LDES NATIONAL CONSORTIUM

Common Terminology

O-Z

The National Consortium for the Advancement of Long Duration Energy Storage (LDES) Technologies

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Table of Contents

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Term	Definition	Source
"Off-grid system"	An energy generation or storage system that is not connected to the main electrical grid, typically used to provide power to remote locations or for backup power during grid outages. As a result, they are often helpful in remote locations where it is not practical or feasible to connect to the grid. They're also popular among homeowners who want to be completely independent of the grid. Off-grid systems are often entirely independent and rely on battery storage.	EcoFlow https://blog.ecoflow.com/us/differences-between-on-grid-off-grid-solar-system/
"Offshore wind"	Offshore wind power or offshore wind energy is the energy taken from the force of the winds out at sea, transformed into electricity and supplied into the electricity network onshore.	National Grid https://www.nationalgrid.com/stories/energy-explained/what-offshore-wind-power
"Onshore wind"	Onshore wind power refers to wind turbines constructed and situated on land.	National Grid https://www.nationalgrid.com/stories/energy-explained/what-offshore-wind-power

"Operating reserve"	Operating reserve (OR) is stand-by power or demand reduction that can be called on with short notice to deal with an unexpected mismatch between generation and load. Operating reserves are the electricity supplies that are not currently being used but can be quickly available in the case of an unexpected loss of generation. Typically an operating reserve can be received within 30 minutes and is power that is typically derived from: • Generators that are synchronized (connected) to the power grid or offline; or • Certain loads, designated as demand side response, which can be removed from the grid	PJM https://learn.pjm.com/three-priorities/buying-and-selling-energy/ancillary-services-market/reserves
"Organic phase change material"	An organic phase change material (PCM) possesses the ability to absorb and release large quantity of latent heat during a phase change process over a certain temperature range.	Science Direct https://www.sciencedirect.com/science/article/pii/S0040603112001773#:~:text=An%20organic%20phase%20change%20material,and%20industrially%20in%20many%20applications.

"Original equipment manufacturers (OEMs)"	OEM, or original equipment manufacturer, is a broad term that describes a web of relationships among IT hardware vendors, hardware component makers, software vendors and channel partners such as resellers and distributors. In the past, OEM referred to the company that originally built a given product, which was then sold to other companies to rebrand and resell. Over time, however, the term has become a label used to describe a variety of companies -- and relationships among companies -- in an increasingly complex IT supply chain. OEM relationships frequently overlap among companies bringing IT products to market. It is not uncommon for a company to act as an OEM and sell systems to other OEMs at the same time. This fluidity makes for ambiguous relationships as lines blur among product designers, manufacturers and resellers.	Tech Target https://www.techtarget.com/searchitchannel/definition/OEM
"Peak capacity"	The capacity of generating equipment intended for operation during the hours of highest daily, weekly or seasonal loads.	EIA https://www.eia.gov/tools/glossary/index.php?id=P
"Peaking demand"	Capacity of generating equipment normally reserved for operation during the hours of highest daily, weekly, or seasonal loads. Some generating equipment may be operated at certain times as peaking capacity and at other times to serve loads on an around-the-clock basis.	EIA https://www.eia.gov/tools/glossary/index.php?id=P

“Peak load”	The maximum load during a specified period of time.	EIA https://www.eia.gov/tools/glossary/index.php?id=P
“Peak matching”	Peak matching is done by power plants to meet the highest electricity use during the day. Demand typically peaks for power grids at a relatively predictable time, depending on culture, weather and geographic location.	Energy Education https://energyeducation.ca/encyclopedia/Dispatchable_source_of_electricity

"Peak shaving"	The practice of reducing energy demand during peak hours by using stored energy or other resources, helping to alleviate stress on the grid. Sometimes called "load shedding," peak shaving is a strategy for avoiding peak demand charges by quickly reducing power consumption during a demand interval. In some cases, peak shaving can be accomplished by switching off equipment with a high energy draw, but it can also be done by utilizing separate power generation equipment, such as on-site battery storage system. This secondary system can be used to temporarily power a facility or specific equipment during on-peak times. Using energy submeters to carefully monitor real-time consumption is required to know precisely when to either shut down or switch to a different energy source. By engaging battery or other power during periods of high demand, the need for grid power is instantly lowered to below the threshold of additional peak demand charges. Unlike load shifting, energy-intensive equipment can continue to run during on-peak times so that disruptions to schedules or production are minimized while saving energy and money.	AccueEnergy https://www.accuenergy.com/articles/what-is-peak-shaving-and-load-shaving/

“Peaker plant”	Any combustion-based power plant that operates less than 20 percent of year, known as the plant’s capacity factor, and has a power rating of at least 10 MW; A power plant that operates only during periods of high electricity demand, often fueled by natural gas or other fossil fuels, providing additional generation capacity to help maintain grid stability and meet peak load requirements.	Renewable Energy World https://www.renewableenergyworld.com/policy-regulation/peaker-power-plant-data-show-persistent-economic-and-racial-inequities/#gref
“Phase change”	A phase change is when matter changes to from one state (solid, liquid, gas, plasma) to another. These changes occur when sufficient energy is supplied to the system (or a sufficient amount is lost), and also occur when the pressure on the system is changed. The temperatures and pressures under which these changes happen differ depending on the chemical and physical properties of the system. The energy associated with these transitions is called latent heat.	Energy Education https://energyeducation.ca/encyclopedia/Phase_change#:~:text=A%20phase%20change%20is%20when,on%20the%20system%20is%20changed.

"PJM Interconnection"	PJM Interconnection is the RTO that coordinates the movement of electricity through all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia. PJM includes both an energy and a capacity market. The PJM Energy Market procures electricity to meet consumers' demands both in real time and in the near term. It includes the sale or purchase of energy in PJM's Real-Time Energy Market (five minutes) and Day-Ahead Market (one day forward). PJM's capacity market, called the Reliability Pricing Model, ensures long-term grid reliability by securing the appropriate amount of power supply resources needed to meet predicted energy demand in the future.	PJM www.pjm.com
"Planning reserve margin" (PRM)	PRM is designed to measure the amount of generation capacity available to meet expected demand in the planning horizon. PRM is designed to measure the amount of generation capacity available to meet expected demand in planning horizon. Coupled with probabilistic analysis, calculated PRMs have been an industry standard used by planners for decades as a relative indication of adequacy. PRM equals the difference in deliverable or prospective resources and net internal demand, divided by net internal demand. Deliverable resources are calculated by the sum of existing, certain and future, planned capacity resources plus net firm transactions. Prospective resources include deliverable resources and existing, other resources.	NERC https://www.nerc.com/pa/RAPA/ri/Pages/PlanningReserveMargin.aspx#:~:text=Planning%20reserve%20margin%20is%20designed,a%20relative%20indication%20of%20adequacy.

"Power (kW)"	Can be thought of as rate of flow of electricity. Power applications involve relatively shorter discharge durations (seconds to minutes) with fast recharging and often require many cycles per day. Applications include frequency and voltage regulation, power quality, renewables generation smoothing and ramp rate control and trackside regulation for electric rail operators.	Power Sonic https://www.power-sonic.com/blog/kw-vs-kwh-explained/
"Power capacity"	The maximum instantaneous amount of electric power that can be generated on a continuous basis and is measured in units of watts (kilowatts [kW], megawatts [MW], or gigawatts [GW])	US Energy Information Administration (EIA) https://www.eia.gov/energyexplained/electricity/energy-storage-for-electricity-generation.php

“Power conversion system”	Battery storage systems release energy in the form of DC or direct current. In a majority of applications, the load is AC-operated. That requires a conversion system, also shortened to PCS. The power conversion device changes DC power to AC or alternating current. AC is a more usable type of electrical current when powering electrical appliances or stabilizing the grid output The PCS primarily consists of a device called an inverter. The typical energy storage system inverter uses a combination of electrical and electronic devices to ensure a smooth transformation of the energy. It also connects to various other parts of the BESS system.	All About Circuits https://www.allaboutcircuits.com/industry-webinars/energy-storage-and-power-conversion-system-pcs-test-regulations-and-requirements/#:~:text=A%20Power%20Conversion%20System%20(PCS,and%20off%2Dline%20switching%20functions.
“Power factor”	Power Factor is the relation between apparent power and active power. Inefficient systems tend to have more apparent power than active power, leading to wastage of energy and possibilities of equipment damages.	Smart Energy International https://www.smart-energy.com/industry-sectors/smart-grid/what-is-power-quality-and-why-is-it-important/#:~:text=Power%20quality%20refers%20to%20the,system%20shutdown%2C%20and%20data%20loss
“Power Flow Controller (PLC)”	A Grid Enhancing Technology; a hardware or software device that can actively push and pull power by changing the reactance in the lines. This is useful for redistributing power flow in a mesh network to relieve congestion.	Idaho National Laboratory https://inl.gov/national-security/grid-enhancing-technologies/

"Power quality"	A measure of the stability and reliability of the electricity supplied to consumers, including factors such as voltage, frequency, and waveform distortion, which can impact the performance and lifespan of electrical equipment and the overall efficiency of the grid. Power quality refers to the level of consistency, reliability, and stability of electrical power. It is important because any deviation from the expected levels of power quality can cause negative consequences such as equipment damage or malfunction, system shutdown, and data loss. Poor power quality can also lead to lower operational efficiency and higher maintenance costs.	Smart Energy International https://www.smart-energy.com/industry-sectors/smart-grid/what-is-power-quality-and-why-is-it-important/#:~:text=Power%20quality%20refers%20to%20the,system%20shutdown%2C%20and%20data%20loss
"Power rating"	The maximum amount of power that an energy storage system can deliver, typically measured in kilowatts (kW) or megawatts (MW), or the maximum rate of discharge that the BESS can achieve, starting from a fully charged state.	NREL https://www.nrel.gov/docs/fy19osti/74426.pdf
"Power to gas"	Power-to-Gas (P2G) is the process of converting surplus renewable energy into hydrogen gas through PEM electrolysis technology. The hydrogen can then be injected into the natural gas grid. In doing so, the hydrogen can displace natural gas, reducing greenhouse gas emissions and reliance on high-carbon fuels. P2G is an effective means of transitioning to a 'greener' natural gas mix.	NelHydrogen https://nelhydrogen.com/market/power-to-gas/#:~:text=Power%2Dto%2DGas%20(P2G,into%20the%20natural%20gas%20grid.

"Private equity firm"	Typically a follow-on investor; private equity is ownership or interest in entities that aren't publicly listed or traded. A source of investment capital, private equity comes from firms that buy stakes in private companies or take control of public companies with plans to take them private and delist them from stock exchanges. Private equity can also come from high-net-worth individuals eager to see outsized returns.	Investopedia https://www.investopedia.com/articles/financial-careers/09/private-equity.asp
"Purchase power agreement (PPA)"	A power purchase agreement (PPA) is a contractual agreement between energy buyers and sellers. They come together and agree to buy and sell an amount of energy which is or will be generated by a renewable asset. PPAs are usually signed for a long-term period between 10-20 years. A PPA is a contract between an energy producer and an energy buyer, specifying the terms for the sale of electricity, including price, volume, and duration.	Pexapark https://pexapark.com/solar-power-purchase-agreement-ppa/

"Pumped hydro energy storage hydro power (PHES)"	A large-scale energy storage technology that uses water and gravity to store and release energy. Pumped-storage hydroelectric (PSH) systems are the oldest and some of the largest (in power and energy capacity) utility-scale ESSs in the United States and most were built in the 1970's. PSH systems in the United States use electricity from electric power grids to operate hydroelectric turbines that run in reverse to pump water to a storage reservoir. When needed, the water is sent back down through the turbines to generate electricity. PSH systems are generally operated most often during summer months to help meet daily peaks in electricity demand that are often the result of increases in cooling demand by utility customers. Excess electricity is used to pump water from a lower reservoir to an upper reservoir, and the stored energy is released by allowing the water to flow back down through a turbine, generating electricity. In 2022, the United States had 40 PSH systems operating in 18 states with a combined total nameplate power capacity of about 22,008 MW. Five states—California, Georgia, Michigan, South Carolina, and Virginia—combined, had 61% of the total U.S. PSH nameplate power generation capacity in 2022, and they accounted for about 67% of total gross electricity generation from PSH facilities in 2022.	US Energy Information Administration (EIA) https://www.eia.gov/energyexplained/electricity/energy-storage-for-electricity-generation.php

“Purchase power agreement (PPA)”	A Power Purchase Agreement (“PPA”) is generally the primary contract between the public and private sector parties which underpin a power sector PPP. It is typically between a public sector purchaser "offtaker" (often a state-owned electricity utility, in jurisdictions where the power sector is largely state operated) and a privately-owned power producer. It usually provides the primary revenue stream which underwrites the PPP project. Therefore, the structure and risk allocation regime under the PPA is central to the private sector participant’s ability to raise finance for the project, recover its capital costs and earn a return on equity. This summary is focused on a base load thermal plant developed pursuant to a PPP. While certain elements may be common across all PPAs, different considerations would apply for mid-range or peaking thermal plants or plants using different generation technology (e.g. wind or solar).	World Bank https://ppp.worldbank.org/public-private-partnership/sector/energy/energy-power-agreements/power-purchase-agreements
“Racks and encloser”	A battery storage system is primarily a set of batteries connected. These are then placed on racks to secure them after installation. The batteries are large-sized and housed in large enclosures in an industrial battery energy storage system. Battery enclosures in large installations typically have cooling systems. That’s because such storages generate heat, which, if uncontrolled, could reach catastrophic levels.	IGOYE https://igoyeenergy.com/battery-energy-storage-system-components/#:~:text=A%20battery%20storage%20system%20is,installations%20typically%20have%20cooling%20systems.

"Ramping"	Ramping refers to a change in power flow (or power generation) from one time unit to the next. Ramping restrictions limit the allowed net flow variations on consecutive hours on specific lines. Ramping restrictions include information about flow in the last hour from the previous day in the calculation.	NORD Pool https://www.nordpoolgroup.com/en/trading/Day-ahead-trading/Ramping/
"Ramp rate"	The speed at which a storage system can increase or decrease output (e.g., 5% per minute systems can increase or decrease discharge at a rate of 5% per minute). Ramp rate is essentially the speed at which a generator can increase (ramp up) or decrease (ramp down) generation. Generating units have different characteristics, making some more suited to supplying certain needed functions.	DOE https://www1.eere.energy.gov/solar/pdfs/50060.pdf

"Reactive power"	Reactive power is the power, measured in VAR or kVAR, released and stored by capacitors and inductors. It is the power that flows back into the source from the inductors and capacitors. It is this opposing power that affects the power factor of a circuit. In a circuit with reactive components, the voltage and current are out of phase. For inductive circuits, the current lags the voltage (see Figure 2). Power is being absorbed by the circuit at those times when the voltage and current are in the same direction (both positive or both negative). Power is returned to the source when the voltage and current are not in the same direction (one positive and one negative). Reactive power is the portion of electricity that is used to maintain the magnetic fields in inductive loads, such as motors and transformers, and is essential for maintaining voltage stability on the electrical grid. Reactive power is measured in volt-amperes reactive (VAR) and is typically provided by generators, capacitors, or grid-support devices.	EE Power https://eepower.com/technical-articles/transformer-power-ratings/
"Reactive power controller"	The reactive power controller aims to maintain the reactive power output constant at the given reference value within the permissible voltage range.	Science Direct https://www.sciencedirect.com/topics/engineering/reactive-power-controller

"Recloser"	A recloser is an automatic, high-voltage electric switch. Like a circuit breaker on household electric lines, it shuts off electric power when trouble occurs, such as a short circuit. Where a household circuit breaker remains shut off until it is manually reset, a recloser automatically tests the electrical line to determine whether the trouble has been removed. And, if the problem was only temporary, the recloser automatically resets itself and restores the electric power. On high-voltage electric lines, 80 to 90 percent of trouble occurrences are temporary – such as lightning, windblown tree branches or wires, birds, or rodents – and will, by their very nature, remove themselves from the electric line if the power is shut off before permanent damage occurs to the lines. The recloser senses when trouble occurs and automatically shuts off the power. An instant later (the length of time may be noticeable only as a lightbulb flicker), the recloser turns the power back on, but if the trouble is still present, it shuts it off again. If the trouble is still present after three such tries, the recloser is programmed to consider the problem permanent and it remains off. A power company crew must then repair the problem on the line and reset the recloser to restore power	Eaton https://www.eaton.com/content/dam/eaton/products/medium-voltage-power-distribution-control-systems/reclosers/recloser-definition-information-td280027en.pdf

"Redox flow battery"	A type of rechargeable battery that stores energy in liquid electrolytes, which are pumped through a cell stack to produce electricity. RFBs are known for their long cycle life, scalability, and the ability to separate energy capacity from power output. Redox flow batteries, also called redox flow battery, flow battery or liquid battery, provide electrical energy from liquid electrolyte solutions, often based on the heavy metal vanadium. The difference to the rechargeable battery (also called accumulator) is the spatial separation between the two stores of the redox flow battery, each containing electrolyte liquids of different concentrations, and the energy converter, whose cells consist of a membrane and two electrodes. These cells process the electrolyte liquid in a chemical reaction that provides usable electrical energy. This reaction is reversible, so that with the help of electrical energy, for example from renewable sources, the electrolyte fluid returns to its original initial concentration and can thus provide electrical energy again in the next step. A sustainable cycle is created that can be used to store electricity.	Dilico https://www.dilico.de/en/redoxflow.php

"Regenertative fuel cell"	A regenerative fuel cell (RFC) sometimes referred to as a "reversible fuel cells" is a hydrogen accumulator which is charged via an electrolyzer (electricity conversion into H2) and discharged via the fuel cell (H2 conversion into electricity), where the storage media is pressurized hydrogen. The also generated oxygen is mostly not stored in terrestrial applications. There are discrete RFCs (DRFC) consisting of two separate stacks (electrolyzer and fuel cell) and unitized RFCs (URFC) with one single stack working during charge in electrolysis mode and during discharge in fuel cell mode. URFCs show a high specific energy up to 1500 Wh kg−1. Furthermore, it is possible to optimize the power and energy of the system independently, which is important for seasonal storage of larger amounts of energy. In contrast to conventional electrochemical accumulators the discharge power of RFCs is unaffected by the state-of-charge of the system. But unfortunately, due to the long conversion chain with associated losses, RFCs generally have low levels of efficiency compared to conventional electrochemical accumulators	Science Direct https://www.sciencedirect.com/science/article/abs/pii/B9780128194249000070#:~:text=A%20regenerative%20fuel%20cell%20(RFC,not%20stored%20in%20terrestrial%20applications.

“Regional Transmission Organization [RTO]”	FERC Order No. 888 promoted the concept of independent system operators (ISOs). Along with facilitating open-access to transmission, ISOs operate the transmission system independently of, and foster competition for electricity generation among, wholesale market participants. Several groups of transmission owners formed ISOs, some from existing power pools. In Order No. 2000, the Commission encouraged utilities to join regional transmission organizations (RTOs) which, like an ISO, would operate the transmission systems and develop innovative procedures to manage transmission equitably. Each of the ISOs and RTOs have energy and ancillary services markets in which buyers and sellers could bid for or offer generation. The ISOs and RTOs use bid-based markets to determine economic dispatch. While major sections of the country operate under more traditional market structures, two-thirds of the nation’s electricity load is served in RTO regions.	FERC https://www.ferc.gov/electric-power-markets

“Regulating reserve”	Regulating reserve is capacity comprising sources of supply whose output can be increased (ramped up or incremented) or decreased (ramped down or decremented) within a few seconds in response to a control signal from the system operations energy management system. Regulating reserve is a defined ancillary service although it may be described using other terms including automatic generation control (AGC), frequency control, frequency regulation, regulation reserve, or as two services called regulation up and regulation down. Resources providing regulating reserve have a very short response time, frequently as short as a few seconds. Unlike other reserves that typically are only used in response to contingencies, regulating reserve is used throughout an operating hour to maintain system frequency in response to fluctuations in loads and in output from variable generation resources.	Energy KnowledgeBase https://energyknowledgebase.com/topics/regulating-reserve.asp
“Regulation”	Fast response to random, unpredictable variations in demand and generation, with a duration of service in the 15 minutes to 1 hour range.	NREL https://www.nrel.gov/docs/fy19osti/74426.pdf

“Renewable energy integration”	The process of incorporating renewable energy sources, such as solar, wind, and hydropower, into the electrical grid, including the development of policies, infrastructure, and technologies to facilitate the efficient, reliable, and cost-effective operation of these resources. Sources of renewable energy, such as water and geothermal, can generate steady and consistent energy to meet baseload power needs, which is the minimum amount of power the grid needs at any given time. These renewables function similar to fossil fuel plants which are able to provide reliable power to meet changing customer demands. However, the amount of energy generated from other renewables, like wind and solar sources, can vary significantly throughout the day, the season, and in different locations. That’s because these renewables rely on resources—wind and sunshine—that fluctuate and are not available everywhere at all times. This is an important consideration because the amount of electricity fed into the grid must always be equal to the amount of electricity used or taken out the grid. Imbalances in grid power can lead to power outages. The increasing reliance on renewable sources for energy requires a flexible grid and new approaches to balance power supply and demand.	PNNL https://www.pnnl.gov/explainer-articles/renewable-integration

"Renewable Portfolio Standard (RPS)"	A policy that requires electricity suppliers to obtain a specified percentage of their electricity from renewable sources, promoting the growth of renewable energy markets and reducing greenhouse gas emissions. Called the Renewables Portfolio Standard (RPS), the policy promotes renewable energy in a way that is compatible with competitive electricity markets, whether wholesale or retail. The RPS promises to contribute to a renaissance of renewable energy markets. Effectively implemented, the RPS policies already adopted will support the development of several thousand megawatts of new renewable energy capacity over the next decade, and help maintain renewable facilities that are already on line. The success of the RPS in some states, particularly Texas, is likely to spur additional interest in the policy in other states and in Congress. By contrast, different results in other RPS states will illustrate the importance of careful policy design.	DOE https://www.energy.gov/oe/articles/renewables-portfolio-standard-renewables-portfolio-standard#:~:text=The%20RPS%20is%20a%20policy,and%20various%20forms%20of%20biomass

"Reserve capacity"	Reserve capacity is a backup energy generation capacity that is used by the electric grid in the occurrence of unexpected fault such as the unavailability of a power plant. Reserve capacity provides the extra generating capacity available to meet peak or abnormally high demands for power and to generate power during scheduled or unscheduled outages. Units available for service, but not maintained at operating temperature, are termed "cold." those units ready and available for service, though not in actual operation, are termed "hot." Energy storage systems have the ability to provide this service and are used to offset or reduce costs incurred for generation of reserve capacity. This service has three categories which include the following: • Spinning reserve: Also referred as synchronized reserve, this type of reserve capacity is the first one used during the occurrence of a shortfall. It is an unloaded online generation capacity used for compensation of transmission or generation outage. It has a response time of 10 min. • Supplemental reserve: This type of reserve capacity is used after spinning reserve. It may be an offline generation capacity, which can respond within 10 min. • Back supply: It is considered as a backup for both supplemental and spinning reserves.	Science Direct https://www.sciencedirect.com/topics/engineering/capacity-reserve

"Reservoir thermal energy storage (RTES)"	Reservoir thermal energy storage (RTES) is a type of underground energy storage. RTES systems store hot or cold water for later use (seasonally or longer).	Science Direct https://www.sciencedirect.com/science/article/pii/S0375650519304729
"Resilience"	Resilience also typically includes more extreme, rare events that go beyond "reasonable" outages considered in resource adequacy and operational reliability. Resilience can address both energy and grid capabilities. The ability of an energy system, such as a building, community, or electrical grid, to withstand and recover from disruptions, ensuring a continuous and reliable supply of energy during and after adverse events. The ability of the electrical grid to withstand and quickly recover from disturbances, such as natural disasters or equipment failures, ensuring a continuous supply of electricity to consumers. Resilience is typically measured by how quickly power can be restored after an outage.	NREL https://www.nrel.gov/research/power-system-resilience.html

"Resource adequacy"	One of the most important aspects of grid reliability is resource adequacy, or the ability of a power system to supply enough electricity—at the right locations—to keep the lights on during all hours of the year. This means system planners must ensure the mix of resources can meet demand during hot summer afternoons and cold winter nights. Resource adequacy is measured by the probability of an outage due to insufficient capacity. It is measured at the system level to capture the overall impact of outages of individual components including generators and transmission. Several metrics are used for resource adequacy. For example, a resource adequacy standard might be less than 1 day in 10 years of outages caused by a lack of generation. Once the target or metric is established, power system planners perform grid simulations of many possible power plant outages under different system conditions to ensure the system can achieve the resource adequacy standard.	NREL https://www.nrel.gov/research/resource-adequacy.html
"Response time"	The time it takes for a system to provide energy at its full rated power (e.g., a system with a 5-minute response time can increase power from zero to full power after five minutes).	*Pathways to Commercial Liftoff: Long Duration Energy Storage* https://liftoff.energy.gov/wp-content/uploads/2023/03/20230320-Liftoff-LDES-vPUB.pdf

"Restructuring / Restructured market"	In the 1990s and early 2000s, a series of state and federal initiatives restructured electric markets. In many areas of the country generation was unbundled from transmission and distribution and competitive markets for energy generation were established. Twenty-four states and the District of Columbia have restructured electricity markets by shifting from service provided through a regulated monopoly to service provided through open competition among the local utilities and their competitors. The restructuring was intended to boost competition and expand consumer choice, increase efficiency, and lower prices	Department of Justice https://www.justice.gov/atr/electricity-restructuring-what-has-worked-what-has-not-and-what-next
"Retail market"	Retail electricity choice in the United States allows end-use customers (including industrial, commercial, and residential customers) to buy electricity from competitive retail suppliers. At present, 13 US states and the District of Columbia have fully restructured retail electricity markets. Some states suspended access to retail electricity choice after the California power crisis of 2000–2001 While residential customer participation rates are low in most of the states with retail electricity choice, a significant number of industrial and commercial customers have switched to competitive service options	NREL https://www.nrel.gov/docs/fy18osti/68993.pdf

"Round-trip efficiency (RTE)"	Round-trip efficiency (RTE) is efficiency of an energy storage system when accounting for both charging and discharging processes, typically expressed as a percentage. RTE is ratio of the energy charged to the battery to the energy discharged from the battery. It can represent the total DC-DC or AC-AC efficiency of the battery system, including losses from self-discharge and other electrical losses. Although battery manufacturers often refer to the DC-DC efficiency, AC-AC efficiency is typically more important to utilities, as they only see the battery's charging and discharging from the point of interconnection to the power system, which uses AC	NREL https://www.nrel.gov/docs/fy19osti/74426.pdf
"Safety system"	Sometimes, the BMS and EMS systems cannot contain the elevated temperature levels. In such situations, a fire suppression system comes in to prevent the flames from propagating. The fire suppression system may rely on various technologies to know when to come on. Standard options are smoke detectors, heat sensors, and specialized gas detectors. In some installations, safety measures include housing the storage in a secure room or enclosure and mounting CCTV cameras. These ensure the system's safe operation and that unauthorized persons do not tamper with its working.	IGOYE Energy https://igoyeenergy.com/battery-energy-storage-system-components/

"SAIDI score"	One metric used to measure the reliability of U.S. electric utilities is the System Average Interruption Duration Index (SAIDI), which measures the total time an average customer experiences a non-momentary power interruption in a one-year period. For utilities that report SAIDI metrics using Institute of Electrical and Electronics Engineers (IEEE) standards, non-momentary interruptions are those lasting longer than five minutes. SAIDI is often paired with the System Average Interruption Frequency Index (SAIFI), an index that measures the frequency of interruptions.	DOE https://www.eia.gov/todayinenergy/detail.php?id=45796
"Salt hydrate"	A salt hydrate is a solid compound that comprises moles of a salt and water. The water molecules are attracted by the salt ions because of the polar nature of water. Consequently, the water molecules get enclosed within the salt crystal lattice. The phase change transformation of salt hydrates involves hydration or dehydration processes. A finite number of hydrates can be formed depending on the ionic structure of the salt, and usually only a few of them (one or two) are thermodynamically stable.	Science Direct https://www.sciencedirect.com/topics/engineering/salt-hydrate#:~:text=A%20salt%20hydrate%20is%20a,within%20the%20salt%20crystal%20lattice.

“Saltwater batteries”	Saltwater batteries are similar in design to other batteries. Much like the name suggests, saltwater batteries use sodium as the primary element for energy storage instead of lithium. That makes these batteries less toxic, but while sodium is abundant, they can be relatively expensive. Saltwater batteries come with a long list of advantages over other battery technologies thanks to the change in element composition. For one thing, saltwater batteries are significantly less flammable than other types of liquid batteries. They also offer improved safety since the batteries don’t use many of the toxic chemicals and acids other batteries rely on.	Aquion Energy https://www.aquionenergy.com/technology/
“Scaling and Selection phase”	The Scaling and Selection phase (2025–2028) proves out which technologies benefit the most from scaling and creates visibility for technology players standing up supply chains for utility-scale deployment (e.g., 100MW+ per year).	*Pathways to Commercial Liftoff: Long Duration Energy Storage* https://liftoff.energy.gov/wp-content/uploads/2023/03/20230320-Liftoff-LDES-vPUB.pdf
“Seasonal”	Multi-day / week LDES.	*Pathways to Commercial Liftoff: Long Duration Energy Storage* https://liftoff.energy.gov/wp-content/uploads/2023/03/20230320-Liftoff-LDES-vPUB.pdf

“Seasonal balancing”	Seasonal energy storage can be used to shift energy from one season to another to accommodate the use of this varying energy throughout the year. Storage of this nature is expected to have output durations from 500 to 1000 hours (21 to 42 days) or more. No clear technological solutions have been demonstrated at scale, although several concepts may be viable—including low-carbon fuels such as hydrogen and ammonia, thermochemical energy storage, or geo-thermal energy storage. As renewables become a larger part of America’s energy mix, the challenge of balancing intermittency will grow exponentially. Eventually, storage could be called upon not only to even out daily fluctuations in energy output, but seasonal variation as well.	*Pathways to Commercial Liftoff: Long Duration Energy Storage* https://liftoff.energy.gov/wp-content/uploads/2023/03/20230320-Liftoff-LDES-vPUB.pdf
“Self-discharge rate”	The rate at which a battery loses stored energy over time when not in use, usually expressed as a percentage per month. Self-discharge occurs when the stored charge (or energy) of the battery is reduced through internal chemical reactions, or without being discharged to perform work for the grid or a customer. Self-discharge, expressed as a percentage of charge lost over a certain period, reduces the amount of energy available for discharge and is an important parameter to consider in batteries intended for longer-duration applications.	NREL https://www.nrel.gov/docs/fy19osti/74426.pdf

"Sensible heat storage"	A thermal LDES technology (e.g., molten salts, rock material, concrete). Sensible heat storage consists of heating a material to increase its internal energy. The resulting temperature difference, together with thermophysical properties (density, specific heat) and volume of storage material, determine its energy capacity. Desirable features of sensible storage materials include large densities, large specific heats, and large temperature differences between the hot and cold states. Key advantages include a low cost of sensible storage materials, high maturity level, and large energy capacities.	Sandia National Laboratories https://www.sandia.gov/ess-ssl/wp-content/uploads/2020/12/ESHB_Ch12_Thermal_Ho.pdf
"Sensitivity cases"	Sensitivity Cases demonstrate durable need for long duration storage applications across a wide array of grid and storage technology outcomes. As the share of variable renewable energies in the power system increases, so does the need for flexibility options. These include, inter alia, energy storage, network optimization and expansion, and demand side management. In this paper, a broad sensitivity analysis is carried out to assess the potential role of innovative electrical energy storage technologies in comparison to well-established ones.	A sensitivity analysis on large-scale electrical energy storage requirements https://elib.dlr.de/143305/1/Moser%20et%20al%20-%20preprint.pdf

"Short duration"	Durations up to 10 hours; shifting power by less than 10 hours, primarily through Li-ion storage.	*Pathways to Commercial Liftoff: Long Duration Energy Storage* https://liftoff.energy.gov/wp-content/uploads/2023/03/20230320-Liftoff-LDES-vPUB.pdf
"Silica gel"	Silica gel has recently been widely studied as a heat storage material. However, most of the research has focused on its heat storage performance in the reactor; the form of water inside silica gel and the specific heat storage mechanism remain to be clarified. Silica gel is highly competitive with other thermochemical heat-storage materials, considering the heat-storage density, reaction difficulty, and cycling performance.	Science Direct https://www.sciencedirect.com/science/article/pii/S0927024822005700#:~:text=The%20theoretical%20heat%2Dstorage%20density,limiting%20step%20for%20the%20reaction.

"Smart grid"	Smart grids are electricity network that use digital technologies, sensors and software to better match the supply and demand of electricity in real time while minimizing costs and maintaining the stability and reliability of the grid. Smart grid technologies are made possible by two-way communication technologies, control systems, and computer processing. These advanced technologies include advanced sensors known as Phasor Measurement Units (PMUs) that allow operators to assess grid stability, advanced digital meters that give consumers better information and automatically report outages, relays that sense and recover from faults in the substation automatically, automated feeder switches that re-route power around problems, and batteries that store excess energy and make it available later to the grid to meet customer demand.	DOE https://www.energy.gov/oe/grid-modernization-and-smart-grid

“Smart inverter”	Smart inverters are an emerging technology that can help integrate solar energy and other distributed energy resources (DERs) into the electric grid. Like traditional inverters, smart inverters convert the direct current output of solar panels into the alternating current that can be used by consumers in their homes and businesses. Smart inverters go beyond this basic function to provide grid support functions, such as voltage regulation, frequency support, and ride-through capabilities. As the number of DERs on the grid increases, the need for additional inverter functionality has grown. Additionally, existing codes and technical standards (e.g., IEEE 1547 and UL 1741) are being updated to ensure that smart inverter capabilities can be fully realized. To unlock the latest inverter functionality, some states are working to incorporate updated codes and standards through months-long processes that are often technical and complex.	IREC https://www.irecusa.org/our-work/smart-inverters/

"Smart meter"	An advanced electronic device that records and communicates detailed information about energy consumption, allowing for more accurate billing, better energy management, and the potential for demand response programs. Millions of smart meters have been installed across the country. Smart meters provide two-way communication between end-use customers and their utility, helping the utility know about blackouts, for example. This helps utilities to maintain more reliable electrical service. Smart meters can also be used with home energy management systems such as Web-based tools that a utility provides or devices that can be installed in an end-user customer's home. Smart meters can display home energy use, help customers find ways to save energy and money, and even allow customers to remotely adjust their thermostat or turn appliances off.	DOE https://www.energy.gov/energysaver/electric-meters
"Social burden"	Social Infrastructure Service Burden (abbr. Social Burden) is defined as the burden to a population for attaining services needed from infrastructure	Sandia National Laboratories https://energy.sandia.gov/wp-content/uploads/2022/12/Social-Infrastructure-Burden-White-Paper_Final.pdf

"Sodium-ion batteries"	Sodium-ion batteries (SIBs), are postulated as the most attractive economical and sustainable alternatives to lithium-ion batteries (LIBs) for light electromobility and large-scale stationary applications. SIBs have attracted much interest as an alternative to lithium-ion batteries for energy storage due to their low cost and natural abundance of sodium resources [14–17]. Furthermore, as nature possesses large amount of sodium and it can provide a replacement for the lithium chemistry, the sodium-ion batteries could be a competitor to the lithium-ion batteries in commercial markets. However, the electrochemical performance of SIBs must be further improved through specific strategies that optimize the cathode active materials in terms of energy density and long-term cycling in line with maintaining their environmental competitiveness.	Science Direct https://www.sciencedirect.com/topics/materials-science/sodium-ion-battery
"Solar energy"	Solar energy provided about 3.4% of total U.S. utility-scale electricity and accounted for 15.9% of utility-scale electricity generation from renewable sources in 2022. Photovoltaic (PV) and solar-thermal power are the two main types of solar electricity generation technologies. PV conversion produces electricity directly from sunlight in a photovoltaic cell. Most solar-thermal power systems use steam turbines to generate electricity. EIA estimates that about 0.06 trillion kWh of electricity were generated with small-scale solar photovoltaic systems.	US Energy Information Administration (EIA) https://www.eia.gov/energyexplained/electricity/electricity-in-the-us.php

“Solid-oxide fuel cells(SOFCs)”	Solid oxide fuel cell (SOFC) is an electrochemical device operating at a high temperature, converting the chemical energy of a fuel directly to electrical energy. Moreover, it can directly convert hydrocarbon fuels to a hydrogen-rich gas via internal reforming inside the fuel cell stack itself. However, the endothermic cooling effect resulting from the reforming reaction at the anode side causes the temperature gradient and thermal stress within the fuel cell stack. This requires an efficient control design for assuring a stability of the system.	Science Direct https://www.sciencedirect.com/topics/chemistry/solid-oxide-fuel-cell
“Solid state batteries”	Solid-state batteries are a huge advancement in battery technology. Most batteries rely on some kind of liquid to allow the transfer of ions across the battery. Solid-state batteries don’t need the liquid but still allow lithium ions to transfer efficiently through the battery. Solid-state batteries tend to be lighter, more efficient, and faster than liquid or gel batteries. The huge advantage of solid-state batteries comes from increased safety. Solid-state batteries can operate safely in a wider range of temperatures. Solid-state electrolytes are also nonflammable, unlike liquid electrolytes. This battery type also has the potential to be lighter, denser, and more powerful than liquid versions. Engineering around these batteries is also easier since they have fewer environmental requirements that need to be managed.	Aquion Energy https://www.aquionenergy.com/technology/

“Southwest Power Pool (SPP)”	SPP is an RTO mandated and regulated by FERC to ensure reliable supplies of power, adequate transmission infrastructure and competitive wholesale electricity prices on behalf of its members. SPP has members in 14 states: Arkansas, Colorado, Iowa, Kansas, Louisiana, Minnesota, Missouri, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas and Wyoming. SPP’s Integrated Marketplace includes a day-ahead market with transmission congestion rights, a reliability unit commitment process, a real-time balancing market replacing the EIS market, and the incorporation of price-based operating reserve procurement. Unlike some other RTOs, SPP does not operate a mandatory all-resource capacity market.	SPP www.swp.org
“Spinning reserves”	Spinning Reserve is the provision of standby “spinning” generation ready to commence generation within a few minutes of receiving a dispatch signal from the grid. The service definition reflects traditional thermal generating assets (e.g., a coal plant) which can take hours to “heat up,” synchronize with the grid power frequency, and begin generation. In recognition of this, spinning reserve generators are compensated through this mechanism to use fuel to be in “hot standby,” spinning and ready to quickly synchronize and generate.	Science Direct https://www.sciencedirect.com/topics/engineering/spinning-reserve

"Stand-alone power system (SAPS)"	A stand-alone power system (SAPS or SPS), also known as remote area power supply (RAPS), is an off-the-grid electricity system for locations that are not fitted with an electricity distribution system. Typical SAPS include one or more methods of electricity generation, energy storage, and regulation. Electricity is typically generated by one or more of the following methods: • Photovoltaic system using solar panels • Wind turbine • Geothermal source • Micro combined heat and power • Micro hydro • Diesel or biofuel generator • Thermoelectric generator (TEGs) Storage is typically implemented as a battery bank, but other solutions exist including fuel cells. Power drawn directly from the battery will be direct current extra low voltage (DC ELV), and this is used especially for lighting as well as for DC appliances. An inverter is used to generate AC low voltage, which more typical appliances can be used with. Stand-alone photovoltaic power systems are independent of the utility grid and may use solar panels only or may be used in conjunction with a diesel generator, a wind turbine or batteries.	UN Climate Technology Centre & Network https://www.ctc-n.org/technologies/grid-systems

"State of charge (SOC)"	– The state of charge (SOC) of a cell denotes the capacity that is currently available as a function of the rated capacity. The value of the SOC varies between 0% and 100%. If the SOC is 100%, then the cell is said to be fully charged, whereas a SOC of 0% indicates that the cell is completely discharged. In practical applications, the SOC is not allowed to go beyond 50% and therefore the cell is recharged when the SOC reaches 50%. Similarly, as a cell starts aging, the maximum SOC starts decreasing. This means that for an aged cell, a 100% SOC would be equivalent to a 75%–80% SOC of a new cell.	Science Direct https://www.sciencedirect.com/topics/engineering/state-of-charge#:~:text=The%20state%20of%20charge%20(SOC)%20of%20a%20cell%20denotes%20the,the%20cell%20is%20completely%20discharged.

"Storage as a Transmission Asset (SATA)")"	As the demand for transmission systems to achieve climate, environmental, curtailment, and economic policy objectives grows, shifting market conditions are eroding traditional wire transmission solutions' value relative to more flexible alternatives, especially with more elastic demand due to demand-side activities, such as distributed energy resources. One flexible alternative is SATA, a storage-based application that can be repurposed and reused for different functions. Furthermore, SATA can be used at different locations as a transmission upgrade deferral asset, wherein the project price is assessed against the transmission upgrade's avoided capital cost. Thus, potential use cases for SATA providing value to the transmission grid include the following: • to increase transmission transfer capability over major bulk transmission interfaces; • to provide stability services; • to meet grid operation flexibility needs with existing transmission infrastructure; • to address lumpiness and provide grid-forming support beyond that of a traditional; • to reduce renewable curtailment by managing congestion on non-bulk transmission networks; and • to allow optionality in transmission planning	Quanta https://cdn.ymaws.com/ny-best.org/resource/resmgr/reports/SATA_White_Paper_Final_01092.pdf

“Storage discharge”	As soon as a battery is manufactured, it immediately begins to lose its charge—it discharges its energy. Discharge occurs at variable rates based on chemistry, brand, storage environment, temperature. Self-discharge denotes the rate at which the battery self-depletes in idle storage. All batteries self-discharge over time even when idle.	MicroBattery https://www.microbattery.com/battery-storage-discharge-expiration
“Summer peaking”	Air-conditioning equipment is used in 87% of homes in the United States. During the middle of summer, air conditioning accounts for a large portion of residential and commercial electricity usage. The daily U.S. load cycle in the summer has a much wider range than in the winter because of the widespread use of air conditioning. Electricity consumption in the summer increases rapidly through the day along with temperature, reaching its maximum around 5:00 p.m. or 6:00 p.m. *Note: Modeling analysis suggests that some regions in the US are transitioning to winter peaking scenarios.*	EIA https://www.eia.gov/todayinenergy/detail.php?id=42915#:~:text=During%20the%20middle%20of%20summer,widespread%20use%20of%20air%20conditioning.

"Supercapacitor"	Supercapacitors are a type of an electrochemical energy storage systems which have great power density and specific capacitance. These systems have the ability to efficiently release energy with a high density over a relatively short time. Depending on their operating principle, supercapacitors are mainly categorized into two types which are pseudocapacitance and electric double-layer capacitance. Carbon-based materials were effectively employed as supercapacitor electrode materials. Among these materials, graphene exhibits excellent energy transfer features and it has proven to be an efficient electrode material for supercapacitors	Science Direct https://www.sciencedirect.com/topics/chemistry/supercapacitors#:~:text=3.5.&text=Supercapacitors%20are%20a%20type%20of,relatively%20short%20time%20%5B150%5D.
"Superconducting Magnetic Energy Storage" (SMES)	Superconducting Magnetic Energy Storage (SMES) is a conceptually simple way of electrical energy storage, just using the dual nature of the electromagnetism. An electrical current in a coil creates a magnetic field and the changes of this magnetic field create an electrical field, a voltage drop. The magnetic flux is a reservoir of energy. Superconducting wires do not deliver energy when conducting a current, so a coil made with that materials maintain the current and the magnetic flux can be stored. The magnetic flux is a reservoir of electrical energy.	EERA https://www.eera-energystorage.eu/component/attachments/?task=download&id=566:EERA_JPES_SP5_Factsheet_final
"Supervisory Control and Data Acquisition (SCADA) systems"	Supervisory Control and Data Acquisition (SCADA) systems are used for controlling, monitoring, and analyzing industrial devices and processes. The system consists of both software and hardware components and enables remote and on-site gathering of data from the industrial equipment. In that way, it allows companies to remotely manage industrial sites such as wind farms, because the	SCADA-International https://scada-international.com/what-is-scada/

	company can access the turbine data and control them without being on site. The main purpose of a SCADA system is to monitor and control equipment in industrial processes. Thus, SCADA systems are seen almost everywhere. Typically, SCADA systems are used in: • Manufacturing • Water management • Oil and gas • Transportation • Renewable energy • Power distributions and control A SCADA system connects to many different types of equipment. It monitors and controls everything from weather sensors and pumps to power production and motors, depending on what kind of data is needed.	

"Supply chain"	A supply chain is the network of all the individuals, organizations, resources, activities and technology involved in the creation and sale of a product. A supply chain encompasses everything from the delivery of source materials from the supplier to the manufacturer through to its eventual delivery to the end user. The supply chain segment involved with getting the finished product from the manufacturer to the consumer is known as the distribution channel. The fundamental steps of a supply chain in order are as follows: • Sourcing raw materials; • Refining those materials into basic parts; • Combining those basic parts to create a product; • Order fulfillment/Sales; • Product delivery; and • Customer support and return services.	TechTarget https://www.techtarget.com/whatis/definition/supply-chain

“Switchgear and protective devices”	Any electrical installation must have switchgear and electrical protection devices. The storage system is no exception. These battery energy-storage system components include circuit breakers, switches, and similar equipment. Protective devices shield the system from electrical faults, and various kinds of switchgear ensure safe connections and disconnections. These BESS components are also helpful when isolating the storage from the grid when needed. Some switchgear components are manual, while some are automated. Automatic switching devices remove electrical faults to protect the system, while manually operated devices allow maintenance and repair work.	Eaton https://www.eaton.com/us/en-us/products/low-voltage-power-distribution-control-systems/switchgear-lv/low-voltage-switchgear-fundamentals---eaton.html
“Synthetic inertia”	Synthetic inertia refers to the contribution of additional electrical power from a source which does not inherently release energy as its terminal frequency varies, but which mimics the release of kinetic energy from a rotating mass. It can also refer to theability of power electronic devices, such as inverters used in renewable energy systems or energy storage systems, to mimic the grid stabilizing properties of traditional generators, providing short-term frequency support in response to grid disturbances.	The Institute of Engineering and Technology https://ietresearch.onlinelibrary.wiley.com/doi/10.1049/iet-rpg.2017.0370#:~:text=We%20refer%20to%20synthetic%20inertia,energy%20from%20a%20rotating%20mass.

"Technology readiness levels (TRLs)"	Technology Readiness Levels (TRLs), which were conceived at NASA in 1974 and formally defined in 1989, are a type of measurement system used to assess the maturity level of a particular technology. Each technology project is evaluated against the parameters for each technology level and is then assigned a TRL rating based on the projects progress. There are nine technology readiness levels. TRL 1 is the lowest and TRL 9 is the highest. • TRL 1: scientific research is beginning and those results are being translated into future research and development. • TRL 2: technology is very speculative, as there is little to no experimental proof of concept for the technology. • TRL 3: when active research and design begin, a technology is elevated to TRL 3. Generally both analytical and laboratory studies are required at this level to see if a technology is viable and ready to proceed further through the development process. Often during TRL 3, a proof-of-concept model is constructed. • TRL 4: reflects that a proof-of-concept technology is ready. During TRL 4, multiple component pieces are tested with one another. • TRL 5: a continuation of TRL 4, however, a technology that is at 5 is identified as a breadboard technology and must undergo more rigorous testing than technology that is only at TRL 4. Simulations should be run in environments that are as close to realistic as possible.	NASA https://www.nasa.gov/directorates/somd/space-communications-navigation-program/technology-readiness-levels/#:~:text=Technology%20Readiness%20Levels%20(TRL)%20are,based%20on%20the%20projects%20progress

	• TRL 6: Reflects a fully functional prototype or representational model. • TRL 7: requires that the working model or prototype be demonstrated in a simulated field environment. • TRL 8: reflects that the technology has been tested and is ready for implementation into an already existing technology or technology system. • TRL 9: reflects that a technology has been sufficiently tested.	

“Thermal energy storage”	Thermal energy storage (TES) allows the storage of heat and cold to be used later. TES is also known as heat or cold storage. TES can aid in the efficient use and provision of thermal energy whenever there is a mismatch between energy generation and use. This mismatch can be in terms of time, temperature, power, or site. Different methods for TES are defined and discussed – sensible (air, water, and underground thermal energy storage), latent (with phase change materials), and thermochemical (chemical reactions and sorption systems) energy storage. TES stores energy in the form of heat or cold, using materials such as molten salts, phase change materials, or ice, and releases the stored energy when needed by transferring the thermal energy to or from a working fluid.	Science Direct https://www.sciencedirect.com/topics/engineering/thermal-energy-storage
“Thermochemical heat storage”	Thermochemical heat storage works on the notion that all chemical reactions either absorb or release heat; hence, a reversible process that absorbs heat while running in one way would release heat when running in the other direction.	Science Direct https://www.sciencedirect.com/topics/engineering/thermochemical-heat-storage#:~:text=Thermochemical%20energy%20storage%20stores%20energy,the%20discharge%20procedure%20is%20required.

"Thermal management system"	A battery thermal management system keeps batteries operating safely and efficiently by regulating their temperature conditions. High battery temperatures can accelerate battery aging and pose safety risks, whereas low temperatures can lead to decreased battery capacity and weaker charging/discharging performance. A battery thermal management system controls the operating temperature of the battery by either dissipating heat when it is too hot or providing heat when it is too cold. Engineers use active, passive, or hybrid heat transfer solutions to modulate battery temperature in these systems. Active solutions typically have a fan or pump pushing working fluid—such as air, water, or some other liquid—to reduce or increase battery temperature. In a passive solution, either heat sinks or pipes with thermally conductive materials transfer heat away from the battery. A hybrid solution combines key design features of both active and passive solutions. The type of battery energy storage thermal management system in use depends on the installation size, energy capacity, and other factors such as battery type.	MathWorks https://www.mathworks.com/discovery/battery-thermal-management-system.html#:~:text=A%20battery%20thermal%20management%20system%20keeps%20batteries%20operating%20safely%20and,and%20weaker%20charging%2Fdischarging%20performance.

“Thermo-photovoltaic”	Thermophotovoltaic (TPV) devices use photovoltaic cells to convert the predominantly infrared light emitted by hot objects (at 600 °C or more) into electrical energy. They can operate with higher-temperature heat sources than those used by turbines, and their range of possible sources is very broad, including combustion, nuclear reactions, waste heat, heat stored in a thermal energy storage system and solar radiation via an intermediate radiation absorber. All these sources are, in principle, more reliable than wind or solar energy generated directly from sunlight, both of which are intermittent.	Physics World https://physicsworld.com/a/thermophotovoltaic-cells-top-40-percent-efficiency/

“Time of Use (TOU) rates”	A pricing structure, TOU rates fall within a broader category of innovative utility rate structures, primarily used for utility retail rates, that varies electricity rates based on the time of day, encouraging consumers to shift their energy consumption to off-peak hours when electricity demand is lower and prices are cheaper. These types of rate structures, commonly referred to as time-varying rates, frequently follow a similar pattern. When both the cost of generating electricity and the electricity demand are low (i.e., in the middle of the night), the rate paid to use electricity is very low. However, when both the cost of generation and demand for electricity are high (i.e., on the afternoon of a hot summer day), the electricity rate is much higher. TOU rates may vary by season, on weekdays versus weekends and holidays, and across multiple periods over an individual day.	EnergySage https://www.energysage.com/electricity/understanding-time-of-use-rates/
“Total cost of ownership”	Total cost of ownership (5-years) of the BESS takes into consideration, initial cost, maintenance costs, warranty costs, guarantee costs, spare parts costs, and degradation over time, replacement costs and schedule, efficiencies, and other costs as identified. (Include only if this applies.)	Sandia National Laboratories https://www.cesa.org/wp-content/uploads/Energy-Storage-Procurement-Guidance-Document.pdf

“Transactive energy”	Transactive energy refers to a system in which anyone on the grid can buy or sell surplus energy. In a transactive energy system, traditional consumers generate their own electric power with DERs like combined heat and power, solar panels, and windmills. Other examples of DERs include nuclear facilities, hydropower, biomass farms, natural gas turbines, and trigeneration units. Utility companies still operate and provide electricity, but they are no longer the only suppliers of electricity. The transactive energy concept requires a decentralized smart grid powered by a DER network. In transactive energy systems, end users are both consumers and producers, or “prosumers.” These prosumers engage in energy trading, which could potentially operate on a P2P blockchain platform. Transactive energy systems connect utility companies, residential and commercial producers, and consumers through energy storage systems, DERs, smart meters, and distributed ledger technologies like blockchain. Producers and consumers can then communicate and trade energy on a P2P platform, which they can potentially access through mobile apps, websites, and smart devices.	IEEE Blockchain https://blockchain.ieee.org/verticals/transactive-energy/topics/what-is-transactive-energy#:~:text=Defining%20Transactive%20Energy,%2C%20solar%20panels%2C%20and%20windmills.

"Transients"	Transients are sudden and brief fluctuations in voltage or current that occur over a short period of time. They can be caused by events such as lightning strikes, switching operations, or faults in the power system. Transients can range from a few microseconds to several milliseconds in duration, and they can have a significant impact on the operation and reliability of electrical systems and equipment. Transient voltage surge suppressors, surge protective devices, and other protective measures can be implemented to limit the effects of transients on electrical systems and equipment.	Smart Energy International https://www.smart-energy.com/industry-sectors/smart-grid/what-is-power-quality-and-why-is-it-important/#:~:text=Power%20quality%20refers%20to%20the,system%20shutdown%2C%20and%20data%20loss
"Transmission capacity"	The power-handling capacity of a specific transmission line (i.e., how much power the transmission line can handle without causing damage to transmission line).	Iowa State University https://www.imse.iastate.edu/files/2021/03/EnergyProject_Capacity_of_Transmission_Lines.pdf
"Transmission & Distribution Deferral (T&D Deferral)"	Transmission & distribution deferral involves delaying—and in some cases avoiding entirely—utility investments in system upgrades across transmission and/or distribution networks by using relatively small amounts of energy storage.	MyPHDEngineer.com https://mypdh.engineer/lessons/transmission-upgrade-deferral/

"Transmission line rating"	Transmission Line Rating means the maximum transfer capability of a transmission line, computed in accordance with a written Transmission Line Rating methodology and consistent with Good Utility Practice, considering the technical limitations on conductors and relevant transmission equipment (such as thermal flow limits), as well as technical limitations of the Transmission System (such as system voltage and stability limits). Relevant transmission equipment may include, but is not limited to, circuit breakers, line traps, and transformers.	PJM https://www.pjm.com/-/media/committees-groups/committees/oc/2022/20220429-special/order-881---education.ashx
"Utility-scale energy storage"	Utility scale or large-scale energy storage systems have at least 1 MW of net generation capacity and are mostly owned by electric utilities or independent power producers to provide grid support services.	US Energy Information Administration (EIA) https://www.eia.gov/energyexplained/electricity/energy-storage-for-electricity-generation.php

“Value of lost load (VOLL)”	The value of lost load (VOLL) is cost-benefit metric meant to encapsulate the societal benefits of reduced outages in a monetary figure. More formally, it represents society’s willingness-to-pay to avoid a power outage and can be estimated using various units of analysis. For instance, the VoLL is sometimes presented as willingness-to-pay to avoid 1 h of outage (i.e. $/hour). Alternatively, researchers sometimes measure willingness-to-pay on a kWh basis (i.e. $/kWh), effectively representing the amount an individual would pay to consume a certain amount of electricity during an outage. This metric was developed given that different consumers’ willingness-to-pay varies due to their different consumption levels.	Science Direct https://www.sciencedirect.com/science/article/pii/S1040619022001130#:~:text=The%20value%20of%20lost%20load%20(VoLL)%20is%20multi%2Ddimensional.&text=The%20VoLL%20is%20applied%20in,and%20electric%20rationing%20decision%2Dmaking.&text=Revealed%20preference%20VoLL%20estimation%20can%20leverage%20uptake%20of%20distributed%20energy.&text=Cost%2Deffectiveness%20analysis%20should%20remain,tool%20of%20reliability%20decision%2Dmaking.
“Value stacking”	BESS can maximize their value to the grid and project developers by providing multiple system services. As some services are rarely called for (i.e., black start) or used infrequently in a given hour (i.e., spinning reserves), designing a BESS to provide multiple services enables a higher overall battery utilization. This multi-use approach to BESS is known as value-stacking.	NREL https://www.nrel.gov/docs/fy19osti/74426.pdf

"Vanadium redox flow batteries (VRFB)"	Vanadium Redox Flow Batteries (VRFB) use vanadium ions as charge carriers. These take advantage of vanadium's ability to exist in four different oxidation states. VRFB systems are the most developed among flow batteries because of their active species remaining in solution at all times during charge/discharge cycling, their high reversibility, and their relatively large power output. The capital cost of these systems remains far too high for deep market penetration. In order to meet the proposed cost targets, recent investigations have highlighted the use of organic active materials in solid-state organic batteries, in which energy is stored within the cell, mainly in the form of a radical polymer.	Science Direct https://www.sciencedirect.com/topics/engineering/vanadium-redox-flow-battery

“Variable renewable energy (VRE)”	During the last 30 years, there has been significant increase in the use of wind and solar power generation. These technologies offer a free fuel source but are variable in nature and only produce power when there are solar or wind resources. Therefore, we call them variable renewable energy (VRE). Wind and solar photovoltaic (PV) do not naturally have on-site energy storage, so their output is typically referred to as non-dispatchable. Other characteristics that make VRE integration a challenge are the uncertainty associated with their output and asynchronous nature of interconnection to the grid. As costs for wind and solar continue to decrease and regulations require the use of more clean energy technologies, there is a need to understand the technical challenges and develop solutions to integrate ultra-high levels of VRE into electrical power systems The use of small amounts of intermittent power has little effect on grid operations. Using larger amounts of intermittent power may require upgrades or even a redesign of the grid infrastructure.	NREL https://www.nrel.gov/docs/fy18osti/70430.pdf

"Vehicle-to-Grid (V2G)"	A technology that allows electric vehicles (EVs) to communicate with the electrical grid and discharge stored energy back to the grid when needed, helping to balance supply and demand and provide ancillary services. Vehicle-to-grid, or V2G for short, is a technology that enables energy to be pushed back to the power grid from the battery of an EV. With V2G technology, an EV battery can be discharged based on different signals — such as energy production or consumption nearby. V2G technology powers bi-directional charging, which makes it possible to charge the EV battery and take the energy stored in the car's battery and push it back to the power grid. While bi-directional charging and V2G are often used synonymously, there is a slight difference between the two. While bi-directional charging means two-way charging (charging and discharging), V2G technology only enables the flow of the energy from the car's battery back to the grid.	Virta https://www.virta.global/vehicle-to-grid-v2g
"Venture capitalist (VC)"	A venture capitalist (VC) is a private equity investor that provides capital to companies with high growth potential in exchange for an equity stake. A VC investment could involve funding startup ventures or supporting small companies that wish to expand but have no access to the equities markets.	Investopedia https://www.investopedia.com/terms/v/venturecapitalist.asp

"Vertically integrated / vertically integrated market"	In vertically integrated electricity markets, utilities are solely responsible for generating, transmitting, and distributing electricity to their customers. In these markets, utilities determine the mix of resources that they use to generate electricity, with approval from state public utility commissions.	EPA https://www.epa.gov/green-power-markets/power-market-structure
"Virtual power plant (VPP)"	Virtual power plants, generally considered a connected aggregation of distributed energy resource (DER) technologies, offer deeper integration of renewables and demand flexibility, which in turn offers more Americans cleaner and more affordable power; a network of DERs, such as solar panels, batteries, and electric vehicles, coordinated through a central control system to provide grid support and generate electricity as if they were a single power plant.	DOE https://www.energy.gov/lpo/virtual-power-plants
"Voltage sag"	Voltage sag or dip is a temporary reduction of voltage below the normal level that lasts for a few cycles to a few seconds. It is caused by a sudden increase in load, a voltage drop in the power grid, or a fault in the system.	Smart Energy International https://www.smart-energy.com/industry-sectors/smart-grid/what-is-power-quality-and-why-is-it-important/#:~:text=Power%20quality%20refers%20to%20the,system%20shutdown%2C%20and%20data%20loss

"Voltage support"	Voltage support is the provision or absorption of reactive power to the grid to maintain acceptable voltage. Transmission and distribution operators must inject appropriate amounts of reactive power into the grid due to resistive losses along transmission and distribution lines and due to consumption of reactive power by consumers. Voltage support is required on the bulk electric system so that acceptable voltage is provided at each distribution substation connecting to the transmission system. It is also required on the distribution system so that the distribution utility can maintain acceptable voltage to customers. • On the bulk electric system, voltage support is commonly provided by generators that have the capability to adjust the ratio of reactive power to real power provided to the grid. Many types of generators have this capability. Voltage support for the bulk electric system can also be provided by synchronous condensors, capacitor banks, and grid-scale batteries. • On distribution grids, voltage support is provided by a variety of utility assets. These include capacitors, resistors, and batteries at distribution substations and line regulators and switched capacitor banks on distribution lines. Voltage is also managed using transformers including transformers with tap changes (although use of transformers utilizes a different principle of electricity than provision of reactive power). Voltage support can also be provided by third-party	Enerdynamics, Energy Knowledge Base https://www.energyknowledgebase.com/topics/voltage-support.asp

	or customer-owned assets such as batteries and smart inverters.	

“Voltage swell”	Voltage swell is a temporary increase in voltage above the normal level that lasts for a few cycles to a few seconds. It is caused by sudden changes in load or when a fault on the system is cleared.	Smart Energy International https://www.smart-energy.com/industry-sectors/smart-grid/what-is-power-quality-and-why-is-it-important/#:~:text=Power%20quality%20refers%20to%20the,system%20shutdown%2C%20and%20data%20loss

"Wholesale electricity markets"	Wholesale electricity markets are generally operated in two ways: • Traditional wholesale markets are operated by regulated electric utilities or federal organizations like the Tennessee Valley Authority in the Southeast and Bonneville Power Administration in the Northwest. These organizations sign contracts for electricity from power generators and are responsible for operating and managing the entire system, including delivering power to customers. • Wholesale markets are operated by organizations known as either independent system operators (ISOs) or regional transmission organizations (RTOs), which independently manage the transmission of electricity across a regional system and foster competition among power generators and buyers. Some wholesale markets only sell energy, while others include separate markets to sell energy and capacity.	NRG https://www.nrg.com/insights/energy-education/electricity-markets-what-s-the-difference-between-a-wholesale-en.html#:~:text=As%20an%20energy%20market%20pays,available%20(measured%20in%20watts
"Wind turbine"	Wind turbines use the power in wind to move the blades of a rotor to power a generator. There are two general types of wind turbines: horizontal axis (the most common) and vertical-axis turbines. Wind turbines were the source of about 10% of U.S. electricity generation in 2022.	US Energy Information Administration (EIA) https://www.eia.gov/energyexplained/electricity/how-electricity-is-generated.php

"Yellow hydrogen"	Yellow hydrogen is a relatively new phrase for hydrogen made through electrolysis using solar power.	National Grid https://www.nationalgrid.com/stories/energy-explained/hydrogen-colour-spectrum#:~:text=Blue%20hydrogen%20is%20produced%20mainly,produced%20as%20a%20by%2Dproduct

"Zero emissions vehicle (ZEV)"	A vehicle that produces no tailpipe emissions during operation, typically powered by electricity or hydrogen fuel cells. Configurations recognized as zero emissions vehicles under state and federal regulations and programs typically include: • Full battery electric vehicles that run on batteries alone and create zero emissions 100 percent of the time, using electricity to power a motor that propels the wheels and accessories. These vehicles are often augmented with electricity produced by regenerative braking and, in some cases, outer shell solar panels. Most charging of the batteries takes place at a charging station when not scheduled to be in service. • Hydrogen fuel cell electric vehicles, also called fuel cell electric vehicles (FCEVs), run on electricity created through a silent, non-polluting process of mixing hydrogen with oxygen through a "stack" of proton exchange membrane electrodes. The only bi-products are heat and water. As with full battery electric vehicles, FCEVs also often use regenerative braking and outer shell solar panels to produce more electricity. • Plug-in electric hybrid vehicles that plug in to charge overnight, but also use a diesel- or gasoline-powered internal combustion engine to keep their storage batteries charged on longer trips. These do emit some carbon, but	BAE Systems https://www.baesystems.com/en-us/definition/what-are-zero-emissions-vehicles

	are significantly more efficient, clean, and quiet than traditional internal combustion engine vehicles.	

“Zinc-based batteries”	Zinc-based batteries consist of a graphite felt and conductive plastic inside, and the zinc essentially adheres to and then releases itself from the graphite and conductive plastic to charge or discharge.	Utility Dive https://www.utilitydive.com/news/energy-storage-long-duration-hydrogen-iron-air-zinc-gravity/698158/
“Zinc-carbon batteries”	These are the most common and inexpensive primary (non-rechargeable) dry cell batteries. They use a zinc anode, a manganese dioxide cathode, and an ammonium chloride or zinc chloride electrolyte.	How To Store Electricity https://howtostoreelectricity.com/dry-cell-batteries/
“Zinc-ion batteries”	Zinc-ion batteries use zinc ions instead of lithium ions to store and release energy. They are considered a promising alternative to lithium-ion batteries because zinc is abundant, low-cost, and environmentally friendly. Zinc-ion batteries are also more stable than lithium-ion batteries and have a longer lifespan	Science Direct https://www.sciencedirect.com/topics/materials-science/zinc-ion-battery#:~:text=Zinc%20ion%20batteries%20(ZIBs)%20work,for%20the%20flow%20of%20ions

"Zonal pricing"	A pricing zone is defined as the largest geographical area within which market participants are able to trade energy without capacity allocation, i.e., an area where grid congestion is assumed to be low. These zones are defined by the regulator and/or the transmission system operator (TSO) and hence the price differentials between the zones reflect the grid congestion between the zones. Such bidding zones represent, for example, the cornerstone of the pan-European electricity market, whereby electricity is traded across bidding zones, based on available transmission capacities calculated by TSOs, while the electricity traded within a bidding zone is considered unrestricted by transmission capacity. While in most cases a bidding zone corresponds to national borders, there are countries that divide their power system into more zones. Italy, for example, has divided the national transmission system into six geographical bidding zones.	IRENA https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Feb/IRENA_Increasing_space_granularity_2019.pdf?la=en&hash=AFFB9C326FDEE85C43B1B6E66F6554F4AF77E23F#:~:text=Nodal%20pricing%3A%20Nodal%20pricing%20refers,deriving%20the%20locational%20marginal%20prices

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