8. Financial Modeling for Off-Grid Solar

Foundations of Off-Grid Solar in Haiti

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Overview

Foundations of Off-Grid Solar in Haiti

1. Basics of Electricity, Energy Access, and Off-grid Solar
2. Key Products and Quality Assurance for Off-grid Solar
3. Market Potential for Off-grid Solar in Haiti
4. Understanding Off-Grid Solar Customers
5. Designing and Modeling Off-Grid Solar Systems
6. Installation, Operations, and Maintenance of Off-Grid Solar Systems
7. Elements of Business Models for Off-Grid Solar
8. Financial Modeling for Off-grid Solar
9. Gender and Off-Grid Solar
10. Productive Use of Energy
11. Climate Adaptation and Resilience

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Overview

The objectives of this module are to provide an overview and key resources/tools for understanding:

- What are the basic components of an off-grid solar financial model? (Go Section)
- How to use the simplified solar financing model? (Go Section)
- Where can I find additional training materials for off-grid solar financial models? (Go Section)

What are the basic components of an off-grid solar financial model?

Introduction

- USAID has developed a comprehensive training material on solar financial model tools which should be viewed to develop an in-depth understanding of off-grid solar financial modeling, particularly for company-level financial modeling of solar home systems and tier 1 lighting products

- This module instead utilizes **a simplified project-level off-grid solar financial model** to illustrate basic concepts for consideration when evaluating the customer cost savings and payback year of shifting from a diesel genset to a larger stand-alone solar system.

- This simplified financial model has been designed to be user-friendly, enabling users to easily input different variables and immediately see the potential financial impacts of making the switch.

Components Covered in this Section

Energy Usage Basics

- Annual Energy Usage (kWh)
- Annual Fuel Usage Liter (L)
- Generator Utilization

Costs

- Off-grid PV Capital Expenditure
- Off-grid PV Operating Cost
- Diesel Genset Operating Cost

Off-grid Solar Savings

- Total Cost Before/After Off-Grid PV adoption
- Inflation and Discount Rate

Key Results

- Business as Usual Cash Flow
- Optimal Case Cash Flow
- Net Present Value
- Payback Year

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Energy Usage Basics

Energy Usage

Customers may specify the energy usage by kilowatt hour (kWh) or Liter (L).

Annual Energy Usage (kWh) = Jan Energy Usage + Feb Energy Usage + ... + Dec Energy Usage

Annual Fuel Usage (Liter) = Jan Fuel Usage + Feb Fuel Usage + ... + Dec Fuel Usage

To convert fuel usage to energy usage.

Energy Usage (kWh) = Fuel Usage (L) x Energy Density (L/kWh)

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Energy Usage Basics

Generation Utilization

Customers may estimate their energy usage based on the size and performance of the generation set.

Diesel Energy Usage (kWh/month) = **Apparent Power Capacity (kVa)** x **Power Factor (%)** x **Operation Hours/day** x **Number of Days/month**

Solar Energy Usage (kWh/month) = **Solar Capacity (kW)** x **Operation Hours/day** x **Number of Days/month**

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Solar Capital Expenditures

In the off-grid solar model, capital expenditures (CAPEX) are the costs to purchase and install the solar equipment, including the cost for the solar PV panels, battery, inverters, charge controller, distribution box, balance of system cost, and other general costs. In some cases, the developer may also allocate a certain development fee to the customer.

In a more complicated model, CAPEX may include funds to acquire or maintain assets such as property, technology, or equipment.

CAPEX = Solar PV Cost + Battery Cost + Inverter Cost + Charge Controller Cost

+ Distribution Box Cost + Balance of Systems Cost + General Cost + % of Development fee

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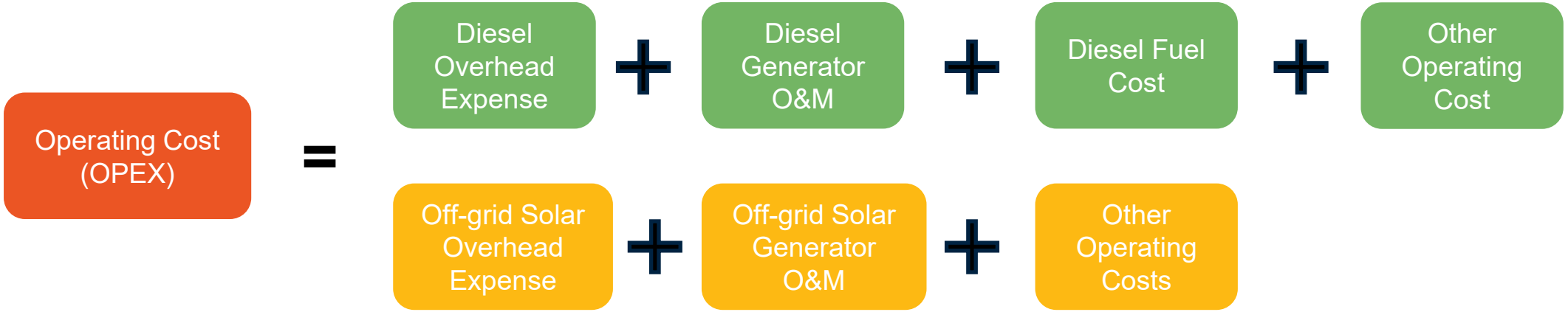
Operating Costs

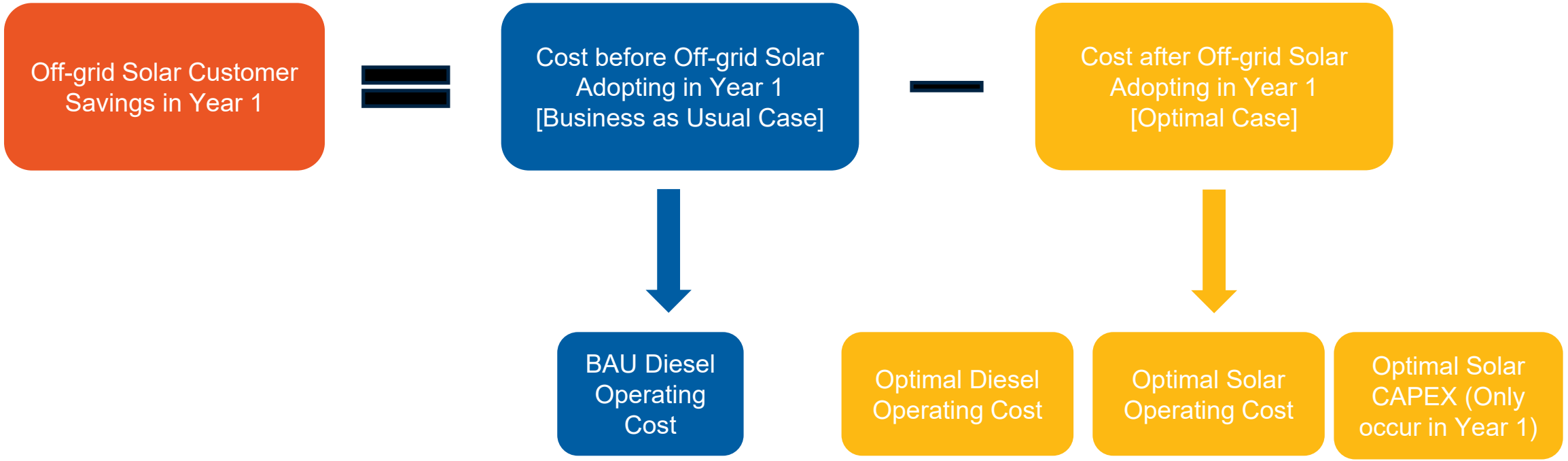
Both diesel and off-grid solar systems also have operational expenses. Operating costs associated with diesel fuel include expenditures for fuel procurement and the operation and maintenance (O&M) of generators. Similarly, off-grid solar systems have their own set of operating costs, which include overhead expenses and O&M costs.

Developers may also apportion pre-development expenses to customers, categorizing them as 'other operating costs' as per the defined terms.



Off-Grid Solar Customer Savings

The customer savings of adopting off-grid solar refer to the difference between costs **before** adoption of off-grid solar and the costs **after** adopting off-grid solar.



In order to determine the profit for Year N, we must also consider macroeconomic factors.

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Inflation

General Cost Inflation (national rate) is the average increase in prices over time. It is often expressed as a percentage and is a key economic indicator for assessing the impact of inflation on an economy.

- For example, if you spend $100,000 on raw materials this year, with a 3% inflation rate, you might need to budget $103,000 for the same materials next year due to inflation.

Discount Rate

Discount Rate is the interest rate used to calculate the present value of future cash flows for an investment. The discount rate reflects the time value of money, which recognizes that a dollar received in the future is worth less than a dollar received today due to factors like inflation and the opportunity cost of not having that money available for investment elsewhere.

The formula for calculating the **present value in year n (Vn)** of a **future cash flow in year n (FVn)** using a **discount rate (r)** and a specific **time period (n)** is as follows:

$$Vn = \frac{FVn}{(1+r)^{N}}$$

For example, if the future costs in year 3 are $1,000 and the discount rate is 3%

$$\text{Present Value in Year 1} = \frac{\$\ 1{,}000}{(1+3\%)^{3}} = \$\ 915$$

Solar Financing Model Result

There are two main results from the model that help to evaluate whether adopting off-grid solar can reduce customer costs.

Net Present Value (NPV) assesses the profitability and financial feasibility of investments or projects by considering the time value of money and comparing the present value of cash inflows to cash outflows. **Positive NPV** generally indicates a financially attractive opportunity, while **Negative NPV** suggests caution or reconsideration.

Payback Year is the first year when the cumulative off-grid solar customer savings are greater than 0. For instance, if the cumulative savings are positive in year 8, it takes 8 years for this project to recover its initial cost through the cumulative cash flows it generates.

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How to use the simplified solar financing model?

How Does the Simplified Model Work?

Step 1

Select the model feature to use based on customer's energy consumption or fuel utilization.

Step 2

Enter fuel usage, energy consumption of diesel genset business as usual setting.

Step 3

Define the off-grid solar system configuration and contribution in the optimal case.

Step 4

Define the off-grid solar system CAPEX.

Step 5

Define the development fee allocated to customers.

Step 6

Define the diesel and off-grid solar operating costs.

Step 7

Define inflation and discount rate.

Step 8

Run model cash flow, customer savings, NPV, and payback year.

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Step 1. Understand the Energy Usage Portfolio

The simplified model asked a few questions in the beginning to understand the customer's energy usage portfolio before replacing diesel fuel and adopting off-grid solar.

Question 1	
Do you know your or your customer's current monthly energy consumption in kWh?	Yes
Question 2	
Do you know your or your customer's current diesel genset size, operation hours, and days per month?	Yes
Question 3	
Do you know your or your customer's monthly or annual current diesel fuel usage in liters?	Yes

Question 1: Yes

- Modeling based on the actual/modeled monthly energy consumption (kWh). Enter monthly energy consumption (kWh) and fuel energy density (L/kWh) to generate the diesel usage (Liter) baseline.

Question 2: Yes

- Modeling based on the diesel genset utilization. Enter the genset capacity (kW), monthly operation time (day/month), operation hours (h), and fuel energy density (L/kWh) to estimate the diesel usage (Liter) baseline.

Question 3: Yes

- Modeling based on the actual/modeled monthly diesel usage (liter) and energy density directly.

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Step 2. Business as Usual Energy Utilization

- Based on the user's answer in Step 1, enter the fuel usage and genset settings to set the business as usual (BAU) case before adopting off-grid solar.

- An example for users that answered "Yes" is shown in the second question in Step 1 below. Overall, we will have the BAU energy total (kWh) and diesel usage (Liter).

Selected Model, Please Enter the Inputs		
Actual Modeled Genset Utilization by Existing Genset		
Apparent power of the genset	*kVA*	3.00
Power factor	*#*	0.8
Active POWER	*kW*	2.40
Operation hours	*h/day*	10
Number of days per month	*#, Average*	30
Energy Density	*L/kWh*	10.00
Energy Total	*kWh*	8640
Diesel Usage	*Liter*	864

Step 3. Sizing Off-Grid Solar (1/3)

- Users define what percentage of annual energy consumption the off-grid solar system will support.
- For example, if users want 65% of energy consumption to come from off-grid solar, the energy usage from existing diesel genset will decrease to 35%.

Question to Answer	
At what % in kWh of annual energy consumption do you want the new Off-grid solar support	65.0%
Based on the solar contribution, the existing genset will contribute to % of energy consumption	35.0%

The Generation Mix Setting

Genset Type	Contribution %	Contribution kWh
New Off-grid Solar	65.0%	5616
Existing Diesel Fuel	35.0%	3024

- The model will populate the off-grid solar and diesel fuel generation mix as the optimal case automatically.

Step 3. Sizing Off-Grid Solar (2/3)

- The business-as-usual diesel usage is 864 liters

Diesel Usage	*Liter*	864

- The table below shows the optimal case results of the diesel usage and solar genset to make the off-grid solar contribute to 65% of total energy usage, as defined in step 2.

Diesel Usage	L/year	302
Solar Genset	kVA	2.56
Modeled Gen Mix: From Solar	kWh	5,616.00
Modeled Gen Mix: From Diesel	kWh	3,024.00
Total Energy Usage	kWh	8,640.00
Modeled Gen Mix: From Solar	%	65.0%
Modeled Gen Mix: From Diesel	%	35.0%

Step 3. Sizing Off-Grid Solar (2/3)

- The next step is to finish the settings of the **off-grid solar system**.
- Users may consider pairing off-grid solar with battery. However, users need to add the size of the inverter, charger controller, and other attributes.
- To determine the off-grid photovoltaic (PV) size, users also need to specify the solar operation hours and number of days in operation.

Modeled Energy Consumption from Solar Genset		
Solar PV	*kWp*	2.56
Battery	*kWh*	1.00
Inverters	*kVA*	1.00
Charge Controller	*kWp*	1.00
Distribution Box	#	1.00
Balance of Systems	#	1.00
Solar Operation hours	*h/day*	6.00
Solar Number of days	#	365

Step 4. Defined Off-Grid Solar CAPEX

- In this section, users can enter the CAPEX of off-grid solar. For example, how much does it cost for solar PV per kWp, and how much does it cost for a paired battery per kWh.

- There are no CAPEX for diesel gensets because they have been built already.

Cost During Solar Intallation (CAPEX)

	Off-grid Solar Genset Cost Per Unit		
	Unit	USD	HTG
Solar PV	*Cost/kWp*	750.00	103,500
Battery	*Cost/kWh*	300.00	41,400
Inverters	*Cost/kVA*	750.00	103,500
Charge Controller	*Cost/kVA*	250.00	34,500
Distribution Box	*Cost/kWp*	200.00	27,600
Balance of Systems	*Cost/#*	100.00	13,800
General Costs	*Cost/#*	40.00	5,520
Total Installation Cost			

Step 5. Development Fee Allocates to Customer

- Sometimes, developers may allocate additional costs for the off-grid solar to customers. In this model, enter the percentage of the solar CAPEX to represent the development fee. In some cases, customers are allowed to lease the solar panel. This model assumes only a one-time upfront payment for 100% solar costs is available.

- The chart below shows a 5% allocation fee example. In this case, besides paying the CAPEX as a one-time upfront cost, the customer needs to pay 5% of CAPEX as a development fee for installing the off-grid solar.

One-time Payment		
	Unit	Customer Pay
One-time Upfront Cost	HTG/system	491,734
Development for Solar Development (% of Solar Installation)	%	5.0%
Development Fee	HTG	24,587

Step 6. Operating Costs

- For a diesel system, there are operating costs from 1) fuel consumption (diesel fuel cost per liter * the total diesel volume) and 2) overhead, O&M, and other costs.

Diesel Set		USD	HTG
Diesel Fuel Cost (per Liter)	*HTG/L*	1.00	138
Overhead	*Cost*	10	1,380
Generator O&M	*Cost*	10	1,380
Other Operating Costs	*Cost*	10	1,380
Total	*Cost*		45,871

- For a solar system, there are no fuel costs, however there are O&M costs.

Solar Set		USD	HTG
Overhead	*Cost*	100	13,800
Generator O&M	*Cost*	100	13,800
Other Operating Costs	*Cost*	100	13,800
Total	*Cost*		41,400

Step 7. Inflation and Discount Rate

- Users can define the cost inflation rate and discount rate in this section.
- The simplified model ignored the depreciation. For more depreciation calculation, see [USAID Off-Grid Clean Energy Financial Modeling Bootcamp.]

Inflation

General Cost Inflation (National Rate)	*%/year*	3.00%

Discount Rate

Discount Rate	*%*	4.00%

Step 8. Dashboard Result (1/2)

- The first section of the dashboard displays the composition of the system's energy generation in both business-as-usual (BAU) and optimal scenarios.
- This section compares:
  - The diesel usage in BAU and optimal cases
  - The solar capacity in BAU and optimal cases
  - The generation mix in BAU and optimal cases.

Your Business as Usual (BAU) Case Outputs

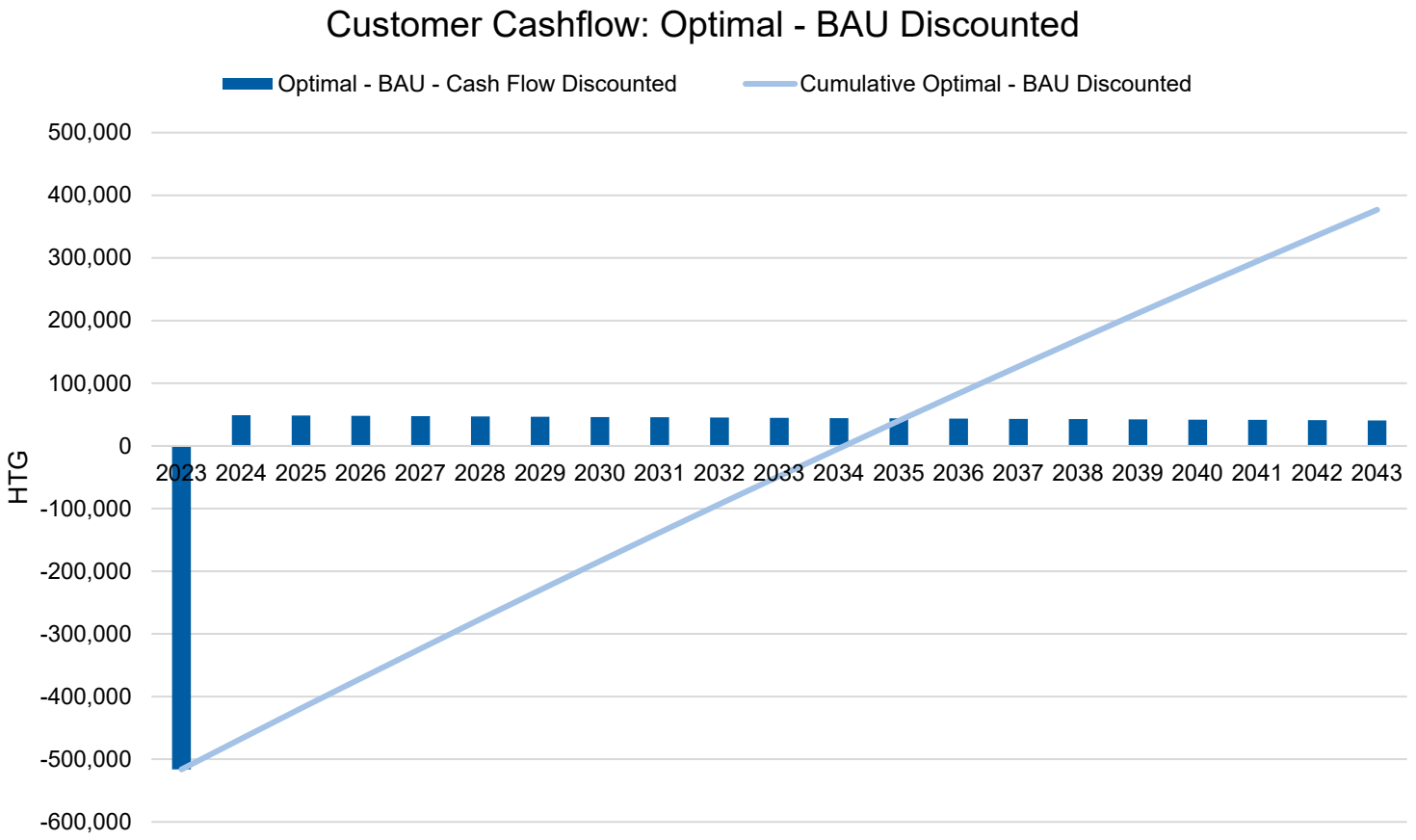
Diesel Usage	L/year	864.00
Solar Genset	kVa	0.00
Gen Mix: From Solar	kWh	0.00
Gen Mix: From Diesel	kWh	8,640.00
Total Energy Usage	kWh	8,640.00
Gen Mix: From Solar	%	0.0%
Gen Mix: From Diesel	%	100.0%

Your Optimal Case Outputs

Diesel Usage	L/year	302.40
Solar Genset	kVA	2.56
Modeled Gen Mix: From Solar	kWh	5,616.00
Modeled Gen Mix: From Diesel	kWh	3,024.00
Total Energy Usage	kWh	8,640.00
Modeled Gen Mix: From Solar	%	65.0%
Modeled Gen Mix: From Diesel	%	35.0%

Step 8. Dashboard Result (2/2)

- The second section of the dashboard displays the NPV and payback year by adopting off-grid solar.
- NPV refers to the lifecycle customer savings:
  - Lifecycle BAU Costs – Lifecycle Optimal Costs
- Payback year is 12, which means it takes 12 years to make true cumulative customer savings positive.



Customer Revenue

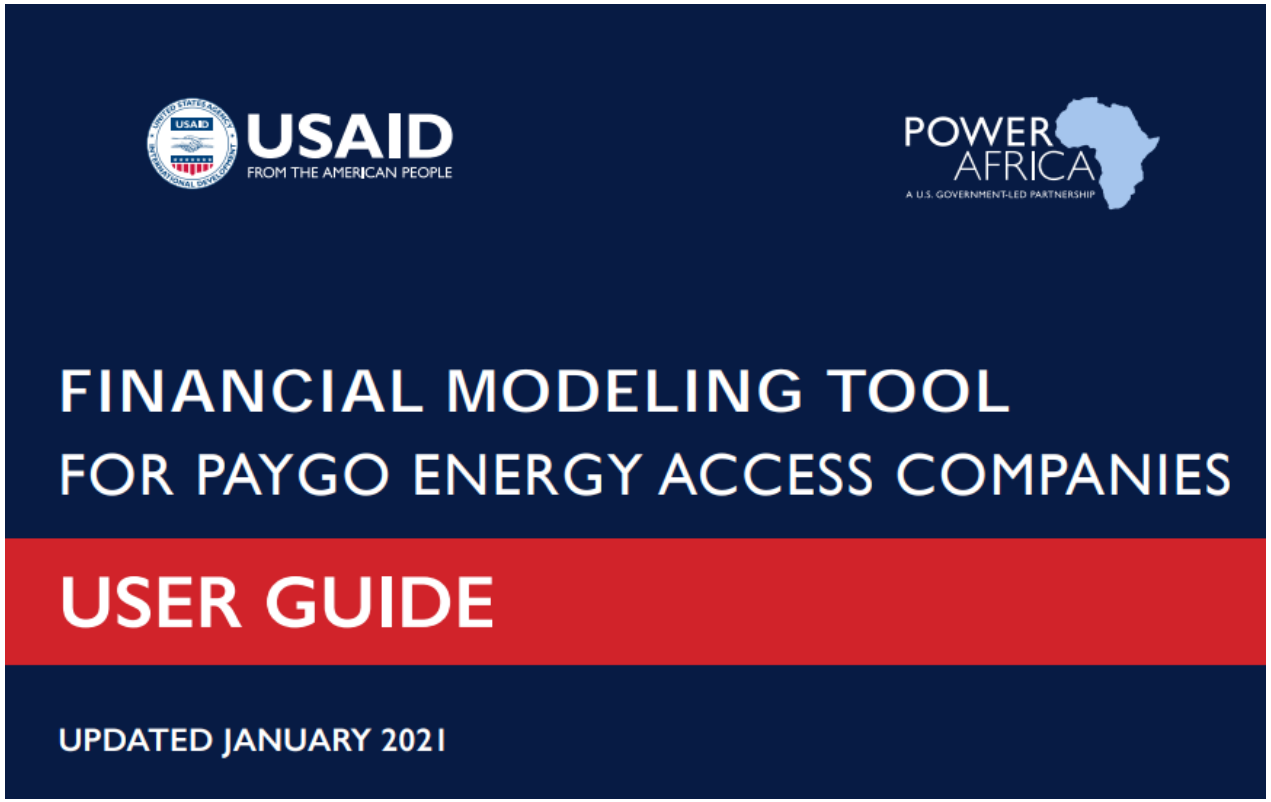
NPV: BAU LLC - Optimal LCC	HTG	376,823.03
Payback Year	Year	12

Where can I find additional training materials for off-grid solar financial models?

USAID Off-Grid Solar Business and Financial Models

USAID has developed a number of tools and documents to support off-grid solar financial modeling including:

- Business Model Tool for PAYGO Companies
- Financial Modeling Tool for PAYGO Companies
- User guide for Financial Modeling Tool
- Webinar for Financial Modeling Tool
- Financial Modeling Lessons Learned
- Additional Off-grid solar resources.



Source: USAID Financial Modeling Tool

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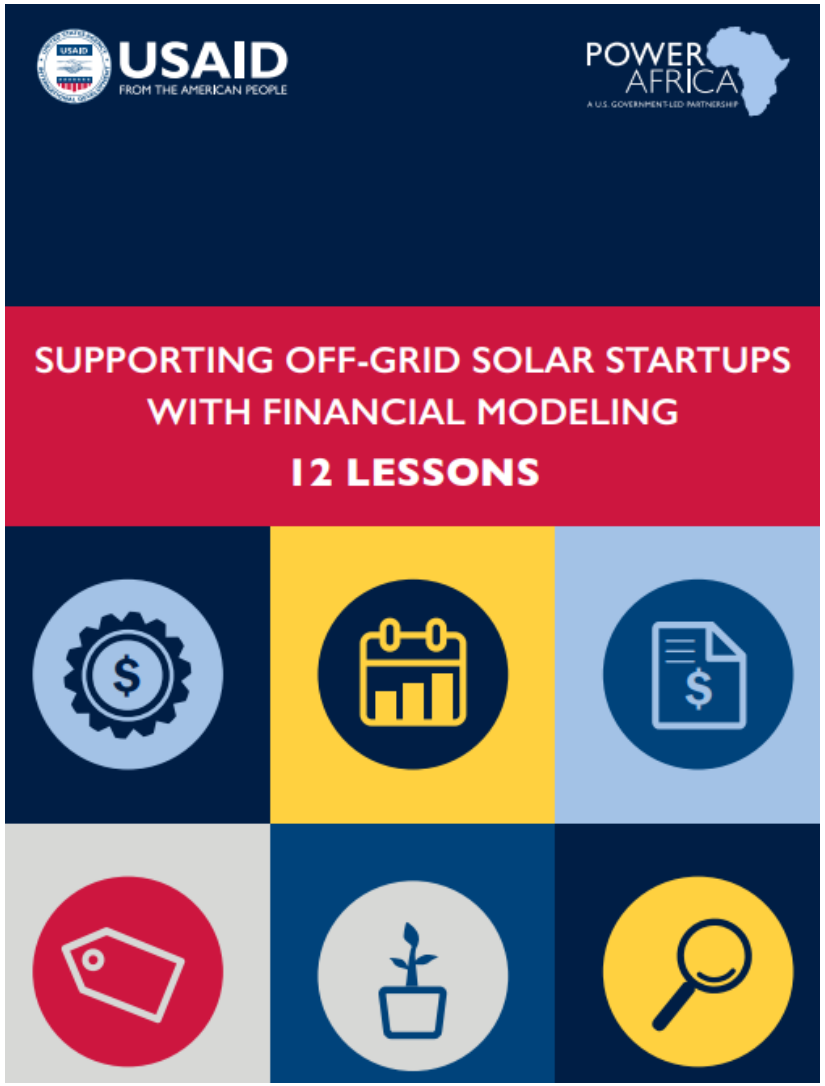
USAID Financial Modeling Lessons

- Based on off-grid solar companies in Africa, USAID has developed a series of financial modeling lessons.



CONTENT

Source: [USAID Supporting Off-Grid Solar Startups with Financial Modeling]

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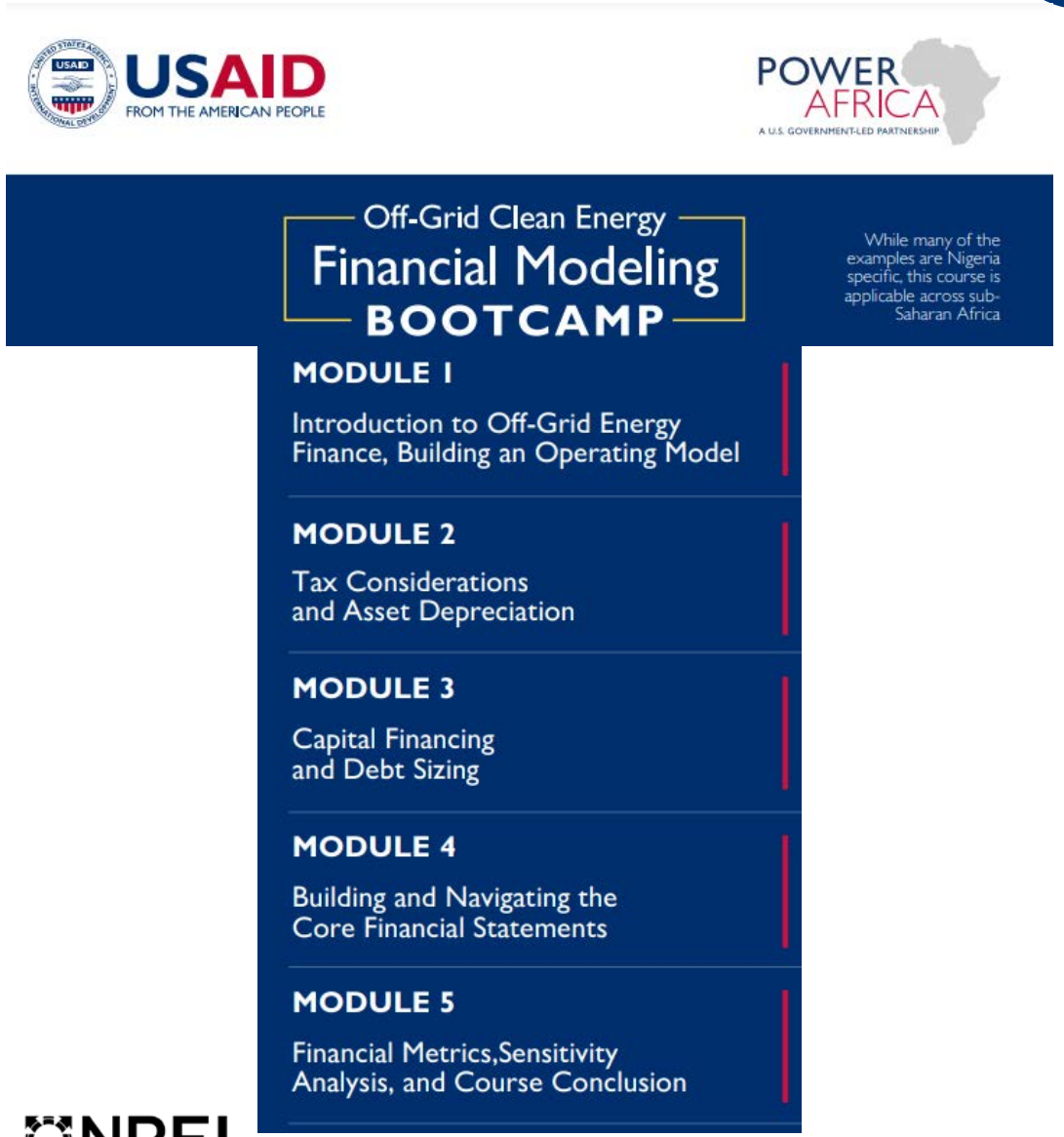
USAID Financial Modeling Bootcamp

- To augment the initial training from the simplified financial model above, it is suggested to review the USAID Financial Modeling Bootcamp, which covers development of financial models in more depth.
- 5 modules include recorded presentations, example comprehension assignments, and full slide decks covering full financial model considerations.
- The bootcamp is focused on Nigeria but the concepts are adaptable and relevant for the Haiti context.
- Take the bootcamp and explore the individual module content linked in the following slides.



Source: USAID Nigeria Financial Modeling for Off-Grid Energy Bootcamp

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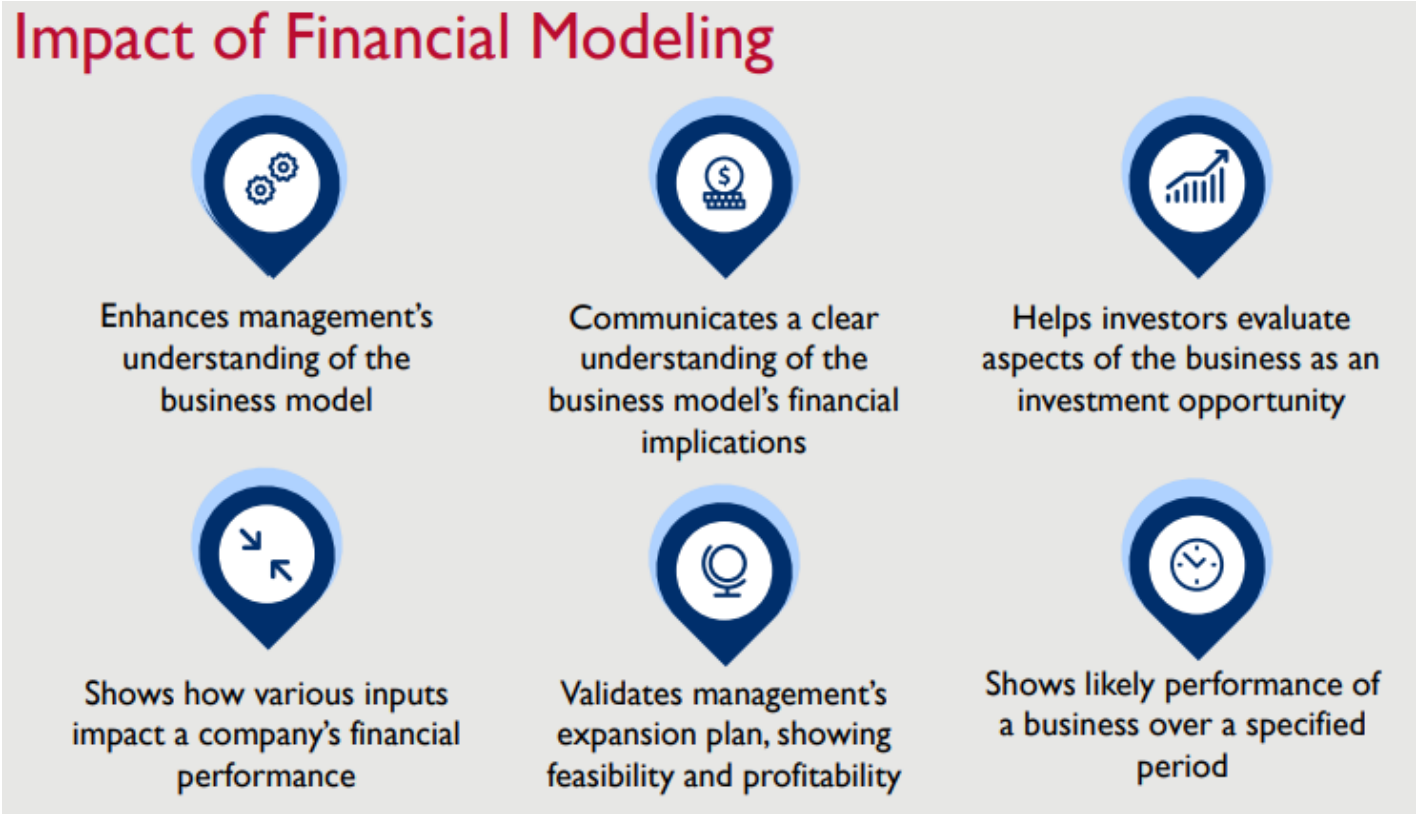
Module 1 – Introduction to Off-Grid Energy Finance, Building a Model

Provides an overview of off-grid energy finance and financial modeling concepts, including a discussion of key inputs and components of financial models.

- Webinar recording
- Example Assignment (instructions)
- Example Assignment (template)
- PDF of slides (slides 21 – 48).



Source: USAID Nigeria Financial Modeling for Off-Grid Energy Bootcamp

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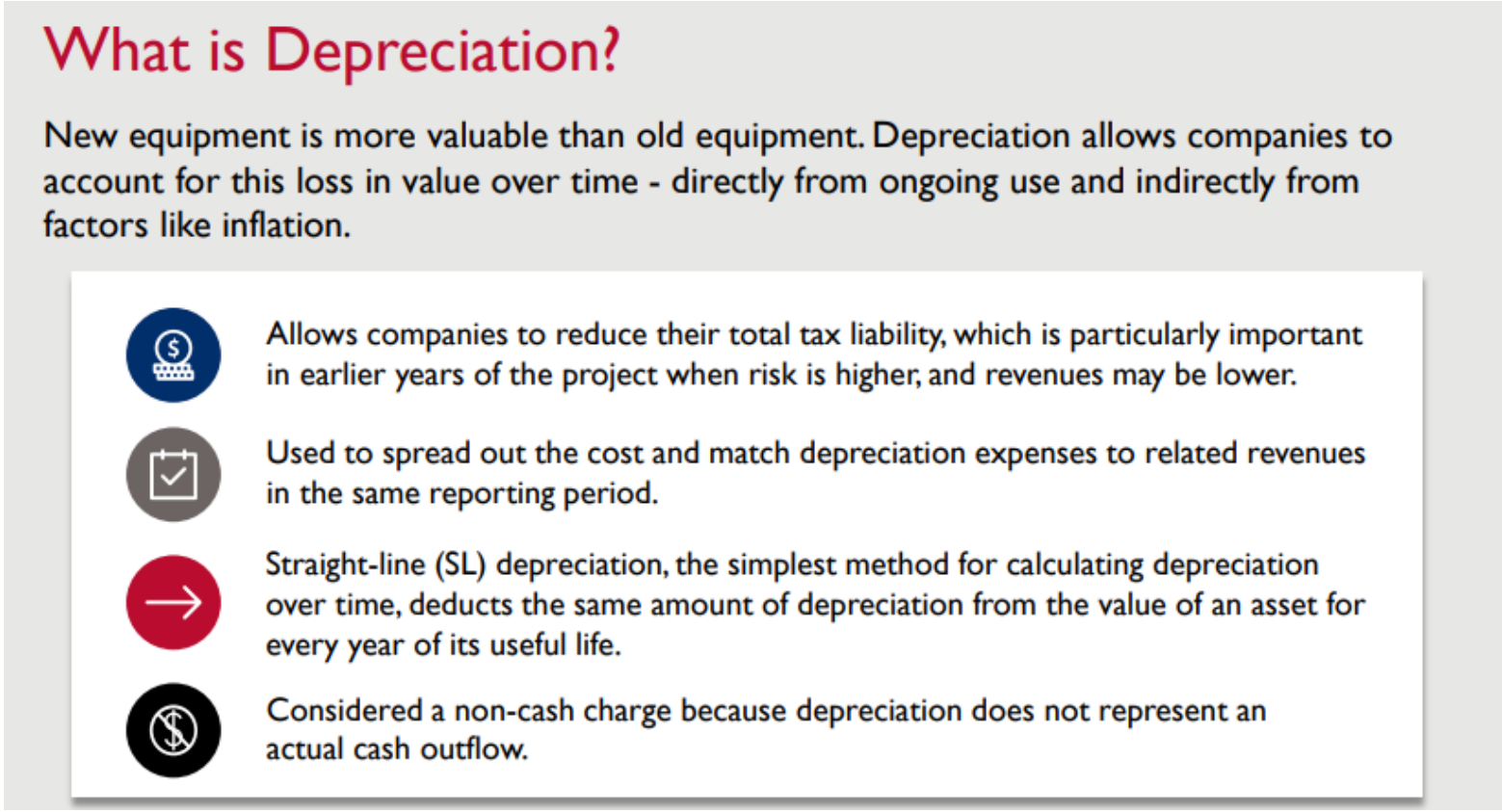
Module 2 – Tax Considerations and Asset Depreciation

How is asset depreciation defined and calculated and what impact does it have on taxes and financial model flows?

- Webinar recording
- Example Assignment (instructions)
- Example Assignment (template)
- PDF of slides (slides 9 – 28).



Source: USAID Nigeria Financial Modeling for Off-Grid Energy Bootcamp

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Module 3 – Capital Financing and Debt Sizing

Overview of project capital financing, debt financing, debt schedules, and ways in which these elements are integrated into financial modeling.

- Webinar recording
- Example Assignment (instructions)
- Example Assignment (template)
- PDF of slides (slides 11 – 40).

Types of Capital for Project Level Financing (cont'd)

	Project Grants	Project Equity	Project Debt (Concessional)	Project Debt (Market Rate)	Credit Enhancements
Risk Profile	**High** (*particularly market risk*)	**High**	**Medium**	**Low**	**High**
Return Expectations	Results / Impact	High	Medium	Low	Fixed Fee
Seniority	N/A	Low	Medium	High	N/A
Description	**"Free money"** provided by foundations and development finance institutions (DFIs).	**Equity** sourced from private investors, impact investors, asset managers in exchange for ownership.	**Loans with preferential terms** (e.g., below market rates) sourced from public FIs or DFIs.	**Market rate debt** sourced from commercial banks, equity or impact investors, DFIs, and multilateral institutions.	**Investment protection** such as political risk insurance, credit enhancements, credit guarantees, etc.

Source: USAID Nigeria Financial Modeling for Off-Grid Energy Bootcamp

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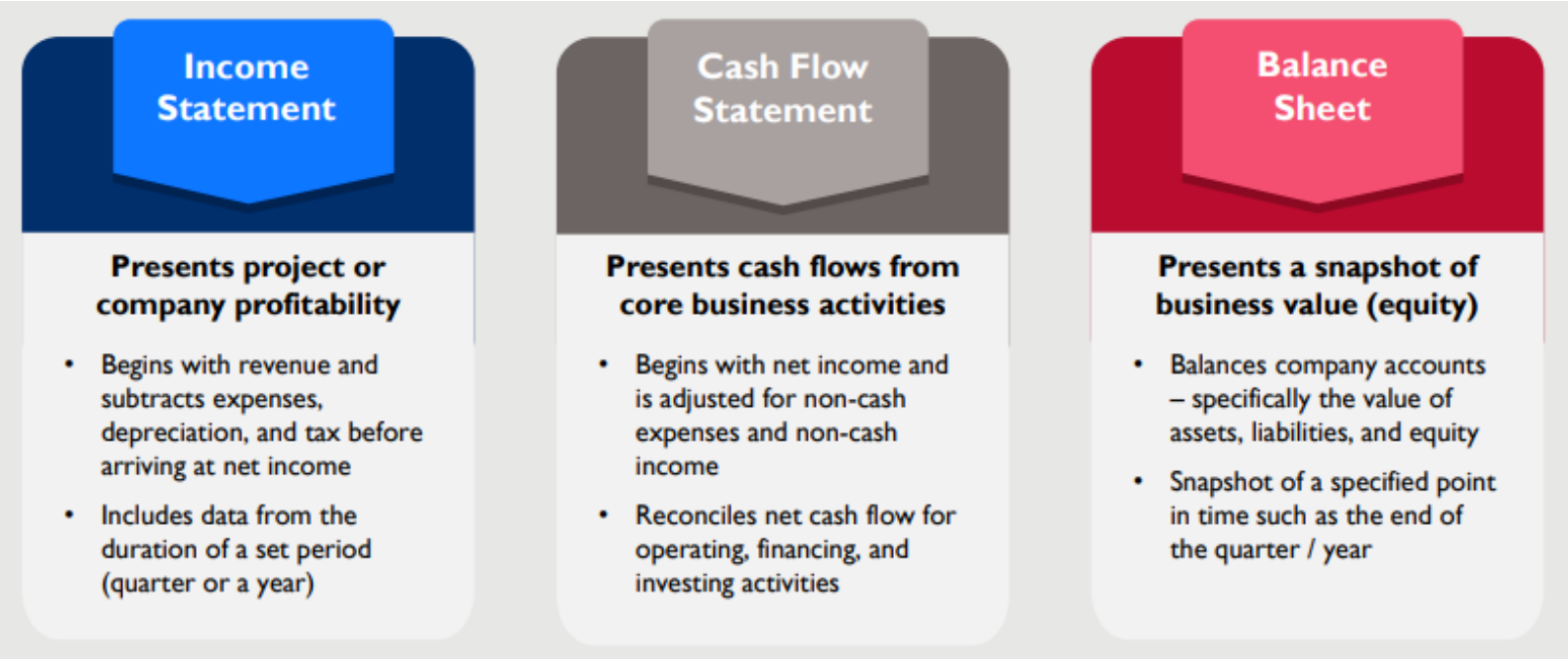
Module 4 – Core Financial Statements

Understanding financial statements, financial analysis, and financial accounting.

- Webinar recording
- Example Assignment (instructions)
- Example Assignment (template)
- PDF of slides (slides 9 – 28).

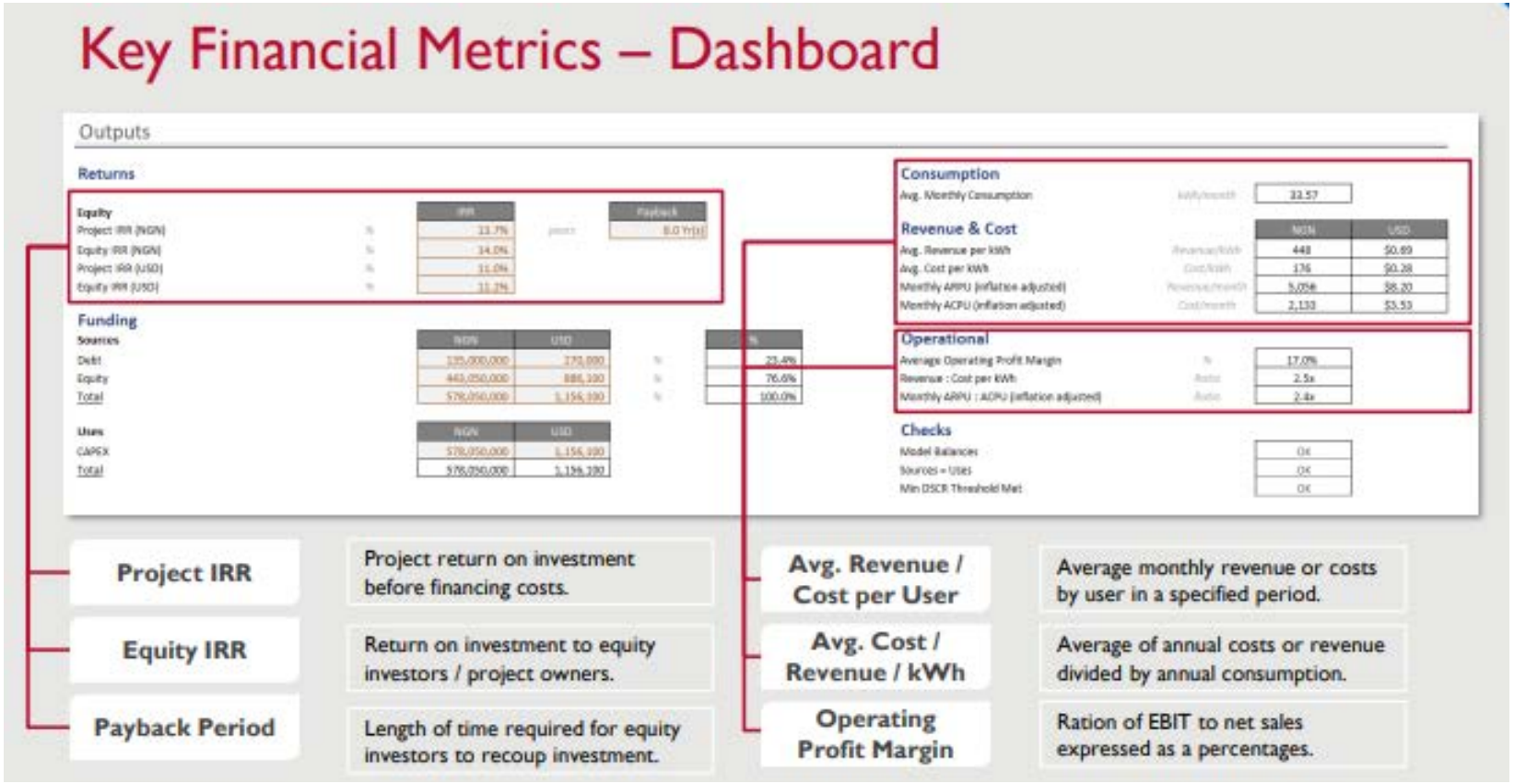


Source: USAID Nigeria Financial Modeling for Off-Grid Energy Bootcamp

Module 5 – Financial Metrics and Sensitivity Analysis

Understanding financial statements, financial analysis, and financial accounting.

- Webinar recording
- PDF of slides (slides 14 – 37).



Source: USAID Nigeria Financial Modeling for Off-Grid Energy Bootcamp

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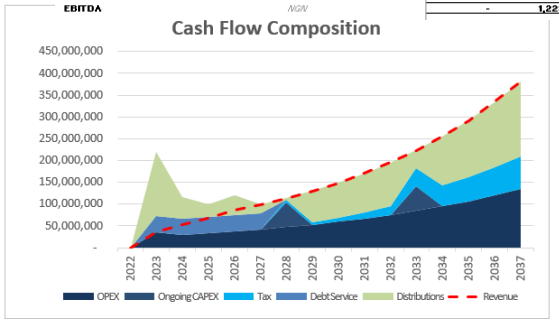
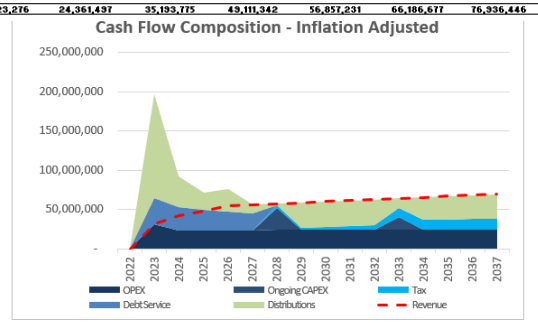
Detailed Financial Model

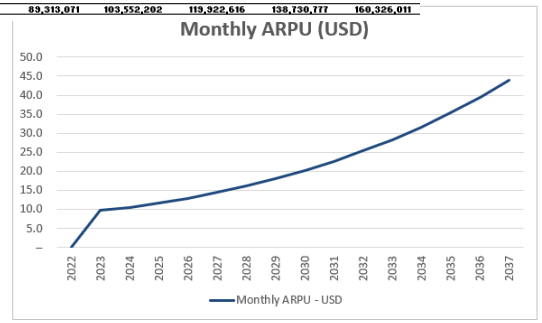
A full example detailed financial model for an off-grid solar company can be found here.

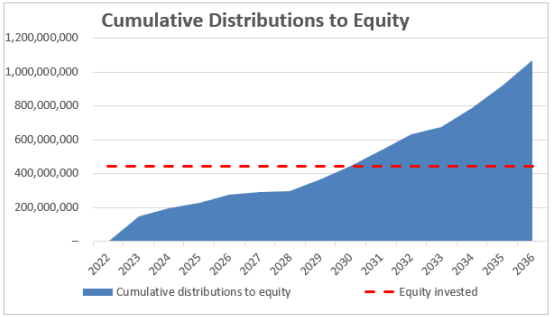
Project Operating Model

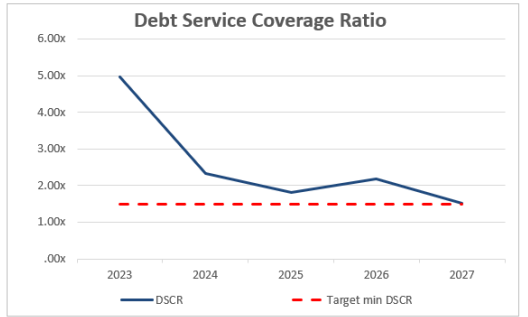
Timing		2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Start date		Jan-22	Jan-23	Jan-24	Jan-25	Jan-26	Jan-27	Jan-28	Jan-29	Jan-30	Jan-31	Jan-32	Jan-33	Jan-34
End date		Dec-22	Dec-23	Dec-24	Dec-25	Dec-26	Dec-27	Dec-28	Dec-29	Dec-30	Dec-31	Dec-32	Dec-33	Dec-34
Inflation escalator		1.00	1.12	1.25	1.40	1.57	1.76	1.97	2.21	2.48	2.77	3.11	3.48	3.90
Depreciation rate		500	513	525	538	552	566	580	594	609	624	640	656	672
Construction flag		1	-	-	-	-	-	-	-	-	-	-	-	-
First year flag		1	-	1	1	1	1	1	1	1	1	1	1	1
Operations flag		-	1	1	1	1	1	1	1	1	1	1	1	1
Operations period count		-	1	2	3	4	5	6	7	8	9	10	11	12
Income Statement														
Revenue														
Tariff	NGN	-	33,058,861	50,848,936	65,335,766	84,375,663	97,101,681	111,666,933	128,329,582	147,383,262	169,161,879	194,045,046	222,464,242	254,909,736
Connection Revenue	NGN	-	2,400,000	800,000	400,000	400,000	-	-	-	-	-	-	-	-
Fixed Charges	NGN	-	3,360,000	5,017,600	6,322,176	7,867,597	8,811,708	9,869,113	11,053,407	12,379,816	13,865,394	15,529,241	17,392,750	19,479,880
Total revenue	NGN	-	38,818,861	56,666,536	72,057,942	92,643,260	105,913,389	121,536,047	139,382,989	159,763,078	183,027,273	209,574,287	239,856,992	274,389,616
Total revenue net VAT	NGN	-	36,110,568	52,713,057	67,066,783	86,179,777	98,524,083	113,056,787	129,658,594	148,616,816	170,251,929	194,952,825	223,122,783	255,246,210
Operating costs														
Site Operational Costs (total)														
Project Development Cost	NGN	-	10,395,000	-	-	-	-	-	-	-	-	-	-	-
Diesel Fuel	NGN	-	1,624,000	1,818,880	2,037,146	2,281,603	2,555,395	2,862,043	3,205,488	3,590,147	4,020,964	4,503,480	5,043,897	5,649,165
Generator O&M	NGN	-	2,800,000	3,136,000	3,512,320	3,933,798	4,405,854	4,934,557	5,526,704	6,189,908	6,932,697	7,764,621	8,696,375	9,739,940
Collection Fees	NGN	-	2,708,293	3,953,479	5,029,159	6,463,483	7,389,306	8,479,259	9,724,335	11,146,261	12,769,345	14,621,462	16,734,209	19,143,466
Other operating costs	NGN	-	4,480,000	5,017,600	5,619,712	6,294,077	7,049,367	7,895,291	8,842,726	9,903,853	11,092,315	12,423,393	13,914,200	15,583,904
Total	NGN	-	22,007,293	13,925,959	16,198,336	18,972,962	21,399,923	24,171,149	27,299,312	30,830,168	34,815,321	39,312,955	44,388,681	50,116,475
Overhead Costs														
Salary Managing Director	NGN	-	8,400,000	9,408,000	10,536,960	11,801,395	13,217,563	14,803,670	16,580,111	18,569,724	20,798,091	23,293,862	26,089,125	29,219,820
Management and technical staff	NGN	-	2,240,000	2,508,800	2,809,856	3,147,039	3,524,683	3,947,645	4,421,363	4,951,926	5,546,158	6,211,696	6,957,100	7,791,952
Accounting	NGN	-	560,000	627,200	702,464	786,760	881,171	986,911	1,105,341	1,237,982	1,386,539	1,552,924	1,739,275	1,947,988
Travel and vehicle costs	NGN	-	560,000	627,200	702,464	786,760	881,171	986,911	1,105,341	1,237,982	1,386,539	1,552,924	1,739,275	1,947,988
Office costs	NGN	-	560,000	627,200	702,464	786,760	881,171	986,911	1,105,341	1,237,982	1,386,539	1,552,924	1,739,275	1,947,988
Company insurance	NGN	-	280,000	313,600	351,232	393,380	440,585	493,456	552,670	618,991	693,270	776,462	869,637	973,994
Other	NGN	-	280,000	313,600	351,232	393,380	440,585	493,456	552,670	618,991	693,270	776,462	869,637	973,994
Total	NGN	-	12,880,000	14,425,600	16,156,672	18,095,473	20,266,929	22,698,961	25,422,836	28,473,577	31,890,406	35,717,254	40,003,325	44,803,724
EBITDA	NGN	-	**1,223,276**	**24,361,497**	**35,193,775**	**49,111,342**	**56,857,231**	**66,186,677**	**76,936,446**	**89,313,071**	**103,552,202**	**119,322,616**	**138,730,777**	**160,326,011**

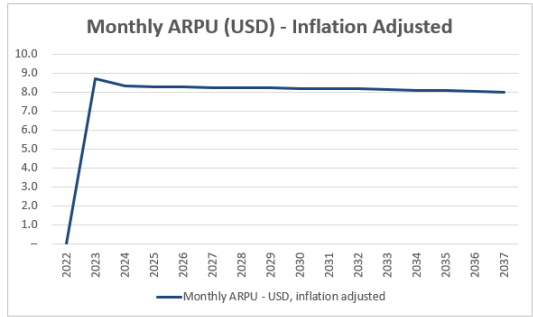












Source: USAID Nigeria Financial Modeling for Off-Grid Energy Bootcamp

Thank you

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