CIGRE PARIS 2022

Study Committee C6

Active Distribution Systems and Distributed Energy Resources

Paper 10175_2022

Distributed Energy Resource Management System – Challenges and Opportunities

Leonardo Leite[1], Herbert Ramos[1], Danilo Alves[2], Hortênsia Américo[2], Keverson Carvalho[3], Bruno Martins[4], Navneet Trived[5], Zeljko Popovic[6]

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Motivation

Increasing penetration of distributed energy technologies presents challenges and opportunities for distribution companies. On one end, uncontrolled DER (Distributed Energy Resources) will threaten the stability and reliability of the distribution grid, on the other end, properly monitored, controlled and optimized DERs can aid the reliable operation of the distribution system. The Distributed Energy Resources Management Systems (DERMS) is a computational tool capable of optimizing, controlling, and managing the operation of multiple DER connected to the power distribution grid to provide reliability, flexibility, and increased quality of power supply service. Through DERMS it is possible to aggregate dispersed DER to coordinate the dispatch of electricity in the network from technical, economic, and strategic factors. This work presents results from a project of DERs integrated into the operation center of a Brazilian distribution company. The main challenges in planning and operation of distribution networks with high penetration of DER are discussed. Tests results based on a site deployment in a 13.8 kV distribution feeder with two storage systems with a total capacity of 1,150 kW / 1,750 kWh and a solar power plant with 1.4 MWp are presented.

Project Architecture

Figure 1 illustrates the general architecture.

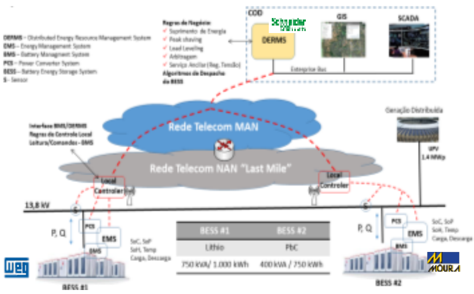

Figure 1 - SIGRED Project Architecture

The following components are identified:

- Battery Energy Storage System **(BESS)**
- Battery Management System **(BMS)**
- Energy Management System **(EMS)**
- Power Converter System **(PCS)**
- Photovoltaic Power Plant **(PV)**
- Distributed Energy Resource Management System **(DERMS)**

DERMS Integratiom

Figure 2 presents the block diagram, focusing on the integration of DERMS with existing systems and DERs units.

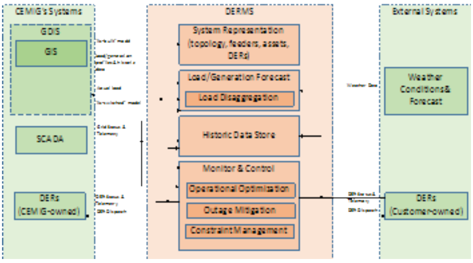

Figure 2 - Integration Block Diagram

Use Cases

In order to know and test the tool's capabilities, it is possible to carry out the use cases represented in Figure 3. These use cases cover the DERMS functionalities related to the registration, monitoring and control of DERs, operation optimization, equipment capacity management, and power supply in contingency situations.

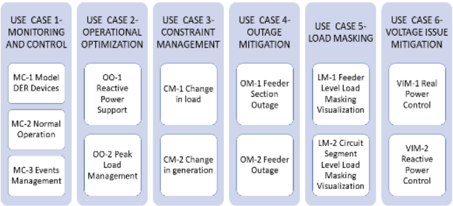

Figure 3 - DERMS Main Functionalities

The main implemented DERMS features are:

- Importing topological and registration information about the feeder and its assets, including DERs, from the GIS.

- Providing load and generation forecasts from historical data, typical load and generation curves and weather forecast data. In addition, DERMS can provide the actual feeder load and DER generation data for GIS.

- Maintenance and management of historical data.

- Monitoring and control, including features such as: peak shaving, voltage deviations minimization in steady-state, DER generated energy limiting, power failures mitigation, among others.

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Experimental setup & test results

Feeder Characteristics

The feeder selected for the application plant has a total length of 11.9 km and meets a demand of 9.257 MVA distributed to 45 non-residential consumers (33 primary consumers and 12 secondary consumers). It has 7 monopole switches, 1 remote-controlled three-pole switch, 10 remote-controlled reclosers, 59 transformers, and 36 fuse switches. The feeder presents a technical loss of 2.4%.

The single line diagram of the feeder under study is shown in Figure 4.

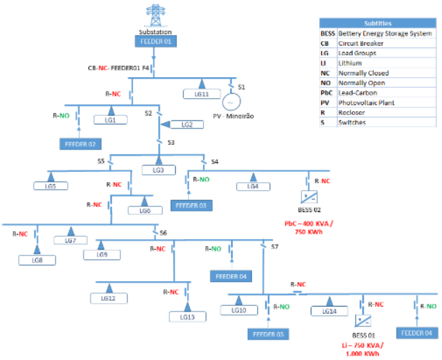


Figure 4 - Single line diagram of the feeder

The 14 load groups (LG1 to LG14) and the DERs: PV Mineirão, lithium-ion BESS (BESS 01) and lead-carbon BESS (BESS 02) are also presented. The loads connected to the feeder are grouped into Load Groups (LG). LGs are divided through grid devices, i.e., reclosers or disconnect switches. These devices can be operated locally or remotely to provide power to one or more groups from different sources. The demand of the feeder varies substantially depending on the month, day, and time considered.

Distributed Energy Resources

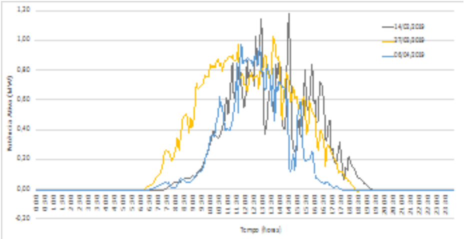
Three DERs connected to the feeder are considered: PV Mineirão, BESS of Lithium-ion technology (BESS 01), supplied by WEG and BESS of lead-carbon technology (BESS 02), supplied by Moura. The PV Mineirão is already connected to the feeder, while the installation of the BESS is scheduled for the begin of 2022.

The characteristics of each distributed energy resource are described in Table I.

Table I - Characteristics of DERs

Characteristics	Mineirão PPP	BESS 01 - Li	BESS 02 - PbC
Power	1.400 kVA	750 kVA	400 kVA
Energy	-	1.000 kWh	750 kWh
Technology	Crystalline Silicon Photovoltaic Panel	Lithium (NMC or LFP)	Lead-Carbon (PbC)
Voltage Connection	276 V, 13,8 kV	13,8 kV	13,8 kV
Nominal frequency	60 Hz	60 Hz	60 Hz
Communication Protocol	DNP3	DNP3	DNP3

PV Characteristics



- ✓ Rate Power: 1420 kWp
- ✓ Medium Year Generation: 1600 MWh /year
- ✓ Area: 9500 m2
- ✓ 5910 polycrystalline silicon modules of 240Wp
- ✓ 88 Smart inverters (15kW/0,380 kV)

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TESTS RESULTS

Energy supply in contingency situation

Power supply in contingency situations have been defined according to each BESS characteristic, the feeder composition and the load group profile. BESS 01 works as the power provider for the load groups LG 10 and LG 14 and BESS 02 for load groups LG 03, LG 04 and LG 05.

Figure 5 presents the first step, performed by SCADA, and the segregated sections that make up the islands that will be powered by both BESS. The blue section in the single line diagram indicates a de-energized region, while the green section indicates that it's being powered by the feeder. Finally, the purple section indicates the section being powered by a DER connected to the grid.

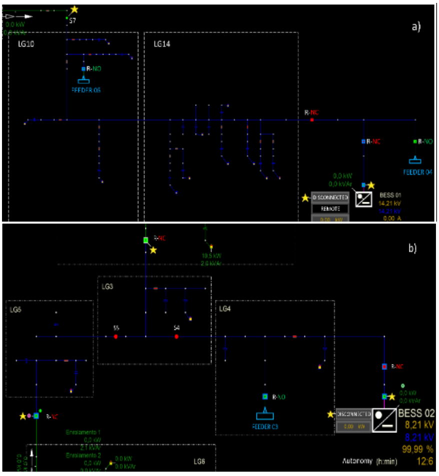

Figure 5 - Islands to be powered by (a) BESS 01 and (b) BESS 02

Figure 6 presents the network view after all steps performed using SCADA and DERMS and the islands being powered by each BESS. Note that the sections of the feeder corresponding to the formed islands in the first step is currently shown in purple, indicating that the load groups that make up the sections are being powered by BESS 01 and BESS 02 as expected. Table II summarizes the main results of contingency supply by Battery Energy Storage Systems.

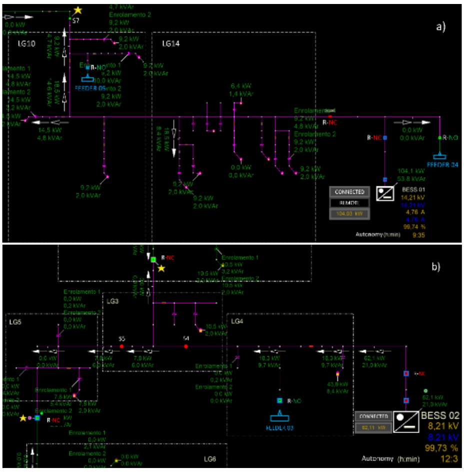

Figure 6 - Island being powered by (a) BESS 01 and (b) BESS 02

Table II - Contingency Supply - Main results

Case	DER	Number of Consumers	Active Power Dispatch (kW)	Reactive Power Dispatch (kVAr)	Autonomy (h:min)
Initial Islands	BESS 01	09	111.3	53.8	08:36
	BESS 02	15	65.8	21.0	11:15
Extended Islands	BESS 01	25	149.4	90.6	06:25
	BESS 02	32	260.6	89.7	02:50

Conclusion

In the new paradigm, the role of distribution operators is changing from centralized planning and operations to more decentralized. While maintaining reliability, power quality, and lower cost of operations are still required, operators are challenged to achieve the same with the growing penetration of DERs. No longer operators can ignore a DER or just curtail them. Increasingly, they are expected to compensate them and treat them as a grid resource. This transactive energy paradigm will transform the role of distribution operators. Our project demonstrated the ability of DERs to enable multiple use cases which can allow applications such as back up energy supply, voltage support, smoothing of renewable generation and more, if managed through an integrated DERMS application.