COUNTRY : Australia
REGISTRATION NUMBER :

GROUP REF. : B5
PREF. SUBJECT : PS1
QUESTION N° : 4

Australian Experience to secure ROCOF

Securing ROCOF Against Maloperation - SA PowerNetworks:

SA Power Networks delay ROCOF protection by 100ms.

Settings of critical protective relays on generation, transmission and distribution must be checked for proper behavior during extreme frequency events. Again, traditional stability programs can be a part of this analysis. However, relay testing of actual devices is a more complete method of testing, since stability models of relays are rather simplified and may not accurately capture the exact relay behavior. Playback of simulated frequency events (from stability programs, EMT programs or real-time simulators) into bench tests with actual relays is best, and should be considered for critical relays. All electro-mechanical relays that are critical to system security for major frequency events should be bench tested this way, as modeling of these devices is notoriously poor.

There is no level of negative RoCoF for which there is confidence that equipment will behave poorly. This observation must be paired with two important points: First, levels of RoCoF in excess of -2 Hz/sec are extreme for industry experience in interconnected systems of any size, so experience is limited. Second, the physics is complex and each OEM has their own specifics. There is no substitute for experience. Imposing tight systemic RoCoF targets based generically estimated vulnerabilities is likely to be uneconomic. Operating strategies for gas fired generation that are biased towards keeping units off of maximum dispatch during periods of highest exposure to high RoCoF, and that consider more conservative operation during extremes of ambient temperature, may be desirable. Positive RoCoF is a known issue for gas fired generation. The consensus opinion is that levels below +0.5 Hz/sec represent a confident lower bound (below which no RoCoF problems are well assured).

https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Reports/2017/20170904-GE-RoCoF-Advisory

Ancillary services are not enough. Cannot sustain the supply at high levels of IBR penetration with just ROCOF and UFLS. Response times of less than 1 second are required. Frequency support is necessary to prevent widespread loss of IBRs, limited ride-through capability. Implies widespread use of STATCOMM and / or SYNCHCON units.

SynchCons
South Australia has become a world leader in renewable energy generation. This means that traditional synchronous generation sources, such as gas-fired units, now operate less often. As more of these energy sources such as wind and solar are connected to the grid, traditional power generation sources such as gas-fired units, operate less often. This has created a shortfall in system strength which was declared by the Australian Energy Market Operator (AEMO) on 13 October 2017 and a shortfall in inertia which was declared on 24 December

2018. The installation of synchronous condensers on the network was necessary to ensure there is adequate system strength and inertia.

https://www.electranet.com.au/what-we-do/projects/power-system-strength/

Emergency Under Frequency Response (EUFR)
SA Power Networks is collaborating with AEMO to define a new service in South Australia: Emergency Under Frequency Response. This service aims to assist in the management of rare, extreme under-frequency events that are traditionally managed with Under Frequency Load Shedding (UFLS). In periods of low operational demand, the availability of traditional UFLS is significantly reduced, so SA Power Networks is seeking complementary services from any proponents that can cost-effectively deliver additional generation increase or load reduction to improve management of these rare events. This includes rapid services (**delivered in 200-500ms following a rapid drop in frequency below 49Hz**), as well as slower services to assist frequency recovery in the subsequent minutes.
SA Power Networks is seeking Expressions of Interests (EOIs) from potential EUFR providers to tender their capabilities in contributing to the resolution of the UFLS shortfalls, where considered technically and economically feasible.

Constraining Interconnector
AEMO assessed UFLS performance in South Australia using a modelled representation of the South Australian network. The model used half-hourly UFLS load data from SAPN and ElectraNet, and the contingency event modelled was the doublecircuit loss of the Heywood interconnector. Hundreds of thousands of simulations were performed across a range of future dispatch projections, including the 2020 Electricity Statement of Opportunities (ESOO) 4 Central scenario and other possible dispatch scenarios that could eventuate. UFLS was defined to be inadequate (a 'fail' condition) if RoCoF exceeded 3Hz/s, or the minimum frequency was below 47.6 Hz. These criteria identify periods where cascading failure to a black system is very likely. AEMO also identified 'high risk' periods where RoCoF exceeded 2Hz/s, or the minimum frequency was below 48 Hz. These 'risk' periods show an increasing risk of complications and adverse outcomes and should be avoided if possible. Regression analysis was applied to the simulation results to develop a constraint which defines an import limit for the Heywood interconnector based on UFLS load, distributed PV generation, power system inertia and the availability of Fast Active Power Response (FAPR) 5 . The constraint will adjust dynamically in real-time based on these factors, constraining flows into South Australia only when required.

https://www.aemo.com.au/-/media/files/initiatives/der/2020/heywood-ufls-constraints-fact-sheet.pdf?la=en

IBRs are tripped for a load of <300MW on the interconnector. This is to trip off IBRs and provide enough GRID (Inertia based) contribution to allow successful operation of the protection and control systems during a frequency excursion.

Controlling IBR to combat minimum load
The high uptake of IBR in South Australia has corresponded to a decrease in minimum demand across this region of the NEM and South Australia has hit zero operational demand multiple times over the course of the last few years. This imposes operational restrictions on the system, the management of which requires the curtailment of renewable generation and placing operational limits on the SA-Vic interconnector flows. It also means that the system faces stability challenges for "non-credible" events such as interconnector separation. SA

Power Networks, along with other distribution network service providers (DNSPs) in the NEM, currently have no control of embedded generation installed at household and small business level. Therefore, a control scheme is required to disconnect these rooftop solar inverters in a controller manner when directed by AEMO. This issue is particularly pertinent in South Australia due to the NEM-leading levels of IBR penetration in the distribution network.

The lack of control at the distribution network level of IBR generation, in combination with a power network originally developed for dispatchable generation, means that DNSPs are ill-equipped to ensure system security in the absence of tools to manage network flows from IBR loads responsively.

The need for capability to disconnect loads roof top solar quickly during periods of high IBR generation coincident with low demand load, so as to maintain a minimum operational demand on the power system; and

SA Power Networks has implemented a scheme of last resort that enables the effective curtailment of IBR via management of distribution network voltage levels. This scheme of last resort must be available to automatically control network voltages within the SA Power Networks electricity infrastructure

The scheme requires capability to remotely increase substation voltage setpoints outside of normal ranges and leads to increased voltages at customer inverters which would causes some inverters above their overvoltage trip settings, leading them to disconnect. Using this scheme ~250MW of IBR curtailment is achieved.

Securing ROCOF Against Maloperation - TasNetworks:

Adaptive UFLS Algorithm

1. Calculates frequency and rate of change of frequency (ROCOF)
2. Takes into account system inertia in real time by monitoring generation
3. Checks available load to trip
4. Sends real-time availability data for bidding into frequency control services market.
5. Noting market operator AEMO controls characteristics