Michigan Wind Zones Transmission Study Report

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Purpose & Background

- **The Michigan Wind Energy Resource Zone Board (WERZB) was formed as part of PA 295 which was signed into law on October 6, 2008**
  - Among other tasks, the Board was mandated to study and identify a list of regions in the state with the highest wind energy harvest potential and develop a proposed and a final report detailing its findings.
- **The WERZB issued their final report on October 15th 2009 and identified 4 potential wind zones**
  - All of the potential zones were located within or adjacent to the ITC Holdings footprint
  - 3 of the potential zones were located within or adjacent to the Wolverine Power Supply Cooperative Inc. (WPSCI)
- **As part of PA 295, transmission entities within or adjacent to regions of the state identified in the Board's report were required to identify existing or new transmission infrastructure necessary to deliver the maximum and minimum wind energy production potential for each of the regions identified and submit this information to the Board for its review by November 30th**

Purpose & Background

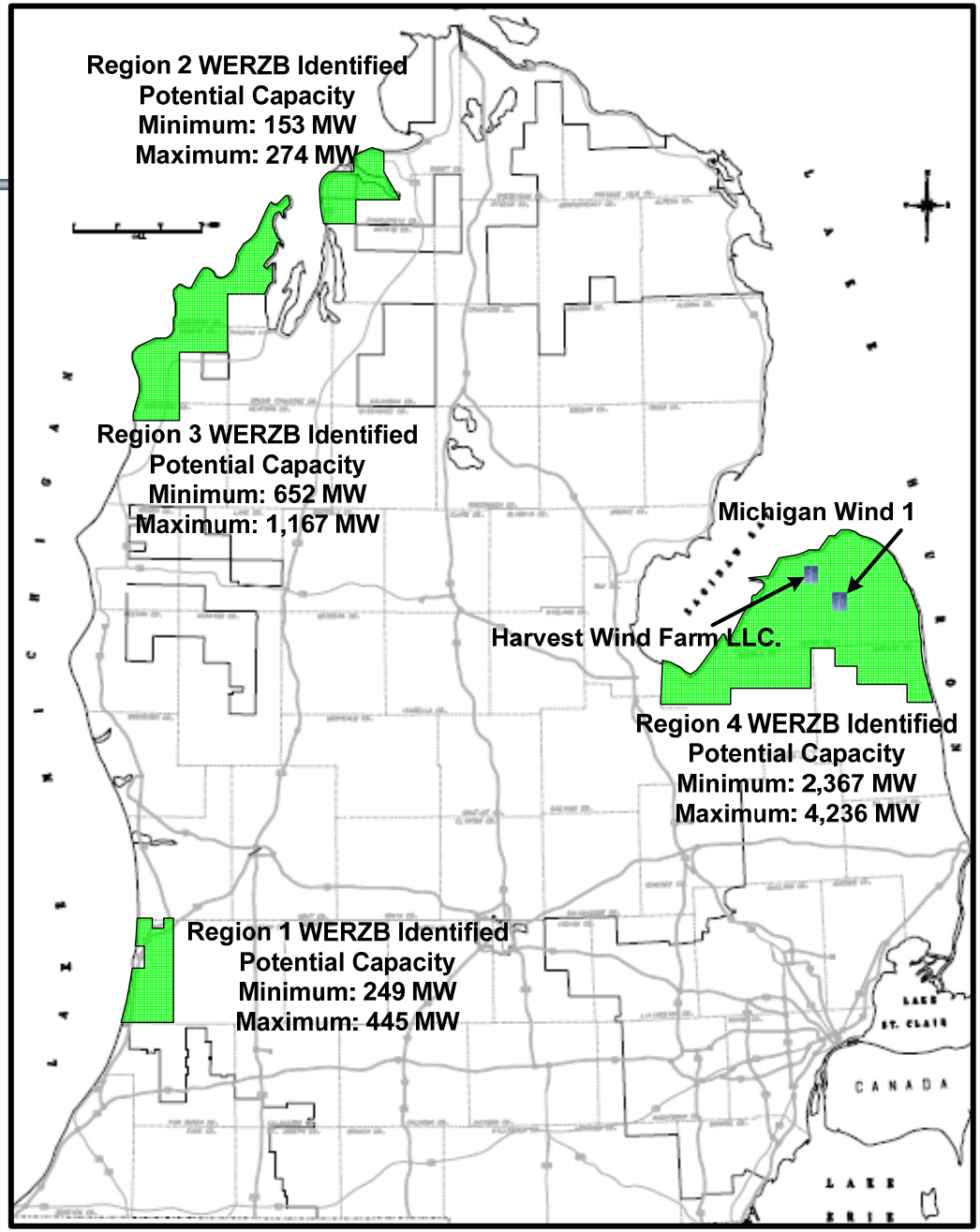
- **Report was coordinated with Wolverine Power Supply Cooperative Inc. (WPSCI) for regions adjacent to or within the WPSCI territory**
- **Development of "backbone" facilities within or directly adjacent to each proposed zone only**
  - Assuming "interconnection" facilities would be determined in the Midwest ISO interconnection process
    - Interconnection facilities would be needed to bridge the gap between wind farms and backbone transmission system
    - Interconnection facilities are not to be confused with wind generation "collector" systems
  - "Backbone" facilities external to proposed zones would be dependent on variations in market dispatch

Purpose & Background

- **Current transmission planning processes focus on solving existing contractual needs:**
  - Solve planning criteria violations identified when attempting to move existing generation (economically) to existing (and forecasted future) loads
  - Move future generation (with signed interconnection agreements) to existing (and forecasted future) loads
  - Fulfill transmission service requests; or
  - Support regulatory requirements
- **Through the forward-looking nature of the wind zone process initiated by the State of Michigan, there now is an opportunity to look beyond the next incremental generation interconnection and plan transmission for reasonably expected future development**
  - A more forward-looking transmission planning process (as embodied in this effort) is conducive to wind development

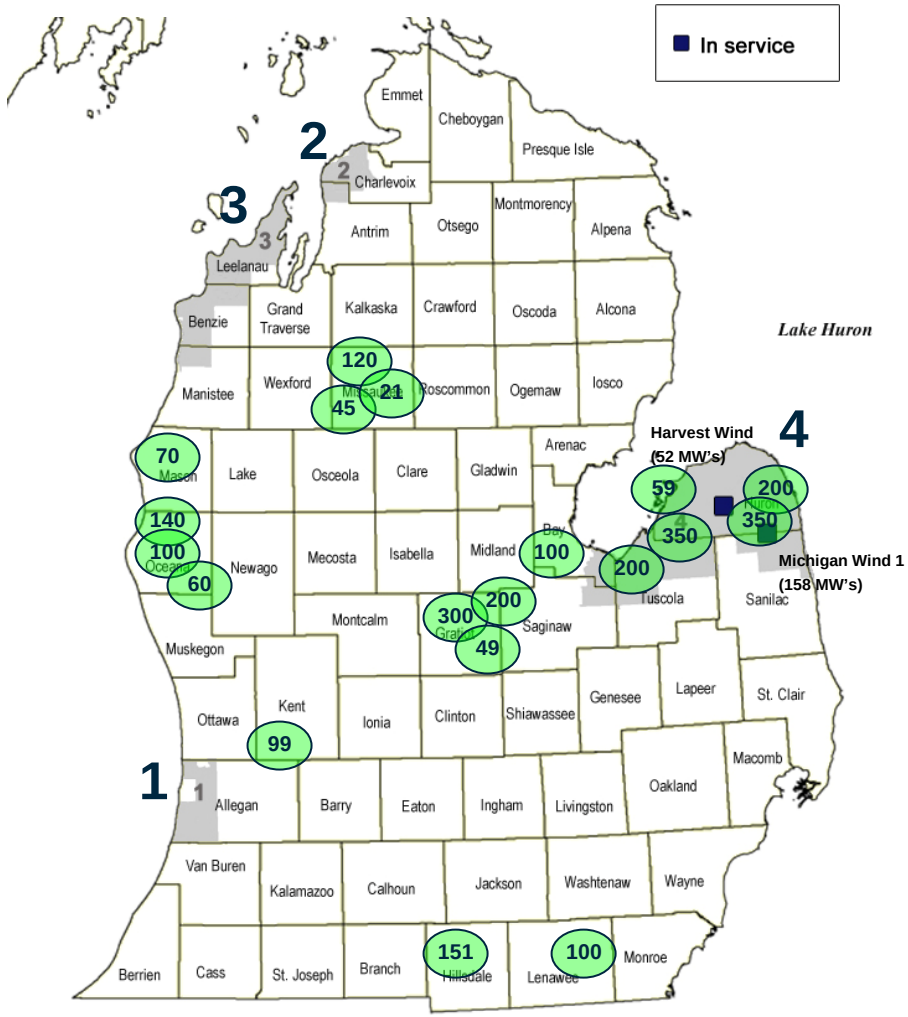
Description of Regions Identified by WERZB

- **Region 1**
  - Parts or all of Allegan county
  - Minimum – 249 MW
  - Maximum – 445 MW
- **Region 2**
  - Parts or all of Antrim and Charlevoix counties
  - Minimum – 153 MW
  - Maximum – 274 MW
- **Region 3**
  - Parts or all of Benzie, Leelanau and Manistee counties
  - Minimum – 652 MW
  - Maximum – 1,167 MW
- **Region 4**
  - Parts or all of Huron, Bay, Saginaw, Sanilac, and Tuscola counties
  - Minimum – 2,367 MW
  - Maximum – 4,236 MW
  - Two wind farms already in-service



Existing Wind Farm Interconnection Requests in Midwest ISO Generation Interconnection Queue

- Interconnection requests as of November 20th 2009
- Map does not include distribution interconnection requests
- May not be all-inclusive as the queue can change significantly on a daily basis
  - Interconnection requests in Thumb have been a moving target
  - 700 MW's of interconnection requests entered Midwest ISO in Thumb area in October
- All projects in different phases of interconnection process



Key Assumptions & Limitations

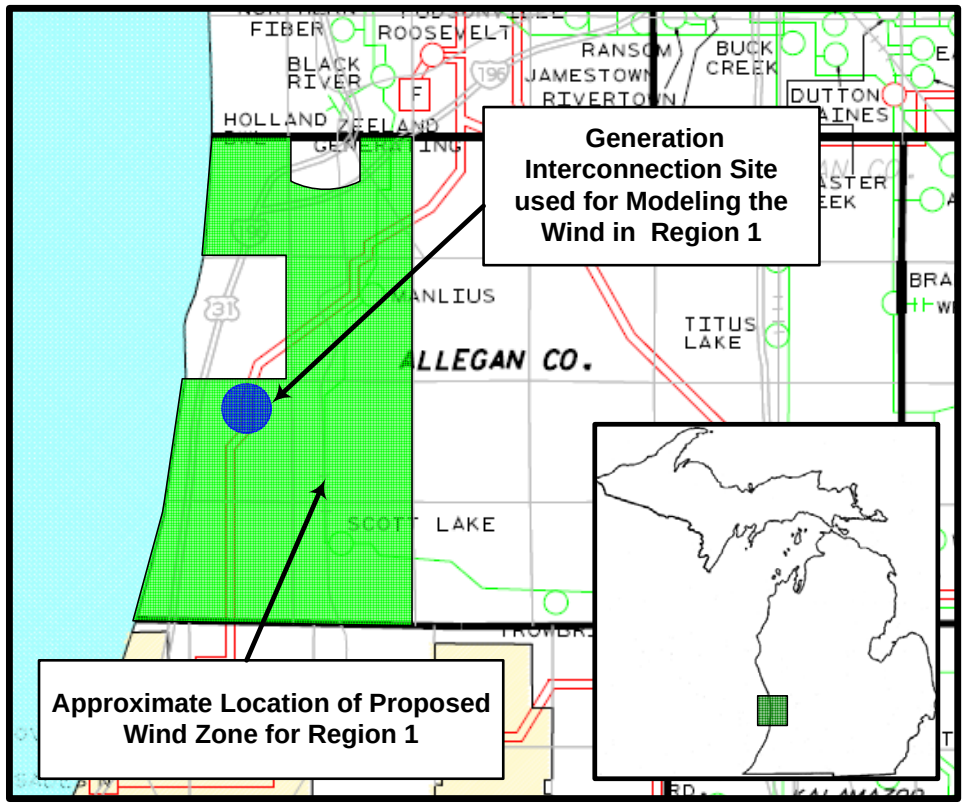
- **Anytime significant amounts of new generation are added, there is the potential to change overall flow patterns significantly enough that transmission issues may emerge in areas remote from the area of interest**
  - This study focused on the areas near the regions proposed as zones
- **This study focused on the backbone *transmission* system only**
  - In some areas, interaction between the transmission system and networked lower voltage facilities can be significant and overloads on the lower voltage facilities can dictate a need for modifications to the transmission system
- **This study focused on thermal issues only**
  - The amount of power that can be carried by the wire
  - Voltage, short circuit and/or transient stability concerns can be of considerable importance and possibly drive different or additional system upgrades

Key Assumptions & Limitations

- **Primarily focused on each region independently of other possible regions (except as discussed below)**
- **Wind generation modeling consistent with Midwest ISO Generation Interconnection procedures**
- ***Conceptual* cost estimates and timeline developed only for backbone transmission facilities**
  - Actual costs and timelines could vary depending on many factors including but not limited to: additional needs related to voltage, short circuit or stability, and actual availability and costs of material and labor among many other factors
  - Cost estimates were not developed for interconnection facilities that would be necessary to bridge the gap between wind farms and backbone transmission system
  - Any references to right-of-way requirements are high level only (actual right-of-way requirements would need to be determined by more detailed review)
- **Projects developed in this process would need to be coordinated with other projects in various stages of the various planning processes**

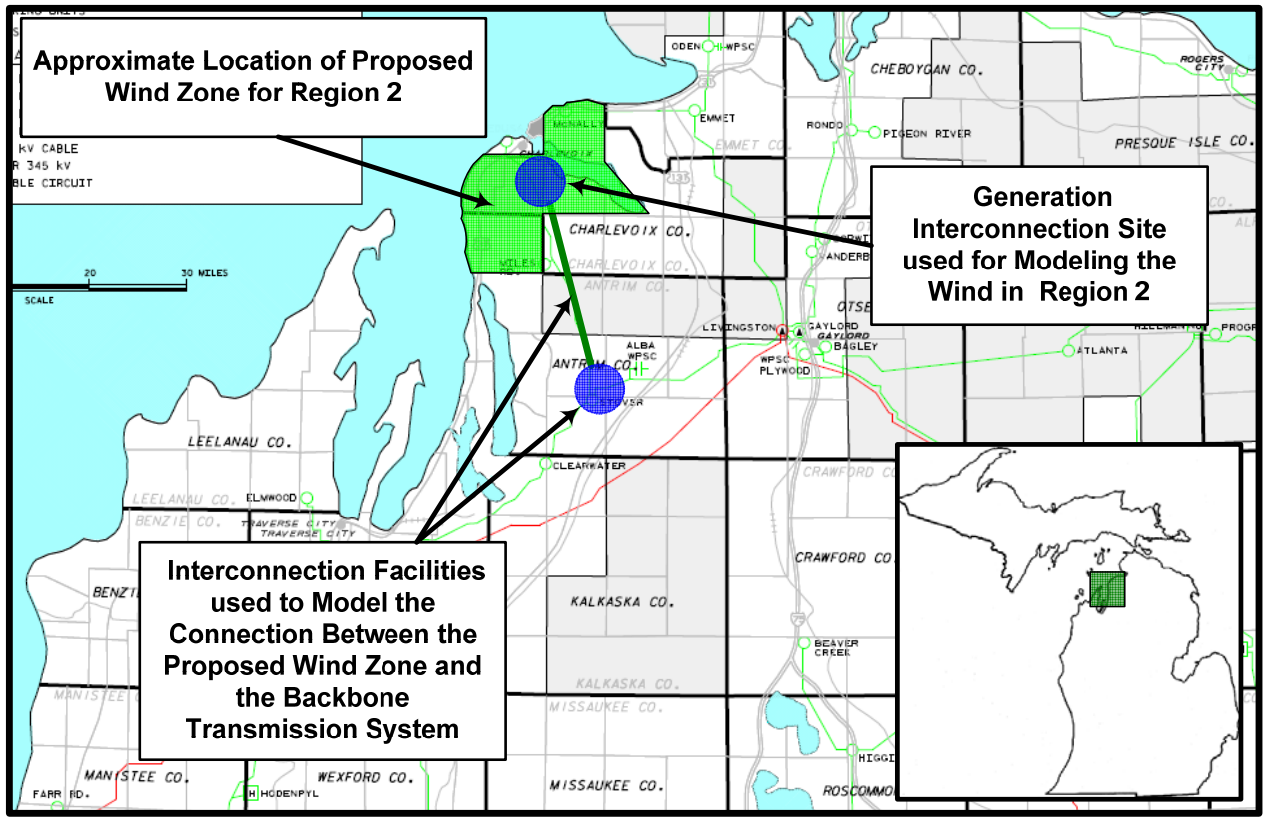
Transmission Requirements (Region 1)

- Region 1 modeled as shown
- Generation modeled at one interconnection location
  - Minimum 249 MW
  - Minimum 445 MW
- No transmission system upgrades on the METC or WPSCI systems were identified for connection of WERZB identified minimum or maximum wind generation capacity levels in Region 1



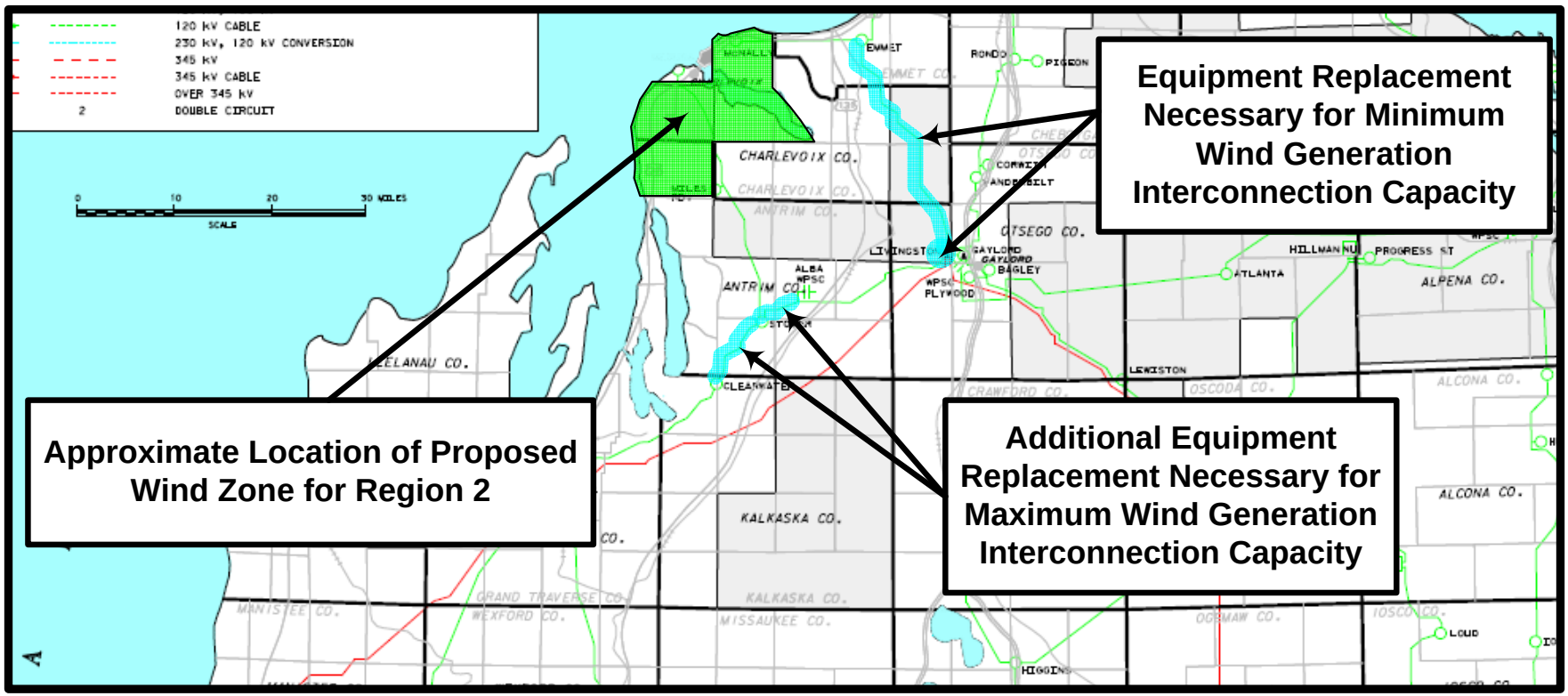
Transmission Requirements (Region 2)

- Region 2 modeled as shown
- Generation modeled at one interconnection location
  - Minimum 153 MW
  - Maximum 247 MW
- Some transmission system upgrades were identified as necessary for connection of WERZB identified minimum or maximum wind generation capacity levels on both the METC and WPSCI transmission systems



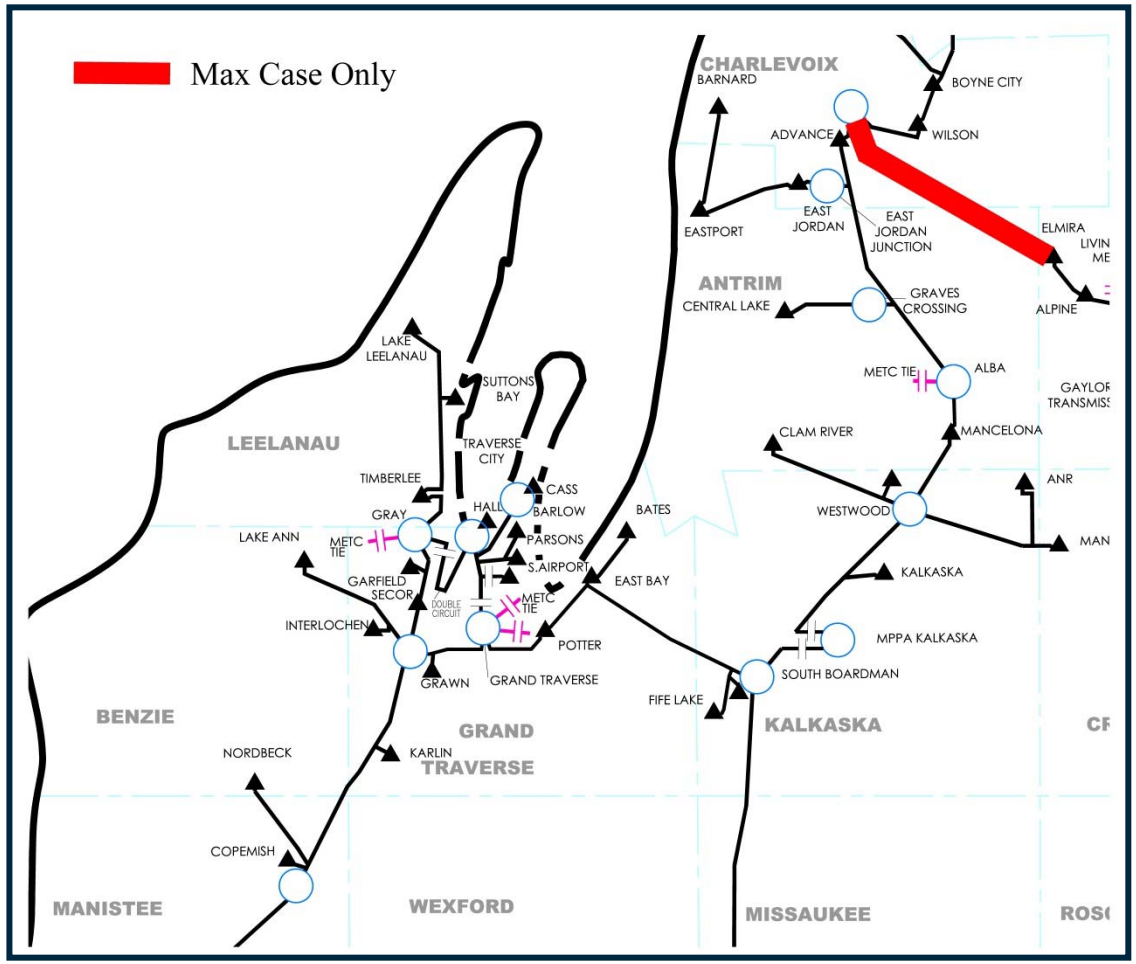
METC Transmission Requirements (Region 2)

- Replacement of existing equipment with little or no ROW implications (subject to detailed investigation)
- ~$24 million for minimum and ~42$ million for maximum



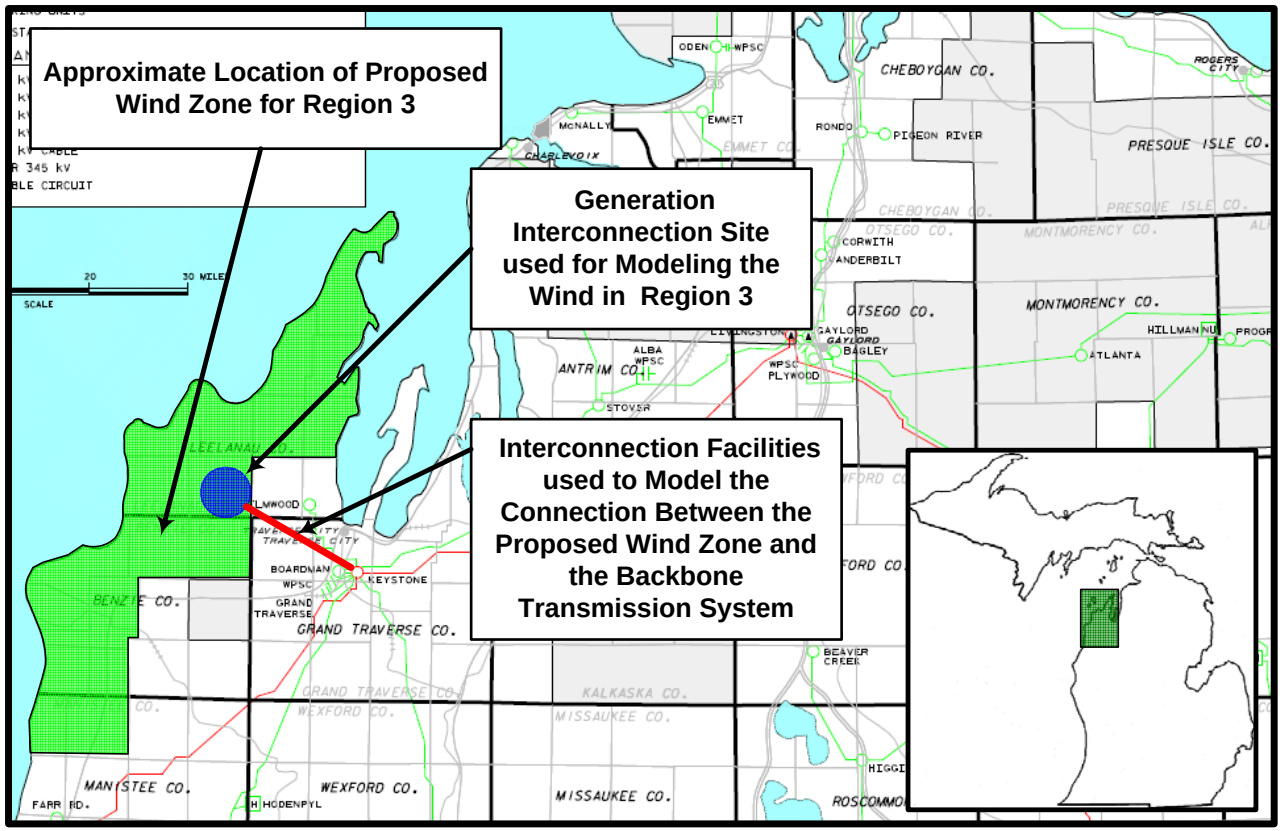
WPSCI Transmission Requirements (Region 2)

- Replacement of existing station equipment and upgrades of overhead lines
- Non-binding cost estimates of ~$0.5 million for minimum and ~$7 million for maximum



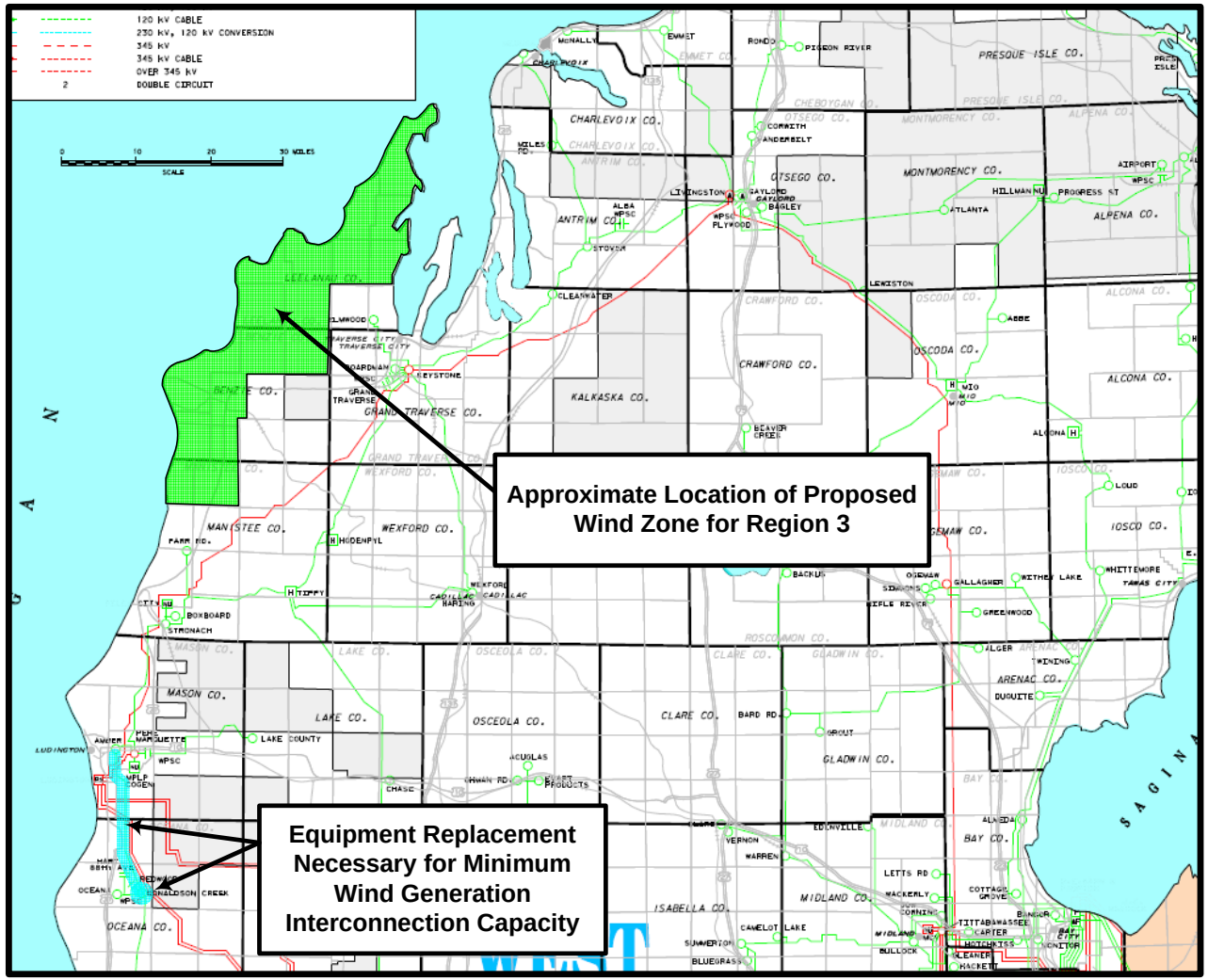
Transmission Requirements (Region 3)

- Region 3 modeled as shown
- Generation modeled at one interconnection location
  - Minimum 652 MW
  - Maximum 1,167 MW
- Some transmission system upgrades were identified as necessary for connection of WERZB identified minimum or maximum wind generation capacity levels on both the METC and WPSCI transmission systems



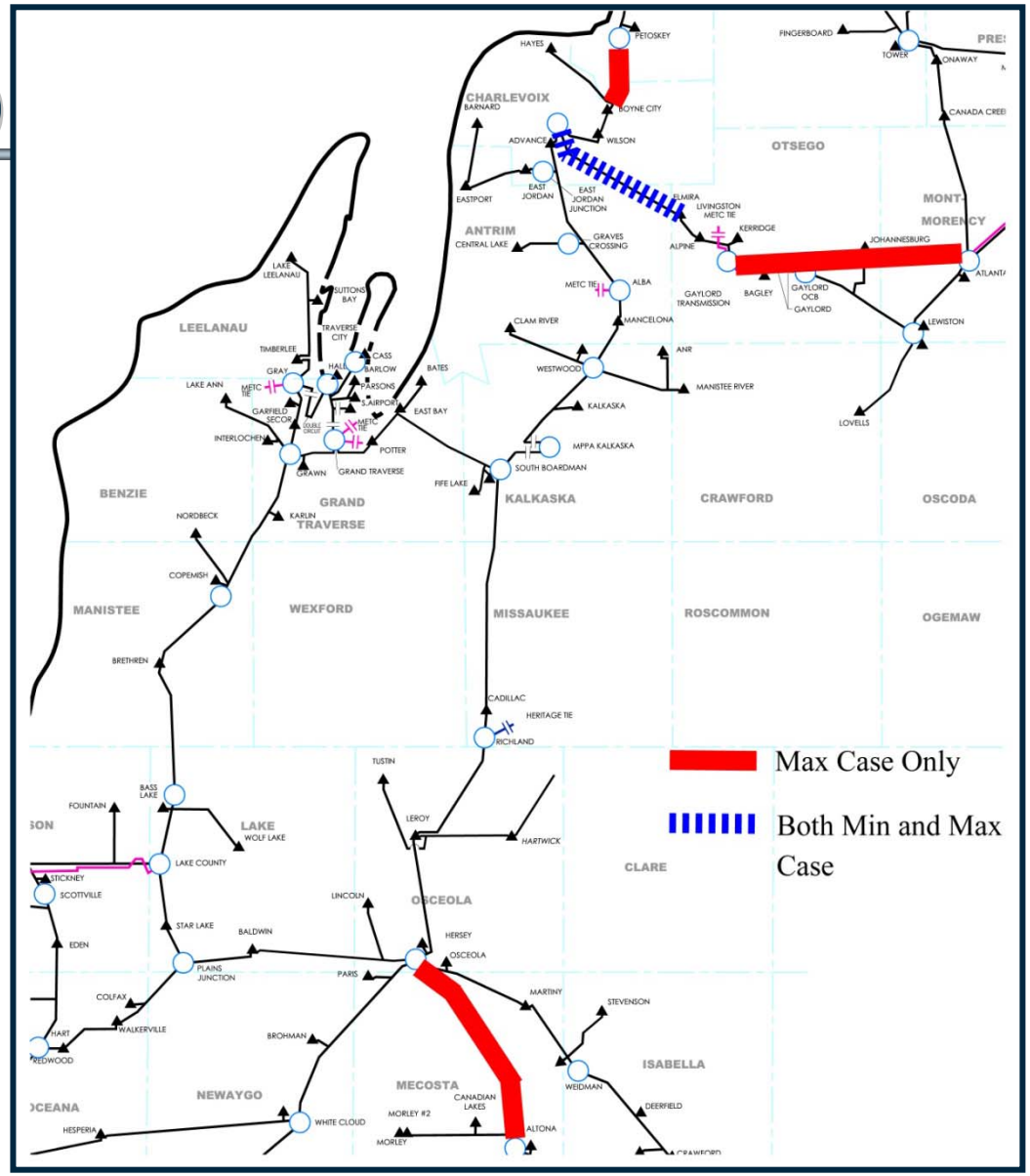
METC Transmission Requirements (Region 3)

- Replacement of existing equipment with little or no ROW implications (subject to detailed investigation)
- ~$36 million for minimum and ~36$ million for maximum
  - No additional costs for maximum



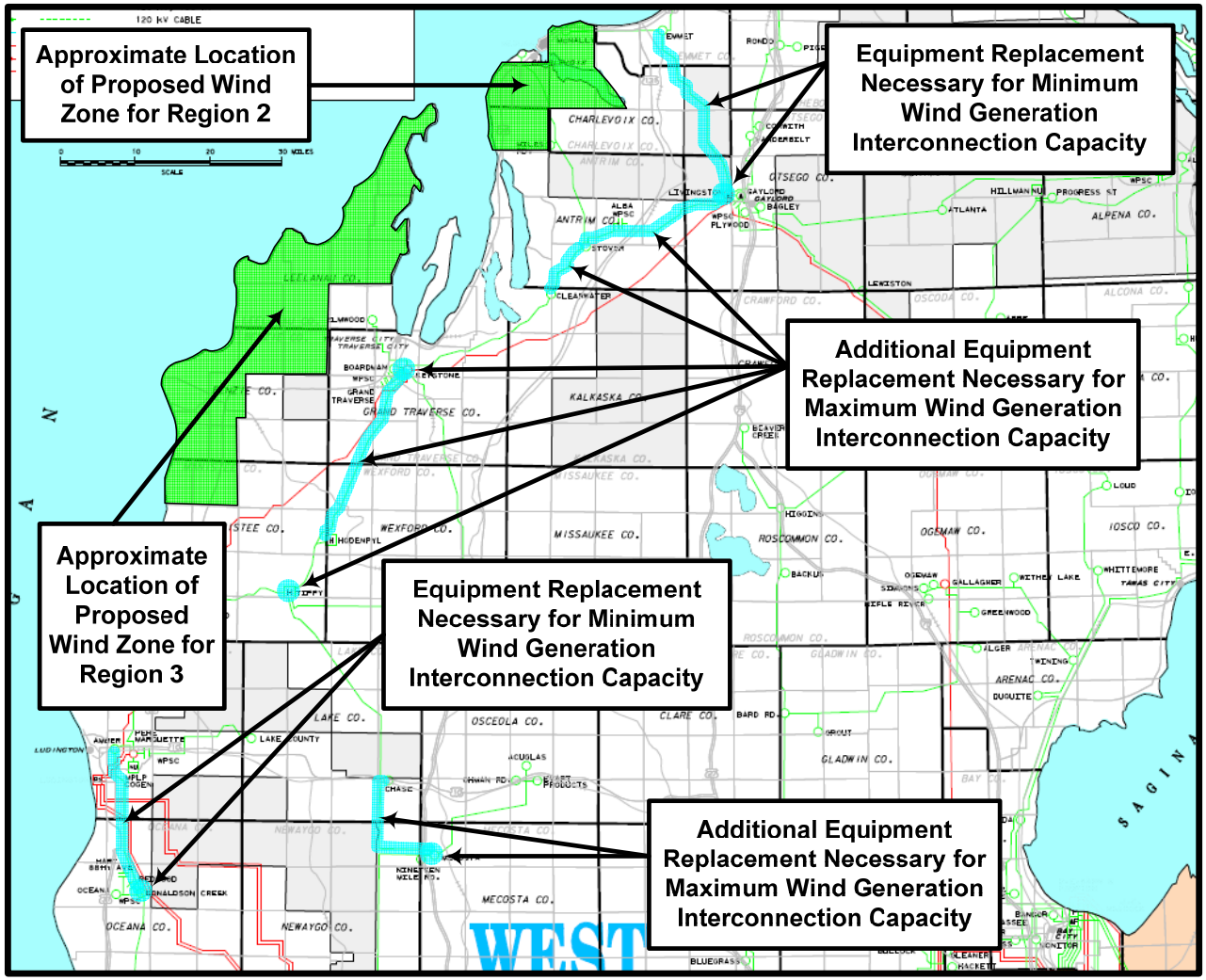
WPSCI Transmission Requirements (Region 3)

- Replacement of existing station equipment and upgrades of overhead lines
- Non-binding cost estimates of ~$7 million for minimum and ~$33 million for maximum



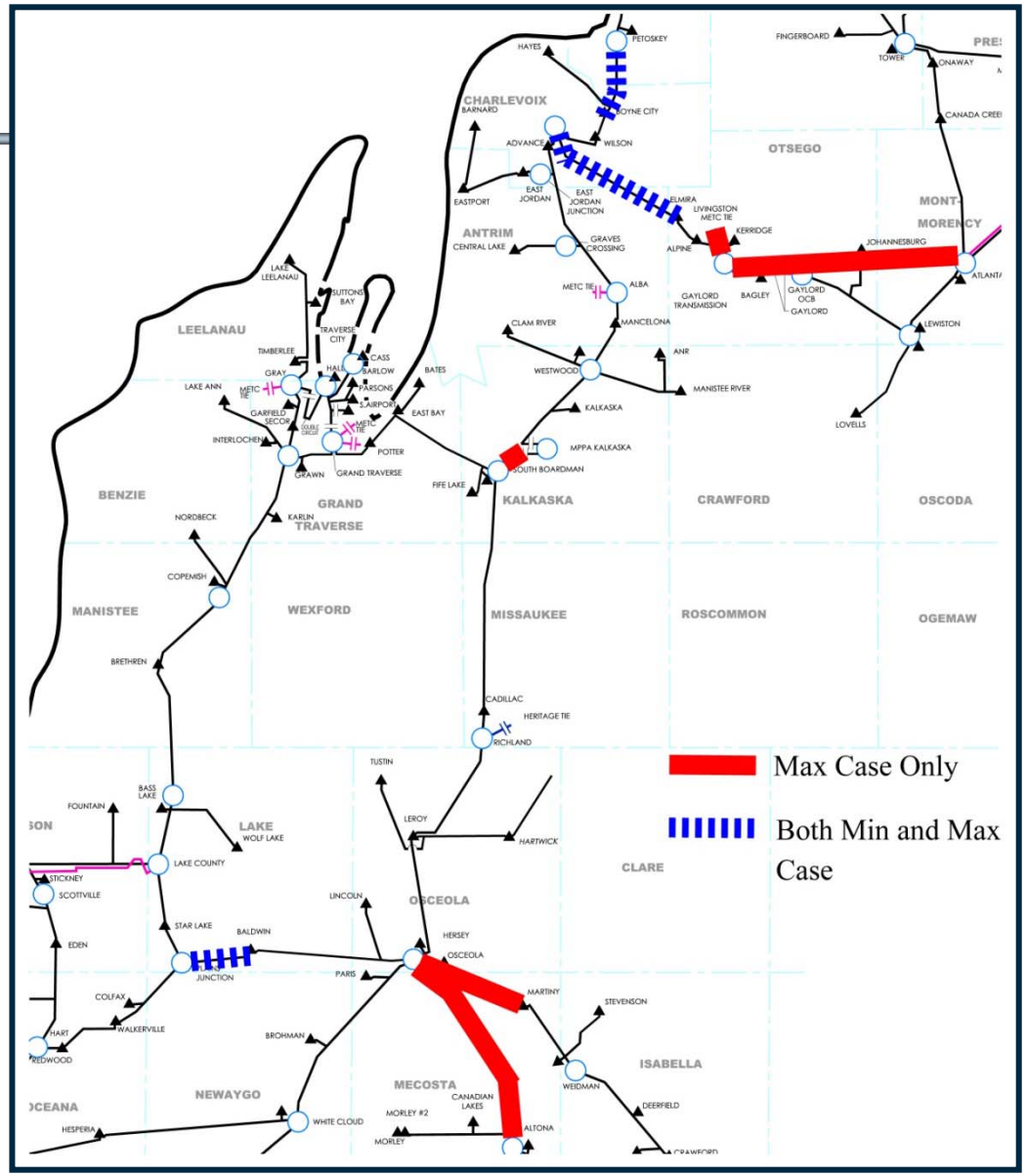
METC Transmission Requirements (Regions 2 & 3)

- Additional transmission system upgrades were identified as necessary on the METC transmission system for simultaneous connection of Regions 2 & 3
- Replacement of existing equipment with little or no ROW implications (subject to detailed investigation)
- ~$59 million for minimum and ~129$ million for maximum



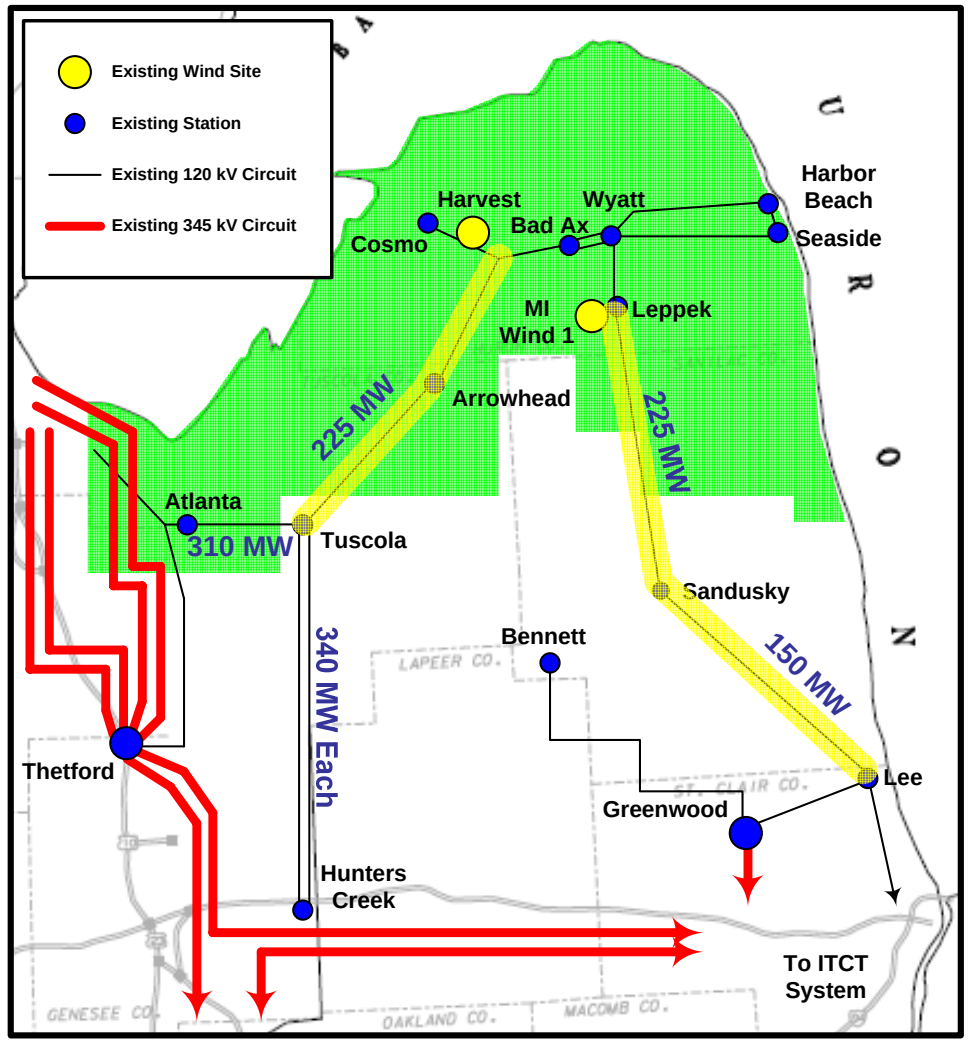
WPSCI Transmission Requirements (Regions 2 & 3)

- Additional transmission system upgrades were identified as necessary on the WPSCI transmission system for simultaneous connection of Regions 2 & 3
- Replacement of existing station equipment and upgrades of overhead lines
- ~$14 million for minimum and ~47$ million for maximum



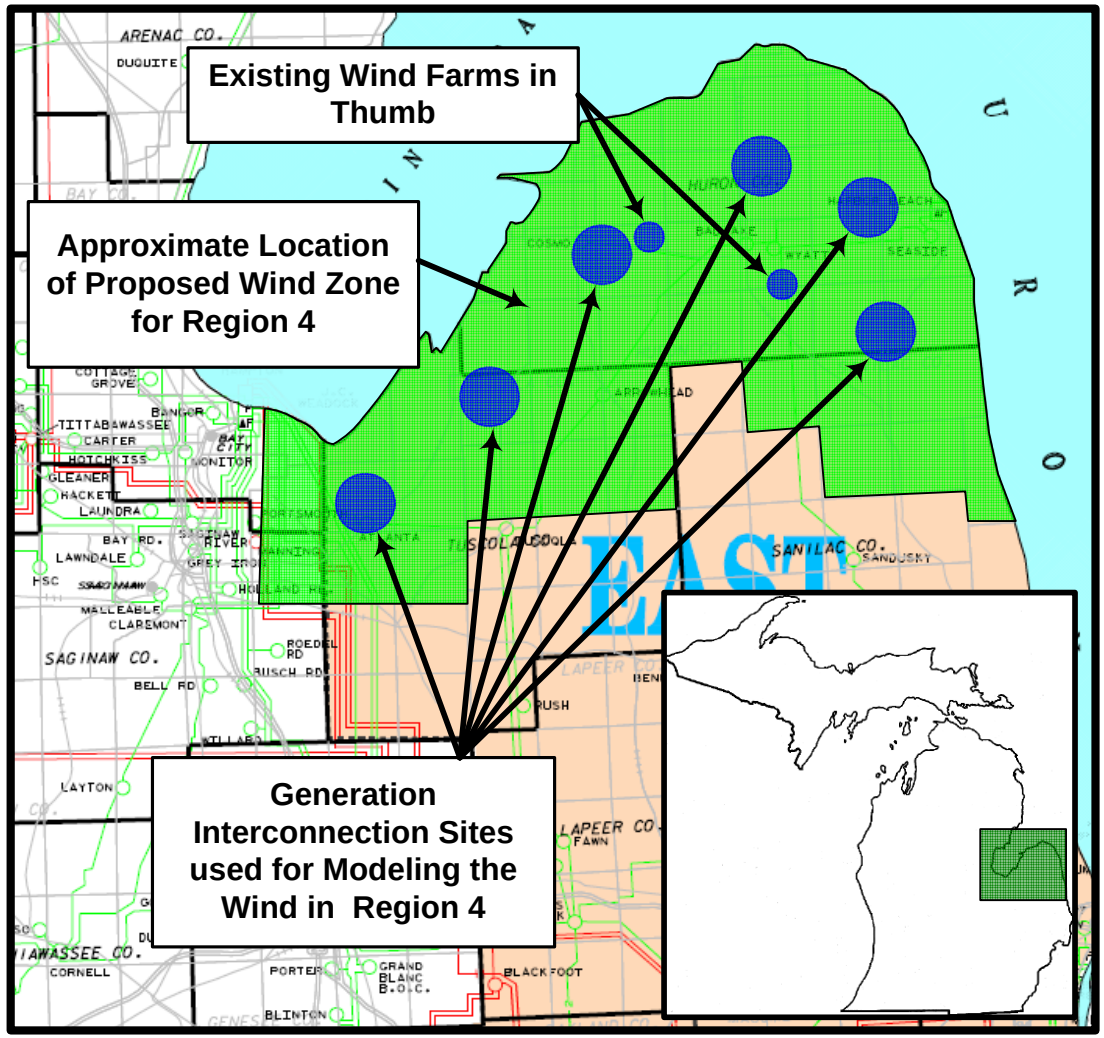
Transmission Requirements (Region 4)

- **Complexities of analysis for region 4**
  - Limited available capacity
  - Large minimum and maximum wind generation capacities identified by WERZB
    - 2,367 MW
    - 4,236 MW
  - Large absolute difference between minimum and maximum values
- **Description of region 4**
  - Two existing 120 kV circuits with limited capability
  - The capability of the existing transmission system is significantly lower than minimum and maximum wind generation capabilities identified by WERZB



Transmission Requirements (Region 4)

- **Region 4 modeled as shown**
  - Generation initially modeled at 6 interconnection locations
  - 210 MW assumed existing
  - 359.5 MW per site for minimum ((359.5 X 6) + 210 = 2,367 MW)
  - 671 MW per site for maximum ((671 X 6) + 210 = 4,236 MW)
- **Significant transmission system overloads on the ITCT transmission system were identified as wind power was connected at the WERZB identified minimum and/or maximum wind generation capacity levels**
  - Specifically the two existing 120 kV circuits exiting the Thumb area were shown to significantly overload
- **No overloads on the WPSCI transmission system were identified as wind power was connected at the WERZB identified minimum and/or maximum wind generation capacity levels**

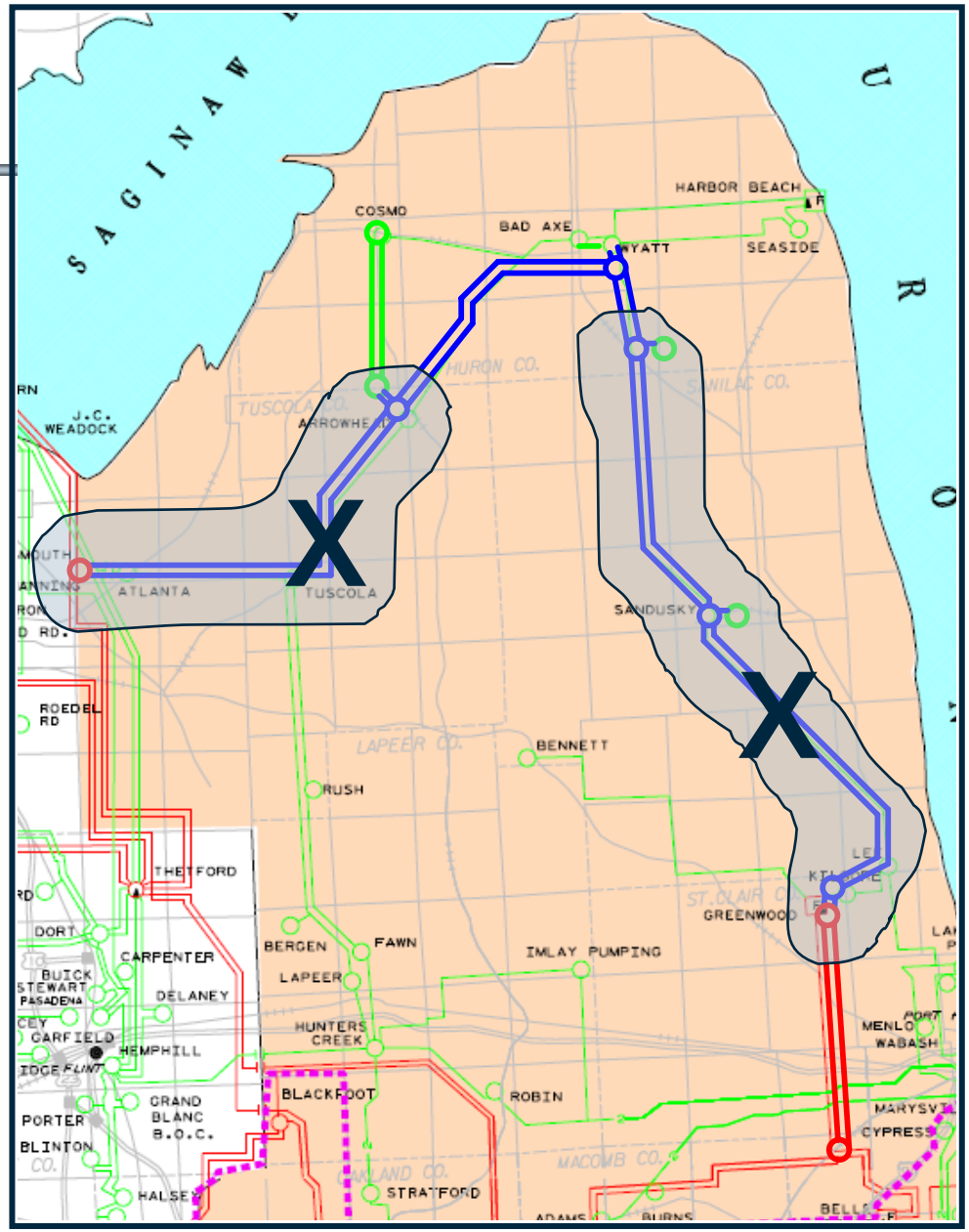


Transmission Requirements (Region 4)

- **Decision "tree" for determining transmission requirements**
- **First attempted to utilize existing rights of way (4-230 kV circuits)**
  - Replace 120 kV single circuit towers with double circuit 230 kV towers
    - Typical configuration operating at 230 kV
    - Larger (high temperature) conductor (more expensive)
  - Significant transmission system overloads were identified as wind power was exported at the WERZB identified minimum (and thus maximum) wind generation capacity levels (even with larger high temperature conductor)
  - Could not support minimum (and thus maximum) wind generation capacity identified by the WERZB
    - Typical 230 kV configuration would allow approximately 1,500 MW of wind generation to interconnect in Region 4
    - Larger high temperature conductor would allow approximately 2,000 MW of wind generation to interconnect in Region 4

4 - 230 kV Circuits Fell Short Because…

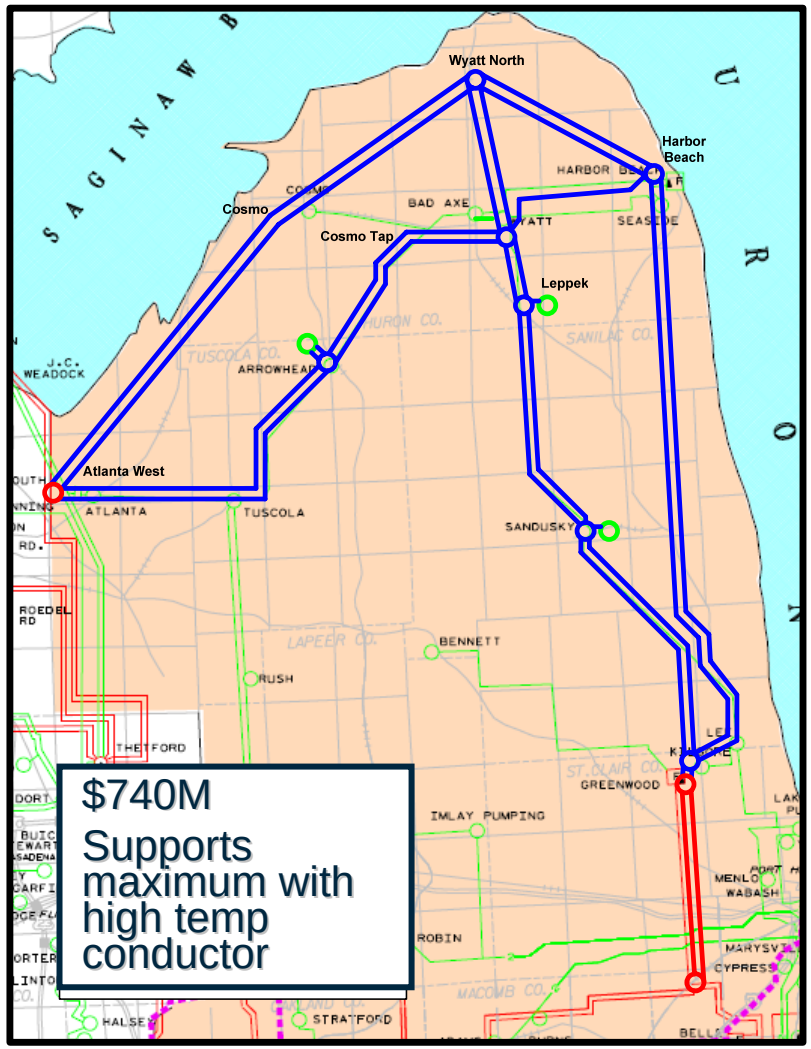
- Loss of one circuit on the west side of the Thumb overloads the other
- Loss of west side double circuit tower causes overloads on the east side circuits
- Loss of the east side double circuit tower causes overloads on the west side circuits



Transmission Requirements (Region 4)

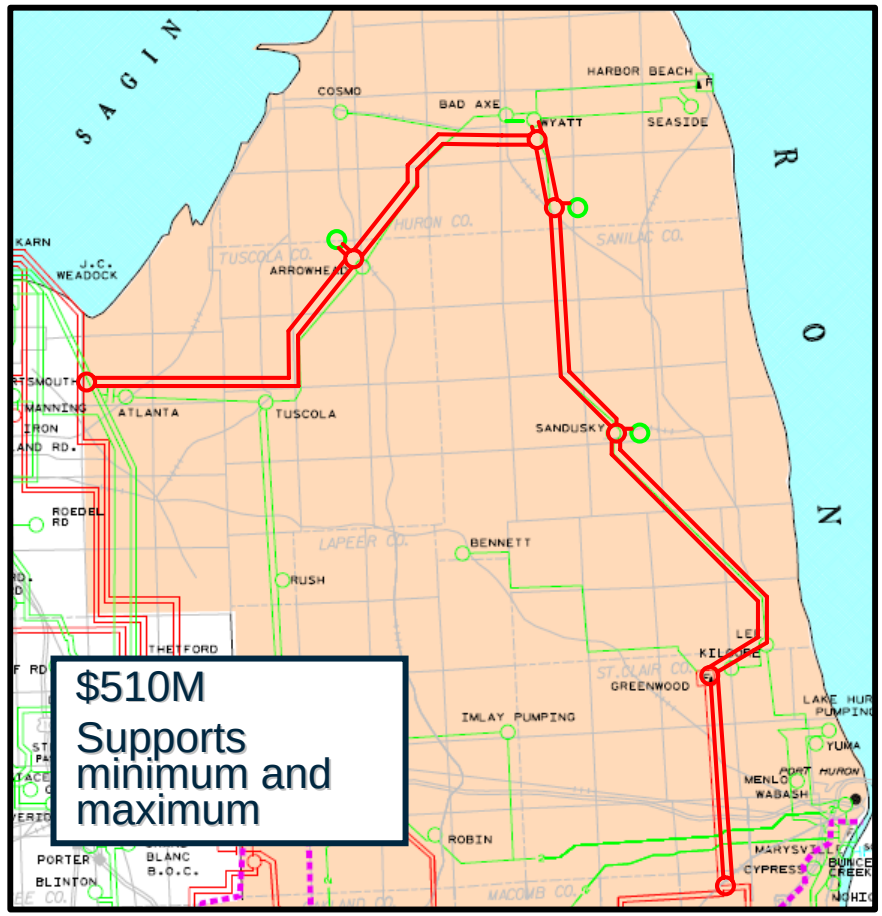
- **In order to support the minimum wind generation capacity identified by the WERZB expanded the 230 kV inner loop by adding two more circuits up and around the north western side of the Thumb (6-230 kV circuits)**
  - Assuming larger high temperature conductor
  - Based on the assumptions considered, was shown to be able to support the minimum wind generation capacity identified by the WERZB and cost about $560M
- **Next further expanded the 230 kV inner loop by adding two more circuits up and around the north eastern side of the Thumb (creating two double circuit 230 kV loops around the Thumb area, 8-230 kV circuits)**
  - Assuming larger high temperature conductor
  - Based on the assumptions considered, was shown to be able to support the maximum wind generation capacity identified by the WERZB and cost about $740M

Transmission Requirements (Region 4) – 230 kV



Transmission Requirements (Region 4) – 345 kV

- **Also considered rebuilding the existing 120 kV circuits with 345 kV**
  - Would require expansion of existing rights of way
  - Based on the assumptions considered, was shown to be able to support the maximum wind generation capacity identified by the WERZB and cost about $510M
- **For all options other upgrades, external to Thumb will be necessary**
  - 2000+ MW to 4000+ MW of new generation will impact flows throughout system
  - Impossible to predict all possible new flow patterns
  - Study focused on backbone system within Thumb area



$510M
Supports minimum and maximum

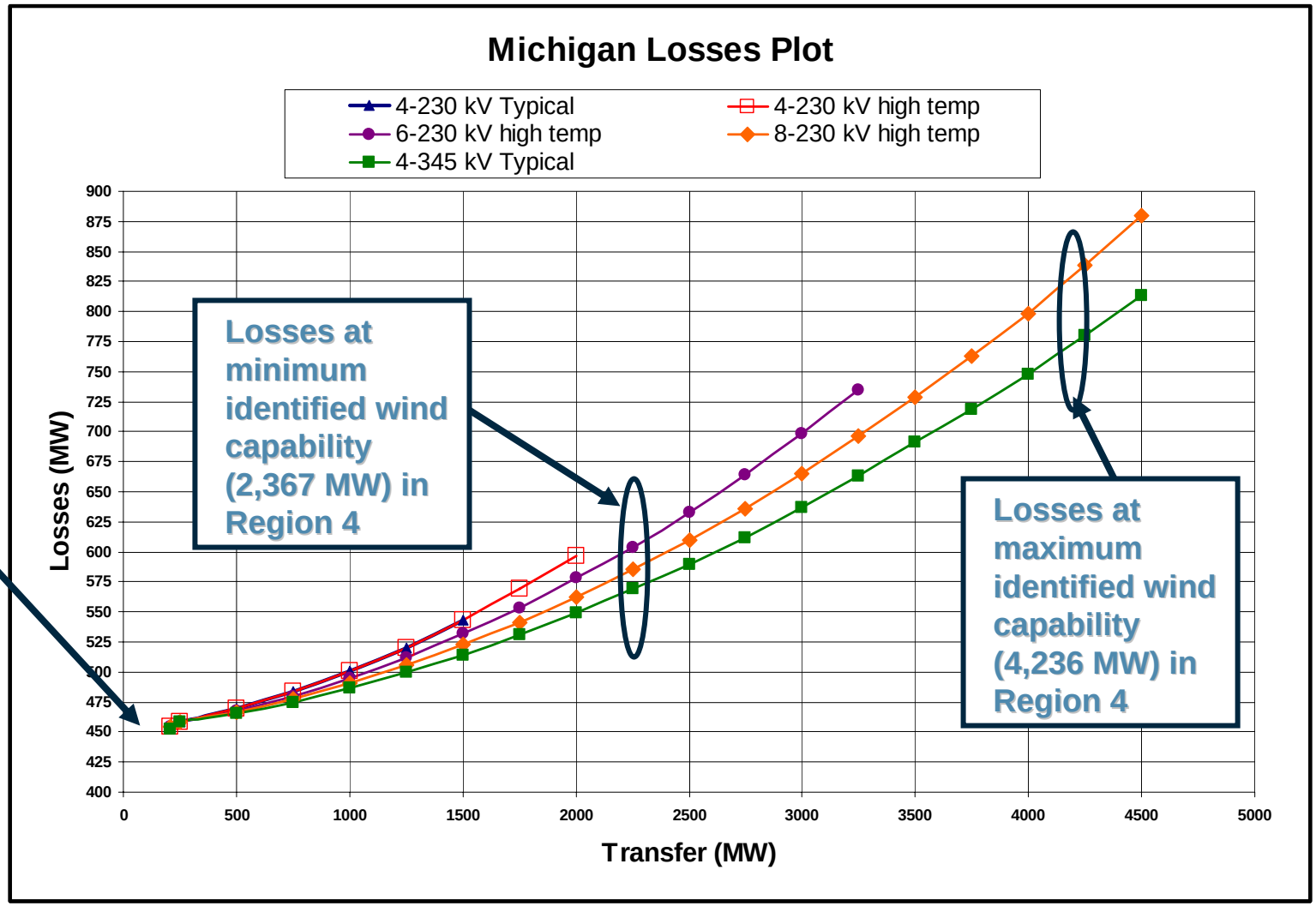
Transmission Requirements (Region 4)

Configuration	4-230 kV Typical[1]	4-230 kV High Temp[2]	6-230 kV High Temp[2]	8-230 kV High Temp[2]	4-345 kV Typical[1]
Cost Estimates (in Millions)	$390	$420	$560	$740	$510
Wind Interconnection Capability	1,500 MW	2,000 MW	3,250 MW	4,750 MW	5,000 MW
Can Support Minimum Wind Capacity Identified by WERZB	No	No	Yes	Yes	Yes
Can Support Maximum Wind Capacity Identified by WERZB	No	No	No	Yes	Yes
ROW Requirements	Minimal Impact	Possible Expansion	Possible Expansion and New ROW	Possible Expansion and New ROW	Expansion Required
Losses for 2,367[3] MW Wind Injection	N/A[4]	N/A[4]	618 MW	596 MW	578 MW
Losses for 4,236[5] MW Wind Injection	N/A[4]	N/A[4]	N/A[4]	836 MW	778 MW

[1] "Typical" refers to a typical configuration utilized for the voltage class denoted.
[2] "High Temp" refer to the utilization of a conductor that can be operated to higher temperatures than that which is typically utilized.
[3] Minimum wind generation capacity identified by the WERZB for Region 4.
[4] This configuration does not support this level of wind injection.
[5] Maximum wind generation capacity identified by the WERZB for Region 4.

Losses Comparison for Region 4

- Total METC and ITC transmission and networked distribution system losses for various options considered
- Base losses with only existing wind connected in the Thumb area were around 450 MW

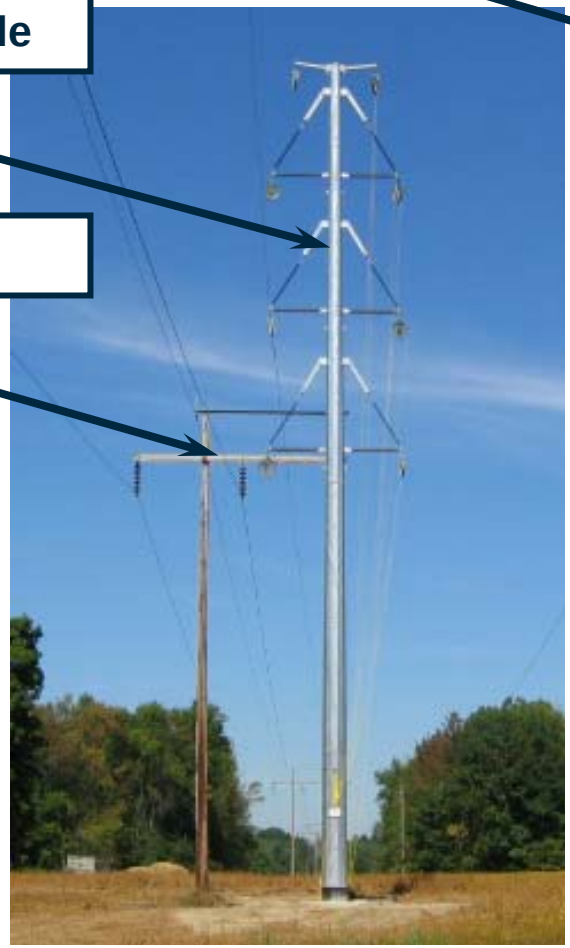


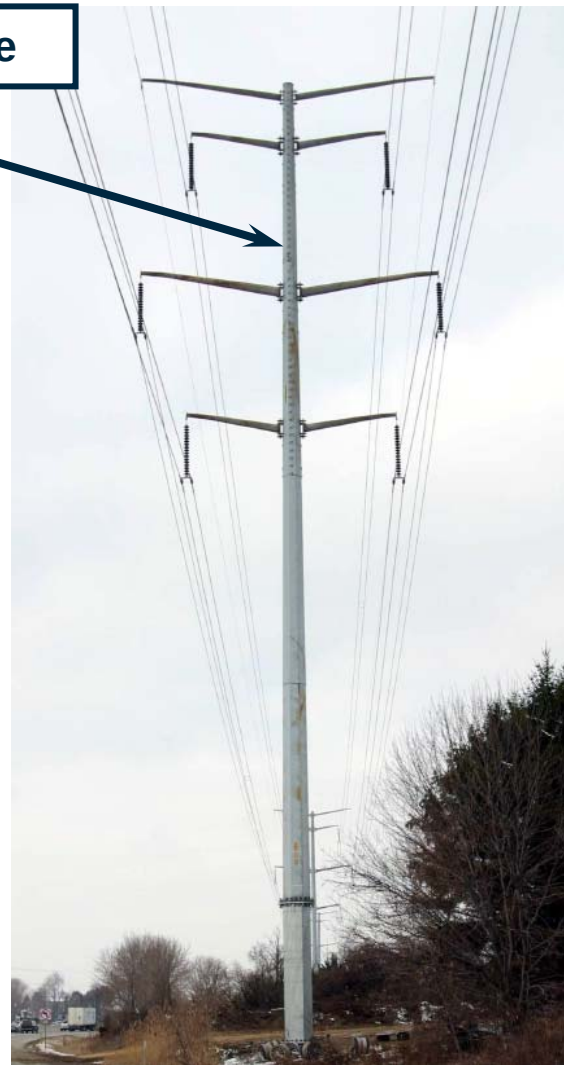
Tower Configurations (120 kV, 230 kV and 345 kV)

345 kV Double Circuit Steel Pole

230 kV Double Circuit Steel Pole

Existing 120 kV wood H-Frame





Note:

Pictures are not to scale.

Study Methodologies

- **Refer to Michigan Wind Energy Transmission Study Phase II scope document developed with input from MI Planning Consortium Renewable and Other Generation Integration Working Group**

- **Models utilized for the study**
  - Midwest ISO Regional Merit Order dispatch ("RMD") 2009 Midwest Transmission Expansion Plan ("MTEP") summer peak load model for the year 2014
  - Midwest ISO Appendix A future projects included in the Midwest ISO Appendix A and expected to be in-service prior to the end of 2009 and in close proximity to the designated areas were included in the base model

- **Wind interconnection assumptions**
  - Wind dispatched at 20% of nameplate capabilities in peak load models & 100% of nameplate capabilities in shoulder peak load models like in Midwest ISO interconnection studies
  - Wind connected directly to "backbone" facilities, assumed "Interconnection" facilities defined via actual interconnection studies

Study Methodologies

- **First Contingency Incremental Transfer Capability ("FCITC") analysis was used to help determine the "backbone" facilities that would be required**
  - Two transfer scenarios were considered:
    - Wind was sunk to (or dispatched against) generators throughout the Midwest ISO market
    - Wind was sunk to (or dispatched against) generators throughout Michigan
  - FCITC analysis helped determine one (or several) sets of system upgrades that might support future wind generation in the proposed wind zones
    - Served as a starting point for project development
- **Further studies utilized to "test" the robustness of the backbone systems developed in the FCITC analysis**
  - Dispatched wind to proxy for Midwest ISO market and focused on "backbone" upgrades within or directly adjacent to proposed zones
  - Considered various underlying power transfers across the system
    - North and south transfers to and from the Ludington pumped storage facility
    - East and west transfers across the Michigan and Ontario interface
  - Considered double circuit tower contingencies

Next Steps (Not part of the report)

- **Based on the Board's findings, the transmission report(s), various public comments and/or other factors, the Michigan Public Service Commission through a Final Order may designate an area of the state likely to be the most productive of wind energy as the primary wind energy resource zone; Commission may also designate additional wind energy resource zones**
- **Once a zone (or zones) has (have) been designated…**
  - Any projects deemed necessary to support wind in that zone would need to be vetted through a Midwest ISO 890 process
  - Further study would need to consider things such as:
    - Possible thermal impacts to distribution system
    - Voltage, short circuit and possibly stability implications on the transmission and distribution systems
- **Actual generator interconnections will be governed by Midwest ISO interconnection queue process**
    - This would include determination of the "interconnection" facilities that would be necessary to interconnect each specific wind site
    - This could also include backbone upgrades external to the zone necessary to make each specific wind site "deliverable" to the Midwest ISO market