



Mana Agua Mini-Hydro Project

Team Name:
Caribbean Energy Alliance

Team members:

Jose Basto (c)

Camilo Conde

Sofia Cubillos

Cristhian Riascos

Home Country:

Colombia

Mentor:

Ryan Grant

San Juan River, Nicaragua

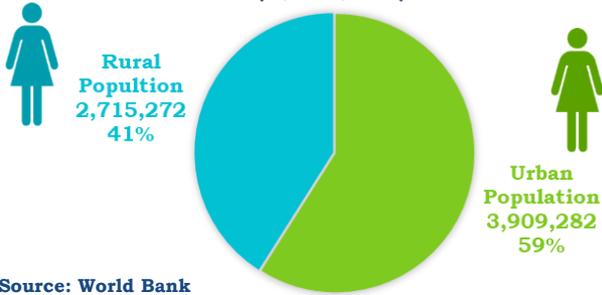
Executive summary

- **OVERVIEW**
 - Coverage of energy supply
 - Nicaragua's poverty distribution
 - Energy Reliability
 - Power generation matrix
- **PROJECT JUSTIFICATION**
 - Mini-Hydro vs other energy sources
 - What about other sources?
 - Mini-Hydro System
 - Mini-Hydro potential
- **PROJECT WORKPLAN**
 - Power capacity needed
 - Timeline
 - Cost of energy
 - Impacts

COVERAGE OF ENERGY SUPPLY

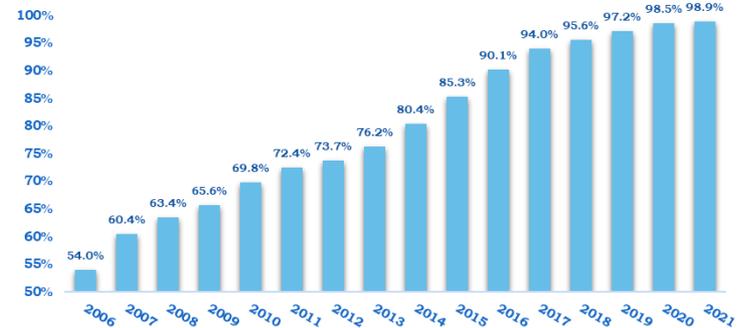
Nicaragua has the lowest value of access to electricity in the region just above Haiti. 776,079, inhabitants.

POPULATION OF NICARAGUA (6,624,554)



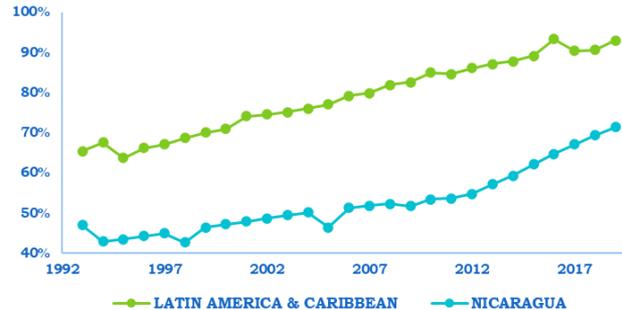
Source: World Bank (2020)

EVOLUTION OF THE NATIONAL ELECTRICITY COVERAGE INDEX



Source: Ministerio de Energia y Minas (2021)

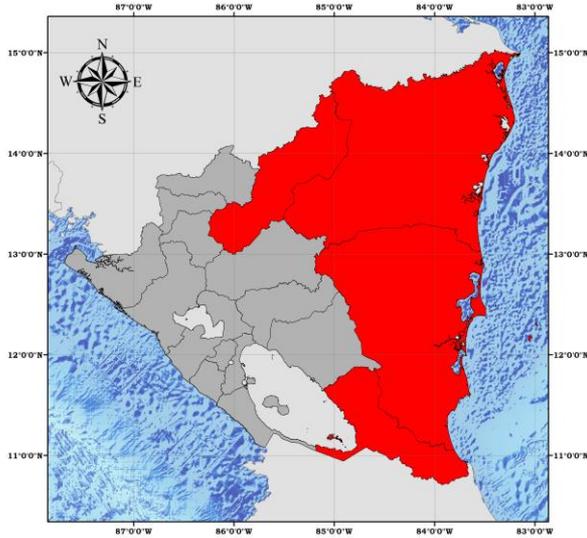
ACCESS TO ELECTRECITY (% RURAL POPULATION)



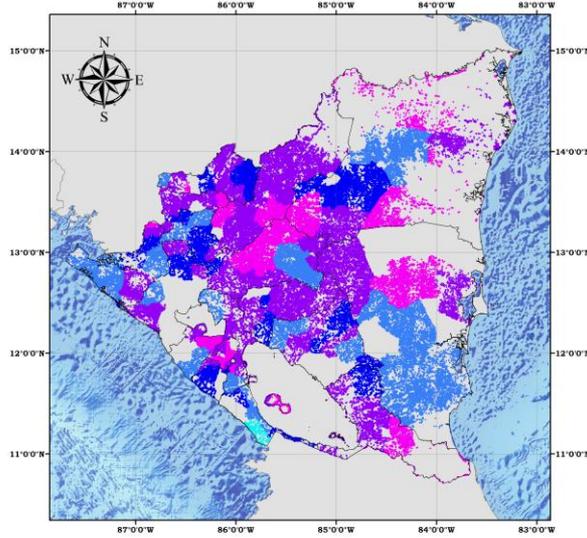
Source: World Bank (2020)

NICARAGUA'S POVERTY DISTRIBUTION

POVERTY DISTRIBUTION



POPULATION DISTRIBUTION



ELECTRICAL GRID



0 15 30 60 90 120 150 Kilometers

0 15 30 60 90 120 150 Kilometers

LEGEND

-  Political-administrative division
-  Regions with extreme poverty

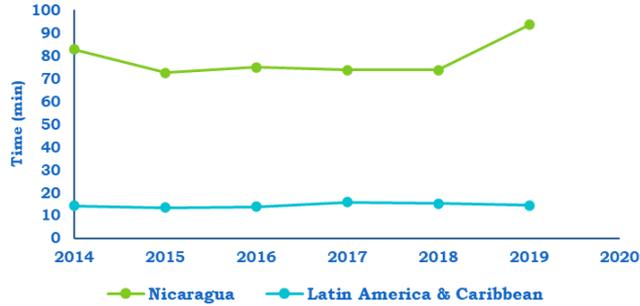
Habitants per [30km²]

-  3,7 - 5,7
-  5,7 - 7,5
-  7,5 - 8,6
-  8,6 - 12,5
-  12,5 - 28,2

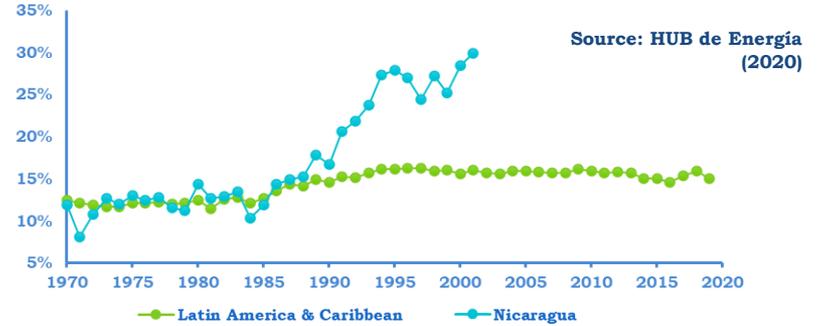


ENERGY RELIABILITY

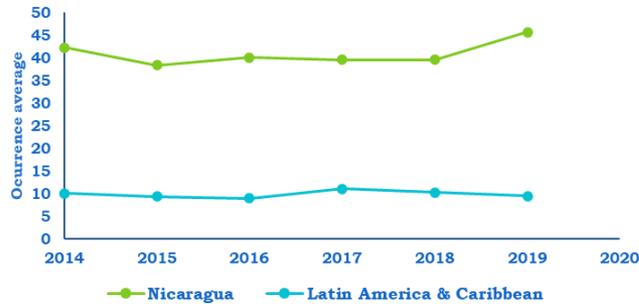
SYSTEM AVERAGE INTERRUPTION INDEX (SAIDI)



ELECTRICITY LOSSES (% OF TOTAL ELECTRICITY SUPPLY)



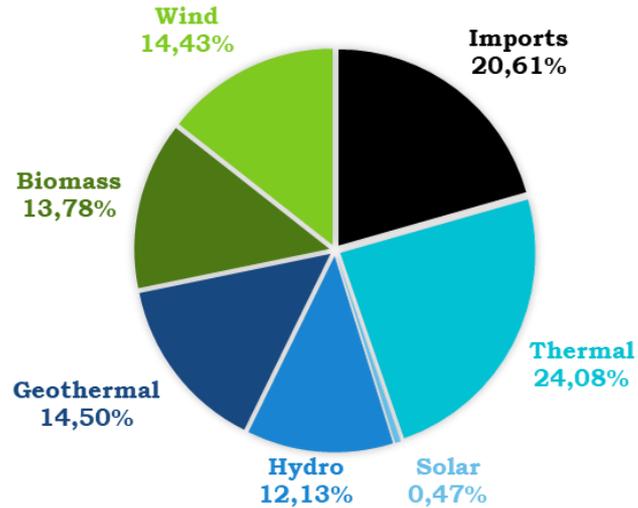
SYSTEM AVERAGE INTERRUPTION FREQUENCY INDEX (SAIFI)



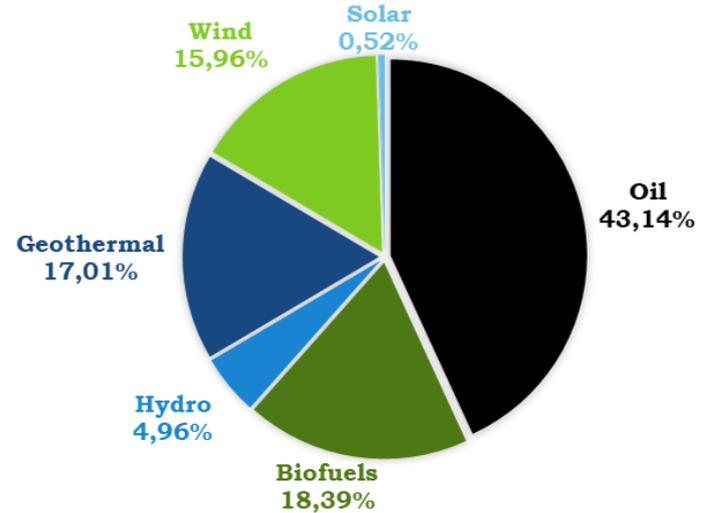
Source: World Bank (2019)

	2018	2019
Distribution - SAN	37.45%	39.41%
Source: Instituto Nicaraguense de Energia, 2019.		

POWER GENERATION MATRIX

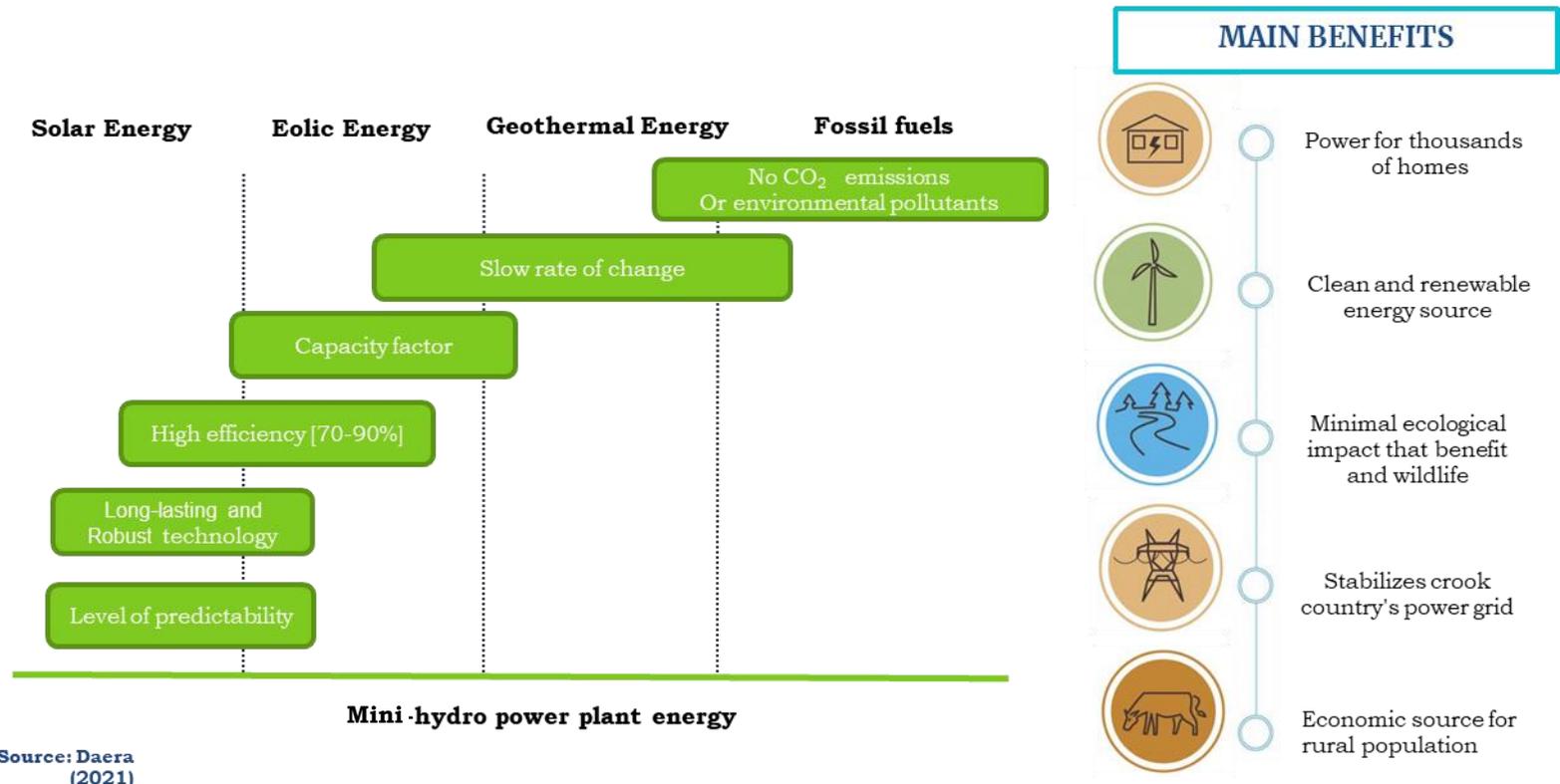


Source: Ministerio de Energía y Minas
(2021)



Source: IEA
(2019)

MINI - HYDRO COMPARISSON WITH OTHER ENERGY SOURCES



Source: Daera (2021)

WHAT ABOUT OTHER SOURCES?



SOLAR
POWER



WIND
POWER



THERMAL
POWER

CONS

- Weather dependent
- PV Energy storage is expensive

- Weather dependent
- Construction is expensive

- Importing Oil is expensive
- Fossil Fuels are not renewable



GEO THERMAL ENERGY



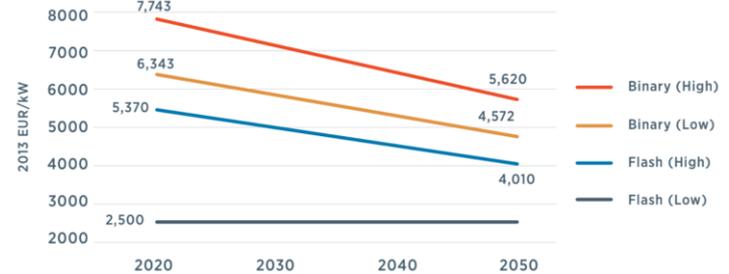
● earthquake activity
 Arcs in the "Ring of Fire"
 Convergent "Teeth" on overriding plate

Source: IRENA (2007)

Distribution of Nicaragua's volcanoes



Cost of power generated by a geothermal plant

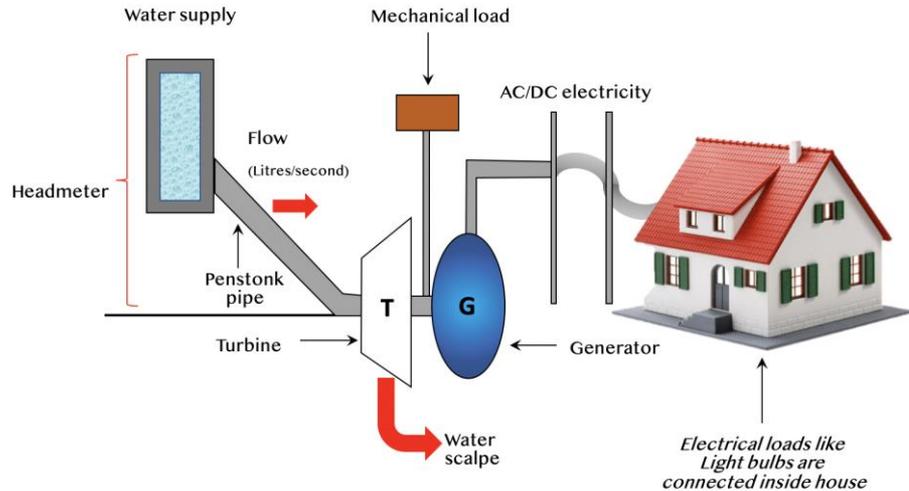


Source: IRENA (2007)

Future geothermal projects in Nicaragua	Price in millions (USD)
Geothermal plant in Mombacho volcano	235,5
Geothermal plant in Casitas-San Cristóbal	158,5
Geothermal plant in Cosigüina volcano	198,6
MEAN	197,5

Source: PRONicaragua (2019)

GENERAL MINI-HYDRO FROM PICOTURBINE



Schematic diagram of micro-hydro power system
Modified from Desai et al (2014)

Simple and reliable power system components

Little maintenance

Versatile power source

No combustible fuel needed

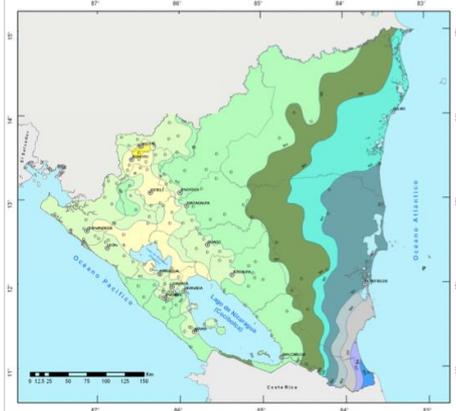
Generation capacity	Classification	Mode of operation	Applicability
<5 kW	Pico	Off-grid	1-2 houses
5-100 kW	Micro	Off-grid	Small isolated communities
0,1 – 1 MW	Mini	Off-grid	Isolated communities
1 – 10 MW	Small	On-grid	Small communities
10 – 100 MW	Medium	On-grid	Medium urban centers
> 100 MW	Large	On-grid	Large urban centers

Table 1. Hydropower plants classification according to their production capacity. (Modified from Carrasco et al.)

NICARAGUA POTENTIAL WITH MINI-HYDRO

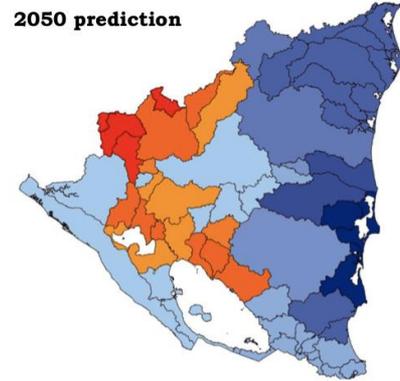
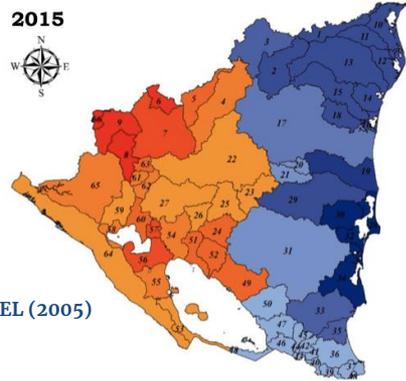


INETREL (2005)



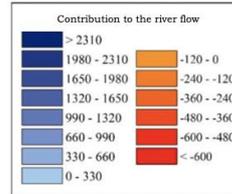
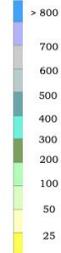
INETREL (2005)

CONTRIBUTION TO THE RIVER FLOW



INETREL (2014)

Mean precipitation (mm)



POWER CAPACITY NEEDED

Estimation
of energy
consumption



Rural
disconnected
households



Total power
generation
needed

Appliance	Wattage (watts)	Mean usage time (hours/day)	Usage per month (kWh)
LED lightbulb (X3)	20	5	9
Small fridge	70	24	50.4
Small TV	60	5	9
Radio	10	7	1.8
Other needs	100	8	24
TOTAL PER HOUSEHOLD	260	-	94.2

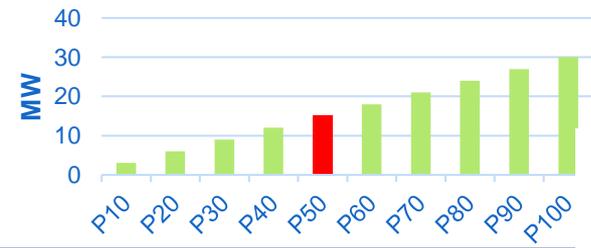
Estimation of total monthly electric energy consumption per household in rural areas

	2019	2052 (Projected ^[2])
Rural disconnected households ^[1]	75,935	97,789
TOTAL POWER NEEDED (MW)	9.8	12.62

Estimation of total power needed for supplying rural households

INSTALLED CAPACITY ESTIMATED

Nicaragua accounts with 30 Hydropower sites with capacities ranging 0.1 – 1.0 MW^[3]



^[1]Rural disconnected households estimated from Sustainable Electrification and Renewable Energy National Program (Ministerio de Minas y Energía, 2020)

^[2]Projected from Population Pyramid (<https://www.populationpyramid.net/>)

^[3] Nicaragua: Policy Strategy for the Promotion of Renewable Energy: Situation and Perspective of Hydroelectric Generation, 2006.

TIMELINE – MINI HYDRO PLANTS CONSTRUCTION

	PRE-FEASIBILITY				CONSTRUCTION			
ACTIVITIES	2022	2023	2024	2025	2026	2027	2028	2029
Pre-feasibility Study	1 YEAR							
Managment of initial investment		1 YEAR						
Supplemental survey			8 MONTHS					
Enviroment impact study (EIA)			6 MONTHS					
Land acquisition / Resettlement				1 YEAR				
Publication of approved EIA					1 MONTH			
Procurement of consultant					2 MONTHS			
Site access road by local fund/tender					6 MONTHS			
Mobilization/Preparatory works						6 MONTHS		
Generating equipment							3 YEARS	
Hydromechanical works							1.5 YEARS	
Generation equipement							1.5 YEARS	
Transmission line 150kV							1.5 YEARS	
Test & Start up								11 MINI-HYDRO
								11 MINI-HYDRO
COST	\$ 3,230,000.00				\$ 18,700,000.00			

TIMELINE – ELECTRICAL GRID CONSTRUCTION

	PRE- FESEABILITY				CONSTRUCTION						
ACTIVITIES	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	
Pre-feasiability Study	3 YEARS										
Managment of initial investment	1 YEAR										
Enviroment study (EIA)			1 YEAR								
Land acquisition / Resettlement				2 YEARS							
Publication of approved EIA					1 MONTH						
Procurement of consultant					6 MONTHS						
Site access road by local fund/tender					3 YEARS						
Mobilization/Pre paratory works					5 YEARS						
Generating equipment							4 YEARS				
Hydromechanical Works								2 YEARS			
cable laying operation									2 YEARS		
Start up										6 MONTHS	
	\$ 3,486,500.00				\$ 18,350,000.00						

TIMELINE – MANA AGUA PROJECT

BID
Banco Interamericano de Desarrollo

INVESTMENT \$ 3.23 M (3%)*

THE WORLD BANK

INVESTMENT \$ 3.49 M (3%)*

BCIE
Banco Centroamericano de Integración Económica

INVESTMENT \$ 18.7 M (3%)*

THE WORLD BANK

INVESTMENT \$ 18.35 M (3%)*

\$ Project Revenue \$ 0.4 M

\$ Project Revenue \$ 3.4 M

2022 2026 2030 2032 2034 2035 2036 2038 2040 2047 2052

TIME LINE

PRE-FESEABILITY (22 MINI-HYDRO)



PRE-FESEABILITY (TRANSMISSION GRID)



CONSTRUCTION (22 MINI-HYDRO)



CONSTRUCTION (TRANSMISSION GRID)



OPERATION (22 MINI-HYDRO)



PRE-FESEABILITY (4 MINI-HYDRO)



CONSTRUCTION (4 MINI-HYDRO)



OPERATION (4 MINI-HYDRO)



REPAID TO BID



FIRST REPAID TO WB



REPAID TO BCIE



SECOND REPAID TO WB



9.8 MW
0 MW

10.85 MW
11 MW

12.7 MW
13 MW

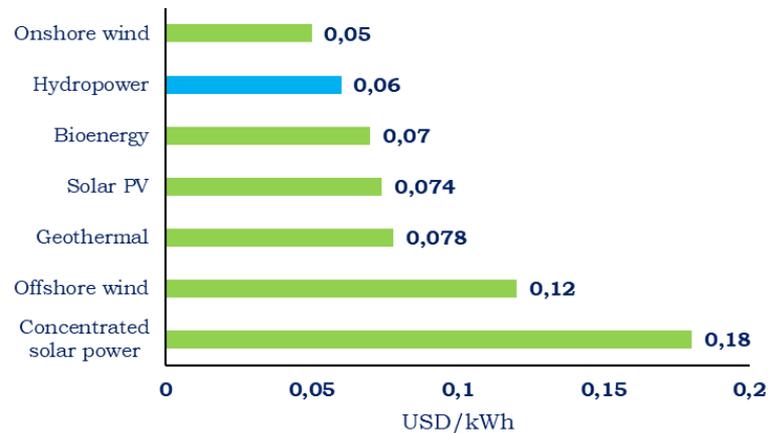
*Interest rate

LEVELIZED COST OF ENERGY

Levelized Cost of Energy (LCOE) Estimation

Initial Investment Cost (MM USD)	25.63
Operation and maintenance cost (MM USD)	1.97
O&M Growth Rate	2.50%
Annual electricity output (MWh)	85,837
Project lifespan (years)	30
Discount rate	3.00%
Entry date	1/01/2022
LCOE	0,06 USD/kWh

Average LCOE Comparison in 2019 ^[1]



^[1]Our World In Data (2020)

IMPACTS

G1: reducing to zero the deaths related to household air pollution (HAP)



91,8% rural population uses biomass



984 annual deaths for HAP

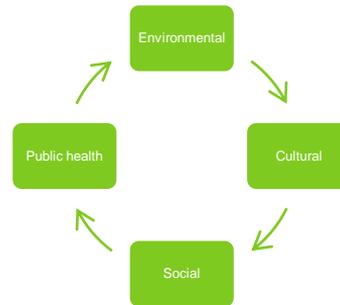
- Access to **electrified healthcare facilities.**

- Promotion of **clean cook stoves.**

G2: increase environmental awareness with the sustainable water resource.



- Sensibilization campaigns



G3: higher rate of employment related to the construction and operation of the project infrastructure



G4: facilitate rural communities access to education resources



Caribbean Energy Alliance



Jose D. Basto-Aguirre
Pokémon Master (ポケモンマスタ)



Sofía Cubillos
Earthbender



Camilo Conde
Genius, billionaire,
playboy, philanthropist



Cristhian Riascos
Chief Alchemist

Team Number: 122

Appendix - Costs and Revenues

ACTIVITIES	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
INTEREST RATE							\$ 201,495.00	\$ 201,495.00	\$ 201,495.00	\$ 201,495.00
M & O								\$ 467,500.00	\$ 467,500.00	\$ 467,500.00
ENERGY NEEDED	9.8							10.65		
R. POPULATION	397,140	400,950	404,760	404,760	408,569	408,569	412,379	412,379	416,189	419,999
HOUSES	75,935	76,663	77,392	77,392	78,120	78,120	78,849	78,849	79,577	80,306
PRICE PER YEAR PER HOUSE									80,306	80,306
EARN									81,034	81,034
EARN - M&O - DEBT									81,034	81,763
	1,396,991									
2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
\$ 1,312,995.00	\$ 1,312,995.00	\$ 1,312,995.00	\$ 1,312,995.00	\$ 1,312,995.00	\$ 1,312,995.00	\$ 1,216,095.00	\$ 1,216,095.00	\$ 1,111,500.00	\$ 1,111,500.00	\$ 1,111,500.00
\$ 1,852,500.00	\$ 1,852,500.00	\$ 1,852,500.00	\$ 1,852,500.00	\$ 1,852,500.00	\$ 1,852,500.00	\$ 1,852,500.00	\$ 1,852,500.00	\$ 1,852,500.00	\$ 1,852,500.00	\$ 1,852,500.00
10.85										
435,238	439,048	442,858	446,667	450,477	454,287	458,097	461,907	465,716	469,526	473,336
83,220	83,948	84,676	85,405	86,133	86,862	87,590	88,319	89,047	89,776	90,504
\$ 60.00	\$ 60.00	\$ 60.00	\$ 60.00	\$ 60.00	\$ 60.00	\$ 60.00	\$ 60.00	\$ 60.00	\$ 60.00	\$ 60.00
\$ 4,993,170.00	\$ 5,036,877.00	\$ 5,080,584.00	\$ 5,124,291.00	\$ 5,167,998.00	\$ 5,211,705.00	\$ 5,255,412.00	\$ 5,299,119.00	\$ 5,342,826.00	\$ 5,386,533.00	\$ 5,430,240.00
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 303,922.50	\$ 347,629.50
				BID	BID	WB	WB	BCIE	BCIE	BCIE
2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	
\$ 1,111,500.00	\$ 1,111,500.00	\$ 1,111,500.00	\$ 1,111,500.00	\$ 550,500.00	\$ 550,500.00	\$ 550,500.00	\$ 550,500.00	\$ 550,500.00	\$ 550,500.00	
\$ 1,852,500.00	\$ 1,852,500.00	\$ 1,852,500.00	\$ 1,852,500.00	\$ 1,852,500.00	\$ 1,852,500.00	\$ 1,852,500.00	\$ 1,852,500.00	\$ 1,852,500.00	\$ 1,852,500.00	
										13
477,146	480,956	484,765	488,575	492,385	496,195	500,004	503,814	507,624	511,434	
91,232	91,961	92,689	93,418	94,146	94,875	95,603	96,332	97,060	97,789	
\$ 60.00	\$ 60.00	\$ 60.00	\$ 60.00	\$ 60.00	\$ 60.00	\$ 60.00	\$ 60.00	\$ 60.00	\$ 60.00	
\$ 5,473,947.00	\$ 5,517,654.00	\$ 5,561,361.00	\$ 5,605,068.00	\$ 5,648,775.00	\$ 5,692,482.00	\$ 5,736,189.00	\$ 5,779,896.00	\$ 5,823,603.00	\$ 5,867,310.00	\$ 114,035,040.00
\$ 391,336.50	\$ 435,043.50	\$ 478,750.50	\$ 522,457.50	\$ 567,164.50	\$ 611,871.50	\$ 656,578.50	\$ 701,285.50	\$ 745,992.50	\$ 790,699.50	\$ 4,259,395.00
BCIE	BCIE	BCIE	BCIE	WB	WB	WB	WB	WB	WB	