Integration of DER in power grid as per IEC 61850 standard

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Abstract: Many utilities are beginning to favor novel and value-added applications of this technology after the release of the IEC 61850 standard on the smart grid powerscape. Since the early 2010s, Jemena, a distribution network service provider (DNSP) in Victoria, Australia, has made headway in adopting this standard. Even though Jemena's electrical network has a lower penetration rate of distributed energy resources (DERs) than some other utilities, Jemena acknowledged the necessity to integrate the larger DERs. The solution implementation covered in this research is based on the IEC 61850 standard and involves the setup of intelligent electronic devices at the Jemena and DER ends to communicate generic object oriented substation event (GOOSE) data.

1 Introduction

Modern power systems are complex and challenging. Bi-directional power flow and proliferation of distributed energy resources (DERs) are already challenging the established paradigms of traditional power systems. This has necessitated a totally different way of looking at the power system, leading to some innovative solutions.

In this ever-changing scenario, a major challenge to electricity utilities worldwide is how to integrate with the DERs within a single grid entity [1]. This paper discusses the methodology being pursued by Jemena in implementing a solution based on IEC 61850 standard. This paper also attempts to look into future prospective areas of evolving technologies that could assist in the integration of DERs into modern grids.

2 Current state of powerscape

The prevalent situation with power systems are in a state of transition: from a one-way energy supply chain, which consisted of large-scale generation units to consumers, to a system consisting of electricity and energy-related services from DER devices scattered geographically and embedded into the electricity grid. The homogenous radial power flow of the past has now given way to what is labelled as a ‘cocktail’ of power, an evolving power supply mix, wherein power generation of various genres such as photovoltaic units, wind generators, biomass generators, fuel cells, and fossil fuel based plants are connected heterogeneously to what was earlier a simple transmission and distribution grid.

Black and Veatch’s *2019 Strategic Directions: Smart Utilities Report*, observed that utility business models are transforming to accommodate the ever-increasing volume of renewable energy coming onto the grid, based on a survey of hundreds of utility operators. At the core of these models is a need to adapt to future distribution and energy storage demands, which will require a highly connected, actively managed electrical grid armed with digital technologies and devices that can support bi-directional real-time power requirements. DER penetration is growing every year. As projected by the electricity network transformation roadmap, a joint publication by Energy Networks Australia and the CSIRO, >40% of energy customers in Australia will use DER by 2027, and by 2050, that figure will grow to >60%.

Much like other transmission and distribution energy regulators worldwide, the Australian Energy Market Operator (AEMO) has acknowledged the technical and operational challenges that increasing amounts of DERs are placing on the Australian energy system; AEMO has subsequently launched a DER Program to ensure a smooth transition from one-way energy supply to a modern electricity grid which would enable technical integration of DERs into the electricity system. This firmly establishes that electric utilities are charting out strategies to address the current power system conundrum in an efficient and technically acceptable way.

The emergence of DERs is thus a key driver for grid modernisation. In this paper, the core components of integration of DERs with grids will be encapsulated and further developed using the acronym DERWENT, as follows:

DER: Distributed Energy Resources
W: Working as
E: Enabler of
N: New
T: Technologies

3 Jemena’s journey: IEC 61850 standard based approach

As a matter of fact, the technology in power systems have been developing over the years e.g. in the form of evolution from archaic electromechanical relays to analogue static relays and then to modern multi-function microprocessor based or digital relays, also known as intelligent electronic devices (IEDs). However, what has more recently occurred is the amalgamation of protection, control and communication into a single IED. This development at the device level has facilitated much larger

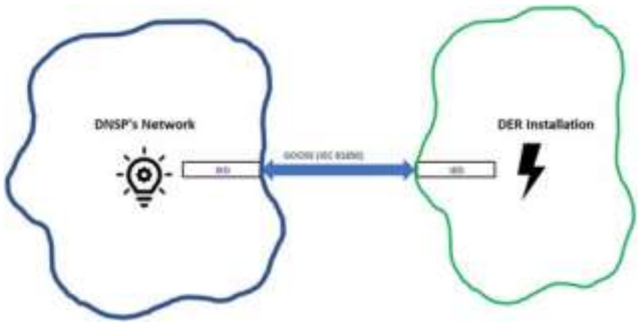

Fig. 1 *GOOSE signalling between grid and DER*

developments at system level. Against this backdrop, it is interesting to now observe what additional requirements are being sought due to emergence of DERs into the power system, as further elucidated below.

In accordance with *Black and Veatch's 2020: Strategic Directions: Megatrends Report* [3], >55% of respondents agreed that innovative, flexible system designs are the most essential tools or resources for managing the complex grid of today. This sets the tone for a renewable-centric grid that is flexible, yet efficient in managing the evolving requirements of a complex power system.

AEMO, in its consultation paper titled '*Technical Integration of Distributed Energy Resources*' Black and Veatch's [3] recognised the need for coordination and interoperability, and proposes 'capabilities for coordination, remote querying of device settings, and remote changes to device settings'.

Against the above backdrop, Jemena like other utilities is also experiencing a proliferation of DERs in its distribution system.

Bolinda Landfill Gas Station is one large DER in Jemena's network, consisting of 7 × 1 MW units. Gas produced from recycled waste is used to generate electricity. When the integration of this DER with the zone substation feeder protection and control schemes was looked at, several options were explored such as proprietary IED specific communication between the grid IED and the DER IED, as well as IEC 61850 standard based communication.

Looking at the long-term strategy for integration of DERs, IEC 61850 standard based scheme was selected for this application. This scheme consists of GOOSE transmission in both directions:

- Status information of DER CBs as well as analogue GOOSE information about DER generation sent to grid IED.
- GOOSE inter-trip signal from grid IED to DER IED asanti-islanding protection (Fig. 1).

Following is a summary of key criteria for using IEC 61850 technology:

- The modern standard for power utility automation.
- Open, non-proprietary standard.
- Interoperability.
- Real-time health monitoring of GOOSE signalling.
- Implement inter-trip which is a deterministic anti-islanding protection scheme.
- Prospect of expanding to DER object modelling with IEC 61850-7-420.
- Building block for modernisation of grid.
- Future-proof platform.

Jemena has experience of having implemented station bus (IEC 61850-8-2) for GOOSE and MMS level applications at its various sites.

4 Potential areas of enhancement

Following are some technologies that are amenable to adoption for DER integration.

Phasor measurement units

The use of phasor measurement units (PMUs) in reliably detecting islanding is increasingly being undertaken. Conventional methods of island detection based on ROCOF or vector shift seem adequate only when the penetration of DERs is minimal. However, these methods have been found to be maloperating during system disturbances, thus are prone to nuisance tripping. Based on the pioneering work of Charles Steinmetz on phasors in 1893, the Virginia Tech researchers Drs. Phadke and Throp developed the first PMU in 1988, by adding timestamps to phasor data, thus providing instantaneous analogue values. PMUs are generally installed at key nodes in the network and they transmit real-time phasor data such as amplitude, frequency, phase angle to phasor data concentrators (PDC) over suitable communication medium; PDCs then process this data and PMUs are useful in providing wide-area situational awareness within power system in areas such as system model validation, situational awareness, stability analysis, islanding detection, disturbance analysis, and wide-area measurement and control. Of late, micro PMUs are being mooted for distribution systems. Moreover, many manufacturers of protection IEDs are now providing PMU functionality within the IEDs! A case in point is an application using SEL relays exchanging slip-acceleration data in real-time [4].

The use of PMUs in improving the selectivity of islanding detection is increasingly being proven [5–7]. The IEEE sub-standards C37.118.1-2011 (measurement of synchro phasors) and C37.118.2-2011 (communication of synchro phasors) are being enhanced to define the PMU applications. The utilisation of IEC 61850 standard for such PMU based wide-area monitoring is, therefore, a very relevant area of further growth in DER integration.

R-GOOSE

GOOSE was originally designed as non-routable information used within substation over local area network.

However, modern distribution systems encompass wide-area monitoring and control. Routable GOOSE or R-GOOSE has been developed as part of the IEC 61850-90-5 suite to enable multicast transmission of GOOSE over a wide area. This is to be considered as another enabler of the smart grid.

Modern IEDs are being developed to establish compliance of R-GOOSE to strict cybersecurity guidelines such as NERC-CIP requirements [8].

What makes R-GOOSE all the more suitable for real-time system, is its low latency (∼20 ms). In the context of DER-integrated smart grid, one possible application of R-GOOSE is in the area of demand response management of DERs from the grid. In its simplest form, a grid initiated command event is sent (as R-GOOSE) to a DER, which switches the mode of operation of DER to one of many pre-defined modes.

5 Conclusion

The above case study demonstrates that the IEC 61850 standard for Power Utility Automation is well-positioned to serve the needs of not only protection and control schemes within substations but also the integration of DERs with the wider distribution system. Although it represents the most current technology, it also proves the ‘DERWENT’ criteria elucidated above, as an enabler of new technologies.

6 References

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