Valuing Solar at Your Electric Utility

March 24, 2016

Solar Powering Iowa
Cedar Rapids

Prepared by:

Ben Norris
Clean Power Research

Clean Power Research Solar Valuation and Fleet Modeling Studies

Utilities	Energy Agencies	Renewables Organizations
Austin Energy CEPCI Duke Energy Nevada Power Portland General Electric SDG&E (USD) Tacoma Power “Utility X” We Energies	California PUC Minn. Dept. of Commerce Maine PUC NYSERDA Ontario Ministry of Energy	IREC MREA MSEIA Solar San Antonio Utah Clean Energy “Organization Z”

Project Overview

- Clean Power Research engaged by MREA
- Goal: Develop a solar valuation methodology
  - Build on existing methodologies
  - Applicable to rural electric cooperatives and small municipals in Iowa
  - Work with at least one utility as a case study (City of Bloomfield)
  - Depending on interest, develop tool (in future) that could be used by utilities directly

Possible Benefits of Solar for Utility Costs

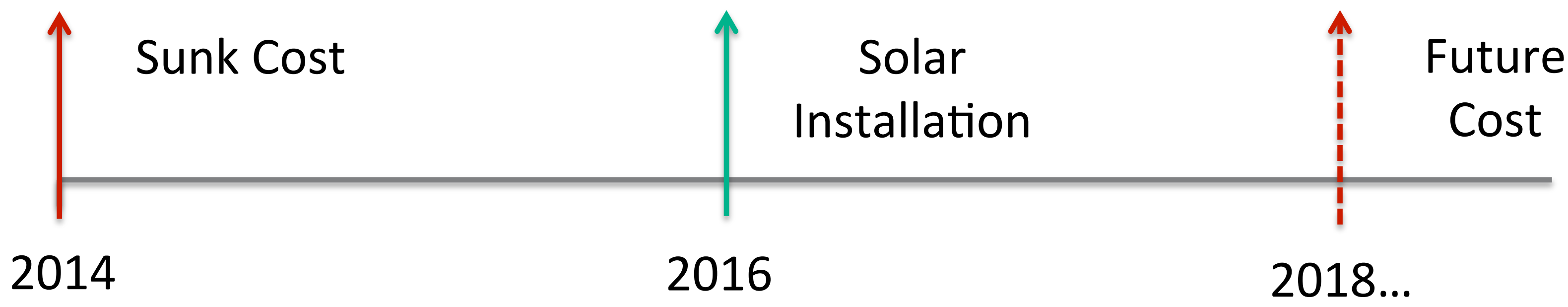
Utility costs		Examples	Benefit of solar
Energy costs		Fuel, plant operations and maintenance, wholesale power purchases	Reduces all of these costs
Capacity costs		Plant capacity, transmission lines, substations, distribution lines	Can reduce these, depending upon how well solar generation matches the corresponding load profile
Fixed costs		Metering, line maintenance, billing, customer service	Generally, no impact

Valuation principles

- The value represents locality-specific savings, minus costs, of distributed solar generation from the utility perspective.
- The value does not represent an incentive, but does not preclude add-on incentives.
- The value must distinguish between utility avoided costs and societal benefits (which do not accrue to the utility).
- Utility avoided costs should be calculated such that the utility is economically indifferent to paying solar customers and delivering conventional energy.
- Societal benefits are a public policy decision. These are paid for by all ratepayers (solar and non-solar) to allow the utility to recover costs.

VOS and Net Metering As Tariff Options

Two different treatments of costs



VOS - based on avoided future costs:

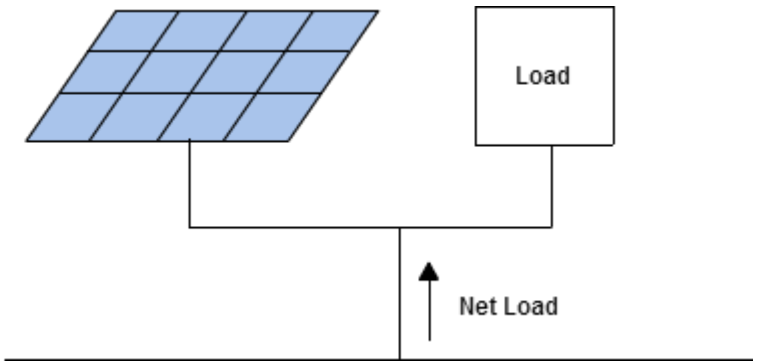
- Estimates reflect uncertainty in cost and timing
- Not based on existing rates
- Future costs are potentially avoidable by solar

NEM - based on sunk/current costs:

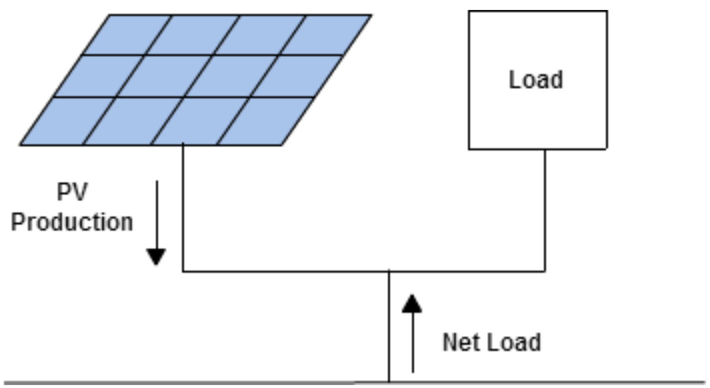
- Known with certainty
- Embedded and quantified in existing rates
- Sunk costs not avoidable by solar
- A "proxy" for avoided costs

Energy Quantities

NET LOAD



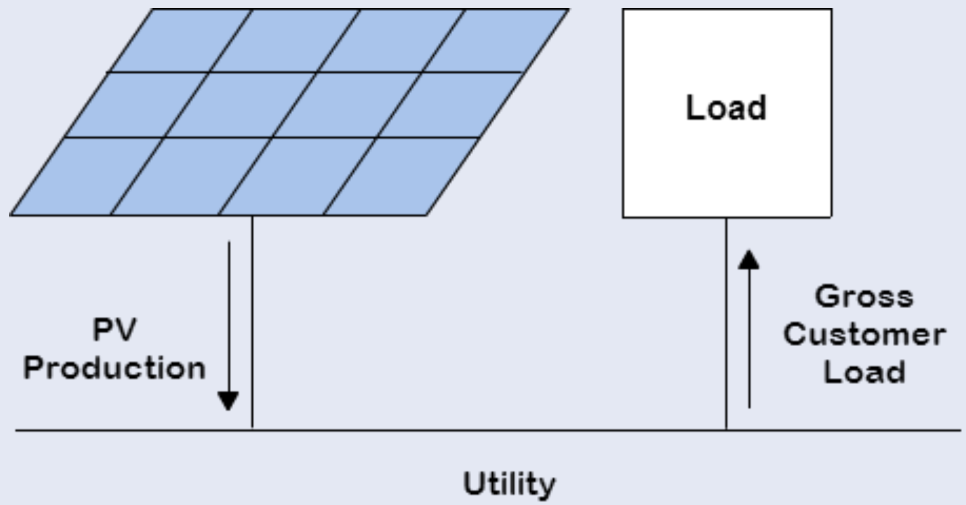
PV AND NET LOAD



VOS FRAMEWORK:

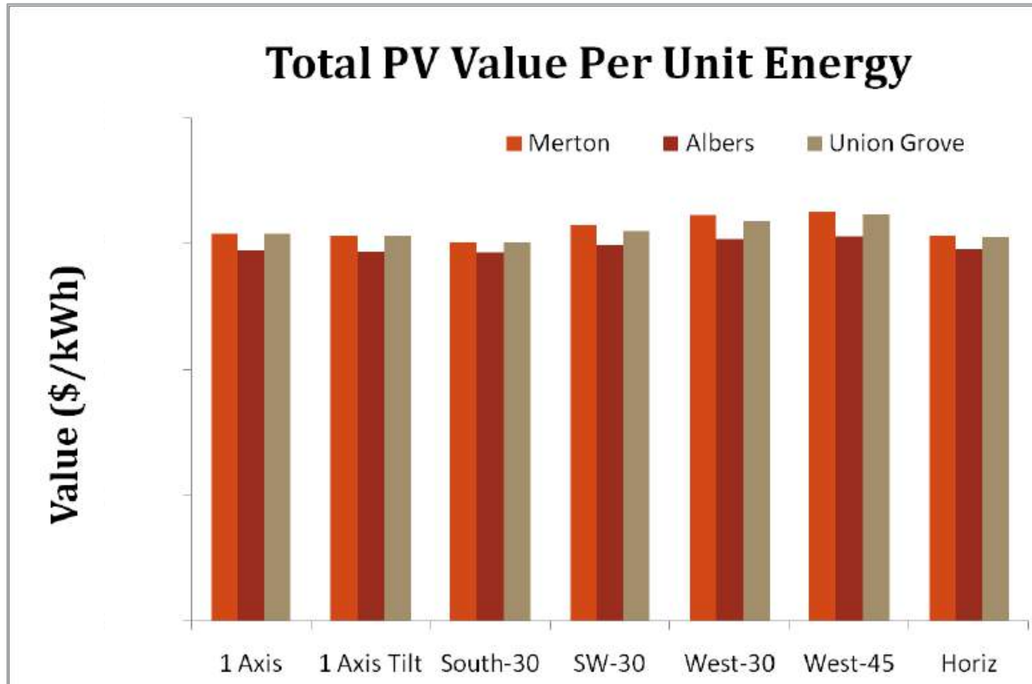
Separates charges and credits

- VOS applies to PV production
- Consumption charges apply to gross Customer Load



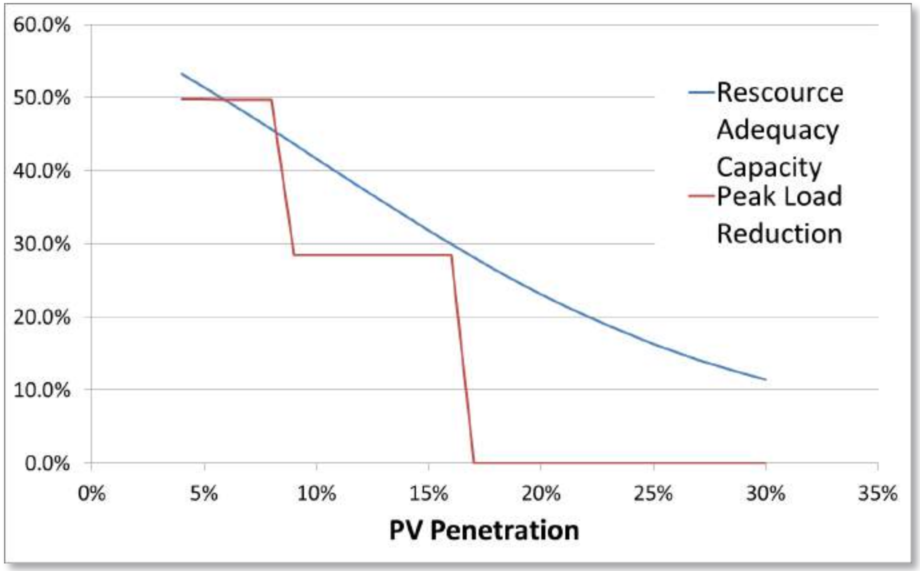
VOS Depends on Location and Orientation

- VOS could be differentiated by location (PV resource, distribution growth/costs, LMP node) and orientation
- Utility service territory provides some inherent geographic differentiation
- These add substantial complexity
- Value can be calculated for utility "fleet," incorporating the diversity of orientations and the overall geographic diversity



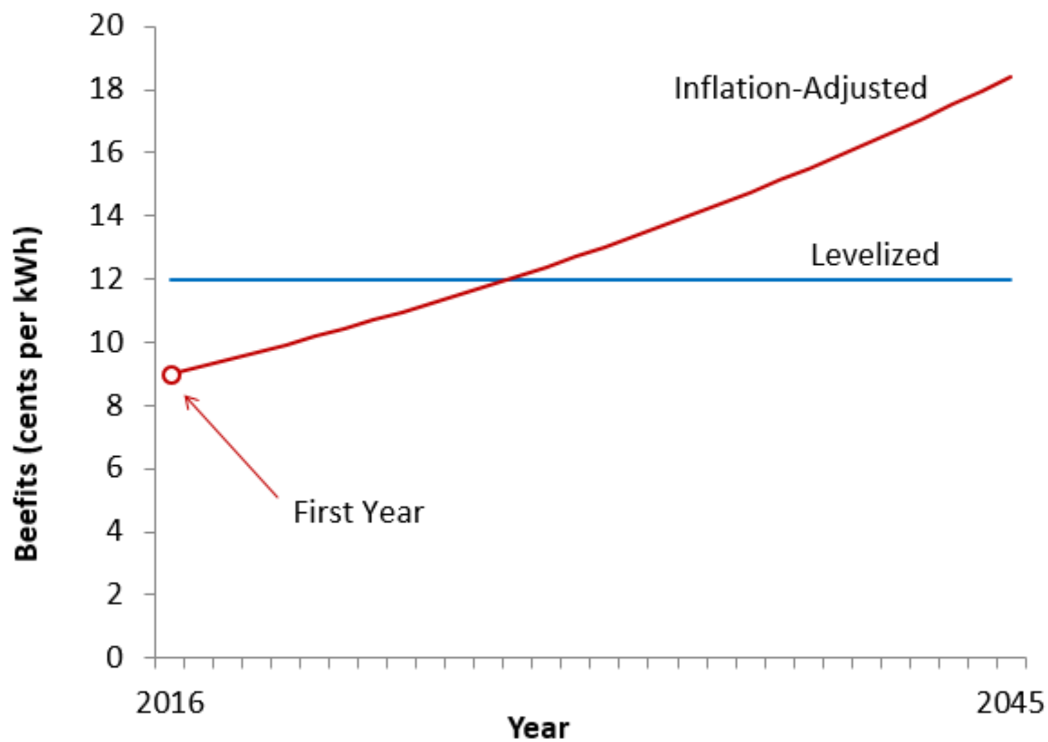
VOS Depends on Penetration Level

- Much higher PV penetration results in less effective capacity.
- This results in lower capacity value for generation, transmission, and distribution.
- To include this upfront:
  - Requires forecast of PV penetration levels
  - Penalizes early adopters for solar capacity brought by late adopters.
- Existing penetration is incorporated in hourly loads
- Solution: use current penetration level. Future year VOS calculation will incorporate actual penetration for that year.



VOS Depends on Term

- Levelized value incorporates value over a fixed study period
- Most value studies set study period equal to useful PV service life (20 to 30 years, degradation included)
- First-year value less dependent on forecasting.



VOS Does Not Necessarily Depend on Rate Class

- Framework
  - A kWh produced and delivered to the grid by PV has a certain value, whether a utility avoided cost or a benefit to society.
  - Whether the kWh was produced by a residential customer, a commercial customer, an industrial customer, and agricultural customer, etc., it provides the same benefit.
  - Systems that are larger, better maintained, better designed with fewer losses, etc., will deliver more energy than others, and consequently more total benefits.
- Conclusions (for VOS tariffs)
  - The credit should be “pay for performance,” computed on a per-energy basis (rather than a per-kW or similar basis).
  - If the system is dirty, off-line, poorly designed, or otherwise not performing well, this will be reflected in the credit amount.
  - The credit should be the same for all kWh as delivered to the grid.

Roadmap: City of Bloomfield

		Gross Value A ($/kWh)	×	Load Match Factor B (%)	×	Loss Savings Factor (1+C) (%)	=	Distr. PV Value D ($/kWh)
Energy Supply	Avoided Energy Purchases	C1				LSF Energy		V1
Transmission Delivery Service	Avoided Demand Charges	C2		LM		LSF Demand		V2
								Total

Roadmap: Maine PUC Study

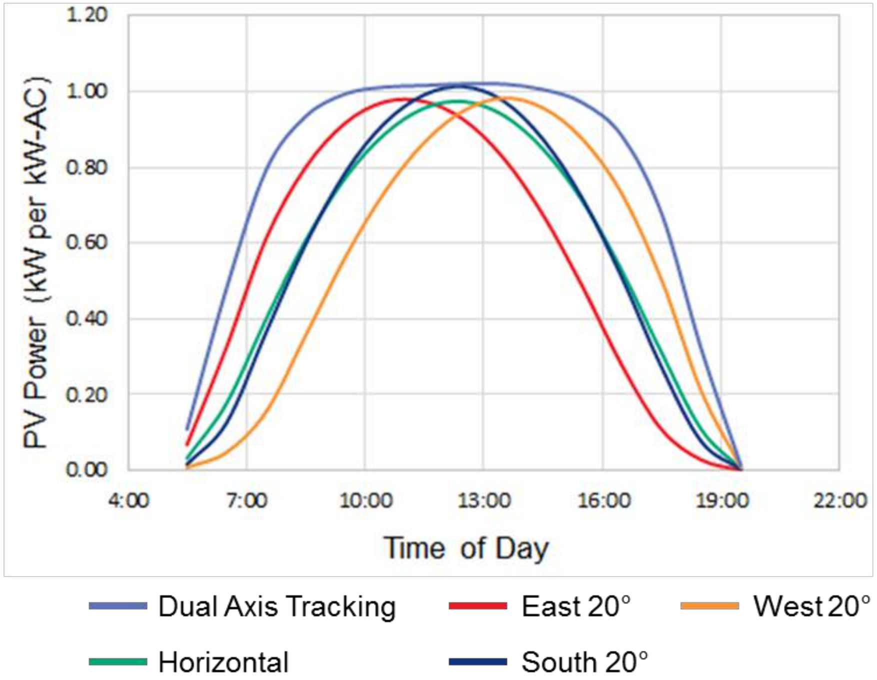
Category	Item	Gross Value A ($/kWh)	×	Load Match Factor B (%)	×	Loss Savings Factor (1+C) (%)	=	Distributed PV Value D ($/kWh)
Energy Supply	Avoided Energy Cost	C1				LSF-Energy		V1
	Avoided Gen. Capacity Cost	C2		ELCC		LSF-ELCC		V2
	Avoided Res. Gen. Capacity Cost	C3		ELCC		LSF-ELCC		V3
	Avoided NG Pipeline Cost	C4				LSF-Energy		V4
	(Solar Integration Cost)	(C5)				LSF-Energy		(V5)
Transmission Delivery Service	Avoided Trans. Capacity Cost	C6		ELCC		LSF-ELCC		V6
Distribution Delivery Service	Avoided Dist. Capacity Cost	C7		PLR		LSF-Dist		V7
	Voltage Regulation	C8						V8
Environmental	Net Social Cost of Carbon	C9				LSF-Energy		V9
	Net Social Cost of SO_2	C10				LSF-Energy		V10
	Net Social Cost of NO_x	C11				LSF-Energy		V11
Other	Market Price Response	C12				LSF-Energy		V12
	Avoided Fuel Price Uncertainty	C13				LSF-Energy		V13
								Total

Simplifications: City of Bloomfield

- Wholesale costs:
  - Energy ($ per kWh)
    - Not differentiated by hour
    - Not differentiated by season
  - Demand ($ per kW per month)
    - Note: avoided *charges*. Costs are still incurred, but re-allocated.
- No load growth
  - Therefore no avoided distribution costs

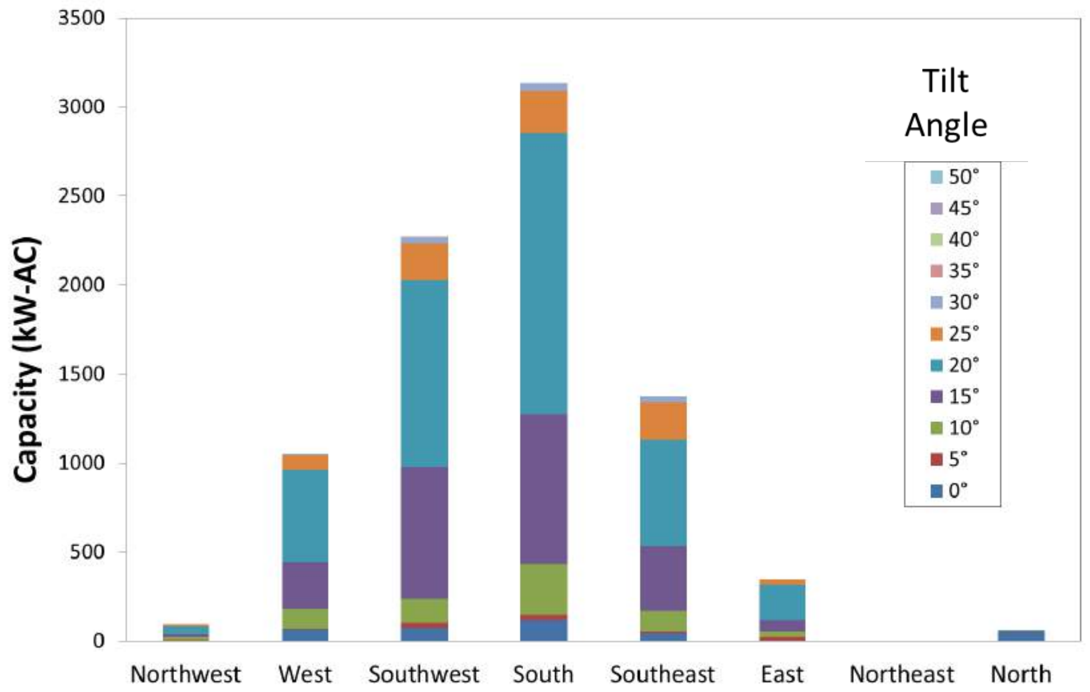
Each System Has a Unique Hourly Profile

- Hourly solar profiles can be obtained either by simulating production of multiple systems or by using measured solar production.
- Each system will have a different production profile depending on location and orientation.
- For example, an east-facing system (red curve) will peak early in the day, while a west-facing system (gold curve) will peak late in the day.



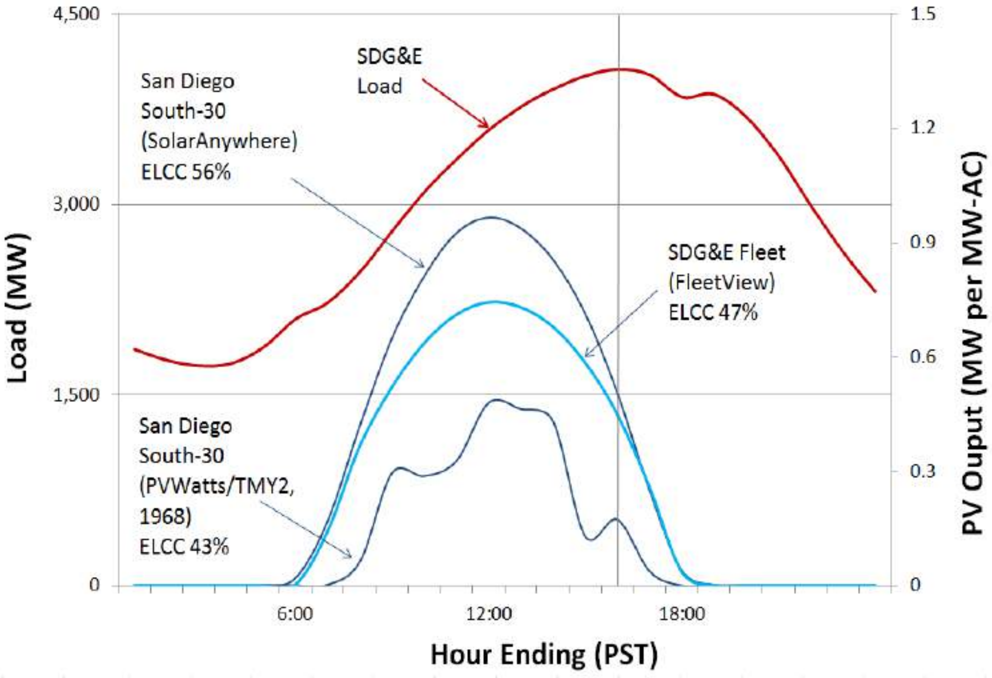
The Fleet Profile Should Be Weighted by Capacity

- When simulated, the systems must reflect the distribution of capacity.
- For example, south-facing capacity should be weighted more than east-facing capacity.
- Data from other jurisdictions may be used to obtain approximate weighting factors.



Obtaining Hourly Solar Profiles

- Hourly solar profiles are critical to the benefit/cost evaluation because they determine hourly load reduction.
- The solar profiles should be based on the aggregate fleet of resources, rather than just a single system.
- If a single system were used, the shape would not be correct and this results in incorrect valuation.
- Also, the solar shape should be taken for the same time interval as load rather than "typical" output.



ELCC: DC and AC Ratings

Selection of rating convention is arbitrary

	AC Rating Convention	DC Rating Convention
Marginal PV Producion Profile	Base Case Time Series	Base Case Time Series
Resource Rating	1 kW AC	1 /0.77 = 1.30 kW DC
ELCC	0.544 kW / 1 kW = 54.4%	0.544 kW / 1.30 kW = 41.9%
Annual Energy	1628 kWh / 1 kW = 1628 kWh/kW	1628 kWh / 1.30 kW = 1252 kWh/kW
First Year Capacity Value (Illustrative)	\$10/kW-mo x 12 mo/yr x 1 kW (dispatchable) x 54.4% (effective) ÷ 1628 kWh/kW = \$0.040 per kWh	\$10/kW-mo x 12 mo/yr x 1 kW (dispatchable) x 41.9% (effective) ÷ 1252 kWh/kW = \$0.040 per kWh

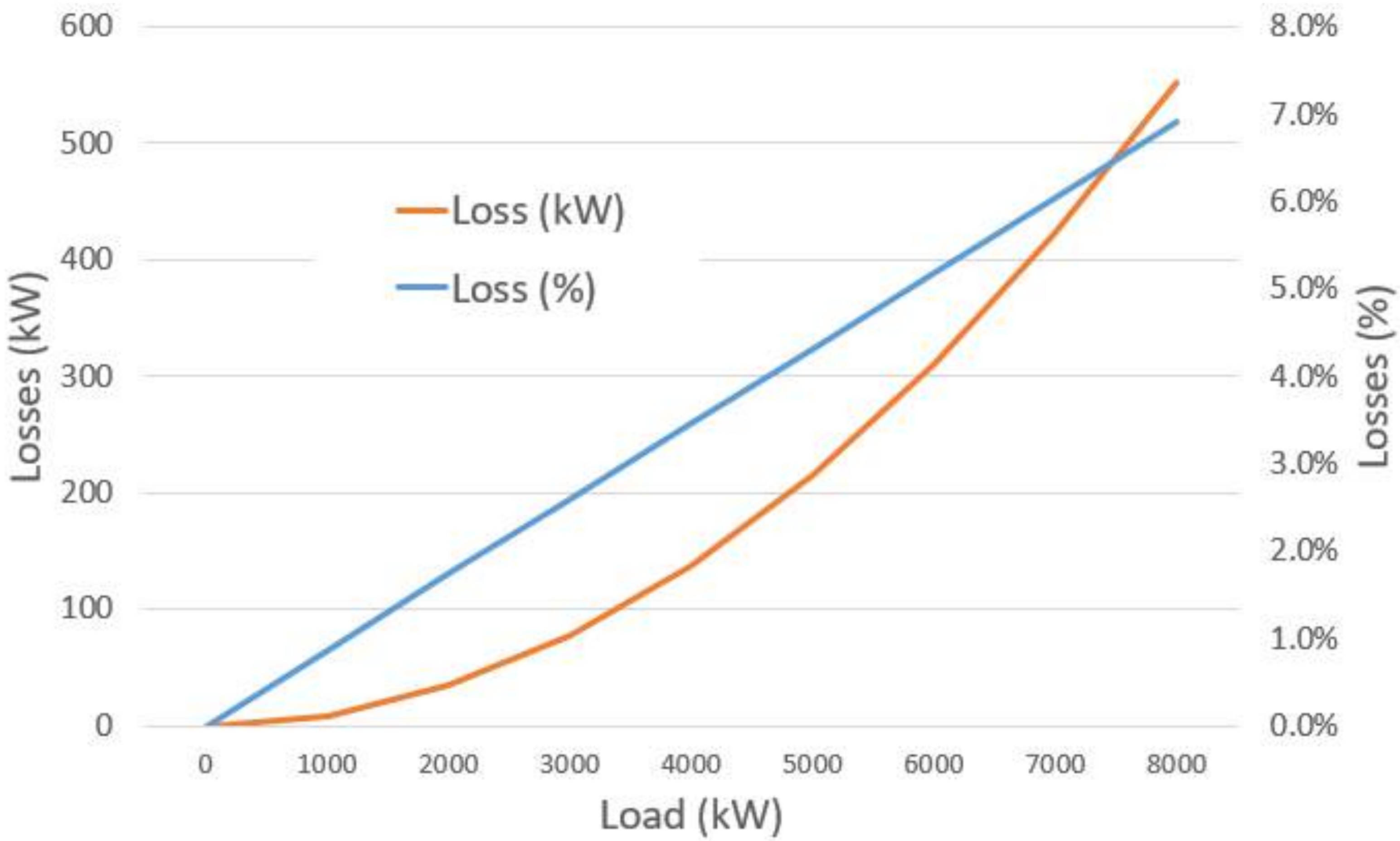
Calculating Line Loss Savings

Illustration: 2007 ConEdison Line Loss Study

Portion of T&D Delivery System	Voltage Segment	Loss Type	
		Fixed	Variable
Transmission	500 kV	0.00%	0.00%
	345 kV	0.32%	0.52%
	138 kV	0.34%	0.50%
	69 kV	0.03%	0.05%
	TOTAL	**0.69%**	**1.07%**
Distribution	Primary	0.02%	1.12%
	Secondary	0.00%	1.56%
	Metering	0.18%	0.00%
	Equipment	0.78%	0.39%
	TOTAL	**0.98%**	**3.07%**
Unaccounted For		0.00%	0.65%
TOTAL		**1.67%**	**4.79%**

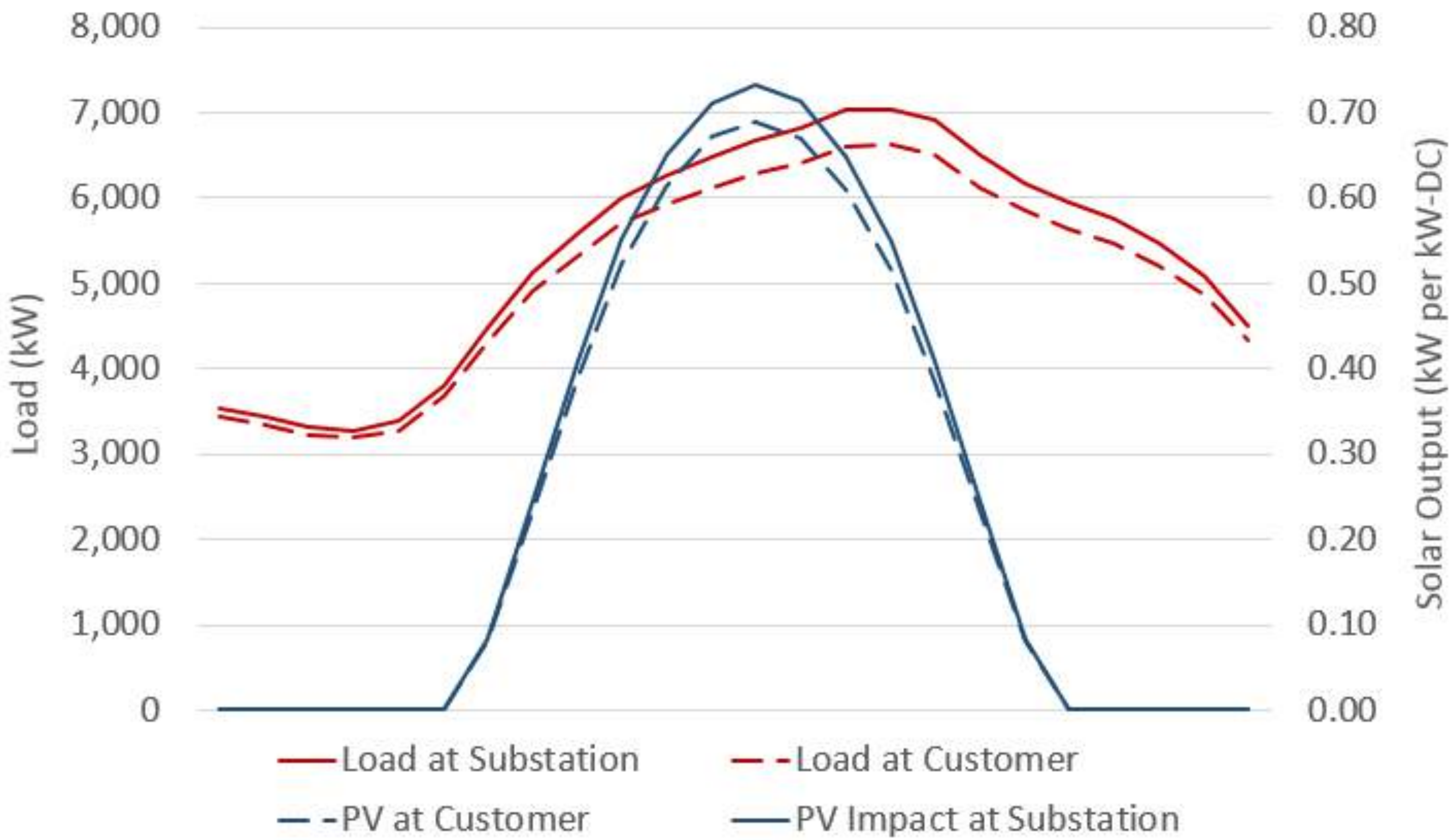
City of Bloomfield Losses (Assumed)

Total Variable Losses 3% of Total Annual Load



City of Bloomfield Peak Day (July 17, 2015)

South-20 Fixed Solar Resource



Avoided Energy - Bloomfield

	Location	kWh per kW-DC	
Energy Produced	Customer	1267	[A]
Energy Avoided	Substation	1309	[B]
"Effective" Loss Savings Factor		**1.033**	**= [B]/[A]**

Peak Demand Reduction - Bloomfield

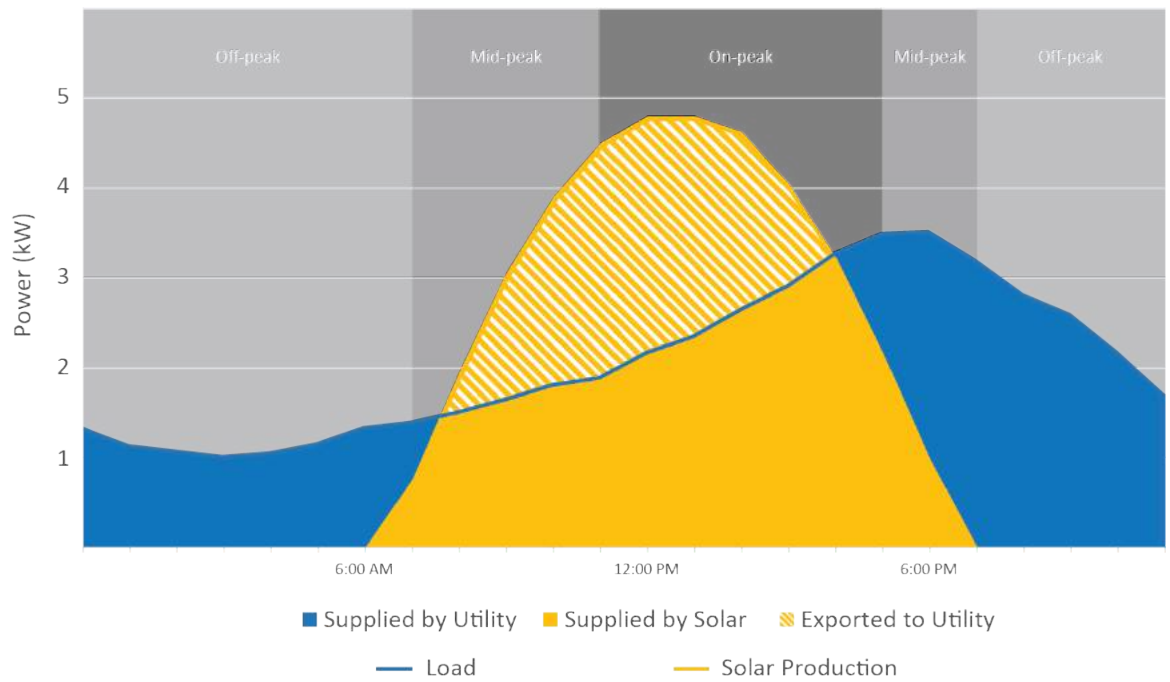
kW Reduction per kW-DC

Month	Customer	Substation	Loss Savings Factor
1	0.119	0.124	1.048
2	0.014	0.015	1.045
3	0.080	0.084	1.042
4	0.251	0.259	1.031
5	0.406	0.420	1.036
6	0.609	0.642	1.055
7	0.516	0.550	1.065
8	0.384	0.404	1.053
9	0.416	0.440	1.058
10	0.357	0.369	1.034
11	0.007	0.007	1.035
12	0.000	0.000	
Avg	**0.263**	**0.276**	**1.049**

Variation: Value of Export Energy

- Between 6am to 6pm, the amount of energy generated by the solar system exceeds the participant's load.

- Only the amount of energy which is generated in excess of that load (i.e. the amount "exported to the utility") would be credited at a value that is meant to reflect its value to the grid.



Additional Resources

- Minnesota Value of Solar Tariff Methodology
  - Developed by CPR for Minnesota Dept. of Commerce, approved by Minnesota PUC
  - Methodology only (not study)
  - Downloadable at: *https://mn.gov/commerce/energy/businesses/energy-leg-initiatives/value-of-solar-tariff-methodology%20.jsp*
- Maine PUC Value of Solar Study
  - Developed by CPR for PUC, delivered by PUC to state legislature
  - Includes study of three jurisdictions and policy options
  - Downloadable at: *http://www.maine.gov/mpuc/electricity/elect_generation/valueofsolar.shtml*

Thank You!

Ben Norris

ben@cleanpower.com