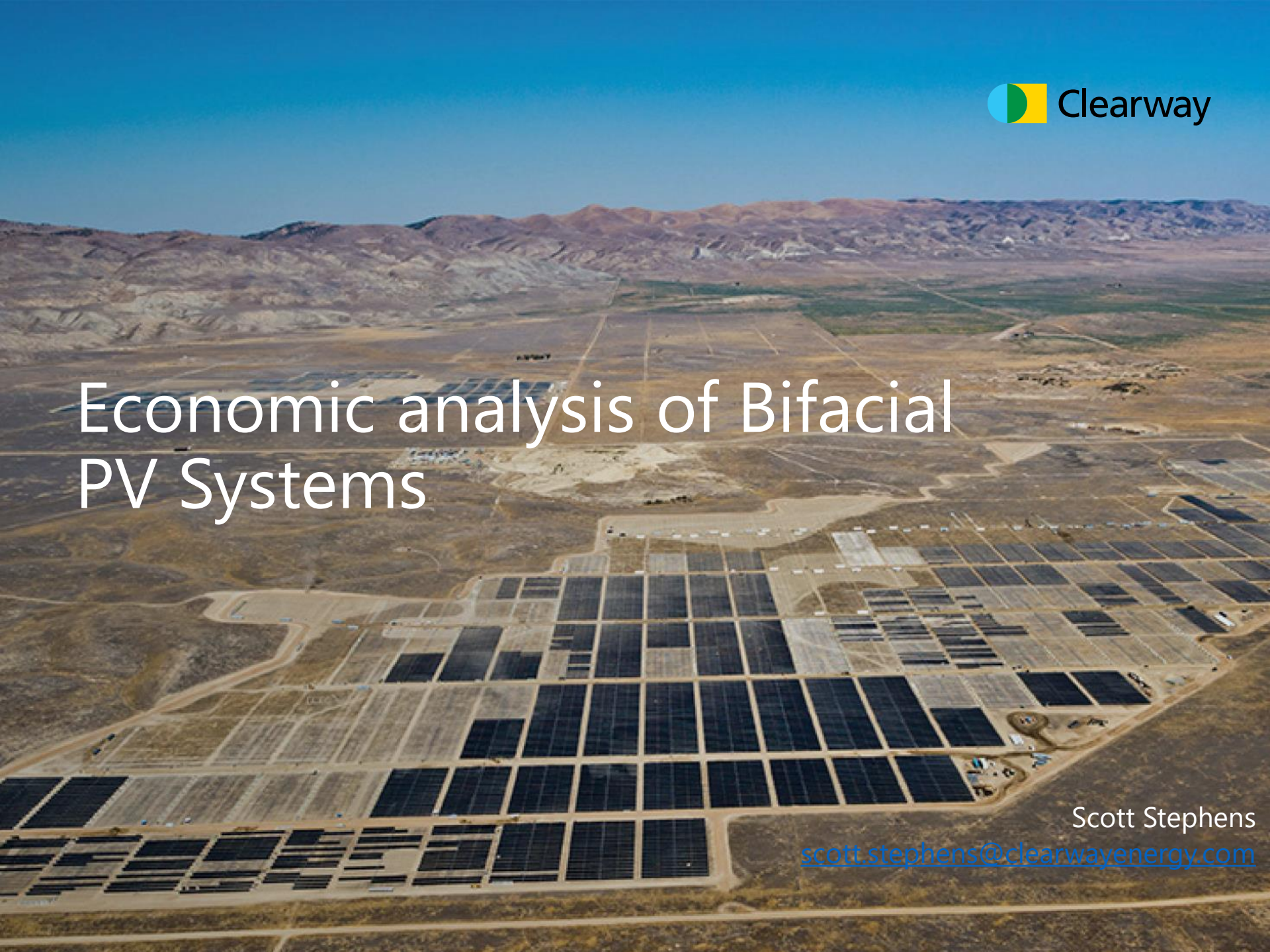

Economic analysis of Bifacial PV Systems

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What is the value of enhanced yield?

- Current 30% ITC improves the value of yield by almost 50%. This impact combine with relatively higher labor costs are the drivers behind the US market's willingness to pay more for yield (e.g. trackers).
- Higher PPA pricing will increase this capex escalation tolerance.
- 30% ITC drives nearly 50% of this capex escalation tolerance.
- Promising implications for MLPE particularly when synergy with bifacial is considered.

$/$W_{dc}$ price increase for equivalent NPV*

Annual Yield Increase	ITC (PPA held fixed at $25/MWh escalating at 2%)				
	30% (2019)	26% (2020)	22% (2021)	10% (2022)	0% (Non-US)
1%	$0.014	$0.014	$0.013	$0.011	$0.010
2%	$0.029	$0.027	$0.026	$0.023	$0.020
3%	$0.043	$0.041	$0.039	$0.034	$0.031
4%	$0.057	$0.054	$0.052	$0.045	$0.041
5%	$0.072	$0.068	$0.065	$0.056	$0.051
6%	$0.086	$0.082	$0.078	$0.068	$0.061
7%	$0.101	$0.095	$0.091	$0.079	$0.071
8%	$0.115	$0.109	$0.104	$0.090	$0.081
9%	$0.129	$0.123	$0.116	$0.101	$0.092

*Total installed price omitted due to confidentiality concerns

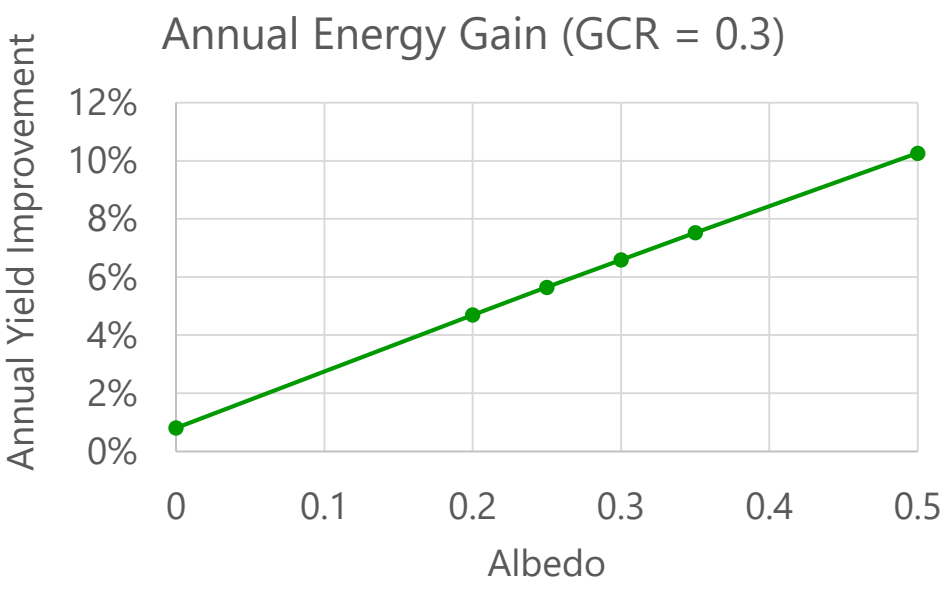
What is the $/W adder for a bifacial system?

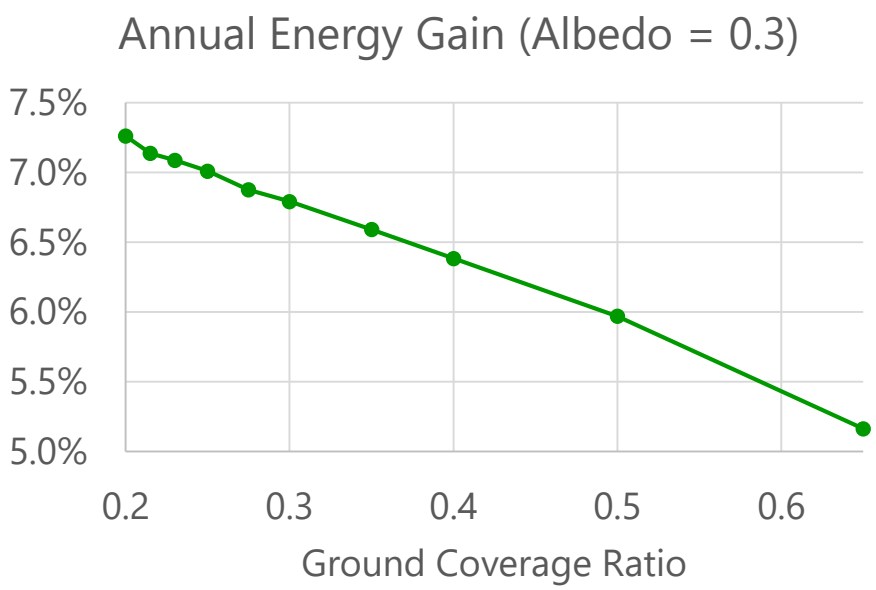
Consideration	$/$W_{dc}$ Adder	Notes
Module Price	$0.025	Likely to fall to <$0.02/$W_{dc}$ by 2020 and beyond.
Tax	$0.002	7% on module price
Contingency	$0.001	4.6% on module price
Efficiency Penalty	$0.004	~10W frontside efficiency penalty due to red light transmission
Potential EPC adder	$0.004	Performance testing complexity may add time and induce indirect costs
Lower DC:AC Ratio	$0.013	Reduced per watt amortization while maintaining same inverter count
Owner contingency	$0.006	$0.002 (driven by EPC and panel price increase), $0.004 reduced amortization interconnection cost due to smaller system.
Development costs	$0.007	Reduced Amortization
Induced small size benefits	-$0.002	Shorter duration, lower construction risk. No area related benefits because we assume that GCR will decrease.
SUM	$0.06	

Total $/$W_{dc}$ impact is > 2x the price premium for bifacial modules

Assumptions used in analysis:

Assumptions: Tracking, Desert Southwest US, DC:AC ratio = 1.0

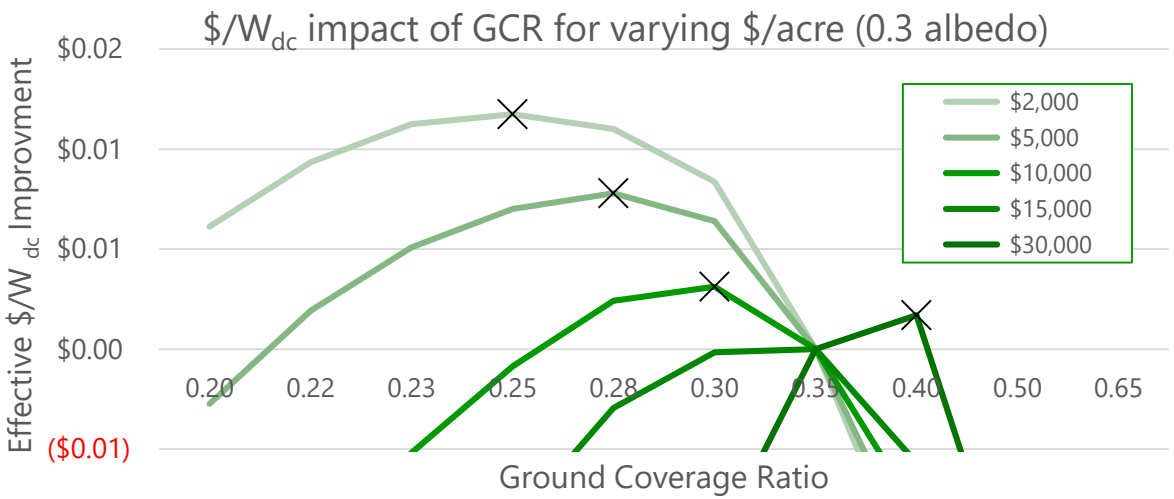




A 6 ¢/W bifacial adder, albedo >0.1 may still justify bifacial adoption for GCR < 0.35

Bifacial drives GCR below 0.3 for typical land costs

- Strong function of land value but strong yield drop-off above 0.35 GCR due to both front and rear irradiance losses suggests an optimum GCR≤0.3 except for very high land costs.
- Sharply negative above 0.35 for typical land costs ($5k-$15k/acre).
- Between 0.28-0.30 GCR there is a relatively flat optimum suggesting perhaps erroring on the higher side of this range to minimize the layout change relative to an optimized monofacial site (typically around 0.35-0.4 GCR).



Sensitivity calculated relative to a base case of 0.35 GCR and assuming 1% energy increase allows for a 1.4¢/W installation increase for equivalent NPV.

Comparison to horizontal tracking:

	Horizontal Tracker (2013)	**Bifacial (2019)**
Energy Increase	~20%	~10%
Price Increase	~$0.10-0.20/W	~$0.05/W
Investment Tax Credit	30%	30%
Ideal Resource	High DNI	High Albedo
Enabling Technology	Monofacial PV Systems	Glass/Glass, PERC
Optimization	GCR, DC:AC	GCR, DC:AC, System Optics
Performance Risk	Uptime and Tracking Accuracy	Modeling Uncertainty

Economic driver for bifacial at least as strong as tracking.
Will adoption rates reflect this?