Designing a 200MW/800MWh BESS project in Italy

Case study | Engineering firm Benny Energia provides us exclusive insights into a 200MW/800MWh project they developed in Italy, where grid-scale deployments are set to soar over the next few years

Project overview:

- Battery energy storage system (BESS) project in Friuli Venezia Giulia, Italy, designed by Benny Energia
- Power installed: 200MW
- Energy capacity: 800MWh
- Charge and discharge hours: four hours

In the last two centuries, there has been a significant increase in the global demand for energy. However, the consequence of this growing demand is the uncontrolled use of fossil fuels. Fossil fuels have played a significant role in the increase of greenhouse gas emissions, triggering a severe environmental crisis.

Human activities contribute to the accumulation of greenhouse gases, causing a rise in global temperatures. This, in turn, leads to changes in snow and precipitation patterns, an increase in average temperatures, and a higher frequency of extreme weather events such as heatwaves and floods.

In order to address climate change, the European Parliament has voted in favor of the European Climate Law, raising the target to reduce net greenhouse gas emissions by at least 55% by 2030, compared to the current 40%, and proposing the legal obligation to achieve climate neutrality by 2050.

To achieve its ambitious goal of climate neutrality by 2050, the European Union is promoting the decarbonisation of the energy sector by gradually replacing fossil fuel energy sources with renewable sources such as wind, solar, and biomass. A significant added value in the decarbonisation process is provided by "sector coupling", which increases the need for flexibility and reliability while reducing the overall costs of the energy transition.

Sector coupling involves two complementary scenarios: the electrification of final consumption and the integration of energy networks and vectors. The first scenario ensures a strong penetration of renewable sources and a push for energy efficiency but requires a high need for flexibility in the network and the enhancement and extension of undersized transmission and distribution networks.

TSO Terna's 150 KV transmission network across Northern Italy.

The second scenario involves supplementing renewable electricity with other energy vectors such as biogas, biomethane, and hydrogen for applications in sectors difficult to electrify [1]. In both scenarios, energy storage systems play a fundamental role, allowing the matching of renewable energy production with demand when they are not simultaneous and storing excess energy to prevent wastage.

The project

Given the importance of energy storage systems in the context of the energy transition, Benny Energia has developed the largest battery energy storage system (BESS) in Europe, to be located in Friuli Venezia Giulia, Italy.

The project, submitted for approval in December 2021, is expected to be operational by the end of 2024.

The design of a BESS, the subject of this article, involves determining a suitable area for the system. The chosen area must meet criteria defined by customer's guidelines.

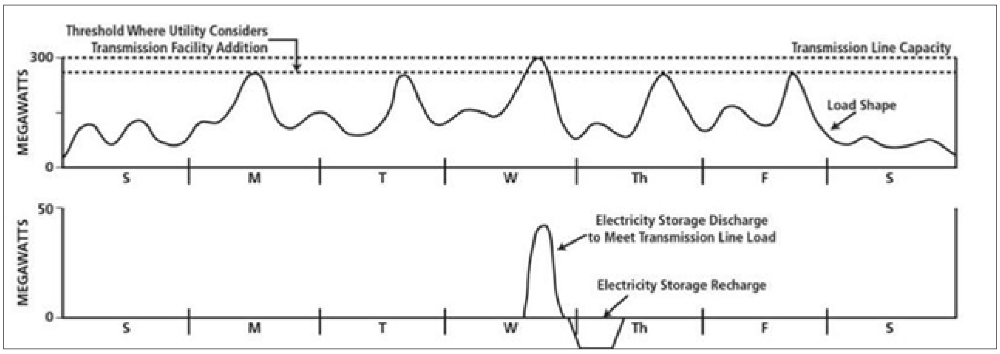
Location and suitability of land

Firstly, the area must be close to the substation, and its dimensions must allow for the placement of all containers and auxiliaries. The connecting roads between the airport and the site, as well as access roads to the area, must be suitable for the transit of vehicles needed for the transport of goods.

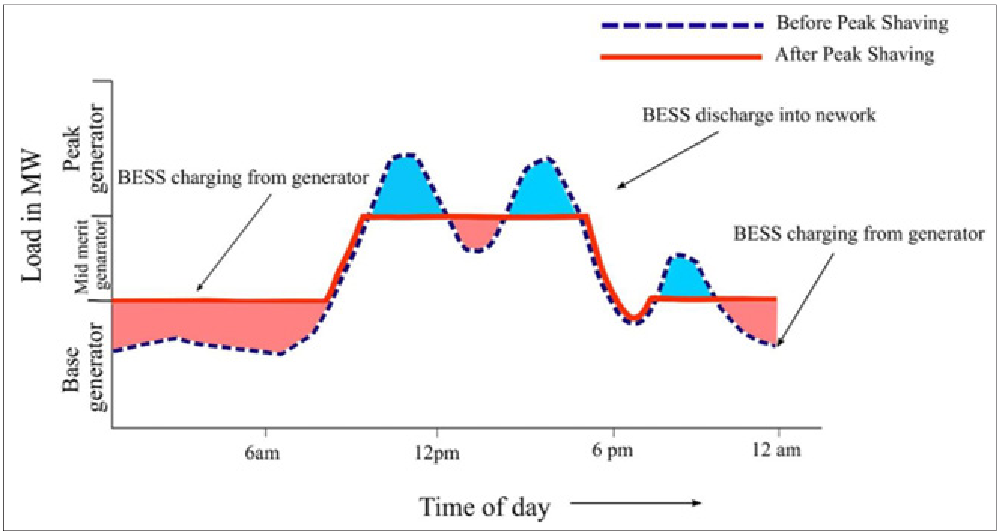
Additionally, the maximum slope of the site must be below 15% to optimize design.

Subsequently, after an analysis of the area within the regional territorial plan, it is necessary to assess urban and territorial compliance through an analysis of landscape, archaeological, and hydrogeological constraints. These are essential to evaluate the risk of possible landslides or seismic events that could lead to ground collapse.

The area identified for the 200MW BESS project is adjacent to one of the main Terna



The operation of a BESS project over the course of a week.



The operation of a BESS project through the day.

substations in Friuli Venezia Giulia Region.

Using the QGIS software, an open-source Geographic Information System (GIS), the slope of the area and its non-interference with constraints have been evaluated. The slope analysis within the QGIS software can be performed using a Digital Elevation Model (DEM).

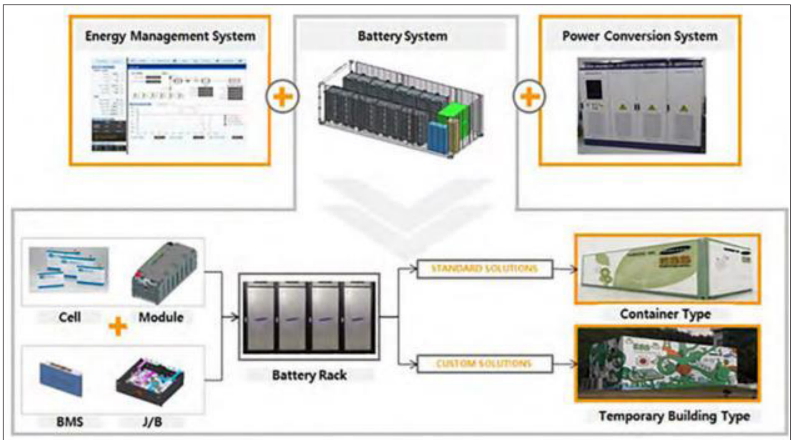
The DEM used, obtained from distinct DEMs of individual administrative regions of Italy, was provided by the Pisa section of the National Institute of Geophysics and Volcanology (INGV) and pertains to the elevation of bare terrain, also known as the Digital Terrain Model (DTM) [2]. The DEM is loaded as a layer and can be used to determine the slope of the area, resulting in a temporary layer automatically overlaid on the DEM that generated it.

The analysis determined that the identified area fell within a zone with a slope of less than 5% and was therefore suitable for the installation of the BESS system. To determine the suitability of the area, it was verified that the chosen area for the BESS system did not interfere with landscape and environmental constraints through overlays of the examined area on maps of the main constraints.

Firstly, Landscape Constraints under Legislative Decree 42/2004 were analysed as well as interference with landscape protection zones such as riverbeds and archaeological areas.

The examined area does not interfere with landslide scenarios and/or seismic events in the territory and complies with the flood risk constraint.

In fact, the area does not fall within flood risk zones and no interference was detected between the area of the BESS system and protected areas.



The composition of a BESS project, including BESS, PCS and energy management system.

Configuration of the BESS project

The design of the BESS system involved a layout sized according to the availability of land use making possible a plant having an installed capacity of 200MW.

The plant layout consists of multiple of containers grouped into base units each equipped with its own Power Conversion System (PCS). Within the area, control cabinets necessary for supervision of the transformers in the area, control of measurements (voltage, current, frequency) and optimal working temperatures of the batteries were set up.

In addition, the connection wiring diagram describing the connection of each individual container of the entire plant to the Terna Station stall was made. The single line wiring diagram was equipped with all the necessary control and protection systems.

The design difficulties that Benny Energia encountered and overcame during the plant design phase were the presence within the area of an overhead HV power line, the need to maintain distances congruent with current fire prevention regulations, and finally the need to keep noise below an acceptable threshold.

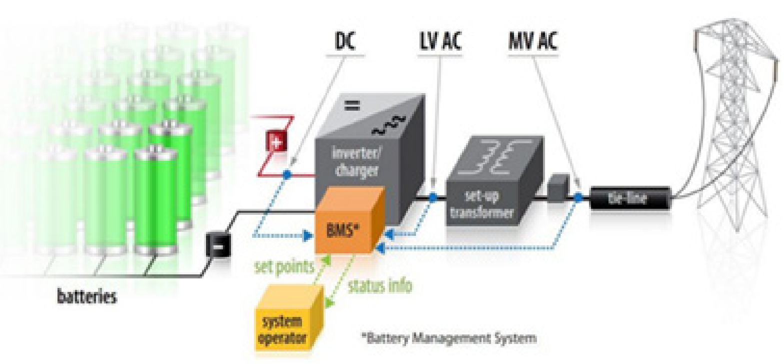
The BESS containers

In the BESS container, secondary lithium-ion batteries are housed, assembled in strings of batteries connected in series, installed in parallel to form modules. These modules, in turn, are connected in strings of modules in series and are housed in rack mounting structures.

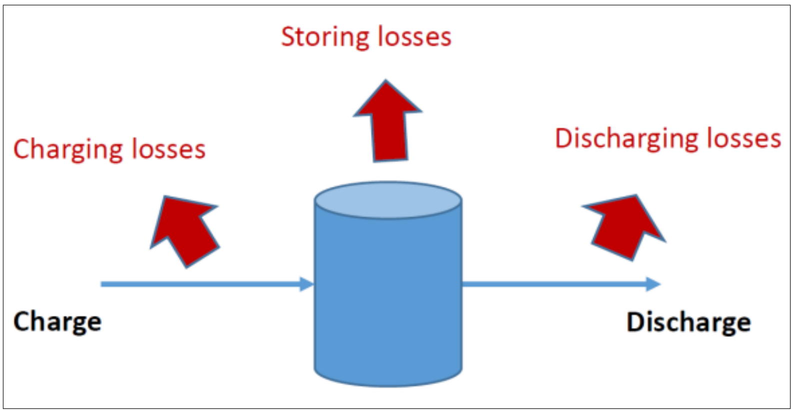
The battery racks are connected in parallel to meet the nominal energy capacity and are arranged inside the battery container.

Lithium-ion battery technology

Lithium-ion batteries represent the most advanced technology in the field of electrochemical storage systems due to their high specific power. However, their



How the batteries connect to the grid via DC, low-voltage AC and medium voltage AC connections.



Energy losses occur to some degree during all stages of a BESS activity.

main disadvantage is the high cost due to the need to implement safety systems to prevent overcharge situations.

Despite the existence of a wide range of lithium batteries with different cathode compositions, they share a common basic structure. These devices include an anode generally made of graphite and a cathode made of a metal oxide, and their assembly creates a layered or tunnel structure to facilitate the insertion and extraction of lithium ions.

The electrolyte, both liquid and polymer, serves as a link between the positive and negative electrode, which are separated by an electronic insulating layer, usually made of polyolefin. The electrochemical reactions vary depending on the type of cell, but the open-circuit voltage ranges between 3.6 and 3.85 V. Lithium batteries are high-energy systems and require extremely cautious handling.

Safety measures

Electrical, mechanical, and thermal abuses can cause problems in their operation such as thermal runaway that damages the cell and, in the worst cases, can lead to gasification and the release of flammable vapors containing solvents present in the electrolyte.

For safety reasons, the cells are often contained in robust metallic containers. One of the most critical aspects of lithium-ion cells is their degradation over time, which leads to a progressive reduction in capacity compared to factory data, even in the absence of charge/discharge cycles.

The system is equipped with a Battery Management System (BMS) capable of monitoring cell-to-cell variations over time: diagnosing errors, detecting safety hazards, and issuing warning signals. It records signals from the battery pack and individual cells, storing data related to the battery's lifecycle history. Additionally, it measures voltage, current, and temperature signals and monitors these parameters to achieve cell balancing and prevent battery damage. Finally, it determines cell and pack levels, such as State of Charge (SOC) and State of Health (SOH).

The container structure considered is self-supporting, metallic, for external installation, built with profiles and insulated panels and is designed for outdoor use. Profiles and insulated panels are used. This design allows the entire system to be transported and installed without the need to disassemble the various components of the container, except for the battery modules, which could be disassembled and transported separately if necessary.

The containers have standard dimensions. Each container is equipped with environmental sensors, including those for temperature and humidity, to constantly monitor internal conditions. If required, the containers have an air conditioning and ventilation system to ensure optimal environmental conditions for the proper functioning of various components. A liquid cooling system is also present.

To prevent emergency situations, the internal temperature of the container is monitored using thermocouples, especially for detecting possible fire residues. The container is protected against the entry of dust and water jets from various directions, providing a safe and secure environment for the energy storage system. ■

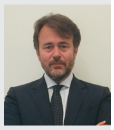
References

[1] E. Rodrigues, R. Godina, S. Santos, B. A.W., J. Contreras e J. Catalao, "Energy storage system supporting increased penetration", Energy, Volume 75, 2014, pages 265-280.

[2] S. Tarquini, I. Isola, M. Favalli, A. Battistini e G. Dotta, "TINITALY, un modello digitale dell'Italia con una dimensione della cella di 10 metri (Versione 1.1)," Istituto Nazionale di Geofisica e Vulcanologia (INGV), 2023.

Authors

Eng. Diego Margione is founder and CEO of Ergon Group Srl, partner of Benny Energia Srl for the for the scouting and development of Renewable Energy Plants. He has 20 years of experience in the field of mechanical engineering as a designer, consultant, and developer in renewable energy.



Dr. Andrea Giulio Barone, founder and CEO of Benny Energia Srl, has more than 20 years of experience in structured finance and 10 years in the financial, economic, and managerial sectors of renewable energy.

Eng. Marta Maiolati, development manager at Ergon Group Srl, has over 10 years of experience in the design and development of renewable energy plants, and has worked on over 300MW of solar PV and 3.5GW of BESS.

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