Northern Area Study

Technical Review Group (TRG)
6th Meeting

Meeting: February 12, 2013
Update: March 4, 2013

March 4, 2013 Updates

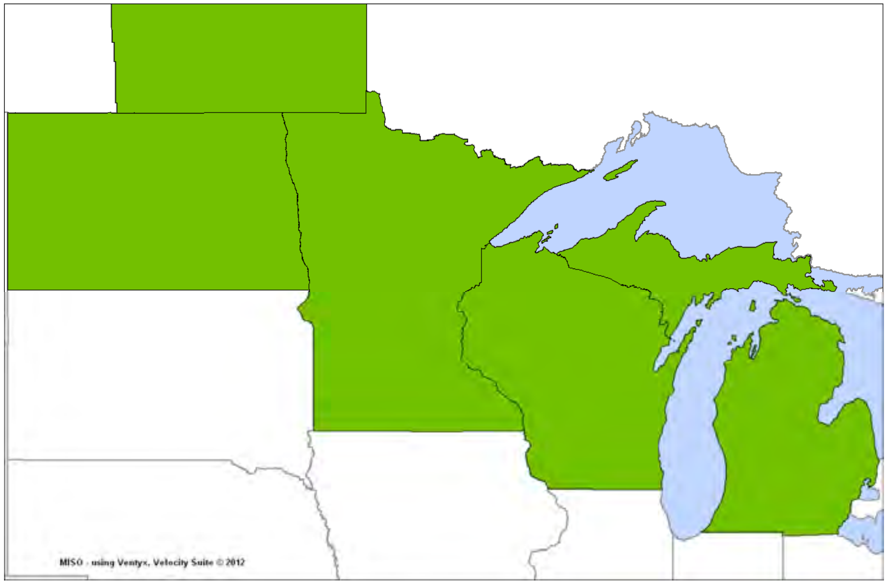
- **Additional details provided on reliability analysis (Slides 87 – 91)**
- **Michigan plants that were retired identified (Slide 18)**
- **Input/output flow chart for the Northern Area Study, Manitoba Hydro Wind Synergy Study, Manitoba-MISO TSR Analysis, and Market Efficiency Planning Study added (Slide 9)**
- **Additional LMP plots provided (Slides 58 – 81)**
  - Market scale
  - Larger geographic view
  - LMPs without losses – explains remaining LMP differences
- **Submarine HVDC cable costs updated (Slides 20, 40-44, and 49)**
- **Updated adjusted production cost savings results provided for all options (separate postings)**

Agenda

• Welcome, Roll Call, and Review Agenda	10:00 AM
• Recap December 7th Meeting	10:15 AM
• Related Study Status Report	10:30 AM
– Manitoba Hydro Wind Synergy Study	
– TSR Update	
– Market Efficiency Study	
• Economic Benefits of New/Refined Options	11:00 AM
• Lunch Break	12:00 PM
• Economic Benefits of Best-Fit Plans/Portfolios	12:30 PM
• Reliability Analysis of Portfolios Work Plan	1:00 PM
• Schedule Update	1:30 PM
• Open Discussion and Next Steps	1:45 PM
• Adjourn	2:00 PM

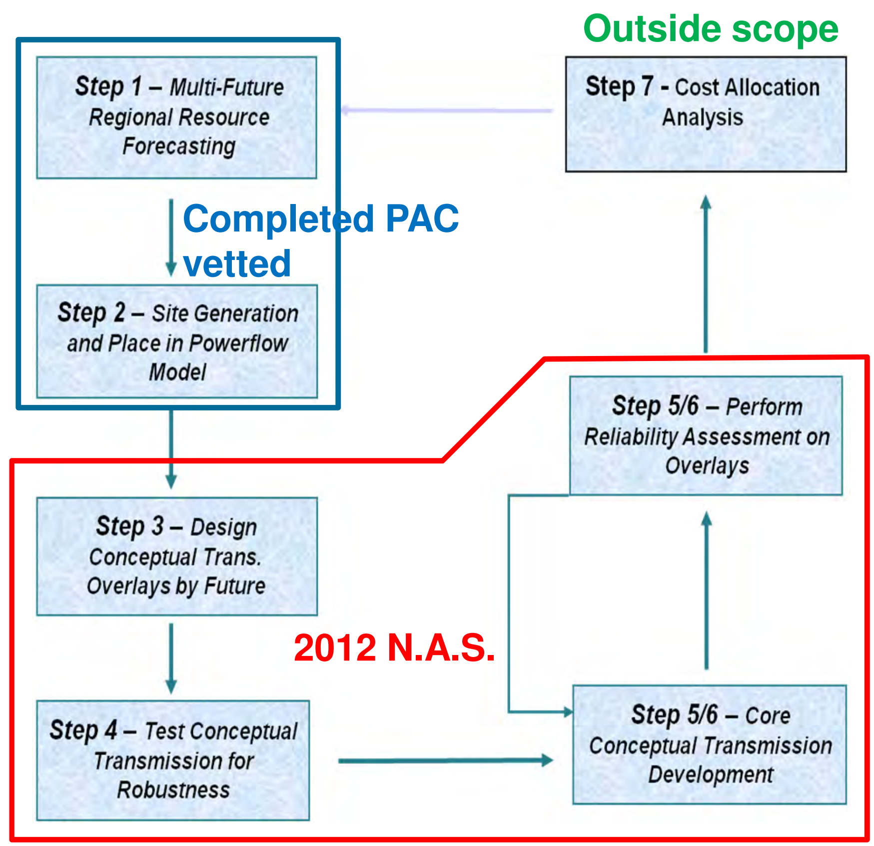
Study Recap

- **Driver: Multiple proposals by stakeholders & reliability issues located in MISO's northern footprint**
- **Objective is to conduct a comprehensive study to:**
  - Identify the economic opportunity for transmission development in the area
  - Evaluate the reliability & economic effects of drivers on a regional, rather than local, perspective
  - Develop indicative transmission proposals to address study results with a regional perspective
  - Identify the most valuable proposal(s) & screen for robustness
- **2012 - 2013 analysis will provide guidance for next steps**



Study Progress

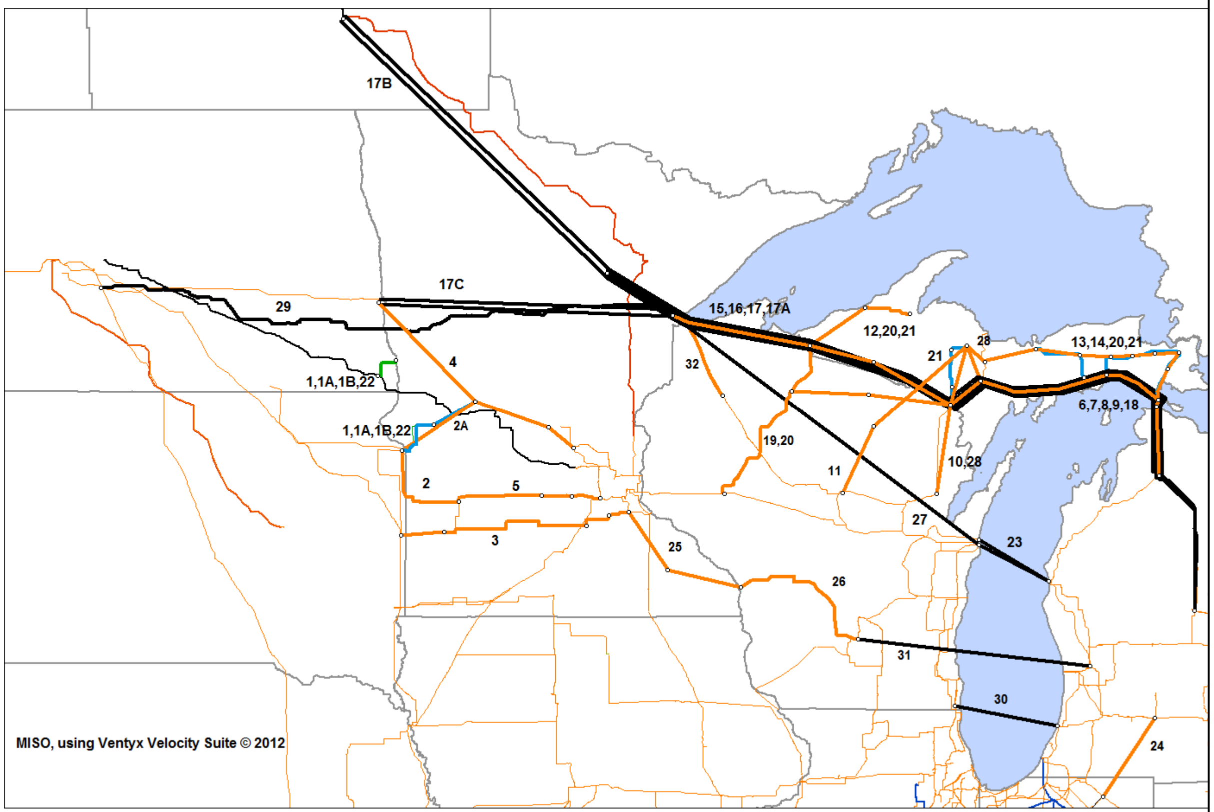
- **Northern Area Study is following the MISO 7 Step Planning Process that has been used for many of MISO's studies, including MTEP**
  - Currently, in Steps 5/6 testing and refining conceptual transmission
  - Northern Area Study is using MTEP12 models as the base with specific updates to:
    - Load levels
    - Imports from Manitoba Hydro
    - Unit retirements
  - Assumptions finalized at July 11th TRG meeting



Economic Results Summary

- **As seen in potential data, APC savings are lower**
  - Multi-Value Projects in-service in out-years
  - Low gas prices
  - Low demand and energy growth levels
- **Highest benefit to cost ratios associated with low voltage line upgrades to mitigate small pocket of wind congestion**
- **Highest benefits from plans that connect Wisconsin and Upper Peninsula to mainland Michigan**
- **DC options are as cost beneficial as AC counterparts**

Northern Area Study Options Summary



Lines are for illustrative purposes only, actual line routing may differ

1. Upgrade Hankinson – Wahpeton 230kV and Big Stone – Morris 115kV
1A. Upgrade Hankinson – Wahpeton 230kV to 2010 TCFS Ratings and Big Stone - Morris 115kV
1B. Upgrade Hankinson – Wahpeton 230kV and Big Stone – Morris 115kV and 2nd Big Stone 230/138/13.8kV Xfmr
2. Big Stone – Hazel 345kV
2A. Big Stone – Alexandria 345kV
3. Brookings – Hampton 345kV
4. Fargo – Monticello 345kV
5. Convert: Hazel – Blue Lake 345kV
6. Arnold – Livingston 345kV
7. Morgan – Arnold – Livingston 345kV
8. Eau Claire – Arnold – Livingston 345 kV
9. Arrowhead – Arnold – Livingston 345 kV
10. Morgan - Plains – National 345kV
11. Gardener Park – National 345kV
12. Arrowhead – National 345kV
13. National – Livingston 345kV (North)
14. Marquette – Mackinac County 138kV
15. Blackberry – MI 500kV DC
16. Blackberry – Plains 500kV DC
17. Blackberry – Plains – MI 500kV
17A. Arrowhead – Plains – MI 500kV
17B. Dorsey – Plains – MI 500kV
17C. Fargo – Plains – MI 500kV
18. National – Livingston 345kV (Straight)
19. Eau Claire – M38
20. Eau Claire – National 345kV
21. Low Voltage Northern WI Upgrade
22. Option 1 plus new Morris – Alex 115kV
23. Kewaunee – Ludington 500kV DC
24. Duck Lake – Hiple 345kV
25. 2nd Hampton – Briggs Rd 345kV
26. 2nd Hampton – Madison 345kV
27. Arrowhead – P. Beach – Lud 500kV DC
28. Morgan – Arnold & Plains – National 345kV
29. Upgrade Square Butte DC Line
30. Pleasant Prairie – Palisades 500kV DC
31. Madison – Tallmadge 500kV DC
32. Upgrade Arrowhead – Stone Lake 345kV

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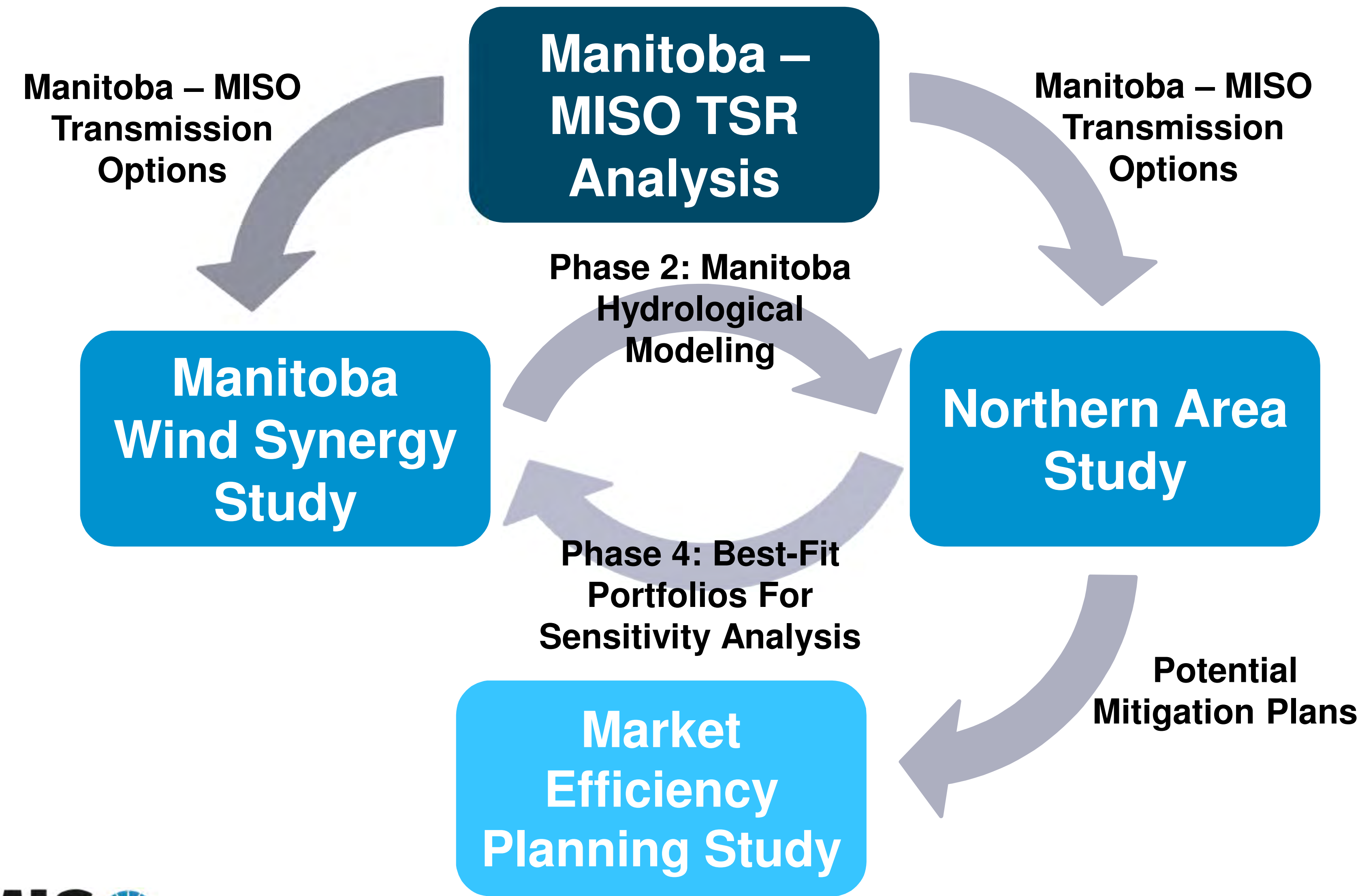
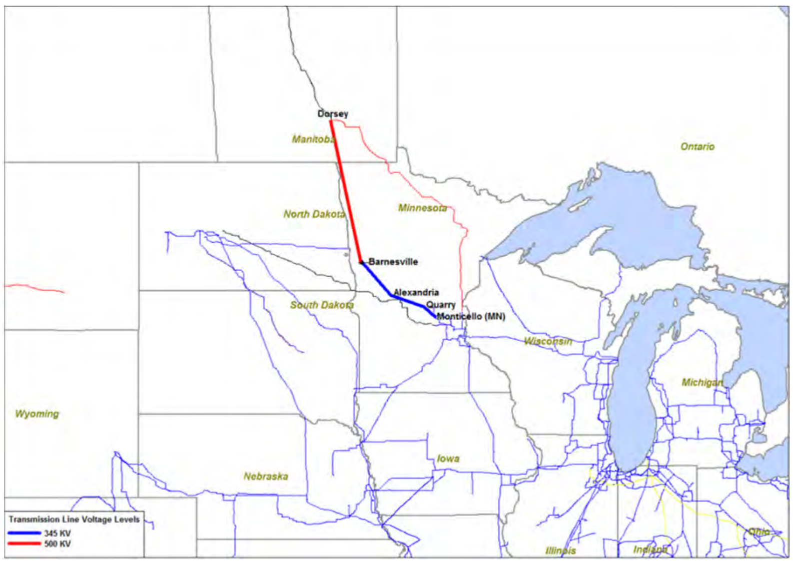
“Hand-Offs” Between Related Studies



MH Wind Synergy Study Status Update

- **6th TRG meeting was held in January 16th, 2013 to present phase 3 final results**
  - Annual production cost savings range from $78-$111 million for 2027
  - The east and west options show similar benefit to cost ratios while the central option shows lower benefit to cost given the higher cost of the line
  - The addition of MH generation and transmission shows good synergy with MN/ND MISO wind
  - All benefit to cost ratios are less than one using the assumptions from the MTEP 12 Business as Usual (BAU) future
- **Next Webcast will be held in February 21st, 2013 to communicate with phase 4 plans**

Transmission Options Studied in MHWSS



Manitoba Hydro Long-Term TSRs

Presently three plans under consideration

- **Western Plan - 1100MW 500kV Option 1**
  - Dorsey, CA - Bison, ND - Helena, MN
  - Estimated cost $1,463,690,000 (US facilities only included)
- **Eastern Plan - 250, 750, 1100 MW (**Presently in draft)
  - Dorsey, CA - Blackberry - Arrowhead, MN
  - Estimated cost $796,549,721 (US facilities only included)
  - Additional $9,660,000 mitigations costs
- **Mid Plan - 500kV Option W1**
  - Dorsey, CA - Barnesville - Alexandria - Quarry- Monticello, MN
  - Estimated cost (Presently being studied 250, 750, 1100 MW)

Western, Eastern & Mid 1100MW Proposals

TSR Customers call set for 2/13/13

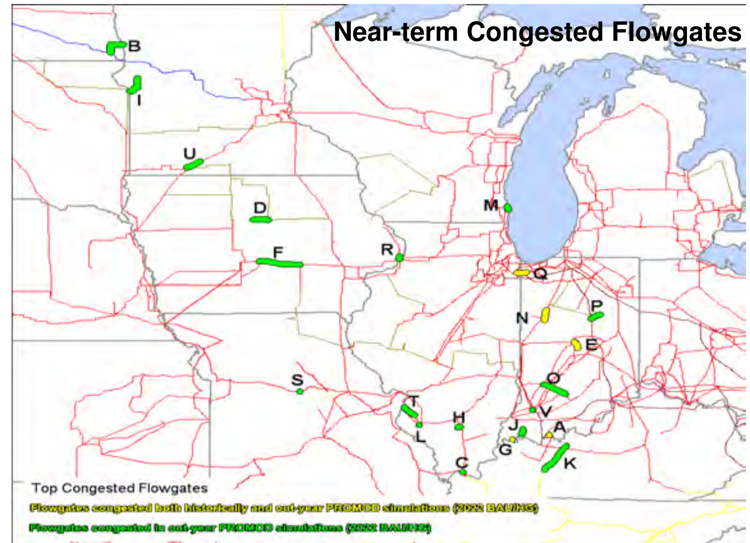
- **Need final plans determined by TO's and MISO**
- **Need to firm up dates for final plan and FCA**
- **Need commitment from TSR Customers to fund upgrades**

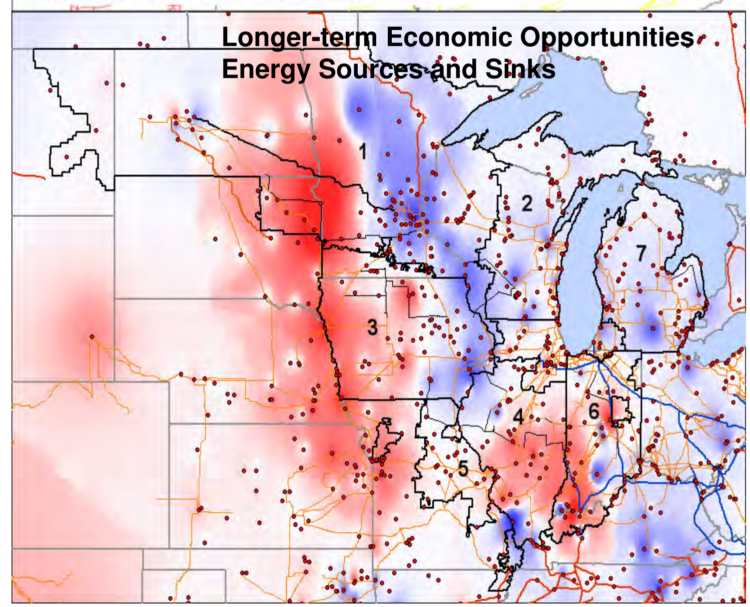
Because

- **Upgrades are required for the TSR's to be approved**
  - Finalizing which upgrade plan is preferred
- **Funding plan required**
- **Once (Multi-Party) Facility Construction Agreement executed, TSRs confirmed subject to upgrades in service**

Market Efficiency Planning Study (MEPS)

- **Objective is to execute an annual structured process to enhance market efficiency**
  - Incorporates both near-term congestion issues and longer-term economic opportunities
  - Encompasses larger scale projects/portfolios beyond flowgate specific congestion mitigation solutions
  - Creates an integrated process linking transmission need and proposed solutions
- **Ultimate deliverable – project recommendations for inclusion in MTEP13 Appendix A, if justified**
- **Study Progress Update**
  - Completed need identification analysis, near-term congestion issues and longer-term economic opportunities
  - Solicited and presented proposed transmission options from TRG
  - Developed transmission screening process and introduced preliminary flowgate/project grouping methodology at February 11th Meeting
  - In the process of evaluating selected projects or portfolios





MISO

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February 12, 2013 Economic Results

- Goal is to determine best-fit plans or portfolios for each scenario
- Results are indicative in nature: These are second round results from a first-take study
- Models updated with TRG feedback
- Benefits of subsequent slides only show adjusted production cost savings and provide no indication of additional benefits including reliability
- In these slides we're only showing iterated, new, or refined options – full results will be posted in a separate presentation

Economic Model Updates

- **The following updates were made to the NAS economic models since the last meeting:**
  - Models updated with Michigan unit retirements identified in the 12/4/12 East SPM
    - Harbor Beach Unit 1
    - Gaylord Units 1, 2, 3, and 4
    - Straights Unit 1
    - Cobb Units 4 and 5
    - Weadock Units 7 and 8
    - Whiting Units 1, 2, and 3
  - Livingston – Gaylord 138kV rating corrected
  - Corrected model data entry for Fargo 500kV tie-line compensation – MHWSS had correct entry
- **Testing shows updates have minimal effect on NAS benefits (<5%) and do not change plan "rankings"**
- **Full updated results for all plans posted with meeting materials**
- **Updated PROMOD models posted to the FTP site (dated 2/12/2013)**

Benefit to Cost Ratios

- **All APC savings in year-2027 dollars**
- **APC savings are an annual benefit**
- **Goal of benefit to cost ratios (B/C) is to compare projects**
  - For the Northern Area Study all projects assumed in-service in 2022
  - Same MISO-average annual charge rate used for all projects

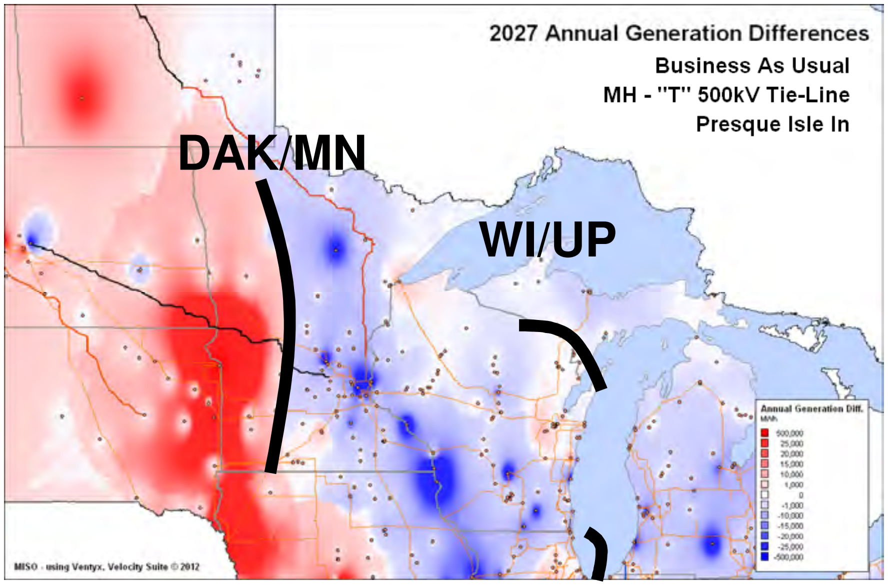
Transmission Line Cost Estimates

- **TRG supplied specific line estimates used if available**
- **Without specific estimates, updated generic $/mile estimates used**
- **A common set of cost assumptions used for 500kV HVDC**
  - A pair of terminals, source and sinks, includes VSCs: $400M
  - Line cost assumption: $2.7M/mile (land) $7.3M/mile (submarine)
- **All costs based on indicative $/mile estimates are denoted with an "*"**

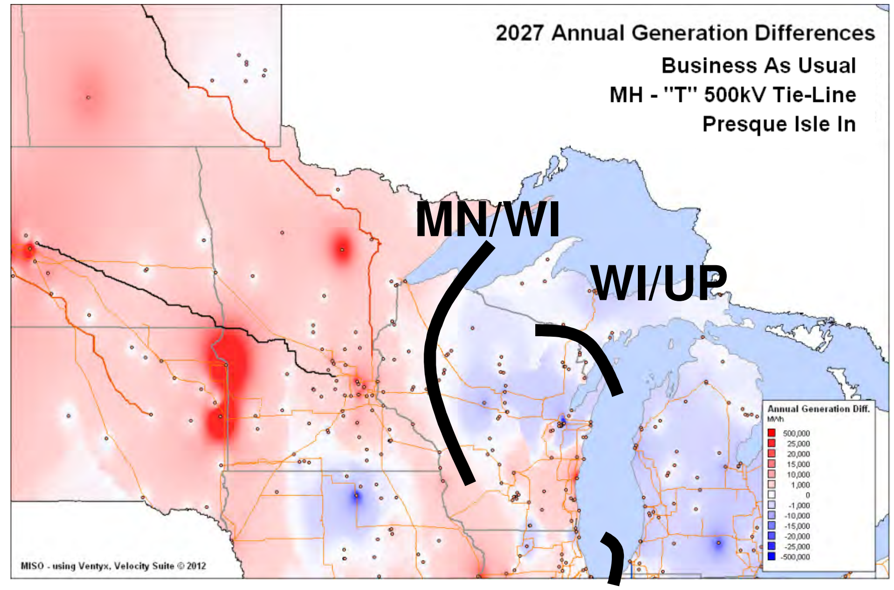
Generic Indicative Transmission Line Estimates ($M/mile)

kV	MN	DAK	WI	WI-ATC	UP	MI	IA
115	$1.00	$0.75	$1.10			$1.10	
138				$1.50	$1.50		
138-2				$1.60	$1.60		
161	$1.25	$0.90	$1.30				$1.10
230	$1.60	$1.25	$1.70			$1.20	
345	$2.70	$2.30	$2.90	$2.70	$2.50	$2.20	$2.20
345-2	$3.25	$3.00	$3.50	$3.00	$2.80	$2.75	$2.75
500	$3.20	$2.80	$3.40				
765	$4.00	$3.50	$4.50			$3.80	$3.80

Economic Potential Trends



Before Mitigating DAK/MN

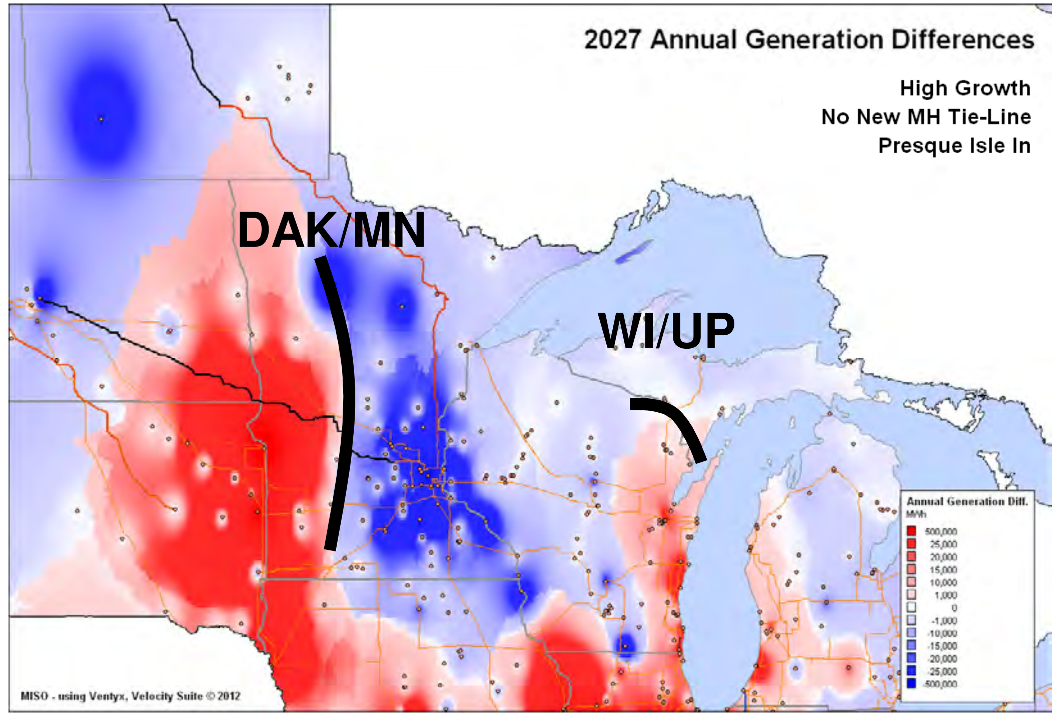


After Mitigating DAK/MN

- **Generally, all scenarios had similar trends**
- **Initially, two primary "pockets" or interfaces for potential benefit**
  - Dakotas – Minnesota border
  - Wisconsin/Upper Michigan
- **Planning is iterative, and after mitigating DAK/MN in select scenarios a new interface between MN/WI is visible**

DAK/MN Plans

- **Congestion from wind on DAK/MN border**
- **Primary Binding Constraints**
  - Hankinson – Wahpeton 230kV
  - Ortonville – Johnson Jct. - Morris 115kV

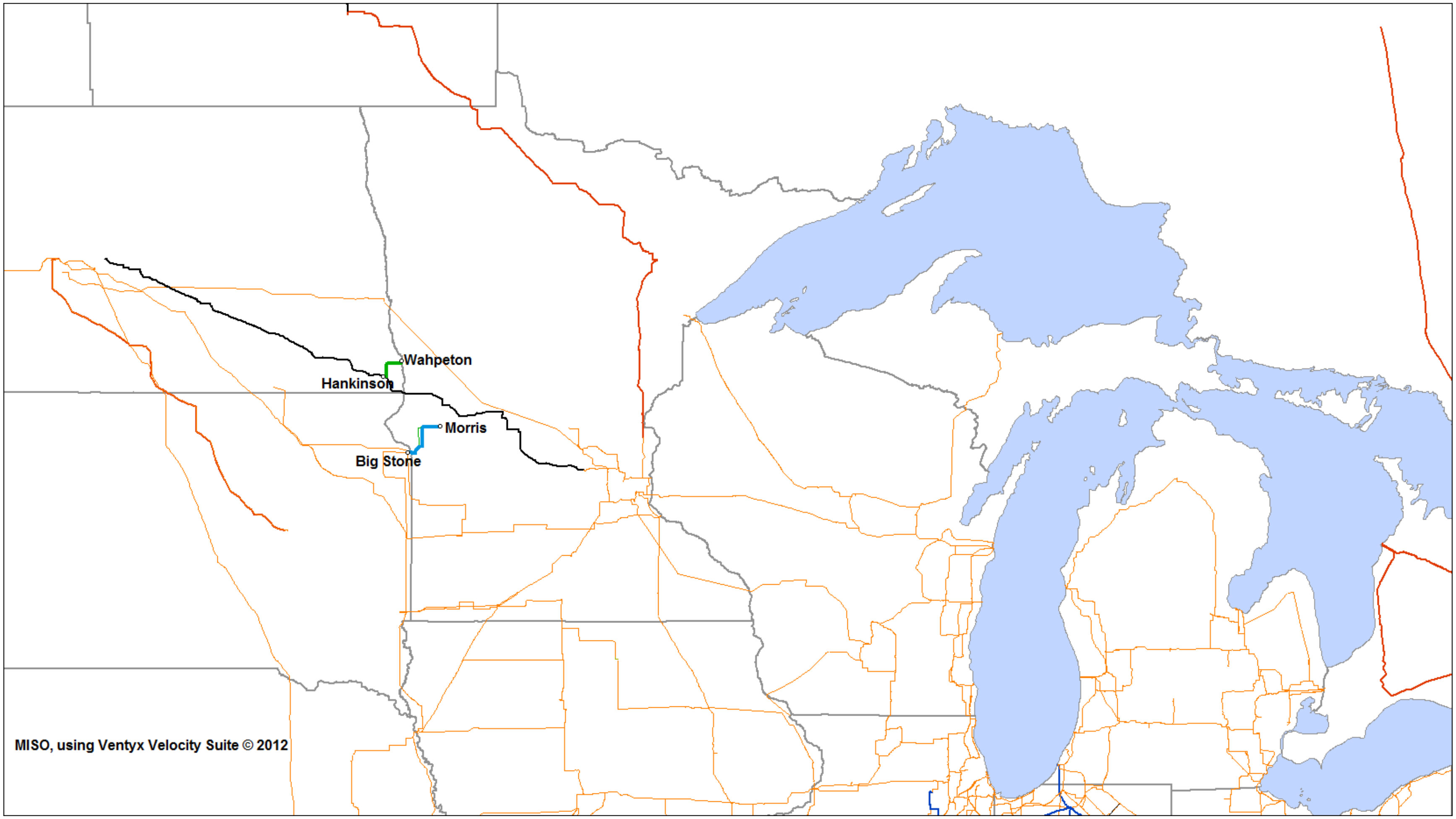


- **At Dec 7th meeting presented analysis of 7 options**
  - Low voltage options yielded B/C ratios in excess of 1.25; however, didn't fully mitigate congestion
  - 345kV options mitigated congestion; however had lower B/C ratios
- **3 additional iterations tested in this round**

Dakotas – MN Transmission Options: Info

Upgrade Hankinson – Wahpeton 230kV and Big Stone – Morris 115kV

Estimated Cost ($-2012): $22.2M



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Dakotas – MN Transmission Options: Results

Upgrade Hankinson – Wahpeton 230kV and Big Stone – Morris 115kV

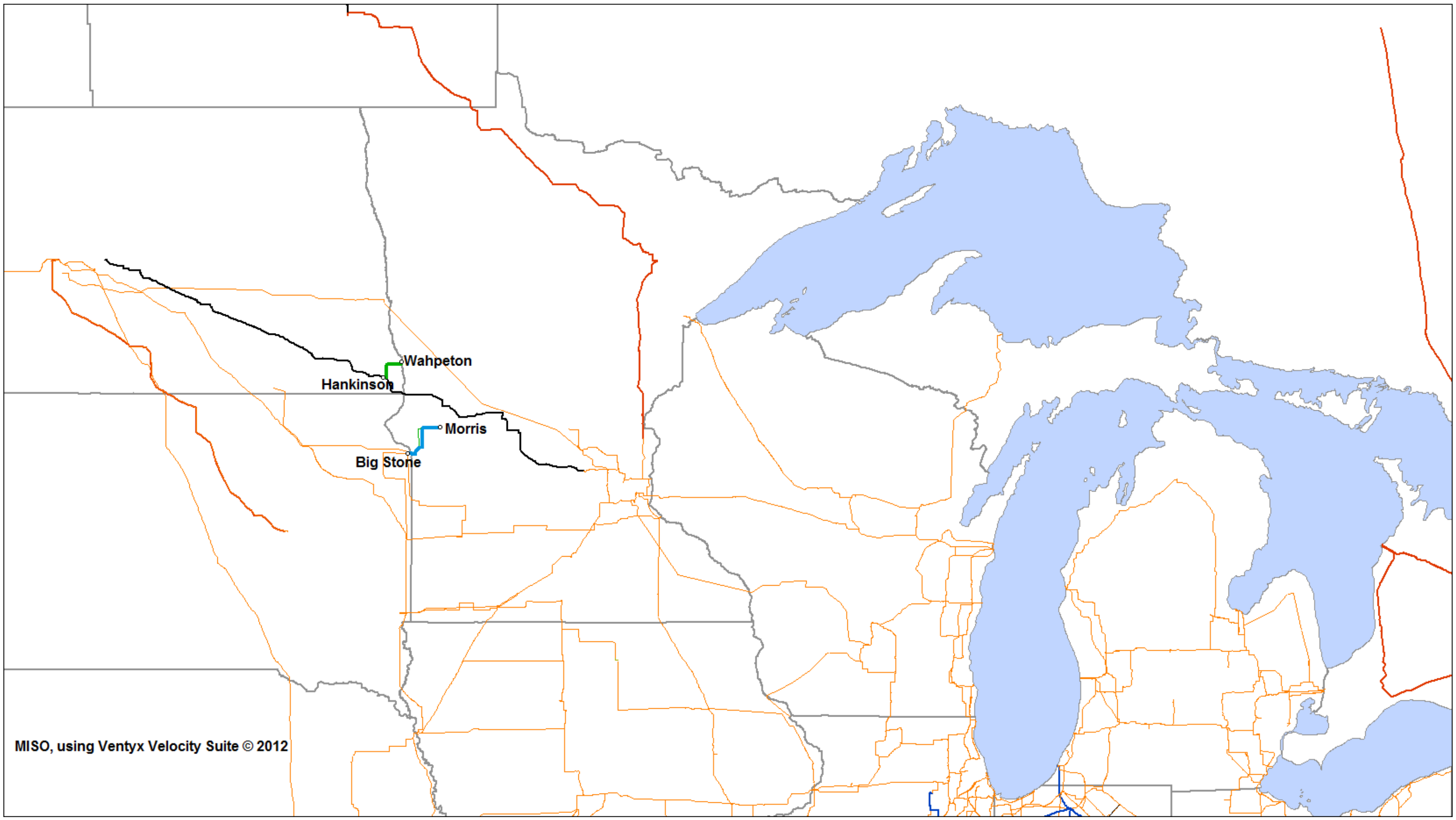
Scenario	APC Savings ($M-2027)	Estimated B/C
BAU, No new MH tie-line, Presque Isle In	24.4	5.59
BAU, MH - Duluth 500kV tie-line, Presque Isle In	19.0	4.35
BAU, MH - Fargo 500kV tie-line, Presque Isle In	15.1	3.46
HDE, No new MH tie-line, Presque Isle In	64.3	14.47
HDE, MH - Duluth 500kV tie-line, Presque Isle In	62.8	14.41
HDE, MH - Fargo 500kV tie-line, Presque Isle In	51.3	11.17

- **Line loading: Hankinson-Wahpeton 60% Big Stone-Morris 25%**
- **Average flow: Hankinson-Wahpeton 250 MW Big Stone-Morris 100 MW**
- **Maximum flow: Hankinson-Wahpeton 400 MW Big Stone-Morris 200 MW**
- **Plan's benefits are proportional to wind and load levels – beneficial in all scenarios**
- **Fargo tie-line relives area congestion, thus option's available benefits are less**
- **Fully mitigates congestion on Johnson Jct. – Ortonville 115kV and reduces Hankinson – Wahpeton 230kV by 75%**
- **After mitigation the Big Stone 230/115/13.8kV transformer binds**
- **Next iteration? Further increase rating on Hankinson-Wahpeton and add a second Big Stone transformer**

Dakotas – MN Transmission Options: Info

Upgrade Hankinson - Wahpeton 230kV to 2010 TCFS Rating and Upgrade Big Stone - Morris 115kV

Estimated Cost ($-2012): $41.6M



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Dakotas – MN Transmission Options: Results

Upgrade Hankinson - Wahpeton 230kV to 2010 TCFS Rating and Upgrade Big Stone - Morris 115kV

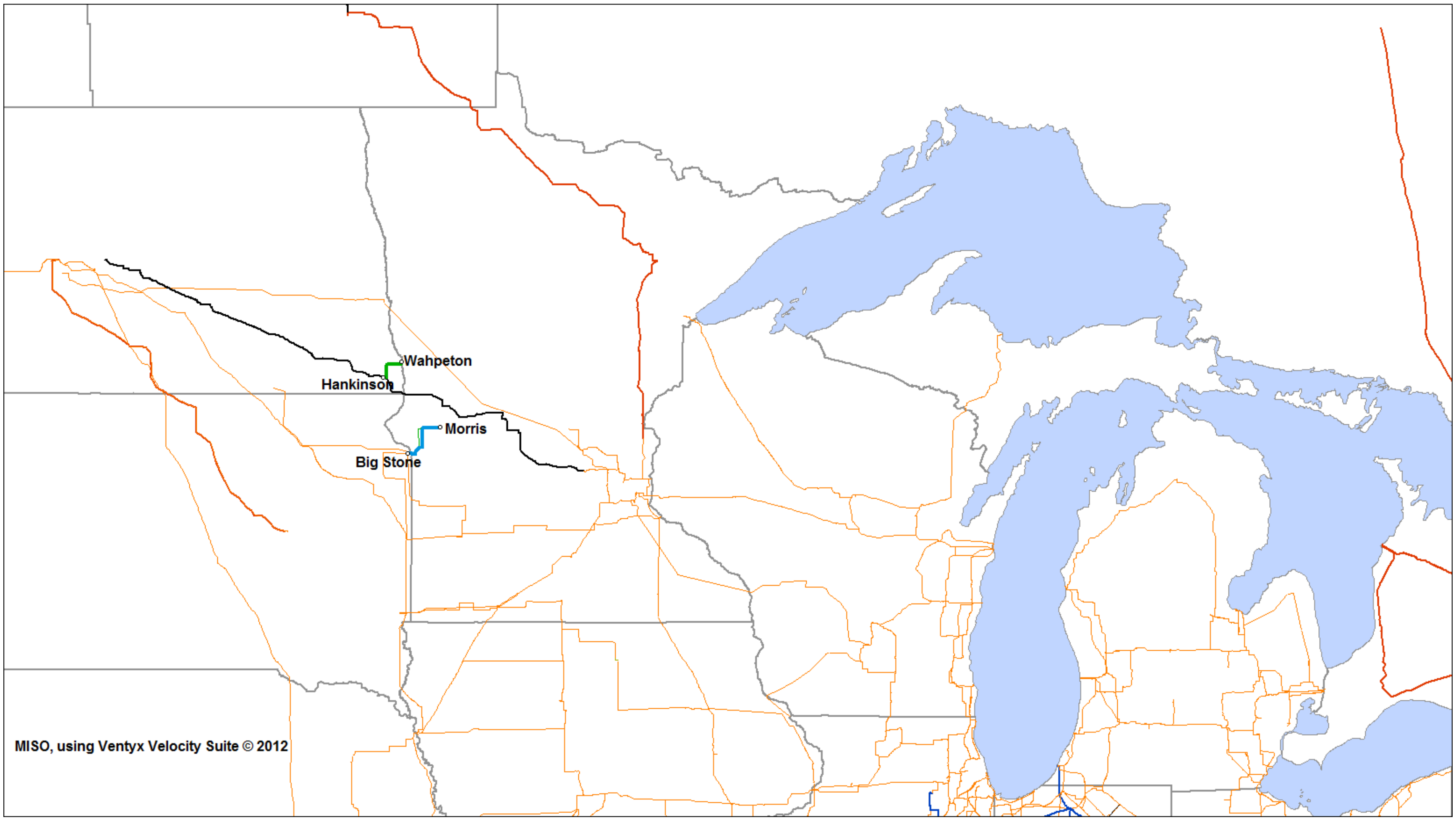
Scenario	APC Savings ($M-2027)	Estimated B/C
BAU, No new MH tie-line, Presque Isle In	25.9	3.17
BAU, MH - Duluth 500kV tie-line, Presque Isle In	20.1	2.46
BAU, MH - Fargo 500kV tie-line, Presque Isle In	16.5	2.02
HDE, No new MH tie-line, Presque Isle In	75.0	9.17
HDE, MH - Duluth 500kV tie-line, Presque Isle In	69.3	8.48
HDE, MH - Fargo 500kV tie-line, Presque Isle In	60.7	7.43

- **Line loading: Hankinson-Wahpeton 35% Big Stone-Morris 25%**
- **Average flow: Hankinson-Wahpeton 275 MW Big Stone-Morris 90 MW**
- **Maximum flow: Hankinson-Wahpeton 540 MW Big Stone-Morris 150 MW**
- **Benefits increase from lesser upgrade; though additional benefits do not justify additional costs**
- **Fully mitigates congestion on Johnson Jct. – Ortonville 115kV and Hankinson – Wahpeton 230kV**
- **After mitigation the Big Stone 230/115/13.8kV transformer binds**

Dakotas – MN Transmission Options: Info

Upgrade Hankinson - Wahpeton 230kV to 2010 TCFS rating and Upgrade Big Stone - Morris 115kV and Add 2nd Big Stone Xfmr

Estimated Cost ($-2012): $49.7M



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Dakotas – MN Transmission Options: Results

Upgrade Hankinson - Wahpeton 230kV to 2010 TCFS rating and Upgrade Big Stone - Morris 115kV and Add 2nd Big Stone Xfmr

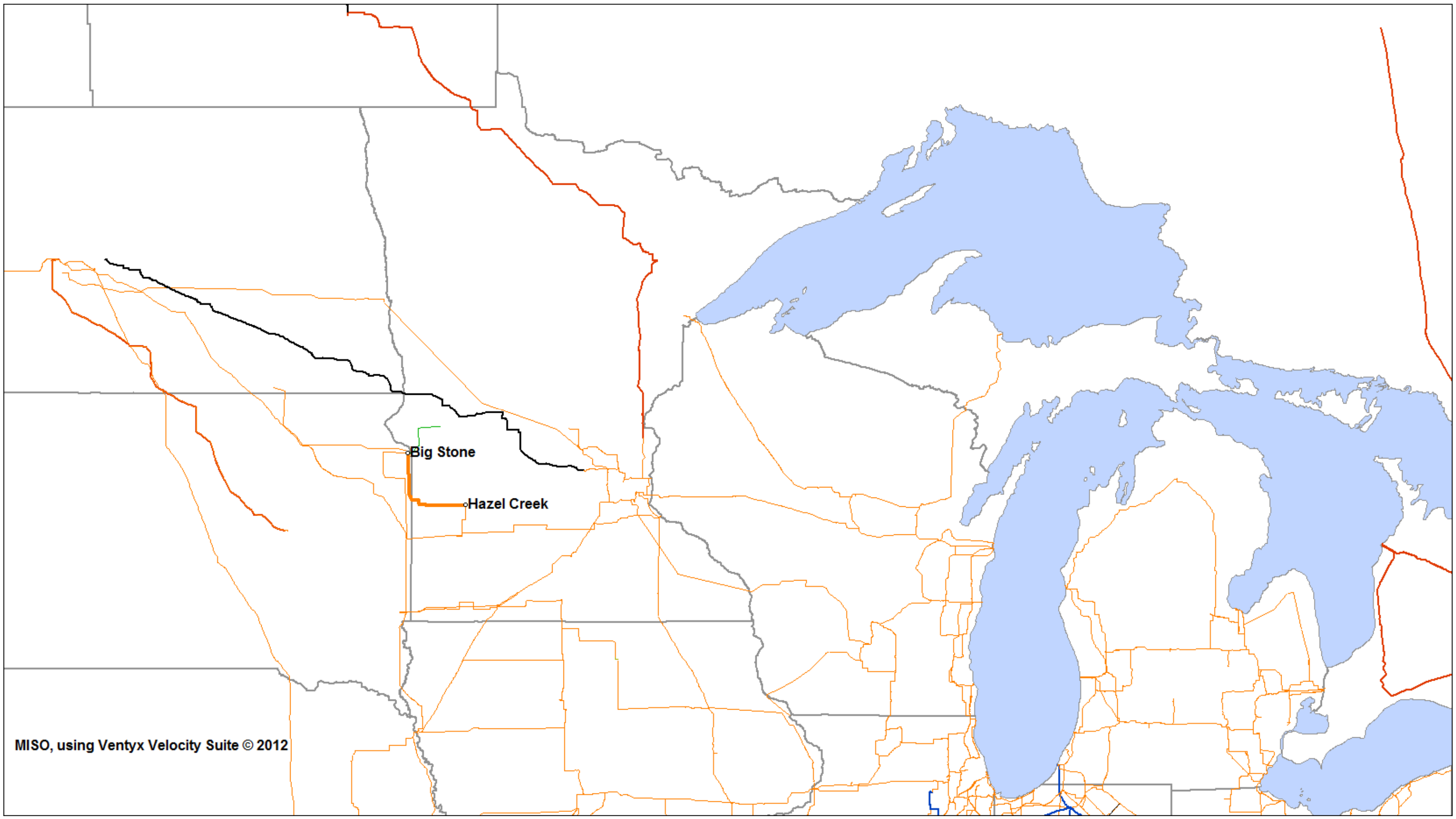
Scenario	APC Savings ($M-2027)	Estimated B/C
BAU, No new MH tie-line, Presque Isle In	26.1	2.67
BAU, MH - Duluth 500kV tie-line, Presque Isle In	20.3	2.08
BAU, MH - Fargo 500kV tie-line, Presque Isle In	16.1	1.65
HDE, No new MH tie-line, Presque Isle In	84.4	8.64
HDE, MH - Duluth 500kV tie-line, Presque Isle In	80.7	8.26
HDE, MH - Fargo 500kV tie-line, Presque Isle In	70.5	7.22

- **Line loading: Hankinson-Wahpeton 35% Big Stone-Morris 25%**
- **Average flow: Hankinson-Wahpeton 260 MW Big Stone-Morris 70 MW**
- **Maximum flow: Hankinson-Wahpeton 450 MW Big Stone-Morris 160 MW**
- **Benefits increase from lesser upgrade; though additional benefits do not justify additional costs**
- **Fully mitigates congestion on Johnson Jct. – Ortonville 115kV and Hankinson – Wahpeton 230kV and Big Stone 3W Xfmr**

Dakotas – MN Transmission Options: Info

Big Stone – Hazel Creek 345kV

Estimated Cost ($-2012): $160.2M



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Dakotas – MN Transmission Options: Results

Big Stone – Hazel Creek 345kV

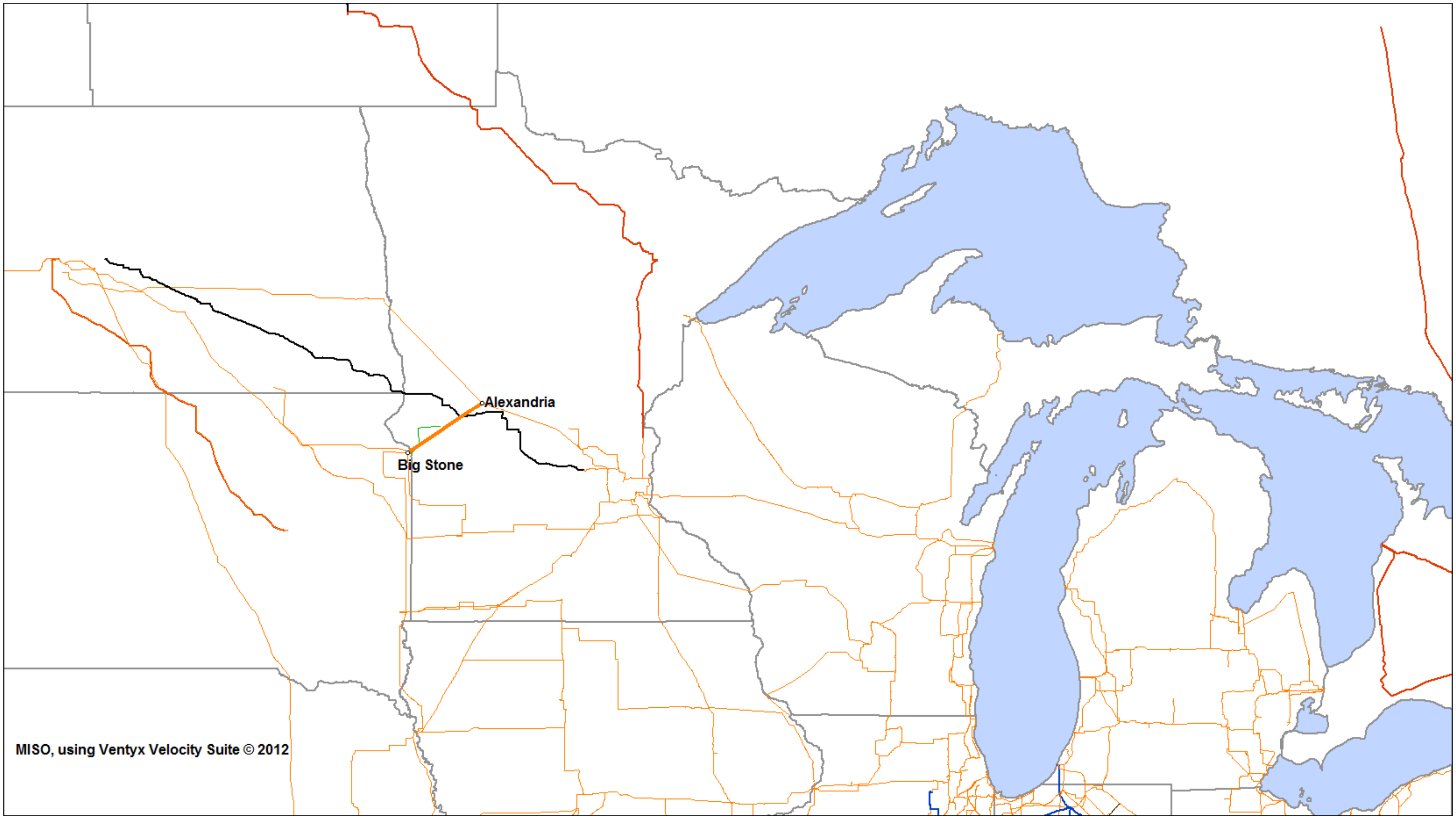
Scenario	APC Savings ($M-2027)	Estimated B/C
BAU, No new MH tie-line, Presque Isle In	22.0	0.70
BAU, MH - Duluth 500kV tie-line, Presque Isle In	17.9	0.57
BAU, MH - Fargo 500kV tie-line, Presque Isle In	13.9	0.44
HDE, No new MH tie-line, Presque Isle In	53.4	1.70
HDE, MH - Duluth 500kV tie-line, Presque Isle In	51.8	1.65
HDE, MH - Fargo 500kV tie-line, Presque Isle In	45.2	1.44

- **Line loading: 25%**
- **Average flow: 350 MW**
- **Maximum flow: 700 MW**
- **Plan's benefits are proportional to wind and load levels – beneficial in all scenarios**
- **Nearly fully mitigates congestion on Johnson Jct. – Ortonville 115kV and reduces Hankinson – Wahpeton 230kV by 50%**
- **No new binding elements or next limiting factors from plan**
- **Next iteration? Reconfigure option to more effectively mitigate Hankinson – Wahpeton 230kV?**

Dakotas – MN Transmission Options: Info

Big Stone – Alexandria 345kV

Estimated Cost ($-2012): $150.6M** **Cost from 2010 TCFS



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Dakotas – MN Transmission Options: Results

Big Stone – Alexandria 345kV

Scenario	APC Savings ($M-2027)	Estimated B/C
BAU, No new MH tie-line, Presque Isle In	26.9	0.91
BAU, MH - Duluth 500kV tie-line, Presque Isle In	20.4	0.69
BAU, MH - Fargo 500kV tie-line, Presque Isle In	19.2	0.65
HDE, No new MH tie-line, Presque Isle In	78.9	2.67
HDE, MH - Duluth 500kV tie-line, Presque Isle In	73.9	2.50
HDE, MH - Fargo 500kV tie-line, Presque Isle In	63.4	2.14

- **Line loading: 20%**
- **Average flow: 300 MW**
- **Maximum flow: 620 MW**
- **Nearly fully mitigates congestion on Johnson Jct. – Ortonville 115kV and reduces Hankinson – Wahpeton 230kV by 90%**
- **Provides APC benefits similar to less expensive line rating upgrades**

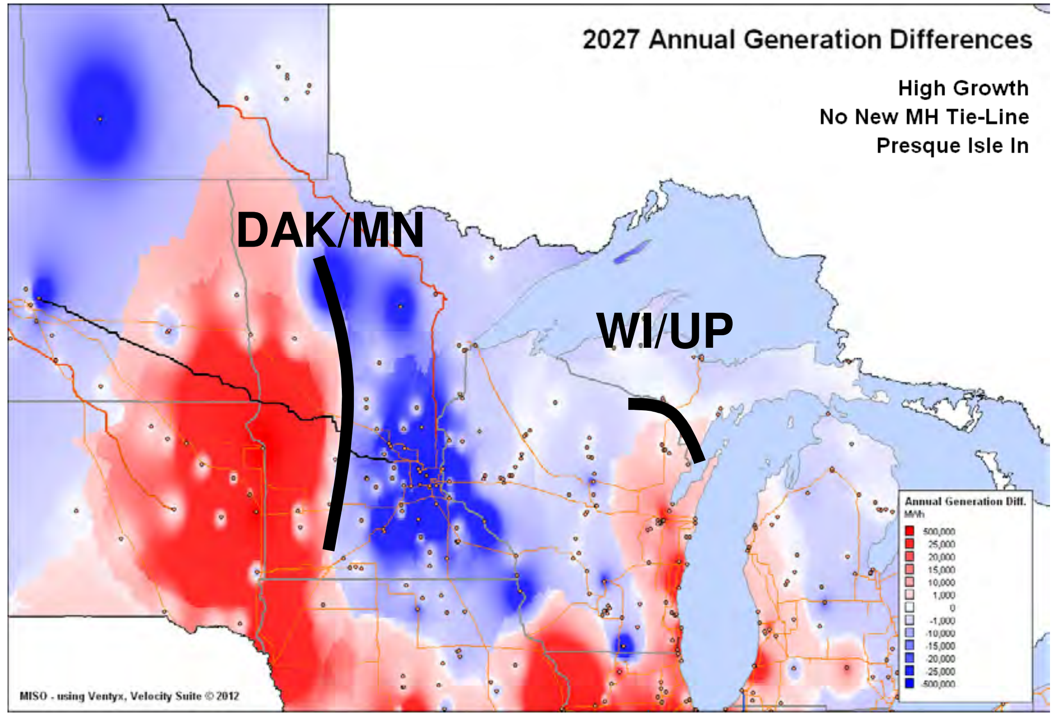
Dakotas – MN Results Summary

Scenario	APC Savings ($M-2027)	Estimated Cost ($M-2012)	Estimated B/C
Upgrade Hankinson – Wahpeton 230, Big Stone – Morris 115	15.1 – 64.3	22.2	3.46 – 14.74
Upgrade Hankinson – Wahpeton, Big Stone – Morris 115, new Morris – Alexandria 115kV	15.2 – 63.3	67.2*	1.15 – 4.79*
Upgrade Hankinson – Wahpeton 230kV (2010 TCFS), Big Stone – Morris 115kV	16.5 – 75.0	41.6	2.02 – 9.17
Upgrade Hankinson – Wahpeton 230kV (2010 TCFS), Big Stone – Morris 115kV, 2nd Big Stone Transformer	16.1 – 84.4	49.7	1.65 – 8.64
Big Stone – Hazel Creek 345kV	13.9 – 53.4	160.2	0.44 – 1.70
Big Stone – Alexandria 345kV	19.2 – 78.9	150.6	0.65 – 2.67
Brookings – Hampton Corners 345kV	11.3 – 28.0	160	0.36 – 0.89
Fargo – Monticello 345kV	-	110	-
Corridor Project	6.2 – 13.2	375	0.08 – 0.18
Upgrade Square Butte – Arrowhead DC	0.5 – 3.3	175	0.01 – 0.10

** Cost estimate based on generic $/mile cost*

- **As tested, rating upgrades were less expensive and more effective than new transmission lines**
- **Upgrading Big Stone – Morris 115kV and the Hankinson – Wahpeton 230kV wave trap replacement (first option) was most cost effective**

Wisconsin – Upper Michigan Plans

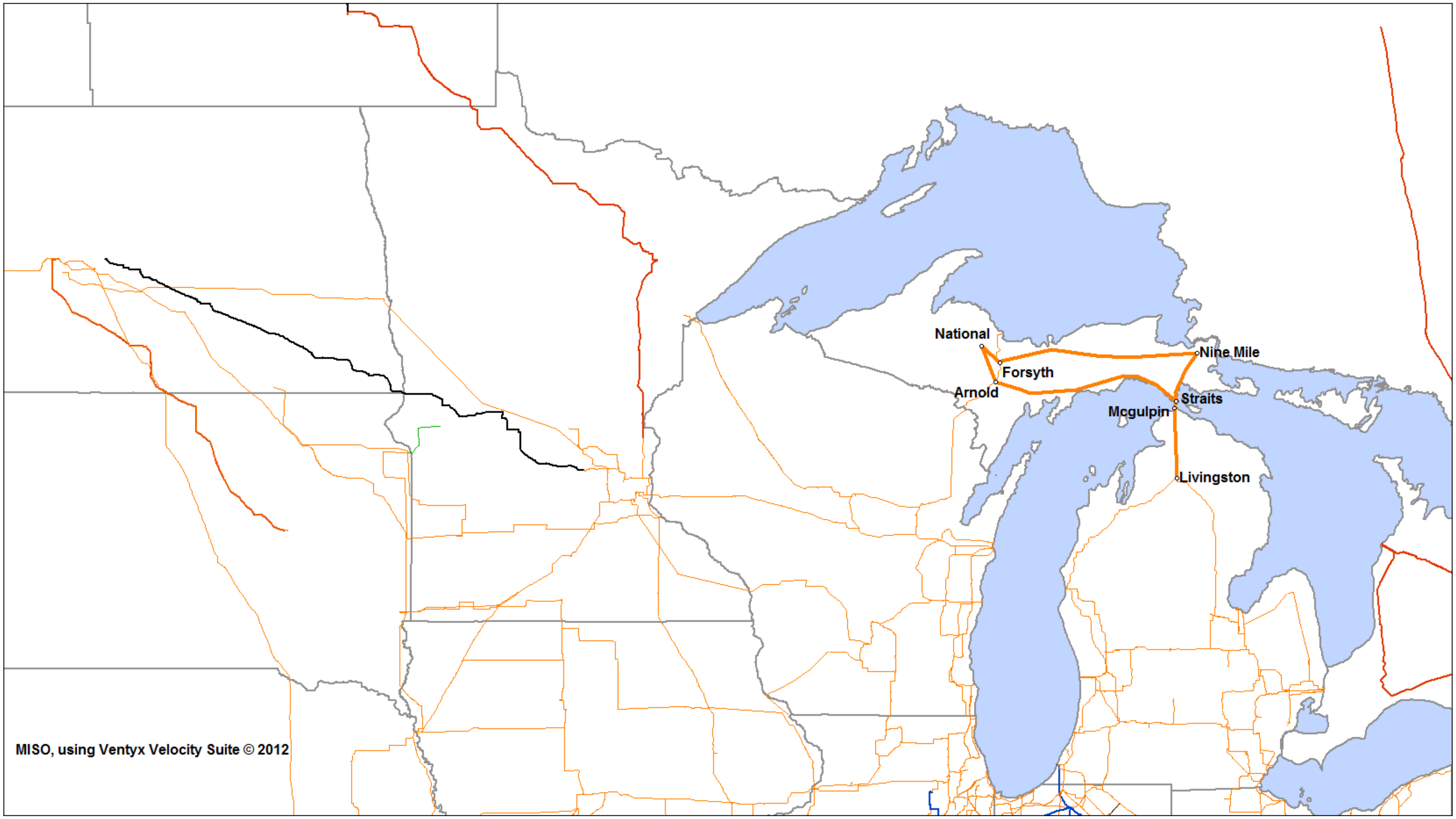


- **Congestion from energy trying to get to around Lake MI**
- **Potential lower when Presque Isle in-service and Kewaunee retired**
- **Highest is HDE future**
- **At last meeting tested 14 options to get around Lake MI**
- **Options were in two distinct categories:**
  - New/Upgrades to the UP AC system
  - DC option across/around Lake Michigan
- **AC options terminating in Livingston performed similar – additional refinements made to further exploit benefits**
- **DC options are dependent on source – additional testing performed**

WI/UP Transmission Options: Info

National/Arnold – Livingston 345kV

Estimated Cost ($-2012): $537.6M – 686.2M



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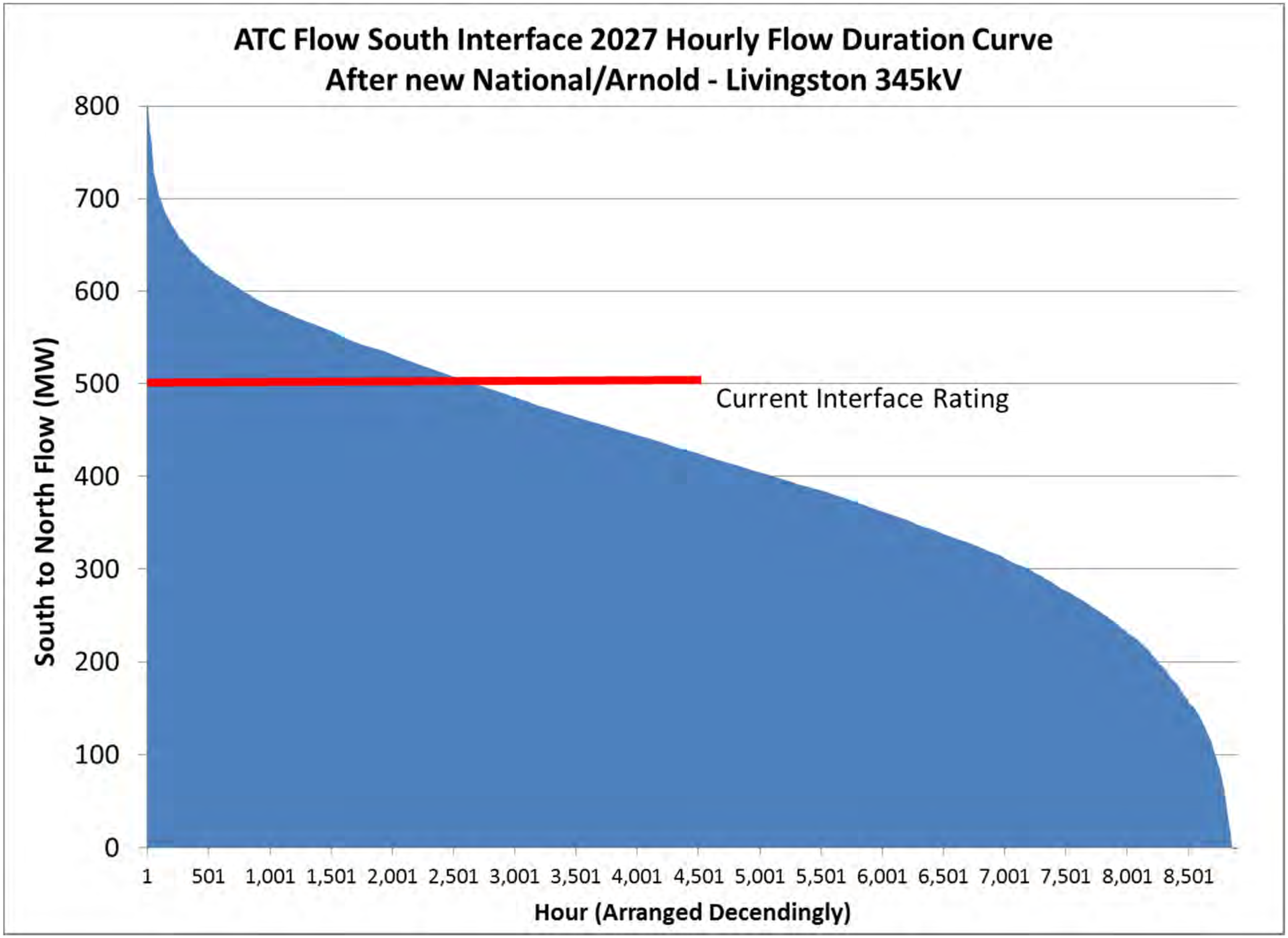
WI/UP Transmission Options: Results

National/Arnold – Livingston 345kV (North, South or Direct)

Scenario	APC Savings ($M-2027)	Estimated B/C
BAU, No new MH tie-line, Presque Isle In	4.3 – 6.3	0.03 - 0.06
BAU, MH - Duluth 500kV tie-line, Presque Isle In	5.3 – 6.1	0.04 - 0.06
BAU, MH - Fargo 500kV tie-line, Presque Isle In	4.9 – 7.7	0.04 - 0.07
HDE, No new MH tie-line, Presque Isle In	14.9 – 18.1	0.12 – 0.17
HDE, MH - Duluth 500kV tie-line, Presque Isle In	16.5 – 20.4	0.14 - 0.19
HDE, MH - Fargo 500kV tie-line, Presque Isle In	15.7 – 19.0	0.12 - 0.18

- **Line loading: ~15%**
- **Average flow: ~250 MW**
- **Maximum flow: ~800 MW**
- **Mitigates congestion on McGulpin Interface decreases South Lake Michigan congestion**
- **Assuming ATC Flow South Interface allowed beyond current stability limit (reliability analysis required to determine new limits after line and upgrades)**
- **Refinement: Placing a phase shifter at Livingston increases benefits proportional to cost increases (neutral B/C)**
- **There's a high potential for reliability issues with this option(s) that still need to be tested – costs and configuration may change**


ATC Flow South Interface 2027 Hourly Flow Duration Curve
After new National/Arnold - Livingston 345kV
800
700
600
500
400
300
200
100
0
South to North Flow (MW)
Current Interface Rating
1
501
1,001
1,501
2,001
2,501
3,001
3,501
4,001
4,501
5,001
5,501
6,001
6,501
7,001
7,501
8,001
8,501
Hour (Arranged Decendingly)

WI/UP Transmission Options: Info

Marquette – Mackinac County 138kV

Estimated Cost ($-2012): $262.85M

Lines are for illustrative purposes only, actual line routing may differ

WI/UP Transmission Options: Results

Marquette – Mackinac County 138kV

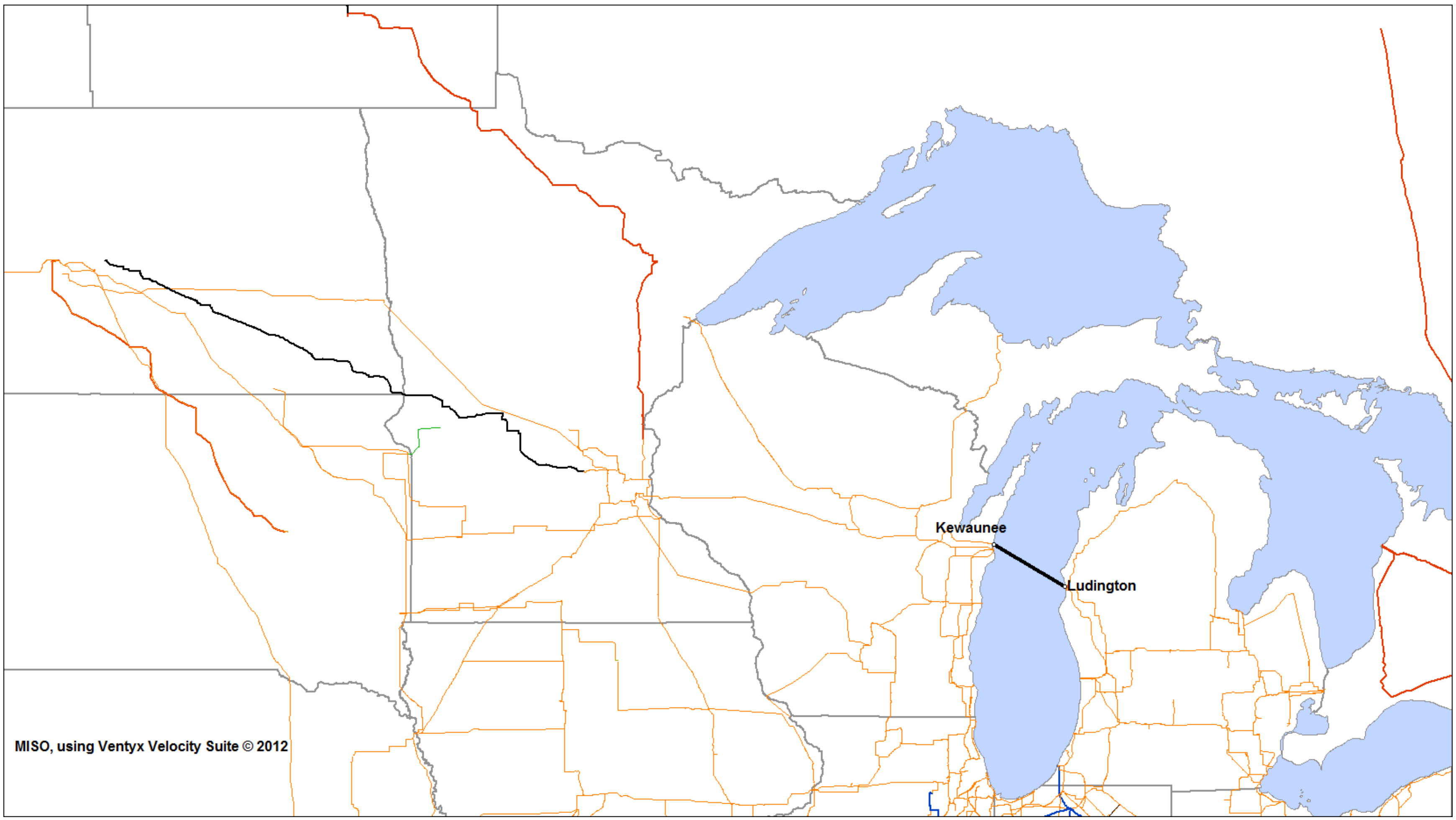
Scenario	APC Savings ($M-2027)	Estimated B/C
BAU, No new MH tie-line, Presque Isle In	4.2	0.08
BAU, MH - Duluth 500kV tie-line, Presque Isle In	2.5	0.05
BAU, MH - Fargo 500kV tie-line, Presque Isle In	4.3	0.08
HDE, No new MH tie-line, Presque Isle In	14.2	0.27
HDE, MH - Duluth 500kV tie-line, Presque Isle In	15.5	0.30
HDE, MH - Fargo 500kV tie-line, Presque Isle In	14.8	0.29

- **Average flow: 30 MW**
- **Maximum flow: 80 MW**
- **Mitigates congestion on McGulpin Interface**
- **Provides approximately half the economic benefits of National/Arnold – Livingston 345kV plans**
- **Options assumes ATC Flow South Interface allowed beyond current stability limit (reliability analysis required to determine new limits after line and upgrades)**

DC Transmission Options: Info

DC Option: Kewaunee – Ludington 500kV

Estimated Cost ($-2012): $872M



Lines are for illustrative purposes only, actual line routing may differ

DC Transmission Options: Results

DC Option: Kewaunee – Ludington 500kV

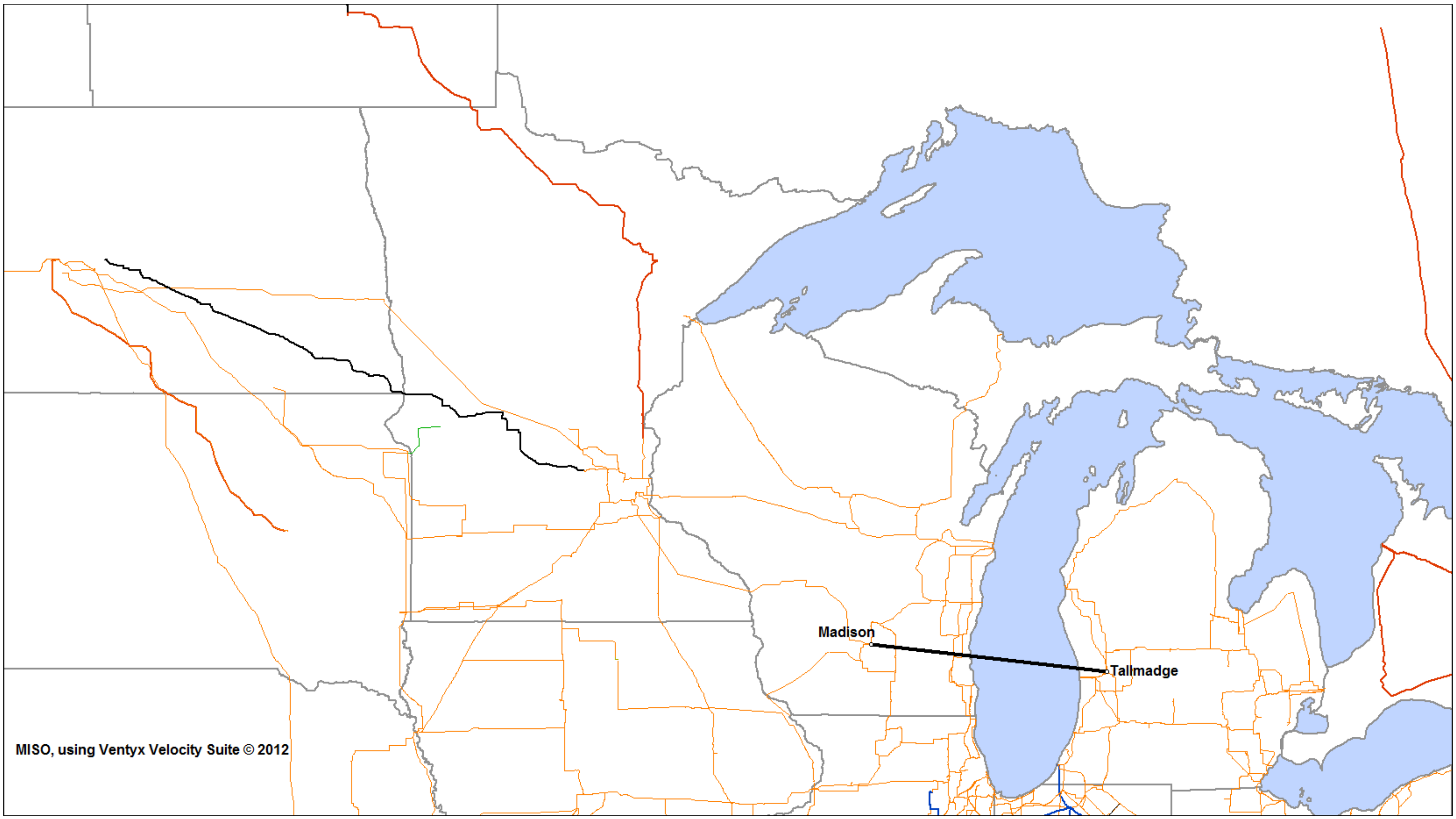
Scenario	APC Savings ($M-2027)	Estimated B/C
BAU, No new MH tie-line, Presque Isle In	19.6	0.11
BAU, MH - Duluth 500kV tie-line, Presque Isle In	20.7	0.12
BAU, MH - Fargo 500kV tie-line, Presque Isle In	22.8	0.13
HDE, No new MH tie-line, Presque Isle In	61.2	0.36
HDE, MH - Duluth 500kV tie-line, Presque Isle In	65.4	0.38
HDE, MH - Fargo 500kV tie-line, Presque Isle In	67.9	0.40

- **Line loading: 70%**
- **Average flow: 1100 MW**
- **Maximum flow: 1600 MW**
- **Provides benefits in all scenarios; highest in Fargo tie-line scenarios**
- **Reduces congestion on the McGulpin Interface (50%) and South Lake Michigan**
- **Increases congestion on Arrowhead – Stone Lake 345kV**
- **Next iteration? Pair MN/WI (holistic) plan**

WI/UP Transmission Options: Info
Madison – Tallmadge 500kV HVDC

Estimated Cost ($-2012): $1,251M*

** Cost estimate based on generic $/mile cost*



Lines are for illustrative purposes only, actual line routing may differ

WI/UP Transmission Options: Results

Madison – Tallmadge 500kV HVDC

Scenario	APC Savings ($M-2027)	Estimated B/C
BAU, No new MH tie-line, Presque Isle In	24.6	0.10
BAU, MH - Duluth 500kV tie-line, Presque Isle In	25.8	0.10
BAU, MH - Fargo 500kV tie-line, Presque Isle In	29.0	0.12
HDE, No new MH tie-line, Presque Isle In	70.5	0.29
HDE, MH - Duluth 500kV tie-line, Presque Isle In	71.7	0.29
HDE, MH - Fargo 500kV tie-line, Presque Isle In	77.4	0.31

- **Line loading: 80%**
- **Average flow: 1252 MW**
- **Maximum flow: 1600 MW**
- **Provides benefits in all scenarios; highest in Fargo tie-line scenarios**
- **Reduces congestion on the McGulpin Interface (50%) and South Lake Michigan**
- **Produces greater APC benefits than Kewaunee – Ludington HVDC; however, additional benefits don't justify additional costs**

WI/UP Results Summary (All Options)

Scenario	APC Savings ($M-2027)	Estimated Cost ($M-2012)	Estimated B/C
Morgan – Plains - National 345kV	-	405	-
Gardener Park – Plains - National 345kV	-	500	-
Morgan – Arnold 345kV and Plains – National 345kV	-	487*	-
Arnold – Livingston 345kV (South Route)	6.1 – 20.4	537.6	0.06 – 0.19
Morgan – Livingston 345kV (Extended South Route)	5.1 – 23.4	843.8*	0.03 – 0.14*
National – Livingston 345kV (Direct Route)	4.9 – 16.5	606.7*	0.04 – 0.14*
National – Livingston 345kV (North Route)	4.3 – 18.4	686.2	0.03 – 0.14
Marquette – Mackinac County 138kV	2.5 – 15.5	262.85	0.05 – 0.30
Low Voltage Northern Wisconsin Upgrade	-	375.8	-
Hiple to Duck Lake 345kV	2.1 – 6.1	259.3*	0.04 – 0.12*
DC Option: Kewaunee – Ludington 500kV	19.6 – 67.9	872	0.11 – 0.40
DC Option: Pleasant Prairie – Palisade 500kV	3.1 – 19.0	981*	0.02 – 0.10*
DC Option: Madison – Tallmadge 500kV	24.6 – 77.4	1251*	0.10 – 0.31*

** Cost estimate based on generic $/mile cost*

WI/UP Results Summary (Reduced List)

(North, South, and Direct Combined; Low Econ. Beneficial Options Removed)

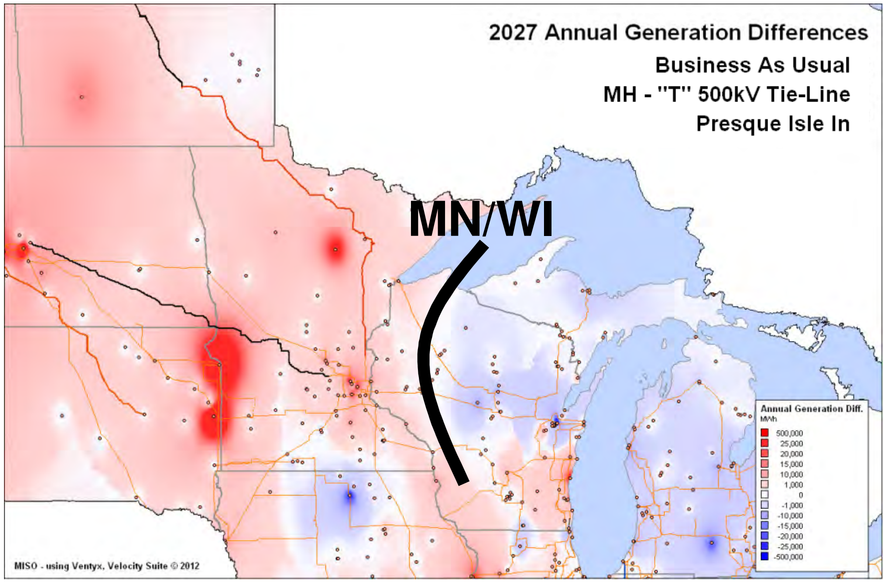
Scenario	APC Savings ($M-2027)	Estimated Cost ($M-2012)	Estimated B/C
Arnold/National – Livingston 345kV	4.3 – 20.4	537.6 – 686.2	0.03 – 0.19
Morgan – Arnold – Livingston 345kV	5.1 – 23.4	843.8*	0.03 – 0.14*
Marquette – Mackinac County 138kV	2.5 – 15.5	262.85	0.05 – 0.30
Hiple to Duck Lake 345kV	2.1 – 6.1	259.3*	0.04 – 0.12*
DC Option: Kewaunee – Ludington 500kV	19.6 – 67.9	872	0.11 – 0.40
DC Option: Pleasant Prairie – Palisade 500kV	3.1 – 19.0	981*	0.02 – 0.10*
DC Option: Madison – Tallmadge 500kV	24.6 – 77.4	1251*	0.10 – 0.31*

** Cost estimate based on generic $/mile cost*

- **All options help to equalize MI LMPs**
- **DC lines connecting Wisconsin – Michigan are the most cost effective options**
  - Kewaunee – Ludington has the highest B/C of options tested
- **AC line connecting UP to MI provide congestion relief especially when higher load modeled in UP**
- **Marquette – Mackinac unlocks north to south flows across the Straights and provides similar B/C ratios to 345kV counterparts**
- **Reliability testing needed for all AC options across the UP**

Minnesota – Wisconsin Plans

- After refinement and testing, interface is only present in the Duluth tie-line scenarios
- Primary binding constraint is Arrowhead – Stone Lake 345kV (MWEX)



After Mitigating DAK/MN

- Testing shows that increasing the interface by ~250 MW will unlock the majority of the potential
- Previous iteration's plans were cross-state AC and HVDC solutions with costs in excess of $1B (B/C ratios in .1 range) – modeled economic conditions don't economically justify this scale of development

MN/WI Transmission Options: Info

Upgrade Arrowhead – Stone Lake 345kV (MWEX)

Estimated Cost ($-2012): $0 – TBD

(Potential mitigation (if any) to be determined in reliability sensitivity analysis)

Lines are for illustrative purposes only, actual line routing may differ

MN/WI Transmission Options: Results

Upgrade Arrowhead – Stone Lake 345kV (MWEX)

Scenario	APC Savings ($M-2027)	Estimated B/C
BAU, No new MH tie-line, Presque Isle In	-	-
BAU, MH - Duluth 500kV tie-line, Presque Isle In	6.4	Inf. - TBD
BAU, MH - Fargo 500kV tie-line, Presque Isle In	-	-
HDE, No new MH tie-line, Presque Isle In	-	-
HDE, MH - Duluth 500kV tie-line, Presque Isle In	3.1	Inf. - TBD
HDE, MH - Fargo 500kV tie-line, Presque Isle In	-	-

- **Line loading: 58%**
- **Average flow: 616 MW**
- **Maximum flow: Thermal rating – though congestion primarily relieved in 972 MVA range**
- **Plan only needed/beneficial in Duluth tie-line scenarios**
- **Benefits of HDE future lower than BAU, because increased northern Minnesota load absorbs power being transferred in the BAU future**
- **Upgrade fully mitigates Arrowhead – Stone Lake 345kV congestion**

MN/WI Results Summary

Scenario	APC Savings ($M-2027)	Estimated Cost ($M-2012)	Estimated B/C
Arrowhead – National 345kV	1.4 – 10.5	1140.1	0.01 – 0.05
Arrowhead – Arnold - Livingston 345kV	7.9 – 32.5	1456.5*	0.03 – 0.11*
Eau Claire – Park Falls – National 345kV	1.7 – 8.8	679.7	0.01 – 0.07
Eau Claire – M38	-	238.5	-
Eau Claire – Arnold - Livingston 345kV	7.7 – 27.2	1300*	0.03 – 0.11*
Double circuit Hampton – Briggs Road 345kV	-		-
Double circuit Hampton – Briggs Road - Madison 345kV	-		-
DC Option: Blackberry – Livingston – Tittabawassee 500kV	26.5 – 85.7	2,020*	0.07 – 0.22*
DC Option: Blackberry – Plains 500kV	4.1 – 14.3	1,143*	0.02 – 0.06*
DC Option: Blackberry – Plains – Livingston – Tittabawassee 500kV	29.0 – 95.8	2,420*	0.06 – 0.20*
DC Option: Arrowhead – Plains – Livingston – Tittabawassee 500kV	23.1 – 96.4	2,245*	0.05 – 0.22*
DC Option: Bison – Plains – Livingston – Tittabawassee 500kV	30.9 – 86.2	2,852*	0.06 – 0.15*
DC Option: Arrowhead – Point Beach – Ludington 500kV	23.5 – 85.6	2,028*	0.06 – 0.21*
Upgrade Arrowhead – Stone Lake 345kV (MWEX)	3.1– 6.4	0 – TBD	Inf. - TBD

** Cost estimate based on generic $/mile cost*

Agenda

• Welcome, Roll Call, and Review Agenda	10:00 AM
• Recap December 7th Meeting	10:15 AM
• Related Study Status Report	10:30 AM
– Manitoba Hydro Wind Synergy Study	
– TSR Update	
– Market Efficiency Study	
• Economic Benefits of New/Refined Options	11:00 AM
• Lunch Break	12:00 PM
• Economic Benefits of Best-Fit Plans/Portfolios	12:30 PM
• Reliability Analysis of Portfolios Work Plan	1:00 PM
• Schedule Update	1:30 PM
• Open Discussion and Next Steps	1:45 PM
• Adjourn	2:00 PM

Agenda

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- Schedule Update 1:30 PM
- Open Discussion and Next Steps 1:45 PM
- Adjourn 2:00 PM

Best Fit Plans/Portfolios

- **The portfolios in this presentation are "proposed" based on B/C ratios of individual options and initial feedback**
- **Goal of portfolios is to find synergic benefits – combined plan's benefits exceed the summation of individual plans' benefits**
- **Created by combining the best plans from each interface/pocket**
- **Portfolios may be different for each scenario**
- **Measure effectiveness:**
  - Compare against Maximum economic potential – historical capture rates in 70% range
  - LMP equalization

Proposed "Best Fit" MN/DAK Plan

Scenario	APC Savings ($M-2027)	Estimated Cost ($M-2012)	Estimated B/C
Upgrade Hankinson – Wahpeton 230, Big Stone – Morris 115	15.1 – 64.3	22.2	3.46 – 14.74
Upgrade Hankinson – Wahpeton, Big Stone – Morris 115, new Morris – Alexandria 115kV	15.2 – 63.3	67.2*	1.15 – 4.79*
Upgrade Hankinson – Wahpeton 230kV (2010 TCFS), Big Stone – Morris 115kV	16.5 – 75.0	41.6	2.02 – 9.17
Upgrade Hankinson – Wahpeton 230kV (2010 TCFS), Big Stone – Morris 115kV, 2nd Big Stone Transformer	16.1 – 84.4	49.7	1.65 – 8.64
Big Stone – Hazel Creek 345kV	13.9 – 53.4	160.2	0.44 – 1.70
Big Stone – Alexandria 345kV	19.2 – 78.9	150.6	0.65 – 2.67
Brookings – Hampton Corners 345kV	11.3 – 28.0	160	0.36 – 0.89
Fargo – Monticello 345kV	-	110	-
Corridor Project	6.2 – 13.2	375	0.08 – 0.18
Upgrade Square Butte – Arrowhead DC	0.5 – 3.3	175	0.01 – 0.10

** Cost estimate based on generic $/mile cost*

- **Upgrading Big Stone – Morris 115kV and the Hankinson – Wahpeton 230kV wave trap replacement (first option) was most cost effective**
- **Option effective in all scenarios**

Proposed "Best Fit" WI/UP Plan(s)

Scenario	APC Savings ($M-2027)	Estimated Cost ($M-2012)	Estimated B/C
Arnold/National – Livingston 345kV	4.3 – 20.4	537.6 – 686.2	0.03 – 0.19
Morgan – Arnold – Livingston 345kV	5.1 – 23.4	843.8*	0.03 – 0.14*
Marquette – Mackinac County 138kV	2.5 – 15.5	262.85	0.05 – 0.30
DC Option: Kewaunee – Ludington 500kV	19.6 – 67.9	872	0.11 – 0.40
DC Option: Pleasant Prairie – Palisade 500kV	3.1 – 19.0	981*	0.02 – 0.10*
DC Option: Madison – Tallmadge 500kV	24.6 – 77.4	1251*	0.10 – 0.31*

** Cost estimate based on generic $/mile cost*

- **DC options most cost effective, in scenario tested**
- **345kV and 138kV AC options nearly equally cost effective**
- **Same solutions for BAU and HDE futures**

MN/WI Results Summary

Scenario	APC Savings ($M-2027)	Estimated Cost ($M-2012)	Estimated B/C
Arrowhead – National 345kV	1.4 – 10.5	1140.1	0.01 – 0.05
Arrowhead – Arnold - Livingston 345kV	7.9 – 32.5	1456.5*	0.03 – 0.11*
Eau Claire – Park Falls – National 345kV	1.7 – 8.8	679.7	0.01 – 0.07
Eau Claire – M38	-	238.5	-
Eau Claire – Arnold - Livingston 345kV	7.7 – 27.2	1300*	0.03 – 0.11*
DC Option: Blackberry – Livingston – Tittabawassee 500kV	26.5 – 85.7	2,020*	0.07 – 0.22*
DC Option: Blackberry – Plains 500kV	4.1 – 14.3	1,143*	0.02 – 0.06*
DC Option: Blackberry – Plains – Livingston – Tittabawassee 500kV	29.0 – 95.8	2,420*	0.06 – 0.20*
DC Option: Arrowhead – Plains – Livingston – Tittabawassee 500kV	23.1 – 96.4	2,245*	0.05 – 0.22*
DC Option: Bison – Plains – Livingston – Tittabawassee 500kV	30.9 – 86.2	2,852*	0.06 – 0.15*
DC Option: Arrowhead – Point Beach – Ludington 500kV	23.5 – 85.6	2,028*	0.06 – 0.21*
Upgrade Arrowhead – Stone Lake 345kV (MWEX)	3.1– 6.4	0 – TBD	Inf. - TBD

- **Only needed in the Duluth tie-line scenarios**
- **Same solution of HDE and BAU future**

Best-Fit Portfolios

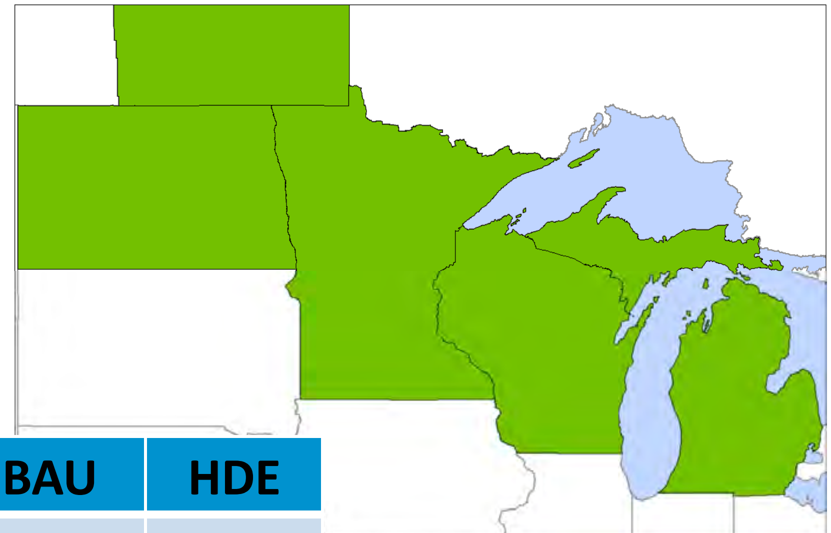
1. Upgrade Hankinson – Wahpeton 230kV & Big Stone – Morris 115kV, Kewaunee – Ludington 500kV DC
2. Upgrade Hankinson – Wahpeton 230kV & Big Stone – Morris 115kV, National/Arnold – Livingston 345kV
3. Upgrade Hankinson – Wahpeton 230kV & Big Stone – Morris 115kV, Marquette – Mackinac County 138kV

- In Duluth scenarios the MWEX upgrade included in all portfolios

Maximum Economic Potential

2027 MISO APC Savings ($M-2027)

Total MISO benefit from relaxing all constraints in NAS footprint



Scenario	BAU	HDE
No new MH tie-line, Presque Isle In	35.7	137.6
MH - Duluth 500kV tie-line, Presque Isle In	37.0	135.4
MH - Fargo 500kV tie-line, Presque Isle In	28.2	120.3

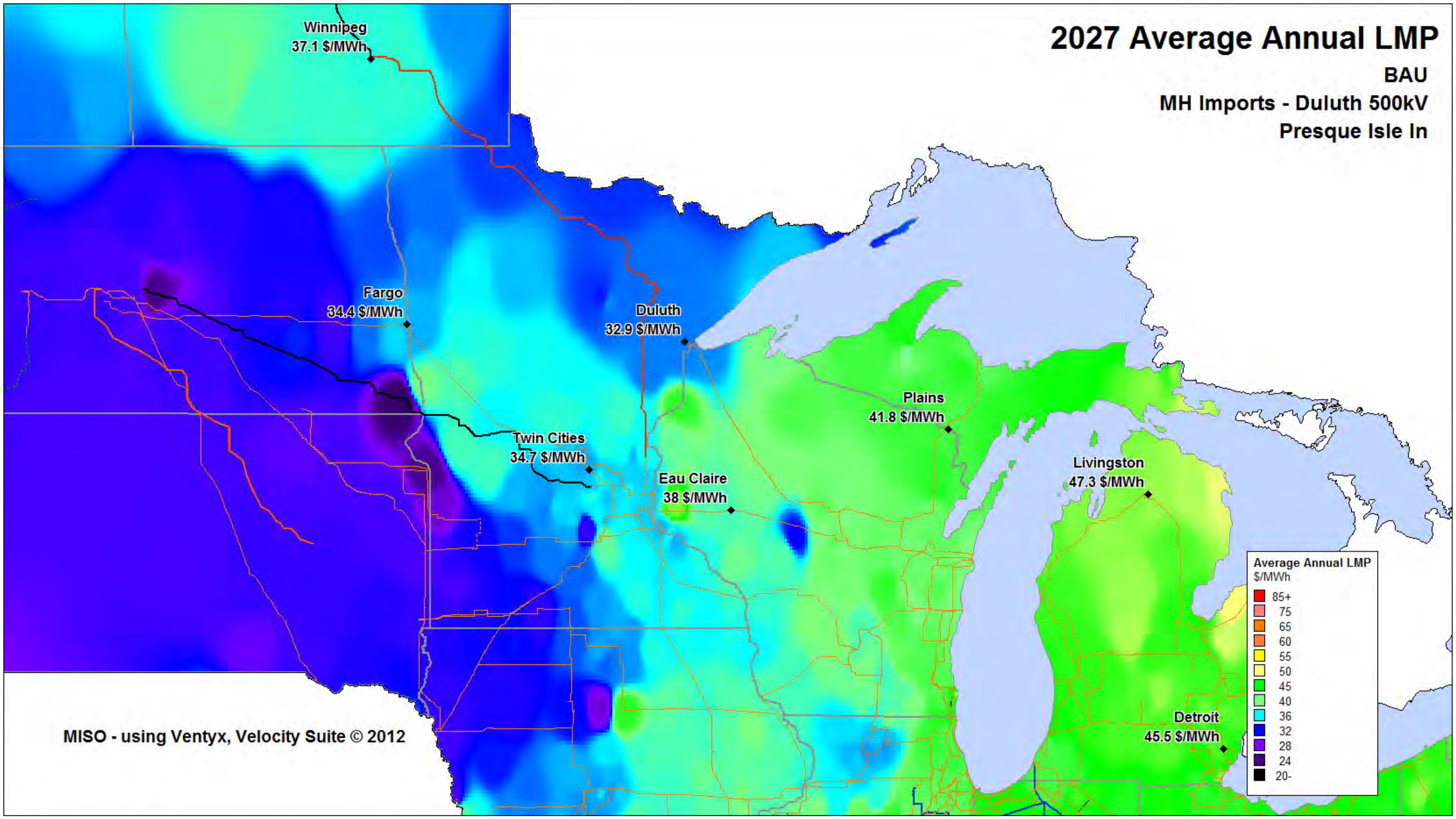
Historically, transmission portfolios have been able to capture ~70% of the maximum economic potential (above numbers)

Capture Rate = Portfolio's APC Savings / Maximum Econ Potential

LMPS Provide Indication For How A Portfolio Performs

LMP scale 3x "zoomed-in" to show differences
Business as Usual

Pre-Portfolio

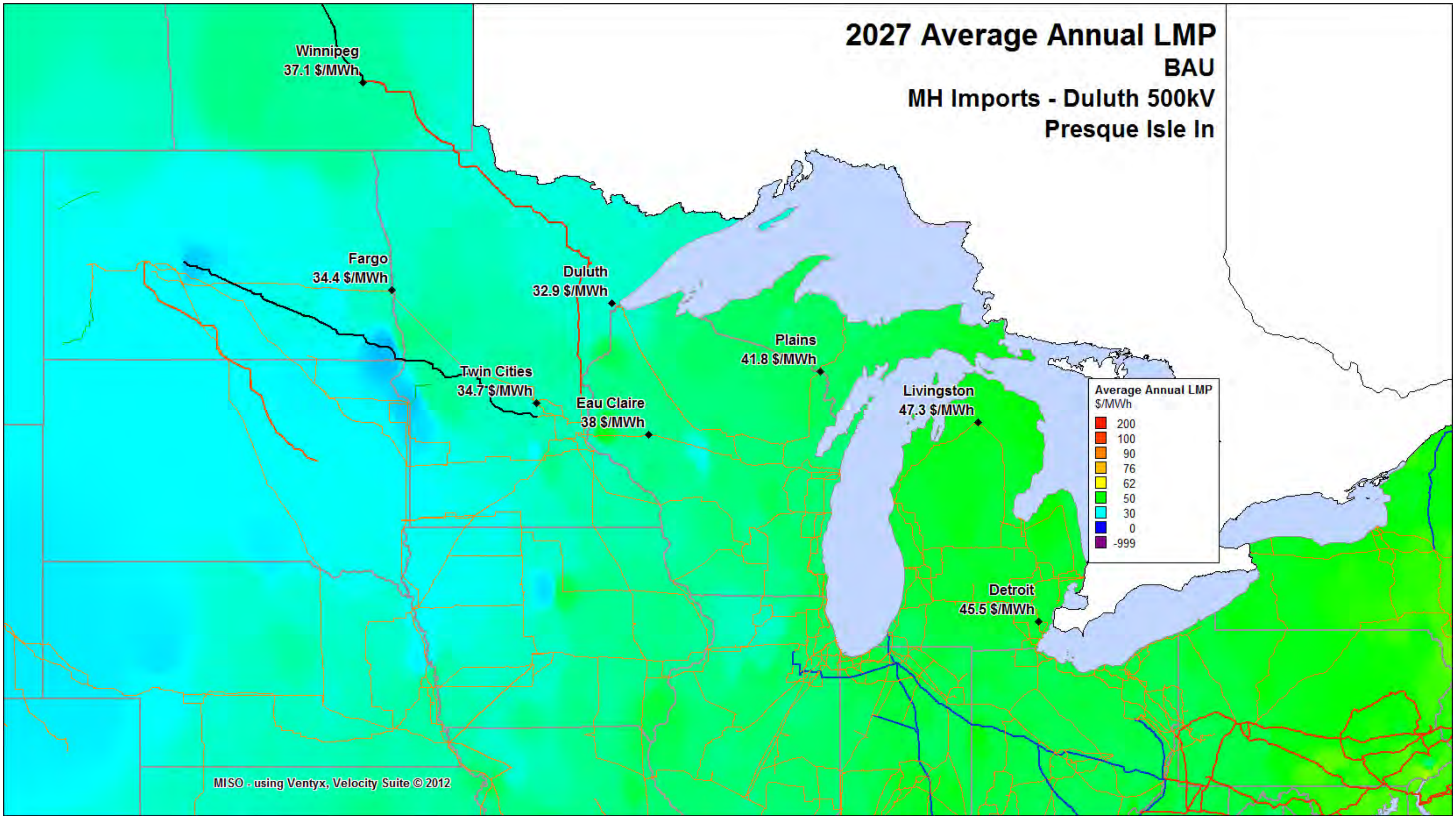


3x "zoomed-in" scale

“Standard MISO Market” Scale – 2027 Average LMPs

Business as Usual

Pre-Portfolio

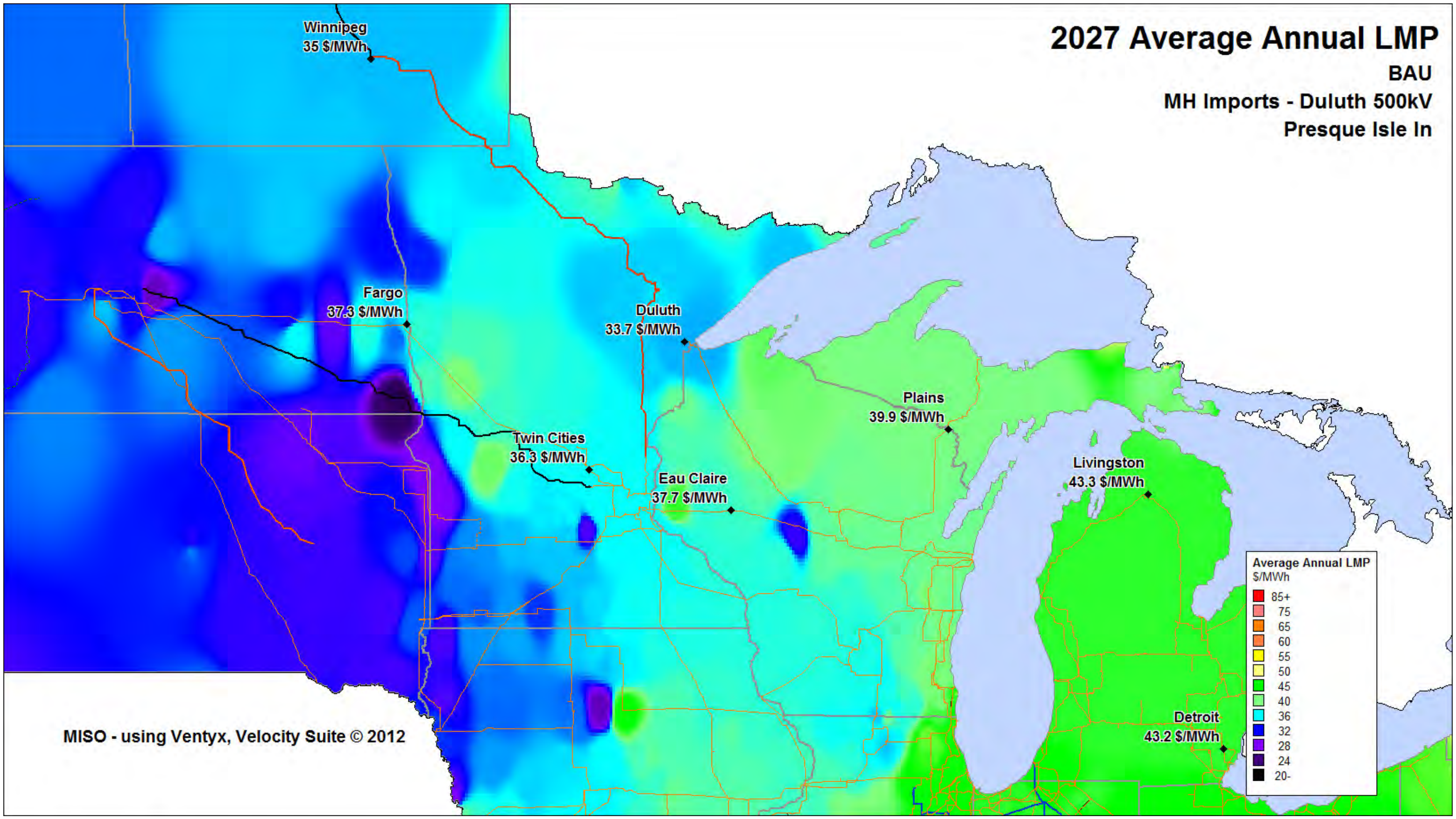


“Standard Market” scale

Plot without line losses

LMP scale 3x "zoomed-in" to show differences
Business as Usual

Pre-Portfolio



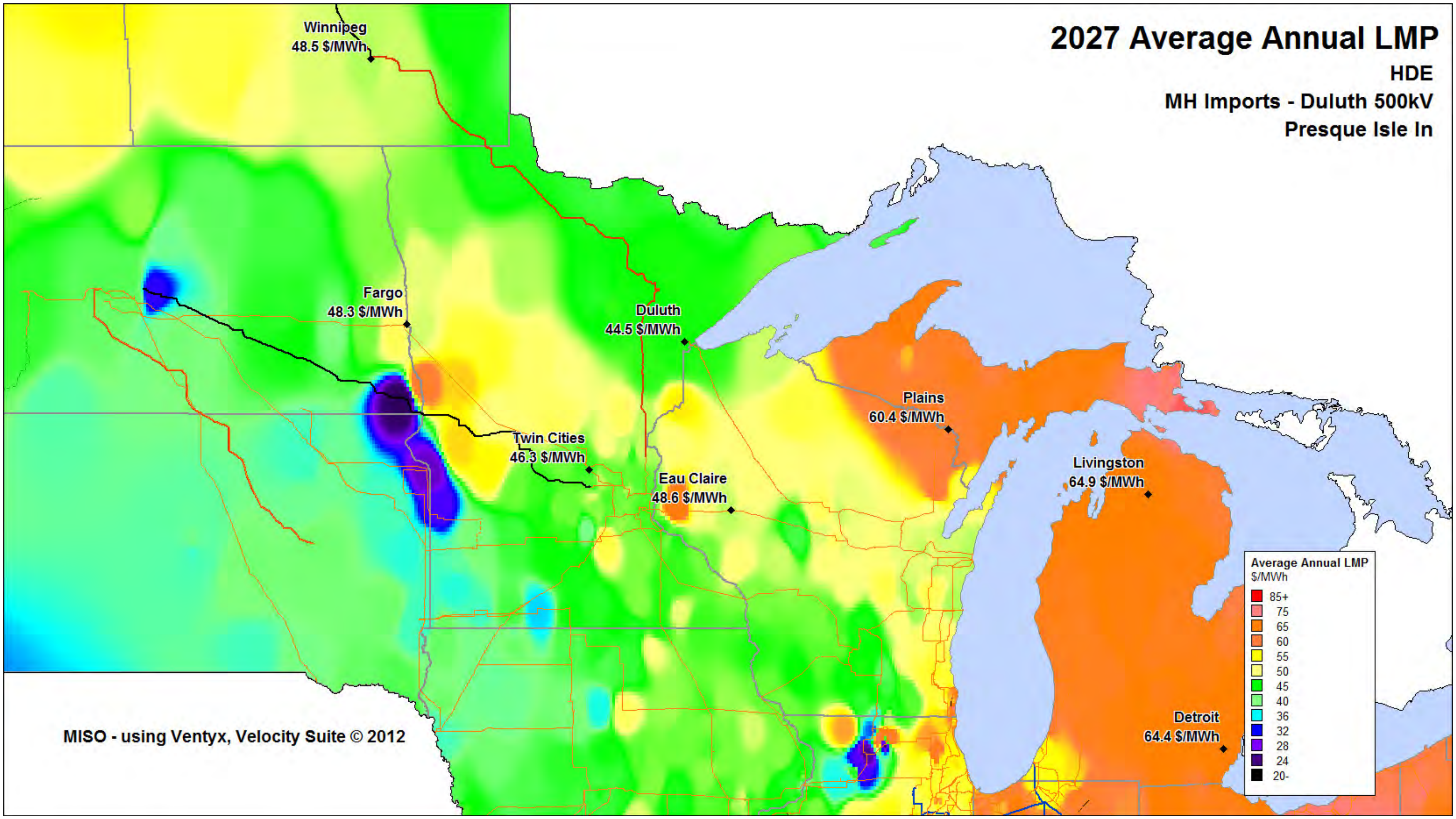
3x "zoomed-in" scale – No Losses

LMPS Provide Indication For How A Portfolio Performs

LMP scale 3x "zoomed-in" to show differences

High Demand and Energy

Pre-Portfolio

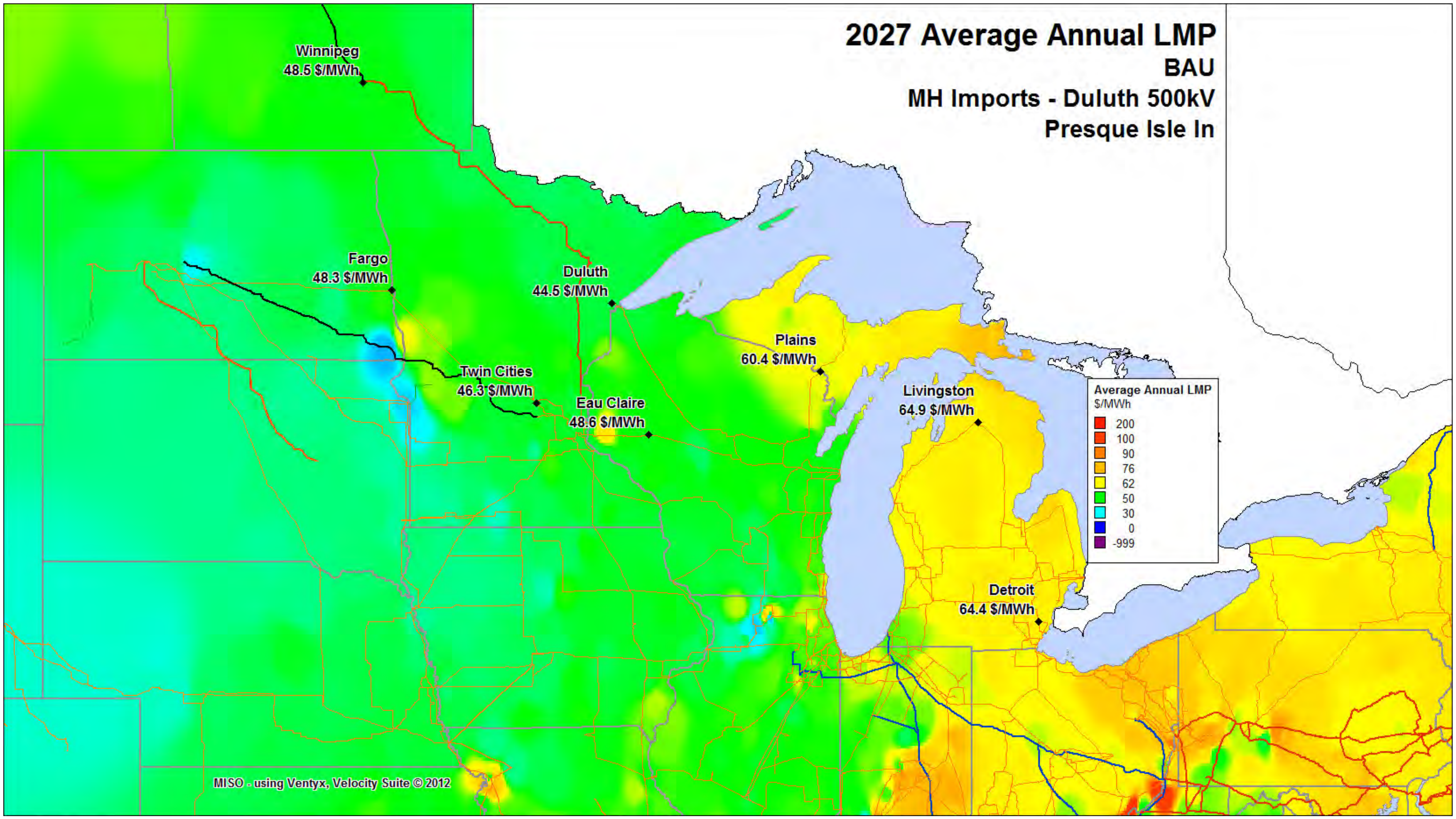


3x "zoomed-in" scale

"Standard MISO Market" Scale – 2027 Average LMPs

High Demand and Energy

Pre-Portfolio



"Standard Market" scale

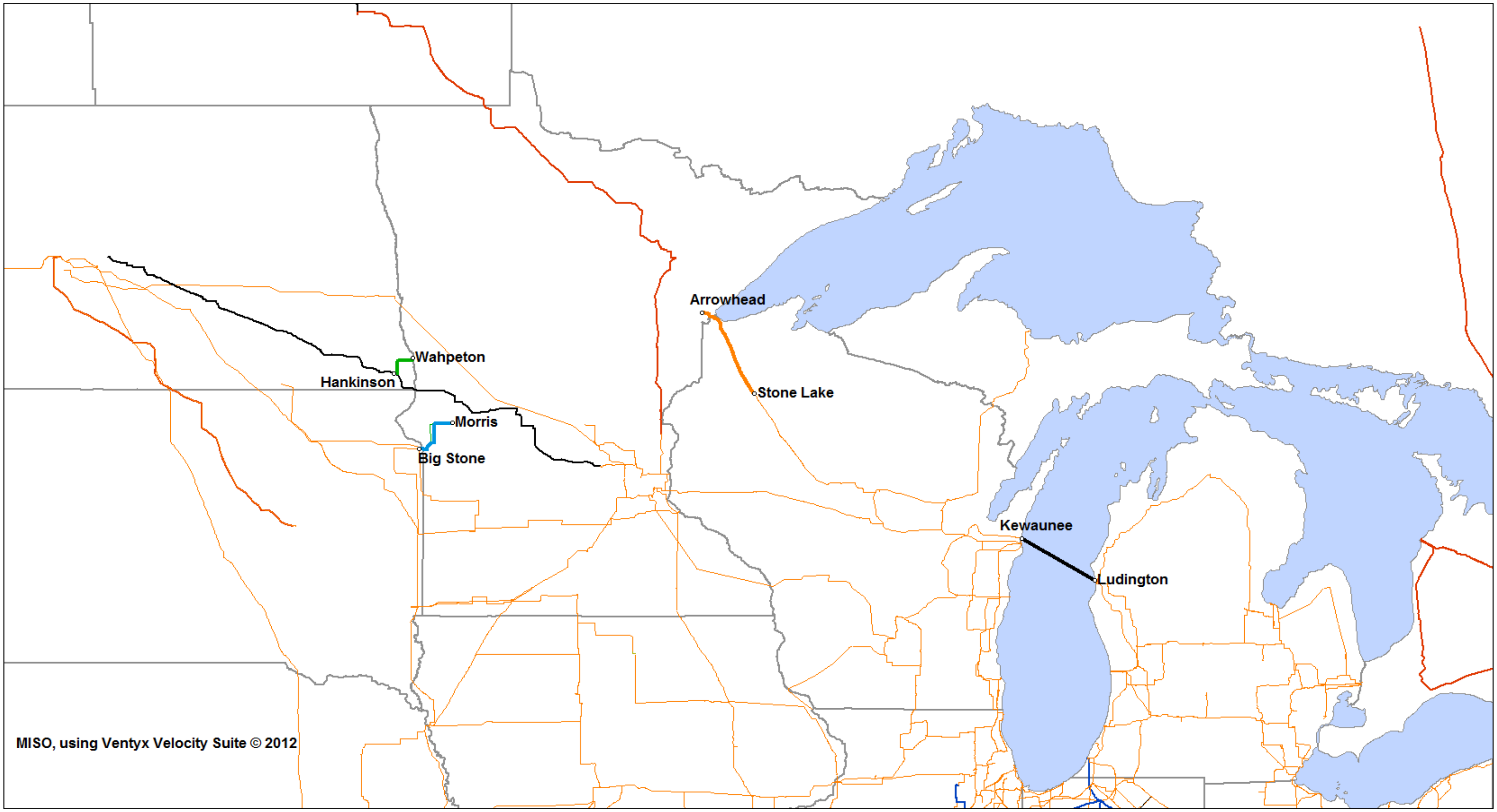
Portfolio 1: Info

Upgrade Hankinson - Wahpeton 230kV and Big Stone - Morris 115kV and Kewaunee – Ludington 500kV HVDC

Duluth Tie-Line Scenarios Include MWEX Upgrade

Estimated Cost ($-2012): $894.2M**

** Assumes $0 for MWEX upgrade; if reliability testing determines add'l mitigation, cost will be updated



Lines are for illustrative purposes only, actual line routing may differ

Portfolio 1: Results

Upgrade Hankinson - Wahpeton 230kV and Big Stone - Morris 115kV and Kewaunee – Ludington 500kV HVDC

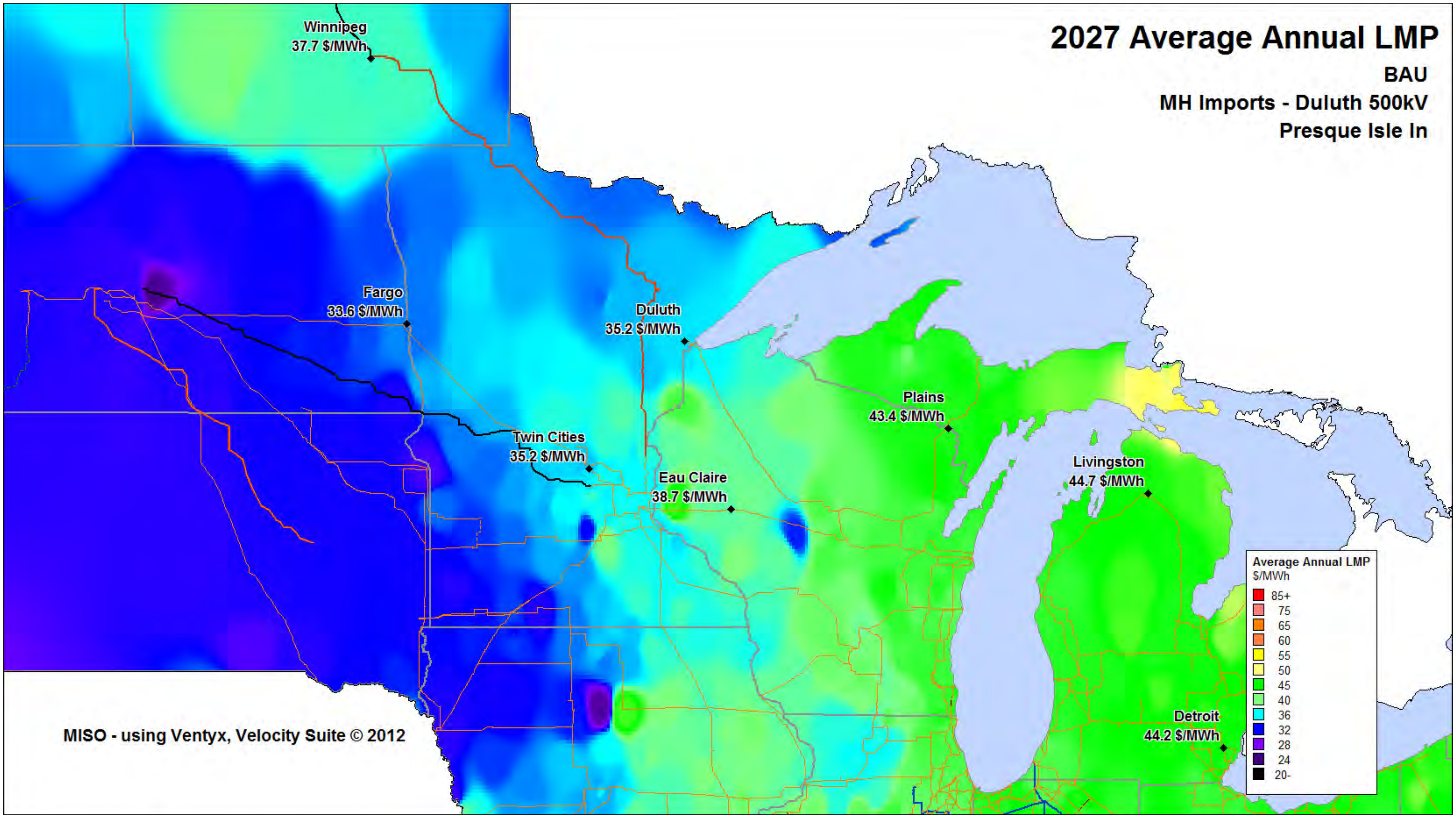
Scenario	APC Savings ($M-2027)	Estimated B/C
BAU, No new MH tie-line, Presque Isle In	45.3	0.26
BAU, MH - Duluth 500kV tie-line, Presque Isle In	53.1	0.30
BAU, MH - Fargo 500kV tie-line, Presque Isle In	39.0	0.22
HDE, No new MH tie-line, Presque Isle In	129.0	0.73
HDE, MH - Duluth 500kV tie-line, Presque Isle In	135.3	0.77
HDE, MH - Fargo 500kV tie-line, Presque Isle In	120.7	0.69

- **Capture Rate: 94% - 100%+**
- **Option relieves additional congestion around Lake Michigan than what was scoped in economic potential work**
- **Up to 15% of options benefits are synergic**
- **Benefits are relatively less in the Fargo tie-line scenarios because Fargo tie-line lessens MN/DAK congestion and Twin Cities absorbs additional power for transfer**
- **Portfolio increases Kewaunee – Ludington HVDC loading from ~65% (stand alone option) to ~85% (portfolio)**
- **Nearly equalizes Michigan and Wisconsin LMPs in BAU**

Portfolio 1: LMP Results

Upgrade Hankinson - Wahpeton 230kV and Big Stone - Morris 115kV and Kewaunee – Ludington 500kV HVDC

Business As Usual

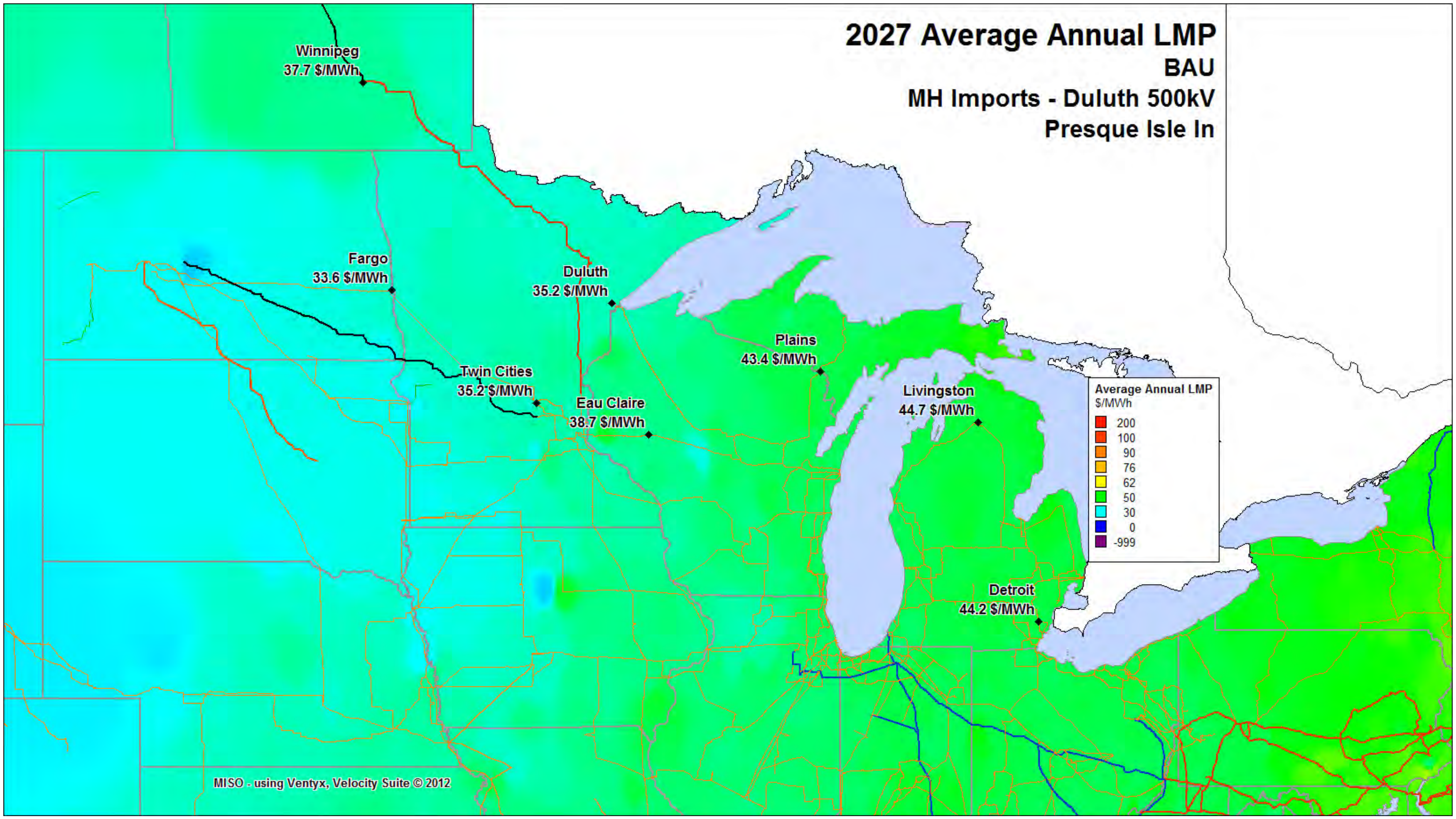


3x "zoomed-in" scale

Portfolio 1: LMP Results

Upgrade Hankinson - Wahpeton 230kV and Big Stone - Morris 115kV and Kewaunee – Ludington 500kV HVDC

Business As Usual

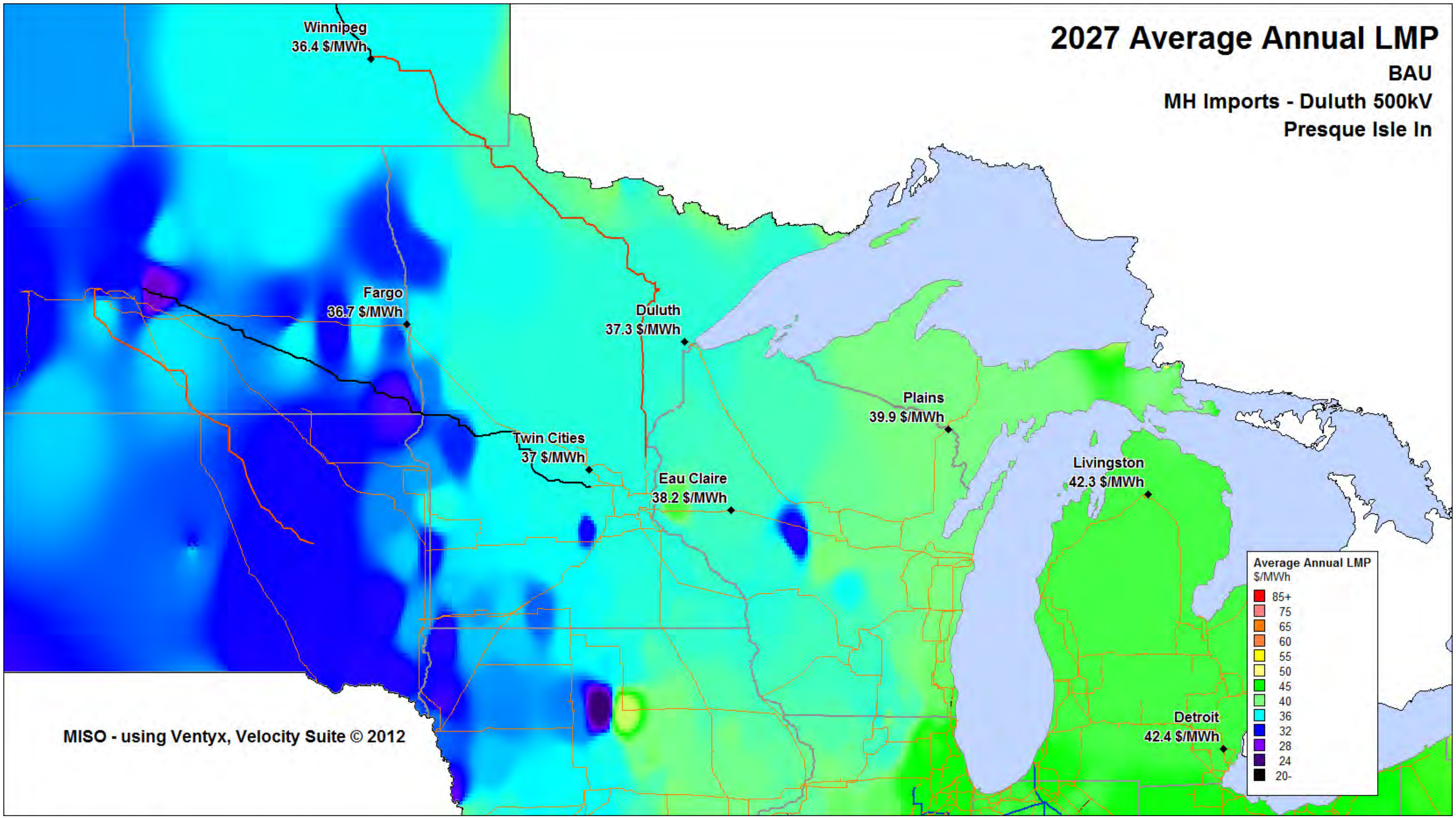


"Standard Market" scale

Portfolio 1: LMP Results – No Losses

Majority of remaining LMP differences from line losses

Business As Usual

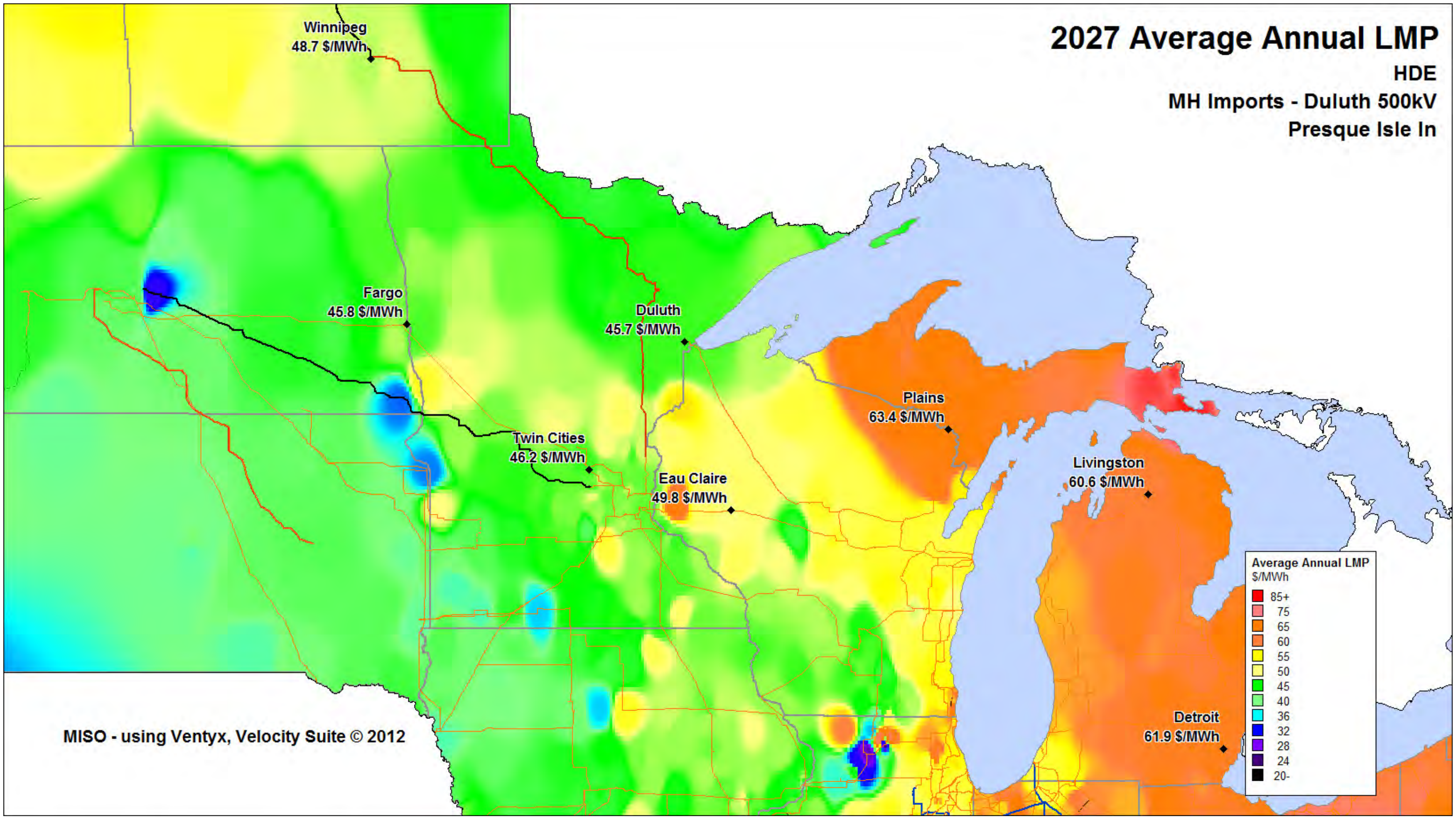


3x "zoomed-in" scale – No Losses

Portfolio 1: LMP Results

Upgrade Hankinson - Wahpeton 230kV and Big Stone - Morris 115kV and Kewaunee – Ludington 500kV HVDC

High Demand and Energy

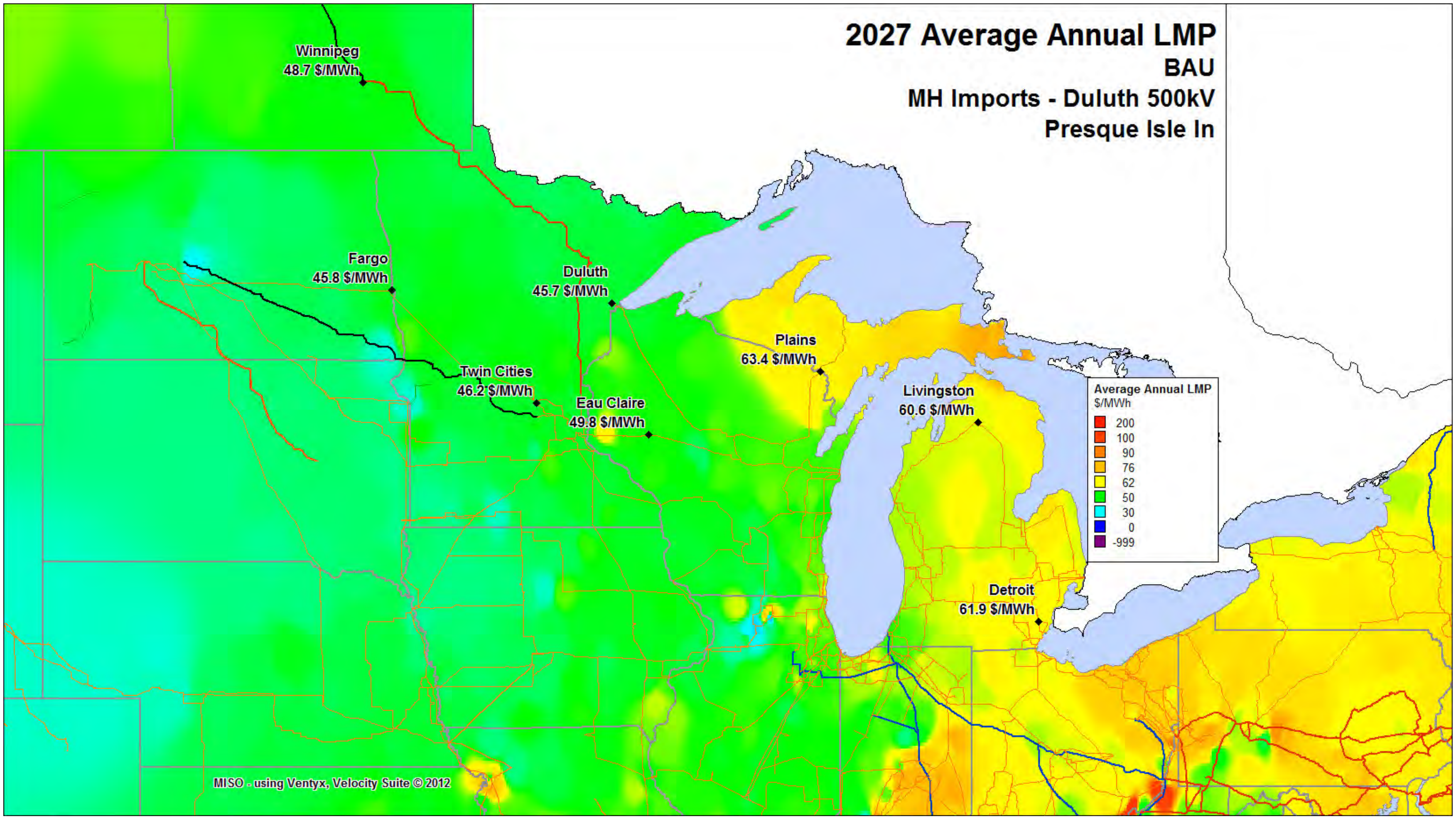


3x "zoomed-in" scale

Portfolio 1: LMP Results

Upgrade Hankinson - Wahpeton 230kV and Big Stone - Morris 115kV and Kewaunee – Ludington 500kV HVDC

High Demand and Energy



"Standard Market" scale

Portfolio 2: Info

Upgrade Hankinson - Wahpeton 230kV and Big Stone - Morris 115kV and Arnold – Livingston 345kV

Duluth Tie-Line Scenarios Include MWEX Upgrade

Estimated Cost ($-2012): $559.8M**

** Assumes $0 for MWEX upgrade; if reliability testing determines add'l mitigation, cost will be updated

Lines are for illustrative purposes only, actual line routing may differ

Portfolio 2: Results

Upgrade Hankinson - Wahpeton 230kV and Big Stone - Morris 115kV and Arnold – Livingston 345kV

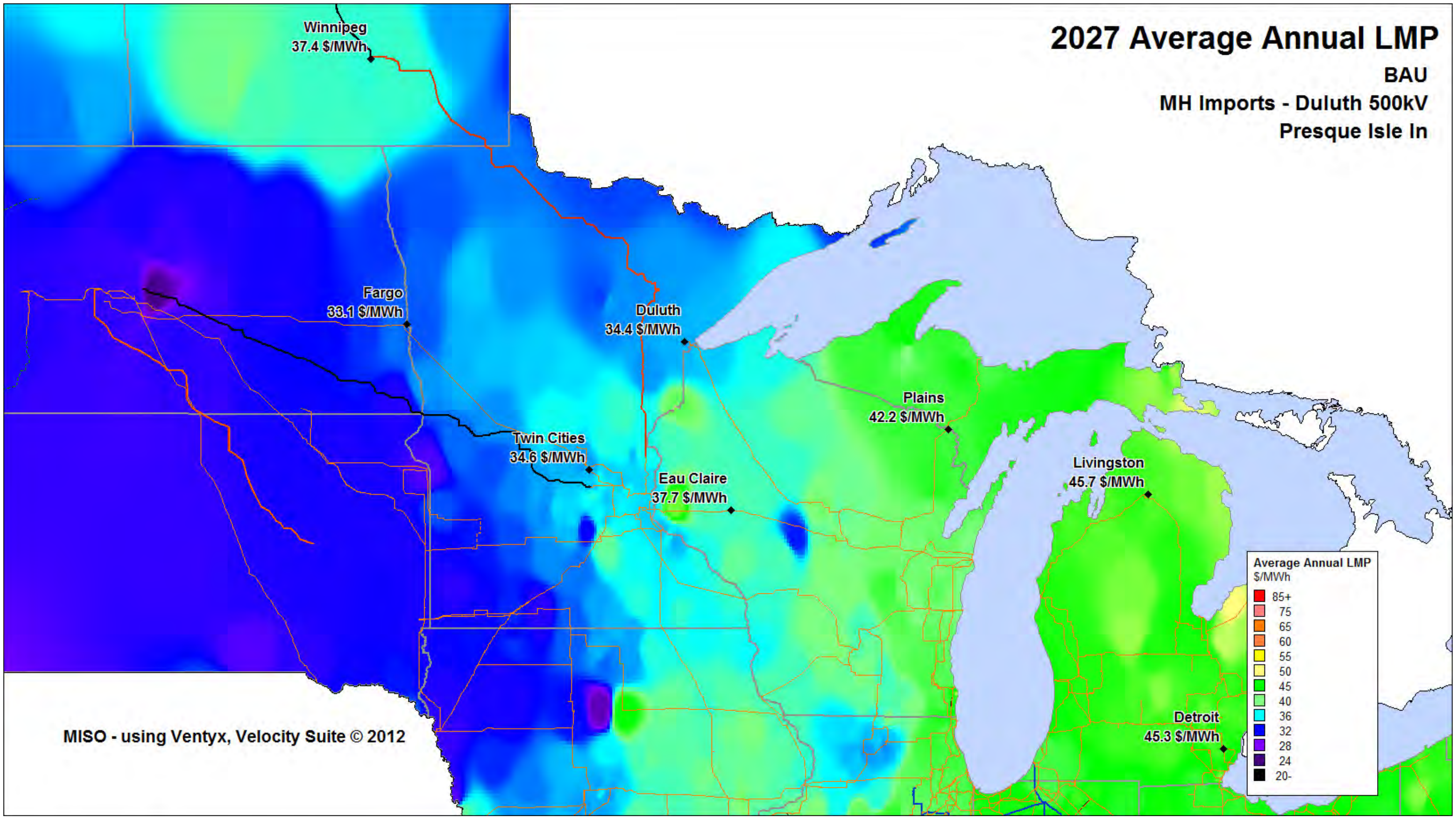
Scenario	APC Savings ($M-2027)	Estimated B/C
BAU, No new MH tie-line, Presque Isle In	28.6	0.26
BAU, MH - Duluth 500kV tie-line, Presque Isle In	31.8	0.29
BAU, MH - Fargo 500kV tie-line, Presque Isle In	22.7	0.21
HDE, No new MH tie-line, Presque Isle In	85.3	0.78
HDE, MH - Duluth 500kV tie-line, Presque Isle In	87.3	0.79
HDE, MH - Fargo 500kV tie-line, Presque Isle In	73.5	0.67

- **Capture Rate: 61 – 86%**
- **Up to 7% of options benefits are synergic**
- **Benefits are relatively less in the Fargo tie-line scenarios because Fargo tie-line lessens MN/DAK congestion and Twin Cities absorbs additional power for transfer**
- **Portfolio increases Arnold – Livingston 345kV loading from ~14% (stand alone option) to ~16% (portfolio)**
- **Helps equalize MI LMPs – halves BAU LMP spread**

Portfolio 2: LMP Results

Upgrade Hankinson - Wahpeton 230kV and Big Stone - Morris 115kV and Arnold – Livingston 345kV

Business As Usual

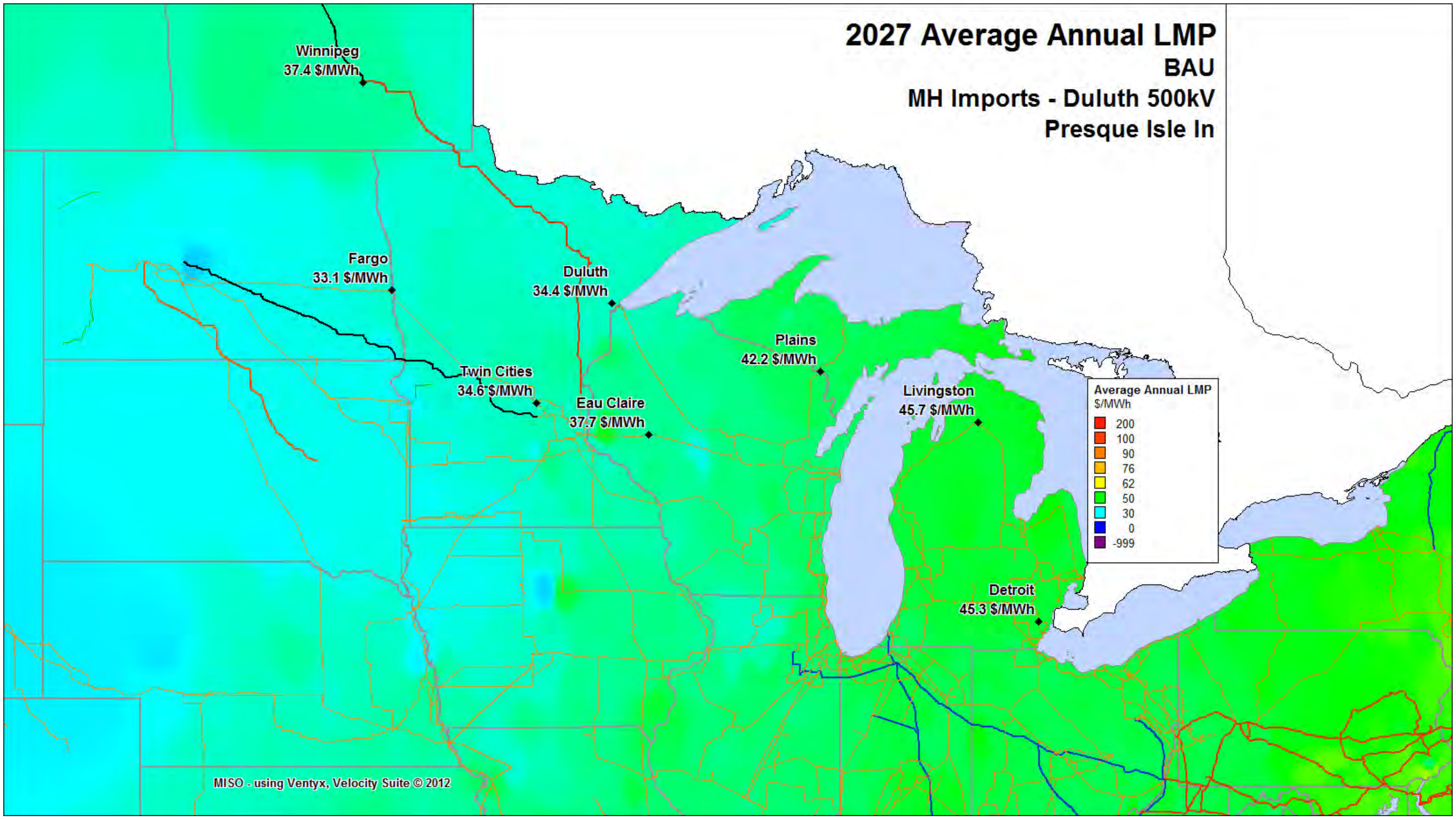


3x "zoomed-in" scale

Portfolio 2: LMP Results

Upgrade Hankinson - Wahpeton 230kV and Big Stone - Morris 115kV and Arnold – Livingston 345kV

Business As Usual



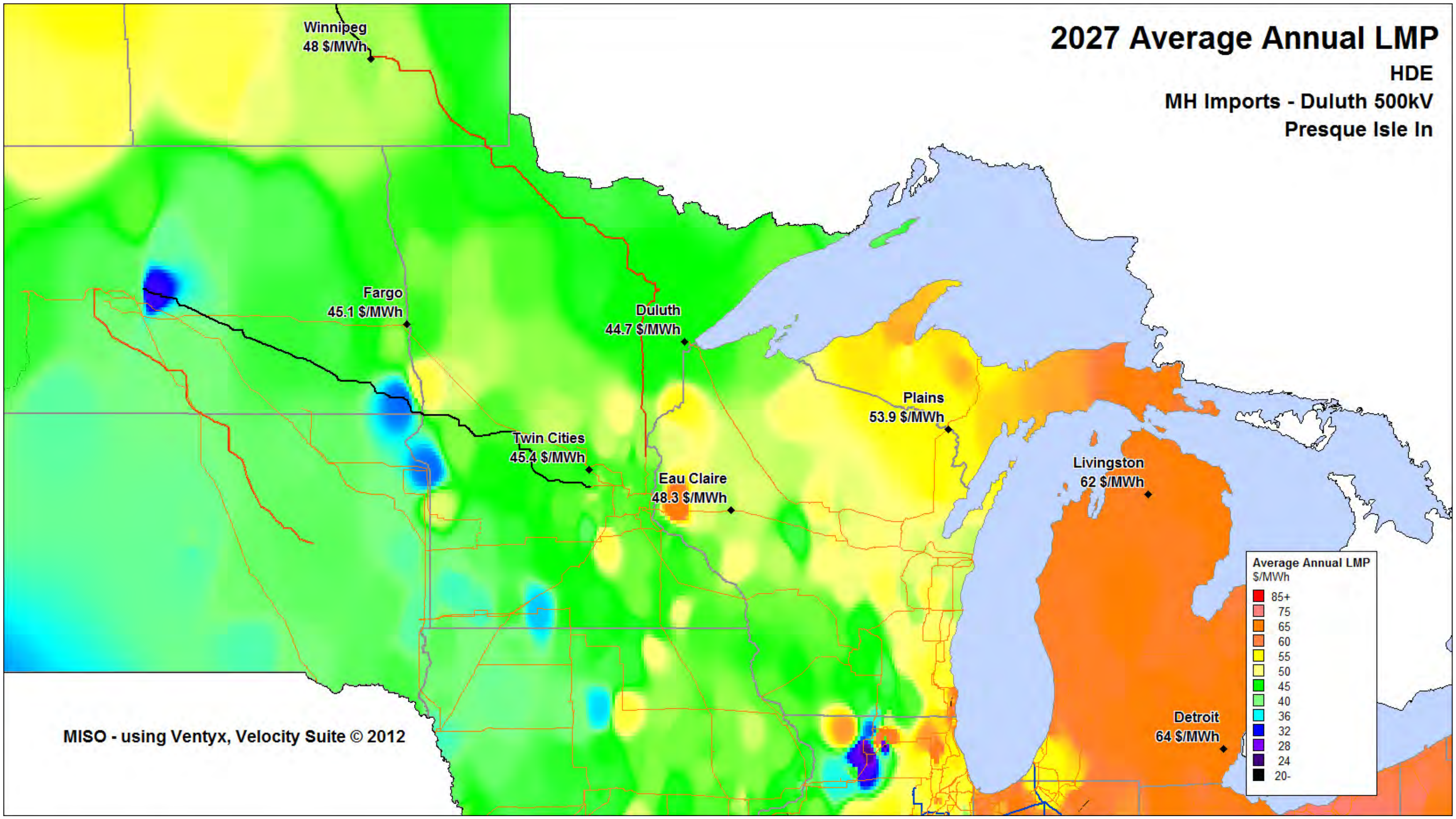
"Standard Market" scale

MISO

Portfolio 2: LMP Results

Upgrade Hankinson - Wahpeton 230kV and Big Stone - Morris 115kV and Arnold – Livingston 345kV

High Demand and Energy

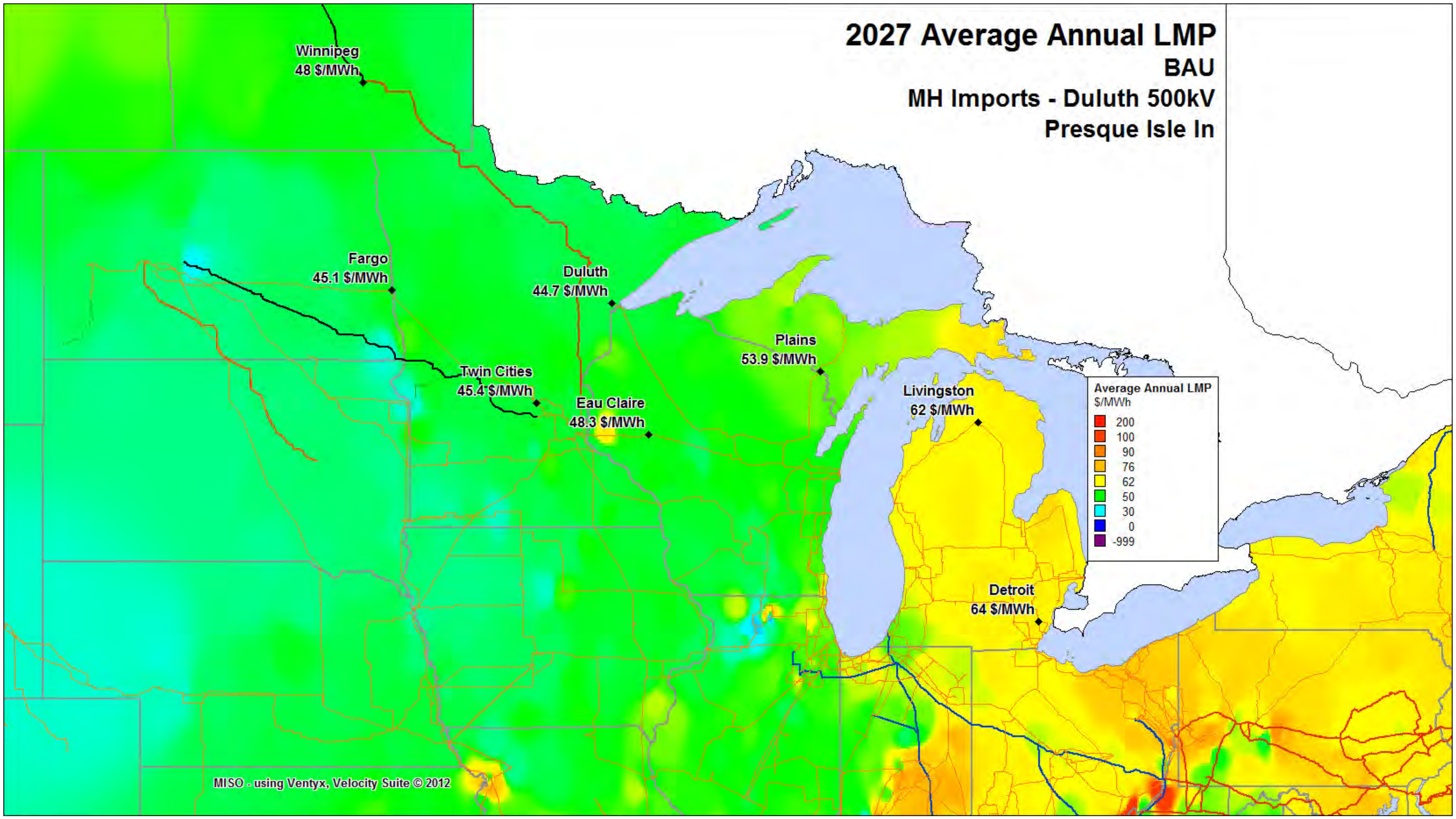


3x ”zoomed-in” scale

Portfolio 2: LMP Results

Upgrade Hankinson - Wahpeton 230kV and Big Stone - Morris 115kV and Arnold – Livingston 345kV

High Demand and Energy



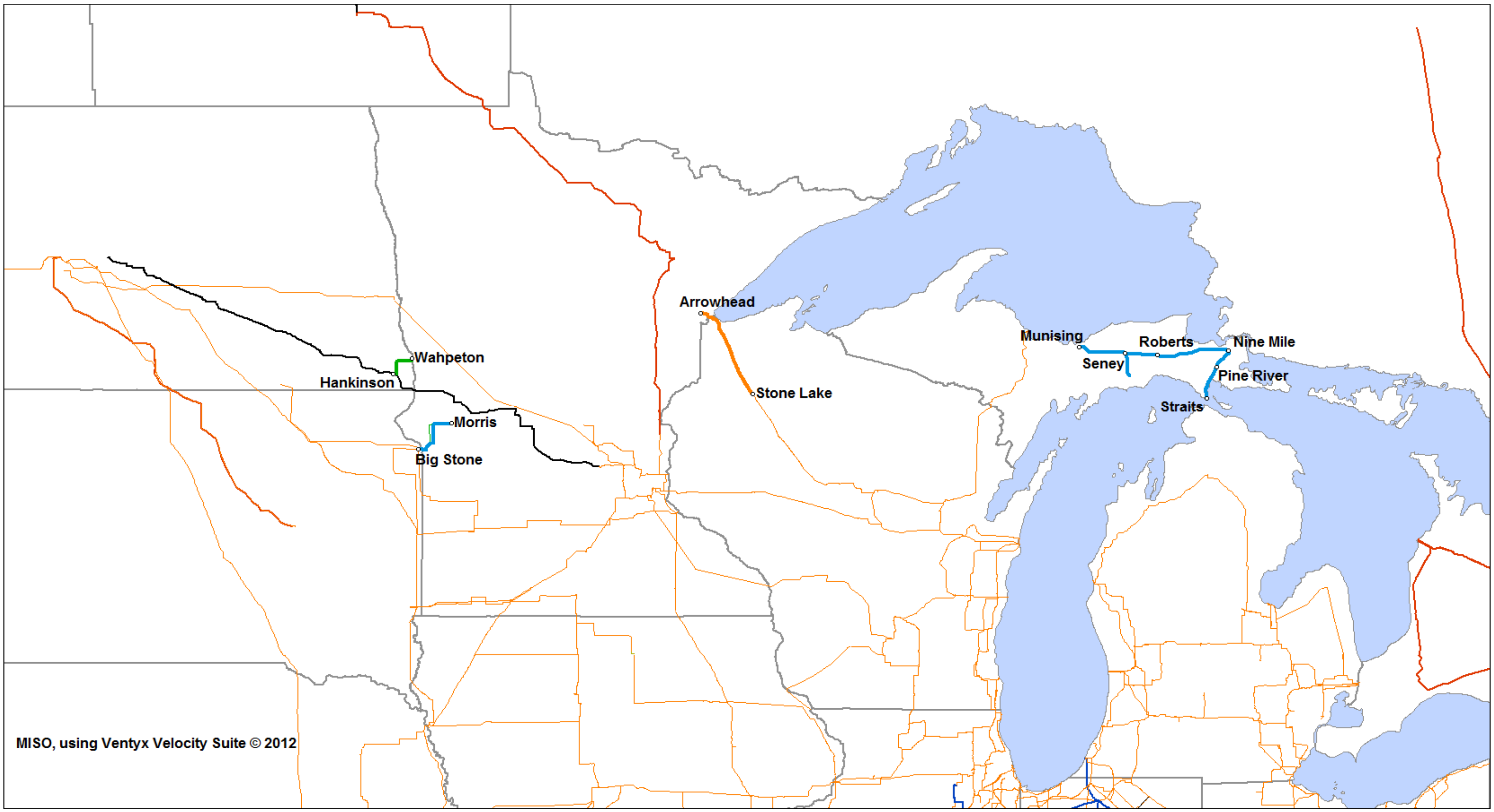
"Standard Market" scale

Portfolio 3: Info

Upgrade Hankinson - Wahpeton 230kV and Big Stone - Morris 115kV and Marquette – Mackinac County 138kV
Duluth Tie-Line Scenarios Include MWEX Upgrade

Estimated Cost ($-2012): $285.05M**

** Assumes $0 for MWEX upgrade; if reliability testing determines add'l mitigation, cost will be updated



Lines are for illustrative purposes only, actual line routing may differ

Portfolio 3: Results

Upgrade Hankinson - Wahpeton 230kV and Big Stone - Morris 115kV and Marquette – Mackinac County 138kV

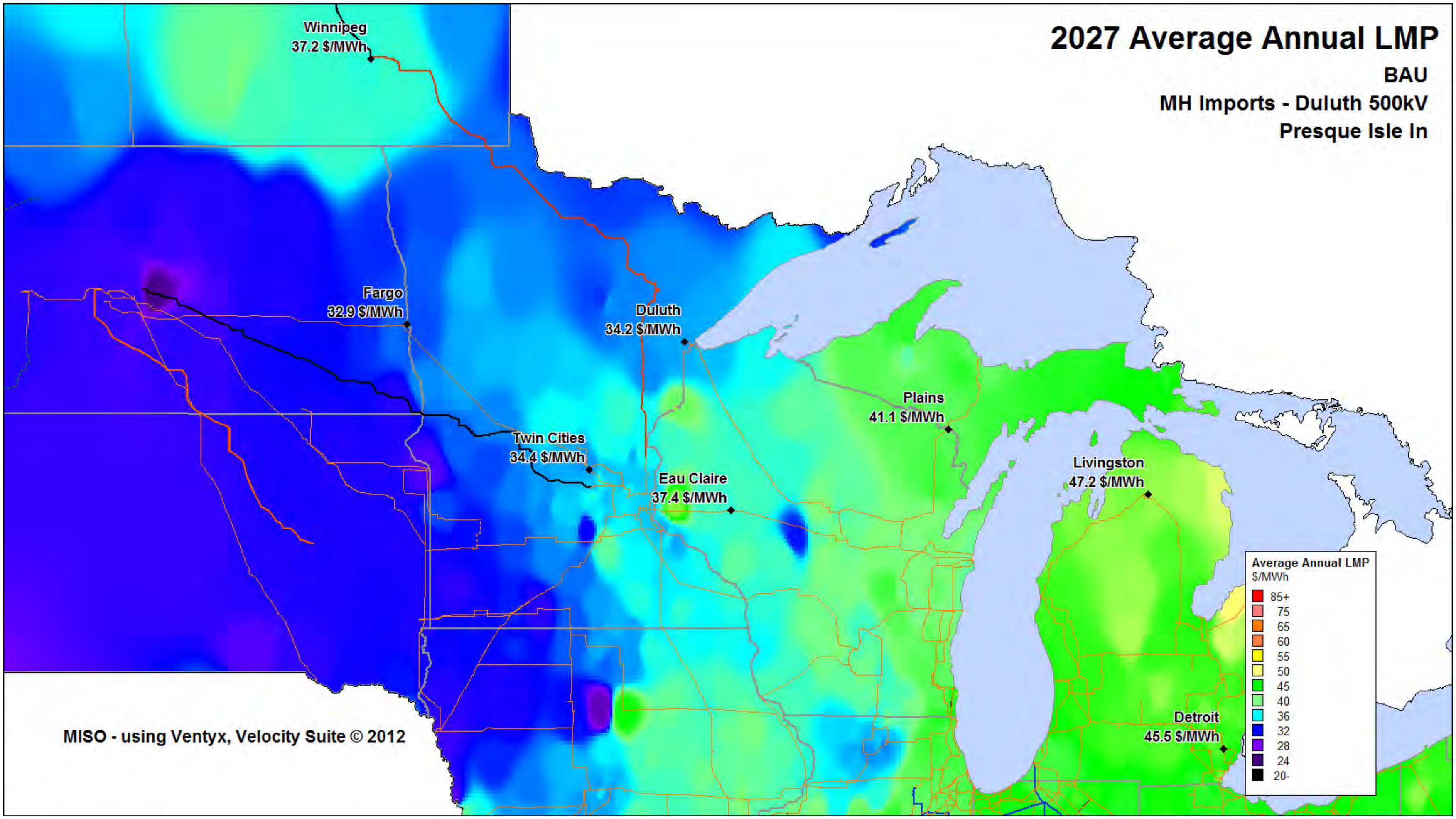
Scenario	APC Savings ($M-2027)	Estimated B/C
BAU, No new MH tie-line, Presque Isle In	24.4	0.43
BAU, MH - Duluth 500kV tie-line, Presque Isle In	24.5	0.44
BAU, MH - Fargo 500kV tie-line, Presque Isle In	17.4	0.31
HDE, No new MH tie-line, Presque Isle In	73.9	1.32
HDE, MH - Duluth 500kV tie-line, Presque Isle In	73.5	1.31
HDE, MH - Fargo 500kV tie-line, Presque Isle In	60.4	1.08

- **Capture Rate: 61 – 86%**
- **Benefits are not synergic**
- **Majority of portfolio B/C from MN/DAK plan – (relatively) higher B/C because portfolio has the lowest incremental cost**
- **Benefits are relatively less in the Fargo tie-line scenarios because Fargo tie-line lessens MN/DAK congestion**
- **Marquette – Mackinac County 138kV line load is similar in stand alone option and portfolio**
- **Does little to equalize MI LMPs**

Portfolio 3: LMP Results

Upgrade Hankinson - Wahpeton 230kV and Big Stone - Morris 115kV and Marquette – Mackinac County 138kV

Business As Usual

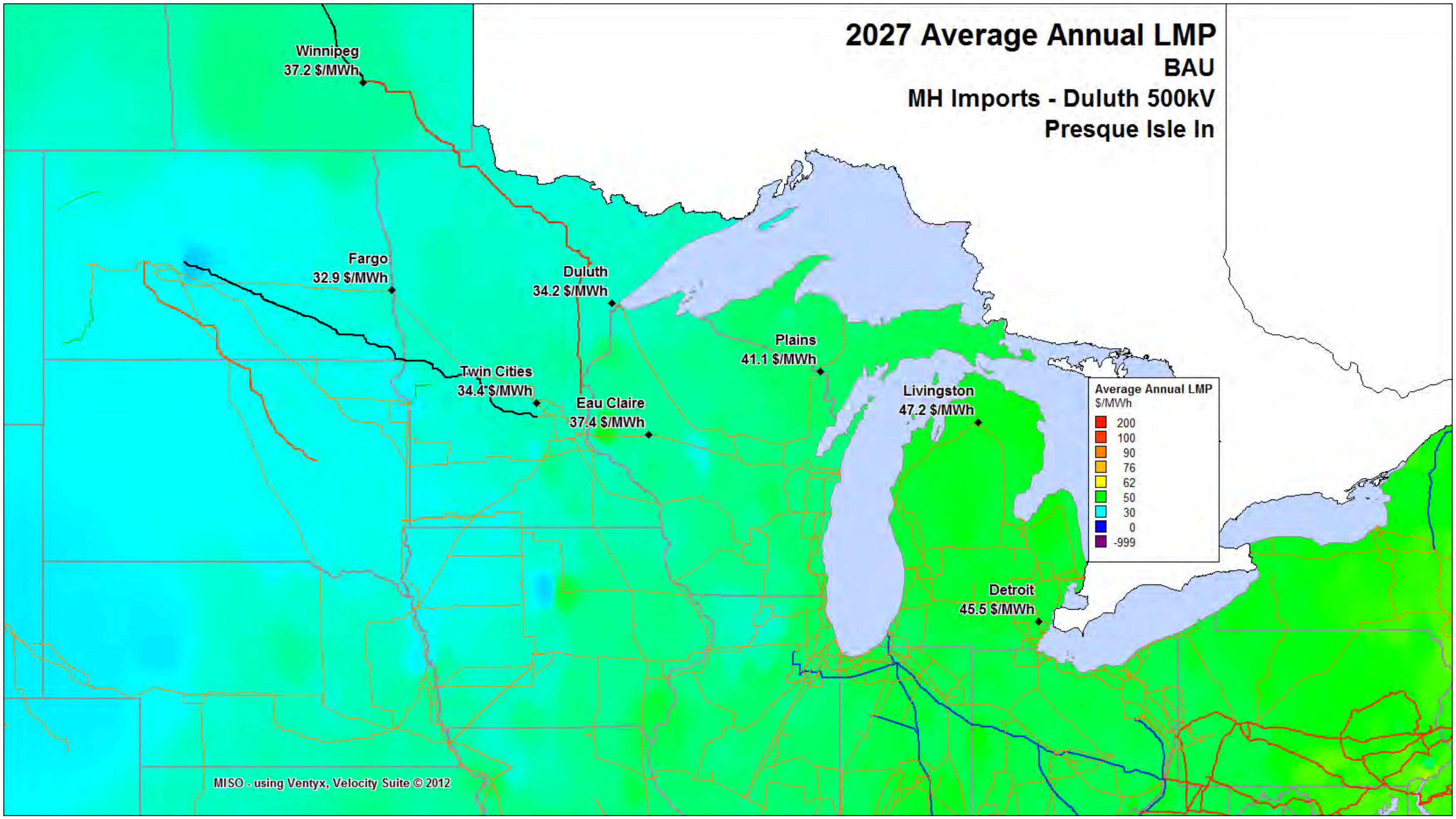


3x "zoomed-in" scale

Portfolio 3: LMP Results

Upgrade Hankinson - Wahpeton 230kV and Big Stone - Morris 115kV and Marquette – Mackinac County 138kV

Business As Usual

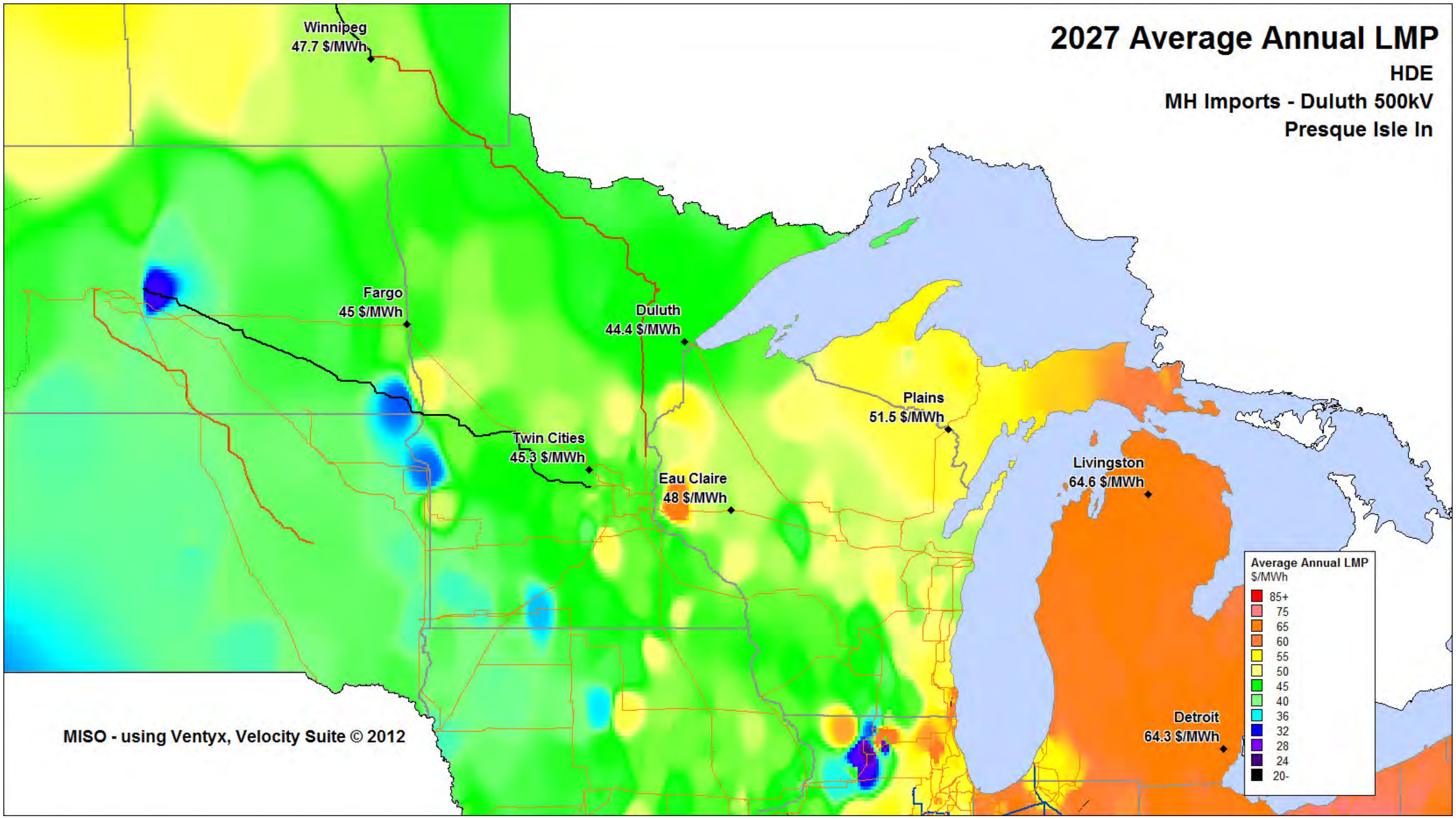


“Standard Market” scale

Portfolio 3: LMP Results

Upgrade Hankinson - Wahpeton 230kV and Big Stone - Morris 115kV and Marquette – Mackinac County 138kV

High Demand and Energy

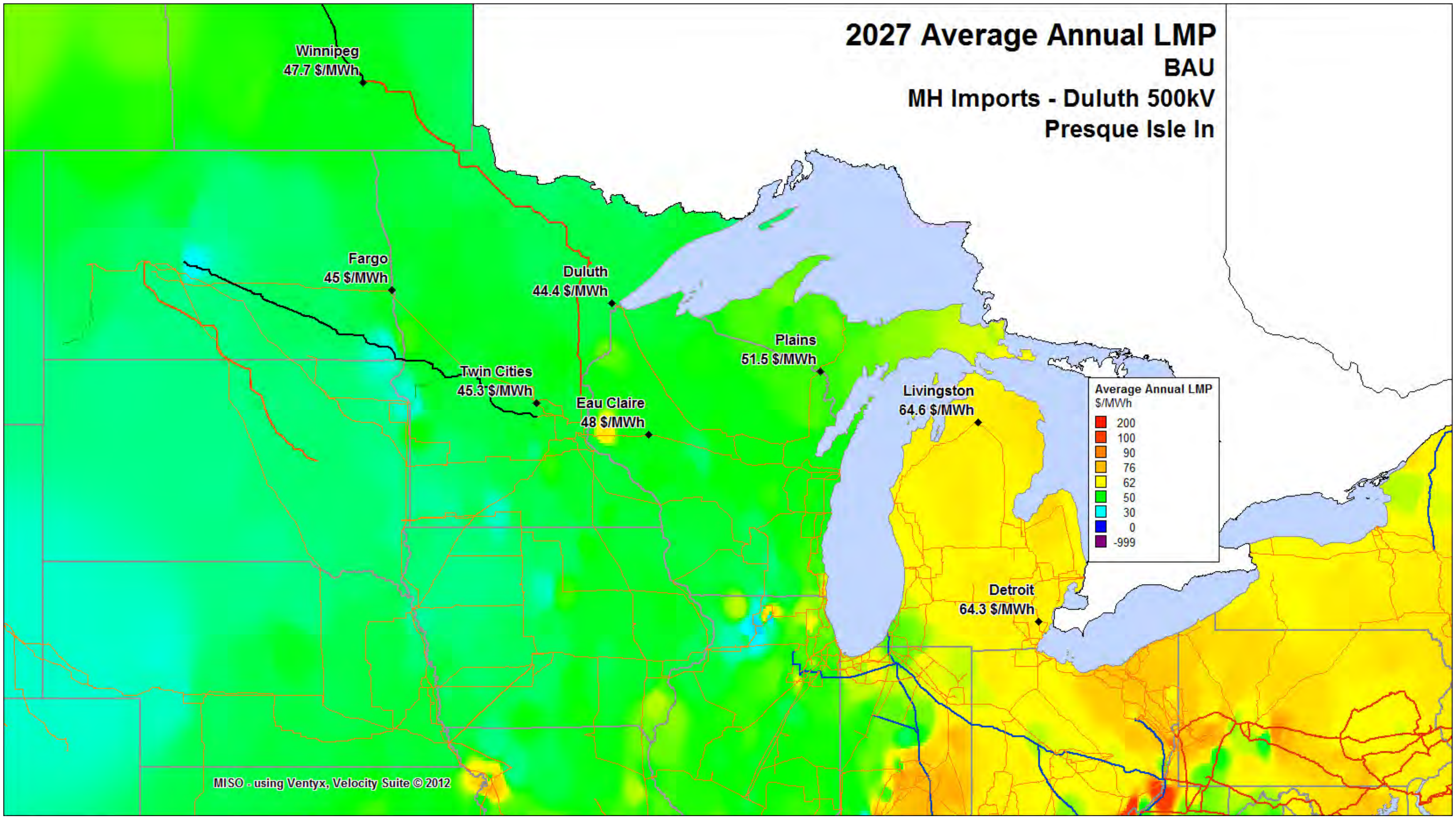


3x "zoomed-in" scale

Portfolio 3: LMP Results

Upgrade Hankinson - Wahpeton 230kV and Big Stone - Morris 115kV and Marquette – Mackinac County 138kV

High Demand and Energy



"Standard Market" scale

First Round Portfolio Results Summary

No new MH-MISO tie-line	APC Savings ($M-2027) (BAU/HDE	Estimated Cost ($M-2012)	Estimated B/C (BAU/HDE)
Portfolio 1: Upgrade Hankinson - Wahpeton 230kV and Big Stone - Morris 115kV, Kewaunee – Ludington 500kV HVDC	45.3 / 129.0	894.2	0.26 / 0.73
Portfolio 2: Upgrade Hankinson - Wahpeton 230kV and Big Stone - Morris 115kV, Arnold – Livingston 345kV	28.6 / 85.3	559.8	0.26 / 0.78
Portfolio 3: Upgrade Hankinson - Wahpeton 230kV and Big Stone - Morris 115kV, Marquette – Mackinac County 138kV	24.4 / 73.9	285.05	0.43 / 1.32

Fargo 500kV tie-line	APC Savings ($M-2027) (BAU/HDE	Estimated Cost ($M-2012)	Estimated B/C (BAU/HDE)
Portfolio 1	39.0 / 120.7	894.2	0.22 / 0.69
Portfolio 2	22.7 / 73.5	559.8	0.21 / 0.67
Portfolio 3	17.4 / 60.4	285.05	0.31 / 1.08

Duluth 500kV Tie-Line	APC Savings ($M-2027) (BAU/HDE	Estimated Cost ($M-2012)	Estimated B/C (BAU/HDE)
Portfolio 1 (Includes MWEX Upgrade)	53.1 / 135.0	894.2	0.30 / 0.77
Portfolio 2 (Includes MWEX Upgrade)	31.8 / 87.3	559.8	0.29 / 0.79
Portfolio 3 (Includes MWEX Upgrade)	24.5 / 73.5	285.05	0.44 / 1.31

First Round Portfolio Economic Results Summary

- **Majority of the B/C ratio from the Hankinson – Wahpeton 230kV and Big Stone – Morris 115kV upgrade**
  - Best portfolio B/C in option with the lowest additional costs
- **In all scenarios, Kewaunee – Ludington 500kV HVDC was only portfolio which yielded significant synergic adjusted production cost benefits**
- **DC and AC solutions produced similar B/C in each of the scenarios – decision on AC or DC should be based on factors outside of production cost savings**
- **In the tested conditions, even with synergic benefits, portfolios' costs were not justified by the benefits**

2/11 NAS Economic Results Summary

- There is an economic opportunity to mitigate the remaining out-year congestion from wind – best solutions are small in scale
- MISO economic benefits from new potential Manitoba Hydro to MISO tie-lines can be realized with minimal incremental transmission investments
- There are economic benefits of equalizing Michigan LMPs; options' adjusted production cost benefits do not exceed costs in tested conditions
- Without Presque Isle retiring, the economic potential for new Upper Peninsula transmission lines is decreased
- Combining high voltage options spanning Lake Michigan with small-scale mitigation plans creates synergic benefits, though total adjusted production cost benefits don't exceed costs in tested conditions

Agenda

• Welcome, Roll Call, and Review Agenda	10:00 AM
• Recap December 7th Meeting	10:15 AM
• Related Study Status Report	10:30 AM
– Manitoba Hydro Wind Synergy Study	
– TSR Update	
– Market Efficiency Study	
• Economic Benefits of New/Refined Options	11:00 AM
• Lunch Break	12:00 PM
• Economic Benefits of Best-Fit Plans/Portfolios	12:30 PM
• Reliability Analysis of Portfolios Work Plan	1:00 PM
• Schedule Update	1:30 PM
• Open Discussion and Next Steps	1:45 PM
• Adjourn	2:00 PM

The Best Fit Transmission Projects

- **Dakota - Minnesota**
  - Hankinson – Wahpeton 230 kV & Big Stone – Morris 115 kV
- **Wisconsin – Upper Peninsula**
  - Arnold – Livingston 345 kV
  - Marquette – Mackinac County 138 kV
  - Kewaunee – Ludington 1600MW HVDC

Reliability Analysis

- **Reliability No Harm Tests**
  - No degradation of system reliability with addition of transmission plans
  - Analyze underbuild requirements
  - Comparison of cases with and without new transmission options will show reliability issues created or mitigated
- **Steady State (Thermal) Study**
  - Looking for overloads and voltage violations under contingency
- **Transient Stability Study**
  - Looking for issues in seconds after disturbance

Reliability Model Assumptions

- **Thermal Study**
  - MTEP12 2022 Summer peak/shoulder with spot load and additional 1100 MW MH import
- **Transient Stability Study**
  - MTEP12 2017 Summer shoulder

Transient Stability Study Scenarios

- **Base Case Scenario**
  - No MH additional import
  - ATC OOC
  - MP load correction
  - Kewaunee generator out of service
- **Reference Scenario**
  - Basecase + MH 1100 MW import at Fargo + MP load addition
  - Basecase + MH 1100 MW import at Duluth + MP load addition
- **Study Scenario**
  - Basecase + MH 1100 MW import at Fargo + MP load addition + Arnold – Livingston 345 kV line
  - Basecase + MH 1100 MW import at Duluth + MP load addition + Kewaunee – Ludington ±800kV 1600MW HVDC line

Transient Stability Analysis

- **Issues identified between study scenario and reference scenario will be addressed**
- **Issues identified between reference scenario and basecase scenario will be for information only**
- **Basecase violation will be addressed in MTEP study**
- **Reference case issue will be addressed in MH Synergy study or TSR study**

Reliability Next Steps

- **Perform Thermal and Transient Studies (Ongoing)**
- **Process results**
  - Identify any additional reliability upgrades needed with proposed transmission plans modeled
- **Report findings back to TRG**

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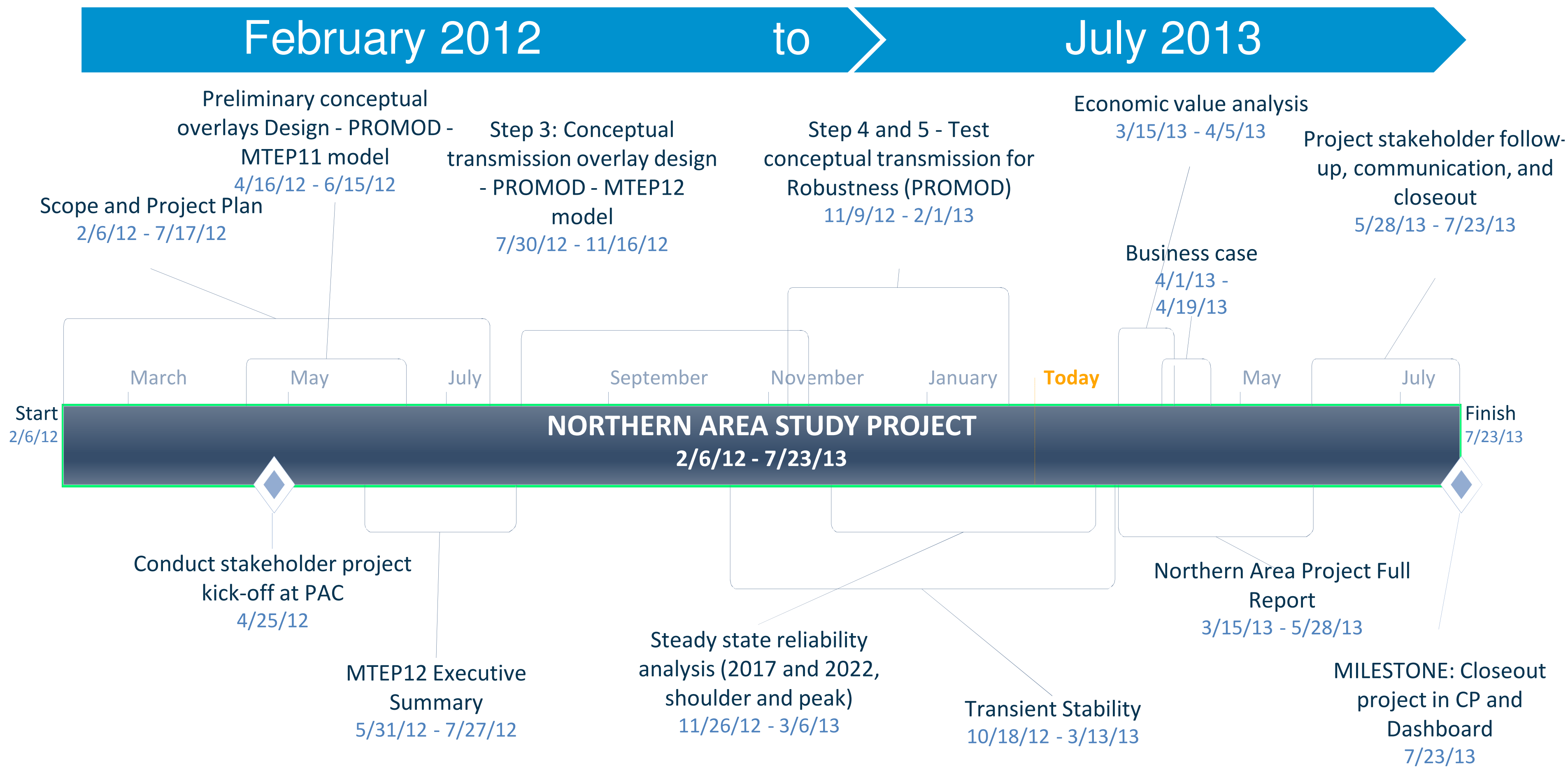
Northern Area Study Project Plan

Task Name	Start	Finish	Adj Finish
NORTHERN AREA STUDY PROJECT	2/6/12	7/3/13	
☑ Scope Development	2/6/12	7/17/12	
☑ Preliminary conceptual overlays Design - PROMOD - MTEP11 (POC)	4/16/12	6/15/12	
☑ Step 3: Conceptual transmission overlay design - PROMOD - MTEP12	7/30/12	11/16/12	
☑ Step 4 & 5 - Test conceptual transmission for Robustness	11/9/12	1/31/13	2/12/13
Step 6 – Reliability Analysis	10/18/12	1/22/13	3/13/13
Steady State Reliability Analysis	10/18/12	1/9/13	3/6/13
Transient Stability Screening	10/18/12	1/22/13	3/13/13
Step 5 - Consolidate and Sequence	1/31/13	2/4/13	3/15/13
Economic value analysis (final production cost calculation)	2/4/13	2/28/13	4/1/13
☑ Construction cost estimates	2/4/13	3/11/13	1/15/13
Business case analysis	3/11/13	4/8/13	4/19/13
☑ MTEP 12 Executive Summary	5/31/12	7/27/12	
Northern Area Project Full Report	2/4/13	4/24/13	5/28/13
Project stakeholder follow-up, communication, and closeout	4/24/13	6/19/13	7/23/13

Northern Area Study Timeline



Northern Area Study – MH Hydro - MEPS Timelines

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What's Next?

- MISO
  - Perform reliability analysis
  - Update economic constraint list pending reliability results
  - Perform 2022 economic analysis on best-fit plans and portfolios
- TRG
  - Provide feedback or refinements
- Next Meeting
  - Tentatively planned for April/May 2013

Contact Information

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- **Northern Area Study Reliability Analysis**
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