AMERICAN TRANSMISSION COMPANY®

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NEV Considerations

for Transmission Line Construction and Maintenance Projects

Andy Eberhardt, ATC
Mike Warntjes, ATC

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Agenda

- About ATC
- Neutral to Earth Voltage (NEV) Background
- NEV collaborative
- Qualifying Project Types & Coordination
- Questions

About ATC

ATC owns and operates the electric transmission system in portions of Wisconsin, Michigan, Minnesota and Illinois

About ATC
Our history

- Began operations January 2001
- Wisconsin Act 9
  - First multi-state, transmission-only utility
  - Equal access
  - Improved capacity
  - Better coordination
    - Planning
    - Construction
    - Operation

About ATC
Business highlights

- Assets grew from $550 million in 2001 to $4 billion in 2016
  - 9,540 miles of line (69kV thru 345kV)
  - 545 substations
- Infrastructure serves about 5 million people
- Saved customers more than $100 million a year in energy costs
- Investing >$300 million/year in new projects
- Construction projects regulated by states
- Rates regulated by FERC

NEV Background

- Distribution systems in Wisconsin have:
  - multi-grounded neutrals
  - return current flows through the neutral and earth
  - Neutral to Earth Voltage (NEV)
- Direct induction due to transmission load current can also affect NEV levels

NEV Background

- Transmission system contribution to NEV:
  - Direct induction to distribution neutral
    - Magnetic field: can induce a current on the distribution system neutral/earth loop
    - Electric field: gradient can create a voltage difference between conductive surfaces (usually not as significant as magnetic field induction)
  - Induction to transmission static/shield wire
    - Magnetic field: can induce a current on the static wire/earth loop
    - This source of current can be conducted to the distribution system neutral through a bond or through the earth

Initial Steps

- Additional experience needed
- Prudent avoidance should be explored
- Design mitigation if avoidance is not feasible
- Mitigation is handled on a case by case basis

NEV Collaborative

- Legislation encourages corridor-sharing (Wis. Act 89)
- Local Distribution Companies (LDC's) have long history and expertise dealing with NEV
- ATC conducted NEV studies on specific transmission projects
- Assessment and mitigation is an iterative process between ATC and LDC's
- Collaborative effort participants included LDC's, Xcel Energy, Dairyland Power, WECA, MEUW and ATC

NEV Collaborative (continued)

- Identify which projects could have NEV impacts
- Developed an interaction and reporting process
- Design guide allows for a consistent review process
- Provides for consistent stakeholder communications
- Process to address non-project NEV inquiries

Qualifying Project Types

- Generally, NEV assessment will be done if:
  - ATC or LDC project work occurs on transmission and/or distribution facilities sharing a corridor with less than 150 feet of horizontal separation for a length greater than 1000 feet

Qualifying Project Types

Qualifying Project Types

- In general, projects that change the conductor configuration, separation, bonding, or grounding in the defined corridor will be evaluated and reported
- Similar treatment to “filing” projects
- Annual reporting to PSCW

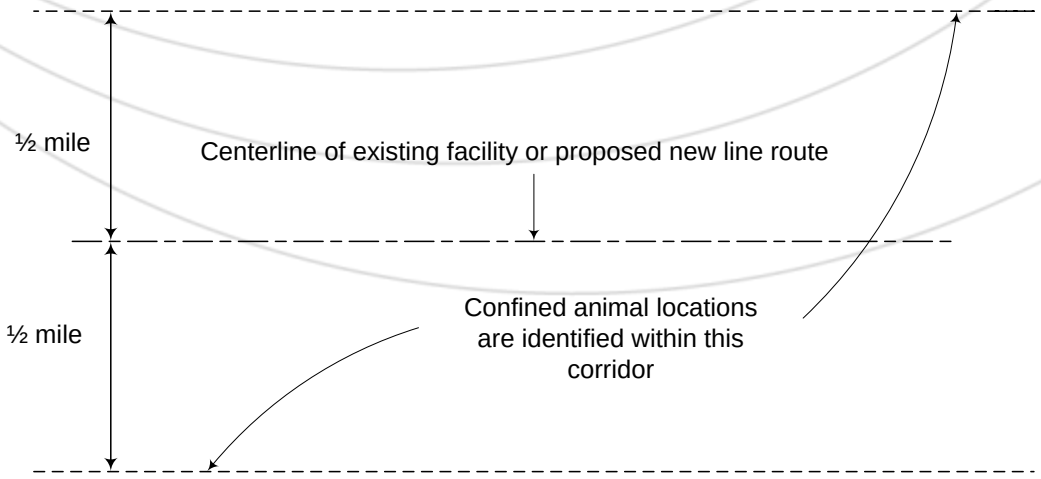
Qualifying Project Types

- New transmission and/or distribution line (excluding perpendicular crossings)
- Changes in transmission system operating voltage, conductor size, thermal capacity, static wire grounding
- Changes in the separation distance between transmission and distribution
- Change in the conductor configuration for either transmission or distribution lines

Project Coordination

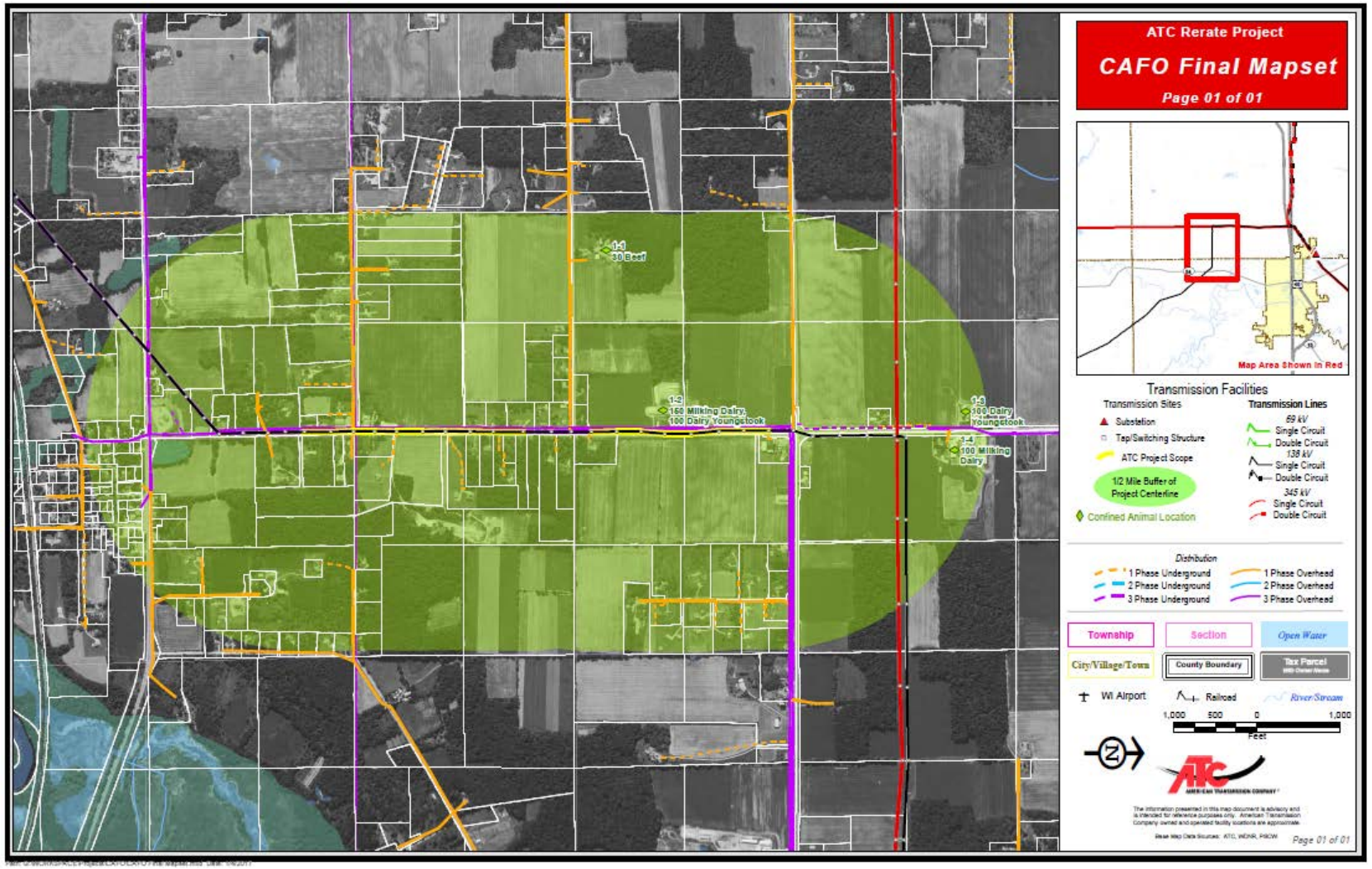
Transmission and distribution share corridor

- ATC and LDC's work together to examine design and route alternatives
- Conduct an NEV Assessment within ½ mile of proposed or existing line routes



Confined Animal Studies

CAFO map set example*



*Confined/concentrated animal feeding operation

NEV Assessment

- Includes:
  - Confined animal study (within ½ mile of the proposed project)
  - Pre and post construction stray voltage testing at identified animal confinement facilities and conducted by the LDC's
  - Possible additional NEV measurements and system modeling
  - Implementation of design alternatives to minimize NEV, if necessary

Inquiries on Non-Project Related Requests

- LDC's will communicate with the end use customer and conduct the initial tests
- The LDC's and ATC will work cooperatively on a testing plan and if necessary a mitigation plan
- Additional testing may be warranted to determine the relative levels of contribution from the distribution system and transmission system

Some Design Options for Reducing NEV

- Bridge discontinuities
- Install an underbuilt transmission shield wire
- Increase separation
- Bond the shield wire to earth and the distribution neutral
- Use a delta configuration
- Bury a counterpoise & bond to the UG neutral
- Incorporate optimal phasing in the design of new double-circuit structures that minimizes induction

Questions