Is PJM a reliable energy storage resource?

PJM has analyzed its reliability requirements and determined that the electricity demand of customers during a peak summer day spans a 10-hour period. The 10-hour duration requirement does not mean that an energy storage resource such as a battery is required to run at full output for 10 hours in order to be considered a capacity resource.

Why did energy storage investment occur in the PJM region?

This design enhanced the ability of energy storage resources to respond to the grid operator's frequency regulation signals by ensuring the storage resource had available capacity to offer. As a result of this design, a lot of energy storage investment occurred in the PJM region.

How many MW of energy will PJM generate?

Looking forward,PJM's queue of new planned generation includes approximately 2,000 MWof stand-alone energy storage and 4,000 MW of resources that package together both energy storage infrastructure and renewable resources.

Is PJM FERC compliant?

As FERC seeks to level the playing field to include energy storage,PJM already is substantially compliant with two of the four requirements in Order 841,specifically: Energy storage resources already have full access to PJM's technology-neutral Energy,capacity and Ancillary Services markets.

Are PJM batteries attracting new energy resources?

This level of interest serves as a clear indication that the PJM markets are attracting new, innovative clean-energy resources and that the opportunities for energy storage through the PJM market are growing. The economic signal being sent by PJM's system needs will spur the market to develop longer-duration batteries.

Is PJM a ready platform for innovative storage resources?

PJM's markets have proven to be a ready platform for innovative storage resources, and the approximately 300 MW of battery storage capacity in PJM is evidence of that.





About Astrap? Press Release: PowerGEM Acquires Astrap? Consulting The Story of Astrap? Astrap? Consulting was founded in 2005 by Kevin Carden to assume development of SERVM from Southern Company. Since then, Astrap? has continuously enhanced SERVM, which is unique in performing resource adequacy and economic analysis simultaneously, producing ???

| Public 2 PJM(C)2020 Timeline for Energy Storage & Order 841 Acceptance Order Initial proposed PJM Energy Storage Resource (ESR) participation model Live Dec. 3 EL19-100 filing 2. Paper hearing on capacity capability of ESR Order 1. RPM requirement for all resources in tariff Sustained Output Duration and Capacity Capability ("10

and 9.2, section B of this Agreement, each of which is composed of Capacity Storage Resources with the same specified characteristic duration of 4, 6, 8, and 10 hours. The characteristic duration of an Energy Storage Resource Class is the ratio of the modeled MWh energy storage capability of members of the class to the modeled MW power





As part of our FERC filings, the U.S. Energy Storage Association (ESA) and National Resources Defense Council (NRDC) commissioned a study by Astrap? Consulting that provides evidence and supporting data that refutes PJM's arguments about capacity limitations, supporting our arguments that FERC should decline PJM's request.





Kevin Carden 2-15-2019. 2 Executive Summary PJM, IESO, HQ ?Include existing PSH with constraints in NYCA ?Include energy limited resources (DR and PSH) in neighboring regions ?Fractional capacity value = Perfect capacity removed / ???

As FERC seeks to level the playing field to include energy storage, PJM already is substantially compliant with two of the four requirements in Order 841, specifically: Energy storage resources already have full access to PJM's technology-neutral Energy, capacity and Ancillary Services markets. Batteries represent, on average, more than 80



Also, in this type of environment, a utility pays for incremental capacity costs which are included as part of total system costs. However, in structured markets, the cost of energy is the same for all load since energy is priced based on the marginal resource. If the market price of energy is \$800/MWh, then all load must pay this price.





solar and wind resources and energy limited resources such as Battery Energy Storage Systems (BESS). The ELCC of such generating resources is often calculated by determining how much additional load can be served by the resource without negatively impacting key reliability metrics, such as Loss of Load



Method Comparison with 6GW Storage Portfolio: Method: PJM Initial Proposal. Dispatch storage first. Assume no reserves. Issue: Dispatch method not consistent with actual operating practices. Kevin Carden, Astrape August 7, 2020 Capacity Capability Senior Task Force (CCSTF) Reserve Target: 0 MW Storage Hours Needed: 6.77



PJM's Capacity Auction Explained. PJM runs a forward capacity auction???electricity generators and demand response making themselves available to support the grid when most needed in exchange for a capacity payment. In this most recent auction (July 2024), the capacity price for most of PJM jumped by eight times, to \$269.92/MW-day or \$8/kW-month.





For a potential investor in battery storage technology, Brattle experts analyzed PJM's real-time market participation rules for storage. We developed a real-time energy and ancillary service bidding strategy that the asset owner could employ to nearly optimize storage operations, given expectations for prices and battery operations and constraints looking ???

PJM Interconnection has long recognized the unique value of energy storage technology and welcomed its development. PJM is working to ensure that energy often based on price signals from the PJM energy and capacity markets. There are approximately 90 MW of aggregated water heater capacity registered to participate in the PJM markets, and



Kevin Carden is the director and Nick Wintermantel is a principal of Astrape Consulting. the economic benefits of reserve capacity go beyond avoiding load-shed events to include reducing high-cost emergency purchases, the dispatch of energy-limited (e.g., intermittent, storage, etc.)





Capacity Value of Energy Storage in PJM ??? Policy Brief As part of our FERC filings, the U.S. Energy Storage Association (ESA) and National Resources Defense Council (NRDC) commissioned a study by Astrap? Consulting that provides evidence and supporting data that refutes PJM's arguments about capacity limitations,

Kevin Carden (ASTRAPE CONSULTING), Energy Storage Capacity and Flexibility Value & Renewable Integration; Daniel Burke (EEE RAWG), Wind and Solar PV Participating in the GB Capacity Market; IEEE LOLE, Multi-Area Reliability Assessment with Variable Energy Resources and Optimal Importance Sampling based on Monte Carlo Markov Chains



PJM(C)2019 PJM Energy Storage Participation Model: Energy Market Laura Walter MIC: Special Session ESR cost offers March 15, 2019 . 22 PJM(C)2019 841 Requirements 1. Can sell* energy, Capacity, and A/S (incl. Black Start etc.) The participant determines the value of energy ??? But what about mitigation?





Solar-plus-storage has 99.8% of the capacity value of a theoretical "perfect generator" in California's CAISO grid region. That's the finding of a study commissioned by California's three major utilities, based on a 500-MW solar farm paired with 500 MW of 4-hour storage, with a 500-MW interconnection.. A similar result emerged from a study of stand-alone ???

MW of Energy Storage in PJM Energy Storage Resources in PJM Other Storage is about ~300 MW of mostly batteries. Pumped Hydro currently participates in capacity, energy, regulation and reserves. 50% Connected to the Bulk Electric System. 50% Batteries connected to the distribution system. value a resource can provide. ELCC



Kevin Carden Nick Wintermantel Astrap? Consulting. 1 INTRODUCTION To inform the CPUC's development of the 2019-2020 Reference System Portfolio for its The capacity value of energy storage is dependent on the volume of renewable capacity in the system. The following table summarizes the projected wind and solar capacity and energy in

OF ENERGY STORAGE IN PJM

KEVIN CARDEN CAPACITY VALUE

NYISO procures enough storage to meet the recently announced New York State's Energy Storage Roadmap goal of 6 GW of storage by 2030 (as identified in the 2022 State of the State Report), 1 the reliability contribution expected from storage will be ???

PJM this week filed a proposal to facilitate the participation of energy storage resources in the capacity, energy and ancillary services markets in compliance with Order No. 841 of the Federal Energy Regulatory Commission (FERC).. The order, issued in February, requires all regional transmission organizations (RTOs) and independent system operators (ISOs) to ???

increase due to their diversity benefit with higher penetrations of energy storage on the system; by 2026, most of their incremental capacity value is from these interactive effects with other resources. In-state wind ELCCs increase as solar and storage additions move reliability need into more favorable time periods











PJM Interconnection has long recognized the unique value of energy storage technology, welcomed its development, and is working to make sure that storage can become an integral part of a more reliable, cost-efficient grid with ever-more renewable resources. and the approximately 300 MW of battery storage capacity in PJM is evidence of that



To calculate the capacity credit of energy storage resources using the capacity value methodology, a "base" case of the system is first established. This involves calibrating SPP to an industry standard of reliability of 0.1 Loss of Load Expectation (LOLE). Once the "base"