NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Lesson Learned

Wind Farm Winter Storm Issues

Primary Interest Groups

Balancing Authorities (BA)
Generator Operators (GOP)
Generator Owners (GO)

Problem Statement

During an extreme cold weather event, a wind farm with 100 wind turbines and a total capacity of over 200 Mw experienced the loss of 75 percent of its generation for over 100 hours due to turbine faults. The lost generation could have helped to prevent a Balancing Authority (BA) and Reliability Coordinator (RC) from having to implement rotating load sheds.

Details

A wind farm experienced rigid winter conditions of temperatures below freezing, ice, as well as snow for over four days. At times the sustained winds were over 20 mph with gusts much higher which created wind chills in the single digits. These weather conditions had been predicted a week earlier by weather services in long range forecasts.

Before the event, the wind facility implemented its Standard Operating Procedure (SOP), "Icing Conditions Action Plan," that established guidelines and steps to be taken during icing conditions. This procedure, among other things, emphasized safety of the crew and turbine equipment both during a winter event and as ice begins to shed from the turbines and turbine blades. Also, in preparation for the upcoming storm, a major upgrade to the Supervisory Control and Data Acquisition (SCADA) server was delayed and the additional manpower for the upgrade was used for restoration efforts. It should be pointed out that the wind facility had established minimum and maximum operating temperatures and during the event the ambient temperature sensors on the turbines reported that the ambient temperature stayed within those parameters.

When the winter storm first began, lightning knocked out many turbine anemometers and related equipment. Because wind turbines require at least one functioning anemometer, the wind turbines could not run. They set for a period because crews were unable to physically get to the faulted turbines during the weather event due to snow and ice covered roads. As repairs from the lightning strikes were completed and turbines were going through their restart procedure, the temperature had been falling and snow and ice had been accumulating on the nacelle-mounted radiators* of each of the wind turbines. Due to not running in a while, oil was not circulating and being stationary in the radiator passages, the oil temperature quickly plummeted and its viscosity increased. Radiator cooling fans had been left on and this added to the rapid cooling of the oil. When the turbines were returned to service from the lightning repairs and the gearboxes heated up, the bypass valves (operating due to high pressure differentials across the radiators) diverted the oil, which was hot now due to cooling the generator parts, directly to the gearbox and the turbines with cold radiators faulted on high gearbox oil temperature. As a result, a majority of the turbines faulted. There were no operator-initiated shutdowns.

Corrective Actions

Besides clearing snow and ice off of the radiators, the wind farm facility personnel consulted with the turbine manufacturer about various methods to heat up the cold oil. Generator tests were performed to warm the valves

and bleed heat through to the cold oil. Parameters were also changed to force cooling fans off that normally were on during circulation of gearbox oil. Crews also climbed turbines with electric heaters to warm the oil. Also, crews manually removed the ice that could be reached from a safe position (standing inside the nacelle, reaching through the top hatch.) The remote operations 24/7 control center was instructed that if the facility should be curtailed, control center personnel should cycle curtailed turbines back online to minimize cooling of the radiators.

Lessons Learned

This event brought forward numerous lessons learned:

- Wind turbine nacelle-mounted oil coolers can accumulate ice quickly in a snowstorm if the oil isn't circulating and creating heat to melt the winter precipitation. During an extreme cold weather event, even if wind turbines are not being used, they should be cycled online to provide flow of cooling oil and therefore aid in the warming of that cooling oil. Owners should consult with manufacturers about the timing needed for this cycling.
- All cooling equipment for radiators on wind turbines should be disabled for cold weather events.
- Entities should investigate the purchase of cold weather packs for wind turbines which enable them to run during extremely cold weather. The cold weather packs provide heat where needed to keep oil and other vital components at operating temperature.
- During preparation for winter operation, generator owners should evaluate their vehicle plans and ensure they have all the necessary equipment to be able to travel safely on winter roads.
- Major updates and upgrades to SCADA and other critical data servers, communications equipment and computers should be delayed if bad weather is forecasted.

*On a wind turbine the nacelle is the enclosure at the top of wind turbine tower which houses the generator and gearbox, and supports the rotor and blades at the hub of the wind turbine generator. In wind turbines both engines and gearboxes in the nacelle need cooling. Often this is done by installing a radiator package either inside or outside the nacelle along with fans to aid the cooling. In very cold winters the same installations that are used for cooling may also be needed for warming. Such were the conditions for this cold weather event.

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