



**Appendix Figure 7.1-4 Comparison of Life Cycle Cost of SHS Versus PV Mini-grid (Break-even Consumption Level)**

### 7.1.5 Cost Comparison of SHS with Diesel Mini-grid Electrification

The life-cycle costs for the PV and diesel systems on a per customer basis are compared in Appendix Table 7.1-2, based on the data in the Pacific islands. The present values of the costs in constant dollars for 15 years, discounted at 10 percent per year, are compared for both cases.

The results show that in the household lights only case (55Wp - 1 set) and in the household lights and TV/VCR case (47Wp - 4 set), the PV system shows cost competitiveness on the life-cycle costs basis.

Another important consideration is the fact that proper maintenance for the diesel system is difficult. In fact, it is almost impossible to ensure stable operation of the diesel systems in a small remote village in Botswana.

**Appendix Table 7.1-2 Life-cycle Costs in Dollars per Customer of The PV and Diesel Systems**

Case	The PV	Diesel
<b>Household Lights Only <sup>a</sup> (55Wp - 1 set)</b>		
Customer: initial appliance costs	132	51
Customer: future appliance costs	133	21
Generation equipment: initial costs <sup>b</sup>	741	750
Generation equipment: future costs <sup>c</sup>	243	189
O&M costs <sup>d</sup>	137	593
<b>Total</b>	<b>1,386</b>	<b>1,604</b>
<b>Household Lights &amp; TV/VCR <sup>b</sup> (47Wp - 4 set)</b>		
Customer: initial appliance costs	732	551
Customer: future appliance costs	476	307
Generation equipment: initial costs <sup>b</sup>	2,216	1,719
Generation equipment: future costs <sup>c</sup>	454	432
O&M costs <sup>d</sup>	137	1,255
<b>Total</b>	<b>4,015</b>	<b>4,264</b>

(Source: World Bank Technical Paper Number 244 Lessons from the Pacific Island Experience, A. Liebenthal et al.)

Note: The present value of costs in constant dollars for 15 years discounted at 10 percent

- a The diesel system will be operated for six hours a day.
- b For the PV system: costs of PV panels, batteries, etc;  
For the diesel system: costs of power generation, distribution and reticulation equipment.
- c For the PV system: replacement costs of batteries and controllers;  
For the diesel system: equipment is assumed to last 15 years, with a major overhaul every five years.
- d For the PV system: cost of maintenance provided by solar ESCO;  
For the diesel system: variable generation (energy) costs.

Appendix Table 7.1-2-1 Comparison of Grid Electrification and SHS

	Variables	Units	Unit cost	Units	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	residual value	Sum of NPV at 0 year		
1-a SHS Electrification	Households(H)	50																										
	Capacity	100		Wp																								
	Annual consumption	0.365	7300	kWp/ly		7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300		45,247		
	Distance from Grid	20		km																								
	Investment costs (A)		96.3	P/Wp	481,500																						418,696	
	Battery replace		500	P								50,000															50,000	182,959
	Operation & maintenance: village		500	P/Village/m		6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000		37,189	
	Agent fee		0.05	%		2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400		14,876	
	:Head office	276		P/Hly		13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800		85,536	
	Total																										739,259	
Cost of electricity																										16.3		
1-b Grid Electrification	Households	50																										
	Annual consumption		7300	kWp/ly		7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300		45,247		
	Distance from Grid	20																										
	Investment costs (A)		102816		2,056,320																						(411,264)	
	Connection costs		4500		223,000																						(45,000)	
	Operation & maintenance	0.02				41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126		254,911	
	Power generation or import cost		0.075	P/kWh		548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548		3,394	
	Total																										1,897,060	
	Cost of electricity																										41.9	
	2-a SHS Electrification	Households	100																									
Capacity		100																										
Annual consumption		0.365	14600	kWp/ly		14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600		90,494		
Distance from Grid		20		km																								
Investment costs (A)			96.3	P/Wp	963,000																						837,391	
Battery replace			500	P								100,000															100,000	365,917
Operation & maintenance: village			500	P/Village/m		6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000		37,189	
Agent fee			0.05	%		4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800		29,752	
:Head office		276		P/Hly		27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600		171,071	
Total																											1,441,320	
Cost of electricity																										15.9		
2-b Grid Electrification	Households	100																										
	Annual consumption		14600	kWp/ly		14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600		90,494		
	Distance from Grid	20																										
	Investment costs (A)		102816		2,056,320																						(411,264)	
	Connection costs		4500		450,000																						(90,000)	
	Operation & maintenance	0.02				41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126		254,911	
	Power generation or import cost		0.075	P/kWh		1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095		6,787	
	Total																										2,062,079	
	Cost of electricity																										22.8	

Appendix Table 7.1-2-2 Comparison of Grid Electrification and SHS

		Variables	Units	Unit cost	Units	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	residual value	Sum of NPV at 0 year	
1-a	SHS Electrification	Households(H)			200																							
		Capacity				100																						
		Annual consumption		Wp		0.365																						
		Distance from Grid		km		20																						
		Investment costs (A)			96.3	1,926,000																						1,674,783
		Battery replace			500																							(66,667)
		Operation & maintenance: village			500																							731,834
		Agent fee			0.05																							37,189
		:Head office			276																							59,503
		Total																										
Cost of electricity																											2,843,451	
1-b	Grid Electrification	Household																										
		Annual consumption			29200																							180,988
		Distance from Grid																										(1 = 0.15)
		Investment costs (A)			102816																							(411,264)
		Connection costs			4500																							(180,000)
		Operation & maintenance		0.02																								0
		Power generation or import cost			0.075																							254,911
		Total																										13,574
		Cost of electricity																										2,392,118
		2-a	SHS Electrification	Households																								
Capacity						300																						
Annual consumption					43800																							271,483
Distance from Grid				km																								(1 = 0.15)
Investment costs (A)					96.3	2,889,000																						2,512,174
Battery replace					500																							(100,000)
Operation & maintenance: village					500																							1,097,751
Agent fee					0.05																							37,189
:Head office					276																							89,255
Total																												513,214
Cost of electricity																										4,249,582		
2-b	Grid Electrification	Households																										
		Annual consumption			43800																							271,483
		Distance from Grid																										(1 = 0.15)
		Investment costs (A)			102816																							(411,264)
		Connection costs			4500																							(270,000)
		Operation & maintenance		0.02																								254,911
		Power generation or import cost			0.075																							20,361
		Total																										2,722,156
		Cost of electricity																										10.0

Appendix Table 7.1-2-3 Comparison of Grid Electrification and SHS

	Variables	Units	Unit cost	Units	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	residual value	Sum of NPV at 0 year
1-a	SHS Electrification																									
	Households(H)	400																								
	Capacity	100		Wp																						
	Annual consumption	0.365	58400	kWp/ly		58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	361,977
	Distance from Grid	20		km																						
	Investment costs (A)		96.3	P/Wp	3,852,000																					
	Battery replace		500	P			400,000																400,000			
	Operation & maintenance: village		500	P/Village/m		6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	37,189
	Agent fee		0.05	%		19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	119,006
	:Head office	276	276	P/H/y	110,400	110,400	110,400	110,400	110,400	110,400	110,400	110,400	110,400	110,400	110,400	110,400	110,400	110,400	110,400	110,400	110,400	110,400	110,400	110,400	110,400	684,285
	Total																									5,653,714
	Cost of electricity			P/kWh																						15.6
1-b	Grid Electrification																									
	Households	400																								
	Annual consumption		58400	kWp/ly		58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	361,977
	Distance from Grid	20																								
	Investment costs (A)		102816		2,056,320																					
	Connection costs		4500		1,800,000																					
	Operation & maintenance	0.02				41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	254,911
	Power generation or import cost		0.075	P/kWh		4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	27,148
	Total																									3,052,195
	Cost of electricity			P/kWh																						8.4
2-a	SHS Electrification																									
	Households	500																								
	Capacity	100																								
	Annual consumption	0.365	73000	kWp/ly		73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	452,471
	Distance from Grid	20		km																						
	Investment costs (A)		96.3	P/Wp	4,815,000																					
	Battery replace		500	P			500,000																			
	Operation & maintenance: village		500	P/Village/m		6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	37,189
	Agent fee		0.05	%		24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	148,758
	:Head office	276	276	P/H/y	138,000	138,000	138,000	138,000	138,000	138,000	138,000	138,000	138,000	138,000	138,000	138,000	138,000	138,000	138,000	138,000	138,000	138,000	138,000	138,000	138,000	855,356
	Total																									7,057,845
	Cost of electricity			P/kWh																						15.6
2-b	Grid Electrification																									
	Households	500																								
	Annual consumption		73000	kWp/ly		73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	452,471
	Distance from Grid	20																								
	Investment costs (A)		102816		2,056,320																					
	Connection costs		4500		2,250,000																					
	Operation & maintenance	0.02				41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	41,126	254,911
	Power generation or import cost		0.075	P/kWh		5,475	5,475	5,475	5,475	5,475	5,475	5,475	5,475	5,475	5,475	5,475	5,475	5,475	5,475	5,475	5,475	5,475	5,475	5,475	5,475	33,935
	Total																									3,382,333
	Cost of electricity			P/kWh																						7.5

Appendix Table 7.1-3-1 Comparison of Grid Electrification and SHS

	Variables	Units	Unit cost	Units	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	residual value	Sum of NPV at 0 year	
1-a	SHS Electrification																										
	Households(H)	50																									
	Capacity	100		Wp																							
	Annual consumption	0.365	7300	kWp/ly	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300		45,247	
	Distance from Grid	6.6		km																							(t = 0.15)
	Investment costs (A)		96.3	P/Wp	481,500																						418,696
	Battery replace		500	P				50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000			182,959
	Operation & maintenance: village		500	P/Village/m		6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000		37,189
	Agent fee		0.05	%		2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400		14,876
	:Head office	276	276	P/H/y		13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800		85,536
	Total																										739,255
	Cost of electricity																										16.3
1-b	Grid Electrification																										
	Households	50																									
	Annual consumption		7300	kWp/ly	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300		45,247
	Distance from Grid	6.6																									
	Investment costs (A)		102816			678,586																					
	Connection costs		4500			225,000																					
	Operation & maintenance					13,572	13,572	13,572	13,572	13,572	13,572	13,572	13,572	13,572	13,572	13,572	13,572	13,572	13,572	13,572	13,572	13,572	13,572	13,572	13,572		84,121
	Power generation or import cost		0.075	P/kWh		548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548	548		3,394
	Total																										736,593
	Cost of electricity																										16.3
2-a	SHS Electrification																										
	Households(H)	100																									
	Capacity	100		Wp																							
	Annual consumption	0.365	14600	kWp/ly	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600		90,494
	Distance from Grid	12.8		km																							
	Investment costs (A)		96.3	P/Wp	963,000																						
	Battery replace		500	P				100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000		365,917
	Operation & maintenance: village		500	P/Village/m		6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000		37,189
	Agent fee		0.05	%		4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800		29,752
	:Head office	276	276	P/H/y		27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600		171,071
	Total																										1,441,320
	Cost of electricity																										15.9
2-b	Grid Electrification																										
	Households	100																									
	Annual consumption		14600	kWp/ly	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600		90,494
	Distance from Grid	12.8																									
	Investment costs (A)		102816																								
	Connection costs		4500																								
	Operation & maintenance					26,321	26,321	26,321	26,321	26,321	26,321	26,321	26,321	26,321	26,321	26,321	26,321	26,321	26,321	26,321	26,321	26,321	26,321	26,321	26,321		163,143
	Power generation or import cost		0.075	P/kWh		1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095		6,787
	Total																										1,438,544
	Cost of electricity																										15.9

Appendix Table 7.1-3-2 Comparison of Grid Electrification and SHS

	Variables	Units	Unit cost	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	residual value	Sum of NPV at 0 year	
<b>3-a SHS Electrification</b>																										
	Households(H)	200																								
	Capacity	100																								
	Annual consumption	0.365	29200		29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200		180,988	
	Distance from Grid	25.1																							(1 = 0.15)	
	Investment costs (A)		96.3	1,926,000																					1,674,783	
	Battery replace		500				200,000		200,000																731,854	
	Operation & maintenance: village		500	P/Village/m	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000		37,189
	Agent fee		0.05	%	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600		59,503
	:Head office	276			55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200		342,142
	Total																								2,845,451	
	Cost of electricity																								15.7	
<b>3-b Grid Electrification</b>																										
	Households	200																								
	Annual consumption		29200		29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200		180,988
	Distance from Grid	25.1																								(1 = 0.15)
	Investment costs (A)		102816	2,580,682																					(516,136)	
	Connection costs		4500	900,000																					(180,000)	
	Operation & maintenance	0.02			51,614	51,614	51,614	51,614	51,614	51,614	51,614	51,614	51,614	51,614	51,614	51,614	51,614	51,614	51,614	51,614	51,614	51,614	51,614	51,614		319,913
	Power generation or import cost		0.075		2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190		13,574
	Total																								2,833,788	
	Cost of electricity																								15.7	
<b>4-a SHS Electrification</b>																										
	Households(H)	300																								
	Capacity	100																								
	Annual consumption	0.365	43800		43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800		271,483
	Distance from Grid	37.7																								(1 = 0.15)
	Investment costs (A)		96.3	2,889,000																					2,512,174	
	Battery replace		500				300,000		300,000																1,097,751	
	Operation & maintenance: village		500	P/Village/m	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000		37,189
	Agent fee		0.05	%	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400		89,255
	:Head office	276			82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800		513,214
	Total																								4,249,582	
	Cost of electricity																								15.7	
<b>4-b Grid Electrification</b>																										
	Households	300																								
	Annual consumption		43800		43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800		271,483
	Distance from Grid	37.7																								(1 = 0.15)
	Investment costs (A)		102816	3,876,163																					(775,233)	
	Connection costs		4500	1,350,000																					(270,000)	
	Operation & maintenance	0.02			77,523	77,523	77,523	77,523	77,523	77,523	77,523	77,523	77,523	77,523	77,523	77,523	77,523	77,523	77,523	77,523	77,523	77,523	77,523	77,523		480,507
	Power generation or import cost		0.075		3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285		20,561
	Total																								4,255,012	
	Cost of electricity																								15.7	

Appendix Table 7.1-3-3 Comparison of Grid Electrification and SHS

	Variables	Units	Unit cost	Units	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	residual value	Sum of NPV at 0 year	
1-a	SHS Electrification																										
	Households(H)	50																									
	Capacity	200		Wp																							
	Annual consumption	0.365	14600	kWp/ly		14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	90,494	
	Distance from Grid	13.7		km																							(i=0.15)
	Investment costs (A)		96.3	P/Wp		963,000																				837,391	
	Battery replace		500	P			100,000																			100,000	
	Operation & maintenance: village		500	P/village/m		6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	37,189
	Agent fee		0.05	%		4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	29,752
	:Head office	276	276	P/H/y		13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	85,536
	Total																									1,355,785	
	Cost of electricity			P/kWh																						15.0	
1-b	Grid Electrification																										
	Households	50																									
	Annual consumption		14600	kWp/ly		14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	14,600	90,494	
	Distance from Grid	13.7																									(i=0.15)
	Investment costs (A)		102816			1,408,579																				1,011,834	
	Connection costs		4500			225,000																				(45,000)	
	Operation & maintenance	0.02				28,172	28,172	28,172	28,172	28,172	28,172	28,172	28,172	28,172	28,172	28,172	28,172	28,172	28,172	28,172	28,172	28,172	28,172	28,172	28,172	174,614	
	Power generation or import cost		0.075	P/kWh		1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	6,787	
	Total																									1,354,861	
	Cost of electricity			P/kWh																						15.0	
2-a	SHS Electrification																										
	Households(H)	100																									
	Capacity	200		Wp																							
	Annual consumption	0.365	29200	kWp/ly		29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	180,988	
	Distance from Grid	27		km																							(i=0.15)
	Investment costs (A)		96.3	P/Wp		1,926,000																				1,674,783	
	Battery replace		500	P			200,000																			200,000	
	Operation & maintenance: village		500	P/village/m		6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	37,189
	Agent fee		0.05	%		9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	59,503
	:Head office	276	276	P/H/y		27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	171,071
	Total																									2,674,380	
	Cost of electricity			P/kWh																						14.8	
2-b	Grid Electrification																										
	Households	100																									
	Annual consumption		29200	kWp/ly		29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	180,988	
	Distance from Grid	27																									(i=0.15)
	Investment costs (A)		102816			2,776,032																				(555,206)	
	Connection costs		4500			450,000																				(90,000)	
	Operation & maintenance	0.02				55,521	55,521	55,521	55,521	55,521	55,521	55,521	55,521	55,521	55,521	55,521	55,521	55,521	55,521	55,521	55,521	55,521	55,521	55,521	55,521	344,130	
	Power generation or import cost		0.075	P/kWh		2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	13,574	
	Total																									2,675,080	
	Cost of electricity			P/kWh																						14.8	



Appendix Table 7.1-3-4 Comparison of Grid Electrification and SHS

	Variables	Units	Unit cost	Units	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	residual value	Sum of NPV at 0 year		
3-a SHS Electrification	Households(H)	200																										
	Capacity	200		Wp																								
	Annual consumption	0.365	58400	kWh/yr	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	361,977	
	Distance from Grid	53.5		km																							(i = 0.15)	
	Investment costs (A)		96.3	P/Wp	3,852,000																						3,349,565	
	Battery replace		500	P				400,000													400,000						1,463,668	
	Operation & maintenance: village		500	P/Village/m		6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	37,189	
	Agent fee		0.05	%		19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	119,006	
	:Head office	276	276	P/Hy		55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	342,142	
	Total																											5,311,571
	Cost of electricity																											14.7
3-b Grid Electrification	Households	200																										
	Annual consumption		58400	kWh/yr	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	361,977	
	Distance from Grid	53.5																									(i = 0.15)	
	Investment costs (A)		102816		5,500,656																						3,951,322	
	Connection costs		4500		900,000																							646,503
	Operation & maintenance	0.02				110,013	110,013	110,013	110,013	110,013	110,013	110,013	110,013	110,013	110,013	110,013	110,013	110,013	110,013	110,013	110,013	110,013	110,013	110,013	110,013	110,013	681,887	
	Power generation or import cost		0.075	P/kWh		4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	27,148	
	Total																											5,506,860
	Cost of electricity																											14.7
	4-a SHS Electrification	Households(H)	300																									
		Capacity	200		Wp																							
Annual consumption		0.365	87600	kWh/yr	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	542,965	
Distance from Grid		80		km																							(i = 0.15)	
Investment costs (A)			96.3	P/Wp	5,778,000																						5,024,348	
Battery replace			500	P				600,000													600,000						2,195,502	
Operation & maintenance: village			500	P/Village/m		6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	37,189	
Agent fee			0.05	%		28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	178,509	
:Head office		276	276	P/Hy		82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	513,214	
Total																												7,948,762
Cost of electricity																												14.6
4-b Grid Electrification	Households	300																										
	Annual consumption		87600	kWh/yr	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	542,965	
	Distance from Grid	80																									(i = 0.15)	
	Investment costs (A)		102816		8,225,280																						5,908,519	
	Connection costs		4500		1,350,000																							969,754
	Operation & maintenance	0.02				164,506	164,506	164,506	164,506	164,506	164,506	164,506	164,506	164,506	164,506	164,506	164,506	164,506	164,506	164,506	164,506	164,506	164,506	164,506	164,506	164,506	1,019,644	
	Power generation or import cost		0.075	P/kWh		6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	40,722	
	Total																											7,938,639
	Cost of electricity																											14.6

Appendix Table 7.1-3-5 Comparison of Grid Electrification and SHS

	Variables	Units	Unit cost	Units	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	residual value	Sum of NPV at 0 year			
5-a SHS Electrification	Households(H)	50																											
	Capacity	400		Wp																									
	Annual consumption	0.365	29200	kWp/ly		29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	180,988		
	Distance from Grid	27.8		km																							(i = 0.15)		
	Investment costs (A)		96.3	P/Wp	1,926,000																						1,674,783		
	Battery replace		500	P			200,000											200,000						200,000				731,834	
	Operation & maintenance: village Agent fee		500	P/Village/m		6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000		37,189	
	Agent fee		0.05	%		9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600		59,503	
	:Head office	276	276	P/H/y		13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800		85,536	
	Total																											2,588,845	
Cost of electricity																											14.3		
5-b Grid Electrification	Households	50																											
	Annual consumption		29200	kWp/ly		29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200		180,988	
	Distance from Grid	27.8																										(i = 0.15)	
	Investment costs (A)		102816		2,855,285																							2,053,210	
	Connection costs		4500		225,000																								161,626
	Operation & maintenance	0.02	0.075	P/kWh		57,166	57,166	57,166	57,166	57,166	57,166	57,166	57,166	57,166	57,166	57,166	57,166	57,166	57,166	57,166	57,166	57,166	57,166	57,166	57,166	57,166		354,326	
	Power generation or import cost					2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190		13,574	
	Total																											2,582,736	
	Cost of electricity																											14.3	
	6-a SHS Electrification	Households(H)	100																										
Capacity		400		Wp																									
Annual consumption		0.365	58400	kWp/ly		58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400		361,977	
Distance from Grid		55.3		km																								(i = 0.15)	
Investment costs (A)			96.3	P/Wp	3,852,000																							3,349,585	
Battery replace			500	P			400,000											400,000						400,000				1,463,668	
Operation & maintenance: village Agent fee			500	P/Village/m		6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000		37,189	
Agent fee			0.05	%		19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200	19,200		119,006	
:Head office		276	276	P/H/y		27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600		171,071	
Total																												5,140,500	
Cost of electricity																											14.2		
6-b Grid Electrification	Households	100																											
	Annual consumption		58400	kWp/ly		58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400	58,400		361,977	
	Distance from Grid	55.3																										(i = 0.15)	
	Investment costs (A)		102816		5,685,725																							4,084,264	
	Connection costs		4500		450,000																								323,251
	Operation & maintenance	0.02	0.075	P/kWh		113,714	113,714	113,714	113,714	113,714	113,714	113,714	113,714	113,714	113,714	113,714	113,714	113,714	113,714	113,714	113,714	113,714	113,714	113,714	113,714	113,714		704,829	
	Power generation or import cost					4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380	4,380		27,148	
	Total																											5,139,492	
	Cost of electricity																											14.2	

Appendix Table 7.1-3-6 Comparison of Grid Electrification and SHS

	Variables	Units	Unit cost	Units	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	residual value	Sum of NPV at 0 year		
7-a SHS Electrification	Households(H)	200																										
	Capacity	400		Wp																								
	Annual consumption	0.365	116800	kWp/ly		116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800	723,953	
	Distance from Grid	110		km																							(I = 0.15)	
	Investment costs (A)		96.3	P/Wp	7,704,000																						6,699,130	
	Battery replace		500	P			800,000					800,000																2,927,336
	Operation & maintenance: village		500	P/Village/m		6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000		37,189
	Agent fee		0.05	%		38,400	38,400	38,400	38,400	38,400	38,400	38,400	38,400	38,400	38,400	38,400	38,400	38,400	38,400	38,400	38,400	38,400	38,400	38,400	38,400	38,400		238,012
	:Head office	276		P/H/y		55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200		342,142
	Total																											10,243,811
Cost of electricity				P/kWh																							14.1	
7-b Grid Electrification	Households	200																										
	Annual consumption		116800	kWp/ly		116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800	116,800		723,953	
	Distance from Grid	110																									(I = 0.15)	
	Investment costs (A)		102816		11,309,760																						8,124,213	
	Connection costs		4500		900,000																							(180,000)
	Operation & maintenance	0.02				226,195	226,195	226,195	226,195	226,195	226,195	226,195	226,195	226,195	226,195	226,195	226,195	226,195	226,195	226,195	226,195	226,195	226,195	226,195	226,195		1,402,010	
	Power generation or import cost		0.075	P/kWh		8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760		54,297	
	Total																											10,227,023
	Cost of electricity				P/kWh																							14.1
	8-a SHS Electrification	Households(H)	300																									
Capacity		400		Wp																								
Annual consumption		0.365	175200	kWp/ly		175,200	175,200	175,200	175,200	175,200	175,200	175,200	175,200	175,200	175,200	175,200	175,200	175,200	175,200	175,200	175,200	175,200	175,200	175,200	175,200		1,085,930	
Distance from Grid		165		km																							(I = 0.15)	
Investment costs (A)			96.3	P/Wp	11,556,000																						10,048,696	
Battery replace			500	P			#####																				4,391,004	
Operation & maintenance: village			500	P/Village/m		6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000		37,189	
Agent fee			0.05	%		57,600	57,600	57,600	57,600	57,600	57,600	57,600	57,600	57,600	57,600	57,600	57,600	57,600	57,600	57,600	57,600	57,600	57,600	57,600	57,600		357,018	
:Head office		276		P/H/y		82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800	82,800		513,214
Total																												15,347,121
Cost of electricity				P/kWh																							14.1	
8-b Grid Electrification	Households	300																										
	Annual consumption		175200	kWp/ly		175,200	175,200	175,200	175,200	175,200	175,200	175,200	175,200	175,200	175,200	175,200	175,200	175,200	175,200	175,200	175,200	175,200	175,200	175,200	175,200		1,085,930	
	Distance from Grid	165																									(I = 0.15)	
	Investment costs (A)		102816		16,964,640																						12,186,320	
	Connection costs		4500		1,350,000																							(270,000)
	Operation & maintenance	0.02				339,293	339,293	339,293	339,293	339,293	339,293	339,293	339,293	339,293	339,293	339,293	339,293	339,293	339,293	339,293	339,293	339,293	339,293	339,293	339,293		2,103,015	
	Power generation or import cost		0.075	P/kWh		13,140	13,140	13,140	13,140	13,140	13,140	13,140	13,140	13,140	13,140	13,140	13,140	13,140	13,140	13,140	13,140	13,140	13,140	13,140	13,140		81,445	
	Total																											15,340,534
	Cost of electricity				P/kWh																							14.1

Appendix Table 7.1-3-7 Comparison of Grid Electrification and SHS

	Variables	Units	Unit cost	Units	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	residual value	Sum of NPV at 0 year
9-a	SHS Electrification																									
	Households(H)	50																								
	Capacity	600		Wp																						
	Annual consumption	0.365	43800	kWp/ly		43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	271,483
	Distance from Grid	42		km																						(i = 0.15)
	Investment costs (A)		96.3	P/Wp	2,889,000																					2,512,174
	Battery replace		500	P			300,000																			1,097,751
	Operation & maintenance: village		500	P/Village/m		6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	37,189
	Agent fee		0.05	%		14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	89,255
	:Head office	276	276	P/Hly		13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	85,536
	Total																									3,821,905
	Cost of electricity																									14.1
9-b	Grid Electrification																									
	Households	50																								
	Annual consumption		43800	kWp/ly		43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	43,800	271,483
	Distance from Grid	42																								(i = 0.15)
	Investment costs (A)		102816		4,318,272																					3,101,972
	Connection costs		4500		225,000																					(45,000)
	Operation & maintenance	0.02				86,365	86,365	86,365	86,365	86,365	86,365	86,365	86,365	86,365	86,365	86,365	86,365	86,365	86,365	86,365	86,365	86,365	86,365	86,365	86,365	535,313
	Power generation or import cost		0.075	P/RWh		3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	20,361
	Total																									3,819,272
	Cost of electricity																									14.1
10-a	SHS Electrification																									
	Households(H)	100																								
	Capacity	600		Wp																						
	Annual consumption	0.365	87600	kWp/ly		87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	542,965
	Distance from Grid	83.6		km																						(i = 0.15)
	Investment costs (A)		96.3	P/Wp	5,778,000																					5,024,348
	Battery replace		500	P			600,000																			2,195,502
	Operation & maintenance: village		500	P/Village/m		6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	37,189
	Agent fee		0.05	%		28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	28,800	178,509
	:Head office	276	276	P/Hly		27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	27,600	171,071
	Total																									7,606,620
	Cost of electricity																									14.0
10-b	Grid Electrification																									
	Households	100																								
	Annual consumption		87600	kWp/ly		87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	87,600	542,965
	Distance from Grid	83.6																								(i = 0.15)
	Investment costs (A)		102816		8,595,418																					6,174,402
	Connection costs		4500		450,000																					(90,000)
	Operation & maintenance	0.02				171,908	171,908	171,908	171,908	171,908	171,908	171,908	171,908	171,908	171,908	171,908	171,908	171,908	171,908	171,908	171,908	171,908	171,908	171,908	171,908	1,065,528
	Power generation or import cost		0.075	P/RWh		6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	6,570	40,722
	Total																									7,603,904
	Cost of electricity																									14.0