Warung</b>	Lembah Derita	NO	NA
26		Paninjauan (Ermawati)	15	3
27		Paninjauan (Deni)	-0.4	2
28		Paninjauan (Agusrinal)	30	3
29		Paninjauan (Erna)	NA	NA
30		Wonorejo (Marsini)	7	2
31		Sungai Keruh (Restita)	53	2
32		Sungai Keruh (Ely Ernita)	NO	NA
33	<b>Workshop</b>	Lembah Derita (Abu Bakar)	34	4
34		Paninjauan (Harmaini)	52	3
35		Paninjauan (Alfimansyah)	NA	NA
36		Wonorejo (Suyatno)	56	2
37		Wonorejo (Junaidi)	44	1
38		Sungai Keruh	45	2

**Carpentry, tailor, and workshop** are the three most promising businesses in the villages. The entrepreneurs, however, need to strengthen their market presence to make their businesses more profitable.

The **tailor** business in Paninggiran Bawah is one example of deep market penetration. In this particular site, one entrepreneur has already established a strong market for both local demand and export. Four female entrepreneurs were supported through the project. They received two sewing machines, one embroidery machine, one lockstitch machine, and five desk lights to improve their productivity.



**Figure 8 Carpentry in Sungai Keruh, West Sumatra**

*In Sungai Keruh, the carpentry is owned by Tagor who has been in the business for quite some time. This is the main livelihood for him and he employs six people now. In addition to one compressor and one circular wood saw supported through the project and operated with the MHP, this business also utilises six other appliances using a diesel-genset. During the project period, the carpentry received an order from three palm oil companies to supply their furniture.*

Several businesses, especially the newly founded ones, were struggling and did not show commercial success yet. **Rice milling** for instance, needed a lot of mentoring in its implementation. In four rice milling businesses, the operator could not produce a quality product; therefore, the market preferred to use the diesel-fuelled rice huller (mobile units travelling set routes, operated by a non-resident entrepreneur). ProWater would need to modify the appliance to improve the output.

**Egg hatchery** is another business which did not show good result, since eggs failed to hatch. Some modification on the egg incubator might be needed to increase the temperature suitable for the eggs to incubate.

### 3.4 MHP performance

In Sumatra, the installation of PUE appliances affected the power output, but not necessarily the MHP operational time. Only one site (Wonorejo), which previously worked for 16 hours per day, is now operational for 20 hours per day.

**Table 9 MHP operational hours in Sumatra sites**

Village ID	Village Name	Before Pilot	After Pilot	Difference
SumBar150	Lembah Derita	24 hours	24 hours	None
SumBar151	IMPP	16 hours (16:00 - 08:00)*	16 hours (16:00 - 08:00)*	None
SumBar152	Paninjauan	24 hours	24 hours	None
SumBar153	Paninggiran Bawah	16 hours (16:00 - 08:00)	16 hours (16:00 - 08:00)	None
SumBar154	Wonorejo	16 hours (16:00 - 08:00)*	20 hours (12:00 - 08:00)*	+ 4 hours
SumBar065	Sungai Keruh	24 hours	24 hours	None

Notes: \*) 24 hours on Friday or Sunday and special holidays



Figure 9 ELC installation in Paninggiran Bawah, West Sumatra

Electronic load control optimises the power output of the turbine generator, by “dumping” excess power generated. This allows the MHP to operate at higher outputs, and stabilises electricity generation.

Power demand increased in all project sites, but this did not affect the use of lighting and other electrical appliances used in households, since PUE appliances are operated during the day. The project installed electronic load control (ELC) at 3 of the 6 project sites in order to ensure good quality electricity supply.

Unfortunately no kWh meters were installed at the sites yet, as means to quantify the improvement in capacity factor.

Table 10 Income and expenses of MHP operation in Sumatra

Description	Sumatra					
	Lembah Derita	IMPP	Paninjauan	Paninggiran Bawah	Wonorejo	Sungai Keruh
Income collected from households (EUR/month)	76	40	200	60	320	480
Income collected from PUE (EUR/month)	<b>No special tariff for PUE applied. The business owners pay only the household tariff.</b>					
Expenses for salary (EUR/month)	No info	16	160	22	72	280
Expenses for maintenance (EUR/month)	36	5	22	24	20	20
Number of customers	22	42	99	28	139	70
Monthly tariff per HH (EUR)	4.00- 6.00	0.80 - 2.40	2.40 - 3.20	2.00	2.40 - 2.70	0.08/kWh
Difference (%) between pre- and post-PUE in profit/loss for MHP	0%	0%	0%	0%	0%	0%

## 4 Sulawesi case study

### 4.1 Methodology

OWT is an NGO working on empowering local communities in environment conservation including rehabilitation of critical land in the upper catchment areas and developing community-based enterprises as alternative livelihoods for better natural resource management.



Figure 10 Warung or kiosk in Salumokanan, West Sulawesi

*OWT's experience in working with other partners, as well as creating awareness, was apparent in the fact that their businesses all displayed signage.*

OWT implemented the project in three (3) villages, i.e. Salumokanan and Tawalian Timur (Mamasa, West Sulawesi) and Tandung (Luwu Utara, South Sulawesi). The project successfully facilitated 6 types of businesses (tailor, carpentry, workshop, bread making, coffee grinder, and black-smith) involving 15 community groups (6 in Salumokanan, 5 in Tawalian Timur, and 4 in Tandung).

Village selection was conducted in June 2012 prior to project start. The criteria of villages selection were: (a) the existence of MHP; (b) MHP management team has been well established; (c) the availability of well-running businesses with demand for electricity power; (d) the high social capital; and (e) accessibility.

OWT's facilitation approach comprised two separate elements:

1. Prior to project implementation: (i) project socialisation and coordination; (ii) community entrepreneur selection; (iii) preparation of PUE project; (iv) procurement of appliances; and (v) installation of appliances.
2. During project implementation: (i) facilitation; (ii) technical assistances; (iii) monitoring and data collection; and (iv) reporting.

Table 11 Overview of pilot sites in Sulawesi

Village ID	Village Name	MHP Capacity (kW)	Customer (HH)	# Business	# Appliances
SulBar033	Salumokanan	7.5	90	6	18
SulBar097	Tawalian Timur	15	50	5	16
Sulsel170	Tandung	15	70	4	15
Total				<b>15</b>	<b>49</b>

### 4.2 PUE Appliances

Equipment procurement took considerable time which led to a 1-month delay in delivering appliances to site. Reason for the delay was the lack of appropriate appliances close to the project sites (hence appliances were procured from Makassar, South Sulawesi) and complex GIZ procurement requirements. The following table gives an overview on what appliances are in place for each business in Sulawesi project sites.

Table 12 Appliances installed in the each site in Sulawesi

No	Type of Business	Appliances	Village		
			Salumokanan	Tawalian Timur	Tandung
1	Blacksmith	Metal grinder	1	1	
		Blower	1	1	
2	Bread making	Mixer	1	1	1
		Hand sealer	1	1	1
		Blender	1		
3	Carpentry	Metal grinder	1	1	1
		Planer machine	1	1	1
		Drilling machine	1	1	1
		Trimmer machine ( <i>profil</i> )	1	1	1
		Sander machine ( <i>ampas</i> )	1	1	1
		Circular saw	1	1	1
		Compressor	1	1	1
4	Coffee grinding	Coffee grinder	1		
5	Tailor	Sewing machine	1	1	
		Embroidery machine			1
		Lockstitch ( <i>obras</i> ) machine	1	1	
		Seaming ( <i>neci</i> ) machine			1
6	Workshop	Metal grinder	1	1	1
		Drilling machine	1	1	1
		Compressor	1	1	1
		Inverter welder			1
<b>Total</b>			<b>18</b>	<b>16</b>	<b>15</b>



Figure 12 Bread making in Salumokanan, West Sulawesi

*This typical “home-based” industry benefits from a multitude of small off-the-shelf appliances that greatly simplifies tasks and saves time. This was especially important since this business is operated by women, with numerous other daily chores and responsibilities.*



Figure 11 Workshop in Tandung, South Sulawesi

*Motorbike repairs and modifications could now be performed closer to the market, creating both a viable business and reducing inconvenience and expense for clients.*

All appliances installed are off-the-shelf items, but some needed to be purchased from hardware stores in Makassar, South Sulawesi, where a wider selection is available. The appliances range in price between EUR 18 and EUR 192 and a listed in the table below:

Table 13 Appliances wattage and price in Sulawesi

No	Appliances	Wattage (W)	Unit Price (EUR)
<b>Blacksmith, carpentry, workshop</b>			
1	Metal grinder	600	38
2	Blower	600	68
3	Planer machine	580	120
4	Hand drilling machine	710	45
5	Trimmer machine ( <i>profil</i> )	530	60
6	Sander machine ( <i>amplas</i> )	180	50
7	Circular saw	900	160
8	Compressor	750	76
9	Arc welder	900	68
<b>Tailoring</b>			
10	Embroidery machine	250	192
11	Sewing machine	100	74
12	Lockstitch machine	100	58
13	Seaming machine	100	80
<b>Food processing</b>			
14	Dough mixer	170	29
15	Blender	170	18
16	Vacuum packing	300	18
17	Coffee grinder	900	100

### 4.3 Business performance

To understand the impacts of PUE to income generation, baseline data was collected prior to appliance installation. The baseline comprised the average profit of the monthly profit of three (3) months preceding the project. All appliances operated as per business expectation, without technical failures. In all instances, the profit of the businesses increased by margins between 20% and 40% within the five (5) month project period.

Table 14 Financial performance of the business, before and after PUE pilot in Sulawesi

No	Business	Village	Baseline Profit (EUR)	Average Profit (EUR)	Increment %
1	<b>Blacksmith</b>	Salumokanan	36	52	30
2		Tawalian Timur	48	68	30
3	<b>Bread making</b>	Salumokanan	32	41	20
4		Tawalian Timur	30	37	20
5		Tandung	38	49	20
6	<b>Carpentry</b>	Salumokanan	112	188	40
7		Tawalian Timur	102	146	30
8		Tandung	80	100	20
9	<b>Coffee grinding</b>	Salumokanan	24	34	30
10	<b>Tailor</b>	Salumokanan	45	65	30
11		Tawalian Timur	51	73	30
12		Tandung	85	142	40
13	<b>Workshop</b>	Salumokanan	32	41	20
14		Tawalian Timur	32	40	20
15		Tandung	152	256	40

The remarkable performances of some of the businesses are further described below:

- **Carpentry in Salumokanan:** During project implementation, the community enterprise received government orders to manufacture and deliver furniture to several elementary schools in Rante Bulahan Timur sub-district.

- **Tailor in Tandung:** The entrepreneur was already well-established prior to the project and is not a merely a part-time job, but managed in a good manner. The appliances have sharply promoted the businesses efficiency.

- **Workshop in Tandung:** The introduction of electric welding in this workshop has attracted motorbike owners from the surrounding sub-districts (especially from Seko Sub-district, in which they used to repair their motorbike in Masamba) to repair their motorbikes in this workshop. They do not need to bring their motorbike to Masamba which is 30 - 40 km away from their villages. In addition, the workshop also does customisations to improve



**Figure 13 Motorbike modification in Tandung, South Sulawesi**

*Normal motorbike ride from Masamba to Seko may take 4 days trip. By improvising the motorbike (suspension, tune-up, etc), the distance can be reached in only 2 days. Furthermore the workshop could offer visual enhancements to make a motorbike a prestige item.*

motorbike appearance. For this the electric compressor for spray painting is used. This is a new high-value service, which did not exist prior to the project.

#### 4.4 MHP performance

Prior to the project, the project sites operated their MHPs primarily during night-time. Day-time operation was reserved for Friday Prayer in the Mosque, Church (Saturday), weekend (Sunday) and public purposes (Monday). Since the project, daily operating times have increased and businesses now operate six (6) days per week (except Sunday).

**Table 15 MHP operational hours in Sulawesi sites**

Village ID	Village Name	Before Pilot	After Pilot <sup>[4]</sup>	Difference
SulBar033	Salumokanan	14 hours (17:00 - 07:00) <sup>[1]</sup>	22 hours (PUE: 08:00-15:00; HH: 16:00 - 07:00)	+ 8 hours
SulBar097	Tawalian Timur	14 hours (17:00 - 07:00) <sup>[2]</sup>	22 hours (PUE 08:00-15:00; HH: 16:00 - 07:00)	+ 8 hours
Sulse170	Tandung	14 hours (17:00 - 07:00) <sup>[3]</sup>	22 hours (PUE: 08:00-15:00; HH: 16:00 - 07:00)	+ 8 hours

**Notes:** [1] 24 hours on Sunday, Monday, and Friday; [2] 24 hours on Sunday and Saturday; [3] 24 hours on Sunday and Friday; [4] All MHPs switched off for removing silt and sediments at 07:00 - 08:00 and 15:00 - 16:00



**Figure 14 Tailor business**

*In Tandung, the production increased mostly because the provision of embroidery and lockstitch machine. Previously they need to travel to the closest town, Masamba, to have this service. Now they can do it in-house.*

In terms of financial performance, a “PUE tariff” was introduced at the project sites. The average tariff for households is EUR 1.2, while the PUE tariff varies. Businesses operating appliances with low electricity demand, such as tailor (sewing machine) and bread maker (mixer etc.) pay additional monthly fee of EUR 0.40 for each appliance, while workshops, blacksmiths and carpenters paid additional monthly flat fee of EUR 2.40 to EUR 4.00 per month for all equipment. This resulted in an increase in income for MHP operating team, with an overall increase in monthly profit of between 60% and 88% for the project period.

**Table 16 Income and expenses of MHP operation in Sulawesi**

Description	Sulawesi		
	Salumokanan	Tawalian Timur	Tandung
Income collected from households (EUR/month)	120	48	52
Income collected from PUE (EUR/month)	20	14	14
Expenses for salary (EUR/month)	80	21	32
Expenses for maintenance (EUR/month)	8	4	4
Number of customers	90	51	70
Monthly tariff per HH (EUR)	1.20 -1.60	1.20	1.20
Difference (%) between pre- and post-PUE in profit/loss for MHP	+63%	+60%	+88%

While this additional income is welcomed, feed-back from the operating team suggests that it is insufficient. Ideally the income from the PUE tariff should be able to cover two (2) operator salaries and the possible increase in maintenance costs. The latter cannot be satisfactorily determined during the short project period, but the MHP operators are concerned about this. MHP operators also have a higher workload now, with having to clean the MHP fore bay and trash rack twice daily.

Unfortunately, raising the electricity tariffs (for both households and businesses) is not so simple, since tariffs are decided upon by the community.

Another concern is the fact that household energy consumption will likely also rise, since electricity is now available throughout the day. Thus households will increasingly benefit from electricity access and add additional appliances to the load. Without installing kWh meters, consumption-based electricity tariff cannot be easily implemented.

## 5 Conclusions and Recommendation

1. Of the 25 different appliances procured under the pilot project, only the specialised ones (egg incubator and rice huller, ordered from a company in West Java) failed to satisfy expectations. Furthermore, the rice huller was the most expensive appliance. This supports the assumption that low to medium-cost appliances, procured off-the-shelf will have a higher chance of success. PUE support initiatives in general might fare better if they **avoid specialised appliances**.

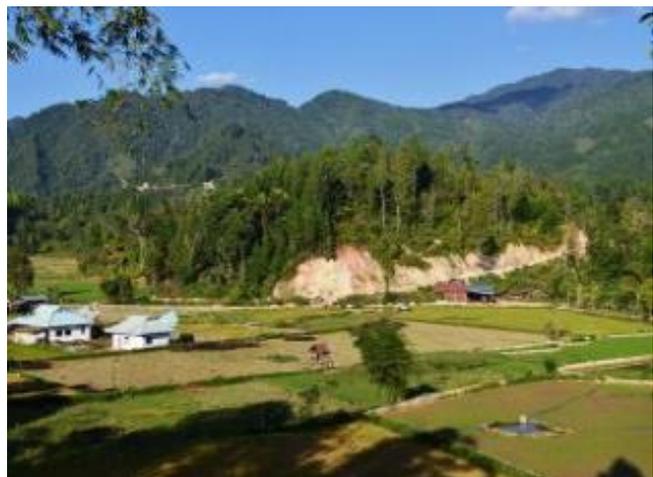


Figure 15 Tawalian Timur landscape, West Sulawesi

*MHPs for rural electrification in Indonesia are located in rugged terrain, often with poor accessibility. This makes sustainability efforts through local empowerment and economic development a vital strategy.*

2. The majority of **businesses reported a profit**, except where specialised appliances were used. However the extent of profitability depends greatly on the business acumen of the entrepreneur. Profitability also depended on the management structure of the business: “group-owned” business in Sulawesi performed better than “individual”-owned businesses in Sumatra. “Community”-owned businesses, which provided a perceived social service, performed the worst.

3. Given the fact that the participating project villages had access to between four (4) and 14 businesses (with average of 6 businesses per village), there is an indication that **several different economic activities** are present in many villages, and most of them have low electricity requirements. The businesses are thus generally very compatible with MHPs and can contribute towards additional MHP income, where a PUE tariff is charged. In Sulawesi, the average of 5 businesses, contributed more than 60% to total MHP income from electricity sales.



Figure 16 MHP powerhouse in Salumokanan, West Sulawesi

*While the increased operating times to accommodate PUE improves the overall economic performance of the MHP, it does require additional efforts from operators. Thus a portion of the PUE tariff should be earmarked for increasing operator income.*

4. Operating times of the MHP increased for sites that operated at only 16 hours per day, without a marked difference in **maintenance requirements**. The short duration of the project (6-months) is however not sufficient to make conclusions about the long-term maintenance implications for the MHP. There are indications though that the work load of operators has increased due to the prolonged operating times.

5. The extended operating hours significantly improve the overall cost-benefit ratio of MHPs, who now operate at an **availability factor** of over 90% per week (compared to a general capacity factor of about 60%<sup>4</sup>). While this results in an improved capacity factor, the actual implications could not be determined, since the sites did not have kWh meters installed. This should be considered for any PUE-related research.



**Figure 17 Carpenter in West Sulawesi**

*Carpentry is a popular business and electrical appliances simplify the manufacture and restoration of furniture and other wooden products. In the case of Sulawesi, the additional profitability through the appliances, imply that they can recover the initial expenditure in less than 6 months.*

6. PUE operating times extend the **household electricity access** without additional costs to the household. This bears a risk of overloading the MHP over time, as households add more appliances. Installing electrical network installation control (e.g. installing timers in households) could be considered as means to avoid increased household consumption during day time. Other options are by establishing automatic transfer switch (ATS) at turbine house or establishing “PUE Energy Centre Areas” (PUECA). The latter would cluster businesses together and provide them with their own dedicated power line from the MHP.

7. Prowater (Sumatra) is a turbine manufacturer based in Padang, Sumatra, with an interest in expanding the MHP market in its region. While Prowater has very well-established technical



**Figure 18 Logging and timber cutting in Sumatra**

*While not all rural productive activities can benefit from electricity, there are numerous economic activities that require energy, and many can be easily accommodated using off-the-shelf electrical appliances.*

expertise, it lacked experience in terms of scientific disciplines in socio-economic research. Between rigid scientific principles and a commercial interest in satisfying market needs, Prowater found itself in a dilemma. The focus on providing good client support and service, resulted in certain **compromises regarding the research elements** of the project. Thus Prowater was not as persuasive in establishing a PUE tariff or to gather a maximum of data for analysis. A similar initiative should either groom a NGO/company such as Prowater more rigorously or find a more suitable NGO.

<sup>4</sup> For 47 MHP sites surveyed in September 2012, the average operating times were 15 hours/day, expressed in Availability Factor of 62% (source: Survey on Key Performance Indicators for Indonesian Micro-hydro Power Sites - EnDev Indonesia - December 2012).

8. In Sumatra, the participating village businesses did not pay a **PUE tariff**. Such a tariff is determined by the MHP management committee, in consultation with the whole community, and ideally reflected in the MHP Village Regulation<sup>5</sup>. The inability to secure this significantly undermined the project's objective. For Sulawesi on the other hand, the income from electricity sales by the MHP increased by over 60%. Thus Sumatra has not ceased a golden opportunity to enhance the financial feasibility of the MHP.



Figure 19 Blacksmith in Salumokanan, West Sulawesi

*This business uses an electric air blower for stoking charcoal to heat metal and a small metal grinder to sharpen tools. Blacksmiths are common in agricultural villages in Indonesia.*

9. **Procurement for appliances** was cumbersome especially when a business changed their appliance specifications. GIZ procurement procedures require at least three quotations for appliances with identical specifications (or a justification why a direct procurement should be made). This proved at times difficult, where local hardware shops did not have a sufficiently large selection of appliances. Options to address this bureaucratic inconvenience may include establishing a revolving fund, through which a business can procure its appliance of choice on a credit basis.



Figure 20 Coffee grinding in Salumokanan, West Sulawesi

*Most of community sell dry coffee cherries without grinding at a price of about EUR 0.60/kg. One kilogram of coffee cherries yields about 0.7 kg of ground coffee. This ground coffee sells at about EUR 2/kg. An electric off-the-shelf coffee grinder costs about EUR 100, and has a production rate of about 36 kg/hour.*

10. **Catchment area management**, while not specifically addressed in the project, emerged as an important aspect of MHP performance. In general it is recommended that catchment area management sensitisation should be conducted for any rural MHP support initiative.

11. The merits of **experienced facilitation** on a regular basis were demonstrated by OWT (Sulawesi) during this project. Not only does OWT have a track record in community mobilisation, MHP technologies and catchment area management, but also undertakes PUE initiatives of their own. In essence this implies that a PUE initiatives, even with such a simple approach utilised in this project, benefits from knowledgeable and practically-oriented partners with grass-roots presence.

<sup>5</sup> Village Regulations describe the modality of electricity supply to households, tariffs, sanctions for non-payment and other aspects critical to administration and sustainable operation of the MHP

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