

Incentives for renewable energy investments through PPA contracts in Panama

Introduction to PPA Assessment Tool

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24 MAY 2018
IRENA PPA MODEL

COWI



Who am I?



- > Gabriel Zeitouni
- > M.Sc. Sustainable Energy – Wind Power Line – DTU
- > 5 years at COWI A/S
- > Focused on wind & solar projects worldwide
- > Prior to PPA modelling, worked with IRENA on developing "Innovative Site Appraisal Models (SAM) for wind, solar and solar-hybrid projects"

Agenda

- › Session one: Introduction to PPA Assessment Tool
 - › Project Background, Scope & Methodology
- › Session two: Training
 - › Simulating various PPA contracts and tactics towards the contract
- › Sessions three: Training
 - › Performing sensitivity analysis of uncertain inputs and logging results

Background

- > Panama targets +70% of RE by 2050
- > High level of RE connection requests (1.5 GW), but low wind and solar implementation suggests **lack of enabling investment environment** i.e. insufficient returns for projects
- > PPA design is focused on dispatchable plants, requiring RE projects to procure energy in the market in order to fulfil contract terms

Project scope

Threefold:

- > Assessment of current economics for wind and solar PV under current PPA contracts
- > Identification of potential alternative PPA contracts
- > Assessment of economic implications of amended PPA contracts

Methodology

1. Successful bids from past auctions are selected to be replicated i.e. incl. location, technology, granted tariff, committed energy level, etc.

TECHNOLOGY	AUCTION DATE	OFFER NUMBER	INSTALLED CAPACITY
Solar	2014	24	21 MWp
Wind	2011	7	62.5 MW

Methodology

2. With IRENA's Site Appraisal Model (SAM), the potential energy production of the selected projects is estimated (P90), with an **hourly resolution**

SOLAR-PV PANEL	
Model	Monocrystalline
Nominal Power at STC*	250 Wp
Efficiency at STC	15.46%
Module area	1.627 m ²
WIND TURBINE	
Model	GW109/2500
Rated Power	2.5 MW
Hub height	90m

	SOLAR	WIND
SOURCE	VORTEX	VORTEX
RESOLUTION	Hourly	Hourly
INCLINATION / HEIGHT	Optimally inclined at 15°	90m
LONGITUDE	-80.551116°	-80.366381°
LATITUDE	8.267150°	8.435972°
AVG. RESSOURCE	Global Incident Irradiation on the tilted coll. plane: 1,834 kWh/m ²	Mean wind speed: 6.9 m/s

Methodology

2. With IRENA's Site Appraisal Model (SAM), the potential energy production of the selected projects is estimated (P90), with an **hourly resolution**

AEP ESTIMATE FOR 25 WTGS WITH 90 M HUB HEIGHT		
Annual Gross Energy Production for 25 WTGs		231.3 GWh/y
Wake Loss	5.0%	11.6 GWh/y
Annual Park Production for 25 WTGs		219.8 GWh/y
Combined Loss and Corrections on AEP	16.0 %	36.9 GWh/y
NET ANNUAL PRODUCTION FOR 25 WTGS (P50)		194.4 GWh/y
Full load hours		3,110 h/y
Capacity Factor		35.5 %
Estimated uncertainty (standard deviation)	9.2 %	17.8 GWh/y
50% probability for an average annual net production of at least (P50)		194.4 GWh/y
90% probability for an average annual net production of at least (P90)		171.5 GWh/y

ARRAY NOMINAL AEP AT STC		38,673 MWh/y
Loss due to temperature and radiance level	9.0%	3,499 MWh/y
ARRAY GROSS ANNUAL AEP ESTIMATE		35,175 MWh/y
Combined Loss and Corrections on AEP	20.0%	7,039 MWh/y
ARRAY NET ANNUAL PRODUCTION (P50)		28,136 MWh/y
Yearly Specific Energy Production, after correction and losses		1,342 kWh/kWp
Performance Ratio		83.2%
Estimated uncertainty (standard deviation)	8.4%	2,372 MWh/y
50% probability for an average annual net production of at least (P50)		28,136 MWh/y
90% probability for an average annual net production of at least (P90)		25,095 MWh/y

Methodology

3. Based on:

- › Hourly balance between potential power production and committed energy through PPA contract
- › Project economy assumptions e.g. OPEX and CAPEX
- › Financial assumptions e.g. loan structure and WACC
- › Energy market assumptions e.g. future wholesale electricity prices
- › Current **OR** amended PPA contract specifications. e.g. awarded tariff level, balancing requirements, penalties
- › Tactic towards the PPA contract e.g. Always supply the PPA contract with at least the required minimum (default at 60% of committed energy) energy every hour.

The investment incentive of each project is evaluated through a financial **model** that draws key project financial performance indicators such as IRR, EIRR, DSCR and payback-time.



The PREDICT model

*Panamanian
Renewable
Energy
Development
Incentives
Case study
Tool*

PREDICT in a nutshell

- > Excel based:
 - > Easily amended, also for future development e.g. more technologies, tactics, PPA amendments, etc.
 - > Targeted to non-expert audience, but also experts
- > Simulates generation, wholesale prices and demand on hourly basis based on user inputs
- > Simulates actual PPA bids based on user inputs

PREDICT in a nutshell

- > Allows easy amendment of PPA and financial structuring
 - > senior & subordinate debt structuring, length of PPA contract, capacity & curtailment remuneration, penalties due to delay in construction and energy delivered, taxes, depreciation method, etc.
- > Detailed sensitivity analysis incl. automated plots and tabled data
- > Goal seek function e.g. find tariff that brings IRR equals to WACC

The Predict model

Navigation & Introduction



RE-Investment incentives for wind and solar power

Financial scenario model

Project number: A-039635
Date: 17-May-18
Created by: MHO
Checked by: GAZE
Approved by: GAZE
Version: 3.8

Navigation

Main interface and output

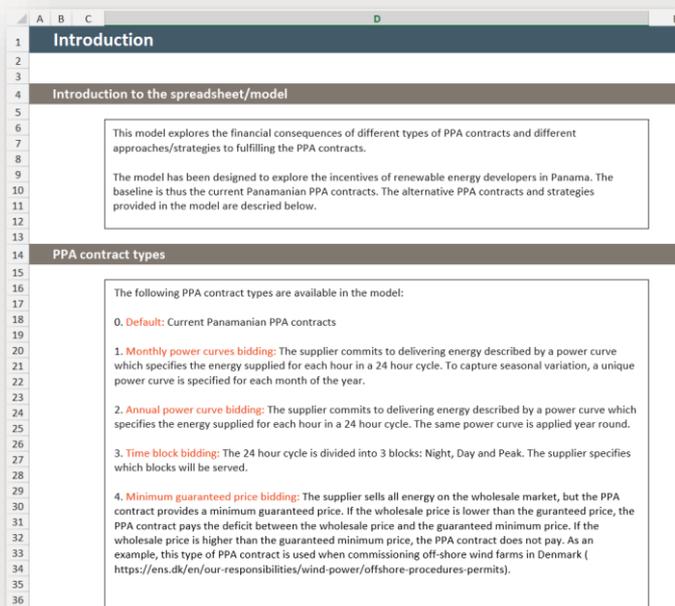
- Introduction** *Gives an introduction to the model*
- User interface & results** *Offers the user a variety of options for customizing input parameters, main*

Input data

- Current PPA** *Inputs on committed power, projected demand, projected capacity and projected*
- Alternative PPA** *Inputs and definitions of alternative PPA contracts*
- Hourly data** *Hourly historical data on energy generation, energy demand and wholesale*

Auxiliary output

- Financing** *A full financial model based on annual figures including cash flows, profit loss*
- Charts** *Charts to visualize and verify input data*
- Sensitivity** *Definition of sensitivity runs and output from sensitivity runs*



User inputs

The screenshot displays the 'User interface & Results' window of the IRENA PPA Model. It is organized into several sections:

- Project type:** Wind turbine (1)
- PPA strategy:** Default (2)
- PPA type:** Current Parana (3)
- Installation:** Nominal capacity MW (62.5), Capacity factor (35%), 1st year of construction (2017), Construction time (3), 1st year of production (2018), Technical life (25.0), Last year of production (2042), Degradation of capacity per year (0.0%).
- PPA contract:** PPA price (USD/MWh) (95.0), Share of PPA tariff corrected for inflation (25%), Min. share of delivered committed energy (60%), Length of PPA contract (15), Underdelivery penalty (% of revenue/year) (5%), Capacity remuneration (USD/MW/month) (0), Firmness factor (% of nominal capacity) (60%).
- Key indicators:** NPV (-3,288,411), Equity NPV (-10,565,238), IRR (9.54%), Equity IRR (13.58%), % of revenue derived from PPA (60%), Minimum Senior DSCR (1.23), Average Senior DSCR (1.86), Break even (years) (10.5), LCOE (USD/MWh) (120.51).
- Hourly data input checks:** Estimated Average AEP (MWh) (187.42), Specific Yield (MWh/MWp) (N/A for wind), Capacity factor (34.2%), Avg wholesale price (USD) (120.51), Avg annual demand (MWh) (8,835.23).
- Investment:** Cat1 (2.00), Cat2 (-), Cat3 (-), Cat4 (-), Cat5 (-), CAPEX (125.00).
- Equity financing:** Cost of equity (18%), Equity share (30%).
- Loan financing:** Interest during construction (15%), Senior Financing share (70%), Interest rate (6%), Loan tenure (25), Hurdle DSCR (25), Average DSCR Achieved (1.86), Subordinate Financing share (0%), Interest rate (15%), Loan tenure (25), Hurdle DSCR (25), Average DSCR Achieved (9.8%).
- Financing:** Interest on cash (2.0%), Minimum Cash (1,000,000), Required DSRA (months) (6), Required DSRA (USD) (3,872,074).
- Taxes:** Corporate income tax (25%), Deduction in interest (100%).
- Depreciation method:** Straight line, Recovery period (25.0), Depreciation rate (10%), Salvage value (0.00).
- Goalseek:** Run Goalseek, Change: Tariff, To make: irr, equal to (0.00).

- > Choose project type, PPA type and PPA tactic
- > Inputs on
 - > Project
 - > PPA contract
 - > Costs
 - > Interest rates
 - > Tax
 - > Depreciation methods
 - > Cash reserves
- > Results

The Predict model

Data

Alternative PPA													
PV data													
Power curves													
kWh	Month												
Hour	1	2	3	4	5	6	7	8	9	10	11	12	Annual
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	280.5	296.4	684.8	896.0	944.1	748.1	612.6	610.1	920.4	1,121.6	906.9	604.0	718.8
8	3,533.5	3,512.0	3,821.6	3,818.0	3,471.3	2,987.7	2,695.4	2,825.0	3,683.7	4,357.8	3,913.6	3,729.7	3,529.3
9	7,354.2	7,425.5	7,550.0	6,911.1	6,030.8	5,345.7	5,058.8	5,484.9	6,515.9	7,087.4	6,506.0	7,165.8	6,532.5
10	9,944.4	10,233.9	10,285.4	9,376.0	8,073.7	6,705.4	6,800.0	7,166.4	8,342.1	9,206.1	8,926.5	9,539.7	8,741.0
11	11,521.7	11,780.2	11,750.4	10,697.7	8,997.0	7,473.4	8,155.6	8,349.4	9,501.7	10,013.9	9,620.2	10,758.5	9,885.0
12	12,399.2	12,933.0	12,824.4	11,215.5	9,440.0	8,008.3	8,245.5	8,623.5	9,690.0	9,897.2	10,115.2	11,053.3	10,370.3
13	12,250.3	13,024.1	12,897.4	10,899.4	8,527.8	7,417.0	7,869.0	7,915.1	8,869.0	8,484.3	9,031.0	10,574.0	9,813.2
14	11,115.6	12,004.8	11,706.8	9,881.4	6,917.7	6,372.8	6,805.0	6,890.5	6,878.9	6,712.0	6,973.6	9,220.5	8,456.6
15	9,703.3	10,342.4	9,837.5	7,945.3	5,029.8	5,084.6	5,025.5	5,141.9	5,165.2	4,651.1	5,238.7	7,451.3	6,718.0
16	6,852.6	7,563.4	7,029.6	5,388.4	3,070.9	3,089.9	3,347.9	3,726.0	3,101.9	2,663.6	3,030.4	4,834.7	4,475.0
17	3,611.2	4,027.7	3,784.9	2,527.0	1,326.5	1,398.5	1,678.7	1,648.2	1,090.5	861.2	945.3	2,041.6	2,080.9
18	250.4	652.6	603.8	249.8	173.8	180.3	280.9	261.4	187.2	38.6	0.0	12.1	239.1
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

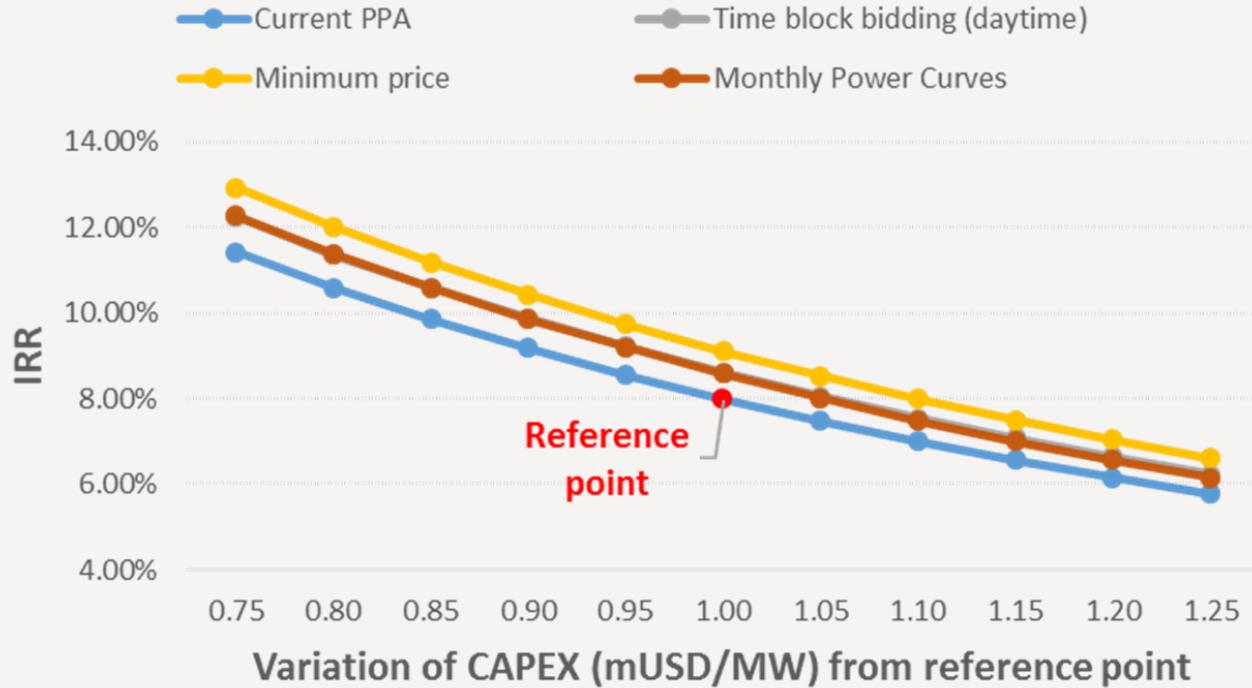
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3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
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8	3,533.5	3,512.0	3,821.6	3,818.0	3,471.3	2,987.7	2,695.4	2,825.0	3,683.7	4,357.8	3,913.6	3,729.7	3,529.3
9	7,354.2	7,425.5	7,550.0	6,911.1	6,030.8	5,345.7	5,058.8	5,484.9	6,515.9	7,087.4	6,506.0	7,165.8	6,532.5
10	9,944.4	10,233.9	10,285.4	9,376.0	8,073.7	6,705.4	6,800.0	7,166.4	8,342.1	9,206.1	8,926.5	9,539.7	8,741.0
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12	12,399.2	12,933.0	12,824.4	11,215.5	9,440.0	8,008.3	8,245.5	8,623.5	9,690.0	9,897.2	10,115.2	11,053.3	10,370.3
13	12,250.3	13,024.1	12,897.4	10,899.4	8,527.8	7,417.0	7,869.0	7,915.1	8,869.0	8,484.3	9,031.0	10,574.0	9,813.2
14	11,115.6	12,004.8	11,706.8	9,881.4	6,917.7	6,372.8	6,805.0	6,890.5	6,878.9	6,712.0	6,973.6	9,220.5	8,456.6
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20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Hourly data												
P value												
Capacity (MW)	P value											
20.96	62.50											
Year	Month	Day	Hour	kWh	kWh	USD/MWh	MWh	MWh	Estimated hourly EAR			
				PV producer	Wind product	Wholesale	Demand					
2014	1	1	0	0.0	0.0	45,594.1	289.3	833.2	29.7			
2014	1	1	1	0.0	0.0	44,577.9	289.3	807.6	28.8			
2014	1	1	2	0.0	0.0	43,282.8	289.3	795.5	28.3			
2014	1	1	3	0.0	0.0	42,311.5	289.3	777.9	27.7			
2014	1	1	4	0.0	0.0	42,311.5	289.3	761.4	27.1			
2014	1	1	5	0.0	0.0	42,311.5	289.3	745.0	26.5			
2014	1	1	6	395.2	41,551.1	289.3	702.1	25.0	25.0			
2014	1	1	7	3,937.0	40,729.9	289.3	672.5	24.0	24.0			
2014	1	1	8	7,691.4	38,666.0	289.3	706.1	25.1	25.1			
2014	1	1	9	10,181.1	40,672.0	289.3	749.2	26.7	26.7			
2014	1	1	10	11,772.2	42,288.4	289.3	778.7	27.7	27.7			
2014	1	1	11	12,555.7	43,906.6	289.3	791.9	28.2	28.2			
2014	1	1	12	12,493.0	43,906.6	289.3	794.3	28.3	28.3			
2014	1	1	13	11,500.0	45,201.2	289.3	792.6	28.2	28.2			
2014	1	1	14	7,451.9	44,384.2	289.3	784.5	27.9	27.9			
2014	1	1	15	1,746.1	43,906.6	289.3	768.7	27.4	27.4			
2014	1	1	16	1,820.4	43,906.6	289.3	753.6	26.8	26.8			
2014	1	1	17	0.0	44,243.7	289.3	744.6	26.5	26.5			
2014	1	1	18	0.0	45,225.4	289.3	814.1	29.0	29.0			

- > Project specific data
 - > Simulated site specific generation
 - > Hourly wholesale prices
 - > Hourly demand
 - > Submitted PPA bids (committed capacity)
 - > Alternative PPA bids

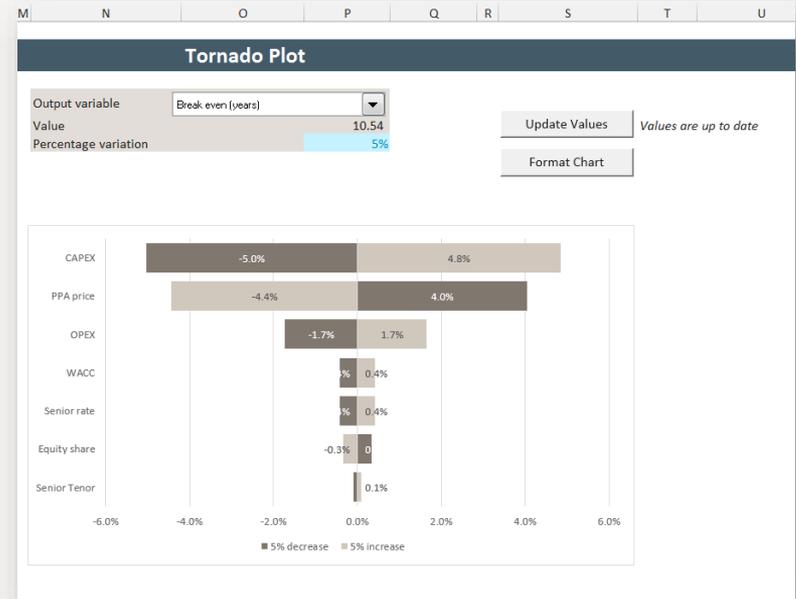
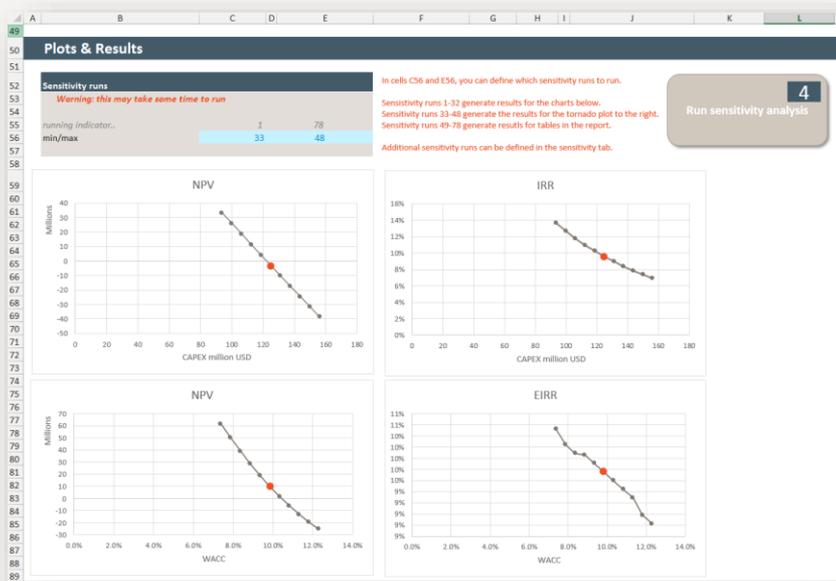


Results



The Predict model

Multiparameter sensitivity and charts





Current PPA in Panama

Current Panamanian PPA - basics

- > Monthly committed capacity
- > Calculation of committed energy on hourly basis
 - > Energy sold through the PPA contract cannot exceed the hourly calculated committed energy
- > Developer must deliver at least 60% of total committed energy per year
 - > subject to a penalty of 5% of expected revenue from the PPA contract

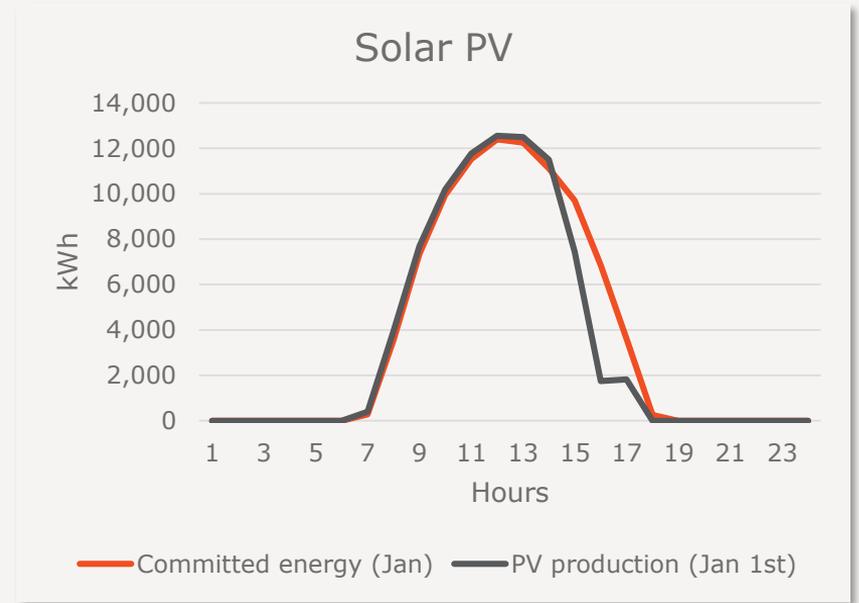
Some advantages & Disadvantages of current PPAs

- > Buying and selling on the whole sale market
 - > Arbitrage – buy cheap and sell expensive
- > Bidding strategies that rely on arbitrage
 - > Exaggerate committed capacity to gain access to arbitrage opportunities
- > Management of trading outside PPA
- > Risk premiums on financing due to exposure to market uncertainty
- > Low competitiveness vis-à-vis conventional technologies

PPA amendments

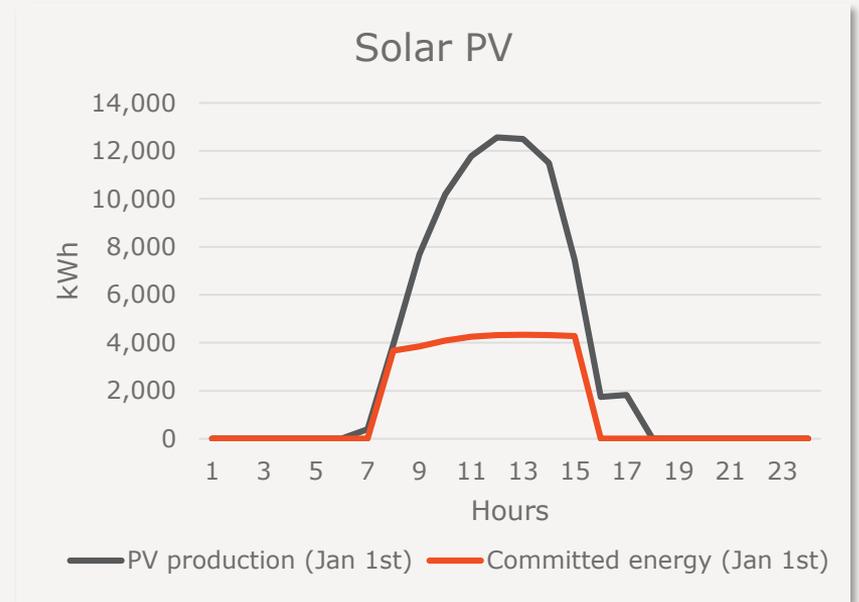
Power curve bidding

- > Power is committed on an hourly basis in a 24 hour cycle
- > Power curves can either be supplied for each month or as an annual average
- > Allows the bidder to take into consideration know intra-day variation and seasonal variation



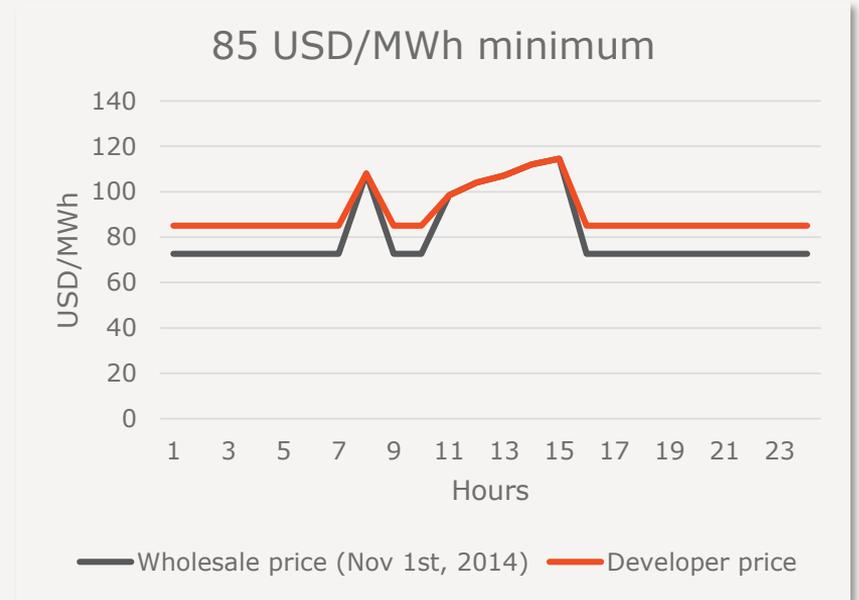
Time block bidding

- > Power is committed in three time blocks: Night, Day, Peak
- > Otherwise power is committed in the same manner as current PPA
- > Energy is only committed in the time blocks that have been chosen



Guaranteed minimum price bidding

- > Developers are awarded a PPA contract based on the lowest minimum price they require
- > All energy is traded on the wholesale market
- > If the wholesale price falls below the guaranteed minimum price, the PPA contract pays out the difference





PPA tactics

Exemplifying real life behaviour

- > Trading energy to fulfil PPA obligations opens for many strategic considerations
- > The prospect of arbitrage affects decisions
 - > Committing more power could open up for more opportunities for arbitrage
 - > Going for arbitrage opportunities must be weighed against penalties
- > Real life behaviour and flexibility cannot be fully reflected in a model
- > Standardized tactics illustrate some of the possibilities

Default tactic

- > No trading
 - > The developer only sells the energy that he produces
- > Energy production which exceeds hourly committed energy is sold to the wholesale market
- > Penalties are applied when relevant

Always deliver >60% of committed energy

- > The developer uses a simplistic tactic to avoid penalties
- > If energy production is less than 60% of the **hourly** committed energy
 - > Buy enough energy from wholesale market up to deliver 60% of **hourly** committed energy
- > On an annual basis this will result in delivering significantly more than 60% of committed energy

Always deliver 100% of committed energy

- > The developer delivers 100% of hourly committed energy
- > This will require a significant amount of trading on the wholesale market
- > Allows increased arbitrage, but also higher risk of losses

No PPA contract

- > The developer has no PPA contract
- > All energy is sold on the wholesale market

Sell all at PPA price

- > All energy is sold through the PPA



Lunch break



Exercise session I

Getting to know the model

Questions

- > What are the levels of curtailment?
- > What are the levels of grid availability ?
- > What are the levels of park availability?
- > What are the levels of distribution loss to metering point?

Basic operations

- > Change the PPA tactic from "Default" to "Always deliver 100% of committed energy"
- > Change PPA type from "Current PPA" to "Monthly power curves"
- > Change PPA type to "Time block bidding" and select time blocks

Tips

- > *Use the drop down menus at the top*
- > *Find the main indicators section and compare results from each change*
 - > *NPV*
 - > *IRR*
 - > *Payback*

Intermediate operations

- > Change the project type from "Wind turbine" to "Solar PV"
 - > Change Nominal capacity, Length of PPA contract, CAPEX and OPEX
 - > Change PPA tactic to "Default"
 - > Change PPA type to "Current PPA"

- > Calculate the LCOE

Tips

	WIND	SOLAR
NOMINAL CAPACITY	62.5 MW	21 MWp
TARIFF	95 USD/MWh	86 USD/MWh
SHARE OF TARIFF CORRECTED FOR INFLATION	25%	25%
CONTRACT DURATION	15 years	20 years

Advanced operations

- > Use the goal seek functionality to find the CAPEX which will result in an IRR equal to the WACC
- > Explore the consequences of changing remuneration for curtailment
- > Change the assignment of hours to time blocks

Tips

- > *Don't forget to provide the model with input on the scale of curtailment (pct. of total generation)*
- > *Time blocks are defined in the "Alternative PPA" tab*
- > *Don't forget to use the PPA type "Time block bidding"*



Exercise section II

Performing sensitivity analysis of uncertain inputs and logging results

Running pre-defined sensitivity analyses

- > Run the sensitivity analyses needed to generate the line charts on the user interface
- > Update the tornado plot
- > Log the results of all combinations of PPA tactic and PPA types

Tips

- > *You don't have to run all sensitivities in one go*
- > *Play around with the functionalities for the tornado plot*
- > *Next to the "Run sensitivities" button is a description of which sensitivity runs do what*

Adding your own sensitivity runs

- > Create a sensitivity run which shows the consequence of a combined 10% increased CAPEX and 10% lower OPEX

Tips

- > *Go to the "Sensitivity" tab*
- > *There's a lot of help to be found in text boxes with red font*
- > *Below the row with the title "data for charts" you can create custom tables that use the output from the runs*

Advanced sensitivities

- > **WARNING:** This will get tricky
 - > If you make a mistake, it might be better to open a fresh copy of the model
- > Add a sensitivity analysis for the tax rate
 - > e.g. +/- 10%

Tips

- > *This is a new row in the top table in the "Sensitivity" tab*
- > *Study how the existing sensitivities feed back into the User Interface*
 - > *Quick fix is to use a formula in the blue cell which currently holds the base tax rate and then move the base tax rate to a new cell next to it*
- > *Be careful which formula you use in column D (two to choose from)*

THANK YOU!