From Megawatts to Reliable Hybrid Power Across Africa.

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Presentation roadmap

A 20-minute path from the problem to the framework

Problem
MW alone is incomplete

2 **Method**
Evidence + cases + equations

3 **Engineering basis**
Power balance + timing

4 **African cases**
Five implementation pathways

5 **Framework**
Six decisions for reliable delivery

The problem is not only capacity

Installed megawatts do not automatically become dependable supply

Capacity-led framing

- MW and MWh specified first
- Delivery window often under-defined

- Interfaces solved late



Reliable power product

- Defined delivery hours and tolerances
- Resource and storage co-optimised

- System-level performance responsibility

Core thesis

The objective is not to procure megawatts. It is to procure reliable power when it is needed.

Structured practitioner review

How the paper connects technical logic to African project evidence

Literature	Official reports	Engineering relationships	Public project evidence
Complementarity Temporal modelling	Storage value Grid integration	Power balance SOC + control	Owners + utilities DFIs + project cases

Analytical workflow

Delivery product → architecture → equations → dispatch test → recurring decisions → six-stage framework

Method strengthened from Reviewer 1 feedback

Hybridisation is an operating problem

The plant must be controlled as one facility at the point of connection

Wind	Solar PV	BESS	POC export
Variable generation	Daytime generation	Power + energy	Contracted delivery

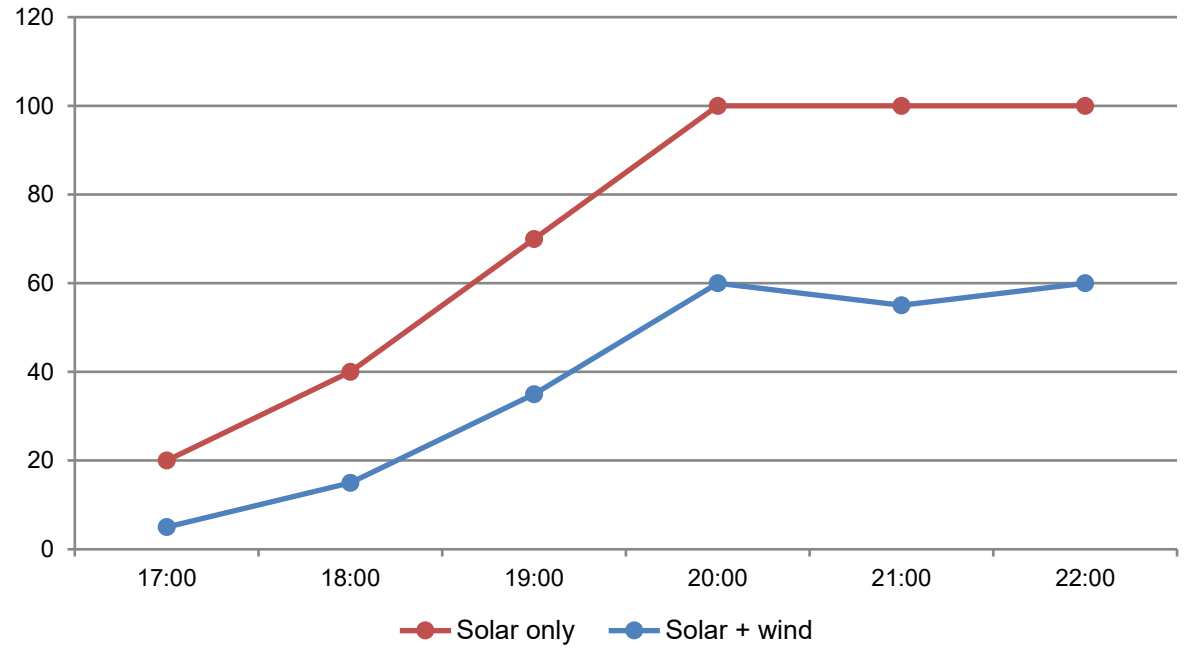
$$Pe(t) = Ppv(t) + Pw(t) + Pdis(t) - Pch(t) - Ploss(t)$$

- Battery MW and MWh must be specified separately
- Controller ownership and testing must be explicit

- Grid studies should shape the plant, not simply confirm it

Evening delivery changes storage requirements

Illustrative six-hour test: 100 MW export from 17:00 to 22:00



Result under simplified assumptions

Peak discharge

100 MW → 60 MW

Cumulative discharge

450 MWh → 250 MWh

Important caveat

Illustrative cumulative discharge only — not full BESS sizing. Charging, losses, reserves, SOC limits and degradation are excluded.

Reviewer clarification added

African project evidence shows multiple pathways

The common feature is a defined system purpose, not a fixed technology ratio

Oya	**Wind + PV + BESS**	Dispatchable hybrid
Kenhardt	**PV + large BESS**	Extended delivery window
Cuamba	**PV + BESS**	Local network support
Walo	**PV + BESS**	Frequency regulation
Abydos	**PV + BESS add-on**	Staged storage integration

Interpretation

- Multi-resource hybrids reduce residual deficits
- Storage-dominant hybrids reshape delivery or provide grid services
- Both require clear interfaces and lifecycle operation

Case comparison strengthened

Six-stage implementation framework

A sequence for reducing interface risk

1	Define system need	2	Screen jointly	3	Co-optimise assets	4	Integrate grid code	5	Allocate interfaces	6	Plan lifecycle

What it changes

The design process moves from “how many MW?” to “what reliable power product is required, and who carries system-level performance responsibility?”

Framework derivation clarified

Procurement must allocate system responsibility

Separate equipment warranties do not guarantee integrated delivery

- Delivery hours and tolerances
- SOC policy and curtailment rules
- Controller and forecast ownership
- Integrated performance testing
- Connection and grid-code studies
- MW and MWh separately specified
- Interface matrix across suppliers
- Penalty and warranty boundaries

Commercial risk

A component can meet its warranty while the combined plant fails the delivery obligation.

A research agenda beyond installed capacity

Four tests can move hybrid design from practitioner logic to operating evidence

Temporal evidence	Test complementarity with sub-hourly African resource + demand data
Operating evidence	Compare predicted delivery with actual plant performance
Lifecycle evidence	Include losses, reserves, degradation + augmentation
Contract evidence	Test interface models that sustain plant-level accountability

Current contribution

A practical framework for earlier technical and commercial decisions — not a universal sizing model.

Conclusion

Reliable delivery is the real project outcome

1. Define the power product before choosing capacities
2. Model wind, solar, load and storage at the right temporal resolution
3. Specify BESS power and energy separately
4. Coordinate control, grid compliance and commercial interfaces
5. Measure success by reliability, timing and system value

Moving from megawatts to reliable power is a design, procurement and accountability shift.

Thank you

Questions

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Key line to remember:
Reliable power is defined by when, how and with what accountability it is delivered.