LDES NATIONAL CONSORTIUM

Common Terminology

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

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Term	Definition	Source
"Advanced distribution management system (ADMS)"	The "advanced" elements of an ADMS go beyond traditional distribution management systems by providing next-generation control capabilities. These capabilities include the management of high penetrations of distributed energy resources (DERs), closed-loop interactions with building management systems, and tighter integration with utility tools for meter data management systems, asset data, and billing.	NREL https://www.nrel.gov/grid/advanced-distribution-management.html
"Advanced metering infrastructure (AMI)"	Refers to the full measurement and collection system that includes meters at the customer site, communication networks between the customer and a service provider, such as electric, gas, or water utility, and data reception and management systems that make the information available to the service provider.	California Energy Commission https://www.energy.ca.gov/resources/energy-glossary
"Aggregator"	An entity responsible for planning, scheduling, accounting, billing, and settlement for energy deliveries from the aggregator's portfolio of sellers and/or buyers. Aggregators seek to bring together customers or generators so they can buy or sell power in bulk, making a profit on the transaction.	California Energy Commission https://www.energy.ca.gov/resources/energy-glossary

"Air-based flow batteries"	Air-based flow batteries composed of O2/OH- and another redox couple have high theoretical energy density and extremely low cost receiving wide attention in large-scale energy storage for intermittent solar and wind powers such as zinc air flow battery (ZAFB), sodium air flow battery, lithium air flow battery, and iron-air flow battery. However, their energy conversion efficiencies are limited by the sluggish kinetics of oxygen reduction reaction (ORR) and oxygen evolution reaction.	Science Direct https://www.sciencedirect.com/science/article/pii/S2211285518301423
"Alkaline batteries"	A type of dry-cell battery, alkaline batteries are also primary batteries, but they offer improved performance compared to zinc-carbon batteries. They use a zinc anode, a manganese dioxide cathode, and an alkaline potassium hydroxide electrolyte.	Science Direct https://www.sciencedirect.com › topics › alkaline-battery
"Alternating current (AC)"	Flow of electricity that constantly changes direction between positive and negative sides. Almost all power produced by electric utilities in the United States moves in current that shifts direction at a rate of 60 times per second.	California Energy Commissionhttps://www.energy.ca.gov/resources/energy-glossary

“Alternating current (AC) coupling”	Coupling is the transfer of energy between two mediums by means of physical contact. AC (alternating coupling) allows only AC signals to pass through a connection. AC coupling removes the DC offset by making use of a DC-blocking capacitor in series with the signal. AC coupling effectively rejects the DC component of the signal normalizing the signal to a mean of zero.	Siemens https://community.sw.siemens.com/s/article/ac-and-dc-coupling-what-s-the-difference

"Aluminum-air batteries"	Aluminum–air batteries are remarkable due to their high energy density, light weight, environmentally friendly, good recyclability, and low cost. Aluminum–air batteries consist of an aluminum anode, an air cathode and an electrolyte which is salty, alkaline, and nonaqueous solutions. In particular, the alkaline electrolyte solution is often used to form aluminum–air cells; since dissolving oxides formed on the electrode surface during neutral electrolyte use are a serious problem for the Al–air material and do not form these oxide species in the alkaline solution. Aluminum–air batteries using alkaline electrolyte have good battery performance, especially under high discharge current. However, alkaline electrolytes, aluminum electrodes tend to be highly corrosive, and the main problem restricting a feasible usage of Al–air batteries is the low coulomb efficiency resulting from the self-corrosion of the electrode. To overcome this problem, aluminum alloys have been chosen as the electrode material [140–142]. The use of Al alloys suppresses a degree of hydrogen evolution due to increased hydrogen over potentials. Aluminum-ion batteries have long been attractive as an alternative to conventional lithium-ion batteries. This is mainly because aluminum, a common and widely available material, is recyclable and inexpensive compared to lithium, a rare and expensive raw material. However, the main drawback of aluminum-ion batteries is their insufficient storage capacity. The challenge is the lack of	Science Direct https://www.sciencedirect.com/topics/engineering/aluminum-air-battery Engineering.com https://www.engineering.com/story/aluminum-ion-batteries-get-major-capacity-boost

	appropriate host electrode materials that can enable the reversible insertion of complex aluminum ions.	

"Ambient adjusted rating (AAR)"	Ambient-Adjusted Rating (AAR) is a Transmission Line Rating that: a) Applies to a time period of not greater than one hour; b) Reflects an up-to-date forecast of ambient air temperature across the time period to which the rating applies; c) Reflects the absence of solar heating during nighttime periods where the local sunrise/sunset times used to determine daytime and nighttime periods are updated at least monthly, if not more frequently; d) Is calculated at least each hour, if not more frequently.	PJM https://www.pjm.com/-/media/committees-groups/committees/oc/2022/20220429-special/order-881---education.ashx
"Ancillary services"	A broad bucket of smaller services that ensure an electric grid remains reliable and resilient and include services that support the transmission of electricity from generation sites to customer loads. Such services may include load regulation, spinning reserve, non-spinning reserve, replacement reserve, and voltage support.	EIA https://www.eia.gov/tools/glossary/index.php?id=Ancillary%20services
"Anode"	An anode is an electrode where an oxidation reaction occurs (loss of electrons for the electroactive species), or more precisely the electrode that supplies electrons, while the cathode is the electrode where reduction takes place, i.e., the electrode that accepts electrons.	Biologic Learning Center. https://www.biologic.net/topics/anode-cathode-positive-and-negative-battery-basics/ Science Direct: https://www.sciencedirect.com/topics/materials-science/anode

"Aqueous electrolyte flow batteries"	An electrochemical LDES technology; flow batteries that use chemical cathodes and anodes separated by electrolytes to store energy.	*Pathways to Commercial Liftoff: Long Duration Energy Storage,* U.S. Department of Energy. https://liftoff.energy.gov/wpcontent/uploads/2023/03/20230320-Liftoff-LDES-vPUB-0329-update.pdf
"(Energy) Arbitrage"	Energy arbitrage is the process through which power is purchased during off-peak hours when grid prices are the cheapest, stored, and used then used or sold during peak hours when grid electricity prices are highest. Energy arbitrage consists of storing surplus electricity (from sources including renewables) when there's ample supply and lower prices and then providing that energy to the grid when demand is greater and prices are therefore higher. The practice leverages variances in prices in two or more markets, creating profit through a combination of matching deals to capitalize on the difference between the market prices at which the units are traded. Battery storage supports this strategy by charging when power prices are low and discharging when prices are high.	Virtual Peaker https://virtual-peaker.com/blog/buy-low-use-high-energy-arbitrage-explained/ CleanTechnica https://cleantechnica.com/2021/11/01/battery-storage-applications-shifting-as-more-batteries-added-to-u-s-grid/

"Base load"	The lowest level of power production needs during a season or year.	California Energy Commission https://www.energy.ca.gov/resources/energy-glossary
"Baseload unit"	Baseload units—typically large nuclear and coal-fired facilities—often supply the same amount of energy around the clock, although many coal units follow the diurnal load cycle, running at minimum generation levels at night and increasing during the day. These units have slow ramp rates and relatively high minimum generation levels, referred to as turn-down capability. They also can take a long time (days in some cases) to start back up once they have been cycled off. Large baseload units also tend to have lower operating costs relative to other fossil-fueled facilities.	DOE https://www1.eere.energy.gov/solar/pdfs/50060.pdf
"Battery"	A device that stores energy and produces electric current by chemical action.	California Energy Commission https://www.energy.ca.gov/resources/energy-glossary

"Battery cells"	The individual units that make up the battery. When combined and enclosed in a frame, several cells make a module. Depending on the required capacity, several modules are joined in stacks to form a rack. Storage battery cells can be of different types, depending on the chemical compounds in the electrolyte and the types of electrodes used. Popular options are lithium ion and lead acid-based storage systems. Others are sodium-sulfur and flow batteries.	Argonne National Laboratory https://publications.anl.gov/anlpubs/2022/07/176234.pdf
"Battery cost"	The cost of a battery system can be expressed in terms of power capacity costs (dollars spent per unit of maximum instantaneous power output as expressed in dollars per kilowatt) or energy capacity costs (dollars spent per unit of total energy stored as expressed in dollars per kilowatt-hour), depending on which attribute is prioritized.	EIA https://www.eia.gov/todayinenergy/detail.php?id=36432
"Battery degradation"	The progressive loss of battery capacity over time, which inevitably affects the battery's ability to store and deliver power efficiently. This process doesn't occur uniformly across all batteries or even within the same battery type. Various factors influence the rate and extent of degradation, making it a complex and multi-dimensional problem. The gradual decline in the performance and capacity of a battery over time, typically resulting from factors such as the number of charge and discharge cycles, depth of discharge, and operating conditions, such as temperature and humidity.	Exro.com https://www.exro.com/industry-insights/battery-degradation-explained

"Battery energy storage system (BESS)"	A battery energy storage system (BESS) is an electrochemical device that charges or collects energy from the grid or a distributed generation (DG) system and then discharges that energy later to provide electricity or other services when needed. A BESS collects energy from renewable energy sources, such as wind and or solar panels or from the electricity network and stores the energy using battery storage technology. The batteries discharge to release energy when necessary, such as during peak demands, power outages, or grid balancing. In addition to the batteries, BESS requires additional components that allow the system to be connected to an electrical network. A bidirectional inverter or power conversion system (PCS) is the main device that converts power between the DC battery terminals and the AC line voltage and allows for power to flow both ways to charge and discharge the battery. The other primary element of a BESS is an energy management system (EMS) to coordinate the control and operation of all components in the system. Battery storage systems store energy generated by renewable sources, like solar or wind, for use during peak demand or when renewable generation is low. This helps balance the grid and reduce reliance on fossil fuels.	NREL https://www.nrel.gov/docs/fy21osti/79393.pdf

"Battery Management System (BMS)"	A system that monitors and controls the performance of a battery, ensuring its safe and efficient operation. A BMS encompasses not only the monitoring and protection of the battery but also methods for keeping it ready to deliver full power when called upon and methods for prolonging its life. This includes everything from controlling the charging regime to planned maintenance. The energy storage battery management system, BMS, consists of electronics monitoring the battery's real-time health. It checks the battery's current, voltage, and other operating parameters such as temperature and charge condition. The function of the BMS system is to protect the battery cells from damage. It ensures the storage doesn't overcharge or undercharge, for instance. It also prevents the batteries from overheating by balancing their operation and keeping them within safe levels.	California Energy Commission https://www.energy.ca.gov/resources/energy-glossary Science Direct https://www.sciencedirect.com/topics/materials-science/battery-management-system
"Battery swapping"	Battery swapping for electric vehicles (EVs) is the process where a drained-out EV battery is exchanged for a fully charged one at specific stations, providing a faster alternative to traditional charging. This process is usually done at specialized stations or facilities equipped with the necessary infrastructure to efficiently exchange batteries. The idea behind battery swapping is to reduce the time it takes to recharge an EV compared to traditional charging methods, which can take a significant amount of time, especially for larger battery capacities.	Intellipaat https://intellipaat.com/blog/battery-swapping-electric-vehicles/#What_is_Battery_Swapping

“Behind-the-meter (BTM)”	The term "Behind the Meter" refers to energy-related activities that occur on the consumer's side, typically within or close to their premises. It involves the generation, consumption, storage, and management of energy using various distributed energy resources (DERs) located on-site. These resources can include solar panels, wind turbines, batteries, fuel cells, and even small-scale cogeneration systems. Applications that are typically associated with BTM include: • Distributed Energy Generation or Distributed Energy: BTM systems enable consumers to generate electricity on their own premises, reducing dependence on traditional utility providers. Solar panels and wind turbines are common examples of BTM generation systems. These installations allow individuals and businesses to generate clean energy, lower their carbon footprint, and potentially save on energy bills. • Energy Storage: BTM solutions often involve energy storage systems, such as batteries, which allow users to store excess electricity for later use. By capturing surplus energy during low demand periods, batteries can help consumers offset peak demand costs and improve grid stability. Additionally, in regions with unreliable power grids, BTM storage systems provide backup power during outages. This is getting considerable focus in emerging markets such as	SSE Energy Solutions https://www.sseenergysolutions.co.uk/behind-the-meter-and-in-front-of-the-meter

	Data Centres where disruption to energy supply is so damaging. • Energy Conversion: instead of traditional batteries storing electricity, new options use surplus onsite electricity to generate and store energy in alternate forms such as hydrogen or heat. With many industrial processes requiring anything from low grade heat to high temperature steam, this type of storage has three benefits: it removes the need for grid export capacity, which can be constrained in many regions; it allows for much longer energy storage, months if needed, increasing the ability to smooth out intermittent generation; it decarbonises heat generation for consumers, which currently relies almost exclusively on gas. • Energy Management: Behind the Meter solutions enable consumers to have greater control over their energy usage. Advanced energy management systems and smart grid technologies provide real-time data on energy consumption, enabling consumers to make informed decisions about their energy usage. This data-driven approach can lead to more efficient energy consumption patterns, cost savings, and increased energy resilience, as well as offering a means of commercial gain through energy trading back to the grid.	

“Behind-the-meter (BTM) energy storage system (BESS)”	Behind-the-meter (BTM) BESS refers to customer-sited stationary storage systems that are connected to the distribution system on the customer’s side of the utility’s service meter. BTM BESS differ from front-of-the-meter storage systems, both interconnected at the distribution system and the transmission system (e.g., utility-scale storage systems), in many ways, including who owns the systems, where they are installed, and the size and number of systems installed. These characteristics influence the role of	NREL https://www.nrel.gov/docs/fy21osti/79393.pdf
“Bi-directional hydrogen fuel cell (BDHFC) storage”	This technology involves using a polymer electrolyte membrane (PEM) electrolyzer to generate hydrogen from water (releasing oxygen as a byproduct) with an electrical current before compressing and storing the hydrogen in underground salt caverns until it's needed. The hydrogen is later re-electrified using fuel cells to produce electricity.	PNNL https://www.pnnl.gov/hydrogen-bi-directional
“Bi-directional inverter”	An inverter that can convert electricity between alternating current (AC) and direct current (DC) in both directions, enabling the charging and discharging of energy storage systems, and the integration of renewable energy sources and electric vehicles with the grid.	DOE https://www.energy.gov/eere/solar/solar-integration-inverters-and-grid-services-basics

"Biogas"	Biogas is an environmentally-friendly, renewable energy source produced by the breakdown of organic matter such as food scraps and animal waste; Biogas is a renewable fuel that's produced when organic matter, such as food or animal waste, is broken down by microorganisms in the absence of oxygen. This process is called anaerobic digestion. For this to take place, the waste material needs to be enclosed in an environment where there is no oxygen. Biogas can be used to fuel vehicles – if biogas is compressed it can be used as a vehicle fuel; and as a replacement for natural gas – if biogas is cleaned up and upgraded to natural gas standards, it's then known as biomethane and can be used in a similar way to methane; this can include for cooking and heating.	National Grid Group https://www.nationalgrid.com/stories/energy-explained/what-is-biogas#:~:text=Biogas%20a%20renewable%20fuel%20that%27s,where%20there%20is%20no%20oxygen
"Biomass"	Energy resources derived from organic matter. These include wood, agricultural waste and other living-cell material that can be burned to produce heat energy. They also include algae, sewage and other organic substances that may be used to make energy through chemical processes. Biomass was the source of about 1.3% of total U.S. utility-scale electricity generation and accounted for 5.9% of electricity generation from renewable sources in 2022. Biomass is burned directly in steam-electric power plants, or it can be converted to a gas that can be burned in steam generators, gas turbines, or internal combustion engine generators.	US Energy Information Administration (EIA) https://www.eia.gov/energyexplained/electricity/electricity-in-the-us.php

"Black start"	Black start is the ability of generation to restart parts of the power system to recover from a blackout. This entails isolated power stations being started individually and gradually reconnected to one another to form an interconnected system again. It is used when the grid experiences a blackout and must be restarted from scratch. As such, black start is a critical resource for maintaining the reliability and resilience of the electric power system and is central to system restoration and recovery plans for system operators.	NREL https://www.nrel.gov/grid/black-start.html
"Blue hydrogen"	Blue hydrogen is produced mainly from natural gas, using a process called steam reforming, which brings together natural gas and heated water in the form of steam. The output is hydrogen, but carbon dioxide is also produced as a by-product.	National Grid https://www.nationalgrid.com/stories/energy-explained/hydrogen-colour-spectrum#:~:text=Blue%20hydrogen%20is%20produced%20mainly,produced%20as%20a%20by%2Dproduct-

"Building automation system (BAS)	Building automation is the use of automation and control systems to monitor and control building-wide systems, such as HVAC, lighting, alarms, and security access and cameras. Converging these systems into a single IT-managed network infrastructure creates a smart building. Smart buildings often use Power over Ethernet (PoE) to power and connect IoT devices and sensors. Building automation systems (BAS)—also known as Building Management Systems (BMS) have been developed to help resolve the issue of siloed operations. These systems combine the control of various building automation functions into common control interfaces.	Cisco https://www.cisco.com/c/en/us/solutions/enterprise-networks/what-is-building-automation.html
"Bulk energy storage shifting"	Energy storage is used to shift energy in time, storing excess energy when available, and then providing it later when needed. Bulk energy storage shifting can support hundreds of MWhs or more and durations beyond the 1-6 hours typically seen in today's market, with a need for both mid-durations (6-48 hours) and longer durations extending out to seasonal storage.	EPRI https://www.epri.com/portfolio/programs/113062
"Bulk power"	Refers to the electric power, and any attendant energy, supplied or made available at transmission or sub-transmission voltage by one entity to another.	Law Insider https://www.lawinsider.com/dictionary/bulk-power

"Bulk power supply"	Often this term is used interchangeably with wholesale power supply. In broader terms, it refers to the aggregate of electric generating plants, transmission lines, and related-equipment. The term may refer to those facilities within one electric utility, or within a group of utilities in which the transmission lines are interconnected.	California Energy Commission, https://www.energy.ca.gov/resources/energy-glossary
"Bulk power system"	"Bulk-power system" means (i) facilities and control systems necessary for operating an interconnected electric energy transmission network (or any portion thereof); and (ii) electric energy from generation facilities needed to maintain transmission reliability. For the purpose of this order, this definition includes transmission lines rated at 69,000 volts (69 kV) or more, but does not include facilities used in the local distribution of electric energy.	Federal Register https://www.federalregister.gov/documents/2020/05/04/2020-09695/securing-the-united-states-bulk-power-system
"Bulk-power system electric equipment"	"Bulk-power system electric equipment" means items used in bulk-power system substations, control rooms, or power generating stations, including reactors, capacitors, substation transformers, current coupling capacitors, large generators, backup generators, substation voltage regulators, shunt capacitor equipment, automatic circuit reclosers, instrument transformers, coupling capacity voltage transformers, protective relaying, metering equipment, high voltage circuit breakers, generation turbines, industrial control systems, distributed control systems, and safety instrumented systems. Items not included in the preceding list and that have broader application of use beyond the bulk-power system are outside the scope of this order.	Federal Register https://www.federalregister.gov/documents/2020/05/04/2020-09695/securing-the-united-states-bulk-power-system

"Calcium-ion batteries"	Calcium ions could be used as an alternative technology to lithium-ion batteries (LIBs), bringing benefits as a result of their abundance and low cost. This article discusses the potential of calcium to be used in batteries and how its properties compare to lithium and sodium-ion batteries. Similar to magnesium, aluminum, and zinc, calcium is a multivalent metal that is 400 times more common and consequently less expensive. It is also widely available and equitably distributed across the planet. Similar to lithium, calcium has a large storage capacity and cell voltage and is safer for short circuits because it does not operate by forming usual dendrites. The biggest problem with using calcium is that it reacts easily and forms surface layers when exposed to moisture, oxygen, or even the electrolyte used in batteries. The oxidized surfaces hinder efficient charging and discharging by obstructing ion diffusion later on. Thus, the creation of a suitable electrolyte assumes a crucial role. In addition, using a sulfur cathode produces soluble polysulfides, which must also be avoided since they can obstruct the Ca anode.	AZO Materials https://www.azom.com/article.aspx?ArticleID=22271

"California Independent System Operator (CA-ISO)"	The California Independent System Operator (ISO) maintains reliability on one of the largest and most modern power grids in the world, and operates a transparent, accessible wholesale energy market. The organization works diligently around the clock to meet the electricity needs of consumers, while increasing the amount of renewable energy to usher in the clean, green grid of the future. The California ISO provides open and non-discriminatory access to the bulk of the state's wholesale transmission grid, supported by a competitive energy market and comprehensive infrastructure planning efforts. The California ISO is regulated by FERC.	CA-ISO https://www.caiso.com/about/Pages/default.aspx
"Cap-and-trade"	"Cap and trade" programs, also referred to as "emissions trading" or "allowance trading" refer to an approach, typically developed within an established regulatory structure, to reducing pollution that has been used successfully to protect human health and the environment. Emissions trading programs have two key components: a limit (or cap) on pollution, and tradable allowances equal to the limit that authorize allowance holders to emit a specific quantity (e.g., one ton) of the pollutant. This limit ensures that the environmental goal is met and the tradable allowances provide flexibility for individual emissions sources to set their own compliance path. Because allowances can be bought and sold in an allowance market, these programs are often referred to as "market-based."	US EPA https://www.epa.gov/emissions-trading-resources/what-emissions-trading

"Capacity"	The amount of energy that an energy storage system can store, typically measured in kilowatt-hours (kWh) or megawatt-hours (MWh); the potential to generate electricity when needed, measured in watts.	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
"Capacity commitment period"	The length of time associated with a capacity commitment. A capacity commitment means an obligation to deliver, during an obligation period, a volume of an offer electric energy expressed as a positive integer, corresponding to the volume of capacity that has cleared in a base auction or a rebalancing auction net of a bid that cleared in a rebalancing auction.	Law Insider https://www.lawinsider.com/dictionary/capacity-commitment

"Capacity cost or charge"	To supply communities with sufficient amounts of energy all year round, electricity suppliers have a concept known as the capacity market. By this design, multiple resources of energy are established in each locale to ensure all homes and buildings are supplied, without fail, throughout each of the four seasons. Even during the hottest summer days when electricity usage is peaking, the capacity market helps keeps electricity flowing. If one supply source becomes tapped to the limit, other nearby sources will handle the balance of businesses and residences in need of electricity. Electricity capacity charges are the rates that users pay to secure a sufficient supply of energy on a power grid during peak hours of electrical consumption. A capacity charge basically serves as insurance against power outages, which sometimes occur in times of high demand. The charges are based on peak hour usage costs, as established during a given year's usage cycle. The price determined by one year's usage figures is used to determine the following year's capacity charges. The capacity costs for a user's account include two main components: • Capacity cost per kilowatt (kW) in that utility. • The capacity tag of the account. These components are multiplied to figure out the kW capacity costs in a given year and then divided by the yearly kilowatt hour (kWh) usage to determine the kWh cost.	Shipley Energy https://www.shipleyenergy.com/resources/commercial/understanding-electricity-capacity-costs-and-ways-to-manage-them/#:~:text=What%20is%20a%20capacity%20demand,in%20times%20of%20high%20demand

"Capacity credit or value"	Capacity credit (aka Capacity Value) is a metric that depends on the generator and also in the system that it is incorporated. It is used with reference to renewable energy systems. It is a measure of the amount of conventional (thermomechanical) power generating system that can be replaced with the addition of the renewable energy system and maintain the same reliability. The key concept here is reliability and one type of measure is Loss-Of-Load expectancy (LOLE) which is the time that the system load exceeds the available generating capacity (There are also other types of measures.)	Stack Exchange https://engineering.stackexchange.com/questions/37625/capacity-credit-vs-capacity-factor
"Capacity factor"	Capacity factor refers to ratio of the energy produced by a power system in a year over the maximum energy that can be produced in a year; a percentage that tells how much of a power plant's capacity is used over time. For example, typical plant capacity factors range as high as 80 percent for geothermal and 70 percent for co-generation.	California Energy Commission https://www.energy.ca.gov/resources/energy-glossary Stack exchange https://engineering.stackexchange.com/questions/37625/capacity-credit-vs-capacity-factor

"Capacity market"	A capacity market adds another layer to a wholesale market, and they exist to increase the certainty that there will be enough electricity supply to meet expected demand years down the road. The PJM, ISO New York, and ISO New England wholesale markets all include an energy market and a capacity market. A capacity market pays generators for the generating capacity they promise to make available (measured in watts). By comparison, an energy market pays generators for the electricity they generate (measured in watt-hours),	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
"Capacity-only contract"	Capacity-only contracts are contracts in which the developer is responsible for the sale of energy and all costs associated therewith—including the costs of the required energy procured from a utility. These contracts shift the task of determining the value of the storage resource back to the developer, and developers that enter into these contracts must have a robust outlook on how the storage resource will be able to generate revenues long into the future.	DOE https://www.energy.gov/sites/prod/files/2019/01/f58/uesc_enabling_documents_jan_19.pdf
"Capacity payment"	To ensure year-round, reliable power supplies, RTOs secure commitments from power plants to generate electricity to meet customer demand during peak periods. To accomplish this, the RTOs incentivize power plants offering capacity with a guaranteed revenue stream in the form of capacity payments.	AEP Energy https://www.aepenergy.com/blog/capacity-costs-what-factors-make-up-your-total-cost/

“Capacity value”	The monetary value of the contribution of a generator (conventional, renewable, or storage) to balancing supply and demand when generation is scarce.	NREL https://www.nrel.gov/docs/fy19osti/74426.pdf
“Capital cost”	Capital costs are the one-time expenses of acquiring the land, equipment, and construction resources to start an energy storage project. Capital costs are necessary to move the project from a concept to commercialization.	ProEst https://proest.com/construction/cost-estimates/capital-cost/
“Carbon offset”	A carbon offset is a credit that a person or organization can buy to decrease its carbon footprint. When the number of carbon offset credits obtained is equal to an individual or organization's carbon footprint, that person or organization is carbon-neutral. Revenue generated from the purchase of carbon offsets is often -- but not always -- invested in environmentally friendly projects, like investments in green computing technologies. More generally, carbon offsetting is any reduction of greenhouse gas (GHG) emissions to make up for emissions that occur elsewhere. Carbon offset credits show that an organization or person has reduced its emissions. The term carbon offset is used to describe both the credit and the act of carbon offsetting. A carbon offset credit represents an emission reduction of 1 metric ton of carbon dioxide. The goal of carbon offsetting is to reduce all or a portion of a carbon footprint.	TechTarget https://www.techtarget.com/whatis/definition/carbon-offset

"Cathode"	A cathode is an electrode where a reduction reaction occurs (gain of electrons for the electroactive species).	Biologic Learning Center https://www.biologic.net/topics/anode-cathode-positive-and-negative-battery-basics/
"Cathode-electrolyte Interface"	The cathode–electrolyte interphase (CEI) formation between the cathode and the electrolyte is a critical factor that determines the stability of lithium-ion batteries.	Journal of Materials Chemistry https://pubs.rsc.org/en/content/articlelanding/2023/ta/d2ta07565b
"Charging load"	A battery's charging load defines the current that is drawn from the battery. Internal battery resistance and depleting state-of-charge (SoC) cause the voltage to drop under load, triggering end of discharge. Power relates to current delivery measured in watts (W); energy is the physical work over time measured in watt-hours (Wh).	Battery University https://batteryuniversity.com/article/bu-105-battery-definitions-and-what-they-mean#:~:text=A%20load%20defines%20the%20current,watt%2Dhours%20(Wh

“Chemical energy storage”	Chemical energy storage technologies are mainly constituted by batteries (secondary and flow batteries) and renewable generated chemicals (hydrogen, fuel cell, SNG, and hydrocarbons). Batteries as electrochemical energy storage bring great promise in a range of small-scale to large-scale applications.	Science Direct https://www.sciencedirect.com/topics/engineering/chemical-energy-storage#:~:text=6.2%2C%20chemical%20energy%20storage%20technologies,scale%20to%20large%2Dscale%20applications

"Clean energy standard"	A policy that requires a certain percentage of electricity generation to come from low- or zero-emission sources, such as renewable energy or nuclear power, helping to reduce greenhouse gas emissions and promote the adoption of clean energy technologies. A clean energy standard, sometimes also called a clean electricity standard, requires a percentage of retail electricity sales to come from low- and zero-carbon "clean" electricity sources. While there are many ways to design this type of policy, the share of clean energy required typically increases over time. This type of policy standard reduces greenhouse gas emissions only in the power sector and is therefore considered a sectoral approach. CESs are similar to renewable portfolio standards, or RPSs, which require that a certain percentage of electricity supplies come from renewable energy sources such as wind, solar, and geothermal generators. These are well-tested and successful policy mechanisms. Numerous states have adopted renewable portfolio standards. A CES differs in that it allows a wider array of low- and zero-carbon sources to be used to meet the standard, including nuclear power and fossil generators with carbon capture and storage.	Bipartisan Policy Center https://bipartisanpolicy.org/download/?file=/wp-content/uploads/2020/03/BPC_Energy_Clean-Energy-StandardV2.pdf

“Climate change”	Also referred to as 'global climate change'. The term 'climate change' is sometimes used to refer to all forms of climatic inconsistency, but because the Earth's climate is never static, the term is more properly used to imply a significant change from one climatic condition to another. In some cases, 'climate change' has been used synonymously with the term, 'global warming'; scientists however, tend to use the term in the wider sense to also include natural changes in climate.	California Energy Commission https://www.energy.ca.gov/resources/energy-glossary
“Cobalt”	Cobalt is a technology-enabling metal that is part of the solution to the green energy transition. Cobalt can be magnetized and is used to make magnets, including particularly powerful magnets when alloyed with aluminum and nickel. Other alloys of cobalt are used in jet turbines and gas turbine generators, where high-temperature strength is important. Cobalt can be used to generate hydrogen from water. The hydrogen is then available as a fuel for heat, vehicles, seasonal energy storage, and long distance transport of energy.	The Cobalt Institute https://www.cobaltinstitute.org/about-cobalt/
“Combined heat and power (CHP)”	Also known as "cogeneration," it is the simultaneous production of electricity and heat from a fuel source such as natural gas, biomass, biogas, coal, waste heat, or oil. Combined heat and power is not a single technology, but an integrated energy system that can be modified depending on the energy user's needs.	California Energy Commission https://www.energy.ca.gov/resources/energy-glossary

“Commercialization”	Programs or activities that increase the value or decrease the cost of integrating new products or services into the electricity sector.	California Energy Commission https://www.energy.ca.gov/resources/energy-glossary
“Communication system”	Various battery energy-storage system (BESS) components, such as the inverter, BMS, or EMS, must communicate to exchange critical information. The entire BESS might also need to communicate with external systems and equipment like meters and the central control system. This communication is achieved via the communication system that is embedded in the BESS .In addition to ensuring the smooth operation of the installation, the communication system allows you to control the entire system or parts and execute various functions such as start/stop, schedule tasks, and carry out diagnostics. Various components facilitate this information exchange. They include various circuits, monitoring and control software and algorithms, and wireless equipment.	IEN.EU https://www.ien.eu/article/communication-solutions-for-battery-energy-storage-systems/

"Community choice aggregation (CCA)"	CCA—also known as municipal aggregation—programs allow local governments to procure power on behalf of their residents, businesses, and municipal accounts from an alternative supplier while still receiving transmission and distribution service from their existing utility provider. CCAs are an attractive option for communities that want more local control over their electricity sources, more green power than is offered by the default utility, and/or lower electricity prices. By aggregating demand, communities gain leverage to negotiate better rates with competitive suppliers and choose greener power sources. CCAs are currently authorized in California, Illinois, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Ohio, Rhode Island, and Virginia	EPA https://www.epa.gov/green-power-markets/community-choice-aggregation

“Community energy storage (CES) system”	CES systems are a collection of two or more battery storage units connected to the low-level transformers that serve houses or small businesses. These systems exist on the utility side of the meter, or “in front” of customer meters, and are typically referred to as front-of-the-meter battery storage. Utilities and electric co-ops that are adding batteries to the grid cite many benefits for residential, commercial, and other grid-level stakeholders. At the local scale, benefits of energy storage include the ability to provide backup power, mitigate flicker, and integrate more renewable capacity while maintaining local grid stability. At the broader grid-scale, these systems can provide voltage regulation, peak demand shaving, load-leveling at substations, power factor correction, and other ancillary services. As an LDES project, a CES system can designed with a community ownership and governance approach to generate socio-economic benefits, including renewable energy penetration, emissions reductions, decreased energy costs, and revenue generation potential.	NREL https://www.nrel.gov/state-local-tribal/blog/posts/community-energy-storage-a-new-revenue-stream-for-utilities-and-communities.html

"Community solar"	A shared solar energy system in which multiple participants, such as households or businesses, invest in or subscribe to a portion of the system's output, enabling them to benefit from clean energy without installing solar panels on their own property. Some utilities are exploring opportunities to incorporate community energy storage (CES) systems into the local grid. Utility-owned CES systems are a collection of two or more battery storage units connected to the low-level transformers that serve houses or small businesses. These systems exist on the utility side of the meter, or "in front" of customer meters, and are typically referred to as front-of-the-meter battery storage. Utilities and electric co-ops that are adding batteries to the grid cite many benefits for residential, commercial, and other grid-level stakeholders. At the local scale, benefits of energy storage include the ability to provide backup power, mitigate flicker, and integrate more renewable capacity while maintaining local grid stability. At the broader grid-scale, these systems can provide voltage regulation, peak demand shaving, load-leveling at substations, power factor correction, and other ancillary services.	NREL https://www.nrel.gov/state-local-tribal/blog/posts/community-energy-storage-a-new-revenue-stream-for-utilities-and-communities.html

“Compound annual growth rate (CAGR)”	Compound annual growth rate, or CAGR, is the mean annual growth rate of an investment over a specified period of time longer than one year. It represents one of the most accurate ways to calculate and determine returns for individual assets, investment portfolios, and anything that can rise or fall in value over time.	Investopedia https://www.investopedia.com/investing/compound-annual-growth-rate-what-you-should-know/#:~:text=Compound%20annual%20growth%20rate%2C%20or,fall%20in%20value%20over%20time.
“Compressed air energy storage (CAES)”	A mechanical energy storage technology that stores energy by compressing air and storing it in underground reservoirs. The stored energy is released by expanding the compressed air through a turbine to generate electricity. The basic idea of CAES is to capture and store compressed air in suitable geologic structures underground when off-peak power is available or additional load is needed on the grid for balancing. The stored high-pressure air is returned to the surface and used to produce power when additional generation is needed, such as during peak demand periods. To date, there are two operating CAES plants in the world; a 110 MW plant in McIntosh, Alabama, commissioned in 1991 and a 290 MW plant in Huntorf, Germany built in 1978. Both plants store air underground in excavated salt caverns produced by solution mining.	PNNL https://caes.pnnl.gov/

"Concentrating Solar Power (CSP)"	Concentrating solar-thermal power (CSP) technologies can be used to generate electricity by converting energy from sunlight to power a turbine, but the same basic technologies can also be used to deliver heat to a variety of industrial applications, like water desalination, enhanced oil recovery, food processing, chemical production, and mineral processing. CSP technologies use mirrors to concentrate (focus) the sun's light energy and convert it into heat to create steam to drive a turbine that generates electrical power.	DOE—Office of Energy Efficiency and Renewable Energy https://www.energy.gov/eere/solar/concentrating-solar-thermal-power
"Contingency"	A contingency is the loss or failure of a small part of the power system (e.g. a transmission line), or the loss/failure of individual equipment such as a generator or transformer. This is also called an unplanned "outage".	EPRI https://smartgrid.epri.com/usecases/contingencyanalysis-baseline.pdf
"Contingency analysis"	Contingency analysis is a computer application that uses a simulated model of the power system, to evaluate the effects and calculate any overloads resulting from each outage event. Contingency analysis is essentially a "preview" analysis tool. It simulates and quantifies the results of problems that could occur in the power system in the immediate future.	EPRI https://smartgrid.epri.com/usecases/contingencyanalysis-baseline.pdf
"Contingency spinning"	Fast response to a contingency such as a generator failure, with a duration of service typically in the 30 minutes to 2 hours range.	NREL https://www.nrel.gov/docs/fy19osti/74426.pdf

"Contracts for Difference"	Contract-for-Difference (CfD) is a mechanism to incentivize investment in energy production assets with a high upfront cost, by providing stable prices over a long period. They can also be used to protect consumers against high electricity prices. For example, renewable energy projects—including wind farms—have relatively low operational costs and typically incur 60%–90% of their lifetime costs upfront. This means they require a lot of investment to get started. To finance these upfront capital needs, renewable energy projects depend on stable, long-term electricity prices to repay their initial investments. However, electricity market prices tend to vary, which can create a barrier to funding for renewable energy projects. By establishing a fixed revenue stream for renewable energy projects, CfDs help create certainty that these projects will be able to pay back those initial investments. As such, the primary role of CfDs is one of risk management.	NREL https://www.nrel.gov/news/program/2023/a-sustainable-solution-to-increase-clean-energy-deployment.html

"Copper"	Copper is one of the few elements that has been used by humans for over 10,000 years. Copper is an excellent conductor of electricity, making it an ideal material for renewable energy systems. Its high electrical conductivity allows for efficient energy transfer, minimizing power losses during transmission and distribution. Moreover, copper's unparalleled malleability and ductility, which refer to its ability to be easily shaped and stretched without breaking, make it incredibly challenging to substitute with other materials. Copper is extensively used in wind turbines. It is employed in generator coils, transformers, and electrical cables. The strong magnetic properties of copper enable efficient power generation and ensure reliable performance in wind turbine systems. Copper is also a crucial element in solar panels. It is used in the wiring, busbars, and connectors within the panels. Copper's excellent electrical conductivity facilitates the efficient conversion of sunlight into electricity and supports the overall performance of solar energy systems. For the power generated from renewables to ultimately be deployed effectively, electrical grid infrastructure and energy storage are also needed. Copper, once again, is integral in building both. In energy storage systems, which complement renewables by storing energy for days when the wind isn't blowing or the sun isn't shining, copper is used in batteries and supercapacitors. It is utilized in the conductive components, such as electrodes and current collectors, enhancing the efficiency and durability of energy storage devices.	DDQ Invest https://ddqinvest.com/copper-the-irreplaceable-raw-material-for-renewable-energy/

	In electrical grid infrastructure, copper is extensively used in power cables, transformers, and distribution systems, ensuring the reliable transmission of electricity from renewable sources to end consumers.	

"(Energy) Curtailment"	The reduction or restriction of energy production from renewable resources, often due to grid constraints or lack of demand. Curtailment is the reduction of output of a renewable resource below what it could have otherwise produced. It is calculated by subtracting the energy that was actually produced from the amount of electricity forecasted to be generated. Unlike other renewable resources like small-conduit hydroelectric, geothermal, biomass and biogas, new solar and wind resources are able, both technologically and contractually, to respond to oversupply conditions by reducing their production output. Curtailments can occur in three ways: economic curtailment, when the market finds a home for low-priced or negative-priced energy; self-scheduled cuts, which reduce generation from self-scheduled bids; and exceptional dispatch, when the ISO orders generators to turn down output.	California Independent System Operator https://www.caiso.com/Documents/CurtailmentFastFacts.pdf
"(Energy) Curtailment management"	The process of reducing or limiting the output of renewable energy generators, such as wind turbines or solar panels, in response to grid constraints or a lack of demand for the electricity being produced.	California Independent System Operator https://www.caiso.com/Documents/CurtailmentFastFacts.pdf

"Cycles / Cycling"	A battery cycle is a complete charge and discharge cycle, so the number of cycles is actually a charge cycle calculation method. The battery discharge to 50% charge twice is counted as a discharge cycle, and the discharge cycle is counted as the cycle number. When the battery reaches a full charge cycle, the number of battery cycle will be +1. A one-charge cycle means that the battery has been fully charged once, but it does not necessarily mean that only one charge has been made. Batteries with a duration between four hours and eight hours are typically cycled once per day and are used to shift electricity from times of relatively low demand to times of high demand. The number of times an energy storage system can be charged and discharged. A higher cycle life indicates longer battery life.	TycoRun https://www.tycorun.com/blogs/news/a-comprehensive-guide-to-understanding-battery-cycle#What_is_a_battery_cycle NREL https://www.nrel.gov/docs/fy19osti/74426.pdf
"DC coupling"	Coupling is the transfer of energy between two mediums by means of physical contact. DC (direct coupling) allows both AC and DC signals to pass through a connection. The DC component is a 0 Hz signal which acts as an offset about which the AC component of the signal fluctuates. Connecting a solar array and energy storage system that uses a single inverter, improving overall system efficiency would be one example of DC coupling.	Siemens https://community.sw.siemens.com/s/article/ac-and-dc-coupling-what-s-the-difference

"Decarbonization"	Decarbonization refers to the process of shifting from a global energy system primarily based on fossil fuels to one that relies more heavily on renewable energy, energy efficiency, and low-carbon technologies to reduce greenhouse gas emissions and mitigate the effects of climate change. To keep the planet from warming more than 1.5°C above pre-industrial levels, most countries, including the U.S., have goals to reach net zero by 2050. Net zero means that all greenhouse gas emissions produced are counterbalanced by an equal amount of emissions that are eliminated. Achieving this will require rapid decarbonization. There are two aspects to decarbonization. The first entails reducing the greenhouse gas emissions produced by the combustion of fossil fuels. This can be done by preventing emissions through the use of zero-carbon renewable energy sources such as wind, solar, hydropower, geothermal and biomass, which now make up one-third of global power capacity, and electrifying as many sectors as possible. Energy efficiency will reduce the demand for energy, but increasing electrification will increase it, and in 2050, the demand for power is expected to be more than double what it is today. Consequently, decarbonization will also require absorbing carbon from the atmosphere by capturing emissions and enhancing carbon storage in agricultural lands and forests. To achieve decarbonization, all aspects of the economy must change—from how energy is generated, and how we produce and	Columbia Climate School https://news.climate.columbia.edu/2022/04/22/what-is-decarbonization-and-how-do-we-make-it-happen/

	deliver goods and services, to how lands are managed. The carbon dioxide and methane emissions that are warming the planet come largely from the power generation, industry, transport, buildings, and agriculture and land use sectors of the global economy, so these sectors must all be transformed. Here's what decarbonization could look like in each sector.	

"Decentralized energy generation systems"	The generation of electricity at or near the point of consumption, as opposed to centralized generation at large-scale power plants, which relies on long-distance transmission and distribution.A decentralized energy system generates electricity close to its consumption point. Advances in energy technologies, especially renewable energy sources, make it financially viable and desirable for on-site electricity generation. Examples of decentralized energy systems, also called distributed energy resources (DERs), include: • Solar photovoltaic panels (solar panels), such as on a rooftop or as part of a community-based project; • Small-scale wind turbines powered by wind energy; • Batteries to store excess energy, including those in electric vehicles (EVs); • Pumped hydro storage or micro-hydro power stations; • Thermal energy used in thermal power plants; • Combined heat and power (CHP), where heat emissions from power plants are captured and reused, perhaps to heat homes or other industrial processes; • Hybrid power generators or power plants that can switch between different energy sources, such as solar power and diesel-generated electricity; hybrids may also burn natural gas, liquefied natural gas, and biofuels; • Biomass generators or energy from waste plants; and • District heating and cooling	JustEnergy https://justenergy.com/blog/decentralization-energy/

"Decommissioning"	Decommissioning is the final process of closing and securing a generation facility consistent with established end states, to provide adequate protection from radiation exposure and isolation from the human environment.	DOE https://www.energy.gov/em/deactivation-decommissioning-dd
"Degradation"	Battery degradation refers to the gradual decline in the ability of a battery to store and deliver energy. This inevitable process can result in reduced energy capacity, range, power, and overall efficiency of a device.	Exro https://www.exro.com/industry-insights/battery-degradation-explained#:~:text=Battery%20degradation%20refers%20to%20the,of%20your%20device%20or%20vehicle.

"Demand charge"	A fee charged by some utilities based on a customer's peak energy demand during a billing period, typically used for commercial and industrial customers to encourage more efficient energy consumption. Demand is the maximum amount of power (kW) drawn for any given time interval (typically 15 minutes) during the billing period, multiplied by the relevant demand charge ($/kW). Demand (measured in kW) is a measure of how much power a customer uses at a given time. Utilities apply demand charges based on the maximum amount of power that a customer used in any interval (typically 15 minutes) during the billing cycle. Demand charges usually apply to commercial and industrial customers, who tend to have higher peak loads (i.e., peak power demand) than residential customers. Most utility rates specify the maximum power demand a customer is allowed to have: exceeding the maximum power demand for consecutive months can result in being moved to a different rate with higher demand charges.	Renewable Energy & World https://www.renewableenergyworld.com/wind-power/making-sense-of-demand-charges-what-are-they-and-how-do-they-work/#gref
"Demand response"	Providing wholesale and retail electricity customers with the ability to choose to respond to time-based prices and other incentives by reducing or shifting electricity use, particularly during peak demand periods, so that changes in customer demand become a viable option for addressing pricing, system operations and reliability, infrastructure planning, operation and deferral, and other issues.	California Energy Commission, https://www.energy.ca.gov/resources/energy-glossary

"Demand-side management (DSM)"	Programs that consist of the planning, implementing, and monitoring activities of electric utilities that are designed to encourage consumers to change their level and pattern of electricity usage	California Energy Commission https://www.energy.ca.gov/resources/energy-glossary
"Demand-side response (DSR)"	Demand-side response (DSR) is a strategy used by utilities and grid operators to manage peak energy demand by incentivizing consumers, through price signals or reliability alerts, to reduce their energy consumption during peak hours and thus help balance supply and demand on the electrical grid. DSR is an umbrella term for a type of energy service that large-scale industrial and commercial consumers of electricity (such as manufacturers) can use to help keep the grid balanced. As a DSR participant, a utility customer will decrease or increase its facility's power consumption when it receives signals (requests) to do so, thereby helping the grid to maintain its frequency balance.	GridBeyond https://gridbeyond.com/demand-side-response-dsr-what-is-it-why-do-it/
"Demonstration phase"	The Demonstrations phase (2023–2025) supports many smaller demonstrations to create a visible set of case studies across the market landscape.	*Pathways to Commercial Liftoff: Long Duration Energy Storage, U.S. Department of Energy* https://liftoff.energy.gov/wpcontent/uploads/2023/03/20230320-Liftoff-LDES-vPUB-0329-update.pdf

"Deployment phase"	The Deployment phase (2028–2030+) features large demonstration projects that affirm the viability of LDES technologies and shows the limited need for outside support (e.g., standalone, bankable use cases).	*Pathways to Commercial Liftoff: Long Duration Energy Storage, U.S. Department of Energy* https://liftoff.energy.gov/wpcontent/uploads/2023/03/20230320-Liftoff-LDES-vPUB-0329-update.pdf
"Depth of Discharge (DoD)"	Depth of Discharge (DoD) refers to how much energy is cycled into and out of the battery on a given cycle. It's expressed as a percentage of the total capacity of the battery DoD is a figure of merit that is often used instead of state of charge (SoC). It is defined as an amount of charge removed from the battery at the given state related to the total amount of charge, which can be stored in this battery and usually expressed as a percentage The percentage of a battery's capacity that has been used. A higher DoD indicates that more of the battery's capacity has been used, which may reduce its life cycle.	EnergySage https://www.energysage.com/energy-storage/depth-of-discharge/
"Direct access"	The ability of a retail customer to purchase commodity electricity directly from the wholesale market rather than through a local distribution utility. Also referred to as "retail competition."	California Energy Commission https://www.energy.ca.gov/resources/energy-glossary

"Direct current (DC)"	Electricity that flows continuously in the same direction. Direct current (DC) is the flow of electrically charged particles in one unchanging direction. DC is more practical than AC in many applications and is found in smartphones, TVs, cars (including EVs), battery-powered devices, photovoltaic solar cells, and much more.	California Energy Commission https://www.energy.ca.gov/resources/energy-glossary All About Circuitshttps://www.allaboutcircuits.com/textbook/direct-current/#:~:text=Direct%20current%20(DC)%20is%20the,solar%20cells%2C%20and%20much%20more.
"Dispatch"	The operating control of an integrated electric system to: Assign generation to specific generating plants and other sources of supply to effect the most reliable and economical supply as the total of the significant area loads rises or falls. Control operations and maintenance of high-voltage lines, substations Energy and equipment, including administration of safety procedures. Operate the interconnection. Schedule energy transactions with other interconnected electric utilities.	California Energy Commission https://www.energy.ca.gov/resources/energy-glossary

"Dispatchable power"	Dispatchability is the ability of a given power source to increase and decrease output quickly on demand. A dispatchable source of electricity refers to an electrical power system, such as a power plant, that can be turned on or off; in other words they can adjust their power output supplied to the electrical grid on demand. Most conventional power sources such as coal or nuclear power plants are dispatchable in order to meet the always changing electricity demands of the population. In contrast, many renewable energy sources are intermittent and non-dispatchable, such as wind power or solar power which can only generate electricity while their primary energy flow is input on them.	Energy Educati https://energyeducation.ca/encyclopedia/Dispatchable_source_of_electricity
"Distributed energy resources (DER)"	Small-scale power generation technologies (typically in the range of 3 to 10,000 kilowatts) located close to where electricity is used (for example, a home or business) to provide an alternative to or an enhancement of the traditional electric power system.	California Energy Commission https://www.energy.ca.gov/resources/energy-glossary
"Distributed energy resource management system (DERMS)"	The coordination and control of multiple distributed energy resources, such as rooftop solar panels, energy storage systems, and demand response programs, to optimize their operation, reduce overall energy costs, and provide grid support services. With DER management systems (DERMS), utilities can apply the capabilities of flexible demand-side energy resources and manage diverse and dispersed DERs, both individually and in aggregate.	NREL https://www.nrel.gov/grid/distributed-energy-resource-management-systems.html

“Distributed generation (DG)”	The production of electricity from small-scale, decentralized energy sources, such as rooftop solar panels, small wind turbines, or combined heat and power systems, located close to the point of consumption. A distributed generation system involves small amounts of generation located on a utility's distribution system for the purpose of meeting local (substation level) peak loads and/or displacing the need to build additional (or upgrade) local distribution lines.	California Energy Commission https://www.energy.ca.gov/resources/energy-glossary
“Diurnal energy storage”	An energy storage system with a typical charge and discharge of a few days; diurnal storage can shift power delivery over a few days.	ScienceDirect https://www.sciencedirect.com/science/article/abs/pii/B9780128034408000154#:~:text=Most%20small%2D%20to%20medium%2Dsized,also%20used%20in%20certain%20applications. Union of Concerned Scientists https://blog.ucsusa.org/maria-chavez/long-duration-energy-storage-is-key-to-cleaning-up-the-power-grid/

"Diurnal price arbitrage"	Arbitrage refers to the strategy to purchase energy when the price is low in the early morning hours and sell when the price is high in the late afternoon and early evening. In diurnal price arbitrage this strategy is applied of multiple days. In addition to the diurnal swing in prices, several days during a week may exhibit an increase in prices in the late morning followed by a decline after lunch, which is then followed by the traditional increase in prices in the early evening. For these days, the optimal policy would be to complete two charge/discharge cycles in one day, which would be an example of diurnal price arbitrage.	Sandia National Laboratories https://www.sandia.gov/ess-ssl/publications/SAND2012-3863.pdf
"Dry cell battery"	A dry cell battery typically consists of an anode (negative electrode), a cathode (positive electrode), and an electrolyte. The electrolyte is in the form of a paste or a solid, which allows for the transfer of ions between the anode and cathode during the electrochemical reactin. When a load is connected to the battery, electrons flow from the anode to the cathode through the external circuit, powering the device.	Dry Cell Batteries: A Reliable Power Source for Everyday Devices https://howtostoreelectricity.com/dry-cell-batteries/

"Duration"	The duration of a battery is the length of time that a storage system can sustain power output at its maximum discharge rate, typically expressed in hours. The energy capacity of the battery storage system is defined as the total amount of energy that can be stored or discharged by the battery storage system. A battery's average duration is the amount of time a battery can contribute electricity at its nameplate power capacity until it runs out. Batteries used for electricity load shifting have relatively long durations.	EIA https://www.eia.gov/todayinenergy/detail.php?id=51798
"Dynamic line rating (DLR)"	Dynamic Line Rating (DLR) is a changing transmission line rating based on local conditions rather than a static rating assumption and provides additional ampacity capacity to a transmission line. The U.S. Department of Energy has identified DLR as a transmission and distribution infrastructure solution to defer upgrades, support line outages and increase yields of distributed power. DLR is also a method of determining the real-time capacity of power lines based on actual weather and operating conditions, allowing for more efficient use of existing transmission infrastructure and reducing the risk of congestion or overloading. DLR is one of many solutions known as Grid Enhancing Technologies.	Idaho National Laboratory https://inl.gov/national-security/dynamic-line-rating/#:~:text=Dynamic%20Line%20Rating%20(DLR)%20is,capacity%20to%20a%20transmission%20line.

"Dynamic load management (DLM)"	Dynamic Load Management, or DLM, is one of many smart energy management tools. DLM ensures that the available power is evenly distributed to all the EVs being charged simultaneously and that charging happens at a full volume whenever there's enough capacity. DLM is the real-time optimization of energy consumption within a facility or across a network of facilities, using automated control systems and communication technologies to balance demand with available supply and grid conditions.	Virta https://www.virta.global/blog/what-is-dynamic-load-management
"Economies of scale"	Economies of scale are cost advantages reaped by companies when production becomes efficient. Companies can achieve economies of scale by increasing production and lowering costs. This happens because costs are spread over a larger number of goods. Costs can be both fixed and variable. Economies of scale are an important concept for any business in any industry and represent the cost-savings and competitive advantages larger businesses have over smaller ones.	Investopedia https://www.investopedia.com/terms/e/economiesofscale.asp

"Effective load carrying capability (ELCC)"	ELCC measures a resource's contribution to reliability based on the incremental quantity of load that can be satisfied by adding the resource to the grid. Measuring the contribution of variable and supply-limited resources to grid reliability is becoming increasingly important as such resources expand their role in the electricity grid. ELCC represents an important advance in calculating resource adequacy, as it better reflects the realities of how supply resources contribute to system reliability compared to previous methods. ELCC reflects the ability of a generator to be available during the period of highest risk of an outage, which typically corresponds to periods of peak demand—or, increasingly, peak net demand, where net demand is the normal demand minus the contribution of variable renewable energy (VRE). Computing ELCC, however, generally involves sophisticated and complex Monte Carlo modeling to account for the numerous factors that affect system reliability. Embedded in this modeling are many judgments that affect the results.	Penn State, Institute of Energy and the Environment https://iee.psu.edu/events/simple-model-effective-load-carry-capability

"(Energy) Efficiency"	The ratio of energy output to energy input, typically expressed as a percentage. A higher efficiency means that less energy is lost during the storage process. Energy efficiency is the use of less energy to perform the same task or produce the same result. Energy-efficient homes and buildings use less energy to heat, cool, and run appliances and electronics, and energy-efficient manufacturing facilities use less energy to produce goods. Energy efficiency is one of the easiest and most cost-effective ways to combat climate change, reduce energy costs for consumers, and improve the competitiveness of U.S. businesses. Energy efficiency is also a vital component in achieving net-zero emissions of carbon dioxide through decarbonization.	DOE https://www.energy.gov/eere/energy-efficiency-buildings-and-industry
"Electric Vehicle (EV) charging infrastructure"	A vehicle powered by electricity, usually provided by batteries but may also be provided by photovoltaic (solar) cells or a fuel cell.	California Energy Commission https://www.energy.ca.gov/resources/energy-glossary
"Electric vehicle (EV) charging infrastructure"	The network of charging stations and equipment required to support electric vehicles, including Level 1, Level 2, and DC fast chargers.	California Energy Commission https://www.energy.ca.gov/resources/energy-glossary

"Electricity Reliability Council of Texas (ERCOT)"	The Electric Reliability Council of Texas (ERCOT) manages the flow of electric power to more than 26 million Texas customers -- representing about 90 percent of the state's electric load. As the independent system operator for the region, ERCOT schedules power on an electric grid that connects more than 52,700 miles of transmission lines and 1,100 generation units, including Private Use Networks. It also performs financial settlement for the competitive wholesale bulk-power market and administers retail switching for 8 million premises in competitive choice areas. ERCOT is governed by a board of directors and subject to oversight by the Public Utility Commission of Texas and the Texas Legislature. Its members include consumers, cooperatives, generators, power marketers, retail electric providers, investor-owned electric utilities, transmission and distribution providers and municipally owned electric utilities.	ERCOT https://www.ercot.com/about

"Electrochemical capacitors"	Electrochemical capacitors (ECCs; sometimes referred to as supercapacitors or ultracapacitors) are energy storage devices that have much higher capacitance and energy density than the traditional dielectric capacitors that are presently sold in various markets by the billions each year. Electrochemical capacitors have much lower energy density and much higher power capacity than batteries. Hence ECCs have characteristics between traditional capacitors and batteries and can compete with both depending on the application. In general, ECCs can be a serious alternative to batteries when the amount of energy to be stored is relatively small for a battery and the peak power requirement of the system is large compared to the average power. The ECC can be a significant alternative to traditional capacitors when the energy storage requirement is large for a traditional capacitor and the high power pulse times are not too short (milliseconds or longer).	Science Direct https://www.sciencedirect.com/topics/materials-science/electrochemical-capacitor

“Electrochemical systems”	An electrochemical system is a term used to describe a cell, apparatus, or general setup consisting of two or more electrodes spatially separated and distributed throughout one or more ionically-conductive media, or electrolytes, while also being in electrical contact with one another via a separate current path. The electrodes in an electrochemical system undergo oxidation and reduction reactions, with movement of electrons producing current raveling through the current path simultaneously with movement of ions through the media producing an overall balance of charge transfer within the system.	Pine Research https://pineresearch.com/shop/kb/theory/glossary/electrochemical-system/
“Electrochemical LDES technologies”	Long duration energy storage includes electrochemical energy storage such as static batteries, flow batteries, metal (iron) air batteries, and other battery chemistries.	LDES Council https://www.ldescouncil.com/ldes-technologies/#:~:text=Currently%2C%20the%20most%20widely%20deployed,air%20energy%20storage%20(LAES

"Electrothermal energy storage"	Electrifying industrial heat is critical for decarbonization and can increase energy security. Electrothermal energy storage (ETES) is a new, commercially available technology to electrify heat in industry and other sectors. It works by converting electrical energy into thermal energy, storing the heat in molten salt and cold in chilled liquid. It then uses a heat engine, powered by the temperature differential, back to electricity. ETES technologies electrify industrial heat processes and store energy as heat. They use electricity to produce heat and then store it in a heat storage medium, such as bricks. Systems can charge when electricity is cheapest – typically when excess renewable electricity is produced. The stored heat is then used to generate a continuous flow of heat on demand. ETES is relevant for decarbonizing industrial sites and other processes that require heat continuously, and for large-scale users that want to use energy from wind or solar instead of from fossil fuels to fulfil their energy needs.	SystemIQ https://www.systemiq.earth/electrothermal-energy-storage/

"Electrolyte"	An electrolyte is a key component of electrochemical energy storage (EES) devices and its properties greatly affect the energy capacity, rate performance, cyclability and safety of all EES devices. The electroactive materials that store electrical energy are dissolved in a supporting liquid and the complete solution is called an electrolyte. The electrolytes are contained in tanks external to the means of energy conversion, and the amount of energy stored is proportional to the amount of electrolyte contained in the tanks.	WattJoule https://www.wattjoule.com/how-it-works/
"Energy (kWh)"	Can be thought of as capacity (power x time). Energy applications involve continuous discharges over extended durations (hours or more) with extended recharge times. Applications include peak shaving, load-leveling, transmission and distribution upgrade deferral, customer demand charge and energy charge reduction, renewables generation shifting and energy arbitrage or commodity storage.	NREL https://www.nrel.gov/docs/fy19osti/74426.pdf

"Energy access"	The availability and affordability of reliable and clean energy sources for households and businesses, particularly in developing countries or rural areas, to support economic development, social well-being, and the transition to a low-carbon energy system. There is no single internationally-accepted and internationally-adopted definition of modern energy access. Yet significant commonality exists across definitions, including: • Household access to a minimum level of electricity. • Household access to safer and more sustainable (i.e. minimum harmful effects on health and the environment as possible) cooking and heating fuels and stoves. • Access to modern energy that enables productive economic activity, e.g. mechanical power for agriculture, textile and other industries. • Access to modern energy for public services, e.g. electricity for health facilities, schools and street lighting. The IEA defines energy access as "a household having reliable and affordable access to both clean cooking facilities and to electricity, which is enough to supply a basic bundle of energy services initially, and then an increasing level of electricity over time to reach the regional average."	IEA https://www.iea.org/articles/defining-energy-access-2020-methodology

“Energy-as-a-Service (EaaS)”	Energy as a service (EaaS) is a business model where customers pay a recurring subscription fee rather than making an upfront capital investment into energy assets. Under this model, a service provider assumes responsibility for the installation, operation, maintenance, and financing of the energy system on behalf of the customer. The customer pays for the energy service on a subscription or pay-per-use basis, rather than owning the energy infrastructure. EaaS can take various forms. For example, a commercial building may contract an EaaS provider to install and operate a rooftop solar system, which generates electricity for the building and feeds excess power into the grid. The EaaS provider would handle the financing, installation, and maintenance of the solar panels, while the building owner would pay a fee for the energy generated by the system. EaaS can offer several benefits to customers, such as reduced upfront costs, improved energy efficiency, and access to the latest technologies. It can also help customers to meet sustainability targets and reduce their carbon footprint.	GridX https://www.gridx.ai/knowledge/energy-as-a-service

"Energy capacity"	The total amount of energy that can be stored in or discharged from the storage system and is measured in units of watthours (kilowatthours [kWh], megawatthours [MWh], or gigawatthours [GWh])	US Energy Information Administration (EIA) https://www.eia.gov/energyexplained/electricity/energy-storage-for-electricity-generation.php
"Energy density"	A measure of how much energy can be stored in a given volume or mass of an energy storage material, typically expressed in watt-hours per liter (Wh/L) or watt-hours per kilogram (Wh/kg). Energy density is the amount of energy that can be stored in a given system, substance, or region of space. Energy density can be measured in energy per volume or per mass. The higher the energy density of a system or material, the greater the amount of energy it has stored.	Energy Education https://energyeducation.ca/encyclopedia/Energy_density
"Energy efficiency"	Using less energy/electricity to perform the same function. Programs designed to use electricity more efficiently - doing the same with less. For the purpose of this paper, energy efficiency is distinguished from DSM programs in that the latter are utility-sponsored and -financed, while the former is a broader term not limited to any particular sponsor or funding source. "Energy conservation" is a term which has also been used but it has the connotation of doing without in order to save energy rather than using less energy to do the same thing and so is not used as much today. Many people use these terms interchangeably.	California Energy Commission, https://www.energy.ca.gov/resources/energy-glossary

"Energy imbalance market (EIM)"	A real-time market for the trading of electricity to help balance supply and demand on the electrical grid, allowing utilities and grid operators to more efficiently manage fluctuations in generation and consumption, and to access lower-cost or cleaner sources of power. An EIM is a means of supplying and dispatching electricity to balance fluctuations in generation and load. It aggregates the variability of generation and load over multiple BAAs.	NREL https://www.nrel.gov/docs/fy12osti/56236.pdf
"Energy management system (EMS)"	A system that monitors and optimizes energy consumption across a building or facility, including demand response, load control, and energy efficiency measures. An EMS can integrate with renewable energy generation and energy storage systems to optimize overall energy use and reduce costs. Controlling energy flow into and out of the storage battery is essential to ensure efficient system utilization. This control requires an energy management system, or EMS in short. The EMS regulates the inverter's working as it converts DC to AC, optimizing its performance and the entire system. In other words, these components of a battery energy storage system ensure the whole system works as it should to produce electrical power as needed.	California Energy Commission, https://www.energy.ca.gov/resources/energy-glossary

"Energy market"	Energy markets are auctions that are used to coordinate the production of electricity on a day-to-day basis. In an energy market, electric suppliers offer to sell the electricity that their power plants generate for a particular bid price, while load-serving entities (the demand side) bid for that electricity to meet their customers' energy demand. Supply side quantities and bids are ordered in ascending order of offer price. The market "clears" when the amount of electricity offered matches the amount demanded, and generators receive this market price per megawatt hour of power generated. ISOs/RTOs typically run two energy markets: the day-ahead and real-time markets. • The day-ahead market, which represents about 95 percent of energy transactions, is based on forecasted load for the next day and typically occurs the prior morning in order to allow generators time to prepare for operation. • The remaining energy market transactions take place in the real-time market, which is typically run once every hour and once every five minutes to account for real-time load changes that must be balanced at all times with supply.	Resources for the Future https://www.rff.org/publications/explainers/us-electricity-markets-101/

"Energy-only wholesale market"	Energy Only Markets (EOM) compensate generators based on the actual amount of energy delivered, rather than potentially deliverable – capacity is only indirectly compensated through agreements like futures contracts. In an energy-only wholesale market, power generators only sell electricity to buyers. Often, generators sign long-term contracts with retail electric providers to provide a large amount of electricity over an extended period of time. Because large power plants take years to build and even small systems like a rooftop solar array can take months to install, the ISO or RTO needs to know years in advance if generators can supply enough electricity to meet demand. ERCOT in Texas is one example of an energy-only market.	Enpowered.com https://enpowered.com/different-markets-energy-versus-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
"Energy payback time (EPBT)"	The time it takes for an energy system, such as a solar panel or wind turbine, to generate the same amount of energy required for its manufacturing, installation, and decommissioning. Although assumptions vary among EPBT calculations, the energy to produce the module should be as inclusive as possible, accounting for everything from the energy needed to mine, transport, refine, produce, and deliver all module subcomponents to that required to deposit/assemble/package the module, deploy it, and eventually recycle the module at the end of its life.	Science Direct https://www.sciencedirect.com/topics/engineering/energy-payback-time

"Energy storage procurement target"	Procurement targets, also referred to as mandates, are established by state regulatory agencies and sometimes state legislatures, and require utilities to acquire a specified quantity of energy storage, typically by a specified deadline. To date, 10 states have adopted procurement targets:	Morgan Lewis https://www.morganlewis.com/pubs/2023/03/storage-strategies-an-overview-of-state-energy-storage-policy

"Energy storage system (ESS)"	A system designed to store energy generated from various sources, such as solar or wind, for use at a later time when needed. An energy storage system (ESS) for electricity generation uses electricity (or some other energy source, such as solar-thermal energy) to charge an energy storage system or device, which is discharged to supply (generate) electricity when needed at desired levels and quality. ESSs provide a variety of services to support electric power grids. In some cases, ESSs may be paired or co-located with other generation resources to improve the economic efficiency of one or both systems. The five types of ESSs in commercial use in the United States, in order of total power generation capacity as of the end of 2022 are: • Pumped-storage hydroelectric • Batteries (electro-chemical) • Solar electric with thermal energy storage • Compressed-air storage • Flywheels Other types of ESSs that are in various stages of research, development, and commercialization include capacitors and super-conducting magnetic storage.	US Energy Information Administration (EIA) https://www.eia.gov/energyexplained/electricity/energy-storage-for-electricity-generation.php

	Hydrogen, when produced by electrolysis and used to generate electricity, could be considered a form of energy storage for electricity generation	

“Environmental justice”	Environmental justice is the fair treatment and meaningful involvement of all people, regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.	DOE https://www.energy.gov/lm/environmental-justice
“(Energy) Equity”	Energy equity recognizes that disadvantaged communities have been historically marginalized and overburdened by pollution, underinvestment in clean energy infrastructure, and lack of access to energy-efficient housing and transportation. An equitable energy system is one where the economic, health, and social benefits of participation extend to all levels of society, regardless of ability, race, or socioeconomic status. Achieving energy equity requires intentionally designing systems, technology, procedures, and policies that lead to the fair and just distribution of benefits in the energy system	PNNL https://www.pnnl.gov/projects/energy-equity#:~:text=What%20is%20Energy%20Equity%3F,energy%2Defficient%20housing%20and%20transportation

"Fast frequency response (FFR)"	Fast frequency response (FFR) is the controlled contribution of electrical power from a generating unit or power plant that rapidly responds to frequency changes to minimize the torque imbalance of synchronous generators by adding or subtracting the output power into a system, thus contributing towards arresting the frequency change and settling the frequency indirectly. This definition focuses on performance requirements more than technical implementation to achieve the controlled performance objectives. The FFR of inverter-based resources is an important mitigation option for maintaining grid security under the conditions of low inertia and insufficient primary frequency response capability.	Science Direct https://www.sciencedirect.com/science/article/pii/S2096511720301146

"Federal Energy Regulatory Commission (FERC)"	The Federal Energy Regulatory Commission, or FERC, is an independent agency that regulates the interstate transmission of electricity, natural gas, and oil. FERC also reviews proposals to build liquefied natural gas (LNG) terminals and interstate natural gas pipelines as well as licensing hydropower projects. The Energy Policy Act of 2005 gave FERC additional responsibilities as outlined and updated Strategic Plan. As part of that responsibility, FERC: • Regulates the transmission and wholesale sale of electricity in interstate commerce • Reviews certain mergers and acquisitions and corporate transactions by electricity companies • Regulates the transmission and sale of natural gas for resale in interstate commerce • Regulates the transportation of oil by pipelines in interstate commerce • Approves the siting and abandonment of interstate natural gas pipelines and storage facilities • Reviews the siting application for electric transmission projects under limited circumstances • Assesses the safe operation and reliability of proposed and operating LNG terminals • Licenses and inspects private, municipal, and state hydroelectric projects • Protects the reliability of the high voltage interstate transmission system through mandatory reliability standards • Monitors and investigates energy markets	FERC https://www.ferc.gov/what-ferc-does

	• Enforces FERC regulatory requirements through imposition of civil penalties and other means • Oversees environmental matters related to natural gas and hydroelectricity projects and other matters • Administers accounting and financial reporting regulations and conduct of regulated companies	

"FERC Order 745"	FERC Order 745 Order No. 745 addresses compensation for demand response (DR)in RTO and ISO wholesale energy markets. In order to operate effectively, an energy market must successfully balance energy supply and energy demand. Generally, the Order states that when DR can provide a balance of supply and demand as an alternative to generation, and dispatching DR is cost-effective (determined by a net benefits test), DR will be compensated at the locational marginal price (LMP). This approach to compensating DR resources aims to improve the functioning and competitiveness of energy markets by: 1. ensuring competitiveness of DR resources in wholesale energy markets, as more DR competition will cause generators to lower bids because of the increased risk they will not be dispatched if their bid prices are too high; 2. removing barriers for DR participation in energy markets pursuant to national policy; 3. producing wholesale energy rates that are just and reasonable; and (4) supporting system reliability; and 4. addressing resource adequacy by providing quick response resources to balance the electricity grid. The Order states that compensation for DR resources at the LMP is only appropriate when: 1. The DR response resource is able to displace a generation resource which assists the ISO/RTO in balancing supply and demand; and	Policy Integrity https://policyintegrity.org/documents/FERC_Order_745_Memo_-_FERC_Conference.pdf

	2. Payment of LMP for the DR resource service is cost-effective, as determined by the net benefits test.	

"FERC Order 841"	In February 2018, the Federal Energy Regulatory Commission (FERC) issued Order No. 841, a landmark final rule amending FERC's regulations to facilitate the participation of electric storage resources in the capacity, energy, and ancillary service markets operated by regional transmission organizations/independent system operators (RTOs/ISOs) (excluding ERCOT). The goal of Order No. 841 is to remove barriers to electric storage resource participation in RTO/ISO markets. Although certain storage resources, such as pumped hydro resources, have been participating in RTO/ISO markets for years, the Commission observed that existing market rules designed for traditional resources do not recognize electric storage resources' unique physical and operational characteristics and can create barriers to entry for emerging technologies. The final rule aims to address those barriers by establishing the minimum requirements by which RTOs and ISOs will facilitate electric storage resource participation in wholesale markets. The final rule applies to electric storage resources, which the Commission defined as any "resource capable of receiving electric energy from the grid and storing it for later injection of electric energy back to the grid." This definition applies to all storage resources, irrespective of their storage medium (e.g., batteries, flywheels, compressed air, and pumped hydro) and location on the grid (i.e., the definition applies to resources on the interstate transmission system, on a distribution system, or behind the meter). This expansive, resource-neutral definition underscores the	Morgan Lewis https://www.morganlewis.com/pubs/2023/03/storage-participation-in-wholesale-markets

	Commission's view that market rules should not be designed for any particular electric storage technology. The final rule imposes a 100 kilowatt (kW) minimum size requirement that is intended to balance the benefits of increased competition in RTO/ISO markets with the potential burden required to update RTO/ISO market clearing software to effectively model and dispatch smaller resources. RTOs/ISOs were required to develop their own models to facilitate the participation of electric storage resources to comply with Order No. 841, including qualification criteria and bidding parameters that reflect the physical and operational characteristics of the resource.	

"FERC Order 881"	On Dec. 16, 2021, FERC issued Order 881. The order requires transmission providers to implement and use ambient-adjusted ratings for transmission lines used to provide transmission service. RTOs and ISOs must develop systems and procedures to allow transmission owners to electronically submit updated transmission line ratings at least hourly. Public utility transmission providers must maintain an accessible, password-protected database of transmission line ratings and rating methodologies of transmission owners. Order 881 mandates new operating practices for transmission service providers, transmission owners and system operators. The order sets several new requirements that move the power industry toward a more dynamic method of transmission line ratings that are adjusted at least hourly based on ambient temperatures. The change is aimed at setting limits that more closely comport with system operating conditions.	Burns & McDonnell https://blog.burnsmcd.com/ferc-order-881-sets-new-standard-for-transparency-and-transmission-asset-utilization

"FERC Order 896"	Issued on June 15, 2023, FERC Order 896 directed the North American Electric Reliability Corporation (NERC) to establish a new Reliability Standard addressing the risks of extreme heat and cold weather events in long-term transmission system planning. NERC will develop extreme heat and cold weather benchmark events, as well as create benchmark planning cases for these events that will serve as the basis for assessing system performance and studying wide-area impacts. The benchmark events also are required to reflect regional climate and weather pattern differences.	Wright & Talisman https://www.wrightlaw.com/ferc-responds-to-extreme-weather-threats-to-reliability-by-mandating-new-reliability-standard-and-transmission-provider-reports

"FERC Order 1000"	In July 2011, FERC issued Order 1000 titled Transmission Planning and Cost Allocation. The Order was designed to address four issues observed in the electricity marketplace: • Existing rules did not require regional transmission planning, so each transmission provider tended to develop plans that created local benefits but did not consider greater regional good. This tended to favor smaller, low-voltage transmission projects. • Existing rules did not require planning to consider public policy requirements such as renewable power portfolio requirements. This tended to hold back development of renewable energy in transmission-short areas. • Independent transmission owners were discouraged from building projects by rules that gave incumbent transmission owners the right of first refusal on new projects. This meant that a developer could spend time and money getting a project conceptualized and included in a transmission plan only to see it built by the incumbent transmission owner. • Cost allocation methodologies did not provide for regional consideration of costs and benefits. This meant that a local project that would have regional benefits might not be able to collect revenue from those benefitting, thus making it much less likely that the project would get built.	FERC https://www.ferc.gov/electric-transmission/order-no-1000-transmission-planning-and-cost-allocation

"FERC Order 2000"	In Order No. 2000, FERC encouraged the voluntary formation of Regional Transmission Organizations (RTO) to administer the transmission grid on a regional basis throughout North America (including Canada). Order No. 2000 delineated twelve characteristics and functions that an entity must satisfy in order to become a Regional Transmission Organization. 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/power-sales-and-markets/rtos-and-isos

“FERC Order 2023”	On July 28, 2023, FERC issued Order No. 2023, which updates the procedures for interconnecting large generating facilities (20MW and above) and small generating facilities (under 20MW). As FERC explained in the Final Rule, the adopted reforms are intended to address interconnection queue backlogs, improve certainty in the interconnection process, and prevent undue discrimination for new technologies. Order No. 2023 adopts a series of mandatory reforms in an attempt to bring uniformity to interconnections across the country. The most significant change is the move away from FERC’s historic “first come, first served” serial approach to interconnections in favor of a “first ready, first served” cluster study approach that requires generators to demonstrate commercial readiness to proceed through the queue.	Troutman Pepper https://www.troutman.com/insights/troutman-pepper-summary-of-ferc-order-no-2023-on-generator-interconnection-reform.html

"FERC Order 2222"	In September 2020, FERC issued Order 2222 with updates in 2021. The main goal of Order No. 2222 is to better enable distributed energy resources (DERs) to participate in the electricity markets run by regional grid operators. The term "DERs" covers a wide variety of resources, including electric battery storage systems, rooftop solar panels, products like smart thermostats that enable one to reduce power usage, energy efficiency measures, thermal energy storage systems such as ice storage, or electric vehicles and their charging equipment. Such DERs may be in your home, business, church or other non-profit organization, community center, local government office, or even a shared solar facility. Since DERs can be small in comparison to traditional resources like power plants and may be widely dispersed, the output of several or many DERs would often need to be combined together so that there is a "bundle" of sufficient size for market participation. This bundle is called an aggregation, with the aggregator being the direct participant in the regional energy market. An aggregator, for example, may be able to bring together dozens of small DERs and use their output to participate in the market, then share compensation back to the individual DERs. This is easier to administer than having thousands of individual DERs participating directly in the market.	FERC https://www.ferc.gov/ferc-order-no-2222-explainer-facilitating-participation-electricity-markets-distributed-energy#:~:text=The%20Federal%20Energy%20Regulatory%20Commission,run%20by%20regional%20grid%20operators.

"Firming capacity"	The amount of installed capacity that can be relied upon to meet demand during peak periods or other high-risk periods. The share of firm capacity to the total installed capacity of a generator is known as its capacity credit (%).	NREL https://www.nrel.gov/docs/fy19osti/74426.pdf
"Firming for PPAs"	Renewable purchase power agreements (PPAs) can use LDES to ensure that businesses can procure 24/7 (and additional) renewable electricity	NREL https://www.nrel.gov/docs/fy19osti/74426.pdf
"Fixed O&M cost"	Operating and maintenance (O&M) costs are the sum of two components, fixed and variable costs. Fixed O&M costs are related to regular system maintenance, component replacement, and labor costs. (By comparison, the majority of variable O&M costs comes from the purchase of power or electricity to supply operating units.	Science Direct https://www.sciencedirect.com/topics/engineering/operation-and-maintenance-cost#:~:text=O%26M%20costs%20are%20the%20sum,supplying%20electricity%20to%20the%20electrolyzer.

"Flexible load"	Load flexibility, also called demand flexibility, is the practice of adjusting load (or energy usage) to match the supply of electricity. Flexible load is the portion of electricity demand that can be adjusted or shifted in response to changes in supply, grid conditions, or price signals, often through demand response programs or automated control systems, helping to balance the grid and improve overall efficiency.	CEC https://www.energy.ca.gov/programs-and-topics/topics/load-flexibility#:~:text=Load%20flexibility%2C%20also%20called%20demand,match%20the%20supply%20of%20electricity.
"Flow batteries"	Flow batteries are a type of electrochemical ES, which consists of two chemical components dissolved in liquid separated by a membrane. Charging and discharging of batteries occur by ion transferring from one component to another component through the membrane. The biggest advantages of flow batteries are the capability of pack in large volumes. Interest in flow batteries has increased considerably with increasing storage needs of renewable energy sources. High-capacity flow batteries, which have giant tanks of electrolytes, have capable of storing a large amount of electricity. However, the biggest issue to use flow batteries is the high cost of the materials used in them, such as vanadium. As a type of rechargeable battery that uses liquid electrolytes, flow batteries are known for their long cycle life and scalability.	Science Direct https://www.sciencedirect.com/topics/engineering/flow-battery

"Flywheel energy storage"	A mechanical energy storage technology that stores energy in a rotating mass, in the form of kinetic energy, by spinning a massive rotor at high speeds. The stored energy is released by using the rotational energy of the flywheel to generate electricity through a generator. Flywheel energy storage systems typically have a fast response time and high efficiency. Flywheels are one of the earliest forms of energy storage and have found widespread applications particularly in smoothing uneven torque in engines and machinery. More recently flywheels have been developed to store electrical energy, made possible by use of directly mounted brushless electrical machines and power conversion electronics. It has numerous merits such as high power density, high conversion efficiency and long life-span. In the past few decades, it has been used in uninterruptible power supplies where the short-duration power changes reduce the battery lifetime. Flywheels have great potential for rapid response, short duration, high cycle applications, many of which are listed and described. For flywheels to succeed beyond niche applications, cost reduction is necessary but certainly possible by use of low-cost materials and innovative design.	Science Direct https://www.sciencedirect.com/topics/engineering/flywheel-energy-storage

"Forward capacity market (FCM"	Forward Capacity Market. ("FCM") refers to the forward market for procuring capacity in an RTO. The FCM is the locational capacity market in which an RTO projects needs of the power system three years in advance and holds an annual auction to purchase power resources to satisfy future electricity demand needs for that region.	Law Insider https://www.lawinsider.com/dictionary/forward-capacity-market
"Fossil fuel"	Oil, coal, natural gas or their by-products. Fuel that was formed in the earth in prehistoric times from remains of living-cell organisms.	California Energy Commission, https://www.energy.ca.gov/resources/energy-glossary
"Frequency regulation"	Frequency Regulation (or just "regulation") ensures the balance of electricity supply and demand at all times, particularly over time frames from seconds to minutes. When supply exceeds demand the electric grid frequency increases and vice versa. It is an automatic change in active power output in response to a frequency change. It is required to maintain the frequency within statutory and operational limits. Frequency regulation is the process of maintaining the electrical grid's frequency at a constant level by adjusting the balance between electricity generation and consumption.	EPRI https://storagewiki.epri.com/index.php/DER_VET_User_Guide/Services/Frequency_Regulation

“(Primary) frequency response”	Primary frequency response (PFR) is one of the important reserve services used by grid operators to uphold steady frequency to maintain nearly constant frequency is an important measure of system reliability and stability. PFR is typically very fast response to unpredictable variations in demand and generation with a duration of service in the range of seconds. Modeling PFR has historically been rare in grid integration and planning studies, but it could become more important with greater deployment of nonsynchronous generators.	NREL https://www.nrel.gov/docs/fy19osti/72355.pdf
“Fuel cell”	A device or an electrochemical engine with no moving parts that converts the chemical energy of a fuel, such as hydrogen, and an oxidant, such as oxygen, directly into electricity. The principal components of a fuel cell are catalytically activated electrodes for the fuel (anode) and the oxidant (cathode) and an electrolyte to conduct ions between the two electrodes, thus producing electricity.	California Energy Commission https://www.energy.ca.gov/resources/energy-glossary

"Geo-mechanical pumped storage"	Geomechanical pumped storage technology mimics conventional "pumped hydro" in its storage mechanism but doesn't require large-scale dams and the costly civil works projects associated with them. Instead, geomechanical pumped storage relies on proven well drilling and construction technologies to pump water into subsurface geological reservoirs at elevated pressure to store energy.	Quidnet Energy https://www.quidnetenergy.com/solution/faqs/
"Geothermal energy"	Natural heat from within the earth, captured for production of electric power, space heating or industrial steam.	California Energy Commission https://www.energy.ca.gov/resources/energy-glossary
"Geothermal power plants"	Geothermal power plants produced about 0.4% of total U.S. utility-scale electricity generation and accounted for 1.9% of electricity generation from renewable sources in 2022. Geothermal power plants use steam turbines to generate electricity.	US Energy Information Administration (EIA) https://www.eia.gov/energyexplained/electricity/electricity-in-the-us.php
"Gigawatt (GW)"	One thousand megawatts (1,000 MW) or, one million kilowatts (1,000,000 kW) or one billion watts (1,000,000,000 watts) of electricity.	California Energy Commission https://www.energy.ca.gov/resources/energy-glossary

“Gravity-based energy storage”	A mechanical LDES technology, gravity energy storage technology (GES) essentially uses a mechanical process of lifting and lowering composite blocks made from soil and waste materials to store and dispatch energy, depends on the vertical movement of a heavy object in a gravitational field to store or release electricity. GES accomplishes energy storage by converting the electrical energy in the power system to the gravitational potential energy of the weight through electromechanical equipment. For example, the gravitational potential energy is stored by absorbing power to drive the electromechanical equipment to lift the height of the weight when there is a power surplus in the power grid and lowering the weight to return power to the grid when there is a power shortage in the power system. Example: Energy Vault’s gravity-based, grid-scale energy storage., which uses excess renewable energy to raise bricks, then lowers the bricks to generate energy during peak demand — all controlled by AI software and executed autonomously. Energy Vault‘s system uses excess renewable energy to raise bricks, then lowers the bricks to generate energy during peak demand — all controlled by AI software and executed autonomously.	Science Direct https://www.sciencedirect.com/science/article/pii/S2352152X22012257

"Green hydrogen"	An emerging energy storage technology, green hydrogen is produced through the electrolysis of water using renewable energy resources, such as wind or solar, resulting in minimal greenhouse gas emissions. It can be stored and used as a fuel when needed. Green hydrogen is made by using clean electricity from surplus renewable energy sources, such as solar or wind power, to electrolyze water. Electrolyzers use an electrochemical reaction to split water into its components of hydrogen and oxygen, emitting zero-carbon dioxide in the process. Green hydrogen currently makes up a small percentage of the overall hydrogen, because production is expensive. Just as energy from wind power has reduced in price, green hydrogen will come down in price as it becomes more common.	National Grid https://www.nationalgrid.com/stories/energy-explained/hydrogen-colour-spectrum
"Grey hydrogen"	Currently, this is the most common form of hydrogen production. Grey hydrogen is created from natural gas, or methane, using steam methane reformation but without capturing the greenhouse gases made in the process. Grey hydrogen is essentially the same as blue hydrogen, but without the use of carbon capture and storage.	National Grid https://www.nationalgrid.com/stories/energy-explained/hydrogen-colour-spectrum#:~:text=Blue%20hydrogen%20is%20produced%20mainly,produced%20as%20a%20by%2Dproduct

"Grid balancing"	Grid balancing is the process of maintaining balance in the grid by ensuring that supply always matches demand. Electricity producers and utilities use different strategies to help ensure this is the case, including: • Adjusting power production: The traditional way to ensure grid balance is to increase or decrease electricity production using gas, biomass or coal. Unlike renewable energy sources, these can be adjusted and controlled manually. • Adjusting energy consumption: Regulating the consumption of large-scale electricity users. • Adjusting electricity prices: Differentiating energy prices to encourage electricity use at off-peak times where supply is traditionally higher than demand (for example, at night).	True Energy https://www.trueenergy.io/blog/what-is-grid-balancing/#:~:text=Electricity%20producers%20and%20utilities%20use,using%20gas%2C%20biomass%20or%20coal.
"Grid conditions"	Grid conditions measure both the desirability and relative feasibility of LDES in a particular state, as well as the overall generation mix. Factors include the percent penetration of variable renewables, the transmission and distribution investment gap, grid resilience as measured by SAIDI/SAIFI scores, and the ease of interconnection.	*Pathways to Commercial Liftoff: Long Duration Energy Storage, U.S. Department of Energy.* https://liftoff.energy.gov/wpcontent/uploads/2023/03/20230320-Liftoff-LDES-vPUB-0329-update.pdf

"Grid congestion"	A condition in which the transmission or distribution infrastructure of the electrical grid is unable to accommodate the flow of electricity from generation to consumption points, leading to inefficiencies, higher costs, and potential reliability issues.	DOE https://www.energy.gov/oe/articles/grid-2030-national-vision-electricitys-second-100-years
"Grid Enhancing Technologies (GETs)"	Grid-enhancing technologies (GETs) provide operational support while larger upgrades are completed enroute to a transmission system that reliably integrates new power sources. GETs devices can support increased power flow across transmission systems, which shows innovative uses of technology. How utilities and transmission operators will implement the capabilities from GETs in practice remains to be seen. Two GETs that represent mature technologies ready for industry deployment today are Dynamic Line Rating and Power Flow Controller.	Idaho National Laboratory https://inl.gov/national-security/grid-enhancing-technologies/

“Grid inertia”	Inertia in power systems refers to the energy stored in large rotating generators and some industrial motors, which gives them the tendency to remain rotating. This stored energy can be particularly valuable when a large power plant fails, as it can temporarily make up for the power lost from the failed generator. This temporary response—which is typically available for a few seconds—allows the mechanical systems that control most power plants time to detect and respond to the failure, and therefore offer the ability of the electrical grid to resist sudden changes in frequency and maintain stability, provided by the rotational energy of large, synchronous generators, such as those in traditional power plants. Historically, in the U.S. power grid, inertia from conventional fossil, nuclear, and hydropower generators was abundant—and thus taken for granted in the planning and operations of the system. But as the grid evolves with increasing penetrations of inverter-based resources—e.g., wind, solar photovoltaics (PV), and battery storage—that do not inherently provide inertia, questions have emerged about the need for inertia and its role in the future grid.	NREL https://www.nrel.gov/news/program/2020/inertia-and-the-power-grid-a-guide-without-the-spin.html

"Grid resiliency"	A resilient power grid withstands, responds to, and recovers rapidly from major power disruptions as its designers, planners, and operators anticipate, prepare for, and adapt to changing grid conditions. Aspects of resilience, specifically the ability to "absorb" an event, overlap with operational reliability and resource adequacy—two other important parts of a reliable grid. However, several aspects of resilience are unique, particularly how quickly power can be restored after an outage. Resilience also typically includes more extreme, rare events that go beyond "reasonable" outages considered in resource adequacy and operational reliability.	NREL https://www.nrel.gov/research/power-system-resilience.html

"Grid-scale energy storage"	Grid-scale storage refers to technologies connected to the power grid that can store energy and then supply it back to the grid at a more advantageous time – for example, at night, when no solar power is available, or during a weather event that disrupts electricity generation. Large-scale energy storage systems, typically with capacities of multiple megawatt-hours or more, designed to provide grid support services, such as frequency regulation, load shifting, and backup power, to help maintain grid reliability and accommodate the integration of renewable energy sources. The most widely-used technology is pumped-storage hydropower, where water is pumped into a reservoir and then released to generate electricity at a different time, but this can only be done in certain locations. Batteries are now playing a growing role as they can be installed anywhere in a wide range of capacities.	International Energy Association https://www.iea.org/energy-system/electricity/grid-scale-storage
"Grid edge"	The interface between the electrical grid and the end users, where distributed energy resources, advanced technologies, and new market opportunities are transforming the traditional model of electricity generation, transmission, and distribution.	Wood Mackenzie https://www.woodmac.com/market-insights/topics/the-grid-edge/

"Grid flexibility"	The ability of an electrical grid to adapt to changing conditions, such as fluctuations in supply and demand or the integration of variable renewable energy sources, without compromising reliability and stability.	MDPI https://www.mdpi.com/2071-1050/15/20/15032
"Grid-forming inverter"	Inverters provide the interface between the grid and energy sources like solar panels, wind turbines, and energy storage. When there is a large disturbance or outage on the grid, conventional inverters will shut off power to these energy sources and wait for a signal from the rest of the grid that the disturbance has settled and it is safe to restart—known as "grid-following." As wind and solar account for increasing shares of the overall electricity supply, it is becoming impractical to depend on the rest of the grid to manage disturbances. Grid-forming inverters are an emerging technology that allows solar and other inverter-based energy sources to restart the grid independently. An advanced inverter technology that can create and maintain an electrical grid, as opposed to grid-following inverters that require a stable grid frequency and voltage to operate. Grid-forming inverters can enable the operation of islanded systems or microgrids and enhance grid stability.	Department of Energy https://www.energy.gov/eere/solar/articles/powering-grid-forming-inverters

"Grid interconnection"	Grid interconnection can be thought of in two primary ways: 1) the processes through which an energy system connects to the electrical grid; and 2) a state in which separate power systems with different types of power supply such as voltage, AC, DC, etc., are operated in parallel for the purpose of interchange of power. Grid interconnection refers to the physical and operational connection of an energy system, such as a renewable energy generator or energy storage facility, to the electrical grid, allowing for the exchange of electricity between the system and the grid. Interconnection standards are the "rules of the road" for the electricity grid. They specify the processes, timelines, costs, and technical processes associated with connecting renewable energy systems, energy storage, and other distributed energy resources to the grid. Grid interconnection also refers to the processes that tie a network of local grids together at a synchronized frequency. This allows the exchange of energy from local grids with surplus power to those having a demand higher than what they can produce locally. A power outage due to a storm or failures in the local grid can become unlikely if the local network can tap electricity from a regional grid.	IREC https://www.irecusa.org/our-work/connecting-to-the-grid/ Clean Energy Finance Forum https://www.cleanenergyfinanceforum.com/2022/03/09/explainer-what-are-grid-interconnections-and-what-complicates-them

"Grid modernization"	The process of upgrading and enhancing the electrical grid to improve its reliability, efficiency, and resilience, and to enable the integration of new technologies, such as renewable energy, energy storage, and advanced communication systems.	DOE https://www.energy.gov/oe/grid-modernization-and-smart-grid
"Grid parity"	Grid parity is the point at which an alternative form of energy generates power at a levelized cost of electricity that's equal to or less than the price of buying power from the electric grid. In other words – as we mentioned earlier – grid parity is the point when the cost of the alternative energy becomes equal to or less than electricity from conventional energy forms like fossil fuels. It's one of the most important things energy analysts look at when determining how economically viable an alternative energy form is for widespread development and adoption.	Clean Technica https://cleantechnica.com/2016/03/30/grid-parity-what-is-it-why-does-it-matter/

"Grid reliability"	The ability of an electrical grid to provide a continuous and stable supply of electricity to consumers, maintaining the appropriate frequency, voltage, and power quality, even in the face of disturbances or fluctuations in supply and demand. The grid remains functional even during unanticipated but common system disturbances, such as loss of a source of energy generation from an energy provider or failure of some other system element. When something fails, the grid has to be able to isolate the problem and keep functioning. Grid reliability is based on two key elements: • Reliable operation – A reliable power grid has the ability to withstand sudden electric system disturbances that can lead to blackouts. • Resource adequacy - Generally speaking, resource adequacy is the ability of the electric system to meet the energy needs of electricity consumers. This means having sufficient generation to meet projected electric demand.	FERC https://www.ferc.gov/reliability-explainer#:~:text=Grid%20reliability%20is%20the%20provision,switch%2C%20the%20lights%20turn%20on.

"Grid-tied system"	An energy system connected to the electrical grid, allowing it to draw energy from or send excess energy back to the grid.	DOE https://www.energy.gov/energysaver/grid-connected-renewable-energy-systems
"High-temperature sensible heat energy storage "	Sensible high temperature heat storage (SHTHS) raises or lowers the temperature of a liquid or solid storage medium (e.g. sand, pressurized water, molten salts, oil, ceramics, rocks) in order to store and release thermal energy for high temperature applications (above 100°C). The amount of stored heat is proportional to the density, specific heat, volume, and temperature variation of the storage materials. Basically, specific heat, density and thermal conductivity are the main thermal properties of sensible heat storage materials. At higher temperatures the most common liquid storage material is molten salt. The salt is pumped between a cold and a hot storage tank for (dis-)charging. In direct systems the salt is used as a storage medium and heat transfer fluid at the same time. Indirect systems employ a heat exchanger with an additional thermal oil cycle. Power and capacity of the storage are thus linked to separate units in the system, heat exchanger and storage tanks, respectively.	Energy Research Alliance https://eera-energystorage.eu/component/attachments/?task=download&id=561:JPES-SP3-2-High-Temperature-Sensible-Heat-Storage#:~:text=Sensible%20high%20temperature%20heat%20storage,(above%20100%C2%B0C).

"Hybrid flow battery"	An electrochemical LDES technology, with liquid electrolyte and metal anode (some are Inter-day). The hybrid flow battery is a type of flow battery where electrolyte contains one or more dissolved electroactive element which flows through an electrochemical cell where the chemical energy is converted into electrical energy. In a hybrid flow battery, electroactive material is deposited on the surface of the electrode during the charge cycle and then dissolved back into the electrolyte solution during discharge. For hybrid technologies, the storage duration is a function of both the electrolyte volume and the electrode surface area. While most hybrid technologies can achieve durations of six to 12 hours, power and energy are not fully decoupled. Hybrid flow batteries are unique in storing grid-scale renewable energy owing to their versatile characteristics such as the decoupled designed of power and energy, no intercalation/de-intercalation and stress build in electrode, active heat management due to the removal of heat by flowing electrolysis and capability of storing large energy in a simple design.	Power Magazine https://www.powermag.com/flow-batteries-energy-storage-option-for-a-variety-of-uses/ Fortune Business Insights https://www.fortunebusinessinsights.com/industry-reports/hybrid-flow-battery-market-100404

"Hybrid solar inverter"	A device that combines the functions of a solar inverter and a battery inverter, hybrid solar inverters enable seamless integration of solar power and energy storage systems. A hybrid solar inverter is a piece of equipment that is created by combining a solar inverter and a battery inverter into a single unit. This allows the hybrid solar inverter to intelligently handle power coming from your solar panels, solar batteries, and the utility grid all at the same time. The direct current (DC) electricity generated by a photovoltaic (PV) system is changed into the alternating current (AC) electricity. This type of solar grid-tie inverter also makes it possible to send any excess electricity generated to the utility grid. The process of converting the DC electricity that is stored in your solar battery storage into AC electricity that can be used by your home is managed by a battery inverter. A solar hybrid grid-tie inverter makes the work of a traditional solar inverter easier and better by putting all of its functions into a single device. These features include grid connection and solar panel charging. Even better, because the amount of solar power that is available can vary depending on the weather and the time of year, a hybrid inverter can, if necessary, draw power from the electricity grid to charge your battery storage system. This is a significant benefit because the amount of solar power that is available can change.	FSP https://www.fsp-group.com/en/knowledge-prd-55.html#:~:text=A%20hybrid%20solar%20inverter%20is,all%20at%20the%20same%20time.

"Hydroelectric turbine"	Hydroelectric turbines use the force of moving water to spin turbine blades to power a generator. Most hydroelectric power plants use water stored in a reservoir or diverted from a river or stream. These conventional hydroelectric power plants accounted for about 6% of U.S. electricity generation in 2022.	US Energy Information Administration (EIA) https://www.eia.gov/energyexplained/electricity/how-electricity-is-generated.php
"Hydrogen energy storage"	A method of storing energy in the form of hydrogen gas, which can be produced by electrolysis of water using electricity from renewable sources, and later used to generate electricity in fuel cells or combustion processes. Hydrogen energy storage is another form of chemical energy storage in which electrical power is converted into hydrogen. This energy can then be released again by using the gas as fuel in a combustion engine or a fuel cell. Hydrogen can be produced from electricity by the electrolysis of water, a simple process that can be carried out with relatively high efficiency provided cheap power is available. The hydrogen must then be stored, potentially in underground caverns for large-scale energy storage, although steel containers can be used for smaller scale storage. Hydrogen can be used as fuel for piston engines, gas turbines, or hydrogen fuel cells, the latter offering the best efficiency. Hydrogen energy storage is of interest because the gas forms the basis for the hydrogen economy in which it replaces fossil fuel in many combustion applications.	Science Direct https://www.sciencedirect.com/topics/engineering/hydrogen-energy-storage#:~:text=Hydrogen%20energy%20storage%20is%20another,engine%20or%20a%20fuel%20cell.

“Hydrogen storage caverns””	Hydrogen storage caverns are created in natural salt domes. Engineers drill through rock layers to get to deep salt domes. Then, they create space — using a process called leaching, where the salt is dissolved by fresh water— within the salt to create the necessary volume to store hydrogen for the long term. Salt is a good geologic substance for storing gas and liquid and has a long track record of success with fossil fuel storage. The caverns developed in salt provide a resilient, protected, leak-proof reservoir to inject, store, and deliver fuels like hydrogen.	American Society of Civil Engineers https://www.asce.org/publications-and-news/civil-engineering-source/civil-engineering-magazine/article/2023/09/what-makes-a-salt-cavern-useful-for-hydrogen-storage

"Hydrogen--tank storage"	Compact, reliable, safe, and cost effective storage of hydrogen is a key challenge to the widespread commercialization of fuel cell electric vehicles (FCEVs) and other hydrogen fuel cell applications. While some light-duty FCEVs with a driving range of over 300 miles are emerging in limited markets, affordable onboard hydrogen storage still remains as a key roadblock. Much of the current development efforts associated with hydrogen tank storage are focused on developing cost-effective hydrogen storage technologies with improved energy density. Research and development efforts include high-pressure compressed storage and materials-based storage technologies. In addition to developing hydrogen storage materials, understanding how the materials would function in a complete system is critical. System design needs to account for factors such as a) how the material is packaged, b) how hydrogen flows into and through the system and c) how heat associated with the charge and discharge of hydrogen is moved into and out of the systems, all while meeting safety requirements.	DOE https://www.energy.gov/eere/fuelcells/articles/hydrogen-storage-fact-sheet

“Hydrometallurgical recycling”	The hydrometallurgical process is considered to be the most suitable method for the recycling of spent lithium-ion batteries. Key aspects of the hydrometallurgical recycling process include pretreatment of the spent lithium-ion batteries, the leaching process and separation of valuable metals from leaching solution. At present, hydrometallurgy is typically used to recover LIBs after pretreatment. According to the physical properties of the materials in the spent LIBs, including morphology, density, and magnetism, etc. The treated battery cases, electrodes and membranes containing electrolytes will be treated separately to improve the safety and recovery rate of hydrometallurgical processes and reduce energy consumption during the use of hydrometallurgical or pyrometallurgical recovery electrode materials. Hydrometallurgy usually involves leaching and reduction. It is usually divided into acid leaching and biological leaching according to the leaching method.	Frontiers https://www.frontiersin.org/articles/10.3389/fchem.2020.578044/full ACS Publications https://pubs.acs.org/doi/10.1021/acssuschemeng.8b03545
“Independent System Operator [ISO]”	An independent system operator, or ISO, is an independent organization that handles electric grid operations, market facilitation for certain electric markets, and bulk electric system planning. If competitive generation markets are to work effectively, generators must have nondiscriminatory access to the transmission system to deliver their power to customers. ISOs were created to facilitate competitive wholesale electric markets.	Energy KnowledgeBase https://energyknowledgebase.com/topics/independent-system-operator.asp

"Installed (or Nameplate) capacity"	The maximum rated output of a generator, prime mover, or other electric power production equipment under specific conditions designated by the manufacturer. Installed generator nameplate capacity is commonly expressed in megawatts (MW) and is usually indicated on a nameplate physically attached to the generator.	EIA https://www.eia.gov/tools/glossary/index.php?id=G#:~:text=Generator%20nameplate%20capacity%20(installed)%3A,conditions%20designated%20by%20the%20manufacturer.

"Integrated resource planning"	A comprehensive process used by utilities and policymakers to evaluate and plan for future energy resource needs, considering factors such as demand forecasts, resource options, costs, environmental impacts, and policy objectives. Integrated resource plans (IRPs) examine both their energy demand and supply and identify any risks that could prevent utilities or other load-serving entities from meeting their customers' long-term energy needs at reasonable costs. Typically, an IRP requires the utility to conduct load forecasting as well as demand-side, supplyside, integration and risk analyses. An IRP is a planning tool– it is neither a metric nor a measure to achieve particular goals. The basic IRP incorporates the following criteria: • Reliability • System demand • System growth • Fossil and renewable energy resources • Base-load and peaking generation • Strategies to enhance energy security • Energy efficiency policies and programs • Applicable federal and state laws/policies • Strategies to minimize costs for customers	DOE https://www.energy.gov/scep/slsc/articles/integrated-resource-plans-criteria-effective-planning-tool

"Inter-day"	Shifting power by 10–36 hours and includes almost all mechanical storage technologies and some electrochemical technologies (e.g., flow batteries).	*Pathways to Commercial Liftoff: Long Duration Energy Storage, U.S. Department of Energy.* https://liftoff.energy.gov/wp-content/uploads/2023/03/20230320-Liftoff-LDES-vPUB.pdf
"Interoperability"	Interoperability is an essential enabler for technology to scale, as it moves us away from today's state of highly customized integration. The desired state of technology interoperability is where end-use resources (generation, storage, and loads) can seamlessly communicate and transact with a range of energy services. This exchange will occur across the meter with the utility and with other end-use loads or generation. Interoperability, in particular as embedded in software, reduces the cost (and time) of technology integration, including the cost of software installation. It offers the benefit of better choices of products with more features and price points and better security that enable enhanced energy management. An electric system with interoperable devices and systems spanning the delivery infrastructure and end-use facilities increases the overall reliability and performance of the grid while facilitating enhanced penetration of variable renewable generation.	DOE https://www.energy.gov/eere/buildings/articles/national-opportunity-interoperability-and-its-benefits-reliable-robust-and

"Investment tax credit (ITC)"	An investment Tax Credit (ITC) is a tax credit given to individual taxpayers or corporations that invest in specific types of projects that engage in renewable energy. ITC is provided by the Internal Revenue Service (IRS) as part of an economic stimulus package. Qualifying entities may claim a tax credit of up to 30% of the capital costs of their specific projects. The primary goal behind the investment tax credit is to stimulate new investment by businesses. This means creating jobs and keeping work in the United States rather than overseas. By providing incentives for both individuals and corporations to invest in specific large-scale projects, it is hoped that the money spent will result in a surge of economic growth.	Carbon Collective https://www.carboncollective.co/sustainable-investing/investment-tax-credit-itc
"Iron air battery systems"	The battery uses a process called "reversible rusting." It converts iron metal to rust to discharge, and uses an electrical current to convert the rust back to iron to charge. Example: Form Energy's Form uses an iron-air battery, which converts iron to rust, then rust back into iron, discharging and charging the battery in the process.	Form Energy Formenergy.com

“Islanding”	A situation in which a portion of the grid, such as a microgrid, becomes disconnected from the main grid and continues to operate independently, maintaining power supply to its local consumers.	Utilities One https://utilitiesone.com/the-role-of-microgrids-in-resilient-electric-service-restoration
“Kilowatt”	One thousand watts.	EIA https://www.eia.gov/tools/glossary/index.php?id=K#:~:text=Kilowatt%20(kW)%3A%20One%20thousand,is%20equivalent%20to%203%2C412%20Btu.

“Kilowatt-hour”	A measure of electricity defined as a unit of work or energy, measured as 1 kilowatt (1,000watts) of power expended for 1 hour. One kWh is equivalent to 3,412 Btu.	EIA https://www.eia.gov/tools/glossary/index.php?id=K#:~:text=Kilowatt%20(kW)%3A%20One%20thousand,is%20equivalent%20to%203%2C412%20Btu.
“Lagging indicators”	Representative of successful scaling and adoption of LDES, in addition to readiness for 2030 and beyond deployment of the technology (e.g., supply readiness).	*Pathways to Commercial Liftoff: Long Duration Energy Storage, U.S. Department of Energy.* https://liftoff.energy.gov/wp-content/uploads/2023/03/20230320-Liftoff-LDES-vPUB.pdf

"Latent heat"	A thermal LDES technology. Latent heat storage involves storing heat in a phase-change material that utilizes the large latent heat of phase change during melting of a solid to a liquid. Thermochemical storage converts heat into chemical bonds, which is reversible and beneficial for long-term storage applications.	Sandia National Laboratories https://www.sandia.gov/ess-ssl/wp-content/uploads/2020/12/ESHB_Ch12_Thermal_Ho.pdf

"Lead acid batteries"	An older technology, invented in 1859 by Gaston Planté, lead-acid batteries are less expensive but have a shorter life cycle and lower energy density than Li-ion batteries. The energy density of lead-acid batteries averages ~30-50 Wh/kg. Lead-acid batteries can typically produce hundreds of cycles. Common grid-integrated applications for lead-acid batteries include renewable integration, load smoothing, time-shifting. Lead–acid batteries are commercially mature in their applications and much work has been done over the decades regarding their development. When comparing lead–acid to other energy storage chemistries, costs are usually the most striking advantage. Therefore, suppliers to this industry, including separator suppliers, will need to provide the best value solutions to the industry regarding each application. This value can be estimated by the purchase price, the ease of utilization in the manufacturing process, the rate of product failure, or the ability to prevent product failure. Due to the obvious cost advantages, scientists are continuing to work through the shortcomings associated with the lead–acid chemistry in order to expand market opportunities, and the developers of separators need to work closely together with the battery industry and determine how they may participate in creative solutions. The need for cost-effective, portable energy storage methods will increase as it has for the past century. However, lead–acid batteries will continue to play a predominant role, especially for new challenges and applying creative solutions	Battery University https://batteryuniversity.com/article/bu-201-how-does-the-lead-acid-battery-work Science Direct https://www.sciencedirect.com/topics/engineering/lead-acid-battery

	to existing problems, which include the development of separators.	

"Leading indicators"	Indicative of the relative readiness of technologies and markets for at-scale adoption (e.g., early signs that LDES is "on-track" to play a role in a net-zero grid).	*Pathways to Commercial Liftoff: Long Duration Energy Storage, U.S. Department of Energy.* https://liftoff.energy.gov/wp-content/uploads/2023/03/20230320-Liftoff-LDES-vPUB.pdf

"Levelized Cost of Energy (LCOE)"	A metric used to compare the lifetime costs of different energy generation technologies, calculated as the net present value of total costs divided by the total energy output over the system's lifetime. The Levelized Cost of Energy (LCOE) is a financial tool that is critical to making an informed decision to proceed with development of a facility, community or commercial-scale project. An LCOE typically relies on the following analytical approaches: • Measures lifetime costs divided by energy production; • Calculates present value of the total cost of building and operating a power plant over an assumed lifetime; and • Allows the comparison of different technologies (e.g., wind, solar, natural gas) of unequal life spans, project size, different capital cost, risk, return, and capacities A simplified LCOE calculation is as follows: $\dfrac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$ I_t = Investment expenditures in year t (including financing) M_t = Operations and maintenance expenditures in year t F_t = Fuel expenditures in year t E_t = Electricity generation in year t r = Discount rate n = Life of the system	DOE https://www.energy.gov/sites/prod/files/2015/08/f25/LCOE.pdf

"Levelized cost of storage (LCOS)"	Cost of the LDES system measured in $ per MWh. Derived by accounting for all costs incurred and the total energy discharged throughout the storage system's lifetime, not accounting for charging costs as they are related to grid prices rather than techno-economics. The levelized cost of storage (LCOS) quantifies the discounted cost per unit of discharged electricity for a specific storage technology and application.7 The metric therefore accounts for all technical and economic parameters affecting the lifetime cost of discharging stored electricity. It is directly comparable to the levelized cost of electricity (LCOE) for generation technologies and represents an appropriate tool for cost comparison of electricity storage technologies	Science Direct https://www.sciencedirect.com/science/article/pii/S254243511830583X
"Liftoff"	The point where the LDES industry became a largely self-sustaining market that does not depend on significant levels of public capital and instead attracts private capital with a wide range of risk.	*Pathways to Commercial Liftoff: Long Duration Energy Storage, U.S. Department of Energy.* https://liftoff.energy.gov/wp-content/uploads/2023/03/20230320-Liftoff-LDES-vPUB.pdf

"Liquid air energy storage (LAES)"	Liquid air energy storage (LAES) is a thermo-mechanical storage solution currently near to market and ready to be deployed in real operational environment. LAES exhibits significant advantages with respect to competing solutions: energy density is 1 to 2 orders of magnitude above the alternatives and no site constraints limit its deployment. Because of the cryogenic temperatures of liquid air, the power generation cycle can be driven by largely available heat sources at ambient temperature. Not only this eliminates the need for combustion and associated carbon emissions, but it also allows the recovery of low-temperature streams such as waste heat within the LAES process. Integration with external sources of heat and/or cold enables energy synergies and symbiosis with other processes, such as industrial sites near the location of LAES process. Underpinned by such compelling features and technical potential, endeavors towards the increase of LAES conversion efficiency – long been identified as a key drawback – and LAES commercialization have achieved significant milestones in the latest years. Liquid air energy storage (LAES) systems, which use electricity generated by renewables to liquefy air that is eventually vaporized, heated, and expanded during the discharging phase. This will happen during nighttime or the peak periods of electricity demands. LAES systems are an evolution of CAES, and liquefying air can substantially increase the energy storage density and thus solve the site dependency by reducing the footprint of the plant. LAES roundtrip efficiency is expected to be in the order of 50–60% [17].	Science Direct https://www.sciencedirect.com/science/article/pii/S2666792421000391

	The limiting aspect for the efficiency of LAES systems is the air compression process at high pressure, which is thermodynamically more energy intensive compared to other storage systems. In reality, a trade-off between energy stored and energy consumption is a key factor. For these reasons, which do not address a more suitable energy storage system, recently, some researchers have tried to investigate the use of CO2 as a working fluid for energy storage, namely liquid or compressed CO2-based energy storage (LCES or CCES). The higher density of CO2 at ambient pressure allows a more efficient compression and therefore a potentially higher roundtrip efficiency. Similarly to CAES and LAES, CCES or LCES compress CO2 with excess electricity at high pressure under gaseous or liquid forms. Such systems usually operate in a closed-loop form since the processed CO2 cannot be released into the atmosphere. Therefore, huge volumes are needed to manage the CO2 in the gaseous form that is required to operate the plantduring the discharge phase.	

“Liquid metal batteries”	The main difference between lithium-ion batteries and Lithium-Sulfur battery technology is that while lithium-ion needs storage structures inside the battery, Lithium-Sulfur batteries do not. Lithium-Sulfur batteries instead use a series of chemical reactions with the sulfur around the anode to charge and discharge energy.	

“Lithium-ion batteries” (Li-ion)	Lithium-ion is the most popular rechargeable battery chemistry used today. Lithium-ion batteries power the devices we use every day, like our mobile phones and electric vehicles. Lithium-ion batteries consist of single or multiple lithium-ion cells, along with a protective circuit board. They are referred to as batteries once the cell, or cells, are installed inside a device with the protective circuit board. . The components of a lithium-ion battery are as follows: • Electrodes: The positively and negatively charged ends of a cell. Attached to the current collectors • Anode: The negative electrode • Cathode: The positive electrode • Electrolyte: A liquid or gel that conducts electricity • Current collectors: Conductive foils at each electrode of the battery that are connected to the terminals of the cell. The cell terminals transmit the electric current between the battery, the device and the energy source that powers the battery • Separator: A porous polymeric film that separates the electrodes while enabling the exchange of lithium ions from one side to the other	UL Research Institutes https://ul.org/research/electrochemical-safety/getting-started-electrochemical-safety/what-are-lithium-ion

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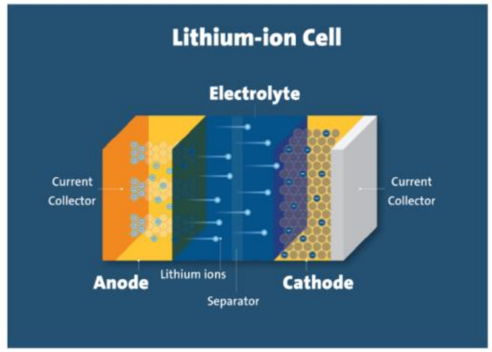

In a lithium-ion battery, lithium ions (Li+) move between the cathode and anode internally. Electrons move in the opposite direction in the external circuit. This migration is the reason the battery powers the device—because it creates the electrical current. While the battery is discharging, the anode releases lithium ions to the cathode, generating a flow of electrons that helps to power the relevant device. When the battery is charging, the opposite occurs: lithium ions are released by the cathode and received by the anode.
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"Lithium-metal batteries"	Generally speaking, Li metal batteries (LMBs) refer to the rechargeable batteries with Li metal as anode, and based on the types of cathode materials, LMBs can be divided into several categories, such as Li–sulfur (Li–S) batteries, Li–air (Li–O2) batteries and Li–lithium metallic oxide (Li–LMO) batteries	Science Direct https://www.sciencedirect.com/topics/chemistry/lithium-metal-battery
"Lithium-sulphur batteries"	The lithium–sulfur battery is a member of the lithium-ion battery and is under development. Its advantage lies in the high energy density that is several times that of the traditional lithium-ion battery. The lithium–sulfur battery is composed of the metal lithium negative pole and elemental sulfur positive pole. During discharge, the negative pole metal lithium dissolves in the electrolyte, and the lithium ion moves to the sulfur positive pole and reacts with sulfur to form polysulfide ion (Li2Sx). During charge, the polysulfide ion decomposes, and the lithium ion returns to the negative pole. Lithium sulfur battery is one of promising candidates for next-generation energy storage device due to the sulfur cathode material with low cost and nontoxicity, and super high theoretical energy density.	Science Direct https://www.sciencedirect.com/topics/engineering/lithium-sulfur-batteries

"Lithium batteries"	Lithium batteries, a term that encompasses lithium-ion batteries and lithium metal batteries, are the leading energy storage technology for portable electronics and electric vehicles. Owing particularly to the low mass and high electropositivity of lithium, lithium-based batteries possess the highest energy density among rechargeable electrochemical energy storage devices.	Science Direct https://www.sciencedirect.com/topics/chemistry/lithium-metal-battery
"Load following"	Load following is an operating strategy in which generators change their output to match changes in electric demand, or load. Batteries are used for load following because their output can be digitally controlled and therefore can respond to load changes with less stress than mechanical systems.	CleanTechnica https://cleantechnica.com/2021/11/01/battery-storage-applications-shifting-as-more-batteries-added-to-u-s-grid/

"Load leveling"	Load leveling refers to the smoothing of the load pattern by lowering on-peak and increasing off-peak loads. The load leveling is also defined as charging ESS by purchased cheap electric energy at periods when prices are low and discharge ESS to sell stored energy at a later time when the prices are high. In principle, energy time-shift includes potential energy transactions with financial advantage based on the differences between the cost to purchase energy (charge) and sell it (discharge). In addition to cost saving, load leveling reduces the need to utilize peaking power plants or augment the transmission and distribution infrastructure. With load-levelling, system operators charge batteries during periods of excess generation and discharge batteries during periods of excess demand to more efficiently coordinate the dispatch of generating resources.	Science Direct https://www.sciencedirect.com/science/article/pii/S2090123216000199 NREL https://www.nrel.gov/docs/fy19osti/74426.pdf

"Load forecasting"	The process of predicting future electricity demand based on historical consumption data, weather patterns, and other relevant factors, helping utilities and grid operators to plan and manage their resources more effectively. Load forecasting minimizes utility risk by predicting future consumption of commodities transmitted or delivered by the utility. Techniques include price elasticity, weather and demand response/load analysis, and renewable generation predictive modeling. Forecasts must use regional customer load data, with time series customer load profiles. Accurate forecasts require adjustments for seasonality. Distribution load forecasting must be reconciled with distribution network configuration as part of the distribution circuit load measurements.	Gartner https://www.gartner.com/en/information-technology/glossary/load-forecasting#:~:text=Load%20forecasting%20minimizes%20utility%20risk,and%20renewable%20generation%20predictive%20modeling
"Load matching"	This refers to the changing need for power throughout the day since generally far less electricity is needed at night than during the day. Load matching plants can vary their output slowly over hours to meet the general trend in this.	Energy Education https://energyeducation.ca/encyclopedia/Dispatchable_source_of_electricity
"Load serving entity"	An entity, typically a utility, energy service provider, or a community choice aggregator, that is required to maintain physical generating capacity and electrical demand response adequate to meet its load requirements, including, but not limited to, peak demand and planning and operating reserves. Load serving entities are typically regulated by a state public utility commission that oversees retail electric markets.	GridWorks https://gridworks.org/2018/06/resource-adequacy-what-is-it-and-why-should-you-care/

"Load shifting"	Load shifting is an electricity load management technique in which load demand is shifted from peak hours to off-peak hours of the day. Or in other words, load shifting simply means moving electricity consumption to a different interval of time, but total consumption remains constant. The practice of adjusting the timing of energy consumption to match periods of lower demand or lower prices, often using energy storage systems or demand response programs to help balance the electrical grid and reduce peak demand. Load shifting can be utilized as a strategy to move energy consumption from periods of high demand to periods of low demand, improving the overall efficiency of the electrical grid.	Exro Energy https://www.exro.com/industry-insights/load-shifting#:~:text=Load%20shifting%20is%20an%20electricity%20load%20management%20technique%20in%20which,but%20total%20consumption%20remains%20constant.
"Long-duration energy storage (LDES)"	Long-duration refers to the amount of time a power system can discharge electricity. That is to say, once a battery is fully charged, the duration is equal to the number of hours that it can deliver power at a certain power capacity. This is different from long-term storage, which refers to the amount of time a system can store energy before discharging it.	Union of Concerned Scientists https://blog.ucsusa.org/maria-chavez/long-duration-energy-storage-is-key-to-cleaning-up-the-power-grid/

"Loss of load expectancy (LOLE)"	Loss-Of-Load expectancy (LOLE) refers to the time that the system load exceeds the available generating capacity; LOLE equals the expected number of loss-of-load days with events, regardless of event length, in a given year. 0.1 LOLE equates to "1 day with an event in 10 years." (There are also other types of measures.)	CPUC https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/resource-adequacy-homepage/finalra_lole_elcc_2024_workshop03032022.pdf
"Low-temperature thermal energy storage (TES)"	Low temperature thermal energy storage (TES) has been defined as the storage of heat that enters and leaves the reservoir at temperatures below 120oC. Storage of this type may permit efficient utilization of heat that otherwise would have been partially or entirely wasted. In principle, low temperature TES permits the storage of heat obtained from solar radiation from day to night or from summer to winter. It permits the storage of heat from central power plants, from hours of low to hours of high demand on both a diurnal and seasonal basis. It permits the storage of heat from industrial processes for later use.	Science Direct https://www.sciencedirect.com/science/article/abs/pii/B9780080217246500098#:~:text=Low%20temperature%20thermal%20energy%20storage%20(TES)%20has%20been%20defined%20as,temperatures%20below%20120oC

"Magnesium batteries"	Magnesium batteries are a promising energy storage chemistry. Magnesium batteries are potentially advantageous because they have a more robust supply chain and are more sustainable to engineer, and raw material costs may be less than state-of-the-art lithium-ion batteries. The theoretical energy density is at least comparable to lithium-ion batteries, and there is the potential to realize a higher energy density than lithium because there are double the electrons for every individual magnesium ion, compared to lithium. Magnesium is also much more abundant than lithium, which can help enable better supply chains. In principle, magnesium-ion batteries function very similarly to current lithium-ion batteries. Magnesium ions are shuttled between a negative anode (typically made of magnesium metal) and a positive cathode, made of a metal-oxide material. Unfortunately, magnesium-ion batteries face several scientific and technical challenges before they will be a commercial competitor with lithium-ion batteries. These challenges almost all stem from the reality that magnesium is a small ion carrying a lot of electric charge. This results in a lot of often unwanted interactions with surrounding materials. For instance, transfer of magnesium from the electrolyte to solid electrodes requires excess energy and often results in "parasitic"	Argonne National Laboratory https://www.anl.gov/article/qa-could-magnesium-be-a-battery-future-argonne-chemist-brian-ingram-weighs-in

	reactions that compete with the process of storing charge, which limits the lifetime of the batteries. Additionally, motion of magnesium through all materials is more sluggish than lithium. Because of this, charge rates are limited.	

"Mechanical energy storage"	Mechanical energy storage works in complex systems that use heat, water or air with compressors, turbines, and other machinery. Currently, the most widely deployed large-scale mechanical energy storage technology is pumped hydro-storage (PHS). Other well-known mechanical energy storage technologies include flywheels, gravity-based, compressed air energy storage (CAES), and liquid air energy storage (LAES). PHS has been deployed since 1907, and CAES since 1978. We are seeing the next wave of innovation with these technologies that are increasing security, reliability, flexibility, and the duration of today's energy storage solutions.	LDES Council https://www.ldescouncil.com/ldes-technologies/#:~:text=Currently%2C%20the%20most%20widely%20deployed,air%20energy%20storage%20(LAES
"Megawatt (MW)"	A megawatt is a unit of power equivalent to one million watts (106 watts), or one thousand kilowatts. As a unit of power, a megawatt expresses the rate at which energy is produced. A megawatt is equivalent to one million joules per second. A megawatt is a fairly large unit of power and is used, therefore, when discussing the size of a power plant, a nation's total energy-generating capacity, or some other such large statistic.	Encyclopedia.com https://www.encyclopedia.com/environment/encyclopedias-almanacs-transcripts-and-maps/megawatt-mw
"Megawatt-hour (MWh)"	A Megawatt-hour (MWh) is a unit of measurement that describes the amount of energy produced by one Megawatt over the course of one hour. Megawatt-hours are used to describe the level of demand for electricity on a utility grid. Megawatt-hours are also used to estimate the amount of energy needed to power equipment, vehicles, and various household appliances over time.	Carbon Collective https://www.carboncollective.co/sustainable-investing/megawatt-hour-mwh

"Metal-air batteries"	Metal-air batteries are one of numerous battery technologies that could improve current energy storage solutions. Like conventional batteries, a metal-air battery comprises an anode, a cathode, an electrolyte, and a separator between the two electrodes. Metal-air anodes are composed of metals such as lithium, sodium, iron, zinc or other elements. Their cathodes are porous materials, and an electrolyte can be aqueous or non-aqueous depending on the material makeup of the anode. In metal-air batteries, the metal dissolves in the electrolyte to produce ions at the anode, and the oxygen transforms into hydroxide ions at the cathode. During the charging operation, this process reverses. This is opposite to the operation of conventional batteries, in which metal ions travel from anode to cathode. Metal-air batteries have significantly greater energy density than Li-ion batteries. Lithium-air (Li-air) batteries, for instance, are 100 times more energy-dense than their Li-ion brethren. That kind of magnitude difference makes metal-air batteries mouthwatering for potential use in EVs and grid storage. That said, there are a number of challenges inherent to the technology that make viable development difficult.	EE Power https://eepower.com/news/the-irresistible-potential-and-undeniable-challenge-of-metal-air-batteries/

“Metal anode batteries”	Developing as an electrochemical LDES technology reversible lithium metal anodes with high rate capability is one of the central aims of current battery research. Lithium metal anodes are not only required for the development of innovative cell concepts such as lithium–air or lithium–sulfur batteries, they can also increase the energy density of batteries with intercalation-type cathodes. The use of solid electrolyte separators is especially promising to develop well-performing lithium metal anodes, because they can act as a mechanical barrier to avoid unwanted dendritic growth of lithium through the cell. However, inhomogeneous electrodeposition and contact loss often hinder the application of a lithium metal anode in solid-state batteries.	Chemical Reviews https://pubs.acs.org/doi/10.1021/acs.chemrev.0c00431
“Meter data management system (MDMS)”	A meter data management system (MDMS) includes a set of software tools and databases, built on top of the meter data center (MDC) system, whose primary functions include the validation, estimation, and editing (VEE) of meter data that are later passed to other utility systems, as billing systems, even in case of disruption of meter data flows. MDM functionalities can usually be distributed over other systems instead of being present as separate systems. It is common practice to find utilities with basic VEE functionalities incorporated as part of their customer information system (CIS) or as part of the newly deployed MDC system.	Science Direct https://www.sciencedirect.com/topics/engineering/meter-data-management-system

"Microgrid"	A localized energy system that can operate independently from the main electrical grid, typically consisting of multiple distributed energy resources. A microgrid is a group of interconnected loads and distributed energy resources that acts as a single controllable entity with respect to the grid. It can connect and disconnect from the grid to operate in grid-connected or island mode. Microgrids can improve customer reliability and resilience to grid disturbances. Advanced microgrids enable local power generation assets—including traditional generators, renewables, and storage—to keep the local grid running even when the larger grid experiences interruptions or, for remote areas, where there is no connection to the larger grid. In addition, advanced microgrids allow local assets to work together to save costs, extend duration of energy supplies, and produce revenue via market participation. Microgrids are becoming an integral part of the global energy transition. Unlike traditional power grids that rely on centralized generation and distribution, microgrids are localized and offer the ability to generate, store, and manage electricity for a specific area. They can operate connected or independently from the main grid, offering several advantages: • Increased resiliency: Microgrids can operate autonomously during power outages, ensuring essential services stay running.	NREL https://www.nrel.gov/grid/microgrids.html#:~:text=A%20microgrid%20is%20a%20group,and%20resilience%20to%20grid%20disturbances. Energy5 https://energy5.com/the-role-of-microgrid-operators-orchestrating-energy-generation-and-demand-response

	• Integration of renewable energy: By integrating renewable energy sources like solar and wind, microgrids contribute to reducing greenhouse gas emissions and promoting sustainable practices. • Enhanced grid stability: Microgrids help stabilize the overall grid by balancing supply and demand locally, minimizing the risk of blackouts and voltage fluctuations. • Cost savings: Microgrids provide energy cost savings by reducing transmission distances and grid losses.	

“Midwest Independent System Operator (MISO)”	The Midwest Independent System Operator (MISO) is an independent, not-for-profit, member-based organization focused on managing the flow of high-voltage electricity across its region, facilitating one of the world's largest energy markets, and planning the grid of the future. Its mission is to manage the reliable delivery of low-cost wholesale energy for distribution to the 45 million people living in its region. Since December 2001, the size of the MISO region has expanded into Canada and down to the Gulf of Mexico.	MISO https://www.misoenergy.org/
“Molten salt battery storage”	Molten salt refers to the molten liquid of salt, and common molten salt refers to the molten body formed when the temperature of inorganic salt rises above its melting point. Molten salt energy storage has important advantages such as large heat capacity, strong heat conductivity, stable properties and good economy. It also has broad application prospects in the field of steam supply. Molten-salt batteries are a class of battery that uses molten salts as an electrolyte and offers both a high energy density and a high power density. Traditional non-rechargeable thermal batteries can be stored in their solid state at room temperature for long periods of time before being activated by heating. Rechargeable liquid-metal batteries are used for industrial power backup, special electric vehicles and for grid energy storage, to balance out intermittent renewable power sources such as solar panels and wind turbines.	SolarPACES https://www.solarpaces.org/nrel-awarded-2-8-million-to-develop-a-long-duration-thermal-energy-storage-technology/

"Monte Carlo simulation modeling"	A Monte Carlo simulation is used to model the probability of different outcomes in a process that cannot easily be predicted due to the intervention of random variables. It is a technique used to understand the impact of risk and uncertainty. A Monte Carlo simulation is used to tackle a range of problems in many fields including investing, business, physics, and engineering. It is also referred to as a multiple probability simulation. A Monte Carlo simulation requires assigning multiple values to an uncertain variable to achieve multiple results and then averaging the results to obtain an estimate. Monte Carlo simulations help to explain the impact of risk and uncertainty in prediction and forecasting models.	Investopedia https://www.investopedia.com/terms/m/montecarlosimulation.asp
"Multi-day"(a/k/a "seasonal") storage	Multi-day / week LDES is defined as shifting power by 36 - 160 + hours and many thermal and electrochemical technologies This market segment can be used for energy shifting like inter-day LDES, but also used during an extended shortfall of power (e.g., multiple days of low wind and solar, resiliency applications) several times per year. Multi-day / week LDES can also reduce the required curtailment / interconnection over-build to support variable renewables.	*Pathways to Commercial Liftoff: Long Duration Energy Storage, U.S. Department of Energy.* https://liftoff.energy.gov/wpcontent/uploads/2023/03/20230320-Liftoff-LDES-vPUB-0329-update.pdf

“Na-Ion (sodium-ion) batteries”	Interest in sodium-ion batteries stems from their many advantages. Two are sustainability and cost. Sodium is far more naturally abundant and easily mined than lithium. It is thus a fraction of the cost per kilogram and much less susceptible to price fluctuations or disruptions in the supply chain. Another benefit is that sodium-ion batteries can retain their charging capability at below freezing temperatures. This addresses one of the notable drawbacks of existing lithium-ion batteries. Also working in favor of sodium-ion batteries is that the technology for battery management and manufacturing already exists. This is because their design closely resembles that of lithium-ion batteries. However, sodium metal is about three times heavier than lithium, and that adds considerably to the battery weight. Another shortcoming of earlier sodium-ion batteries is a short cycle life. But with the team’s cathode material, battery cells can be charged and discharged the same number of cycles as their lithium-ion counterparts.	Argonne National Laboratory https://www.anl.gov/article/cathode-innovation-makes-sodiumion-battery-an-attractive-option-for-electric-vehicles

"Nameplate capacity"	The maximum amount of electric energy that a generator can produce under specific conditions, as rated by the manufacturer. Generator nameplate capacity is usually expressed in kilovolt-amperes (kVA) and kilowatts (kW), as indicated on a nameplate that is physically attached to the generator.	Nuclear Regulatory Commission https://www.nrc.gov/reading-rm/basic-ref/glossary/generator-nameplate-capacity.html
"Net load"	The net load of an electric grid is the difference between the total electricity demand, and the electricity generation from behind-the-meter resources such as solar and other distributed generators.	DOE https://www.energy.gov/eere/solar/american-made-net-load-forecasting-prize#:~:text=The%20net%20load%20of%20an,solar%20and%20other%20distributed%20generators.

"Net metering"	Net metering is a billing mechanism that credits solar energy system owners for the electricity they add to the grid. For example, if a residential customer has a PV system on their roof, it may generate more electricity than the home uses during daylight hours. If the home is net-metered, the electricity meter will run backwards to provide a credit against what electricity is consumed at night or other periods when the home's electricity use exceeds the system's output. Customers are only billed for their "net" energy use. On average, only 20-40% of a solar energy system's output ever goes into the grid, and this exported solar electricity serves nearby customers' loads.	SEIA https://www.seia.org/initiatives/net-metering#:~:text=What%20Is%20Net%20Metering%3F,home%20uses%20during%20daylight%20hours
"Net present value"	Net present value (NPV) is a financial metric that seeks to capture the total value of an investment opportunity. The idea behind NPV is to project all of the future cash inflows and outflows associated with an investment, discount all those future cash flows to the present day, and then add them together. The resulting number after adding all the positive and negative cash flows together is the investment's NPV. In theory, an NPV is "good" if it is greater than zero.	Investopedia https://www.investopedia.com/terms/n/npv.asp#:~:text=Net%20present%20value%20(NPV)%20is%20a%20financial%20metric%20that%20seeks,and%20then%20add%20them%20together

"Net qualifying capacity (NPC)"	Net qualifying capacity (NPC) represents the value that a particular resource contributes to a load-serving entity's resource adequacy requirements. The amount of resource adequacy capacity that a resource can provide is based upon various methodologies, typically regulated by a state commission, that establish the "qualifying capacity" of various types of resources (solar, natural gas, energy storage, etc.), and then further adjusts that value based upon deliverability studies performed by theRTO/ISO to determine whether that qualifying capacity is deliverable to load at peak. The final result of these calculations is a resource's NQC.	Stoel Rives LLP https://www.lawofrenewableenergy.com/2021/09/articles/states/california/cpuc-issues-net-qualifying-capacity-values-to-be-used-for-mid-term-reliability-procurement/
"Net-zero energy building (NZEB)"	A building that produces as much energy as it consumes over the course of a year, typically through the use of energy efficiency measures and onsite renewable energy generation. A building characterized by a very high-energy performance during the operation and most of the energy required is covered by energy from renewable sources [typically solar thermal and photovoltaic (PV) systems]. An energy-efficient building, equipped with energy-efficient systems and effective insulation materials to curb the heating and electricity demand, which produces as much energy as it consumes and interacts with the energy grid.	Science Direct https://www.sciencedirect.com/topics/engineering/nearly-zero-energy-building

"New England Independent System Operator (NE-ISO)"	ISO New England is the independent, not-for-profit company authorized by the Federal Energy Regulatory Commission (FERC) to perform three critical, complex, interconnected roles for the region spanning Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, and most of Maine. The three roles are: grid operation, market administration, and power system planning.	New England ISO https://www.iso-ne.com/
"Nickel"	Nickel (Ni) has long been widely used in batteries, most commonly in nickel cadmium (NiCd) and in the longer-lasting nickel metal hydride (NiMH) rechargeable batteries, which came to the fore in the 1980s. In the mid-1990s the first commercial applications for Li-ion batteries emerged, initially in camcorders and eventually finding their way into smartphones, laptops and the numerous other portable devices we now take for granted. The major advantage of using nickel in batteries is that it helps deliver higher energy density and greater storage capacity at a lower cost. Further advances in nickel-containing battery technology mean it is set for an increasing role in energy storage systems, helping make the cost of each kWh of battery storage more competitive. It is making energy production from intermittent renewable energy sources such as wind and solar replace fossil fuels more viable.	The Nickel Institute https://nickelinstitute.org/en/about-nickel-and-its-applications/nickel-in-batteries/#:~:text=The%20major%20advantage%20of%20using,capacity%20at%20a%20lower%20cost.

"Nickel-cadmium (NiCd) batteries"	NiCd batteries are rechargeable dry cell batteries that use a nickel oxide hydroxide cathode and a cadmium anode.	How To Store Energy https://howtostoreelectricity.com/dry-cell-batteries/
"Nickel-metal hydride (NiMH) batteries"	A type of dry-cell batteries, nickel-metal hydride (NiMH) batteries are also rechargeable and offer higher energy density than NiCd batteries. They use a nickel oxide hydroxide cathode and a hydrogen-absorbing allloy anode.	How To Store Energy https://howtostoreelectricity.com/dry-cell-batteries/
"Nodal pricing" (a/k/a "locational pricing")	Nodal pricing refers to prices paid for electricity consumed or generated at a given transmission node. Under this option, transmission constraints are explicitly observed while determining the optimal dispatch of the system and deriving the locational marginal prices. Nodal pricing better depicts the technical and economic effects of the network on the price of electricity as it implicitly includes the impact of grid losses and transmission congestion. For example, several independent system operators (ISOs) in the United States use nodal prices from which are derived the locational marginal price (LMP).	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

"Nominal capacity"	The nominal capacity is the amount of charge delivered by a fully charged battery under specified conditions of temperature and load. The nominal capacity is therefore application specific. Nominal capacity refers to the amount of energy a battery can store and subsequently release under optimal conditions. It serves as a fundamental indicator of a battery's performance, providing insights into the driving range, efficiency, and overall capabilities of an electric vehicle. Nominal capacity is denoted in ampere-hours (Ah) or kilowatt-hours (kWh).	Science Direct https://www.sciencedirect.com/topics/engineering/nominal-capacity#:~:text=The%20nominal%20capacity%20QN,capacity%20is%20therefore%20application%20specific. Everything PE https://www.everythingpe.com/community/what-do-you-mean-by-nominal-capacity-of-an-ev-battery

"Nominal duration"	Measure of how long the storage system can discharge at its maximum power rating (e.g., a 20 MW LDES systems with a 30-hour duration can provide 20 MW of energy for 30 hours)	*Pathways to Commercial Liftoff: Long Duration Energy Storage, U.S. Department of Energy* https://liftoff.energy.gov/wpcontent/uploads/2023/03/20230320-Liftoff-LDES-vPUB-0329-update.pdf
"Non-wire alternatives"	Non-wire alternatives are technologies or operating practices intended to reduce grid congestion and manage peak demand to offset a utility's need to make additional investments in conventional assets like wires, poles, and substations. The technologies can include distributed energy resources, such as microgrids or batteries, and practices and programs focused on load management, demand response or energy efficiency.	American Public Power Association https://www.publicpower.org/periodical/article/exploring-non-wire-alternatives-wired-industry

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.