Supplementary Information

Title:

Cost and performance data for distributed energy resources: Literature review, harmonization, and synthesis

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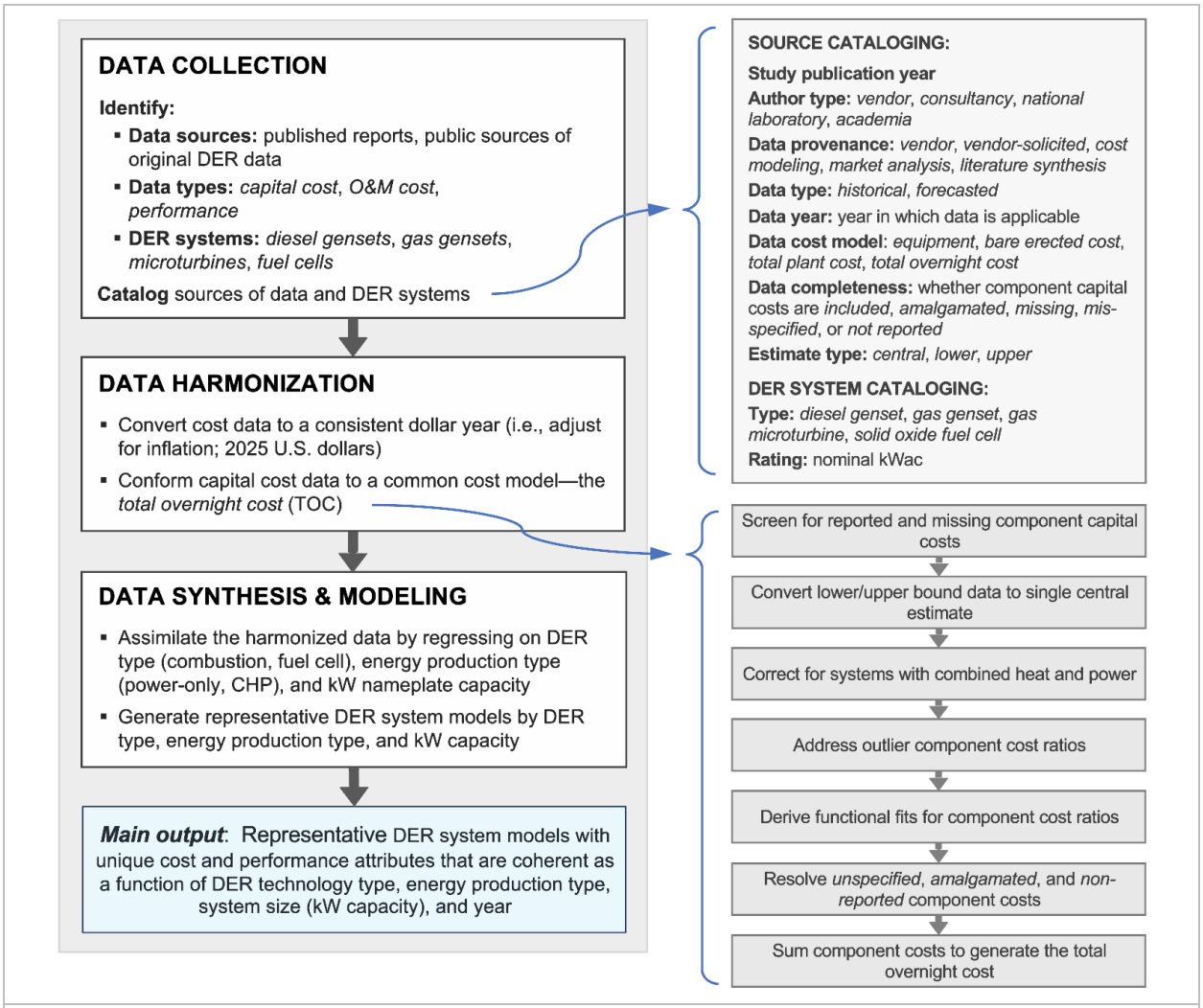
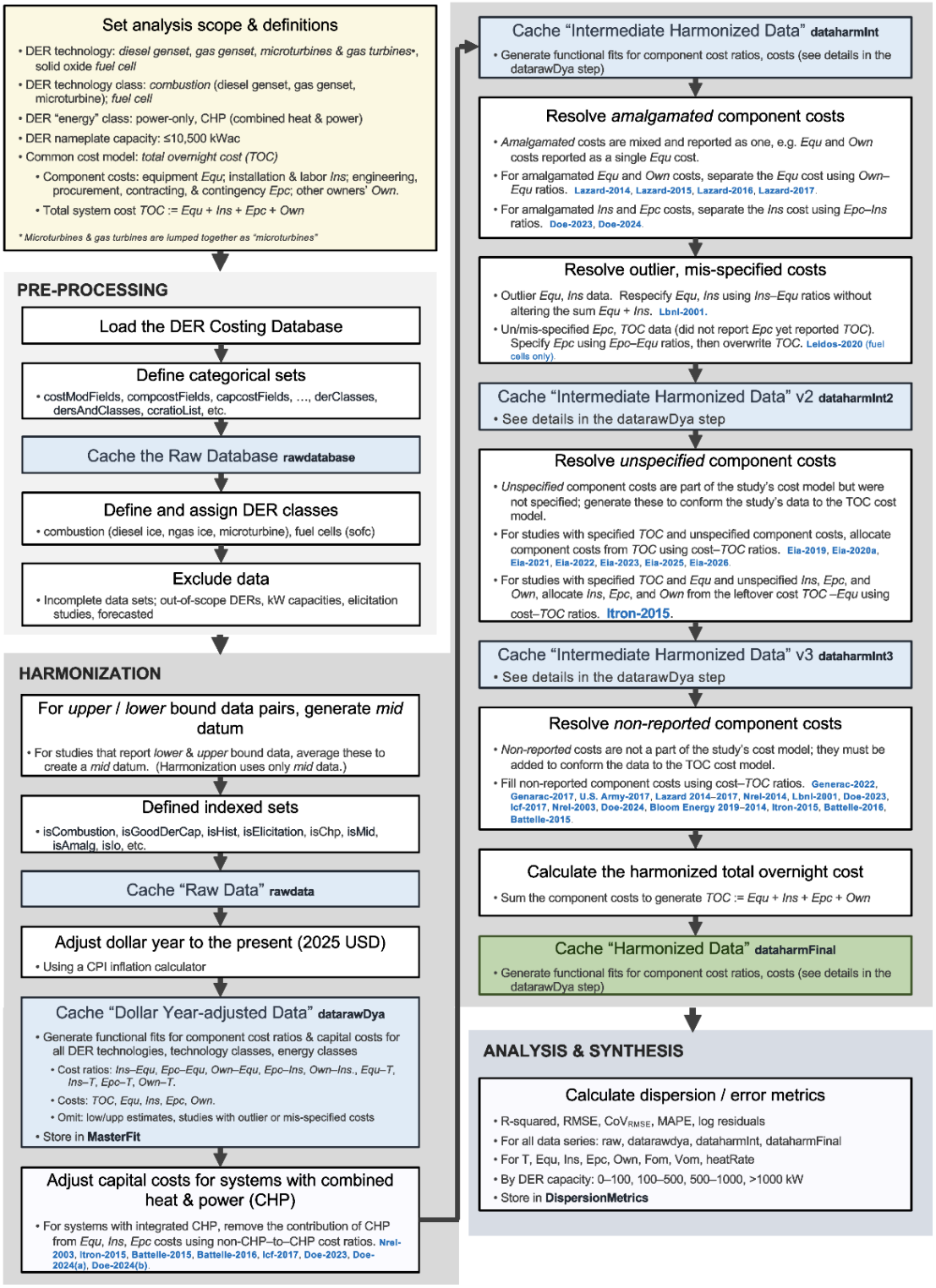
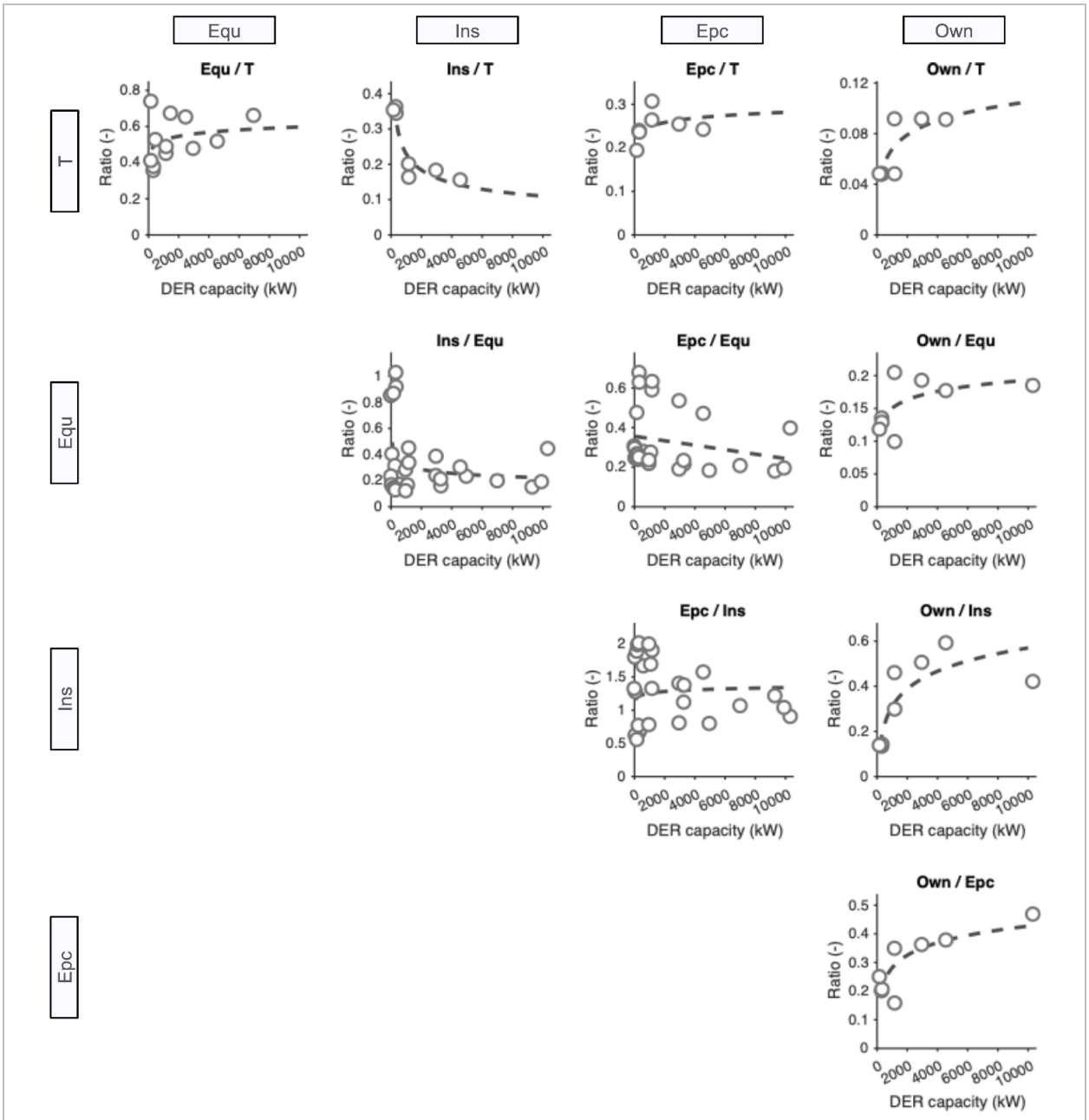


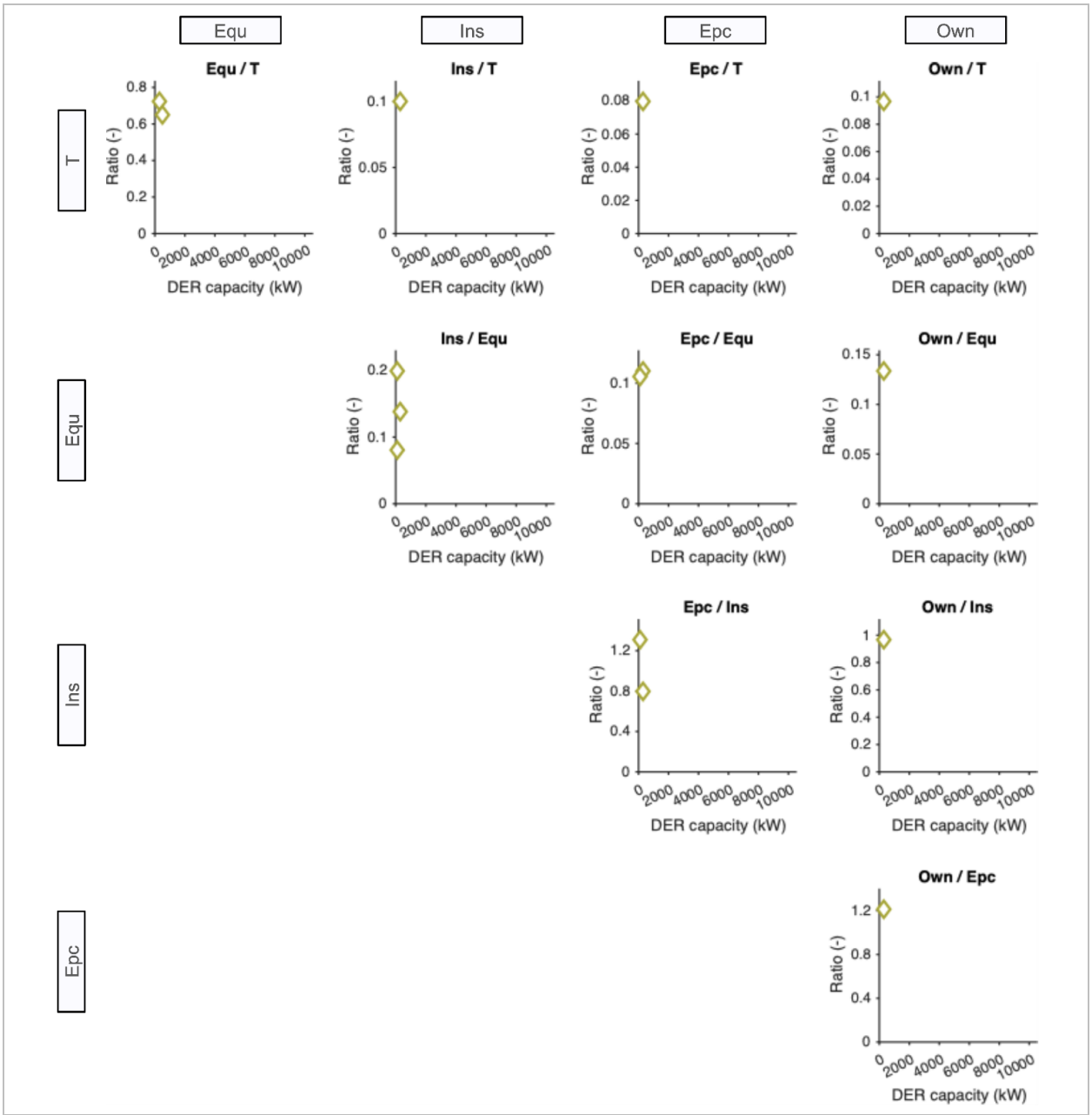
Fig. 1. Detailed summary of the data collection, harmonization, and synthesis process.



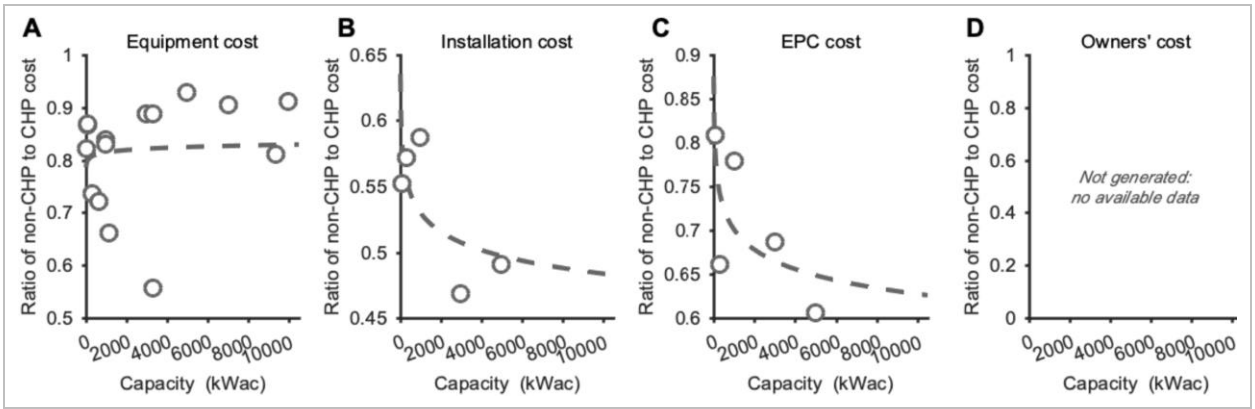
SI Fig. 2. Detailed steps in the harmonization methodology.



SI Fig. 3. Component cost ratios as a function of DER capacity, for combustion DERs (diesel gensets, gas gensets, microturbines). Columns (rows) denote the numerator (denominator) in each component cost ratio. Shown are the dollar-year adjusted base data for systems that generate power only, from which the component cost ratios used to generate new harmonized data are taken. This base data set is the most complete set of data available for identifying trends in costs and cost ratios. T–total overnight cost; Equ–equipment cost; Ins–installation and labor cost; Epc–engineering, procurement, and construction cost; Own–owners' costs.



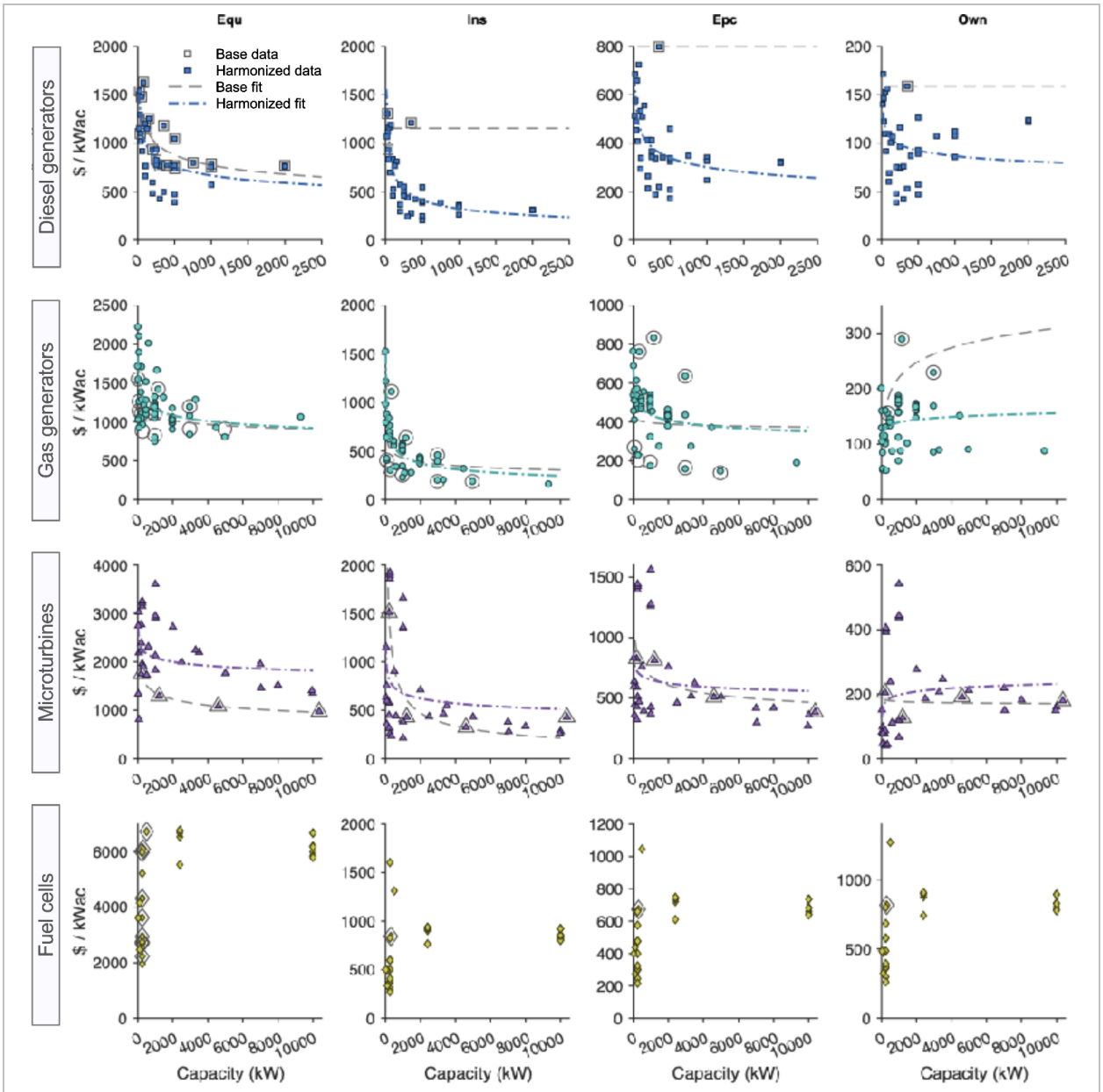
SI Fig. 4. Component cost ratios as a function of DER capacity, for fuel cells. Columns (rows) denote the numerator (denominator) in each component cost ratio. Shown are the dollar-year adjusted, CHP-corrected base data, from which the component cost ratios used to generate new harmonized data are taken. This base data set is the most complete set of data available for identifying trends in costs and cost ratios. T–total overnight cost; Equ–equipment cost; Ins–installation and labor cost; Epc–engineering, procurement, and construction cost; Own–owners' costs. Fits are not generated for fuel cells due to data sparsity.



SI Fig. 5. Component cost ratios as a function of DER capacity, for power-only and CHP systems. Marks denote the ratio in cost between power-only and CHP systems. Data come from two studies in the literature that specify both types of systems (DOE, 2003; ICF, 2017).

SI Table 1 | Functional forms for the dollar-year adjusted component cost ratios. The functional forms below are associated with the fits in SI Fig. 3. Equ–equipment cost; Ins–installation and labor cost; Epc–engineering, procurement, and construction cost; Own–owners' cost. Fits are not generated for fuel cells due to data sparsity.

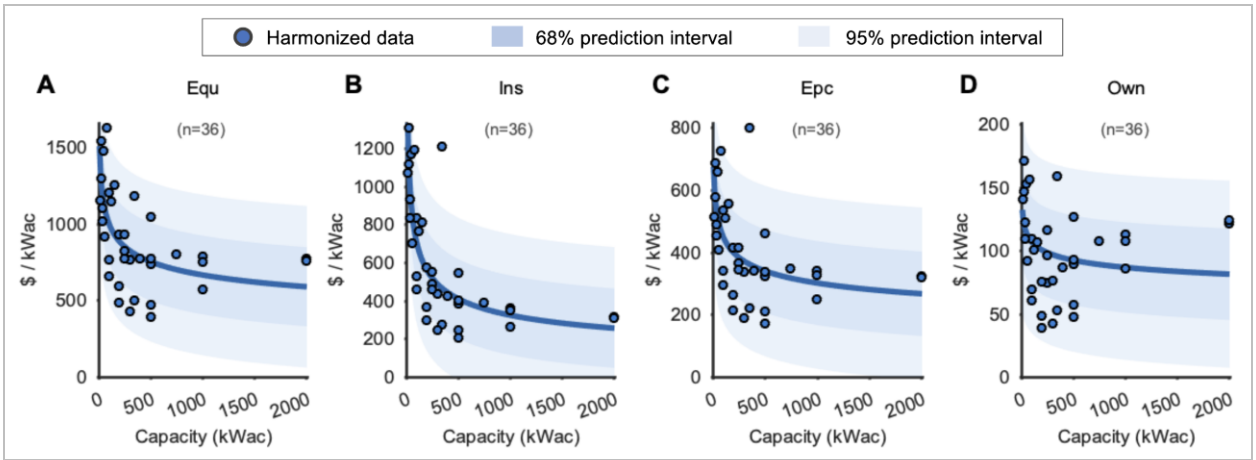
DER class	Cost ratio	Form	*a*	*b*
Combustion	Ins / Equ	$y = ax^{-b}$	0.461	0.178
	Epc / Equ	$y = ax + b$	–0.013	0.446
	Own / Equ	$y = a + b \cdot \ln(x)$	0.150	0.019
	Epc / Ins	$y = a + b \cdot \ln(x)$	0.967	0.138
	Own / Ins	$y = a + b \cdot \ln(x)$	0.310	0.113
	Own / Epc	$y = a + b \cdot \ln(x)$	0.281	0.063
	Equ / T	$y = a + b \cdot \ln(x)$	0.441	0.045
	Ins / T	$y = ax^{-b}$	0.229	0.319
	Epc / T	$y = a + b \cdot \ln(x)$	0.248	0.015
	Own / T	$y = a + b \cdot \ln(x)$	0.068	0.016



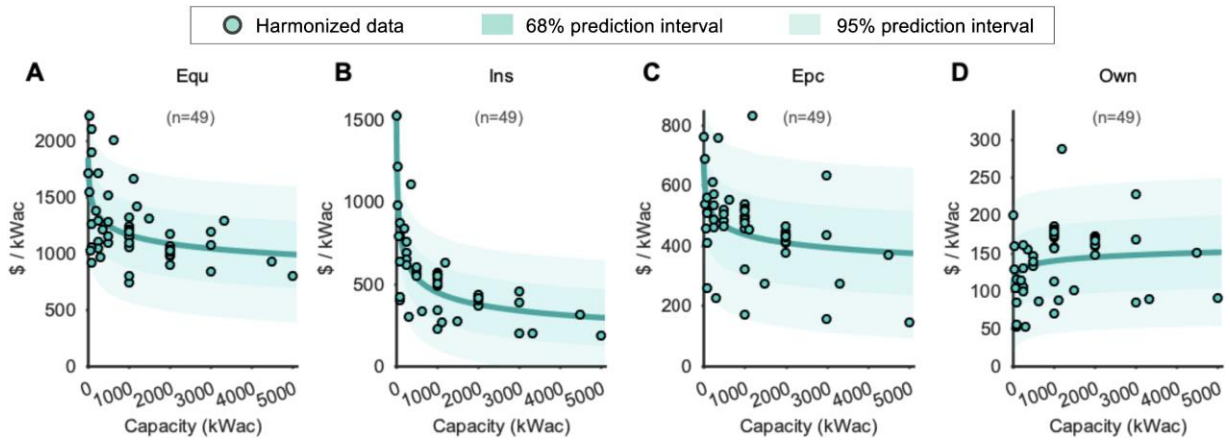
SI Fig. 6. Comparison of unharmonized and harmonized component costs, by DER type, as a function of DER capacity. ***Top row*****,** Diesel gensets. ***Second row***, Gas gensets. ***Third row*****,** Microturbines. ***Bottom row*****,** Fuel cells. Shown are the dollar-year adjusted base data and harmonized data. Equ–equipment cost; Ins–installation and labor cost; Epc–engineering, procurement, and construction cost; Own–owner' costs. In some cases fits are constant across DER capacities due to data sparsity (Ins, Epc, and Own for diesel generators). Fits are not generated for fuel cells due to data sparsity.

SI Table 2 | Functional forms for the harmonized capital cost data. The functional forms below are associated with the harmonized fits in SI Fig. 5. TOC–total overnight cost; Equ–equipment cost; Ins–installation and labor cost; Epc–engineering, procurement, and construction cost; Own–owners' cost. Fits are not generated for fuel cells due to data sparsity.

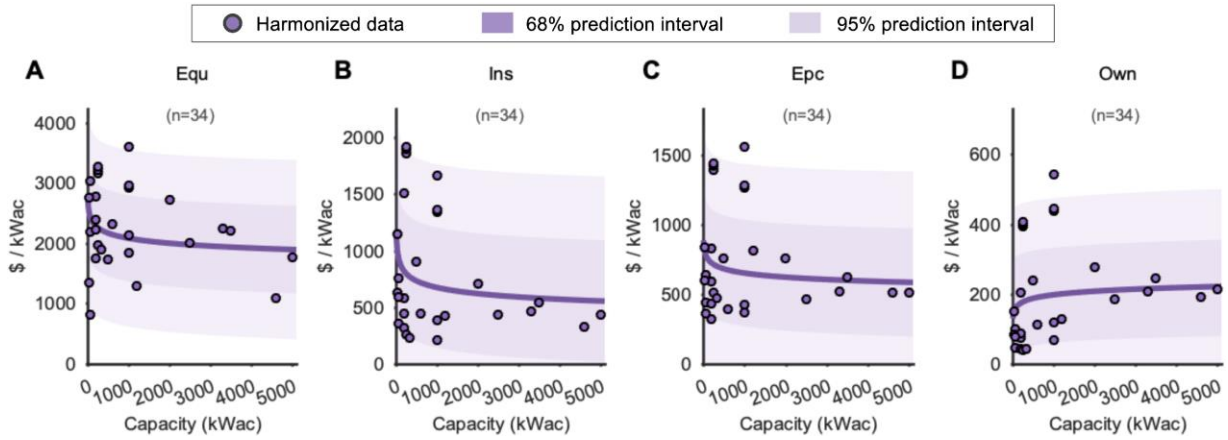
DER	Cost	Form	*a*	*b*
Diesel gensets	TOC	$y = ax^{-b}$	1361	0.224
	Equ	$y = ax^{-b}$	667	0.177
	Ins	$y = ax^{-b}$	324	0.341
	Epc	$y = ax^{-b}$	301	0.175
	Own	$y = ax^{-b}$	87	0.092
Gas gensets	TOC	$y = ax^{-b}$	2196	0.129
	Equ	$y = ax^{-b}$	1163	0.100
	Ins	$y = ax^{-b}$	449	0.261
	Epc	$y = ax^{-b}$	437	0.095
	Own	$y = a + b \cdot \ln(x)$	139	7.09
Microturbines	TOC	$y = ax^{-b}$	3612	0.066
	Equ	$y = ax^{-b}$	2083	0.058
	Ins	$y = ax^{-b}$	676	0.121
	Epc	$y = ax^{-b}$	652	0.067
	Own	$y = a + b \cdot \ln(x)$	198	14.7
Fuel cells	TOC	–	–	–
	Equ	–	–	–
	Ins	–	–	–
	Epc	–	–	–
	Own	–	–	–



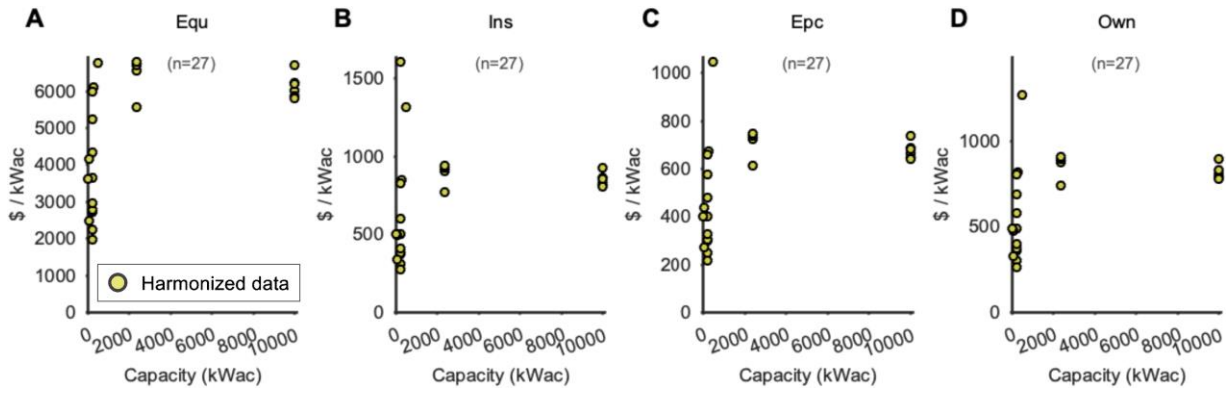
SI Fig. 7. Component costs vs. system capacity for diesel generators. **A**, Equipment cost; **B**, Installation cost; **C**, EPC cost; **D**, Owners' cost. Marks show the harmonized data; lines show the harmonized mean (the best fit on the harmonized data); and ribbons denote prediction intervals. In each panel, *n* denotes the number of data. Equ–equipment cost; Ins–installation and labor cost; Epc–engineering, procurement, and construction cost; Own–owners' costs.



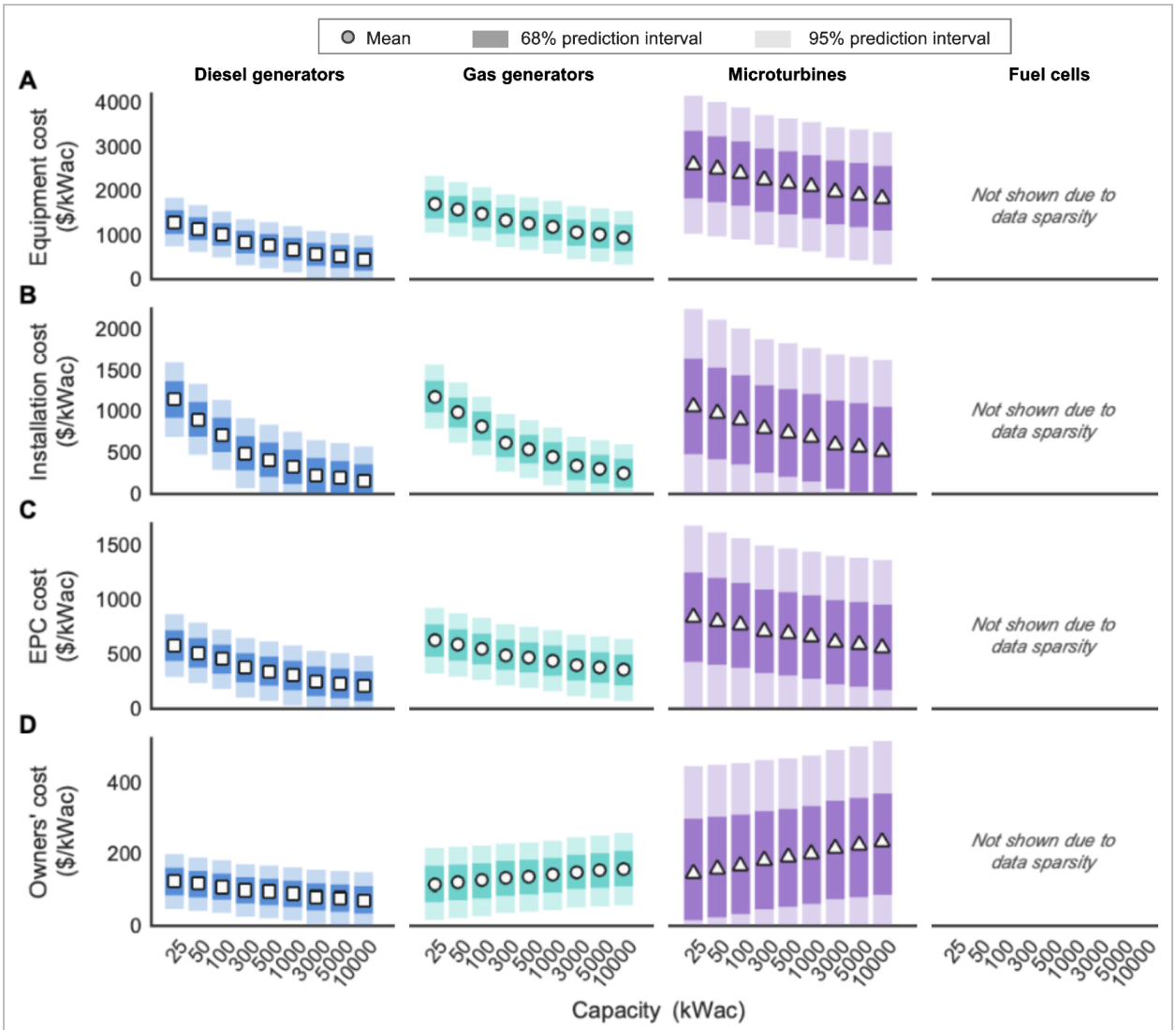
SI Fig. 8. Component costs vs. system capacity for gas generators. **A**, Equipment cost; **B**, Installation cost; **C**, EPC cost; **D**, Owners' cost. Marks show the harmonized data; lines show the harmonized mean (the best fit on the harmonized data); and ribbons denote prediction intervals. In each panel, *n* denotes the number of data. Equ–equipment cost; Ins–installation and labor cost; Epc–engineering, procurement, and construction cost; Own–owners' costs.



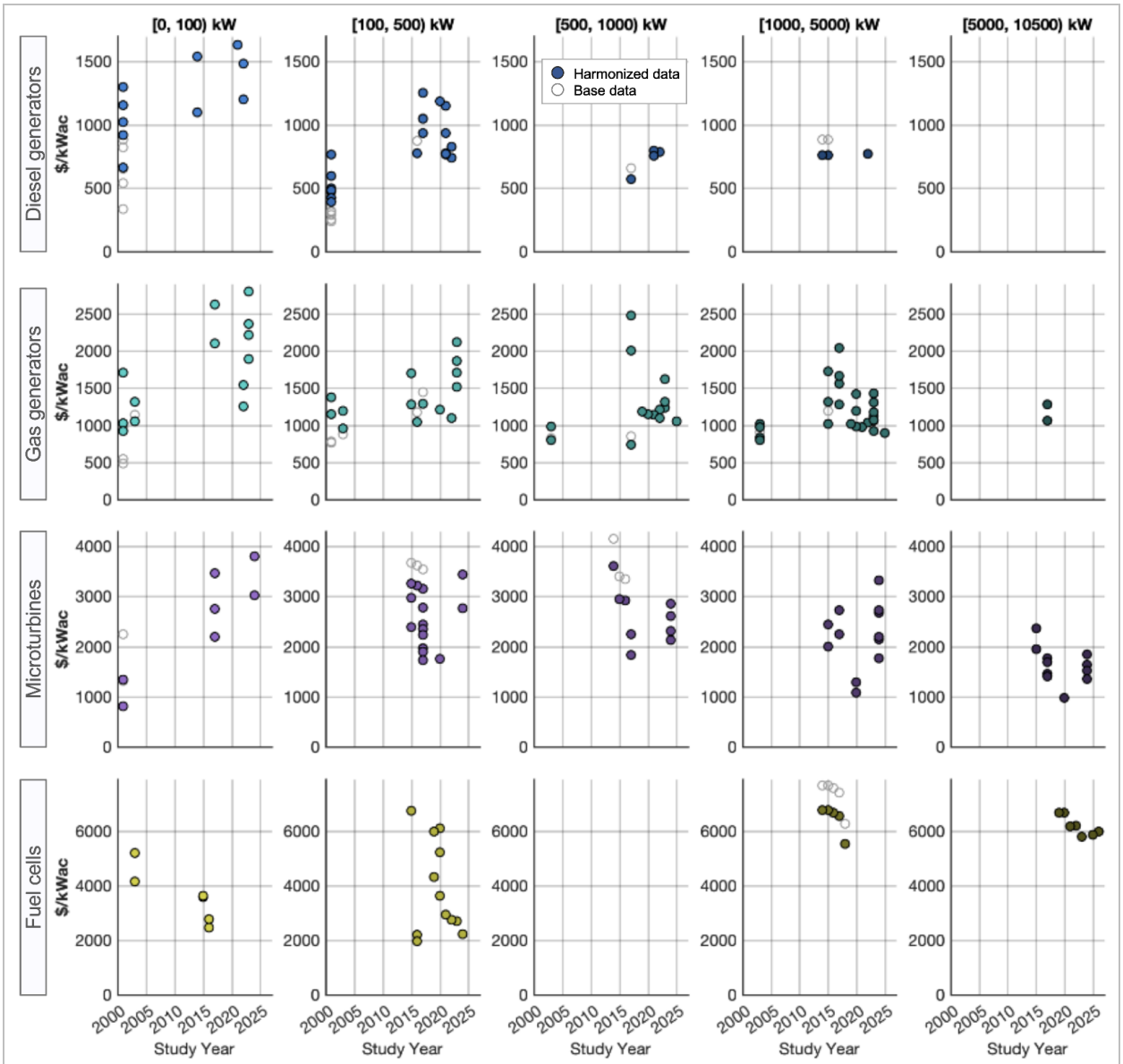
SI Fig. 9. Component costs vs. system capacity for microturbines. **A**, Equipment cost; **B**, Installation cost; **C**, EPC cost; **D**, Owners' cost. Marks show the harmonized data; lines show the harmonized mean (the best fit on the harmonized data); and ribbons denote prediction intervals. In each panel, *n* denotes the number of data. Equ–equipment cost; Ins–installation and labor cost; Epc–engineering, procurement, and construction cost; Own–owners' costs.



SI Fig. 10. Component costs vs. system capacity for fuel cells. **A**, Equipment cost; **B**, Installation cost; **C**, EPC cost; **D**, Owners' cost. Fits are not generated due to data sparsity. In each panel, *n* denotes the number of data. Equ–equipment cost; Ins–installation and labor cost; Epc–engineering, procurement, and construction cost; Own–owners' costs.



SI Fig. 11. Component costs vs. system capacity for representative power-only DER systems. **A**, Equipment cost; **B**, Installation cost; **C**, EPC cost; **D**, Owners' cost. Results are not generated for fuel cells due to data sparsity.



SI Fig. 12. Potential technological learning: Equipment cost vs. study year for all DER types. Equipment cost by DER type (rows) and kW nameplate capacity (columns) by the publication year of the estimate. Marks denote individual estimates and show the dollar year-adjusted (base) data and harmonized data. We do not find a systematic trend of falling equipment costs over time that would indicate technological learning. This does not imply an absence of learning, but rather that variation in the reported data dominates any trend in learning that may exist.

Supplementary References

Darrow, K., Tidball, R., Wang, J., & Hampson, A. Catalog of CHP Technologies. (ICF, 2017).

Goldstein, L., Hedman, B., Knowles, D., Freedman, S.I., Woods, R., & Schweizer, T. Gas-fired Distributed Energy Resource Technology Characterizations. Report No. NREL/TP-620-34783. (NREL, 2003).