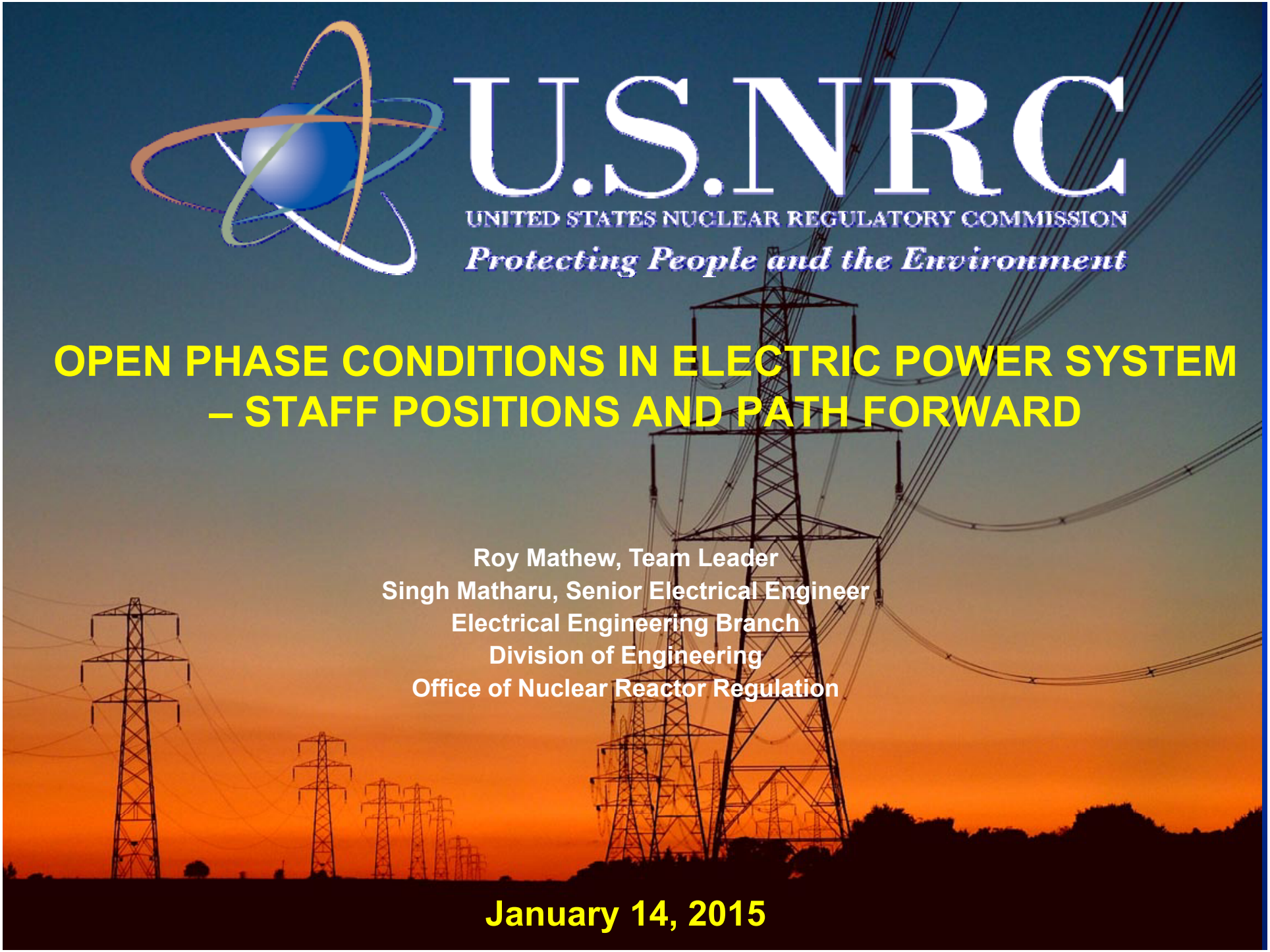

OPEN PHASE CONDITIONS IN ELECTRIC POWER SYSTEM – STAFF POSITIONS AND PATH FORWARD

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AGENDA

- Open Phase Condition (OPC)
- Operating Experience
- Regulatory Requirements
- NRC Actions
- Staff Position
- Branch Technical Position (BTP 8-9)
- Path Forward

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OPC

- **Loss of one of the three phases** of the offsite power circuit on the high voltage side of a transformer connecting an offsite power circuit to the transmission system coincident with or without a high-impedance ground fault; or

- **Loss of two of the three phases** of the offsite power circuit on the high voltage side of a transformer connecting an offsite power circuit to the transmission system

- **Creates Unbalance in AC power system** (sequence voltages and currents)
  - Transformer winding configuration (Wye-Wye-Wye, Delta-Wye-Wye, Wye-Delta-Delta, Wye-Wye-Buried Tertiary Delta, Delta-Wye, Wye- Delta, Wye-Wye-Delta, and Wye-Wye with Delta stabilizing winding)
  - Grounding (solid or resistance ground)
  - Type of transformer core (Shell or Core)
  - Loading condition and operating configuration (standby/no load/lightly loaded)
  - Phase angle shift
  - Reduced starting torque for motors
  - Overheating of motors/overload/loss of life/damages to rotating machines
  - Protective device actuation and lock out

OPERATING EXPERIENCE

- **Eleven operating events (2001-2014)**
  - Failure of insulators and switchyard connections
  - Malfunction of breakers

❖ South Texas Project Unit 2, US – March 1, 2001
❖ Koeberg, South Africa – November 11, 2005
❖ Fitzpatrick/Nine Mile, US – December 19, 2005
❖ Vandellos, Spain – August 9, 2006
❖ Dungeness A, UK – May 14, 2007
❖ Beaver Valley Unit 1, US – November 1, 2007
❖ Byron Unit 2 – January 30, 2012
❖ Byron Unit 1 – February 28, 2012
❖ Bruce Power Unit 1, Canada – December 22, 2012
❖ Forsmark Unit 3, Sweden – May 30, 2013
❖ Dungeness B, UK - April 2014

REGULATORY REQUIREMENTS

- **General Design Criterion (GDC) 17, "Electric Power Systems," or the applicable principal design criteria in the updated final safety analysis report**
- **Design criteria for protection systems under 10 CFR 50.55a(h)(2) or 10 CFR 50.55a(h)(3)**
- **Technical Specification (TS) requirements**
  - 10 CFR 50.36(c)(2) & (3)
  - TS LCO 3.8.1 – offsite and onsite power systems
  - TS Surveillance Requirements

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NRC ACTIONS

- **NRC Special Inspection**[1] at Byron Station
- **Information Notice** 2012-03[2]
- **Bulletin** 2012-01: Design Vulnerability in Electric Power System[3]
- **Summary Report** - documented NRC staff review of licensee responses and staff recommendations[4]
  - All operating nuclear power plants susceptible to OPC except Seabrook Station
    - SF6 insulated Switchyard
    - Single pole breaker failure protection scheme
  - Existing protection schemes based on voltage magnitude cannot identify OPC and take appropriate mitigation measures (i.e., automatically transfer power to ESF buses from an alternate offsite or onsite power source)
  - Staff recommended regulatory action to address the open phase issue
- **Supported development of industry initiative** to resolve OPC
- **Briefed Advisory Committee for Reactor Safeguards (ACRS)**
  - Full Committee (December 4, 2014)
  - Sub-Committee (November 17, 2014)
- **Participating in an IAEA effort** to issue a Safety Report and also an IEEE working group to develop a Standard.

1. Agencywide Documents Access and Management System (ADAMS) Accession No. ML12087A213
2. ADAMS Accession No. ML120480170
3. ADAMS Accession No. ML12074A115
4. ADAMS Accession No. ML13052A711

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STAFF POSITION

CURRENT Operating Reactors and ACTIVE New Reactor Designs

Must be able to:

1) Detect an open phase condition on the high side of the transformer connected to the offsite power system;
2) Alarm in the main control room; and
3) Automatically Actuate and Mitigate the event.

Bases: The isolation and actuation of onsite power system have to be automatic to satisfy the time criteria specified in Chapter 15 as required by GDC 17 to meet fuel design limits, core cooling and maintaining containment integrity

PASSIVE New Reactor Designs

Must be able to:

1) Detect an open phase condition on the high side of the transformer connected to the offsite power system; and
2) Alarm in the main control room.

Bases: Design Certification requires, in accordance with GDC 17, onsite AC power distribution system to be powered from either from one offsite circuit or onsite diesels for all modes of operation, including during a safe shutdown, and the offsite circuit serves a defense-in-depth function for maintaining reactor safety and charging safety-related batteries.

STAFF'S POSITION (Cont.)

Licensee solution (Class 1E or non-Class 1E) to address OPCs, should meet the following functional requirements:

- The design should address single failure criteria as outlined in the GDCs or the principal design criteria specified in the updated final safety analysis report for the specific nuclear power plant (i.e., for an OPC, a non-Class 1E circuit should not preclude the onsite electrical power system from being able to perform its safety function given a single failure in the onsite power system).
- The OPC should be automatically detected and alarmed in the main control room under all operating electrical system configurations and loading conditions
- If offsite power circuits are degraded due to OPC, the power source should be transferred automatically to the onsite power system within the time assumed in the accident analysis and without actuating any protective devices, given a concurrent design basis event.
- TS Surveillance Requirement and Limiting Condition of Operation for equipment used for mitigation of OPC should be consistent with the operability requirements specified in the existing plant TSs.

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DRAFT BRANCH TECHNICAL POSITION (BTP 8-9)

- OPC is a credible event of safety significance and must be considered in the electric power system design for nuclear power plants in accordance with GDC 17
- Single OPC with and without high impedance ground fault conditions and two OPCs (without ground fault) considered for resolution of OPC
- Staff will issue BTP 8-9 after incorporating the industry and ACRS comments
- BTP guidance will be consistent with the functional requirements specified in November 25, 2014 letter addressed to NEI (See ADAMS Accession Package No. ML14120A196)
- Staff plans to use the BTP guidance in accordance with 10 CFR 50.34(h) for any future licensing actions
- Staff briefed the Advisory Committee on Reactor Safeguards (ACRS) Subcommittee for Digital Instrumentation & Control Systems on November 17, 2014, and the ACRS full committee on December 4, 2014
- ACRS Letter (ADAMS Accession No. ML14343A485)

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PATH FORWARD

- Staff provided response to NEI regarding regulatory requirements for OPC Detection and Isolation (See ADAMS Accession Package No. ML14120A196)

  To continue the NRC and industry's efforts to resolve and close-out Bulletin 2012-01, each licensee should do the following. This will be addressed in the proposed Interim Enforcement Policy

  - Provide a Commitment letter to the NRC stating that the OPC issue will be resolved in accordance with the schedule established in the industry initiative and how the solution addresses GDC 17 or the principal design criteria specified in the updated final safety analysis report for their specific nuclear power plant
  - Develop and maintain detailed a plant-specific analysis and documentation which established the resolution of the OPC design vulnerability, including failure mode analysis that is available for NRC staff's audits or inspections
  - Provide a close-out letter to the NRC when full compliance is achieved

- Staff is planning to seek Commission approval of Interim Enforcement Policy by the end of 1Q 2015

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QUESTIONS ?