

# Design and optimization of off-grid solar PV systems for an indigenous peoples' community in the Philippines

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## Research Description

The study is an **applied research** aimed to **design two types** of off-grid solar lighting systems: a **Solar Home Lighting System (SHLS)** for households; and the **Church Complex Solar System (CCSS)** serving a micro-grid complex. The research determines the **most optimized** designs according to energy performance, economics, and environmental benefits

## Background & Motivation

In the **Philippines**, the *Dumagat indigenous peoples* living in the remote mountains of *Sierra Madre* belongs to the **16 million** of the population who **lack access to electricity**. Due to their remoteness, providing basic government services such as health, education and electricity is indeed a great challenge.



## Study Objectives



Determine the most techno - economically feasible design for the two systems – **26 units** of SHLS & CCSS microgrid serving a **church, K3 schools & a pastoral house**



Identify the amount of **capital investment** for these systems



Estimate the systems positive environmental impact in combatting climate change : **Carbon Offsets & Carbon payback times**

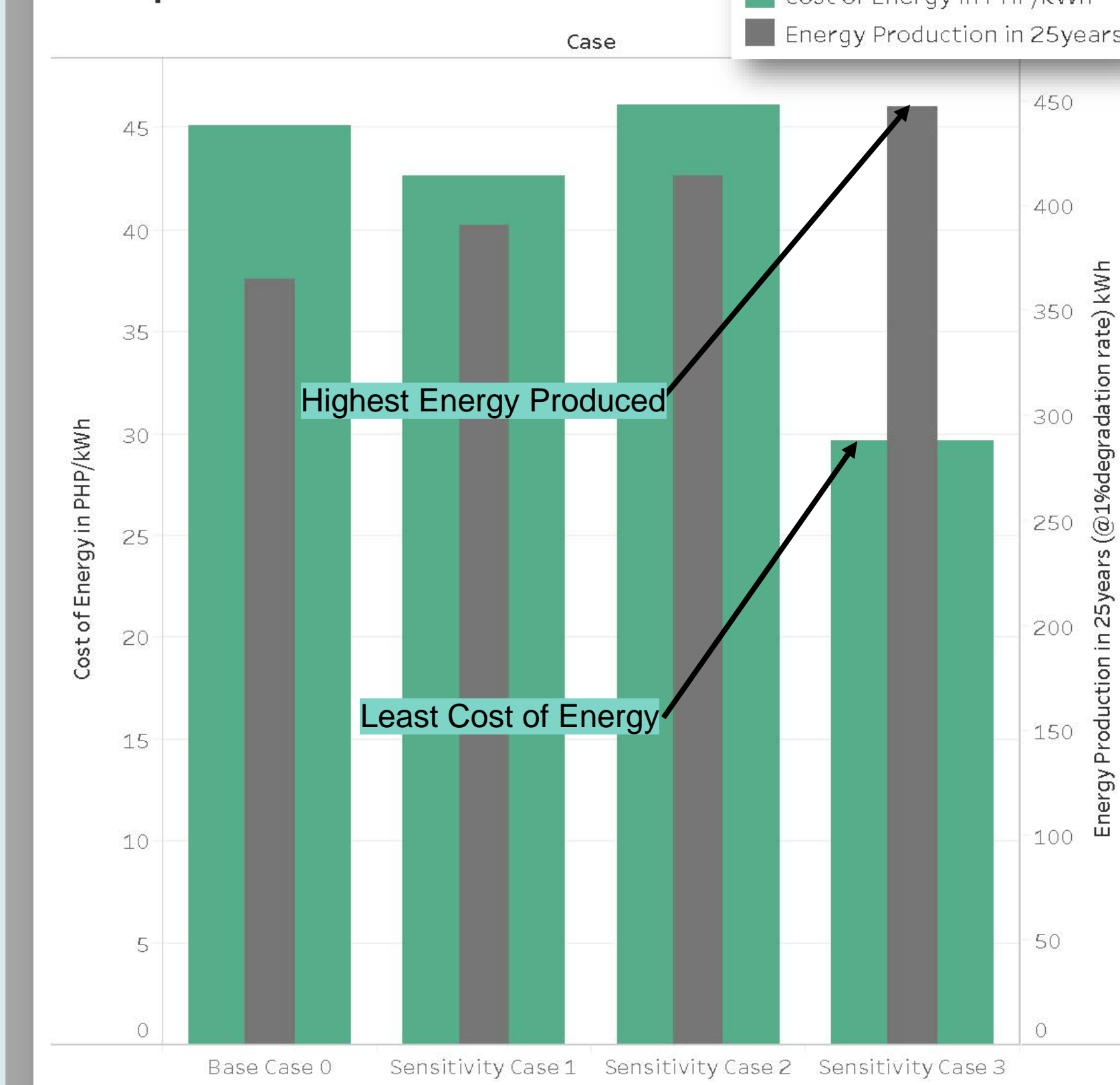
## Methodology

- 1 Establish **base case scenarios** through manual calculation.
- 2 Research for alternatives and form **sensitivity cases**.
- 3 Using **PVsyst software**, run computer simulation for each case (base and sensitivities) to determine system performance.
- 4 Determine investment cost for each case using **PRESENT WORTH ANALYSES**.
- 5 Calculate the **COST of ENERGY** for each cases (Energy produced / Present worth).
- 6 The "case" with **least cost of energy** is identified to be the most optimised case.
- 7 From Step 4, extract the cases' **capital investment** & determine the cases' **Carbon Payback Time** and **Carbon Offsets**.

## SHLS Analyses & Results

Base Case is compared to 3 Sensitivity Cases

SHLS : Cost of Energy & Energy Produced Comparison



Case	Energy Prod. (kWh)	Present Worth	Energy Prod. (Economic Life)	COE in PHP/kWh	COE in CAD/kWh
Base Case 0	16.39	PHP 16,468.92	365	45.13	1.13
Sensitivity Case 1	17.57	PHP 16,668.92	391	42.64	1.07
Sensitivity Case 2	18.62	PHP 19,097.83	414	46.14	1.16
Sensitivity Case 3	20.13	PHP 13,267.81	448	29.62	0.75

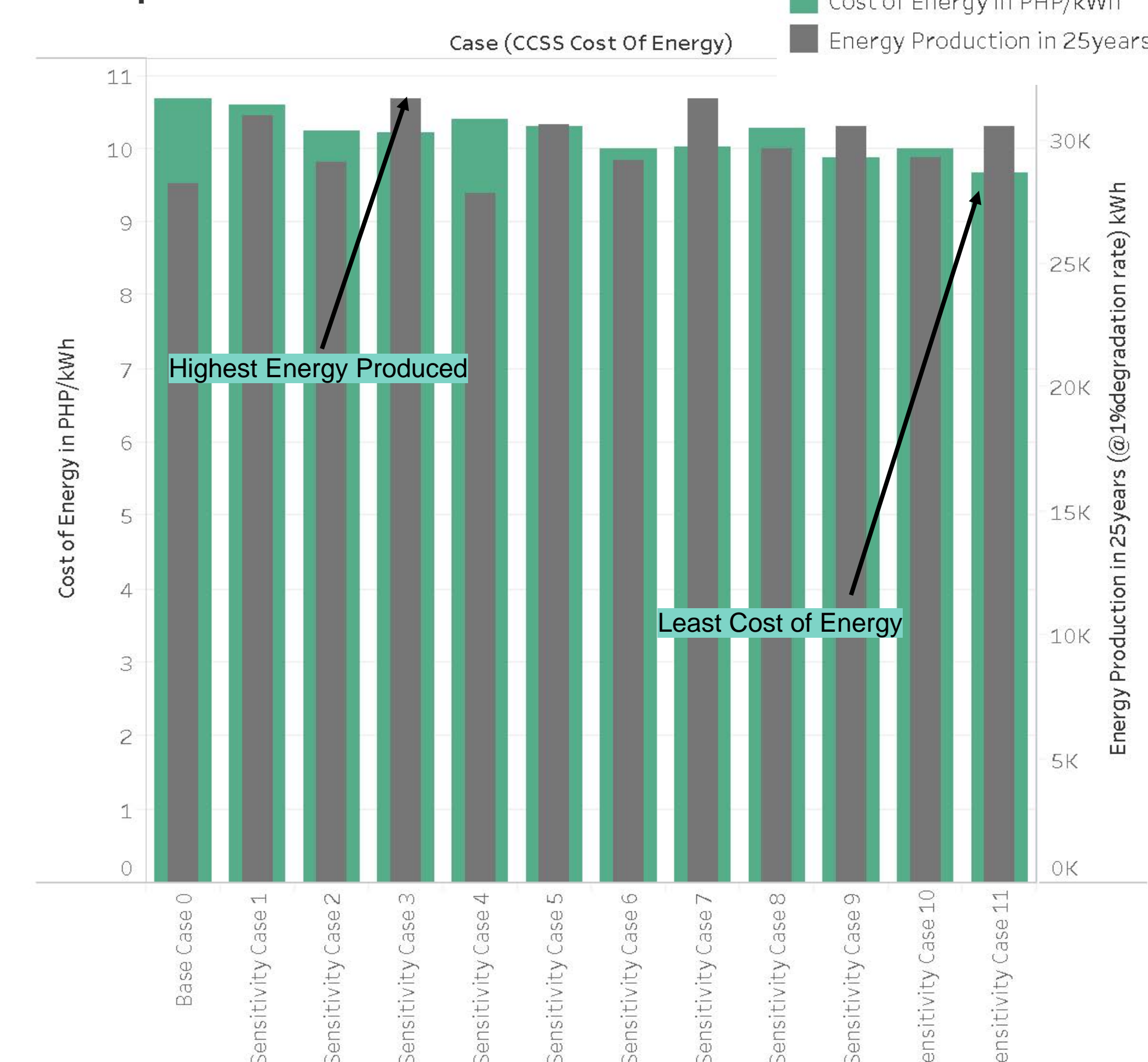
### Significant Findings:

- **Case 3** has the least cost of energy (**75cents/kWh**) which is **35% cheaper** than base case
- **Energy:** Produced **23% more energy\***
- **Economics:** Provide **50% savings** on battery replacement cost\* \*as compared to base case

## CCSS Analyses & Results

Base Case is compared to 11 Sensitivity Cases

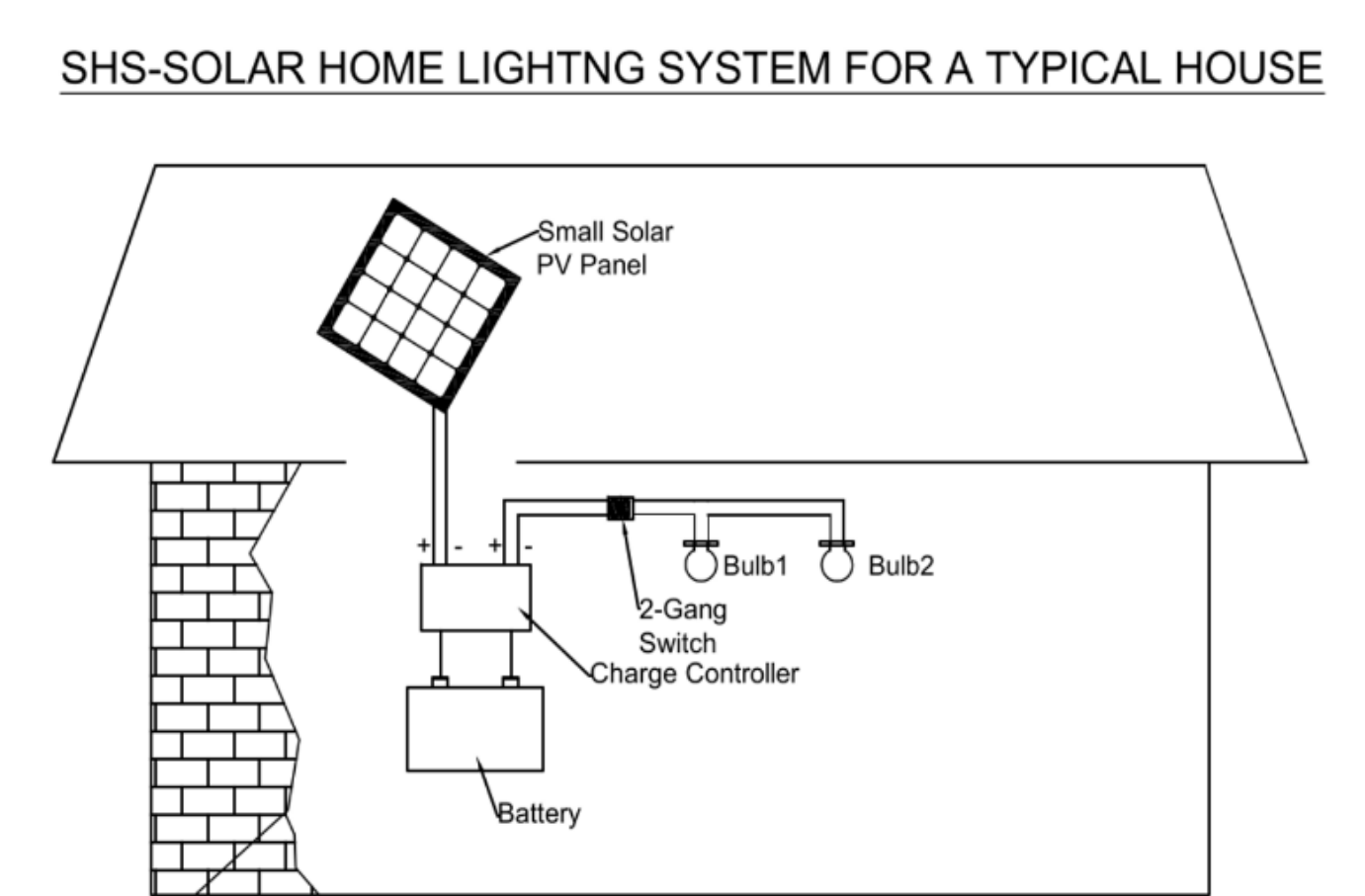
CCSS: Cost of Energy & Energy Production Comparison



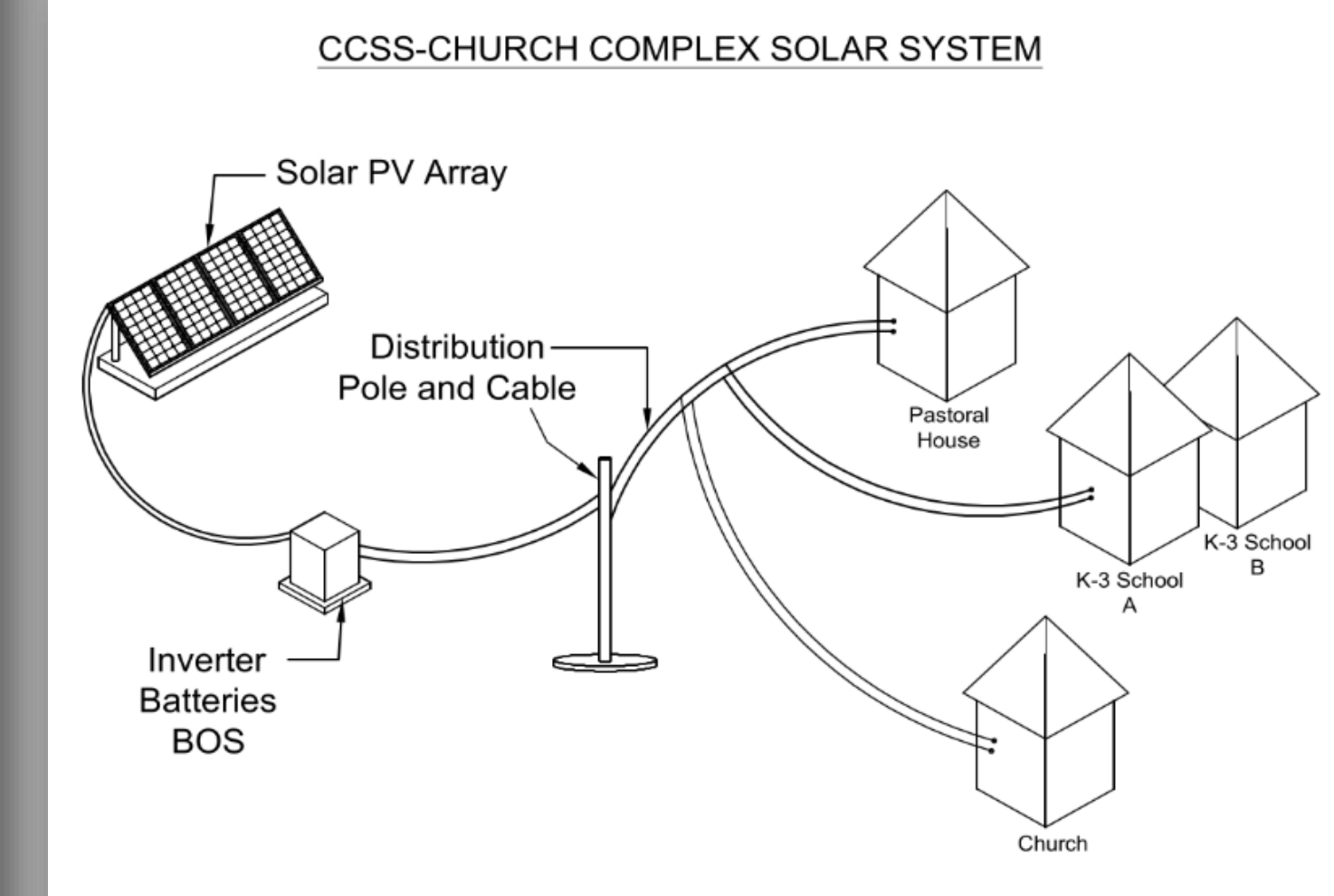
Case	Energy Prod.	Present Worth	Energy Prod. kWh	COE in PHP/kWh	COE cents/kWh
Base Case 0	1269	PHP 301,193.00	28195	10.69	26.73
Sensitivity Case 1	1393	PHP 327,277.00	30950	10.58	26.45
Sensitivity Case 2	1308	PHP 297,193.00	29061	10.23	25.58
Sensitivity Case 3	1426	PHP 323,277.00	31683	10.21	25.53
Sensitivity Case 4	1253	PHP 289,193.00	27839	10.39	25.98
Sensitivity Case 5	1377	PHP 315,277.00	30594	10.31	25.78
Sensitivity Case 6	1311	PHP 291,193.00	29128	10.00	25.00
Sensitivity Case 7	1426	PHP 317,277.00	31683	10.02	25.05
Sensitivity Case 8	1335	PHP 304,914.00	29661	10.28	25.70
Sensitivity Case 9	1373	PHP 300,914.00	30506	9.87	24.68
Sensitivity Case 10	1319	PHP 292,914.00	29306	10.00	25.00
Sensitivity Case 11	1373	PHP 294,914.00	30506	9.67	24.18

## Conceptual Layout

SHLS Conceptual System Layout



CCSS Conceptual System Layout



### Significant Findings:

- **Case 11** has the least cost of energy (**24 cents/kWh**) which is **10% cheaper** than the base case
- **Energy:** Produce **10% more energy\***
- **Economics:** **Same** initial cost as the base case \*as compared to base case

The SHLS could provide a 25-year supply of clean, sustainable electricity for the 26 recipient families.



30Wp Solar PV Panel  
10Ah Lead-acid Battery  
Charge Controller  
Balance of System



SHLS Unit Cost  
**\$ 165.00**  
SHLS Total Cost  
**\$ 4290.00**



Carbon Offsets:  
**8.4 tons CO2eq**  
Carbon Payback Time:  
**4 yrs (cradle-to-grave)**

## Conclusions

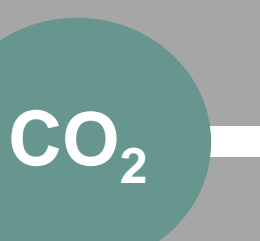
The CCSS could provide a 25-year supply of clean electricity for the church, K3 School & pastoral house.



4x325Wp Solar Panels  
200Ah Pb-ac Bat. Bank  
Hybrid C/C Inverter  
Lighting/Ventilation  
Balance of System



CCSS Capital Cost  
**\$ 4000.00**



Carbon Offsets:  
**14 tons CO2eq**  
Carbon Payback Time:  
**6 yrs (cradle-to-grave)**

## Acknowledgements

This research was done in cooperation with my partner NGO in the Philippines: *Trigo Para Sa Tribu (TPST) Org. Inc. (or in English – The Wheat for the Tribes Foundation)*

My sincerest gratitude for the *Dumagat Indigenous Peoples* in the Sierra Madre Mountains in the Philippines for their warm welcome during our field visits.

The *Dumagat Community Solar Project* will be implemented in 2019 through the efforts of the *Light in the Darkness Alliance* – an NGO we created as a result of this SEDV research. For more information visit [www.litdalliance.org](http://www.litdalliance.org) or email: [info@litdalliance.org](mailto:info@litdalliance.org)

The *Dumagat Community Solar Lighting Project*

For more information, Scan here:



Light in the Darkness Alliance  
[www.litdalliance.org](http://www.litdalliance.org)

### Works Cited:

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