STORAGE PILOT PROJECTS

Terna

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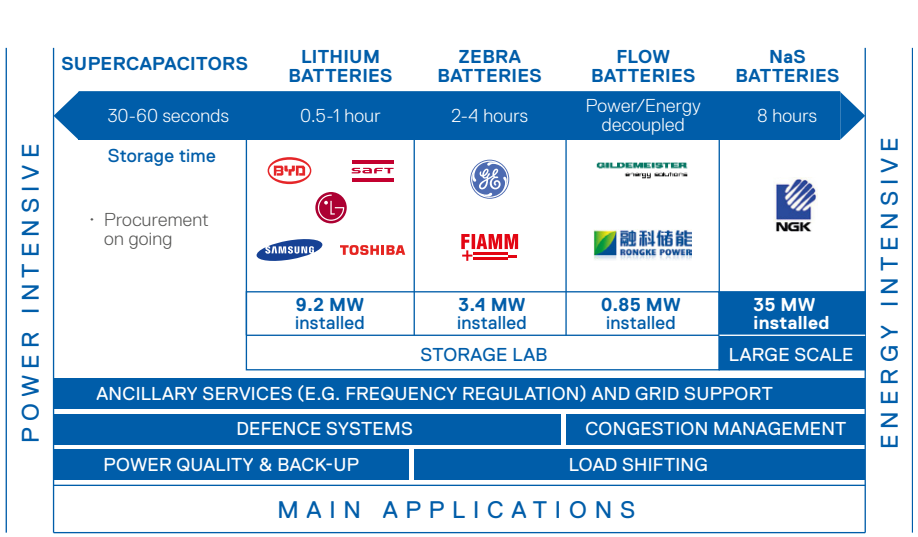
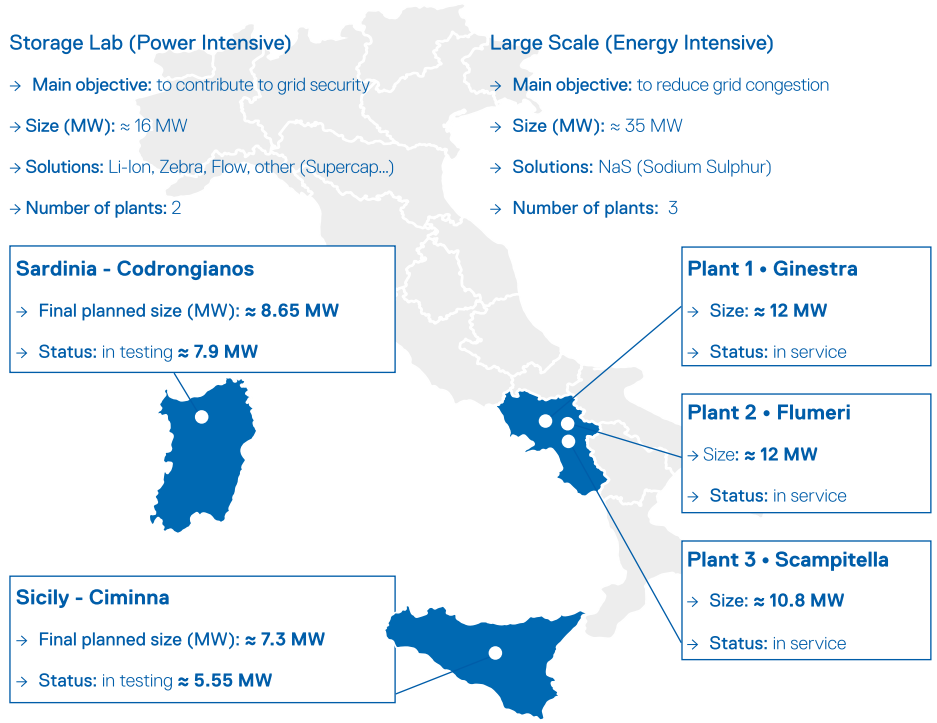
The growing increase in electricity generation plants using non-programmable renewable sources (NPRSs) in Italy in recent years, especially in the south and on the two biggest islands, has had an increasingly tangible impact on processes for management of electricity flows (dispatching) and the safe operation of the National Electricity System (NES) in general.
In order to optimise generation from renewable sources and at the same time ensure increased security management margins in the electricity system, Terna has identified energy storage as one of the possible solutions to the problem, planning the installation of technologies in strategic locations across Italy and connected to the National Electricity Transmission Grid (NTG).
This innovative use of storage systems connected to the NTG has led Terna to launch an experimental programme aimed at implementing pilot projects designed to test and validate the use of electrochemical storage at the "utility-scale" level.
The first project launched by Terna focused on Large-Scale storage plants, connected to sections of the high-voltage (HV) grid in southern Italy which are critical due to the high levels of penetration from NPRSs.
The storage systems are based on "Energy Intensive" electrochemical storage systems characterised by a high stored-energy to installed-power ratio. The primary objective of this project is to reduce the amount of network congestion in the hours when wind production exceeds the transport capacity in the relative parts of the grid, experimenting with additional services and useful applications for the grid operator.
More experimental in nature and structured like a true energy-storage laboratory, the second project (Storage Lab) has been launched in Sicily and Sardinia, focusing on installing systems using different storage technologies with a focus on "Power Intensive" units characterised by short-term high power output. This project aims to evaluate and validate the integration of storage systems with Terna Defence Systems, analysing their performance and the potential for applications aimed at increasing the security of NES management activities, namely those which do not require large storage capacities but rather high levels of efficiency in the partial charge/discharge cycles and fast response times.
The outcome of the experiments conducted by Terna will help us to stabilise potential and improve our battery-storage margins, placing an emphasis on technological development in the sector and accelerating the integration of such resources in the Dispatching Service Markets as well as in the National Electricity System in general.





REGULATORY AND LEGISLATIVE CONTEXT OF REFERENCE

The Concession for the electricity transmission and dispatching activities in Italy, which Terna holds, states that the Concessionaire can create and operate electricity storage plants in order to guarantee the security of the National Electricity System and the good operation of the same as well as the maximum exploitation of production from renewable sources and the procurement of resources for the dispatching services.
Legislative Decree no. 28 of 03 March 2011 and Legislative Decree no. 93 of 01 June 2011 provide for the extension of the concession and the possibility for Terna to include battery-storage systems into its own National Transmission Grid Development Plan.
In Resolution 288/2012/R/eel and the relative Ruling no. 08/2012, the Italian Regulatory Authority for Electricity, Gas and Water (AEEGSI) specified the minimum mandatory and optional requirements for the selection of experimental pilot projects regarding energy storage, as well as the minimum content for applications. Resolution 66/2013/R/eel of 21 February 2013 approved the pilot projects presented by Terna in its 35 MW programme planned in the Development Plan 2011 and approved by the Italian Ministry for Economic Development (MiSE) on 02/10/2012.
Resolution 43/2013/R/EEL of 11 February 2013 approved the "Power Intensive" pilot projects presented by Terna as part of the first phase (16 MW) of the Defence Plan 2012 and approved by the MISE on 02/10/2012.

LARGE SCALE PROJECTS (ENERGY INTENSIVE)

The Large Scale storage projects, specifically Energy Intensive projects, are included in the scope of the NTG Development Plan 2011 and were approved by the Ministry of Economic Development in 2012 for a total of 35 MW connected to parts of the 150 kV grid in Southern Italy with critically high congestion volumes due to excessive penetration of NPRSs. With the primary focus on reducing such congestion, Terna planned a project based on the use of electrochemical storage technologies characterised by a high storage capacity compared to plant power; furthermore, Terna conducted a public tender process leading to the selection of the NAS battery technology (sodium/sulphur technology) as the most suitable for the purpose.
The total storage programme of 35 MW is composed of three plants known as NCSS (Non-Conventional Storage Systems), each connected to the NTG via a 20/150 kV Electrical Substation.

1 → Ginestra NCSS: a 12 MW plant with a net energy capacity of approximately 80 MWh, located in Castelfranco in Miscano (Benevento) and part of the 150 kV "Benevento 2 – Montefalcone – Celle San Vito" backbone.

2 → Flumeri NCSS: a 12 MW plant with a net energy capacity of approximately 80 MWh, located in Flumeri (Avellino) and part of the 150 kV "Benevento 2 – Bisaccia 380" backbone.

3 → Scampitella SANC: a 10.8 MW plant with a net energy capacity of approximately 72 MWh, located in Scampitella (Avellino) and part of the 150 kV "Benevento 2 – Bisaccia 380" backbone.

These plants are among the most powerful in Europe, as well as the first to be adapted to meet the requirements of the Grid Operator, remotely controlled and conducted from Terna centres.
In order to guarantee the safe and efficient management of the charge/discharge phases of the different applications and operating conditions, as well as optimum "field-centre" integration, it was necessary to define and plan a local Integrated Control System (ICS) for each site on an ad hoc basis.
This will be equipped with conduction, control and monitoring capacities, the SCI is able to interface with remote systems and the relative control systems of machines and apparatus in the single Storage Units (control systems relating to batteries, transformers etc.), as well as equip Terna's Central Systems (such as the Central Control and Teleconduction System - CCTS) with additional innovative functions and new applications.
The logic developed in such control systems enables the optimisation of the primary objectives (mitigating congestion from NPRSs) and the effective experimentation with highly innovative grid delivery services aimed at the safe operation of the NTG with improved performance compared to conventional resources (e.g. experimental calibration of the primary regulation, adaptation to the secondary regulation f-P, development of new and advanced conduction, monitoring and dispatching services, etc.).

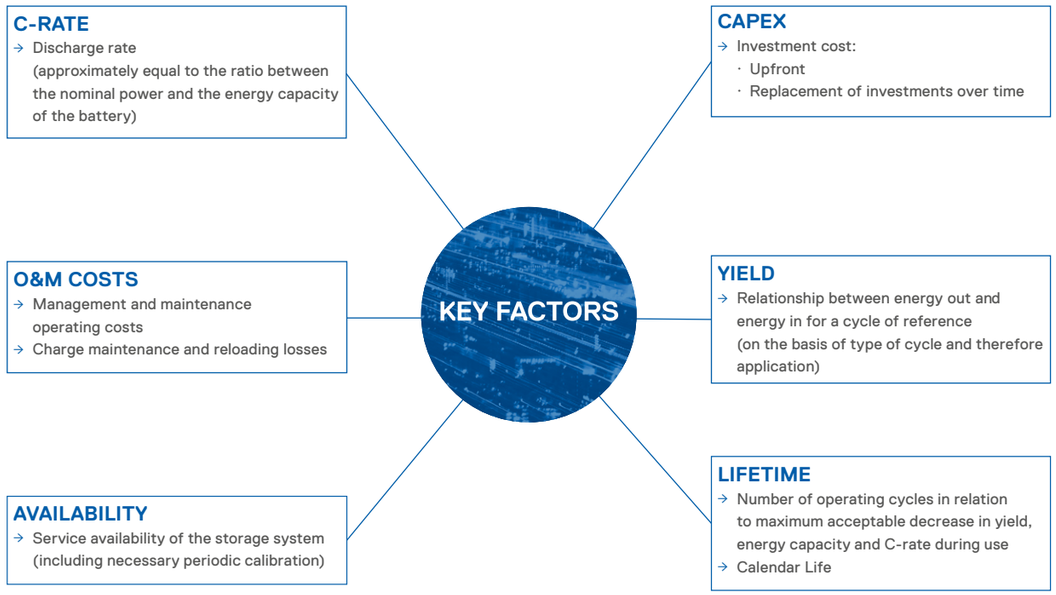
Large-Scale Energy-Intensive 12MW/80MWh plant – Ginestra NCSS in Castelfranco in Miscano (prov. Benevento)

Power-Intensive Storage Lab in Sicily at Ciminna (prov. Palermo)

Storage Lab – Codrongianos: Battery container details – ZEBRA technology

STORAGE LAB PROJECT (POWER INTENSIVE)

The Storage Lab Project is part of the Defence Plan for the Security of the National Electricity System 2012-2015 and consists of the installation of 16 MW of multi-technology storage systems in Sicily and Sardinia, aimed at increasing the safety margins of the management systems of the HV networks on Italy's two largest islands.
The highly experimental project involves the installation of two plants of approximately 8 MW each in Sicily and Sardinia.
With 13.4 MW total capacity already installed (equating to 21.2 MWh of storage capacity), the Storage Lab project is the only one of its kind in the world in terms of the variety of available technologies and the innovative nature of the control systems.
The individual storage units, approximately 1 MW, are lithium (9.2 MW, 5 types) ZEBRA (3.4 MW, 2 types) and flow (0.85 MW, 2 types) based.
To complement the existing technological portfolio, in the future Terna also plans to use super-capacity systems.
The experimental approach to different storage technologies is based on the preliminary identification of objective criteria for technological comparison, designed to evaluate the storage for different "utility-scale" uses.
As such, the experimental programme involves two test environments, in the field and in the lab, designed to access the key factors and performance indicators for each technology, which will typically be used in a cost-benefit analysis for the aforementioned applications (see figure below).
The continuous experiments carried out on-site (grid scale) are designed to not only test the operation and performance of the storage systems in standard and critical service conditions, but also to assess the decline of standard services and characteristics (capacity, performance and response time) following the implemented service strategies through a continuous monitoring process and the implementation of various periodic tests.
Such tests on grid-scale systems are accompanied with laboratory tests (module scale) necessary to further define the performance of battery modules, conducted at some of Italy's leading certified laboratories: RSE, ENEA, CNR, CESI.
The laboratory tests are designed to provide an exhaustive representation of the relative operational models and behaviours of each technology in both standard and critical conditions by carrying out tests which cannot be replicated in the field (overcharge and overdischarge tests, short-circuit tests, ageing tests, performance tests, thermal tests and the creation of equivalent circuits).
With the Storage Lab project, Terna is able to experiment with the main storage technologies currently available on the market and test their performance and technical characteristics in terms of supporting essential conventional services such as primary frequency regulation, secondary frequency regulation and Defence System easement, as well as testing innovative applications and features which could be implemented in the Dispatching Resources Grid Code in the future.



TWO DIFFERENT TEST ENVIRONMENTS →

On-site Storage Unit tests

Grid Scale (>1MW)

1 Focus Grid Scale test (field test)

- → Frequency regulation
- → Voltage regulation
- → Yield
- → Rated/overload capability curve
- → Black start
- → Defence system easement

Laboratory test on battery modules

Module Scale (<100kW)

2 Module Scale Test Focus (lab test)

- → Ageing test
- → Performance test
- → Heat and climate tests
- → Overcharge/discharge test
- → Overload Test
- → Short-circuit test

OBJECTIVES

To collect sufficient know-how so as to be able to select the best technology with regard to each application, optimising their integration with each other and with Terna tools.

The Storage Lab aims to analyse the performance of technologies selected during their use within the System.

Technology considered for the comparative testing phase:
→ Lithium-Ion → Zebra → Flow → Other (Supercaps...)

LAB

Module tests carried out by:

RSE Ricerca Sistema Energetico · CESI · Consiglio Nazionale delle Ricerche · ENEA Ente per le nuove tecnologie, l'energia e l'ambiente

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