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Residential Energy Storage: U.S. Manufacturing and Imports Grow Amid Rising Demand

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Abstract

The U.S. residential energy storage market grew rapidly during 2017–20, driven by homeowners seeking to increase resiliency, changes in net metering programs, and the financial benefits of installing a system. The residential energy storage system (ESS) market was dominated by Tesla in 2020 and, as a result, domestic production met most U.S. demand. Smaller U.S. producers are also benefiting from market growth, with residential ESS sales substantially increasing in the last few years. There were several new entrants with foreign production to the residential market in 2019–20, however, some of which have a number of competitive advantages that enabled them to quickly gain U.S. sales in the second half of 2020. As a result, U.S. residential ESS imports rapidly increased in 2020. South Korea was historically the largest foreign residential ESS supplier, but an increasing share of imports are shipped from China and Vietnam.

U.S. international Trade Commission

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Introduction

The U.S. residential energy storage market has undergone rapid growth in the last few years and is projected to continue growing at a fast pace. This growth has created substantial opportunities for residential energy storage system (ESS) manufacturers.[1] This paper examines the size of the ESS market, the leading companies in the market, the U.S. ESS manufacturing industry, and U.S. imports of ESS. The results of this analysis indicate that the U.S. residential market was dominated by domestic producers in 2020, largely due to the large share of the market accounted for by Tesla, but that competition and imports are rapidly increasing.

The first two sections of this paper provide background on residential ESSs, with a description of the products covered in this paper and an overview of the U.S. market. The paper then discusses the companies that compete in the U.S. residential market and how competition in the market has changed in the last few years. The next section examines U.S. ESS production, including the major domestic producers, trends in U.S. production, and the supply chain. The final section looks at U.S. imports, including trends since the start of 2019 and the major countries of origin.

Residential Energy Storage Systems

This paper covers residential ESSs, which are installed at homes to store energy for later use, such as at night when a solar photovoltaic (PV) system is not producing electricity or when there is a power outage (figure 1).[2] An ESS includes the storage batteries and components that connect and integrate the storage system with the electric grid and any on-site power generation and provide system monitoring and user control.[3] ESSs use a range of battery chemistries, but various types of lithium ion batteries, such as nickel manganese cobalt (NMC) and lithium iron phosphate ($LiFePO_4$, also known as lithium ferro phosphate or LFP), are the most commonly used in U.S. installations.[4] The batteries and other components may be combined in a single unit or may be separate components. Some ESSs include inverters—which are capable of changing between direct current (DC) and alternating current (AC)—as part of the system, while others require separate inverters.[5] ESSs range in size, with U.S. manufacturers generally supplying units ranging from 5 kilowatt-hours (kWh) to 30 kWh for residential use in the

[1] All references in this paper to ESSs are to residential systems unless otherwise noted.
[2] This paper will not cover portable units or batteries sold separately and used to build an ESS on-site. While this paper focuses on residential energy storage, some of the same ESSs may be used in small nonresidential systems. Nonresidential installations include installations at industrial sites, commercial buildings, nonprofits, government buildings, and similar locations, and do not include utility installations.
[3] Tesla, "Backup Gateway 2," May 23, 2020; Enphase, "Seamless and Automatic," 2020.
[4] Based on data compiled by USITC staff. These are the same battery technologies used in other industries such as electric vehicles, e-bikes, and utility energy storage systems. DeCarlo and Matthews, "More than a Pretty Color," February 2019, 5; Lambert, "Elon Musk Says Tesla," February 25, 2021; Plautz, "Tesla Shifts," March 18, 2021.
[5] Sun Solar Electric, "Sonnen Battery Information," March 5, 2021; Tesla, Powerwall Datasheet, June 11, 2019; Generac, "PWRcell Solar," October 2020, 6, 10; Enphase, "Seamless and Automatic," 2020.

United States.[6] The mostly commonly installed ESS in 2020 was the 13.5 kWh (usable energy capacity) Powerwall produced by U.S.-headquartered firm Tesla.[7]

Figure 1 Example of an installed Tesla Powerwall and Backup Gateway

Source: Erne, "California Native American," August 21, 2020; Tesla, "Backup Gateway 2," May 23, 2020.
Note: The Backup Gateway "provides energy management and monitoring."

Rapid Growth in U.S. Energy Storage Market

The U.S. residential energy storage market has undergone substantial growth in the last few years, with installations, by energy capacity, increasing from 29 MWh in 2017 to 540 MWh in 2020 (figure 2).[8] In terms of power capacity, installations increased from 13 MW in 2017 to 235 MW in 2020.[9] On a quarterly basis, there was a gradual increase in installations from the first quarter of 2017 to the third quarter of 2020, though there was a decline in the second half of 2018. In the fourth quarter of 2020

[6] The size of an ESS is typically measured in two ways, the power capacity and the energy capacity. The power capacity is the maximum amount that an ESS can discharge at any single point in time. The power capacity is measured in kilowatts (kW), megawatts (MW), or gigawatts (GW). The energy capacity is how much energy capacity a battery is able to store and is typically measured in kilowatt-hours (kWh), megawatt-hours (MWh), or gigawatt-hours (GWh). ESSs have a total energy capacity and a usable energy capacity. Market size data in this paper is presented both in terms of power capacity and energy capacity, but other data in this paper use the best available data set. DOE, EIA, *Battery Storage in the United States*, July 2020, 5, 8; Leisch and Chernyakhovskiy, *Grid-Scale Battery Storage*, September 2019, 2.

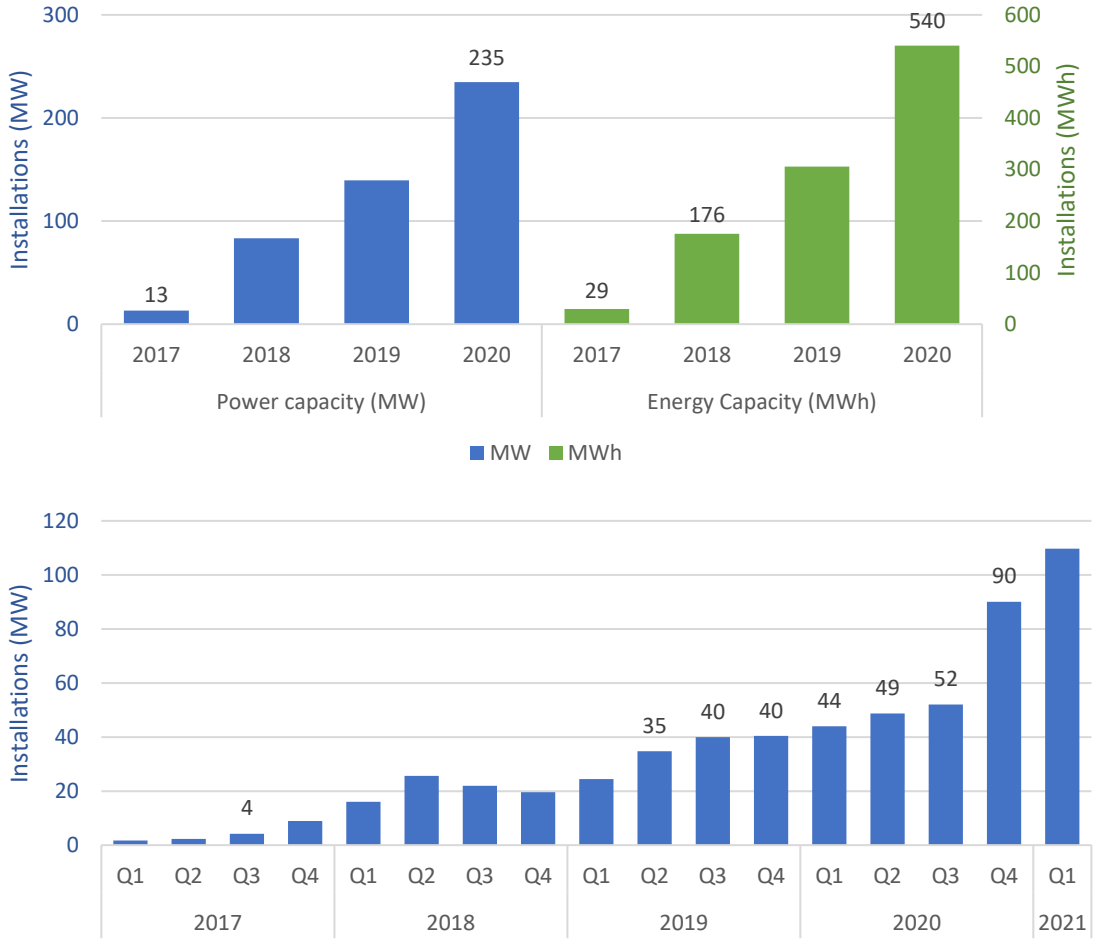
[7] Based on data compiled by USITC staff.

[8] Installations in front of the meter (most commonly utility installations) totaled 3,511 MWh in 2020 and nonresidential installations totaled 298 MWh in 2020. ESA, "U.S. Energy Storage Monitor," March 17, 2021, 10; SEPA, *2018 Utility Energy Storage*, August 2018, 13; Spector, "U.S. Residential Storage," June 2, 2020; Spector, "As Residential Solar," September 3, 2020; Spector, "WoodMac: Biggest U.S. Battery," December 2, 2020; ESA and WoodMac, *U.S. Energy Storage Monitor*, March 2021, 5.

[9] WoodMac projects significant growth in all market segments through 2025, with the residential sector projected to reach 1.2 GW in annual installations in 2025. WoodMac projects that installations in all market segments combined will increase from 1.5 GW in 2020 to 7.8 GW in 2025. ESA, "U.S. Energy Storage Monitor," March 17, 2021, 14, 22; SEPA, *2018 Utility Energy Storage*, August 2018, 13; Spector, "U.S. Residential Storage," June 2, 2020; Spector, "As Residential Solar," September 3, 2020; Spector, "WoodMac: Biggest U.S. Battery," December 2, 2020; ESA and WoodMac, *U.S. Energy Storage Monitor*, March 2021, 4–5, 8.

there was a large jump in installations to 90 MW, and installations continued to increase to more than 100 MW in the first quarter of 2021. California was the largest market in 2020 (accounting for 57 percent of installations) and Hawaii was the second largest market (16 percent).[10]

Figure 2 U.S. residential energy storage installations, 2017–20, annual (top) and quarterly (bottom)



Source: SEPA, *2018 Utility Energy Storage*, August 2018, 13; SEPA, *2019 Utility Energy Storage*, August 2019, 9; Spector, "U.S. Residential Storage," June 2, 2020; Spector, "As Residential Solar," September 3, 2020; Spector, "WoodMac: Biggest U.S. Battery," December 2, 2020; ESA and WoodMac, *U.S. Energy Storage Monitor*, March 2021, 4–5; St. John, "U.S. Storage Market Rebounds," December 3, 2019; Spector, "U.S. Storage Industry," March 10, 2020; Spector, "U.S. Storage Market Hits," September 10, 2019; ESA, "Energy Storage Monitor," June 17, 2020, 9; ESA and WoodMac, *U.S. Energy Storage Monitor*, June 2021, 4–5; Munsell, "US Energy Storage," December 7, 2017.
Note: Totals are only displayed for columns where an exact value was available. Annual power capacity data for 2017 and annual energy capacity data for 2017 and 2018 are from SEPA. All other data are from WoodMac.

Customers are increasingly interested in installing energy storage with PV systems, though there are also stand-alone storage installations. According to a survey of PV installers, which includes firms installing residential and/or nonresidential systems, 33 percent of quotes provided by PV system installers in 2020

[10] SEPA, *2018 Utility Energy Storage*, August 2018, 13; SEPA, *2019 Utility Energy Storage*, August 2019, 9; Spector, "U.S. Residential Storage," June 2, 2020; Spector, "As Residential Solar," September 3, 2020; Spector, "WoodMac: Biggest U.S. Battery," December 2, 2020; ESA and WoodMac, *U.S. Energy Storage Monitor*, March 2021, 4–5, 7; St. John, "U.S. Storage Market Rebounds," December 3, 2019; Spector, "U.S. Storage Industry," March 10, 2020; Spector, "U.S. Storage Market Hits," September 10, 2019; ESA, "Energy Storage Monitor," June 17, 2020, 9; ESA and WoodMac, U.S. Energy Storage Monitor, June 2021, 4–5.

included energy storage, up from 14 percent in 2017. In terms of installations, 20 percent of PV installations included energy storage in 2020, compared with 7 percent in 2017.[11]

The increase in installations was primarily driven by rising demand for backup power in response to power outages and changes to utility net metering and rate structures. These changes significantly increased the financial benefits of installing energy storage.[12] A 2019 survey of residential storage system owners in California found that backup power and financial benefits were the two most important reasons that customers installed an ESS.[13] Similarly, residential and nonresidential customers requesting quotes on EnergySage, an online marketplace through which customers can get quotes from multiple PV installers, most commonly cited resilience and/or financial savings as the reason they were interested in an ESS.[14]

There are a number of other factors that have also driven the growth of the residential energy storage market, including environmental benefits, homeowners' desire to use self-produced electricity, and government policies.[15] Residential energy storage benefits from federal policies (e.g., ESSs paired with a PV system may—depending on the configuration and timing of the ESS installation—be eligible for the investment tax credit) and state and local policies (e.g., the Self-Generation Incentive Program (SGIP) in California).[16] A number of utilities are also implementing virtual power plant programs, whereby ESSs are installed at residences and the utility can pull electricity from the ESSs as needed—such as in periods of peak demand.[17]

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[11] EnergySage, *Solar Installer Survey: 2020 Results*, March 2021, 8.

[12] In first generation net metering programs, customers who installed renewable energy systems, such as rooftop PV, often received a credit for the amount of excess electricity (i.e., beyond what is used at the residence) supplied to the electric grid. This credit could be used to draw the same amount of electricity from the grid at a later time. Some newer net metering programs add additional fees and adjust credits on a value basis, such as the price of electricity at the time it was generated or to a rate that is lower than the retail electricity rate. These factors make it less advantageous for homeowners to supply electricity to the grid at the time it was generated, and incentivize the installation of ESSs. CPUC, "Net Energy Metering (NEM)," n.d. (accessed March 5, 2021); Matasci, "California Net Metering," June 2, 2020; N.C. Clean Energy Technology Center, DSIRE database (accessed March 5, 2021); HECO, "Customer Grid-Supply Plus," n.d. (accessed March 5, 2021); EnergySage, *Solar Installer Survey: 2020 Results*, March 2021, 8; Generac, "Q4 2020 General Holdings," February 11, 2011; HECO, "Smart Export," n.d. (accessed March 5, 2021); NeoVolta, Form 1-K, October 2, 2020, 6–7; SunPower, "Q4 2020 SunPower," February 17, 2021; Eguana, Management's Discussion, January 21, 2021, 2–3.

[13] Itron, *2019 SGIP Energy Storage*, December 3, 2019, B.1-4.

[14] EnergySage, *Solar Marketplace Intel Report*, October 2020, 5.

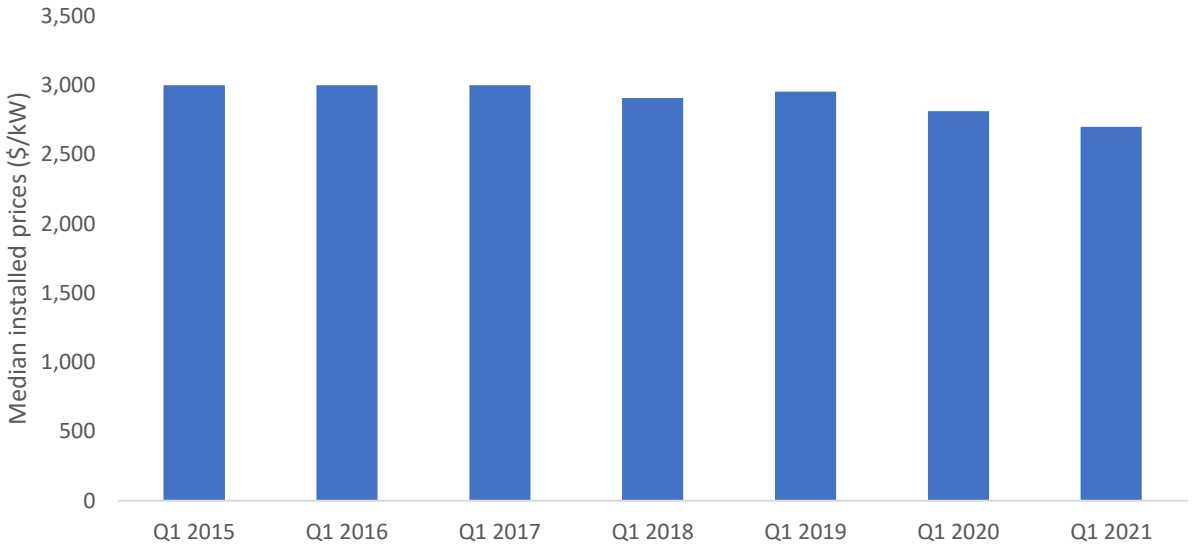
[15] Itron, *2019 SGIP Energy Storage*, December 3, 2019, B.1-4–B.1-5; EnergySage, *Solar Installer Survey: 2020 Results*, March 2021, 8.

[16] The investment tax credit is a credit, currently equal to 26 percent of the value of the system, for homeowners that install certain renewable energy systems, including PV systems. The SGIP provides rebates to customers of certain utilities in California that install distributed energy technologies, including ESSs. N.C. Clean Energy Technology Center, DSIRE database (accessed March 5, 2021); EnergySage, "Using the Solar," January 11, 2021; California Public Utilities Commission. "Self-Generation Incentive Program," n.d. (accessed March 5, 2021).

[17] For example, Tesla Powerwall owners in Massachusetts and Rhode Island can allow National Grid to pull electricity from their system during periods of peak demand and are compensated for any electricity that they provide. In one installation in California, ESSs are installed at an apartment complex. In return, residents receive discounts and the ability to access the systems in the event of a power outage. In other instances, customers can pay a utility a monthly fee for their installed ESS and gain the benefits of the system most of the time, with the utility able to pull energy during peak usage periods. S&P Global Market Intelligence, "'The Perfect Place,'" August 28, 2020; Lambert, "Tesla Powerwall Owners," June 21, 2019.

The historical decline in battery prices may underpin the ability of some residential customers to afford energy storage, but ESS prices do not appear to be a major driver of the quarterly rise in installations as prices have fluctuated over the last few years.[18] Tesla, for example, significantly increased Powerwall prices in 2018, lowered prices slightly in mid-2019, and then increased prices in the fall of 2020 and early 2021.[19] WoodMac data indicate that median first quarter installed system prices were flat from the first quarter of 2015 to the first quarter of 2017, dropped slightly in 2018, increased in 2019, and then declined in the first quarter of 2020 and 2021 (figure 3).[20]

Figure 3 Median installed system price (including equipment and installation services), first quarter 2015–21, $/kW



Source: WoodMac data from ESA, "U.S. Energy Storage Monitor," March 17, 2021, 17.
Note: Q=quarter. The exact numbers were not published in this source, so values are not included.

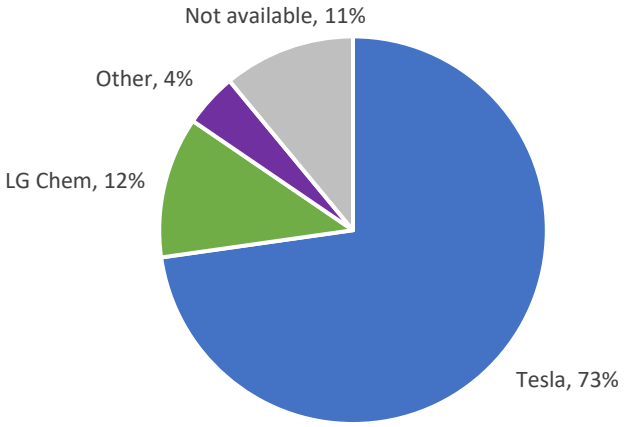
Further, despite the financial benefits to system owners that accrue over time, the up-front cost remains the most significant barrier to the growth of the ESS market. Both a survey of California homeowners with installed PV systems that have not installed an ESS and a survey of solar installers identified cost as the most significant barrier to installing an ESS.[21] Other barriers cited in the surveys include insufficient or confusing government incentives, the lack of available ESS supply (discussed below), a lack of consumer education, consumer safety concerns, aesthetics, available space, and the lack of experience and expertise among ESS installers.[22]

[18] Go Solar California, Self Generation Incentive Program (SGIP) data (accessed April 5, 2021); Pyper, "Tesla Hikes Powerwall," October 12, 2018; Lambert, "Tesla (TSLA) Increases Powerwall," October 1, 2020; Lambert, "Tesla Increases the Price," January 17, 2021.
[19] Pyper, "Tesla Hikes Powerwall," October 12, 2018; Field, "Everything You Need to Know," February 9, 2020; Lambert, "Tesla (TSLA) Increases Powerwall," October 1, 2020; Lambert, "Tesla Increases the Price," January 17, 2021.
[20] WoodMac data from ESA, "U.S. Energy Storage Monitor," March 17, 2021, 17.
[21] Itron, *2019 SGIP Energy Storage*, December 3, 2019, B.2-3, B.2-5–B.2-6; EnergySage, *Solar Installer Survey: 2020 Results*, March 2021, 9.
[22] EnergySage, *Solar Installer Survey: 2020 Results*, March 2021, 9; Itron, *2019 SGIP Energy Storage*, December 3, 2019, B.2-5–B.2-6.

Companies in the U.S. Market

U.S. producer Tesla dominated the residential energy storage market in 2020, based on data from energy storage installations in 20 states and the District of Columbia, even though there were more than 35 companies supplying products to the U.S. market (figure 4).[23] LG Chem (which imports ESSs from Korea) was the second largest supplier.[24] The substantial market share of Tesla reflects a number of factors, including the low cost of the Powerwall, its name recognition and customer preferences for the Powerwall systems, the downstream sales channel via Tesla's in-house installation business, and the large number of installers that carry the Powerwall (figure 5).[25] The product that Tesla sold during most of the time period covered in this paper, its Powerwall 2, also included more advanced features (e.g., a high energy capacity and integrated inverter) than competing products when introduced in 2016, though many competitors have since caught up.[26] LG Chem, like Tesla, benefits from its brand recognition and widespread distribution network, though the share of installers reporting LG Chem as their most requested brand has fallen from 25 percent in 2018 to 10 percent in 2020.[27]

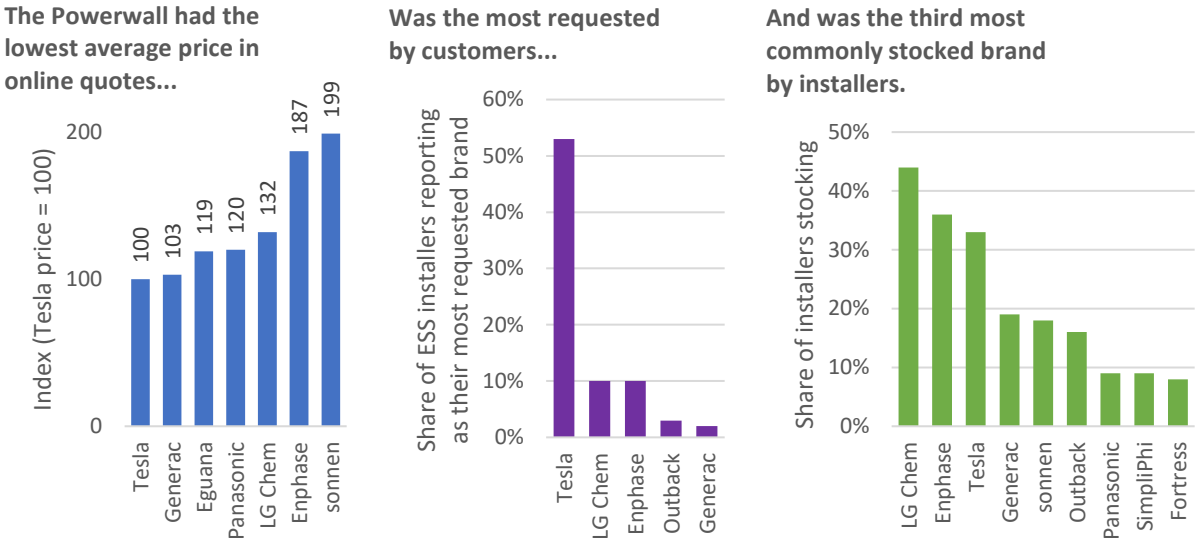
Figure 4 U.S. ESS market share in certain states, by kWh installed, 2020



Sources: Data are compiled from state incentive program data sets and city/county building permit applications. "Not available" are those records for which an equipment provider was not specified and could not be identified. Data are a subset of all installations nationally and are based on states and localities where data were available. The data set totals 263 MWh, and covers all or a portion of installations in 20 states and the District of Columbia. WoodMac estimated that U.S. residential energy storage installations were 540 MWh in 2020, though an exact share of the market is not calculated here due to differences in the data such as when systems are considered installed. California accounted for the largest share of installations in the data set, followed by Hawaii. Underlying data for this figure can be found in appendix A.

[23] This section will discuss the firms competing in the U.S. market, regardless of where the products are produced. The following sections will break out domestic production and imports separately.
[24] Data compiled by USITC staff.
[25] Data compiled by USITC staff; EnergySage, *Solar Installer Survey: 2020 Results*, March 2021, 10; EnergySage, *Solar Installer Survey: 2019 Results*, February 2020, 9; EnergySage, *Solar Installer Survey: 2018 Results*, February 2019, 9; Go Solar California, Self Generation Incentive Program (SGIP) Data (accessed May 14, 2021).
[26] Lambert, "Tesla Powerwall 2 is a Game Changer," October 28, 2016; Lambert, "Tesla Powerwall 2 Has No Competition," October 31, 2016; Spector, "Here's Everything New," November 7, 2014; Muoio, "11 Home Batteries," November 1, 2016.
[27] EnergySage, *Solar Installer Survey: 2020 Results*, March 2021, 10; EnergySage, *Solar Installer Survey: 2018 Results*, February 2019, 9

Figure 5 Competitive position of Tesla in the residential ESS market, select factors, 2020



Sources: EnergySage, *Solar Marketplace Intel Report*, May 2021, 5; EnergySage, *Solar Installer Survey: 2020 Results*, March 2021, 10.
Note: The report does not specify whether price data are for the full year or second half of 2020 and whether the data only include the equipment. Underlying data for this figure can be found in appendix A.

Tesla and LG Chem's residential energy storage businesses both benefit from and are negatively impacted by their role as battery producers for the auto industry as well as suppliers of battery technology for larger ESSs, such as utility and nonresidential systems.[28] Tesla, for example, benefits from the battery supply chain that it has developed primarily for the auto industry, the production of modular components that go into multiple products, its ability to utilize battery technology and technology for ESS components originally developed for the auto sector, and the engineering and technical expertise embedded within the company.[29] However, corporate diversification has not always led to better supply to the U.S. residential energy storage market as companies have, at times, prioritized production for different products or markets. Tesla, for example, has prioritized production for vehicles over ESS production in the past and LG Chem has also been unable to supply U.S. demand for its home ESSs at times due to battery demand in other countries and for other applications.[30]

Tesla and LG Chem have experienced a number of challenges in recent years. Tesla, for example, has a significant backlog of orders for its Powerwall and has struggled to keep up with demand.[31] In April 2021, the firm reported that it had a "a multi-quarter backlog" for the Powerwall and that demand "continues to far exceed our production rate."[32] The firm continued to have a significant backlog as of

[28] Tesla, Form 10-K, February 8, 2021, 5–6; Fortuna, "Tesla's 5 Biggest," July 16, 2020; Spector, "Here's Everything New," November 7, 2016; EnergyTrend, "LG Chem Unveils," July 24, 2020; Sunrun, "Sunrun and LG Chem," October 26, 2016; LG Chem, "Advanced Batteries for Energy Storage," 2018, 2.
[29] Tesla, Form 10-K, February 8, 2021, 5–6; Fortuna, "Tesla's 5 Biggest," July 16, 2020; Spector, "Here's Everything New," November 7, 2016.
[30] Pyper, "Tesla Hikes Powerwall," October 12, 2018; Lambert, "Tesla Powerwall Captures," February 19, 2019; CED Greentech, "The LG Chem RESU10H Shortage," n.d. (accessed April 23, 2021); Merchant, "Tesla Powerwalls," February 20, 2019; Spector, "Will Safer Batteries," February 17, 2021; Eckhouse, "For Now," October 1, 2018.
[31] Pyper, "Tesla Hikes Powerwall," October 12, 2018; Lambert, "Tesla Powerwall Captures," February 19, 2019; Lambert, "Elon Musk: Tesla is Working," August 14, 2020.
[32] Tesla, "Q1 2021 Update," April 26, 2021, 9; Tesla, "Q1 2021 Tesla," April 26, 2021.

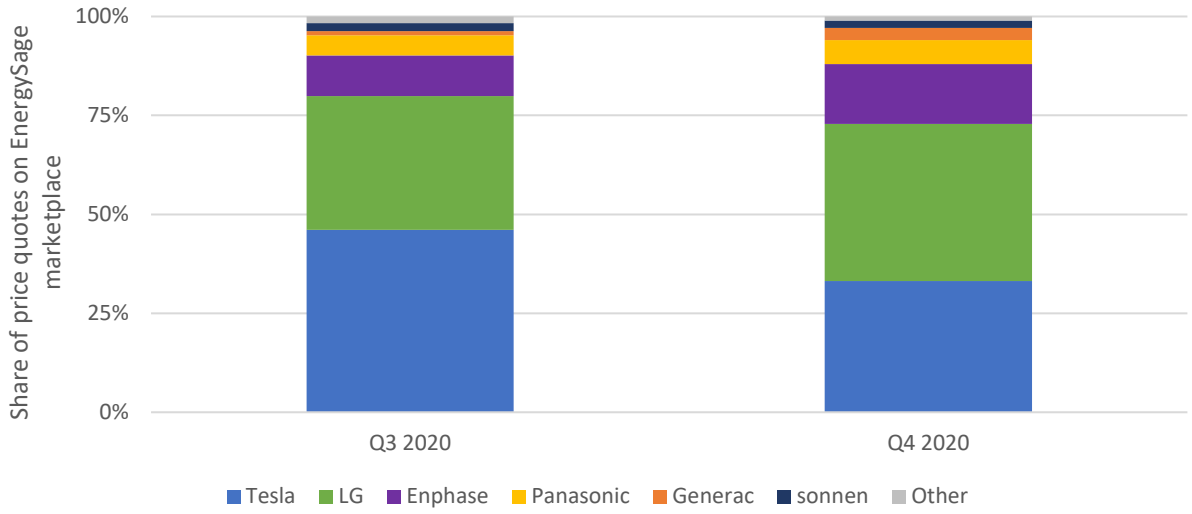
July 2021, with the situation exacerbated by the semiconductor shortage.[33] There have also been shortages of LG Chem's Resu ESS at times.[34] In addition, LG Chem issued a recall in December 2020 for certain ESSs installed during January 2017 to March 2019.[35]

Tesla's current challenge in meeting demand coincides with a period of rising competition in the U.S. market, with large U.S.-based multinationals that provide related products or services entering the market, additional foreign firms starting exports to the United States, and smaller U.S.-based firms developing new products.[36] The large multinationals that entered the industry in 2019–20 bring a number of strengths, such as established distribution and installer networks; existing customer relationships; brand recognition; experience in supply chain management; the financial capability to advertise, increase distribution, and introduce new products; sales of related products with which ESS sales can be paired; and the ability to utilize expertise in other aspects of their business to support the development of differentiated products (such as improved software solutions).[37]

Competition ramped up in the second half of 2020, in particular, when large multinational corporations introduced new products to the market.[38] For example, Enphase—a U.S. headquartered firm that manufactures inverters for PV systems—started large volume U.S. sales of its home ESS (manufactured in China) in July 2020. Enphase sold 56 MWh and generated revenue of more than $40 million in the second half of 2020. By the third quarter of 2021, the firm expects to have 480 MWh of production capacity on an annualized basis.[39] Generac—a U.S. headquartered manufacturer of generators—acquired small ESS firm Pika Energy in 2019, introduced new products in August 2020 (manufactured in Vietnam), and generated 2020 sales of $115 million.[40] The share of installers stocking Pika Energy ESSs in 2018, prior to its acquisition by Generac, totaled only 3 percent of installers. By 2020, 19 percent of installers stocked Generac ESSs.[41] Further, Generac's prices are very close to those of the market leader, Tesla.[42] The increase in competition is reflected in quotes on the online EnergySage marketplace, where the share of quotes including products other than Tesla and LG Chem ESSs increased to more than 25 percent in the fourth quarter of 2020 (figure 6).[43]

[33] Kolodny, "Elon Musk Says," July 13, 2021.
[34] CED Greentech, "The LG Chem RESU10H Shortage," n.d. (accessed April 23, 2021); Tandem Solar Systems, "SMA Sunny Boy," n.d. (accessed April 23, 2021).
[35] CPSC, "LG Energy Solution Michigan Recalls," December 16, 2020
[36] See, for example, Generac, "Generac Acquires Pika Energy," April 29, 2019; NeoVolta, Form 1-K, October 2, 2020, 3; SunPower, "Q3 2020 SunPower," October 28, 2020; Trade Data Services, Import Genius database (accessed April 2021); Enphase, Form 10-K, February 16, 2021, 9.
[37] Generac, "Q4 2020 General Holdings," February 11, 2011; BayWa, "BayWa r.e. Partners with Generac," August 18, 2020; NeoVolta, Form 1-K, October 2, 2020, 8, 13; SunPower, Form 10-K, February 22, 2021, 7; SunPower, "Q3 2020 SunPower," October 28, 2020; SunPower, "Q4 2020 SunPower," February 17, 2021; Field, "Generac Pivots," October 4, 2019; Eguana, Management's Discussion, January 21, 2021, 16–17; Enphase, Form 10-K, February 16, 2021, 8–9; Enphase, "Q3 2020 Enphase," October 27, 2020.
[38] The significant sales by these companies may start to show up more in 2021 installation data, as there is a lag between when an ESS is sold and when it is connected to the grid.
[39] Enphase, "Q4 2020 Enphase," February 9, 2021; Enphase, "Q3 2020 Enphase," October 27, 2020.
[40] Generac, "Q4 2020 General Holdings," February 11, 2011; Generac, "Generac Acquires Pika Energy," April 29, 2019; Bates, "Generac Expands," August 11, 2020.
[41] EnergySage, *Solar Installer Survey: 2020 Results*, March 2021, 10; EnergySage, *Solar Installer Survey: 2018 Results*, February 2019, 9.
[42] EnergySage, *Solar Marketplace Intel Report*, May 2021, 5.
[43] EnergySage, *Solar Marketplace Intel Report*, May 2021, 5.

Figure 6 Share of price quotes on the EnergySage online marketplace, Q3–Q4 2020



Source: EnergySage, *Solar Marketplace Intel Report*, May 2021, 5.
Notes: Q3=third quarter; Q4=fourth quarter. These are price quotes on the EnergySage online marketplace and provide some indication of the frequency with which installers are offering these products for sale. However, they do not necessarily reflect sales of products as most customers request multiple quotes. Exact shares were not published in this report and, therefore, are not include in the figure.

Domestic Industry and Supply Chain

Domestic Industry

There are at least 8 companies that assemble ESSs in the United States, with most headquartered in California (table 1). Most of the U.S. manufacturers of ESSs are small and medium-sized enterprises (SMEs), though a majority of production takes place at Tesla's plant in Nevada. The U.S. industry produces a range of product sizes, and ESSs using both NMC and LFP batteries. U.S. manufacturers supply a majority of the domestic ESS market, largely due to the large market share of Tesla (figure 7).[44]

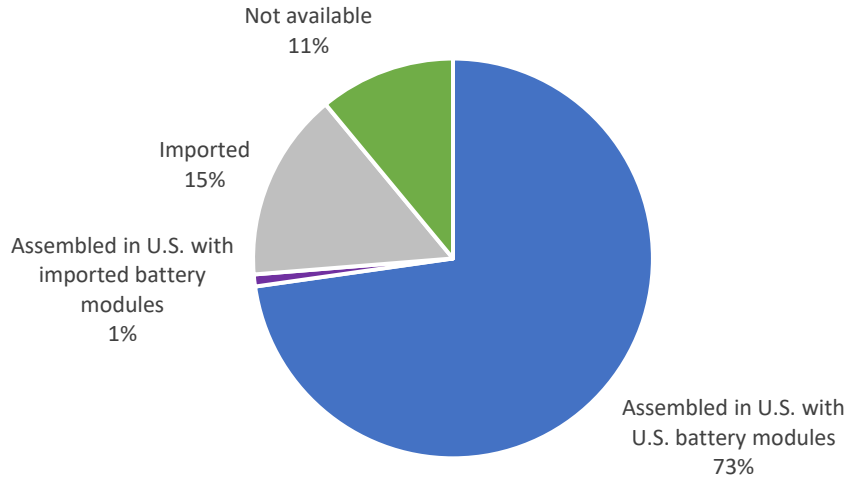
[44] Based on information compiled by USITC staff.

Table 1 Examples of firms that assemble ESSs in the United States and their supply chain, May 2020

Company	Headquarters	Product name	ESS sizes in kWh	Assembly location	Identified battery module source in 2020–21	Company employees	Revenue from ESS, in million $ (year)
Blue Planet Energy	Hawaii	Blue Ion	8–16	Hawaii	China	≤50	NA
Electriq Power	California	PowerPod, PowerPod 2	10–20	California	China	≤50	NA
NeoVolta	California	NV14, NV24	14.4–24	California (contracted)	China	5	4 (2020)
Paladin Power	California	Stackbatt	7 and up	NA	NA	≤10	NA
Simpliphi Power	California	AccESS, ExprESS	7.6–22.8 (systems)	California	China	≤200	>20 (projected 2019)
sonnen	Germany	ECO, ECOLINX, sonnenCore	5–30	Georgia	China	>300 (40 U.S.)	NA
SunPower	California	SunVault	13–26	NA	China	2,200 (1,300 U.S.)	$100 (projected 2021)
Tesla	California	Powerwall	13.5	Nevada	United States	70,757	NA

Source: Compiled by USITC staff.
Notes: NA=not available. sonnen has its headquarters in Germany, and is a subsidiary of European firm Royal Dutch Shell. The list of battery module sources is not exhaustive, and it is possible some firms have more sources than listed here. Company employment is all employees at the company, and is not specific to ESS production. NeoVolta employment includes contractors. Tesla also produces ESS components at its factory in New York.

Figure 7 Share of U.S. ESS installations accounted for by domestic production in certain states, by kWh installed, 2020



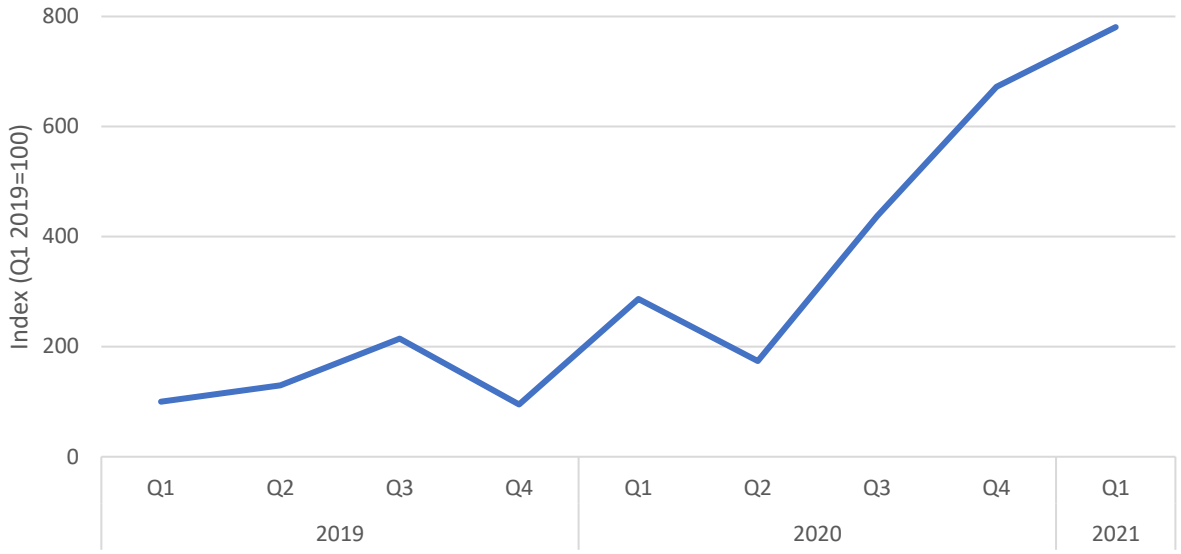
Sources: Data are compiled from state incentive program data sets and city/county building permit applications. "Not available" are those records for which an equipment provider was not specified and could not be identified. Data are a subset of all installations nationally and are based on states and localities where data were available. The data set totals 263 MWh, and covers all or a portion of installations in 20 states and the District of Columbia. WoodMac estimated that U.S. residential energy storage installations were 540 MWh in 2020, though an exact share of the market is not calculated here due to differences in the data such as when systems are considered installed. California accounted for the largest share of installations in the data set, followed by Hawaii. Underlying data for this figure can be found in appendix A.

Tesla, the largest U.S. producer, has substantially ramped up U.S. Powerwall production. Tesla reported that cumulative Powerwall installations increased from 100,000 in the first quarter of 2020 to 200,000 by the end of May 2021. This implies Powerwall production of around 1.4 gigawatt-hours (GWh), with a sales value of about $700 million (before associated equipment and services) during this time period.[45] Given the size of the U.S. market, it also indicates that Tesla was a significant exporter in 2020.[46] Tesla's production in the third quarter of 2021 is projected to be 30,000 to 35,000 units.[47]

Smaller U.S. companies have significantly increased their ESS production in the last few years.[48] U.S. imports of batteries by select ESS manufacturers, which serve as a proxy for non-Tesla U.S. production of ESSs as these firms do not have internal battery production, increased by almost 700 percent from the first quarter of 2019 to the first quarter of 2021 (figure 8).[49] The rapid increase in U.S. production and sales is also reflected in firm revenue. For example, Blue Planet Energy's revenue increased by more than 1,500 percent from 2016 to 2019.[50] NeoVolta's revenue increased from $0.8 million in the second half of 2019 to $2.5 million in the second half of 2020.[51] SimpliPhi Power's revenue doubled or tripled in some years, and the firm projected more than $20 million in revenue in 2019.[52] SunPower is targeting $100 million in ESS revenue in 2021.[53]

[45] Tesla reported energy generation and storage revenue, which includes revenue from Powerwalls and other products and services, of $2.0 billion in 2020. This includes energy generation and storage sales of $1.5 billion in 2020, and revenue from energy generation and storage leasing of $517 million. The segment reported a gross profit of $18 million. The firm reports that it has "good margins" on Powerwall sales. Tesla, Form 10-K, February 8, 2021, 55, 61, 105; Field, "Everything You Need to Know," February 9, 2020; Lambert, "Tesla (TSLA) Increases Powerwall," October 1, 2020; Lambert, "Tesla Increases the Price," January 17, 2021; Tesla, "Q1 2020 Update," April 29, 2020, 9; Tesla, "Q1 2021 Tesla," April 26, 2021; Lambert, "Tesla Has Doubled," May 26, 2021.
[46] Official U.S. export statistics are not specific to residential ESSs, so the value of U.S. exports is not available.
[47] Kolodny, "Elon Musk Says," July 13, 2021.
[48] Data compiled by USITC staff; Trade Data Services, Import Genius database (accessed April 2021); Inc., "Annual Inc5000 2020," August 11, 2020; NeoVolta, Form 1-SA, March 17, 2021, 7; Leiber, "Building a Lithium-ion Battery," November 15, 2019; SimpliPhi Power, "Energy Storage Provider," January 11, 2017.
[49] Trade Data Services, Import Genius database (accessed April 2021).
[50] Inc., "Annual Inc5000 2020," August 11, 2020.
[51] NeoVolta, Form 1-SA, March 17, 2021, 7.
[52] Leiber, "Building a Lithium-ion Battery," November 15, 2019; SimpliPhi Power, "Energy Storage Provider," January 11, 2017.
[53] SunPower, "Q3 2020 SunPower," October 28, 2020.

Figure 8 Quantity of identified U.S. imports of battery modules for ESSs, index, Q1 2019–Q1 2021



Source: Trade Data Services, Import Genius database (accessed April 2021).
Note: Based on quantity (by weight) of imports. These data are based on companies supplying systems for residential installations, though they also include some batteries for nonresidential installations as some companies supply both market segments. The data are only for battery imports that could be specifically identified as being used in domestic ESS assembly.

Supply Chain

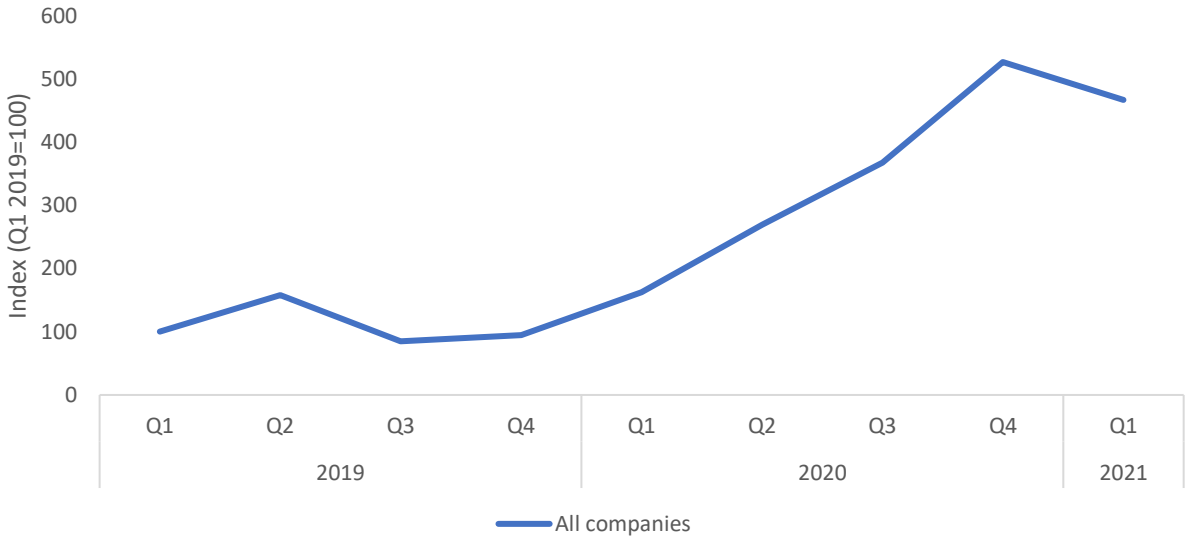
Tesla has used both domestically produced and imported cells in modules for its Powerwall, with the modules for its Powerwalls produced domestically.[54] Tesla also produces some ESS components, such as inverters, at its plant in New York.[55] The other U.S. firms that assemble ESSs mostly rely on imports of batteries from China (see table 1).[56] These imports, as noted above, increased almost 700 percent from the first quarter of 2019 to the first quarter of 2021.[57] Battery suppliers in China include a mix of Chinese firms (e.g., Poweramp Technology) and subsidiaries of multinational companies (e.g., Japan-headquartered Murata Manufacturing).[58] China is also a major supplier of other components of ESSs, such as the metal cabinets that house the batteries and inverters. Other suppliers of components include Germany, Japan, and South Korea.[59]

[54] Huang, "Bye-Bye Panasonic?" June 27, 2019; Tesla, Form 10-K, February 8, 2021, 8; Tesla, "Battery Cell Production," January 4, 2017; Lambert, "Tesla to Supply," March 28, 2018
[55] Tesla, Form 10-K, February 8, 2021, 8; Robinson, "Tesla's Buffalo Plant," November 8, 2019.
[56] U.S. battery imports from China are subject to a 3.4 percent normal trade relations rate of duty and 7.5 percent Section 301 rate of duty. Trade Data Services, Import Genius database (accessed April 2021); NeoVolta, Form 1-K, October 2, 2020, 13–14; USITC, Harmonized Tariff Schedule of the United States, Revision 3, 2021.
[57] Trade Data Services, Import Genius database (accessed April 2021).
[58] Trade Data Services, Import Genius database (accessed April 2021).
[59] This is not a comprehensive list of all countries that provide components. Trade Data Services, Import Genius database (accessed April 2021); NeoVolta, Form 1-K, October 2, 2020, 14.

U.S. Imports[60]

The volume of U.S. ESS imports by all companies (including LG Chem) substantially increased from the start of 2019. Complete ESS imports increased by more than 400 percent from the first quarter of 2019 to the fourth quarter of 2020 (figure 9). Imports then declined in the first quarter of 2021, though imports were up almost 200 percent compared with the first quarter of 2020. U.S. imports excluding LG Chem increased at a much faster rate, reflecting the large number of new entrants with rapid sales growth, as discussed above.[61]

Figure 9 Identified U.S. imports of ESSs, index, Q1 2019–Q1 2021

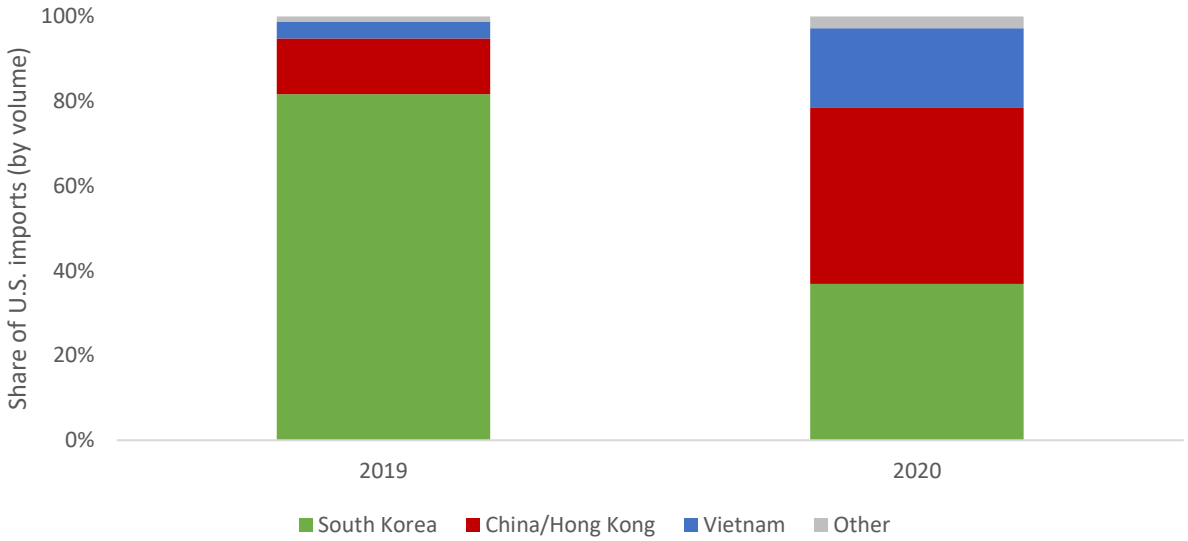


Source: Trade Data Information Services, Import Genius database (accessed April 2021).
Note: Based on quantity (by weight) of imports. The data are for 24 companies that sell ESSs in the United States. These data are based on companies supplying systems for residential installations, though they also include some ESSs for nonresidential installations as some companies supply both market segments.

U.S. imports of ESSs in 2019 were primarily shipped from South Korea and, to a lesser extent, China and Vietnam (figure 10). In 2020, however, the share of imports accounted for by China and Vietnam substantially increased. This reflect, in part, growing sales by U.S.-based multinationals such as Generac (production in Vietnam) and Enphase (production in China), which contract with companies in Asia to produce their products. A number of smaller U.S.-based companies also increased their imports from China. Further, some Chinese companies and other foreign multinationals with production in China increased sales of their own product brands in the U.S. market in 2020. U.S. imports include both NMC and LFP batteries.[62]

[60] Official U.S. import statistics are not specific to residential ESS, so this section will rely on imports identified in shipping manifest data.
[61] Trade Data Information Services, Import Genius database (accessed April 2021).
[62] These data are based on shipping manifest information, and the country from which the products are shipped may differ from the country of origin in official import statistics. Trade Data Information Services, Import Genius database (accessed April 2021); Field, "Generac Pivots," October 4, 2019; Enphase, Form 10-K, February 16, 2021, 10.

Figure 10 Source of identified U.S. imports of ESSs, by volume, 2019–20



Source: Trade Data Information Services, Import Genius database (accessed April 2021).
Note: Based on quantity (by weight) of imports. The data are for 24 companies that sell ESSs in the United States. These data are based on companies supplying systems for residential installations, though they also include some ESSs for nonresidential installations as many companies supply both market segments. These data are based on shipping manifest information, and the country from which the products are shipped may differ from the country of origin in official import statistics.

Conclusion

The U.S. market for residential ESSs substantially increased during 2017–20, driving growth in both U.S. manufacturing and imports. The market was dominated by Tesla in 2020 and, as a result, domestic production supplied most of the market. Smaller U.S. producers are also benefiting from the market growth, and substantially increased production and sales in the last few years. There have been a large number of new entrants to the market in the last few years, however, some of which have a number of competitive advantages that enabled them to quickly gain U.S. sales in the second half of 2020. As a result, U.S. imports rapidly increased in 2020, with an increasing share of products assembled in low labor cost locations such as China and Vietnam. It is likely that these imported products will have an increased presence in the U.S. market going forward, given their rapid market penetration in 2020.

The results of this analysis provide a picture of the residential market, but do not provide insights into competition, production, and trade for the nonresidential and utility markets. These market segments utilize both the lithium ion technologies as well as a range of other energy storage technologies. Further, though there is some overlap, not all of the companies participating in these markets are the same as the firms participating in the residential market. A comprehensive analysis of these market segments would provide further insights into the U.S. energy storage market and U.S. trade.

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Appendix A: Data Tables for Figures

Table A.1 U.S. ESS market share in certain states, by kWh installed, 2020

Company	2020
Tesla	73%
LG Chem	12%
Other	4%
Not available	11%

Source: Data are compiled from state incentive program data sets and city/county building permit applications. "Not available" are those records for which an equipment provider was not specified and could not be identified. Data are a subset of all installations nationally and are based on states and localities where data were available. The data set totals 263 MWh, and covers all or a portion of installations in 20 states and the District of Columbia. WoodMac estimated that U.S. residential energy storage installations were 540 MWh in 2020, though an exact share of the market is not calculated here due to differences in the data such as when systems are considered installed. California accounted for the largest share of installations in the data set, followed by Hawaii.
Note: Corresponds to figure 4.

Table A.2 Average price on online EnergySage marketplace, index, Tesla price=100, 2020

Company	Price index
Tesla	100
Generac	103
Eguana	119
Panasonic	120
LG Chem	132
Enphase	187
sonnen	199

Source: EnergySage, *Solar Marketplace Intel Report*, May 2021, 5.
Note: The report does not specify whether price data are for the full year or second half of 2020 and whether the data only include the equipment. Corresponds to figure 5.

Table A.3 Share of ESS installers reporting as their most requested brand, 2020

Company	2020
Tesla	53%
LG Chem	10%
Enphase	10%
Outback	3%
Generac	2%

Source: EnergySage, *Solar Installer Survey: 2020 Results*, March 2021, 10.
Note: Corresponds to figure 5.

Table A.4 Share of installers stocking each brand, 2020

Company	2020
LG Chem	44%
Enphase	36%
Tesla	33%
Generac	19%
sonnen	18%
Outback	16%
Panasonic	9%
SimpliPhi	9%
Fortress	8%

Source: EnergySage, *Solar Installer Survey: 2020 Results*, March 2021, 10.
Note: Corresponds to figure 5.

Table A.5 Share of U.S. ESS installations accounted for by domestic production in certain states, by kWh installed, 2020

Source	2020
Assembled in U.S. with U.S. battery modules	73%
Assembled in U.S. with imported battery modules	1%
Imported	15%
Not available	11%

Source: Data are compiled from state incentive program data sets and city/county building permit applications. "Not available" are those records for which an equipment provider was not specified and could not be identified. Data are a subset of all installations nationally and are based on states and localities where data were available. The data set totals 263 MWh, and covers all or a portion of installations in 20 states and the District of Columbia. WoodMac estimated that U.S. residential energy storage installations were 540 MWh in 2020, though an exact share of the market is not calculated here due to differences in the data such as when systems are considered installed. California accounted for the largest share of installations in the data set, followed by Hawaii.
Note: Corresponds to figure 7.