Power Purchase Agreement
Financial Models in SAM
2013.1.15

SAM Webinar
Paul Gilman
June 19, 2013
Session Outline

• Short demonstration in SAM
• Overview of SAM financial models
• SAM PPA model metrics
• Troubleshooting PPA model results
Financial model FAQ

• What is the difference between Utility IPP and Single Owner model?
• Why is the energy term in the LCOE equation discounted?
• What is the difference between nominal and real LCOE?
• If I set the discount rate to the IRR, will the NPV be zero?
• What value should I choose for the discount rate?
• Why does SAM calculate the LCOE using revenue instead of cost?
Overview of SAM’s Financial Models
SAM can model two types of projects

• **Distributed** – Customer side of meter
  Buy and sell electricity at retail rates
  o Net present value (NPV)
  o Payback period
  o Levelized cost of energy (LCOE)

• **PPA** – Power generation project
  Sell electricity at a price negotiated through a power purchase agreement
  o PPA price
  o Internal rate of return (IRR)
  o NPV
  o LCOE is “levelized PPA price”
Residential lease: Coming soon to SAM?

- SAM’s distributed financial models assume that the building owner purchases the system.

- The Commercial PPA financial model is from the perspective of the company offering the lease:
  - “What PPA price must the lessor negotiate to cover its costs?”

- The current version of SAM cannot evaluate questions from the perspective of the building owner:
  - “Is it better to lease or buy a project in terms of NPV?”
  - “Is it better to pay all of the lease up front?”
  - “What impact do changes in inflation, PPA price escalation, discount rate, etc. have on the answers to these questions?”

We would like to add a model for residential lease and are pursuing funding options.
Distributed project involves a building or facility load

18 kW PV system on a children’s care facility in Chicago

Photo by Spire Solar Chicago NREL 632223
PPA project sells all electricity to the grid

2 MW photovoltaic facility near an airport in Prescott, Arizona

Photo by Arizona Public Service NREL 13338
SAM has two financial models for distributed projects

- **Residential**
  - Debt with tax deductible or non-tax deductible loan payments

- **Commercial**
  - Tax deductible loan payments
  - Depreciation options
For PPA projects, it has several models

- **Commercial PPA and Utility IPP**
  - A single owner builds and operates the project
  - Utility IPP option offers financial constraints to help ensure SAM can find solution
  - Debt fraction is an input

- **Advanced financial models**
  - Single Owner: Like Utility IPP, but with reserve accounts, and SAM calculates debt fraction
  - Partnership Flip: Tax investor and developer share cost and benefit of project, Benefits go to developer after “flip year”
  - Sale Leaseback: Tax investor purchases project from developer and leases it back to the developer
What are the main differences between the Utility IPP and Single Owner models?

<table>
<thead>
<tr>
<th>Utility IPP</th>
<th>Single Owner</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IRR:</strong> The IRR is over the entire analysis period</td>
<td><strong>IRR:</strong> You can specify a target year for the IRR</td>
</tr>
<tr>
<td><strong>Project term debt:</strong> You specify the debt fraction</td>
<td><strong>Project term debt:</strong> You specify a debt-service coverage ratio (DSCR), and SAM calculates the debt fraction</td>
</tr>
<tr>
<td><strong>Constraints:</strong> You can choose options to constrain PPA price solution</td>
<td><strong>Reserve accounts:</strong> Reserve accounts for funds to cover equipment replacement, capital reserves, and debt service reserves</td>
</tr>
</tbody>
</table>
  - Automatically optimize debt fraction and/or PPA price escalation
  - Force positive cash flow and minimum DSCR

Compare the Financing page for the two models to see the differences.
A Note about the PPA Models

• Models are general pro forma models
  o Enough detail for pre-feasibility project evaluation
  o Simple enough to generate quick results

• PPA Commercial, Utility IPP, and Single Owner all make the following assumptions
  o A single entity builds, owns, and operates the project
  o The project has sufficient tax liability to benefit from tax credits

• Partnership and Sale Leaseback models are simplified representations of actual partnership agreements
Anatomy of a SAM Model Run

Inputs
- System design parameters

Calculations
- Performance Model
- 8760 simulation
- Calculate production in each year

Results
- Financial Model
- Project cash flow

Analyze
- Performance adjustment factors

Present
- Cost and financial parameters

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NATIONAL RENEWABLE ENERGY LABORATORY

Warren Gretz NREL 10852
Jim Yost NREL 12872
Financial model inputs include energy (kWh), costs ($), and financial parameters.

Performance model output
kWh of Electricity

User inputs
Installation and operating costs

Performance Adjustments

Financial parameters: debt, taxes and incentives

Result: Project cash flow and metrics
Each of SAM’s PPA financial models reports a set of interdependent metrics and a project cash flow.

- PPA price and LCOE, cents/kWh
- PPA price escalation rate
- Internal Rate of Return, %/year
- Net Present Value, $
- Debt service coverage ratio (DSCR)
- Debt Fraction

Avoid evaluating a single metric!
- Evaluate the metrics as a set
SAM calculates financial metrics from the cash flow.

Include the cash flow in your evaluation of the metrics.
The net after-tax annual benefit (positive) or cost (negative) to the project

- Year zero value accounts for initial investment, incentives, and construction financing cost
- Years 1 and later account for revenue, expenses, taxes, incentives, and debt costs
- From project perspective, and from each partner’s perspective as applicable
- You specify costs in Year 1 $, SAM applies inflation to calculate out-year values
- SAM does not apply inflation to revenue. Use the PPA escalation rate to inflate revenue.

\[
CF_0 = B_0 - C_0
\]
\[
CF_n = P_n \times Q_n + B_n - C_n
\]
\[
C_n = C_1 \times (1 + i)^n
\]

CF = after-tax cash flow in $, B = Project benefit in $, C = Project cost in $

P = PPA price, n = year, Q = Energy in kWh, i = annual inflation rate
The present value of the after-tax cash flow \( (\text{CF}_n) \) over the analysis period \( (N) \) discounted at the nominal discount rate \( (d) \)

- A negative value may indicate a financially infeasible project
- From project perspective, and from each partner’s perspective as applicable
- SAM applies inflation to costs, but not to revenue. Use the PPA escalation rate to inflate revenue

\[
\text{NPV} = \sum_{n=0}^{N} \frac{\text{CF}_n}{(1 + d)^n}
\]

\[
\text{NPV} = CF_0 + \sum_{n=1}^{N} \frac{P_n \times Q_n + B_n - C_n}{(1 + d)^n}
\]

\( \text{CF} = \) after-tax cash flow in $, \( P = \) PPA price, \( Q = \) Energy in kWh, \( B = \) Project benefit in $, \\( C = \) Project cost in $, \( n = \) year, \( N = \) analysis period in years, \( d = \) nominal discount rate
The nominal discount rate that, when applied to the after-tax cash flow (Cn) over the analysis period (N), results in a net present value of zero

- From project perspective
- For partnership and sale lease back models, also from each partner’s perspective

\[
\text{NPV} = \sum_{n=0}^{N} \frac{\text{CF}_n}{(1 + \text{IRR})^n} = 0
\]

\[
\text{NPV} = \text{CF}_0 + \sum_{n=1}^{N} \frac{P_n \times Q_n + B_n - C_n}{(1 + \text{IRR})^n} = 0
\]

CF = after-tax cash flow in $, P = PPA price, Q = Energy in kWh, B = Project benefit in $, C = Project cost in $, n = year, N = analysis period in years, d = nominal discount rate
IRR is the nominal discount rate that results in an NPV of zero.

To create this graph in SAM: Set the inflation rate to zero so that the real and nominal discount rates are equal, and set up a parametric analysis on Real Discount Rate with values ranging from 0 to 100% in increments of 10%.
SAM calculates the NPV and IRR from the after-tax cash flow

Utility IPP and Commercial PPA: After tax net equity cash flow, toward bottom of cash flow table

<table>
<thead>
<tr>
<th>Federal depreciation ($)</th>
<th>0</th>
<th>12,847,206</th>
<th>20,555,530</th>
<th>12,333,318</th>
<th>7,3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal Income Taxes ($)</td>
<td>0</td>
<td>-3,240,001.5</td>
<td>-5,723,512</td>
<td>-3,020,249.75</td>
<td>-1,386</td>
</tr>
<tr>
<td>Federal tax savings ($)</td>
<td>0</td>
<td>25,911,542</td>
<td>5,723,512</td>
<td>3,020,249.75</td>
<td>1,386</td>
</tr>
<tr>
<td>After tax net equity cash flow ($)</td>
<td>-37,785,900</td>
<td>28,579,892</td>
<td>8,939,922</td>
<td>5,669,018.5</td>
<td>3,696</td>
</tr>
</tbody>
</table>

Single Owner: After tax, Total near middle of cash flow table

<table>
<thead>
<tr>
<th>Pre-tax cash flow ($)</th>
<th>1,233,916</th>
<th>1,247,120</th>
<th>1,260,264</th>
<th>1.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulative IRR</td>
<td>0</td>
<td>-96.804</td>
<td>-80.359</td>
<td>0</td>
</tr>
<tr>
<td>Cumulative NPV</td>
<td>-38,611,868</td>
<td>-37,499,280</td>
<td>-36,485,352</td>
<td>-35,561,488</td>
</tr>
<tr>
<td>After-Tax Cash</td>
<td>-38,611,868</td>
<td>1,233,916</td>
<td>1,247,120</td>
<td>1,260,264</td>
</tr>
<tr>
<td>Total</td>
<td>-38,611,868</td>
<td>26,411,244</td>
<td>7,876,492</td>
<td>4,762,089</td>
</tr>
<tr>
<td>Cumulative IRR</td>
<td>0</td>
<td>-31.598</td>
<td>-9.146</td>
<td>0.784</td>
</tr>
<tr>
<td>Cumulative NPV</td>
<td>-38,611,868</td>
<td>-14,797,571</td>
<td>-8,383,872</td>
<td>-4,902,923</td>
</tr>
</tbody>
</table>
For partnership and sale-leaseback models, SAM calculates the metrics for the project and each party’s perspective. SAM calculates the NPV and IRR from the total after-tax cash flow for each perspective.
Power Price (PPA Price)

• Price paid to the project for electricity it delivers to the grid
• May be modified by a set of TOD factors
• May be an input or result:

Specify PPA Price
You specify the price, and SAM calculates the IRR

Specify IRR Target
You specify a target IRR, and SAM finds the PPA price that results in that IRR
**PPA Price Escalation Rate**

- SAM reports the PPA price in the Metrics table as a first year value.
- You can apply an optional escalation rate to the PPA price.
  - SAM does not apply inflation to the PPA price.

The next version of SAM will allow you to specify a different PPA price for each year.
Debt Service Coverage Ratio and Debt Fraction

• Debt fraction is the ratio of amount borrowed to the total installed cost

• Debt service coverage ratio (DSCR) is the ratio of operating income to expenses in each year

• For Commercial PPA and Utility IPP models, debt fraction is an input
  o You can have SAM optimize the debt fraction for you
  o DSCR for each year is a result in the cash flow table
  o Minimum DSCR is a result in the Metrics table

• For single owner, partnership and sale leaseback models, DSCR is an input
  o Debt fraction is a result that depends on DSCR and debt terms
  o Models assume constant DSCR
Flat Plate PV and Single Owner financing with and without debt

- **$76M installed cost**
- 51% debt
- 17.3 cents/kWh PPA Price
- 12.6% IRR
- $1.7M NPV

- **$76M installed cost**
- 0% debt
- 17.3 cents/kWh PPA Price
- 6.89% IRR
- -$13M NPV
The levelized cost of energy (LCOE) definition

The value in $/kWh, which, if multiplied by energy in kWh generated (or saved) over the project life, equals the present value of the project in $.

\[
\sum_{n=1}^{N} \frac{Q_n \times LCOE}{(1 + d)^n} = \sum_{n=0}^{N} \frac{CF_n}{(1 + d)^n}
\]

Cost of installing, financing and operating the system per unit of energy over the project life in $/kWh

Energy is electricity

Accounts for:
- Installation costs
- Operating costs
- Electric energy generated

LCOE = \[
\frac{\sum_{n=0}^{N} CF_n}{\sum_{n=1}^{N} Q_n (1 + d)^n}
\]

\[Q = \text{energy in kWh, } CF = \text{after-tax cash flow in $}\]

\[n = \text{year, } N = \text{analysis period in years, } d = \text{annual discount rate}\]
LCOE for PPA projects

Amount the project must receive for each unit of energy ($/kWh) to cover costs and project IRR requirements

Accounts for:
- Installation costs
- Operating costs
- Electric energy generated
- Additional revenue required to meet target IRR

\[
LCOE = \sum_{n=1}^{N} \frac{P_n \times Q_n}{(1 + d)^n} \div \sum_{n=1}^{N} \frac{Q_n}{(1 + d)^n}
\]

Q = energy in kWh,  P = PPA price in $/kWh
n = year,  N = analysis period in years,  d = annual discount rate
### PPA price, real LCOE, and nominal LCOE for PPA Projects

**Real LCOE:** Constant dollar, inflation-adjusted value  
**Nominal LCOE:** Current dollar value

<table>
<thead>
<tr>
<th>Escalation (%)</th>
<th>0</th>
<th>0.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPA Price</td>
<td>8.60</td>
<td>8.19</td>
</tr>
<tr>
<td>Nominal LCOE</td>
<td>7.91</td>
<td>7.95</td>
</tr>
<tr>
<td>Real LCOE</td>
<td>8.28</td>
<td>7.53</td>
</tr>
</tbody>
</table>

SAM calculates the nominal discount rate from the real discount rate and inflation rate

\[
d_{\text{nominal}} = (1 + d_{\text{real}}) \times (1 + i) - 1
\]

The PPA Price may be fixed, or increase annually based on the escalation rate you specify

\[
P_n = P \times (1 + e)^n
\]

The form of the discount rate in the denominator determines the form of the LCOE

**nominal LCOE**

\[
\text{nominal LCOE} = \frac{\sum_{n=1}^{N} P_n \times Q_n}{\left( \sum_{n=1}^{N} Q_n \right) \left(1 + d_{\text{nominal}}\right)^n}
\]

**real LCOE**

\[
\text{real LCOE} = \frac{\sum_{n=1}^{N} P_n \times Q_n}{\left( \sum_{n=1}^{N} Q_n \right) \left(1 + d_{\text{nominal}}\right)^n}
\]

\[
\sum_{n=1}^{N} P_n \times Q_n = \sum_{n=1}^{N} \frac{P_n \times Q_n}{\left(1 + d_{\text{nominal}}\right)^n}
\]

\[
\sum_{n=1}^{N} Q_n = \sum_{n=1}^{N} \frac{Q_n}{\left(1 + d_{\text{nominal}}\right)^n}
\]

\[
d = \text{annual discount rate}, \ i = \text{inflation rate}, \ P = \text{PPA price in $/kWh}, \ e = \text{PPA price escalation rate}
\]

\[
Q = \text{energy in kWh}, \ n = \text{year}, \ N = \text{analysis period in years}
\]
Summary of SAM Financial Models

- They are pro forma cash flow models from the project perspective.
- They use hourly output values calculated by the performance model to represent power production in Year 1.
  - Optional performance adjustment factors can adjust Year 1 production to estimate effects of annual degradation, system availability, curtailment, etc.
- You provide input values for installation and operating costs, financial parameters, and incentives.
- Different models generate different metrics, but all show LCOE, PPA price, IRR, and NPV.
- You should evaluate the metrics as a set.
Troubleshooting PPA Model Results
The financial model results may not be valid for different reasons

• Your assumptions are for a financially infeasible project
  o Negative NPV
  o IRR much greater than the desired target
  o IRR is zero

• SAM could not find a solution
  o PPA Price = 400 cents/kWh (maximum limit)
Calculating the IRR from a given PPA price is fairly straightforward

\[ \text{NPV} = CF_0 + \sum_{n=1}^{N} \frac{P_n \times Q_n + B_n - C_n}{(1 + \text{IRR})^n} = 0 \]

A simple two-year example to calculate by hand:
IRR = 38.4%

You can use a parametric analysis on discount rate in SAM to see how it determines the IRR
Calculating a PPA price to meet a desired minimum IRR is not trivial

\[
NPV = CF_0 + \sum_{n=1}^{N} \frac{P_n \times Q_n + B_n - C_n}{(1 + IRR)^n} = 0
\]

After Tax Cash Flow in Year Zero = - ( 1 - Debt Fraction )
× ( Total Installed Cost
  + Total Construction Financing Cost
  - Total IBI
  - Total CBI )

After Tax Cash Flow in Year n>0 = Operating Income
+ State Tax Savings
+ Federal Tax Savings
+ Total PBI
- Total Debt Payment

Operating Income = Energy Value - Operating Costs

Energy Value ($) = Energy (kWh) × Energy Price ($/kWh)

Operating Costs = Fixed O&M Annual + Fixed O&M + Variable O&M + Fuel + Insurance + Property Taxes - Salvage Value
The solution is iterative

1. Calculate after-tax cash flow based on initial PPA price guess
2. Solve for IRR
3. If resulting IRR is less than minimum target, increase PPA price guess
4. Repeat Steps 2 and 3 until IRR is within an acceptable tolerance

\[
NPV = \sum_{n=0}^{N} \frac{CF_n}{(1 + IRR)^n} = 0
\]
Utility IPP constraints help ensure that the algorithm finds a reasonable solution

- **Require a minimum DSCR**
  - Forces PPA price to be high enough to ensure the minimum DSCR value you specify

- **Require a positive cash flow**
  - Forces the PPA price to be high enough to ensure a positive cash flow in all years
Scenario 1: Negative NPV

Symptoms:
• Reasonable PPA price
• Meets target IRR
• Reasonable minimum DSCR
• Negative NPV

Possible solutions:
• Increase debt (decreases initial investment, increases tax savings)
• Decrease operating expense(s) or increase production-based incentives
• Decrease discount rate
• Impose positive cash flow constraint (Utility IPP only)
• Impose minimum DSCR constraint (Utility IPP only)
Scenario 2: IRR is too high

Symptoms:
• Reasonable-to-high PPA price
• High IRR
• Reasonable minimum DSCR
• Positive NPV

Project income is more than needed to cover initial investment.

Possible solutions:
• Increase PPA escalation rate
• Increase operating expense(s) or decrease production-based incentives
• Decrease discount rate
• Impose positive cash flow constraint (Utility IPP only)
• Impose minimum DSCR constraint (Utility IPP only)