FROST & SULLIVAN

Market Engineering

Outlook for the Global Energy Storage Industry, 2020

The United States and China Continue to be the Key Energy Storage Markets, Supported by Strong Regulations, Legislative Policies, and Incentives

Global Energy & Environment Research Team at Frost & Sullivan

MEEC-14

January 2020

Contents

Contents (continued)

Contents (continued)

Contents (continued)

Contents (continued)

Author: Jonathan Robinson

Executive Summary

Return to contents

Energy Storage Market Predictions for 2020

Residential energy storage system (ESS) and molten salt thermal storage will record strong growth.

Strong global growth in capacity forecast with a large volume of projects on-going

Thermal storage the leading alternative storage technology

Li-ion will remain dominant, with notable growth expected for flow batteries

Government incentives and supportive regulations key to market growth

Storage + renewable + EVs key to attractiveness of home storage proposition

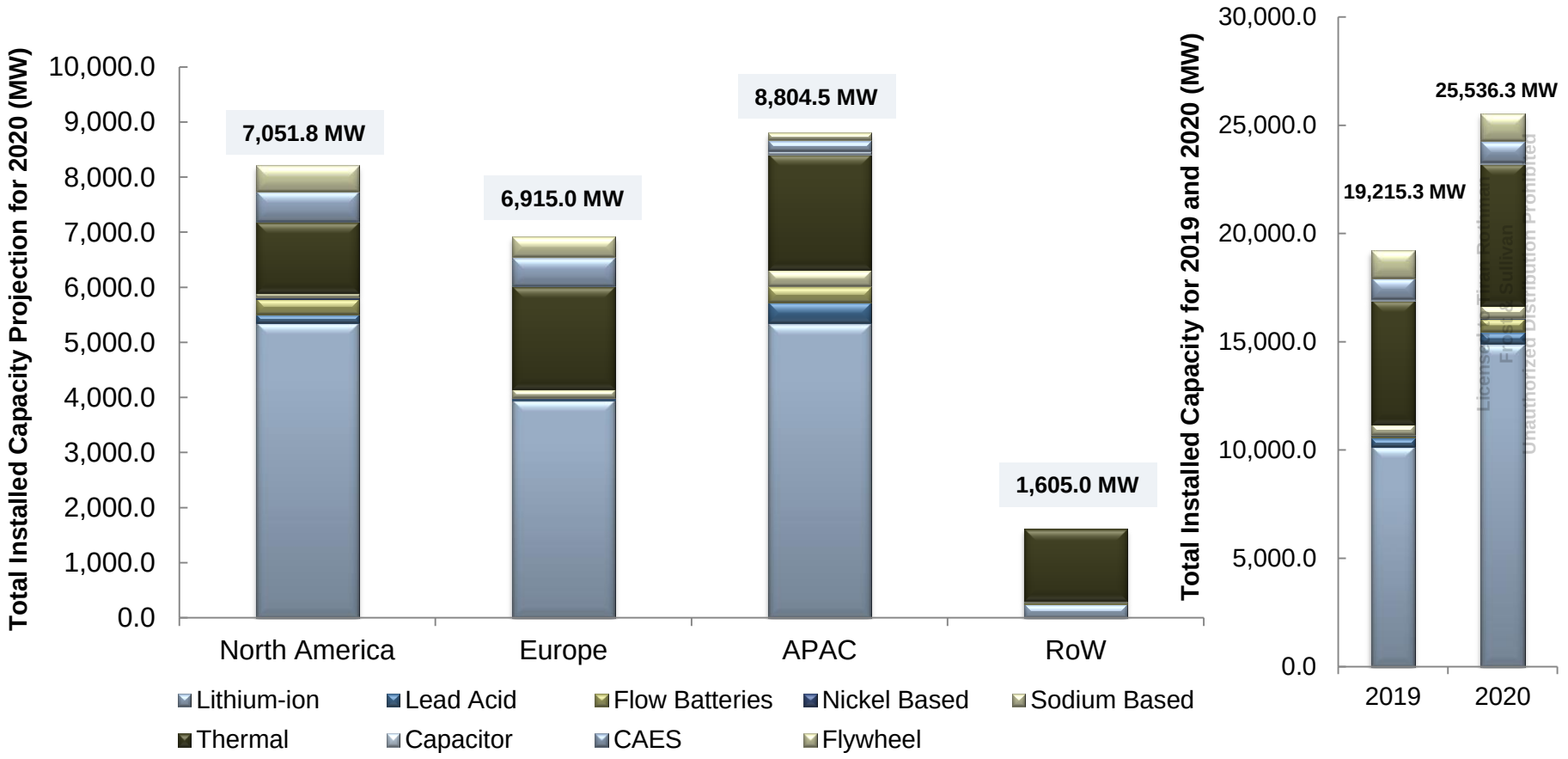
Strong partnership with Integrators will be winning formula for battery OEMs

Source Images: Wikipedia. Source: Frost & Sullivan

Global Energy Storage Technologies Forecast for 2020

4.94 GW of storage capacity to be added globally in 2020, as the installed base crosses 20 GW.

Energy Storage Outlook: ESS Installed Capacity by Technology and Region, Global, 2020



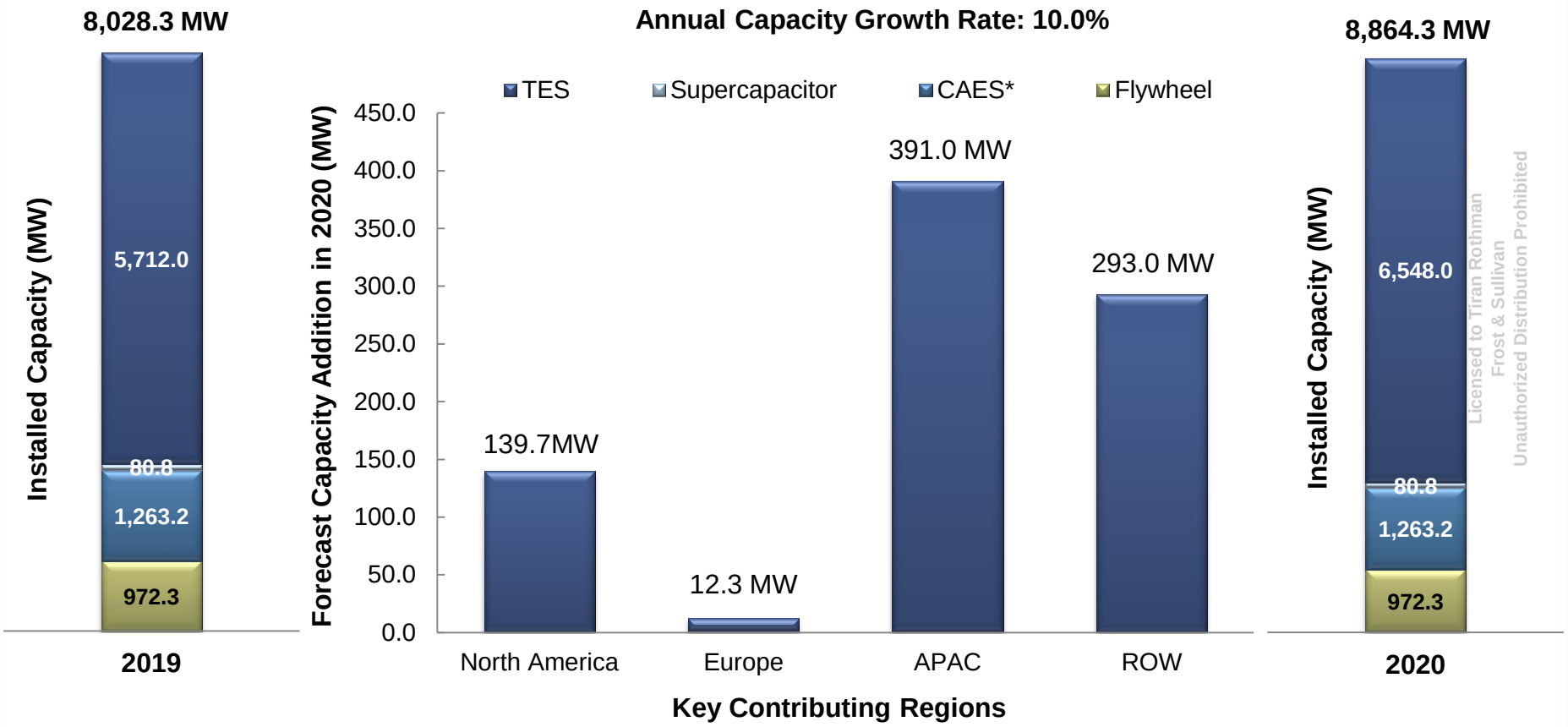
RoW = Rest of World

Note: All figures are rounded. The base year is 2019. Source: Frost & Sullivan

Global Alternative Energy Storage Technologies Forecast for 2020

Installed capacity will reach 8.86 GW in 2020, at an annual growth rate of 10.0%.

Energy Storage Outlook: Alternative ESS Technology Installed Capacity, Global, 2019 and 2020



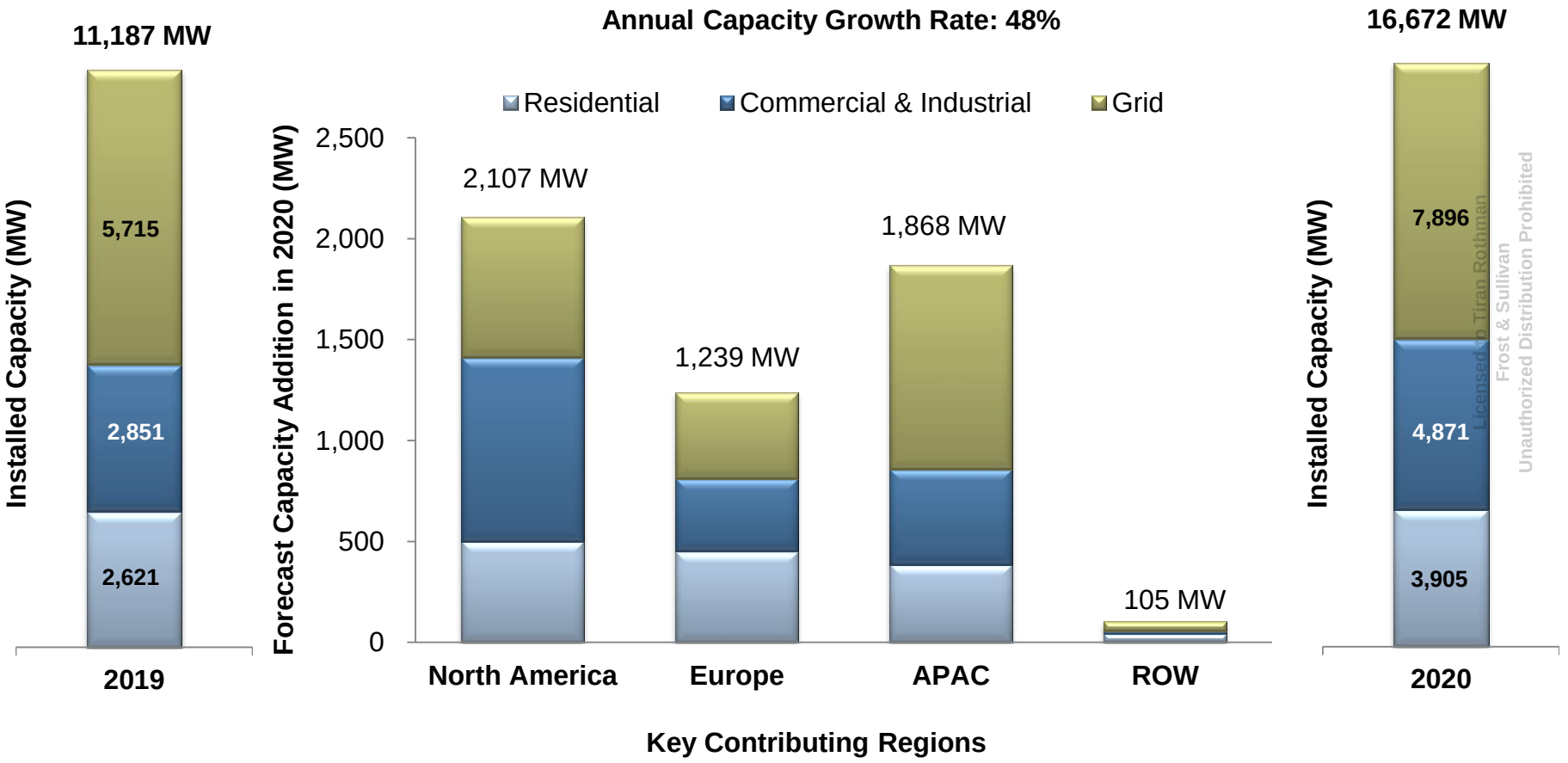
*CAES projects indicated here are contracted and announced, and the commissioning date is not yet finalized.
Thermal energy values are related to grid-connected capacity.

Source: DOE Global Energy Storage Database; Frost & Sullivan

Global Battery Energy Storage Technologies Forecast for 2020

Installed capacity will reach 11.3GW in 2020, an increase of 4.1GW on 2019.

Energy Storage Outlook: Battery Technology Installed Capacity, Global, 2019 and 2020



Source: DOE Global Energy Storage Database; Frost & Sullivan

Research Scope and Segmentation

Return to contents

Research Scope

Base Year	2019
Forecast Period	2020
Industry Area	Energy Storage • BESS (lead acid, Li-ion, sodium based, nickel based, and flow batteries) • Alternative energy storage technologies (including Thermal Energy Storage, Compressed Air Energy Storage, Supercapacitor and Flywheel Storage) Pumped hydro energy storage, the largest grid storage technology, is not covered in this outlook study because it is a mature technology with limited major developments.
Geographical Scope	Global

Source: Frost & Sullivan

Market Definition and Segmentation

Segment	Sub-segment Type	Definition
Mechanical	CAES	This technology is mature, with growth expected only in its advanced form called advanced-adiabatic compressed air energy storage (AA-CAES). Air is compressed and stored in underground storage cells and released into the turbine during peak hours to meet demand. The requirement for suitable geographic locations for implementing CAES limits the long-term growth of this market.
	Flywheel energy storage	This sub-segment stores energy from wind or solar energy in the form of rotational kinetic energy in a vacuum cistern and releases the energy when needed.
Electrical	Supercapacitor	These capacitors have high power density. Renewable energy is stored as static electricity in these capacitors.
TES	Hot water storage	This TES uses molten salt energy storage technology. The high temperature in the molten salt is converted to electricity through a conventional thermal power plant.
	Ice storage	Ice storage is a method of TES that freezes water and stores it at low temperatures.
	Chilled water storage	Water is cooled and stored at night when electricity is cheaper and used during the day for air conditioning.
	Molten salt	This method of TES is used to retain heat energy from concentrated solar power (CSP) plants to generate electricity at night or during bad weather.
Electro-chemical	BESS	BESS utilizes electrochemical potential energy stored in electrodes and electrolytes and allows for rapid charging and discharging of energy. Types of BESS covered in the study are lead acid, Li-ion, sodium based, nickel based, and flow batteries.

Note: Thermal is the most prominent among alternative technologies and so other technologies are not mentioned

Source: Frost & Sullivan

2020 Industry Outlook—Alternative Energy Storage Technologies: Market Overview

Return to contents

Key Alternative ESS Market Predictions for 2020

Molten salt thermal storage will emerge as a dominant technology in 2020.

Thermal storage to be the most promising alternative storage technology, particularly molten salt and ice thermal

TES is penetrating into industrial applications after successful integration with CSP renewable installations in 2018–19

Levels of R&D investment for alternative storage technologies continue to rise as investors look for alternatives to batteries

Sodium Sulphur gains momentum and moves beyond Japan as the world's largest plant (108MW) was installed in Abu Dhabi in 2019

Surge for supercapacitors expected as Tesla's acquisition of Maxwell Technologies boosts interest in the technology

Government policies and mandates continue to be a key influencer on growth

Source Images: Wikipedia. Source: Frost & Sullivan

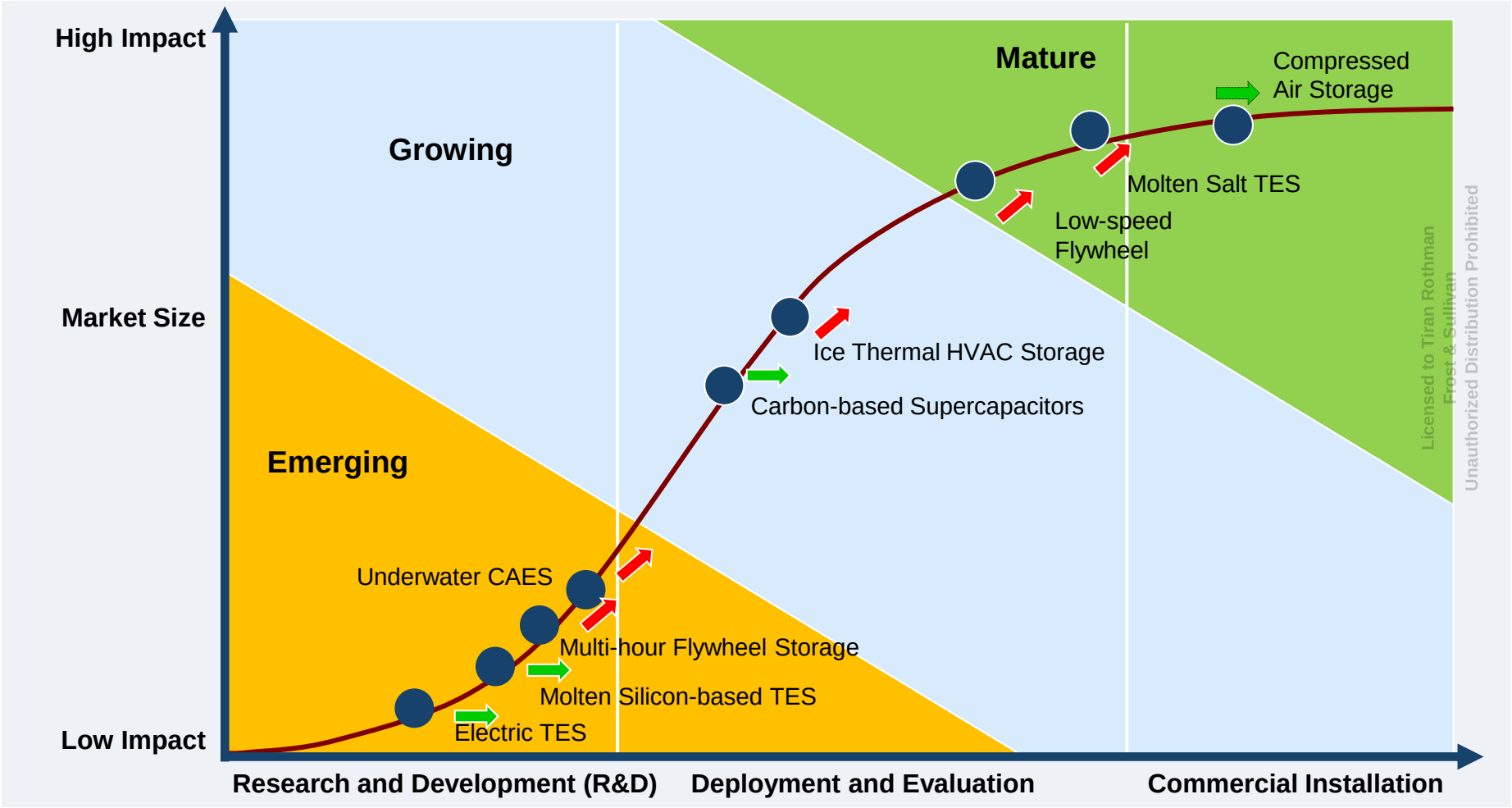
Alternative Energy Storage Technologies—Technology Trends

Return to contents

Alternative Energy Storage Technologies Lifecycle

Ice thermal storage for heating, ventilation, and air conditioning (HVAC), electric thermal storage and multi-hour flywheel storage applications are the key alternative solutions that should gain momentum in 2020.

Energy Storage Outlook: Technology Lifecycle, Global, 2020



Source: Frost & Sullivan

Key Alternative Storage Technology Trends and Market Watch for 2020

Thermal energy storage (TES) has come a long way with multiple types of storage and growing installations.

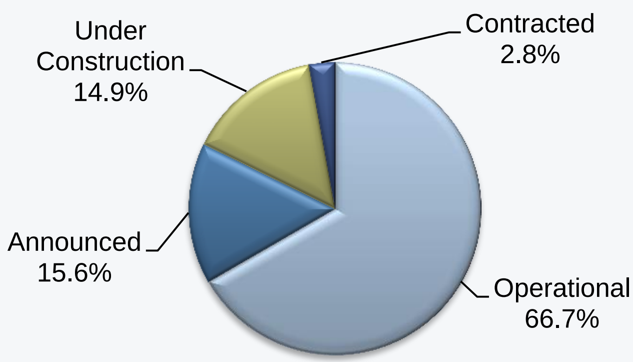
TES	TES was once restricted to molten salt storage, but now has grown significantly and is gaining interest globally. Other technologies including cryogenic storage, solar energy storage, hot silicon, and pumped-heat storage will attract further interest and investment in 2020. The technology that was once limited to Europe is now spread across the United States, China, Middle East and Africa. The launch of a containerized, module-based TES by Climate Change Technologies based in Australia is a big breakthrough that could enable TES to operate in the industrial and residential storage too. These activities prove TES to be the most prominent ESS among all other alternative storage solutions.
Flywheel Energy Storage	Flywheel storage has not witnessed major project installations in 2019. Yet, it is used along with a battery energy storage system (BESS) or ultracapacitor or other forms of storage. However, large-scale installations are unlikely till 2020. Some major participants including Beacon Power, Siemens, and EnSync Energy are all involved in backup power based systems, and an exclusive energy storage provider is not seen in this market. This trend is likely to continue in 2020 as well.
Supercapacitor	The biggest impact supercapacitors are expected to have is in high-power applications with short bursts of energy such as the automotive electrification and backup power applications. Augmented Optics Ltd has come up with groundbreaking research on supercapacitor polymer material which increases the power density by 1000-10,000 times than the existing ultracapacitor. This breakthrough technology, when commercialized, is expected to be a feasible solution for transportation, grid storage, and consumer electronics. Superconducting Magnetic Energy Storage (SMES) is another area keenly researched in Spain and Italy for feasibility in grid storage applications. However, this technology is in research and is unlikely to gain momentum till 2020.
CAES	Canadian start-up Hydrostor has introduced the advanced compressed air energy storage (A-CAES) known as Terra which can be installed at any location in the vicinity of a water body, eliminating the requirement of a suitable geologic site. The off-peak electricity is compressed and stored in specially designed tanks. When electricity is required, the extra pressure is released to turn the turbine. The company claims a record lowest installed cost/kWh available for bulk energy storage.

Source: Hydrostor; Frost & Sullivan

TES Technology

Low pricing of solar CSP with TES, ranging at under 5 cents/kWh in Chile, followed by the influx of projects in China, Middle East, and Africa is making TES attractive.

Energy Storage Outlook: TES Capacity Addition Status, Global, 2020

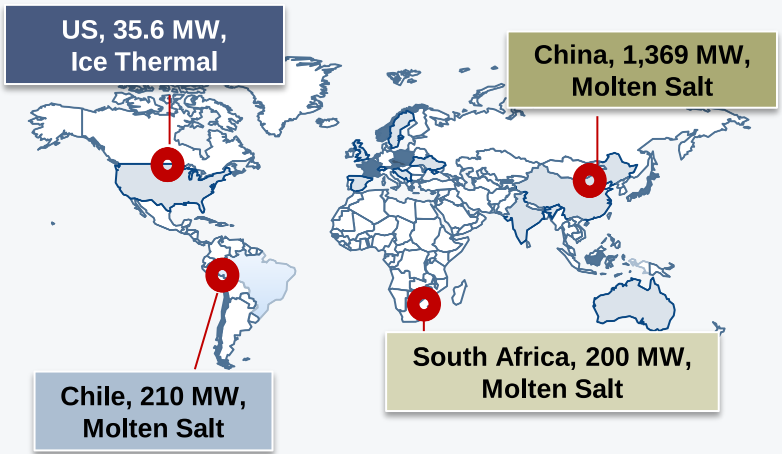


Total TES Capacity, Proposed and Operational (2019): 5,712.0 MW

Market Discussion

- TES is the most widely used among alternative energy storage technologies with the highest installed capacity.
- Globally, 5.7 GW was operational as of the end of 2019. Spain is an important market in Europe, while Chile, South Africa, and Israel have significantly high installed capacities.
- 2020 will see the development of nearly 1.1 GW of installed capacity with key contributions from South Africa, India and China. China, in particular, is keen to increase TES installations and has ongoing projects that will help it reach 1,369 MW by 2020.
- Chile, the United States, India and China are forecast to be attractive markets in the next few years.

Energy Storage Outlook: Ongoing TES Projects, Global, 2020



Technology Trends

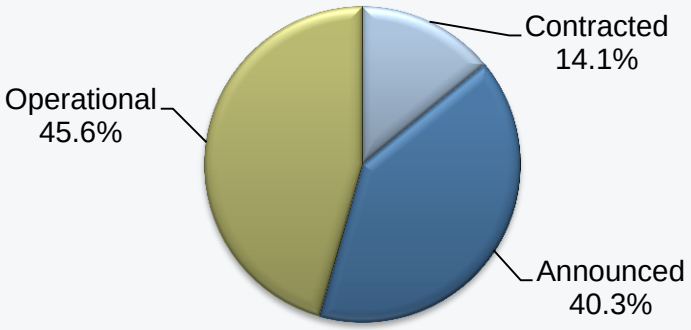
- Molten salt thermal storage has been the prevailing storage technology, with its levelized cost of electricity (LCOE) falling under $0.05/kWh for a PV based storage; the long cycle life of 30 years makes it more attractive than BESS. It is also proving to be enticing for bulk energy storage as seen with the Crescent Dunes project in the United States with 10 hours of storage.
- An Australian venture, Climate Change Technologies (CCT) has launched a Thermal Energy Device that is the first modular TES solution, which could store any kind of electricity – be it solar, wind or fossil-fuel generated. This offers one module storage at a capacity of 1.2MWh in a 6-meter container.

Source: DOE Global Energy Storage Database; Frost & Sullivan

CAES Technology

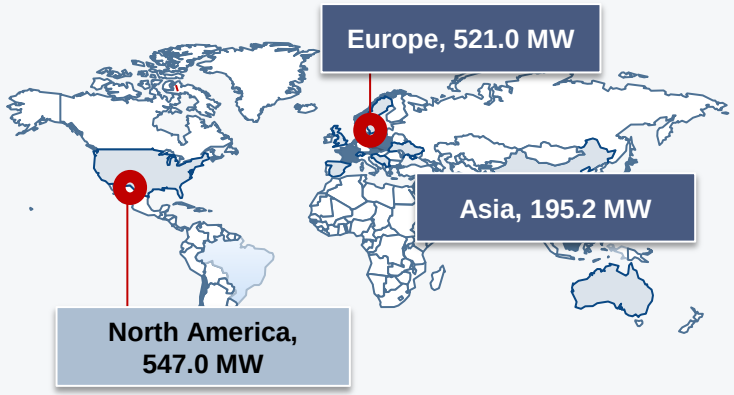
CAES technology will be driven by innovative technological advancements such as underwater CAES. As it takes years to complete a project, not many installations will come up in 2 years.

Energy Storage Outlook: CAES Capacity Addition Status, Global, 2020



Total CAES Capacity (Proposed and Operational) (2019): 1,263.2 MW

Energy Storage Outlook: CAES Installed Capacity by Region, Global, 2020



Market Discussion

- CAES is a mature technology with a fast response, high-economic performance, and a low environmental impact. Grid storage is the key application for CAES.
- In 2017, 330 MW of CAES generation capacity was commissioned by Gaelectric in Northern Ireland to power more than 200,000 homes.
- The 317MW CAES capacity at Apex's Bethel Energy Center in Texas is likely to be operational in 2020.

Technology Trends

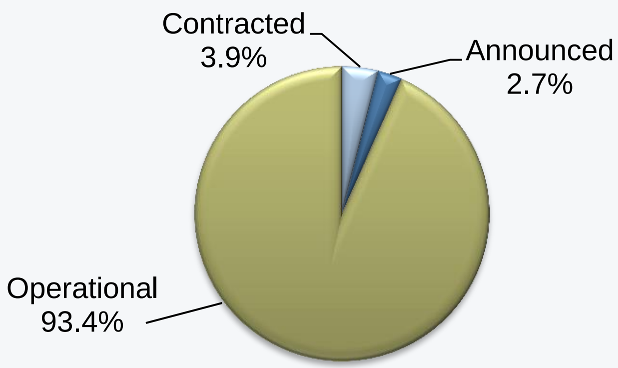
- The underwater compressed air storage method has been successfully tested by Canadian start-up Hydrostor in Toronto. Air balloons are filled with pressurized air and located on the ocean floor. When electricity is revoked, the system operates reversely, and the water weight pushes air back to land to convert back to energy. This technique can be used for peak demand shifting. The company has also launched a storage system called "Terra" which can store compressed air in underground caverns.
- APEX CAES, the new entrant in the space, backed by Siemens has bagged a 317 MW CAES project in Texas which is expected to be completed in 2020.

Source: DOE Global Energy Storage Database; Frost & Sullivan

Flywheel Energy Storage Technology

Innovations in flywheel technologies to increase the storage capacity will decide the adoption of Flywheel storage.

Energy Storage Outlook: Flywheel Capacity Addition Status, Global, 2020

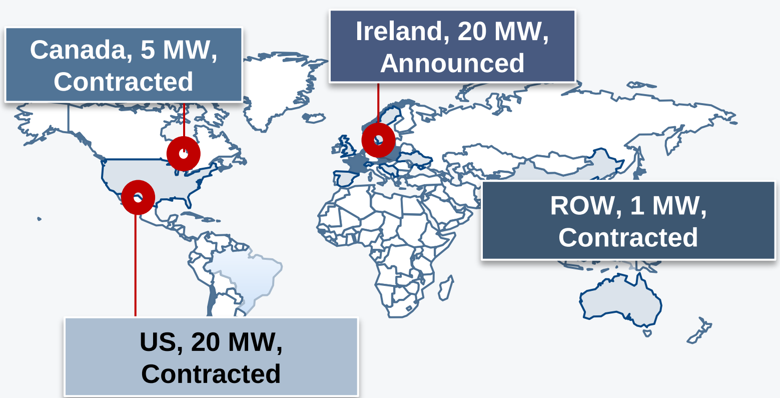


Total Flywheel Capacity (2019): 972.3 MW

Market Discussion

- Major countries contributing to the growth are Canada, Ireland, the United States, and the United Kingdom.
- Schwungrad is testing a 4x 150KW flywheel system for grid stabilization, while it is involved in deploying 20MW of storage across Ireland.
- Flywheel system is deployed for short-term storage and is used in applications such as energy time shifting, renewable firming, and peak shaving in a grid connected network.
- One flywheel system of 20MW capacity is likely to be operational at the Nuevo Storage farm, California in 2020.

Energy Storage Outlook: Flywheel Energy Storage – Ongoing Projects by Region, Global, 2019



Technology Trends

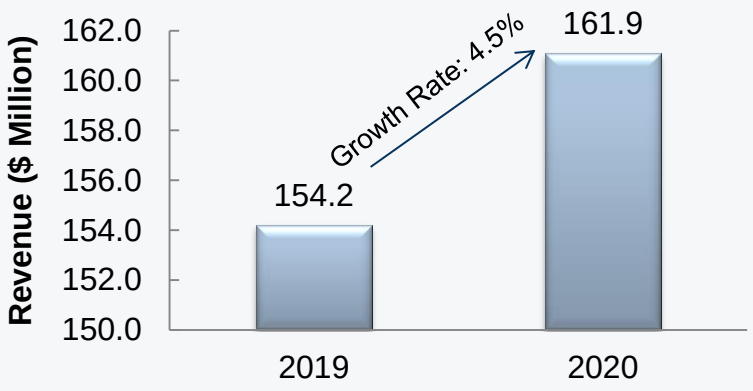
- Traditionally, flywheels have been deployed for short durations when short bursts of energy were required. Participants such as Amber Kinetics, and Vycon, as well as upcoming companies such as Kubotek and Omnes Energy are all involved in making flywheel an integral energy storage technology.
- Intensive R&D is being pursued to extend flywheel applications to transportation industries. Vycon has successfully demonstrated the Flywheel ESS in Los Angeles Metro to recover 60% of energy from regenerative braking. The rail transit energy storage can potentially reduce electricity consumption.

Source: DOE Global Energy Storage Database; Frost & Sullivan

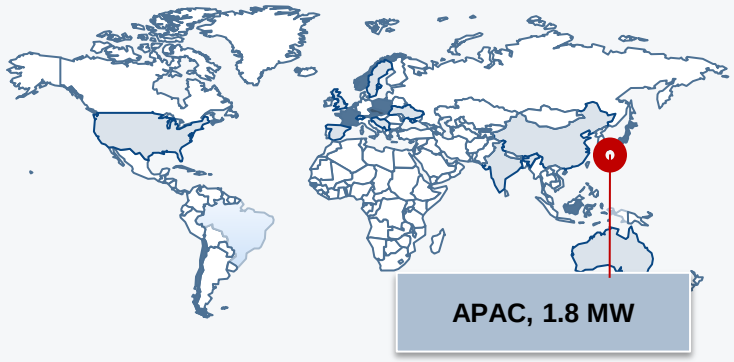
Supercapacitors

Supercapacitors are used for storing energy for very short, intermittent durations. Hence, it is usually combined with another technology in ESS application and used for regenerative braking in transportation applications.

Energy Storage Outlook: Supercapacitors Revenue Forecast in Transportation, Global, 2019 and 2020



Energy Storage Outlook: Supercapacitors Ongoing Projects by Region, Global, 2020



Market Discussion

- Tesla's acquisition of Maxwell Technologies indicates the importance of supercapacitors. However, this technology is likely to gain momentum in transportation applications, typically in electric vehicles (EVs) for regenerative braking. Its application in transportation services has been tested in South Korean and Chinese metro rail projects with promising results.
- The United States has traditionally been the market leader in terms of supercapacitor production and application. However, the APAC region including China, South Korea, and Japan is a promising market given the significant adoption of electric and hybrid vehicles.

Key Trends

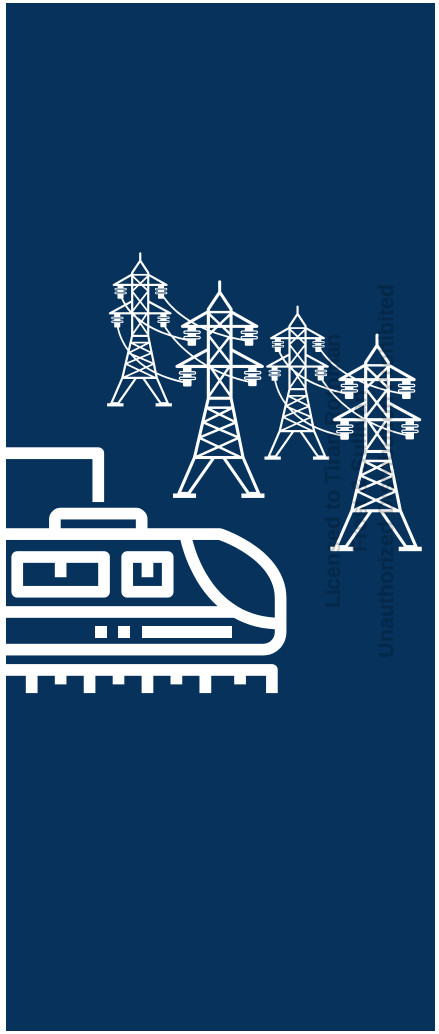
- Skeleton Technologies in Germany has developed a supercapacitor that can be used in trucks, buses, and trains and operates the biggest supercapacitor factory in Europe. It has a patented synthetic process for the curved graphene material which gives it an edge to achieve the highest commercially available energy density. This enables its supercapacitor to perform efficiently even at temperatures of -40°C.
- Supercapacitors are being explored for grid storage and data center applications by tapping their quick recharge and higher power density potential to act as a back-up for critical loads.

Source: DOE Global Energy Storage Database; Frost & Sullivan

New Technologies—Advanced Rail Energy Storage (ARES)

Energy stored is based on the gravitational potential principle.

- ARES is a grid-scale energy storage methodology developed by ARES North America.
- The pilot test bed was initiated in 2016, and the mode of storage is gravitational potential energy. In 2017, ARES got approval for a 50MW project in Nevada to stabilize the energy grid in the region. Excessive energy in the grid is stored by ARES shuttle trains. An automated steel rail network connects storage yards at different locations.
- Using grid power, motors drive the trains uphill against the force of gravity, stored as gravitational potential energy. During peak hours in the grid, these trains are driven down the hill to the lower storage yard, and the motors now operate as generators, reversing the process.
- **Project scalability:** 10 MW/20 MWh to 2 to 3 GW/16/24 GWh
- **Key applications of this technique:** Ancillary services and renewables integration
- **US patents:** 8593012 and 8674541
- **Storage method:** Gravitational potential energy
- **Promised efficiency:** 78%
- **Advantages:**
  - Lower CAPEX: About 60% of that of pumped hydro storage
  - Low Operating Expenditure (OPEX): Lowest of the existing storage technologies



Source: Frost & Sullivan

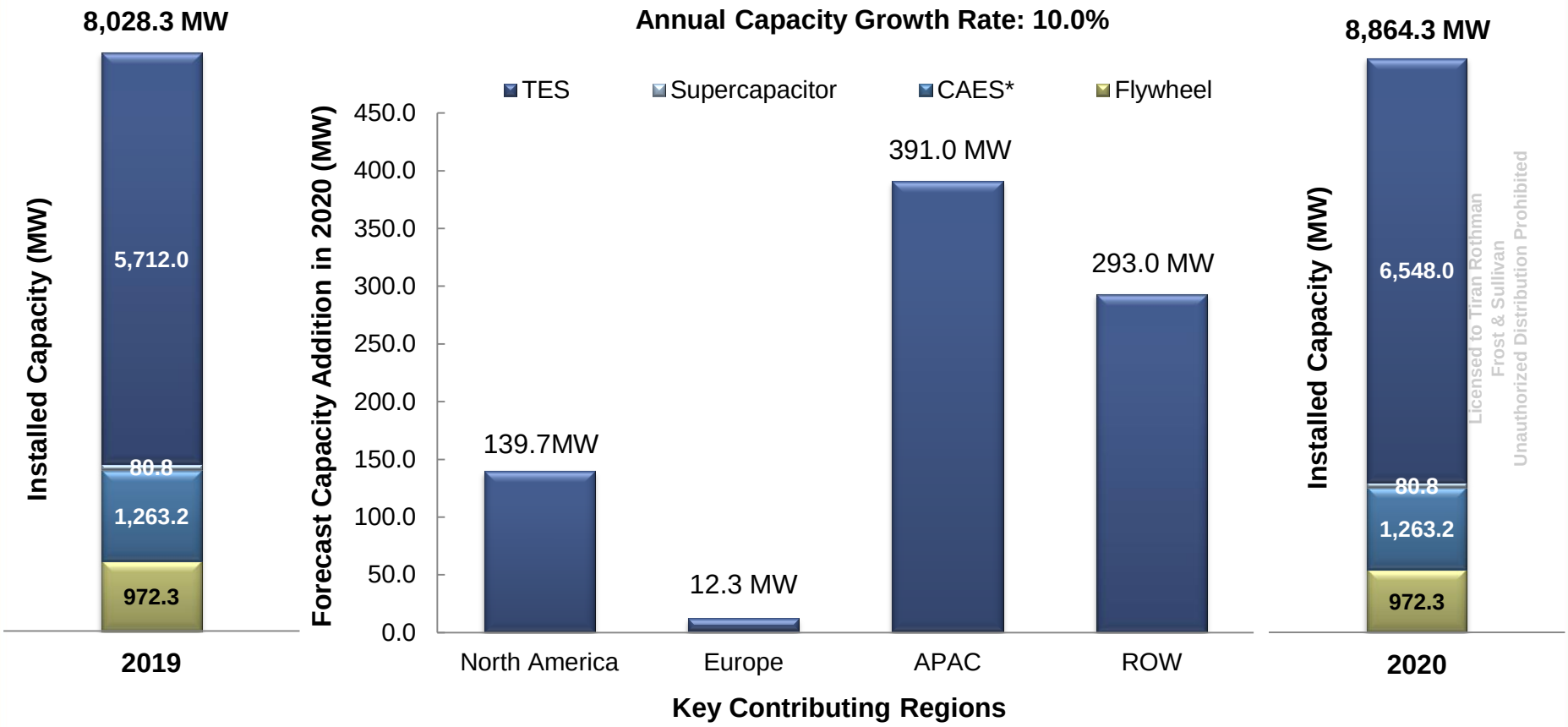
Alternative Energy Storage Technologies—Regional Analysis

Return to contents

Global Alternative Energy Storage Technologies Forecast for 2020

Installed capacity will reach 8.86 GW in 2020, at an annual growth rate of 10.0%.

Energy Storage Outlook: Alternative ESS Technology Installed Capacity, Global, 2019 and 2020



*CAES projects indicated here are contracted and announced, and the commissioning date is not yet finalized.
Thermal energy values are related to grid-connected capacity.

Source: DOE Global Energy Storage Database; Frost & Sullivan

Regional Trends—North America

Technological innovations in alternative ESS such as Advanced CES, multi-hour flywheels, and BTM thermal storage systems are driving the market in North America.

Energy Storage Outlook: Capacity Addition, North America, 2019

Country	ESS Type	Capacity Additions Announced in 2019
United States 	Thermal Storage	210.6 MW
	Advanced CAES	1000 MW*

*This project was announced in 2019 and will be operational by 2025.

Technology

Advanced CAES technologies have made significant inroads into the United States, with the project in Utah that Mitsubishi Hitachi Power Systems (MHPS) is developing with its partners to store 1000 MW of renewable energy. This project is likely to be operational by 2025.

TES for peak capacity, demand response, and HVAC replacement for BTM installations is garnering attention in the United States. The concept of using old coal power plants for thermal storage is gaining attention in the United States.

Application

- Thermal energy is used primarily for HVAC power replacement and demand response during peak hours. For large industrial systems, this technology has been well received in the United States, with venture capital (VC) partnered companies keen on building scalable and cost-effective TES that enables to meet the 100% renewable energy target by 2045 set by California.
- The flywheel system is meant for short-term storage, primarily for frequency response applications in addition to existing electro-chemical or alternative storage solutions. This system, along with thermal energy storage, is employed in service use cases such as Electric Energy Time Shift, Electric Supply Capacity, and Transmission Congestion Relief.
- Existing flywheel systems have low cycle life, and current projects are used for frequency regulation and ramp control. Multi-hour flywheel systems with longer cycle life have been tested in O'ahu, which was able to significantly improve the application of flywheel systems to peak load replacement and energy time shifting.

Source: Frost & Sullivan

Regional Trends—Europe & Israel

Europe has a strong R&D focus on alternative materials for energy storage. BTM thermal storage systems are being tested in several countries in the region. The success of these projects will result in widespread adoption in the residential sector.

Energy Storage Outlook: Capacity Addition, Europe & Israel, 2019

Country	ESS Type	Capacity Additions Announced in 2019
Germany	TES (ETES)	31 MW, 50MW* (2020)
Israel	TES	121MW

* - Project will be completed by 2020

Technology

Siemens Gamesa Renewable Energy (SGRE) commissioned the first electric thermal energy storage that could store 130 MWh of power for seven days. SGRE has made meticulous efforts towards R&D on storing thermal energy in rock fills at Hamburg, in a program named the “Future Energy System” project. The surplus power generated from the wind plant is stored in rocks as hot air which then releases the heat when called upon to turn a generator producing electricity. This plant could generate a massive 31 MW energy to be pumped into the German grid. This could solve renewable energy intermittency issues as well as help in cases where renewable energy based power generation exceeds grid capacities and storage makes absolute sense to act as a buffer.

Market Trends

- Key applications of alternative ESS include renewable energy firming and peak load shifting. R&D in molten silicon, smart thermal storage, and advanced supercapacitors could result in more price-competitive ESS, with a wider application portfolio introduced in the short term.
- Germany has been pioneering the deployment of Electric Thermal Energy Storage (ETES) with 100 MW of installed capacity from 2012, which includes the 31 MW project commissioned in 2019 and another 50 MW project under construction, which is scheduled to be commissioned by 2020.
- Israel is another important country harnessing TES to achieve a target of 17% of electricity generated by renewable energy by 2030. The Negev Energy Project is a ‘sea of mirrors’ project, Israel’s largest renewable energy project that is capable of generating 310 MW of power.

Source: Solar Power And Chemical Energy Systems; Frost & Sullivan

Regional Trends—APAC

Disruption in competition will likely be intense with new partnerships and entrants into the ESS market.

Energy Storage Outlook: Capacity Addition, APAC, 2019

Country	ESS Type	Capacity Additions Announced in 2019
China	TES	750 MW

Technology

In South Australia, 1414 Degrees, an energy storage company, has developed a silicon-based TES prototype that has higher efficiency and a lower cost than a typical molten salt TES.

Market Trends

- The APAC region is expected to make significant progress particularly in the CSP + Thermal storage technology with a plethora of projects under construction in 2019. Supportive energy storage policies in China will drive the market growth, which is progressing towards a capacity of 1369 MW of operational capacity by 2020. Australia and China are touted to be the main markets for deploying CSP plants with molten salt-based storage solutions.
- Climate Change Technologies from South Australia has launched the first modular TES that is scalable depending on the capacity. It is suitable for industrial and commercial applications. Australia is all set to gain momentum in the TES space with multiple companies coming up with different types of TES systems.
- SuunPower, a major EPC and CSP project developer, has agreed to develop CSP projects with a cumulative capacity of 1GW. Interestingly, the storage technology will be Norway's EnergyNest TES which captures waste heat from industrial and power plant facilities to convert into electricity.

Source: Frost & Sullivan

Alternative Energy Storage Technologies—Application Analysis

Return to contents

Alternative Energy Storage Technologies—Applications

North America is ahead of Europe in using TES and flywheels for renewable capacity firming and frequency regulation. Globally, the United States leads the installation of alternative storage solutions.

Energy Storage Outlook: Key Applications by Alternative ESS Technology Type, Global, 2020

Key Application	CAES	Thermal Storage	Flywheel	Supercapacitor	Regional Hotspots
Electricity/renewable energy time shifting	○ ○ ○ ○	● ◐ ◔ ◔	◐ ◐ ○ ○	○ ◔ ◔ ◔	United States, Spain, Germany, China, South Africa and France
Renewable capacity firming	◐ ○ ○ ○	● ● ◔ ◔	○ ○ ○ ○	○ ○ ○ ○	Spain, France, Italy, United States, India
Black start	○ ◐ ○ ○	○ ○ ○ ○	○ ○ ○ ○	○ ○ ○ ○	Germany
Electricity supply capacity	● ◐ ○ ○	● ○ ◔ ○	● ◐ ○ ○	○ ○ ○ ○	United States, Germany
Renewable shifting/ramping	◐ ○ ○ ○	◐ ○ ◔ ◔	● ◐ ○ ○	○ ○ ○ ○	United States, Germany, Malaysia, Israel, Spain, Portugal
Frequency regulation	○ ○ ○ ○	● ○ ○ ○	● ◐ ◑ ◔	○ ○ ○ ○	Australia, United States, Spain, Antarctica
Transportation	○ ○ ○ ○	○ ○ ○ ○	○ ◐ ◑ ○	◐ ○ ○ ○	United States, South Korea

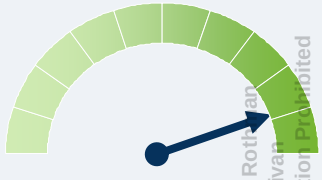
Impact : High ● ◕ ◐ ◔ ○ Low

● North America ● Europe ● APAC ● ROW

Source: Frost & Sullivan

ESS Business Model Developments

Energy Storage Outlook: ESS Business Models—Emerging Models and Trends across the Energy Value Chain, Global, 2019

	GENERATION »	TRANSMISSION »	DISTRIBUTION »	CONSUMPTION
	TRENDS IN EMERGING BUSINESS MODELS			
TRENDS IN EMERGENCE OF NEW MODELS	 **SLOW GROWTH**	 **MODERATE GROWTH**	 **STRONG GROWTH**	 **STRONG GROWTH**
TYPE OF ESS DEPLOYED	• Large-scale energy storage systems are employed here	• Large-scale ESS and distributed ESS, and employed by transmission system operators	• Distributed ESS is deployed to DSOs	• Prosumers that are households, industrial units and commercial complexes use ESS for demand charge reduction or demand response.
EMERGING BUSINESS MODELS	• VPP Model2- GENCO Aggregator Model • Third Party-owned ESS Model • Shared Assets ESS Model	• Utility-owned ESS Model • Shared Assets Model • Third Party-owned Model	• Utility-owned ESS Model • Shared Assets Model • Third Party-owned Model • Community ESS Trading Model • District Storage Model	• VPP Model 1- DR Aggregator Model • VPP Model 2- GENCO Aggregator Model • Technologies/Services Leasing Model • Community ESS Trading Model • District Storage Model

Source: Frost & Sullivan

2020 Industry Outlook—Battery Energy Storage Systems: Market Overview

Return to contents

Key Battery Market Predictions for 2020

Li-ion, flow batteries, and sodium are the key battery chemistries that will be prominent in utility-scale and residential applications in 2020.

Strong global growth in capacity forecast with a large volume of projects on-going

Strong growth in the commercial and industrial market as businesses look to minimise energy cost risk

Li-ion will remain dominant, with notable growth expected for flow batteries

Government incentives and supportive regulations key to market growth

Storage + renewable + EVs key to attractiveness of home storage proposition

Strong partnership with Integrators will be winning formula for battery OEMs

Source Images: Wikipedia. Source: Frost & Sullivan

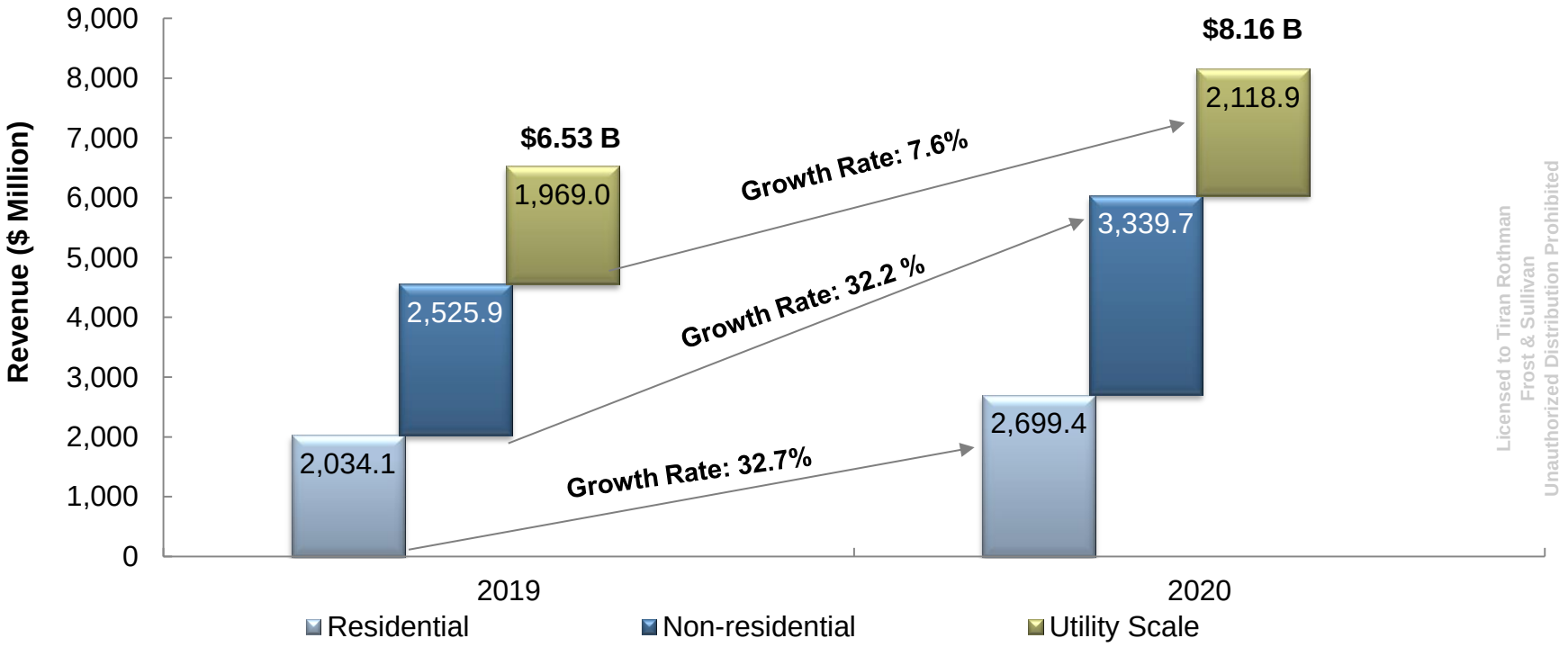
Battery Energy Storage Systems—Market Analysis

Return to contents

Market Size and Growth

Residential battery storage is expected to represent the largest growth segment in 2020. Growth in this segment will exceed that from the utility-scale storage segment in the United States.

Energy Storage Outlook: Revenue Forecast by Segment, Global, 2019 and 2020



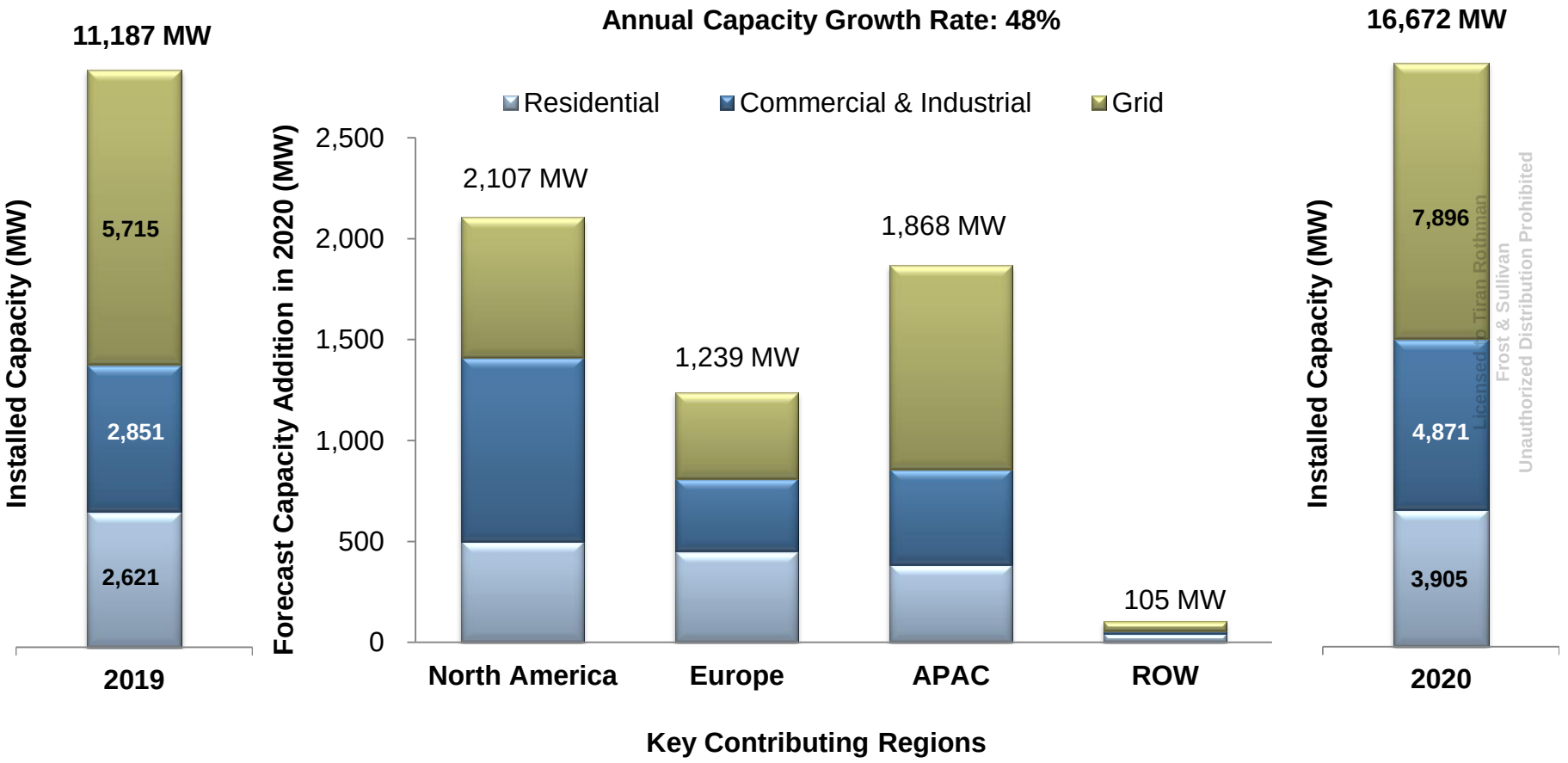
- The residential battery storage market will continue to grow the fastest in 2019 and 2020 driven largely by the surge in BTM residential deployments in the United States, Germany, and Australia.
- Being regulation driven, the utility-scale market is expected to continue its strong growth into 2020. Strong mandates in United States, Germany, and China, coupled with evolving business models, are driving this market as countries are recognizing the value of services offered by energy storage systems.

Note: All figures are rounded. The base year is 2019. Source: Frost & Sullivan

Global Battery Energy Storage Technologies Forecast for 2020

Installed capacity will reach 11.3GW in 2020, an increase of 4.1GW on 2019.

Energy Storage Outlook: Battery Technology Installed Capacity, Global, 2019 and 2020



Source: DOE Global Energy Storage Database, Frost & Sullivan

Regional Trends—APAC

APAC is an important region, with installations in China, Australia, Japan, South Korea and India contributing to strong growth in the energy storage market with multiple battery chemistries.

Markets

High-growth Segment (> 20% YOY Growth)

China	2020 will maintain growth predominantly through Li-ion, with influence from megafactories.
South Korea	The growth witnessed in 2018 is unlikely to repeat; yet, storage projects are in progress and growing.
Japan	The country will be strongly supported by the development of NaS battery technology.
Australia	Solar + storage is an important segment, with strong demand for Li-ion in both the commercial and residential segments.

Technologies

Li-ion batteries

- Li-ion is the dominant battery technology with maximum number of installations in APAC countries.
- NEC's Chinese distributor, Puxing Energy is deploying 24MW of energy storage for frequency regulation.
- Li-ion is the major storage technology backed by Tesla's gigafactory and megafactories. Tesla has launched 7MWh, the largest in Asia, of emergency power in Japan.

Applications

APAC is emerging as a hotbed for residential-scale ESS installations as more attractive products from Panasonic, Reflow (Z cell), and Tesla (Powerwall) proliferate the market. In Australia, Panasonic is collaborating with retailers and network operators to sell a complete solar PV+ storage package to residential customers.

Renewable energy firming and frequency regulation are the major applications for which BESS is employed, and hotpots are China, Australia, Japan, and South Korea.

Policies

In China, several supporting policies have been released, including Innovation in the Energy Storage Technology Revolution: New Action Plan (2016–2030), which outlines the roadmap for development and innovation in energy storage, project demonstrations, and tackling key problems in the industry. Additionally, to effectively integrate its large intermittent renewable resources, China's ambitious 13th FYP emphasizes the significance of energy Internet and smart energy.

South Korea is planning to invest $27 billion in renewable energy generation with planned incentives for solar + storage over the next 5 years.

Source: Frost & Sullivan

Regional Trends—Europe

Utility-scale projects in the United Kingdom and Germany will be the major growth engine for ESS development in Europe in 2020.

Markets

High-growth Segment (> 20% YOY Growth)

Germany — Germany is the European leader in energy storage, and has reached over 150,000 residential energy storage units with a capacity above 1GWh. Commercial and utility-scale projects are also on the rise.

United Kingdom — By end-2019, the United Kingdom had 1.2GW of installed storage projects. However, the increase in VAT for ESS from 5% to 20% from 1st Oct'19 will significantly hamper growth in residential units.

Technologies

Li-ion

- Li-ion is set to be the dominant battery technology in the European market. A 22MW energy storage facility was inaugurated in Germany by Enel Power and its partners at Cremzow, at an investment of €17 million in 2019. A significant utility-scale storage project is setting up the trend of many more utility-scale installations in Germany.
- The UK market is driven by commercial and utility-scale storage with over 10MW and over 50MW of projects under construction. This is in addition to the 800MW of large-scale storage projects in the pipeline.

Applications

The ancillary services market (transmission congestion relief and frequency regulation) will drive utility-scale applications.

Through an extension of its PV-with-storage subsidy program, Germany is expected to continue driving BTM applications in the residential and commercial sectors.

Policies

- The 'Zero Carbon' fanfare with a tax increase on renewable equipment which is effective from 1 Oct'19 is likely to dampen residential storage projects as the price soars.
- The Department of Environment, Energy, and Sustainable Development of Northern Italian region announced €4.4 million for rebates to support residential and commercial PV storage in 2019. This is in addition to the €3 million in 2018, €4 million in 2017, and €2 million granted in 2016.
- The European Commission announced spending the last €11 billion of the EU research and innovation funding program Horizon 2020. Of this, €132 million will be to support development and production of batteries for energy storage in Europe.

Source: Frost & Sullivan

Regional Trends—North America

The United States will increase its global lead in installed battery storage capacity, primarily using Li-ion technology in both utility-scale and BTM applications.

Markets

High-growth Segment (> 20% YOY Growth)

United States

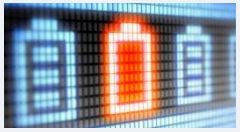
Irrespective of the Trump administration pulling the country out of the COP21 agreement, energy storage is expected to have a strong growth in 2020 backed by Li-ion installations as well as the launch of Advanced Energy Storage Caucus to create awareness about storage in the US grid.

Canada

Canada has seen slow progress on BESS, with small-scale lithium-based ESS installations expected in 2020.

Technologies

Li-ion



- The commissioning of the 30MW, the world's largest, lithium-ion battery energy facility in San Diego is attracting further large-scale energy storage installations in North America.
- Strong energy storage policies in the region, ramping up of Li-ion battery production by Tesla Giga Factory, and declining lithium battery prices will drive the BESS market.

Applications

Utility-scale applications for renewable energy firming, integration, electric energy time shift, and frequency regulation will drive growth, particularly in California.

BTM installations will continue to see strong adoption, driven by government incentives and significant economic benefits. The need for end users to protect themselves during blackouts and damages during hurricanes is attracting BTM installations.

Policies

- California's AB 2514 legislation mandates utilities to procure 1.3 GW of storage by 2020.
- Massachusetts and New York have set 2020 procurement mandates for 200 MWh and 100 MWh, respectively.
- Battery storage is included as part of the California self-generation incentive program (SGIP), along with a 30% federal income tax subsidy. In addition, SPIG has increased the funds for energy storage to $141 million to meet the growing energy demand.
- Maryland has a 30% tax rebate for energy storage technologies deployed between 2018 and 2022.

Source: Frost & Sullivan

BESS—Global Market Attractiveness

Strong energy storage mandates in the United States and APAC will result in a strong push for renewable energy storage solutions.

Energy Storage Outlook: Attractiveness of Geographic Markets for BESS, Global, 2016 and 2020

United States

2020
2016

In California, 1.3 GW of storage is mandated. Massachusetts and New York have implemented storage procurement mandates of 500 MW and 100 MW, respectively, for 2020. Duke Energy Florida proposed 50MW of energy storage with $6 billion investment into renewable energy. Portland General Electric has plans of investing around $100 million to commission 39MW of ESS projects.

Europe

2020
2016

The UK EFR program has established the first procurement plan for utility-scale battery storage systems in Europe. In addition, the UK's phasing out of coal by 2025 is a positive indication towards integration of battery energy storage. Germany extended its direct subsidization incentive for small-scale PV-coupled storage to 2018. Other key country markets in the region include Spain, Ireland, Italy, and Denmark.

China

2020
2016

China's Energy Technology Revolution Innovation Action Plan (2016–2030) has progressive plans for energy storage technologies. The construction of the 200 MW Dalian Flow Battery Energy Storage Peak-Shifting Power Station National Demonstration Project has disrupted the emerging storage technology market.

India

Initiatives such as 175 Renewable target, National Electric Mobility Mission, National Smart Grid Mission and India's Smart Cities mission have made India an important market for energy storage globally. The country has the potential for 70GW of energy storage installation by 2022. The presence of Tesla, Panasonic, Delta Electronics, Indian Oil Corporation, and other emerging local companies makes the country an attractive market for storage.

Japan

2020
2016

Japan's FiT policy for rooftop solar comes to an end in 2019. This has made the country an attractive market, with many Chinese participants venturing into it. BYD, CATL, Trina Solar and Suntech Power are some of the companies that aim to promote battery storage systems and self-consumption in the residential, commercial and industrial segments.

Australia

2020
2016

Australia has the highest residential solar penetration rates in the world. 70,000 residential solar + storage installations in this country make it an attractive market in the APAC region. An additional AUD200 million towards subsidies for another 100,000 household batteries in 2020 makes Australia an important country in the energy storage market.

Policy Support | Market Maturity | Supporting Infrastructure | Demand | Future Market Potential

Source: Frost & Sullivan

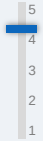
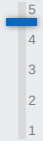
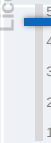
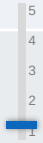
Battery Energy Storage Systems—Technology Spotlight

Return to contents

Technology Spotlight*

The vanadium redox flow battery (VRFB) will be the disruptor in 2020, while NaS is growing steadily.

Energy Storage Outlook: Key BESS Technology Comparison, Global, 2019

Technology	Description	Key Advantages	Market Acceptance	Market Potential	Disruptive Index	Maturity	Funding
Advanced Lead Acid	This battery has a mature technology and is the most widely used. It demonstrates high reliability and efficiency at the lowest cost, relative to other widely used battery technologies.	• Mature battery technology • Low cost • High recycled content • Good battery life	Mature				
Sodium Based	The technology is mature and has historically represented the dominant battery technology for utility-scale grid-connect storage systems, primarily through widespread implementation across Japan.	• High energy density • Long discharge cycles • Fast response • Long life • Good scaling potential	Mature				
Li-ion	This technology has the highest energy density of all rechargeable systems operating at room temperature. Steady decline in battery costs and a smaller footprint make it the most preferred chemistry for ESS applications.	• High energy densities • Good cycle life • High charge/discharge efficiency	2018				
Zinc-Bromine (ZnBr)—Flow	These technologies allow instant battery rechargeability through the replacement of electrolytes, while simultaneously cycling the spent material for re-energization. They have longer cycle lives and allow for longer discharge durations, compared to other battery technologies.	• Ability to perform a high number of discharge cycles • Lower charge/discharge efficiencies • Very long life	2020				
Vanadium Redox Flow Battery (VRFB)			2020				

*The top 4 BESS technologies are discussed here.

Source: Frost & Sullivan

Battery Energy Storage Technology Trends

The emergence of advanced battery chemistries presents stiff competition to Li-ion batteries.

Li-ion Chemistry Continues to Dominate

Li-ion batteries are expected to account for the overwhelming majority of battery storage additions in 2020, standing out to be the dominant chemistry accounting for more than 70% of BESS installations. Strong product lines of established leaders such as Tesla, Panasonic, Sonnen, Narada, and Fluence, coupled with strong performance in the utility storage segment by South Korean manufacturers (e.g., LG Chem and Samsung SDI) and AES Energy Storage dominate the contribution of Li-ion batteries in ESS. Launch of 'Giga Factories' and multiple 'Mega Factories', fuelled by rapidly falling lithium battery prices, should enable Li-ion to continue its dominance.

Sodium-based Battery is Truly a Game Changer

Sodium-based battery, initially installed in from Japan, now has acceptance in all geographies. Recent technological advancements have ensured the utilization of sodium batteries for micro grids and remote location grids. NaS batteries have a strong presence in Japan and other Asian countries, while the United Kingdom, Ireland, Germany, Italy and Middle East are the other promising markets. With advanced design features and application portfolio, this technology is expected to prove its worth by 2020, and the next decade will then see a strong push for sodium-based batteries.

VRFB will Gain Momentum in 2020

Utility-scale is becoming a well-established market for flow batteries with multiple projects planned till 2020. Non-degradable, non-flammable vanadium redox flow batteries are seen as the best alternative to Li-ion chemistries for utility-scale storage. Recent fire accidents from Li-ion storage have made vanadium redox as a suitable option for utility, commercial and industrial storage. The success of the Dalian project has added to the credibility of this chemistry, which could disrupt the existing business model. There are over 100 VRFB installations with a capacity of over 209 MWh globally. Australia, the United States, and China account for over 70% of these energy storage installations. Availability of vanadium as a raw material as well as the strong presence of local manufacturers favors Australia to be an important market. The highly competitive nature of the Li-ion battery market ecosystem with several participants across multiple applications has shifted the attention towards flow batteries as they are used only in the energy storage market.

Source: Frost & Sullivan

Key Technology Trends

New emerging technologies in ESS are researched and developed at various institutions.

Energy Storage Outlook: Key Technology Trends, Global, 2020

Technology Impact | Weight | Year

NantEnergy Lithium-air hybrid battery

NantEnergy

- NantEnergy's innovation is path breaking as it offers zinc-air batteries for energy storage solutions.
- This chemistry is a completely safe and green battery. The company offers cost-effective environment-friendly zinc-air battery solutions for low-cost storage options. Another product line, through the acquisition of Sharp's energy storage division, offers zinc-air/lithium-ion hybrid storage solutions for high capacity installations. This hybrid storage solution has all the potential to disrupt the market.

2020

Sand battery for EV applications

Sila Nanotechnologies

- The company has launched a silicon-based anode that replaces graphite in Li-ion batteries without requiring changes to the production process.
- Through this technology, a Li-ion battery can improve its energy density by 20% to 40% depending on the cathode material.
- Silica-based Li-ion battery provides more space for the cathode material, and also reduces the overall battery cost. The company has Amperex Technology as its battery partner and BMW and Daimler as its EV partners to use this technology in their EVs.

2020

Flow batteries for energy storage

CellCube

- CellCube is an important participant offering both vanadium and VRFB in the United States.
- The company's acquisition of Enerox (former Gleidemeister) has enhanced its product offerings. The redox flow batteries are already employed in grid -scale and grid-connected storage systems . As a result of the improved stability and performance, flow batteries are expected to further penetrate into large-scale energy storage installations.

2020

Heavy investment in R&D to develop better Lithium – XX batteries

Universities in the United States, Germany, China and Australia are keen on developing improved battery materials and other alternative storage technologies.

- University of Kansas, Argonne National Laboratory, Brookhaven National Laboratory, and University of Colorado, Stanford University from the United States; Curtin University, Australia; Shanghai Jiao Tong University and University of Science and Technology, Beijing from China; as well as Karlsruhe Institute of Technology from Germany are all working on improving the electrode or battery material of Li-ion and other alternative technologies to improve energy storage capacity and efficiency in future years.

2020

Source: Frost & Sullivan

Battery Energy Storage Systems—Global Policies

Return to contents

Storage Market Policies—Global Incentives

United States

- Federal Energy Regulatory Commission (FERC) approved Order No. 841 in Feb'2018, that requires Independent System Operators (ISO) and Regional Transmission Organizations (RTO) to remove barriers to entry for energy storage technologies.
- DoE Advanced Research Projects Agency (ARPA-E) allocated a $30 million funding to Duration Addition to Electricity Storage (DAYS) program for developing new storage facilities in the United States.
- In addition to federal policies, Massachusetts, New York, New Jersey, Oregon and Arizona have come up with supportive policies that promote energy storage.
- Massachusetts has set a goal of 1000 MWh of energy storage by 2025, through a regulation in July 2018. Similarly, New York has set a goal of 1500 MW of energy storage by 2025, and has invested $200 million towards this program.
- Law HB 2193 in Oregon mandates 5MWh of energy storage in the grid by 2020, while New Jersey passed A3723 in 2018 that set a target of 2000MW by 2030. Similarly, Arizona has proposed a target of 3000 MW for energy storage by 2030.

Germany

- Electricity stored in a storage system qualifies for the feed-in premium (Marktprämie), which is granted to the plant operator under the Renewables Act 2017 (EEG 2017) once the electricity is fed into the public grid.
- A specific provision of the EEG 2017 ensures that the EEG surcharge is not imposed twice on the electricity stored in a storage system, but only on the electricity fed from the storage into the public grid.

South Korea

- South Korea's Green Energy Policy is continuing to drive energy storage installations in the country.
- However, a series of fire accidents in 2018, and the probe into them is 2019, made United States to surpass South Korea to become to the leader in energy storage installations.
- However, favorable subsidies for both ESS consumers and producers drive ESS installations in the country.

Source: DOE; Frost & Sullivan

Storage Market Policies—Global Incentives (continued)

Australia

- Following Clean Energy Council (CEC), the National Energy Guarantee (NEG) plays a major role in promoting energy storage in Australia.
- This agency, with government support, is likely to have 70,000 Australian households fitted with batteries in 2019, which makes Australia account for 30% of the global household battery market.
- Australian Renewable Agency (ARENA) has committed a minimum of $20 million for flexible capacity and energy storage demonstration, as a part of advancing renewables program.
- ARENA is funding a $7.7 million support to Simply Energy to deliver up to 1200 homes with rooftop solar systems.
- The country is planning to install between 150,000 and 450,000 battery storage systems by 2020.

China

- The 2017 Document 1701 "Guidance on the Promotion of Energy Storage Technology and Industry Development" (NDRC and NEA with MOF, MOST, MIIT) is a regulation for promoting energy storage in China.
- This document released in 2017 is still the only proper legislation or guideline for the Chinese energy storage industry. The release of this guideline paved way for massive growth.
- Both China State Grid and China Southern Grid released "Guiding Opinions" policies for the development of energy storage, that boosts grid-connected storage.
- Launch of these guiding opinions paved way for large-scale grid-side energy storage projects in Jiangsu, Henan, Beijing, and Zhejiang, increasing China's total energy storage capacity from 3% to 21.4%.

Source: Frost & Sullivan

2019 Industry Outlook—Battery Storage (Consumer, Industrial, and EV Applications)

Return to contents

Battery Storage Trend for Consumer, Industrial, and EV Applications

Lead acid chemistry will lead in industrial applications, while Li-ion in EVs will lead in consumer devices.

Li-ion to Dominate

Li-ion is the most prominent battery powering EVs, mobile phones, laptops, and most other widely used consumer gadgets. This chemistry has almost become a monopoly in powering these devices. Despite the failure of Li-ion batteries in the Samsung Note 7, Li-ion will continue to exert influence in 2020; however, new technologies, such as solid-state batteries, will be tested for applications in laptops, mobile phones, tablets, and wearable gadgets in 2020. This product is witnessing steady growth every year, with a gradual increase in the number of applications to which it caters. This trend will continue in 2020 in the consumer electronics space as well.

Lead Acid to Continue Leading in Industrial Applications

Lead acid battery technology is considered the most dependable, affordable, and proven for backup applications in UPS and inverters. In the multi-billion dollar UPS industry, lead acid chemistry is still in demand for this application. Major application sectors such as telecom and UPS are still in the nascent stage in terms of Li-ion battery adoption with increased acceptance expected in the next 3-5 years.

Li-ion Battery to be the Unchallenged Chemistry in EVs

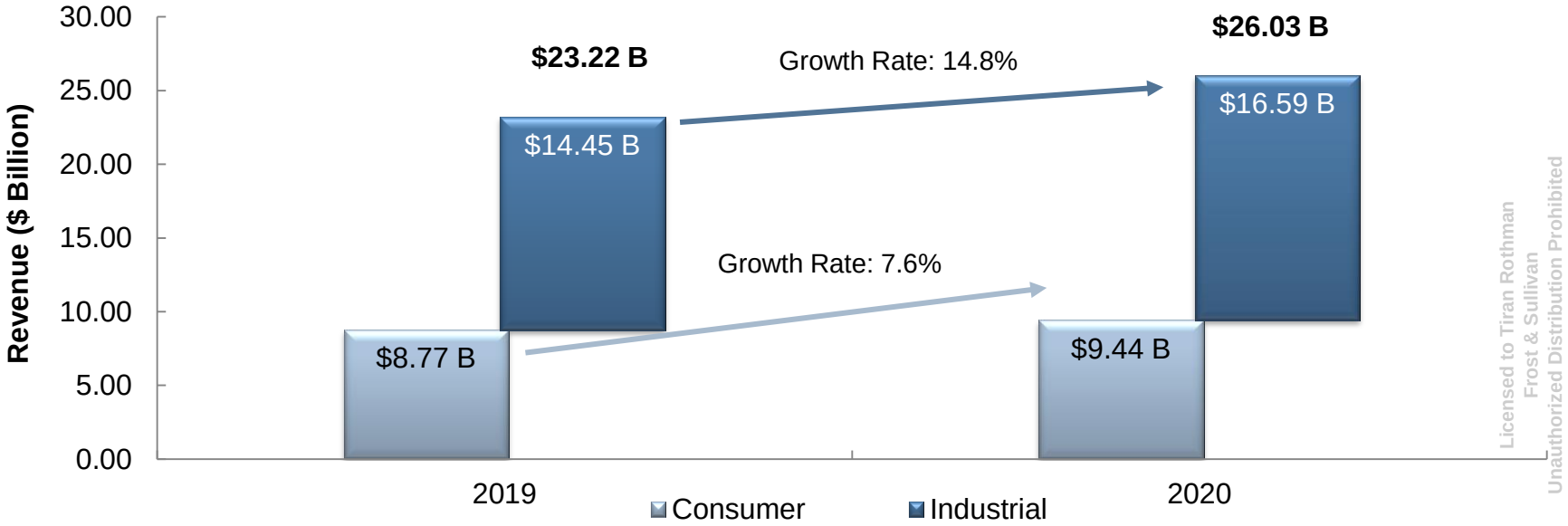
Li-ion has established itself as the dominant technology owing to the consolidated value chain, proven performance and falling prices. The price of the EV Li-ion battery has dropped significantly during the past 5 years and is expected to hit $100 per kWh by 2020. However, R&D efforts have been in full swing to look beyond Li-ion. Most notably, Fisker has been making the headlines for its solid-state batteries with higher energy and safety features, as well as being more light weight than Li-ion batteries.

Source: Frost & Sullivan

Market Size and Growth

Battery energy storage for industrial applications witness strong demand and growth, while that for consumer applications is seeing a steady price reduction although unit volumes increase.

Energy Storage Outlook: Li-ion Battery Revenue Forecast by Segment, Global, 2019 and 2020



The consumer electronics segment is witnessing a slow growth as it has become a commoditized market, with stiff pricing pressure and intense competition. However, the segment maintains the largest share of unit shipments, with a steadily rising demand from smartphones, tablets, mobility devices, gaming, and audio and video devices. APAC will remain the hub for consumer battery manufacturing, with more than 50% of the total production based in this region.

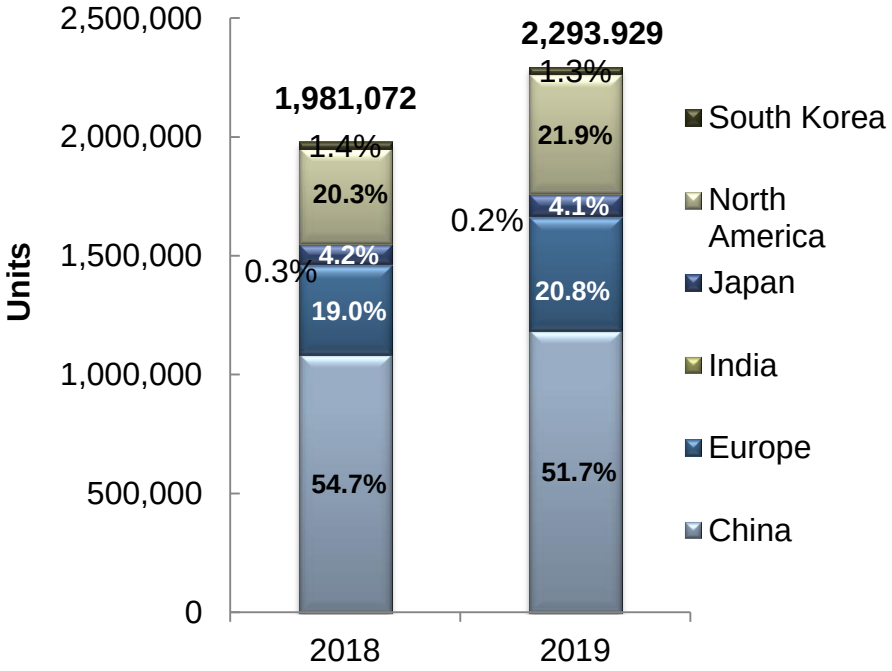
The industrial applications segment is a strong growth area for Li-ion batteries because of the increasing usage of this battery chemistry in material handling equipment, military, medical, communication equipment, and cordless tools and drills. Key growth sectors for 2020 would be batteries for electric forklifts, cordless power drills , equipment in military sector, with its greater utilization of various remote target acquisition capabilities, such as drones, and the medical sector, with its wearable patient monitoring devices and portable medical diagnostic devices.

Note: All figures are rounded. The base year is 2019. Source: Frost & Sullivan

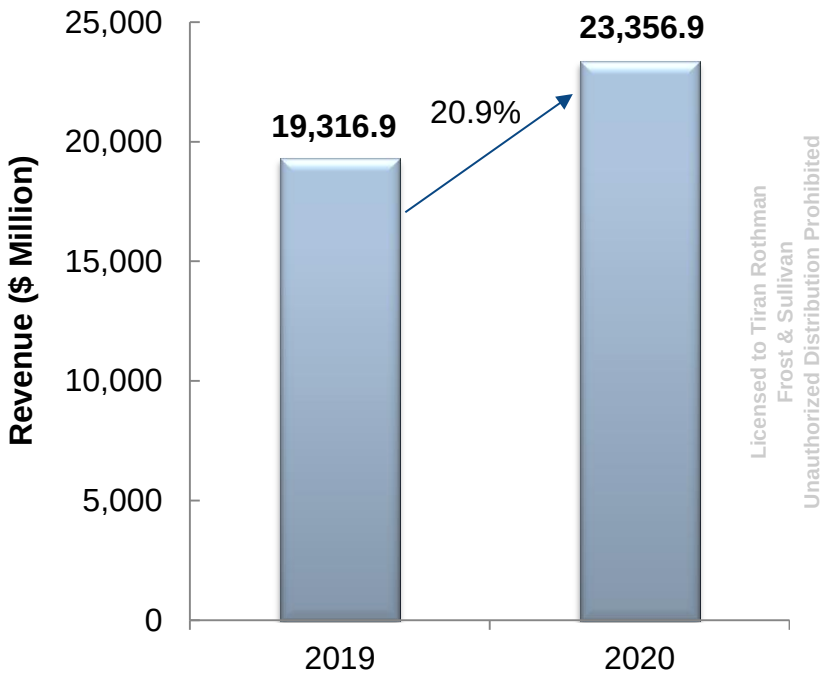
EV Battery Market Size and Growth

The EV market will drive production, innovation, and cost efficiencies for Li-ion batteries and battery systems.

Energy Storage Outlook: Total EV Units, Global, 2018–2019



Energy Storage Outlook: Automotive EV Li-ion Battery Revenue Forecast, Global, 2019–2020



The Li-ion battery market for EVs and HEVs is expected to witness steady growth in 2019 and 2020, as the projects are launched at a steady pace owing to the global slowdown, specifically in the automobile industry. However, the demand for EVs is modest in China, Europe, and North America. Li-ion batteries are thus projected to grow at 20.9% from 2019 to 2020. Continued growth in the global EV market, with most countries having the long-term goal of eliminating fossil fuel vehicles, coupled with a steady decrease in battery costs per kW, will drive the demand for Li-ion batteries.

Note: All figures are rounded. The base year is 2019. Source: Frost & Sullivan

Battery Storage (Consumer, Industrial, and EV Applications)—Regional Analysis

Return to contents

Regional Trends—APAC

China will be the largest energy storage market, driven by affordable battery pricing and large-scale project installations.

Markets

High-growth Segment (> 10% YOY Growth)

China	Despite the slowdown in 2019, China is a high-growth market due to high domestic demand and Chinese participants expanding their footprint to other countries excluding the United States.
South Korea	South Korea witnessed the highest growth in 2018 and this trend will continue in 2019 and 2020. Supportive policies and domestic demand drive battery demand across all applications.
Japan	10-year FiTs for households is expiring, and so residential storage is increasing. CATL is venturing into Japan to benefit from the rising demand in residential, commercial, automotive and industrial sectors.

Technologies

Solid-State Batteries

Solid-state batteries are an emerging trend in replacing conventional Li-ion cells. EV, industrial and commercial applications will witness explosive growth in usage of solid-state technology. China is leading in this product, while APAC region will be a strong market by 2020.

Japan will be an important market in using solid-state batteries in EVs. Toyota has formed a team exclusively to develop advanced solid-state batteries in its EVs by 2020.

Applications

- The EV battery market is expected to grow markedly as APAC battery material manufacturers are ramping up battery production capacity. In particular, Panasonic which produces Li-on batteries domestically as well as in Nevada, US, for Tesla is stepping up its production to cash in on the explosive growth in the EV market.
- The demand from consumer equipment will likely witness a stable trend, with growth largely from OEMs. The EV market is increasing targeting 5 million EVs on the road by 2020.
- Industrial applications, such as cordless drills, power tools, medical devices, and military equipment, that find Li-ion ideal for specific equipment will drive growth.

Market Trends

- The EV market sees intense competition with major market participants such as LG Chem (South Korea), BYD (China), Panasonic (Japan), and Samsung SDI (South Korea) constantly increasing their production capacities to meet the unprecedented demand for storage solutions. The battery manufacturing trend is shifting away from the clutches of South Korea and Japan towards China with CATL, Lishen, BYD and CALB constructing mega factories as part of the “Made in China 2025” plan to increase the country’s cumulative battery capacity to nearly 175 GWh by 2021.
- India is also emerging as an attractive market for energy storage in the EV and consumer electronics space with a focus on “Make in India” and spurred by the “Digital India” revolution.

Source: Frost & Sullivan

Regional Trends—Europe

Wearable devices, advanced smartphones, and unprecedented EV production rates are driving the demand for advanced Li-ion batteries in Europe.

Markets

High-growth Segment (> 20% YOY Growth)

Germany

With its ability to adopt advanced technology, Germany is proceeding towards 5G, which will demand better smartphones with advanced batteries.

United Kingdom

The demand for Li-ion batteries in the United Kingdom is driven by wearable devices for medical and communication purposes, mobile phones, and mobile-based remote management devices for healthcare support.

Technologies

Li-ion

Li-ion is expected to be the dominant battery technology in the consumer electronics segment across Europe.

Smart batteries (batteries with embedded electronics to control and initiate charging algorithms) are gaining significance in the telecom and consumer electronics sectors.

In Germany, with consistent R&D, a EV battery price of €300 was achieved in 2017, while IEA predicts the global average to drop to €283 per kWh by 2020.

Applications

Advancements to the telecom infrastructure will play a major role in the consumer battery market. With advancements in telecom networks (e.g., LTE upgrading to 5G), smartphones are dependent on better batteries.

There is a bright outlook for the adoption of flexible batteries in the European region owing to the demand from industrial and consumer electronics applications in Western European countries.

Market Trends

- Europe is one of the key markets for wearables with major demand emanating from Germany, the United Kingdom, and France. Fitness tracker is the most widely used wearable device in both Germany and the United Kingdom.
- Europe is planning its own gigafactory to capitalize on the EV revolution. LG Chem is opening Europe's largest Li-ion factory in Poland by 2019. Other companies such as Daimler, and NorthVolt look set to make up for the lost ground.

Source: Frost & Sullivan

Regional Trends—North America

The widespread use of tablets, smartphones, and Internet of Things (IoT) makes Li-ion batteries the power hub for smartphones that connect and control multiple gadgets.

Markets

High-growth Segment (> 20% YOY Growth)

United States

The United States remains the focal point of innovation, nurturing breakthroughs in the industrial battery ecosystem. Major manufacturing facilities in the country, backed by strong R&D spending, are constantly introducing high-performance battery technology in the mix to flex their muscles. The launch of advanced gadgets tagged to mobile phones makes them an important device in the United States. Wearables will continue to drive the growth of thin film batteries as well.

Technologies

Li-ion

As the most sought after battery chemistry, Li-ion is reaching its limit, thus paving the way for advanced chemistries, such as metal-air, flow batteries, and NaS.

The US DOE had projected that the battery price would fall to $125 per kWh by 2022; however, current trends show that the price is expected to reach $100 per kWh by 2020.

Applications

A boom in wearable devices and IoT is driving battery manufacturers to invest heavily in producing batteries that are flexible, thin, and stretchy. Curved, foldable, and pin-sized batteries are some good examples.

With the completion of Tesla's Gigafactory in Nevada, Li-ion battery production is expected to cross the 4.9 gigawatt-hour (GWh) capacity. The increased production is expected to meet the demand from the EV industry.

Market Trends

- The Joint Center for Energy Storage Research (JCESR) is functioning with a $120 million grant from the DOE in collaboration with major scientists and companies to develop breakthrough advanced battery technologies. This is likely to open up new manufacturing opportunities that would surpass Asian capacities.
- The consumer and industrial market is driven by innovation, with multiple players staking claim in this lucrative industry. Vuzix is one of the first companies to produce a device that can be used for industrial applications. The device has embedded, customized software suitable for industries. The wearable eye piece, supported by iOS and Android applications, includes a long-lasting battery for up to 12 hours of operation.

Source: Frost & Sullivan

Growth Opportunities and Companies to Action

Return to contents

Growth Opportunity 1—New Manufacturing Destinations

Applicable Segments	Automotive	Commercial	Industrial	Residential

- Vision Transformation
- Mega Trends' Impact
- Disruptive Applications
- Business Models
- Current Offerings
- New Capabilities
- Value-add Services
- Vertical Integration
- **Geographic Expansion**
- Partnerships
- Investment/M&A

Context and Opportunity

- Over 55% of the total production capacity is concentrated only in China, Japan and South Korea.
- With growing demand from North America and Europe, companies are looking to set up production facilities closer to these markets.
- Further, with the trade war between China and the United States, it is imperative for countries to focus on setting up facilities in diverse geographical locations, preferably closer to the demand centers.

Call to Action

- Europe is expected to have over 10 battery manufacturing plants for the automotive segment with a production capacity of over 180 GWh by 2025.
- Companies should develop strategies to widen their market presence by setting up plants in countries including Mexico, Turkey, Poland and other countries that are closer to the growing markets like the United States and Europe.

Source: Frost & Sullivan

Growth Opportunity 2—Partnerships

Applicable Segments	Automotive	Commercial	Industrial	Residential

- Vision Transformation
- Mega Trends' Impact
- Disruptive Applications
- Business Models
- Current Offerings
- New Capabilities
- Value-add Services
- Vertical Integration
- Geographic Expansion
- **Partnerships**
- Investment/M&A

Context and Opportunity

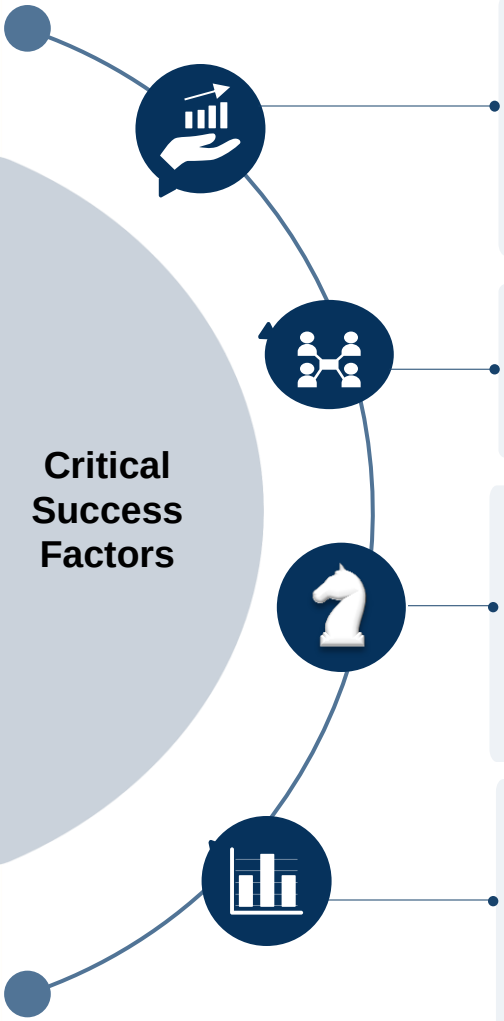
- Currently, global lithium production is controlled by a few companies, namely Tianqi (Australia), SQM (Chile), Albemarle (United States), FMC (United States) and Orocobre (Argentina).
- With a surge in demand for Li-ion batteries, existing players are expected to increase their capacity while new players are expected to enter the market.
- A number of companies like BASF, LG Chem, DuPont, 3M are entering the battery materials market.

Call to Action

- With a €400 million multi-stage investment, BASF has selected Finland as its initial location for producing battery materials to serve the European market.
- Johnson Matthey expects to start battery material production in 2021–2022 with reduced cobalt content.
- Battery manufacturers should partner with such new entrants to ensure a reliable supply of materials and better bargaining power.

Source: Frost & Sullivan

Strategic Imperatives for Success and Growth—Critical Success Factors for Growth of ESS Technologies across Regions



Next to BESS, molten salt technology has the highest market potential among ESS technologies. Molten silicon TES, which has 10 times higher energy density and 50% higher efficiency than the molten salt type, has been developed in Spain. These advantages make molten silicon TES an ideal candidate to replace the molten salt technology. In addition, smart ice storage system is finding more takers in the United States and Europe.

Deep understanding of the BESS technology is currently a roadblock for its widespread adoption. It is imperative for companies in this market to have a strong local presence with technical teams that can be readily dispatched to the site in case of any technical issues.

Companies should embrace technologies such as energy storage virtual power plants to not only reduce the demand charges during peak demand periods but also offer a revenue generation opportunity by participating in utilities' DR and other load-balancing programs. This will provide a strong business opportunities for ESS. The most attractive business case for VPP are in the United States, Japan, Canada and Australia with pilot projects already being run.

Integration of innovative business models and multiple revenue streams such as revenue stacking must be adopted by storage providers to tap the full potential while enhancing the attractiveness of energy storage solutions. ESS companies, project developers, and ESS aggregators have to forge partnerships with stakeholders across the energy value chain (such as ISOs, TSOs, DSOs, and GENCOs) for the proper functioning of the emerging business models.

Source: Frost & Sullivan

Value Chain—Alternate Battery Energy Storage Systems

Return to contents

Battery Energy Storage Systems Value Chain

Project Developers	BESS Technology Providers	Power Electronics Suppliers	Utilities	Software Solutions	System Integrators	O&M Operators
• AES • Aggreko • NEC Energy Solution • Wartsila (Greensmith Energy) • S&C Electric • LG CNS • Advanced Microgrid Solutions • Convergent Power + Energy • Duke Energy • Tesla • Nextra Energy	• Redflow • NGK INSULATORS • BYD • Sumitomo • Tesla • Samsung SDI • LG Chem • Kokam • FIAMM Energy Storage Solutions • SAFT • NEC Energy Solutions, Inc. • Panasonic • Simpliphi Power • Powin Energy • Adara Power	• ABB • Acme Electric Corporation • Alfen • Eugana Technologies • Clean Energy Storage Inc. • LG CNS • GE industrial • Dynapower • Eaton Corporation • Hyosung Corporation • Nidec ASI • Parker Hannifin • Princeton Power Systems • S&C Electric • Schneider Electric • Woojin Industrial Systems • ZBB Energy Corporation • SMA • Bosch	• Consolidated Edison Company of New York (Con Edison) • Duke Energy • EDF Renewable Energy • Enel • National Grid • E.on • RWE AG • San Diego Gas & Electric (SDG&E) • Hawaiian Electric Company • Korea Electric Power Corporation (KEPCO) • Kyushu Electric Power Company • Pacific Gas & Electric • Southern California Edison • Terna • Western Power	• Stem Inc. • Greencharge • Wartsila (Greensmith Energy) • Geli • Fluence • JLM Energy • Sunverge • Advanced Microgrid Solutions, Inc.	• ABB • 1Energy Services, LLC • AES Energy Storage • Alfen • Bosch • EaglePicher Technologies • Ecoult • Energy Made Clean (EMC) • FIAMM Energy Storage Solutions • General Electric • Global Energy Storage Solutions • Engie Storage • Ingeteam • Princeton Power Systems • Tesla	• California Solar Electric • Canadian Solar Solutions Inc. • Alfen • Global Energy storage Solutions • San Diego Gas and Electric

Source: Frost & Sullivan

Flywheel Storage Stakeholders

Energy Storage Technology Providers

- Amber Kinetics
- Beacon Power, LLC
- ABB
- Calnetix (formerly VYCON)
- Temporal Power
- Piller Group
- GKN Hybrid Power
- Siemens

Power Electronics Suppliers

- ABB
- Emerson Control Techniques
- Beacon Power, LLC
- Cirtem

Integrators

- Beacon Power, LLC
- ABB
- TDX Power
- Socabelec East Africa Ltd.
- CleanSpark

Utilities

- PPL Corporation
- Endesa
- Southern California Edison
- Kodiak Electric Association

Project Developers

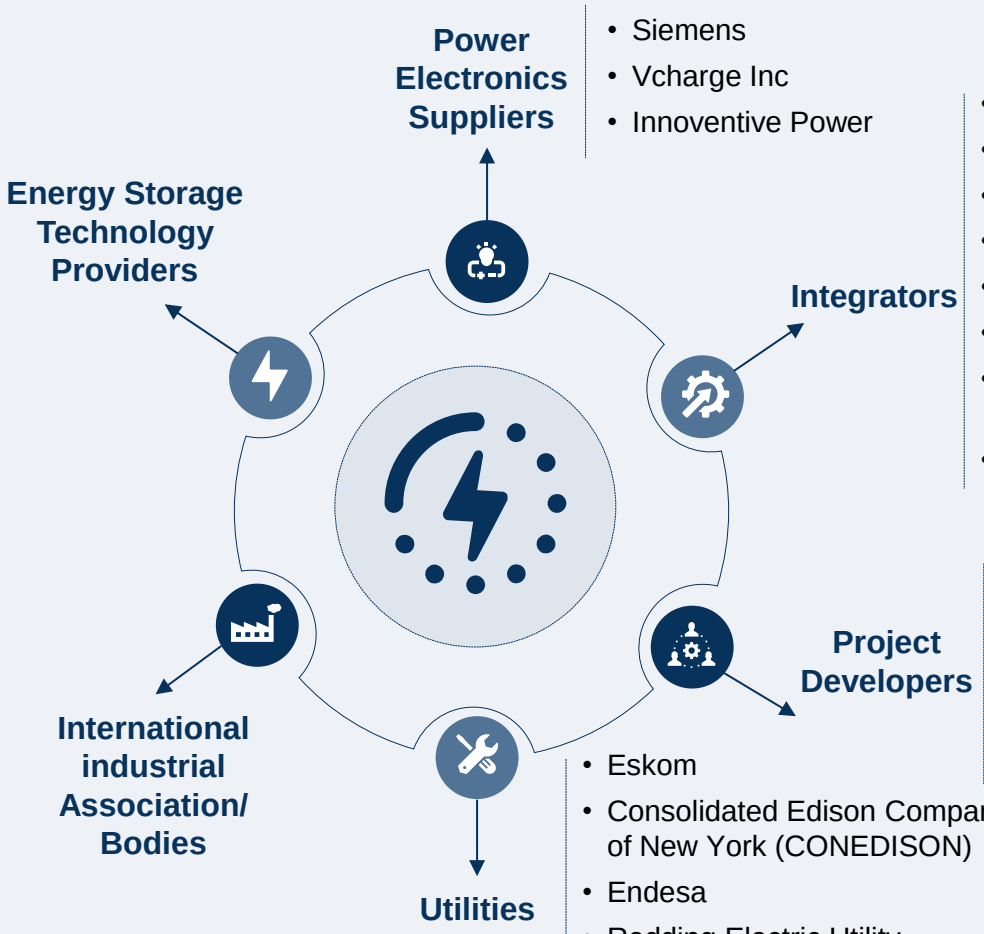
- Beacon Power, LLC
- Convergent
- Mainstream Renewable Power
- Amber Kinetics
- CleanSpark
- Schwungrad Energie
- Chugach Electric Association
- NRStor Inc.

Source: Frost & Sullivan

Thermal Energy Storage Stakeholders

- Ice Energy
- CALMAC
- DN Tanks
- Baltimore Aircoil Company
- Areva S.A.S
- Cryogel
- Abengoa Solar
- SolarReserve

- American National Standards Institute
- American Society of Heating, Refrigerating, and Air-Conditioning Engineers
- Electricity Storage Association
- International District Energy Association
- German association for concentrated solar power
- Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA)



- Siemens
- Vcharge Inc
- Innoventive Power

- Ice Energy
- Abeinsa EPC
- Spirae
- Goss Engineering
- EnergyNest AS
- Acciona Energy
- Ecovat Renewable Energy Technologies
- Abengoa

- Ice Energy
- BrightSource Energy
- ACWA power
- GDF Suez
- Solar Millennium AG

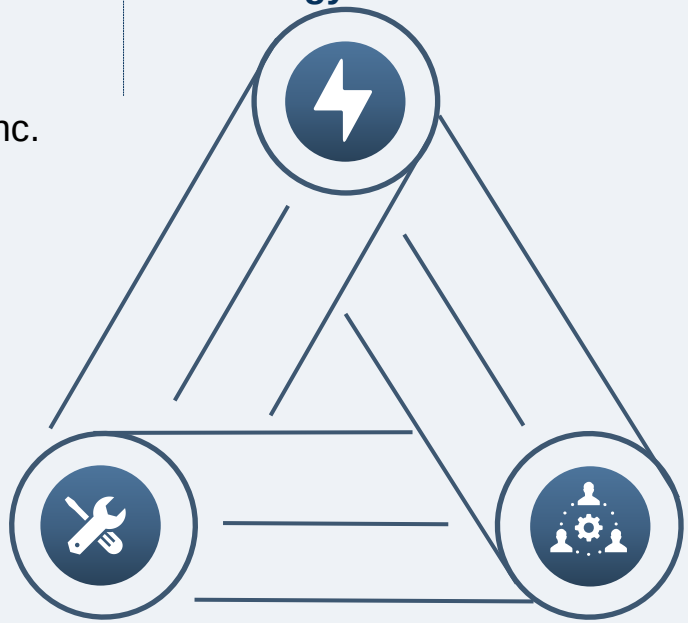
- Eskom
- Consolidated Edison Company of New York (CONEDISON)
- Endesa
- Redding Electric Utility
- Burbank Water and Power
- Israel Electric Corporation

Source: Frost & Sullivan

Compressed Air Energy Storage Stakeholders

Energy Storage Technology Providers

- Hydrostor
- Dresser-Rand
- Sustain X
- ALACAES
- General Compression, Inc.



Utilities

- E.ON
- Southern California Edison
- WEB Aruba N.V.ctric
- New York State Electric & Gas

Project Developers

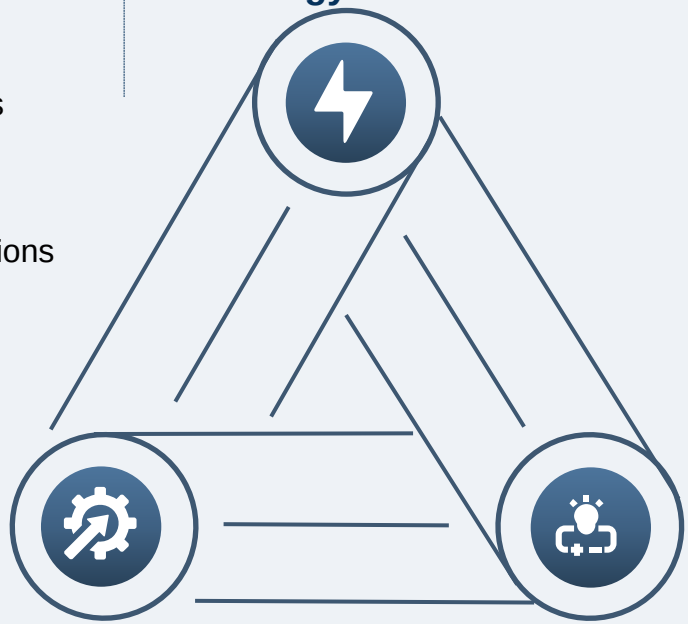
- Iberdrola USA
- Apex Compressed Air Energy Storage
- Hydrostor
- ALACAES
- ATK Launch Systems
- Storelectric Ltd
- NRStor

Source: Frost & Sullivan

Supercapacitors Energy Storage Stakeholders

- Ioxus
- Panasonic
- Nesscap
- Murata Manufacturing
- Nippon Chemi-Con
- AVX corporation
- Skeleton Technologies
- Yunasko
- Maxwell Technologies
- Supreme Power Solutions
- Aowei Technology
- SAFT

Energy Storage Technology Providers



- Woojin Industrial Systems
- Ingeteam
- Win Inertia

Power Electronics Providers

Integrators

- Electrical Power worX Corp
- ABB Envitech, Inc.
- Northern Power

Source: Frost & Sullivan

Companies to Watch—New Product/Technology/Service Launches in 2020

ESS Inc	
North America	Energy Warehouse™ System: launched in Europe through a partnership with InoBat
BlueSky Energy	
Austria	Compact, ready to connect, plug-and-play saltwater power storage solutions
Powin Energy Corporation	
North America	Stack140 is a modular, purpose-built 125KW/140KWh to multiple MW storage Solutions
Energy Nest	
Norway	TES solutions in Europe
Climate Change Technologies	
Australia	TES is offered as a battery as Thermal Energy Device (TED)
Innolith	
Switzer-land	Energy-dense storage solutions with 1KWh density for multiple applications
Fluence	
Global	Energy storage technology and services
Adara Power	
North America	Solar + Storage battery energy storage system
Alfen	
Nether-lands	Industrial plug-and-play energy storage solutions
Simpliphi Power	
The U.S	Simplified storage solutions using Li-ion batteries
Greensmith Energy Storage	
The U.S	GridSolv: Li-ion based standardized battery energy storage system

Source: Frost & Sullivan

Key Conclusions

Return to contents

Key Conclusions and Future Outlook

Battery energy storage will represent the fastest growing market for distributed energy storage systems in 2020.

Energy Storage Outlook: Key Conclusions and Future Outlook, Global, 2020

Excluding BESS, TES will see the highest growth among energy storage technologies in 2020. Nearly 836 MW will be added globally in 2020, with a overall installed capacity of above 6GW.
The United States and China are set to be the major two participants both in terms of number of installations and installed capacity. South Korea, which witnessed significant growth in 2018, is likely to slip to the top 5 positions along with Germany. In addition to the Asian countries, Middle East countries including UAE are joining the trend of large-scale energy storage installations.
APAC, and in particular China, South Korea, Australia and India, is turning out to be the most attractive market for BESS. The Luneng Haixi Multi-mixed Energy Demonstration Project integrates 650MW of combined wind, solar and CSP and uses CATL's lithium-ion storage, adding 100MWh of storage.
Lithium battery chemistry will continue to dominate the BESS market in terms of installed capacity; however, flow batteries and sodium-based batteries are likely to make significant inroads in 2020.
Compressed air and supercapacitors are the other two storage technologies that are gaining momentum. However, inherent challenges in these systems limit the technologies from growing at the same pace as the overall energy storage industry.

Source: Frost & Sullivan

Legal Disclaimer

Frost & Sullivan is not responsible for any incorrect information supplied to us by manufacturers or users. Quantitative market information is based primarily on interviews and therefore is subject to fluctuation. Frost & Sullivan research services are limited publications containing valuable market information provided to a select group of customers. Our customers acknowledge, when ordering or downloading, that Frost & Sullivan research services are for customers' internal use and not for general publication or disclosure to third parties. No part of this research service may be given, lent, resold or disclosed to noncustomers without written permission. Furthermore, no part may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the permission of the publisher.

For information regarding permission, write to:

Frost & Sullivan

3211 Scott Blvd., Suite 203

Santa Clara, CA 95054

Appendix

Return to contents

Abbreviations and Acronyms Used

APAC	Asia-Pacific
ARES	Advanced Rail Energy Storage
BESS	Battery Energy Storage System
BTM	Behind-the-meter
C&I	Commercial and Industrial
CAES	Compressed Air Energy Storage
CAPEX	Capital Expenditure
CPUC	California Public Utilities Commission
CSP	Concentrated Solar Power
EFR	Enhanced Frequency Regulation
EPC	Engineering, Procurement, and Construction
ESS	Energy Storage System
EU	European Union
EV	Electric Vehicle
FDI	Foreign Direct Investment
FiT	Feed-in-tariff
FMCG	Fast-moving Consumer Goods
GDP	Gross Domestic Product
GW	Gigawatt
GWh	Gigawatt-hour
HESS	Hybrid Energy Storage System
HEV	Hybrid Electric Vehicle
HVAC	Heating, Ventilation, and Air Conditioning
IoT	Internet of Things
kWh	Kilowatt-hour
LED	Light-emitting Diode
Li-ion	Lithium-ion
Li-S	Lithium-Sulphur
METI	Ministry of Economy, Trade and Industry
MW	Megawatt

Source: Frost & Sullivan

Abbreviations and Acronyms Used (continued)

NAFTA	North American Free Trade Agreement
O&M	Operations and Maintenance
OEM	Original Equipment Manufacturer
OLED	Organic Light-emitting Diode
OPEC	Organization of the Petroleum Exporting Countries
OPEX	Operational Expenditure
PV	Photovoltaic
R&D	Research and Development
RCEP	Regional Economic Comprehensive Partnership
RoHS	Restriction of Hazardous Substance
ROW	Rest of World
SGIP	Self-generation Incentive Program
T&D	Transmission and Distribution
TES	Thermal Energy Storage
TISA	Trade in Services Agreement
ToU	Time-of-use
UPS	Uninterruptible Power Supply
V2H	Vehicle-to-home
VRFB	Vanadium Redox Flow Battery
Wh/Kg	Watt-hour per Kilogram
ZnBr	Zinc-Bromine

Source: Frost & Sullivan

Market Engineering Methodology

One of Frost & Sullivan's core deliverables is its Market Engineering studies. They are based on our proprietary Market Engineering Methodology. This approach, developed across the 50 years of experience assessing global markets, applies engineering rigor to the often nebulous art of market forecasting and interpretation.

A detailed description of the methodology can be found here.

Source: Frost & Sullivan

List of Exhibits

List of Exhibits (continued)