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Solar Plant Full SCADA System Study

From System Design Document Chapter 8: Verification and Acceptance
Testing

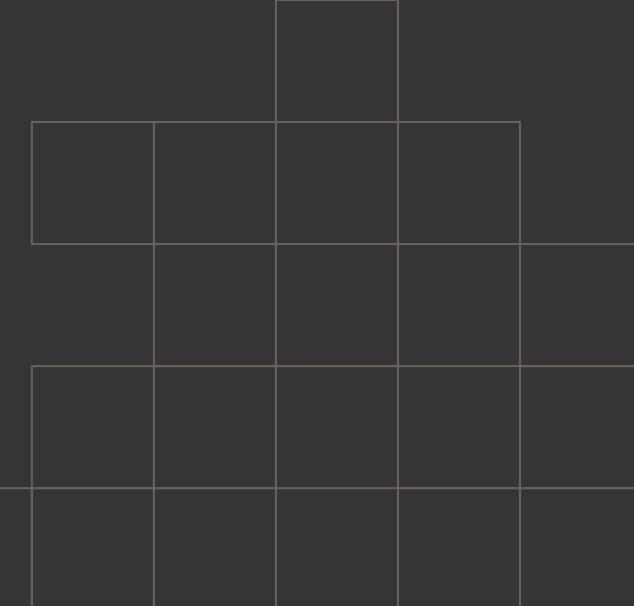
System Overview and Validation Context

This slide deck demonstrates the operation and validation of a utility-scale Solar Plant SCADA and Power Plant Controller (PPC) implemented in CODESYS.

The system models a 100 MW photovoltaic plant with hybrid energy storage, including a 50 MW / 200 MWh Battery Energy Storage System (BESS) and a 10 MW / 2 MWh Flywheel Energy Storage System (FESS).

The SCADA interface presents plant-level behavior as seen by a grid operator, including dispatch tracking, ramp enforcement, asset coordination, curtailment behavior, and alarm conditions.

All demonstrations are based on ISO-style dispatch logic and reflect expected operational behavior in CAISO- or ERCOT-like environments.



Operator Controls

This panel shows the operator-accessible control inputs to the plant.

Operators can:

Set the dispatch real power command (MW) for the plant

Toggle Day / Night mode, which determines solar availability and charging permissions

These controls represent the highest-level operator authority.

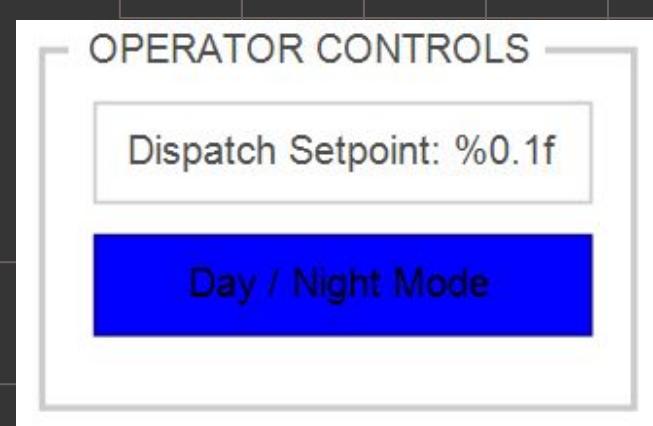
All operator inputs are subject to:

Plant-level ramp rate limits

Asset availability and energy constraints

Safety and protection logic

The operator cannot directly command individual assets; all actions are mediated by the Power Plant Controller.



Solar (PV) Panel and Dispatch / POI Tracking

This slide presents solar generation behavior alongside dispatch tracking at the point of interconnection (POI).

The Solar panel shows:

Available solar power based on Day/Night state

Solar power delivered to the grid

Solar power diverted to storage charging

Solar curtailment when excess generation cannot be absorbed

The Dispatch / POI panel shows:

Requested dispatch setpoint

Ramp-limited target

Actual delivered power at the POI

Total plant available capacity

Dispatch tracking status



Together, these displays show how the plant prioritizes solar generation, enforces ramp limits, and transparently reports tracking capability.

Battery (BESS) and Flywheel (FESS) Panels

These panels display the state and behavior of the energy storage systems.

The Battery (BESS) panel shows:

State of charge (SOC)

Charging or discharging power

Operating mode (Charging / Discharging / Idle)

Available charge and discharge capacity

Low SOC and unavailable status indicators

The Flywheel (FESS) panel shows:

Stored energy level

Instantaneous power output

Operating mode

Available discharge capacity

Empty and unavailable status indicators



Together, these panels illustrate how long-duration and short-duration storage assets are coordinated to support dispatch tracking and ramp enforcement.

Alarm Banner and Abnormal Conditions

This slide shows the plant alarm banner, which aggregates critical abnormal conditions into clear operator-visible indicators.

Active alarms include:

Dispatch not tracked

Plant saturated

Battery at minimum SOC

Flywheel empty

Solar unavailable (night)



Alarms are asserted based on real-time plant conditions and automatically clear when the underlying condition resolves.

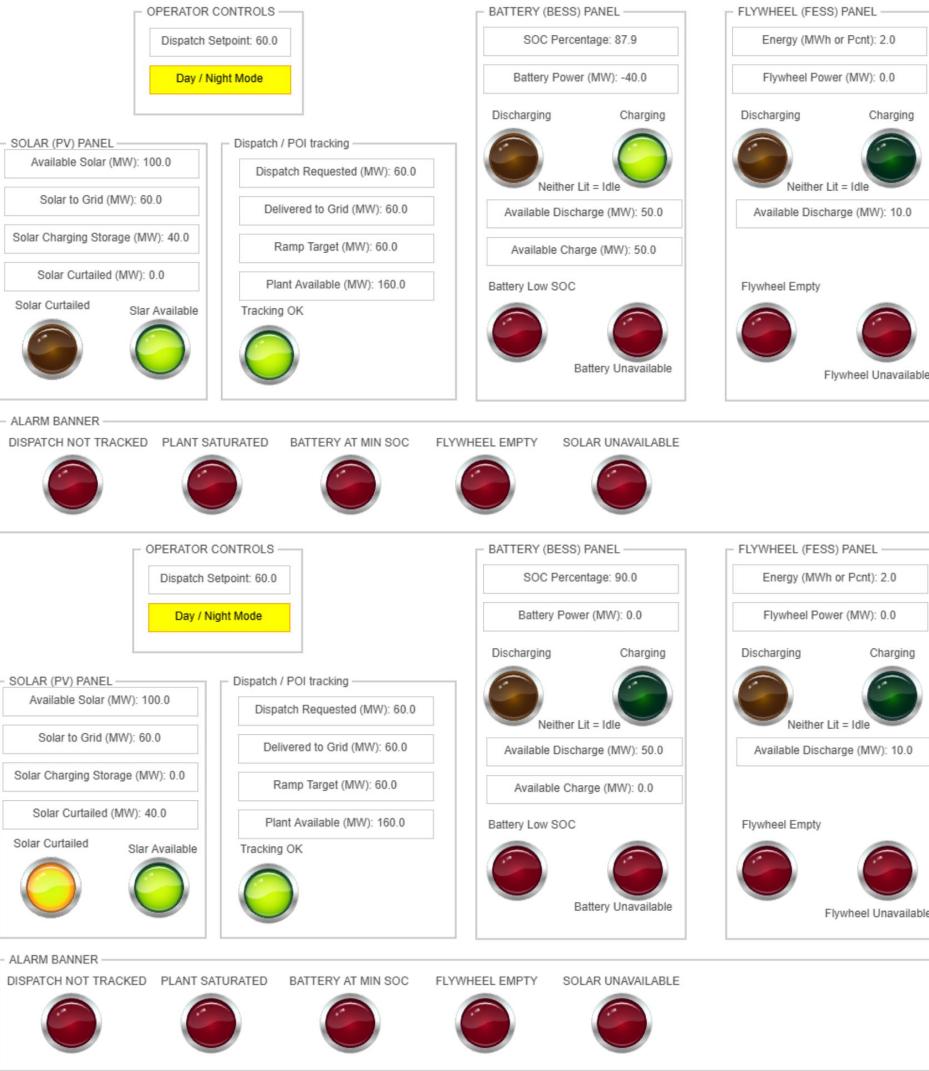
This banner provides immediate situational awareness and supports rapid operator decision-making without exposing internal control complexity.

Dispatch set From 20MW to 60MW

Validates Sections 8.1, 8.2, and 8.3

A step change in dispatch from 20 MW to 60 MW is applied. The plant output ramps smoothly to the new setpoint, demonstrating plant-level ramp enforcement and stable POI tracking consistent with ISO-style dispatch requirements.

As the BESS reaches its maximum SOC (90%), excess solar generation is automatically curtailed, confirming correct energy limit enforcement and normal-operation behavior. No ramp violations, instability, or asset limit violations occur.



Dispatch set From 60MW to 150MW

A dispatch command of 150 MW is issued and successfully met using the full available solar generation (100 MW) combined with battery discharge (50 MW). The plant delivers the requested output without curtailment, confirming correct asset coordination, dispatch tracking, and normal high-output operation.

Solar remains available and uncurtailed, while the battery transitions to discharge as expected, demonstrating proper allocation logic when operating at maximum combined plant capacity.



Dispatch set From 150MW to 160MW

Validates Sections 8.1, 8.2, and 8.4

A dispatch command of 160 MW is issued, temporarily met using solar (100 MW), battery discharge (50 MW), and flywheel discharge (10 MW). Upon flywheel energy depletion, total plant capability reduces to 150 MW, and the system correctly transitions to a plant-saturated condition.

The following behaviors are observed and verified:

Plant Available MW drops to 150 MW

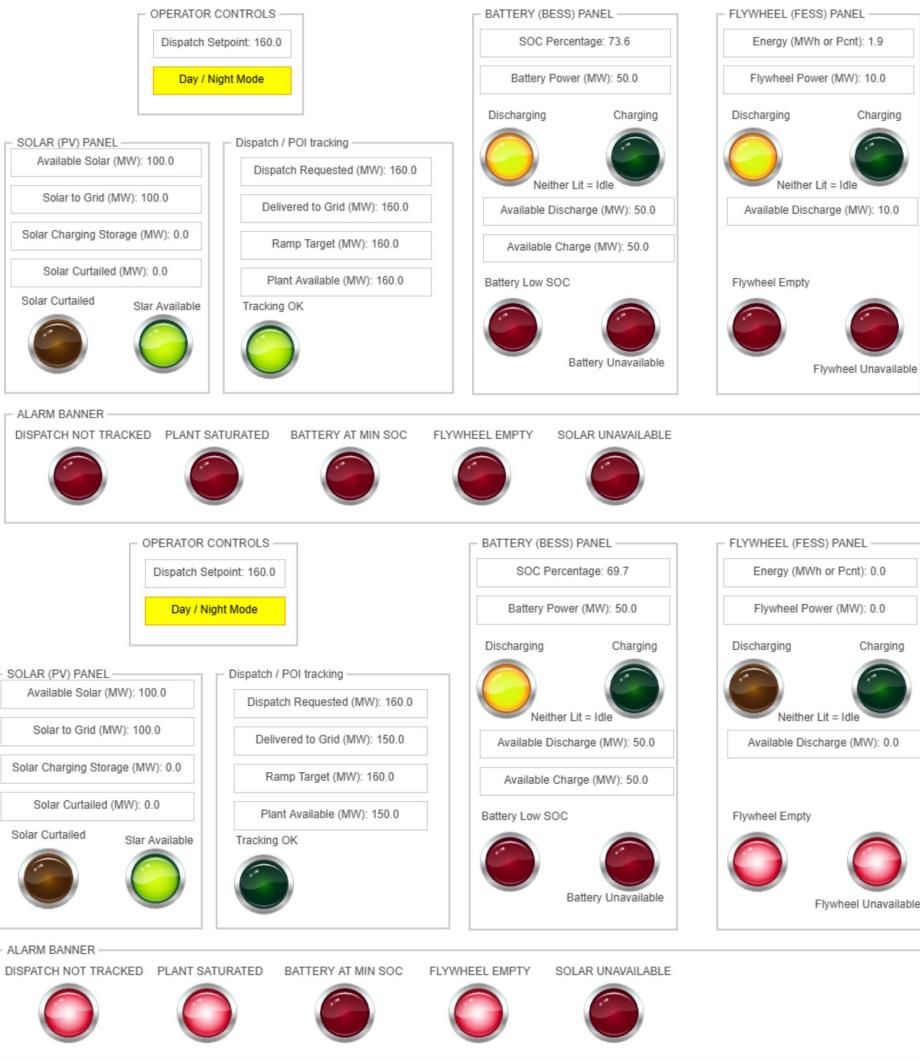
Dispatch Not Tracked and Plant Saturated alarms assert

Flywheel Empty alarm asserts

Battery continues discharging within limits

Tracking OK de-asserts deterministically

This confirms correct handling of dispatch exceeding plant capability, deterministic degradation, and proper alarm signaling without instability or limit violations.



Dispatch set From 160MW to 50MW

Day Changes to Night

Validates Sections 8.1, 8.3, and 8.4

The dispatch command is reduced from 160 MW to 50 MW concurrent with a day-to-night mode transition. Solar availability drops to zero, and the Solar Unavailable alarm asserts as expected.
Observed system behavior:

Solar Available = 0 MW with curtailment disabled
Battery remains in discharge to meet the 50 MW dispatch
POI Delivered MW tracks dispatch
Tracking OK remains asserted
Plant Available MW reflects storage-only capability

This confirms correct handling of operating mode transitions, loss of solar resource, and storage-only dispatch tracking without instability or limit violations.



Dispatch Still Set to 50MW No Available Plant Power

Validates Section 8.5 and 8.6

This test validates correct system behavior under fault-like and fully unavailable operating conditions. With dispatch remaining at 50 MW and all generation and storage assets unavailable (night mode active, battery and flywheel unavailable), the plant correctly delivers 0 MW at the point of interconnection.



Dispatch objectives are deterministically overridden by operating constraints. Plant Saturated, Dispatch Not Tracked, Solar Unavailable, Battery Unavailable, and Flywheel Empty alarms assert as expected, while no power, ramp, or energy limits are violated.

This scenario confirms that the system transitions to a safe, bounded state under loss of capability, provides accurate operator visibility, and behaves predictably and repeatably. All acceptance criteria for fault response, safety priority, and status indication are satisfied.

Verification and Test Summary

This test sequence demonstrates that the solar-plus-storage plant operates as a compliant, ISO-style dispatchable resource across normal, saturated, degraded, and fault-like conditions. The system consistently tracks dispatch commands when capability allows, enforces plant-level ramp limits, and deterministically transitions to safe, bounded states when limits are exceeded.

Asset coordination, availability reduction, curtailment behavior, and alarm assertion occur predictably and transparently through the SCADA interface. Under loss of generation and storage capability, dispatch objectives are safely overridden and operator visibility accurately reflects plant limitations.

These results confirm correct control authority hierarchy, constraint enforcement, and alarm behavior, validating the system for professional demonstration, technical review, and portfolio presentation.

