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Customized Predictions of the Installed Cost of Behind-the-Meter Battery Energy Storage Systems

Andrew G. Benson

Motivation

- Deployment of behind-the-meter (BTM) battery energy storage systems (BESS) is accelerating.
- Bottom-up, detailed engineering estimates of the cost of a particular system at a single site are outside the scope of many research applications.
- Recent scholarly literature assumes a linear equation relating the total cost of BTM BESS to its energy capacity and power capacity.

Research Question

What equation best fits the data for the fully installed cost of BTM BESS?

Methodology

16 candidate equations were estimated and compared on the Akaike Information Criterion:

$$AIC = 2k - 2\ln(\hat{L})$$

k = number of parameters

$\hat{L}$ = maximum of the likelihood function

Independent Variables	Dependent Variable			
	\$	\$/kWh	ln(\$)	ln(\$/kWh)
level, linear	6.65×10^5	5.54×10^5	5.43×10^5	5.17×10^5
level, quadratic	6.59×10^5	5.44×10^5	5.41×10^5	5.17×10^5
log, linear	7.04×10^5	5.43×10^5	5.14×10^5	5.14×10^5
log, quadratic	6.85×10^5	5.40×10^5	5.13×10^5	5.13×10^5

Results

A translog equation best fits the SGIP data:

$$ln(C_i) = \alpha_t^s + \beta_1 ln(E_i) + \beta_2 ln(P_i) + \gamma_1 \ln(E_i)^2 + \gamma_2 \ln(P_i)^2 + \gamma_3 \ln(E_i) \ln(P_i) + \delta_1 AC_i + \delta_2 DC_i + \delta_3 \ln(w_t^c) + \varepsilon_i$$

Variable	Meaning	Unit of Measure
C_i	installed cost	inflation-adjusted 2020 USD
E_i	energy capacity	kWh (AC-rated, usable)
P_i	power capacity	kW (continuous max)
AC_i	AC-coupled w/ DG	= 1 if yes, 0 otherwise
DC_i	DC-coupled w/ DG	= 1 if yes, 0 otherwise
w_t^c	median local wage for electricians	inflation-adjusted 2020 USD / hour

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Data Sources

- publicly-available Administrative data from the Self-Generation Incentive Program (SGIP) for California utility customers
- Tracking The Sun (TTS) database from Lawrence Berkeley National Laboratory

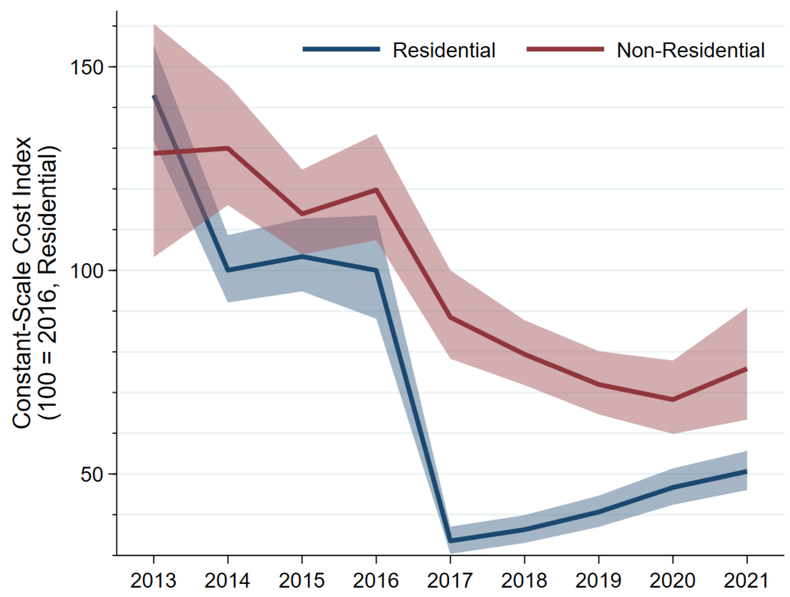
Parameter Estimates

Scale Parameters	
Energy (β_1)	*Power* (β_2)
-0.132 (0.043)	0.959 (0.038)
Energy^2 (γ_1)	*Power*^{2} (γ_2)
0.551 (0.021)	0.601 (0.025)
Energy × *Power* (γ_3)	
-1.141 (0.045)	
Coupling with DG	
AC (δ_1)	*DC* (δ_2)
0.058 (0.010)	0.029 (0.012)
Hourly Wage of Electricians (δ_3)	
0.042 (0.009)	

Sector-Year Fixed Effects (α_t^s)		
year	*Residential*	*Non-Residential*
2013	8.75 (0.07)	8.61 (0.11)
2014	8.40 (0.04)	8.64 (0.07)
2015	8.43 (0.05)	8.51 (0.05)
2016	8.39 (0.06)	8.51 (0.06)
2017	7.28 (0.05)	8.22 (0.06)
2018	7.37 (0.05)	8.09 (0.05)
2019	7.48 (0.05)	7.97 (0.05)
2020	7.62 (0.05)	7.92 (0.06)
2021	7.71 (0.05)	7.96 (0.06)
N = 25,896	adj. R^2=0.892	RMSE = 0.263

95% Confidence Interval

$e^{\pm 1.96 \times RMSE} - 1 \approx (-40\%, +68\%)$

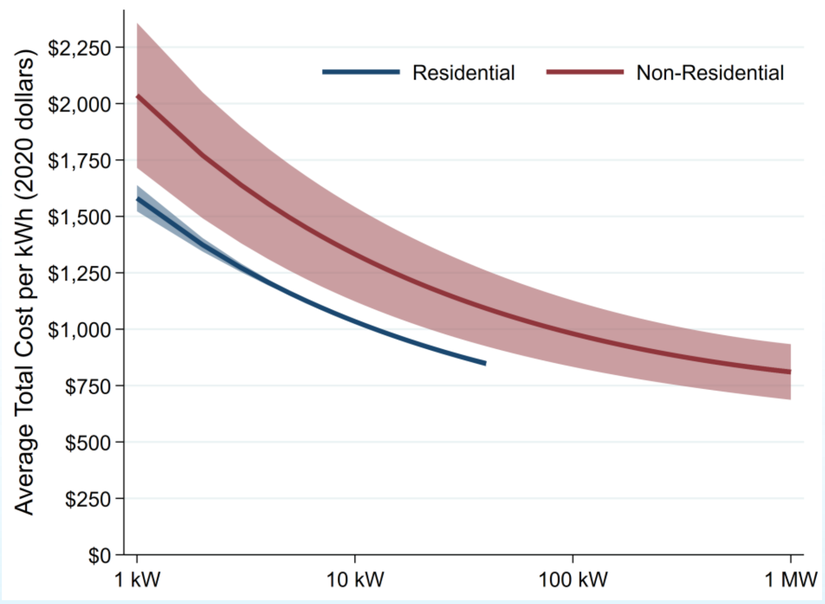


Trends in the Installed Cost of BTM BESS in California, by sector

variables held constant: system size, choice of AC or DC coupling, and electrician wages

Economies of Scale in BTM BESS

values assumed: year = 2021, discharge duration = 2.64 hours, AC coupling, electrician wages = statewide median for 2021



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