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AES INDIANA | INTEGRATED RESOURCE PLAN

2025 IRP: Portfolio Reliability and Data Center Dynamics

Essential Reliability Services assessment, and 345 kV dynamic performance under large data center loads

Danovo Energy Solutions, former Quanta Technology, LLC

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OVERVIEW

What the reliability assessment covered

The 2025 AES Indiana IRP included a reliability and energy adequacy assessment of the candidate resource portfolios, addressing the Essential Reliability Services that a resource plan has to deliver.

1 Transmission capability

How much power the system can import from, and export to, neighboring areas under both normal and contingency conditions.

2 Energy adequacy

Whether the portfolios can serve load in every hour of the year, not only at the system peak.

3 Frequency response

Inertial and primary frequency response following the sudden loss of a large generating unit.

4 Short circuit strength

Whether the network is electrically strong enough to integrate the proposed inverter-based resources.

Each area was assessed across multiple candidate portfolios and planning years, using chronological hourly simulation, power flow and contingency analysis, and dynamic simulation.

FINDINGS

What the assessment found

Operating interconnected with the wider regional system, the candidate portfolios performed well across all four areas.

Transmission capability strengthens over the horizon

Planned network reinforcement, including new extra-high-voltage capacity, materially increases the import capability available to the system across the planning horizon.

Energy adequacy is met with import capability available

With transmission import capability available, the portfolios reliably serve demand throughout the planning horizon, including under high-load forecast conditions.

Frequency response is adequate when interconnected

All portfolios maintain acceptable frequency stability across the horizon, with no violations of primary frequency response criteria. Repowering retired coal units with new synchronous generation supports system inertia.

Inverter-based resources integrate fully

With the system interconnected, every portfolio evaluated achieved full integration of its proposed inverter-based resource capacity.

Source: Portfolio Reliability Analysis and Ranking to Support the 2025 IRP Process, prepared for AES Indiana, October 2025.

PART TWO · TECHNICAL DEEP DIVE - ADDITIONAL RELEVANT VALIDATIONS

Assessment of Power System Dynamics Due to Large Data Center Facilities

Dynamic performance of the system and the effect of the data center load models

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STUDY DEFINITION

Proposed study Scope and objectives

1. **Dynamic performance**

   Verify voltage recovery, machine angle stability and damping across a critical contingency set, with and without new large loads.

2. **Load-model sensitivity**

   Quantify how much of the predicted response is an artefact of the data center load representation rather than of the network itself.

Three representations of the same 200 MW test load

PSS®E default

Constant admittance

- No protection, no motor dynamics
- Power follows V^2
- Full, instantaneous restoration after clearing
- Least conservative for an electronic load
- Screening use only

Composite load model

CMPLDW-type

- Constant-P / constant-Z split at the LV bus
- Electronic fraction with voltage ride-through
- Explicit shedding on undervoltage, with time delay
- ≈50% of load retained after a near 345 kV fault
- Primary model for planning studies

EV charger

Ramp-controlled

- Power-electronic front end
- Reconnection blocked, or restored on a ramp
- No post-fault power surge
- Bounding case: 0–100% retained
- Reconnection-policy studies

What each representation actually models

PSS®E default
Constant admittance

Transmission bus V

↓

Constant admittance $Y = P_0 / V_0^2$

↓

$P = P_0 (V / V_0)^2$

No protection, no timers and no restoration logic — the load follows voltage and nothing else

Composite load model
CMPLDW-type

Transmission bus

↓

Substation transformer (LTC)

↓

Feeder equivalent R + jX, shunt

↓

Low-voltage bus

↓

- Three-phase motors A / B / C
- Single-phase motor D
- **Electronic load + trip logic**
- Static load P(V, f), Q(V, f)

EV charger
Ramp-controlled

Transmission bus V

↓

Rectifier front end (power-electronic interface)

↓

Undervoltage detection V < V_trip for t > T_delay

↓

Trip / block load

↓

Restore after T_rec, ramp-rate limited dP/dt

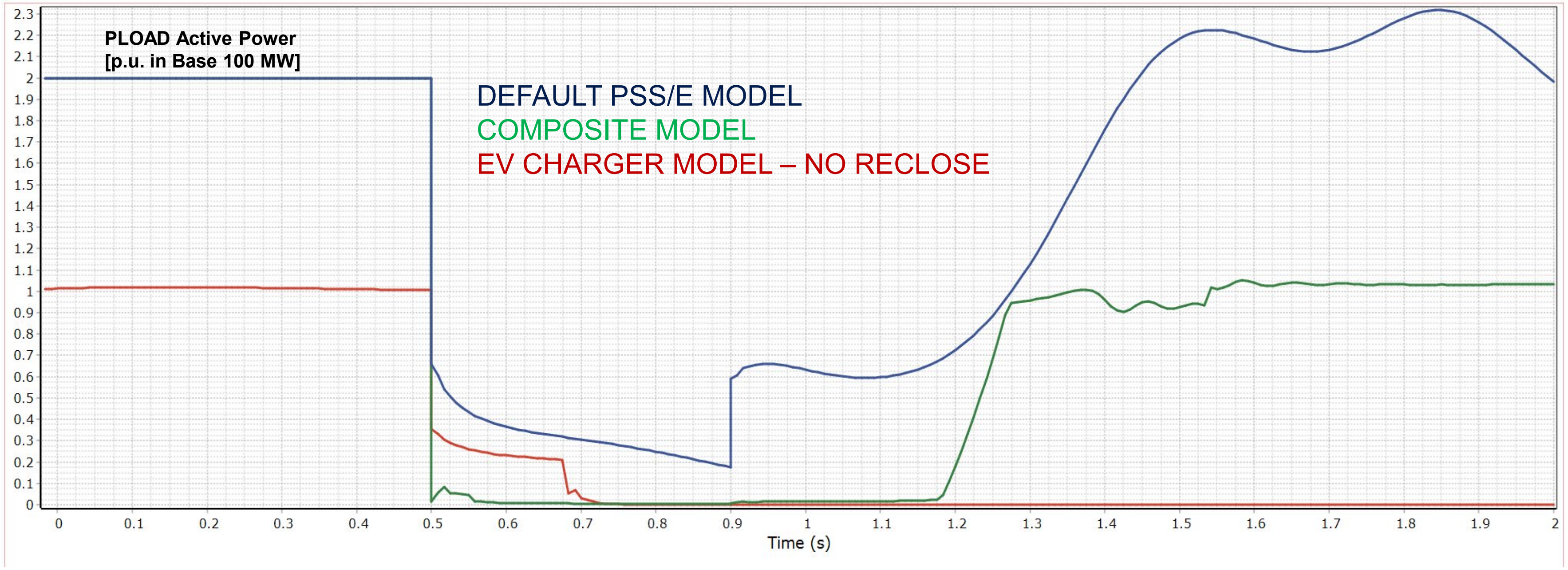
↓

P command → load

The ramp rate is a control setting, not a property of the network

Structures shown are the model arrangements, not a parameter set: the composite column follows the WECC/EPRI CMPLDW layout. Facility-specific parameters are set per study.

The same disturbance, three different answers for a test load



- PSS®E default model
- Composite model
- EV charger model — no reclose

Data center load response (PLOAD) — 400 ms three-phase fault applied at t = 0.5 s, faulted line tripped at t = 0.9 s

PSS®E default

Overshoots to 2.3 p.u. at t = 1.85 s before returning toward 2.0 p.u. — a ≈15% surge that is an artefact of the constant-admittance model.

Composite

Electronic fraction trips during the fault; load restores to ≈1.03 p.u., about half the pre-fault value.

EV charger, no reclose

Load remains at 0 MW after the event — the bounding case.

The three traces bracket the plausible behaviour of one facility and differ by more than 200 MW in the seconds after fault clearing.

Conclusions and recommendations

WHAT WE CONCLUDE

1. **Model selection sets the answer**
   Composite and EV-charger models change the retained load by more than 200 MW against the static model. The default is a screening tool only.
2. **Restoration behaviour can be represented**
   Models are available that hold the load off after a disturbance, or return it on a controlled ramp, rather than restoring it instantly.
3. **The cases tested remained stable**
   Every contingency simulated remained stable across the representations examined.

WHAT WE RECOMMEND

1. **Match the load model to the load**
   Where large flexible loads are material to a study, consider representations that reflect facility protection and restoration behaviour.
2. **Confirm behaviour with the facility**
   Where the restoration rate affects the result, confirm the assumed rate with the operator rather than assuming it.
3. **Test the sensitive parameters**
   Run sensitivities on the voltage trip threshold and time delay, which drive the modelled outcome.
4. **Support the network explicitly**
   Flexible grid support (FACTS, STATCOM, BESS), updated reliability criteria and operating procedures.

OPEN QUESTIONS FOR FURTHER WORK

- **Shed fraction**
  Sensitivity on the voltage trip threshold and time delay — it decides the binding condition.
- **Facility reality**
  Reconcile modelled shedding with the actual UPS and backup generator transfer schemes.
- **Ramp rates**
  Confirm the assumed reconnection ramp rates with the facility operator.