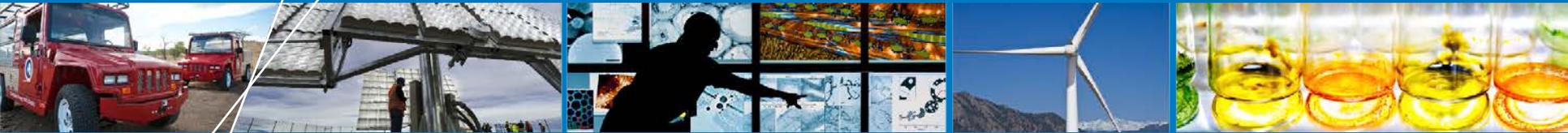


Analysis of Electricity Rate Structures for Residential and Commercial Projects



SAM Webinar

Paul Gilman

April 16, 2014 1:00 p.m. MDT



Schedule

- **New Features in SAM 2013 and Beyond**
 - October 9, 2013: Paul Gilman
- **SAM PV Model Validation using Measured Performance Data**
 - December 11, 2013: Janine Freeman
- **Solar Resource Data 101**
 - February 12, 2014: Janine Freeman
- **Analysis of Electricity Rate Structures for Residential and Commercial Projects**
 - April 16, 2014: Paul Gilman
- **Modeling Parabolic Trough Systems**
 - June 18, 2014: Michael Wagner
- **Photovoltaic Shading Analysis**
 - August 27, 2014: Aron Dobos

Details

- All sessions last one hour and begin at 1 p.m. Mountain Time
- You must register to participate
- Registration is free, but space is limited
- More details, registration information, and recordings of past webinars on Learning page of SAM website

<https://sam.nrel.gov/content/resources-learning-sam>



- **Energy and demand charges**
- **Time-of-use and tiered structures**
- **Net metering**
- **OpenEI Utility Rate Database (URDB) V.2**
- **Using SAM to determine the value of PV**

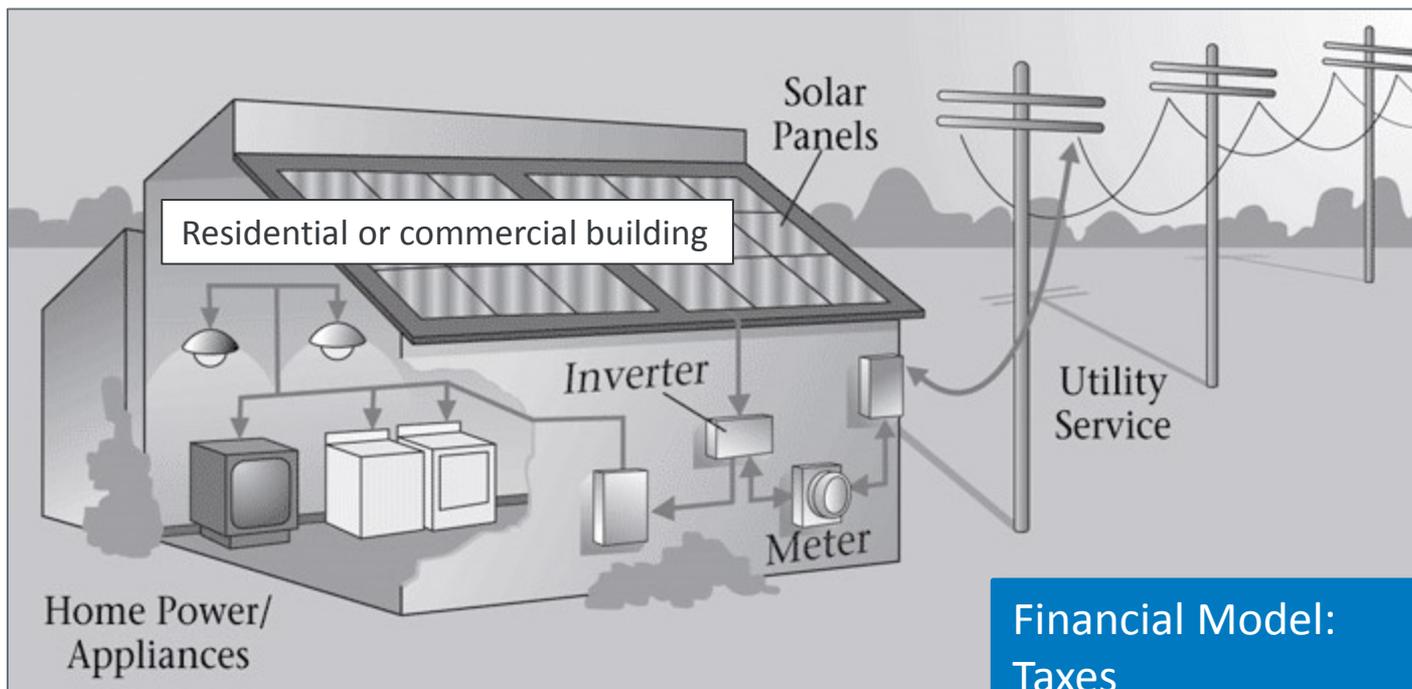
Distributed energy system



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Renewable energy system

Grid: Utility Rates



Electricity consumption:
Electric Load

Financial Model:
Taxes
Debt
Incentives
Installation, operating costs



- **Residential**
 - Debt with tax deductible or non-tax deductible loan payments
- **Commercial**
 - Tax deductible loan payments
 - Depreciation options

Residential and commercial models are identical except for loan options and depreciation.

See July 2013 webinar “Modeling Residential and Commercial PV Systems in SAM”

Residential and Commercial options



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Project configuration: select a technology and then a financing option.

Photovoltaics
Direct conversion of sunlight to electricity using solar cells.

- Flat Plate PV**
A detailed PV performance simulator that uses component-based CEC and Sandia models for modules and inverters. This model can also be used for some low-X CPV systems.
- High-X Concentrating PV**
A system model specific for high concentration (HCPV) photovoltaic system modeling.
- PVWatts System Model**
A simplified system model that assumes typical module and inverter characteristics.

Concentrating Solar Power
CSP systems use mirrors or lenses to focus sunlight to generate a heat source for conventional type power plant.

Generic System
The simplest plant model that uses a nameplate size and capacity factor or user supplied production profile.

Solar Water Heating
Represents a flat plate closed-loop glycol water heating system with auxiliary. Uses a variable node volume tank model.

Wind Power
An hourly model meant to simulate wind power production from single turbine installations to a full scale wind farm providing power to the electricity grid.

Geothermal
Geothermal systems extract heat energy from the relatively large heat content of the earth for conventional power cycles.

Residential
Project cash flow is based on value of avoided retail electricity purchases. SAM calculates project LCOE, NPV, and payback period.

Commercial
Project owned by commercial entity that buys and sells electricity at retail rates. Project cash flow is based on value of electricity purchases offset by the renewable energy system and depreciation tax benefit. SAM calculates project LCOE, NPV, and payback period.

Commercial PPA
Project developed and owned by single entity that sells electricity at price negotiated through power purchase agreement (PPA). SAM calculates project LCOE, NPV, and can either calculate project PPA price based on target IRR that you specify as input, or calculate project IRR based on PPA price you specify.

Utility Independent Power Producer (IPP)
Project developed and owned by single entity that sells electricity at price negotiated through power purchase agreement (PPA). SAM calculates project LCOE, NPV, and can either calculate project PPA price based on target IRR that you specify as input, or calculate project IRR based on PPA price you specify. You also specify debt fraction as input. This option is a simple version of the Single Owner option.

Advanced Utility IPP Options
Advanced financial models appropriate for utility scale power generation projects.

Help... Reset new inputs to Tech/Market-specific default values OK Cancel



- **How much money will a homeowner save on her monthly electricity bill by installing a renewable energy system?**
- **What is the value of the electricity generated by the renewable energy system?**

The answers require:



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- **Building's electricity consumption (kWh)**
- **Retail electricity rate structure (\$/kWh)**
 - Net metering rules (if applicable)
- **Renewable energy system's electrical output (kWh)**
- **Renewable energy system's lifecycle cost (\$)**

Inputs in SAM



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Select Technology and Market... **PVWatts, Residential**

Location and Resource
Location: PHOENIX SKY HARBOR INTL AP, AZ
Lat: 33.5 Long: -112.0 Elev: 337.0 m

PVWatts Solar Array
DC Rating: 4 kW
AC-DC Derate: 0.77

Performance Adjustment
Percent of annual output: 100 %
Year-to-year decline: 0.5 % per year

PV System Costs
Total: \$ 15,060.00
Per Capacity: \$ 3.77 per Wdc

Financing
Analysis: 25 years
Debt Fraction: 100.0% percent

Incentives
Fed. ITC, State ITC
No cash incentives

Utility Rate
Net Metering? Yes

Electric Load
Annual Energy: 12917.8 kWh
Annual Peak: 4.39428 kW

Exchange Variables
(For Excel Exchange and custom TRNSYS only.)

Open
Down rate
copy

Fixed

Time-
 E

The performance model input pages are where you define the system's design parameters:

- Renewable energy system's electrical output (kWh)

The Costs, Financing and Incentives pages determine the renewable energy system's cost (\$)

The Utility Rate and Electric Load pages are where you define the parameters of a utility rate structure analysis:

- Retail electricity rates (\$/kWh)
- Electricity consumption (kWh)



- **Model a basic distributed project with a flat buy rate, flat sell rate, no net metering or other complex elements**
 - Use default inputs for a PVWatts System – Residential case
 - Electric Load page: Use default load, view hourly data
 - Utility Rate page: Flat buy rate = \$0.09/kWh, flat sell rate = \$0.06/kWh, clear all check boxes on the Utility Rate page
 - Parametric analysis to see how metrics vary with sell rate

ur-demo-1-basic.zsam

For more on working with the Electric Load page, see July 2013 webinar “Modeling Residential and Commercial PV Systems in SAM”



Metric	Value
Annual Energy	9,430 kWh
LCOE Nominal	10.56 ¢/kWh
LCOE Real	8.56 ¢/kWh
Electricity cost without system	\$ 1,162.61
Electricity cost with system	\$ 313.88
Net savings with system	\$ 848.73
Net present value (\$)	\$ 209.41
Payback (years)	17.6276
Capacity Factor	17.9 %
First year kWhac/kWdc	1,572

A = Annual electric bill without renewable energy system

B = Annual electric bill with renewable energy system

A - B = Annual savings

Annual savings assumes that utility rate structure with and without the renewable energy system are the same.

Net present value

Total cost of installing and operating the renewable energy system over its life including financial costs, tax benefits, and incentives.

Payback period

Number of years it takes for savings (energy value + tax savings + incentives – expenses) to equal the initial investment.



Energy rate

A price per unit of electricity (\$/kWh)

Demand charge

A price per peak consumption over a given period (\$/kW)

Fixed charge

A fixed monthly amount (\$)

Time of use (TOU) rate/charge

Varies with time, typically with time of day

Tiered rate/charge

Varies with electricity consumption

Fixed rate

Does not vary with time or consumption, aka flat rate



Buy rate

A price paid by the consumer to the utility

Sell rate

A price received by the consumer from the utility



- **An arrangement that allows the consumer to use electricity generated by the renewable energy system to offset electricity purchases**
- **Terms of the arrangement are determined by law, so details vary by jurisdiction**



- **The system owner purchases electricity at either a fixed or tiered time-of-use buy rate**
- **The owner receives a monthly credit for each month that the electricity generated by the system exceeds the total monthly electricity load**
- **That credit is applied to the next month's electricity purchases**
- **Any credit that remains at the end of the year is paid to the project at the year end sell rate**



- **Compare net metering to flat buy/sell rates**
 - Start with the file from Demonstration I, and create a duplicate case
 - Utility Rate page: Flat buy rate = \$0.09/kWh, enable net metering, year end sell rate = \$0.03/kWh
 - Run simulation: No net metering credits because load always exceeds PV system output
 - Increase system size from 4 kW to 6 kW and run simulation

ur-demo-2-compare-basic-net-metering.zsam



- **Resides on the NREL OpenEI platform**
 - <http://en.openei.org/wiki/Gateway:Utilities>
- **URDB Version 2 is the current version**
 - Older versions of SAM worked with Version 1, but that version is no longer maintained
- **3,831 electric utilities and 44,586 rates**
- **United States only**
- **SAM can download rate structures from URDB so you don't have to enter data by hand**

Downloading a rate structure in SAM



1. Click Search for Rates

2. Click name of utility company

3. Choose a rate category

4. Click name of rate structure

Go to URDB website home page

Type a few letters to filter the list

Go to URDB website page for this rate structure to find a link to the official rate sheet

Go to rate page on OpenEI.org...

Search for rates... [Go to website...](#)

Search: pacifi Refresh

Available rate schedules Residential Only

Pacific Gas & Electric Co
Pacific Northwest Generating Coop
Pacific Power (California)
Pacific Power (Oregon)
Pacific Power (Washington)

PacifiCorp (Washington)
PacifiCorp (Wyoming)
Sierra Pacific Industries Inc
Sierra Pacific Power Co
Sierra Pacific Power Co (Nevada)

Residential-E-1 - Baseline Region Q
Residential-E-7 - Baseline Region P
Residential-E-1 - Baseline Region R
Residential-E-1 - Baseline Region S
Residential-E-1 - Baseline Region T
Residential-E-1 - Baseline Region U
Residential-E-1 - Baseline Region V
Residential-E-6 - Baseline Region Z
Residential-E-1 - Baseline Region R
Residential-E-1 - Baseline Region Z
Residential-E-7 - Baseline Region Y

Name Pacific Gas & Electric Co: E-6 - Baseline Region Z

Description
This voluntary schedule is available to custom
Fixed Monthly Charge was calculated off of the
Has Flat Rate? yes
Has Energy Charges? yes
Has Demand Charges? yes
GUID: '1b1fb7a4-df4e-456d-988d-ac18c5758ee6'

Download and apply utility rate Close

Ready.

Weekday			
	12am	1am	2am
Jan	1	1	1
Feb	1	1	1
Mar	1	1	1
Apr	1	1	1
May	2	2	2
Jun	2	2	2
Jul	2	2	2
Aug	2	2	2
Sep	2	2	2
Oct	2	2	2
Nov	1	1	1
Dec	1	1	1

Period 1	
Max Usage kWh	Buy Rate \$/kWh
Tier 1 1e+099	0.0
Tier 2 1e+099	0.0



- **Be sure to compare the values that SAM downloads to the utility company's rate sheet**
 - There may be errors in the URDB
 - The rate structure may have changed since it was added to the URDB
- **Several rates on the rate sheet may be consolidated into a single input in SAM**
- **SAM may not be able to exactly replicate the rate structure**
- **You can download the rate sheet from its page on the URDB website**
- **Report any problems you find with the data to the OpenEI team using the OpenEI Community page**



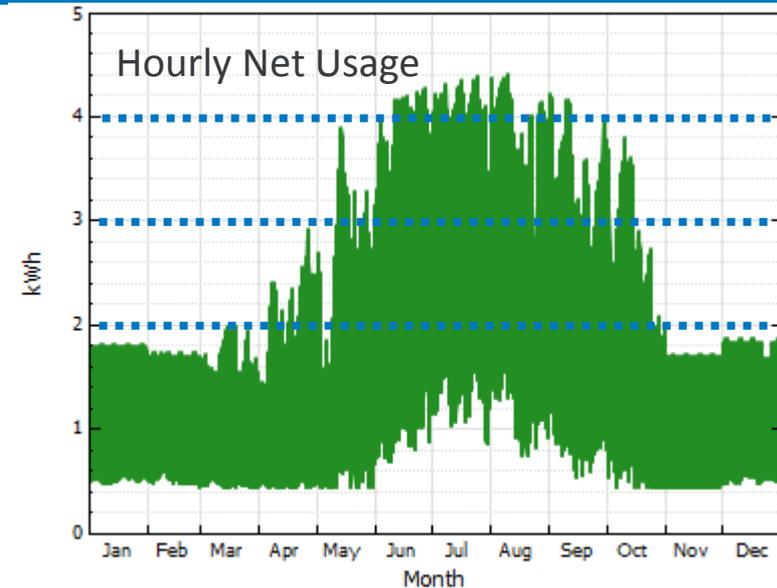
- **Mechanics of the Utility Rate page**
- **Download a rate structure from the URDB**
- **Flat rates**
- **Net metering**
- **Time of use rates**
- **Tiered rates**

Note about tiers *without* net metering

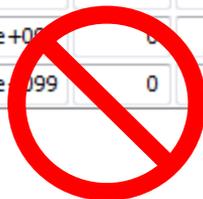


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- Tiers (or blocks) are hourly, not monthly
 - For structures with tiers, SAM does not accumulate kWh by month



Period 1			
	Max Usage kWh	Buy Rate \$/kWh	Sell Rate \$/kWh
Tier 1	500	0.06	0.06
Tier 2	1000	0.09	0.06
Tier 3	1500	0.12	0.06
Tier 4	1e+099	0	0
Tier 5	1e+099	0	0
Tier 6	1e+099	0	0



Period 1			
	Max Usage kWh	Buy Rate \$/kWh	Sell Rate \$/kWh
Tier 1	2	0.06	0.06
Tier 2	3	0.09	0.06
Tier 3	4	0.12	0.06
Tier 4	1e+099	0	0
Tier 5	1e+099	0	0
Tier 6	1e+099	0	0





- **Method described in Ong et al 2012:**

$$\text{Value (\$/kWh)} = \frac{\text{Savings (\$)}}{\text{Generation (kWh)}}$$

- **Value is the value of the electricity generated by the PV system**
- **Generation is the amount of electricity generated by the system**
- **Savings depends on the electric load, utility rate structure, and generation:**

$$\text{Savings} = \text{Cost without System} - \text{Cost with System}$$

Ong, S.; Campbell, C.; Clark, N. (2012). "Impacts of Regional Electricity Prices and Building Type on the Economics of Commercial Photovoltaic Systems." NREL/TP-6A20-56461. Golden, CO: National Renewable Energy Laboratory.



- **Determine value of PV for a particular rate structure *A***
- **Compare a building's electricity cost without PV at the least-cost rate *B* to the cost with PV at *A***
 - To do this in SAM, you have to use two different electricity rates, which is not possible in the user interface.
 - The SamUL script in the sample file *SamUL Cost Savings with Different Rate Structures.zsam* does the calculation
 - The script in the sample file *SamUL Download Building Load Data.zsam* automatically downloads load data from an OpenEI database, and populates the inputs on the Electric Load data

Ong, S.; Campbell, C.; Clark, N. (2012). "Impacts of Regional Electricity Prices and Building Type on the Economics of Commercial Photovoltaic Systems." NREL/TP-6A20-56461. Golden, CO: National Renewable Energy Laboratory.



- **Using SamUL sample scripts:**
 - Download electric load data from OpenEI
 - Calculate savings when the rate structures with and without the renewable energy system are different



- **Residential and commercial models require:**
 - System design parameters
 - Financial assumptions (debt, tax, incentives)
 - Installation and operating costs
 - Load data
 - Utility rate data
- **Utility rate page is flexible to represent many different rate structures**
 - Interface with URDB to download utility rate data for U.S.
- **SamUL scripts help overcome two of SAM's limitations:**
 - With and without system cost is calculated using the same rate structure
 - Model needs difficult-to-find hourly load data