MINI GRID COSTING AND INNOVATION

MINI GRIDS FOR HALF A BILLION PEOPLE

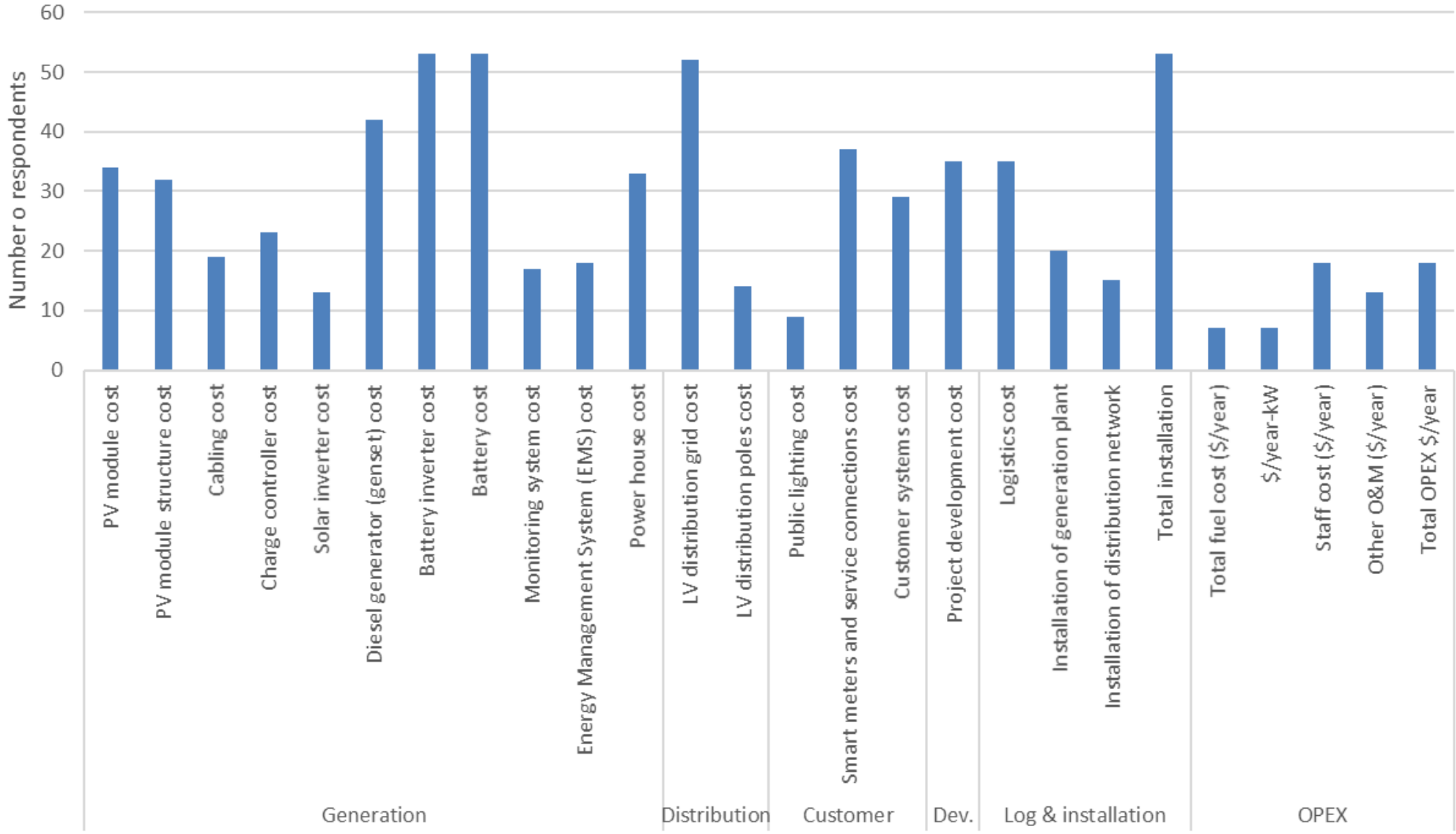
THE WORLD BANK

Treasury | IBRD • IDA

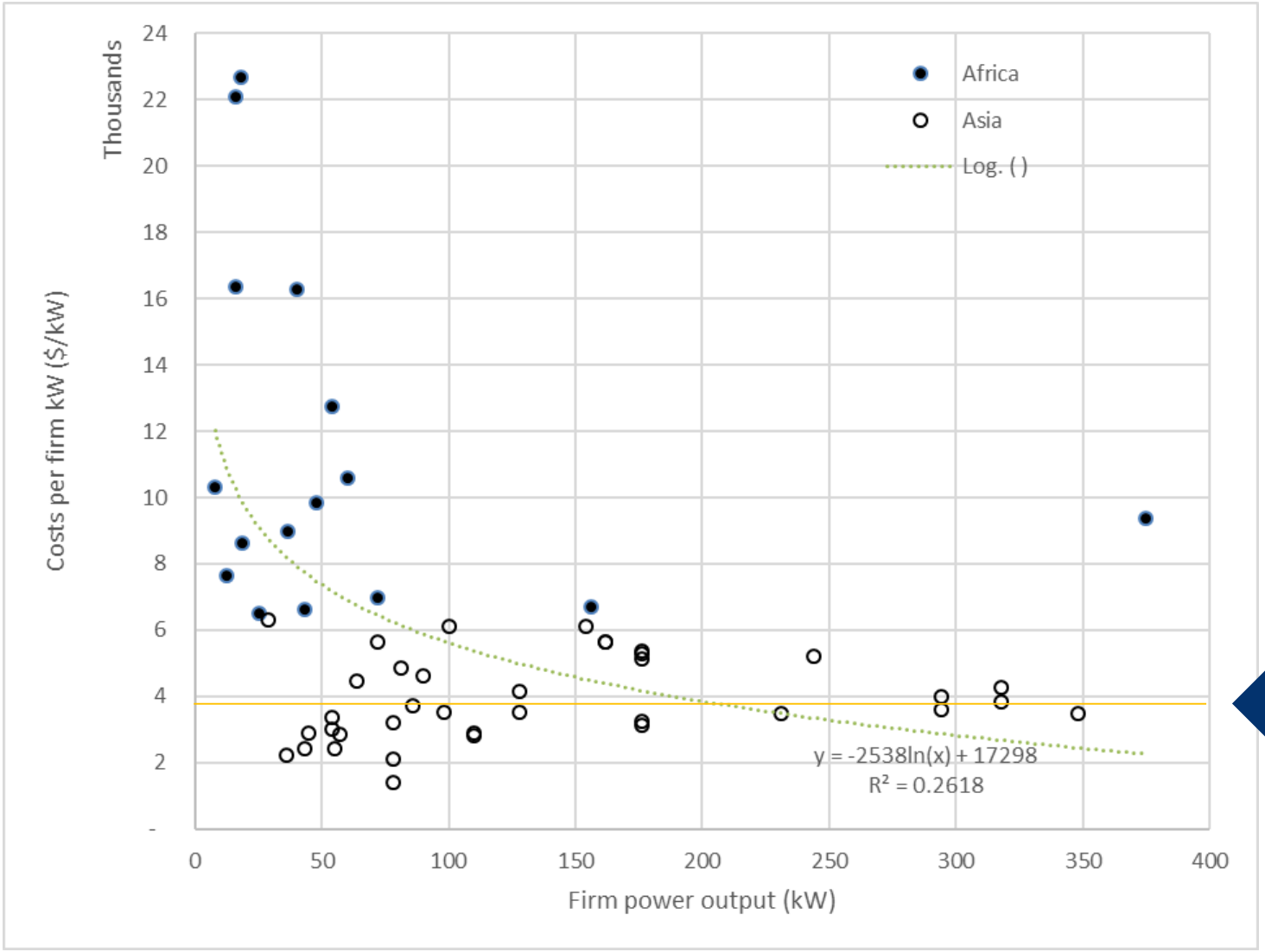
Chris Greacen
Global Facility on Mini Grids
Learning Event
Accra, Ghana

June 26, 2019

Our data set: 53 mini grids



Total cost of mini grids per kW_{firm} as a function of firm power output



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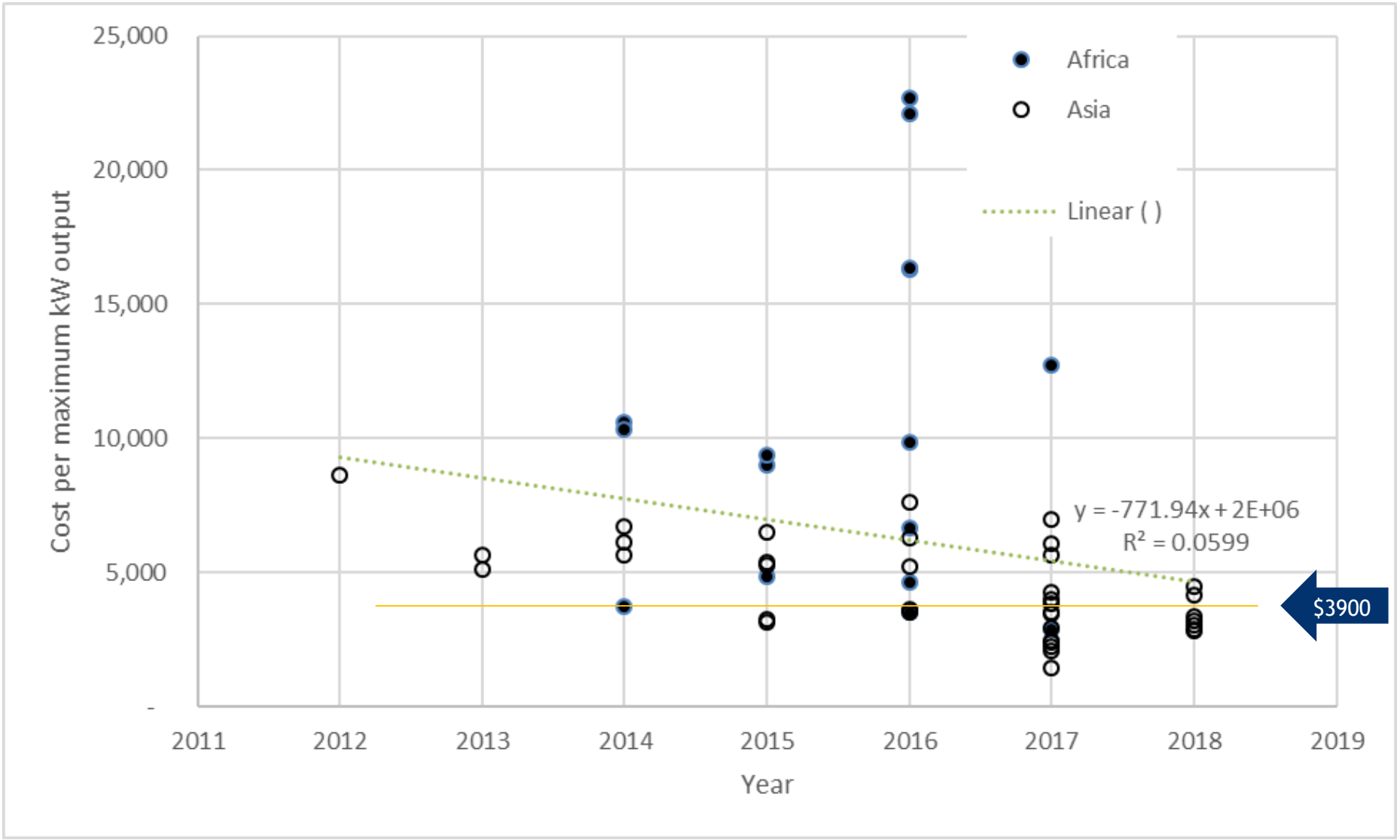
Median cost $3,900 per kW_{firm} and coming down



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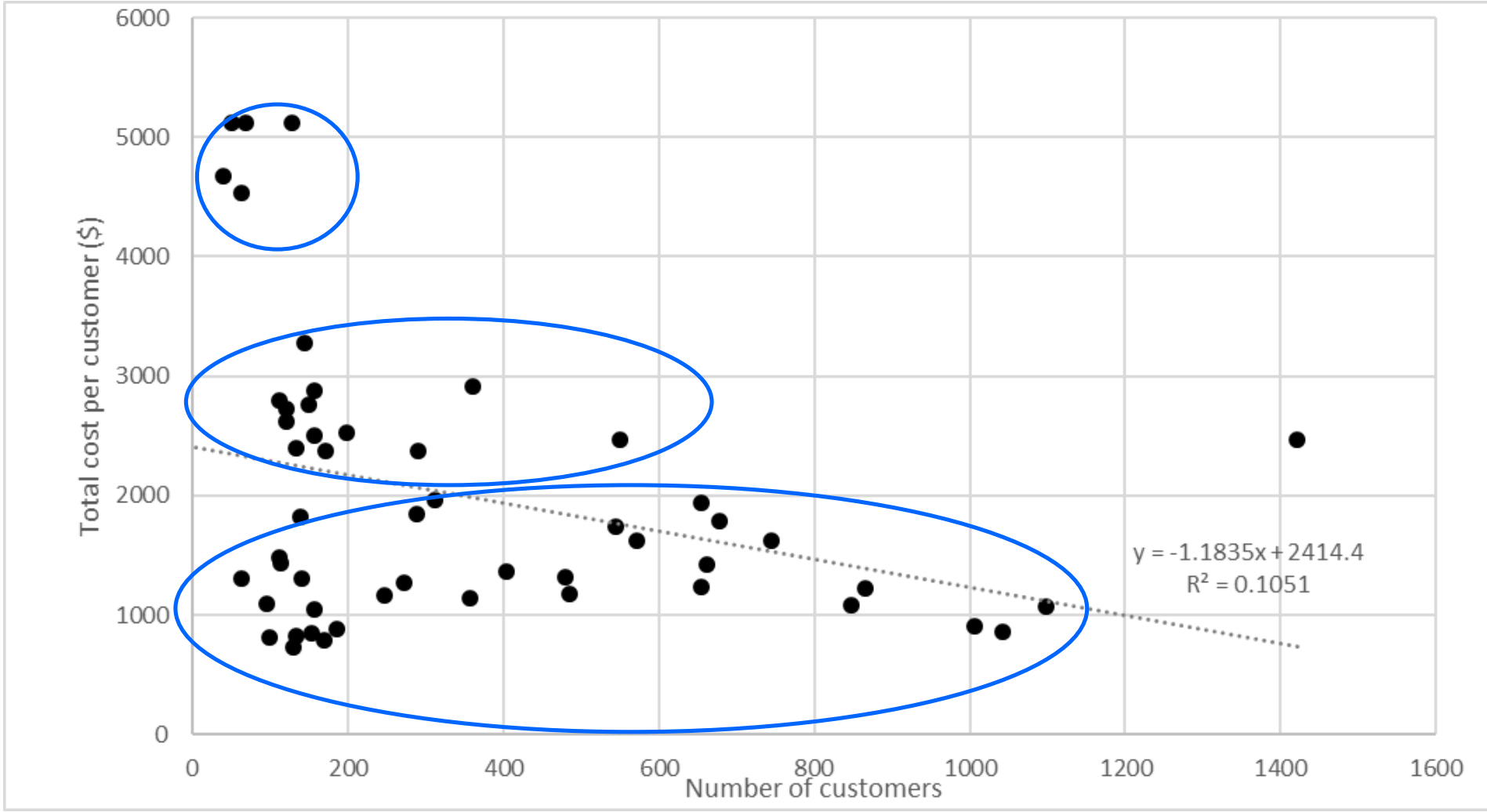
Total costs per customer $730 to $2000 for most mini grids



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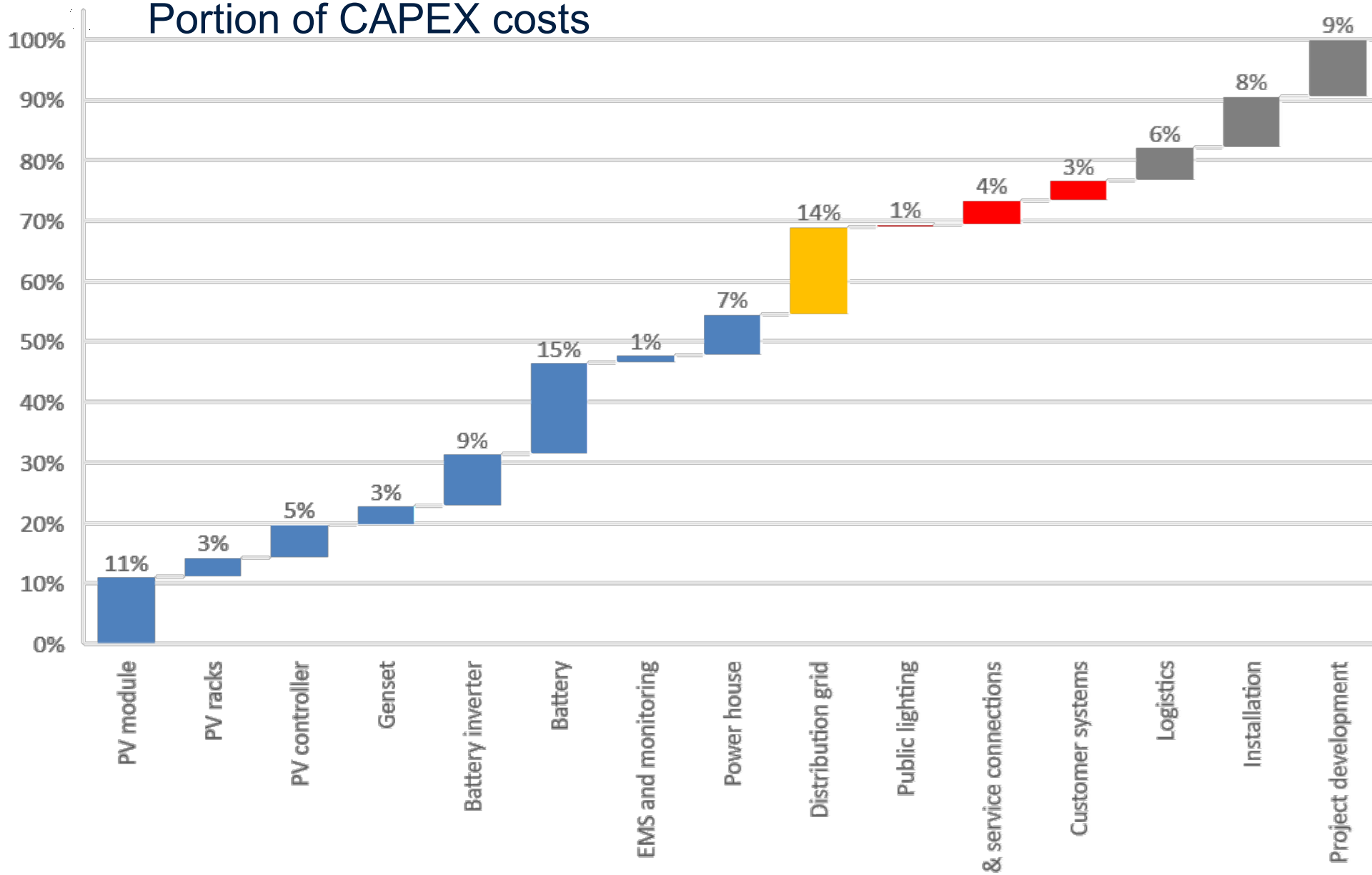
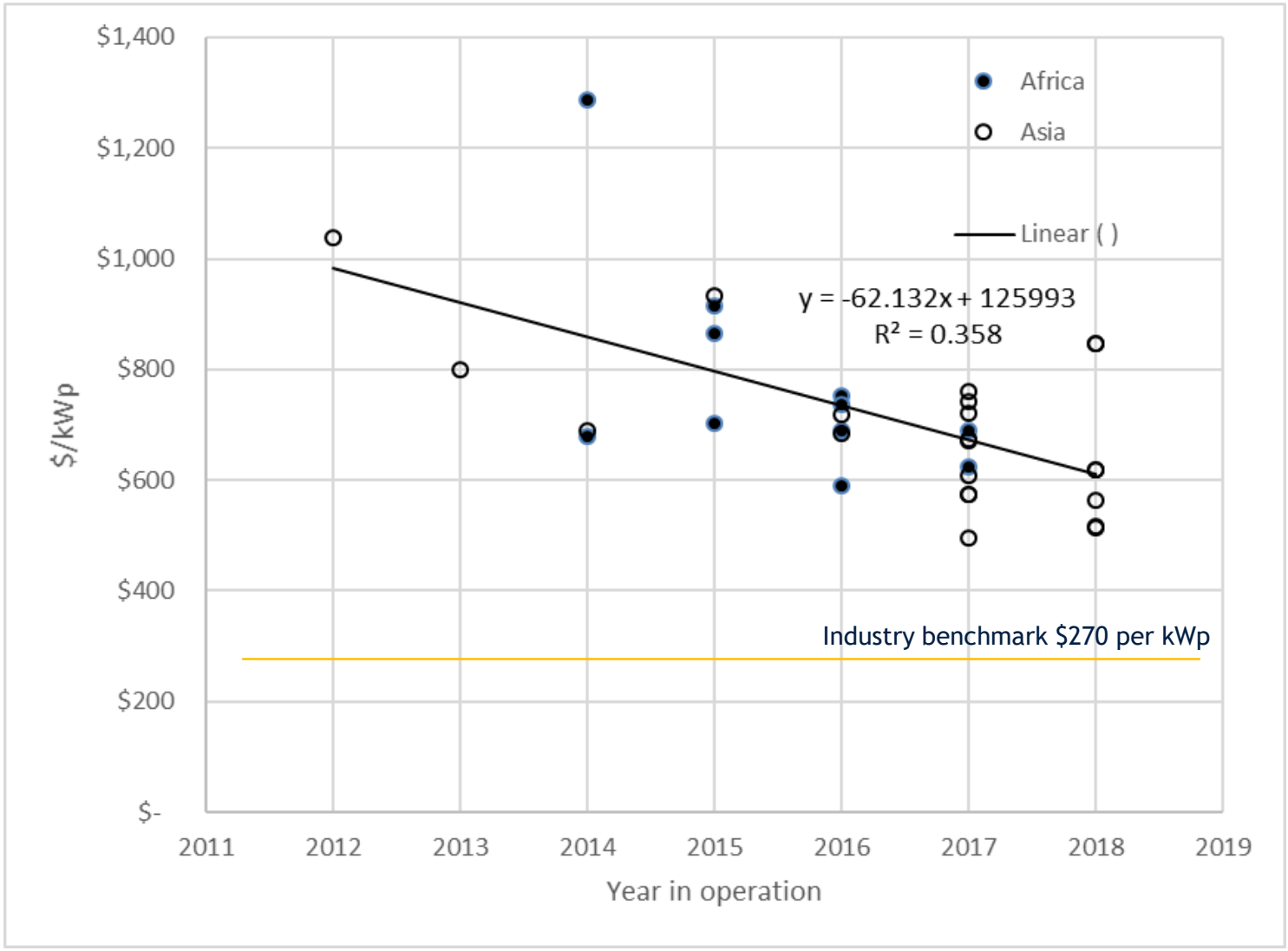
Portion of CAPEX costs



PV module costs declining



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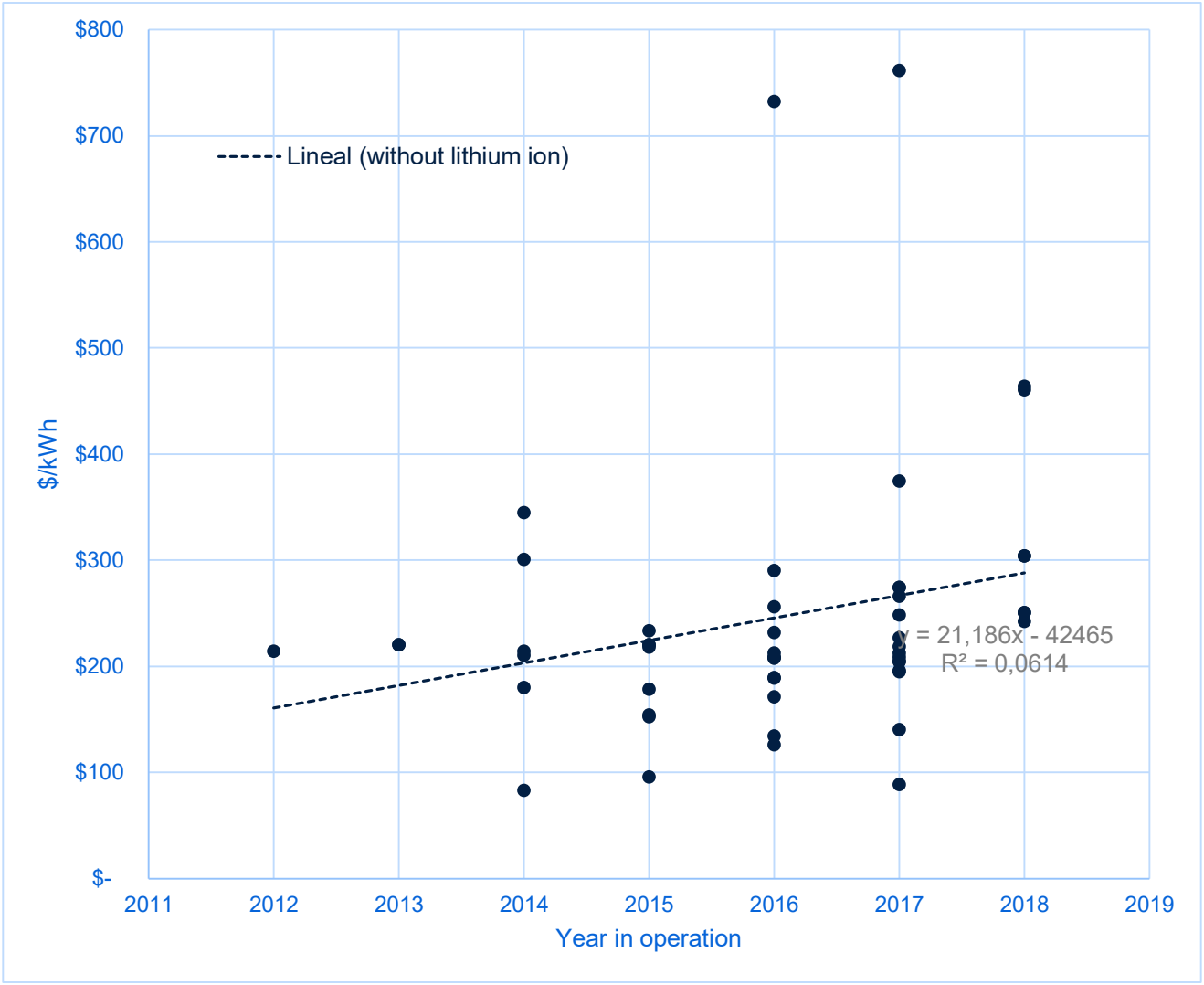
Cost of (lead acid) batteries increasing…



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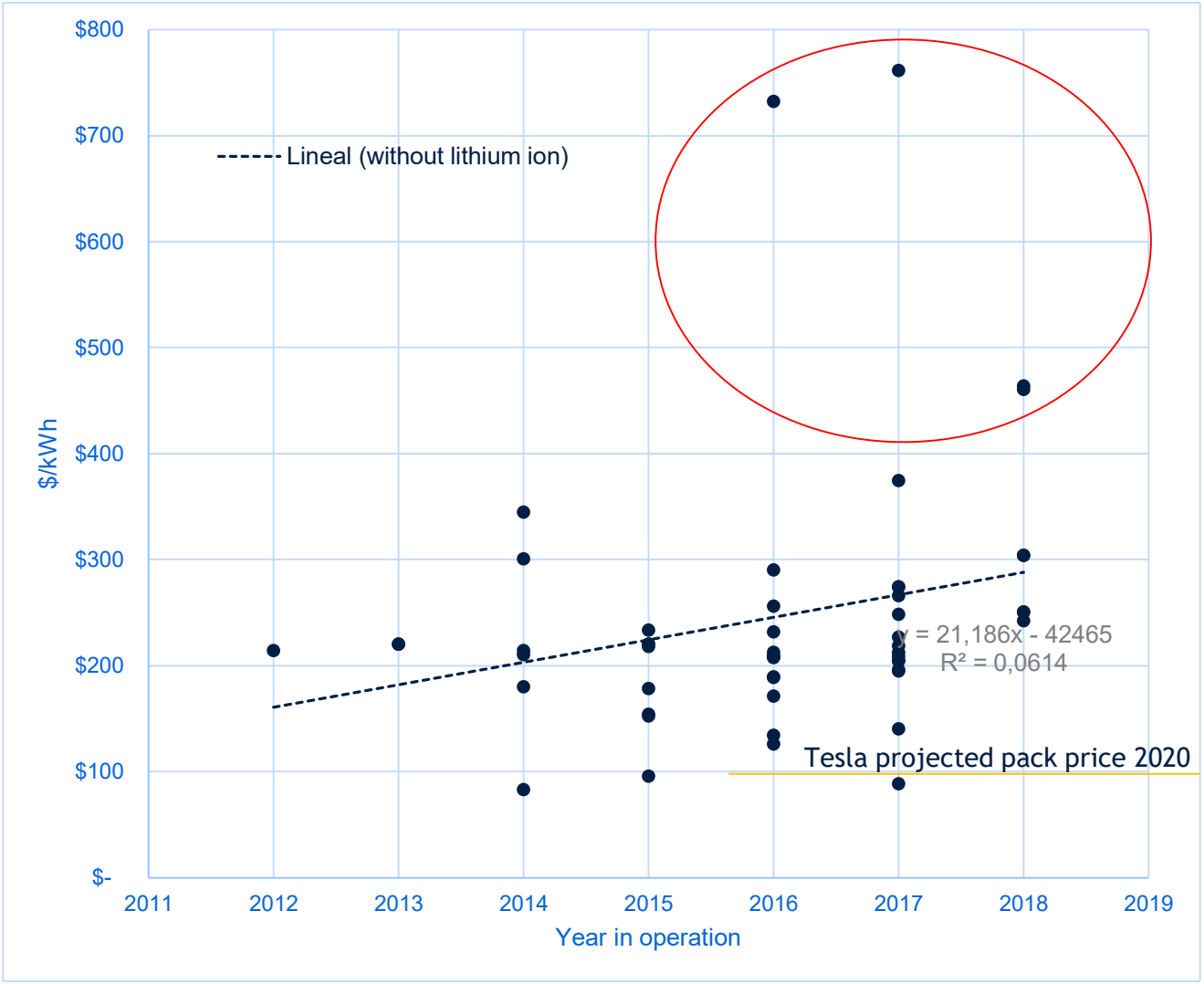
But Li-ion battery costs are falling



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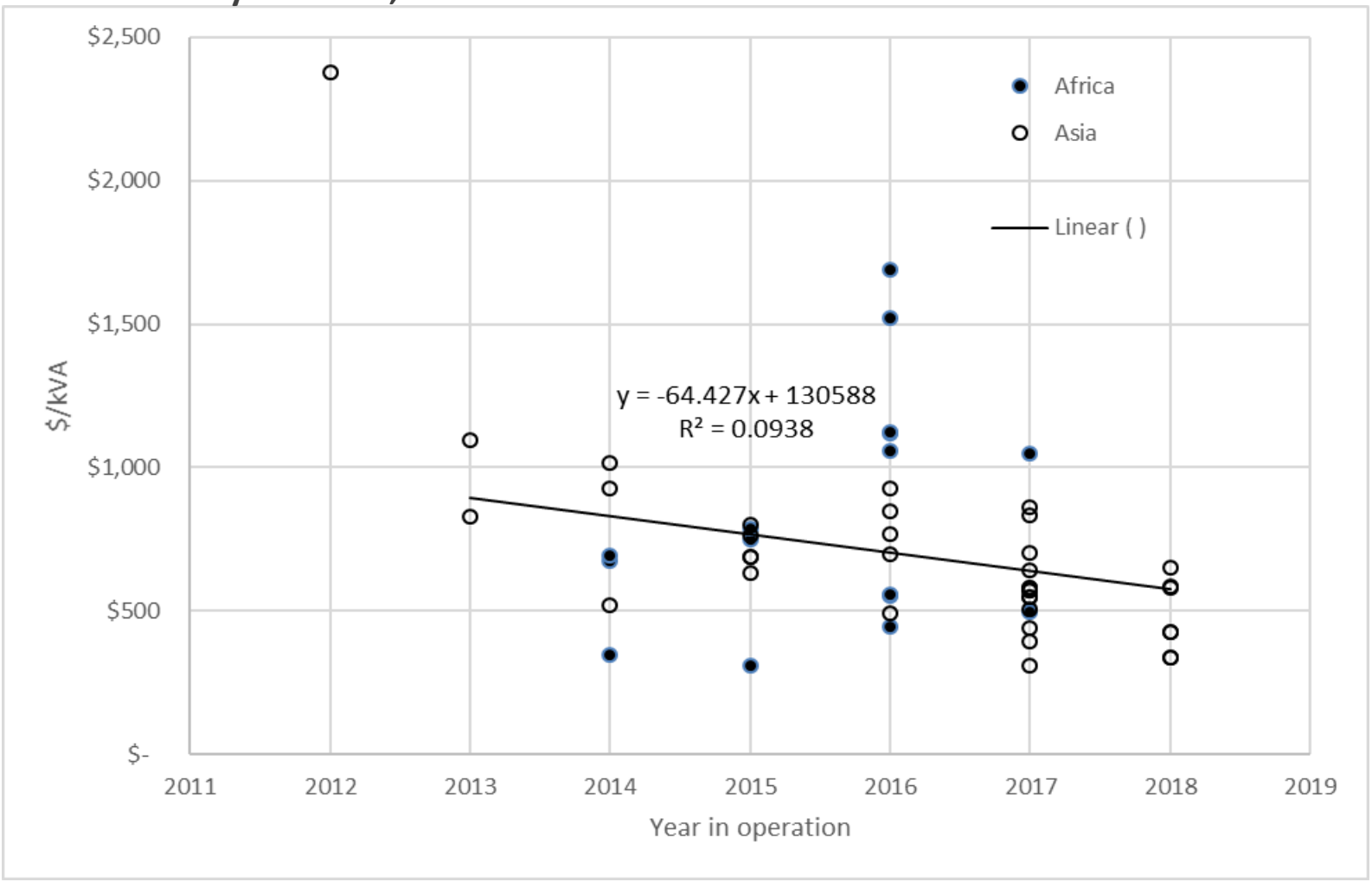
Power electronics getting cheaper

Cost of battery inverters, 2011–18



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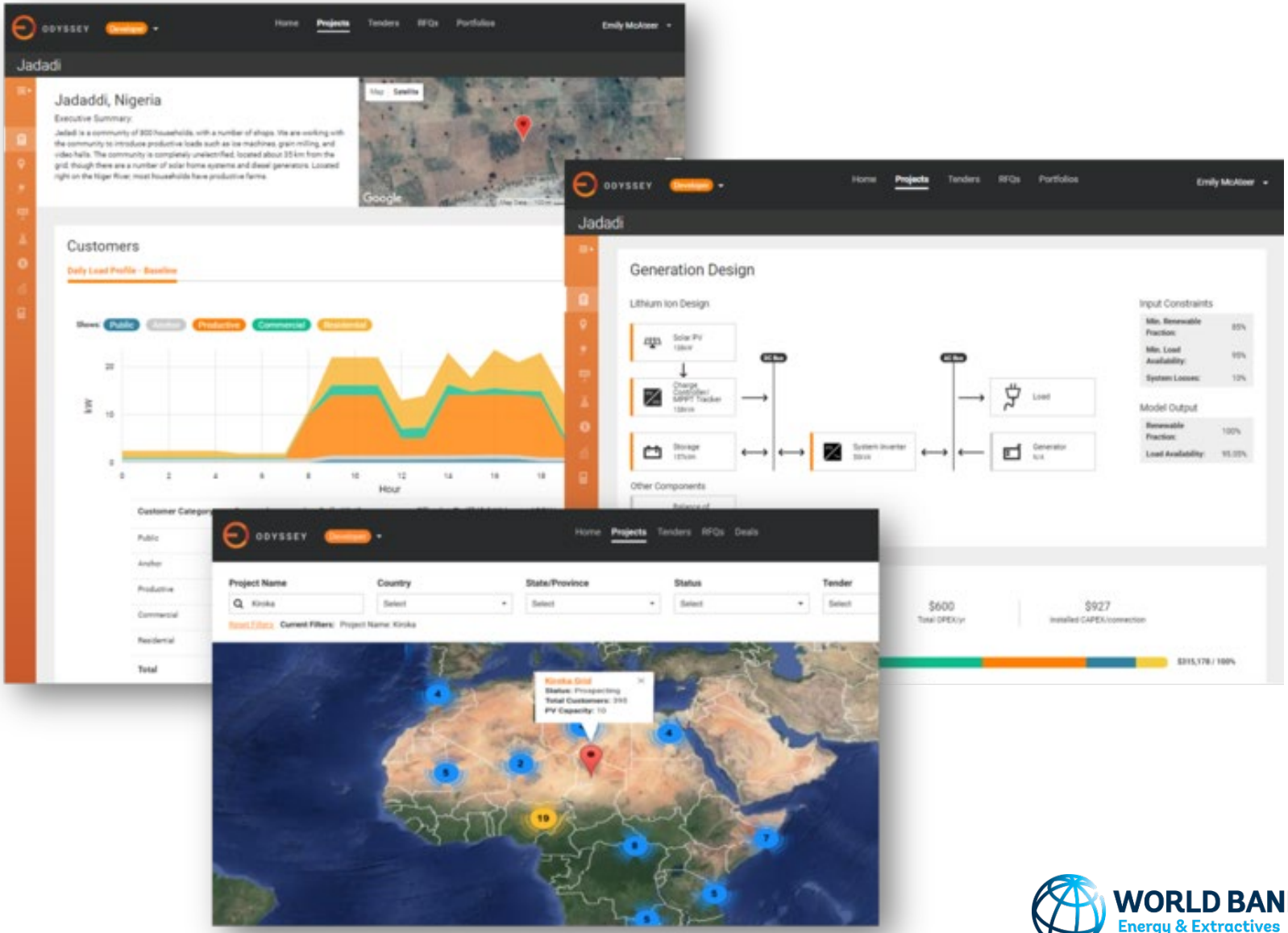
Geospatial technologies have decreased the cost of preparation and planning by an order of magnitude



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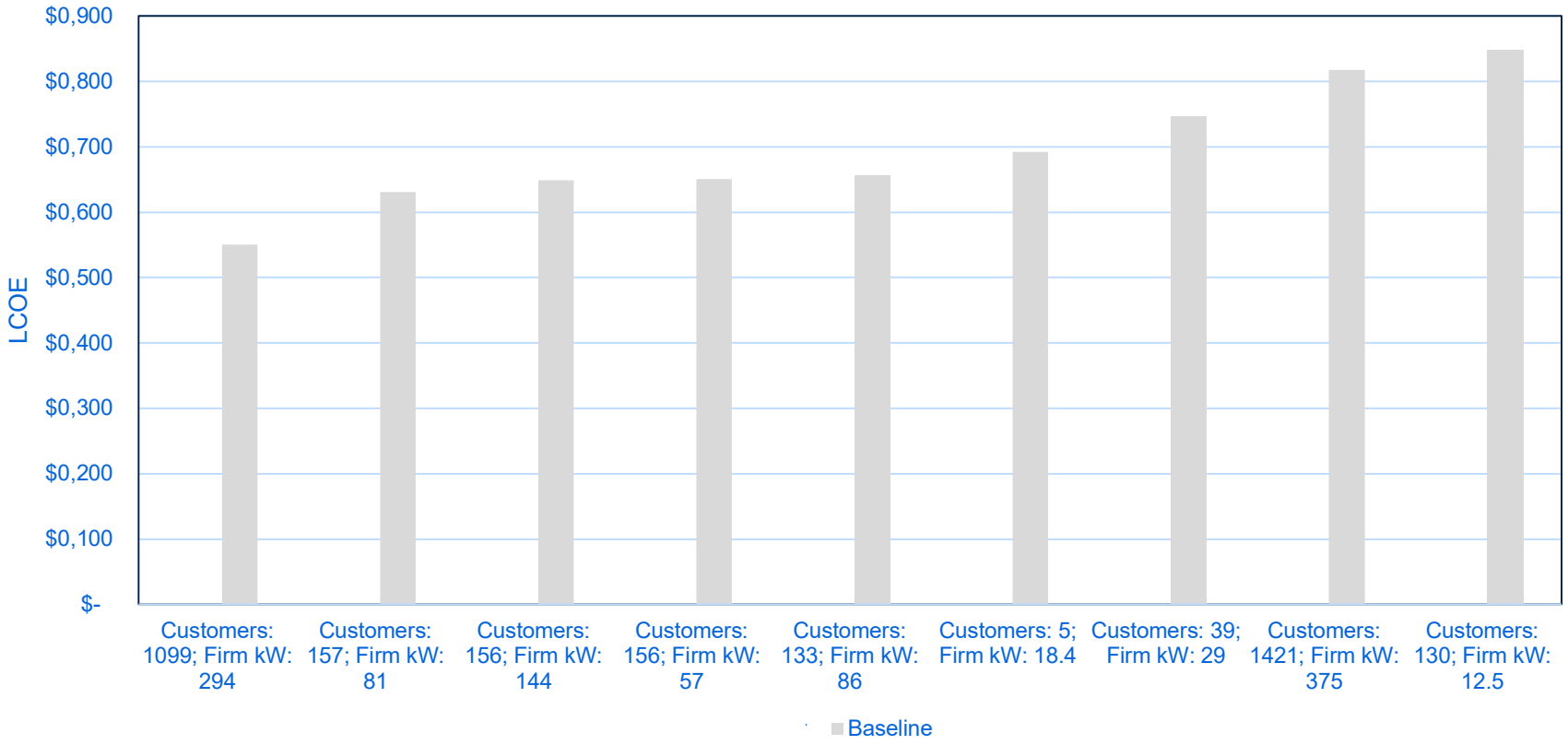
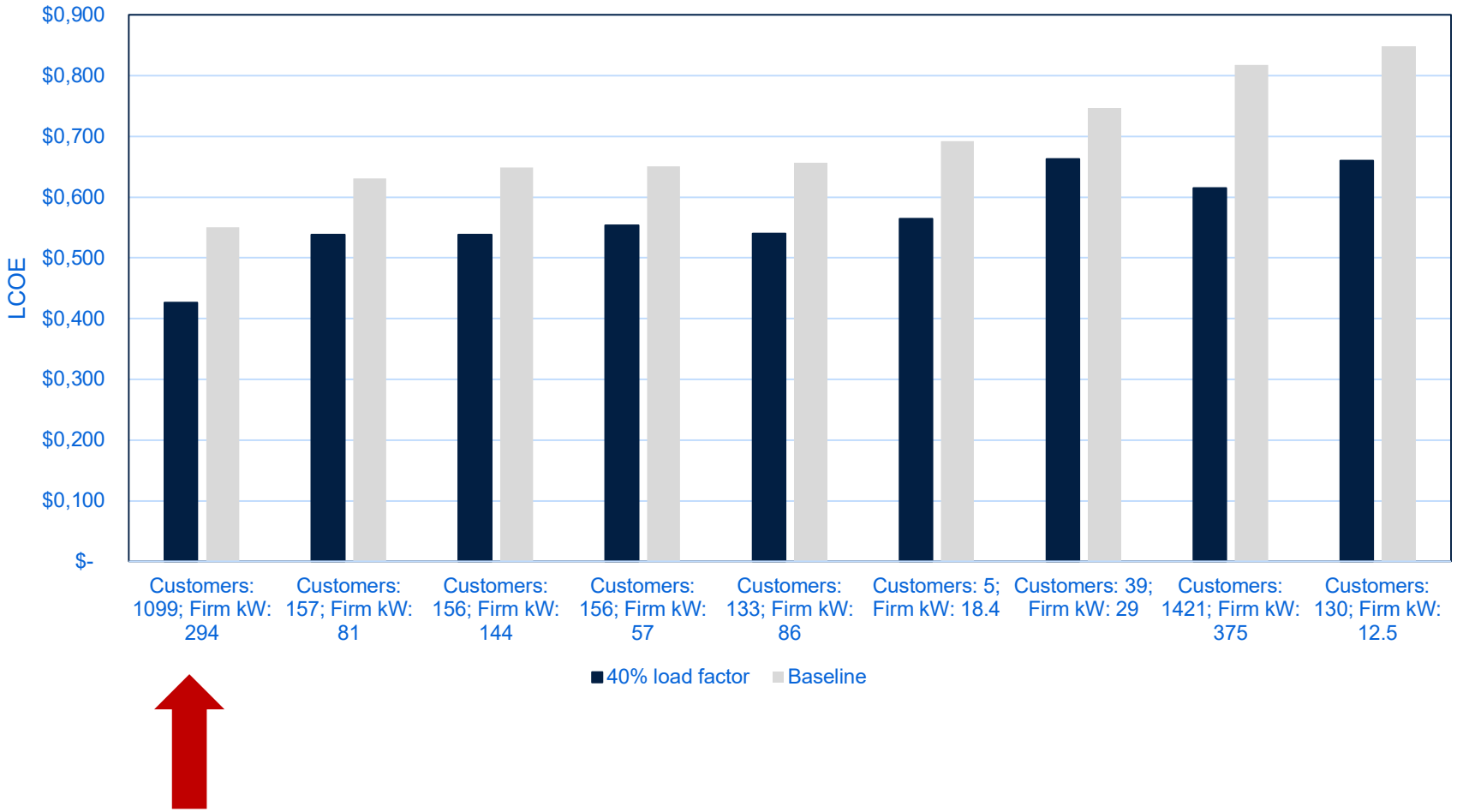
HOMER modeling of LCOE: $0.55 to $0.85/kWh



Increasing income-generating uses can decrease LCOE by 25%



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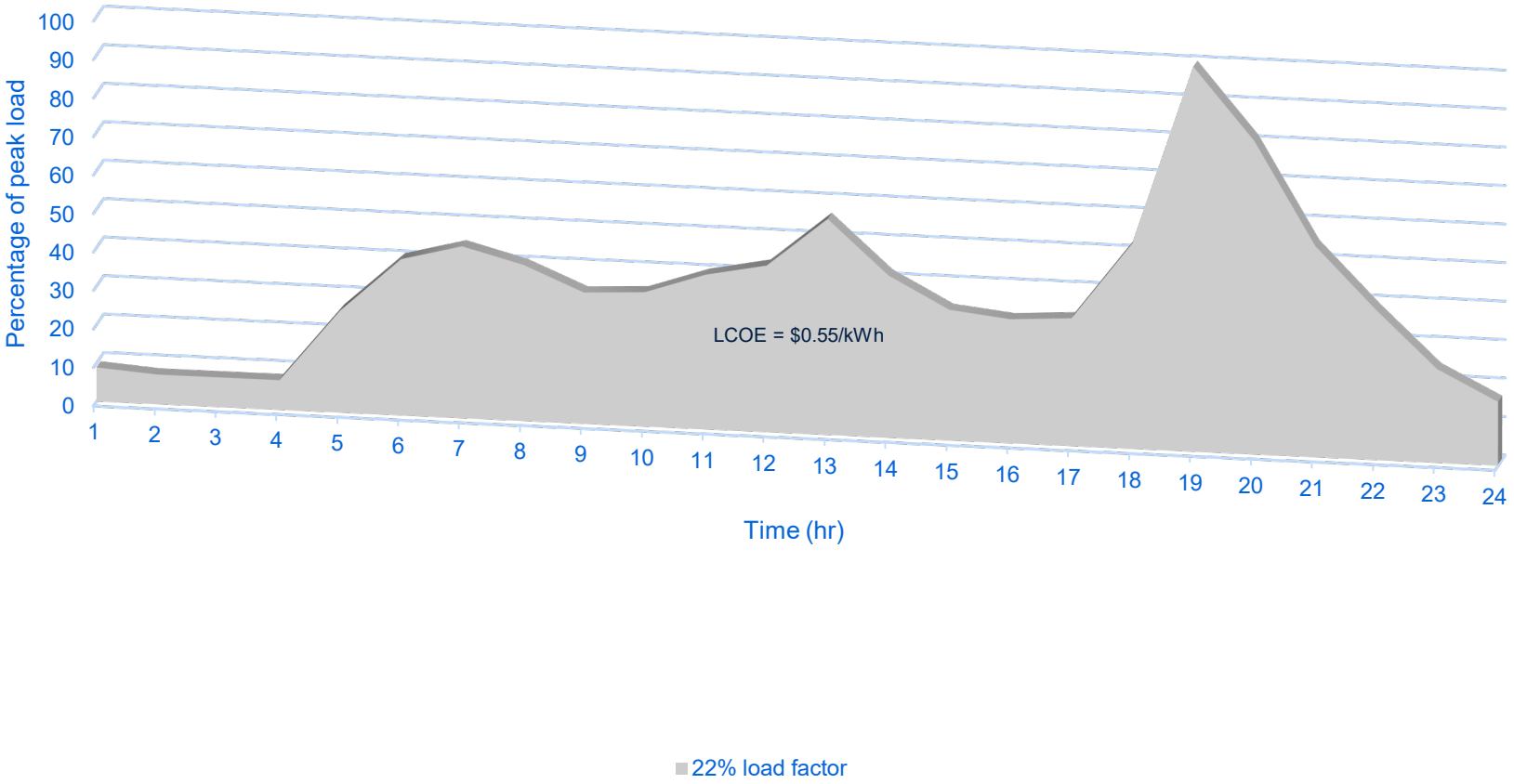

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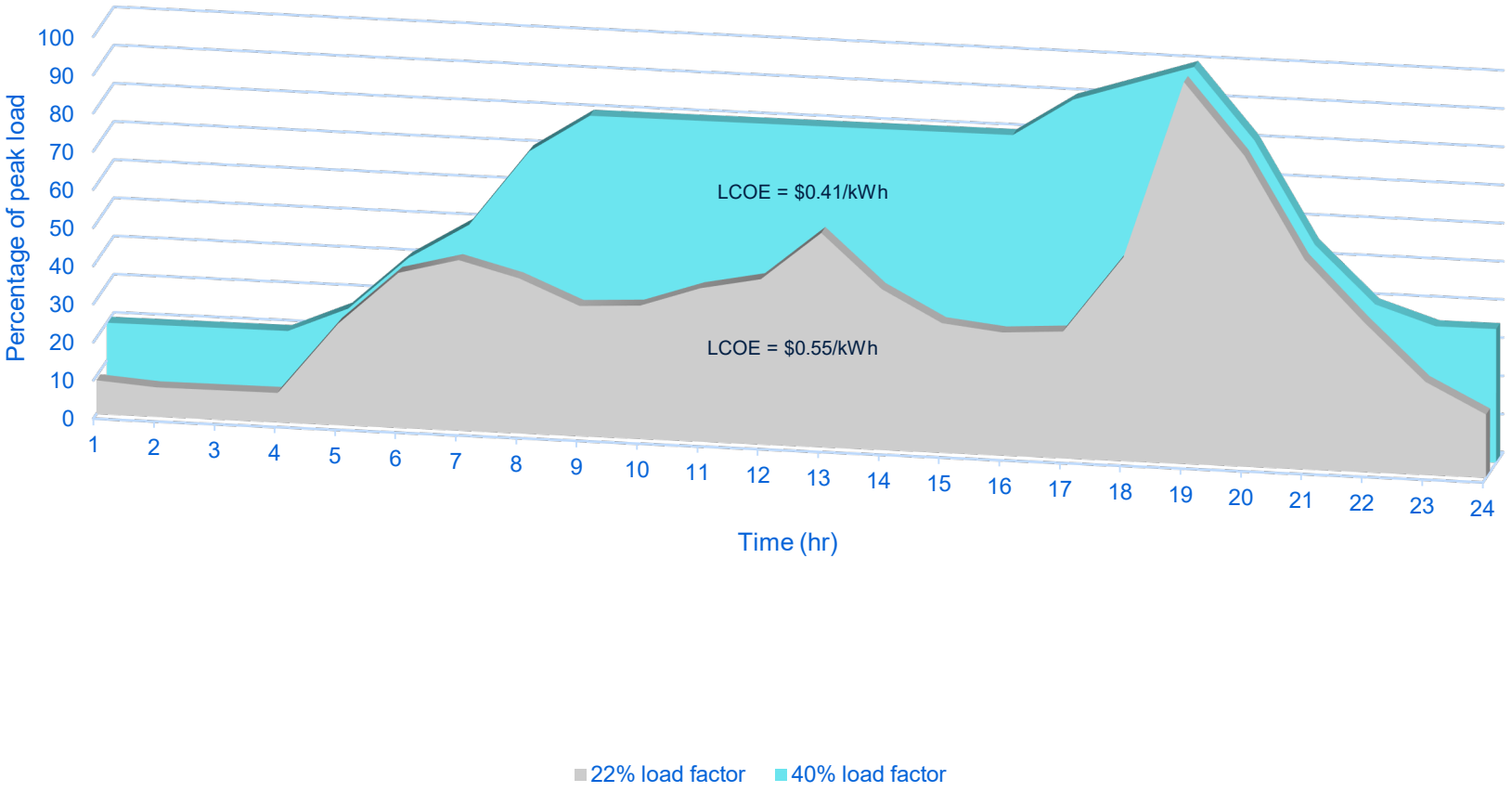

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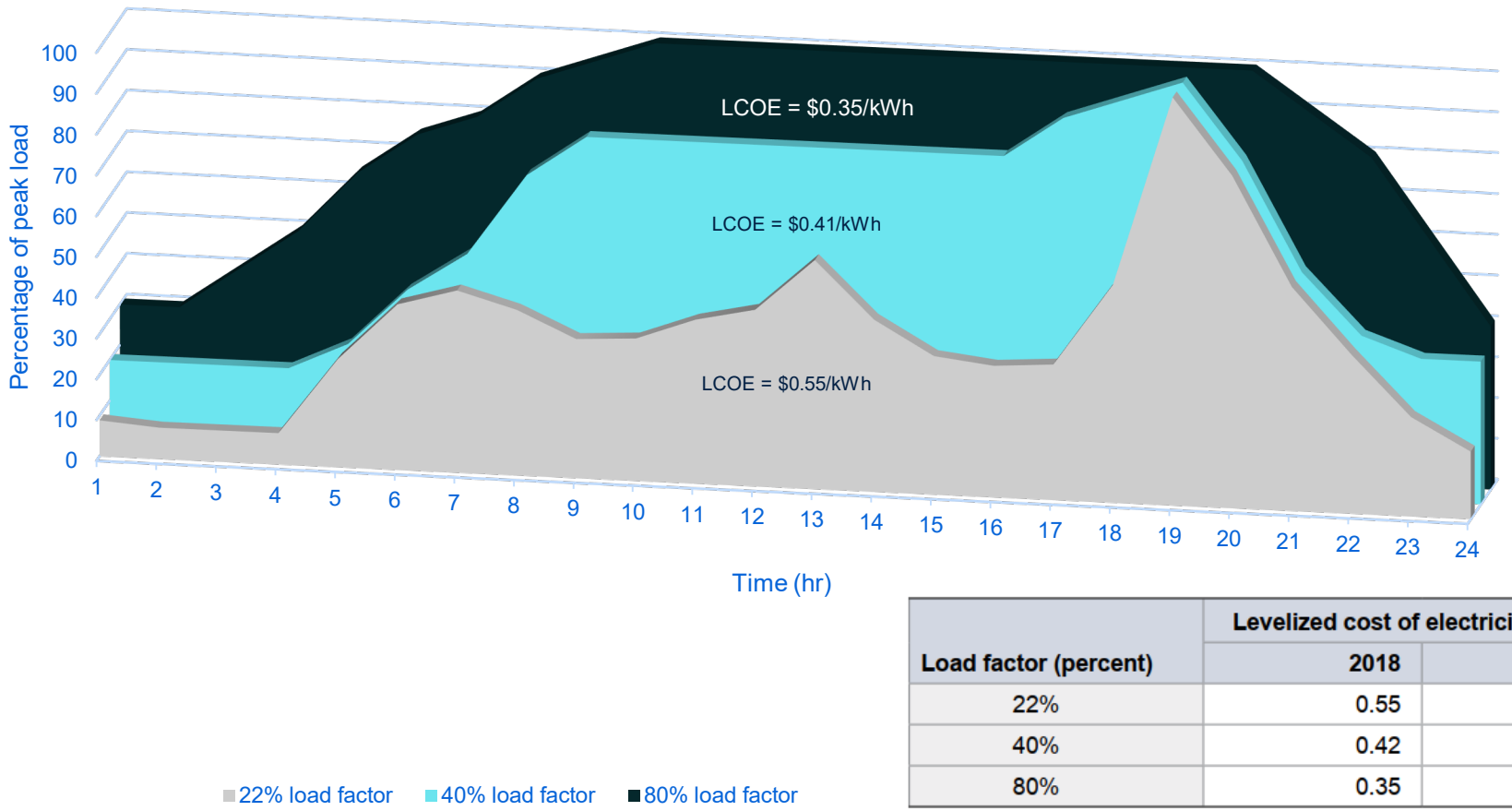


Load factor (percent)	Levelized cost of electricity ($/kWh)	
	2018	2030
22%	0.55	0.33
40%	0.42	0.22
80%	0.35	0.23

Summary

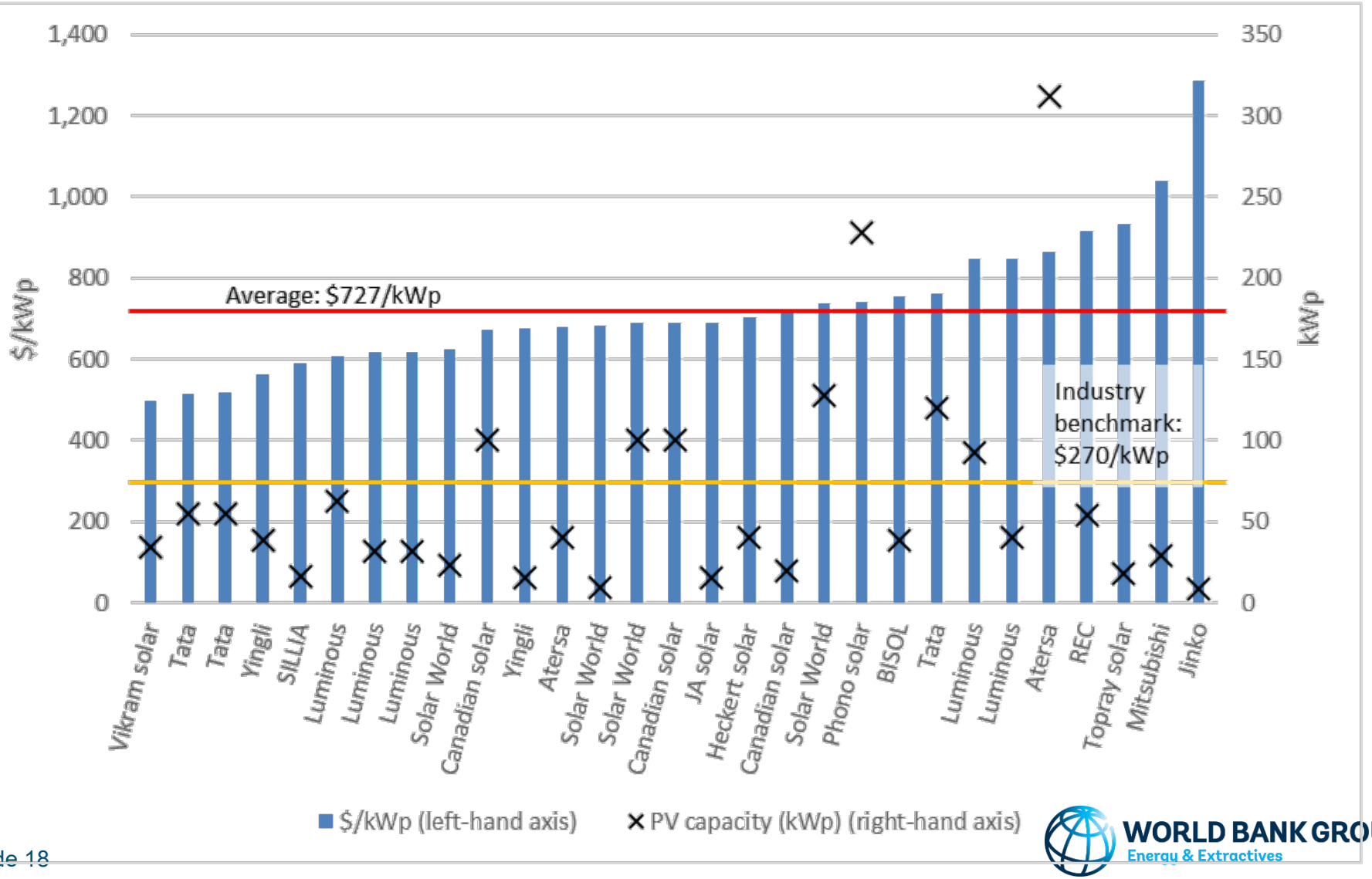
- Solar hybrid mini grids median price: $3,900/$kW_{firm}$
- Component costs vary significantly
- Capital costs falling
  - PV
  - Battery
  - Power electronics
- Preparation and planning costs falling
- LCOE varied from $0.55 to $0.85/kWh (median $0.66) with 22% load factor
- Increasing income-generating uses can decrease LCOE by 25% or more
- LCOE mini grid with high productive use can drop to $0.22/kwh by 2030

Questions / Discussion

Any mini grid cost data you can share?

chrisgreacen@gmail.com

Cost of solar modules



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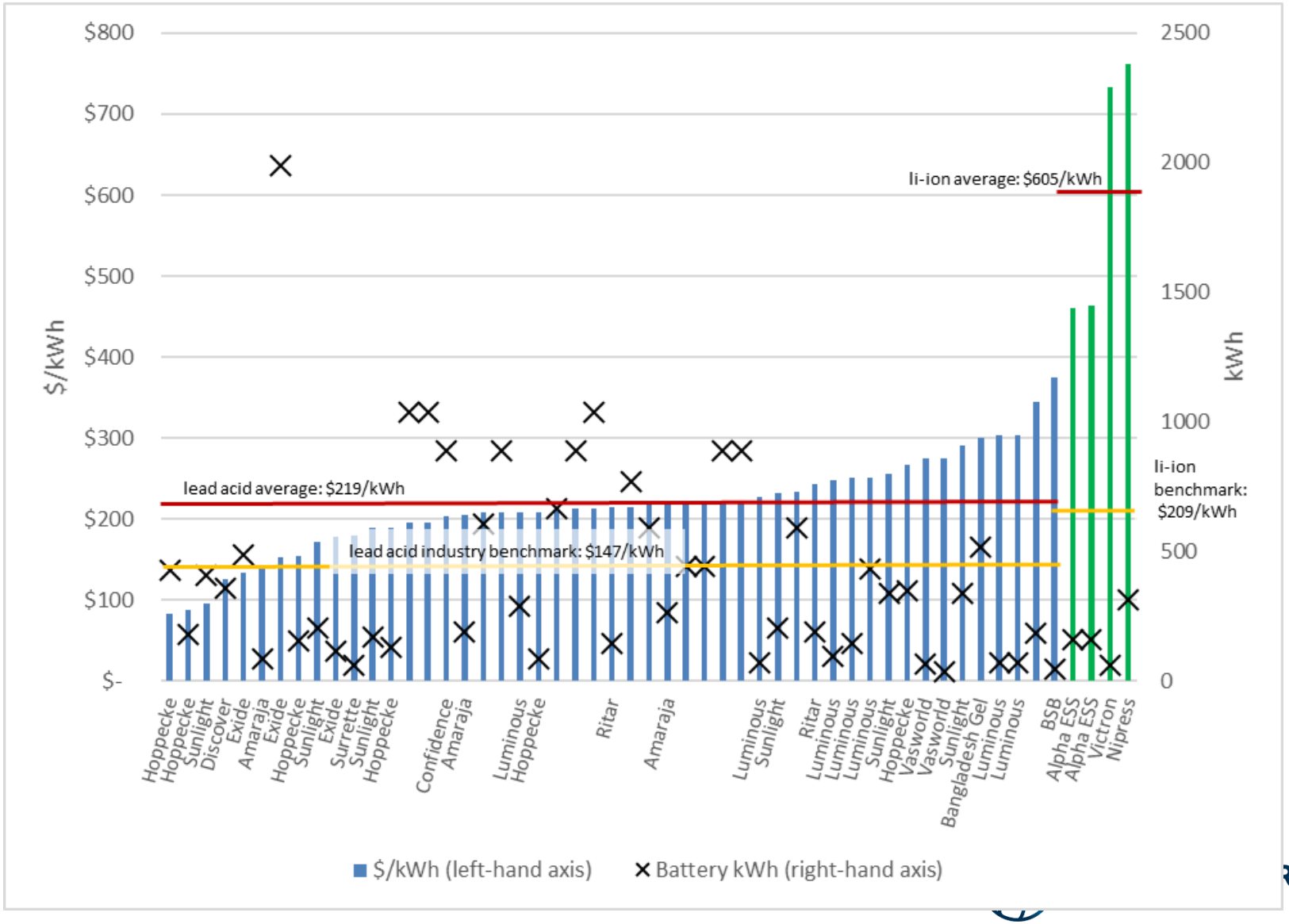
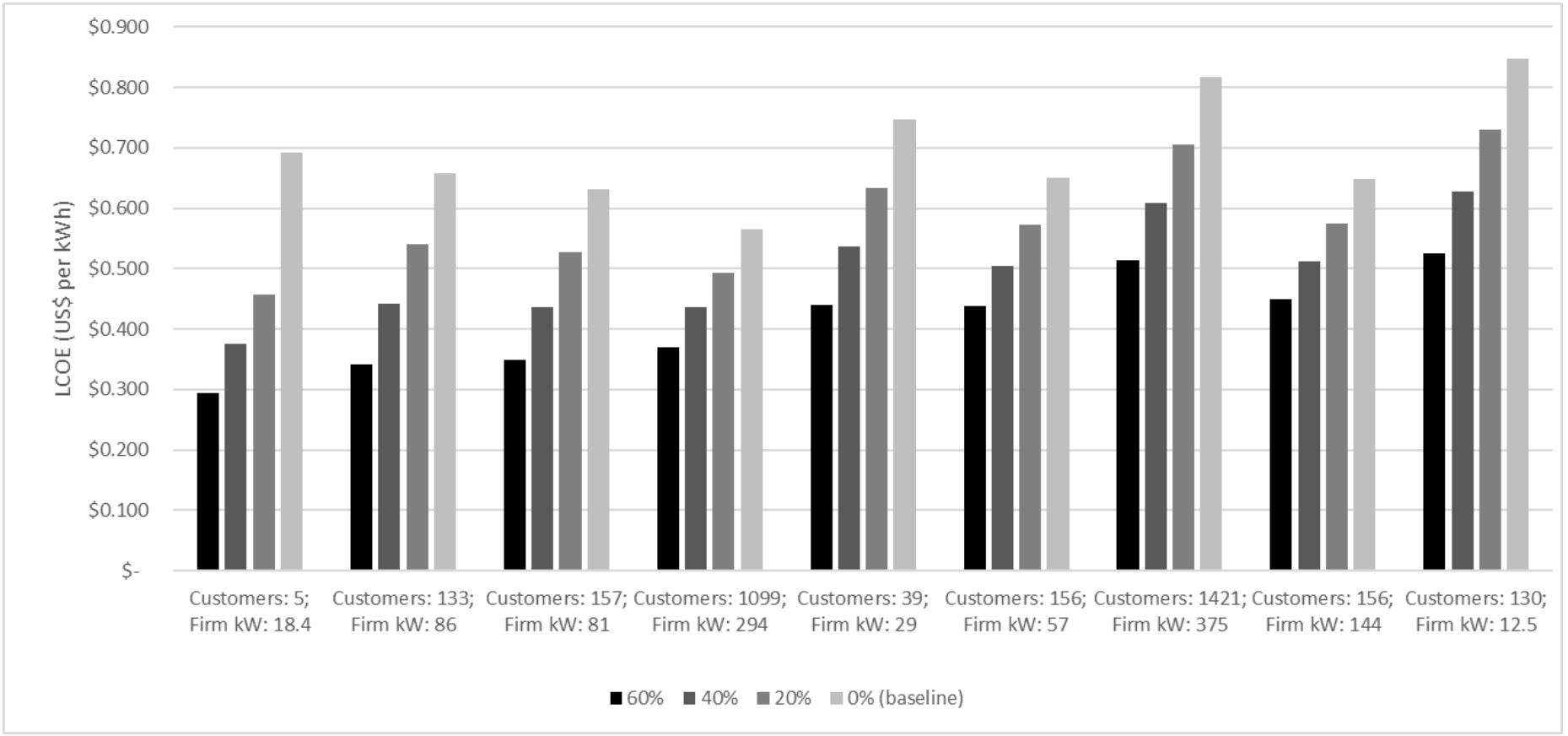
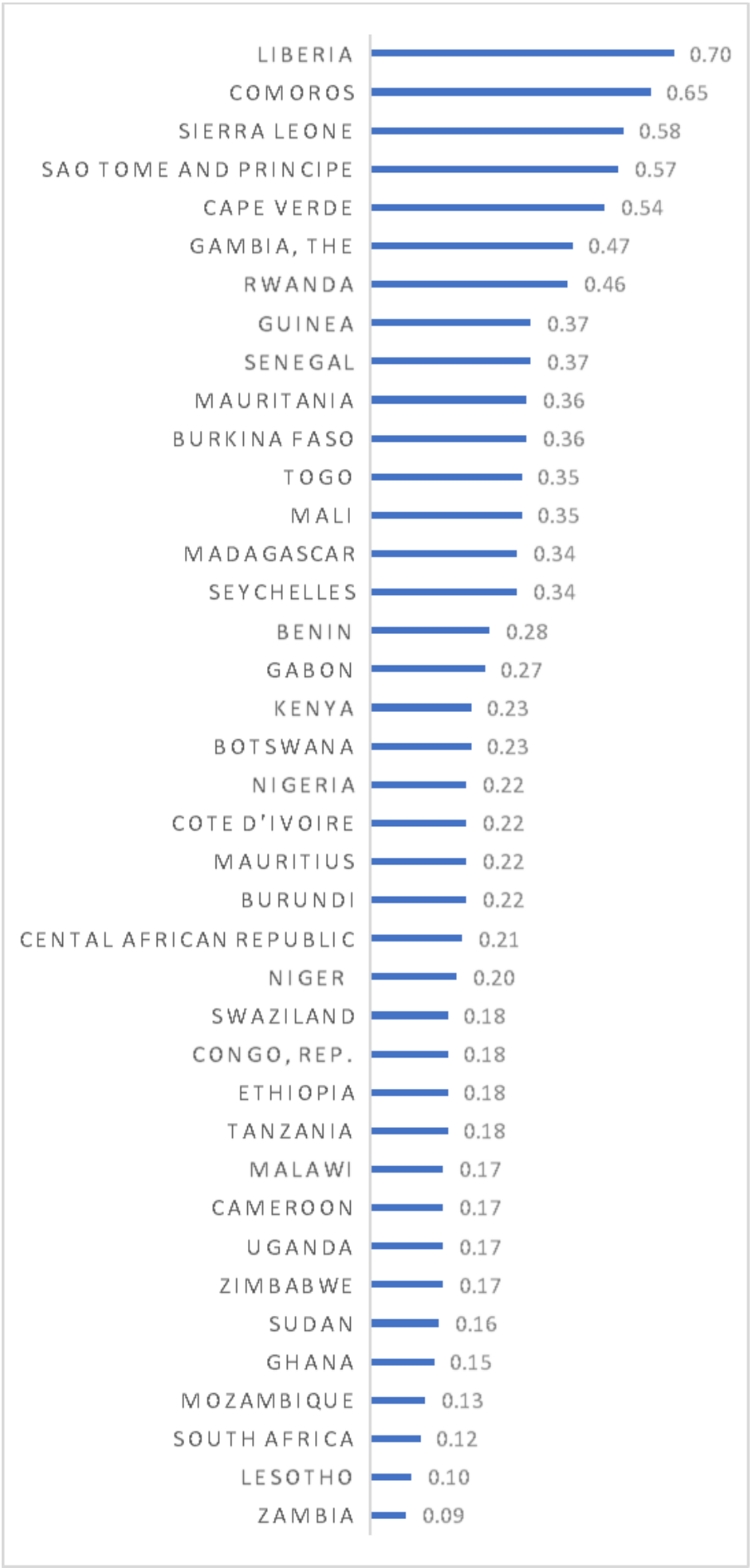
BATTERY COSTS



LEVELIZED COST OF ENERGY (LCOE): IMPACT OF CAPEX SUBSIDIES





World Bank 2016. *Making Power Affordable for Africa and Viable for Its Utilities*. https://www.esmap.org/node/57463

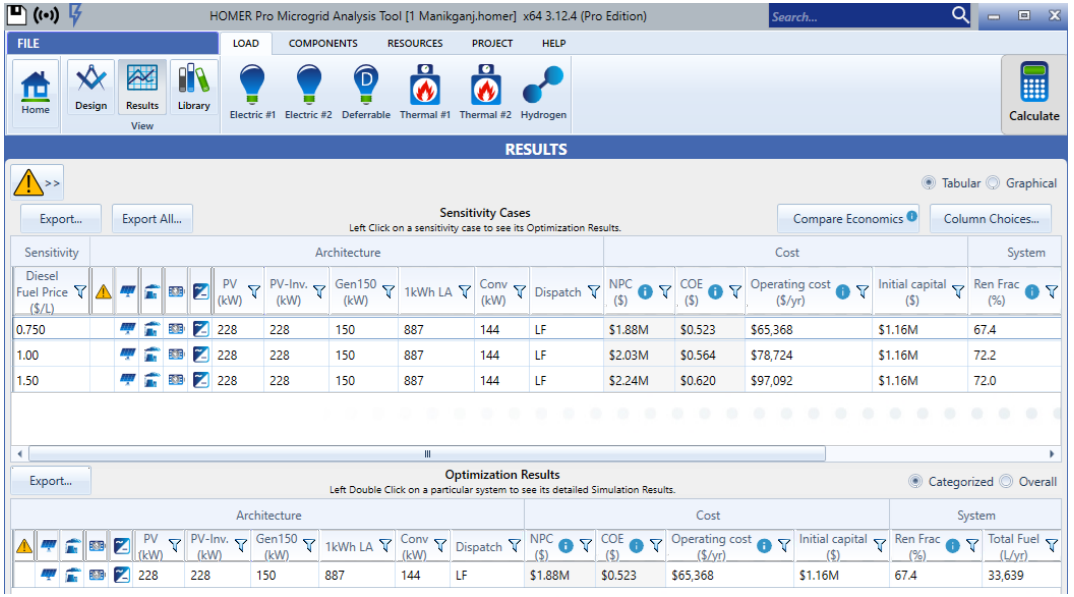
The data

Inclusion of diesel generator	PV/diesel hybrids: 38 Solar PV only: 15
Region	Asia: 37 Africa: 16
Business model (for 24 projects for which data was available)	Private: 10 Public utility: 8 Community: 5 Private-public partnership: 1

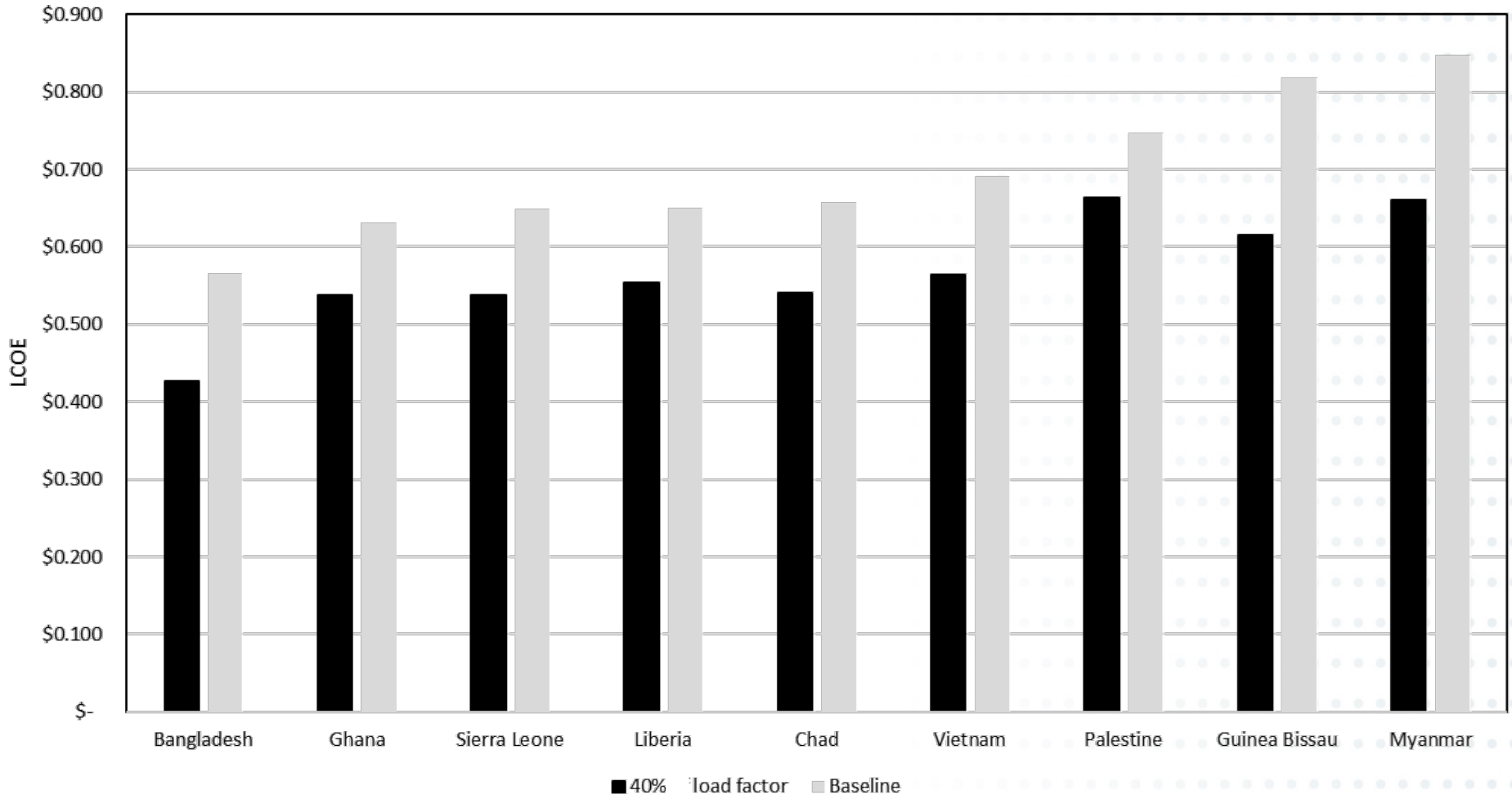
Feature	Average	Minimum	Maximum
Installed "firm" capacity (kW)	115	8	375
Installed solar capacity (kWp)	88	9	312
Number of customers	253	39	1,421

Levelized cost of energy (LCOE) modeling

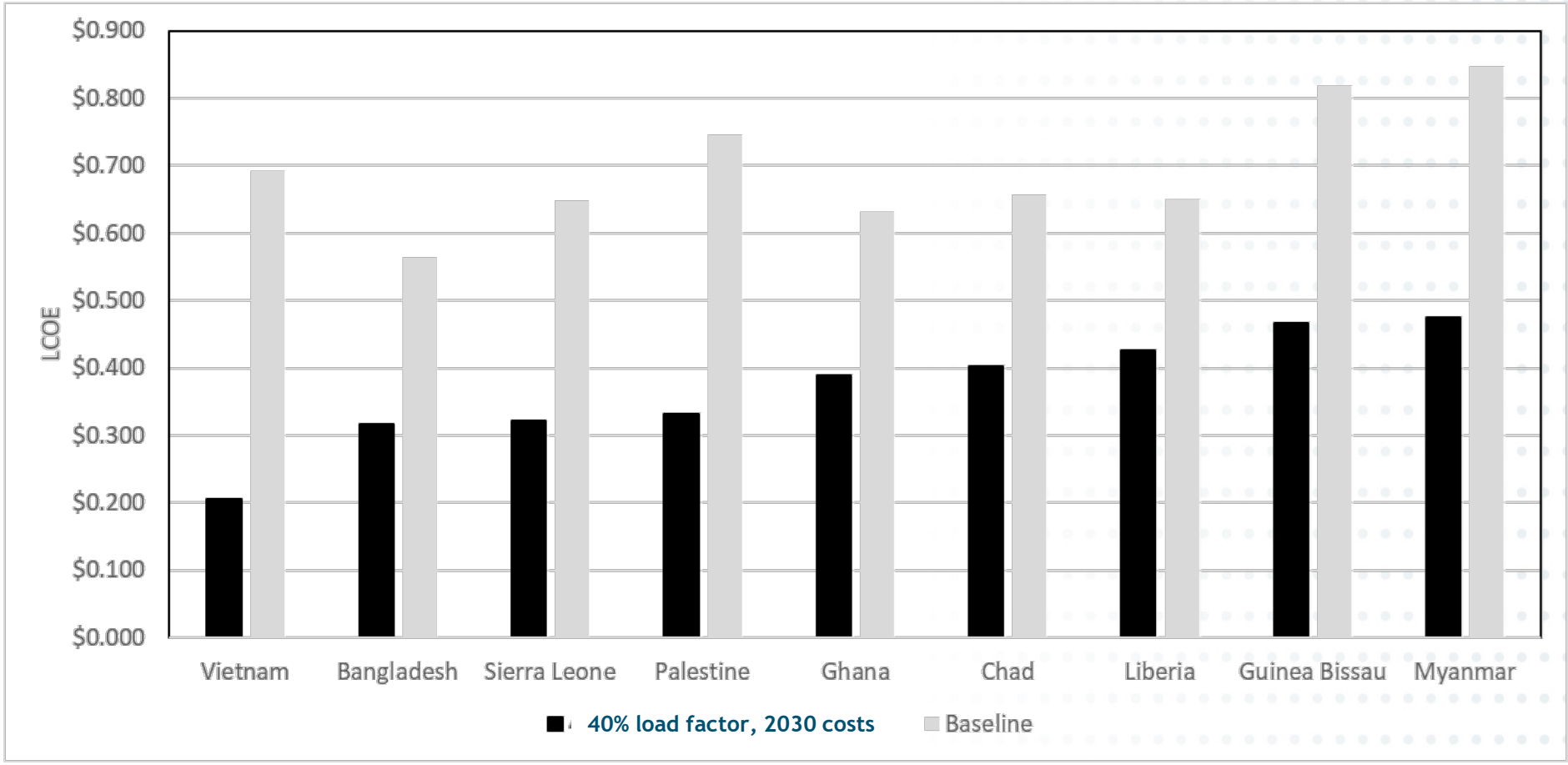
- **Base case**
- **High productive use**
  - Load factor 22% → 40%
- **High productive use & 2020 equipment cost**
- **CAPEX subsidies**
  - 20%
  - 40%
  - 60%



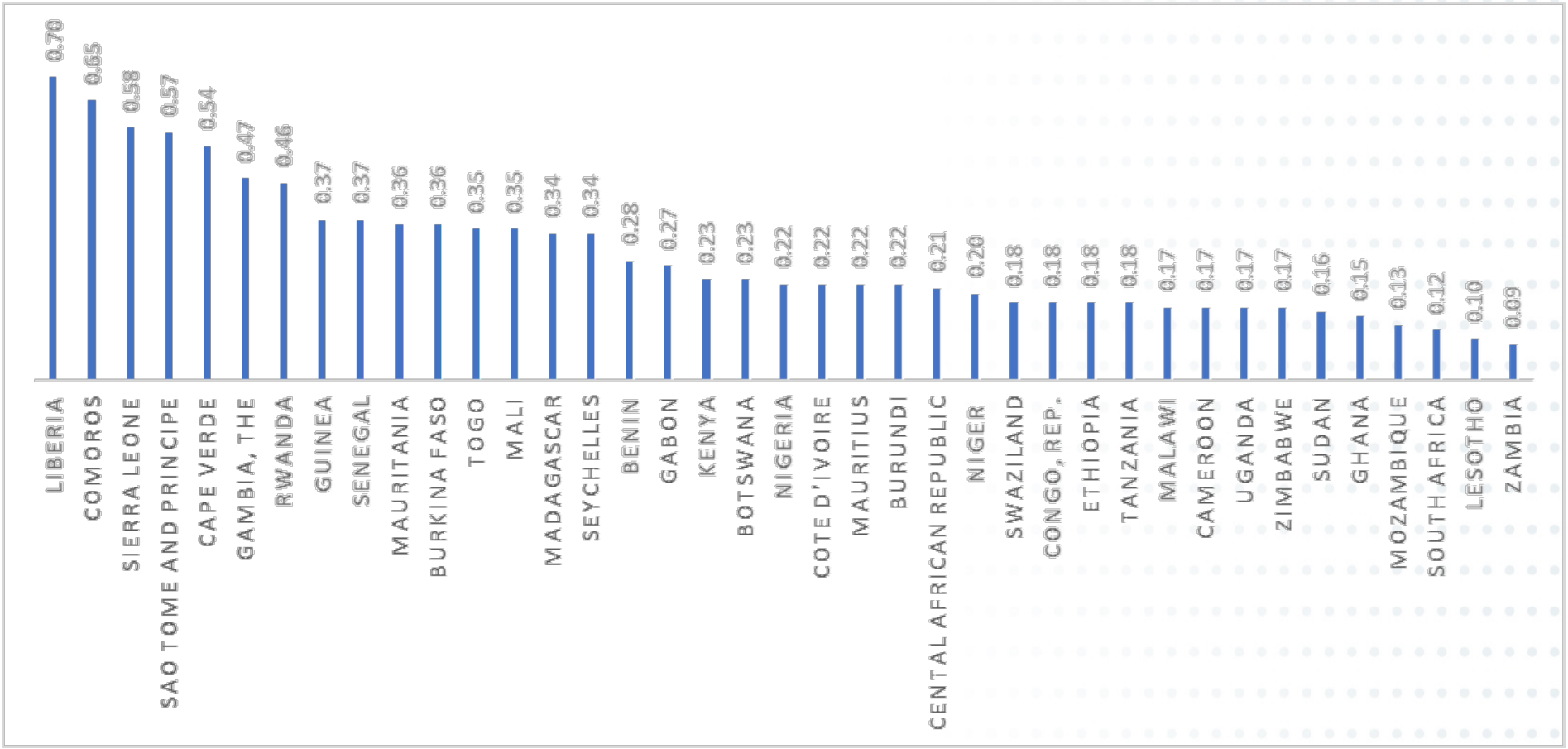
HOMER LCOE modeling – Impact of high productive use



LCOE: Base case vs. 2030 benchmark prices + productive use



Cost of Utility Electricity in Africa
($2019 per kWh)



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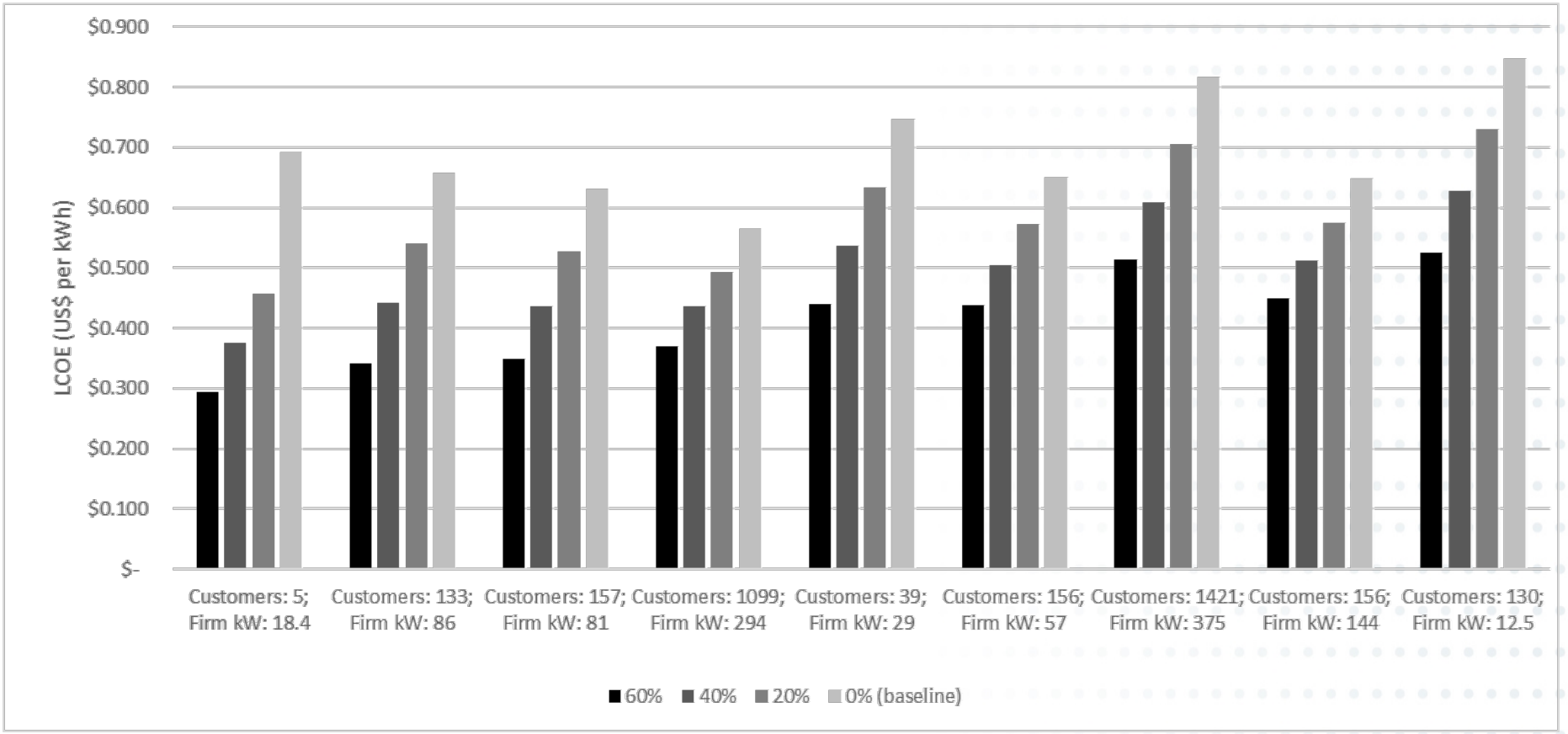
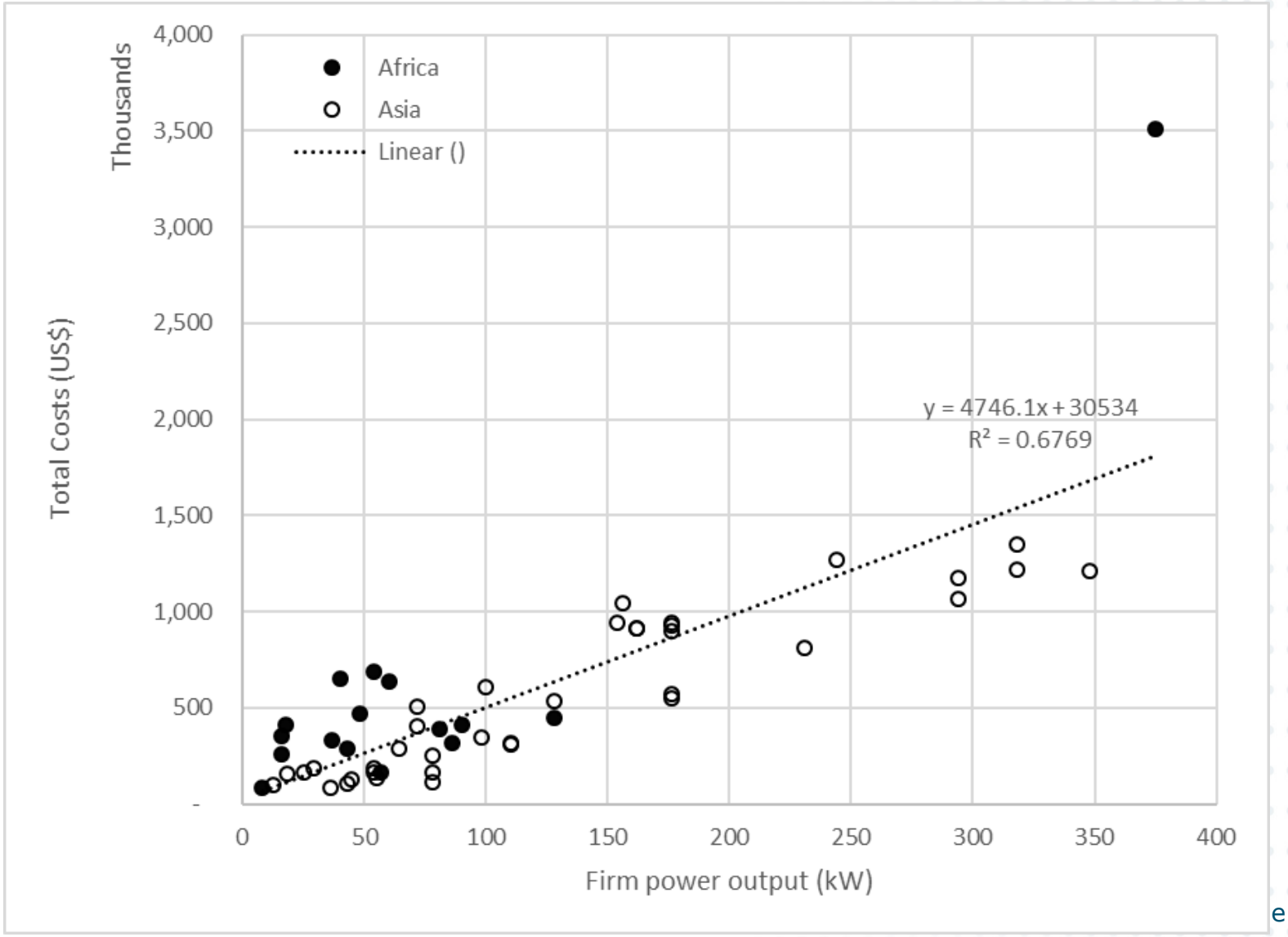
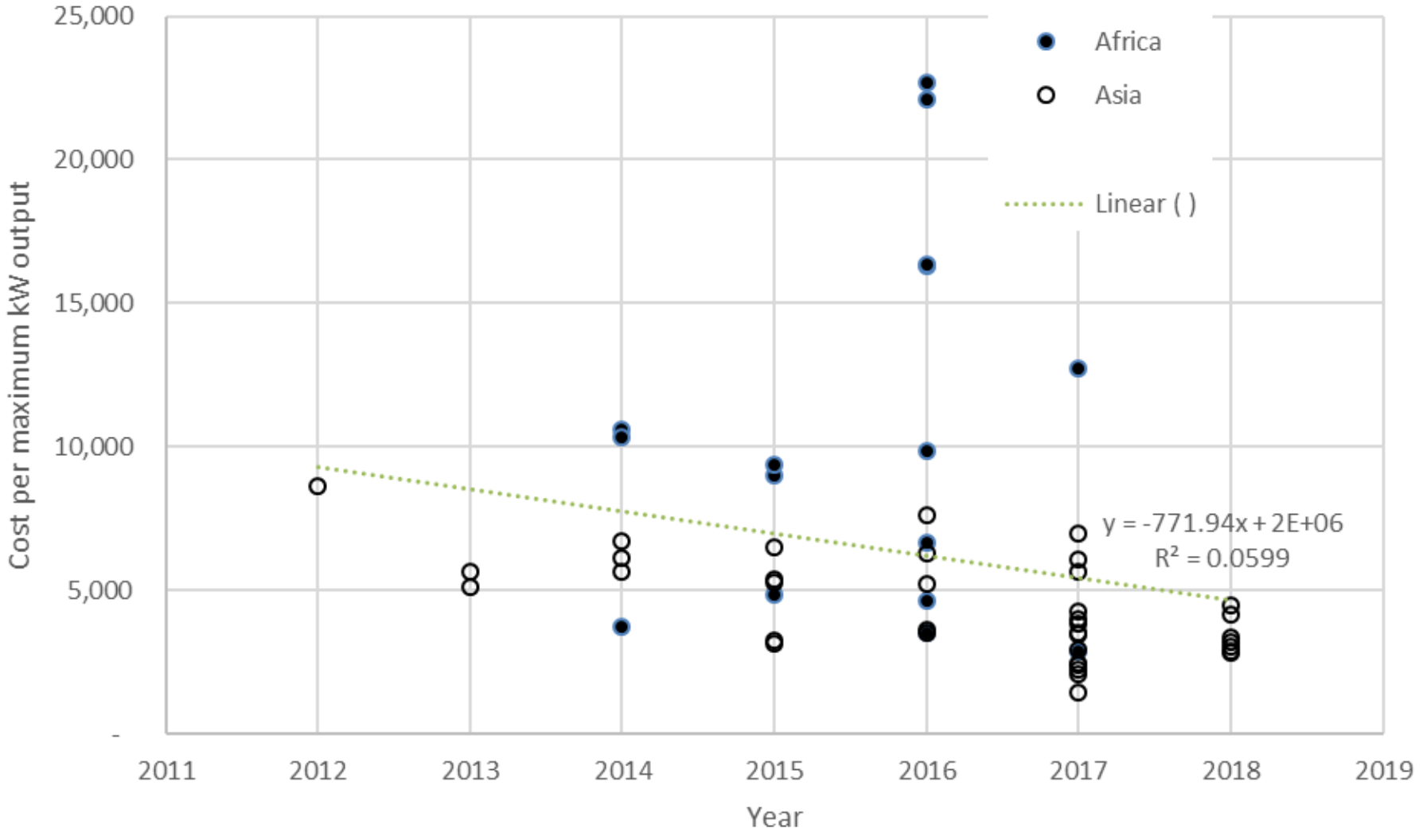
Levelized cost of energy (LCOE): impact of CAPEX subsidies

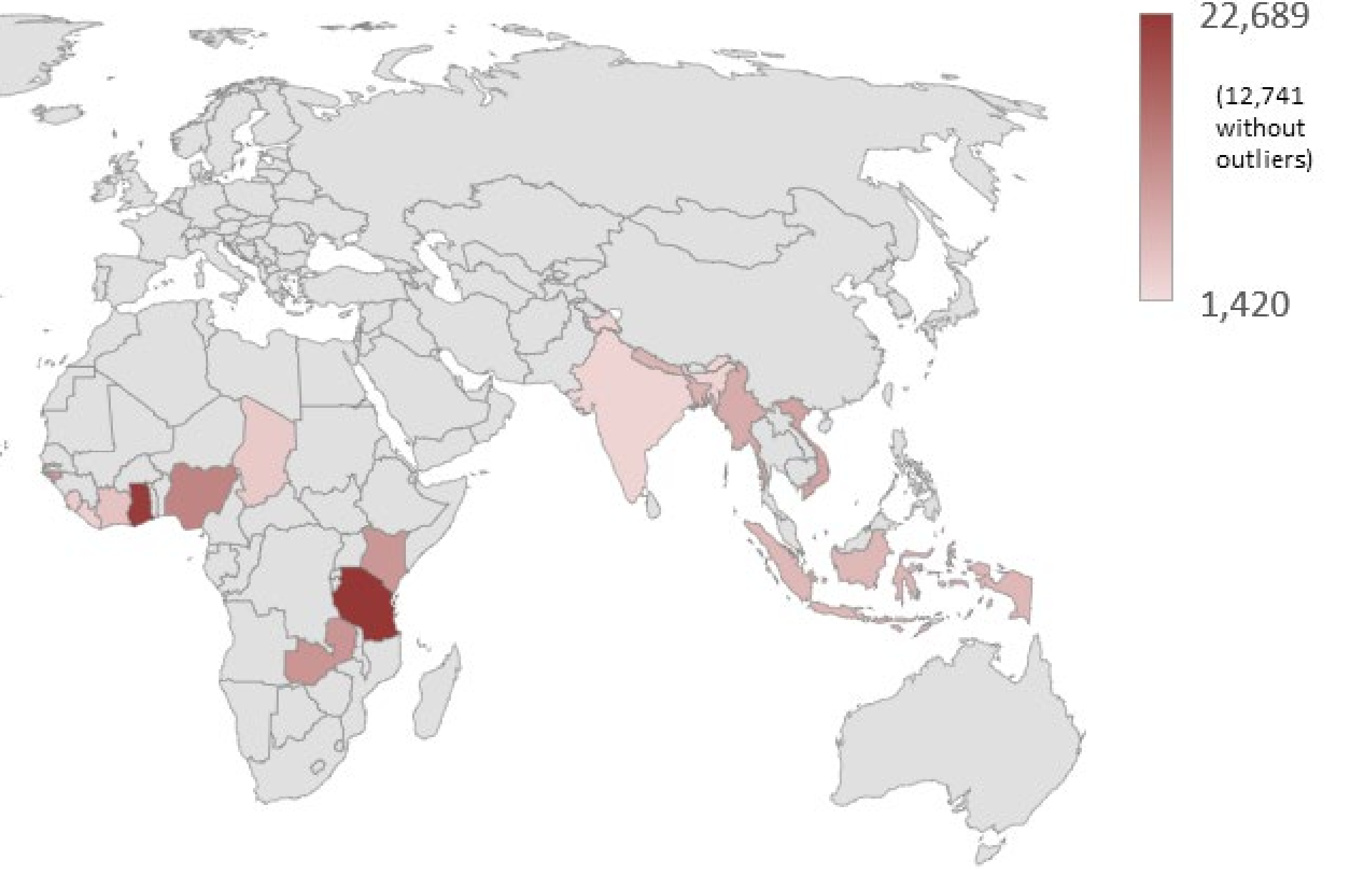


Total cost of mini grids as a function of total firm AC power output

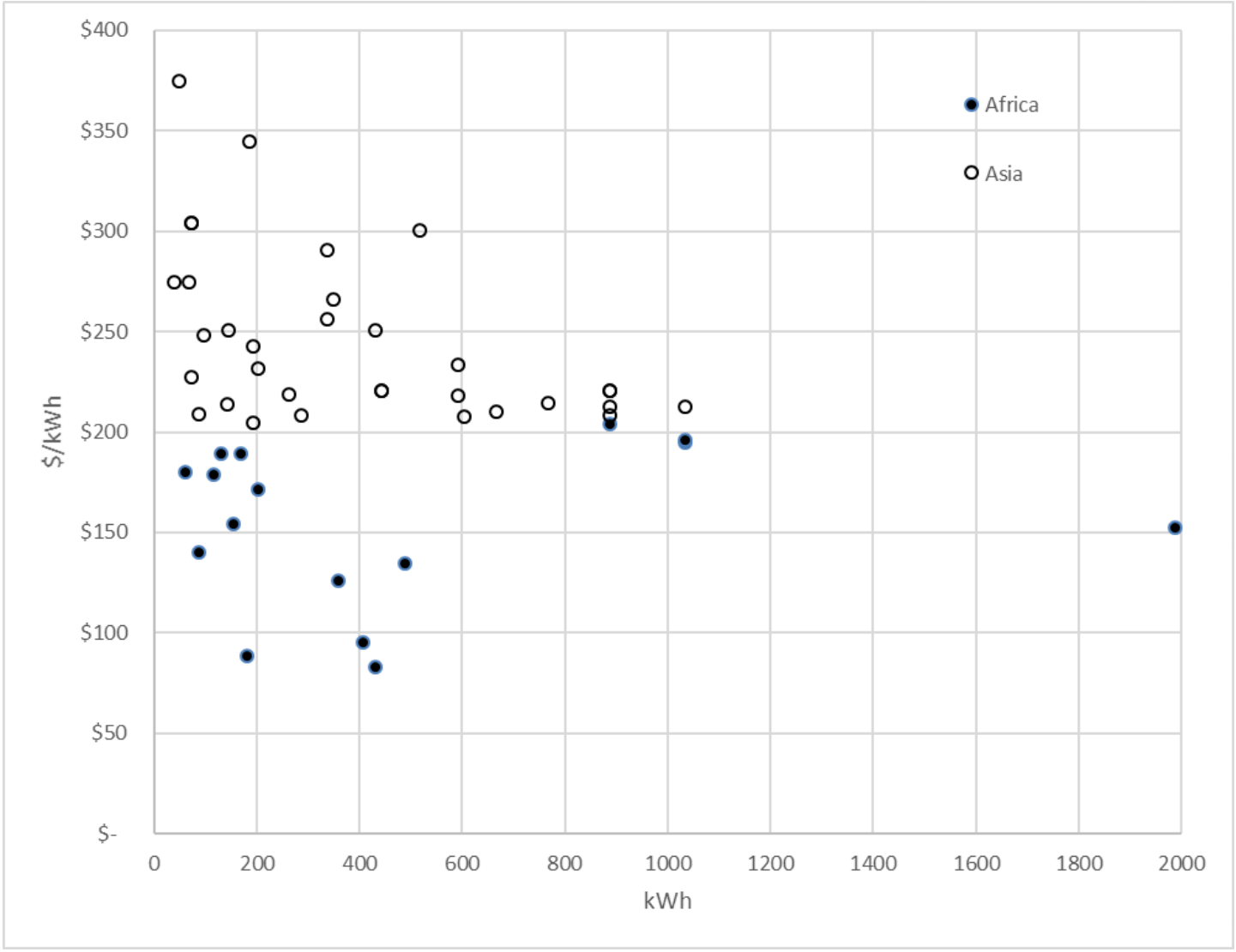


Mini grid cost per kW of firm output, 2011–18

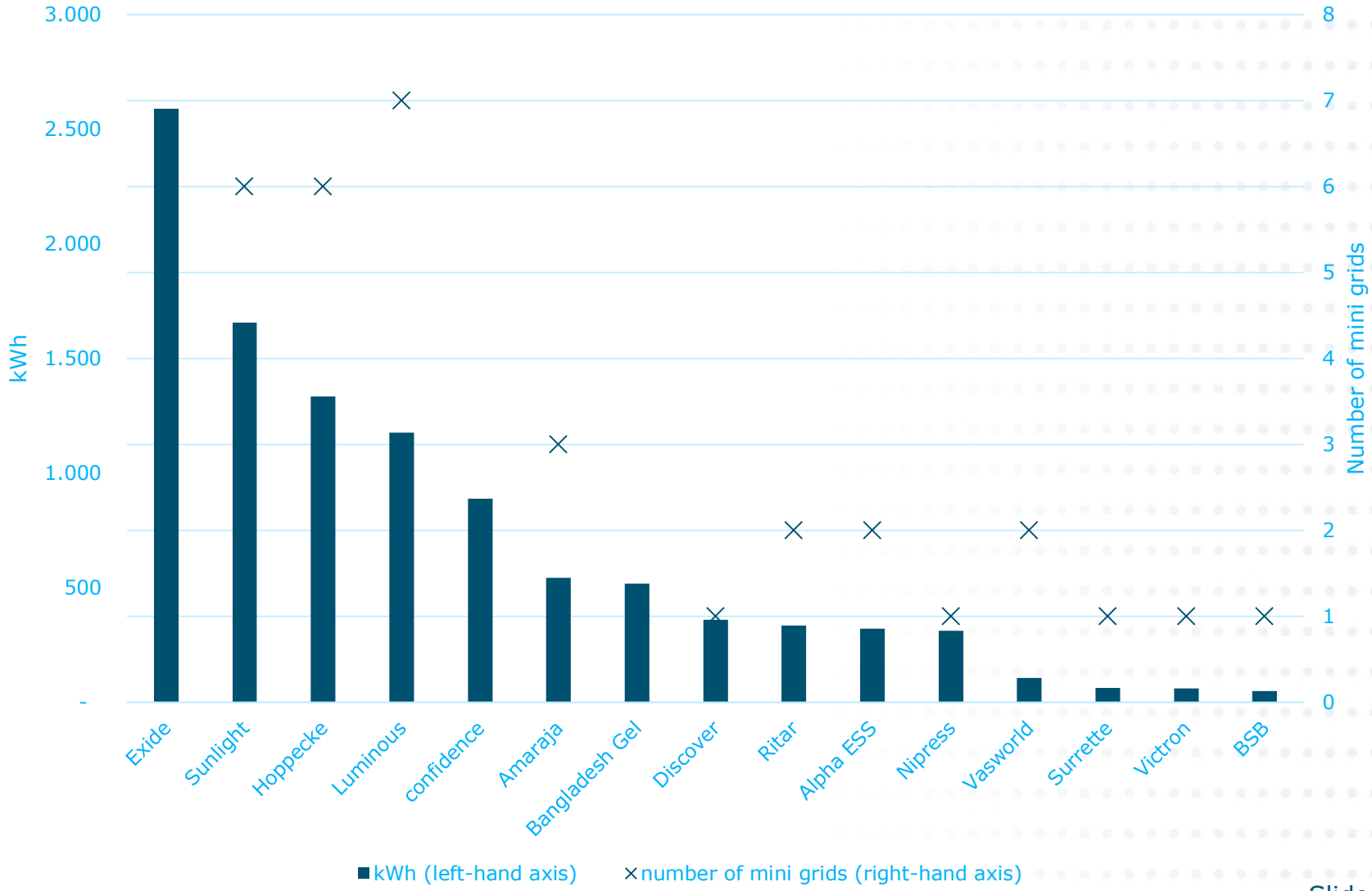



Total USD/kW
22,689
(12,741 without outliers)
1,420

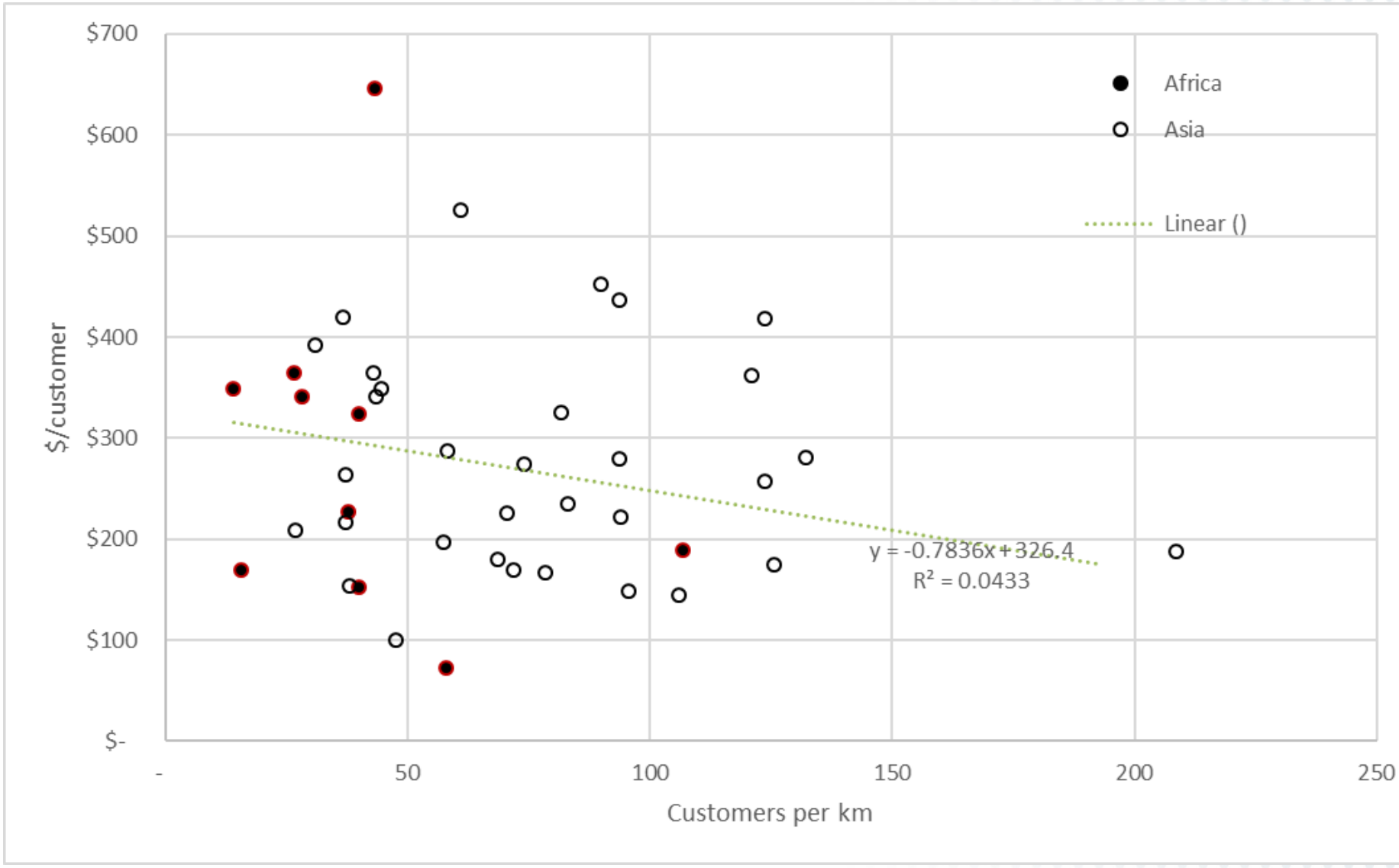
Cost of lead acid battery as a function of battery capacity



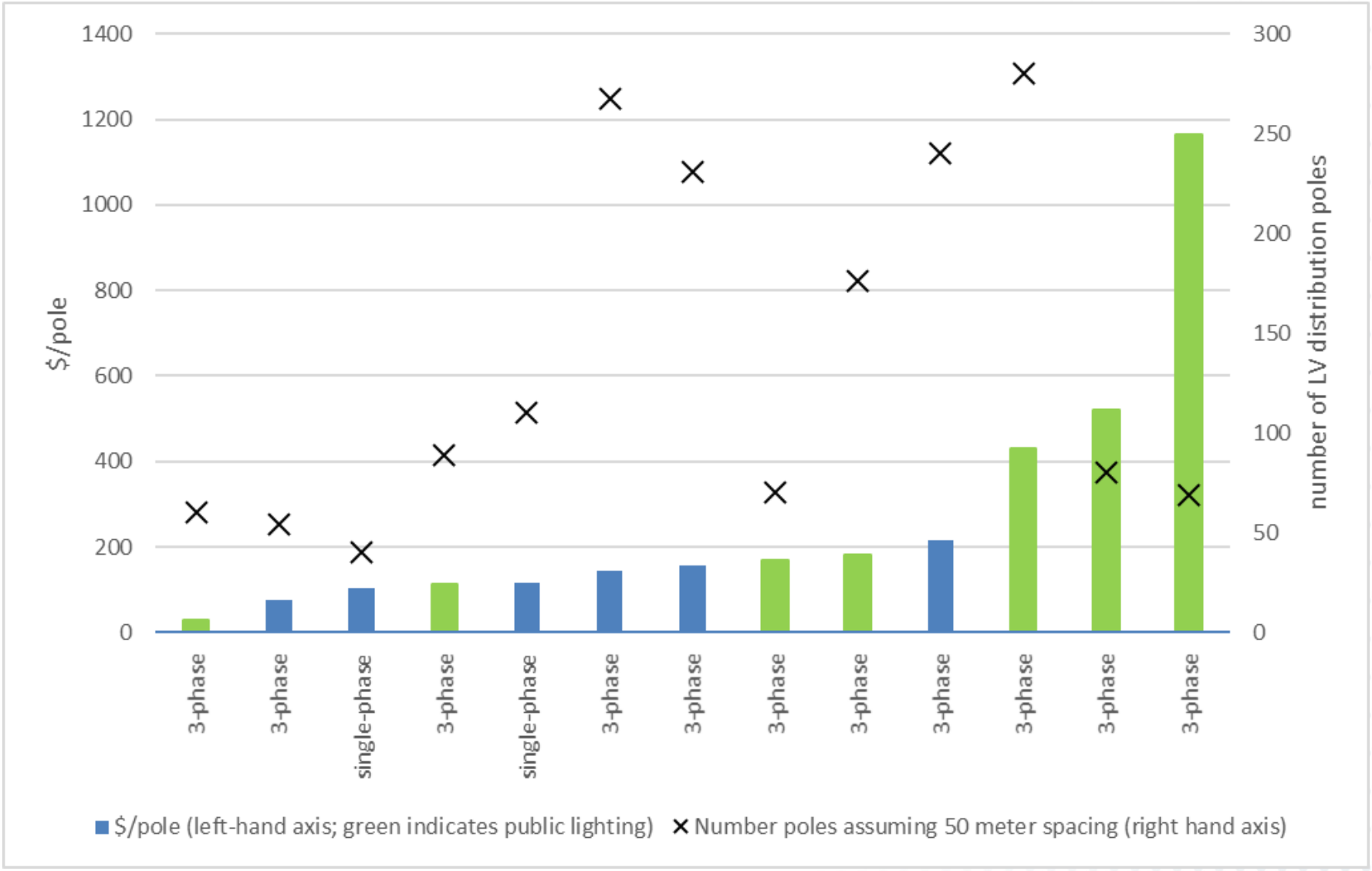
Market share of batteries by manufacturer



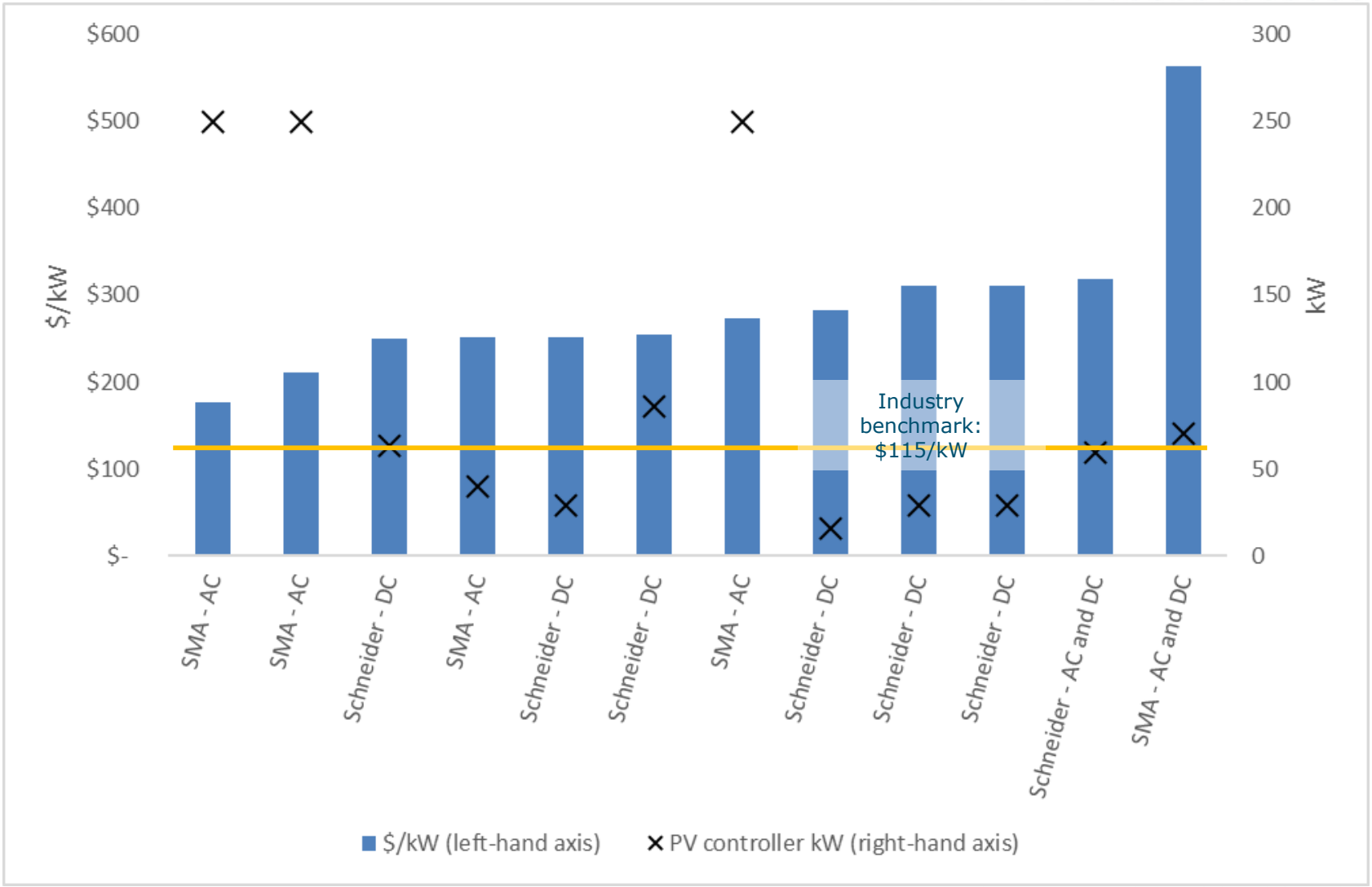
Correlation between cost per customer and the number of customers per kilometer



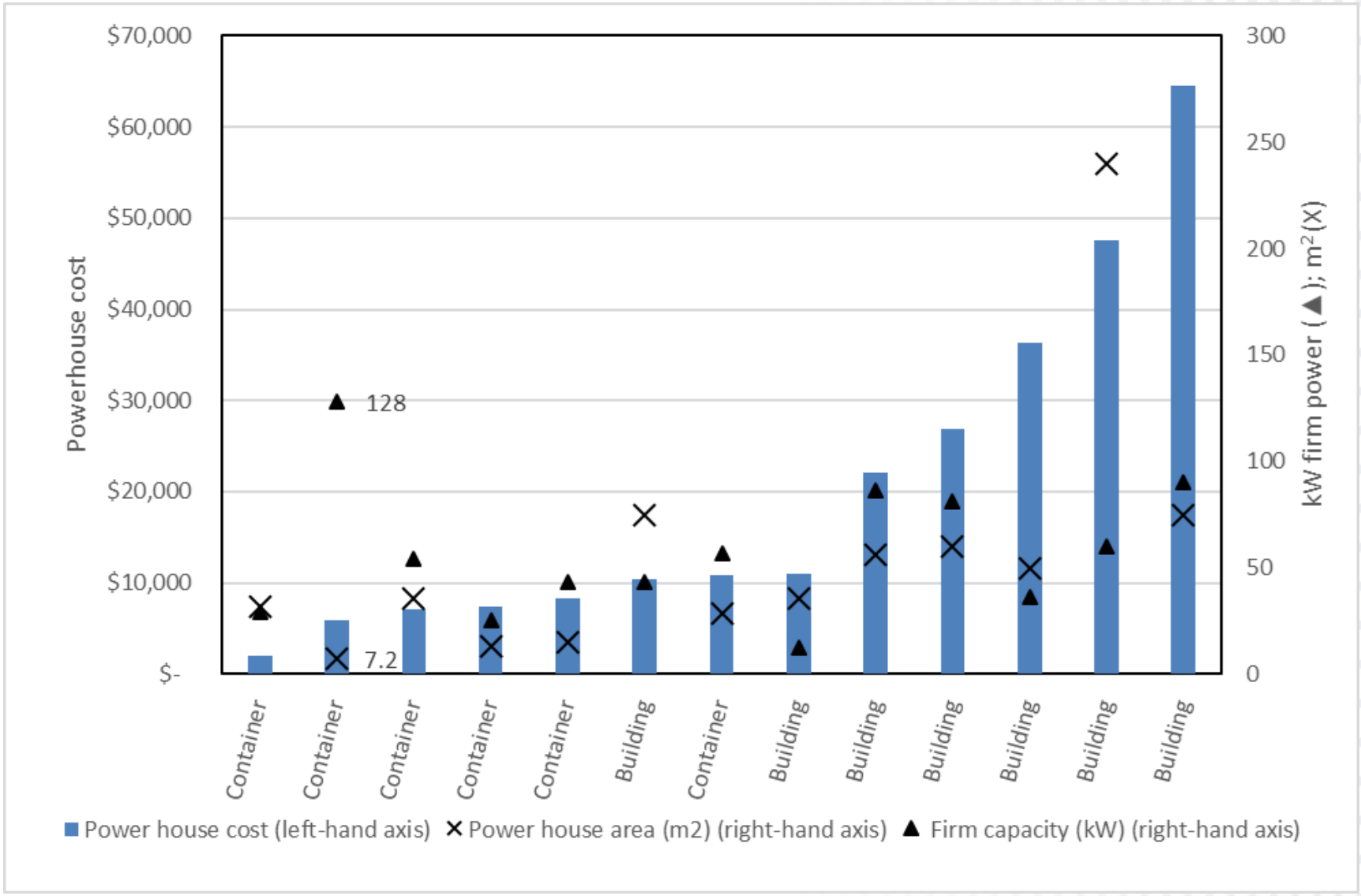
Cost of low-voltage distribution poles, by line type



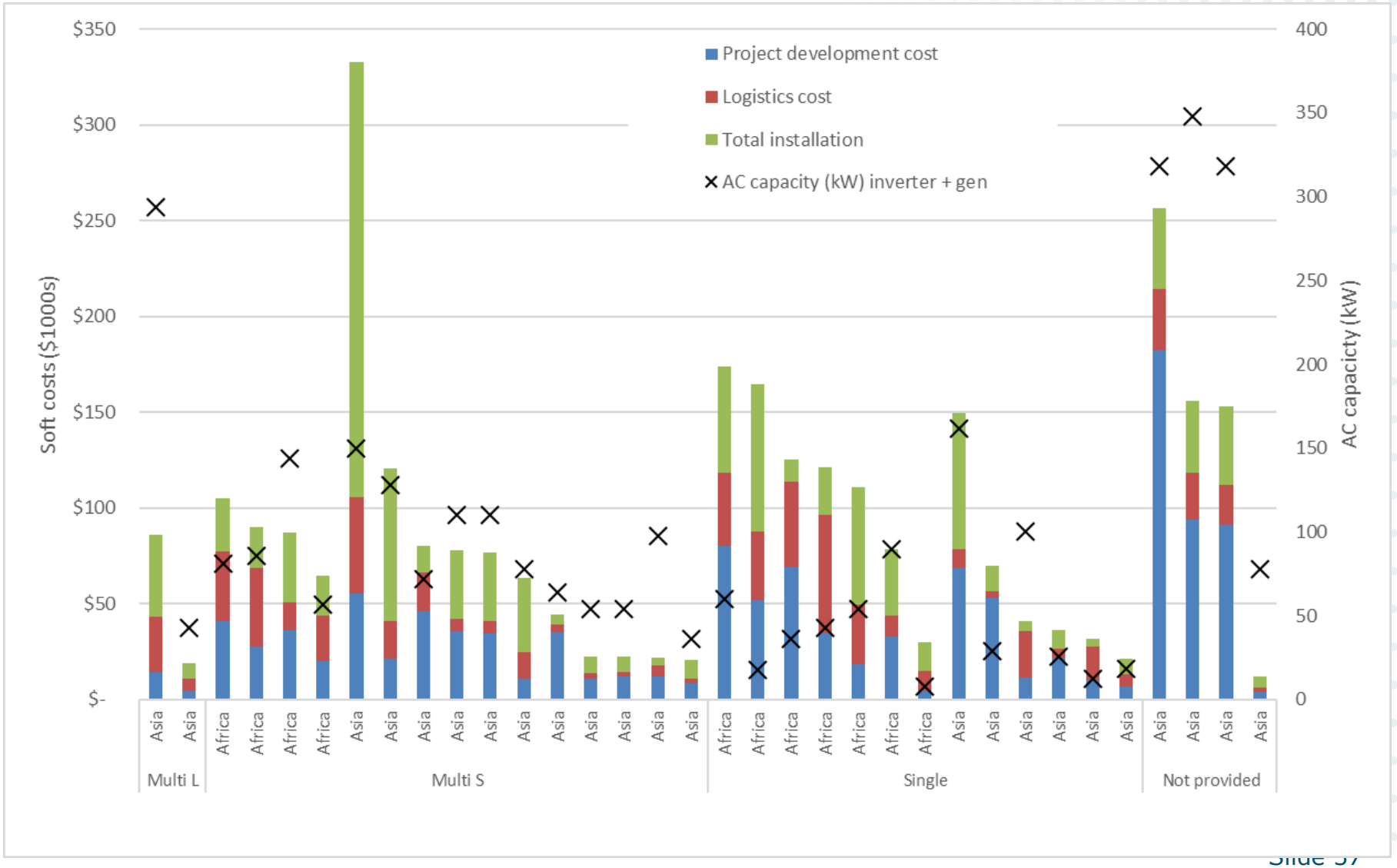
Cost of PV inverters/charge controllers



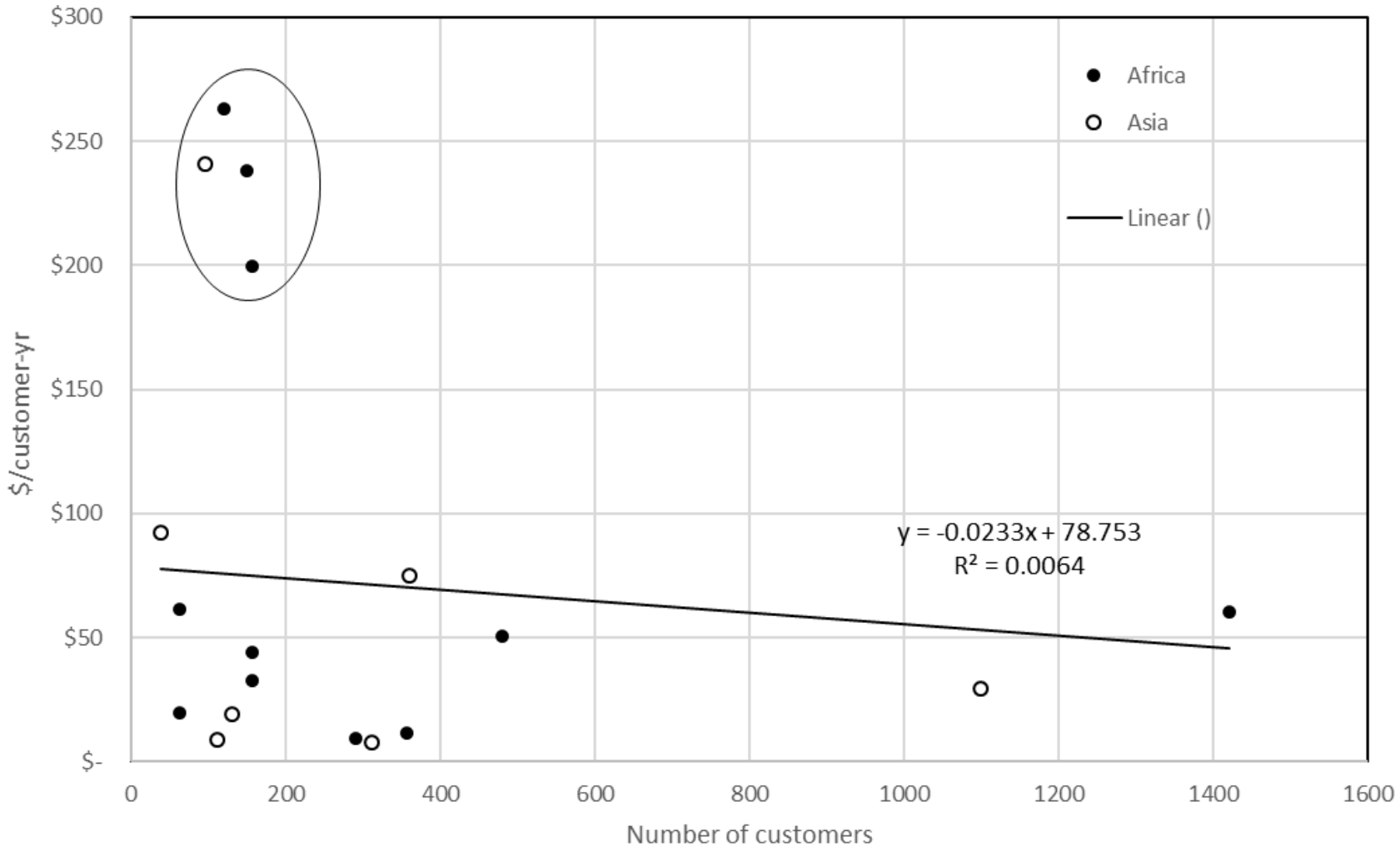
Cost of power houses



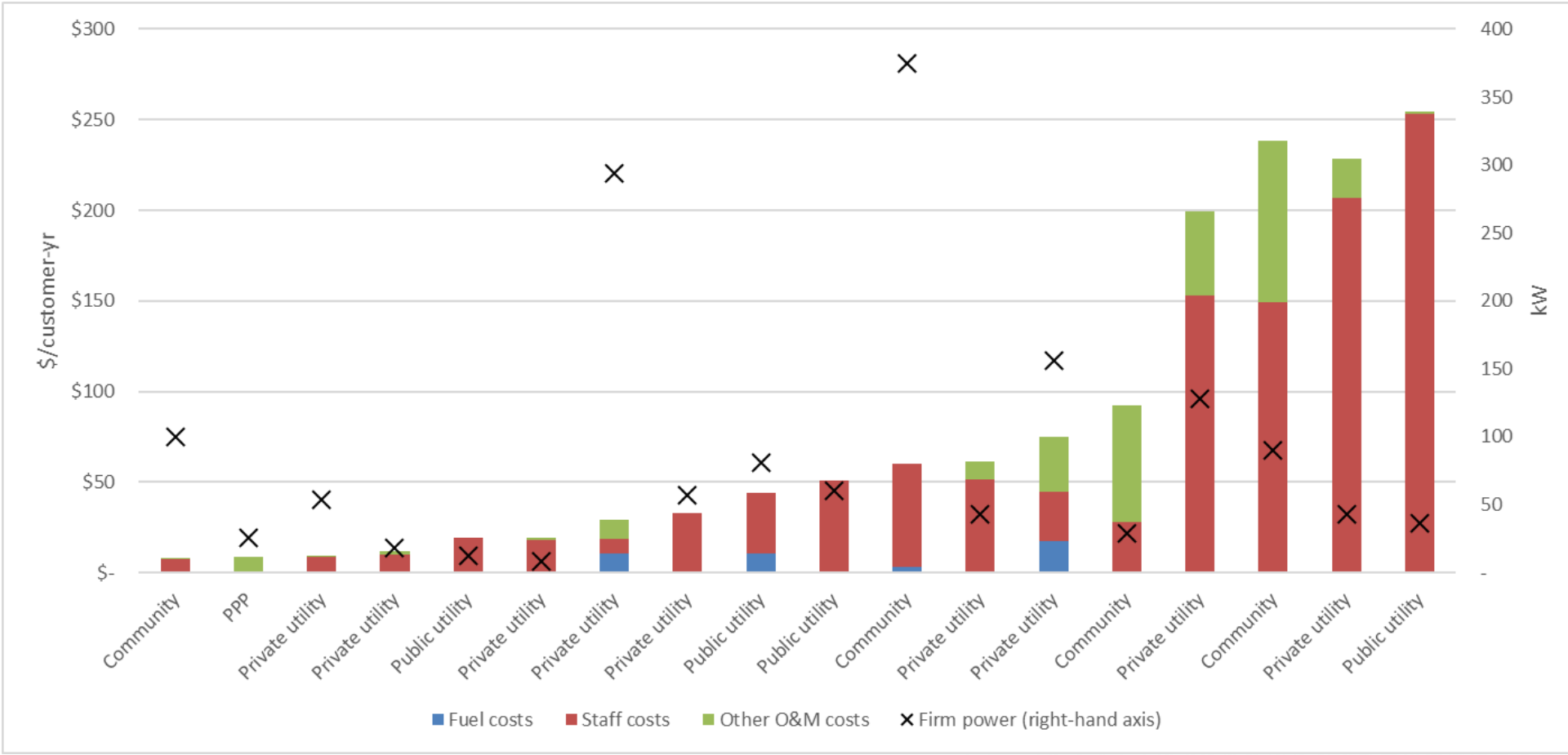
Cost of project development, logistics, and installation



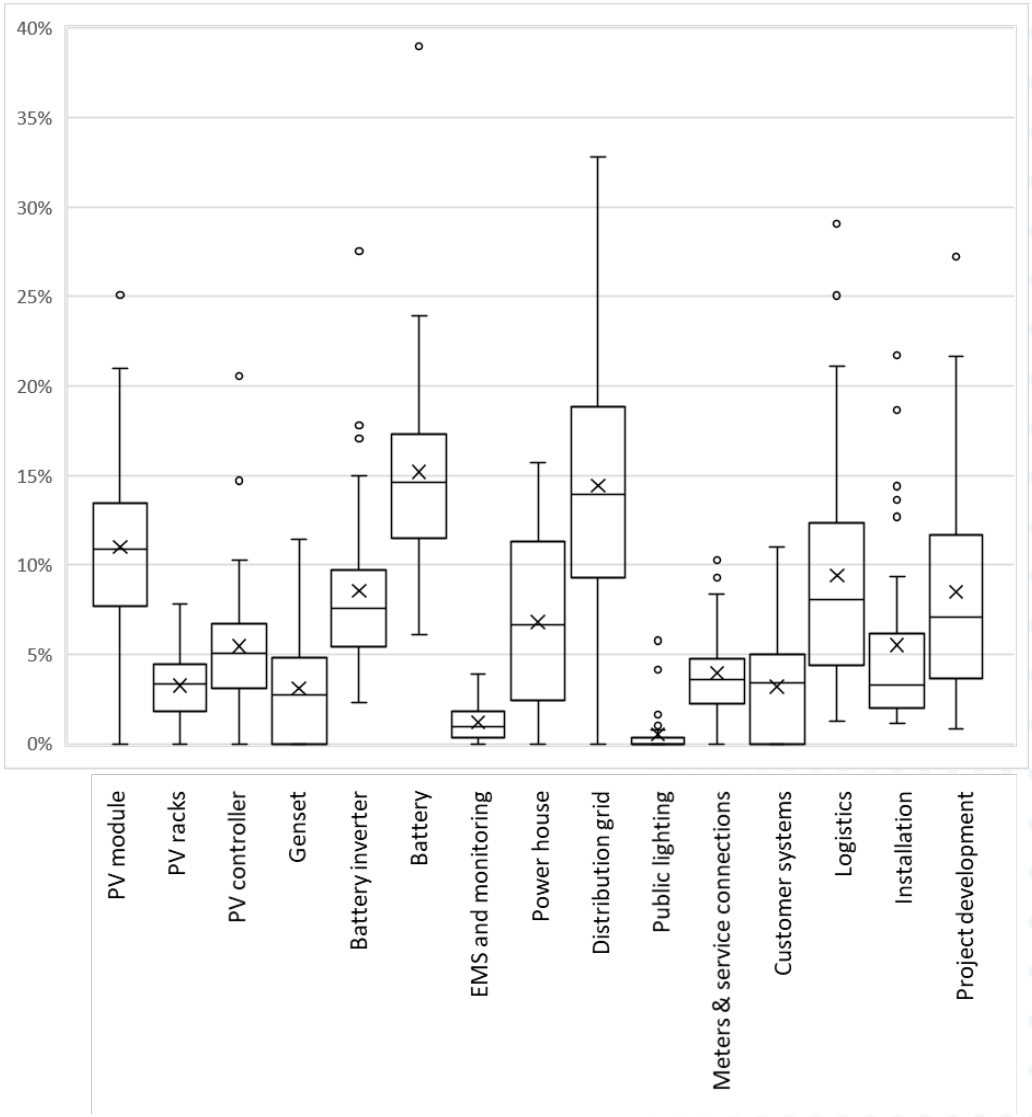
Correlation between OPEX costs and number of customers



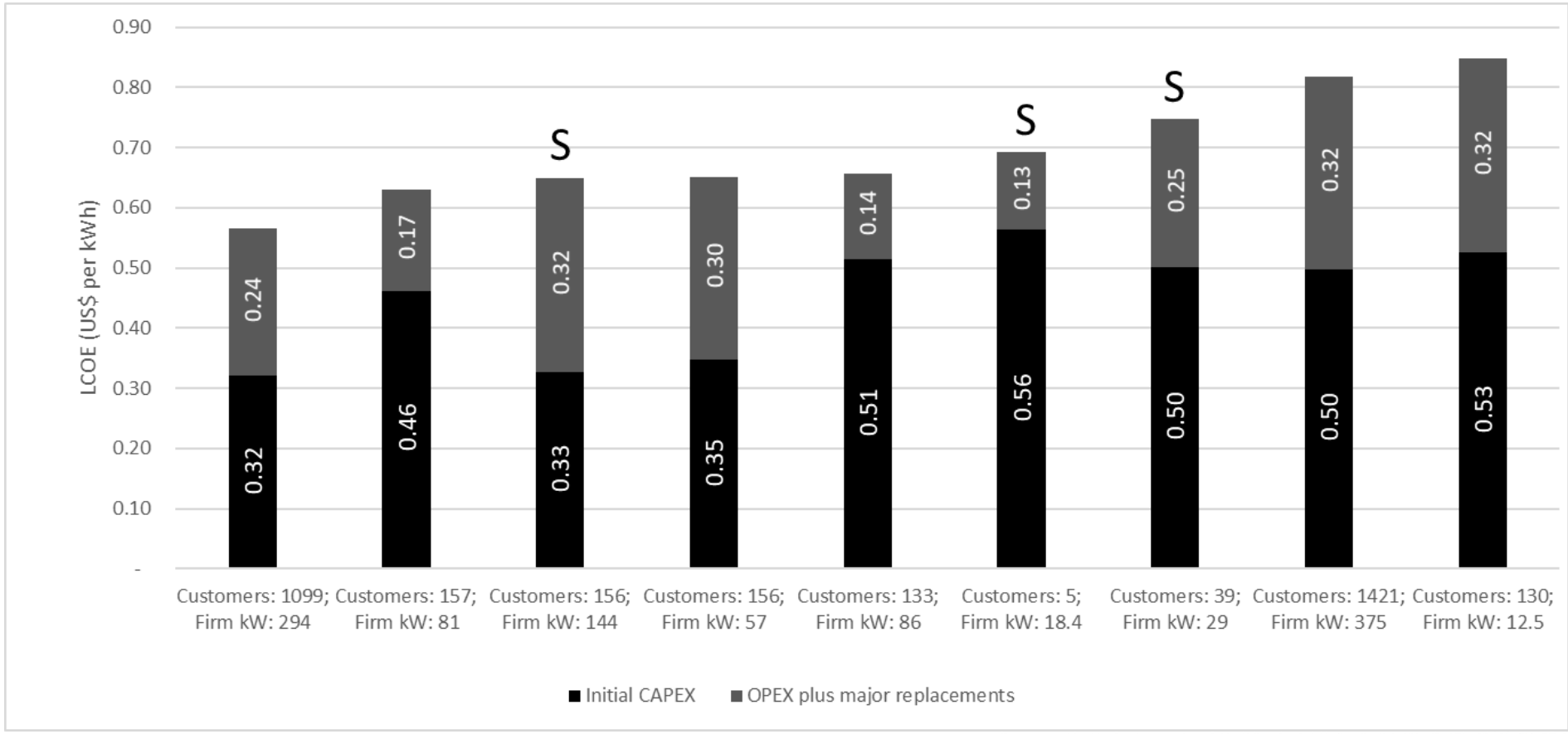
Fuel, staff, and other operations and maintenance costs



Portion of mini grid cost attributable to different components



LCOE attributable to initial CAPEX vs OPEX and major replacements



Industry benchmarks and 2020 cost projections

Mini grid component	Average cost	Minimum cost	Maximum Cost	Mainstream industry benchmark	Price estimate by 2020	Cost drivers and Innovations
PV module ($ per kWp)	719	497	2,652	290[a]	240 [b]	Solar farms & rooftop solar
PV inverter ($ per kWp)	228	176	564	115[c]	80[d]	Solar farms and rooftop solar
Battery inverter ($ per kVA)	729	311	2,377	203[e]	142	EV
Lithium Ion battery ($ per kWh)	605	461	762	209[h]	150[i]	EV
Lead Acid battery ($ per kWh)	240	126	348	147	127	

Surprises

- **Batteries and wooden poles are cheaper in Africa than Asia**
- **Shipping containers as power houses are cheaper (and smaller) than custom-built structures**
- **CAPEX subsidies**

Questions

- **What are mini grid costs?**
- **What are component cost?**
  - Already operating
  - Near future (2020)
- **What are the drivers of mini grid costs**
- **What opportunities exist for cost savings?**
- **What can data tell us about how can ministries, regulators, and development agencies work together to lower mini grid electricity cost?**