

Merlin Pricing Model & Calculations Reference

For Engineering Review - December 4, 2025

Executive Summary

This document outlines Merlin's internal pricing model, validated against **6 professional quotes** from October-December 2025. All calculations use a **single source of truth** (`pricingModel.ts`) with **three pricing tiers** based on system scale.

1. Pricing Tiers

Tier	Power Range	Description	Example
Residential	< 50 kW	Home battery systems, premium pricing	Tesla Powerwall, Enphase
Commercial (C&I)	50 kW - 1 MW	Business-scale, modular systems	Car wash, hotel, small EV hub
Utility-Scale	> 1 MW	Volume pricing, standardized units	Data center, large solar farm

2. BESS (Battery Energy Storage System) Pricing

2.1 Battery Module Pricing (\$/kWh)

Tier	Price	Source
Residential	\$350/kWh	Tesla Powerwall, Enphase benchmarks
Commercial	\$175/kWh	CATL/BYD containerized systems
Utility	\$140/kWh	UK EV Hub (\$120), Hampton Heights (\$190), avg

Validated Quotes:

- UK EV Hub (10 MWh): \$120/kWh
- Tribal Microgrid (200 kWh): \$140/kWh
- Hampton Heights (1.25 MWh): \$190/kWh
- Data Center UK (100 MWh): £190/kWh (~\$240)

2.2 PCS/Inverter Pricing (\$/kW)

Tier	Price	Source
Residential	\$200/kW	Integrated hybrid inverters
Commercial	\$120/kW	UK EV Hub quote (validated)
Utility	\$100/kW	Large central inverters

2.3 Transformer Pricing (\$/kVA)

Tier	Price	Notes
Residential	\$0	Not needed (LV only)
Commercial	\$68/kVA	480V/208V step-down

Utility	\$80/kVA	MV/LV (35kV/13.8kV/480V)
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2.4 Switchgear Pricing (\$/kW)

Tier	Price	Type
Residential	\$15/kW	LV distribution panel
Commercial	\$30/kW	LV/basic MV switchgear
Utility	\$50/kW	Full MV switchgear suite

2.5 BESS Calculation Formula

Battery Cost = Capacity (kWh) × Price per kWh × Chemistry Multiplier × Duration Discount
PCS Cost = Power (kW) × Price per kW
Transformer Cost = (Power × 1.25 for margin) × Price per kVA
Switchgear Cost = Power (kW) × Price per kW
BOS Cost = Subtotal × BOS Percentage (10–15%)
EMS Cost = Base Cost + (Power × Per kW rate)
 BESS Total = Battery + PCS + Transformer + Switchgear + BOS + EMS

2.6 Chemistry Multipliers

Chemistry	Multiplier	Notes
LFP (Lithium Iron Phosphate)	1.00x	Baseline, most common
NMC (Nickel Manganese Cobalt)	1.15x	Higher energy density
NCA (Nickel Cobalt Aluminum)	1.20x	Tesla cells
Vanadium Flow	1.40x	Long duration (6–12 hr)
Sodium-Ion	0.85x	Emerging, lower cost

2.7 Duration Discounts

Duration	Discount	Notes
1 hour	0%	No discount
2 hours	5%	Short duration
4 hours	10%	Most common, best value
6 hours	13%	Extended duration
8 hours	15%	Long duration

3. Solar PV Pricing

3.1 Turnkey Pricing (\$/W)

Tier	Price	Source
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Residential	\$2.80/W	Rooftop residential
Commercial	\$1.05/W	Tribal Microgrid (\$1.05/W validated)
Utility	\$0.65/W	Hampton Heights (\$0.60/W validated)

Validated Quotes:

- Tribal Microgrid (250 kWdc): \$1.05/W (\$262,500)
- Hampton Heights (2 MWp): \$0.60/W (\$1,200,000)
- GoGoEV Clubhouse (250 kW): ~\$1.00/W (£252,000)

3.2 Solar Calculation Formula

Solar Cost = System Size (kW) × 1000 × Price per Watt
Space Required = System Size (kW) × Space Factor

Space Factors:

- Rooftop: 100 sq ft/kW
- Ground Mount: 200 sq ft/kW
- Carport: 150 sq ft/kW

3.3 Capacity Factors by Region

Region	Capacity Factor
Southwest US	25%
Southeast US	20%
Midwest US	18%
Northeast US	16%
Northwest US	15%
UK	11%
Northern Europe	10%
Southern Europe	18%
Middle East	25%
Australia	22%

4. EV Charger Pricing

4.1 Hardware Costs (Per Unit)

Type	Power	Hardware Cost	Source
Level 1	1.4 kW	\$500	Standard outlet
Level 2	7 kW	\$2,500	Basic commercial
Level 2	11 kW	\$5,000	UK EV Hub (validated)
Level 2	19 kW	\$8,000	High-power L2

Level 2	22 kW	\$10,000	Max L2
DCFC	50 kW	\$35,000	Entry DC fast
DCFC	150 kW	\$55,000	UK EV Hub (validated)
HPC	250 kW	\$100,000	High power
HPC	350 kW	\$130,000	UK EV Hub (validated)

4.2 Installation Costs (Per Unit)

Type	Power	Install Cost	Source
Level 1	1.4 kW	\$300	Simple outlet
Level 2	7 kW	\$2,000	Basic install
Level 2	11 kW	\$3,000	UK EV Hub (validated)
Level 2	19 kW	\$4,000	Panel upgrade likely
Level 2	22 kW	\$5,000	Significant electrical
DCFC	50 kW	\$20,000	Concrete pad + electrical
DCFC	150 kW	\$30,000	UK EV Hub (validated)
HPC	250 kW	\$40,000	Utility coordination
HPC	350 kW	\$50,000	UK EV Hub (validated)

4.3 Additional EV Costs

Item	Cost	Notes
Networking/OCPP	\$500/port	Annual software
Make-ready	\$50/kW	Site infrastructure
Utility upgrade	\$50,000+	If > 200 kW total

4.4 EV Calculation Formula

Hardware Cost = Σ (Charger Count \times Unit Hardware Cost)
Installation Cost = Σ (Charger Count \times Unit Install Cost)
Networking Cost = Total Ports \times \$500
Make-ready Cost = Total Charging kW \times \$50/kW
EV Total = Hardware + Installation + Networking + Make-ready

5. Generator Pricing

5.1 Equipment Pricing (\$/kW)

Fuel Type	< 100 kW	100-500 kW	500 kW - 2 MW	> 2 MW
Diesel	\$600/kW	\$450/kW	\$350/kW	\$300/kW

Natural Gas	\$700/kW	\$550/kW	\$450/kW	\$400/kW
Propane	\$650/kW	\$500/kW	\$400/kW	\$350/kW

Source: Hampton Heights quote (Eaton Cummins gensets)

5.2 Generator Calculation Formula

Equipment Cost = Capacity (kW) × Price per kW
Installation Cost = Equipment Cost × 25%
Generator Total = Equipment + Installation

6. Wind Power Pricing

6.1 Turnkey Pricing (\$/kW)

Scale	Price	Typical Sizes
Distributed	\$3,500/kW	10-100 kW turbines
Commercial	\$2,500/kW	250 kW - 1 MW turbines
Utility	\$1,350/kW	2-5 MW turbines

6.2 Capacity Factors

Scale	Capacity Factor
Distributed	20%
Commercial	30%
Utility	40%

7. Installation & Soft Costs

7.1 Standard Percentages (of Equipment Cost)

Item	Percentage	Description
Logistics	8%	Shipping, handling, delivery
Import Duty	2%	China-sourced equipment
EPC/Integration	25%	Engineering, procurement, construction
Contingency	5%	Permitting, unexpected costs
TOTAL	40%	Added to equipment cost

Source: Consistent across all professional quotes analyzed

7.2 Regional Adjustments (Installation Multiplier)

Region	Multiplier	Notes
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California	1.25x	High labor costs
Texas	0.90x	Lower costs
Northeast US	1.15x	Union labor
Midwest US	0.95x	Moderate
Southeast US	0.92x	Lower costs
UK	1.10x	Higher than US avg
Germany	1.20x	High labor
Asia	0.80x	Lower labor costs

7.3 Installation Calculation Formula

Logistics = Equipment Cost × 8%
Import Duty = Equipment Cost × 2%
EPC/Integration = Equipment Cost × 25% × Regional Multiplier
Contingency = Equipment Cost × 5%
Installation Total = Logistics + Import Duty + EPC + Contingency

8. Financial Assumptions

8.1 Federal Tax Credits (ITC)

Credit Type	Rate	Eligibility
Base ITC	30%	All solar + storage
Domestic Content Adder	+10%	US-manufactured components
Energy Community Adder	+10%	Coal/brownfield areas
Low Income Adder	+10%	Qualifying locations
Maximum Total	50%	Cannot exceed

8.2 Project Economics

Parameter	Value	Notes
Discount Rate	8%	Standard for energy projects
Inflation Rate	2.5%	Annual
BESS Round-trip Efficiency	85%	LFP batteries
BESS Degradation	2%/year	Capacity loss
Solar Degradation	0.5%/year	Output decline

8.3 Project Lifetimes

Asset	Lifetime	Warranty Typical
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BESS	15 years	10 years
Solar PV	25 years	25 years performance
Wind	25 years	10 years
Generator	20 years	2-5 years

8.4 Annual O&M (% of CapEx)

Asset	Annual O&M	Notes
BESS	2.5%	Includes augmentation
Solar	1.5%	Cleaning, monitoring
Wind	2.0%	Mechanical maintenance
Generator	3.0%	Fuel system, filters
EV Chargers	5.0%	Network, repairs

9. Utility Rate Assumptions

9.1 Electricity Rates (\$/kWh)

Region	Rate
California	\$0.22
Texas	\$0.11
Northeast US	\$0.18
Midwest US	\$0.12
Southeast US	\$0.11
UK	\$0.35 (£0.28)
Germany	\$0.40
Australia	\$0.25

9.2 Demand Charges (\$/kW-month)

Region	Rate
California	\$25
Texas	\$15
Northeast US	\$20
Midwest US	\$12
Southeast US	\$14
UK	\$18
Germany	\$22

Australia

\$16

10. Complete Quote Calculation Flow

Step 1: Determine Pricing Tier

IF power < 50 kW → Residential
IF power 50 kW – 1 MW → Commercial
IF power > 1 MW → Utility

Step 2: Calculate Equipment Costs

BESS Cost = Battery + PCS + Transformer + Switchgear + BOS + EMS
Solar Cost = System kW × 1000 × \$/W
Generator Cost = Capacity × \$/kW × 1.25 (install)
EV Cost = Hardware + Install + Network + Make-ready
Wind Cost = Capacity × \$/kW

Total Equipment = BESS + Solar + Generator + EV + Wind

Step 3: Calculate Installation Costs

Logistics = Equipment × 8%
Import Duty = Equipment × 2%
EPC = Equipment × 25% × Regional Multiplier
Contingency = Equipment × 5%

Total Installation = Logistics + Duty + EPC + Contingency

Step 4: Calculate Total Project Cost

Gross Project Cost = Total Equipment + Total Installation
Tax Credit = Gross Cost × ITC Rate (30–50%)
Net Project Cost = Gross Cost – Tax Credit

Step 5: Calculate Financial Metrics

Annual Savings = Energy Savings + Demand Charge Reduction + Arbitrage
Payback Period = Net Project Cost / Annual Savings
ROI (10–year) = (Total Savings – Net Cost) / Net Cost × 100%
 $NPV = \sum (Cash\ Flow_t / (1 + r)^t) - Initial\ Investment$

11. Example Calculation: Car Wash (Commercial Tier)

Inputs:

- Peak Demand: 200 kW
- BESS Size: 80 kW / 320 kWh (4-hour)
- Solar: 100 kW
- Location: California

Equipment Costs:

Battery: $320 \text{ kWh} \times \$175/\text{kWh} \times 0.90 \text{ (4hr discount)} = \$50,400$
PCS: $80 \text{ kW} \times \$120/\text{kW} = \$9,600$
Transformer: $100 \text{ kVA} \times \$68/\text{kVA} = \$6,800$
Switchgear: $80 \text{ kW} \times \$30/\text{kW} = \$2,400$
BOS: $\$69,200 \times 12\% = \$8,304$
EMS: $\$15,000 + (80 \times \$10) = \$15,800$

BESS Total: \$93,304

Solar: $100 \text{ kW} \times 1000 \times \$1.05/\text{W} = \$105,000$

Total Equipment: \$198,304

Installation Costs:

Logistics: $\$198,304 \times 8\% = \$15,864$
Import Duty: $\$198,304 \times 2\% = \$3,966$
EPC: $\$198,304 \times 25\% \times 1.25 \text{ (CA)} = \$61,970$
Contingency: $\$198,304 \times 5\% = \$9,915$

Total Installation: \$91,715

Final Costs:

Gross Project Cost: $\$198,304 + \$91,715 = \$290,019$
Federal ITC (30%): $-\$87,006$
Net Project Cost: \$203,013

Financial Metrics:

Annual Savings: $\sim \$35,000$ (demand charges + TOU arbitrage)
Payback Period: $\$203,013 / \$35,000 = 5.8 \text{ years}$
10-Year ROI: $(\$350,000 - \$203,013) / \$203,013 = 72\%$

12. Data Sources

1. **NREL ATB 2024** - National Renewable Energy Laboratory Annual Technology Baseline
2. **UK EV Hub Quote** (Oct 2025) - 10 MWh BESS + EV chargers
3. **Tribal Microgrid Quote** (Nov 2025) - 100 kW BESS + 250 kW solar
4. **Hampton Heights Quote** (Oct 2025) - 1.25 MWh BESS + 2 MWp solar + generators
5. **GoGoEV Clubhouse Quote** (Oct 2025) - 418 kWh BESS + 250 kW solar
6. **Data Center Quote** (Sep 2025) - 200 MW off-grid hybrid system
7. **Train Project Quote** (Oct 2025) - 2 MWh BESS + 2 MWp solar

13. Questions for Review

1. **Pricing Accuracy:** Do these benchmarks align with your experience in the market?
2. **Tier Boundaries:** Are 50 kW and 1 MW the right thresholds for pricing tiers?
3. **Regional Adjustments:** Should we add more regions or adjust multipliers?
4. **Missing Components:** Are there any common project components we're missing?

5. **UX Simplification:** What questions confuse users most? How can we simplify?

6. **Advanced vs Basic Mode:** Should we have a "simple mode" with fewer questions for non-engineers?

Document prepared by Merlin AI - December 4, 2025 Version 1.0 - For Internal Review