C2 – Power System Operation and Control

PS 1 – System Control Room Preparedness:
Today and in the Future

Paper no. 10791_2022

Islanded Operation of the HV/MV network: a Dynamic Study based on a Real-Life Experiment Data

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Motivation

- Focus on the black start test carried out by Terna to manage an electric island involving a part of 132 kV system and the MV/LV network in the Trentino-Alto Adige region
- The test, performed in September 2020, was organized with the goal to increase the resilience of the network after a blackout occurred in November 2019 caused, by a heavy snowstorm and consequent unsuccessful reenergization attempts
- Dynamic analyses were performed in the DigSilent PowerFactory software in order to investigate the events that occurred during the islanded operation, the main problems encountered, and the root causes.

Method

Terna, in agreement with the DSO Edyna, the producer Alperia and other minor local DSOs in the area, carried out an activity of coordination to better analyse and reconstruct the dynamics that led to the creation of the load island in Val Pusteria and the causes that brought several times the area back into a black-out condition during the emergency of 2019

Tools available

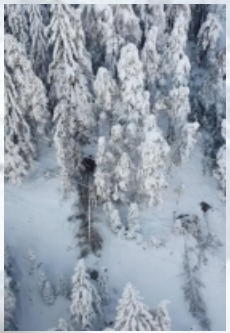
- DigSilent PowerFactory
- pre-test studies identified safe conditions and proper characterization of the load steps to be implemented during the trial
- a new monitoring system was also installed

Prior events

- The November 2019 weather emergency: heavy rainfalls and snowfalls occurred, even at low altitudes

→ power grid was considerably affected by damages to its infrastructures, with consequent multiple faults on power lines and trips of relevant protections

→ causing the entire Val Pusteria area to be disconnected from the power supply



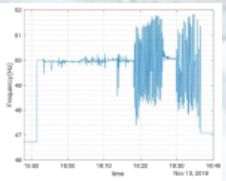
Broken pilon during snowstorm 2019

Prior events

- during the 2019 emergency the black-start capability of the hydro units of the Lappago power plant in the area has been exploited
- the hydro groups of the Brunico power plant were also synchronized to the islanded grid

→ However, this grid setup has shown to be often unstable

The HV network affected by the events in 2019



Frequency during the island in 2019

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The black-start test of September 2020

The test was divided into several phases:

1. Setup of the facilities involved

2. Black-start of the Lappago hydro unit(s)

3. Islanded operation of the sub-transmission system with a portion of the distribution system

4. Synchronization to load island to the National Grid after the end of the test

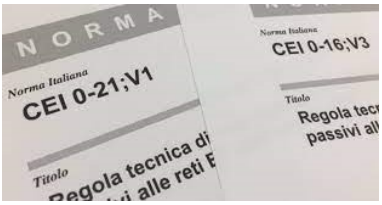
The HV network during the 2020 test

The technical prescriptions for Dispersed Generation (DG) in Italy

- Before 2012 no particular requirements
- In 2012 frequency (47,5-51,5 Hz and 49,7-50,3 Hz in case of ground fault) and voltage (85%Vn<V<110%Vn) thresholds introduced for MV and LV generators

→ the generator must remain connected to the grid

- O-LVRT characteristics introduced, but the generators can temporarily interrupt the active power delivery
- Retrofit plan by the Italian Authority (ARERA)

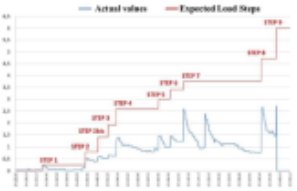


Procedure

- the Lappago Unit 1 was started-up and the line to Molini di Tures was energized
- the various secondary substations along the MV lines of the DSO were re-energized in steps
- 10 load steps were scheduled, from 0.2 MW to 1.3 MW each

Unexpected events

- the initial value of the load supplied at each step has shown to be in many cases smaller than expected
- for almost all the steps, after the connection of the load, the power supplied by the black-start generator started decreasing
- in the last load steps, a partial DG disconnection was observed (most likely caused by frequency/voltage oscillations at the time of the step connection), causing a fictitious increase in load for the Lappago unit



The time behaviour of the expected load Steps (in red) and their actual values (in blue)

Reconnection of Dispersed Generation in Italy

Dispersed generators can automatically reconnect if:

- Voltage in the range 90 – 110% Vn
- Frequency in the range 49,90 – 50,10 Hz

→ For at least 300 s

The power injection must restart gradually

Possible behaviour of the DG

Instability of the electrical island would be caused by a voltage drop occurred during the service restoration procedure

→ all PV power plants may have interrupted temporarily the supply of active power

→ some plants could also have disconnected from the grid and then reconnected later (not complaint with the requirements)

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The numerical models developed

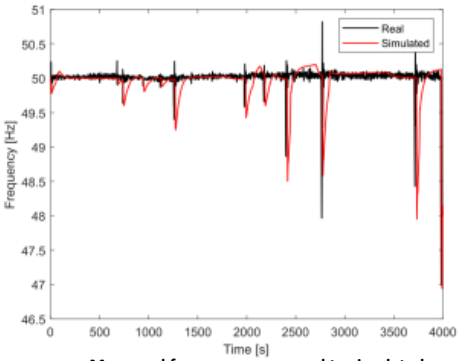
In DigSilent the Lappago units, load and DG have been recreated. The frequency regulator of the hydro unit has been replicated as well

Deviation of the expected values

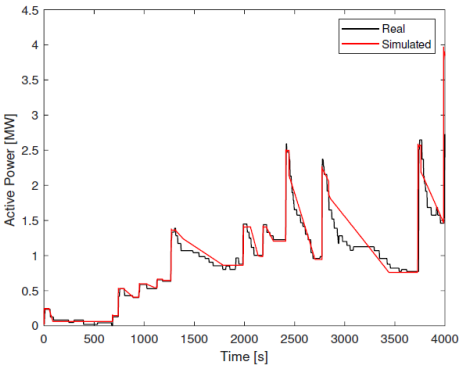
- Many customers, in particular industrial customers, decided to stop their productive activities during the test, thus reducing the load available
- a slow decrease of the power generated by the Lappago unit involved was systematically recorded

→ This could possibly be explained by a DG unexpected behaviour

- The last load step could be related to the unexpected disconnection of the DG connected, due to the DG protection system itself



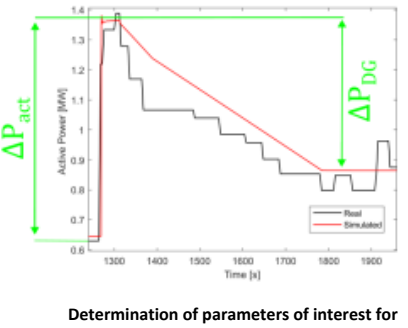
Measured frequency compared to simulated frequencv



Measured active power compared to simulated one

Estimation of the amount of DG connected at each step of the dynamic simulation and the relative amount of DG lost

- an initial value of the power step, typically different from the expected value
- a slow, linear decrease of the power withdrawn from the newly connected feeder or load that was assumed to be due to the unexpected and unsuitable re-connection of DG



Determination of parameters of interest for the dynamic simulation

Conclusions and next steps

- the black-start generator proved to operate correctly and to be able to manage load steps even higher than those estimated during the planning of the test
- the different normative prescriptions in place for DG caused their behaviour to be hardly predictable and made it very difficult to manage the electric island during the test
- since during the island operation the system is usually very weak, a single fault is likely to bring it back to black-out
- possible, the adoption of ballast load in the areas of the network more subject to blackouts could allow the entry into service of a greater number of black-start groups