Artificial Intelligence formulated this projection for compatibility purposes from the original article published at Global Journals. However, this technology is currently in beta. *Therefore, kindly ignore odd layouts, missed formulae, text, tables, or figures.*

An Innovative Zero-Emission Energy Model for a Coastal Village in Southern Myanmar Prof. Aung Ze Ya¹ and Prof. Aung Ze Ya² ¹ Yangon Technological University

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7 Abstract

5

Myanmar boosts the Renewables harvesting with On-Grid and Off-Grid options to implement 8 2030 Agenda. Reversing the degradation of the Coastal Eco-System is also the prioritized 9 Agenda. The research and deployment of Photovoltaic (PV), Wind, and Hybrid Mini-Grids 10 are at the initial state. This work imagined for supporting these. Thus, a village Lel Hpet, 11 located in Palaw Township, Tanintharyi Region chose due to its blessings of PV and Wind 12 resources. The villagers currently use the Diesel Generators for the industrial loads and the 13 fuelwood for the cooking. These cause the negative impacts. Hence, Zero-Emission Energy 14 Model analyzed. The total demand separated into Primary Load and Deferrable Load. The 15 simulation innovated with four Models on the excellent platform for Energy Planning, 16 HOMER (Hybrid Optimization of Multiple Energy Resources) Pro (version 3.11.4). Then, the 17 Best Model is selected. Its simulative results proved Wind is more feasible than PV on the 18 Tanintharyi Coast, PV and Wind can compensate each other during their less generation 19 months, and the larger Off-Grid Mini-gird is more cost-effective. The savings of the Diesel fuel 20 usage and its costs, and the reduction of GHG (greenhouse gas) Emissions predicted. The 21 proposed Climate-friendly, standalone PV-Wind-Battery Hybrid Mini-Grid can improves the 22

 $_{\rm 23}$ $\,$ Green penetration in Southern Myanmar.

24

Index terms— southern Myanmar, Tanintharyi coast, village lel hpet, HOMER Pro, zero-emission energy model, simulation, standalone PV-wind-battery hybrid mini-grid.

27 1 INTRODUCTION

yanmar, 40 th largest nation in the world, geographically located between 9° 32' and 28° 31' N latitude; and 92°
10' and 101° 11' E. It situated as the strategic link of South Asia and South East Asia. It covers a land area of
over 676,577 square kilometers and stretches over 2280 kilometers ??3].

³¹ 2 a) Myanmar's Three Coasts

Myanmar is very susceptible to extreme weather risks, landslides, sea-level rise related to air-current, and predicted future climate change. Coastal erosion and flooding are further risks which are predicted to grow. Tropical storms, occasional cyclones suffer regularly. The coastline is nearly 3000 km, extending about 1900 km from 10° to 21° North of the Equator, and 93° to 97° East of Greenwich [4].

Author: PhD, Post Doc, Honorary Professor and Honorary Doctor of Science, Professor of Department of Electrical Power Engineering, and Director of Department of Maintenance Engineering, Yangon Technological University (YTU), Myanmar. e-mails: profazyytumm10@gmail.com, dr.aungzeya010@gmail.com Unsustainable development can exacerbate the rural poverty in the coastal areas, and cause to leave the native villagers and

40 weaken the majority of the population. Consequently, the rural population is behind the urban populations grow

8 F) INPUTS OF MAIN COMPONENTS

41 and prosper. Rural poverty remains the problem, and in the context of rising sea levels, and increasingly unstable

42 weather. Coastal resilience is an issue of ever growing importance [4].

⁴³ 3 b) Standalone Mini-Grids in Myanmar

National Electrification Planning (NEP) of Myanmar Agenda 2030 aimed to electrify 7.2 million households, and achieve universal access to electricity by 2030. In the long term, the least cost extension of the National Grid System (NGS) included. For preelectrification, the standalone Mini-Grids and Solar Home Systems (SHS) are the options for the rural areas far from that National Grid will take many years to reach [13]. The criteria to implement the standalone Mini-Grid are the village can't electrify by the NGS in the next five to ten years, its location is at least 10 kilometers from the NGS, the sufficient demand for Mini-Grid scale, and the number of households should be 150 to 200 with the concentrated group. Large villages with high demands are preferable

as a high possibility of the stronger revenue streams to achieve Sustainable Mini-Grids [9].

$_{52}$ 4 c) Motivation

53 The motivation of this work is to energize the village with the Innovative Hybrid System to conserve the Coastal 54 Eco-System. Also, it targeted to promote the Rural Electrification rate by improving the Green Growth.

55 5 d) e) Identification of the Problems

The inhabitants are commonly using the small Diesel Generators for the water pumping and the industrial loads. 56 All the houses apply the Compact Fluorescent Lamps (CFL) for the lightings and the fuelwood for the cookings. 57 The hierarchical methodology is comprehensive process that involved the seven steps depicted as the pyramid in 58 Fig. 2. The site survey is the fountain and essential work to know the real ground situation. The problems of the 59 existing Energy access identified. Then, the appropriate Energies selected due to the potentials of the site and 60 the priorities of the country. As the third step, the relevant technology and components chose. The load profiles 61 predicted. The input parameters To solve above problems, the Standalone PVWind-Battery Hybrid Mini-Grid 62 modeled in HOMER Pro. 63

64 6 Global

⁶⁵ 7 b) Selection and Inputs of the Resources

Due to the geographical location, Myanmar has a rich Solar potential, and 60% of the land area appears suitable 66 for PV deployments [10]. Fig. 4 [11] illustrates GHI (Global Horizon Irradiation) of Myanmar. From it, it is 67 clear that the project location has the potential of Solar PV Energy. There are a few months (June, July, and 68 August), which cannot favor for the PV generation. Hence, PV Energy is firstly selected to harvest. The strong 69 70 winds can damage not only PV modules but also the construction components. However, the positive impacts 71 can cause the low and medium speed winds. These winds create the cooling effects on PV modules and increase 72 the power generation [11]. Hence, the Wind potential showed in Fig. 6 is not high, but, it can be beneficial for PV system. In June, July, and August, Wind has the high potentials. Thus, Wind System can compensate the 73 less generation of PV System in these months. This point is the advantage of PV-Wind Hybrid System. The 74 Eco-friendly and the Energy Efficient loads are considered. To apply the effective simulation features of HOMER 75 Pro, the total demand divided into two main types, Primary Load (PL) and Deferrable Load (DL) as depicted 76 in Fig. 7. PL is sub-divided into two types. PL1 (small) includes the LED lamps, flat TVs, and other small 77 loads. PL2 (large) consists of the kitchen loads (the ricecookers, the cooking pots), the cooling loads (the fans, 78 the air-coolers, and the water-coolers) and the small industrial loads listed in Table 1. DL composed of two 79 categories. DL1 (small) contains the mobile chargers, the power banks, and the rechargeable LEDs. DL2 (large) 80 involves the fifteen 1.5 kW water pumping loads. Based on the collected data from a site visit in January 2018, 81 the load profiles predicted for a one Pagoda, a one Monastery, 250 households (HH), and the school, the street 82 lightings, the water pumping loads, and the small industrial loads. The households (HH) are classified as the 83 three groups depending on the demands. The low and high demand groups have 25 and 50 households. The 84 medium demand group has 175 households. All demands (PL1, PL2 and DL) connected in the M3 and M4. PL1 85 is 108.6 kWh per day and 37.34 kW peak. PL2 is 336.14 kWh per day and 59.28 kW peak. Deferrable Load is 43 86 kWh per day and 28.75 kW peak. 87 Globally, the largest amount of GHG is significantly emitted from the fossil fuels utilizations for Electricity 88

Generations [23]. Hence, the notable point is Diesel Mini-Grid (M4) modeled with the same demands as M3 to determine the specific amount of GHG Emissions, also, the fuel usage and the fuel cost from it.

⁹¹ 8 f) Inputs of Main Components

⁹² The parameters of the main components of the standalone PV Mini-grid modeled in HOMER Pro.

93 9 RESULTS AND DISCUSSIONS

The thousands of Techno-Economic designs simulated for the four Models in HOMER Pro. Then, the optimum 94 designs calculated with the Tabular results of two: the upper portion is the Sensitivity Cases and the lower portion 95 is the Optimization Results as reflected in Figs. 19 to 22. The displayed results are listed for the models from 96 the top to bottom of the optimistic to the least cost-effective options [24]. M1 to M3 connected with the different 97 demands. Hence, the different capacities of the Architecture, the costs, system and other respective results 98 predicted. The outcomes of M4 (the same demands as M3 with the different type of generation) reflected its 99 consequent negative impacts. The main results of four models mentioned in Table 4. M3 can supply all demands 100 with the lowest cost of energy (COE) among three Models of PV-Wind-Battery Hybrid. Also, it observed that 101 COE of M3 and M4 are not much differed. Fig. 23 mentioned the evident Emissions, the six pollutants from M4. 102 There are no Diesel fuel consumptions, Diesel fuel costs, and no impacts (zero GHG Emission) by M3. Thus, M3 103 is selected as the proposed system of this research. Figs. 24 to 33 revealed the graphical results of M3.

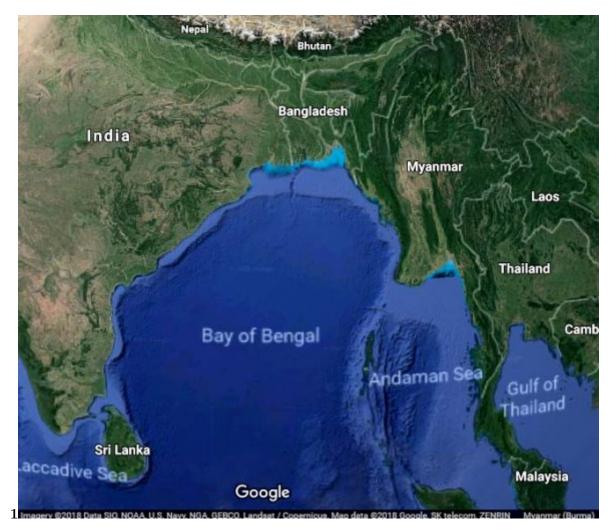


Figure 1: Fig. 1

104 105



Figure 2: Fig. 1 :

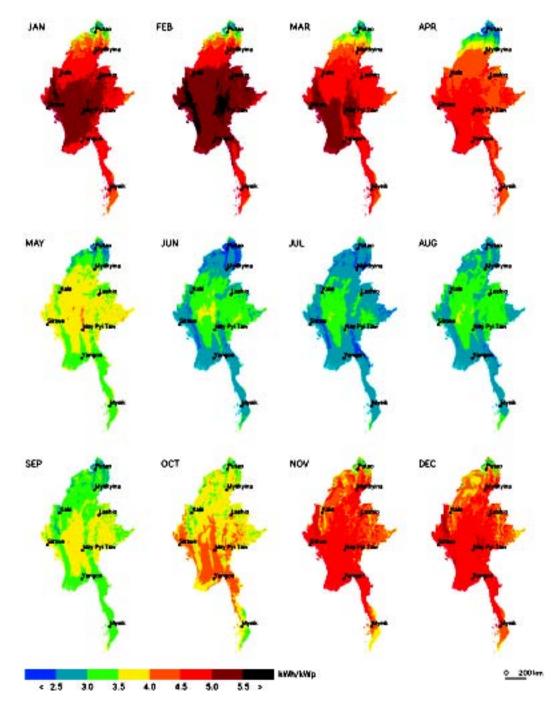


Figure 3: F



Figure 4: Fig. 2 :



Figure 5: F

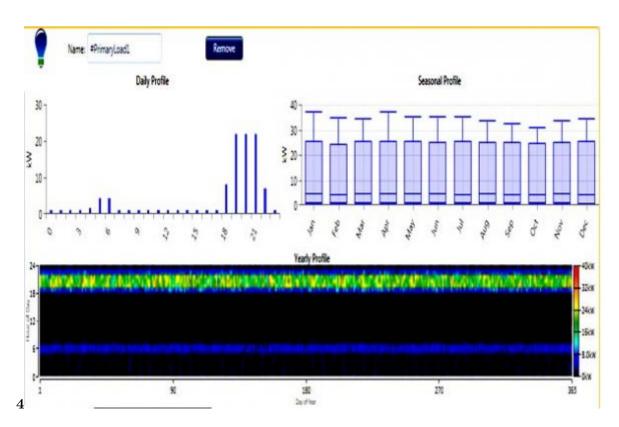


Figure 6: Fig. 4 :

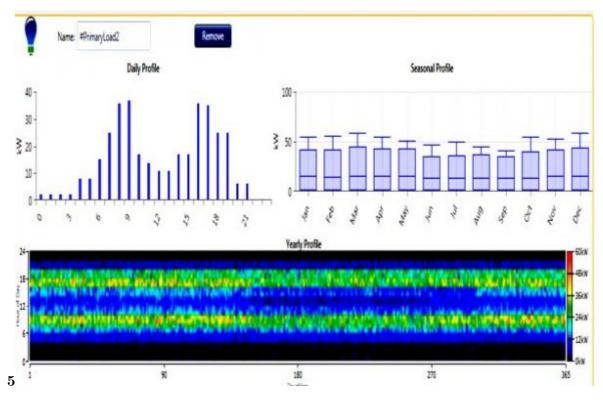


Figure 7: Fig. 5 :

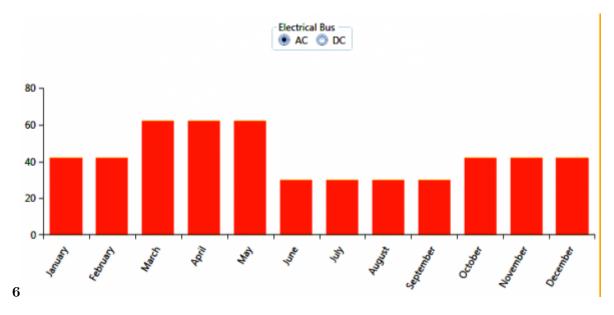


Figure 8: Fig. 6 :

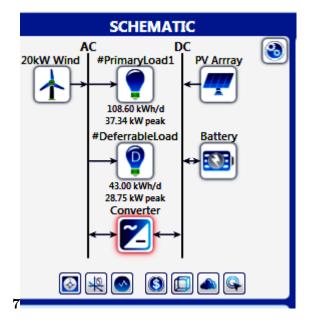


Figure 9: Fig. 7 :F

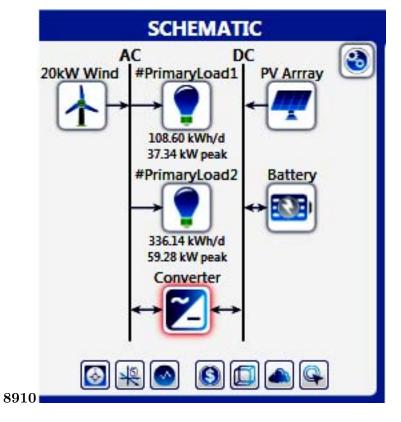


Figure 10: Fig. 8 : Fig. 9 : Fig. 10 : F

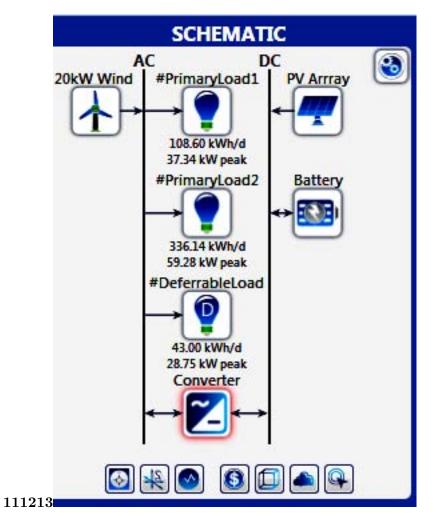


Figure 11: Fig. 11 : Fig. 12 : Fig. 13 : F

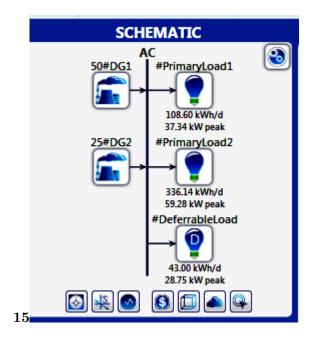


Figure 12: Fig. 15 :

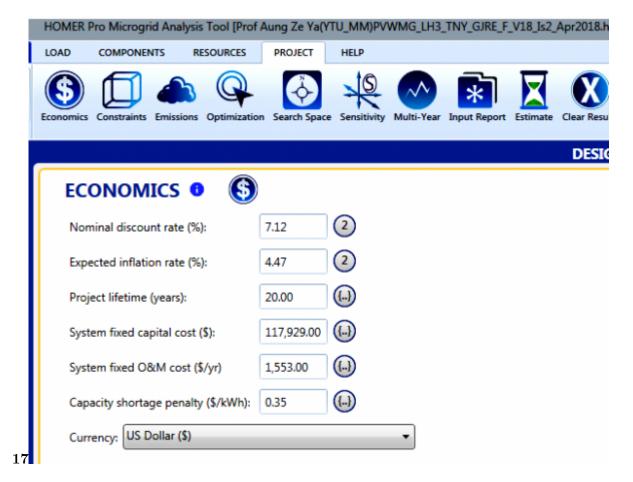


Figure 13: Fig. 17 :

AD COMPONENTS RESOURCES PR	ROJECT HELS	•	
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nomics Constraints Emissions Optimization Se	arch Space Sens	itivity Multi-Year Input R	eport Estimate Clear Results
			DESIGN
CONSTRAINTS •			
Maximum annual capacity shortage (%):	15.00	2	
Minimum renewable fraction (%):	100.00	0	
Operating Reserve			
As a percentage of load			
Load in current time step (%):	10.00	(
Annual peak load (%):	10.00		
As a percentage renewable output			
Solar power output (%):	5.00	(
	(-	

Figure 14: F

			DESIG	5N				
Add/Remove Generic flat plate PV								
PV Name: Generic flat plate PV		abreviations PV A	(m)					
Properties	792	PV Capacity	Capital		eplacement		O&	
Name: Generic flat plate PV	- 10	(kW)	(5)		(S)		(\$/ye	
Abbreviation: PV Arrray		1 1.300.	00	0.00			10.00	
Panel Type: Flat plate	- 11	Lifetime						5
Rated Capacity (kW): 1 Temperature Coefficient: -0.4300	- 11		time (years)		20.00	6	2	
remperature coemicent woods	14							
Operating Temperature (*C): 43								
Operating Temperature (*C): 43 Efficiency (%): 15.5								
Operating Temperature (*C): 43 Efficiency (%): 15.5 Manufacturer: Generic		Site Specific Inc	st					
Operating Temperature (*C): 43 Efficiency (%): 15.5		Site Specific Ing	ut			80.00	Θ	

Figure 15: Fig. 19:



Figure 16: Fig. 22 :F

<u>1</u> **															 Tab 	ular 🔿 Graphic
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NominalDiscountRate V (%)	EspectedInflationRate V (%)	Capacity Shortage (%)	۸ ۷	- +		PV Annay (kW)	🍸 20kW Wi	nd 🛛 Battery 🖓	Converter V	Dispatch 🍸	(d) 0 1	NPC 0 1	Operating co (\$/yr)	et 🛛 🖓 🔤	tial capital 💡	Ren Frac 0
7.12	4,47	15.0		- +		29.4	3	344	28.8	LF	\$0.597	\$479,476	\$13,990	\$2	62,097	100
8.63	4.47	15.0		- +	•	29.1	3	344	28.3	LF U	\$0.644	\$452,252	\$14,020	\$2	51,449	100
7.12	7.50	15.0		- +		29.2	3	344	30.0	LP	\$0.513	\$550,753	\$13,878	\$2	62,557	100
8.63	7.50	15.0		• +	•	29.3	3	344	28.8	LF	\$0.553	\$512,720	\$13,969	\$2	61,979	100
7.12	4,47	20.0		- +		15.4	4	126	26.1	LF	\$0.611	\$472,999	\$14,168	52	52,852	100
163	4.47	20.0		• +		28.9	3	126	26.1	LF	\$0.653	\$448,038	\$14,260	\$2	52,959	100
4					-	····										
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Figure 17: Fig. 24 :

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712		7.50		150			ł 0	2 9	18	8	243	541	UF	\$0.338	\$10EM	\$28,876	545	883	100
8.63		7.50		15.0			† D	2	30	B	243	54.0	IJ	\$0.362	\$979,521	\$28,993	\$46	0,190	100
712		4.0		20.0			ł 🖬	2 9	48	7	198	51.1	UF .	\$0.395	\$895,811	\$29,997	\$43	0,639	100
8.63		40		20.0			ł 0	2	33	7	207	53.6	UF	\$0.420	\$835,321	\$20,431	54	1171	100
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			Achitecture								Cost			System		9	V Array		20kW Wind
▲ = + s			? 208111lind ?	Battery	Converter (kW)	7 Dis	atch 🕈	COE (\$)	0 7 NPC	07	Operating cost () (\$/yr)	Y Initial capit (S)	tal 🌱 Ren Fra (%)		tal Fuel Y LVyi	Capital Cost (S)	Production (kWh/yr)	Capital C (\$)	lest Y Product (RWh/
7+5	B 🛛 🖉 BAS		1	270	55.7	IF		\$0.38	\$90	9,898	529,893	\$45,400	100	0		101,713	125,593	105,000	266,711
	1 🔁 BIO		1	270	558	F		\$0.38	591	0 652	529,761	\$448,220	100	0		104,451	128,973	115,000	286,711
# † 6	862		1	270	57.0	F		\$0.38	591	898	529,804	\$447,790	100	0		103,406	127,683	115,000	286,711
	B 🖪 87.6		7	270	565	ŀ		\$0.38	591	1126	\$29,724	\$449,268	100	0		105,152	129,839	105,000	285,71
	81.2		7	279	55.7	F		\$0.38	591	1148	530,053	\$44(179	100	0		97,413	120,270	105,000	286,711
	885		1	270	552	if		\$0.387	591	1255	529,633	\$450,800	100	0		107,366	132,573	105,000	286,711
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Figure 18: Fig. 25 :Fig. 26 :

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					Sensitivity					k	chitecture			Cost					
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712				40		150		# 🛉 🖬	801	8	243	543	F	90352	\$902,973	\$29,267	5445	,223	100
8.63				40		150		# 🛉 🖬	878	7	261	542	F	\$0.375	\$846,119	\$29,791	5440	671	100
712				7.50		150		# 🛉 🖬	2 10	8	25	523	UF	\$0.305	\$1.05M	£8511	5458	148	100
8.63				7.50		150		# 🛉 🖬	2 980	8	234	54.4	UF	\$0.328	\$971,906	\$28,950	5452	259	100
712				40		20.0		# 🛉 🖬	800	7	207	48.3	UF	\$0.355	\$887,798	\$30,757	\$409	896	100
8.63				4.0		20.0		# + B	2 788	8	189	463	UF	\$0.380	\$828.337	\$30,305	\$415	585	100
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B	pot.							ut	Dauble Clat on		tion Results en 10 one 10 detailed S	mulation Results.						Categ	orized 🖲 Ove
					Architecture						Cost			System		PV .	keray		200W Wird
4	• 1	-	9	PV Armay (kW)	7 2001 Wind 7	latey 🕈	Converter P	Dispatch 🕈	COE O P	NPC OP	Operating cost (\$/yr)	P Initial capit [3]	al 🍸 Ren Fra (%)	0 9 Tat	al Foel 💡	Capital Cost 💡	Production Y (kWh/yr)	Capital Co (\$)	st Y Product (dills/
1		- 6		871	8	248	543	UF	\$0352	\$902,973	\$29,257	\$448,223	100	0		104,508	129,044	116,000	327,67
1		-		87.6	6	26	535	U.	\$0.352	\$903,6062	\$29,255	\$448,436	100	0)	105,133	129,815	116,000	327,67
1		- 6		881	1	243	545	ø	\$0352	\$903,586	\$29,219	\$449,579	100	0	3	105,767	130,598	116,000	327,67
1		- 8		927	I	234	55.9	U	\$0352	\$903,599	529,022	\$452,657	100	0	1	111,204	137,311	116,000	327,57
1		-		948	1	234	542	F	\$0352	\$908,793	\$28,926	\$454,273	100	0	-	113,700	140,394	116,000	327,67
1		-		85.4	1	252	525	UF .	\$0351	5908,798	\$29354	\$448,306	100	0	1	102,436	125,485	116,000	327,67
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Figure 19: Fig. 30 :FF

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Epot.	Epot	AL					uec	laior	Sensitiv a sensitivity case	ity Cases to see to Opt	nication Result						Comp	are Economics	Column	Choices.
			Sensibility						Archit	sclure					Cost			Sy	sten	
NominaDiscount (%)	Rate P	Espectedin (1		Capacity Shor (%)	SP Ph	Diesel ael Price 🍸 (\$11)	4		50#061 P	25#062 (kW)	Dispatch N	COE ()	P NPC	0 9 0	perating cost (\$/jr)	P Initial co	ipital 🖓	Ren Frac 👩	Total Fuel 7	Hours 1
112		40		150		600	1	1	50.0	25.0	ii	\$0.351	5970	51.5 8	53 997	\$132,42	9	0	61,923	4517
165	J.	4.0		150	0	620	1	1	50.0	25.0	F	\$0.358	\$966	605 8	53,945	\$132,42	9	0	61,923	4,517
12		7.50		150	0	620	1	1	50.0	25.0	F	\$0.339	\$12	5M 5	53 901	\$132,42	9	0	61,923	4517
16		7.50		150	0	620	1	1	50.0	25.0	ı	\$0344	\$11	M S	53,922	\$132,42	9	0	61,923	4517
112	4	w	_	20.0	0	620	1	1	500	25.0	ţ	\$0.351	\$970	51.5 8	53,997	\$132,42	9	0	61,923	4507
Epot.							et Dad	e Old	Optimi ton aparticular s	cation Resu start to see to		etor Reuls.							Categorize	d 🗘 Over
	Archite	eture				Cest					System				50#0G	1				25#052
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\$ 500	É.		UF	\$0.412	113M	\$54,494			\$1,27,929	0	69,2	73 1	8,760	200,802	69,273	13,140	42,949			

Figure 20:

	validated as the fifth step. The principal	work is
	the Techno-Economic Optimizations of d	
	models performed in the well-proven tool	
	Pro (version 3.11.5). The final step is the	
	of the Best Model.	
		The identified problems
		are:
	1) Contribution to the Global Warming of	
	i) contribution to the chobar warming (GHG Emissions from the
		burning of the Diesel
		fuels and the fuelwood [15-
		-
		18],
	2) Deforestation and Climate Change fro	
		application of the fuelwood
		for the cooking,
	3) Degradation of the bio-diverse eco-sys	
		the Coastal Region,
	4) Health problems from the burning of t	the Diesel
		fuels and the fuelwood [20-
		22],
	5) Easy to be fire hazards from the appli	cations of
	,	the Diesel Generators and
		the firewood,
Hierarchical	6) Insufficient and the limited supply from	,
Methodology	,	
00		existing SHS and the Diesel
		Generators, and
Selection	7) Environmental (Negative) impacts fro	m the usages of the Fluorescent Lamps [19-21].
of the Best		in one asagos er one i raereseene hampe [10 -1].
Model		
Simulation in	II.	ZERO-EMISSION EN-
Simulation in	11.	ERGY (STANDALONE
HOMER Pro		PV-WIND-BATTERY
HOWER 110		HYBRID) MODEL IN
V-1:1-4:f		· · · · · · · · · · · · · · · · · · ·
Validation of		HOMER PRO
Input Param-		
eters		
Selection of		
Technology		
and		
Component		
Evaluations		
of Load		
Profiles		
Selection of		
Renewables		
Site Survey		
-		Fig. 3: Project Location
		(Villago I ol Hpot)

(Village Lel Hpet)

[Note: a)]

Figure 21: Project Location in Tanintharyi Cqqst Fig. 3 mentions the project location in the map- box of HOMER Pro. The village Lel Hpet in Tanintharyi Coast placed according to its geographical coordinates

Load Type	Description	Power	Amount
		(kW)	
PL2	Carpentry Workshop	1000	8
	Cold Storage	140	20
DL2	Water Pumping	1500	15

Figure 22: Table 1 :

 $\mathbf{2}$

1

Group	Primary Load 1	Primary	Small Deferrable
		Load 2	Loads
	(kilowatt, kW)	(kW)	(kilowatt hour,
			kWh)
Low	1.320	22.5	1.305
Medium	13.833	192.5	13.020
High	11.600	60	4.350

Figure 23: Table 2 :

 $\mathbf{4}$

Mo-	Design	Capacity	Annual	Cost	Net	Operati	nginitial		Diesel Fuel	
del			Production/ Throughput	of Energy	Present Cost	Cost	Capital			
			(kWh/yr)	(\$)	(\$)	(\$/ yr)	(\$)	(L/yr)) (/L)	(\$/yr)
M1	PV	29.4 kW	43504	0.597	479476	13990	262097	-	-	-
	Wind	60 kW	122876							
	Battery	144 kWh	19037							ļ
	Converter	28.8 kW	-							ļ
M2	PV	84.8 kW	125593	0.388	909898	29893	448220	-	-	_
	Wind	140 kW	286711							ļ
	Battery	270 kWh	38361							
	Converter	$55.7 \ \mathrm{kW}$	-							
M3	\mathbf{PV}	$87.1 \ \mathrm{kW}$	129044	0.352	902973	29267	448223	-	-	-
	Wind	160 kW	327670							
	Battery	243 kWh	34360							
	Converter	$54.3 \mathrm{kW}$	-							
M4	DG1	50	137742	0.351	970515	53937	132429	45057	0.62	27935
									0.72	32441
	DG2	25	45975					16867	0.62	10457
									0.72	12144

Figure 24: Table 4 :

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