



Distributed vs. Utility-scale: The Key Role of T&D Costs

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The Debate

- Utilities and some consumer advocates argue:
 - Utility-scale solar costs less than DG solar.
 - Utility-scale provides the same benefits as DG solar at lower cost.
- Examine this argument in detail
 - Use costs & benefits from California & Colorado
 - Numbers are indicative, and state-specific

What is the Same? What is Different?

10 MW of utility-scale vs. 10 MW of rooftop solar



Look at the Products Provided

- Do rooftop and utility-scale solar provide the same product? *No.*
 - Rooftop competes with delivered retail power.
 - A minority of output is exported to the neighbors.
 - Utility-scale competes with wholesale generation.
 - Cost of delivery separates the two products.

Colorado: Rooftop Solar Benefits

Benefit / (Cost)	Rooftop Case	Utility-scale vs. Rooftop	
	<i>cents/kWh</i>	Same?	Different?
Avoided Energy Costs	5.2	✓	
Fuel Hedge Value	0.7	✓	
Avoided Emissions	2.7	✓	
Avoided Generation Capacity	5.1		✓
Avoided Distribution	0.6		✓
Avoided Transmission	1.8		✓
Avoided Line Losses	0.6		✓
(Solar Integration Costs)	(0.2)	✓	
Subtotal	16.5		
10% Adder: Societal Benefits	1.7		✓
Total Benefits / (Costs)	18.2	8.4	9.7

Summary of Cost / Benefit Comparison: Rooftop vs. Utility-scale Solar

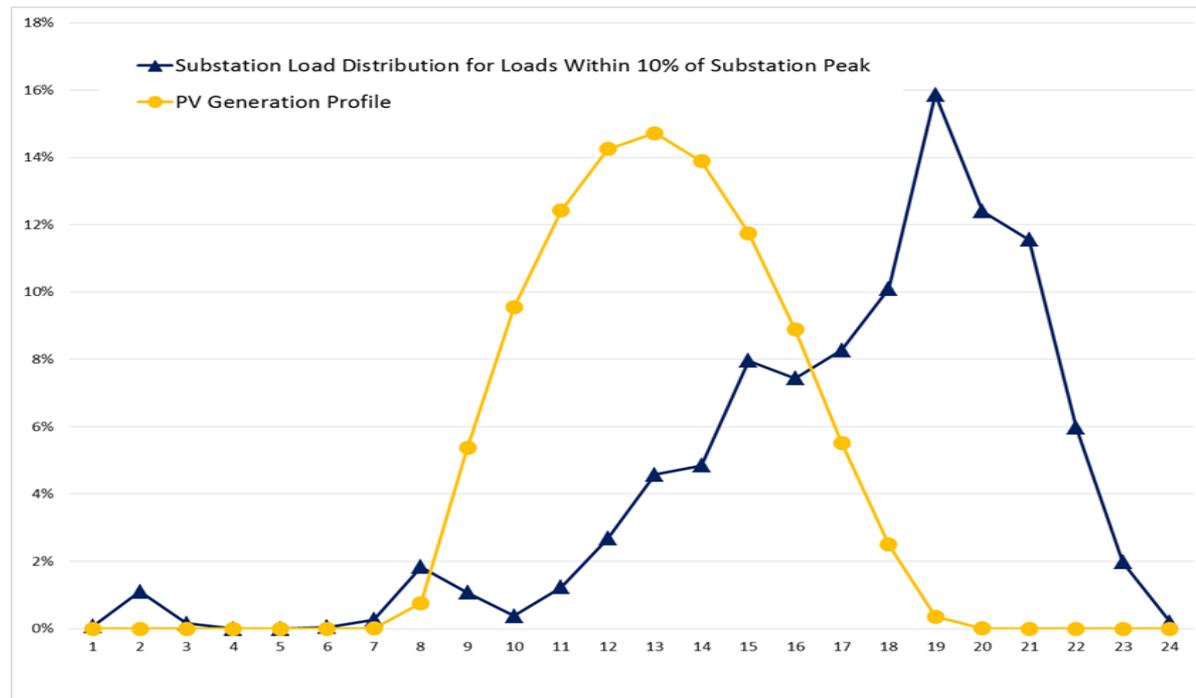
Category	Comments	Difference: Rooftop vs. Utility-scale
Costs		<i>cents/kWh</i>
LCOE	Economies of scale favor utility-scale.	-5.6 to -7.7
Transmission	Utility-scale requires new transmission.	+0.6 to +1.2
Benefits		
Generation Capacity	Utility-scale has higher capacity factors; rooftop avoids reserve margin capacity.	-0.6 to +0.8
T&D and Line losses	Range based on the location of utility-scale solar facilities.	+0.9 to +3.0
Avoided RPS	Varies based on state RPS rules. Rooftop best serves demand for 100% renewables.	+1.5 to +3.0
Reliability	Rooftop enables on-site backup power, esp. when combined with storage.	+1.1 to +2.2
Societal	Rooftop has economic development and land use benefits compared to utility-scale.	Favors rooftop
Customer choice	Rooftop promotes customer choice and engagement, and accesses new capital.	Favors rooftop
Total Net Benefits	Assumes utility rate base financing of utility-scale plants.	-4 to +5

Transmission for Utility-scale Solar

- Utility-scale solar requires new transmission.
 - California (E3 Report on 50% RPS)
 - 4.6 c/kWh for out-of-state renewables
 - 3.4 c/kWh for in-state renewables
 - 2.1 c/kWh for small wholesale solar
 - Colorado (Crossborder, from Xcel/SB 100 data)
 - 1.3 c/kWh for Pawnee-Smoky Hill 345 kV (400 MW of wind)
 - 1.3 c/kWh for Lamar-Front Range 345 kV (900 MW of wind)
 - 1.2 c/kWh for San Luis-Calumet-Comanche (solar)
 - PJM (GE): 0.5 c/kWh at 30% renewables

Solar Coincidence with T&D Peaks

- Transmission peak = system peak
 - Generation ELCC (49%)
- Distribution peaks are variable
 - Distribution substation “ELCC” (23%)



Other Differential Benefits

- **Avoided renewables (state specific)**
 - Behind-the-meter DG reduces utility sales & can meet RPS requirements.
 - Solar DG serves demand for 100% renewables.
- **Grid security & reliability**
 - DG diversity enhances reliability.
 - DG enables distributed storage.
- **Land use: DG uses the built environment**
- **Economic: DG spends more locally.**

Soft Benefits of Customer-Generation

- A new source of capital for clean energy infrastructure
- Competition for the utility's retail power
- Customer engagement
 - Synergies with EE / DR – informed consumers
 - Appeal of clean tech / no moving parts
 - DIY / self-reliance
 - Jeffersonian ideal of the citizen (solar) farmer
- Silicon-on-the-roof vs RECs
- All of the above are strong policy drivers.

Conclusions

- Quantifiable **net** benefits of utility-scale and rooftop solar are roughly comparable.
- Cost advantage of utility-scale are offset by certain advantages of rooftop:
 - Avoided T&D costs
 - RPS and Reliability benefits
 - Customer choice and engagement benefits
 - Societal (land use / economic development)
- **These differences are debatable & challenging to quantify.**
- Both types of solar have important roles as part of a clean energy infrastructure.