FRACTAL EMS

Top Integration Mistakes: Battery Storage & Hybrid Projects

Fractal EMS Inc.

The following tools help developers and owners maximize investments in storage

PROJECT LOCATION	PROJECT MODELING	CONTROLS	MONITORING / O&M	BID OPTIMIZER	ANALYTICS
Identify locations with line capacity that have existing or forecasted volatility.	Technoeconomic tool that maximizes project value that balances CAPEX, OPEX and revenue	Vertical controls platform that includes software, controllers, and integration	Real-time human monitoring and asset management, including remote troubleshooting and system restoration	Optimize between revenue and costs, then submit offers automatically to the QSE.	Tools that identify anomalous batteries, predict equipment failures and create automated reports
1	2	3	4	5	6

DEVELOPMENT

OPERATIONS

Software Stack

PROJECT LOCATION	PROJECT MODELING	CONTROLS	MONITORING / O&M	BID OPTIMIZER	ANALYTICS
Identify locations with line capacity that have existing or forecasted volatility.	Technoeconomic tool that maximizes project value that balances CAPEX, OPEX and revenue	Vertical controls platform that includes software, controllers, and integration	Real-time human monitoring and asset management, including remote troubleshooting and system restoration	Optimize between revenue and costs, then submit offers automatically to the QSE.	Tools that identify anomalous batteries, predict equipment failures and create automated reports
1	2	3	4	5	6
BatterySIMM BatteryOS PowerDev	Fractal Model Ascend Analytics	Fractal EMS Wartsila GEMS Fluence FlexGen	Fractal O&M NAES CAMS Pierce	Fractal Optimizer Autobidder Tenaska CES Habitat	Fractal Reports Twaice Voltaiq Accure

DEVELOPMENT | **OPERATIONS**

15% IRR: Key Data

1. CAPEX:

- 100 MW / 400 MWh → $100 million
- Battery enclosures + inverters + MV transformer → $125 - $230/kWh
- EPC: (100 + 400) * $40,000 = $20 million
- Substation, dev costs, land

2. OPEX:

- $10,000/yr * MWh: $10,000 * 400 = $4M/yr
- Augmentations, maintenance, warranties, performance guarantees, trading services, insurance, remote O&M, EMS

3. Revenue:

- $200/kW/yr
- ERCOT merchant revenue: $36 - $156/kW/yr

4. Availability:

- 95% BOL, then 98%

5. Mistakes:

- EPC is late: $1 million per month

1. Location / Procurement:

- Nodal vs hub volatility
- Self-integration vs traditional integrator

2. Availability:

- Causes of downtime
- 95% vs 98%

3. Warranty Optimization:

- Sizing (MW / MWh) and augmentations
- Business model / revenue stack (365 cycles/yr vs reality)

4. Long-term Health:

- Prolong the lifetime
- Avoid fires

5. Bid Optimization:

- Market revenue: Baseline vs reality (70%-90% of perfect)
- Rent vs Buy

1. Location / Procurement: +$200M (10.7%)

- Nodal vs hub volatility
- Self-integration vs traditional integrator

2. Availability:

- Causes of downtime
- 95% vs 98%

3. Warranty Optimization:

- Sizing (MW / MWh) and augmentations
- Business model / revenue stack (365 cycles/yr vs reality)

4. Long-term Health:

- Prolong the lifetime
- Avoid fires

5. Bid Optimization:

- Market revenue: Baseline vs reality (70%-90% of perfect)
- Rent vs Buy

1. Location / Procurement: +$200M (10.7%) / -$35M (3.4%)

- Nodal vs hub volatility
- Self-integration vs traditional integrator

2. Availability:

- Causes of downtime
- 95% vs 98%

3. Warranty Optimization:

- Sizing (MW / MWh) and augmentations
- Business model / revenue stack (365 cycles/yr vs reality)

4. Long-term Health:

- Prolong the lifetime
- Avoid fires

5. Bid Optimization:

- Market revenue: Baseline vs reality (70%-90% of perfect)
- Rent vs Buy

1. Location / Procurement: +$200M (10.7%) / -$35M (3.4%)

- Nodal vs hub volatility
- Self-integration vs traditional integrator

2. Availability: -$24M (1.4%)

- Causes of downtime
- 95% vs 98%

3. Warranty Optimization:

- Sizing (MW / MWh) and augmentations
- Business model / revenue stack (365 cycles/yr vs reality)

4. Long-term Health:

- Prolong the lifetime
- Avoid fires

5. Bid Optimization:

- Market revenue: Baseline vs reality (70%-90% of perfect)
- Rent vs Buy

1. Location / Procurement: +$200M (10.7%) / -$35M (3.4%)

- Nodal vs hub volatility
- Self-integration vs traditional integrator

2. Availability: -$24M (1.4%)

- Causes of downtime
- 95% vs 98%

3. Warranty Optimization: -$23M (1.3%)

- Sizing (MW / MWh) and augmentations
- Business model / revenue stack (365 cycles/yr vs reality)

4. Long-term Health:

- Prolong the lifetime
- Avoid fires

5. Bid Optimization:

- Market revenue: Baseline vs reality (70%-90% of perfect)
- Rent vs Buy

1. Location / Procurement: +$200M (10.7%) / -$35M (3.4%)

- Nodal vs hub volatility
- Self-integration vs traditional integrator

2. Availability: -$24M (1.4%)

- Causes of downtime
- 95% vs 98%

3. Warranty Optimization: -$23M (1.3%)

- Sizing (MW / MWh) and augmentations
- Business model / revenue stack (365 cycles/yr vs reality)

4. Long-term Health: +$19M (0.6%)

- Prolong the lifetime
- Avoid fires

5. Bid Optimization:

- Market revenue: Baseline vs reality (70%-90% of perfect)
- Rent vs Buy

1. Location / Procurement: +$200M (10.7%) / -$35M (3.4%)

- Nodal vs hub volatility
- Self-integration vs traditional integrator

2. Availability: -$24M (1.4%)

- Causes of downtime
- 95% vs 98%

3. Warranty Optimization: -$23M (1.3%)

- Sizing (MW / MWh) and augmentations
- Business model / revenue stack (365 cycles/yr vs reality)

4. Long-term Health: +$19M (0.6%)

- Prolong the lifetime
- Avoid fires

5. Bid Optimization: +$22M (1.3%) / -$28M (1.6%)

- Market revenue: Baseline vs reality (70%-90% of perfect)
- Rent vs Buy

1. Location / Procurement: +$200M (10.7%) / -$35M (3.4%)

- Nodal vs hub volatility
- Self-integration vs traditional integrator

2. Availability: -$24M (1.4%)

- Causes of downtime
- 95% vs 98%

3. Warranty Optimization: -$23M (1.3%)

- Sizing (MW / MWh) and augmentations
- Business model / revenue stack (365 cycles/yr vs reality)

Pre-COD

4. Long-term Health: +$19M (0.6%)

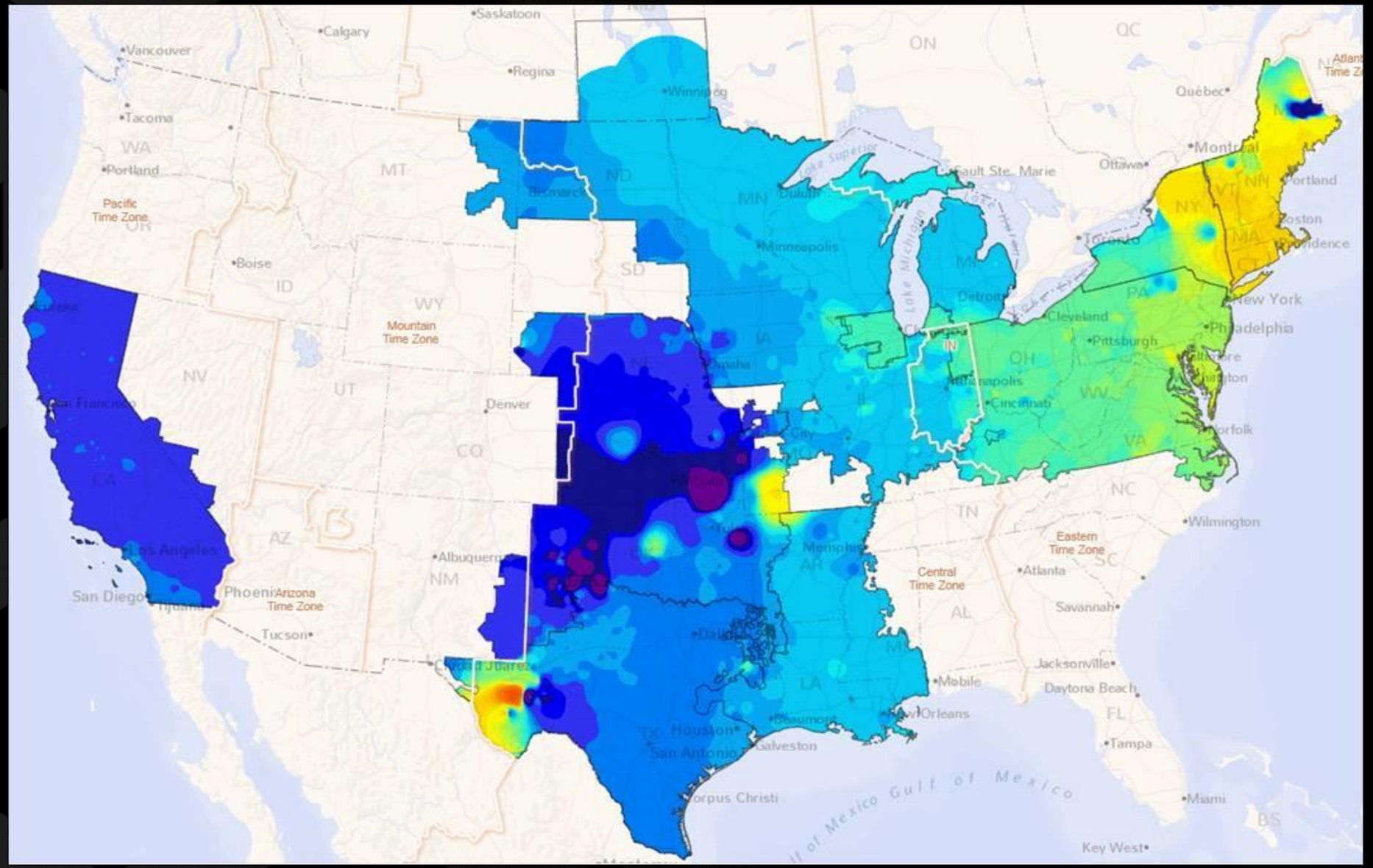
- Prolong the lifetime
- Avoid fires

5. Bid Optimization: +$22M (1.3%) / -$28M (1.6%)

- Market revenue: Baseline vs reality (70%-90% of perfect)
- Rent vs Buy

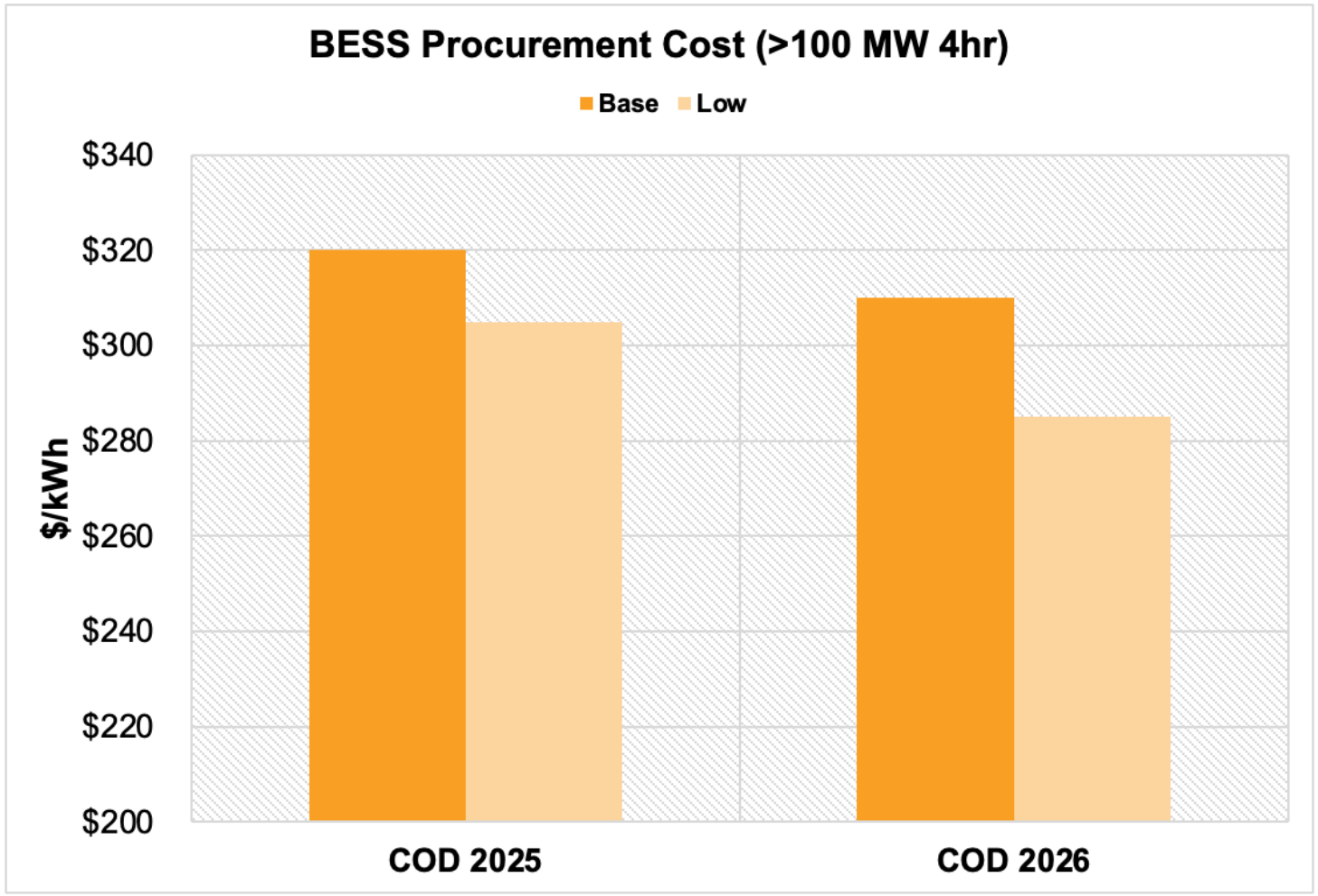
Post-COD

1. Location +$200M (10.7%)



https://www.energyacuity.com/blog/lmp-mapping-with-energy-acuity/

1. Procurement -$35M (3.4%)



Feb 2023 $500,000 RMB per Ton LCE
Today $105,000 RMB per Ton LCE.

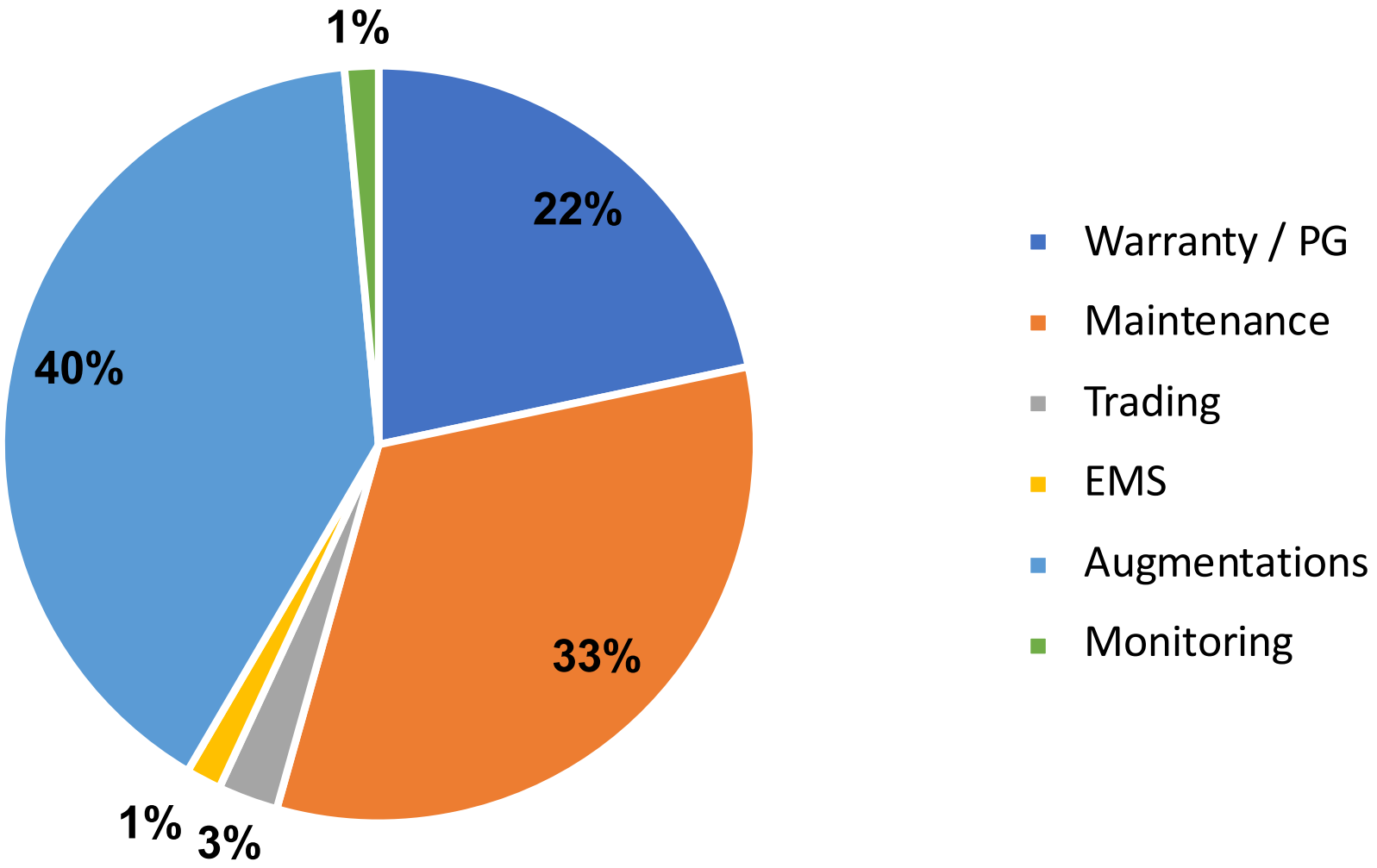
- Self Integration: $260/kWh
- Traditional Integrator: $305/kWh

- Self Integration:
  - $130/kWh battery containers (50%)
  - Substation + Inverter cost of (25%)
  - EPC + BOP cost of (25%)
  - Total: $260/kWh

- OPEX
  - Self Integration: $10,000 * MWh
  - Trad Integration: $12,000 * MWh

Total BESS OPEX ~$120/kWh

- 20-year present value terms discounted at 5% annually
- Augmentations and LTSA costs form the largest percentage of total costs
- Full OPEX cost may not be represented in pricing



2. Availability -$24M (1.4%)

Internet

Most internet is only 98% available, some offer 99% SLA's, but it's often difficult to find reliable internet in remote locations → mitigate by using several sources (e.g., two land lines and two cell modems)

Inverters

Inverters are one of the lowest cost components, but they cause an outsized amount of site downtime. Paying for higher quality inverters or having a large spare parts inventory will pay dividends.

Thermal Management

Thermal management works well…until it doesn't. Adjusting an air cooled system can delay COD, while replacing proprietary liquid cooled equipment will be a risk.

Fire System

Many fire systems have accidentally discharged. This has resulted in lost equipment and has caused sites to lose revenue.

EMS / Batteries

These are lower risks, but can be painful to repair.

2. Availability -$24M (1.4%)

Internet

Most internet is only 98% available, some offer 99% SLA's, but it's often difficult to find reliable internet in remote locations → mitigate by using several sources (e.g., two land lines and two cell modems)

Inverters

Inverters are one of the lowest cost components, but they cause an outsized amount of site downtime. Paying for higher quality inverters or having a large spare parts inventory will pay dividends.

90%

Thermal Management

Thermal management works well…until it doesn't. Adjusting an air cooled system can delay COD, while replacing proprietary liquid cooled equipment will be a risk.

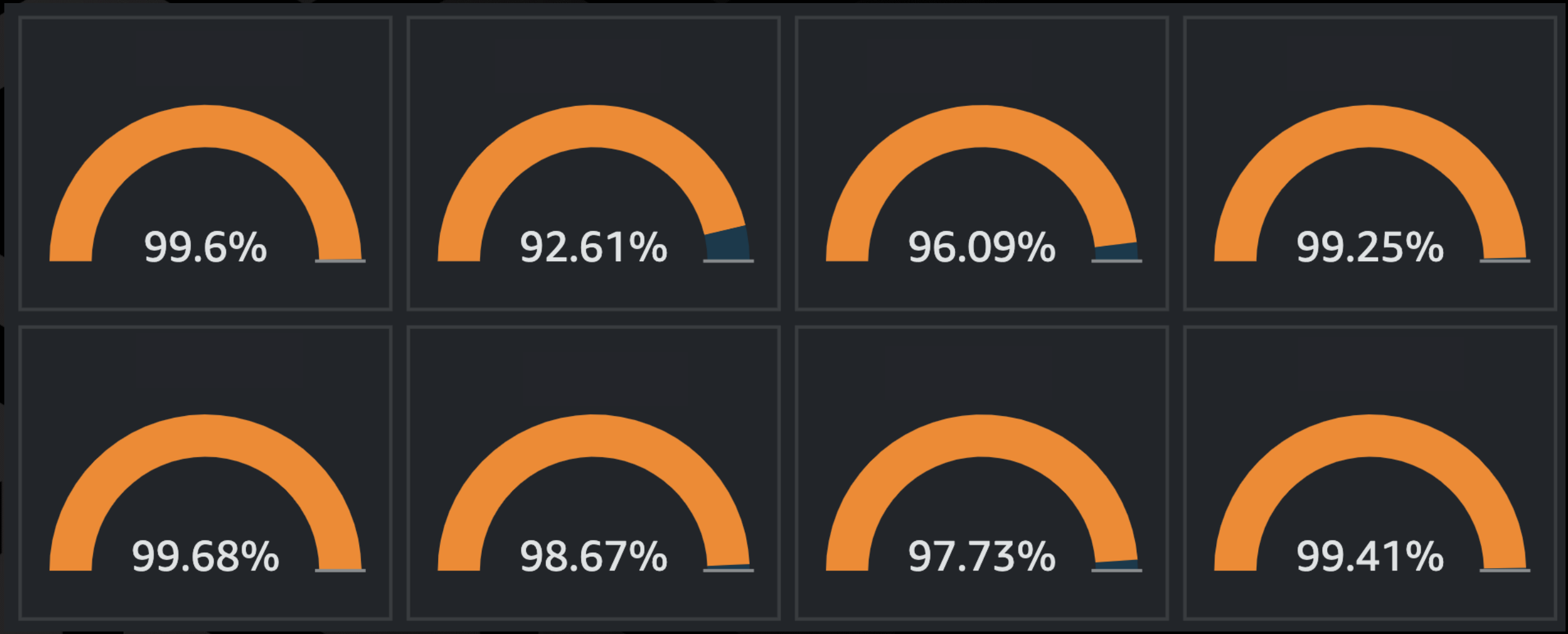
Fire System

Many fire systems have accidentally discharged. This has resulted in lost equipment and has caused sites to lose revenue.

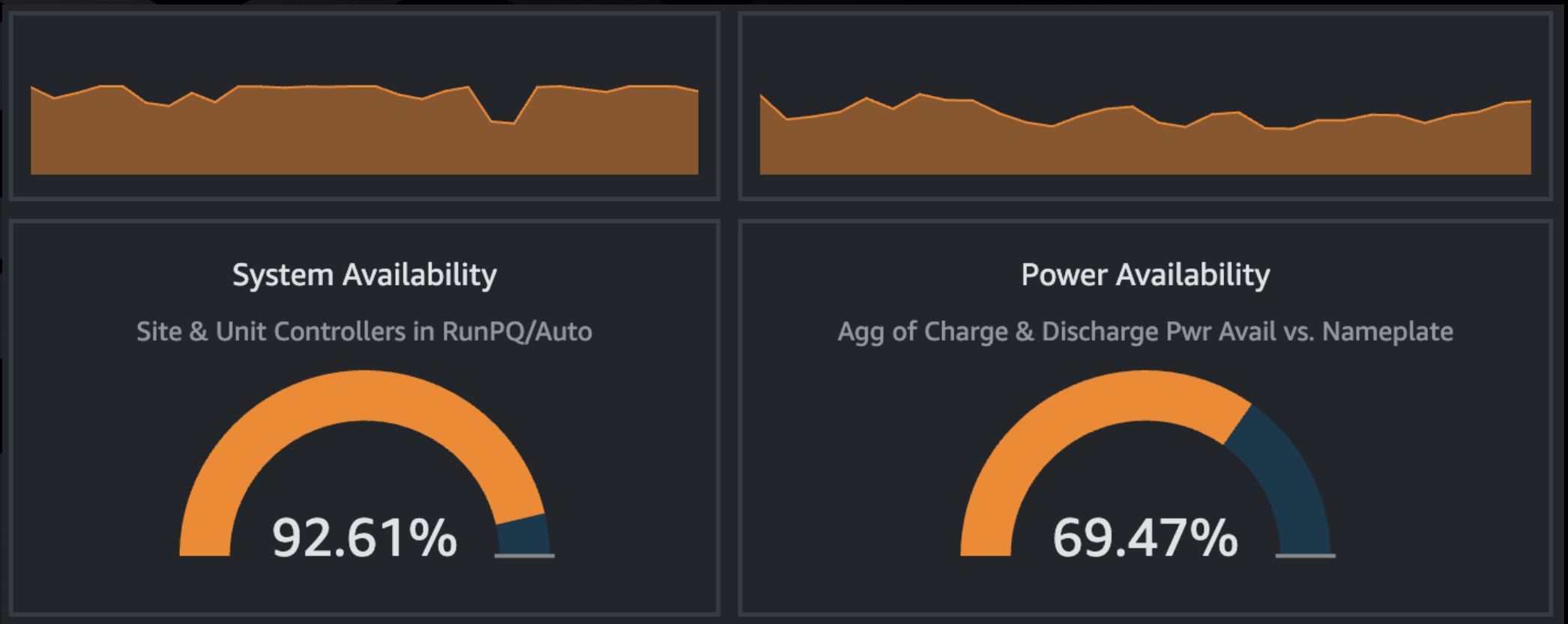
EMS / Batteries

These are lower risks, but can be painful to repair.

2. Availability -$24M (1.4%)

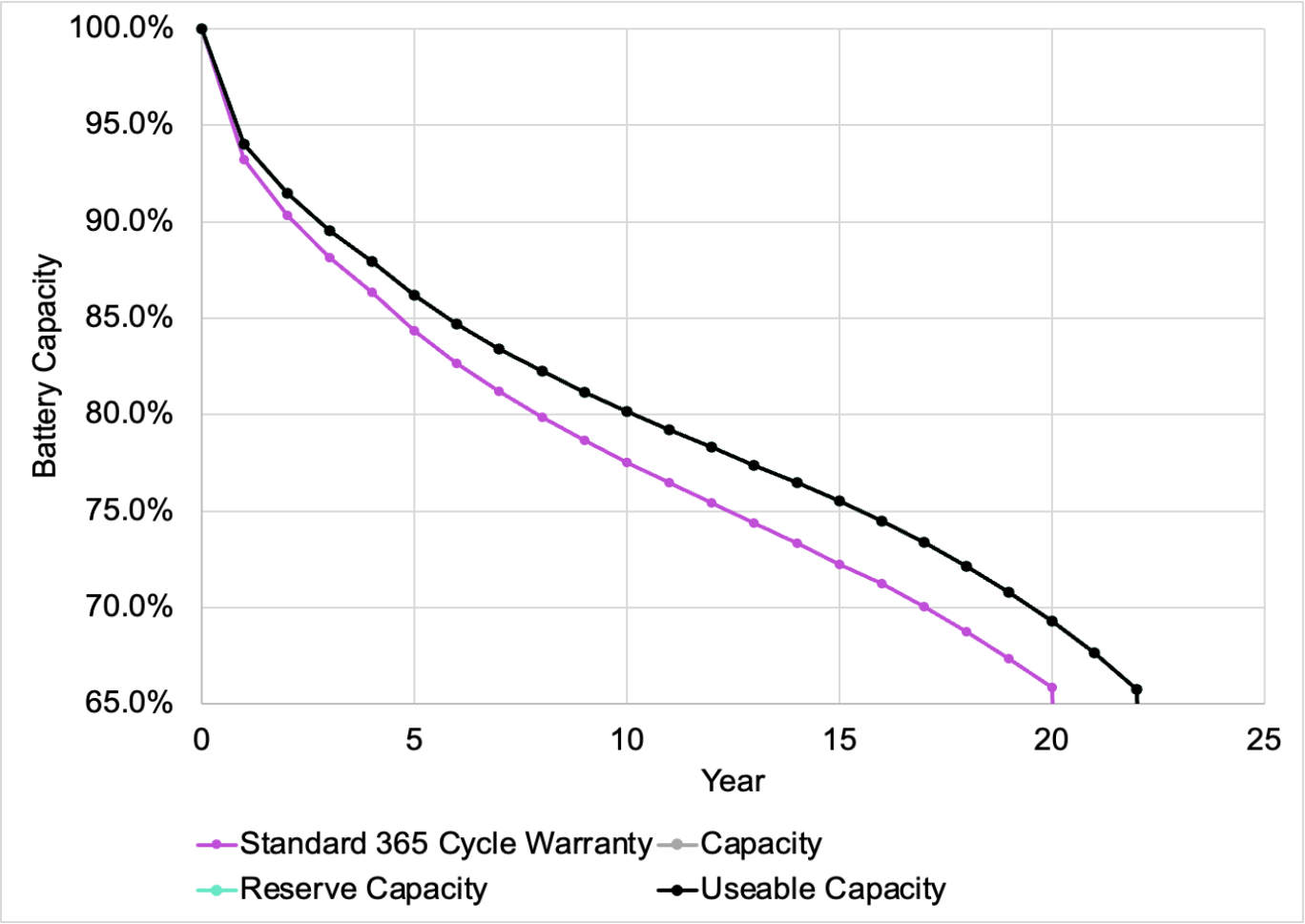


2. Availability -$24M (1.4%)



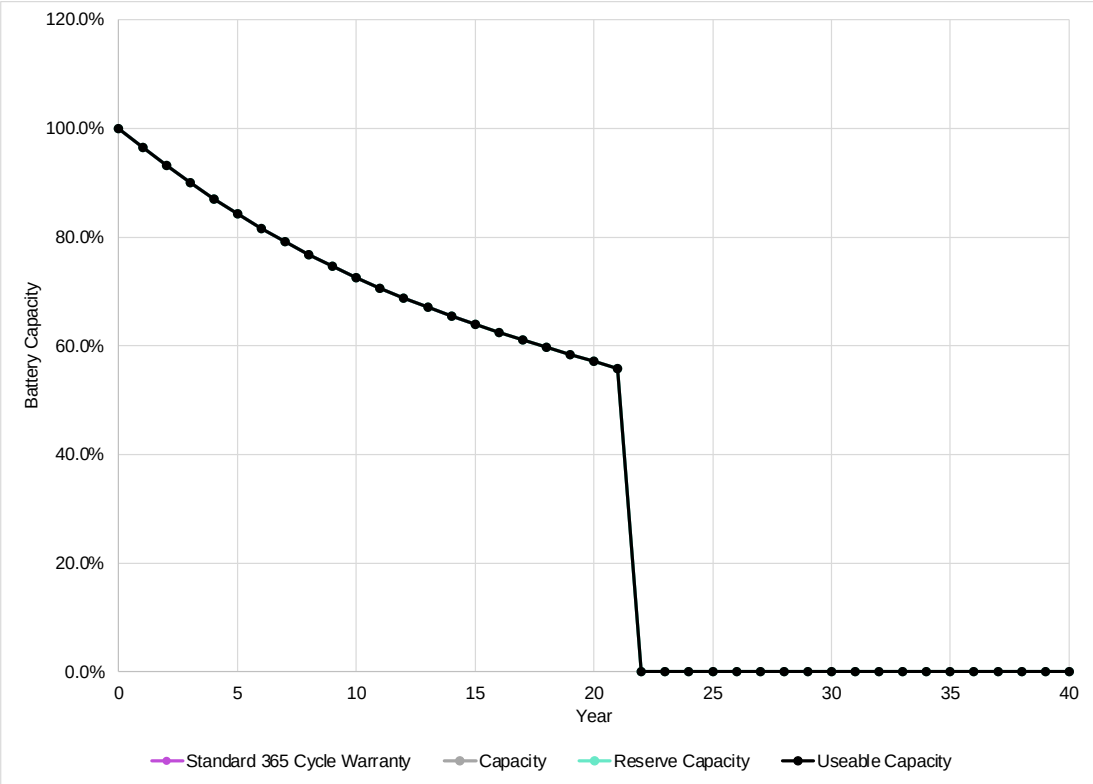
25% more expensive inverters and thermal management → 99% Availability → **365 cycles** per year → 15.2% IRR

25% more expensive inverters and thermal management → 99% Availability → **300 cycles** per year → 16.5% IRR

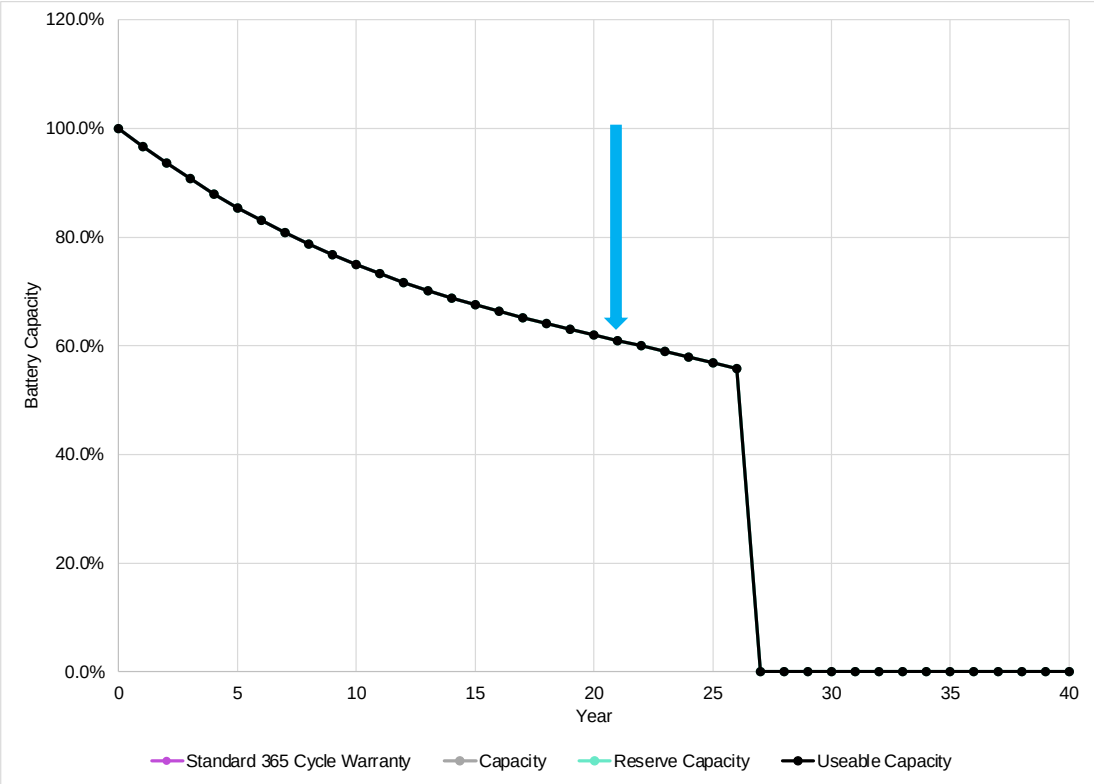


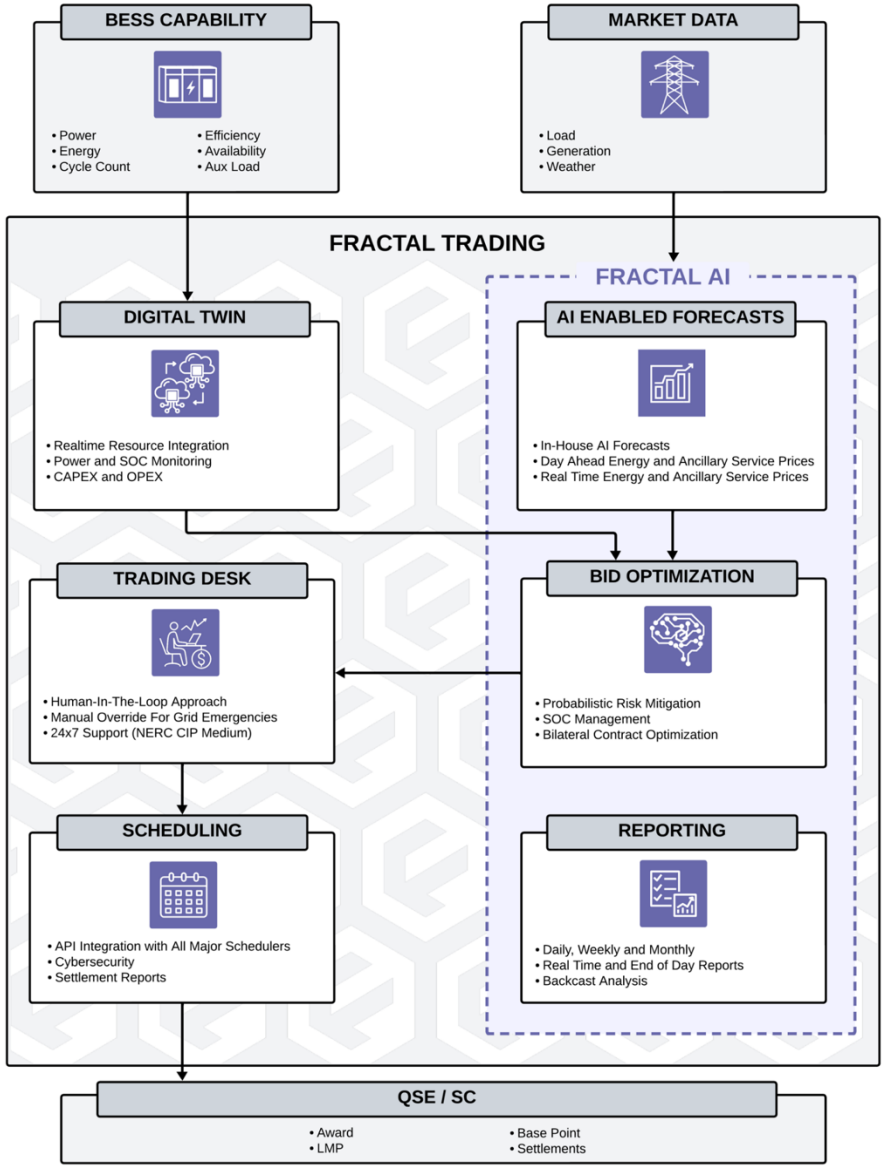
4. Prolong Health +$19M (0.6%)

25% more expensive inverters and thermal management → 99% Availability → 300 cycles per year → **50% rSOC** → 21 yr → 16.1% IRR



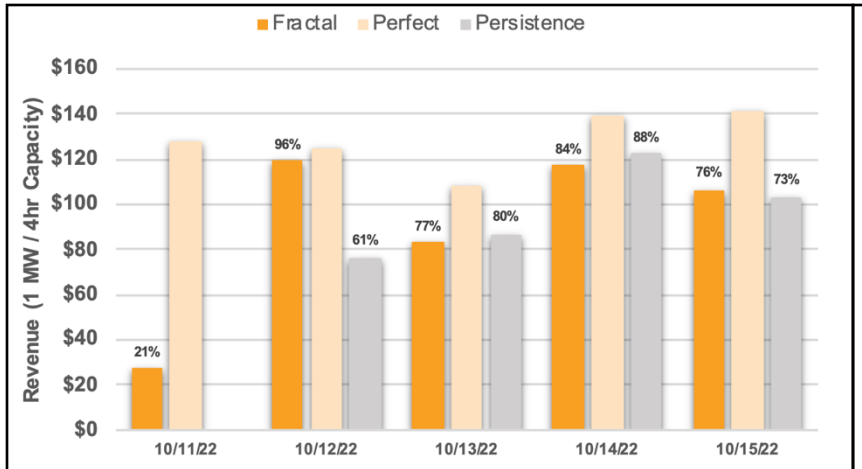
25% more expensive inverters and thermal management → 99% Availability → 300 cycles per year → **25% rSOC** → 26 yr → 16.7% IRR



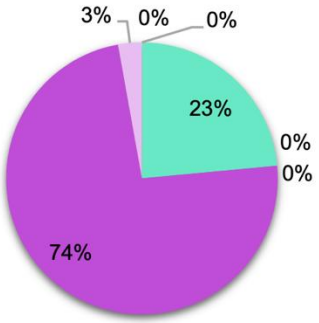


Service or Deliverable	Daily	Monthly	Quarterly
Dedicated Analyst / POC	✓		
Day Ahead and Real Time Energy and Ancillary Service Price Forecasts	✓		
Bid Optimization Using Fractal Optimizer	✓		
Offer Curve Submission to QSE/SC	✓		
Detailed Performance and Benchmarking Report		✓	
ISO/RTO Settlements Review		✓	
Digital Twin Calibration			✓

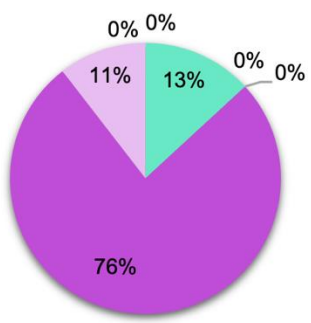
Inconsistent Forecasts



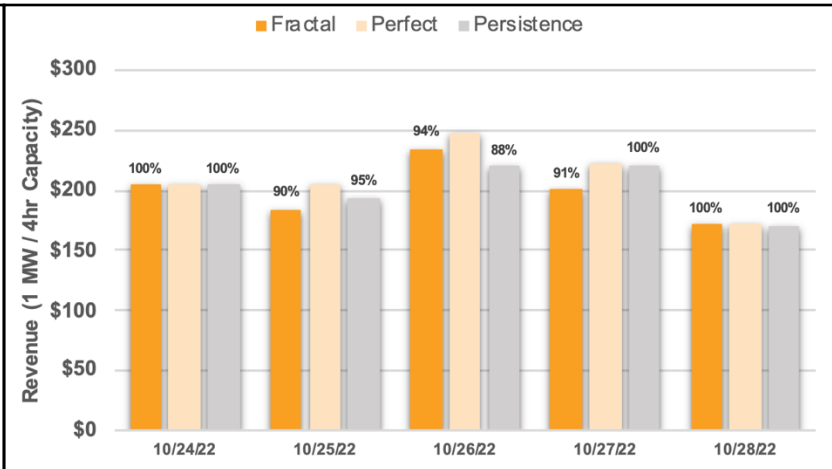
Optimized Daily Revenue: Oct 11, 2022 - Oct 15, 2022



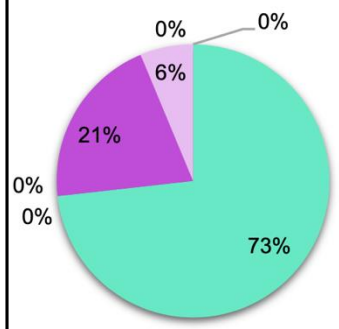
Fractal



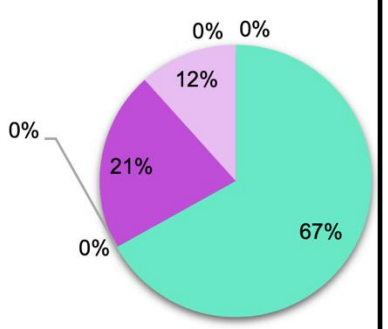
Perfect



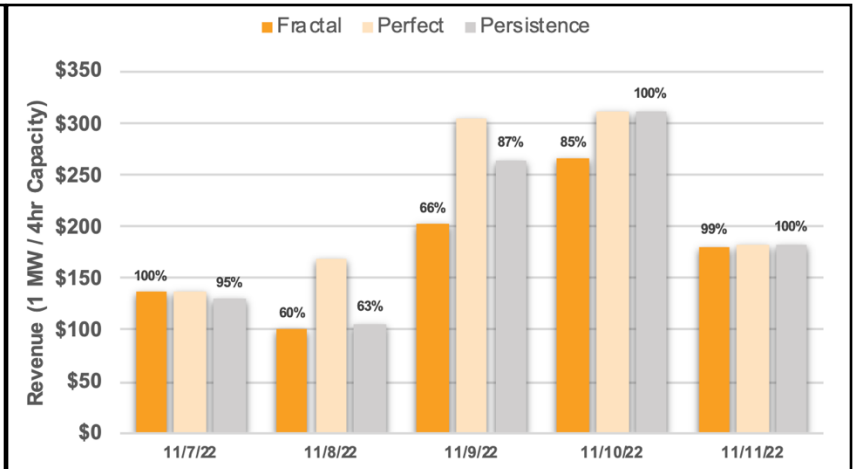
Optimized Daily Revenue: Oct 24, 2022 - Oct 28, 2022



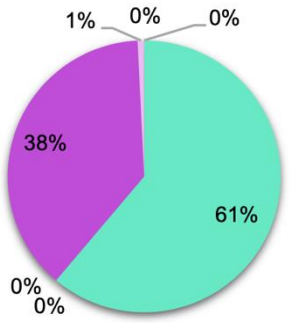
Fractal



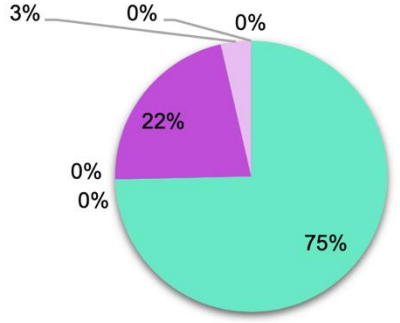
Perfect



Optimized Daily Revenue: Nov 07, 2022 - Nov 11, 2022



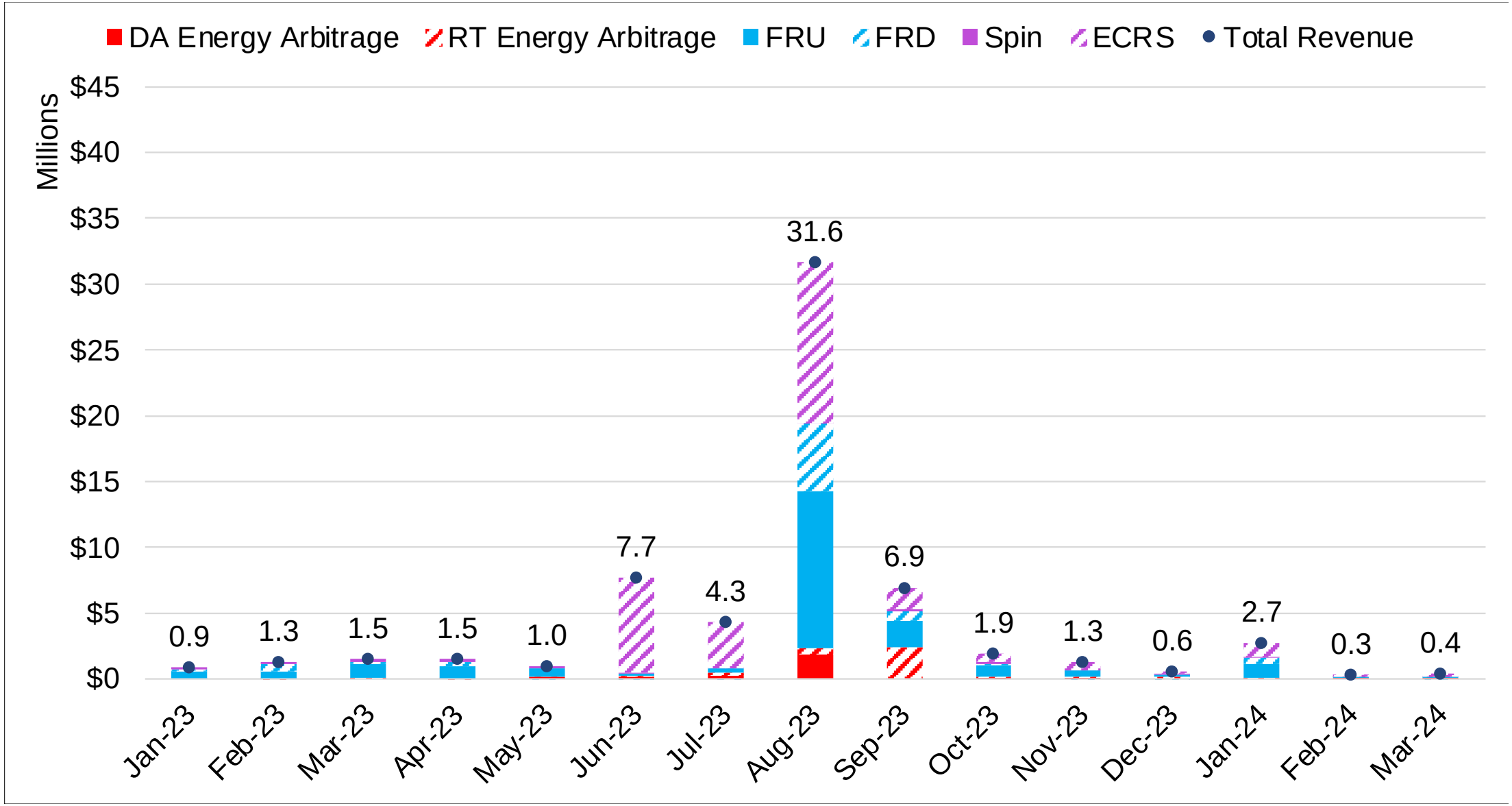
Fractal



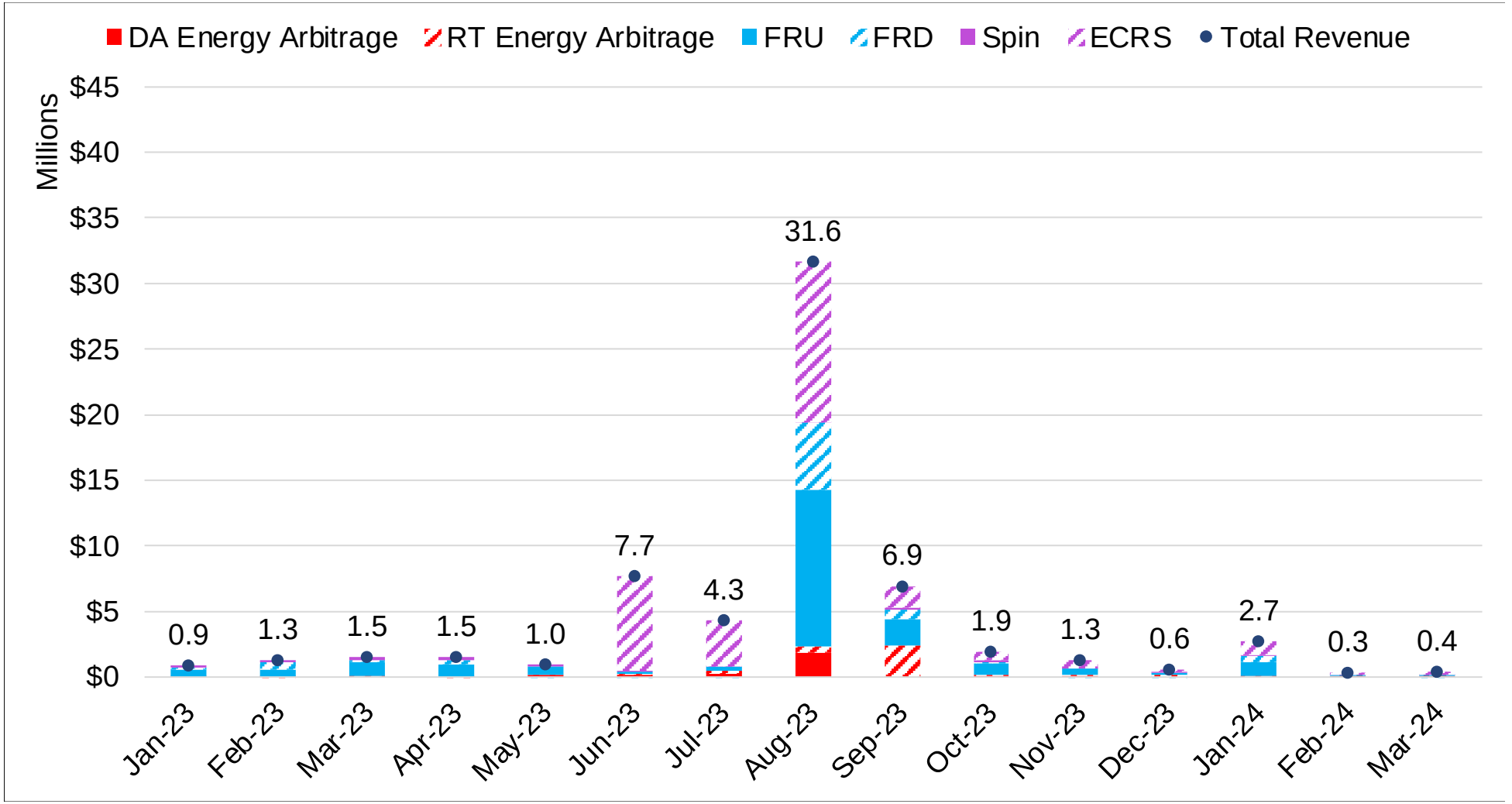
Perfect

Energy **Reg Up** **Reg Dn**

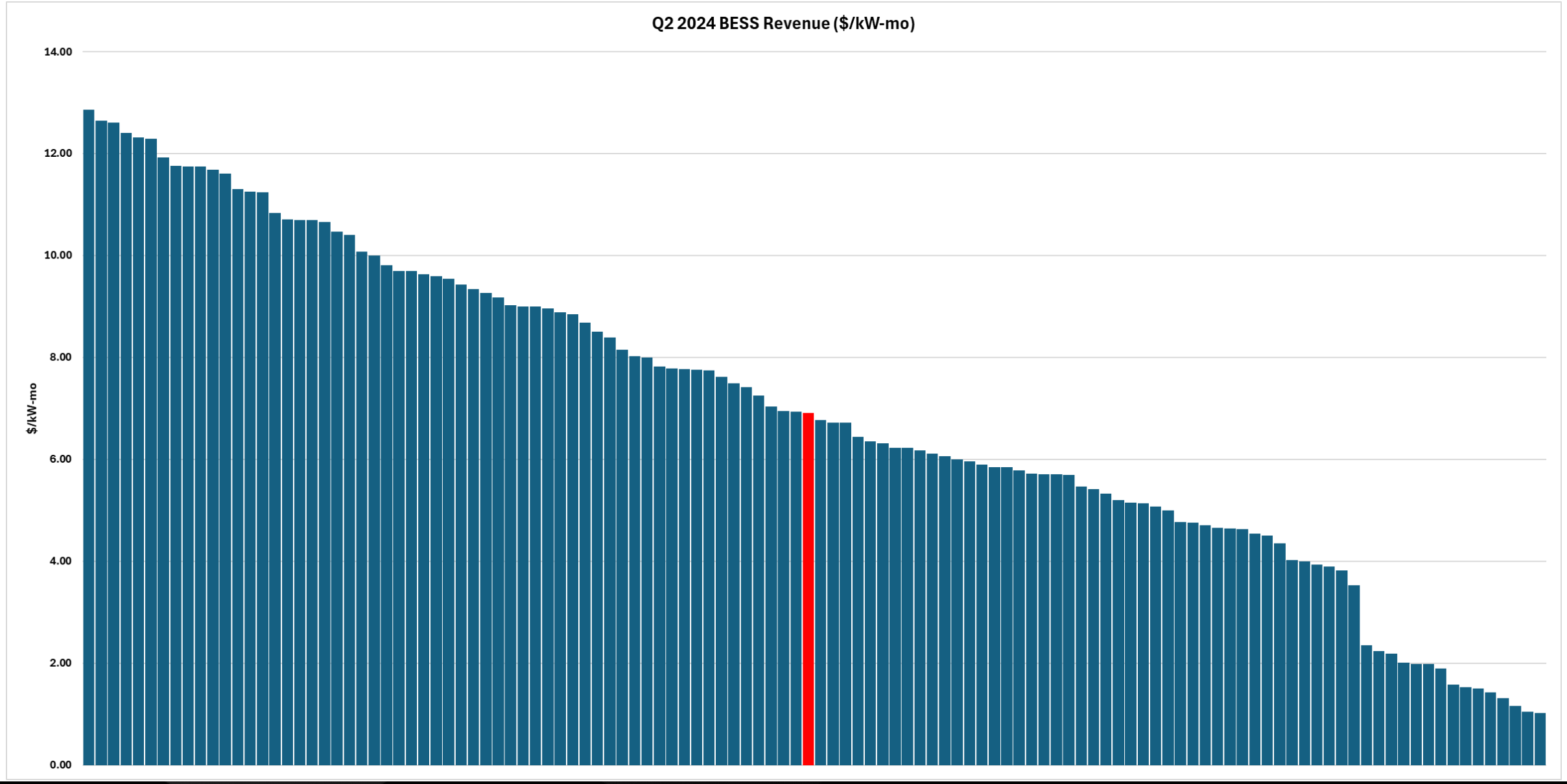
5. Bid Optimization +$22M (1.3%) / -$28M (1.6%)



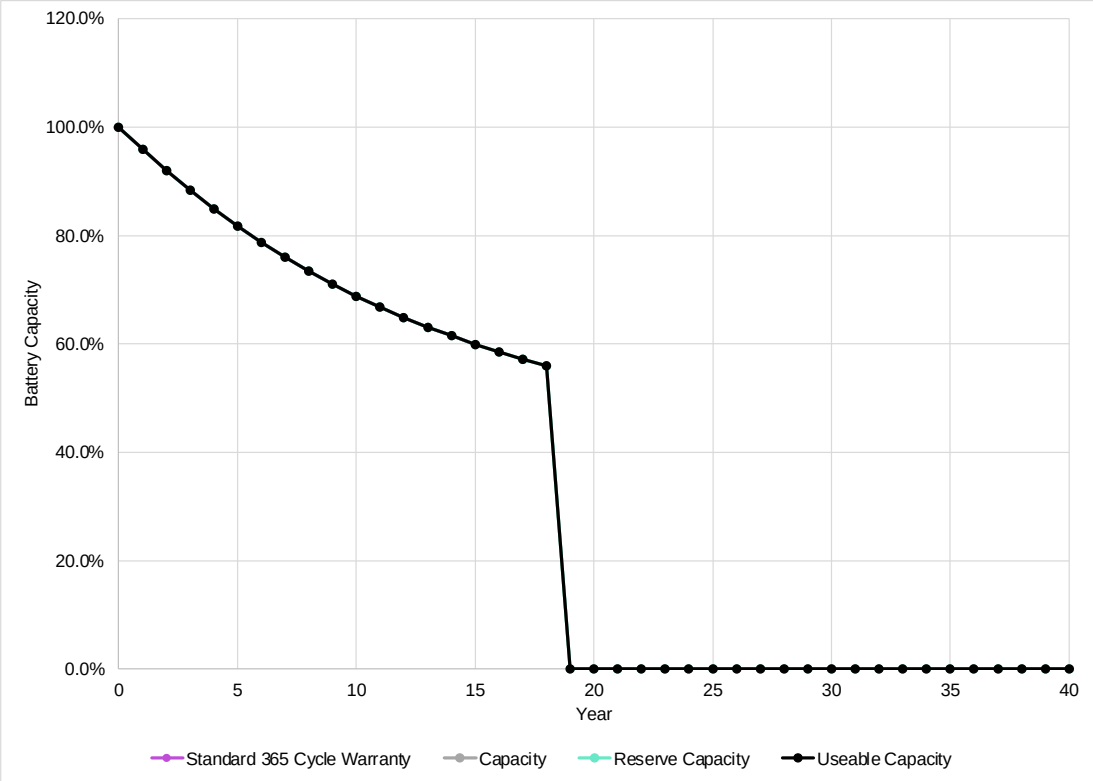
5. Bid Optimization +$22M (1.3%) / -$28M (1.6%)



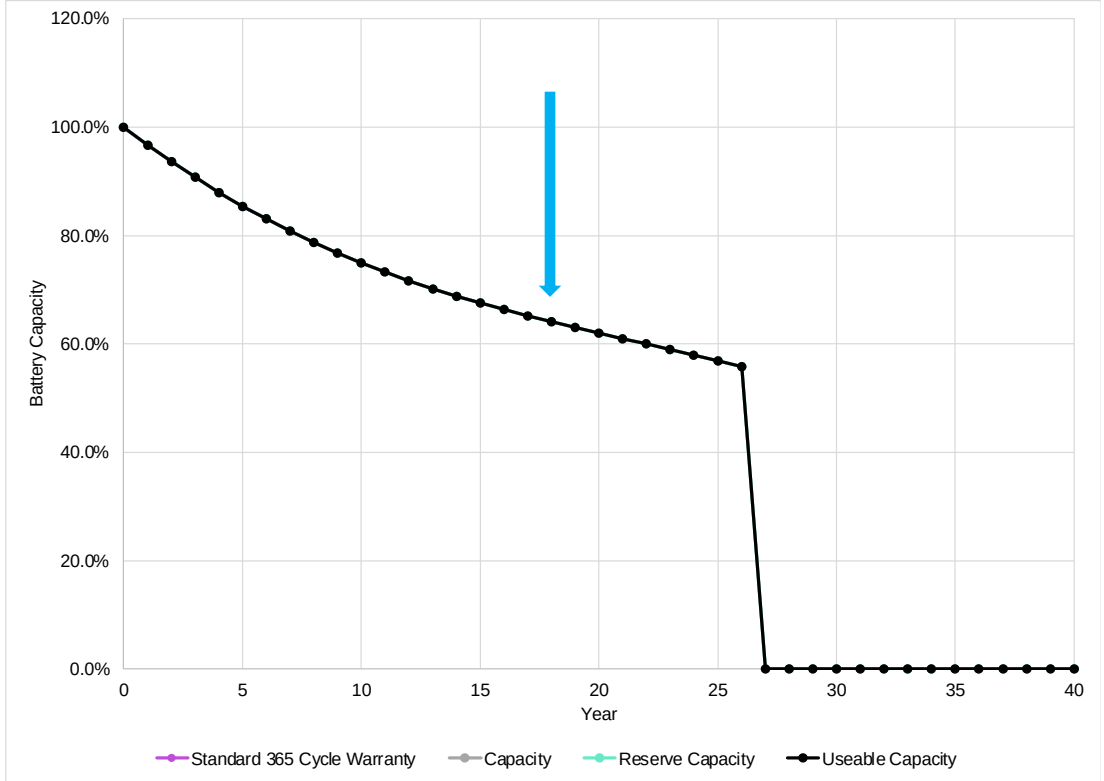
Month	Percent of Annual Revenue
Jan-23	1.4%
Feb-23	2.0%
Mar-23	2.4%
Apr-23	2.4%
May-23	1.5%
Jun-23	12.0%
Jul-23	6.7%
Aug-23	49.5%
Sep-23	10.8%
Oct-23	3.0%
Nov-23	2.0%
Dec-23	0.9%


Q2 2024 BESS Revenue ($/kW-mo)
$/kW-mo
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00

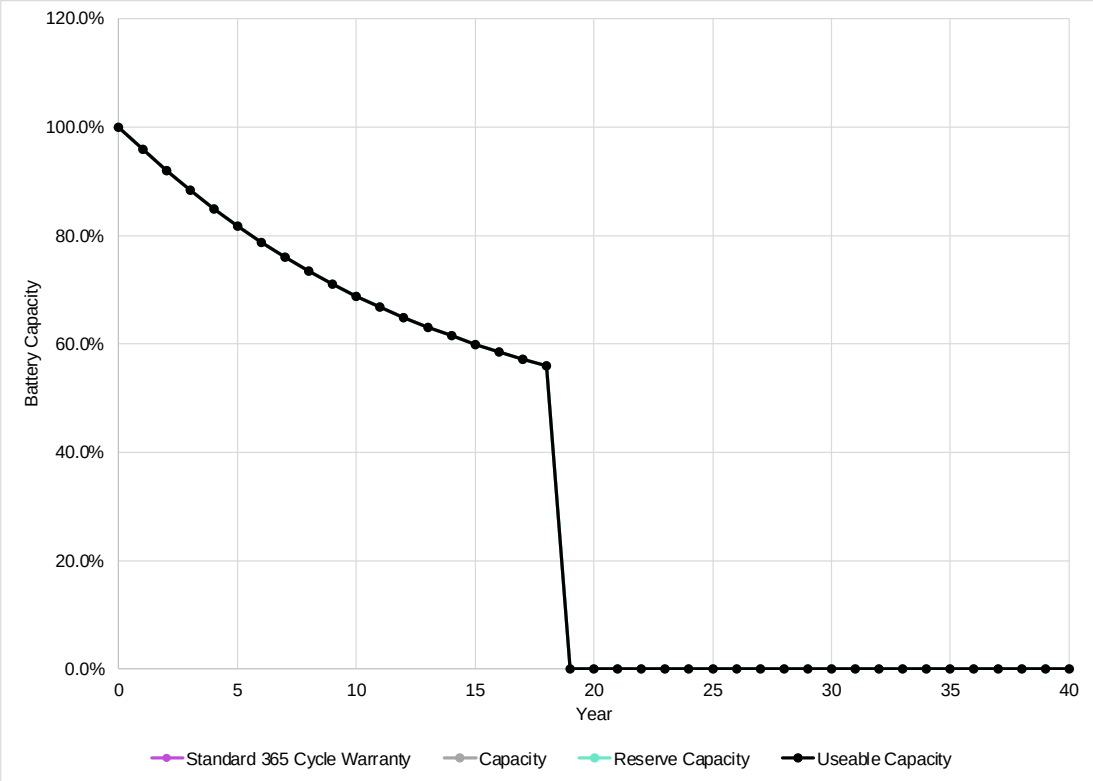
Cheap inverters and thermal management → 95% Availability → 365 cycles per year → 99% perfect, 1% fee → 50% rSOC → 18 yr → 14.4% IRR



25% more expensive inverters and thermal management → 99% Availability → 300 cycles per year → 98% perfect, 0.5% fee → 25% rSOC → 26 yr → volatile node→ **18.3% IRR**

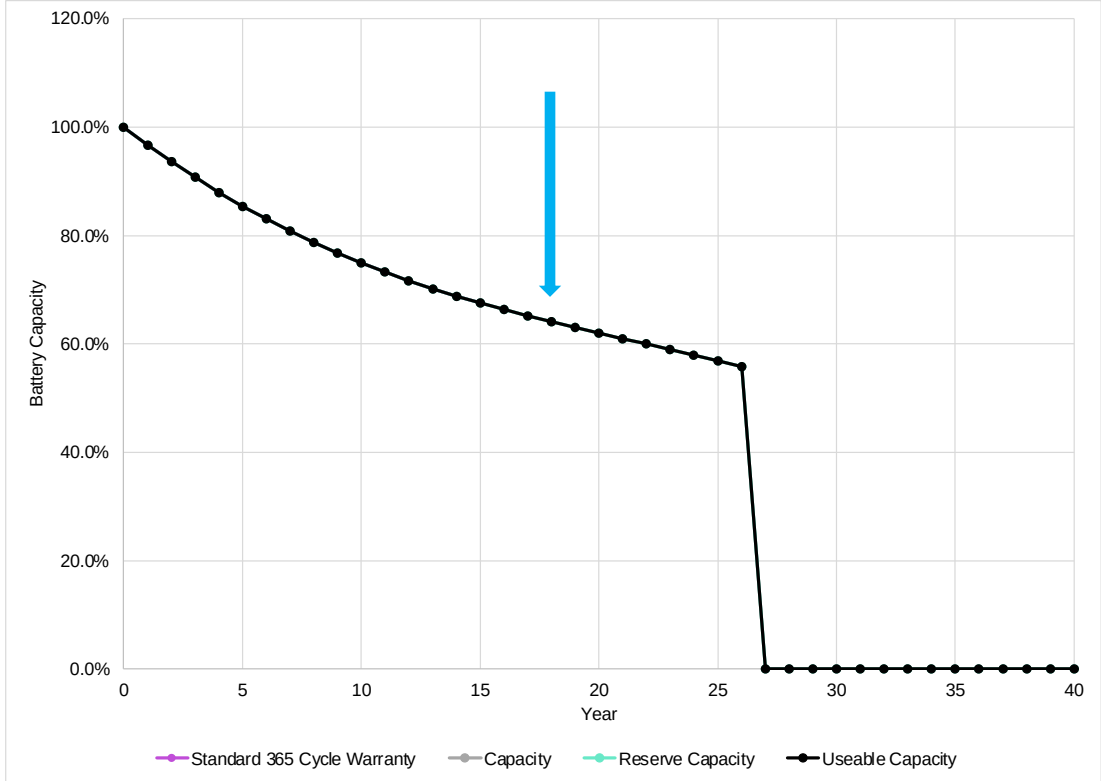


Cheap inverters and thermal management → 95% Availability → 365 cycles per year → 99% perfect, 1% fee → 50% rSOC → 18 yr → 14.4% IRR



Traditional Integrator: 11.0%

25% more expensive inverters and thermal management → 99% Availability → 300 cycles per year → 98% perfect, 0.5% fee → 25% rSOC → 26 yr → volatile node→ **18.3% IRR**



Traditional Integrator: 14.9%

Bonus: Integration Issues

1. Sequence of events
    1. Procurement
    2. Delivery
    3. Installation
    4. Energization
    5. Integration
    6. Site testing
    7. Offsite telemetry
    8. Fire system testing
    9. System Operator testing
    10. Ancillary services qualification
2. Troubleshooting equipment
3. Troubleshooting communications
4. Cybersecurity
5. Operations

1. Location / Procurement: +$200M (10.7%) / -$35M (3.4%)

- Find a volatile location
- Self-integrate and save millions

2. Availability: -$24M (1.4%)

- Spend more on inverters
- Procure premium EMS and remote O&M

3. Warranty Optimization: -$23M (1.3%)

- Use a financial model to establish the business model
- Don’t buy vendor warranties (if you can afford it)

4. Long-term Health: +$19M (0.6%)

- Pay attention to average SOC and C-rates
- Find weak cells

5. Bid Optimization: +$22M (1.3%) / -$28M (1.6%)

- Market revenue: Baseline vs reality (70%-90% of perfect)
- Rent vs Buy

CONTACT US

Daniel Crotzer
Chief Executive Officer
Mobile: 512-574-3113
Office: 512-366-8132
Email: Daniel@FractalEMS.com

Fractal EMS Inc.
8656 W Hwy 71
Bldg F Ste 100
Austin, TX 78735
https://www.FractalEMS.com
https://www.FractalModel.com

Bonus: 95% vs 99% Availability (+0.4%)

Cheap inverters and cheap thermal management → 95% Availability → 15.7% IRR

Battery hard cost	**$125,755,154**	**314.39**	**$/kWh**
Dev Fee	$0	**0.00**	$/kW
Total capitalized ITC eligible costs	**$125,755,154**	**314.39**	**$/kWh**
Network Upgrades, not ITC eligible	$0	**-**	$/kW
Battery soft cost, not ITC eligible	$1,000,000	**10.00**	$/kW
Total battery cost	**$126,755,154**	**316.89**	**$/kWh**

25% more expensive inverters and thermal management (1.5% CAPEX) → 99% Availability → **16.1% IRR**

Battery hard cost	**$127,680,379**	**319.20**	**$/kWh**
Dev Fee	$0	**0.00**	$/kW
Total capitalized ITC eligible costs	**$127,680,379**	**319.20**	**$/kWh**
Network Upgrades, not ITC eligible	$0	**-**	$/kW
Battery soft cost, not ITC eligible	$1,000,000	**10.00**	$/kW
Total battery cost	**$128,680,379**	**321.70**	**$/kWh**

Payback: 2.5 years

Bonus: 95% vs 99% Availability (+0.4%)

Cheap inverters and cheap thermal management → 95% Availability → 15.7% IRR

Battery hard cost	**$125,755,154**	**314.39**	**$/kWh**
Dev Fee	$0	**0.00**	$/kW
Total capitalized ITC eligible costs	**$125,755,154**	**314.39**	**$/kWh**
Network Upgrades, not ITC eligible	$0	**-**	$/kW
Battery soft cost, not ITC eligible	$1,000,000	**10.00**	$/kW
Total battery cost	**$126,755,154**	**316.89**	**$/kWh**

25% more expensive inverters and thermal management (1.5% CAPEX) → 99% Availability → 16.1% IRR

Battery hard cost	**$127,680,379**	**319.20**	**$/kWh**
Dev Fee	$0	**0.00**	$/kW
Total capitalized ITC eligible costs	**$127,680,379**	**319.20**	**$/kWh**
Network Upgrades, not ITC eligible	$0	**-**	$/kW
Battery soft cost, not ITC eligible	$1,000,000	**10.00**	$/kW
Total battery cost	**$128,680,379**	**321.70**	**$/kWh**

Availability Performance Guarantee @ 1.3%/yr of equipment → 98% Availability → 14.3% IRR (-1.4%)

Description	Fractal	Optional	EPC / 3rd Party / Customer
HMI - Local	X		
HMI - Cloud	X		
Historian	X		
Main Network Switch	X		
Fire Wall /VPN / ISP	X		
Site Controller	X		
Unit Controller	X		
Unit Network Switches	X		
Unit Controller Enclosure	X		
Server Rack	X		
Weather housing for Server Rack / Site Equipment (NEMA 3R)		X	X
RTAC for BESS	X		
Unit Controller Power Supply	X		
Site Controller Power Supply	X		
Site Controller UPS	X		
Unit Controller UPS		X	X
60% - Drawing Set (EMS and Comms)	X		
90% - Drawing Set (EMS and Comms)	X		
IFC - Drawing Set (EMS and Comms)	X		
Control Narrative	X		
IP Schema	X		
Points List - Consolidated	X		
Points List - Individual Components			X
Communication Flow / Network Comms Diagram	X		
Provide EMS PSSE / PSCAD Models	X		
PSSE / PSCAD Study			X
Utility / ISO Interface using RTAC	X		X
Balance of Plant - Design			X
Balance of Plant - Breaker Control			X
Balance of Plant - Transformer / POI Overload Protection			X
Balance of Plant - Metering			X
Balance of Plant - Capacitor Banks			X
Non-Storage Generation design			X
Site controller / server rack patch panel		X	X
Unit controller patch panel		X	X

Bonus: EPC/EMS DOR Issues

1. Commissioning documentation and execution of site level testing
2. Firewall scope including ISP design, designation, and implementation
3. Utility or system operator integration
4. Substation RTAC / RTU programming
5. Gathering of points list and defining of site IP schema and control narrative (e.g., who is providing and responsible for these deliverables)
6. External communication connections of equipment external to EMS field network and site network (e.g., to the BESS / PCS / Substation devices)
7. Fiber design including splicing and termination details
8. Fiber patch panels and patch cables
9. Field splicing and terminations
10. Mounting / securing of EMS equipment
11. Running of power / receptacles to EMS field equipment
12. Power to EMS rack / site equipment including UPS / battery backup