PVOperations & Maintenance
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Introduction to the Energy Accounting Workgroup

PVPMC 2026

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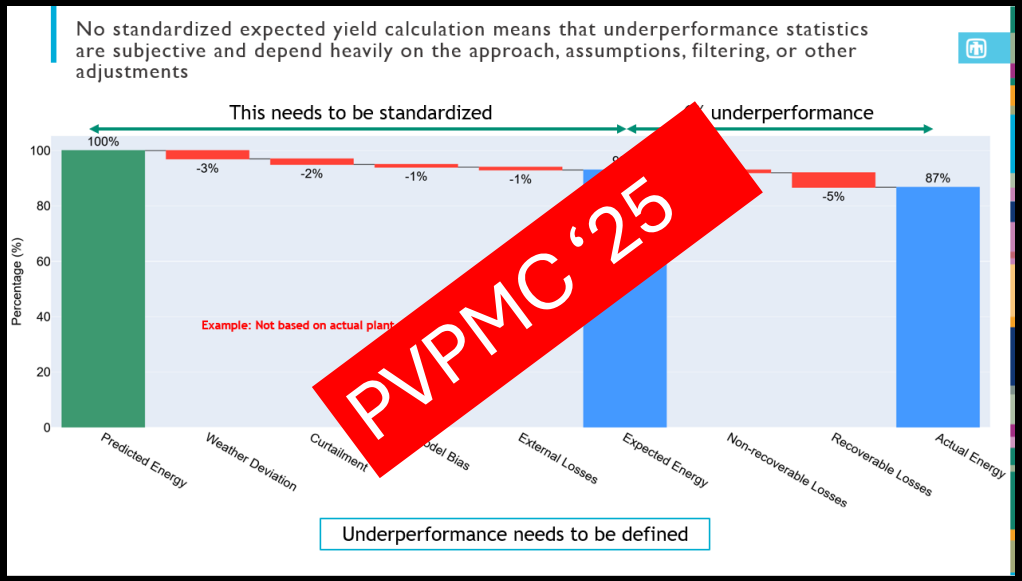
Contributor

The Problem:

No Standard to Account for Underperformance



Energy Accounting Workgroup

- Established to formalize performance reporting for Solar Assets
- Spearheaded by PVMAC, supported by industry
- Monthly meetings to define key elements

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PVMAC EA Workgroup Objective:

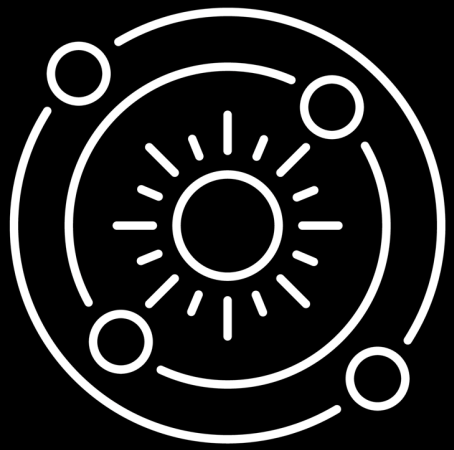
Publish a Reproducible and Auditable framework to account for solar performance, including critical elements:

1. Test Boundaries
2. Loss Categories
3. Energy Waterfall
4. Loss Reporting

A Financial Parallel: GAAP

Generally Accepted Accounting Principles

Accounting standards established to determine how financial statements are prepared



Big Idea #1:

Testing

vs.

Accounting

- **Testing** fulfills contractual obligations, i.e., ASTM E2848 and IEC 61724-series
- The “Truth” is the Expected model, which has no uncertainty
- The result of Testing is to report the measured production to the Truth

Big Idea #1:

Testing

vs.

Accounting

- **Accounting** assumes an Operating model that solves for observed performance—the “Reality”
- The result of Accounting is to report performance variation between models
- No existing standards cover this, but IEC 61724-series is a good starting point

Big Idea #2:

Expected Harmonization

- Testing standards state that Expected Energy must use congruous modeling
- Accounting standards can fix this problem with the Operating Model

Big Idea #2:

Expected Harmonization

- Deterministic: Losses with a known time element, given independent variables (Irradiance, Temperature, and Solar Position). For example: Shade, Inverter Clipping, Ohmic, etc.
- Non-deterministic: Losses with an unknown time element. For example: Snow, Inverter Availability, Curtailment, etc.

Big Idea #2:

Expected Harmonization

We must clarify that Expected Energy is a purely deterministic function of the Operating model.

Big Idea #3:

Solar

GAAP

We propose to define GAAP using:

- Test Boundaries
- Loss Categories
- Waterfalls
- Loss Buckets

Test Boundaries

Defined by typical commercially available test points:

Solar and Hybrid System Common Test Boundaries								
Common Test Boundary Name	**GHI Satellite Benchmark (G4)**	**GHI Ground Benchmark (G3)**	**Global POA Benchmark (G2)**	**Reference POA Benchmark (G1)**	**Effective Benchmark (G0)**	**Array Power (P2)**	**Production Power (P1)**	**Grid Power (P0)**
Measurements	Satellite GHI Ambient Temp Wind Speed	Ground GHI Ambient Temp Wind Speed	Global POA Module Temp	Reference POA Module Temp	Effective POA Cell Temp Calculated, Not Measured	Solar Module DC Power	Solar Production Active Power	Grid Active Power
							DC Coupled Storage DC Power	AC Coupled Storage Active Power
Common modeling terms	GHI, TAmb, Vwind	GHI, TAmb, Vwind	GlobInc, TArray, Vwind	GlobEff-IAM, TArray	GlobEff, TArray	EArray		EGrid
Equipment	Satellite and Remote-based data	Spectrally Flat Pyranometer	Spectrally Flat Pyranometer	Fast Response Pyranometer or Reference Device	Not Feasibly Measured	MPPT Controllers and Inverters	Meter	Meter
Standard	OSCAR?	ISO 9060	ISO 9060	ISO 9060 or IEC 60904-2		Non-Revenue Grade	ANSI C12.20	ANSI C12.20

Loss Categories

Approximately 30 Loss Categories, defined by "Can be measured in the field or in a lab."

Deterministic

Resource Model:
- Transposition
- Spectral
- Reflection
- Shade

Physical Model:
- Temperature
- Mismatch
- Clipping
- Ohmic

Non-deterministic

External:
- Reactive Energy
- Grid Availability
- Curtailment
- Snow

Internal:
- Inverter Derating
- Inverter Availability
- Tracker Alignment
- Soiling

Waterfalls

A Waterfall is a model summary. A project can have many model variants and waterfalls, but there are two primary ones for reporting performance:

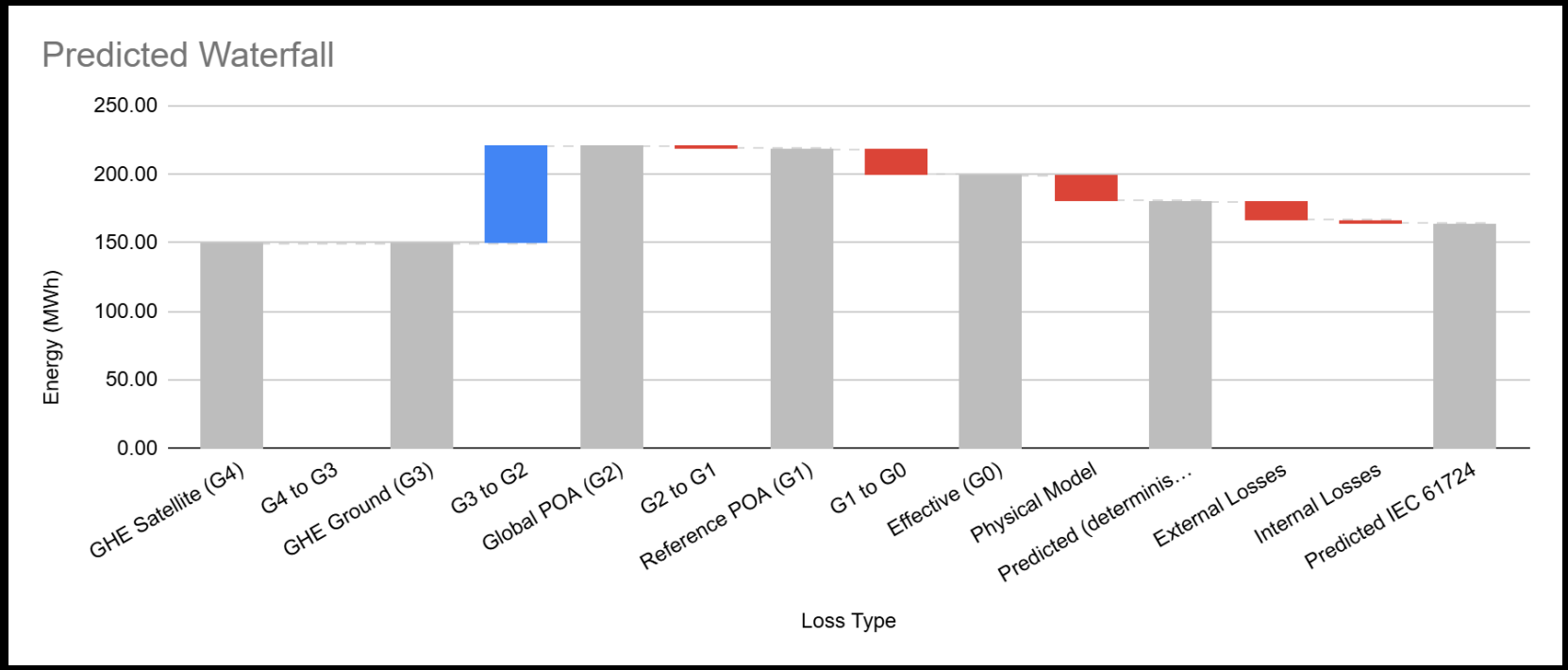
Predicted Waterfall

- P50 Scenario
- Truth—the Budget
- For Underwriting

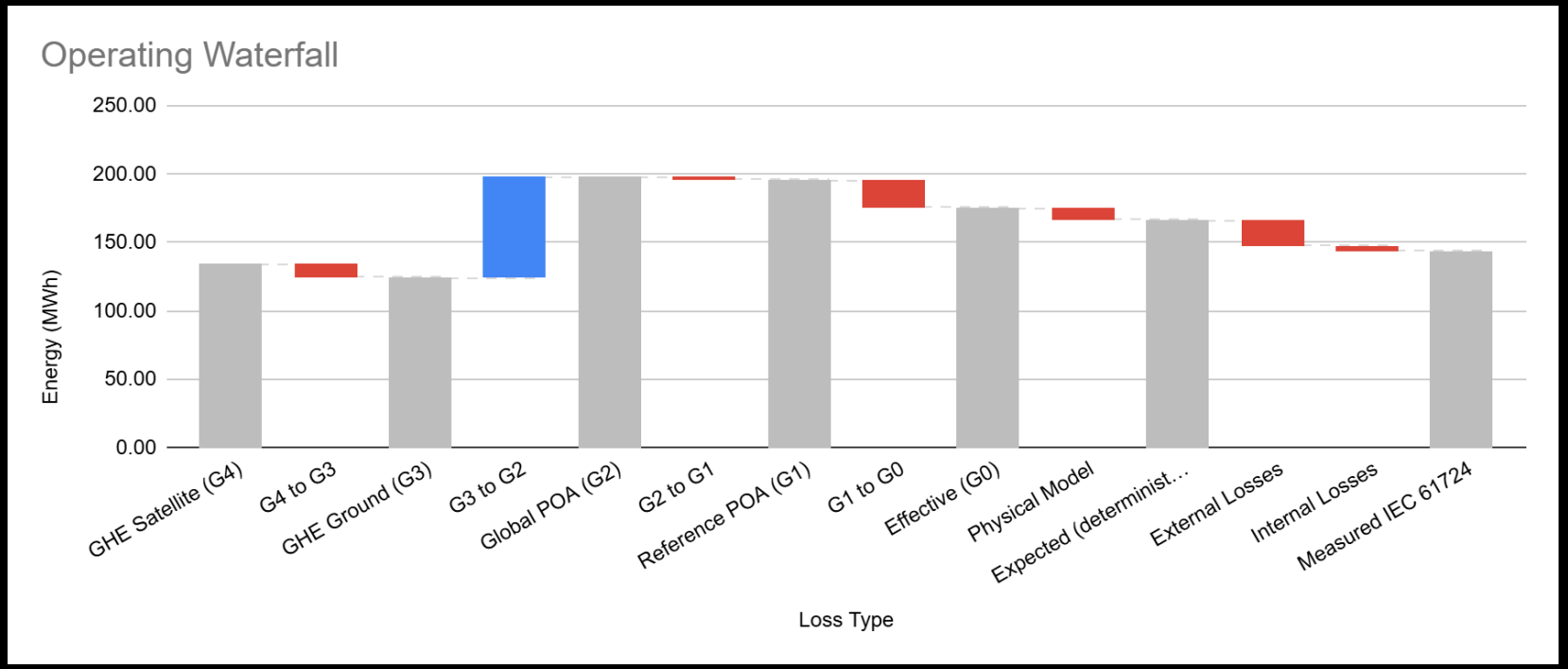
Operating Waterfall

- Measured Scenario
- Reality—the Actuals
- For Operations

Predicted Waterfall



Operating Waterfall

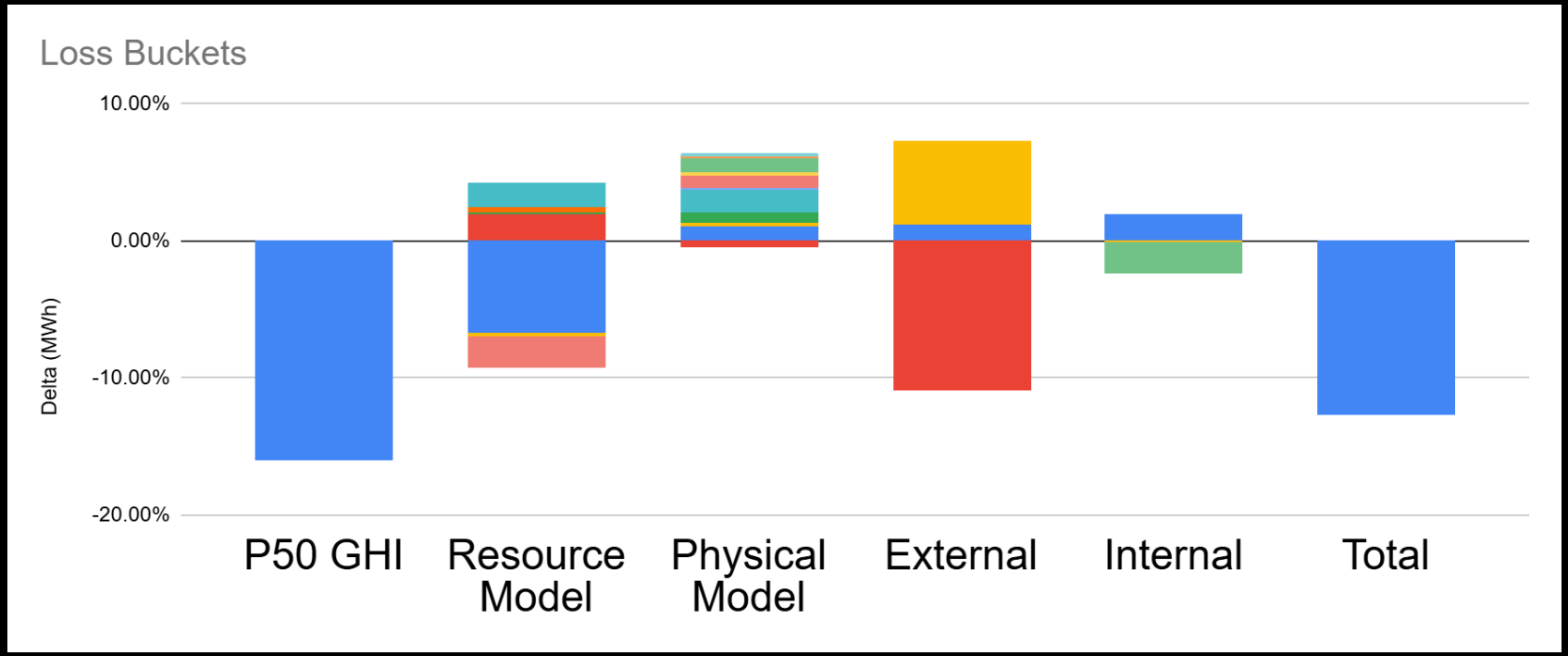


Loss Buckets

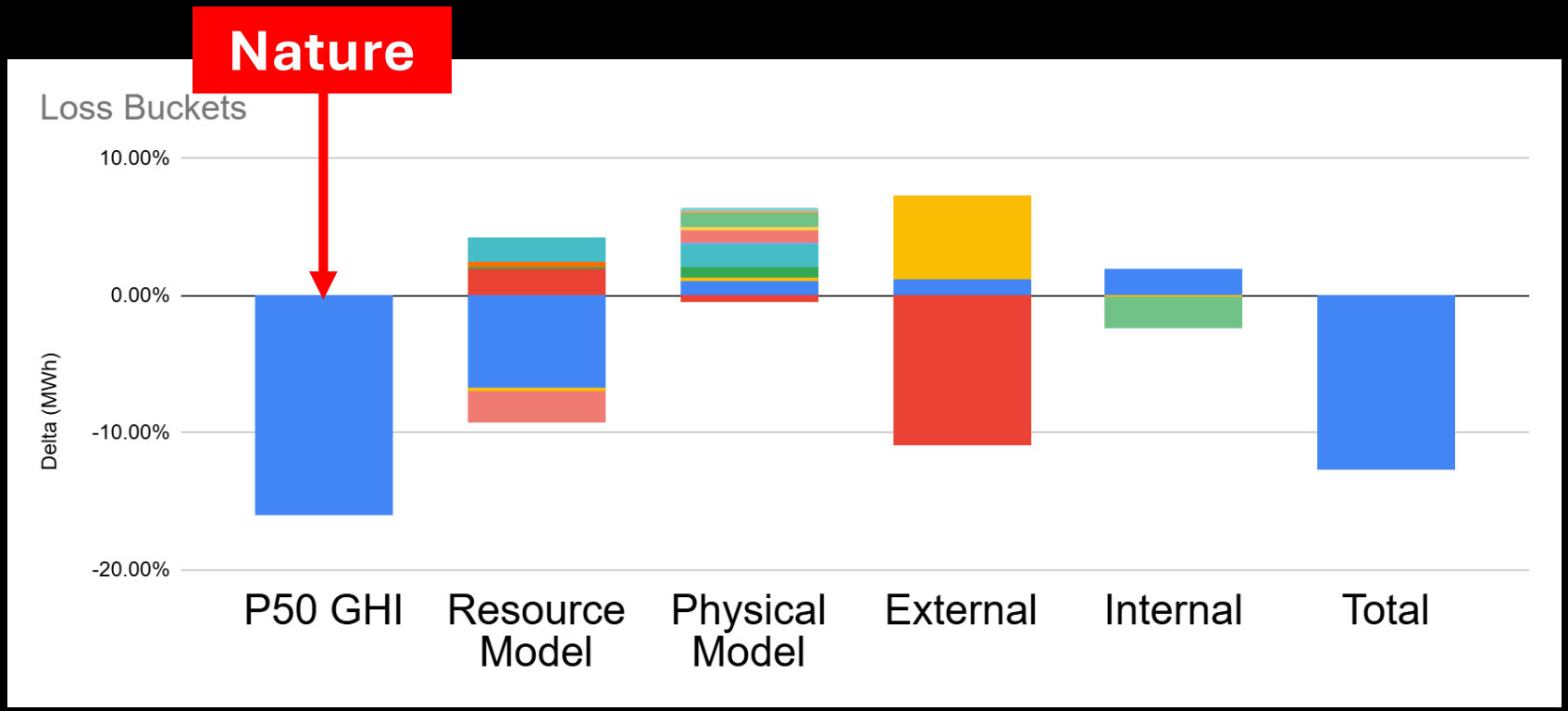
There are 5 Loss Buckets, grouped by “ownership”

Buckets:	In the hands of:
1. GHI	Nature
2. Resource Model	Satellites, Scientists, and Modelers
3. Physical Model	Engineers, Designers, and Modelers
4. External Loss	Nature and Utilities
5. Internal Loss	System Owners and their Vendors

Loss Bucket “Ownership”

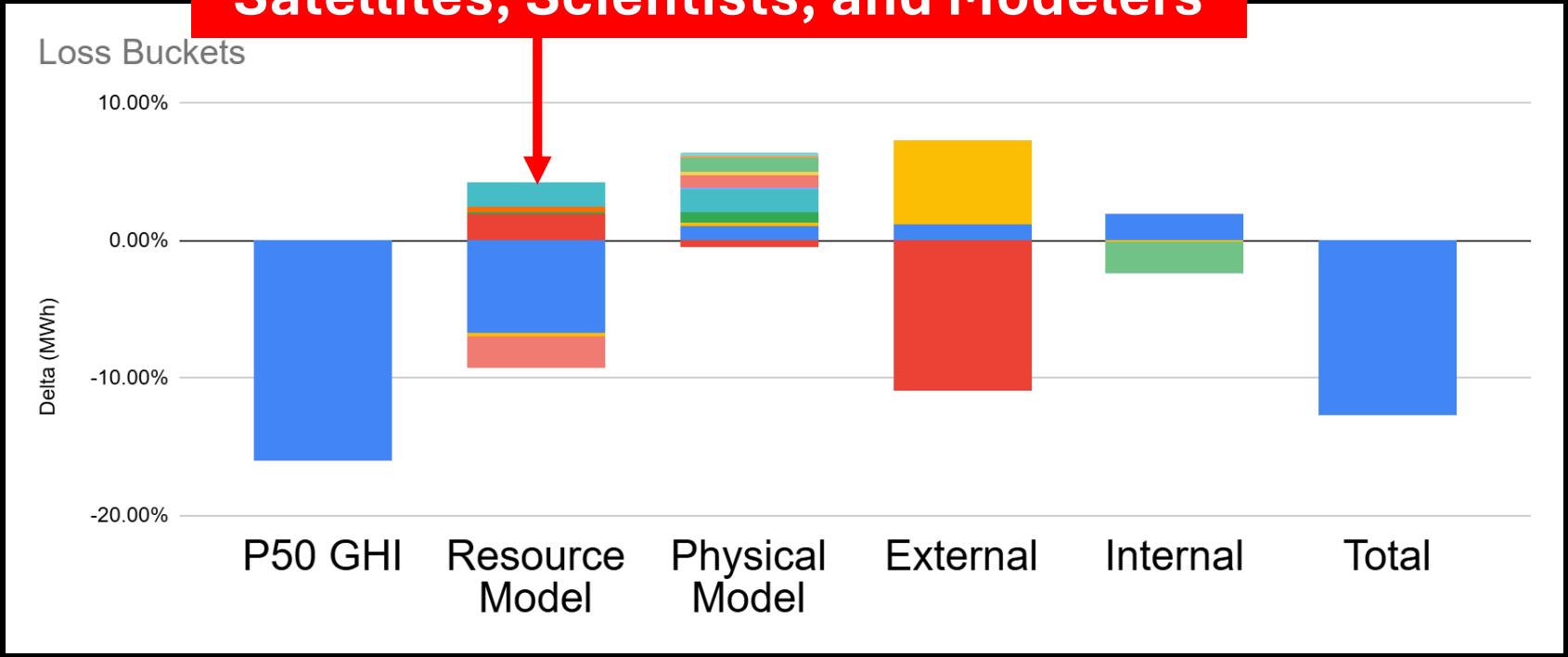


Loss Bucket “Ownership”



Loss Bucket “Ownership”

Satellites, Scientists, and Modelers



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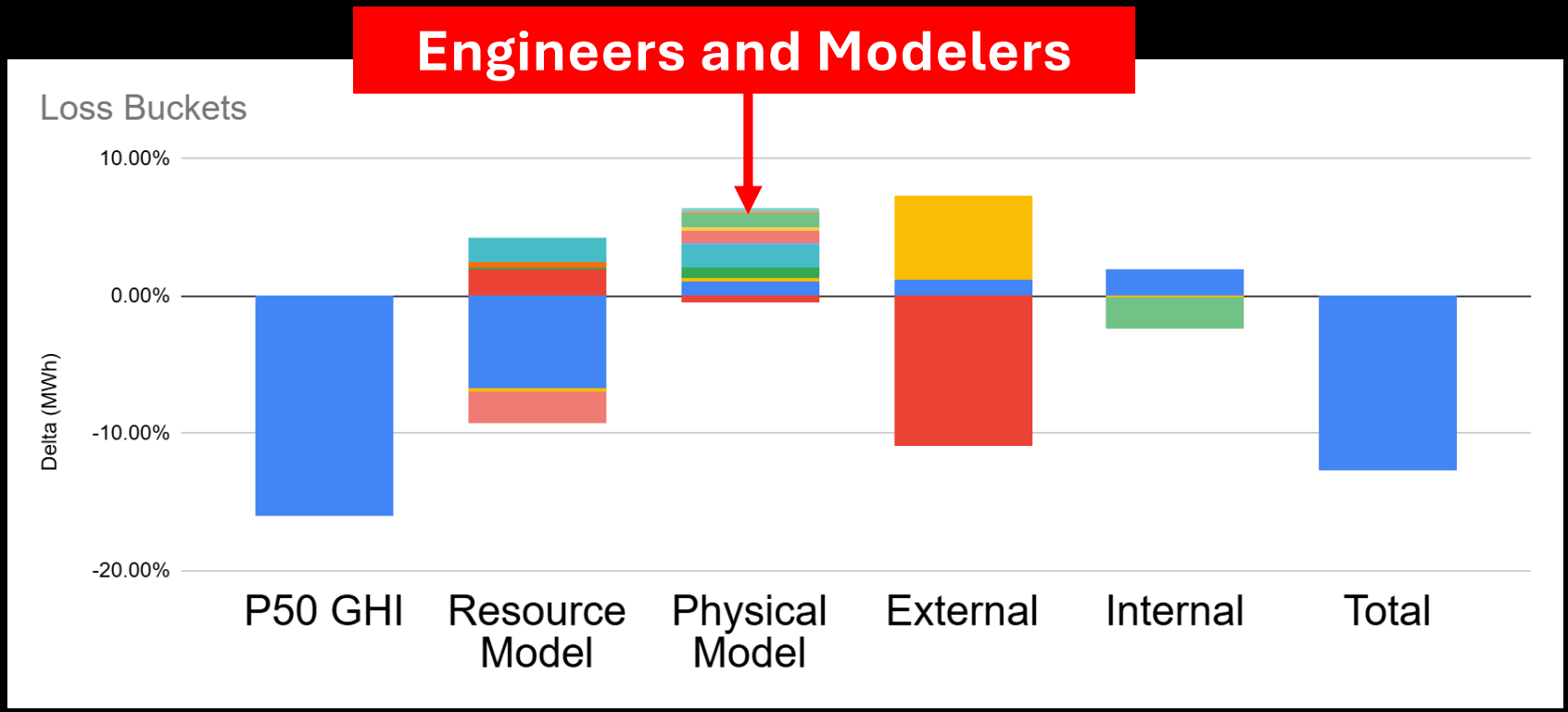

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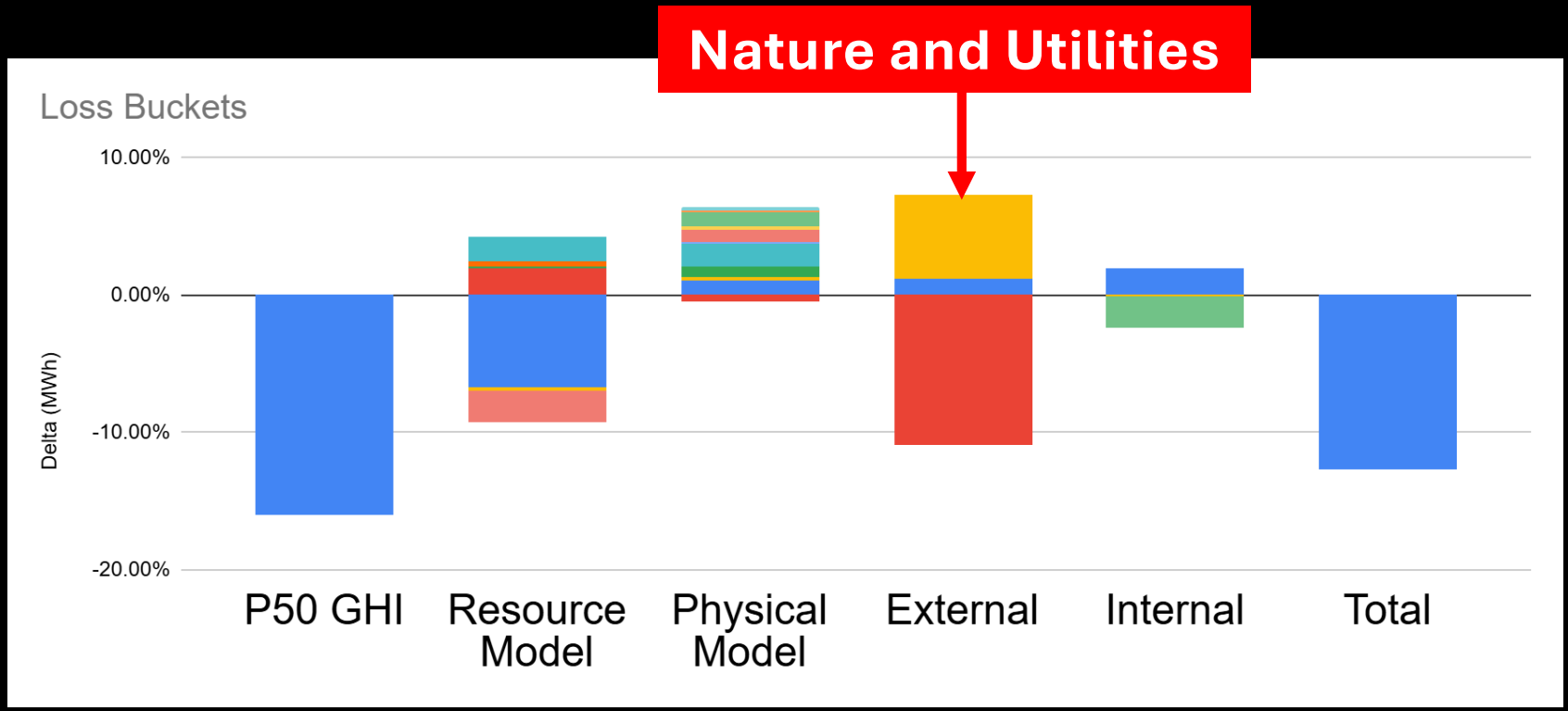

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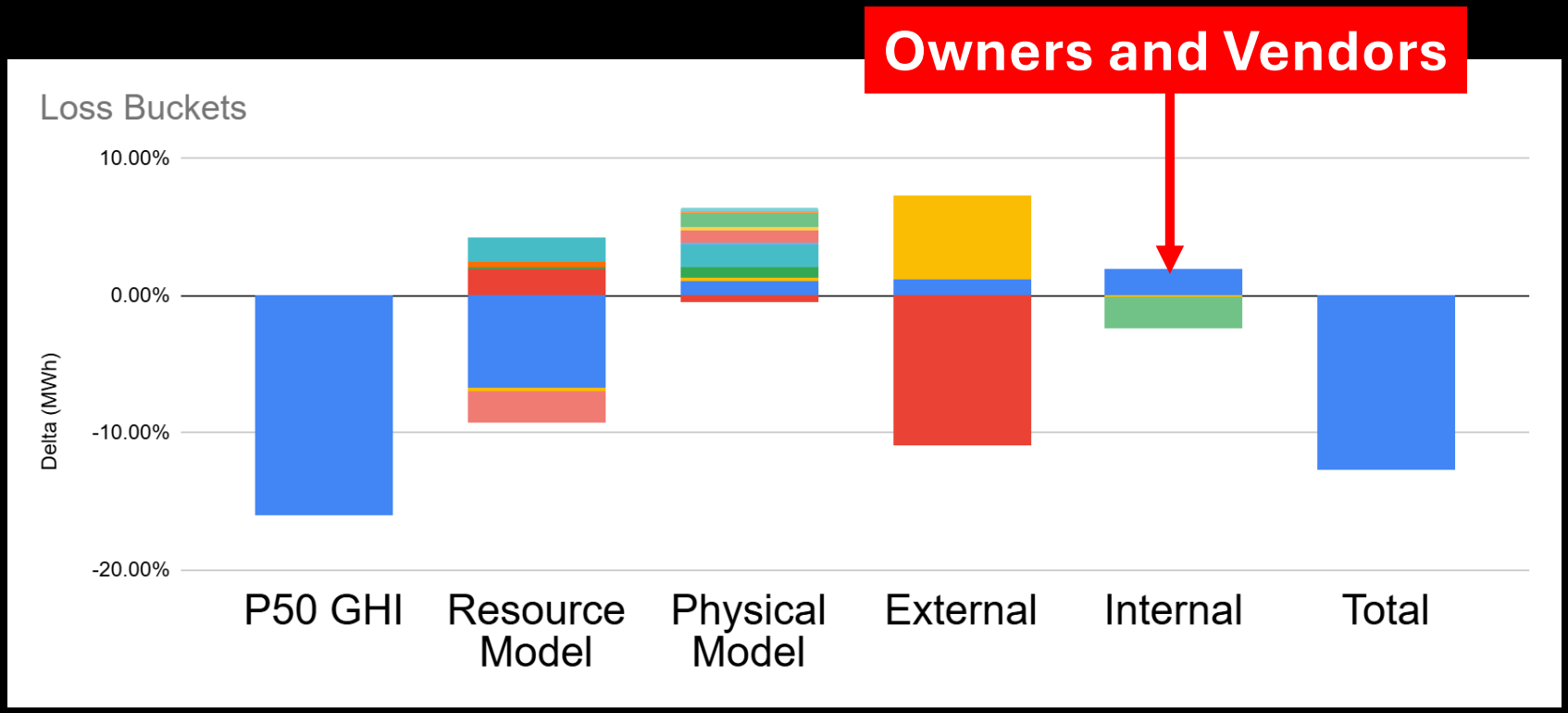
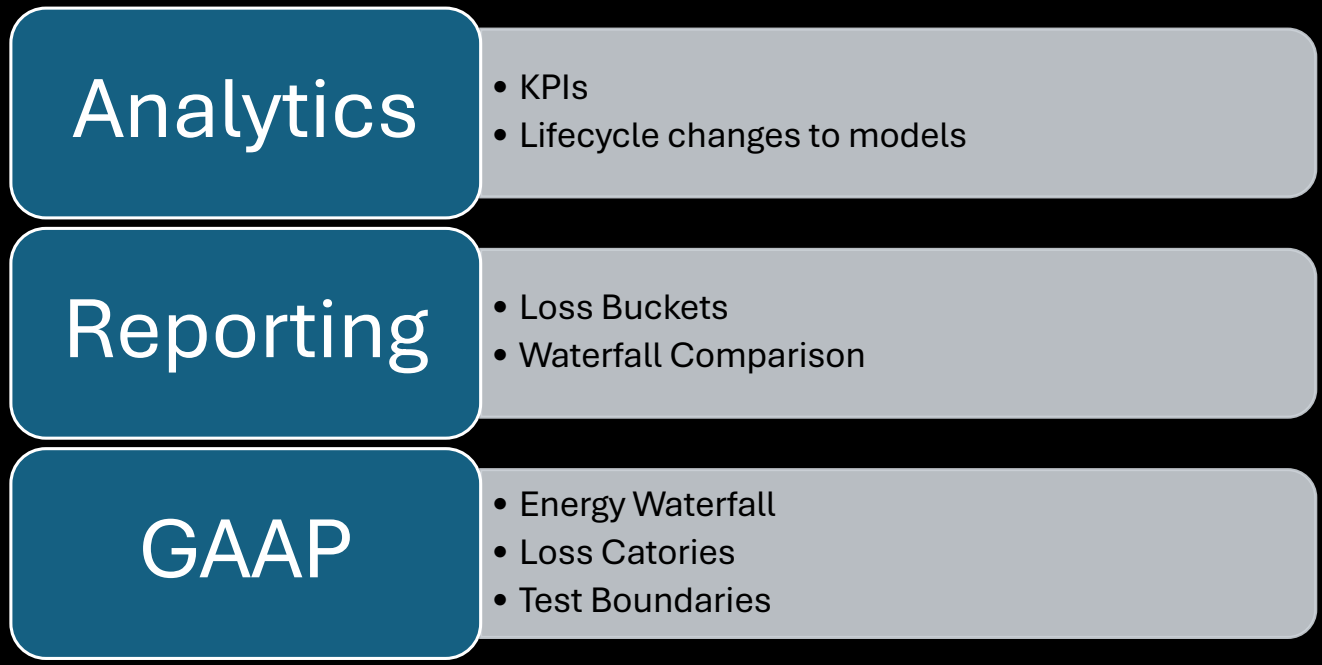


Energy Accounting Stack



EA Work Plan and Timeline

Define Key Energy Accounting Elements-3Q 2026

Publish Whitepaper and GIT-4Q 2026

Blind Study to Test and Refine-1Q 2027

Recap

- Solar Performance Reporting has no GAAP. Let’s fix that!
- Accounting is different from Testing.
- Define Test Boundaries, Loss Categories, and Waterfalls.
- Loss buckets are organized by “ownership”.
- Build on the IEC 61724-series to harmonize Expected Energy and introduce Energy Accounting.

thank you

PVMAC Energy Accounting Workgroup is an open invitation!
Contact Marios, mtheris@sandia.gov, Join tomorrow .