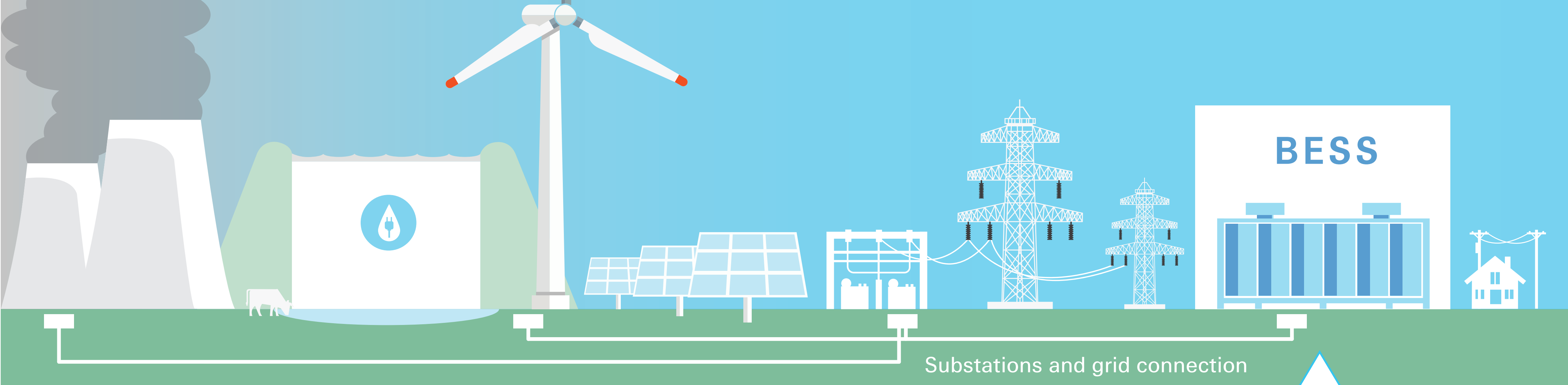
Swiss Re Institute

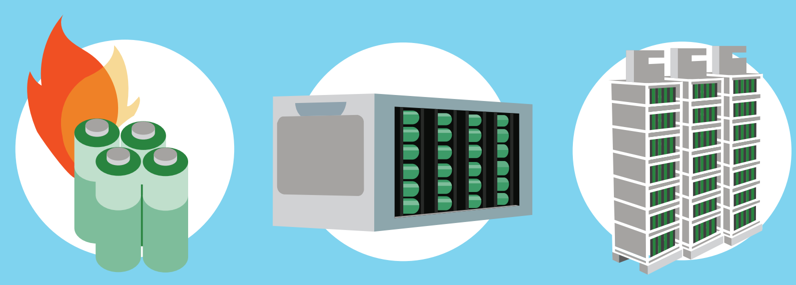
Battery Energy Storage Systems



Power generation = Power consumption

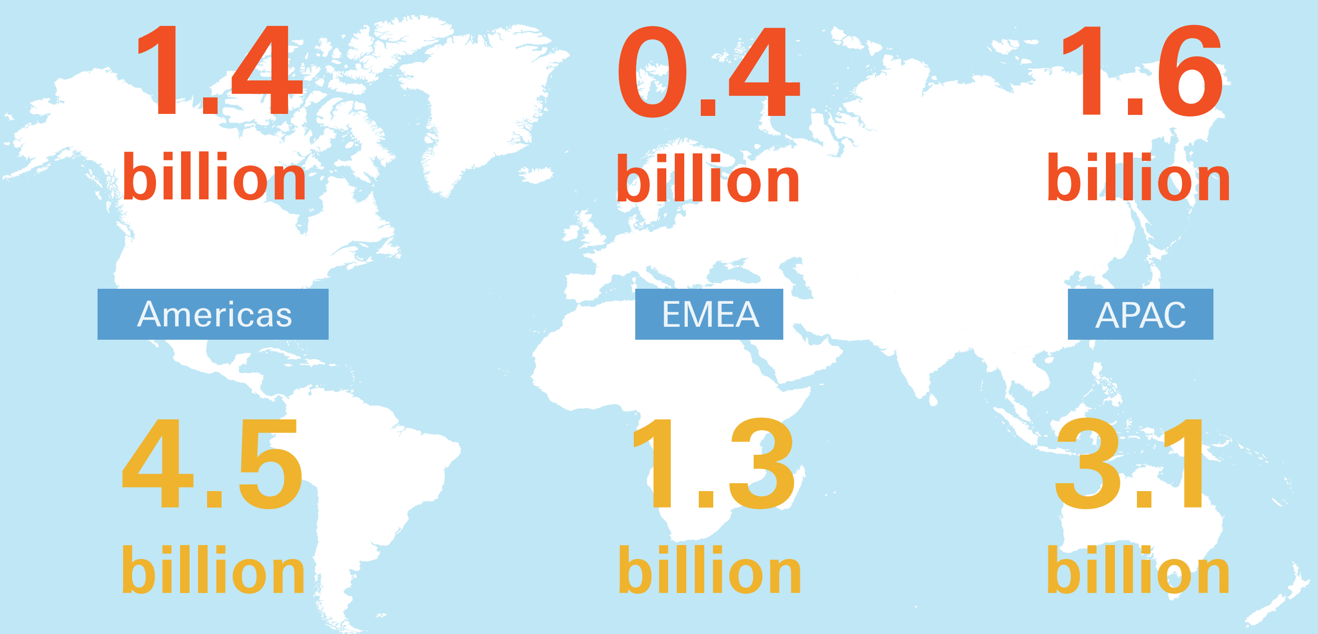
Increasing penetration of renewables demands more flexibility of the power grid in matching supply and demand

The inherent energetic failure risk is at the cell level



Risk propagation is through the product architecture

Annual BESS construction value at risk in 2020

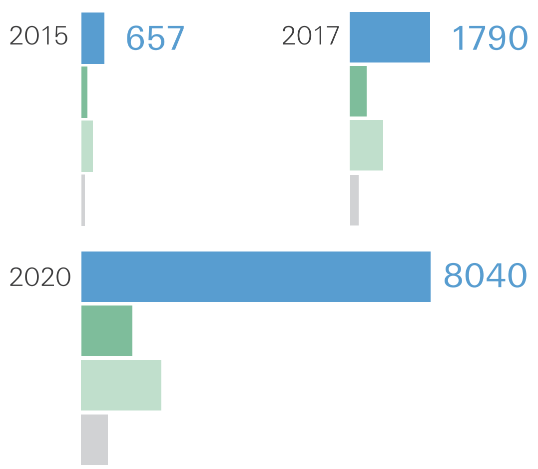


	Americas	EMEA	APAC
Annual BESS construction value at risk in 2020	1.4 billion	0.4 billion	1.6 billion
Annual BESS revenue at risk in 2020	4.5 billion	1.3 billion	3.1 billion

Annual BESS revenue at risk in 2020

Source: Swiss Re maximum estimates in USD based on different sources (US Dept. of Energy, Technavio, Deutsche Bank, Goldman Sachs and Malhotra)

Estimation of installed BESS capacities in MW



Main **BESS** battery types

- Lithium-ion LIB
- Lead-acid LAB
- Sodium salt SSB
- Flow

The combination of these four **BESS** battery types represented more than

99.5%

of the global cumulated energy and power capacity of utility scale batteries in 2015.

BESS **energetic & technology risks**

Lithium-ion LIB

LIB have a generally high exposure to energetic failure, which is mainly the result of the composition of their electrodes. The cobalt content of some sub-chemistries exposes LIB to raw materials shortages and potential sustainability issues in the mining and pre-processing phases. The current lack of a large-scale commercial recycling solution for LIB is also giving rise to uncertainty about their decommissioning phase and the associated costs.

Lead-acid LAB

LAB systems have a relatively high risk of energetic failure, mostly related to the increased production of a highly flammable hydrogen-oxygen mixture in the case of overcharge or abuse current. In spite of lead's major eco-toxicity, fully mature and commercially profitable recycling processes considerably reduce the environmental risks during LAB end of life.

Sodium salt SSB

SSB systems have a relatively low risk of energetic failures, but are exposed to high intrinsic fire and chemical hazards, due mainly to the sodium and sulphur composition of their electrodes. They are judged to have low to very low exposure to sustainability risk, supply risk and material risk. In spite of the high eco-toxicity of their components, there are commercially-ready recycling processes to avoid environmental pollution during their end of life.

Flow

Flow batteries have the lowest risk of energetic failure of these four BESS technologies, mostly due to the important thermal momentum brought about by the water-based solvent, which makes any thermal runaway reactions virtually impossible. The most important risk is that of electrolyte leakage, particularly in view of its volume and caustic nature.

BESS **technologies to monitor**

UltraBattery®

UltraBattery® is a hybrid technology between a conventional Valve Regulated Lead Acid (VRLA) battery and ultra-capacitor technology. The cell manufacturer claims increased performance (more energy delivered, less aging) and reduced costs over the BESS lifetime. This technology has already been developed successfully in US and Australia in multiple utility-scale projects.

Rechargeable zinc-air systems

Rechargeable zinc-air systems will be attractive for utility applications if their ability to charge and recharge can be improved. These systems are in the early stages of commercialisation and, as such, manufacturing is limited. Although being researched by more than one company, the earliest product being actively used in demonstration projects has been produced by EoS under the name of Znyth.

Liquid metal LMB

LMB was developed to meet the need for cheap and robust large battery systems for the grid. Its design consists of three layers of liquid metal kept at a high temperature, all three active components being in liquid form when the battery operates. Although not at the commercialisation stage yet, among the main advantages promised by LMB is its low cost (use of inexpensive, abundant materials), easy scalability (inherent to electro-metallurgy and conventional manufacturing) and long lifespan (liquid electrodes avoid cycle-to-cycle capacity fade as the electrodes are reconstituted with each charge).

BESS **outlook**

As the share of renewables in the power production increases, so does its intermittency. This leads to an increased need for flexibility providers, such as BESS, on the electricity grid. BESS have a substantial technical advantage over conventional generation units in terms of load shifting capacities thanks to their fast ramping rate. The systems are clearly the dominant technology systems currently.

Of the BESS technologies investigated, lithium-ion systems clearly are currently the dominant technology. Supported by emerging large economies of scale, which are leading to major cost reductions, lithium-ion systems are set to maintain their dominant position in all markets in the short and medium term (coming ten years). Given the development in battery energy technologies and the diverse needs of the grid, multiple BESS technologies are likely to prevail, and the dominant position of lithium-ion should not be assumed in the future.

The generalisation of storage capacities and decentralised production at grid level could lead to a phenomenon known as grid defection. As end consumers become producers (prosumers), and thus able to produce and even store their own electricity, they could literally become electrically independent. This could result in an extremely reliable system, as it would be composed of a constellation of independent and redundant sub-systems. However, for this to be realised, the regulatory framework needs to follow, as uncertainty about the future evolution of the grid can have a negative impact on further investments. Thus clarification through clear and consistent public policies of the nature and importance of storage as a grid flexibility provider is necessary to provide the right commercial environment for further investments in grid storage.

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