NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Lesson Learned

Forecasted High Wind Speeds

Primary Interest Groups
Transmission Owners (TO)
Transmission Operators (TOP)
Generator Owners (GO)
Generator Operators (GOP)
Reliability Coordinators (RC)
Balancing Authorities (BA)

Problem Statement
High-speed wind days can pose challenges to transmission, distribution, and wind-generation availability.[1] This lesson learned focuses on the implementation of coping strategies by a specific utility developed from prior experience; it is largely a success story.

Details
Throughout the course of a particular winter day, certain areas of an entity's system experienced high wind speeds (the "high wind-speed day").

In anticipation of forecasted high wind-speeds for most of the day, the entity postured the system by performing the following actions:

- Consulting with the TO to postpone certain non-critical transmission outages
- Consulting with generators that reported increased requirements of must-run capabilities at certain generation stations to identify potential operational issues/restrictions impacting the fleet
- Preemptively reducing variable generation forecasts[2] (due to the expected exceedance of cut-out speeds) to allow for market tools to schedule other resources in the place of variable generation

The TO prepared for the high wind-speed day by scheduling additional staff at the main control center on the high wind-speed day.

Distribution companies prepared for the high wind-speed day by activating operations dispatch at various distribution operating centers with regional coordination to allow for quicker and proactive response in coordination with the TO.

During the event, the entity adjusted the hourly variable generation forecasts to reflect actual trends.

[1] This Lesson Learned is about near-term (1–5 day forecast) damaging wind warnings and actions to take. There is another lesson learned under development on system hardening that is about longer term work to improve the system's resistance to damage.
[2] Variable generation forecasts provide energy and ramp forecasts to the Entity for all variable (wind and solar) generators, and used by the Entity's energy market dispatch software for scheduling.

The high wind-speeds caused forced outages of various transmission and distribution lines, resulting in load loss. Wind generation stations were removed from service from the high winds as well due to high-speed wind cut outs. Forced outages of various transmission lines also contributed to the event.

Cumulatively across the day, total affected loads as a result of the forced outages of various transmission lines were 161 MW with a maximum simultaneous load loss of 100 MW for less than 20 minutes.

The maximum recorded hourly wind speeds at affected wind generation stations on the high wind-speed day are depicted in **Figure 1**. A normal day's maximum wind speed in the area is less than 30 mph.

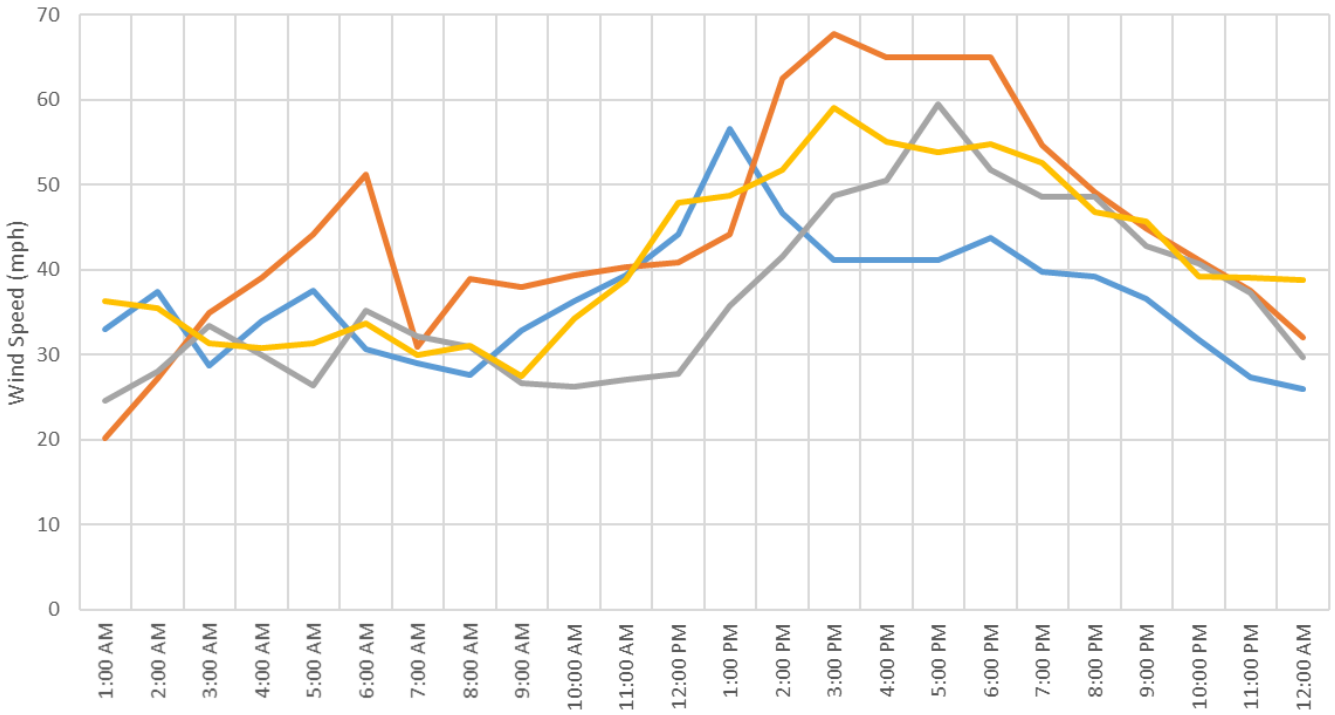

Figure 1: Maximum Recorded Hourly Wind Speeds at Affected Wind Generation Stations on the High Wind-Speed Day

In anticipation of forecasted high wind-speeds for most of the day, the TO scheduled additional staff at the main control center in anticipation of greater needs for monitoring, alarm response, problem diagnosis, dispatching of recovery crews, clearance development, and communication on the high wind-speed day. Additionally, distribution companies activated operations dispatch at various distribution operating centers with regional coordination to allow for quicker and proactive response in coordination with the TO.

To start posturing the system, the impacted entities agreed to delay a planned outage to a 230 kV transmission line due to high wind and freezing rain forecast for the day.

The entity inquired with the generators whether the high winds were expected to cause them any operation issues. Some reported that they increased the must-run quantity at certain generation stations at their discretion.

As the day progressed, high wind speeds were reported in various areas. Available information indicated wind speeds exceeding cut-out thresholds (typically 55 mph) caused by the high wind gusts, reported at up to approximately 70 mph.

Later, high wind speeds resulted in wind cut outs at several wind generation stations. Numerous wind generation stations (with a combined installed capacity of 530 MW) were either removed from service entirely or derated. The removal from service and derates of wind generation stations resulted in actual wind output being below the variable generation forecast and contributed to a low area control error (ACE). Hourly wind forecasts were adjusted to more accurately reflect actual outputs.

Additionally, two 230 kV and four 115 kV transmission lines were forced out of service due to the high wind speeds at midday and continuing throughout the day. Durations of the interruptions varied throughout the day. Forced outages of various transmission lines also resulted in wind generation stations being removed from service by configuration. Despite wind generation stations experiencing cut outs and forced outages by configuration, the lowest wind output percentage of the entire wind generation fleet was 19% (as depicted in **Figure 2**). This is attributed to the high wind speeds not being a single, local, and high wind speed event but rather a series that occurred across the area and throughout the course of the high wind-speed day.

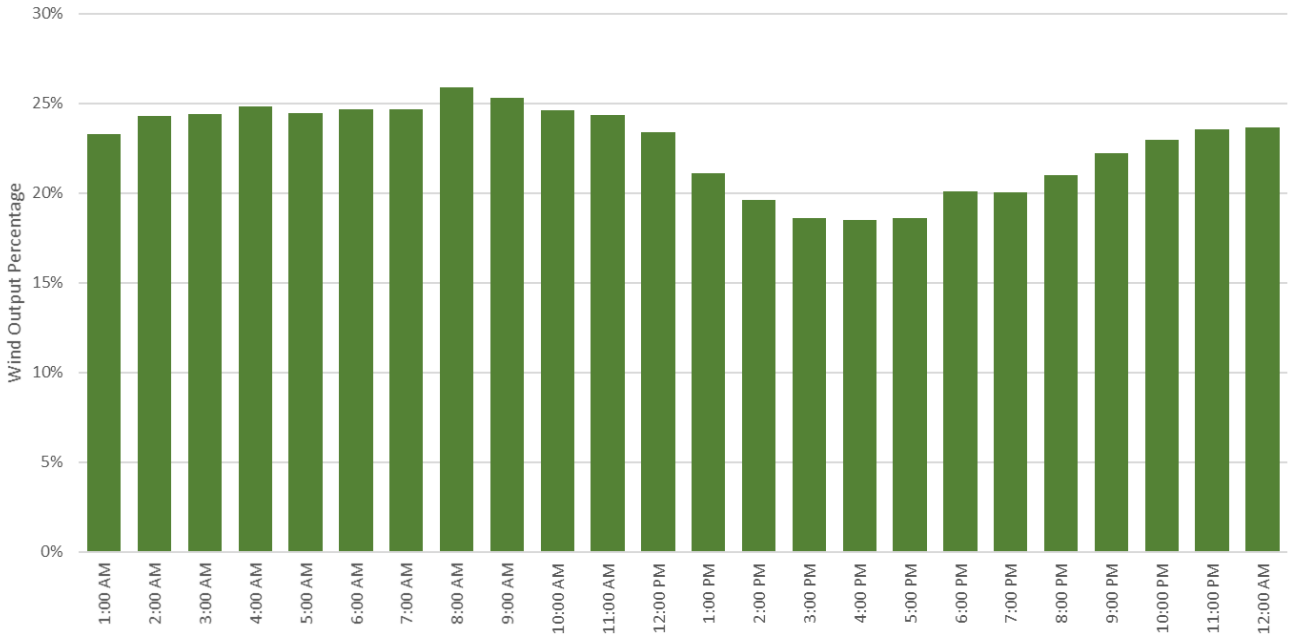

Figure 2: Wind Output Percentage of Total Energy Output across the Entity on the High Wind-Speed Day

The affected wind generation stations' cumulative output on the high wind-speed day is depicted in **Figure 3**. The maximum cumulative generation decreased from 490 MW before 12:00 p.m. to 70 MW just before 6:00 p.m. Eastern, representing a cumulative combined reduction in output of 420 MW.

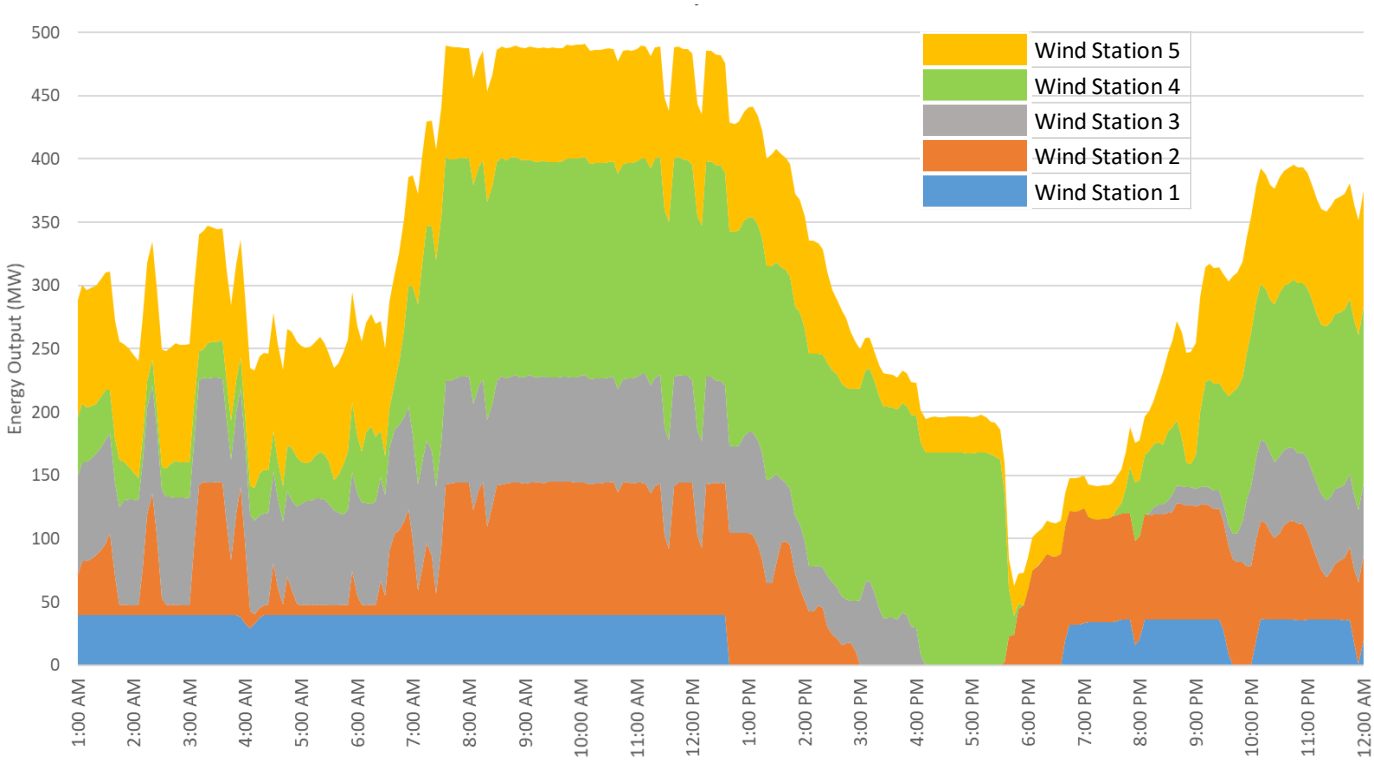

Figure 3: Cumulative Output of Affected Wind Generation Stations on the High Wind-Speed Day

Most of the transmission lines experiencing forced outages on the high wind-speed day were returned to service with only a few whose restoration efforts continued into the next day.

Corrective Actions

The entity successfully used previous experience to improve their high speed wind forecast response. This information is being shared to help other entities in their preparations.

Lesson Learned

The above discussion highlights the actions taken by one utility for a high wind-speed day that preserved reliability and improved resilience of the transmission system. The entity in this case has implemented improvements learned over time similar to the expectations set forth in the Event Response Improvement Cycle (**Figure 4**), which is not specific to wind speed issues but is a generic continuous improvement process applicable to any area where improvement in event preparedness/resilience is desired.

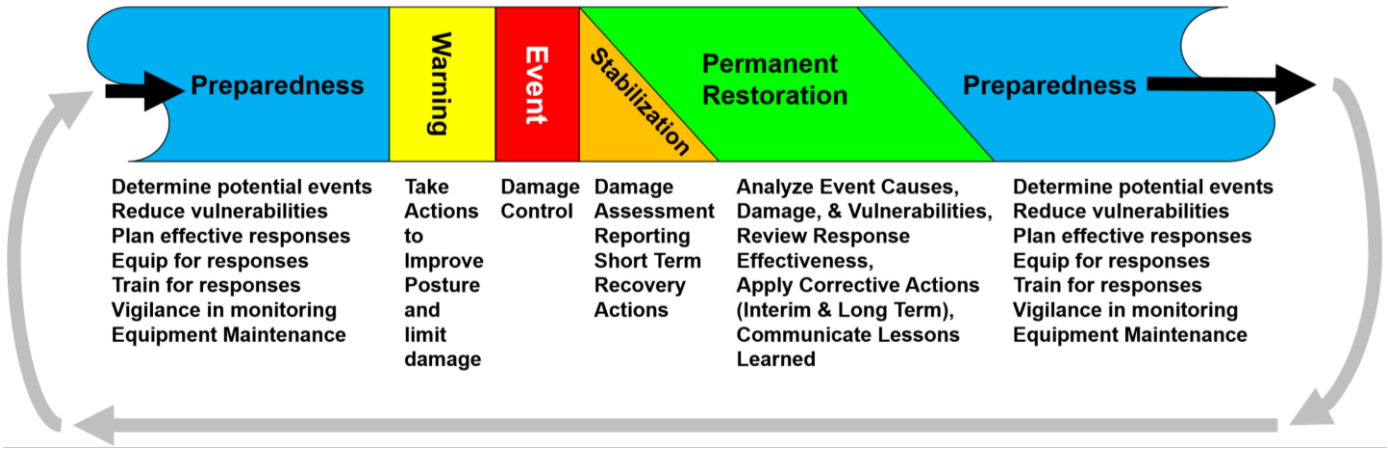

Figure 4: Event Response Improvement Cycle

- **Preparedness:** This is focused on event prevention: determine potential events, reduce vulnerabilities, plan effective responses, equip for responses (parts inventory, locations, personnel availability, logistics, assistance agreements, etc.), train for responses, vigilance in monitoring, and equipment maintenance.
- **Warning:** Generally, weather events can be predicted, but there is not always a warning for every event. If warned, take actions to improve posture (e.g., specific vulnerability reduction measures, move parts and personnel for anticipated needs, alert resources, staff up as needed) regarding the impending event and take steps to limit damage.
- **Event:** This refers to damage control, or keeping the event from being worse or more widespread than it has to be.
- **Stabilization:** This refers to damage assessment, reporting, and short term recovery actions to restore; it may overlap with permanent restoration work.
- **Permanent Restoration:** This involves analyzing event causes, damage, and vulnerabilities; reviewing response effectiveness; applying corrective actions (interim & long term to prevent event recurrence); and communicating lessons learned. This is likely to overlap with the Return to Preparedness step.
- **Return to Preparedness:** This is not an idle phase but rather a time to study, learn the lessons from the previous event, monitor conditions and effectiveness of the prior response, and plan further improvements, whether they be process, procedural, software, settings, or physical. This step is also for gathering resources to prevent and deal with future events.

The following additional practices are used by various entities in anticipation of forecasted high wind-speeds:

- RCs could initiate calls with various facility owners and operators in order to proactively posture the transmission system.

- The postponement of non-critical transmission planned outages could be employed to improve the resiliency of the transmission system and reduce the risk of planned outages being extended if high wind-speeds were to disrupt the maintenance activities.
- Scheduling additional staff and maintaining constant communication between the RCs and facility owners and operators could enable for quicker and proactive response to correct or alleviate the events as they occur, aiding in manageable task demands of control room operators and other staff.
- Position recovery staff and material for both transmission and distribution purposes in protected locations near the areas expecting damage. If the event is expected to create widespread damage, consider asking for other entities and contractors to help in the recovery and have them prepare as well.
- Preemptively reducing variable generation forecasts could allow for market tools to schedule other resources in the place of variable generation (if applicable as per design of energy market dispatch software).
- Secure loose, light weight material in or around substations and generation switchyards (this is often an issue where construction is on-going).
- Primary interest groups are advised that weather forecasts could indicate potential inclement weather similar to the high wind-speed day as described in this lessons learned document. Any necessary preparations through preventative actions to mitigate any potential adverse effects of inclement weather are recommended.
- Some entities disable automatic reclosing during the summer fire season, and high winds (>60 mph is the trigger) are one factor that lead to the "Red Flag Warning," which is a special weather watch. During that time, dispatchers generally don't "test" the line (trying to close it after it has tripped to lockout) until a patrol of the line is completed.
- For safety concerns of field personnel, repair work should not start until after the wind storm has subsided to safe velocity.

NERC's goal with publishing lessons learned is to provide industry with technical and understandable information that assists them with maintaining the reliability of the bulk power system. NERC is asking entities who have taken action on this lesson learned to respond to the short survey provided in the link below.

Click here for: Lesson Learned Comment Form

For more Information please contact:

NERC – Lessons Learned (via email)

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