

Effective Integration of Hybrid Solar & Storage Plant to Provide Maximum Value Mahesh Morjaria, Ph.D. & Rajni Burra, Ph.D.



Key Theme

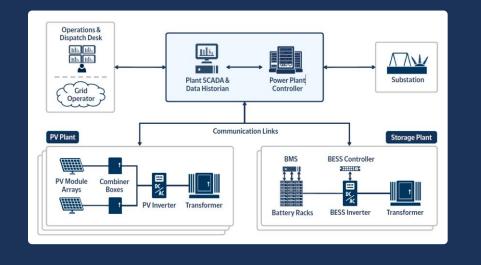
Capability of Grid Friendly PV Plant



Utility-scale PV Solar provides Energy, Essential Reliability Services & Flexibility



Coupling storage with PV enables Clean & Competitive Firm Capacity & Grid Enhancements



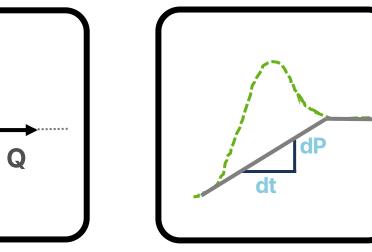
Plant controls play a critical role in

Base Capability

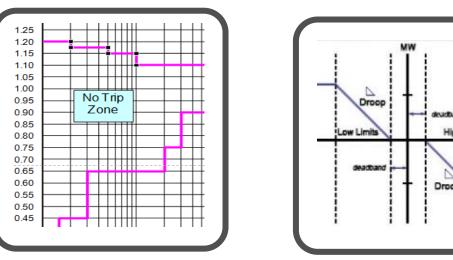
Features Required by NERC to be a Good Grid Citizen

Voltage Support Po

t Power Control





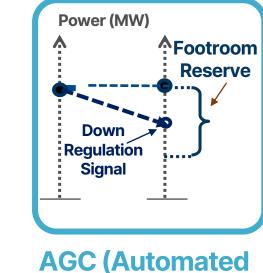


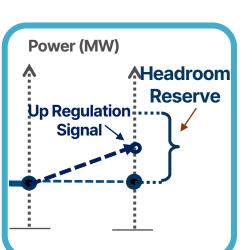
Grid-Reliability Services

Capable of grid services reserved for Synchronous Generators today

Down-Regulation

Up-Regulation

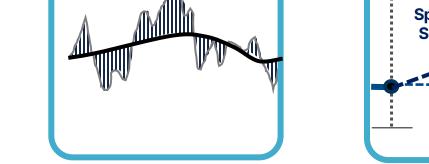


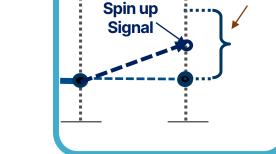


Generation Spinning Reserve



unleashing hybrid plant's Full Operational Capabilities





Grid Capability Enhanced with	Hybrid Plant Control System Architecture				
Storage Clean dispatchable firm capacity	Hybrid Plant Dispatcher	AC Coupled	 Dispatcher determines PV and BESS setpoints Power plant controller (PPC) 	Hybrid Plant Dispatcher	DC Coupled
Capacity FirmingEnergy ShiftingFlexibilityImage: ShiftingImage: Shiftin			 ensures that the plant meet the utility and interconnection requirements EMS operates the BESS system to meet the requested set points while optimizing its life 		
Hour of the Day 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 January February March April May June July Game Changer: Dispatchable clean energy plant more cost- effective than conventional	PV Inverter DC	BESS Inverter DC	 BMS ensures that the battery system is protected and operates safely The control system architecture is the same for 	PV Inverter DC	BESS DC-DC







AC and DC Coupled systems

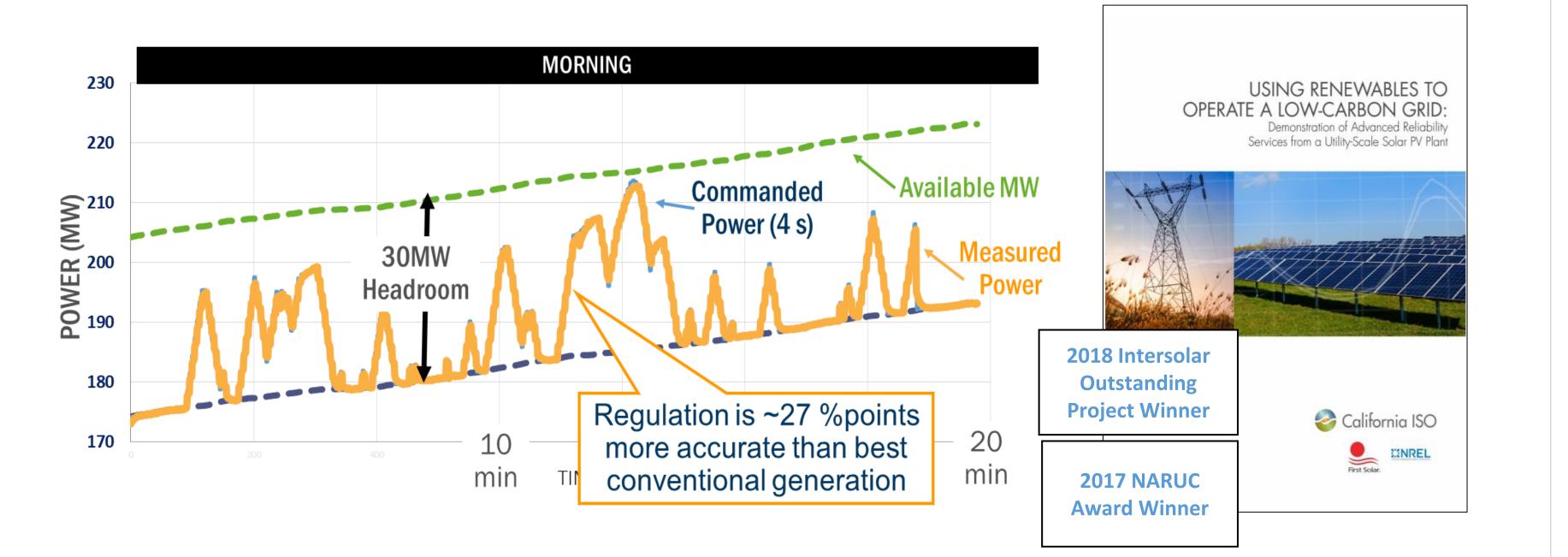


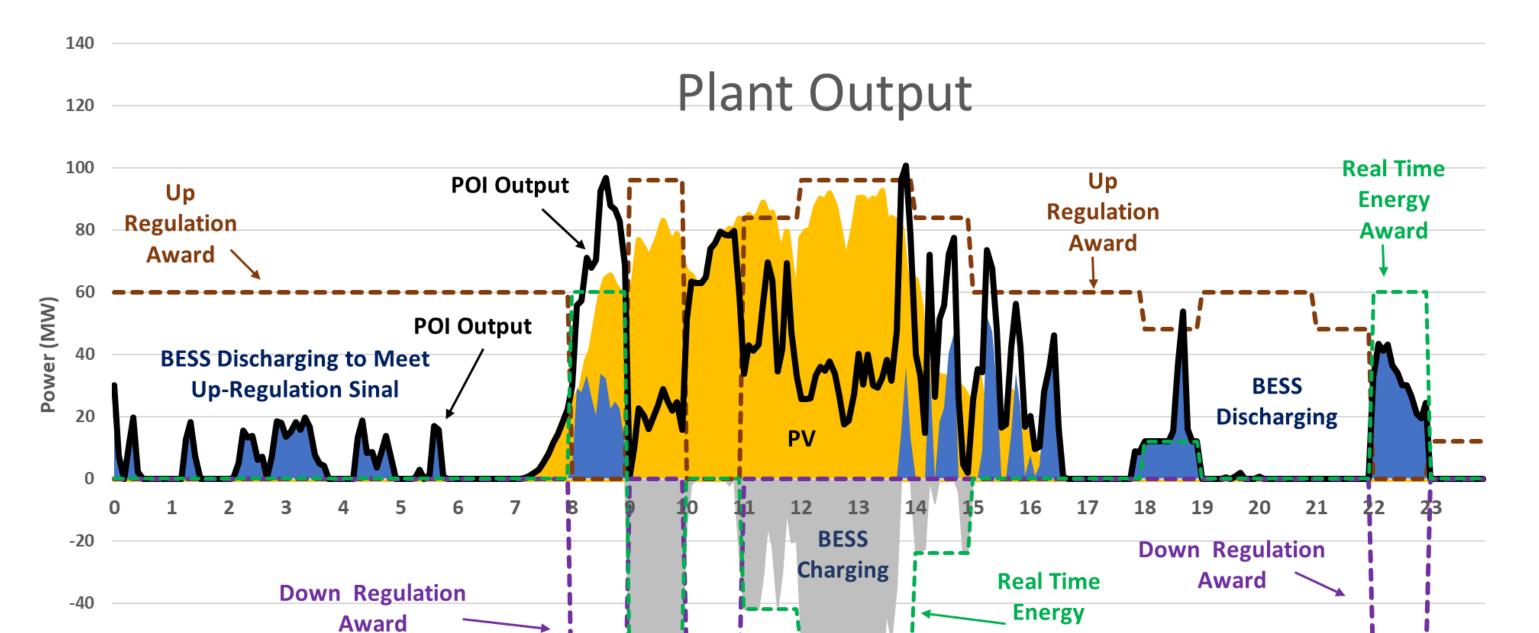


Plant Controls Enable Grid Services with Superior Performance

Power Electronics Enable Fast, High Accuracy Dispatch

Hybrid Plant Dispatch Unleashes Full Plant Value





Time of the Day

SOURCES

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ACRONYMS **IBRs: Inverter Based Resources** GFM: Grid Forming Inverters



Terabase Energy, Inc. Berkeley, California, USA www.terabase.energy Mahesh Morjaria, Ph.D. EVP, Plant Operational Technology mmorjaria@terabase.energy

Rajni Burra, Ph.D. VP, Plant Operational Technology rburra@terabase.energy

Award