Eversource
345 kV Breaker Replacements: Manchester (CT) and Amherst (NH)

Planning Advisory Committee Meeting

September 18, 2024

Overview

- Eversource has experienced frequent problems with 345 kV circuit breakers using pneumatic air tripping mechanisms
- Eversource intends to replace the problematic 345 kV circuit breakers currently installed on its system with more reliable models gradually over time

- This presentation covers:
  - Background on 345 kV circuit breakers and tripping mechanisms
  - Identification of asset condition need and reliability concerns
  - Discussion of solution alternatives
  - Upcoming 345 kV circuit breaker replacements at two substations

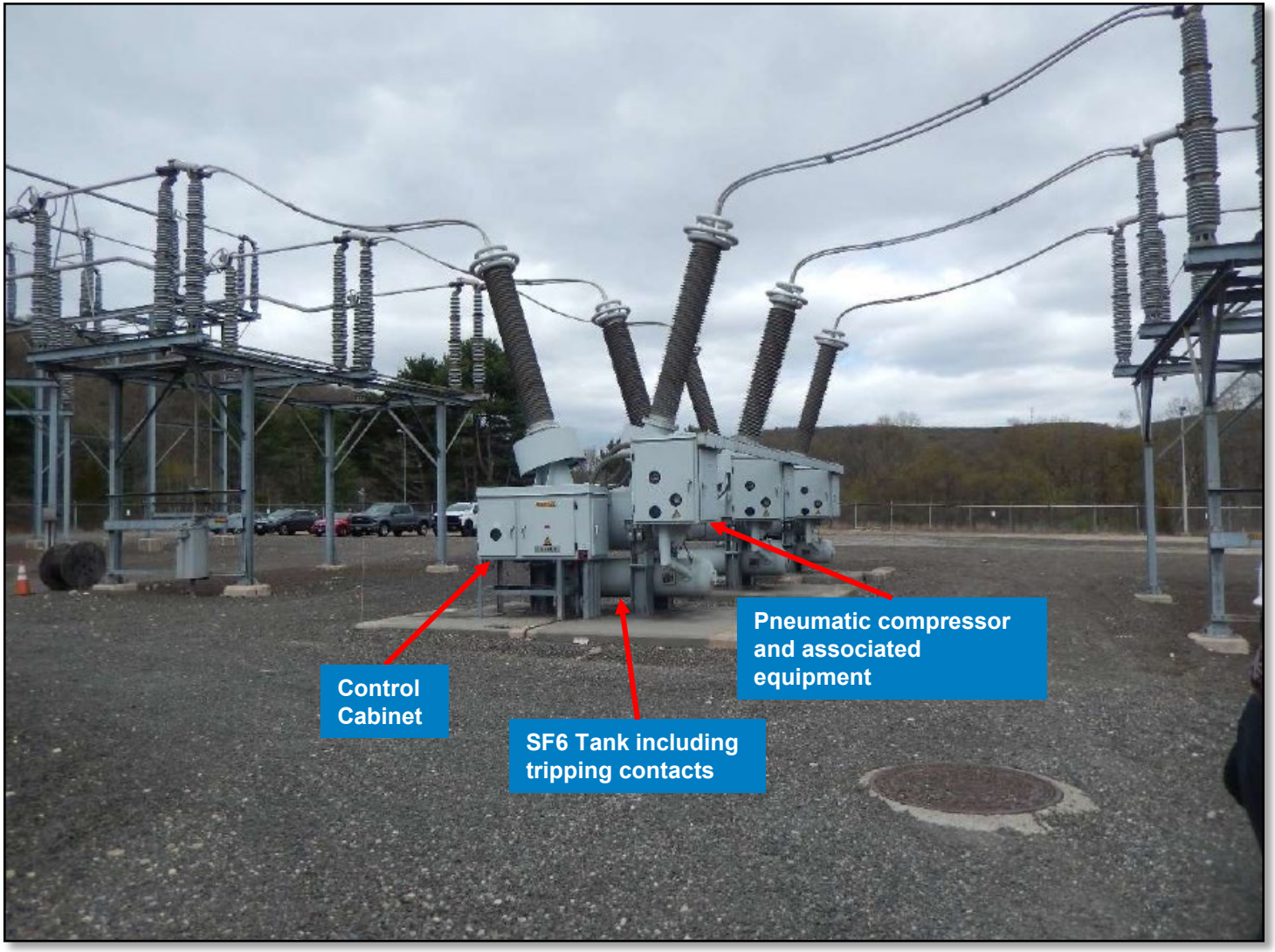
Background on 345 kV circuit breakers

- A circuit breaker is a device for interrupting an electrical circuit
- On the transmission system, circuit breakers are used to de-energize transmission facilities in response to faults (i.e. short circuits) and to energize and de-energize transmission facilities under normal conditions
  - 345 kV circuit breakers are typically designed to interrupt fault currents of up to 50,000-63,000 amps
- Circuit breakers interrupt electrical currents by creating a physical gap between electrical contacts inside of the circuit beaker
  - When a transmission facility is energized, a physical connection is made between the electrical contacts within the circuit breaker
  - When a transmission facility needs to be de-energized, an operating mechanism inside the circuit breaker physically moves the contacts to create a gap, interrupting the electrical current
- The internal components of the circuit breaker are contained within a chamber filled with an insulating gas
  - Insulating gas is usually sulfur hexafluoride (SF6)
  - Older circuit breakers may use dielectric oil instead of gas

Circuit breaker operating mechanisms

- Several types of mechanisms are used to operate the physical contacts within a circuit breaker
- Pneumatically-driven circuit breakers use compressed air to operate the contacts
  - The pneumatic air system includes an air compressor, storage tank, valves, pneumatic tubing and desiccant (air dryer) system to remove moisture from the air
- Spring hydraulic circuit breakers use mechanical springs to operate the contacts
  - A hydraulic pump uses mechanical force to compress the spring
  - The stored energy in the spring is then used to open the circuit breaker with the required force to interrupt a fault
  - These mechanisms are mechanically simpler than pneumatic air systems

Pneumatically-driven 345 kV circuit breaker



Asset condition need and reliability concerns with pneumatic air tripping mechanisms

Primary asset condition need

- Eversource has experienced frequent failures associated the air compression systems on pneumatically operated breakers, including:
  - Failures of the desiccant (air dryer) systems leading to failures of the entire compressed air system
  - Air system leaks
- Eversource is no longer able to source replacement compressors or replacement parts/components for compressors and desiccant systems
- Failures within the pneumatic air systems have resulted in breakers not operating properly, including:
  - Delayed or incomplete opening of electrical contacts (i.e. failure to trip)
  - Trips under no-fault conditions due to low air pressure resulting in unplanned outages and emergency repairs
- Circuit breakers that fail to trip or trip unintentionally present serious reliability risks to the 345 kV transmission system
  - Failure-to-trip will delay clearing of 345 kV transmission system faults and increase risk of cascading transmission outages
  - Unintentional trips can threaten integrity of 345 kV transmission network

Secondary asset condition needs

- Some pneumatically-operated 345 kV circuit breakers also have history of SF6 leaks and other mechanical issues
  - SF6 is a potent greenhouse gas
  - Loss of SF6 gas may require emergency outages and repairs

Repair or refurbishment

- Eversource first investigated retrofitting existing pneumatically-operated breakers with new compressor and desiccant systems
  - Eversource discussed potential retrofit options with circuit breaker manufacturers
  - Manufacturers were unable to offer replacement pneumatic air systems that could adequately address known reliability issues with existing systems
  - Some circuit breaker models also have known issues that extend beyond the pneumatic air systems
    - SF_6 leaks and mechanical issues would not be addressed by replacement of the pneumatic air systems
- Given the lack of refurbishment options, Eversource determined that replacement of pneumatically-operated circuit breakers with new circuit breakers using spring hydraulic mechanisms would be necessary

Overview of solution alternatives

- **Alternative 1 (Base Alternative):** Replace existing pneumatically-operated circuit breakers with circuit breakers units employing a more reliable spring hydraulic operating mechanism
  - Lowest cost, like-for-like replacement
- **Alternative 2:** Replace existing pneumatically-operated circuit breakers with **non-SF6** circuit breakers units employing a more reliable spring hydraulic operating mechanism
  - Eversource installed its first 345 kV Hitachi ABB EconicQ circuit breaker at the Haddam Neck substation in December 2023
    - This style breaker utilizes a mixture of Carbon Dioxide (CO2), Oxygen (O2) and a specific Fluoronitrile (C4-FN) as the insulating medium
  - This installation is a pilot to test performance of this new design as an alternative to traditional SF6 circuit breakers
- **Additional alternatives**
  - Eversource may consider additional alternatives that address multiple asset condition needs at specific substations on a case-by-case basis

345 kV Pneumatic Circuit Breaker Replacement Program

- Eversource currently has 127, 345 kV circuit breakers with pneumatic tripping systems in-service across 28 substations throughout CT, MA, and NH which are under review
  - At the May 18, 2022 PAC meeting Eversource presented 23 breakers across 4 stations for replacement
  - These circuit breakers are excluded from the total as replacement projects are either complete or underway

- Eversource intends to gradually replace the remaining pneumatically-operated 345 kV circuit breakers over time
  - Eversource will prioritize replacements at substations with higher-than-normal rates of corrective maintenance or at substations with opportunities for coordination with other projects

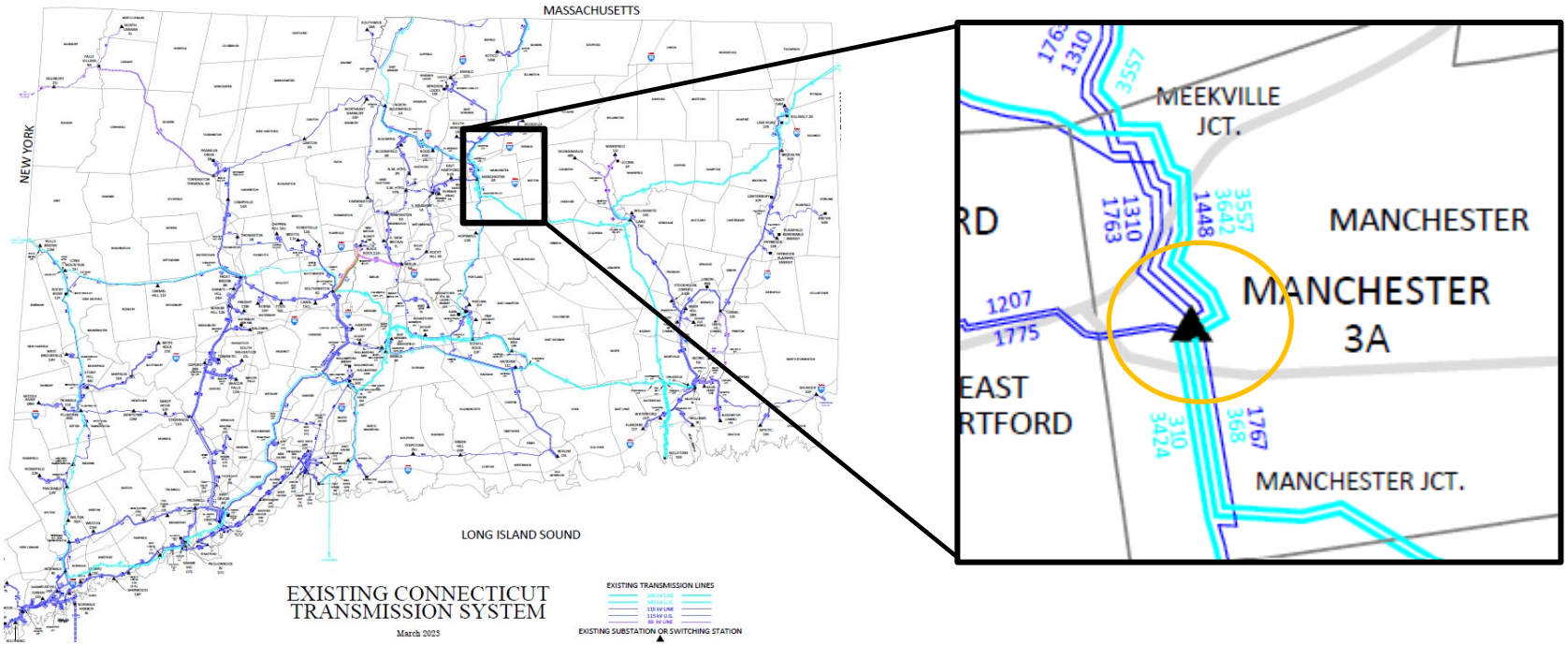
- **Preliminary assessment of solution alternatives**
  - For most substations, Eversource anticipates that Alternative 1 will be the most cost-effective solution
  - Eversource will continue evaluate the performance of pilot projects using non-SF6 circuit breakers and will consider transitioning to these breakers in the future (Alternative 2)
  - Additional alternatives will be evaluated on a case-by-case basis

Near-term 345 kV pneumatically-operated circuit breaker replacement projects

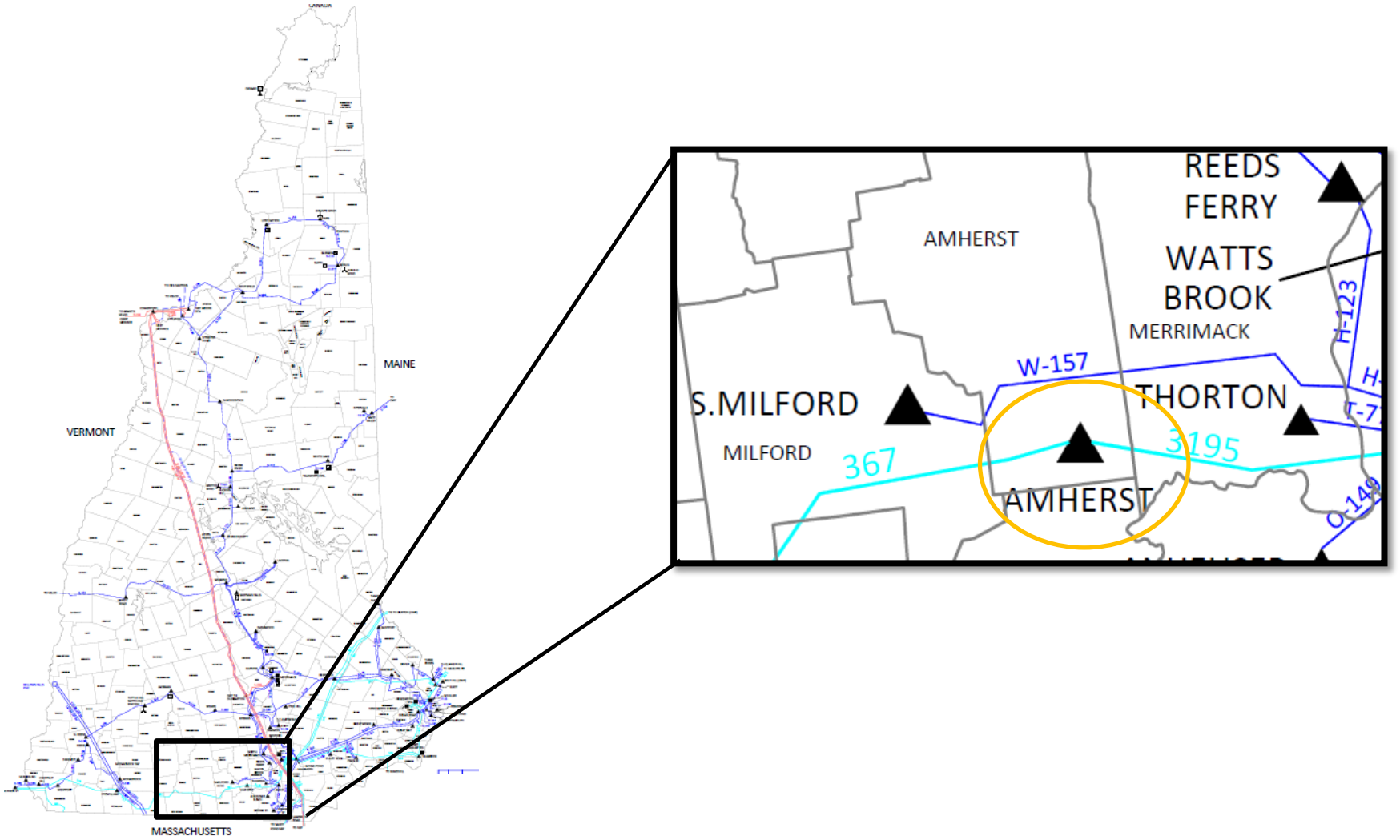
- Manchester (CT)
  - 345 kV and 115 kV transmission substation in located in Manchester, CT
  - Terminal for five 345 kV and six 115 kV lines
  - Contains nine 345 kV circuit breakers, of which eight use pneumatic operating mechanisms
  - Remaining 345 kV circuit breaker uses spring hydraulic mechanisms

- Amherst (NH)
  - 345 kV transmission substation in located in Amherst, NH
  - Terminal for two 345 kV lines
  - Contains four 345 kV circuit breakers, all of which use pneumatic operating mechanisms

Project Location: Manchester (CT)



Project Location: Amherst (NH)



Photos

345 kV breaker at
Manchester Substation

345 kV breaker at
Amherst Substation

345 kV breaker operating history

Station	Average Age of Breakers	Corrective Maintenance Actions*	Identified issues

Manchester	30 years old	133	• **Compressor related issues:**
			  • Compressor pressure switch failures, leaks on pneumatic assembly, low air pressure alarms, leading to full compressor replacement and compressor belt replacement
			• **Valve related issues**:
			  • Leaking valves leading to the replacement or rebuild of the valve
			• **Other**:
			  • SF6 leaks and other mechanical issues

Amherst	21 years old	62	
Total		195	

- The breakers at Manchester and Amherst substation have a history of corrective maintenance
  - Maintenance on pneumatically operated breakers is 3 times that of spring hydraulic units
- The ongoing pneumatic system component failures have resulted in increased inspection intervals and pneumatic system corrective & preventative maintenance activities

*Corrective maintenance actions represent activity over the past 21 years (since 2003).

Preferred Solution

- **Alternative 1 (Base Alternative):** Twelve 345 kV circuit breakers will be replaced across the Manchester (CT) and Amherst (NH) substations within the next few years
- Scope includes replacement/refurbishment of existing foundations, control boxes, connections and cabling, as needed
  - New cabling will comply with NPCC Directory 4, which requires physical and electrical separation of the cables that transmit the control signals and power to the control enclosure and power panels.
- New breakers will improve system reliability, reduce frequency of breaker mis-operations and corrective maintenance, and have a 10-year manufacturer warranty
- Other alternatives:
  - Non-SF6 circuit breakers were not considered for these locations. As described on slide 7, Eversource is evaluating the performance of non-SF6 circuit breakers on a pilot basis
  - No expanded alternatives were identified for analysis. At these substations, direct replacement of the problematic circuit breakers is the lowest cost solution

Station	345 kV Breakers to be Replaced	Cost Estimate	In-Service Date
Manchester (CT)	8	$16.4	Q2 2026
Amherst (NH)	4	$9.3	Q4 2026
Total	12	**$25.7M**	

Feedback and Next Steps

- Please submit any written comments on these projects to:
  - pac.responses@eversource.com
  - pacmatters@iso-ne.com

Presentation	Date	Description
Initial Presentation	September 18, 2024	Presentation on 345 kV Breaker Replacements
Questions/Feedback	October 2, 2024	Comment deadline

Questions