#### How much does a storage energy capacity cost?

We estimate that cost-competitively meeting baseload demand 100% of the time requires storage energy capacity costs below \$20/kWh. If other sources meet demand 5% of the time,electricity costs fall and the energy capacity cost target rises to \$150/kWh.

Is energy storage a viable resource for future power grids?

With declining technology costs and increasing renewable deployment, energy storage is poised to be a valuable resource on future power grids--but what is the total market potential for storage technologies, and what are the key drivers of cost-optimal deployment?

How much energy is stored in the world?

Worldwide electricity storage operating capacity totals 159,000 MW,or about 6,400 MW if pumped hydro storage is excluded. The DOE data is current as of February 2020 (Sandia 2020). Pumped hydro makes up 152 GW or 96% of worldwide energy storage capacity operating today.

How much does energy capacity cost?

Ranges of storage power capacity costs (\$0-\$2,000/kW) and energy capacity costs (\$0-\$300/kWh)were used as simulation inputs, in order to cover a variety of cost combinations for current and potential future technologies.

What is the current energy storage capacity of a pumped hydro power plant?

The DOE data is current as of February 2020 (Sandia 2020). Pumped hydro makes up 152 GWor 96% of worldwide energy storage capacity operating today. Of the remaining 4% of capacity, the largest technology shares are molten salt (33%) and lithium-ion batteries (25%).

What is the market potential of diurnal energy storage?

The market potential of diurnal energy storage is closely tied to increasing levels of solar PV penetration on the grid. Economic storage deployment is also driven primarily by the ability for storage to provide capacity value and energy time-shifting to the grid.





alifornia's electricity. Further, since 2010, alifornia has procured 1,514 MW of new energy storage capacity to support grid operations. Also in 2010, California became the first U.S. state to mandate energy storage procurement with targets imposed on the state's three investor-

The caps, a constraint on how much an LSE can rely on resources with different energy and duration limits to meet its capacity needs, limit the LSE's exposure to shortages in one type of resource (particularly storage resources), but they do not efficiently identify when those resources stop adding capacity value to the system.



new resource adequacy criteria for the energy transition: modernizing reliability requirements page 5 The figure illustrates the trade-off between resource adequacy as a function of added capacity (x-axis) and cost (y-axis).





energy storage (ES) and supply-side demand response (DR) resources. A resource's Qualifying Capacity (QC) is the number of Megawatts eligible to be counted towards meeting a load serving entity's (LSE''s) System and Local Resource Adequacy (RA) requirements, subject to ???



Storage Resources Value of ESRs in providing grid services. requirements to allow ISO to limit infeasible schedules Add linking constraint to increase ability to operate resource in combined Lannoye et al, Energy Storage Capacity Value Estimation, EPRI, Palo Alto, CA:



841 Requirements 1. Can sell\* energy, Capacity, and A/S (incl. Black Start etc.) the resource is technically capable of providing 2. Dispatched and sets price as seller and buyer 3. Bid parameters that account for ESR characteristics 4. Min market threshold is 100 kW 5. Stored MWh are billed at LMP as wholesale \* "Eligible to provide???"





A Battery Energy Storage Task Force was established in 2019 to identify key topics and concepts for the integration of Energy Storage Resources in ERCOT. The task force is developing Nodal Protocol Revision Requests (NPRRs) that will address technical requirements, modeling needs and market rules for these resources. The policy recommendations can be found in this section.



? India has set a target to achieve 50% cumulative installed capacity from non-fossil fuel-based energy resources by 2030 and has pledged to reduce the emission intensity of its GDP by 45% by 2030, based on 2005 levels. (NEP) 2023 of Central Electricity Authority (CEA), the energy storage capacity requirement is projected to be 82.37 GWh (47.



Energy capacity in the country in order to satisfy the peak electricity demand. 3.2. As per NEP2023 the energy storage capacity requirement is projected to be 16.13 GW (7.45 GW PSP and 8.68 GW BESS) in year 2026-27, with a storage capacity of 82.32 GWh (47.6 GWh from PSP and 34.72 GWh from BESS). The energy storage capacity





Peaking Capacity: Energy storage meets short-term spikes in electric system demand that can otherwise require use of lower-efficiency, higher-cost generation resources. Maximizing Renewable Energy Resource: Energy storage reduces curtailment of renewable generation resources and maximizes their contribution to system reliability.

Capacity Market Capability of Energy Storage Resources. ??? If granted CIRs the storage unit can elect to offer into RPM having met the requirements for offers ??? IA: ISA or WMPA ??? BRA: Facilities Study Agreement > 20 MW or Impact Study Agreement <= 20 MW ??? a Capacity Storage or Intermittent Resource shall satisfy the



also relied upon in several cases to help meet local capacity resource requirements and there are additional opportunities expected in the future. Given the unique characteristics of energy storage resources compared to traditional energy generation or load resources, new market rules and changes to the ISO's





1. As the resource mix changes and decarbonizes, so do the system needs for reliability. The proliferation of variable renewable energy, energy storage, flexible load, and fossil retirements are altering the way resource adequacy analysis needs to be conducted and the way it is translated to procurement decisions and capacity accreditation. 2.



Tx15. Develop policy for ESR s used for capacity, energy and transmission. Tx16. Coordinate interconnection, deliverability and transmission planning studies. Tx17. Develop policy regarding upgrade costs for ESRs used for transmission and capacity Tx18. Determine appropriateness of capacity resource cost recovery in transmission charges. Tx19.



fleet with energy limited resources require industry to consider both capacity requirements and energy adequacy, and by extensionfuel availability. Even if sufficient capacity is available, a level of certainty in, the delivery of fuel is required to ensure ???





In response to the order, each market operator specified a minimum duration for storage resources to meet or exceed to qualify as peaking capacity. In this work, we assess the impacts of minimum storage duration requirements on energy storage buildout and system operation through 2050 in the United States electricity grid.

In July 2021 China announced plans to install over 30 GW of energy storage by 2025 (excluding pumped-storage hydropower), a more than three-fold increase on its installed capacity as of 2022. The United States'' Inflation Reduction Act, passed in August 2022, includes an investment tax credit for sta nd-alone storage, which is expected to



Duration requirements for storage capacity credit reflect this limitation of energy storage, but they also strongly influence the cost-competitiveness of storage resources. Batteries with shorter durations cost less than those with longer durations, so regions with shorter duration requirements will be more favorable to battery storage as a





This project studied the value of long duration energy storage (LDES) to support decarbonization at three geographic levels: (a) meeting Senate Bill 100 (De Len, Chapter 312, Statutes of 2018) and statewide electric sector decarbonization planning, (b) providing local capacity and criteria air pollutant reductions in a Los Angeles Basin case

elevated load but as the amount of energy storage resources on CAISO's system is increased, the gross load shape flattens. The incremental energy storage resources are then expected to serve 3 The energy storage capacity values shown in Table 2 are a result of an updated analysis by Astrap? and are not



Capacity: With more than 32,000 MW of capacity, the regional power system appeared to have enough capacity to satisfy the forecasted winter peak demand of 21,197 MW plus reserve requirements. Energy: However, a historic two-week cold snap and winter storms severely challenged the power system's actual performance. The cold forced some





further New York's Clean Energy Standard requirements of 50% renewable generation by 2030 and a 40% reduction in carbon emissions compared to 1990 levels, Governor Cuomo launched an initiative to deploy 1,500 megawatts of energy storage by 2025 on a path toward a 2030 energy storage goal that the Public Service Commission will

Storage technologies. Pumped storage resources act as load while using energy to pump water to higher elevation reservoirs, and then act like generators by creating energy when releasing water back to lower reservoirs.. Non-generator resources (NGR) have the capability to serve as both generation and load and can be dispatched to any operating level within their ???



system resource adequacy requirements Depending on the resource type, derating factors are a function of one or ??? A resource's capacity accreditation is used both for ICAP Market payments as well as the current derating factor for Energy Storage Resources (ESRs) uses an Unavailability Factor calculated as an average of the