May 30 2008
Upper Midwest APDA
"Arrowhead Weston"

Francis Esselman

Mgr Regional Reliability ATC

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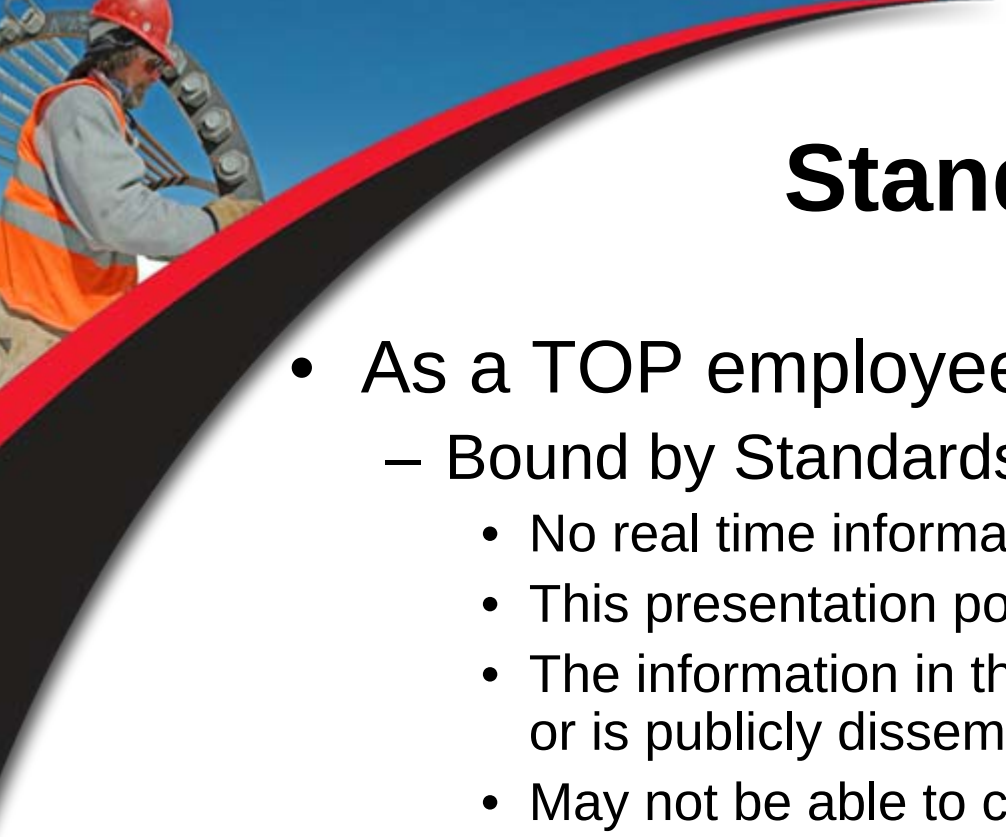

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  - Bound by Standards of Conduct
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    - This presentation posted to OASIS
    - The information in this presentation is generalized and or is publicly disseminated information
    - May not be able to comment to or on certain issues.

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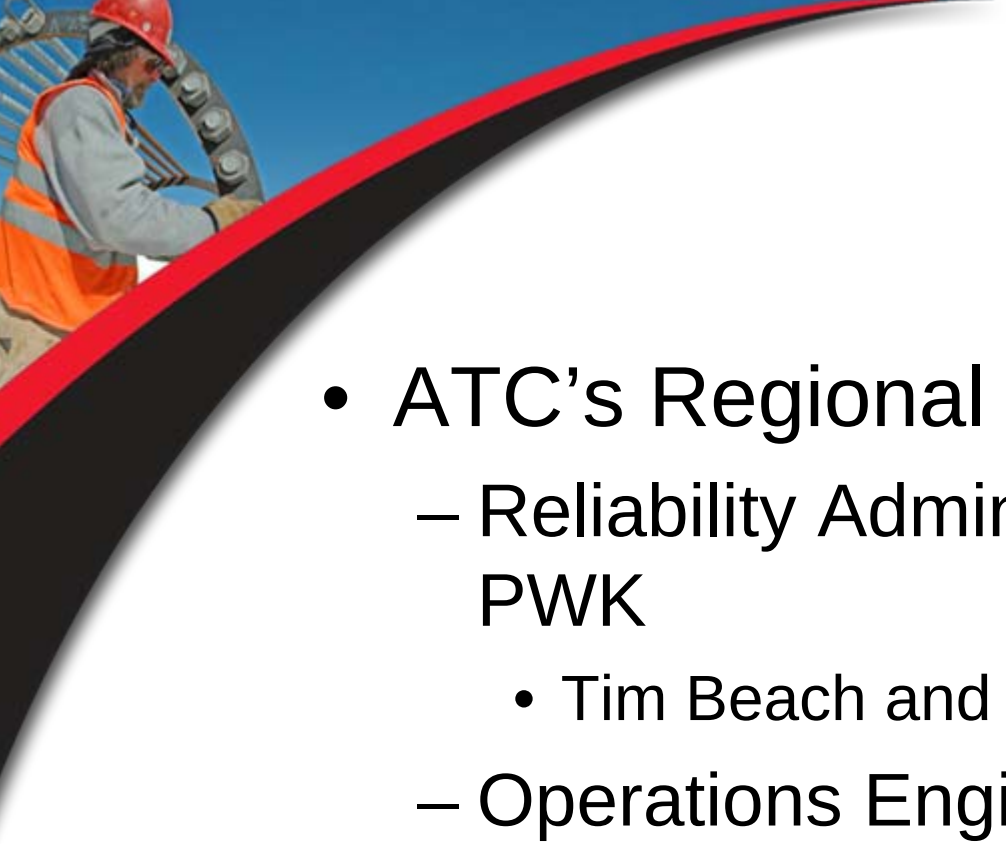

What is RR?

- ATC's Regional Reliability Group
  - Reliability Administrator at CG and PWK
    - Tim Beach and Paul Walter
  - Operations Engineering
    - Edina Bajrektarevic
    - Prabhu Gnanam
    - Eric Fleming
    - TBA (August 08)
    - TBF (October 08)

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AW Overview

- Brief History
- Approval
- Construction
- Operations
- Benefits to date

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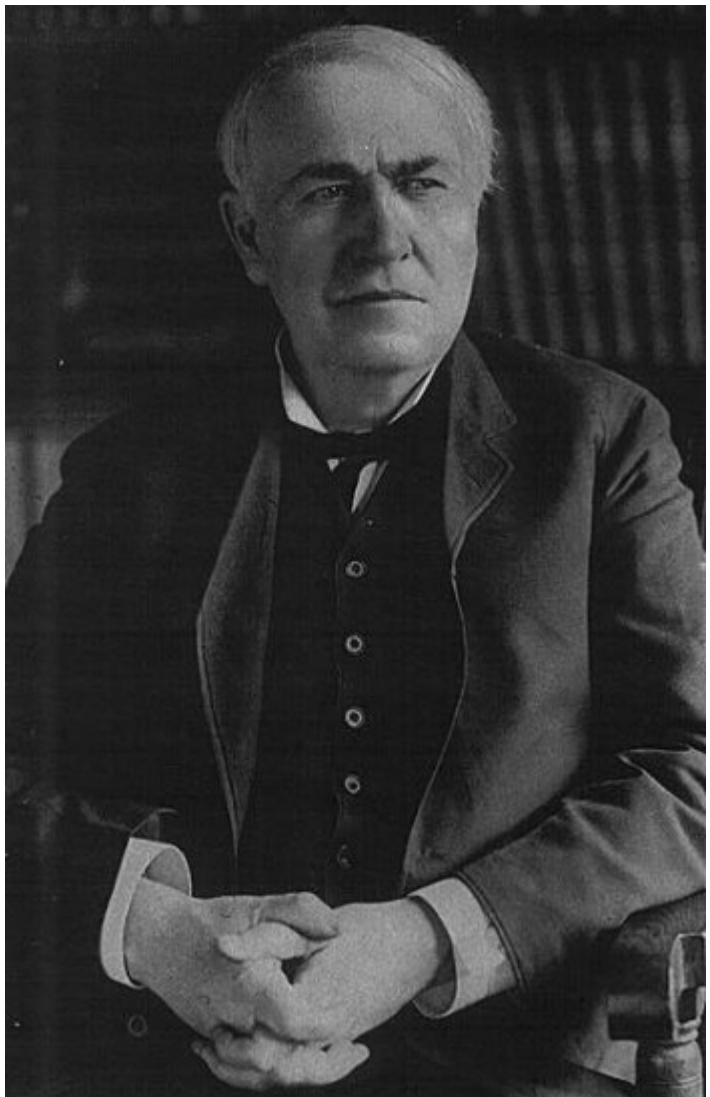
History
What was he thinking of?
Arrowhead Weston



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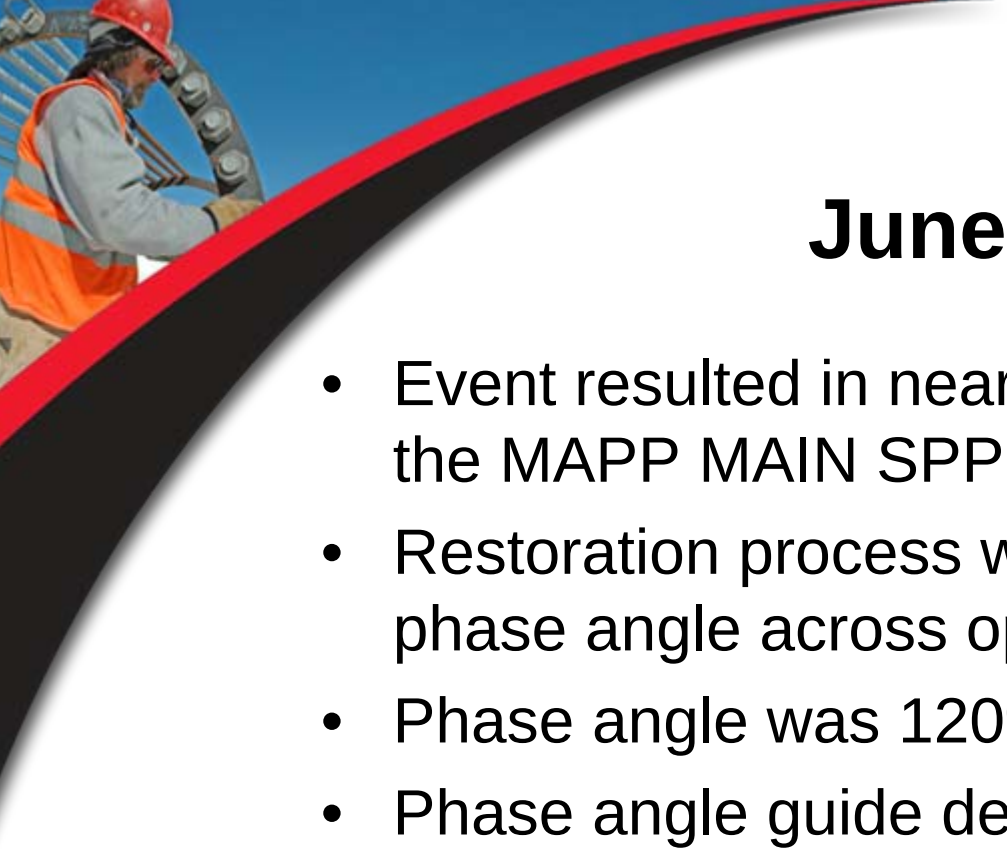

History
June 11 1997 Separation

- Event resulted in near separation of portions of the MAPP MAIN SPP Interconnections
- Restoration process was lengthy due to large phase angle across open circuit
- Phase angle was 120^{o} across open breaker
- Phase angle guide developed following June 11, 1997 trip of the line to preserve system stability

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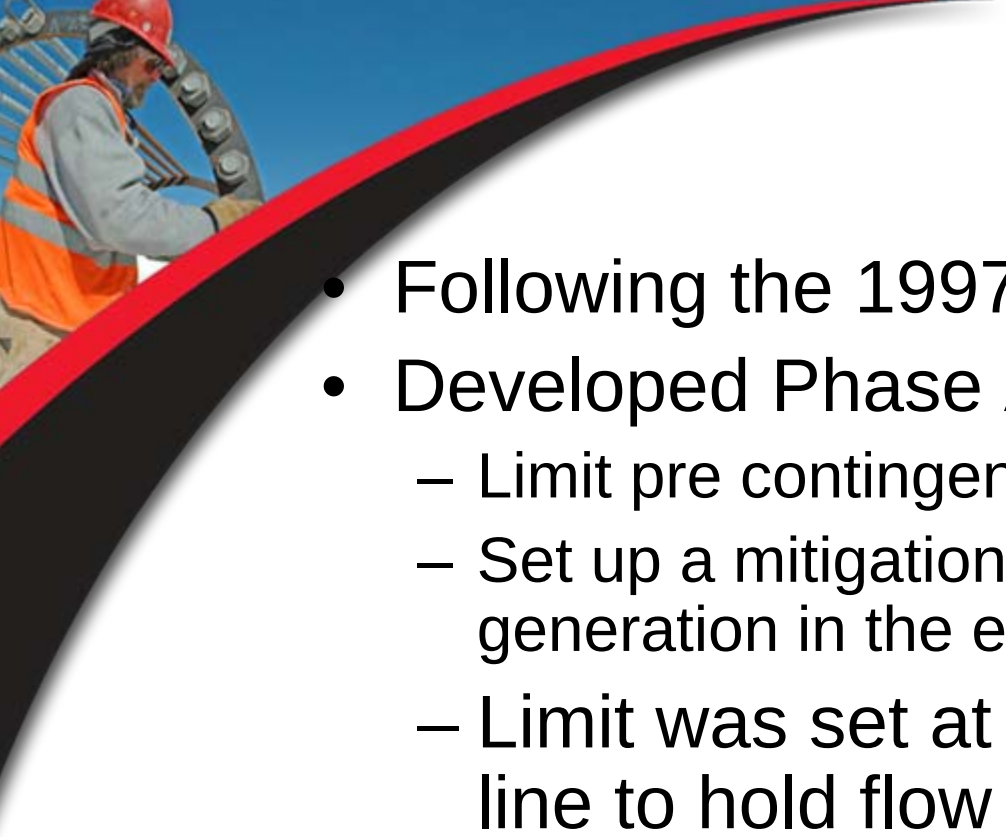

History

- Following the 1997 near miss….
- Developed Phase Angle Guide
  - Limit pre contingent transfers
  - Set up a mitigation plan to redispatch generation in the event of a trip.
  - Limit was set at 775 MW flow on the line to hold flow level, 825 MW to make curtailments
  - At 825 MW the post contingency open angle at Arpin will be about 110 degrees!
  - Closing is limited to 60 degrees!

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History
June 25 1998 Separation

- TCEX
  - Twin City Exports within limit
    - Loss of 2nd line (King Eau Claire while angle was too high to re-close Prairie Island Byron

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History

- MISO organized
  - VSAT studies on Eau Claire Arpin
    - Generally 790 MW as limit as measured at King.
    - Used for several years for intact system
    - MISO market replaced Phase Angle Guide for most part by congestion binding.
    - Even MISO can’t change physics

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History

- May of 2000:
  - Upper Midwest APDA in Madison
    - Presentation on congestion of King Eau Claire Arpin
    - Separation events and the plan for the future
    - Arrowhead Weston

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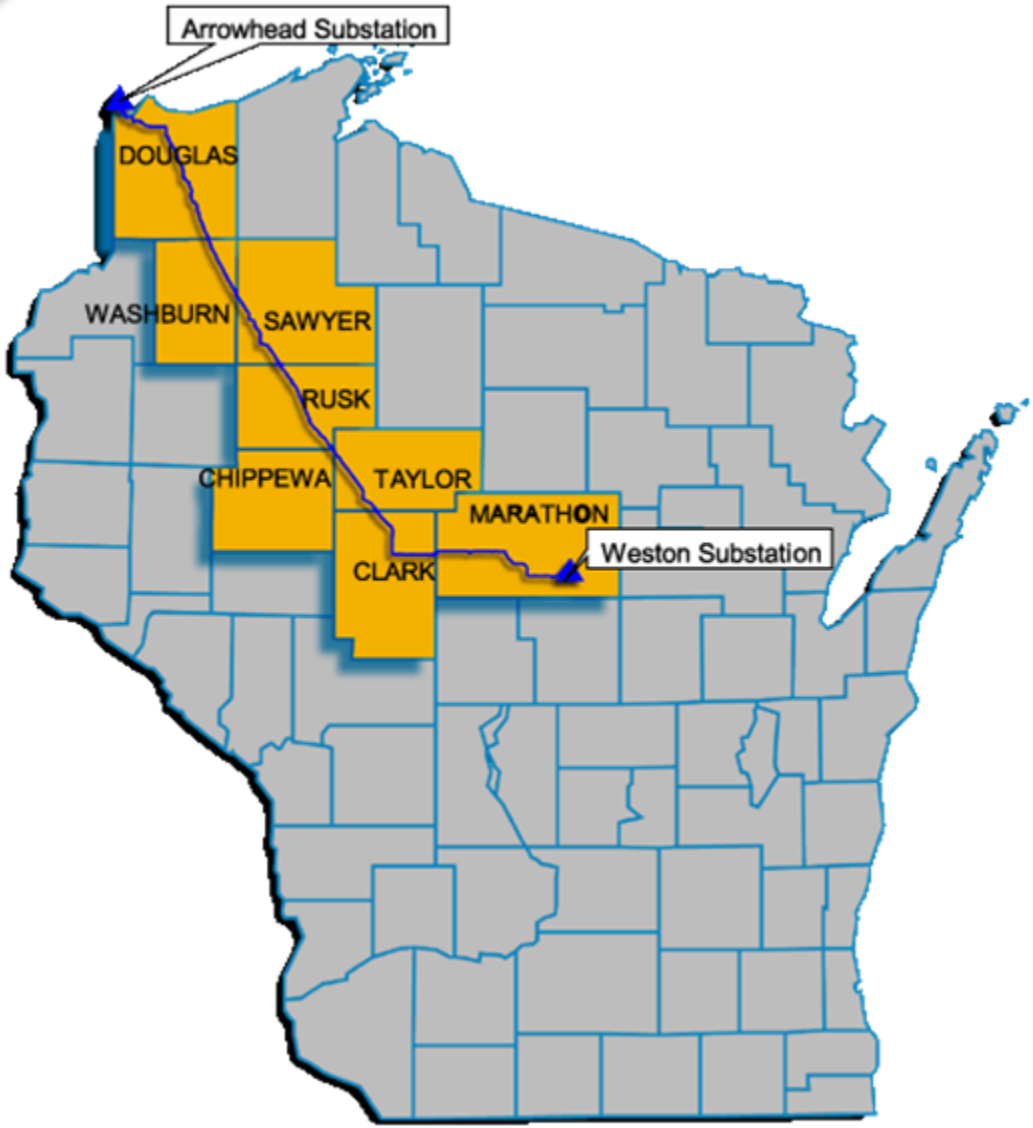
220-mile project route



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Going for approval

- Fall of 1999:
  - Applications filed by WPS and MP
    - 30 days of technical hearings
  - Project approved March 2001 by Minnesota regulators
  - Project approved October 2001 by Wisconsin regulators
    - 165 Million dollars
  - Line route established by orders

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Approvals
Going for approval (chapter 2)

- ATC now in business and will build with engineering and construction partners
  - November 2002:
    - ATC filed a notice of cost increase and petition to amend the final order
    - Cost now estimated at 420 Million
  - December 2003:

    Regulators approve new order at the revised cost levels.

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Some other Approvals

- Corp of Engineers (river crossings and wetlands
- WDNR (Temporary bridges) Mitigation plans for construction methods
- National Park Service (Namekagan National Scenic Riverway

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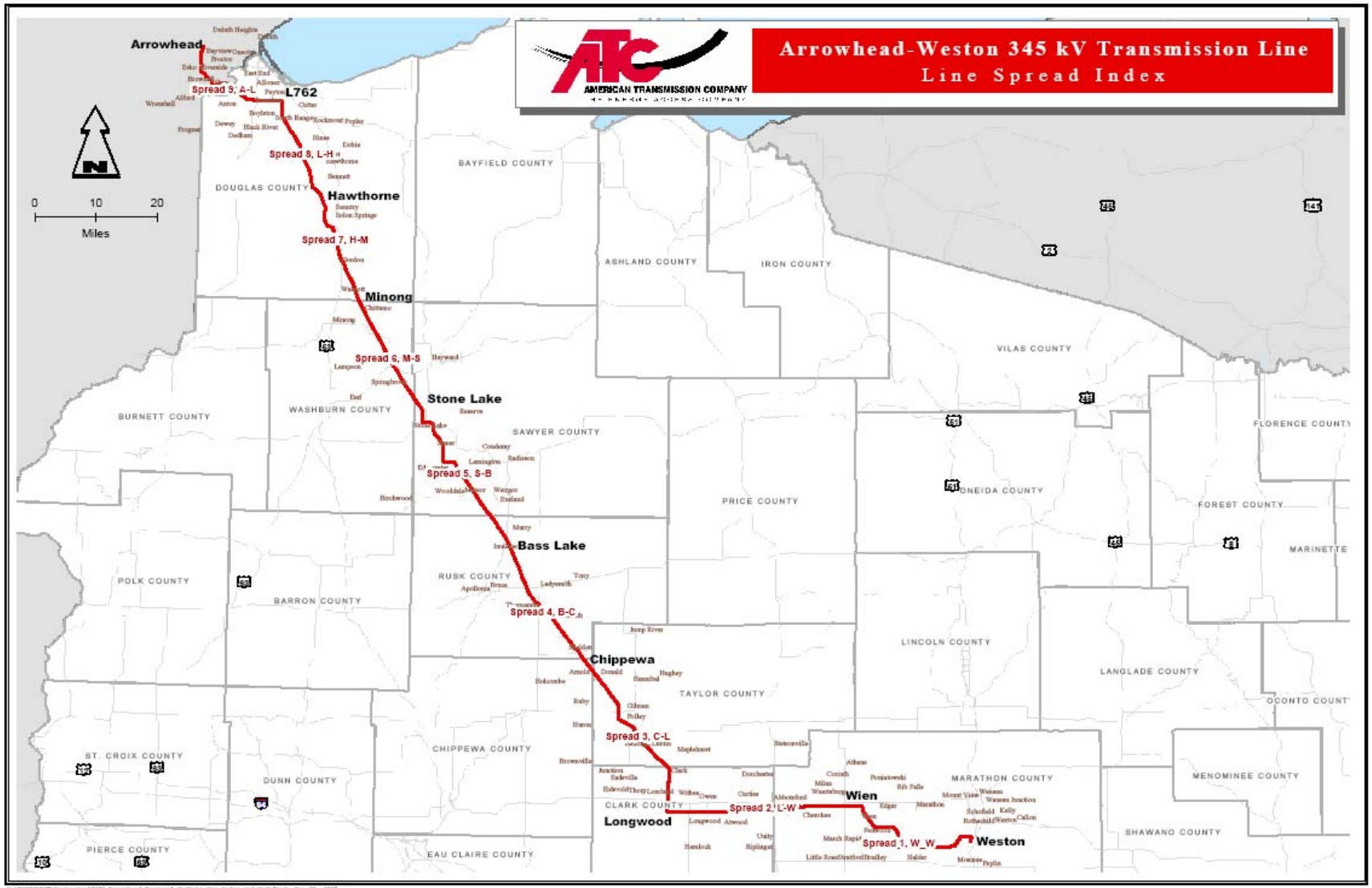

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Arrowhead – Stone Lake – Gardner Park Transmission Line

- Transmission Line – Electrical Characteristics
  - Line thermally capable of carrying 1400 MVA
    - Sizing optimized for losses and other factors resulting in far more thermal capacity than needed for transfer capability
  - Surge Impedance Loading is Roughly 450 MVA
  - Realistic maximum loading due to other transmission system limitations is approximately 750 MVA
  - Transpositions
    - Arrowhead – Stone Lake transposed roughly every 20 miles
    - Stone Lake – Gardner Park is transposed at roughly 40 mile increments
  - Fully shielded, except for short discontinuity at Namekagon river
    - Line merges into a single phase conductor with no shielding across river

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Arrowhead – Stone Lake – Gardner Park Transmission Line

- Transmission Line – Structural Capabilities
  - Arrowhead Sub/Lake Superior Area
    - Designed to withstand 1.85” radial ice Extreme Wind Loading 108.4 mph
  - Wisconsin
    - Designed to withstand .925” radial ice Extreme Wind Loading 108.4 mph

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Arrowhead Substation

- Bulk System Transformer & Switching Station just west of Duluth, Minnesota
- Inverter end of the +/- 250 kV Square Butte HVDC Line
  - 500 MW HVDC line which transports energy from lignite fired MR Young #2 station and local wind farms
  - Includes 300 MVar of shunt reactive support (filters & caps)
- 3 x 230 kV Lines
- 8 x 115 kV lines
- 2 x 230/115 kV Transformers (750 MVA Net capacity)
- Closely coupled to Winnipeg – Twin Cities 500 kV system

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New Arrowhead 230/345kV Station

- Built just to the south of the existing 230 kV sub
- Includes the following equipment:
  - 230 kV busses #3 and #4
  - #8 TR – 800 MVA, +/- 35 degree Phase Shifting Transformer
  - #9 TR – 800 MVA, 230/345 kV Auto Transformer w/LTC
    - 4 - single phase units, 3 active, one spare in cold standby position
  - 345 kV Ring bus with three breakers
  - 2 x 75 MVar / 345 kV capacitor banks (30K/31K)
  - Arrowhead – Stone Lake line termination

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Stone Lake 345/161 kV Station

- 345/161/69 kV Switching and Transformer Station
- 345 kV Ring Bus – 4 breakers
  - Two 345 kV line positions
  - Transformer position
  - Cap & Reactor position
- T9- 336 MVA 345/161 kV auto-transformer
- 345kV Capacitor and Reactor banks
  - Capacitor C31 – 75 MVar, 345 kV bank with automatic controls
  - Reactor R31 – 75 MVar shunt reactor

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Gardner Park 345/115 kV Station

- 345 kV generator outlet and transformer station
- 345 kV – Ring Bus
- 2 x 345 kV lines (+ one future 345 kV line)
  - Stone Lake – Gardner Park 345 kV
    - 75 MVar line connected reactor bank
  - Gardner Park – Rocky Run 345 kV
- 2 x 500 MVA, 345/115 kV autotransformers
- Weston G4 – 550 MW coal fired generation

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Video

- From Concept to Completion:
  - The Arrowhead Weston Story

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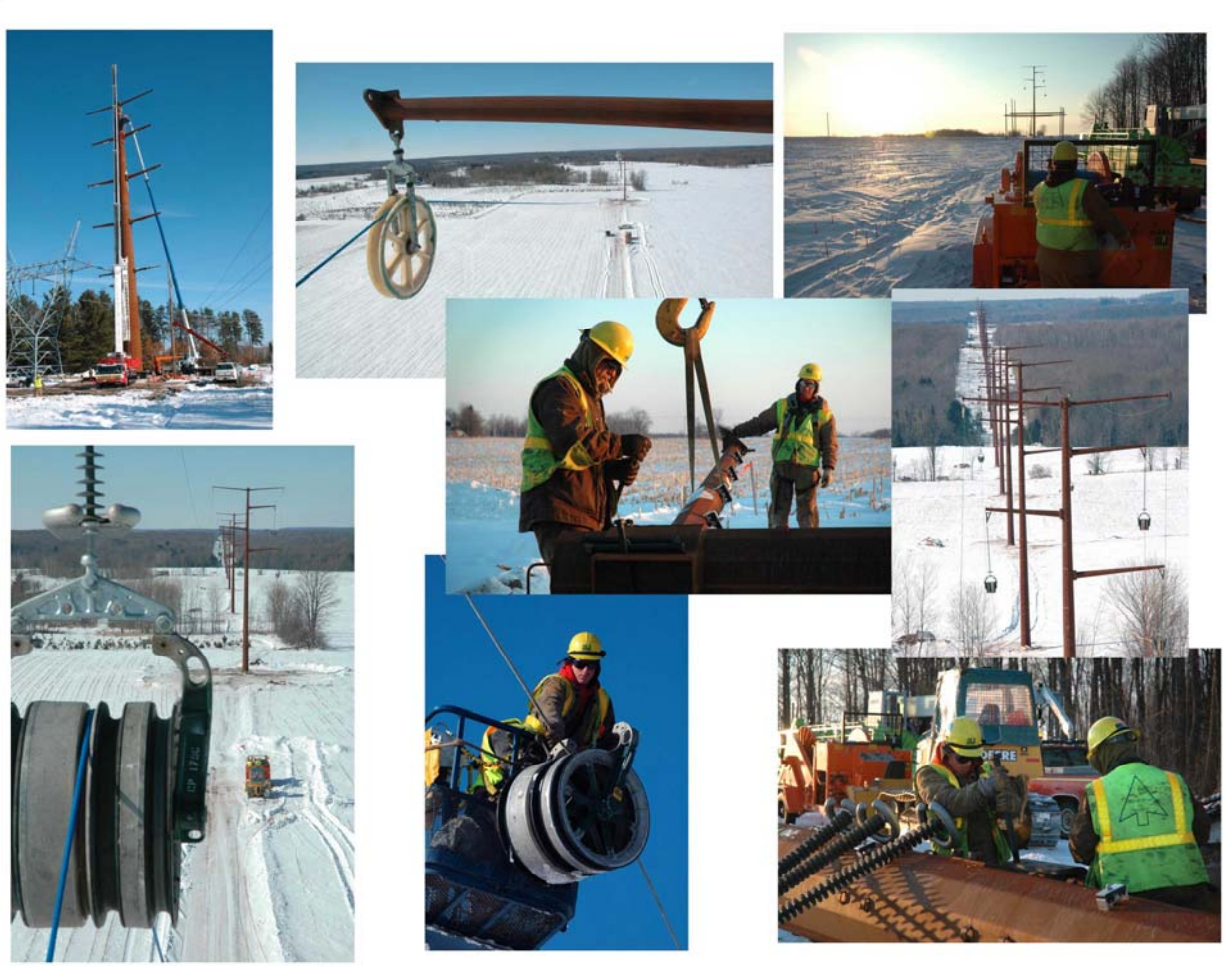
Construction



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Outages

- Line construction was simultaneous with other projects in Wausau area
  - Weston 4 Plant interconnection
  - Uprates for that interconnection
    - Dedicated Outage Coordination services
    - Adjusted workload in the Control Center
    - Energizing transformers
      - Studies, Coordination, Keeping the lights on!

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Outages

- Build Gardner Park 345 Station
- Rebuild Weston 115 station
- Reconductor numerous 115 lines
- Move most of them!

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Outages

- Need to serve Northwest Wisconsin
  - 77% of line on existing ROW
  - 50% on transmission ROW
  - Need to serve Northwest Wisconsin so Gardner Park to Stone Lake built first
    - Added load to already stressed system during construction

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Picture Show

- Construction photos….
  - To save paper this is not in the power point presentation…

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Operations

- Upper Midwest Stability Interfaces
  - MHEX
  - NDEX
  - MWSI (Retired)
  - MWEX (new)

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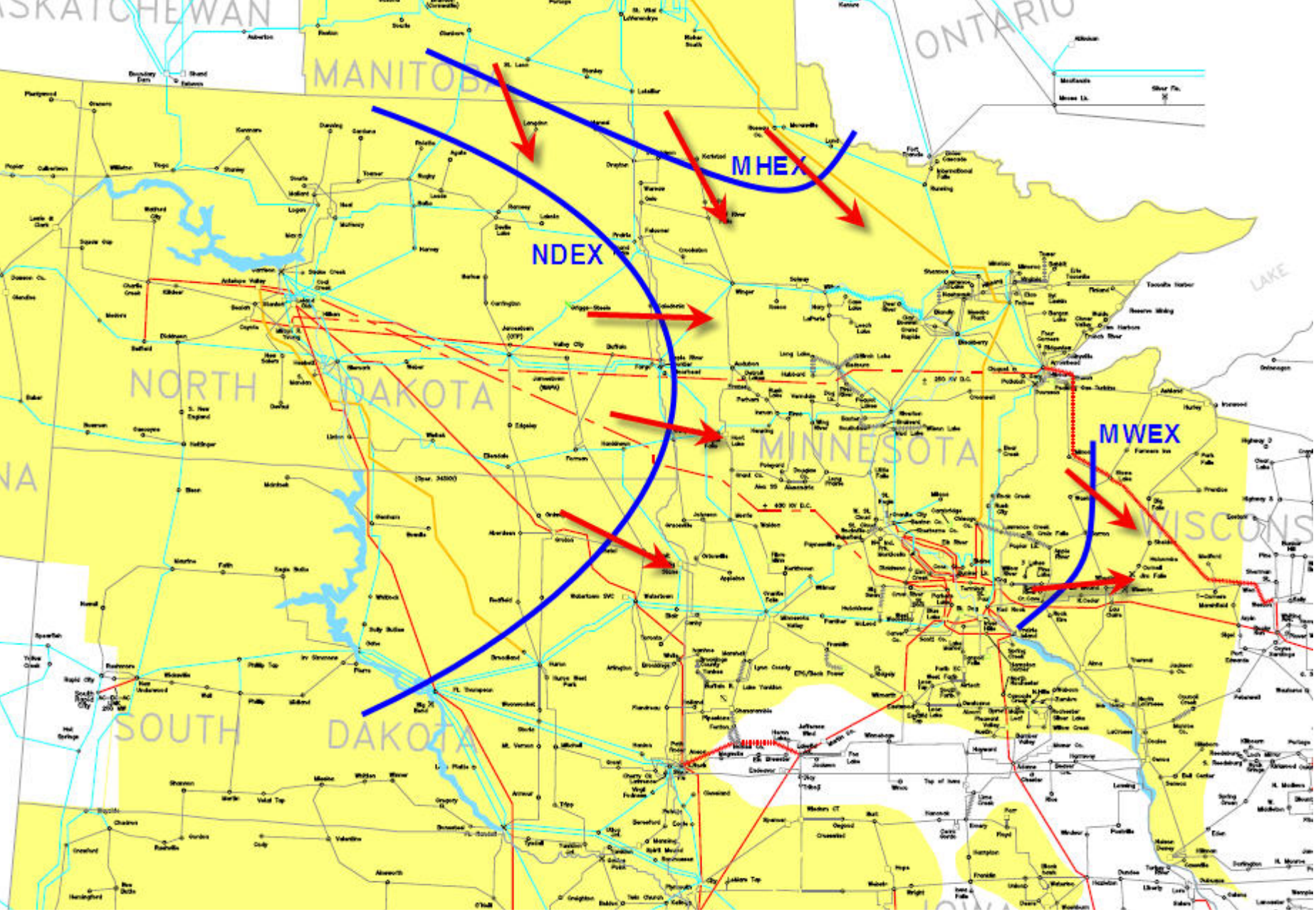

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MWEX

Minnesota Wisconsin Export Interface (MWEX) System Intact

Monitored Facility:	Minnesota Wisconsin Export Interface (MWEX)	Coordinated:	√
Contingent Facility:	None	Reciprocal:	√
Concurrent Outages:	None	MAPP TLR Avoidance:	√
Written By:	Dede Subakti, MISO; George Sweezy (MP), Mark Tiemeier (XEL), Michelle Wood (XEL), Brenda Johnson (XEL), Prabhu Gnanam (ATC), Peter Schommer (MP)		
Reviewed By:	Dede Subakti (MISO)		
Issued By:	Abiodun Olayiwola (MISO)		
Effective:	05/02/2008 Expires: 10/01/2008		

1.0 Purpose/Background

This guide establishes the operating limits and OASIS posting values for the constrained Minnesota Wisconsin Export Interface (MWEX). MWEX is the summation of the flows on the King-Eau Claire 345 kV line measured at King and the Arrowhead 230 kV phase shifter as measured at the Minnesota Power 230kV side of the Arrowhead substation.

MWEX was established to protect the system from transient under voltages in the Minong area following loss of the King – Eau Claire – Arpin line.

MWEX System Intact

Table 1: MWEX Limit

Critical Facility Conditions	MWEX CONTROL POINT (MW)	MWEX SOL	MWEX IROL
System Intact [1]	1495	1525	1650

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Operations

- Phase Shifter installed to control flow
  - Reactive requirement of line can exceed the available reactive.
  - Must reduce MW flow if exceeded.
  - MISO may use PST for congestion mitigation during area outages within reserve
  - Reactor and Capacitors depend on transfer levels.

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MISO roles

- MISO St Paul is the RC for the new line to a demarcation at the line side of Stone Lake substation.
- MISO Carmel is the RC for the Stone Lake to Gardner Park line and east.

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System Operations General
EMS Model expansion

- Necessitated by the Arrowhead in service date:
  - Electrically the Arrowhead interconnection brings South Dakota Generation connected to ATC by the Arrowhead Bus.
  - The expansion of the model enhances our advanced application capability.
    - We do not like surprises!

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The end of the line

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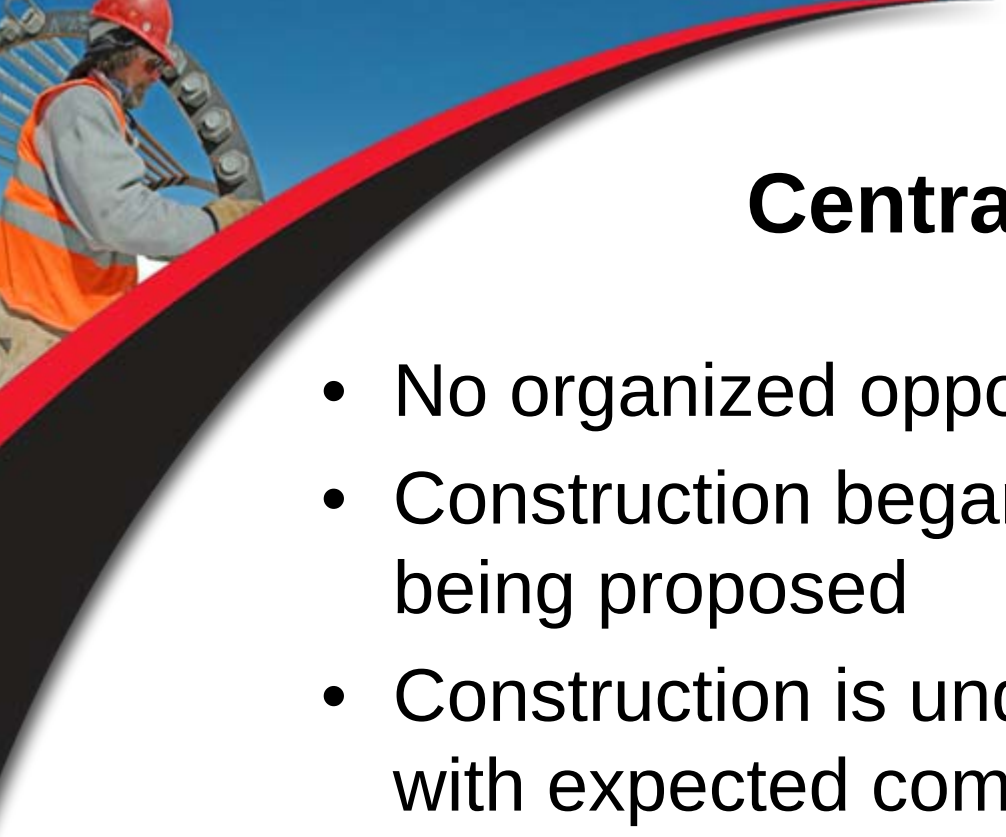

Next steps: Central Wisconsin- Status

- No organized opposition
- Construction began only 2 years after being proposed
- Construction is under way on 1st phase with expected completion in December 2009

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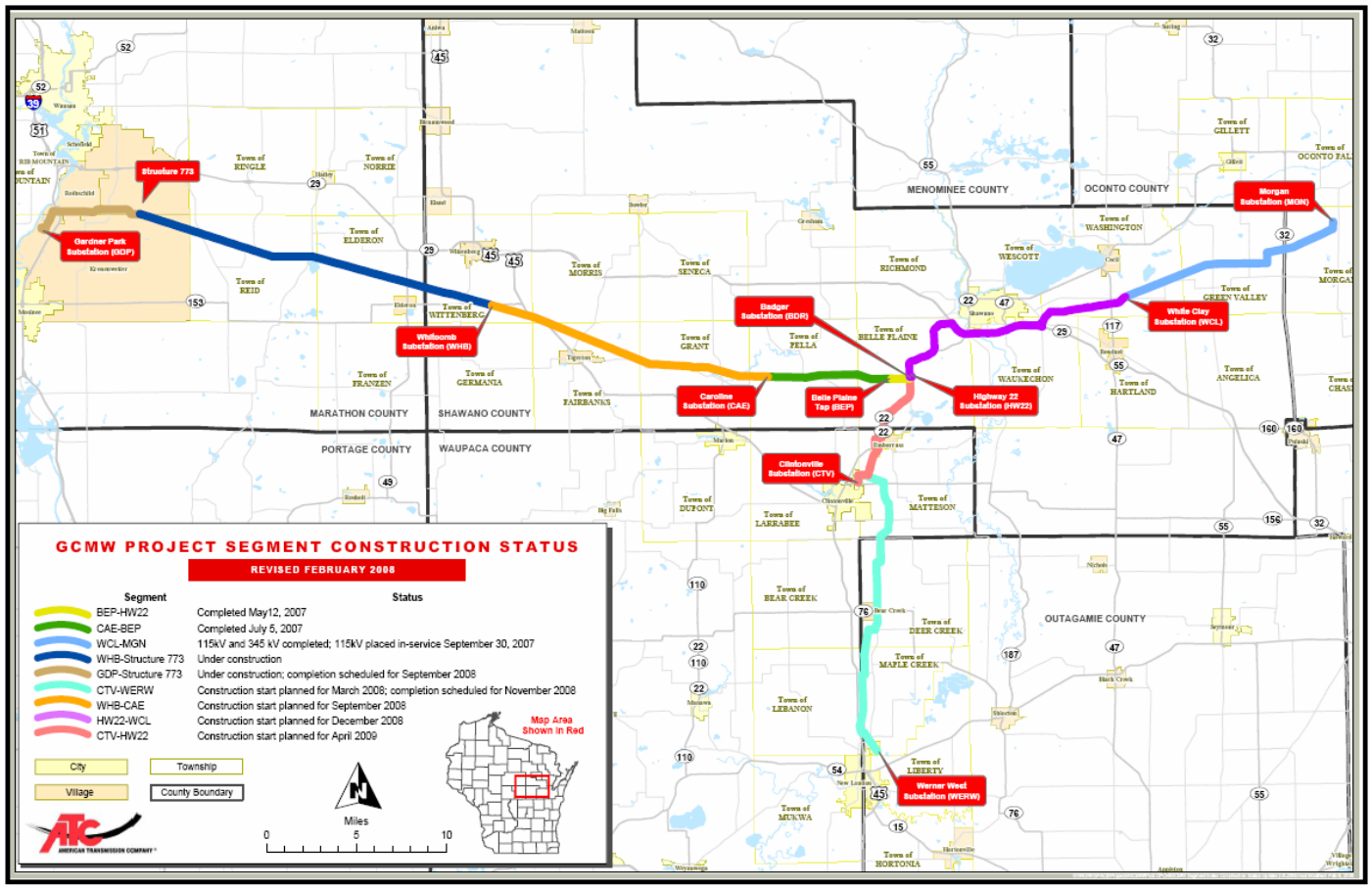
Central Wisconsin Map



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Questions?

Helping to **keep the lights on**,
businesses running and communities strong.

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