CHARGING FORWARD: ACCELERATING LONG-TERM ENERGY STORAGE DEVELOPMENT

---

*Collin Wilfong and Robert Bullington**

INTRODUCTION

In the summer of 2020, unprecedented heat and raging wildfires created a major energy shortage across the southwestern United States.[1] The temperature in Death Valley, California, reached a scorching 130°F on August 16, 2020,[2] while Los Angeles County logged its highest recorded temperature of 121°F.[3] This excessive heat caused a spike in electricity demand across the Southwest region which triggered major brownouts throughout much of California.[4] This occurred because utility companies shut off electric transmission infrastructures to reduce the risk of the equipment creating more fires.[5]

The Southwest's growing fleet of utility-scale lithium-ion battery facilities and other short-term energy storage systems eased some of the stress placed on the region's electricity grid during the 2020 heat wave.[6] Ultimately, it could not prevent the disruptive power outages that ensued.[7] Public safety power shutoff (PSPS) requirements, instituted after recent wildfires, required California grid operators to shut down parts of the state's grid to avoid sparking new blazes amid the hot, dry conditions.[8] Unfortunately, the region presently lacks the energy storage capacity to compensate for such shutdowns, especially on blistering days

---

* Robert Bullington and Collin Wilfong are both 2021 J.D. Candidates and Sustainability Law Research Fellows at Arizona State University's Sandra Day O'Connor College of Law. Robert graduated with a B.S. in Economics and a B.A. in Business-Law from Arizona State University in 2018. Collin graduated with a B.S. in Criminology and Criminal Justice from Arizona State University in 2018. Many thanks ASU's other 2020-21 Sustainability Law Student Research Fellows and Professor Troy Rule for their invaluable comments and input on the issues covered in this article.

[1] Robert Hart, *280,000 Customers Face Losing Power in California Amid Fire-Safety Blackouts*, FORBES (Jan. 19, 2021), https://www.forbes.com/sites/roberthart/2021/01/19/280000-customers-face-losing-power-in-california-amid-fire-safety-blackouts/?sh=211ef5fb1675.

[2] Kasha Patel, *California Heatwave Fits a Trend*, NASA EARTH OBSERVATORY (2020), https://earthobservatory.nasa.gov/images/147256/california-heatwave-fits-a-trend#:~:text=The%20darkest%20red%20areas%20are,Palmdale%2C%20also%20hit%20record%20highs.

[3] Alex Wigglesworth, et al., *Intense Heat Wave Breaks Numerous Records, Fuels Dangerous Fires Across California,* L.A. TIMES (Sept. 6, 2020), https://www.latimes.com/california/story/2020-09-05/heres-where-record-breaking-heat-is-forecast.

[4] Doha Madani et al., *Threat of Rolling Blackouts in California Passes—for Now,* NBC NEWS (Aug. 18, 2020), https://www.nbcnews.com/news/us-news/millions-facing-power-outages-heatwave-overwhelms-california-energy-grid-n1237015.

[5] *See* Hart, *supra* note 1 (explaining that utility companies shut off power due to events such as downed trees and power lines).

[6] Jeff McMahon, *How California Wildfires Are Driving Energy Storage Beyond Lithium-Ion*, FORBES (Oct. 5, 2020), https://www.forbes.com/sites/jeffmcmahon/2020/10/05/how-california-wildfires-are-driving-energy-storage-beyond-lithium-ion/?sh=51e8cf914954.

[7] *Id.*

[8] *Id.*

when air conditioning use and electricity demand are high.[9] During California's November 2019 wildfires, the average time for a short PSPS outage was 11 hours, with longer outages lasting three to five days—much longer than the four-hour duration that most lithium-ion batteries can reliably supply backup power.[10]

Although California and numerous other states are aggressively promoting buildouts of short-term energy storage capacity, batteries alone cannot protect against drawn out power supply disruptions.[11] Accordingly, much more long-term energy storage capacity is needed to allow states to continue their shift to wind and solar energy sources while simultaneously preparing for the intensifying heat and wildfire risks brought about by climate change.[12] Long-term energy storage devices can store massive quantities of energy when there is excess supply in the grid system.[13] Then, it can dispatch electricity to address power supply shortages for days or even longer.[14] Microgrids, supported by long-term energy storage capacity, could also enable some rural communities in the West to become less dependent on the larger grid and more resilient against brownouts during wildfire seasons.[15] Such reliability and resiliency advantages are only some of the potential benefits that long-term energy storage could provide as the nation transitions to a carbon-free renewable energy system.

Despite the importance of long-term energy storage development, it has been underemphasized in sustainable energy policy over the past quarter-century.[16] Long-term storage can provide unique stabilizing and security benefits presently available through no other carbon-free energy

---

[9] *See*, *e.g., id*. (discussing how California will have only mere fraction of the energy it needs by 2045).

[10] *Id.*

[11] Gregory Meyer, *California Bets on Batteries to Ease Blackout Worries*, FIN. TIMES (Aug. 25, 2020), https://www.ft.com/content/2c5f7678-1323-4886-9917-a77ef86f1e4d.

[12] *See* McMahon, *supra* note 6 (explaining that California officials believe other technologies can provide reliability and safety during long power outages).

[13] *California Opens Up Opportunities for Microgrids to Play Role in Boosting Reliability of Energy Mix*, ENERGY STORAGE NEWS (Jan. 21, 2021), https://www.energy-storage.news/news/california-opens-up-opportunities-for-microgrids-to-play-role-in-boosting-r.

[14] Ken Silverstein, *For the U.S. to Become Carbon Neutral, Long-Term Energy Storage is a Must*, FORBES (July 26, 2021), https://www.forbes.com/sites/kensilverstein/2021/07/26/for-the-us-to-become-carbon-neutral-long-term-energy-storage-is-a-must/?sh=644aadfb241e.

[15] ENERGY STORAGE NEWS, *supra* note 13.

[16] *See* Omar J. Guerra, *Beyond Short-Duration Energy Storage*, 6 NATURE ENERGY 460, 460 (2021) (stating that long-duration energy storage accounts for only 7% of total energy storage capacity compared to 93% for short-term energy storage).

strategies.[17] Yet, government programs aimed at facilitating their advancement and deployment have lagged those focused on renewable energy generation or short-term storage.[18] Fortunately, it is possible to fill this gap through innovative new policies designed to incentivize far more private investment in long-term storage development.

Part I of this article describes the history and importance of long-term energy storage and provides an overview of current policies aimed at promoting long-term energy storage development. Part II outlines certain frameworks for analyzing long-term energy storage policies and applies those frameworks to highlight shortcomings in the policy regimes that presently govern these technologies. Part III then identifies specific policies capable of accelerating the advancement and deployment of long-term energy technologies throughout the U.S.

I. AN OVERVIEW OF LONG-TERM ENERGY STORAGE TECHNOLOGIES AND POLICIES

Because of the intermittent nature of wind and solar resources, long-term energy storage capacity is crucial to building any clean and renewable energy system. The term "energy storage" describes systems and devices capable of storing energy for dispatch as electricity at a later time.[19] Electric energy storage systems (the primary focus of this article) store electrical energy primarily through chemical or physical means.[20] Longer-term energy storage facilities and devices are just one category within this broader class of energy storage systems.[21]

A. A Long History of Energy Storage

For as long as humankind has been gathering resources, it has been storing energy resources for later use.[22] Practices and methods for storing and preserving food, which itself is a form of stored energy, are

---

[17] ETHAN N. ELKIND ET AL., THE POWER OF ENERGY STORAGE: HOW TO INCREASE DEPLOYMENT IN CALIFORNIA TO REDUCE GREENHOUSE GAS EMISSIONS 5 (2010).

[18] *See id.* at 8 (discussing how California has taken multiple steps to reduce greenhouse gas emissions through increased use of renewable energy technology).

[19] *Id.* at 1.

[20] YE JI-LEI ET. AL., GRID-SCALE ENERGY STORAGE SYSTEMS AND APPLICATIONS 3 (Fu-Bao Wu et al. eds., 2020).

[21] Examples of other energy storage systems include pumping water, multiple battery technologies, flywheels, and more. ELKIND ET AL., *supra* note 17, at 1.

[22] Tim Maly, *A Brief History of Human Energy Use*, THE ATLANTIC (Nov. 13, 2015), https://www.theatlantic.com/technology/archive/2015/11/a-brief-history-of-human-energy-use/415749/.

well documented across a variety of ancient civilizations.[23] Early Middle Eastern, Asian, and Roman cultures, some dating as far back as 12,000 B.C., utilized the sun's rays to build up dried fruit reserves.[24] Alternatively, prehistoric cultures in colder climates used ice to freeze and refrigerate meats.[25] After the advent of farming some 12,000 years ago, Greek farmers in the Neolithic era used ceramic vessels and clay-lined pits to store surplus crops.[26] Such food-based energy storage strategies eventually gave way to harnessing the power of domesticated animals, waterwheels, and windmill-powered wells, each of which allowed humans to utilize stored energy in various ways.[27]

Energy storage technologies advanced dramatically in the late 18th century.[28] The electric battery was invented by Italian scientist Alessandro Giuseppe Antonio Anastasio Volta in 1799.[29] Almost a century later, a utility company in New York City began utilizing lead-acid batteries to power its road lamps at night.[30] These advancements eventually paved the way for the emergence of early long-term energy storage systems in the late 19th and early 20th centuries.[31] It primarily took the form of pumped hydro storage projects—facilities that use electricity to pump water uphill and then release that water down through turbines to generate power at a later time.[32] In the 1950s, a flurry of pumped hydro storage construction began spreading across the globe.[33] From the 1950s through the early 1990s, worldwide pumped hydro storage capacity grew rapidly from 1600 megawatts (MW) to 79,000 MW.[34] However, pumped hydro storage growth then ground to a near

---

[23] Linda Hyuck, *Food Preservation Is as Old as Mankind*, MICH. STATE UNIV. EXTENSION (June 11, 2012), https://www.canr.msu.edu/news/food_preservation _is_as_old_as_mankind.

[24] Dushka Urem-Kotsuo, *Storage of Food in the Neolithic Communities of Northern Greece*, 49 WORLD ARCHEOLOGY 73, 82–83 (2017).

[25] *See* Brian A. Nummer, *Historical Origins of Food Preservation, National Center for Home Food Preservation*, NAT'L CTR. HOME FOOD PRES. (May 2002), https://nchfp.uga.edu/publications/nchfp/factsheets/food_pres_hist.html. (discussing different methods of food preservation across various cultures and countries).

[26] Dushka Urem-Kotsuo, *supra* note 24, at 82–83.

[27] *See* Maly, *supra* note 22 (discussing the evolution of energy-generating inventions and strategies).

[28] JI-LEI ET AL., *supra* note 20, at 3.

[29] *Id.*

[30] *Id.*

[31] *Id.* at 3–4.

[32] *Id.* at 4.

[33] *Id.*

[34] *Id.*

halt—especially in the U.S., where the last pumped hydro storage facility was built in 1995.[35]

Although pumped hydro energy storage development all but ceased in the U.S. a quarter century ago, new energy storage technologies have filled some of that gap in recent years. Lithium-ion battery technologies have matured and driven a new type of energy storage development boom.[36] This recent surge in lithium-ion battery innovation is attributable in part to the rise of electric vehicles.[37] These battery systems are also increasingly serving roles in utility-scale energy storage and grid management.[38] Lithium-ion battery prices have plummeted over the past decade, with one 2018 projection estimating that the capital cost of a utility-scale lithium-ion storage system would fall by 52% by 2030.[39] Simultaneously, demand for these batteries has more than doubled since 2015, while their per unit cost has dropped by about 87% in the last ten years.[40]

B. Why Growing the Nation's Long-Term Energy Storage Capacity Matters

Energy storage systems operate much like a sponge, soaking up excess energy and then feeding it back into the grid when needed. "Short-term" energy storage systems generally supply electricity for only a few hours, while "long-term" energy storage typically can supply stored electricity for ten hours or longer.[41] Energy storage capacity—including long-term energy storage—is taking on an increasingly important role as the nation transitions toward a carbon-free, sustainable energy system.

---

[35] Charles R. Sensiba et al., *Deep Decarbonization and Hydropower*, 48 ENV'T. L. REP. NEWS & ANALYSIS 10309, 10331 (2018).

[36] *The Battery Boom Is Coming, as Costs Drop Quickly*, BLOOMBERG (Nov. 15, 2018), https://www.industryweek.com/supply-chain/article/22026687/the-battery-boom-is-coming-as-costs-drop-quickly.

[37] *Id.*

[38] *See id.* (explaining that "the majority of storage capacity will be utility-scale until the mid-2030s.").

[39] *Id.*

[40] *Virus Crisis Halts EV Battery Boom, for Now*, AUTOMOTIVE NEWS EUR. (June 30, 2020), https://europe.autonews.com/automakers/virus-crisis-halts-ev-battery-boom-now.

[41] David Schmitt & Glenn M. Stanford, *Energy Storage: Can We Get It Right?* 39 ENERGY L.J. 447, 457 (2018).

1. Renewable Energy and Energy Storage

Large amounts of short-term and long-term energy storage capacity will be needed to support a full transition to renewable energy sources in the U.S.[42] Short-term energy storage systems are helpful in addressing the "duck curve" problem—a grid load balancing challenge that results from the fact that solar energy production tends to peak in the early afternoon, but electricity demand generally peaks in the early evening.[43] In regions where solar energy systems account for a large proportion of a grid's electricity supply, short-term energy storage technologies are well-suited to combat the duck curve problem by supplying a few hours of stored solar power to help fill this gap.[44]

Unfortunately, short-term energy storage systems are far less equipped to deal with electricity shortages that persist for days at a time. An energy system dependent largely on wind and solar energy can be particularly vulnerable to such days-long electricity shortages during extended periods of cloudiness or non-windy conditions.[45] As an increasing proportion of the nation's energy generation is supplied by these renewable sources, the need for longer-term reserves of power to address prolonged periods of intermittency also increases.[46] Longer-term reserves of power also serve crucial roles in certain crises, such as California's deadly combination of heat and wildfires and Texas' recent severe ice storm that resulted in rolling blackouts for roughly four million people.[47] Evidence suggests that such extreme weather events are likely to occur even more frequently with climate change in the coming years.[48]

---

[42] *Long Duration Storage Shot*, OFF. OF ENERGY EFFICIENCY & RENEWABLE ENERGY (July 2021), https://www.energy.gov/eere/long-duration-storage-shot.

[43] Becca Jones-Albertus, *Confronting the Duck Curve: How to Address Over-Generation of Solar Energy*, OFF. ENERGY EFFICIENCY & RENEWABLE ENERGY (Oct. 12, 2017), https://www.energy.gov/eere/articles/confronting-duck-curve-how-address-over-generation-solar-energy.

[44] *Id.*

[45] Max Tuttman & Scott Litzelman, *Why Long-Duration Energy Storage Matters*, ADVANCED RSCH. PROJECTS AGENCY-ENERGY (Apr. 1, 2020), https://arpa-e.energy.gov/news-and-media/blog-posts/why-long-duration-energy-storage-matters#_ftn3.

[46] *Id.*

[47] Brad Plumer, *A Glimpse of America's Future: Climate Change Means Trouble for Power Grids*, N.Y. TIMES (Feb. 18, 2021), https://www.nytimes.com/2021/02/16/climate/texas-power-grid-failures.html ("But as climate change accelerates, many electric grids will face extreme weather events that go far beyond the historical conditions those systems were designed for, putting them at risk of catastrophic failure.").

[48] *See* Meyer, *supra* note 11 (quoting Benoit Allehaut, managing director in Capital Dynamics' clean energy infrastructure team, "'Unfortunately, climate change is a reality. And climate change leads to fires. Fires sometimes hit transmission lines.'").

Energy storage systems can also help to reduce renewable energy waste by allowing wind and solar energy project operators to store excess energy rather than curtailing their projects' generation of power.[49] When there is a surplus of electric power on the grid, grid operators sometimes issue curtailment orders compelling wind or solar generators to temporarily reduce the amount of power they are feeding onto the grid to help avoid grid overloads.[50] Such curtailment orders can be costly for wind and solar farm operators but could become more common as renewables supply an ever-increasing proportion of the nation's electricity.[51] For example, one study projected that if the share of renewable energy were to double between now and 2030, total energy storage capacity would need to grow from 4.67 terawatt-hours to 11.89–15.72 terawatt-hours to handle this change.[52] By contrast, current estimates suggest that there will be only about 4,500 MW of total energy storage in the U.S. by the year 2024.[53] This suggests the nation will need significantly more energy storage capacity to accommodate these changes to the energy mix.

A few technical terms are helpful when assessing the effectiveness and features of energy storage systems. The term "levelized cost of storage" (LCOS) describes the total lifetime cost of an energy storage technology divided by its cumulative delivered electricity, expressing it as the discounted cost of electricity per unit discharged.[54] The LCOS, which is generally expressed in dollars per kilowatt-hour (kWh), is a versatile metric that is used to compare the costs of various energy storage technologies.[55] Another common metric "roundtrip efficiency" describes the amount of energy a storage system loses from charge to discharge.[56] A storage device's "cycle life" and "calendar life" describe

---

[49] *See* Schmitt & Stanford, *supra* note 41, at 465–66 (outlining various renewable energy methods).

[50] *Id.* at 466.

[51] Michelle Bowman, *EIA Projects that Renewables will Provide Nearly Half of World Electricity by 2050*, ENERGY INFO. ADMIN. (Oct. 2, 2019), https://www.eia.gov/todayinenergy/detail.php?id=41533 (expressing that the U.S. Energy Information Administration projects that by 2050, renewable sources will supply almost half of the world's electricity).

[52] *Electricity Storage and Renewables: Costs and Markets to 2030*, INT'L RENEWABLE ENERGY AGENCY 8 (2017).

[53] Oliver Schmidt et al., *Projecting the Future Levelized Cost of Electricity Storage Technologies*, 3 JOULE 81, 81 (Jan. 2019).

[54] Schmidt et al., *supra* note 53, at 81.

[55] *Id.* at 81–82.

[56] Robert Fares & Michael Webber, *What are the Tradeoffs Between Energy Storage Cycle Life and Calendar Life in the Energy Arbitrage Application*, 16 J. ENERGY STORAGE 37, 37–40 (2018).

how quickly the device's capacity to store energy degrades over time.[57] Collectively, these metrics assist industry in comparing and evaluating energy storage systems.

2. Short- versus Long-Term Energy Storage: Limitations and Costs

Although short-term energy storage technologies and markets have expanded significantly in the past decade, these developments alone will be unable to support a rapid and complete transition to intermittent, renewable energy sources.[58] Short-term energy storage technologies can typically supply their maximum power output only for about four hours on average.[59] Because lithium-ion batteries are a relatively inexpensive and efficient form of short-term energy storage, boasting a $0.35/kWh LCOS,[60] utilities have increasingly relied on them in recent years to help mitigate "duck curve" problems arising from increased reliance on wind and solar energy.[61] Although lithium-ion batteries are well-suited for supplying short-term energy storage capacity, they are a costly and inefficient approach to bulk long-term storage.[62] Much of this is due to the poor scalability of lithium-ion battery systems.[63] These systems can only double their storage capacity through a doubling of the size or number of batteries involved.[64]

Although there is clearly a growing need across the country for additional energy storage capacity designed to store power for just a few hours, there is also an unprecedented need for a long-term energy storage that is engineered and rated to store energy for 24 hours or longer.[65] It is estimated that roughly $662 billion of investment will be needed to address the "storage gap" of energy storage technologies for the 6–100+ hour range.[66] Recognizing this challenge, California officials have

---

[57] *Id.*

[58] Silverstein, *supra* note 14.

[59] Emily Pontecorvo, *How do You Save Clean Energy? This Company Plans to p=Pump it Underground*, GRIST (June 30, 2020), https://grist.org/energy/how-do-you-save-clean-energy-this-company-plans-to-pump-it-underground/.

[60] *Id.*

[61] Louis Brasington, *The Long Duration Energy Storage Search – How Close are we to Low Costs and Zero Carbon*, CLEANTECH GRP. (Dec. 29, 2019), https://www.cleantech.com/the-long-duration-energy-storage-search-how-close-are-we-to-low-costs-and-zero-carbon/.

[62] *Id.*

[63] *Id.*

[64] Pontecorvo, *supra*59 note 59.

[65] Brasington, *supra* 61note 61.

[66] *Id.*

determined that their state alone will need to add at least one gigawatt (GW) of new long-term storage by 2026.[67]

3. Existing Long-Term Energy Storage Technologies

A diverse array of long-term energy storage technologies already exists, although many of these technologies are not fully matured and are still quite expensive.[68] Arguably, the five most promising long-term energy storage technologies today are: (1) pumped hydro; (2) flow batteries; (3) compressed-air; (4) gravity-based; and (5) hydrogen energy.[69] Each of these technologies has its own strengths and weaknesses in terms of efficiency, cost, calendar life, and geographic range, among other factors.[70] However, many of them are novel and remain somewhat unproven.[71] No single technology is the clear front-runner for meeting the planet's long-term energy storage needs. Accordingly, all of them could potentially play a role in providing long-term energy storage support for a carbon-free and sustainable energy sector.

Pumped hydro-electric energy storage technologies have existed in multiple forms for over a century.[72] Conventional pumped hydro facilities consist of two water reservoirs, each at a different elevation.[73] When there is an abundance of low-cost electricity on the grid, these facilities pump water from their lower reservoir to the higher reservoir to store energy.[74] Then, when there is a need for greater electricity supply on the grid, facility operators release water down through electromagnetic turbines to the lower reservoir, generating dispatchable

---

[67] Julian Spector, *California: We Need 1GW of New Long-Duration Energy Storage by 2026*, GREENTECH MEDIA (Apr. 7, 2020), https://www.greentechmedia.com/articles /read/california-we-need-1gw-long-duration-storage-by-2026.

[68] Jason Plautz, *Long-Duration Storage Market on the 'Cusp of Maturity': ESS CEO*, UTILITY DIVE (July 29, 2021), https://www.utilitydive.com/news/long-duration-storage-market-on-the-cusp-of-maturity-ess-ceo/604106/.

[69] Julian Spector, *The 5 Most Promising Long-Duration Storage Technologies Left Standing,* GREENTECH MEDIA (Mar. 31, 2020), https://www.greentechmedia.com/articles/read/most-promising-long-duration-storage-technologies-left-standing.

[70] Nestor A. Sepulveda et al., *The Design Space for Long-Duration Energy Storage in Decarbonized Power Systems*, 6 NATURE ENERGY 506, 506–07 (May 2021).

[71] *See* Plautz, *supra* note 68.

[72] *Pumped Storage Hydropower*, OFF. OF ENERGY EFFICIENCY & RENEWABLE ENERGY, https://www.energy.gov/eere/water/pumped-storage-hydropower (last visited Aug. 17, 2021).

[73] Schmitt & Stanford, *supra* note 41, at 457.

[74] *Id.*

power.[75] In the U.S., pumped hydro energy storage accounts for 95% of existing energy storage used by utilities,[76] providing it at an average LCOS of \$0.17/kWh.[77] Unfortunately, new pumped hydro storage development projects tend to involve relatively high initial capital costs and face significant geographical constraints because most of the viable sites for pumped hydro facilities are already in use.[78]

Another potential form of long-term energy storage—flow batteries—consists of chemically complex battery systems that store electrical charges in tanks of liquid electrolytes.[79] Most current flow battery technologies utilize significant amounts of vanadium, which is becoming increasingly rare and expensive.[80] However, there are alternative approaches in development that use less rare materials and show some promise.[81] The flow battery market is projected to become a \$1 billion annual industry over the next five years.[82] Flow batteries' per unit storage costs are still relatively high, but they have long cycle and calendar lives that allow for service times up to 30 years.[83]

Compressed-air energy storage systems use energy to cool, compress, and store air over long periods so it can later be released to generate electric current.[84] Although compressed-air storage facilities have relatively low roundtrip efficiencies and are somewhat geographically limited, they are not as geographically constrained as pumped hydro storage facilities and can store vast amounts of energy.[85] Compressed-air storage facilities often store air underground, and some existing caverns or man-made subsurface structures such as mineshafts present good candidates for hosting such systems.[86]

---

[75] *Id.*

[76] Pontecorvo, *supra* note 59.

[77] Brasington, *supra* note 61.

[78] *Id.*

[79] Robert Service, *New Generation of 'Flow Batteries' Could Eventually Sustain a Grid Powered by the Sun and Wind*, SCIENCE (Oct. 31, 2018), https://www.sciencemag.org/news/2018/10/new-generation-flow-batteries-could-eventually-sustain-grid-powered-sun-and-wind.

[80] *Id.*

[81] *Id.*

[82] *Id.*

[83] Tisha Scroggin-Wicker & Kieran McInerney, *Flow Batteries: Energy Storage Option for a Variety of Uses*, POWERMAG: SOLAR (Mar. 2, 2020), https://www.powermag.com/flow-batteries-energy-storage-option-for-a-variety-of-uses/.

[84] Schmitt & Sanford, *supra* note 41, at 483.

[85] Spector, *supra* note 69.

[86] *Id.*

Gravity-based energy storage systems, like pumped hydro storage facilities, use gravitational potential to store energy.[87] Most gravity-based energy storage systems in development store that energy using heavy concrete blocks that are stacked vertically by robotically operated cranes.[88] Gravity-based energy storage systems are appealing in that they have relatively small land footprints, can operate in most any geographic area, and require little or no water—a feature that could make them particularly useful in arid climates.[89] Gravity-based energy storage systems could also be scaled down and fitted to meet the long-term energy needs of smaller, isolated communities.[90]

Hydrogen energy storage technologies involve the use of excess energy to produce hydrogen, which is then stored for conversion into electric current at some point in the future.[91] Hydrogen energy storage strategies have a high energy density, do not generate carbon dioxide emissions, and are increasingly cost-competitive on the wholesale energy market with an LCOS of around $0.16–$0.19.[92] Hydrogen energy storage technologies have some additional appeal because of hydrogen's ability to serve a wide variety of industrial and commercial uses beyond energy storage as well.[93]

C. Current Energy Storage Policies

Energy storage policies currently in place at the federal and state levels provide valuable support for energy storage development but have some shortcomings that prevent them from adequately driving growth in the long-term energy storage industry.[94] Many of these existing policies do not even distinguish between long-term and short-term energy storage, and those that do generally fail to provide meaningful incentives for targeted private investments of long-term energy storage technologies.[95]

---

[87] Julian David Hunt, et al., *Mountain Gravity Energy Storage: A New Solution for Closing the Gap Between Existing Short- and Long-Term Storage Technologies*, 190 ENERGY 1, 2 (2020).

[88] *Id.*

[89] *Id.* at 1.

[90] *Id.* at 4.

[91] PAUL BREEZE, POWER SYSTEM ENERGY STORAGE TECHNOLOGIES 69–77 (2018).

[92] *Id.*

[93] *See id.* (discussing hydrogen's use in hydrocarbon reformation, vehicle fuel cells, and capturing energy from wind farms).

[94] Richard L. Revesz & Burcin Unel, *Managing the Future of the Electricity Grid: Energy Storage and Greenhouse Gas Emissions*, 42 HARV. ENV'T L. REV. 139, 174 (2018).

[95] *Id.* at 181.

At the federal level, the Federal Energy Regulatory Commission (FERC) is the primary regulator of long- and short-term energy storage.[96] FERC Orders 755 and 841 constitute the latest and most significant efforts by the agency to advance long-term energy storage.[97] FERC Order 755 attempts to open up more energy storage revenue streams.[98] Specifically, Order 755 makes it possible for technologies such as lithium-ion batteries and flywheels, that can regulate frequency on the grid, to be compensated for that service.[99] FERC Order 841 seeks to open additional streams of revenue for long-term energy storage providers by providing capacity, energy, and certain other ancillary services.[100] Both FERC Order 755 and 841 help to provide some extra incentives for the advancement of the long-term energy storage industry.[101] In crafting policies to promote long-term energy storage, it is important to ensure that the unique benefits and services long-term energy storage can provide are recognized and fairly compensated so that there will continue to be adequate private investment in long-term energy storage development.

At the state government level, California and New York are at the forefront of long-term energy storage policy. California was the first state to enact a state-level energy storage mandate.[102] California's SB 2514, enacted in 2010, required the California Public Utilities Commission to study the need for energy storage capacity in California.[103] Additionally, it issued an energy storage procurement target for the load-serving entities in the state.[104] This led the California Public Utilities Commission to require that the state's regulated utilities procure at least 1,325 MW of energy storage by the year 2024.[105] In 2017, New York's state government also created an Energy Storage Deployment Program.[106] In 2018, this led to a goal of developing 3,000 MW of long-

---

[96] *Id.* at 174.

[97] *Id.*; *see also*, *Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators*, Order No. 841, 162 FERC ¶ 61 (2018) [hereinafter Order No. 841].

[98] Revesz & Burcin Unel, *supra* note 94, at 174; *see also*, Order No. 841, *supra* note 97.

[99] *Id.*

[100] Nathan Howe et al., *California Energy Storage Initiatives: Surfing the Storage Wave*, 34 CHI. AM. BAR ASS'N NAT'L RES. & ENV'T 18, 20 (2019); *see also*, *see also*, Order No. 841, *supra* note 97.

[101] Howe et al., *supra* note 100, at 20; *see also*, Order No. 841, *supra* note 97.

[102] Howe et al., *supra* note 100, at 20.

[103] *Id.*

[104] *Id.*

[105] *Id.*

[106] *Id.*

term energy storage capacity in the state by the year 2030.[107] New York has also set the goal of being 100% free from carbon emissions in their energy generation by the year 2040.[108] California and New York's energy storage mandate policies are creating additional demand for energy storage capacity in those states. However, they could be strengthened if the states were to provide special incentives for long-term energy storage technologies, which remain comparatively less developed and in need of more targeted government support.

There is evidence that California and New York's policies are already beginning to successfully drive some long-term energy storage development. For example, in February 2017, California's San Diego Gas & Electric deployed what was, at the time, the world's largest lithium-ion battery storage facility.[109] It can store up to 120 MWh of electricity.[110] The construction of the facility was laudable, but it fulfilled only a tiny percentage of the total California energy storage goal and did little to increase the state's long-term energy storage capacity.[111] Moreover, a majority of states will have no long-term energy storage incentive policies, and the federal government's policies are far too modest to propel the type of growth needed to support the country's transition to renewable energy.[112] In short, federal and state energy storage incentive policies are helping to jumpstart the long-term energy storage industry. However, they still fall short of promoting the long-term energy storage development that will be needed to support the nation's accelerating transition to a carbon-free, sustainable energy system.

II. ANALYZING THE GAPS IN LONG-TERM ENERGY STORAGE POLICIES

A few specific factors have contributed to the relatively slow pace of long-term energy storage development in the United States over the past

---

[107] *Id.*

[108] *New York Announces $280 Million Available for Energy Storage Projects*, T&D WORLD: DISTRIBUTED ENERGY RES.: ENERGY STORAGE (May 1, 2019), https://www.tdworld.com/distributed-energy-resources/energy-storage/article/20972530/new-york-announces-280-million-available-for-energy-storage-projects.

[109] *Id.*

[110] Thomas Overton, *SDG&E Unveils World's Largest Li-Ion Storage Battery*, POWERMAG: ENERGY STORAGE (Feb. 24, 2017), https://www.powermag.com/sdge-unveils-worlds-largest-li-ion-storage-battery/.

[111] *Id.*

[112] Revesz & Unel, *supra* note 94, at 169.

few decades. In particular, existing market structures often fail to fully compensate producers for the unique benefits long-term energy storage provides.[113] Long-term energy storage projects involve comparatively high investment risks, and the high capital costs of these projects create barriers to entry that further deter private investment.[114] Recognizing these factors is an important first step towards addressing them and ultimately accelerating the growth of the long-term energy storage industry over the coming years.

A. Under-internalization of Long-Term Energy Storage Benefits

Externality problems, both negative and positive, are partly to blame for the nation's comparatively slow long-term energy storage development. Negative externality problems arise when actors do not internalize all the costs of a particular activity, leading to over-engagement in it.[115] For instance, when a coal plant burns coal—a form of chemical energy storage—that combustion process results in emissions of sulfur dioxide, nitrous oxide, and carbon dioxide.[116] The process imposes substantial environmental and health costs borne by parties other than coal plant operators or owners.[117] Because they do not bear all of these external costs, rational and self-interested coal plant operators are incentivized to engage in sub-optimally high levels of coal-fired power generation.[118] The electricity industry's long-standing strategy of relying heavily on inventories of coal as a primary means of storing energy for future use results in environmental and health costs that coal-fired power generators do not fully internalize in many jurisdictions.[119]

A positive externality problem also exists in the context of long-term energy storage because some of the unique benefits of long-term storage

---

[113] Lawrence Wai-chung Lai, '*The Problem of Social Cost': The Coase Theorem and Externality Explained: Using Simple Diagrams and Examples to Illustrate the Role of Land Use Planning in Tackling Externalities,* 78 TOWN PLANNING REV. 335, 344 (2007).

[114] DHRUV BHATNAGAR ET AL., MARKET AND POLICY BARRIERS TO ENERGY STORAGE DEPLOYMENT 21–34 (2013).

[115] Wai-chung Lai, *supra* note 113, at 344.

[116] Patrick Charles McGinley, *Climate Change and the War on Coal: Exploring the Dark Side*, 13 VT. J. ENV'T L. 255, 278 (2011).

[117] Xinming Du et al., *Transboundary Air Pollution from Coal-Fired Power Generation*, 270 J. ENV'T MGMT. 1, 2 (2020) ("Coal was also estimated to have produced 77% of SO emissions from fossil fuel-burning power plants, 75% of nitrous oxide emissions, and 73% of carbon dioxide emissions.").

[118] McGinley, *supra* note 116, at 278.

[119] *Id.* at 324.

are not presently accounted for and rewarded in most markets.[120] This leads to under-investment in new long-term energy storage development.[121] Positive externalities arise when actors do not internalize all the benefits of a particular activity, leading to under-engagement in it.[122] For example, individuals who receive a vaccination benefit not only benefit themselves but also benefit society by reducing the risk of further transmission.[123] Absent government intervention, the fact that individuals do not recognize all the broader societal benefits of getting vaccinated tends to lead to sub-optimally low vaccination rates.[124]

Considering these market failures, government interventions that compel or enable energy industry stakeholders to internalize more of the costs and benefits of their actions are needed to bring long-term energy storage development investment to more optimal levels.[125] Today's U.S. energy industry relies heavily on coal, oil, and natural gas—carbon-rich substances packed with chemically stored energy—to store energy for future use.[126] These fossil fuels are fairly easy to extract and stockpile to burn at later times when additional energy is needed at a low cost.[127] A basic way to encourage energy industry actors to transition away from these socially costly energy storage strategies could be to implement policies that require industry actors to internalize more of the broader social costs of this practice. For instance, a tax on burning fossil fuels or other carbon-based energy sources could lead to more efficient levels of this activity by compelling actors to internalize more of the societal costs associated with it.[128]

Conversely, policies designed to allow long-term energy storage facility owners to internalize more of the unique, broader benefits of their

---

[120] Susannah Maltz, *Rights in Common: A Deconstruction of Political Speech, Agency Fee Structure, and The Union as Commons After Janus v. AFSCME,* 21 CUNY L. REV. 285, 316 (2018).

[121] Ian Oxenham, *Charging Onwards: Removing Barriers to Energy Storage in Restructured New England States*, 43 VT. L. REV. 575, 611 (2019).

[122] Maltz, *supra* note 120, at 316.

[123] FE Andre et al., *Vaccination Greatly Reduces Disease, Disability, Death and Inequity Worldwide*, BULLETIN OF THE WORLD HEALTH ORG. 140, 143 (Feb. 2008) https://www.who.int/bulletin/volumes/86/2/07-040089.pdf.

[124] COREY WHITE, MEASURING THE SOCIAL AND EXTERNALITY BENEFITS OF THE INFLUENZA VACCINE 1 (2018).

[125] Kevin Counsell, *Privacy Versus Views: A Law and Economics Approach to Balancing Conflicting Urban Values*, 22 N.Z. J. ENV'T L. 147, 147, 163 (2018).

[126] John B. Goodenough, *Electrochemical Energy Storage in a Sustainable Modern Society*, 7 ENERGY & ENV'T SCI. 14, 14 (2014).

[127] *Id.*

[128] GILBERT E. METCALF, PAYING FOR POLLUTION: WHY A CARBON TAX IS GOOD FOR AMERICA 45 (2018).

operations could lead to more optimal levels of investment in their development.[129] For instance, increasing long-term energy storage capacity can: (1) improve grid reliability; (2) provide critical temporary backup energy supplies for emergency use; and (3) mitigate challenges associated with some renewable energy sources' intermittency.[130] At least some of these unique broader societal benefits are not as available through short-term energy storage, and yet, they are not fully accounted for in existing policies. This contributes to sub-optimally low levels of investment.[131] Tax credit programs, targeted grant programs, and other policies that enable long-term energy storage project developers and owners to internalize more of these unique benefits could help address this underinvestment problem.[132] Some programs could act as a Pigouvian Subsidy, seeking to promote more optimal levels of long-term energy storage development that better reflect its distinct value to society and to the broader energy.[133]

B. Reducing Investment Risks for Long-Term Energy Storage Development

Another obstacle to the advancement, and deployment, of long-term energy storage technologies is the relatively high investment risk associated with many types of long-term energy storage development.[134] Introducing new policies aimed at better mitigating these risks could be another potential way of accelerating long-term energy storage development.[135]

Many long-term energy storage strategies are relatively new and unproven, making them an inherently riskier investment than many other types of investments. As discussed above, the most well-established types of long-term energy storage are presently pumped hydro facilities and lithium-ion battery systems. However, both strategies suffer major geographical or cost constraints. Other potential long-term energy storage technologies are unproven and plagued by investment

---

[129] Revesz & Unel, *supra* note 94, at 180–83.

[130] *See id.* at 147–48 (explaining the multiple ways energy storage systems can optimize supply).

[131] *Id.* at 167–68.

[132] Morgan Lewis, *Are Investment Tax Credit Changes in Store for Energy Storage?*, JD SUPRA (June 15, 2021), https://www.jdsupra.com/legalnews/are-investment-tax-credit-changes-in-8883438/.

[133] Lisa Grow Sun & Brigham Daniels, *Mirrored Externalities*, 90 Notre Dame L. Rev. 135, 170–71 (2014).

[134] *Id.* at 82.

[135] *Id.*

uncertainty.[136] Such uncertainty tends to lead to under-investment and tepid growth,[137] and policy uncertainty related to these technologies has also contributed to the slow advancement of long-term energy storage.[138] Policies that mitigate either of these types of uncertainty could further help to accelerate U.S. long-term energy storage development.

C. Lowering Barriers to Entry in the Long-Term Energy Storage Industry

Unusually high barriers to entry, due to the inherently large size of many types of long-term energy storage facilities, may also be contributing to the slow growth in development of these projects.[139] These barriers exist for three reasons: novelty, high capital costs, and the lack of an adequate policy structure focused on long-term energy storage and investment risks.[140] By contrast, short-term energy storage developers do not face similar barriers to entry because most short-term energy storage projects do not match long-term projects in size, budget, or minimum scale.[141] For example, lithium-ion batteries are currently a popular source of energy storage.[142] Accordingly, potential developers tend to need far less capital for typical short-term energy storage projects.[143] This makes it comparatively more difficult for long-term energy storage developers to enter these markets and compete.[144]

---

[136] Jacques-Bernard Sauner-Leroy, *Managers and Productive Investment Decisions: The Impact of Uncertainty and Risk Aversion,* 42 J. SMALL BUS. MGMT. 1, 13 (2004) (discussing investment risk).

[137] LUKE C.D. STEIN & ELIZABETH STONE, THE EFFECT OF UNCERTAINTY ON INVESTMENT, HIRING, AND R&D: CAUSAL EVIDENCE FROM EQUITY OPTIONS 1 (2013) (on file with Arizona State University) (discussing how uncertainty has been found to depress capital investment).

[138] Merrill Jones Barradale, *Impact of Public Policy Uncertainty on Renewable Energy Investment: Wind Power and the Production Tax Credit*, 38 ENERGY POL'Y 7698, 7700 (2010) ("The wind industry experienced a 'boom-bust' cycle as there would be an increase in wind plant production during times of production tax credits, and a sharp decrease during the expiration of those credits.").

[139] Iordanis M. Eleftheriadis & Evgenia G. Anagnostopoulou, *Identifying Barriers in the Diffusion of Renewable Energy Sources*, 80 ENERGY POL'Y 153, 163 (2015).

[140] Edward Peter Stringham et al., *Overcoming Barriers to Entry in an Established Industry: Tesla Motors*, 4 CAL. MGMT REV. 85, 86 (2015) (expressing that it is similar to the barriers to entry in the electric car industry).

[141] *See Id.* (describing the cost of lithium-ion battery energy storage).

[142] MAMDOUH EL HAJ ASSAD & MARC. A ROSEN, DESIGN AND PERFORMANCE OPTIMIZATION OF RENEWABLE ENERGY SYSTEMS Ch. 14 (Mamdouh El Haj Assad & Marc A. Rosen eds. 2021).

[143] *See* K. Mongird et al., *Energy Storage Technology and Cost Characterization Report*, U.S. DEP'T OF ENERGY (2019), https://energystorage.pnnl.gov/pdf/PNNL-28866.pdf (comparing multiple examples of performance improvement forecasts).

[144] *Id.* at 8 (The projected cost of a lithium-ion energy storage project is projected at $362/kWh in the year 2025. However, in order to meet the demands and services of long-term energy storage, the

Policies designed to remove or lower such barriers to entry into long-term energy storage development markets could do much more to increase competition and overall investment, thereby driving more rapid expansion and maturation of these markets.

III. ACCELERATING THE LONG-TERM ENERGY STORAGE BUILDOUT

Although the U.S. long-term energy storage industry has, before now, faced numerous obstacles to its growth, there are policy strategies with the capability of addressing these challenges.[145] The policies also unleash much more rapid long-term energy storage growth.[146] Research grant programs specifically targeting long-term energy storage innovation could help to accelerate investment in the research needed to speed up the maturity of these technologies, just as they have with other ventures. Policies focused on monetizing the unique capabilities and value of long-term energy storage within relevant markets could address positive externality problems limiting development. Energy storage investment tax credits and energy storage loan guarantees could reduce investment risks for long-term energy storage projects, lower barriers to entry, and further overcome these externality problems.[147] Additionally, long-term energy storage portfolio standards at the state level could generate additional market demand for long-term energy storage projects, helping to accelerate the pace of such developments.[148]

A. Targeted Research Grants

Expanding grant programs targeted at long-term energy storage research could be one way for the federal government to accelerate innovation in long-term energy storage markets. The U.S. Department of Energy (DOE) uses various grant programs to incentivize and subsidize

---

capacity must be exponentially larger into multiple MW's. This increase in necessary capacity increases the overall size of the project and results in a larger overall cost as compared to even short-term energy storage.).

[145] *See generally, Energy Dep't Grants & Funding,* FED. REG., https://www.federalregister.gov/energy-department-grants-funding (last visited Mar. 17, 2021) (listing the various energy grant and funding opportunities) .

[146] Mongird et al., *supra* note 143.

[147] Patrick Lam & Angel Law, *Financing for Renewable Energy Projects: A Decision Guide by Developmental Stages with Case Studies*, 90 RENEWABLE & SUSTAINABLE ENERGY REVS. 937, 938 (2018).

[148] Anthony E. Chavez, *Using Renewable Portfolio Standards to Accelerate Development of Negative Emissions Technologies*, 43 WM. & MARY ENV'T L. & POL'Y REV. 1, 9 (2018).

certain energy-related research.[149] Such programs can be well structured to be accessible to businesses, non-profit organizations, and research institutions that may have difficulty receiving funding through other sources.[150] For instance, the DOE's Energy Storage Grant Challenge aims to position the U.S. as a world leader in energy storage and has invested $7.6 million in energy storage research.[151] Unfortunately, grant programs for long-term energy storage research are slow to materialize; most research funding is allocated to short-term storage projects.[152] Expanding and more narrowly targeting these grant programs to promote long-term energy storage would help to address this funding gap and accelerate innovation related to long-term storage technologies. The DOE has the resources and authority to create such targeted research grant programs for long-term energy storage.[153] As of February 2021, the DOE had not allocated $27.5 billion of its $66.5 billion budget.[154] Based on future cost estimates, it would be much more worthwhile for research grant funding to go to long-term energy storage projects than short-term projects.[155] Such research grants would create a viable option for investors and research institutions to break into the long-term energy storage market.

B. Long-Term Energy Storage Investment Tax Credits

Another policy strategy for incentivizing investment in long-term energy storage development is to enact tax credit programs and other policies. These policies better compensate developers for the unique

---

[149] *Id.* at 39.

[150] *Grant Eligibility*, GRANTS.GOV, https://www.grants.gov/web/grants/learn-grants/grant-eligibility.html (last visited Jan. 30, 2022).

[151] *DOE Invests Nearly $7.6 Million to Develop Energy Storage Projects,* OFF. OF FOSSIL ENERGY (Dec. 22, 2020), https://www.energy.gov/fecm/articles/areas-interest-doe-invests-nearly-76m-develop-energy-storage-projects.

[152] Andy Colthorpe, *$1.3 Billion Funding Proposed for U.S. energy Storage R&D, Demonstrations, and Manufacturing*, ENERGY STORAGE NEWS (2020), https://www.energy-storage.news/news/us1.3-billion-funding-proposed-for-us-energy-storage-rd-deployment-manufact (In 2020 a subcommittee of the U.S. House Appropriations Committee approved a bill allowing research grants for the development of new energy storage technologies and advancements to help reliability on the grid).

[153] Chavez, *supra* note 148.

[154] *Status of Funds*, DEPARTMENT OF ENERGY BUDGETARY RESOURCES, https://www.usaspending.gov/agency/930 (stating that the U.S. Department of Energy has $65.5 Billion in budgetary resources and as of February 28, 2021 they have only obligated $26.5 Billion of that total budget) (last visited Feb. 2, 2021).

[155] Mongird et al., *supra* note 143 (estimating that by the year 2025, the total project cost for lithium-ion battery storage will be $362/kWh).

benefits that long-term energy storage capacity provides. Today's energy storage markets, which focus primarily on short-term energy storage, arguably fail to account for these distinct benefits.[156] Thus, the markets under-incentivize private investment in long-term energy storage development.[157] This market failure results because long-term energy storage providers are unable to internalize all the benefits of their products, leading to sub-optimally low investment in long-term energy storage.[158] Introducing a new federal tax credit program specifically targeting long-term energy storage development would be a straightforward way to help mitigate this problem.

Long-term energy storage capacity provides several specific benefits that short-term energy storage cannot. One of these benefits is greater grid resiliency against prolonged disruptive events.[159] The days-long backup energy supplies available through long-term energy storage capacity can help prevent brownouts and other power outages during disasters, potentially avoiding billions of dollars in monetary losses each year and even sparing lives.[160] During prolonged spikes in wholesale electricity prices, long-term storage capacity can also help utilities access the banked energy.[161] The increased storage saves millions of dollars in expenses that the utilities will later pass along to retail customers through rate adjustments.[162] Like short-term storage facilities, long-term energy storage systems can also provide valuable ancillary grid management services, such as frequency response, voltage support, and spinning.[163] FERC has recently made it possible for long-term energy storage providers to enter the markets for these services.[164] The possibilities create new market opportunities that could expand through additional incentives and programs.[165]

---

[156] Andy Colthorpe, *US Department of Energy: Cost Reduction Target of 90% by 2030 Set for Long-Duration Energy Storage*, ENERGY STORAGE NEWS (July 14, 2021), https://www.energy-storage.news/us-department-of-energy-cost-reduction-target-of-90-by-2030-set-for-long-duration-energy-storage/.

[157] Jeremy Richardson, *How to Ensure Energy Storage Policies Are Equitable*, UNION OF CONCERNED SCIENTISTS (Nov. 19, 2019), https://ucsusa.org/resources/equitable-energy-storage.

[158] Ramteen Sioshansi et al., *Market and Policy Barriers to Deployment of Energy Storage,* 2 ECON. ENERGY & ENV'T POL'Y. 47, 49 (2012).

[159] Revesz & Unel, *supra* note 94, at 147–49.

[160] *Id.* at 149.

[161] Colthorpe, *supra* note 156.

[162] ADITYA MISHRA ET AL., SCALING DISTRIBUTED ENERGY STORAGE FOR GRID PEAK REDUCTION, e-Energy 13 (2013).

[163] Revesz & Unel, *supra* note 94, at 148.

[164] Colthorpe, *supra* note 156.

[165] Sepulveda, *supra* note 70.

Congress could easily reform existing energy incentive policies to reward long-term energy storage developers more fully with the unique additional benefits of these services. Congress would be able to provide for this through investment tax credits.[166] Investment tax credit programs allow taxpayers that expend funds on specific qualifying activities to reduce their tax liability by amounts based on the magnitude of those investments.[167] In recent years, the federal government has offered investment tax credits of up to 30% for qualifying investments in solar energy development.[168] Investment tax credits can act as a type of Pigouvian Subsidy to subsidize an activity that would otherwise suffer from under-investment due to positive externality problems such as those plaguing the long-term energy storage industry.[169]

Congress would need to create a new federal investment tax credit program targeted at long-term energy storage. This targeted credit could be made available only for long-term energy storage systems and facilities—those with the capacity to store energy in excess of 24 hours. As it has done in the past for the Solar Investment Tax Credit,[170] Congress could likewise set forth a phase-out period for this long-term energy storage credit program that gradually reduced the amount of credit over several years.[171] This phase-out approach is generally preferred over a single program termination date because it allows the industry to adjust to scaled-back government support over time as the industry matures.[172] Congress would have the power to adjust this phase-out schedule as needed in future years to help maintain desired levels of long-term energy storage investment.[173]

---

[166] Colthorpe, *supra* note 156.

[167] 26 U.S.C. § 48.

[168] Stephen Comello & Stefan Reichelstein, *The U.S. Investment Tax Credit for Solar Energy: Alternatives to the Anticipated 2017 Step-down*, 55 RENEWABLE & SUSTAINABLE ENERGY REV. 591, 591 (2016).

[169] Gregmar I. Galinato & Jonathan Y. Yoder, *An Integrated Tax-Subsidy Policy for Carbon Emission Reduction*, 32 RES. & ENERGY ECON. 310, 311 (2010).

[170] The solar investment tax credit was extended to its current form where there will be a step down from 30% to 22% and so on until it eventually reaches 0%. The extension was necessary as George Washington University Solar Institute projected data that without the extension, utility-scale solar projects would have declined 100%. *ITC Step Down: Understanding Solar Federal Tax Credits*, THE URBAN GRID (June 18, 2019), https://www.urbangridsolar.com/itc-step-down-understanding-solar-federal-tax-credits/.

[171] Lewis, *supra* note 132.

[172] Girish Upreti et al., *Impacts of the American Recovery and Reinvestment Act and the Investment Tax Credit on the North American Non-Automotive PEM Fuel Cell Industry*, 41 INT'L J. HYDROGEN ENERGY 3664, 3674 (2016).

[173] Lewis, *supra* note 132.

C. Federal Loan Guarantees

A new federal loan guarantee program could also accelerate utility-scale, long-term energy storage development by improving developer access to capital and helping to lower the barriers to entry associated with these large projects. Federal loan guarantee programs can reduce a private lender's risks associated with helping to finance new types of development.[174] In 2019, $1.4 trillion of the $1.5 trillion in federally provided credit assistance took the form of loan guarantees.[175] The availability of a federal loan guarantee makes private lenders more willing to provide financing, which can be crucial in the context of large long-term energy storage projects.[176] This increased access to capital could help drive increased investment activity within the long-term energy storage development industry.[177] There are examples of loan-guaranteed solar ventures that failed and cost the government millions of dollars.[178] However, loan guarantees have proven to be a successful tool in accelerating solar industry development and innovation in the U.S.[179]

Congress could create a program for long-term energy storage development like it did for the solar industry's 2009 American Recovery and Reinvestment Act's Section 1705 loan guarantee program.[180] The DOE administered Section 1705, and under the program, the federal government guaranteed $16.15 billion in loans for renewable energy projects.[181] Of that $16.15 billion, $13.27 billion in guaranteed loans were for solar projects.[182] A detailed application process and clear eligibility guidelines could help ensure a new loan guarantee program

---

[174] *Id.*

[175] Natalie Bachas et al., *Loan Guarantees and Credit Supply*, 139 J. FIN. ECON. 872, 872 (2020).

[176] *Id.* at 894.

[177] Qigui Liu et al., *To What Extent Did the Economic Stimulus Package Influence Bank Lending and Corporate Investment Decisions?*, 86 J. BANKING & FIN. 177, 178–79 (2018).

[178] Jeff Brady, *After Solyndra Loss, U.S. Energy Loan Program Turning a Profit*, NPR (Nov. 13, 2014), https://www.npr.org/2014/11/13/363572151/after-solyndra-loss-u-s-energy-loan-program-turning-a-profit (last visited Feb. 2, 2021) (U.S government had to pay out $535 million in loan guarantees to the failure of the solar project Solyndra).

[179] *Key Facts: Solyndra Solar*, DEP'T OF ENERGY, https://www.energy.gov/key-facts-solyndra-solar (last visited Feb. 2, 2021) (Loan guarantees from the Department of Energy now have forty successful solar projects and 60,000 people employed).

[180] PHILLIP BROWN, R42059, CONG. RSCH. SER., SOLAR PROJECTS: DOE SECTION 1705 LOAN GUARANTEES 1 (2011).

[181] *Id.*

[182] *Id.*

that specifically targets long-term energy storage rather than short-term energy storage development.[183] Such a program would lower barriers to entry into these markets and help address the obstacle of high investment risk that currently constrains growth in the long-term energy storage development industry.

D. Long-Term Energy Storage Portfolio Standard Carve-outs

At the state government level, one other potential strategy for driving long-term energy storage growth is the introduction of energy storage portfolio standards with special carve-out provisions requiring utilities to steadily increase their long-term energy storage capacity. State-level renewable portfolio standards have been tremendously influential in driving renewable energy development across much of the U.S.[184] These standards require regulated electric utilities to procure certain percentages of their electric power from qualifying renewable energy sources.[185] Some standards feature additional "carve-out" provisions requiring that specific minimum percentages of renewable energy production are obtained from rooftop solar, wind, or other sources.[186] These policies create additional market demand, helping to drive investment in these new technologies.[187] Renewable portfolio standards have especially benefited the U.S. wind[188] and solar[189] industries in recent years.

California set a goal of installing 1 GW of energy storage by the year 2026.[190] This has already led to Southern California Edison announcing contracted projects for 770 MW of primary solar-paired energy storage

---

[183] *See* FED. REG., *supra* note 145 (explaining factors the Department of Energy looked at before granting a loan guarantee and the timeline associated with granting the loan guarantee).

[184] Vicki Arroyo et al., *State Innovation on Climate Change: Reducing Emissions from Key Sectors While Preparing for a "New Normal,"* 10 HARV. L. & POL'Y REV. 385, 398 (2016).

[185] Corey N. Allen, *Untapped Renewable Energy Potential: Lessons for Reforming Virginia's Renewable Energy Portfolio Standard from Texas and California*, 35 VA. ENV'T L.J. 117, 120 (2016).

[186] U.S. ENV'T PROT. AGENCY, ENERGY AND ENV'T GUIDE TO ACTION 5-10 (2015).

[187] *Id.* at 5.

[188] By 2016, seventy-nine percent of wind power additions either were in RPS states but exceeded RPS mandates or were installed in non-RPS states. RYAN WISER & MARK BOLINGER, WIND TECHS. MKT. REP. 67 (2016).

[189] In 2016, solar accounted for seventy-nine percent of all new builds for renewables under an RPS. GALEN BARBOSE, U.S. RENEWABLES PORTFOLIO STANDARDS: 2017 ANN. STATUS REPORT 6 (2017).

[190] Spector, *supra* note 69.

to meet regional needs.[191] However, even California's goal does not have a carve-out provision aimed specifically at long-term storage. Moreover, most states in the U.S. presently have no portfolio standards relating to energy storage.[192] Adding such standards and including long-term energy storage carve-out provisions in them could be another impactful way to hasten the pace of this increasingly important type of energy development.

CONCLUSION

As intermittent renewable energy sources comprise an increasing share of the nation's energy mix, long-term energy storage capacity will need to greatly expand to help ensure the lights stay on—even when it is not windy, or the sun is not shining. As climate change causes extreme weather events like those in California and Texas to become more common, greater long-term energy storage capacity could help limit the impacts of these growing threats to the resiliency of the nation's critically important electricity grid infrastructure. Sadly, the nation's existing policy regime is failing to generate the degree of private investment needed to ensure that adequate long-term energy storage capacity is in place to support the transition to a zero-carbon, fully sustainable energy system. Although policies adopted in recent years have accelerated short-term energy storage growth, long-term storage growth continues to lag and could hamper the nation's shift to renewable energy.

Fortunately, several policy strategies are available that have proven successful in other areas of energy policy and could provide the government assistance needed to drive rapid progress in the United States' long-term energy storage markets. By enacting targeted research grant programs, investment tax credits, federal loan guarantee programs, and state long-term energy storage portfolio standards, policymakers have an opportunity to facilitate a massive expansion of the nation's long-term energy storage industry and lay critical groundwork for a far more sustainable energy future.

---

[191] Jeff St. John, *Southern California Edison Contracts Huge Storage Portfolio to Replace Gas Plants*, GREENTECH MEDIA (May 01, 2020), https://www.greentechmedia.com/articles/read/southern-california-edison-picks-770mw-of-energy-storage-projects-to-be-built-by-next-year.

[192] *See* U.S. ENV'T PROT. AGENCY, *supra* note 186, at tbl. 5.1 (demonstrating that while there is a mandatory requirement for states to have energy storage standards, most states do not).