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Cost and LCOE by Generation Technology, 2009-2020

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LCOE Inputs

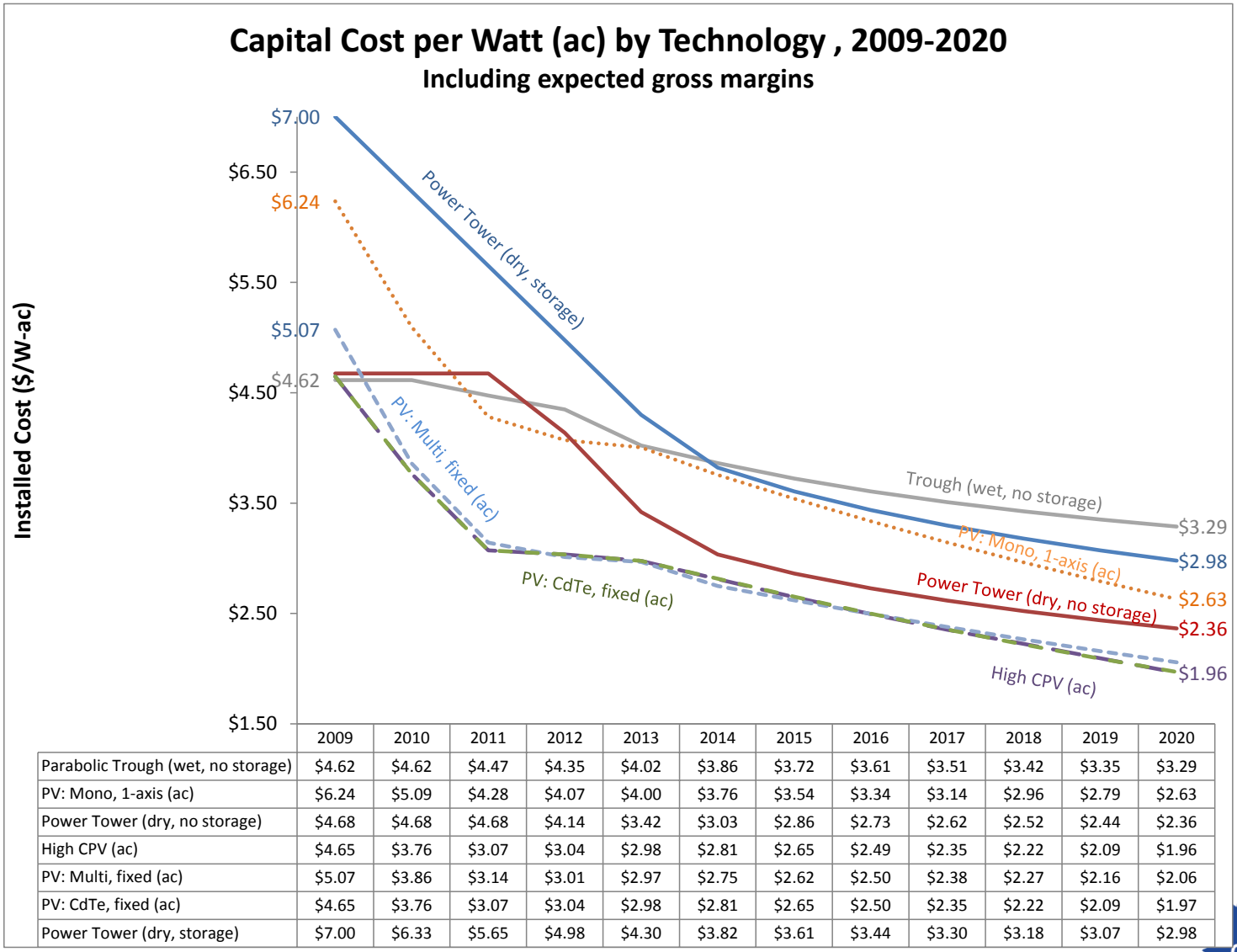
2011 LCOE Inputs for a hypothetical plant in the Southwest US (DNI of 6.85 kWh/m^2/day)

Technology	Trough		Tower		CLFR	PV: CdTe, fixed	PV: Mono, 1-axis	PV: Multi, fixed	High CPV (lens)	Wind	Gas CC
Cooling	Wet	Dry	Dry	Dry	Dry						
Storage	No	No	No	Yes	No						
Technology Assumptions											
Project Capacity (MW)	250	250	250	250	250	250	250	250	250	250	250
EPC Cost ($/kW-ac)	$4,067	$4,249	$4,250	$5,136	$3,482	$2,791	$3,893	$2,856	$2,791	$2,205	$909
Other Owner's Costs ($/kW-ac)*	$407	$425	$425	$514	$348	$279	$389	$286	$279	$220	$91
Capital Cost ($/kW-ac)	$4,474	$4,674	$4,675	$5,650	$3,830	$3,071	$4,282	$3,141	$3,071	$2,425	$1,000
Fixed O&M ($/kW-ac)	$66	$66	$55	$65	$48	$32	$36	$30	$36	$60	$6
Fixed O&M Escalation	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Variable O&M ($/MWh)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$3
Variable O&M Escalation	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Fuel Cost ($/MBtu)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$6
Fuel Cost Escalation	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Heat Rate (Btu/kWh)	0	0	0	0	0	0	0	0	0	0	7000
Capacity Factor	27%	26%	30%	43%	25%	21%	27%	20%	25%	35%	90%
Misc Escalation	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Degradation	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.5%	0.5%	0.5%	0.0%	0.0%
Financial/Economic Asumptions											
Debt Percentage	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	60%
Debt Rate	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%
Debt Term (years)	20	20	20	20	20	20	20	20	20	20	20
Economic Life (years)	25	25	25	25	25	25	25	25	25	25	25
Percent 5-year MACRS	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Tax Rate	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%
Cost of Equity	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%
Incentives											
ITC	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
ITC Depr Basis	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%

* Other Owner's Costs includes site permits & preparation, project management costs, sales taxes, land, property taxes, insurance, architectural costs, interconnection fees, public relations, debt reserve, lender fees, and other administrative costs

Source: GTM Research

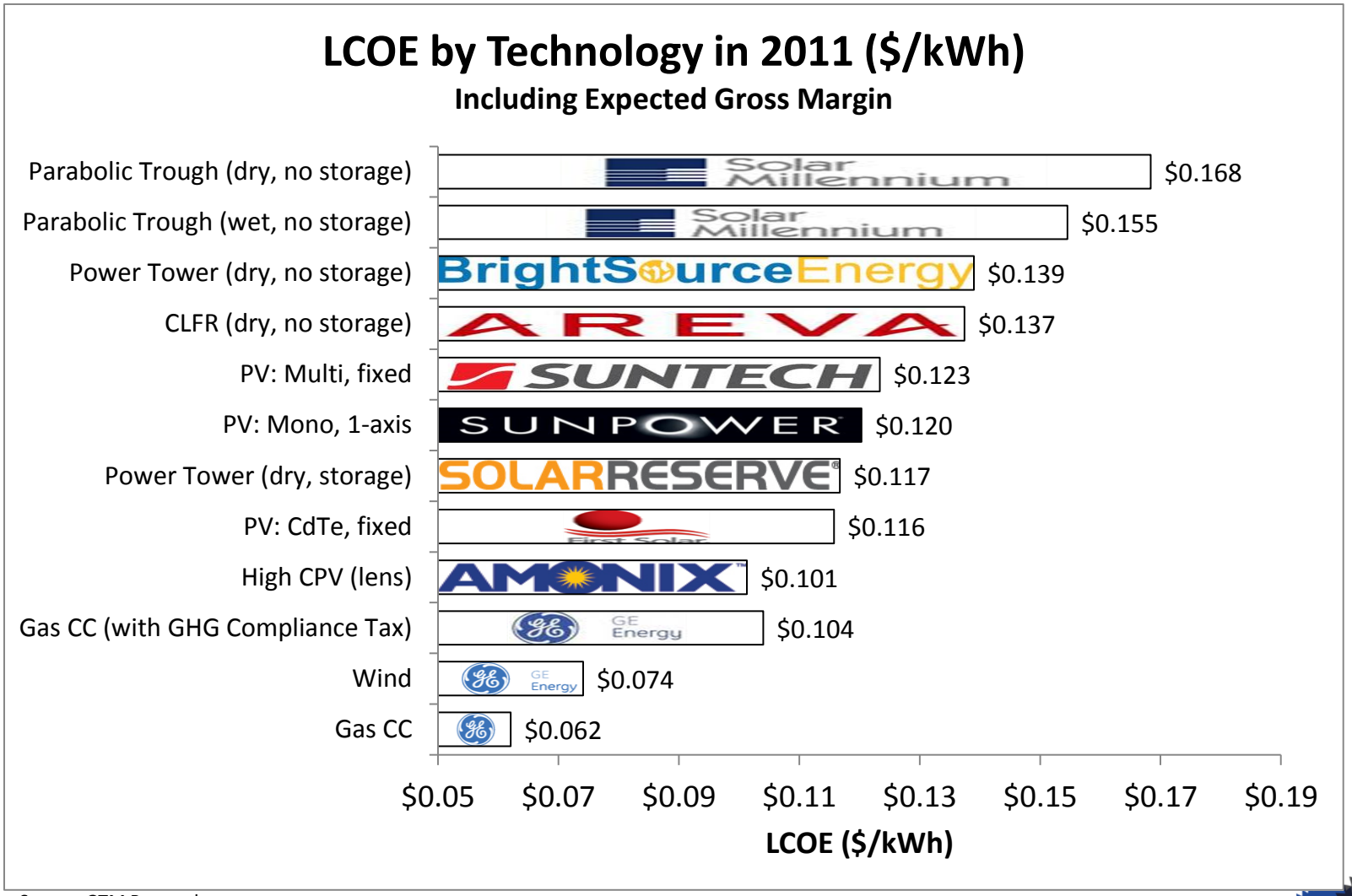
Capital Cost per Watt (PV costs converted to AC)



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Parabolic Trough (wet, no storage)	$4.62	$4.62	$4.47	$4.35	$4.02	$3.86	$3.72	$3.61	$3.51	$3.42	$3.35	$3.29
PV: Mono, 1-axis (ac)	$6.24	$5.09	$4.28	$4.07	$4.00	$3.76	$3.54	$3.34	$3.14	$2.96	$2.79	$2.63
Power Tower (dry, no storage)	$4.68	$4.68	$4.68	$4.14	$3.42	$3.03	$2.86	$2.73	$2.62	$2.52	$2.44	$2.36
High CPV (ac)	$4.65	$3.76	$3.07	$3.04	$2.98	$2.81	$2.65	$2.49	$2.35	$2.22	$2.09	$1.96
PV: Multi, fixed (ac)	$5.07	$3.86	$3.14	$3.01	$2.97	$2.75	$2.62	$2.50	$2.38	$2.27	$2.16	$2.06
PV: CdTe, fixed (ac)	$4.65	$3.76	$3.07	$3.04	$2.98	$2.81	$2.65	$2.50	$2.35	$2.22	$2.09	$1.97
Power Tower (dry, storage)	$7.00	$6.33	$5.65	$4.98	$4.30	$3.82	$3.61	$3.44	$3.30	$3.18	$3.07	$2.98

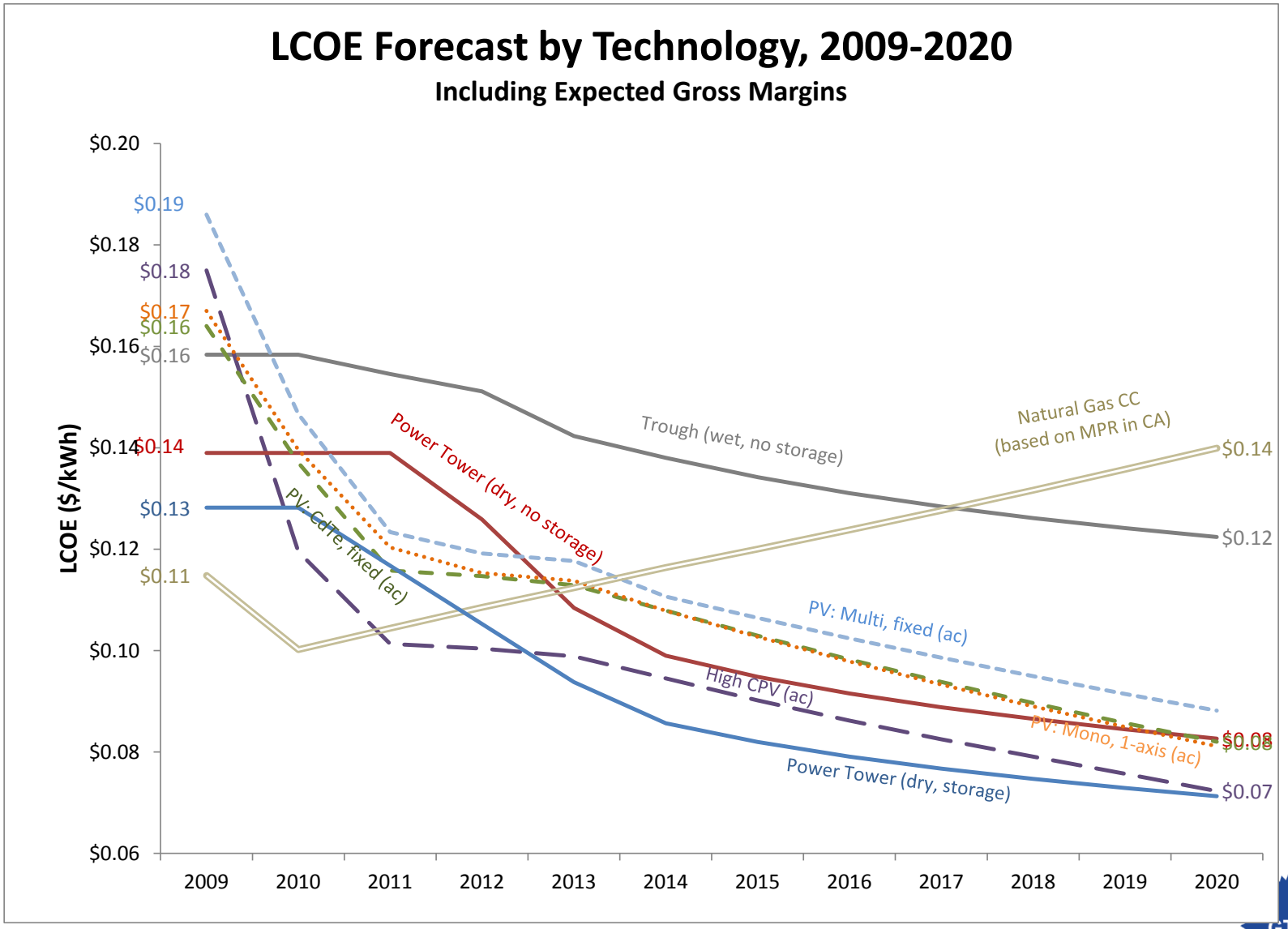
Source: GTM Research

LCOE for a plant in US Southwest by technology



Source: GTM Research

LCOE Forecast by Technology



Source: GTM Research

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Shortcomings of LCOE

- LCOE allows for comparison across technologies, but it ignores two of the key characteristics for generation assets:

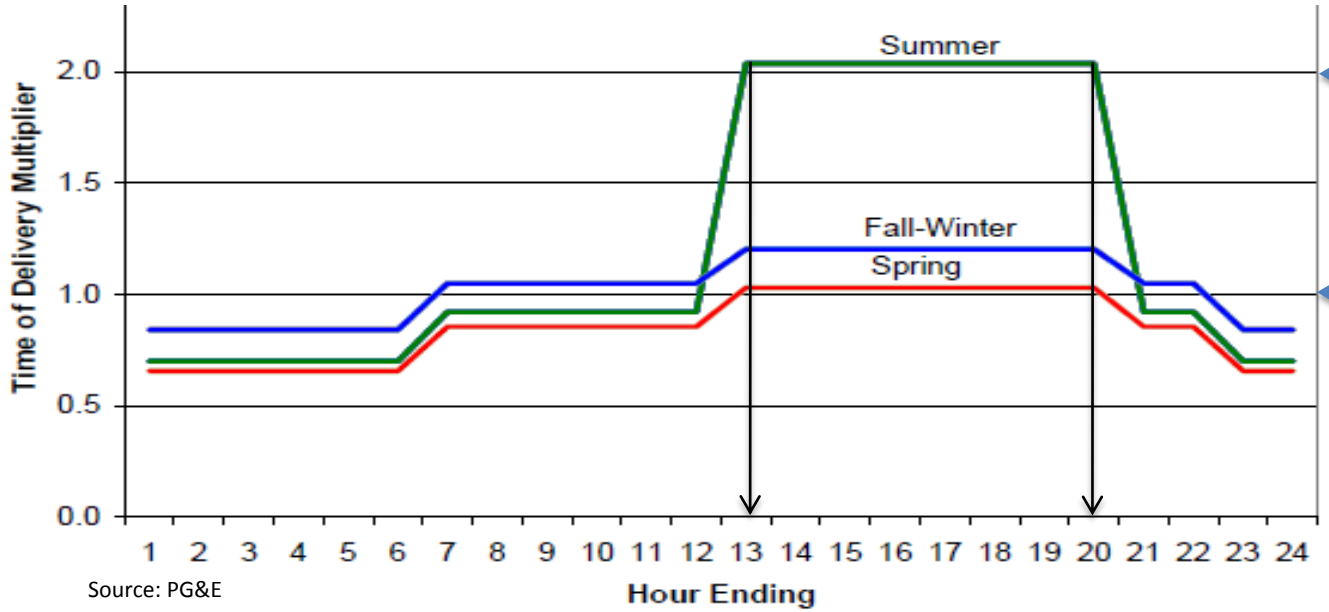
  - Dispatchability
    Natural gas plants can provide firm power, wind and solar plants cannot. LCOE also ignores the capacity payments that are associated with operating a firm generating asset

  - Generation Time-of-Day (TOD)
    LCOE doesn't consider the time of day when the power is generated. This can be a significant driver of profitability as many PPAs include TOD factors which determine the effective revenue earned per kWh

LCOE doesn't consider differing revenue/kWh from TOD effects

Time of Delivery (TOD)

Solar systems earn higher payments due to TOD multiplier effects. In this example, a PPA with a base rate of $0.10/kWh pays 2.0x ($0.20/kWh) for power generated between 1 pm to 8 pm in the summer.



Source: PG&E

Each kWh generated receives $0.10/kWh x 2.0 = $0.20/kWh

Each kWh generated receives $0.10/kWh x 1.0 = $0.10/kWh

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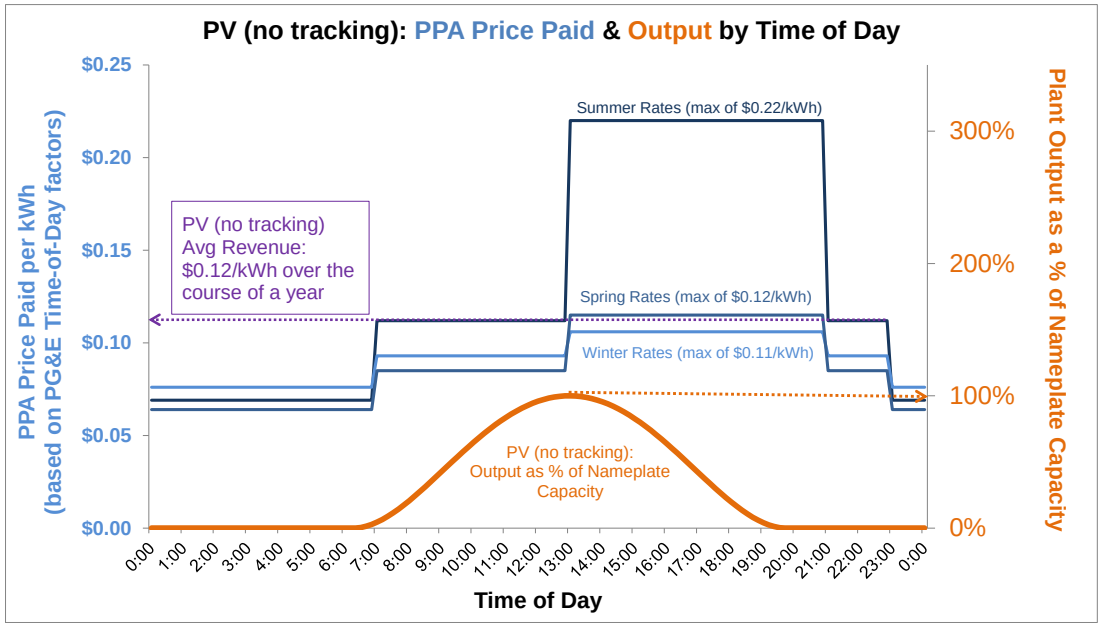
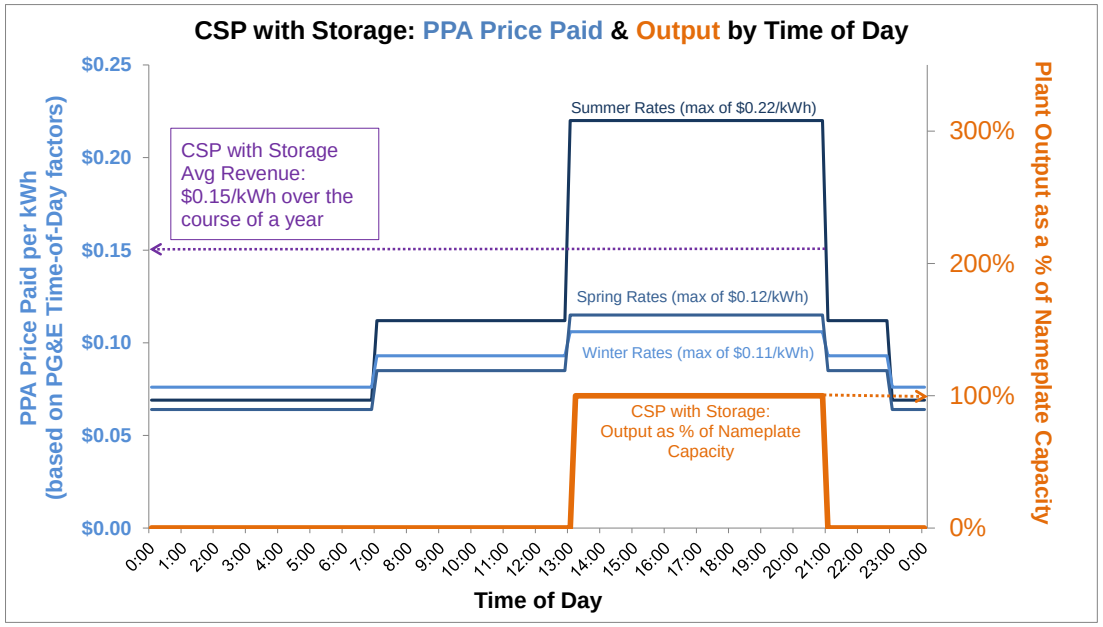
CSP with storage can earn higher revenue & profits per kWh than PV





Project Economics: PV vs. CSP with Storage

	PV (no tracking)	CSP (with storage)
PPA Price ($/kWh)	$0.10	$0.10
Avg TOD Factor	1.2x	1.5x
Avg Revenue ($/kWh)	$0.12	$0.15
Levelized Cost ($/kWh)	$0.11	$0.12
Avg Profit ($/kwh)	$0.01	$0.03
Equity Investor IRR	10%	20%

= better technology choice