Cloud-based analytics for de-risking BESS deployment and operation

BESS analytics | Energy storage assets are versatile, profitable low carbon resources that need the right conditions and guidance to deliver value from the very start of operation. How we look at commissioning can determine the outlook for the asset for a lifetime, write Dr Stephan Rohr, Sebastian Becker and Dr Mathias Simolka from TWAICE.

Introduction

More than 1,600 battery energy storage projects with a total capacity of 386GWh have been announced for 2023-2025 around the world, according to market research group Rho Motion. One visible trend is an increase in the average size of storage systems. The average storage size planned to be deployed in 2023 is 170MWh, this will increase to 230MWh in 2024, and is likely to reach 600MWh in 2025.

Another trend that has been shaping the energy storage market over the past years is, however, coming to an end. Companies were enjoying favourable battery and project costs, but due to recent developments, project costs can exceed US$1 million per installed MWh. The increasing prices have led to an adoption of lithium iron phosphate (LFP) cells in the battery energy storage system (BESS) industry, but whilst these come with a cost advantage, they come with a disadvantage – accuracy in controlling the BESS.

BESS projects do not only come with high costs, but also with high risks of failure or unplanned downtime. Between 2015 and 2022, 58% of energy storage system failures happened in the first two years of operation. Two thirds of the incidents occurred in the first year, shortly after the storages were deployed.

These incidents have many different causes, from cell and fan issues, cooling system errors, inverter breaks, battery management system (BMS) malfunctions, and more. Figure 1 below illustrates this point with data taken from the EPRI BESS Failure Event Database.

Energy storage system failures do not only pose safety risks, but they also cause storage downtime. Availability rate is a crucial part of the equation to ensure a profitable business case for the energy storage project. Fixing malfunctions and repairing defects lead to temporary downtime of the system, hence, negatively affecting the business case of asset owners. Whilst downtime for BESS maintenance can be scheduled to keep revenue loss to a minimum, unplanned downtime cannot be accounted for in daily operation.

In a worst-case scenario, asset owners miss out on significant revenue because their energy storage system is out of operation during a spike in energy prices, as seen in the Texas power crisis in 2021.

Not all detectable errors will immediately lead to BESS failure. Some issues appear less serious as they do not pose an immediate safety risk but can have considerable financial consequences. For example, a poorly configured cooling system (e.g. the cooling swirls are not ideally positioned in the container) can cause inhomogeneous aging, therefore leading to a shorter battery lifetime, in which case the overall return on investment is lower.

Despite these challenges, storage projects can be extremely profitable when you have an ecosystem of partners and tools in place to help you prevent costly failures and ensure availability.

Get what you pay for (since you are paying a lot!)

Commissioning

Before deploying an energy storage system, a process generally referred to as "commissioning" takes place to test and verify that the storage system and its components are installed and configured correctly.

Commissioning is performed once the project is handed over from the EPC to the owner. The aim is also to test the operability of the storage at its initial state in terms of performance, reliability and safety. To put it simply, not only are the keys handed over, but also the responsibilities and risks regarding the asset.

The results of this process are provided in a commissioning report that provides detailed information about the system's set-up and performance, which can be used to identify and resolve manufacturing issues, underperforming components and to ensure compliance with regulations.

Energy storage commissioning is not a standardised process and includes different aspects depending on what has

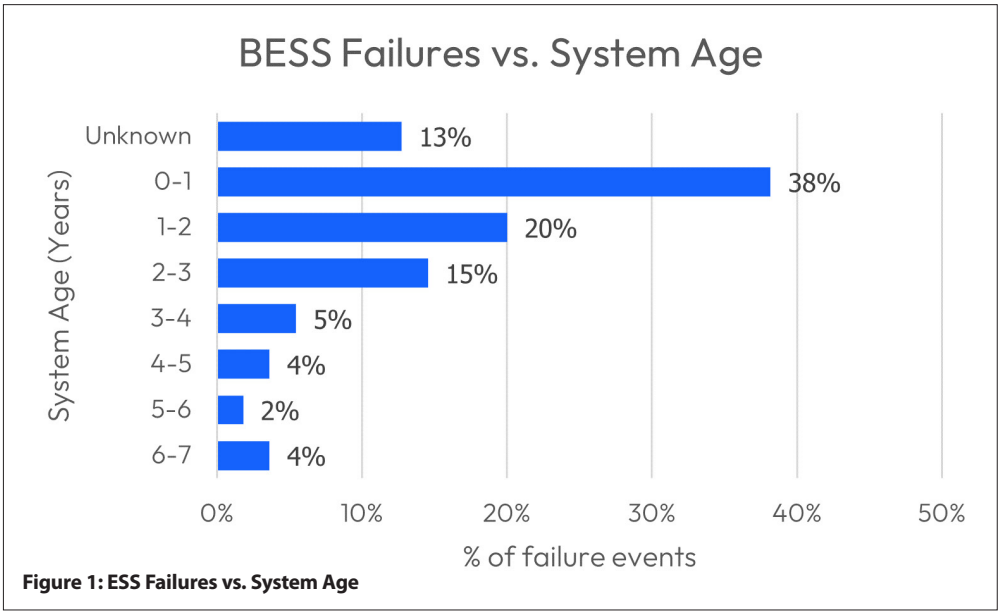


Figure 1: ESS Failures vs. System Age

been agreed between the different parties. So it is not only about testing all physical components and electrical connections for functionality. As the BESS also needs to be compliant with local and national safety regulations, the report usually also includes details on safety features of the system and the fire protection concept. The report provides evidence that the system has been configured correctly (particularly software), to ensure that operation within the specified parameters.

Industry standards for commissioning reports have not yet been developed, but more and more common practices are emerging.

Importance of the battery in the commissioning process

The battery is the most expensive part of energy storage projects (making up 40-50% of the cost) and the most complex, for number of different reasons. Let's focus on why that is from a commissioning perspective.

- Unlike most other components, the battery is not either working or not working – there are many shades of grey when assessing a battery's performance. What is the system's state of health? To what degree is the promised round-trip efficiency achieved?
- The commissioning process is usually carried out at system level, thus providing system-level KPIs. This only tells half the truth about what is really going on within a battery energy storage system, as it does not provide the vital information about issues on cell or module levels. What is the state of health of each module? Is the HVAC system capable of controlling the temperature homogeneously within the entire container? What is the initial energy spread of the single strings?

What commissioning typically includes

The part of the commissioning covering the battery typically includes information such as the system's capacity, efficiency, and power output. It also includes details on issues that were identified during the commissioning process and the steps taken to resolve them. Additionally, the report will serve as the foundation in case of warranty claims or disputes about the asset's status.

What commissioning does not typically include

However, conventional storage commissioning comes with drawbacks.

Incident	Action
Weak cells are identified due to observations in various KPIs	Modules with self-discharge issues should be replaced
System design failure diagnosis based on temperature analyses	Cooling system should be redesigned
Strings and Modules should showcase data sheet based behaviour	Modules with identifiable outlier for relevant KPIs which represent manufacturing issues and defects should be replaced

One of the significant drawbacks of commissioning reports for batteries is that they often focus on the system level, which is not where most issues are happening. Most problems occur at the sub-component level, such as individual cells, modules or strings.

Therefore, a commissioning report that only analyses the system level may miss crucial information about underperforming sub-components, leading to decreased efficiency and potential system failure. For example, if one cell is not functioning correctly, it may not be detected by the process if the other cells in the module are compensating for its lack of performance. This can lead to continued use of an underperforming cell, ultimately affecting the overall efficiency of the system.

The overall system performance is determined by the weakest sub-component; hence it is essential to identify underperforming and high-risk strings and modules as early as possible. Identifying and replacing these underperforming sub-components can significantly improve the efficiency and lifespan of the system. However, commissioning reports that only focus on the system level may not provide this level of detail, leading to continued use of underperforming sub-components and decreased efficiency.

Commissioning reports require a lot of work and time onsite, which can prolong the construction timeline and push the start of revenue generation further into the future. It is essential to invest the necessary time and resources to ensure that the battery system is functioning optimally, but efficiency should be the key.

Lastly, if the commissioning report is carried out by the EPC contractor, there may be no neutral party involved, meaning that incentives for detailed checks might be limited. While neutrality is difficult to define, conflicts of interest could arise when multiple projects need to be commissioned within a tight timeline. Thus, having a neutral party involved in the commissioning process is essential to ensure that the report is unbiased and thorough.

The benefits of more insights

Deeper insights than can be provided with onsite commissioning are crucial to get

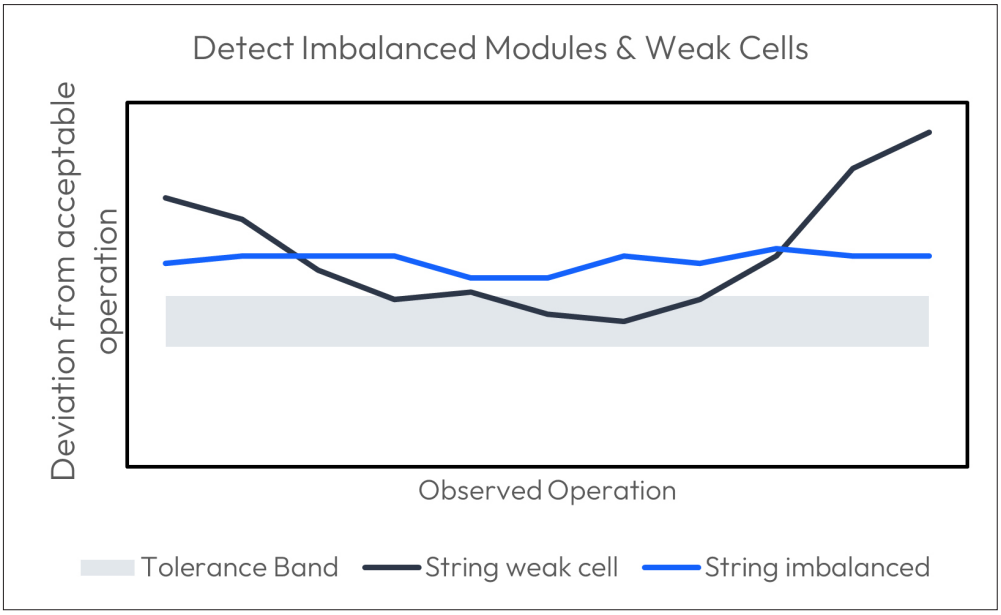


Figure 2: All strings are tested in the observed operation range, levering different methods. The deviation from the acceptable operations can be observed and underlying issues can be identified, which are in these cases weak cells within the string and imbalances

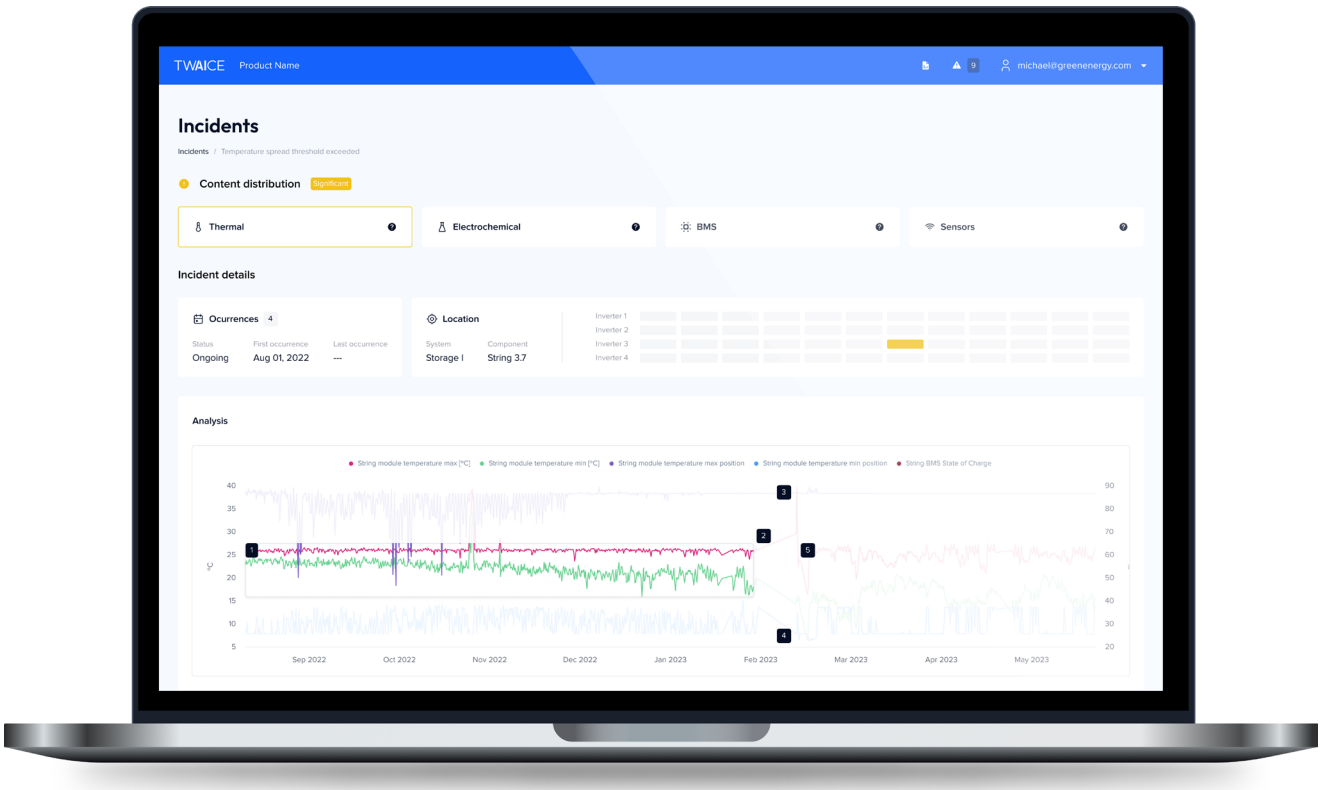


Figure 3: Screen from TWAICE Safety Solution

an overall picture of the asset and uncover more manufacturing failures, system design failures or other issues.

Let's look into the inside of a storage system and at three common findings that could be fixed with additional KPIs.

You got off to a great start – now keep up the good work!

Successful commissioning and the detection of potential anomalies in the early phase of storage life is only the first step to profitable and reliable energy storage operations. After deployment, in-life monitoring and analytics is essential to ensure high availability and avoid safety-critical incidents.

In-life analytics for a safe and healthy operation

Using safety analytics, possible safety incidents can not only be identified, but grouped into meaningful technical units so that trends can be detected, and Operation & Maintenance (O&M) teams can plan and act accordingly.

One temperature or voltage value outside the boundaries is not necessarily a cause for immediate concern, but an accumulation could be a long-term risk. Values occurring outside safety-critical thresholds must be interpreted correctly and considered in the context of other KPIs. Notifications can be helpful in finding out when an unsafe level has been reached. This is where battery analytics is the ideal solution.

To make it more concrete, a vital component of battery safety involves detecting anomalies and trends outside the norm. Deviations from the average distribution in resistance and temperature, for example, could indicate side reactions within battery cells. These are the incidents you want to know about and fix as quickly as possible. Having enough time to fix such anomalies before they escalate will help to keep storage availability high.

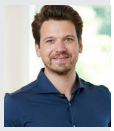
Energy storage management systems (ESMS) usually do not provide sufficient information to ensure health and safety of energy storage systems. Such systems do not provide an analysis of historical data and hence do not supply the necessary data to detect long term trends or anomalies.

Conclusion

Battery energy storage systems are valuable assets. As much as BESS are advantageous in storing and trading energy, reliable insights are essential to ensure continuous operation and optimal performance of the batteries. At the beginning of the storage life, the storage needs to be commissioned. However, the main concern with conventional commissioning is that it often lacks detailed insights into the batteries. Digital commissioning can provide the necessary insights to ensure problems can be solved before deployment. This lays the foundation for a safe and long lifetime as well as high availability.

Digital commissioning is one option to deal with these challenges. Once digital commissioning has been carried out on an asset, the data connection is established and in-life analytics can finish what digital commissioning has started.

Authors



Dr. Stephan Rohr is Co-CEO of TWAICE. Before founding TWAICE with Dr. Michael Baumann, Stephan completed his Ph.D. at the Technical University of Munich after working in start-ups, PE, and in consulting.

Sebastian Becker: Sebastian is Director of Partnerships & Industry Strategy for the Energy sector at TWAICE. In his role, he drives the TWAICE go-to-market approach to enable integrators, developers and owners of battery energy storage systems to get the most out of their assets.

Dr. Matthias Simolka: Matthias Simolka is part of Technical Solution Engineering at TWAICE. In this capacity, Matthias bridges the gap between Sales, Product and Tech, working with all teams to ensure maximum value and the optimal solution is delivered to battery customers.