SINO VOLTAICS
ZERO RISK BESS™

BATTERY ENERGY STORAGE SYSTEMS

from selection to commissioning: best practices

Version 1.0 - November 2022

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LIST OF ACRONYMS

A	Amp
AC	Alternating Current
BESS	Battery Energy Storage System
BMS	Battery Monitoring System
BoL/ BL	Bill of Lading
CESS	Containerized Energy Storage System
C&I	Commercial & Industrial
DC	Direct Current
DDP	Delivery Duty Paid
DoD	Depth of Discharge
EMS	Energy Management System
ESS	Energy Storage System
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
EV	Electric Vehicle
EXW	Ex Works
FAT	Final Acceptance Testing
FQC	Final Quality Control
HS	Harmonized System
HVAC	Heating, Ventilation and Air Conditioning
Hz	Hertz
IEC	International Electrotechnical Commission
IP	Ingress Protection
IPQC	In-Production Quality Control
IQC	Incoming Quality Control
ISO	International Organization for Standardization
kW	Kilowatt
kWh	Kilowatt Hours
LFP	Lithium Iron Phosphate
MW	Megawatts
MWh	Megawatt Hours
NMC	Nickel-Manganese-Cobalt
NRECA	National Rural Electric Cooperative Association
OAT	Operational Acceptance Test
O&M	Operation & Maintenance
OQC	Outgoing Quality Control
PCS	Power Conversion System
PMS	Power Management System
PV	Photovoltaic
R&D	Research & Development
RFP	Request for Proposals
SAT	Site Acceptance Test
SOC	State of Charge
SOH	State of Health
SOP	Standard Operating Procedure
TCP/IP	Transmission Control Protocol/Internet Protocol
UN	United Nations
UPS	Uninterruptable Power Supply
V	Volt
VAR	Volt-Amps-Reactive
W	Watt

1 INTRODUCTION

At Sinovoltaics we're actively involved in the technical compliance of PV + BESS systems. Our company BESS activities include:

- **Quality Assurance Plan creation:** Our team helps to design a solid Quality Assurance Plan (QAP) for your BESS projects to ensure your components are tested according to the latest industry best practices.
- **RFP creation:** Our team supports you in establishing the key aspects to evaluate when starting your next BESS project.
- **Sinovoltaics platform:** Access the Sinovoltaics Platform and benefit from our resources to streamline your Energy Storage System Supply Chain.
- **Contract optimization:** Sinovoltaics has overseen contracts of GWs of renewable energy projects to ensure quality is covered in yours.
- **Factory audits at factories in Asia Pacific:** Our IRCA-accredited and BESS-specialized audit team performs technical audits to ensure your selected suppliers are well positioned to produce quality BESS equipment.
- **ESG audits:** In addition to supplier's quality evaluation, Sinovoltaics provides ESG audits following the major ESG frameworks for both buyers and investors.
- **Factory Acceptance Testing (FAT):** Our team ensures that all BESS components, including the battery racks, modules, BMS, PCS, battery housing as well as wholly integrated BESS leaving the factory are of the highest quality.

This document e-book aims to give an overview of the full process to specify, select, manufacture, test, ship and install a Battery Energy Storage System (BESS). The content listed in this document comes from Sinovoltaics' own BESS project experience and industry best practices. It covers the critical steps to follow to ensure your Battery Energy Storage System's project will be a success.

Throughout this e-book, we will cover the following topics:

- Battery Energy Storage System specifications
- Supplier selection
- Contractualization
- Manufacturing
- Factory Acceptance Testing (FAT)
- BESS Transportation
- Commissioning
- Operations & Maintenance

At the end of each section there will be a tabular summary that can be directly used during the evaluation process.

2 BATTERY ENERGY STORAGE SYSTEM SPECIFICATIONS

It might sound like a cliché, but the first step to ensure that your BESS' project will be successful is to ensure that everyone agrees on the Energy Storage System specifications.

To do that, the following question can act as a useful checklist:

- **Who is the customer?** Residential households? Commercial and industrial (C&I) entities? Grid utilities. Knowing where your customer comes from will trigger different energy storage needs and products, as shown on the pictures below:
- **What is the customer application?** Is it to lower the grid power usage? To function as an Uninterruptible Power Supply (UPS)? For peak shaving?
- **Is the site on-grid or off-grid?** What is the grid frequency? The US electricity grid frequency is 60Hz, while the European grid frequency is 50Hz.
- **What will charge the BESS?** Solar photovoltaic (PV), wind, grid, diesel generators are all different options.
- **Is there any Energy Management System (EMS) already used on site? What is the communication protocol used?** For example, Modbus TCP/IP.
- **What is the BESS charging profile (if any)?** Is it coming from dispatchable energy sources? It might be only during specific hours.
- **What is the electricity consumption profile?** There could be daily, weekly, or seasonal patterns.

Various BESS for various applications; source: Sinovoltaics

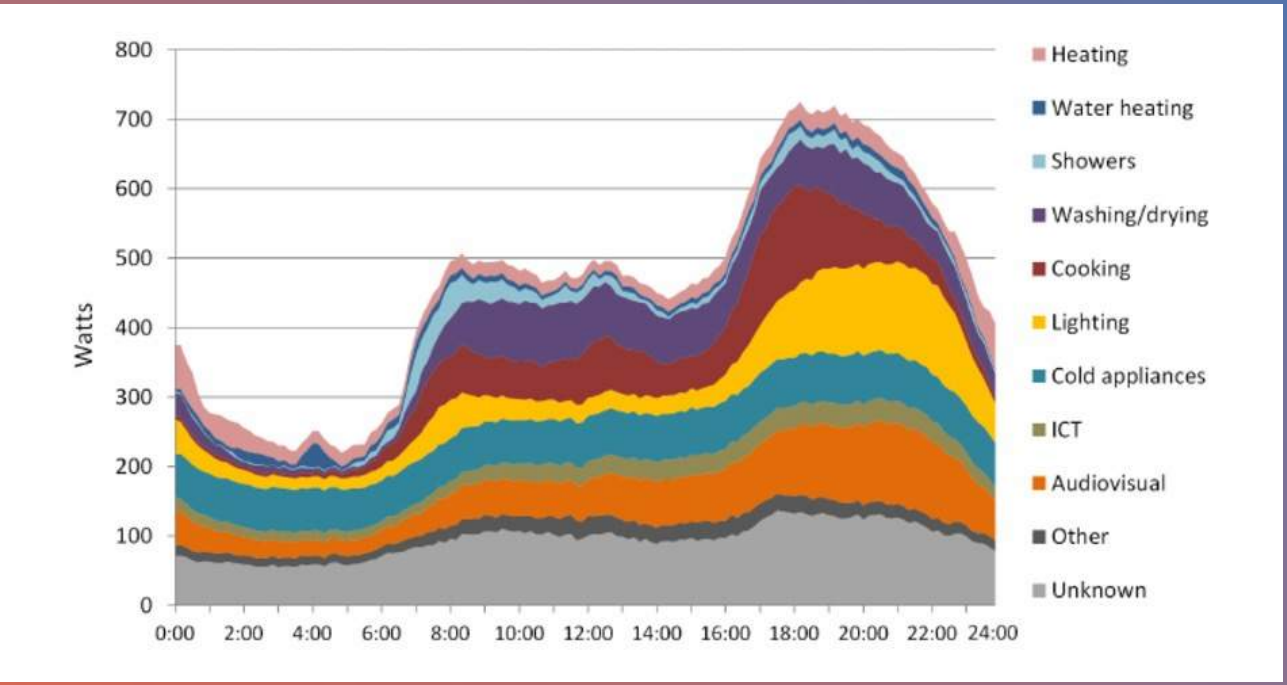


Illustration of the hourly energy consumption of different appliances (per household) source: Jovanovic et al., 2016

- **How much power does the BESS need to supply?** It is critical to know the maximum power needed.
- **For how long does the BESS need to power the load by itself?** In hours or days.
- **What is the selected site's typical climate?** Is it indoors or outdoors? Is there a typical rainy season?
- **How can we access the site?** BESS being heavy, we cannot transport them easily.
- **Is the site well protected from natural disasters and theft?** We have seen BESS being damaged by rhinoceroses...
- **For how long is the BESS supposed to be used?** In years or in number of cycles.
- **Does the client or site require any specific certificates?** There are two main families of Battery Energy Storage standards: those from Underwriters' Laboratories (UL) in North America, and from the International Electrotechnical Commission (IEC).
- **How much should the system cost?** In terms of $, that can be translated into $/kWh, the main data to compare Battery Energy Storage Systems.

> ***Sinovoltaics' advice**: after explaining the concept of usable capacity (see later), it's always wise to ask for a target price for the whole project in terms of $/kWh and $.*

- **When should the BESS be delivered?** There may be a hard deadline to meet.
- **Is this a one-shot project, or a standard product?** In such a case, you may reuse the same product for other projects.

Overall, to fully understand the site's requirements, you need to be able to fill the following table:

BESS' project first overview checklist	
Parameters	**Comment**
Customer name	**Distributor or end user?**
Customer application	**UPS, grid frequency response…**
Grid connection	**On-grid or off-grid**
Other Energy Generation connected	**Solar PV, wind, diesel generator…**
Site location	**City, climate, protection, access**
Charging profile	**In kWh and hours**
Consumption profile	**In kWh and hours**
Target price	**In $**
Target date	**Date**
Volume	**One-shot project?**

Also, at this stage, you should be able to have a good understanding of what the BESS will look like:

- **BESS capacity:** in Kilowatt-hour (kWh) or Megawatt-hour (MWh)
- **BESS power:** in Kilowatt (kW) or Megawatt (MW)
- **Target $/kWh** for the whole system.
- The maximum charging and discharging **C-rate**: for example, 0,5C 1C or 2C
- What is the **voltage range** acceptable to power the load?
- **BESS form factor:** small home storage, 10' 20' or 40' Containerized Energy Storage System (CESS -

one container for both battery and PCS), or grid-scale BESS (with dedicated containers for both batteries and PCS)

- **Grid frequency** in Hertz (Hz)
- **Ingress protection (IP)** requirements. For example, IP55
- **Communication protocol** standard
- **Operating temperature**
- **Humidity rate**
- **Standards** compliance
- **Number of cycles needed**. For example, 6000 cycles.

Sinovoltaics' advice: *we advise our clients to consider only a 70% usable capacity for the BESS because:*

- BESS own consumption can range from 10-15%
- several BMS (Battery Management Systems) do not allow a 100% Depth of Discharge (DoD). Sometimes only 80%
- battery usable capacity will decrease over time. This parameter varies given the cell technology used, cell quality, average cell temperature, and C-rate used. Most of those points must be double confirmed with the BESS manufacturer.

In the end, if the client requires 100kWh for his application, a battery with a capacity of 143kWh should be chosen. At first sight the difference is massive, but you will avoid troubles in the future if you apply this rule of thumb. Plus you will ensure your batteries use a lower C-rate during their lifetime, prolonging the BESS' overall life.

This can be summarized in the table below:

Battery Energy Storage System Specifications checklist

Parameter	Unit
Power	kW or MW
Capacity	kWh or MWh
Price	$/kWh
Maximum Charge/Discharge Rate	C-rate
Voltage range	Volts
(Rough) Dimensions	Form factor or meters
Grid Frequency	Hz
Ingress Protection	IP
Communication protocol	N/A
Operating Temperature	Degrees
Humidity rate	%
Standards	IEC XXXXX, UL XXXX...
Lifecycle	Number of cycles or years

At this stage, we have a good overview of what kind of products we are looking for, and we can start looking for the right partner to work with.

3 REQUEST FOR PROPOSAL (RFP)

Sinovoltaics assists companies with the creation of RFP's. For more information, please get in touch: contact@sinovoltaics.com.

A request for proposal (RFP) is a business document that announces a project, describes it, and solicits bids from qualified contractors to support completing it.

Sinovoltaics' advice: *always introduce extra information to give some context to the supplier, it can only improve the quality of the proposals. For example: site description and what characterizes it (on or off-grid, connected to solar modules etc.), company introduction, missions and ambition. And potential future volume.*

The Request for Proposal should cover multiple aspects of the project:

- Target technical specifications and price
- Supply chain-related information
- Company-related information

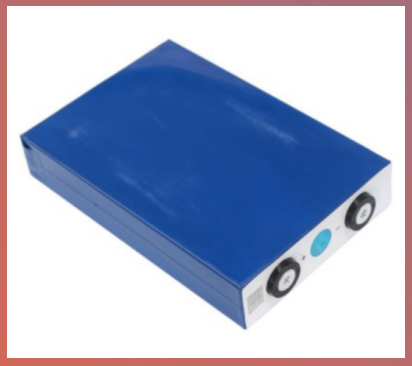
We will cover each of those points in the following sections.

A. Battery Energy Storage System technical specifications

You need to ask for the characteristics of each critical component of your Energy Storage System, namely:

- **Battery:** The battery is the basic building block of a BESS. The first block is the battery cell. When connecting several battery cells in series or/and in parallel, you will create a battery pack (or battery module). When connecting several battery packs in series, you will create a battery rack (or battery string). Usually, the battery rack provider is the same company that designed the battery module. Unless you buy the battery module from a battery cell manufacturer like Samsung, the battery pack manufacturer will buy the cells from a 3rd party. The composition of the battery can be broken into different units as illustrated below.

The 3 blocs of battery*; source: Sinovoltaics*

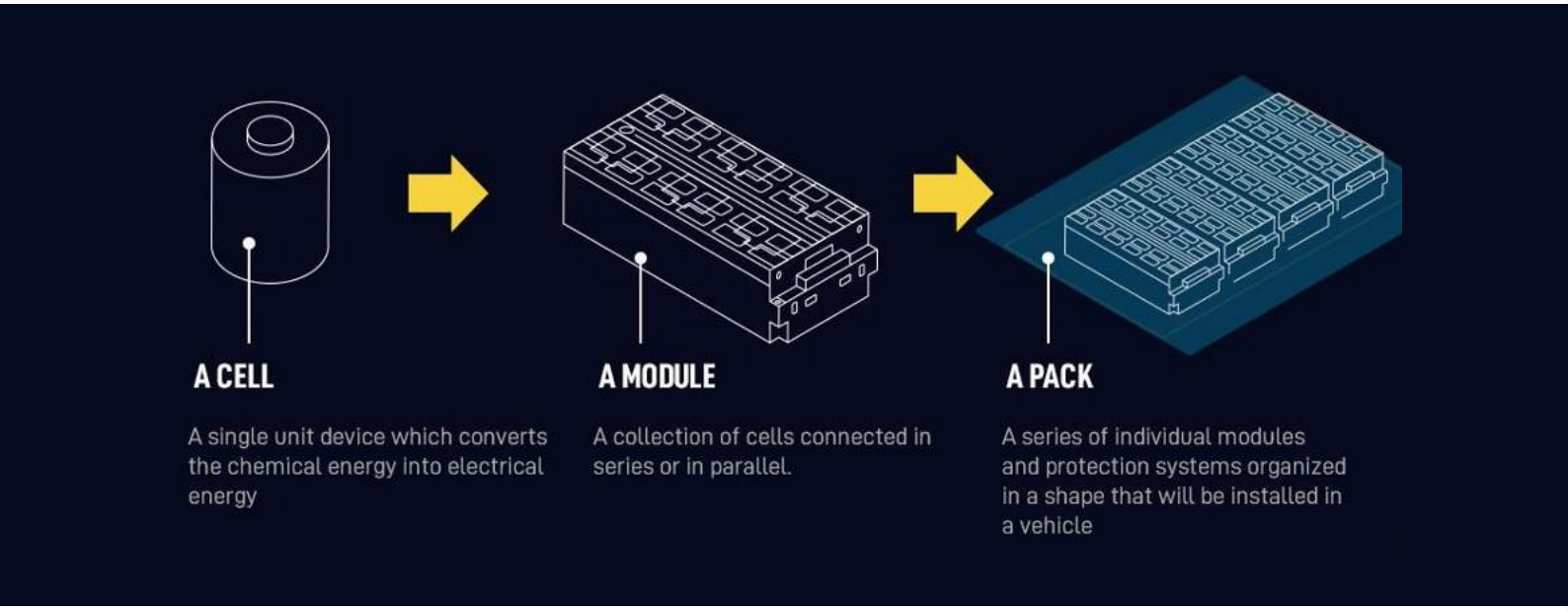


Cell

Pack: mukltiple cells connected in series & parallel

Rack: mukltiple cells connected in series

Note: Batteries are sometimes called Modules and Packs. The main difference is that a Pack contains housing and extra protection. In the Energy Storage System Field, Battery Pack and Battery Module usually refer to the same thing. In the Automotive application, a pack may refer to several modules connected together in the same casing, as illustrated in the picture below:



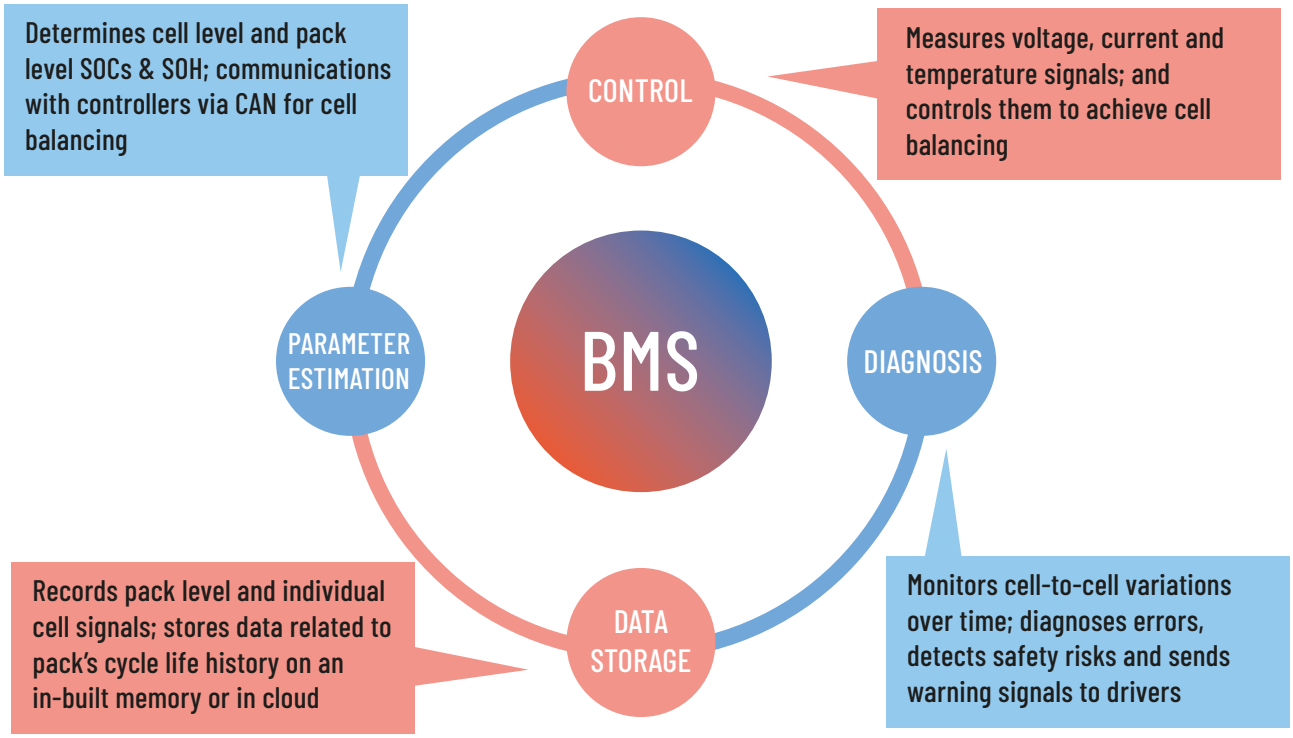
Difference between Battery Pack and Battery Module; source: ACC

- **PCS:** Power Conversion System or Power Conditioning System or Hybrid Inverter. Those devices can convert DC to AC current and AC to DC current, while adapting quickly to the charge or discharge rate needed by the load or by the batteries. This component is more commoditized than the battery part of the Energy Storage System, and you can find components from 50kW to MW-scale power. Just as for the batteries, several PCS can be connected together to increase the BESS' power output.

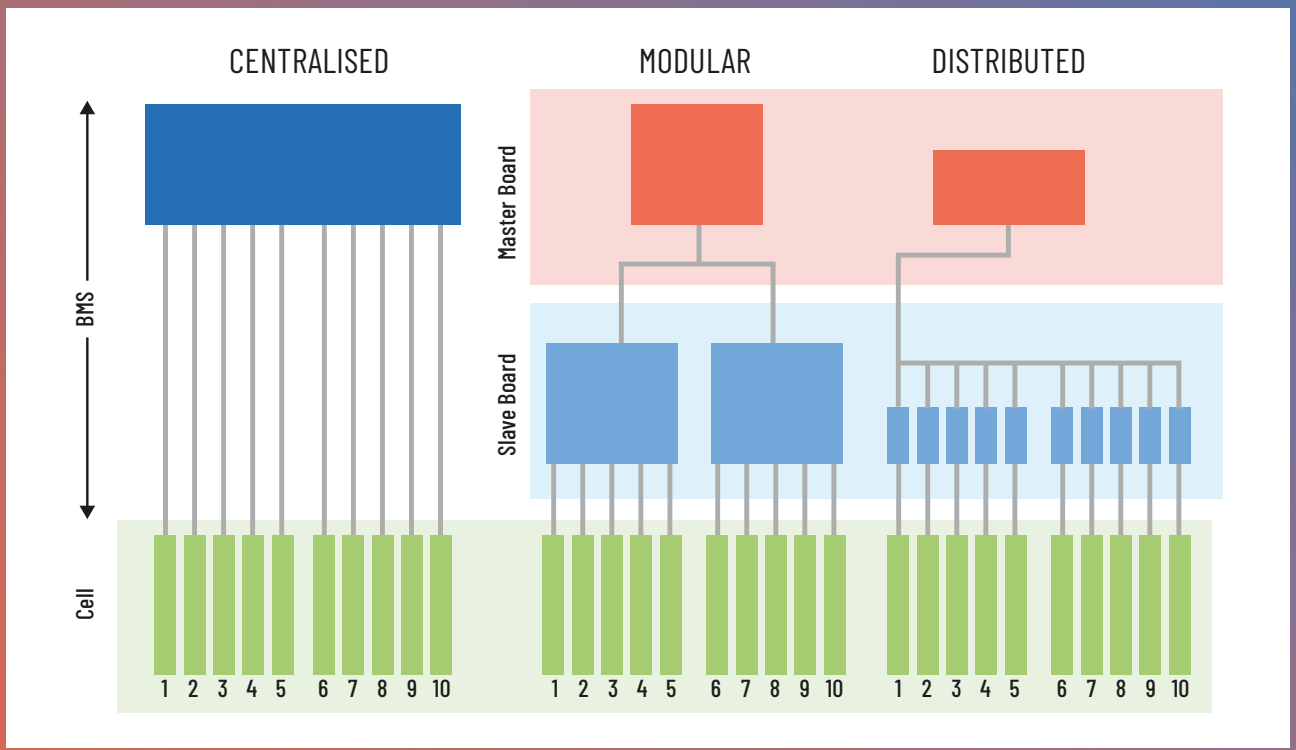
- **BMS:** Battery Management System. The Battery Management System is the brain of the battery pack. "The main goal of BMS is to keep the battery within the safety operation region in terms of voltage, current, and temperature during the charge, the discharge, and in certain cases at open circuit." (Gao, 2015):

Inside a Power Conversion System (PCS); source: Reinhausen, 2021

Battery Management System functionalities; source: Arora et al., 2021



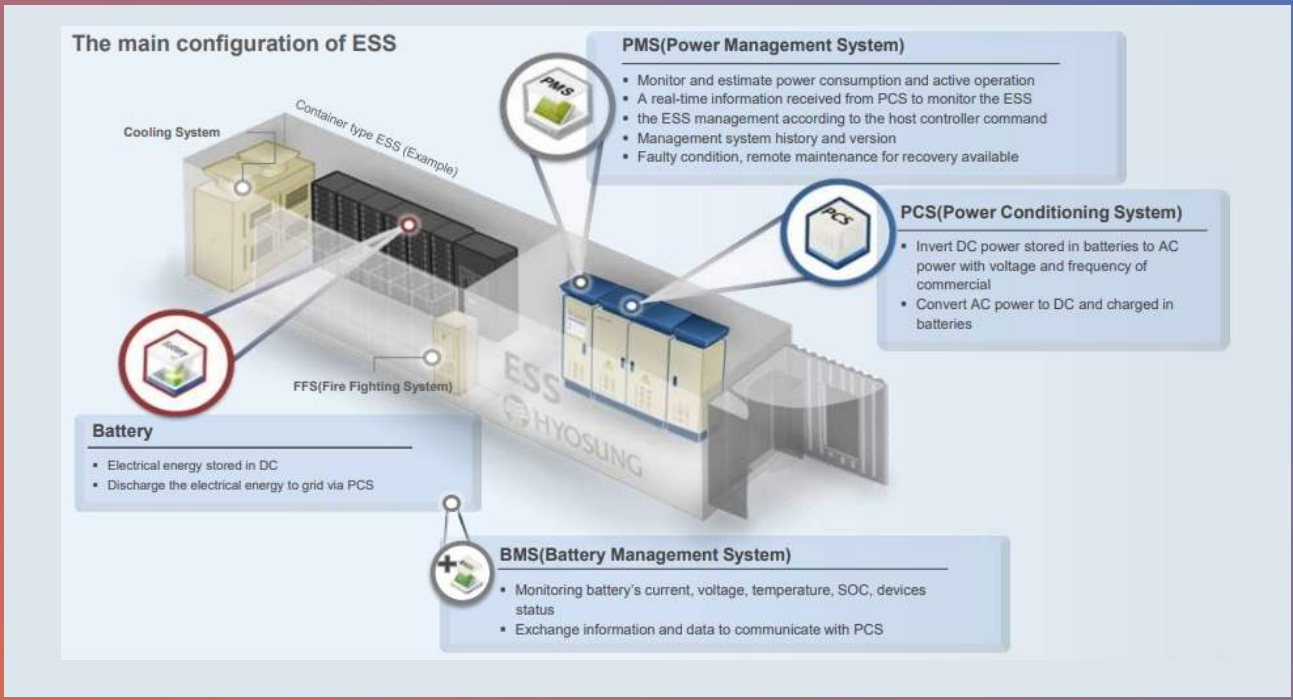
There are three main BMS architectures used in BESS, as described below:



BMS architecture models; source: Cheow, 2020

- **PMS:** Power Management System. The Power Management System monitors and controls the PCS so it can convert AC to DC or DC to AC at the right level. Usually, it is provided by the PCS manufacturer.
- **EMS:** Energy Management System. The Energy Management System uses and controls all the energy resources (solar, wind, load, grid, BESS, EV charger) to optimize the energy consumption.

An illustrative overview of those components can be found below.



The main components of an Energy Storage System; source: Hyosung Heavy Industries

When writing the Request for Proposal, several key technical points must be covered:

BATTERY ENERGY STORAGE SYSTEM COMPONENTS

- **Battery module manufacturer and model:** it is critical for you to understand who designed and manufactured the battery pack you will be using during your project. And what are its standard specifications: has the battery pack already been developed? If so, since when?
- **Battery cell manufacturer:** it is equally critical that you know the battery cell model and specifications: since when this battery cell is on the market. Do a quick research.
- **Battery cell chemistry:** LFP (Lithium iron phosphate – chemical formula LiFePO4) is the main chemistry used in the Battery Energy Storage System industry due to lower cost and increased safety. For some specific applications however, like the ones that have some space requirements and require high charge or discharge rate, NMC (Lithium-Nickel-Manganese-Cobalt-Oxide – chem-

ical formula LiNiMnCoO2) can be the best solution, but it usually comes with higher cost. In any case, you must have a clear understanding of the battery cell chemistry used in your project.

- **Battery Management System manufacturer and model name:** who designed and manufactured the BMS? What is the BMS architecture?
- **Recommended DoD (Depth of Discharge):** how deep can we discharge the batteries for an optimal usage?
- **PCS manufacturer:** same as for the battery side of your Battery Energy Storage System, it is key that you know what the Power Conversion System (PCS) (or Power Conditioning System) manufacturer and model name are.
- **Power Management system manufacturer:** who designed and manufactured the PMS?
- **EMS manufacturer** (might not be application to the use case): is there any EMS provided? If so, who is the manufacturer?

Sinovoltaics' advice: *the more your supplier owns and controls the Battery Energy Storage System value chain (EMS, PCS, PMS, Battery Pack, BMS), the better, as it streamlines any support or technical inquiry you may have during the BESS' life.*

COOLING TECHNOLOGIES

- **Battery pack cooling:** what is the cooling technology used to cool down the battery pack?
- **PCS cooling:** what is the cooling technology used to cool down the PCS?
- **Container cooling:** what is the cooling technology used to cool down the whole container?

The technical specifications can be condensed in the table below:

RFQ Technical Specifications Checklist	
Parameter	**Comments**
Battery module manufacturer & model	**Ask for datasheet and certifications**
Battery cell manufacturer & model	**Ask for datasheet and certifications**
Battery cell chemistry	**LFP, NMC etc.**
Battery Management System manufacturer	**Ask for datasheet and certifications**
Recommended DoD	%
PCS manufacturer & model	**Ask for datasheet and certifications**
Power Management System manufacturer	**Ask for datasheet and certifications**
EMS manufacturer	**Ask for datasheet and certifications**
Battery module cooling system	**Active, passive**
PCS cooling system	**Active, passive**
Container cooling system	**Active, passive**

Now after the technical specifications, we can focus on the supply chain related topics:

B. BESS container and logistics

Now we look at the key aspects regarding the containerization and logistics of your BESS:

- **Container Customization:** do you want the container to be painted in a specific colour? Do you want to print your own company logo on the container?
- **Container dimensions:** how big is the container? Does it fit a standard shipping size (20ft or 40ft container for example)?
- **HS code:** what is the HS (Harmonized System) code for each of the components? This point will directly impact the customs-related costs of your project.
- **UN38.3 certificate:** "Before lithium cells/batteries can be transported in the first place, they must have successfully passed certain tests. These tests simulate transport conditions like pressure, temperature, crush, impact etc. These tests are described in the United Nations manual called "UN manual of tests and criteria". Part III of this manual describes in subsection 38.3 the 8 test modules which in some documents or data sheets are also called T.1 to T.8 test." (Lithium Battery Service, 2021).

Test Series	Content	Lithium Ion Cells/Batteries			
		Cells	Batteries	Single Cell Batteries	Component Cell**
T.1	Altitude Simulation	X	X	X	
T.2	Thermal Test	X	X	X	
T.3	Vibration	X	X	X	
T.4	Shock	X	X	X	
T.5	External Short Circuit	X	X	X	
T.6	Impact / Crush Test	X		X	X
T.7	Overcharge		X	X*	
T.8	Foirced Discharge	X		X	X

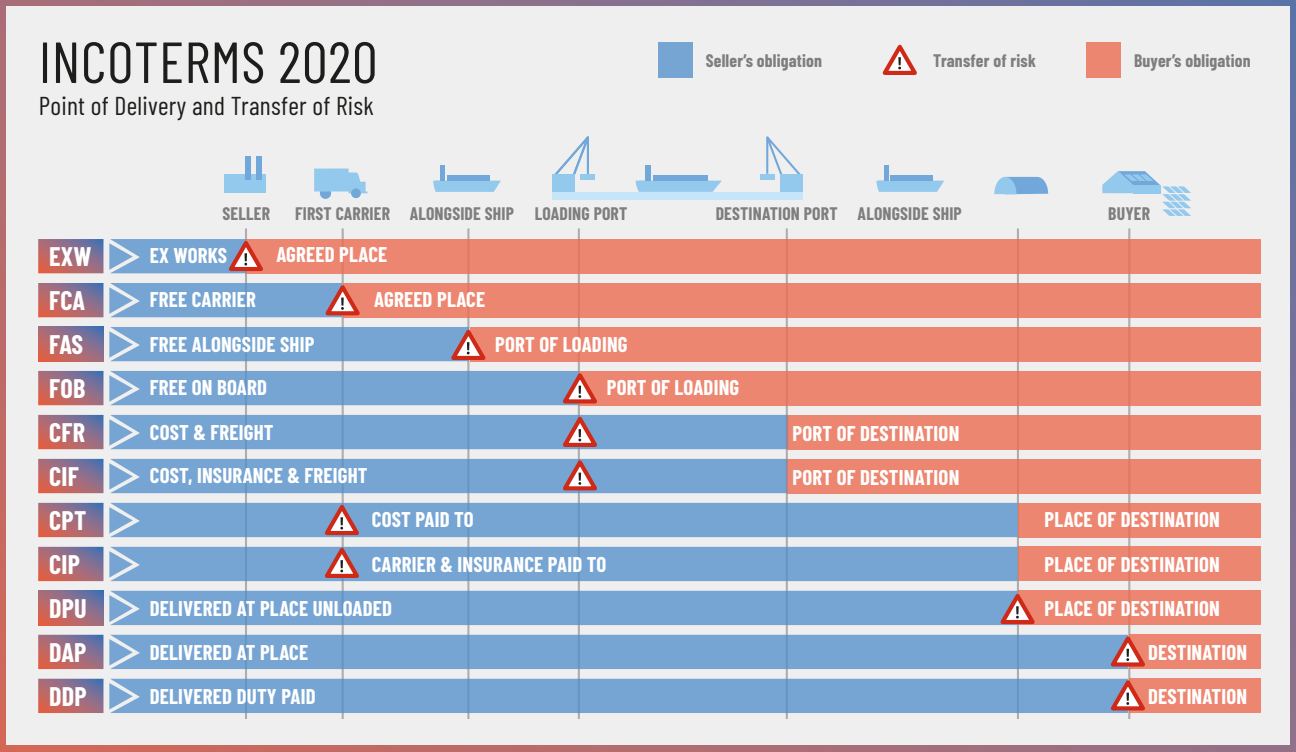
** With overcharge protection*
*** No transport separated from battery, otherwise tests equal those of a cell*

Test Series	Content	Lithium Metal Cells/Batteries			
		Cells	Batteries	Single Cell Batteries	Component Cell**
T.1	Altitude Simulation	X	X	X	
T.2	Thermal Test	X	X	X	
T.3	Vibration	X	X	X	
T.4	Shock	X	X	X	
T.5	External Short Circuit	X	X	X	
T.6	Impact / Crush Test	X		X	X
T.7	Overcharge				
T.8	Foirced Discharge	X		X	X

Test Requirements according to the UN Manual of Tests and Criteria, Subsection 38.3 source: Lithium Battery Service

Sinovoltaics' advice: *it is important that your battery system's supplier shares with you the UN38.3 certificate of the specific batteries you will use. If you use customized battery cells, modules or racks, then the supplier may have to apply again for this certificate. Confirm this point carefully to avoid last minute delays before shipment*

- **Payment terms:** what are the payment terms for this project?
- **Manufacturing time:** what is the manufacturing time for this project? Does that include Factory Acceptance Test duration?
- **Manufacturing location:** where are the supplier's manufacturing lines located?
- **Incoterms:** what is the incoterm used? What is the city or port mentioned in the contract? You can find an overview of the different incoterms below:



Overview of Incoterms 2020; source: Velotrade

Those supply chain related topics can be summarized in the table below:

RFQ Supply Chain Parameters Checklist	
Parameters	**Comments**
Container Customization	Specific logo or colours to use
Container dimensions	In meters for each dimension
Harmonized System (HS) code	Ask for each of the components
UN38.3 certificate available	Ask for certificate
Payment terms	Upfront payment, payment on delivery…
Manufacturing time	In working days or weeks
Manufacturing location	Location
Incoterms	EXW, DDP etc.

Finally, it is important to learn more about your potential BESS solution provider. And what kind of services they provide.

C. BESS supplier's company information

Let's look at the key points we want to understand about the prospective supplier of our BESS:

- **Company size:** how big is the company in terms of revenue and number of employees?
- **Company shareholders**: is the company publicly listed? If not, who are their major investors?

Sinovoltaics' advice: *If the company is publicly listed, it might be interesting to read their annual report.*

With the help of our quarterly Sinovoltaics Energy Storage Manufacturer Ranking Report, you can also check the financial health of your supplier (if publicly listed) which is important in terms of the manufacturer's warranties.

CLICK HERE *to download the latest version.*

Also, it is interesting to search the latest news regarding your supplier. The latest point is valid for both private and public companies.

- **Reference customers:** who are the supplier's previous customers? Any reference projects to share?
- **Shipped capacity in previous 2 years:** how many BESS has the supplier shipped in the last two years (in MWh)?

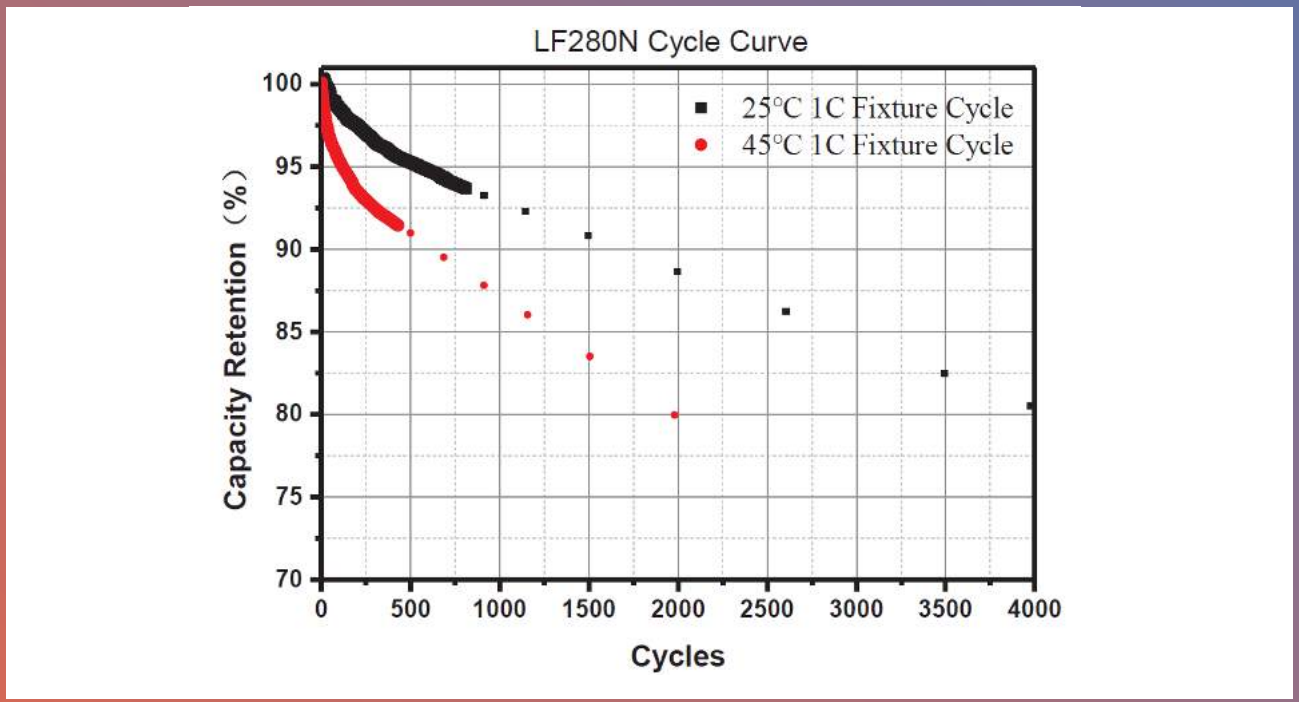
Sinovoltaics' advice: *knowing how many MWh the supplier shipped in the previous recent years will show you how much market share you will represent*

for this supplier. It will be a good indicator of how much bargaining power your company will have in the future. On the other side, it could show that your company orders might be delayed if you only represent a fraction of their market share, while another client represents an extensive amount of market share for that supplier.

COMMISSIONING AND SUPPORT:

- **Offices and support team locations:** are there any support offices? Where are they located?
- **Training to your team:** will any training be provided before the BESS commissioning? If so, how long is the training? And is there any specific certification to pass?
- **Commissioning process:** is there any standard process for commissioning? Does the supplier expect to send someone to your target site?
- **Commissioning cost:** is there any cost associated with the commissioning? Are any potential travel expenses included?
- **Support process:** what is the troubleshooting process? Is there any hotline to contact? Is on-site support possible?
- **Spare parts:** are spare parts provided by the supplier for troubleshooting? For which components? At what cost (if any)?
- **Warranty:** what are the standard warranty durations for each of the critical components? For the battery, it is in both years and number of cycles. In this regard also important to look at: is the warranty insured by reputable financial institutions?
- **Recycling process:** what happens when the BESS are over the cycle life? Is there any local partner taking care of the recycling of the units?

Sinovoltaics' advice: *the warranty for the battery is usually given in number of cycles. Always clarify the conditions to reach that lifecycle (depth of discharge, C-rate, temperature) with the supplier. Those parameters deeply impact the cycle life. So when you compare two cells or two battery packs, ensure that the same parameters are used when comparing cycle life. Ideally, you should get from the supplier a cycle curve as below:*



EVE LF280N Cycle Curve; source: EVE Energy

The information to gather regarding the supplier is listed below:

Supplier Information Checklist	
Parameter	**Comments**
Company size	Revenue, number of employees...
Company shareholders	Public of private
Reference customers	China grid, EDF,...
Shipped capacity in recent 2 years	in MWh
Offices and support team locations	Locations
Training to your team	Any internal certificate to pass?
Commissioning process	Any standard process to follow?
Commissioning cost	in $
Support process	Any standard process available?
Spare parts	Are spare parts provided by the supplier for troubleshooting?
Warranty	In number of cycles and years
Recycling process	This is still a new topic, but better be prepared for that.

Sinovoltaics' advice: *generally, it is better to have a direct collaboration with the battery manufacturer, even though that is sometimes not possible. Power Conversion Systems being commoditized goods, there is usually a more standardized support process to follow.*

At this stage, we can contact potential suppliers, answer their questions, and gather their proposals.

4 SUPPLIER SELECTION

Now that several suppliers have answered your Request for Proposal, you will need to evaluate the different suppliers' feedback and select the partner you will want to work with.

Primarily, you must evaluate the different parameters that you include in the RFQ. We covered that in the previous sections. For the supplier selection process, the importance given to the different parameters won't be commented on, as it is very company and people dependent.

In addition to the parameters already asked, the following points are critical to ensure you select the right supplier.

Technical review: in addition to checking how well the supplier's RFQ answers your technical proposal, it would make sense to check the following parameters:

- **Cross-checking system specifications:** since you have the BESS, the battery pack and the battery cell specifications, you can cross-check the BESS specifications, starting from the battery cell specifications. After calculating the battery pack, and then the BESS specifications (voltage, current, capacity, power etc.) from the number of cells connected in series/parallel, and the number of packs connected in series/parallel, you should find the same BESS specifications provided by the RFQ. If not, do not hesitate to come back to the supplier to explain the differences, you may learn valuable insights.
- **Vertical integration:** What is done in-house by the supplier: BESS, PCS, BMS, PMS, Battery…?
- **Certification body:** who certified the different standards? Are they a renowned company (For example TÜV Rheinland, TÜV Süd)?

Sinovoltaics' advice: *if you are working with suppliers with certifications of some standards in two languages (for example English and Chinese), ask the standards in both languages and compare the two certificates' information. There might be some surprises there.*

Supplier behaviour: note that those parameters are qualitative, and hard to define properly.

- **Reactivity:** how quickly does the supplier answer your questions or requests?
- **Professionalism:** how well does the supplier conduct and behave?
- **English level** (English selected as reference language here, but it could be any other language): Who can speak English? How well?

Sinovoltaics' advice: *ensure that both business and technical stakeholders are able to speak English. If you need to have a supplier's salesperson available each time you are willing to discuss with the technical team (support or R&D), it will quickly become hard to manage.*

The different parameters to evaluate can be outlined in the table at the following page:

Supplier Selection Checklist	
Parameter	**Comments**
Parameters listed in the RFQ	See previous sections
Cross-checking system specifications from battery cells specifications	Major specifications (voltage, current, power, capacity…) to check
Vertical integration	How much is done in-house by the supplier?
Certification body	Who is the certification body?
Site location	How fast are they answering your questions?
Professionalism	Behaviour
English level	Who can speak english? How well?

Now that you have all the information necessary to evaluate the different suppliers, you can select the right partner to work with.

Sinovoltaics' advice: *another important thing to do before selecting the right partner is to perform factory audits of the short-listed suppliers. A professional, thorough audit on-site at the factory to qualify your prospective supplier, performed by accredited and BESS-specialized auditors is a formidable practice to validate these parameters and obtain in-depth insights on the reality of a factory's setup, quality management and manufacturing processes. Sinovoltaics audits factories in Asia on a weekly basis. For more information, please get in touch:*

contact@sinovoltaics.com.

In the next section, we will discuss the contractualization of the project.

5 CONTRACTUALIZATION

The preferred supplier now being selected, we can start legal discussions to agree on a purchase contract for the Battery Energy Storage System.

Agreeing on a contract can be time-consuming and nerve breaking. This report is not a reference legal paper but can give a few tips to look at when contractualization of an Energy Storage System contract.

Several points to include when building the contract of an Energy Storage System:

- **Description of components with critical technical parameters:** power output of the PCS, capacity of the battery etc.
- **Quality standards:** list the standards followed by the PCS, by the Battery pack, the battery cell directly in the contract.
- **Price:** to ensure there is no misunderstanding.
- **Terms & Conditions:** like Incoterms, manufacturing time. This should be the same as in the RFQ. This is also to avoid misunderstandings.
- **Warranty duration:** in terms of cycles and in years. Same as RFQ.
- **Warranty terms:** suppliers usually have a standard warranty terms document to share. Ensure that this is the reference document or add any modification directly in the contact.

This can be summarized in the table below:

Contractualization Checklist	
Parameter	**Comments**
Description of components with critical technical parameters	Same as RFQ
Quality standards	List of standards per component
Price	Same as RFQ
Terms & Conditions	Same as RFQ
Warranty duration	Same as RFQ
Warranty terms	Warranty terms

Also, please do not hesitate to add the following information in the annexes of the contract:

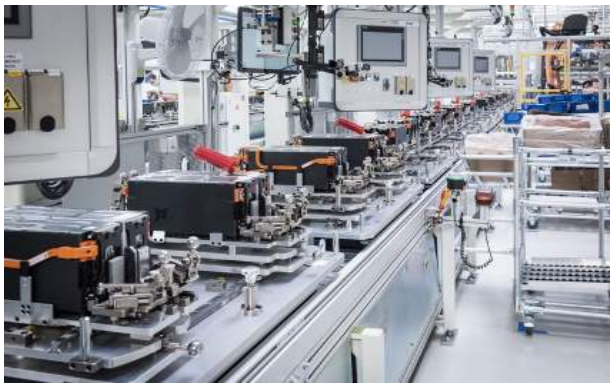
- Latest Request for Proposal (RFQ)
- Battery Energy Storage System, PCS or Battery pack specifications
- Factory Acceptance Test template

Now that the contract is signed, usually a first payment is made, and the manufacturing of the units can start.

6 MANUFACTURING

After the contract signature, the manufacturing of the Battery Energy Storage System can start.

For this section, the best practices from suppliers' management can be applied, and we won't detail them in this report.



Skoda battery manufacturing line; source: Skoda

Energy Storage Systems usually have a long manufacturing time, so we would suggest asking for weekly updates and updated production and FAT schedules from the supplier.

If this is the first time that you are working with BESS, a specific supplier, or a new technology, or in general to have a close tap on the quality of your BESS, it is recommended to make sure the factory is in good shape and all required quality tests are performed:

A starting point is to perform a pre-production factory audit. This allows you to evaluate if the factory is able to perform all required quality tests in-house, and if all manufacturing lines and processes are optimised.

Once production starts, quality inspections can be performed during the entire manufacturing period. There are several interesting milestones to oversee when manufacturing a Battery Energy Storage System:

- Battery pack assembly and testing
- PCS assembly and testing
- Container visual inspection
- Container final assembly

Note: *the order above does not have to be followed. Some suppliers may decide to manufacture the PCS before the battery packs, others do everything at the same time. There is no specific rule there.*

Sinovoltaics' advice: *factory visits can become tricky if you cannot communicate in the local language. It is recommended to bring someone with you (e.g., your quality assurance consultant) that can speak the local language in order to be able to ask questions to the supplier's operators or read some documents. You might also catch an "industrial secret" like a subordinate telling his superior that the factory cleaning operation is not yet completed before your visit (true story).*

Let's now dig into each of those categories:

A. Battery manufacturing and testing

The battery modules and battery racks manufacturing might be outsourced by your BESS' solution provider. To have a comprehensive grip on the quality of your BESS solution, it is highly recommended to visit the Battery Module factory. During the Battery Module manufacturer's visit, you should take care of the following points:

- **Manufacturing environment:** How clean is the battery module assembly line? What are the operators wearing? Is the garment conductive to a clean manufacturing environment?

Sinovoltaics' advice: *due to the reactive nature of lithium with moisture in the air, it is recommended to do battery manufacturing in a clean room in order to ensure a controlled environment (humidity rate, temperature, dust etc). Such standards also ensure proper protection and equipment for the operators. Clean room classifications as per ISO 6 or higher should be met for the production of lithium-ion batteries.*

Below table details the maximum permitted concentration of particles per m3 for each ISO clean room classifier:

DIN EN ISO 14644-1	Maximum permitted concentration (Particle per m^3)					
Class	≤ 0,1 µm	≤ 0,2 µm	≤ 0,3 µm	≤ 0,5 µm	≤ 1,0 µm	≤ 5,0 µm
ISO 1	10					
ISO 2	100	24	10			
ISO 3	1.000	237	102	35		
ISO 4	10.000	2.370	1.020	352	83	
ISO 5	100.000	23.700	10.200	3.520	832	
ISO 6	1.000.000	237.000	102.000	35.200	8.320	293
ISO 7				352.000	83.200	2.930
ISO 8				3.520.000	832.000	29.300
ISO 9				35.200.000	8.320.000	293.000

Clean room classification environment; source: Implasens

- **Standard Operating Procedures (SOP)** for assembly and testing: are SOPs available for each step of the assembly manufacturing steps as well as the testing procedures? Are they easily accessible? Are they regularly updated? Can the language be understood by the operator?

Sinovoltaics' advice: *it is normal behaviour for a supplier to get ready for a quality audit or client visit. We have witnessed elaborated SOP documents arriving on the production line right before a factory visit, though their implementation may differ then in real operations. As such, we would recommend asking an*

operator to show the auditor where the SOPs are. It will allow you to quickly assess if the SOPs are actually used or not. This advice is valid for any component inspection, including battery modules, racks, PCS and so on.

- **Battery Pack tracking:** how are the battery packs tracked? Do they have a unique identification number?
- **Battery cell Incoming Quality Control (IQC):** there is a good chance that the battery cells are bought from a third-party cell manufacturer. As such, how are the cells tested? What sampling level is applied?
- **Battery In-Production Quality Control (IPQC):** what quality control protocol and test procedures does the manufacturer have in place during the production of the (semi-finished) battery? Are the protocols followed by the respective operators?
- **Battery Pack appearance:** after manufacturing, what does the battery pack look like? Are the mechanical dimensions correct?
- **Battery polarity:** is there a clear indication of the polarity for the battery?
- **Battery pack Final Quality Control (FQC) / Outgoing Quality Control (OQC):** which tests are performed? What is the sampling size for each test?
- **Battery test report:** are Battery test reports generated and available for the client?
- **Battery pack storage:** how are the battery packs stored before shipment?

At the end, those sections can be summarized in the checklist below:

Battery Pack Manufacturing and Testing Checklist

Parameter	Comments
Manufacturing Environment	ISO clean room classification, cleanliness
Standard Operating Procedures for Assembly and Test	Should be available, updated, and easily accessible by the operators.
Battery Pack Tracking	Each Battery Pack can easily be identified
Battery Cell IQC	Which tests, any sample size?
Battery Cell IPQC	Which in-line quality control processes, which tests?
Battery Pack Appearance	Any deformation or flow? Correct dimensions?
Battery Polarity	Polarity of the terminal is correct
Battery Pack FQC/ OQC	Capacity test, cycling test etc.
Battery Test Report	Should be available and unique
Battery Pack Storage	Storage conditions

Sinovoltaics' advice: *it is highly recommended to supervise battery pack manufacturing and testing through on-site production monitoring in order to ensure that all applicable manufacturing steps and testing protocols are being complied to, corrective actions are being implemented in timely manner and provided measurement data are accurate.*

The batteries are now produced, tested, and ready for shipment or installation in the Battery Energy Storage System.

B. PCS manufacturing and testing

Same as with the Battery, the PCS manufacturing might be outsourced by your BESS' solution provider. PCS being more commoditized than battery packs, it is however also important to visit your PCS' supplier, and a good practice to monitor production and quality control of your PCS.

When at the PCS manufacturer, following points should be focused on:

- **Manufacturing environment:** how clean is the PCS assembly line? What are the operators wearing?
- **Standard Operating Procedures (SOP) for assembly and testing**: are SOPs available for each step of the assembly manufacturing steps as well as the testing procedures? Are they easily accessible? Are they regularly updated? Can the language be understood by the operator?
- **PCS tracking:** how are the PCS tracked? Do they have a unique identification number?
- **PCS In-Production Quality Control (IPQC):** what quality control protocol and test procedures does the manufacturer have in place during the production of the (semi-finished) PCS? Are the protocols followed by the respective operators?
- **PCS appearance:** after manufacturing, what does the PCS look like? Are the mechanical dimensions correct?
- **PCS Final Quality Control (FQC)/ Outgoing Quality Control (OQC):** which tests are performed? What is the sampling size for each test?
- **PCS test report:** are PCS test reports generated and available for the client?
- **PCS storage:** how are the PCS stored before shipment?

Same as with the batteries, the PCS Manufacturing and Testing checklist is outlined below:

PCS Manufacturing and Testing Checklist	
Parameter	**Comments**
Manufacturing Environment	ISO clean room classification, Cleanliness
Standard Operating Procedures for Assembly and Test	Should be available, updated, and easily accessible by the operators
PCS Tracking	Each PCS can easily be identified
PCS IPQC	Which in-line quality control processes, which tests?
PCS Appearance	Any deformation or flow? Correct dimensions?
PCS FQC/ OQC	Electrical tests, final tests
PCS Test Report	Should be available and unique
PCS Storage	Storage conditions

The PCS are now produced, tested, and ready for shipment or installation in the Battery Energy Storage System.

C .Container assembly

Container manufacturing can take (a lot of) space. If your project requires a 40ft container, your container manufacturing will probably take place outdoors. During that step, several points need to be looked at:

- **Manufacturing environment:** no clean room required here, but is there any risk of electrocution following a heavy rain?

Sinovoltaics' advice: *BESS' Factory Acceptance Testing generally happens at the same location as the BESS' assembly steps. Consequently, the BESS might stay days, if not weeks, at the same location. If the soil can become muddy after a heavy rain, it might become problematic to safely operate or move the BESS in that environment. Also, the BESS should not be exposed to looting, and be correctly secured at night.*

- **Protection for outdoors assembly:** Are any protections (e.g. tents) there to protect water, wind or excessive dust to penetrate inside the Battery Energy Storage System?

Sinovoltaics' advice: *Check that the tents or protective gear used to protect rain from entering the BESS can also withstand moderate wind gust as they will otherwise be fairly useless.*

- **Standard Operating Procedures for Assembly:** are the BESS' assembly instructions available for each step of the manufacturing? Are they regularly updated? Can the language be understood by the operator?
- **BESS tracking:** are the BESS uniquely identified? Can you trace which batteries & PCS are mounted in it?
- **HVAC correctly installed:** are the HVAC correctly mounted and not loose?
- **Safety systems correctly installed:** are all safety systems in place and ready to operate?
- **Ingress protection rating:** does the BESS meet at minimum an ingress protection rating of IP55?
- **BESS appearance:** is there any deformation? Any difficulties to close or open a door?
- **BESS customization:** are the client's logo and company colours correctly used? Are the logos at the correct location?

Those questions can be summarized in the table below:

Container Assembly Checklist	
Parameter	**Comments**
Manufacturing Environment	No risk of floodings or electrocution
Protection for Outdoors Assembly	Tents, protection etc.
Standard Operating Procedures for Assembly	Should be available, updated, and easily accessible by the operators
BESS Tracking	Each BESS can easily be identified, as well as its components
HVAC Installation	Should be correctly sealed
Safety Systems Installation	No components should be missing
Ingress Protection Rating	What ingress protection (IP) rating does the BESS comply to?
BESS Appearance	Any deformation or flow? Correct dimensions?
BESS Customization	Correct colour pattern, logo at the right dimensions and location?

The BESS is now fully assembled, and ready for the Factory Acceptance Test (FAT).

7 FACTORY ACCEPTANCE TESTING (FAT)

The Energy Storage System is finally assembled, and the supplier can proceed with the Factory Acceptance Testing (FAT).

Sinovoltaics' advice: *If you can be there for the Factory Acceptance Test, try to join. You will be able to see your Battery Energy Storage System for the first time and learn more about its functionalities and performances. In general, your quality assurance consultant can support you here to witness those tests and review the FAT protocol and validate the measured data.*

Regarding Battery Energy Storage System Testing, IEEE 1547-2018 (Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces) lists each possible test. The standard is updated every two to three years, but it does not describe FAT tests precisely.

However, it is a good database of potential tests to perform. In any case, the tests we will cover in this section are relevant to perform during a FAT.

A. BESS' interconnection verification

The first step of the Factory Acceptance Testing (FAT) is to test that the different components work well together as part of the BESS. This will confirm the cross functionality of the different components:

- **BESS components discovery:** Are the PCS, Battery, HVAC identified as working normally by the BESS?
- **Verification of sensors, metering, and alarms:** Are all the sensors and alarms identified by the BESS, and working as intended?
- **Verification of the Human-Machine Interface (HMI):** Are newly input parameters taken into account by the Energy Storage System?

Typical BESS' Human Machine Interface (HMI); source: Ampd Energy

- **Verification of remote control and monitoring:** Can the BESS be monitored & controlled correctly?

This section of the FAT is detailed in the table at the following page:

FAT's BESS Interconnection Verification Checklist	
Parameter	**Comments**
BESS Components Discovery	**All subsystems must be correctly identified**
Verification of sensors, metering, and alarms	**All components must be working correctly**
Verification of HMI	**Must be working as intended**
Verification of remote control and monitoring	**Must be working as intended**

Now that we know that the BESS is responding correctly to the input commands, we can proceed with the BESS' specifications verification phase.

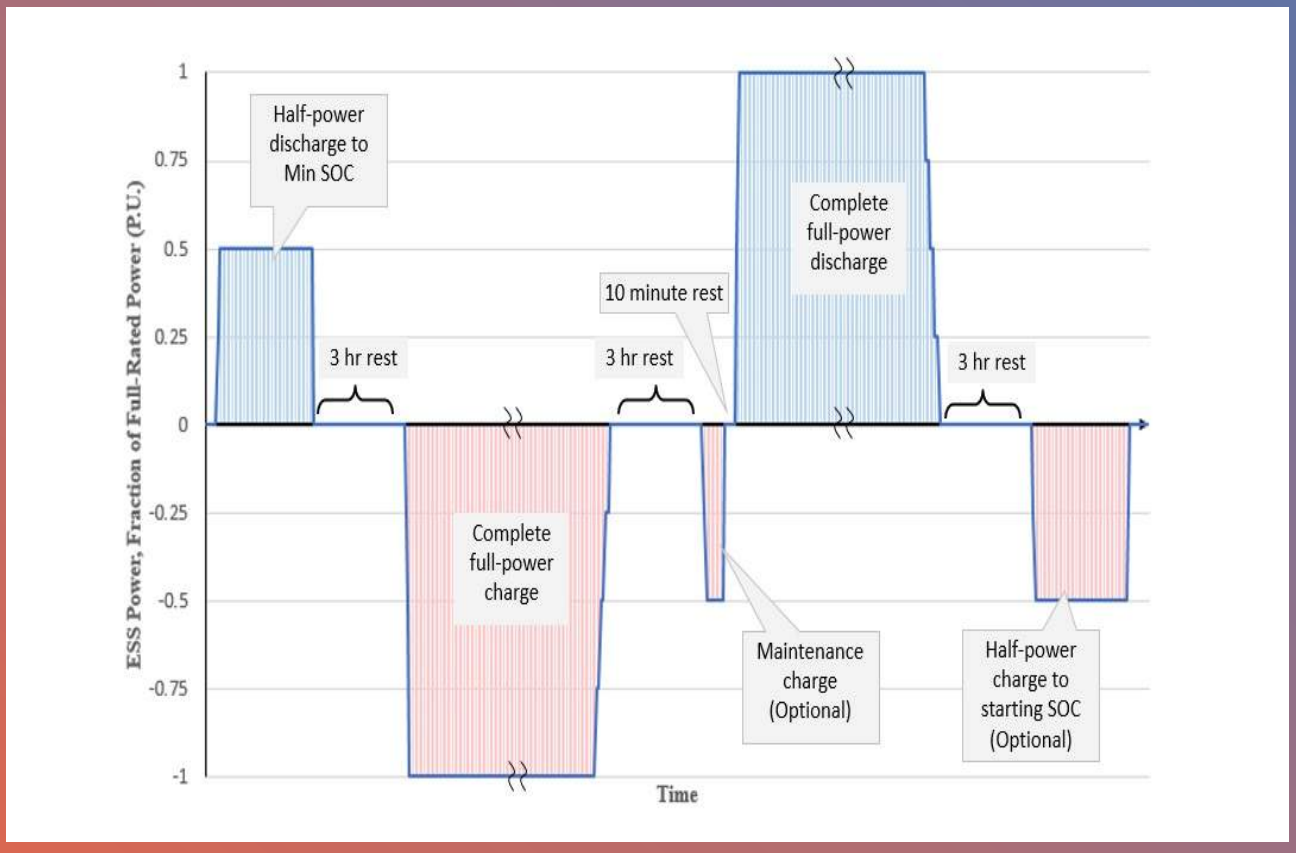
B. BESS' specifications verification

Sinovoltaics' advice: *Before proceeding with the BESS' FAT, cross-check the supplier's capability to be sure that they have the right equipment to perform the tests you want. A classic example is to test a big PCS with undersized load banks.*

Various tests can be performed to confirm the BESS specifications. In this section, we will detail several tests to be performed to confirm the Energy Storage System's performances:

POWER & ENERGY PERFORMANCE TESTS:

For this test, the duty cycle is as below:



Operation performance test charging & discharging profile; source: ESIC

From this profile, you can extract the following information to evaluate your BESS' performances:

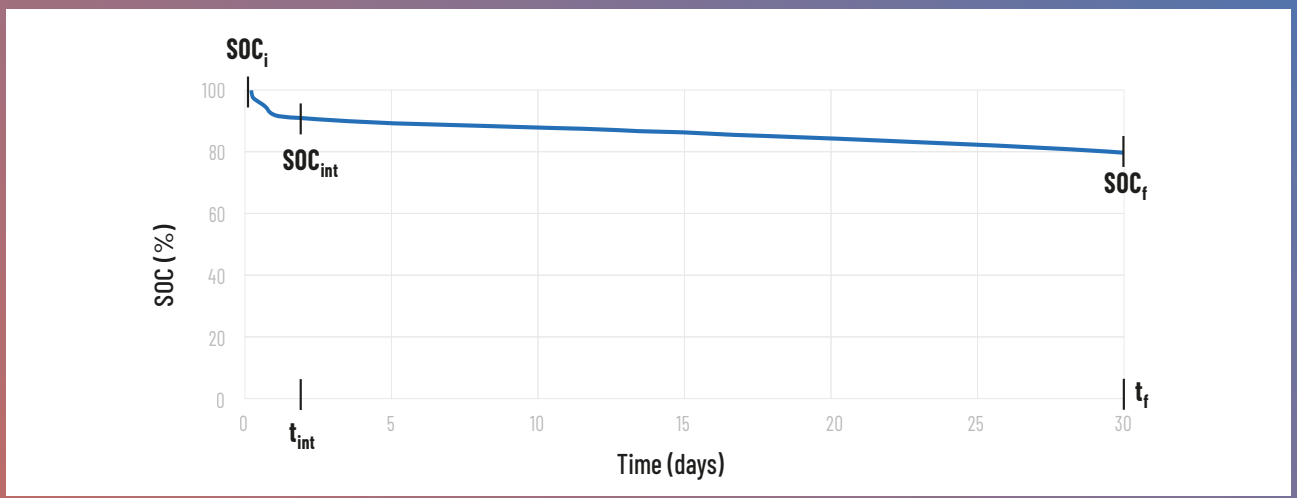
- **Available Energy Capacity for charging:** how much energy was used to fully charge the BESS: it can be done for 50% SoC & 100% SoC
- **Charge Duration:** how long did it take to charge the BESS? It can be done for multiple SoC
- **Rated continuous active charge power:** what was the average AC rated power value delivered during BESS charging?
- **Available Energy Capacity for discharging:** how much energy was outputted to fully discharge the BESS: it can be done for 50% SoC & minimum SoC
- **Discharge Duration:** how long did it take to discharge the BESS? It can be done for multiple SoC
- **Rated continuous active discharge power:** what was the average AC rated power value delivered during BESS discharging?
- **Round trip efficiency:** what is the ratio between the Available Energy Capacity for discharging and the Available Energy Capacity for charging?

The Power and Energy performance tests are listed below:

FAT's Power & Energy Performance Checklist	
Parameter	**Unit**
Available Energy Capacity for charging	kWh
Charge Duration	time
Rated continuous active charge power	kW
Available Energy Capacity for discharging	kWh
Discharge Duration	time
Rated continuous active discharge power	kW

SELF-DISCHARGE RATE PERFORMANCE TEST:

For this test, we need to let idle a fully charged BESS so we can evaluate the BESS' own consumption, and the impact on its SoC. Usually, a BESS has the following discharging curve, with a bigger ramp at the beginning.



Operation performance test charging & discharging profile; source: ESIC

As you can see from the curve above, this test can take time to be performed, especially to determine the longer-term trend. Depending on the time available, you can decide to focus solely on the short-term ramp.

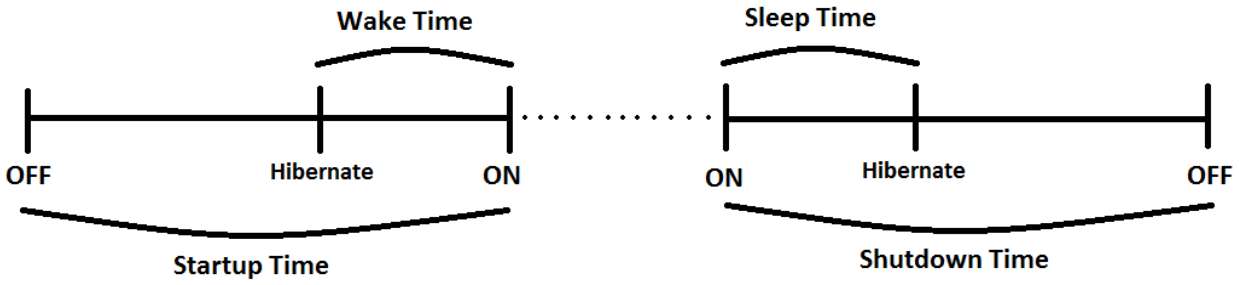
- **Intermediate State of Charge (SOCint):** what is the SOC of the BESS after X amount of time? You can take multiple intermediate points.
- **Final State of Charge (SOCf):** what is the SOC of the BESS at the end of the rest/idle period?
- **Intermediate Time (tint):** how long of self-discharge until the BESS reaches the intermediate SOC? You can take multiple intermediate points.

The Self-discharge performance tests parameters are reminded in this table:

FAT's Self-Discharge Performance Checklist	
Parameter	**Unit**
Intermediate State of Charge	%
Final State of Charge	%
Intermediate time	time

STARTUP AND SHUTDOWN PERFORMANCE TEST:

The goal of this test is to evaluate the duration of the BESS startup and shutdown sequences. From both a black-start or from a "hibernation"/stand-by state, as shown below:



Startup time, Wake time, Sleep time and Shutdown time definitions; source: ESIC

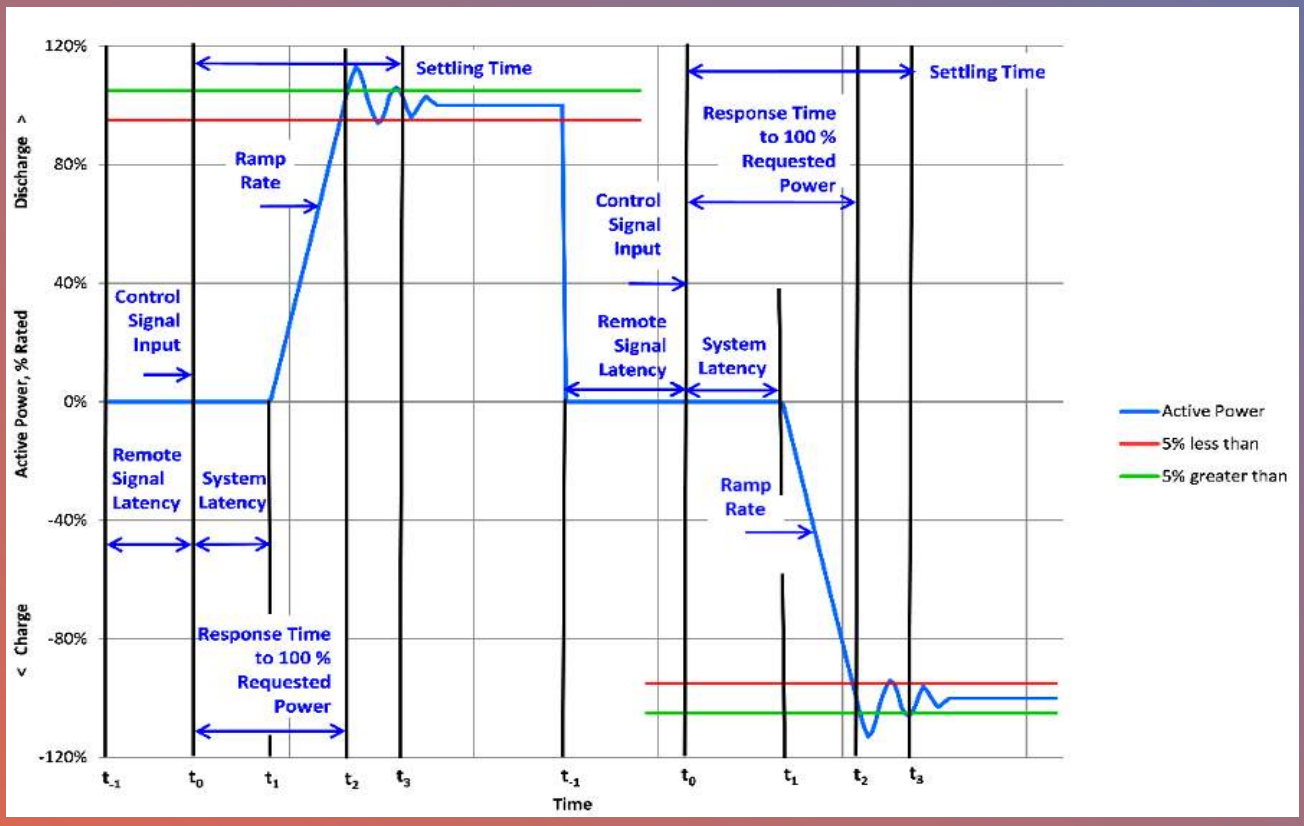
- **Startup time:** how long does it take to power-on the Battery Energy Storage System from an OFF-mode?
- **Wake time:** how long does it take to power-on the Battery Energy Storage System from a Hibernate-mode?
- **Shutdown time:** how long does it take to power-off the Battery Energy Storage System from an ON-mode?
- **Sleep time:** how long does it take to hibernate the Battery Energy Storage System from an ON-mode?

As for the previous tests, they are listed in the table at the following page:

FAT's Startup and Shutdown Performance Checklist	
Parameter	**Unit**
Startup time	time
Wake time	time
Shutdown time	time
Sleep time	time

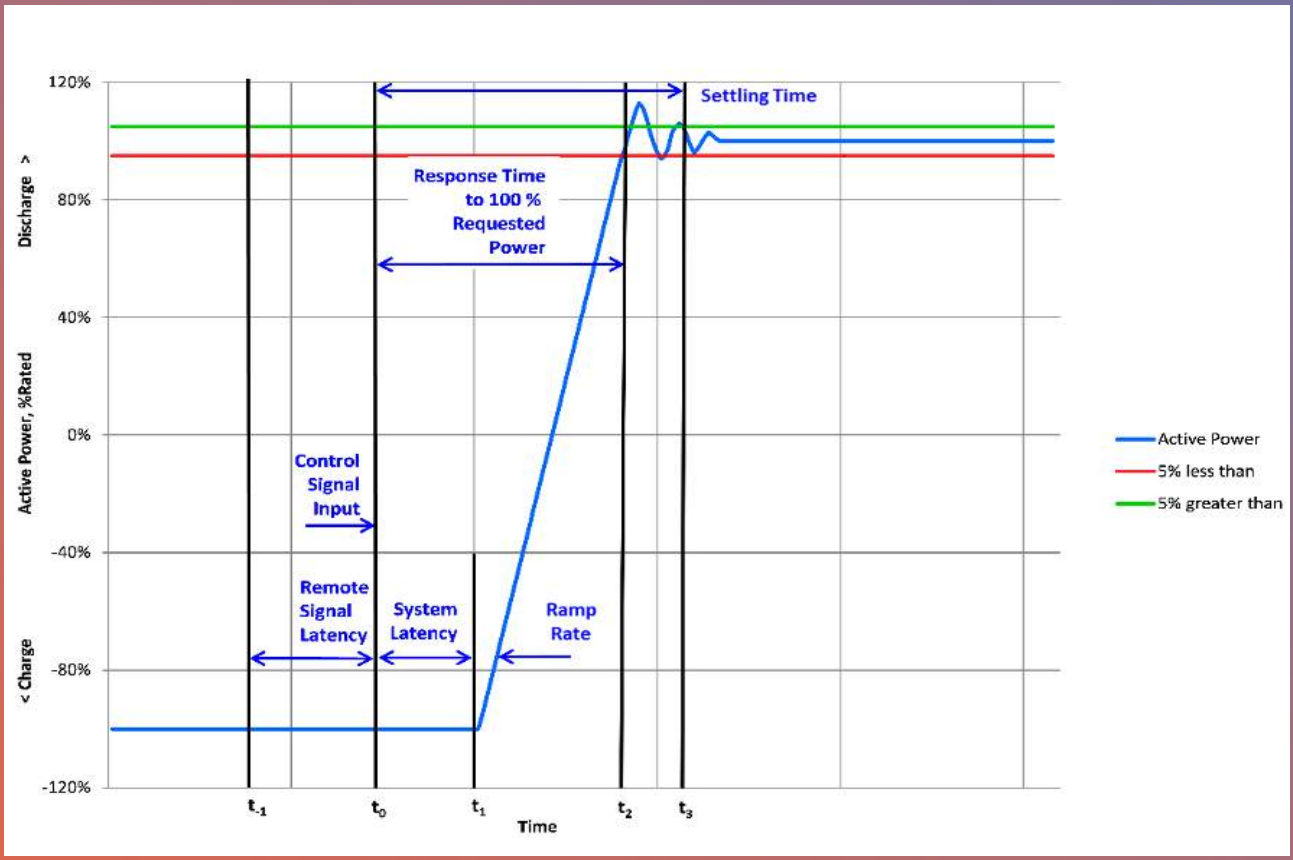
RESPONSE PERFORMANCE TEST:

This idea here is to evaluate how quickly, and how well does the BESS react to an input command. It is interesting to evaluate this firstly from a "same direction" command change (from 0% charge to 100% charge for example) as below:



Full charge and full discharge response tests profile; source: ESIC

And from a bidirectional change (from discharge to charge for example) as below:



Bidirectional response tests profile; source: ESIC

In each case, it is interesting to evaluate the following parameters:

- **System Latency:** how long between the command and the start of the BESS response?
- **Response Time:** how long between the command and the measured targeted power?
- **Settling Time:** how long between the command and a stabilized targeted power?
- **Ramp Rate:** what is the EES power increase/decrease per unit of time?

Overall, it can be listed in the table below:

FAT's Response performance checklist	
Parameter	**Unit**
System Latency	time
Response Time	time
Settling Time	time
Ramp Rate	power / time

We can now proceed to application specific tests, if any.

C. Application specific tests

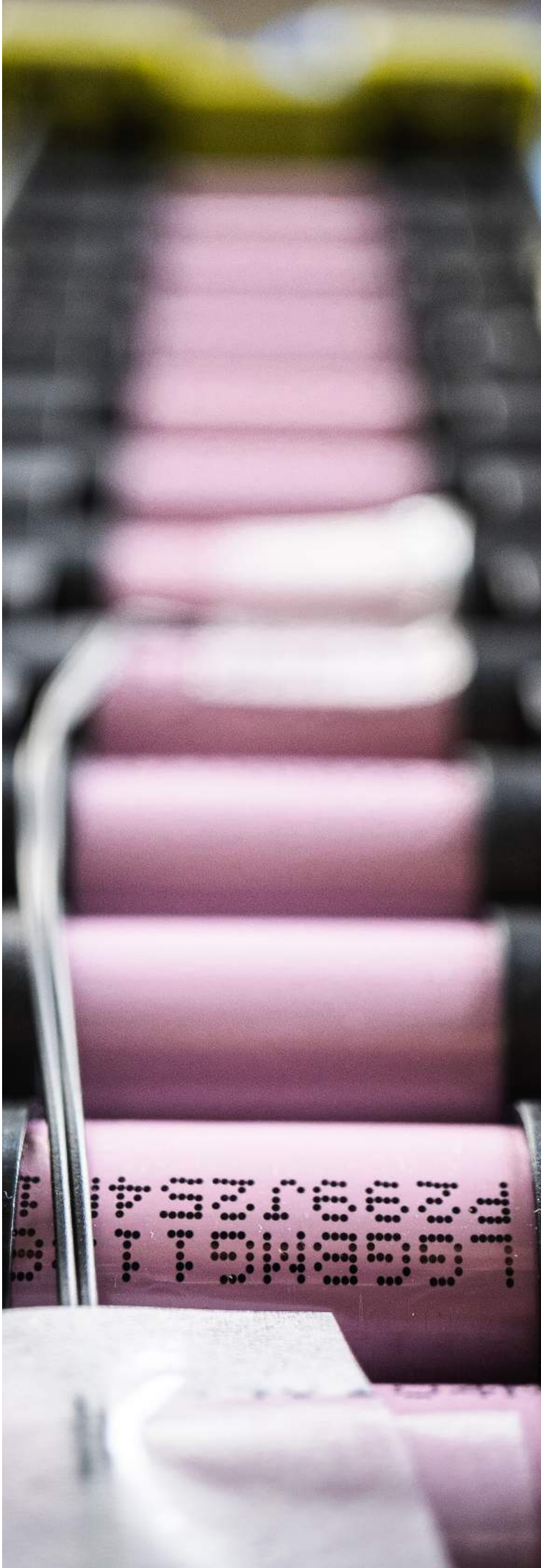
Additional tests are relevant to perform during the Factory Acceptance Test (FAT) to confirm the correct BESS' behaviour in specific applications:

- BESS' response based on price signal (section 7 of ESIC - Energy Storage Test Manual). For example, the BESS response to abnormal voltage.
- BESS' response based on a measured frequency signal (Hz) (section 8 of ESIC - Energy Storage Test Manual). For example, the BESS response to abnormal voltage.
- DC-coupled solar + storage systems (section 9 of ESIC - Energy Storage Test Manual)

Those tests being application specific, and well explained in the ESIC's Energy Storage Test Manual, they won't be covered in that report.

The FAT is now completed, and the BESS is ready to be shipped.

Sinovoltaics' advice: *Depending on your BESS and the vessel you will use, you may have to ship some components like the batteries separately. Vessel captains sometimes refuse to handle batteries on their ship. Check with the supplier beforehand to ensure if that case applies to your project. If so, check that you have the correct installation instructions for when you will receive the units on site.*



8 BESS TRANSPORTATION

Given the Battery Energy Storage System's dimensions, BESS are usually transported by sea to their destination country (if trucking is not an option), and then by truck to their destination site.

A. Logistics

The consequence is that the shipment process can be worrisome. It is sometimes hard to get regularly updated information about your shipment vessel's location while it is in the middle of the ocean for weeks.

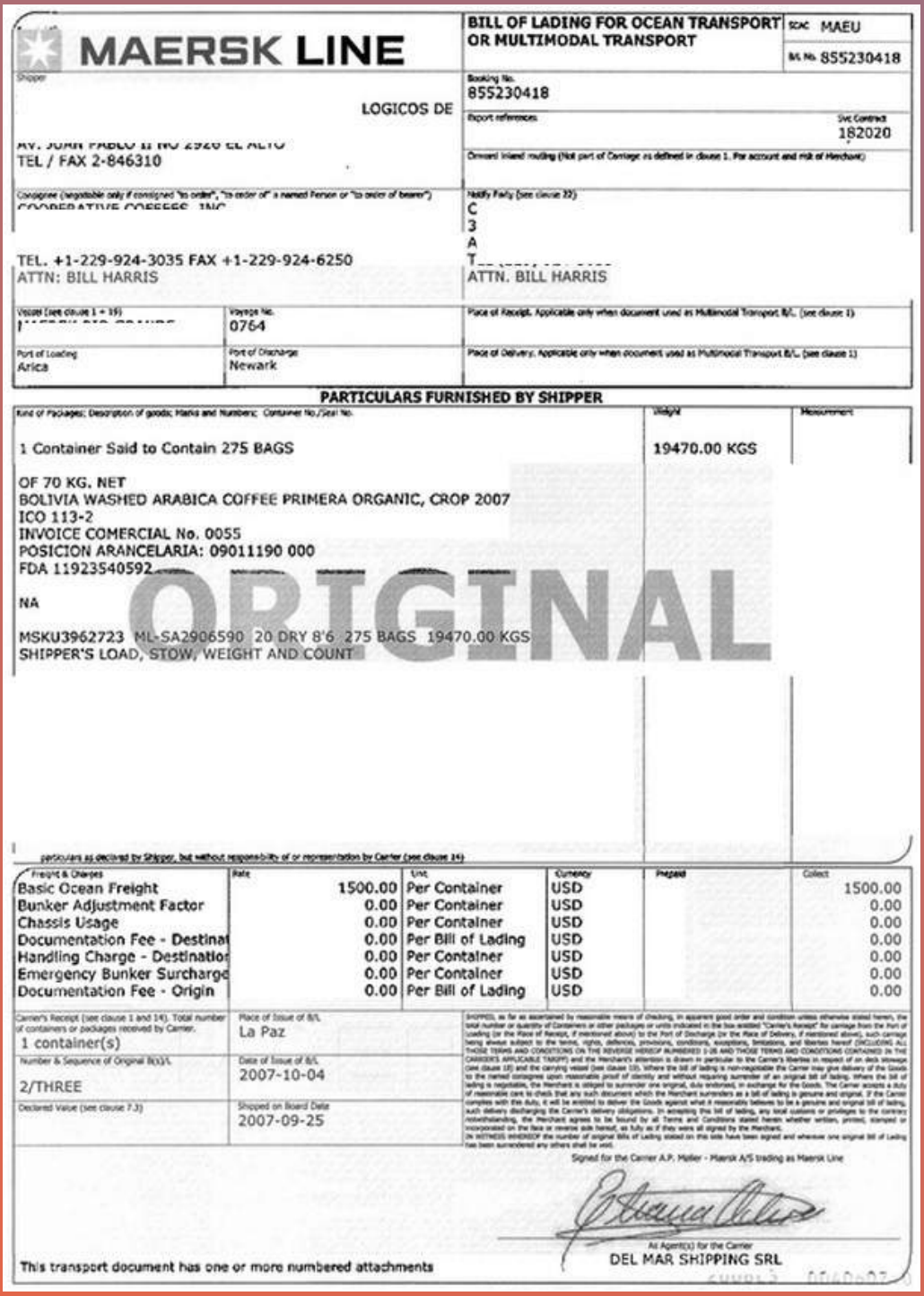
Note: The latest edition of this guide is from 2022, when the Covid-19 pandemic triggered massive logistics cost increase, and multiple shipment delays. It is hard to anticipate how the situation will evolve in the next months or years, but some of the parameters discussed may gain in importance, while others become redundant.

Sinovoltaics advice: *even though you cannot book vessels weeks in advance, some time needs to be spent on the destination country's customs process. This process can be extremely time consuming, as well as costly. Evaluating those needs before buying the partner's solution is the right thing to do.*

In order to anticipate and evaluate the competitiveness of your company's logistics process, several points are relevant to check when shipping a Battery Energy Storage System:

- **Time needed to book a vessel:** how long does it take to book a vessel?
- **Vessel information:** what is the vessel name and identification number?
- Time between vessel booking and shipment: how long does it take to ship the BESS after booking?
- **Delay between Estimated Time of Departure (ETD) and actual departure:** Any delay occurred?
- **Bill of Lading:** a bill of lading (BL or BoL) is a legal document issued by a carrier to a shipper that describes the type, quantity, and destination of the goods being carried. A bill of lading also serves as a shipment receipt when the carrier delivers the goods at a predetermined destination.

Sinovoltaics advice: *if you are subcontracting the logistics aspect of your BESS project, the Bill of Lading can be a good trigger point for a payment, as it proves that the BESS is actually on the right vessel.*



MAERSK LINE

BILL OF LADING FOR OCEAN TRANSPORT OR MULTIMODAL TRANSPORT

SCAC MAEU

B/L No. 855230418

Booking No. 855230418

Export references

Svc Contract 182020

Onward inland routing (Not part of Carriage as defined in clause 1. For account and risk of Merchant)

Shipper

LOGICOS DE

AV. JUAN PABLO II NO 2926 EL ALTO

TEL / FAX 2-846310

Consignee (negotiable only if consigned "to order", "to order of" a named Person or "to order of bearer")

COOPERATIVE COFFEES INC

TEL. +1-229-924-3035 FAX +1-229-924-6250

ATTN: BILL HARRIS

Notify Party (see clause 22)

C

3

A

T

ATTN. BILL HARRIS

Vessel (see clause 1 + 19)

Voyage No. 0764

Port of Loading Arica

Port of Discharge Newark

Place of Receipt. Applicable only when document used as Multimodal Transport B/L. (see clause 1)

Place of Delivery. Applicable only when document used as Multimodal Transport B/L. (see clause 1)

PARTICULARS FURNISHED BY SHIPPER

Kind of Packages; Description of goods; Marks and Numbers; Container No./Seal No. | Weight | Measurement

1 Container Said to Contain 275 BAGS | 19470.00 KGS

OF 70 KG. NET
BOLIVIA WASHED ARABICA COFFEE PRIMERA ORGANIC, CROP 2007
ICO 113-2
INVOICE COMERCIAL No. 0055
POSICION ARANCELARIA: 09011190 000
FDA 11923540592

NA

MSKU3962723 ML-SA2906590 20 DRY 8'6 275 BAGS 19470.00 KGS
SHIPPER'S LOAD, STOW, WEIGHT AND COUNT

ORIGINAL

particulars as declared by Shipper, but without responsibility of or representation by Carrier (see clause 14)

Freight & Charges	Rate	Unit	Currency	Prepaid	Collect
Basic Ocean Freight	1500.00	Per Container	USD		1500.00
Bunker Adjustment Factor	0.00	Per Container	USD		0.00
Chassis Usage	0.00	Per Container	USD		0.00
Documentation Fee - Destinat	0.00	Per Bill of Lading	USD		0.00
Handling Charge - Destinatio	0.00	Per Container	USD		0.00
Emergency Bunker Surcharge	0.00	Per Container	USD		0.00
Documentation Fee - Origin	0.00	Per Bill of Lading	USD		0.00

Carrier's Receipt (see clause 1 and 14). Total number of containers or packages received by Carrier.
1 container(s)

Number & Sequence of Original B(s)/L
2/THREE

Declared Value (see clause 7.3)

Place of Issue of B/L
La Paz

Date of Issue of B/L
2007-10-04

Shipped on Board Date
2007-09-25

SHIPPED, as far as ascertained by reasonable means of checking, in apparent good order and condition unless otherwise stated herein, the total number or quantity of Containers or other packages or units indicated in the box entitled "Carrier's Receipt" for carriage from the Port of Loading (or the Place of Receipt, if mentioned above) to the Port of Discharge (or the Place of Delivery, if mentioned above), such carriage being always subject to the terms, rights, defences, provisions, conditions, exceptions, limitations, and liberties hereof (INCLUDING ALL THOSE TERMS AND CONDITIONS ON THE REVERSE HEREOF NUMBERED 1-26 AND THOSE TERMS AND CONDITIONS CONTAINED IN THE CARRIER'S APPLICABLE TARIFF) and the Merchant's attention is drawn in particular to the Carrier's liberties in respect of on deck stowage (see clause 18) and the carrying vessel (see clause 19), where the bill of lading is non-negotiable the Carrier may give delivery of the Goods to the named consignee upon reasonable proof of identity and without requiring surrender of an original bill of lading. Where the bill of lading is negotiable, the Merchant is obliged to surrender one original, duly endorsed, in exchange for the Goods. The Carrier accepts a duty of reasonable care to check that any such document which the Merchant surrenders as a bill of lading is genuine and original. If the Carrier complies with this duty, it will be entitled to deliver the Goods against what it reasonably believes to be a genuine and original bill of lading, such delivery discharging the Carrier's delivery obligations. In accepting this bill of lading, any local customs or privileges to the contrary notwithstanding, the Merchant agrees to be bound by all Terms and Conditions stated herein whether written, printed, stamped or incorporated on the face or reverse side hereof, as fully as if they were all signed by the Merchant.
IN WITNESS WHEREOF the number of original Bills of Lading stated on the side have been signed and whereof one original bill of Lading has been surrendered any others shall be void.

Signed for the Carrier A.P. Møller - Mærsk A/S trading as Maersk Line

As Agent(s) for the Carrier
DEL MAR SHIPPING SRL

This transport document has one or more numbered attachments

Example of a Bill of Lading; source: Knowledge of Sea

- **Vessel transportation time:** how long did it take to transport the unit by sea?
- **Delay between the Estimated Time of Arrival (ETA) and actual arrival:** any delay occurred?
- **Customs process documents needed:** what are the documents needed by the customs authority to clear your shipment?
- **Customs process duration:** how long did it take to clear the customs clearance process?

- **Customs import duties:** how much do the import duties and process cost?
- **Site transportation means:** how will you move the BESS from the vessel to your destination site?
- **Site transportation duration:** how long did it take to transport the BESS from the port to the destination site?
- **Logistics process duration:** how long did it take to complete the whole logistics process?

Those topics can be summed up in the table below:

Logistics Key Performance Indicators & Checklist	
Parameter	**Comments**
Time needed to book a vessel	Time
Vessel information	Name and ID
Time between vessel booking and shipment	Time
Delay between ETD and actual departure	Time
Bill of Lading	Official document
Vessel transportation time	Time
Delay between ETA and actual arrival	Time
Customs process documents needed	List of documents
Customs process duration	Time
Customs import duties	In %
Site transportation means	Specific truck needed?
Site transportation duration	Time
Logistics process duration	Time

B. Battery transportation

As mentioned in the Request for Proposal section, the UN38.3 certificate is the standard of reference when it comes to Lithium-ion battery transportation.

However, if you are using customized batteries for your project, it is possible that the batteries transported are not UN38.3 certified at the time of transportation. The solution here is to transport the batteries using specific battery pack shipping boxes that are compliant with the "recommendations on the transport of dangerous goods" of the United Nations. Usually those battery prototypes can be transported in UN 50H or UN 4H2 compliant boxes.

Sinovoltaics' advice: *the UN standard to follow for prototypes transportation depends on the size and weight of your battery pack. We suggest checking directly with a packing supplier to confirm which standard your battery packs need to follow.*

C. Container transportation

Even though Battery Energy Storage Systems look like containers, they might not be shipped as is, as the logistics company procedures are constraining and heavily standardized.

Firstly, ensure that your **Battery Energy Storage System dimensions** are standard.

"The following table gives the overall dimensions and the minimum internal dimensions and door openings for general purpose containers as standardized in ISO 668" (Hapag-Lloyd, 2016):

	Length			Width	Height	
	mm ft	mm ft	mm ft	mm ft	mm ft	mm ft
Dimensions	6,058 20′	12,192 40′	13,716 45′	2,438 8′	2,591 8′ 6″	2,896 9′ 6″
Minimum internal dimensions	5,898 19′ 4 1/8″	12,029 39′ 5 1/2″	13,556 44′ 5 5/8″	2,350 7′ 8 1/2″	2,350 7′ 8 1/2″	2,667 8′ 9″
Minimum door opening dimensions				2,337 7′ 8″	2,261 7′ 5″	2,565 8′ 5″

Container dimensions according to ISO; source: Hapag-Lloyd

If they are not standardized, you might need to put your BESS on a Flat-rack container like the one below, and your logistics costs could skyrocket:

Also, ensure that your Energy Storage System can be easily transported using lashing systems as highlighted in green below:

Container lashing system

Sinovoltaics advice: *we suggest having the logistics company come inspect your Battery Energy Storage System at the end of manufacturing, in order for them to get accustomed to the BESS design and anticipate potential roadblocks that could delay the shipping procedure of the Energy Storage System.*

Another step prior to shipment is to prepare your Battery Energy Storage System for the transportation. In order to do that, you will need to check that there is no component preventing the BESS to be stacked on other containers. The usual suspect is the HVAC (Heating, ventilation, and air conditioning) system, like shown on the picture below:

Such HVAC system can prevent the BESS to be shipped as a standard container

In such a case, the HVAC usually has to be removed and shipped aside the Energy Storage System.

There is also work to do inside the BESS. You will need to ensure that each **battery, PCS or other components cannot move during a storm while transported on a sea vessel**. Extra protection and ropes are usually sufficient to prevent damages.

The different topics mentioned in this section are listed below:

Container Transportation Checklist	
Parameter	**Comments**
Are the BESS dimensions standard?	**Do we need to use a Flat Rack or not?**
Response Are lashing systems available?	**To allow better fixation of the BESS during transportation**
Is there a component preventing the BESS from being stacked on other components?	**For example the HVAC system**
Are BESS components securely attached?	**It needs to go through a sea storm without any damage**

D. Site arrival

The BESS has arrived on site. The objective is now to ensure that the BESS can correctly be installed at its final location. But firstly, you would have to receive the shipment. At this stage, you must carefully inspect the shipment, as the logistics partner transfers the sole responsibility of the BESS to your company

When preparing for site arrival, and BESS final installation, several details come into the spotlight:

- **Truck delivery access:** how can the delivery truck access the BESS final location? Can the road/path sustain the heavy load?
- **Unloading the truck:** which equipment (e.g. crane, forklift) will be used to unload the BESS?
- **On-site location:** where will the BESS be located on site?
- **Communication with local Fire Service:** is the local fire department aware of the unit's deployment?
- **Emergency BESS access:** in case of emergency, how can the first responders access the BESS?
- **Shipment inspection:** has the shipment been damaged in any way?
- **Components quantity:** are there any missing components?
- **BESS Identification:** does the BESS identification number match the FAT's ID?
- **BESS cosmetics check:** are the logo and model names printed correctly?
- **Components Visual Inspection:** is there any damage on one of the components?
- **BESS location:** where will the BESS be located on site?
- **BESS orientation:** what's the BESS' orientation?

Sinovoltaics' advice: *ensure that the BESS orientation allows an easy flow for the air coming from the fans and the HVAC, as well as an easy access to the Input/Output table. You also need to be able to open all the necessary doors for the commissioning and support operations.*

- **BESS shelter:** if needed, does the shelter efficiently protect the BESS from direct sunshine or rain?

Sinovoltaics' advice: *even though the BESS is said to be (at least) IP55 or outdoors compliant, it might be smart to protect the unit from direct sunshine. The BESS being a temperature-controlled environment, it will most probably need extra cooling if it is in direct sunlight. By avoiding direct sunlight, you will then reduce the BESS' own energy consumption.*

This can be summarized in the table on the following page:

Logistics Key Performance Indicators & Checklist

Parameter	Comments
Truck delivery access	Ensure the delivery truck can access the site location
Unloading the truck	Ensure the forklift capacity is above X tons
On-site location	Avoid placing the units in an area that can be easily flooded (hole, beach etc.)

On-site location	Avoid placing the units in an area that can be easily flooded (hole, beach etc.)
Communication with local Fire Service	Site visit with product introduction is a best practice.
Emergency BESS access	Is there any access to the BESS location for the fire department or first responder needs
Shipment inspection	Check the outer packaging of each package (Battery, HVAC, Cables etc.)
Components quantity	Ensure that match the invoice and Bill of Lading
BESS Identification	Should match the FAT's ID.
BESS Visual Inspection	Any damage happened during transportation?
Components Visual Inspection	Appearance: no deformation or flaw on the shell, smooth, dry; no trauma or dirt on the surface, regularly arranged, clearly marked, reliably connected
BESS location	Ensure the location follow the supplier's space requirements
BESS orientation	Ensure that Input/Output are easily accessible, and the HVAC/fans outgoing air can flow correctly
BESS shelter	If needed, ensure that the shelter is well positioned to protect the units

After completion of the goods reception, you must now put the RED tag on the Battery Energy Storage System (provided by the supplier, or designed by you) as below:

Commissioning RED tag example

Safety consideration: it is **FORBIDDEN TO POWER ON THE BATTERY ENERGY STORAGE SYSTEM** when the RED tag is on the BESS.

Note: *Depending on your BESS, you may have to install some components back to the Energy Storage Systembefore starting the Commissioning process. Ensure that those steps are completed before Commissioning.*

Safety consideration: Manufacturer's safety, installation and testing instructions must be followed at all times. This guide is not meant to replace any instructions from your BESS' supplier.

We can now proceed to the commissioning stage.

9 COMMISSIONING

Commissioning phase is one of the most critical phases of the BESS' supply process. It marks the official transition from a factory to a customer owned and operated BESS.

"Commissioning helps ensure that a system was correctly designed, installed and tested. The value of commissioning is to ensure proper operation of the energy storage system, safety systems, and ancillary systems. Moreover, commissioning is an excellent means to help familiarize the Operation & Maintenance (O&M) staff with the system, how it operates, and how to respond in an emergency." (Sandia, 2014)

The renowned Commissioning process to follow at the moment has been developed by Sandia National Laboratories, and is defined as bellow:

1. Operational Acceptance Test (OAT)
2. Apply YELLOW tag
3. Start-up
4. Functional Acceptance Test (FAT)
5. Apply GREEN tag
6. Shakedown
7. Post commissioning

Note: *the different tests to be performed or topics to be analysed are usually project and application dependent. This section hence presents general requirements needed to commission the Battery Energy Storage Systems and need to be refined with specific tests and specifications data coming from the project stakeholders.*

Sinovoltaics' advice: *one of the challenges when performing a commissioning is the availability of a load to charge and discharge the BESS at will. Try to anticipate that challenge when planning for the commissioning. Sometimes, you may use the site load to do commissioning.*

We will now dig into the different sections.

A. Operational Acceptance Test (OAT)

This section aims to confirm that the individual components of the Battery Energy Storage System operate individually. At that point, we need to check the electrical and mechanical integrity of the different components:

Battery mechanical check:

- The battery modules & battery racks are not damaged, there is no unusual smell, leak or spill, or damaged enclosure.
- The battery modules & battery racks have been installed correctly, and the installation location (cross-check battery module & rack IDs) is consistent with the installation manual.
- All battery modules & battery racks have been fixed firmly with bolts, with no loose or missing bolts. And battery racks with modules are clean after installation.
- The battery rack fixation to the ground is not loose.

Battery electrical check:

- All cables have been connected tightly and there is no looseness
- All battery module cables are connected in series
- All battery rack cables are connected correctly
- All communication cables are connected correctly, and the connections are not loose
- The cable trend looks beautiful, no wiring errors, no crossover. It is usually designed that way

PCS mechanical check:

- The PCS are not damaged.
- The PCS have been installed correctly, and the installation location (cross-check PCS IDs) is consistent with the installation manual.

PCS electrical check:

- Verify that all terminals of the converter have been powered off with a multimeter
- All PCS are connected correctly
- Do Point-to-point check of the PCS
- Verify electrical protection and relays are coordinated and are operational

HVAC mechanical check:

- Verify that the HVAC are well mounted and not loose
- The HVAC units are not damaged

HVAC electrical check:

- The HVAC can be powered on normally
- Point-to-point check
- Verify electrical protection and relays are coordinated and are operational

Safety components mechanical check:

- Safety components' seals are not broken
- Emergency procedures are in place

Safety components electrical check:

- Verify and test that all safety systems are installed and can operate normally: Temperature, security, fire alarm, pressure etc.
- Verify and test that all communication systems are operating
- Point-to-point check

Operational Acceptance Test (OAT) Checklist	
Parameter	**Comments**
Battery mechanical check	**No visible damage, nothing loose**
Battery electrical check	**Cables connected correctly, point-to-point check**
PCS mechanical check	**No visible damage, nothing loose**
PCS electrical check	**Cables connected correctly, point-to-point check?**
HVAC mechanical check	**No visible damage, nothing loose**
HVAC electrical check	**Can be turned on/off**
Safety components mechanical check	**No broken seals**
Safety components electrical check	**Point-to-point check**

The Operational Acceptance Test (OAT) section is now completed. The Yellow tag can now be applied.

B. Apply YELLOW tag

Now that the different components of the system are ready for start-up, please put a yellow tag on the Battery Energy Storage System, as below:

Commissioning In Progress

Commissioning YELLOW tag example

Safety consideration: ONLY TRAINED TECHNICIANS CAN POWER ON THE BATTERY ENERGY STORAGE SYSTEM when the YELLOW tag is on the BESS.

The system is now ready to operate for the Start-up.

C. Start-up

The objective of this section is to start-up the BESS as a system and ensure that the operation goes smoothly.

Safety consideration: this section contains general ways to proceed with start-up, which might not fully correspond to your site's installation. As a consequence, **the installation manual and manufacturer's safety procedures must be followed at all times**.

BESS final interconnection: before starting the Battery Energy Storage System, you will need to connect the different components together:

- Connect the battery racks to the PCS
- Connect the PCS to the I/O distribution box
- Connect the the load to the I/O distribution box
- Ensure the EMS is well connected to the BESS
- Ensure the circuit breakers are disconnected

Start-up sequence: at that point, and following the installation manual process, you start-up the Battery Energy Storage System. **No alarms should be triggered**. After the Start-up sequence, you must be able to **access and monitor the data** from the Battery Energy Storage Systems:

- PCS & Battery racks voltages
- PCS & Battery racks currents
- Charging & Discharging status
- BMS information including State of Charge
- PMS information including input and output power
- EMS information from the different components
- Safety components appear as working
- And all the data that must be sent to the monitoring solution

While following the manufacturer's safety measures, the trained stakeholder can proceed to an **IR scan inspection** of the BESS, in order to cross check the data shared by the EMS with actual measurements.

Start-up checklist	
Parameter	**Comments**
BESS final interconnection	PCS to Battery, Load, EMS etc.
Start-up sequence	From the manufacturer's installation manual
Live data are accessible	Voltage, Current, SoC etc.
Live data are matching expectations	Voltage, Current, SoC etc.?
Safety systems appear online and working	No error message
Alarms	No alarms should be triggered
IR scan inspection	Temperature must match safety temp range

We now have a working BESS, and we can proceed with the Site Acceptance Test of the commissioning.

D. Site Acceptance Test (SAT)

During commissioning, the Site Acceptance Test aims to test the system's performance of the Battery Energy Storage System.

Testing plans and procedures should be provided by the BESS manufacturer for that section. It generally included various test to verify that:

- **BESS functioning well together:** components are working well together as intended
- **Performance testing:** depth of discharge, output power and currents should be especially monitored
- **BESS' behaviour analysis:** BESS behaves correctly in the different scenarios (charging, discharging, off-grid, on-grid)
- **Communication check:** communication system is sending and receiving the right data, with the right frequency, and system announcements are in line with the actual events.
- **On-site team training finalization:** complete on-site stakeholders' training and certification

Sinovoltaics' advice: *Several tests coming from the FAT can be redone at this stage, in order to verify potential deviation from the factory's measurements.*

As a quick checklist, the following points should be confirmed at this stage:

Functional Acceptance Test (FAT) Checklist	
Parameter	**Comments**
BESS functioning well together	**All subsystems connected**
Performance testing	**Depth of Discharge, Output power and currents should be especially monitored**
BESS' behaviour analysis	**the different application scenarios should be covered**
Communication check	**The information transferred are in line with actual behaviour**
On-site team training finalization	**Using the site's BESS to complete the training, show real-life examples**

We have now verified that the BESS' actual performances match its specifications, and we can apply the green tag to continue with the commissioning process.

E. Apply GREEN tag

With the SAT now completed, we can apply the GREEN tag on the Battery Energy Storage System.

Commissioning GREEN tag example

Safety consideration: ONLY TRAINED TECHNICIAN CAN POWER ON THE BATTERY ENERGY STORAGE SYSTEM when the GREEN tag is on the BESS.

F. Shakedown

We now have verified that the BESS is operating correctly in normal conditions. The "Shakedown" section of the commissioning process seeks to confirm the normal behaviour of the BESS in problematic situations. During those unexpected events, the BESS' behaviour should always prioritize the safety of the people around the unit, as well as its own system and the environment nearby.

The BESS' manufacturer should have incorporated some safety processes in the commissioning sequence, for example:

- **Normal shutdown procedure**
- **BESS start-up procedure** after normal shutdown
- **Emergency shutdown procedure:** following manually triggered emergency shutdown, or automatically triggered (through EMS)
- **BESS start-up procedure** after emergency shutdown

During all the different sequences, **no unexpected alarm should be triggered**. Also, those tests should help to train and confirm that the **on-site support**

team masters the safety procedures of the Battery Energy Storage System.

At that stage, the site's support team should have **a clear and full understanding of the different potential alarms** that could be triggered by the BESS system. Ideally, from a standard document from the BESS' manufacturer.

Finally, the shakedown can conclude on the training of the site support team on the common and easy-to-solve **troubleshooting advice**.

Safety consideration: always follow the manufacturer's procedures when shutting down and restarting the BESS, whether in normal, or in emergency conditions.

Sinovoltaics' advice: *always perform those tests with the utmost carefulness. And only with professionally trained technicians.*

Shakedown activities are recapitulated in the table below:

Shakedown Checklist	
Parameter	**Comments**
Normal shutdown procedure	Work as intended
Emergency shutdown procedure	Determine if safety systems work as designed or needed. Evaluate if systems fail in a safe mode
Restarting procedure	Following both normal and emergency shutdown
On-site team masters the safety procedures	Safety protocols during operation, shutdown, maintenance, and restart
Alarms	must worked as intended
Alarms & Fault code	Clear and full understanding of the different alarms must be done
Common troubleshooting procedures	Safety should be assured at all time

Finally the BESS is ready to be operated normally, but there are final steps to perform to ensure a smooth transition to the site management teams.

G. Post commissioning

Before completing the commissioning activities, there are a few final steps related to the operation of the BESS to confirm with the different stakeholders:

- **Final sealing:** is there any hole in the BESS that needs to be sealed to prevent water or small animals from entering the unit?
- **Locking the BESS:** are the doors well closed, and the locks set up so no one can open the unit without the safety keys? Where are the safety keys located during the BESS operation phase?
- **BESS manual:** is a BESS manual available for the support team on site?
- **BESS inspection plan:** does the site have a periodic inspection plan set up?
- **BESS cloud monitoring:** can the site information be monitored online? Are the critical stakeholders trained to access the monitoring platform?
- **BESS support communication line established:** do the people on site know how to contact the BESS' manufacturer support team? How?
- **BESS commissioning signature:** sign the handover document with the client.

This information can be recapitulated in the checklist below:

Post-Commissioning Checklist	
Parameter	**Comments**
Final sealing	Potential cables holes
Locking the BESS	Safety key storage, doors are closed
BESS manual	Ensure the support/site team has the BESS user manual available
BESS inspection plan	Monthly and Quarterly maintenance operations are identified
BESS Cloud Monitoring	Ensure that the Cloud monitoring platform is accessible by the right stakeholders, and is accessible
BESS support communication line established	Email or direct phone number
BESS Commissioning signature	Ensure that critical stakeholders signed it

The commissioning phase is now completed. It kicks off the beginning of the operation of the BESS in its operating environment.

10 OPERATIONS & MANTEINANCE

This section will cover some best practices for the Operations & Maintenance of an Energy Storage System.

"The operations and maintenance phase of an energy storage project begins when the system has been successfully commissioned and the owner has obtained approval to operate the system. This phase continues until the end of the project's operational life and also includes any planned or unplanned repair, renovation, renewal (...) to the system between initial commissioning and final decommissioning." (EPRI, 2018).

When monitoring the BESS, the minimum information that should always be accessible are listed in the table below (source: IEEE 1547-2018):

Necessary parameters to monitor	
Parameter	**Description**
Active Power	Active power in W
Reactive Power	Reactive power in VAR
Voltage	Voltage in V
Frequency	Frequency in Hz
Operational State	Operational state of the BESS. The minimum supported states are on and off, but additional states may also be supported
Connection Status	Power-connected status of the BESS
Alarm Status	Active alarm status
Operational State of Charge	0% to 100% of operational energy storage capacity

The main points to create a sustainable and safe Operations & Maintenance plan actually took place in the previous sections of this report:

During site installation:

- Communication with local Fire Service: Is the local fire department aware of the unit's deployment?
- Emergency BESS access: In case of emergency, how can the first responders access the BESS?

During Commissioning:

- Complete on-site stakeholders' training and certification
- Ensure that the on-site team masters the safety procedures
- Common troubleshooting can be handled by the site's team
- Alarms and fault code must be well understood by the site's team
- BESS manual: is a BESS manual available for the support team on site?
- BESS inspection plan: Does the site have a periodic inspection plan set up?
- BESS cloud monitoring: Can the site information be monitored online? Are the critical stakeholders trained to access the monitoring platform?
- BESS support communication line established: Do the people on site know how to contact the BESS' manufacturer support team? How?

The maintenance schedule, with which tests to perform, and in which conditions, should be provided by the BESS' manufacturer

Sinovoltaics' advice: *Before a new maintenance round, the site team should confirm with the manufacturer for any update to implement (EMS, BMS etc.), or any updated default parameters to modify in the BESS to maximize the system's life.*

The BESS is now fully operational and well maintained. Should another project come up, do not hesitate to evaluate your experience with that BESS, and decide at that time if you would like to go with a similar solution.

We at Sinovoltaics hope that you will have a successful Battery Energy Storage System project!

Are you working on Battery Energy Storage Systems and do you require any assistance at any stage of your project?

Contact our BESS quality engineers at contact@sinovoltaics.com

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