Strategic Midwest Area Renewable Transmission (SMARTransmission) Study

QUANTA TECHNOLOGY

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Open Stakeholder Meeting

American Electric Power
Columbus, OH
April 27, 2010

Agenda for Stakeholder Web Conference

- 10:00 am (EST) Welcome – Lisa Barton, Vice President Transmission Strategy and Business Development and President of ETA
- 10:15 am SMARTransmission Study – Don Morrow, Vice President -Transmission, Quanta Technology
  - Study Overview
  - Phase 1 Results
  - Phase 2 Update
  - Schedule & Next Steps
- 12:00 pm Program Ends

Study Overview

- Comprehensive study of the transmission needed in the Upper Midwest
- Supports renewable energy development and facilitates the transportation of that energy to consumers throughout the study area
- Not in competition with any other study
- Existing studies and results were included as appropriate
- Study focus is 20 years into the future
- Transcends traditional utility and regional boundaries

Phase 1 Summary

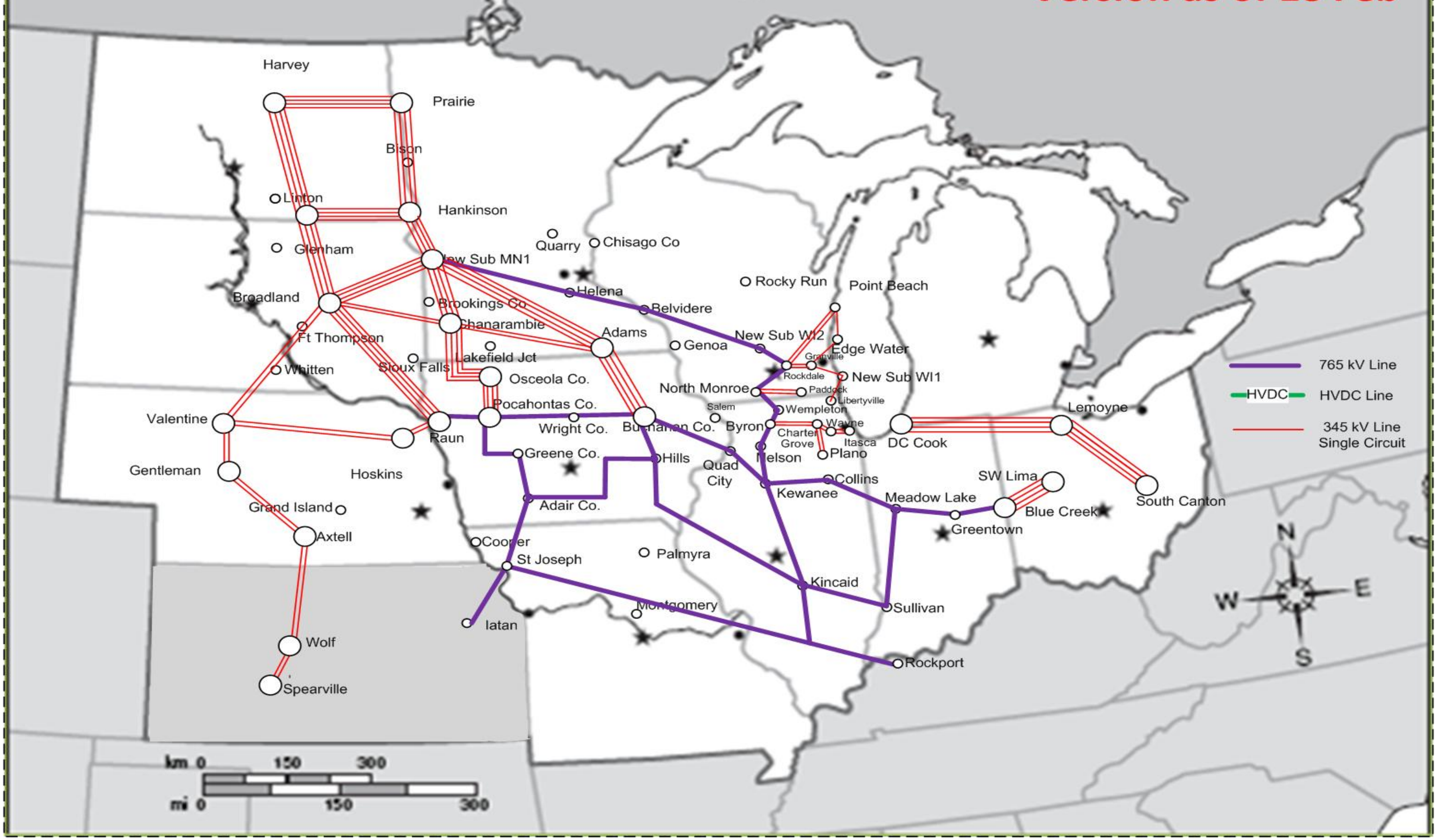
- Initially developed eight proposed alternatives
  - 1 - All 345kV
  - 2 – Combination 345kV and 765kV
  - 5 – 765kV
- Developed on-peak & off-peak cases for the following futures
  - Base Wind
  - High Gas
  - Low Carbon
- Five Sensitivities
  - High Wind, Low Wind
  - High Load, Low Load
  - Imports SPP
- Based on performance and cost, reduced the number of alternatives from eight to five to three
  - Combination 345kV and 765kV – Alternative 2
  - 765kV – Alternative 5
  - 765kV – Alternative 7

Phase 1 Summary (Con't)

- Based on Performance, Alternative 1 (345kV) was feasible for the low wind case of 35.6 GW name plate rating
- Based on performance analysis, improvements to Alternative 7 resulted in Alternative 7 looking similar to Alternative 5.
  - Combination 345kV and 765kV – Alternative 2
  - 765kV – Alternative 5
  - 765kV with long HVDC – Alternative 5A
- Natural applications of HVDC were considered and the following were applied:
  - Underwater cables across waterways
  - Long distance transmission

2029 Conceptual Alternative 2- 345 kV and 765 kV

Version as of 18 Feb



Alternative 2
- No non-solving contingencies on EHV overlay for off peak case
- Four major paths west to east
- Reasonable preliminary cost estimate

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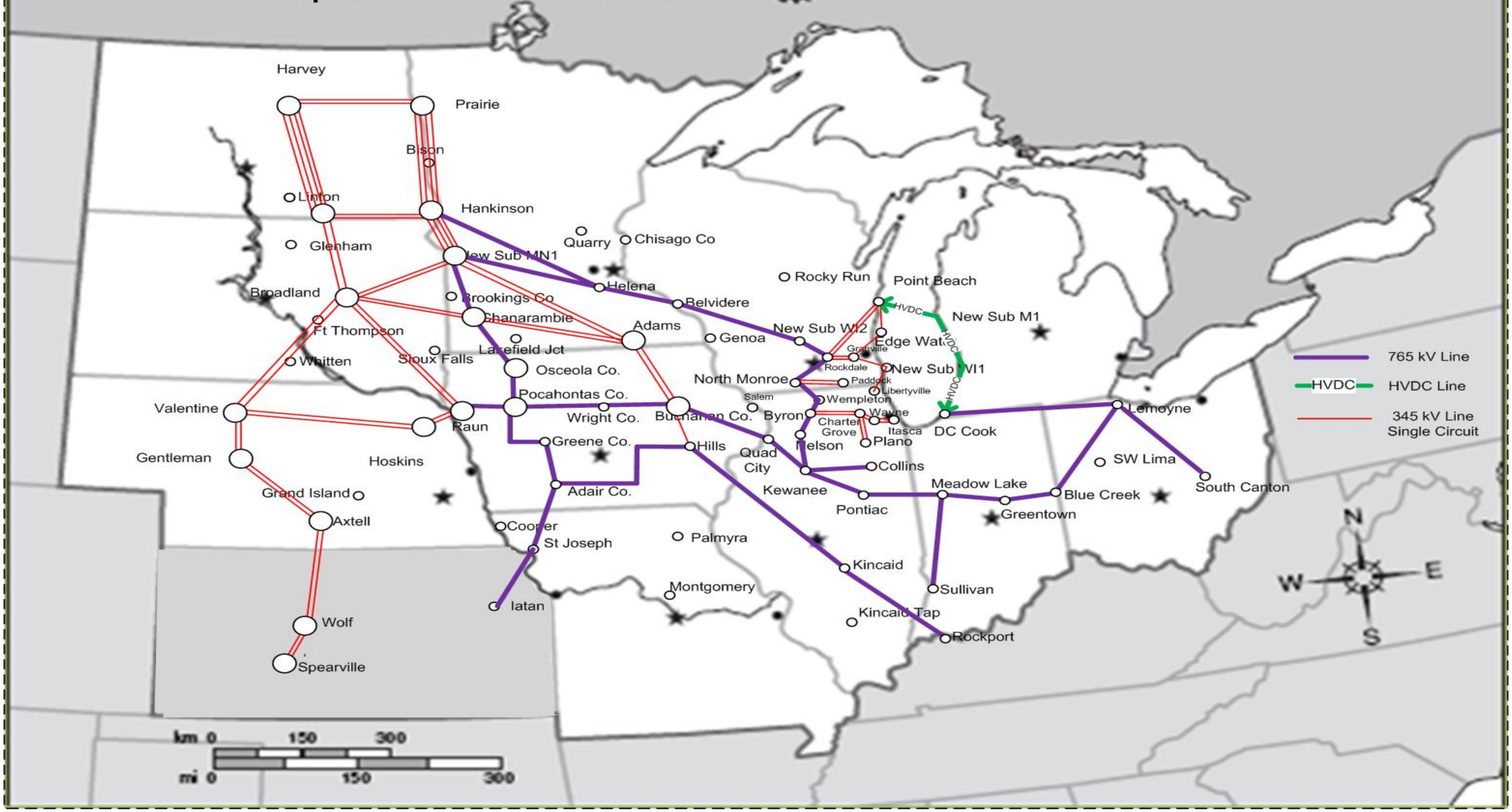
2029 Revised Conceptual Alternative 2- 345 kV and 765 kV



Based on performance results, a number of 345kV and 765kV lines were removed

- Removed 345kV Double Circuits from Harvey – Prairie, Linton – Hankinson, Linton – Broadland, Broadland – New Sub MN1, Broadland – Raun, New Sub MN1 – Adams – Buchanan
- Replaced 2-345kV Double Circuits from New Sub MN1 – Chanarambie – Osceola - Pocahontas with single circuit 765kV line
- Replaced 2-345kV Double Circuits from DC Cook – Lemoyne – South Canton with single circuit 765kV line
- Added HVDC from Pt Beach – New Sub MI1 to DC Cook

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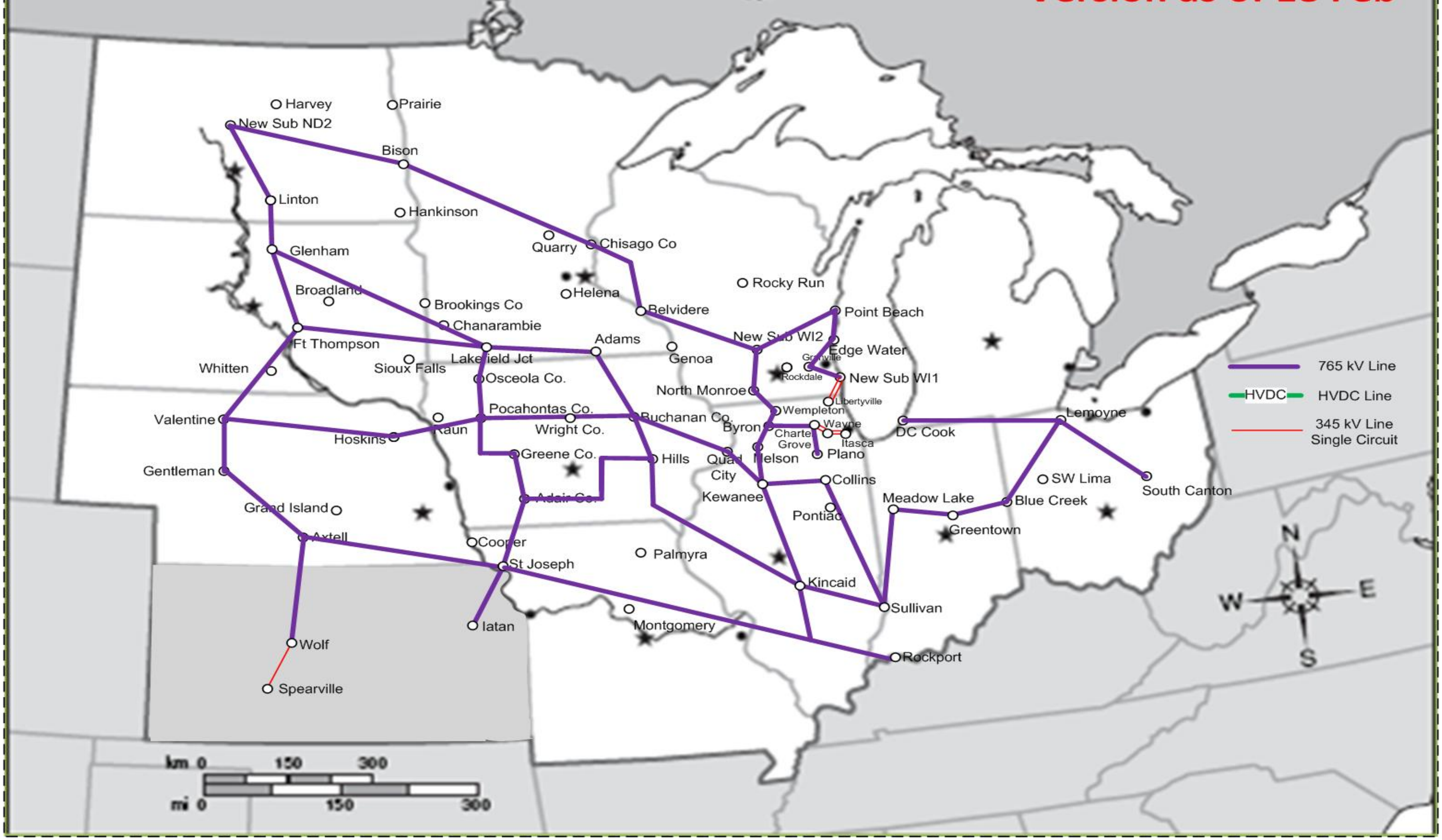
2029 Conceptual Alternative 5- 765 kV

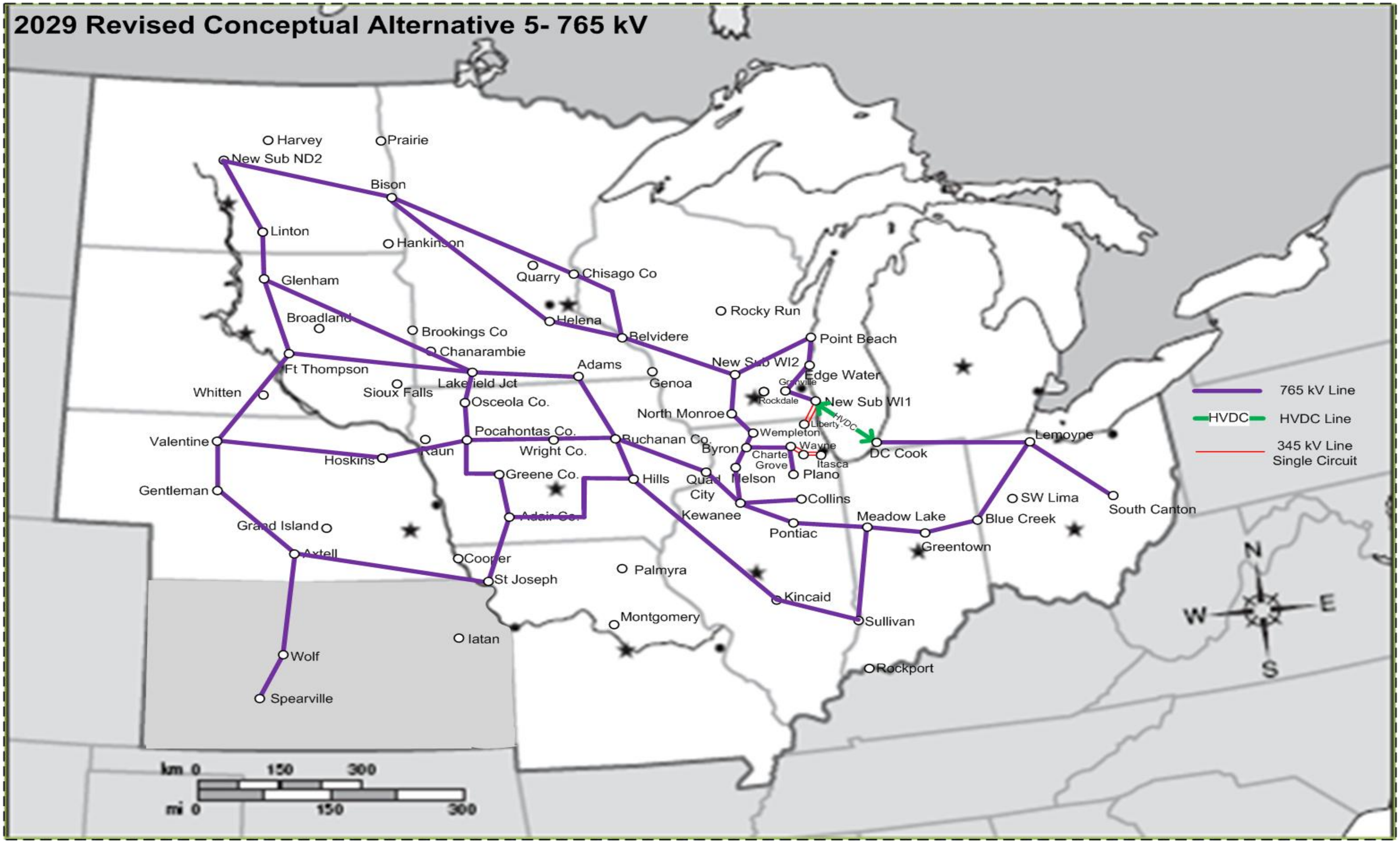
Version as of 18 Feb



Alternative 5

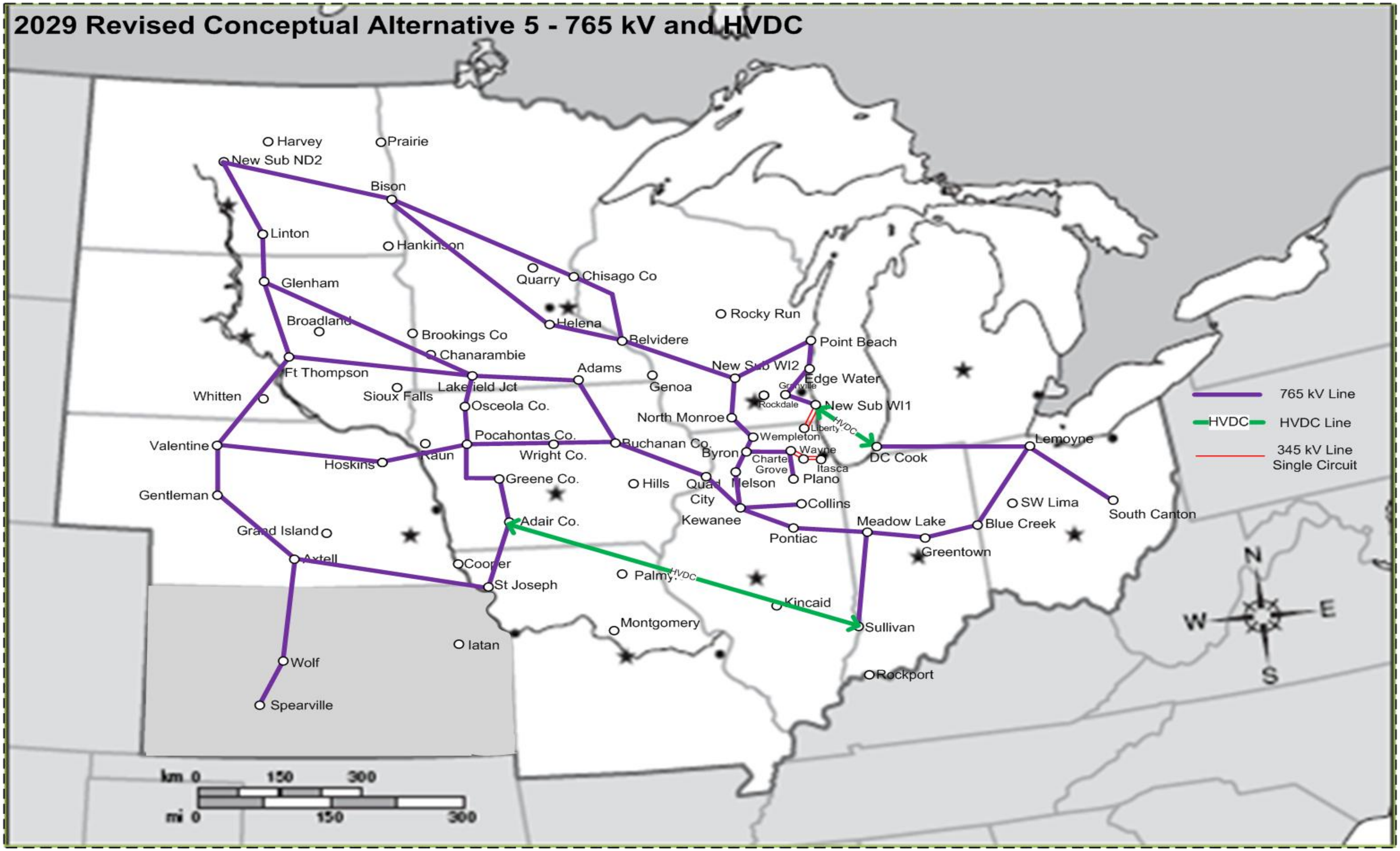
- A large loop in the upper Midwest study area – contingency issue
- Four major paths west to east
- One of the lower preliminary cost estimates

2029 Revised Conceptual Alternative 5- 765 kV



Based on performance results the following changes were made

- Added Bison - Helena – Belvedere
- Removed Collins – Sullivan, Kewanee – Kincaid, St Joseph – Rockport
- Added Kewanee – Pontiac – Meadow lake
- Added HVDC New Sub WI1 – DC Cook



Added HVDC from Adair Co to Sullivan

Removed 765kV lines form Adair Co to Hills to Kincaid to Sullivan

Phase 1 Results

Phase 1 Results Summary

- 2029 Results
  - Base Wind
  - High Gas
  - Low Carbon
- Sequencing
  - Summary of Wind Models
  - 2024 Results
  - 2019 Results

Phase 1 Results

2029 Base Wind

2029 Base Wind Results

Ref	2029 Base Case Wind	Off Peak			On Peak		
		Alt 2	Alt 5	Alt 5-A	Alt 2	Alt 5	Alt 5-A
1	Number of EHV voltage violations-Basecase	0	0	0	0	0	0
2	Number of EHV Thermal violations- Basecase	0	0	0	0	0	0
3	Number of EHV unsolvable-contingency	0	0	0	0	0	0
4	Number of EHV thermal violations-contingency	0	0	0	0	0	0
5	Number of EHV voltage violations-contingency	1	0	0	2	1	1
6	Number of other Line Thermal violations-Basecase	7	8	8	10	12	13
7	Number of other unsolvable-contingency	4	3	3	12	12	12
8	Number of other element thermal violations resulting from EHV contingency	5	21	23	3	6	4
9	Number of other thermal violations resulting from contingencies on existing system	54	56	56	106	113	85

Notes:

1. Ref 1-5 reflect the results directly related to the proposed EHV alternative
2. Voltage violations in Ref 5 can be fixed with the addition of capacitors or reactors.
3. Ref 6-9 reflect the results of the facilities other than the proposed EHV alternative. Violations in Ref 6-9 are shown for completeness and are generally a function of load growth or where the wind resources are located. Those violations are expected to be picked up during the annual planning studies. Ref 8 gives an indication of the impact on the underlying system from contingencies on the EHV alternatives. However, solutions for those violations are not proposed because the uncertainty of the underlying system for 2029.

2029 Base Wind Results - Sensitivities

Ref	2029 Base Case Wind Sensitivities	High Wind			Imports from SPP			Low Wind		
		Alt 2	Alt 5	Alt 5-A	Alt 2	Alt 5	Alt 5-A	Alt 2	Alt 5	Alt 5-A
1	Number of EHV voltage violations-Basecase	0	0	0	0	0	2	0	0	0
2	Number of EHV Thermal violations- Basecase	0	0	0	0	0	0	0	0	0
3	Number of EHV unsolvable-contingency	14	7	12	13	3	4	0	0	0
4	Number of EHV thermal violations-contingency	4	3	1	0	0	0	0	0	0
5	Number of EHV voltage violations-contingency	6	8	3	2	1	1	8	11	11
6	Number of other Line Thermal violations-Basecase	18	18	20	11	9	11	2	2	2
7	Number of other unsolvable-contingency	8	3	3	22	5	2	4	4	3
8	Number of other element thermal violations resulting from EHV contingency	11	93	68	4	39	46	1	3	3
9	Number of other thermal violations resulting from contingencies on existing system	58	244	195	95	94	98	23	12	13

Notes:

1. Ref 1-5 reflect the results directly related to the proposed EHV alternative
2. Ref 3 for the sensitivities of High Wind and Imports from SPP show a number of contingencies that would not solve. Also Ref 4 indicates there are thermal violations. These results indicate that the system is stressed and that we are seeing the capability limits of the proposed alternative.
3. Ref 6-9 reflect the results of the facilities other than the proposed EHV alternative. Violations in Ref 6-9 are shown for completeness and are generally a function of load growth or where the wind resources are located. Those violations are expected to be picked up during the annual planning studies. Ref 8 gives an indication of the impact on the underlying system from contingencies on the EHV alternatives. However, solutions for those violations are not proposed because the uncertainty of the underlying system for 2029.

2029 Base Wind Results - Sensitivities

Ref	2029 Base Case Wind Sensitivities	High Load			Low Load		
		Alt 2	Alt 5	Alt 5-A	Alt 2	Alt 5	Alt 5-A
1	Number of EHV voltage violations-Basecase	0	0	0	0	0	0
2	Number of EHV Thermal violations- Basecase	0	0	0	0	0	0
3	Number of EHV unsolvable-contingency	2	0	0	0	0	0
4	Number of EHV thermal violations-contingency	0	0	0	0	0	0
5	Number of EHV voltage violations-contingency	2	2	2	2	2	1
6	Number of other Line Thermal violations-Basecase	11	13	14	10	10	11
7	Number of other unsolvable-contingency	22	16	18	11	12	12
8	Number of other element thermal violations resulting from EHV contingency	9	33	14	3	7	4
9	Number of other thermal violations resulting from contingencies on existing system	146	283	187	101	172	83

Notes:

1. Ref 1-5 reflect the results directly related to the proposed EHV alternative.
2. Ref 3 for the sensitivity of High Load for Alt 2, two contingencies did not solve, (2 lines) 345kV Charter Grove – 345kV Wayne.
3. Voltage violations in Ref 5 can be fixed with the addition of capacitors or reactors.
4. Ref 6-9 reflect the results of the facilities other than the proposed EHV alternative. Violations in Ref 6-9 are shown for completeness and are generally a function of load growth or where the wind resources are located. Those violations are expected to be picked up during the annual planning studies. Ref 8 gives an indication of the impact on the underlying system from contingencies on the EHV alternatives. However, solutions for those violations are not proposed because the uncertainty of the underlying system for 2029.

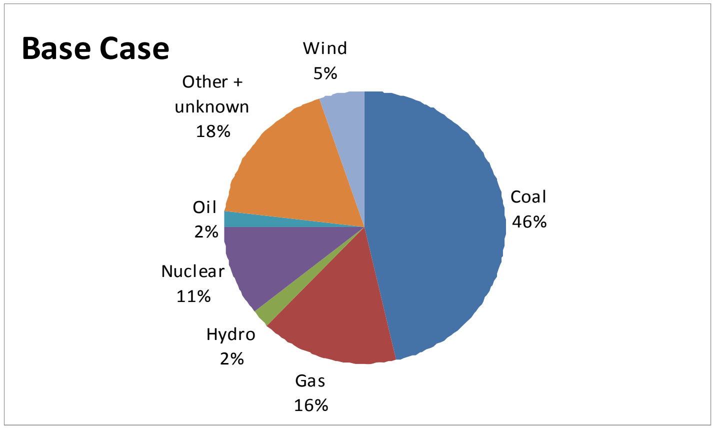
2029 N-2 Results

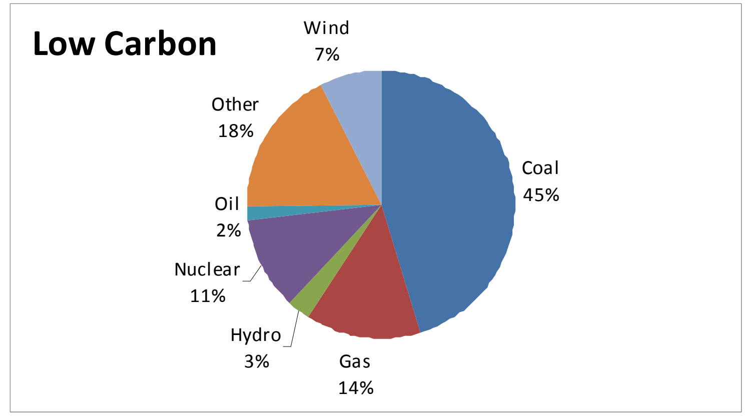
- With wind generation re-dispatch, the system was tested under N-2 contingencies to emulate N-1-1. Results indicate that:
  - For off-Peak Base Wind & Low Wind cases, there are no unsolvable contingencies in the EHV overlay.
  - For the Off-Peak SPP Import case, there are many unsolvable contingencies in the EHV overlay. There are existing violations for N-1.
  - Violations on the underlying system for N-2 are numerous and are expected to be addressed with re-dispatch and local planning upgrades. The case with the most underlying system issues is SPP imports. Additional upgrades would be required to improve the performance.

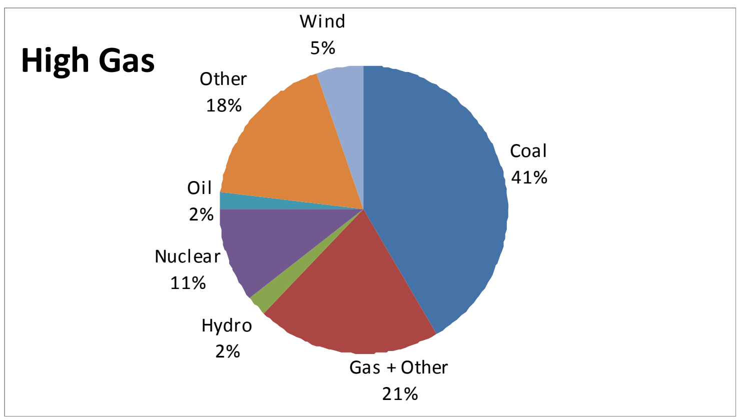
Phase 1 Results

2029 High Gas & Low Carbon

High Gas & Low Carbon Futures – On Peak

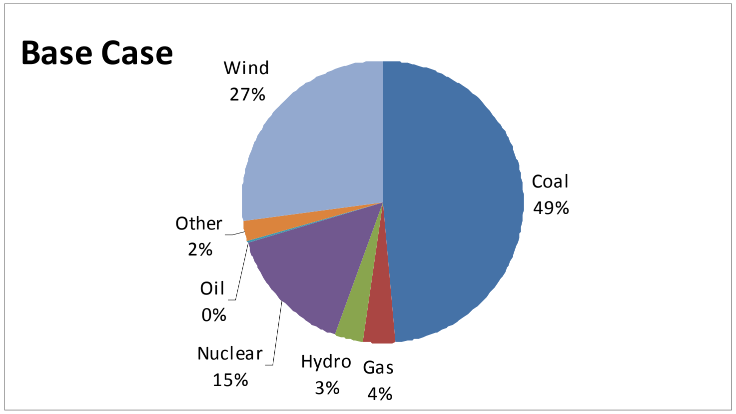


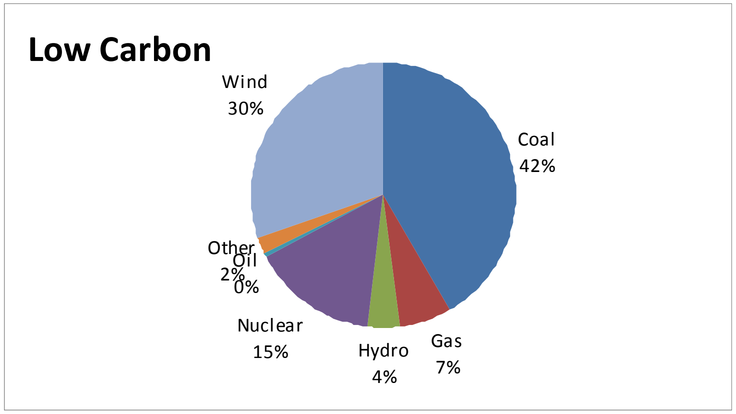


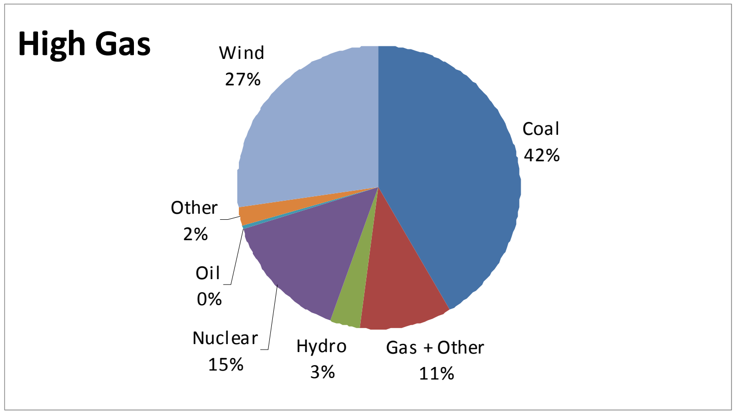


- High Gas – 16% to 21%
  ~11.7GW increase in Gas
- Low Carbon – Added 1.1GW Hydro + 1GW Nuclear + 3GW SPP imports + 2GW wind increase + 4GW new gas
- Low Carbon - 2GW retirement of Coal Units 250MW or less & over 40 yrs old

High Gas & Low Carbon Futures – Off Peak







- High Gas 0n-peak 4% to 11% ~11.7GW increase in Gas
- Low Carbon – Added 1.1GW Hydro + 1GW Nuclear + 3GW SPP imports + 2GW wind increase + 4GW new gas
- Low Carbon - 2GW retirement of Coal Units 250MW or less & over 40 yrs old

2029 High Gas Results

Ref	2029 High Gas Case	Off Peak			On Peak		
		Alt 2	Alt 5	Alt 5-A	Alt 2	Alt 5	Alt 5-A
1	Number of EHV voltage violations-Basecase	0	0	0	0	0	0
2	Number of EHV Thermal violations- Basecase	0	0	0	0	0	0
3	Number of EHV unsolvable-contingency	0	0	0	0	0	0
4	Number of EHV thermal violations-contingency	0	0	2	0	0	0
5	Number of EHV voltage violations-contingency	1	0	0	2	2	2
6	Number of other Line Thermal violations-Basecase	4	4	4	11	11	11
7	Number of other unsolvable-contingency	5	3	3	11	13	13
8	Number of other element thermal violations resulting from EHV contingency	7	13	17	2	3	6
9	Number of other thermal violations resulting from contingencies on existing system	74	58	41	84	89	111

Notes:

1. Ref 1-5 reflect the results directly related to the proposed EHV alternative
2. Thermal violations shown in Alt 5A Off-Peak, Ref 4, reflect the over loading of 2 transformers at Nelson.
3. Voltage violations in Ref 5 can be fixed with the addition of capacitors or reactors.
4. Ref 6-9 reflect the results of the facilities other than the proposed EHV alternative. Violations in Ref 6-9 are shown for completeness and are generally a function of load growth or where the wind resources are located. Those violations are expected to be picked up during the annual planning studies. Ref 8 gives an indication of the impact on the underlying system from contingencies on the EHV alternatives. However, solutions for those violations are not proposed because the uncertainty of the underlying system for 2029.

2029 High Gas – Sensitivities

Ref	High Gas Case Sensitivities	High Wind			Imports from SPP			Low Wind		
		Alt 2	Alt 5	Alt 5-A	Alt 2	Alt 5	Alt 5-A	Alt 2	Alt 5	Alt 5-A
1	Number of EHV voltage violations-Basecase	0	0	0	0	0	0	0	1	1
2	Number of EHV Thermal violations- Basecase	0	1	1	0	0	0	0	0	0
3	Number of EHV unsolvable-contingency	18	15	13	15	24	27	0	0	0
4	Number of EHV thermal violations-contingency	3	1	1	0	0	0	0	0	0
5	Number of EHV voltage violations-contingency	2	2	1	4	0	0	8	2	3
6	Number of other Line Thermal violations-Basecase	14	20	20	5	7	6	2	0	0
7	Number of other unsolvable-contingency	12	13	8	19	34	43	3	2	1
8	Number of other element thermal violations resulting from EHV contingency	10	41	41	4	13	12	0	1	1
9	Number of other thermal violations resulting from contingencies on existing system	87	151	125	85	94	97	16	13	16

Notes:

1. Ref 1-5 reflect the results directly related to the proposed EHV alternative
2. Ref 3 for the sensitivities of High Wind and Imports from SPP show a number of contingencies that would not solve. Also Refs 2 & 4 indicate there are thermal violations. These results indicate that the system is stressed and that we are seeing the capability limits of the proposed alternative.
3. Ref 6-9 reflect the results of the facilities other than the proposed EHV alternative. Violations in Ref 6-9 are shown for completeness and are generally a function of load growth or where the wind resources are located. Those violations are expected to be picked up during the annual planning studies. Ref 8 gives an indication of the impact on the underlying system from contingencies on the EHV alternatives. However, solutions for those violations are not proposed because the uncertainty of the underlying system for 2029.

2029 High Gas – Sensitivities

Ref	High Gas Case Sensitivities	High Load		
		Alt 2	Alt 5	Alt 5-A
1	Number of EHV voltage violations-Basecase	0	0	0
2	Number of EHV Thermal violations- Basecase	0	0	0
3	Number of EHV unsolvable-contingency	1	0	0
4	Number of EHV thermal violations-contingency	0	0	0
5	Number of EHV voltage violations-contingency	2	3	3
6	Number of other Line Thermal violations-Basecase	13	12	11
7	Number of other unsolvable-contingency	18	17	19
8	Number of other element thermal violations resulting from EHV contingency	2	3	7
9	Number of other thermal violations resulting from other contingencies	90	98	134

Notes:

1. Ref 1-5 reflect the results directly related to the proposed EHV alternative.
2. Ref 3 for the sensitivity of High Load for Alt 2, one contingency did not solve, (2 lines) 345kV Charter Grove – 345kV Wayne.
3. Voltage violations in Ref 5 can be fixed with the addition of capacitors or reactors.
4. Ref 6-9 reflect the results of the facilities other than the proposed EHV alternative. Violations in Ref 6-9 are shown for completeness and are generally a function of load growth or where the wind resources are located. Those violations are expected to be picked up during the annual planning studies. Ref 8 gives an indication of the impact on the underlying system from contingencies on the EHV alternatives. However, solutions for those violations are not proposed because the uncertainty of the underlying system for 2029.

2029 Low Carbon Results

Ref	2029 Low Carbon Case	Off Peak			On Peak		
		Alt 2	Alt 5	Alt 5-A	Alt 2	Alt 5	Alt 5-A
1	Number of EHV voltage violations-Basecase	0	0	0	0	0	0
2	Number of EHV Thermal violations- Basecase	0	0	0	0	0	0
3	Number of EHV unsolvable-contingency	3	4	6	0	0	1
4	Number of EHV thermal violations-contingency	0	0	0	0	0	0
5	Number of EHV voltage violations-contingency	5	1	2	3	2	2
6	Number of other Line Thermal violations-Basecase	2	6	6	13	15	16
7	Number of other unsolvable-contingency	2	3	0	10	9	9
8	Number of other element thermal violations resulting from EHV contingency	24	16	13	6	4	4
9	Number of other thermal violations resulting from other contingencies	90	44	46	148	130	129

Notes:

1. Ref 1-5 reflect the results directly related to the proposed EHV alternative
2. Ref 3 for the Off Peak Low Carbon case shows a number of contingencies that would not solve. These contingencies were located in the vicinity of Belvedere – New Sub WI2, Kewanee – Quad City – Buchanan.
3. Voltage violations in Ref 5 can be fixed with the addition of capacitors or reactors.
4. Ref 6-9 reflect the results of the facilities other than the proposed EHV alternative. Violations in Ref 6-9 are shown for completeness and are generally a function of load growth or where the wind resources are located. Those violations are expected to be picked up during the annual planning studies. Ref 8 gives an indication of the impact on the underlying system from contingencies on the EHV alternatives. However, solutions for those violations are not proposed because the uncertainty of the underlying system for 2029.

2029 Low Carbon - Sensitivities

Ref	2029 Low Carbon Case - Sensitivities	High Wind			Imports from SPP			Low Wind		
		Alt 2	Alt 5	Alt 5-A	Alt 2	Alt 5	Alt 5-A	Alt 2	Alt 5	Alt 5-A
1	Number of EHV voltage violations-Basecase	0	0	0	0	0	0	0	0	0
2	Number of EHV Thermal violations- Basecase	0	0	0	0	0	0	0	0	0
3	Number of EHV unsolvable-contingency	69	27	42	10	9	15	0	0	1
4	Number of EHV thermal violations-contingency	0	2	2	3	0	0	1	1	1
5	Number of EHV voltage violations-contingency	0	0	1	2	0	2	8	6	7
6	Number of other Line Thermal violations-Basecase	8	14	12	2	7	7	2	3	3
7	Number of other unsolvable-contingency	231	10	104	1	3	5	1	1	2
8	Number of other element thermal violations resulting from EHV contingency	1	15	19	17	21	14	5	1	0
9	Number of other thermal violations resulting from other contingencies	227	163	108	135	60	57	26	17	16

Notes:

1. Ref 1-5 reflect the results directly related to the proposed EHV alternative
2. Ref 3 for the sensitivities of High Wind and Imports from SPP show a number of contingencies that would not solve. Also Ref 4 indicates there are thermal violations. These results indicate that the system is stressed and that we are seeing the capability limits of the proposed alternatives.
3. Ref 6-9 reflect the results of the facilities other than the proposed EHV alternative. Violations in Ref 6-9 are shown for completeness and are generally a function of load growth or where the wind resources are located. Those violations are expected to be picked up during the annual planning studies. Ref 8 gives an indication of the impact on the underlying system from contingencies on the EHV alternatives. However, solutions for those violations are not proposed because the uncertainty of the underlying system for 2029.

2029 Low Carbon - Sensitivities

Ref	2029 Low Carbon Case - Sensitivities	High Load		
		Alt 2	Alt 5	Alt 5-A
1	Number of EHV voltage violations-Basecase	0	0	0
2	Number of EHV Thermal violations- Basecase	0	0	0
3	Number of EHV unsolvable-contingency	0	0	1
4	Number of EHV thermal violations-contingency	0	0	0
5	Number of EHV voltage violations-contingency	3	3	3
6	Number of other Line Thermal violations-Basecase	14	15	16
7	Number of other unsolvable-contingency	12	13	14
8	Number of other element thermal violations resulting from EHV contingency	10	5	14
9	Number of other thermal violations resulting from other contingencies	197	160	191

Notes:

1. Ref 1-5 reflect the results directly related to the proposed EHV alternative.
2. Ref 3 for the sensitivity of High Load for Alt 2, one contingency did not solve, (2 lines) 345kV Charter Grove – 345kV Wayne.
3. Voltage violations in Ref 5 can be fixed with the addition of capacitors or reactors.
4. Ref 6-9 reflect the results of the facilities other than the proposed EHV alternative. Violations in Ref 6-9 are shown for completeness and are generally a function of load growth or where the wind resources are located. Those violations are expected to be picked up during the annual planning studies. Ref 8 gives an indication of the impact on the underlying system from contingencies on the EHV alternatives. However, solutions for those violations are not proposed because the uncertainty of the underlying system for 2029.

Summary of Conceptual Alternatives

High Level Summary	Alt 2	Alt 5	Alt 5A
Number of 345kV new Lines, single circuit.	63	6	6
Total Single Circuit miles 345 lines	245	0	0
Total Structure miles of 345 double circuit lines	4,776	80	80
Number of 765kV new Lines, single circuit.	32	53	49
Total Circuit miles length of 765 lines	3,950	8,156	7,448
Number of 765/345 kV Transformers	35	53	53
Number of 230/345 kV Transformers	1	1	1
Number of River Crossing lines	8	7	7
HVDC Underwater Cable Circuit miles	64	91	91
HVDC Overhead Cable Circuit miles	200	0	385
Number of 345kV new buses or connection to existing buses	34	5	5
Number of 765kV new buses or connection to existing buses	32	46	44

Cost Assumptions

Element	Value
Transmission Lines	
Single circuit 345 kV - $M/mile	1.5
Double structure 345 kV - $M/mile	1.97
Single circuit 765 kV - $M/mile	2.71
Transformers	
230/345 kV, 500 MVA - $M	6.5
765/345 kV, 1000 MVA - $M	12
765/345 kV, 2250 MVA - - $M	21.2
Network Stations	
345 kV three terminals - $M	11.8
765 kV three terminals - $M	25.1
River Crossing costs	7
HVDC	
HVDC OH Cable - $M/mile	1.92
HVDC UW Cable - $M/mile	8.8
Converter/Inverter Station - $M	240

Cost Estimates for Updated Alternatives

Line Costs in Millions of Dollars	Alternative 2	Alternative 5	Alternative 5A
Estimated Cost for 345kV Lines	$9,776	$158	$158
Estimated Cost for 765 kV Lines	$10,705	$22,102	$20,185
Total Cost Transmission Lines	**$20,481**	**$22,259**	**$20,342**
Transformers Costs			
Estimated Cost of 765/345 kV Transformers	$742	$1,124	$1.124
Estimated Cost of 230/345 kV Transformers	$7	$7	$7
Total Costs Transformation	**$749**	**$1130**	**$1130**
Network Substation/Station Costs 345 Kv	$496	$24	$24
Network Substation/Station Costs 765 kV	**$527**	$879	$853
Total cost	**$1,023**	**$902**	**$877**
River Crossing line costs	$56	$49	$49
HVDC Costs	$1,427	$1,281	$2,500
Total Estimated Costs	**$23,735**	**$25,621**	**$24,898**

Phase 1 Results

2024 & 2019 Wind Models

Wind Models – RPS Basis for 2024 & 2019

Year	IA	IL	IN	MI	MN	MO	ND	NE	OH	SD	WI	Average
2029	20%	25%	20%	20%	28%	20%	20%	20%	25%	20%	25%	22%
2024	15%	23.5%	15%	15%	25%	15%	16%	15%	25%	16%	24%	18%
2019	12.5%	16%	12.5%	12.5%	20%	12.5%	12.5%	12.5%	15%	12.5%	19%	14%
2015	10%	10%	10%	10%	15%	10%	10%	10%	5%	10%	13%	10%

- The focus of this chart is to show how the RPS requirements of were developed for 2024 and 2019 analysis with a given 2029. Requirements for each state were incorporated into the development.
- Yellow highlights are known values taken from: http://www.dsireusa.org/summarymaps/index.cfm?ee=1&RE=1
- Gray Highlights are estimated values

Wind Models

State	Base Case Wind			Low Wind			High Wind		
	2029	**2024**	**2019**	**2029**	**2024**	**2019**	**2029**	**2024**	**2019**
IA	6,694	5,753	4,696	5,078	4,869	4,102	7,684	6,331	4,969
IL	7,919	6,774	4,486	5,026	4,774	3,466	10,198	8,641	5,446
IN	3,577	2,905	2,482	1,035	1,035	1,035	4,537	3,351	2,703
MI	8,201	5,852	4,640	3,519	3,466	3,415	10,186	6,919	5,222
MN	5,876	5,082	3,869	5,042	4,967	4,448	7,298	6,009	4,354
MO	3,070	2,357	1,555	1,845	1,686	1,104	3,821	2,795	1,762
ND	4,833	3,783	2,602	3,029	2,795	1,938	5,939	4,428	2,906
NE	5,196	3,893	2,429	2,958	2,668	1,606	6,567	4,693	2,806
OH	4,729	4,500	2,570	4,059	3,999	2,365	5,873	5,320	2,893
SD	4,208	3,196	2,057	2,469	2,243	1,417	5,274	3,818	2,351
WI	2,506	2,483	1,998	2,061	1,852	1,686	3,152	2,859	2,169
Total	56,809	46,579	33,384	36,121	34,355	26,582	70,528	55,164	37,581

Variables: RPS requirements and yearly Energy Growth

Base Wind: Federal RPS 20% - State RPS – Utility RPS – 1% Energy Growth

Low Wind: State only RPS requirements - 0.3% Energy Growth

High Wind: RPS is the same as Base Wind – 2% Energy Growth

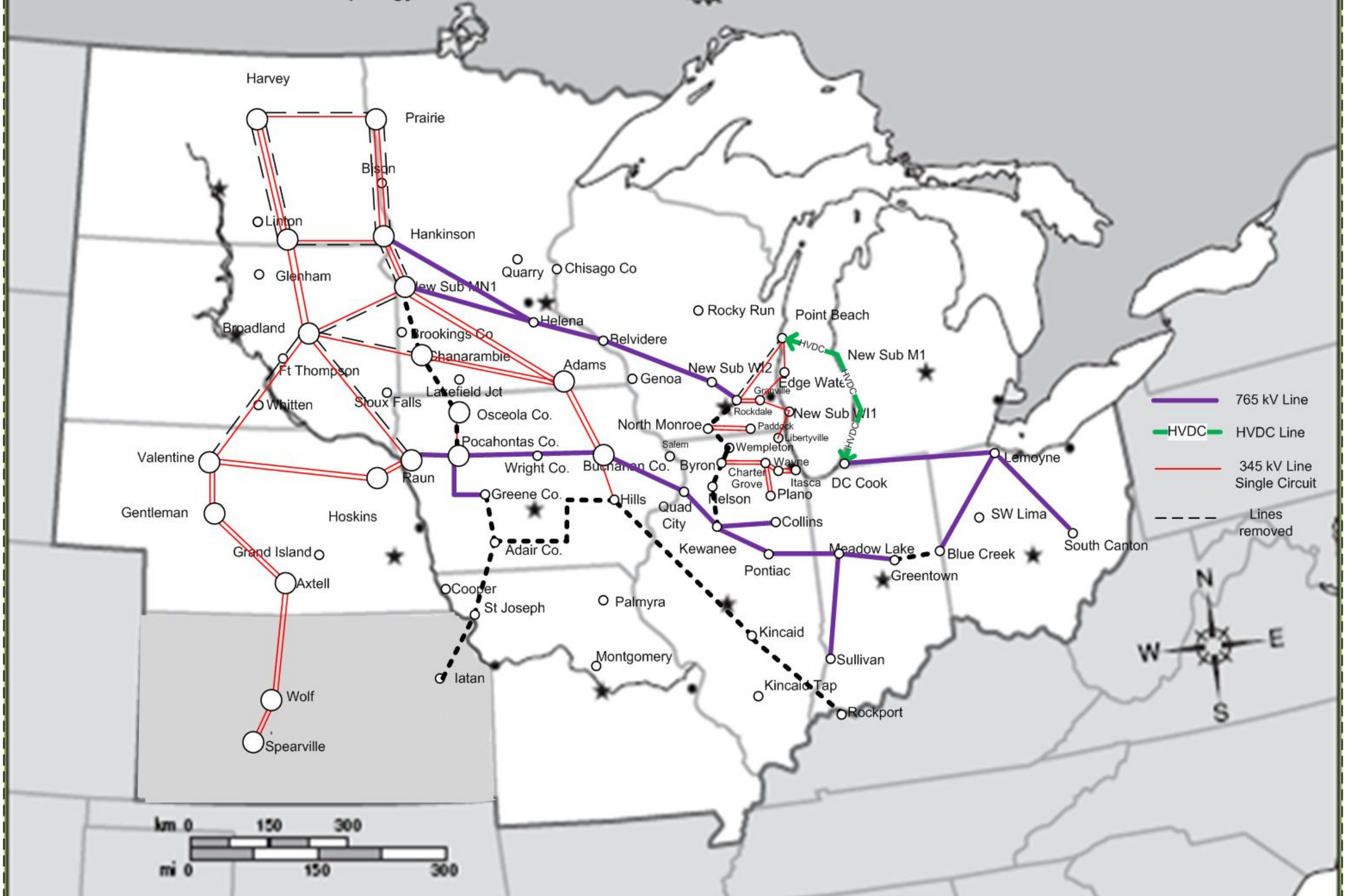
Phase 1 Results

2024 & 2019 Sequencing

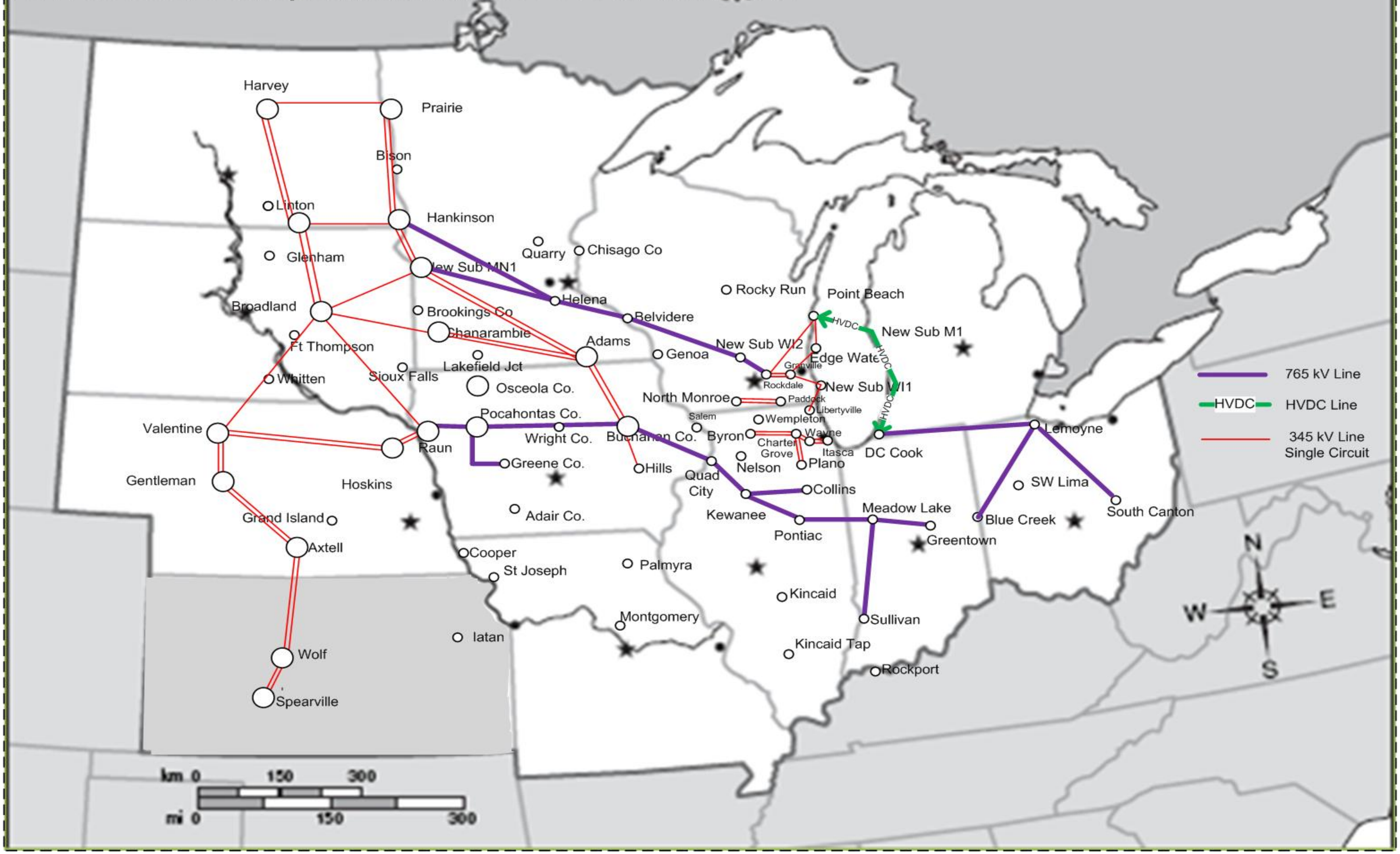
Approach on Sequencing

- Wind locations are an important assumption that drives the transmission designs
- Wind locations are not changed over the years, but scaled from 2029 to 2024 and 2019 requirements
- Lightly loaded lines are removed
- 2024 and 2019 designs are tested for N-1 contingencies.
- Light loaded lines are removed and retested

2024 Lines removed from 2029 Topology Alternative 2- 345 kV and 765 kV

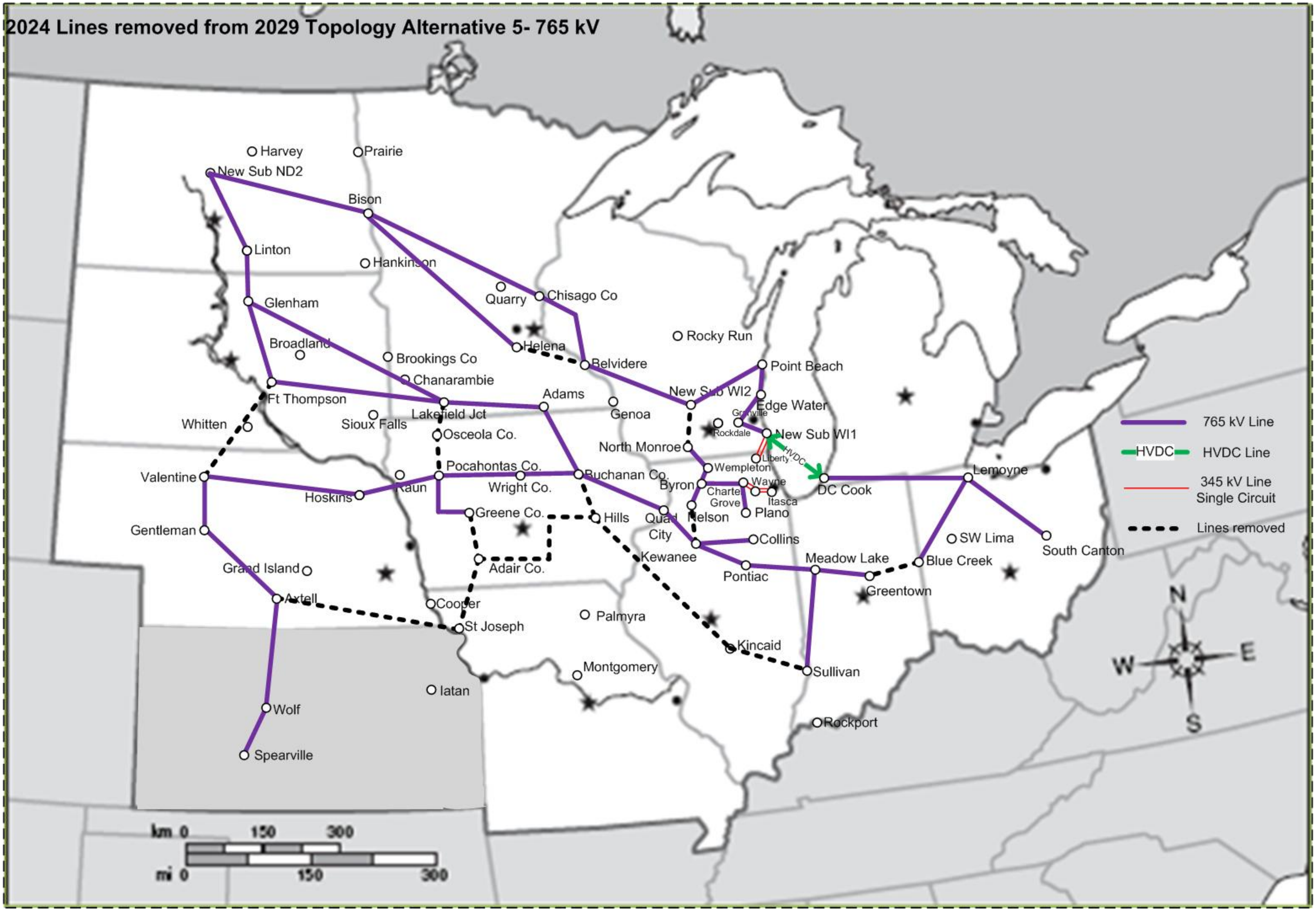


2024 Revised Conceptual Alternative 2- 345 kV and 765 kV



Based on performance results, a number of 345kV and 765kV lines were removed

- Removed Rockport-Kincaid-Hills-Adair Co-St Joseph-Iatan, and Adair-Green Co
- Removed Kewanee to…to Rockdale
- Removed 345kV lines from Harvey-Prairie, Ft Thompson – NS MN1, Chanarambie, Raun, Valentine


2024 Lines removed from 2029 Topology Alternative 5- 765 kV
Harvey
Prairie
New Sub ND2
Bison
Linton
Hankinson
Quarry
Chisago Co
Glenham
Broadland
Brookings Co
Chanarambie
Helena
Belvidere
Rocky Run
Point Beach
Ft Thompson
Adams
Genoa
New Sub WI2
Edge Water
Whitten
Sioux Falls
Lakefield Jct
Osceola Co.
Granville
Rockdale
New Sub WI1
North Monroe
Liberty
HVDC
Pocahontas Co.
Buchanan Co.
Wempleton
Valentine
Raun
Wright Co.
Byron
Wayne
DC Cook
Lemoyne
Hoskins
Charter Grove
Itasca
Greene Co.
Hills
Quad City
Nelson
Plano
Gentleman
Collins
SW Lima
South Canton
Adair Co.
Kewanee
Meadow Lake
Blue Creek
Grand Island
Pontiac
Greentown
Axtell
Cooper
Palmyra
St Joseph
Kincaid
Montgomery
Sullivan
Iatan
Wolf
Rockport
Spearville
765 kV Line
HVDC Line
345 kV Line Single Circuit
Lines removed
N
W
E
S
km 0 150 300
mi 0 150 300

2024 Revised Conceptual Alternative 5- 765 kV

Based on performance results, a number of 765kV lines were removed

- Removed Rockport-Kincaid-Hills-Adair Co-St Joseph-Iatan, Adair-Green Co
- Removed Kewanee – Nelson, North Monroe – NS WI2
- Removed Helena – Belvedere
- Removed Lakefield Junction – Osceola – Pocahontas
- Removed Green Town – Blue Creek

2024 Base Wind Results

Ref	2024 Base Case Wind	Off Peak		On Peak	
		Alt 2	Alt 5	Alt 2	Alt 5
1	Number of EHV voltage violations-Basecase	0	0	0	0
2	Number of EHV Thermal violations- Basecase	0	0	0	0
3	Number of EHV unsolvable-contingency	0	0	0	0
4	Number of EHV thermal violations-contingency	0	0	0	0
5	Number of EHV voltage violations-contingency	3	1	0	1
6	Number of other Line Thermal violations-Basecase (Direct result of the wind injections)	3	11	0	0
7	Number of other unsolvable-contingency (Direct result of load growth - not on EHV)	5	5	10	9
8	Number of other element thermal violations resulting from EHV contingency(Wind injections)	4	6	0	0
9	Number of other thermal violations resulting from other contingencies(result of Load growth)	29	17	45	69

Notes:

1. Ref 1-5 reflect the results directly related to the proposed EHV alternative
2. Voltage violations in Ref 5 can be fixed with the addition of capacitors or reactors.
3. Ref 6-9 reflect the results of the facilities other than the proposed EHV alternative. Violations in Ref 6-9 are shown for completeness and are generally a function of load growth or where the wind resources are located. Those violations are expected to be picked up during the annual planning studies. Ref 8 gives an indication of the impact on the underlying system from contingencies on the EHV alternatives. However, solutions for those violations are not proposed because the uncertainty of the underlying system for 2024.

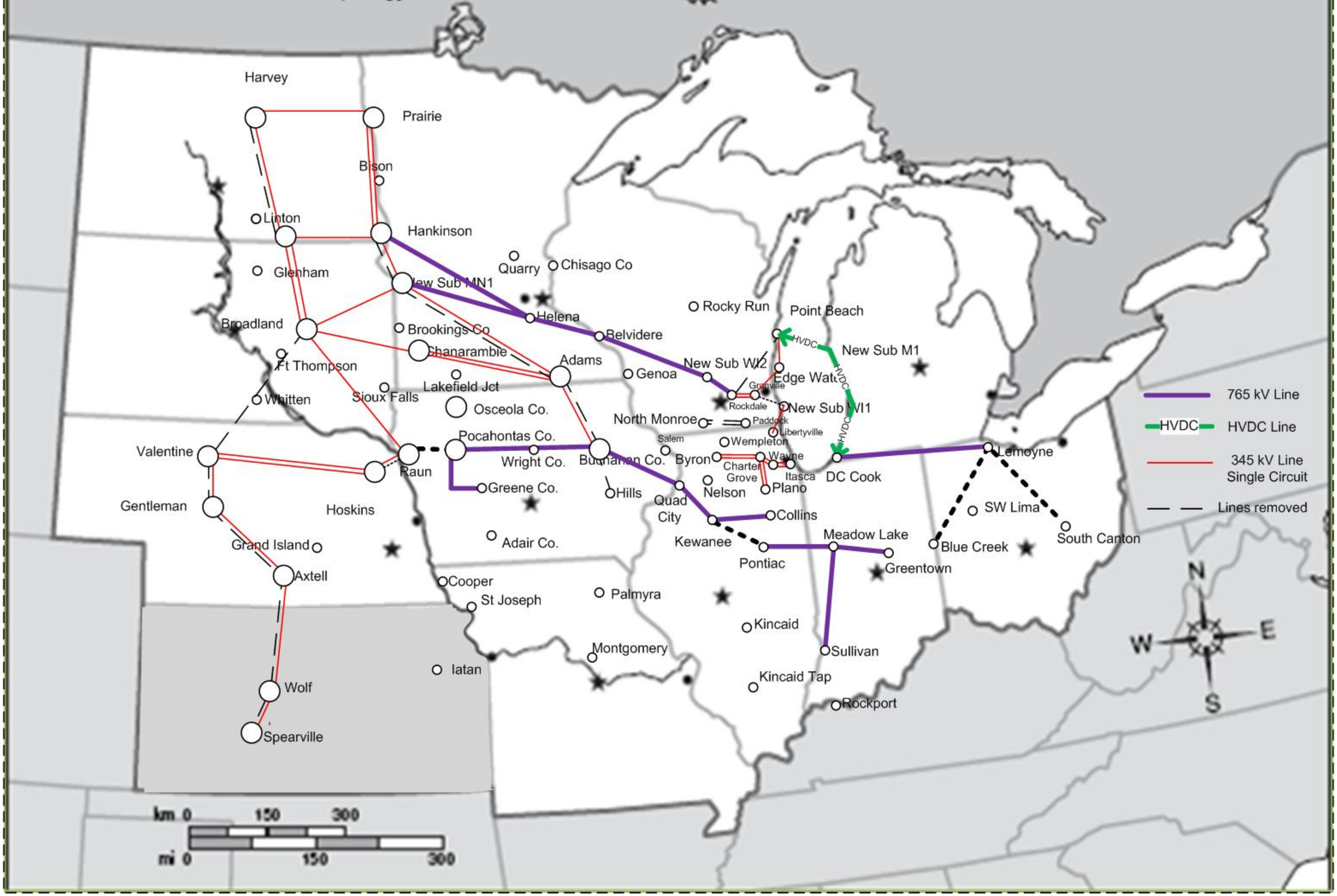
2024 Base Case Wind - Sensitivities

Ref	2024 Base Case Wind	High Wind		Import SPP		Low Wind		High Load	
		Alt 2	Alt 5	Alt 2	Alt 5	Alt 2	Alt 5	Alt 2	Alt 5
1	Number of EHV voltage violations-Basecase	0	0	0	0	0	0	0	0
2	Number of EHV Thermal violations- Basecase	0	0	0	0	0	0	0	0
3	Number of EHV unsolvable-contingency	11	4	1	2	0	0	0	0
4	Number of EHV thermal violations-contingency	0	2	0	0	0	0	0	0
5	Number of EHV voltage violations-contingency	9	3	1	0	4	29	0	1
6	Number of other Line Thermal violations-Basecase	10	6	7	5	2	3	6	5
7	Number of other unsolvable-contingency	6	4	3	3	2	3	11	13
8	Number of other element thermal violations resulting from EHV contingency	17	28	1	18	0	1	0	19
9	Number of other thermal violations resulting from other contingencies	198	90	31	22	13	9	79	261

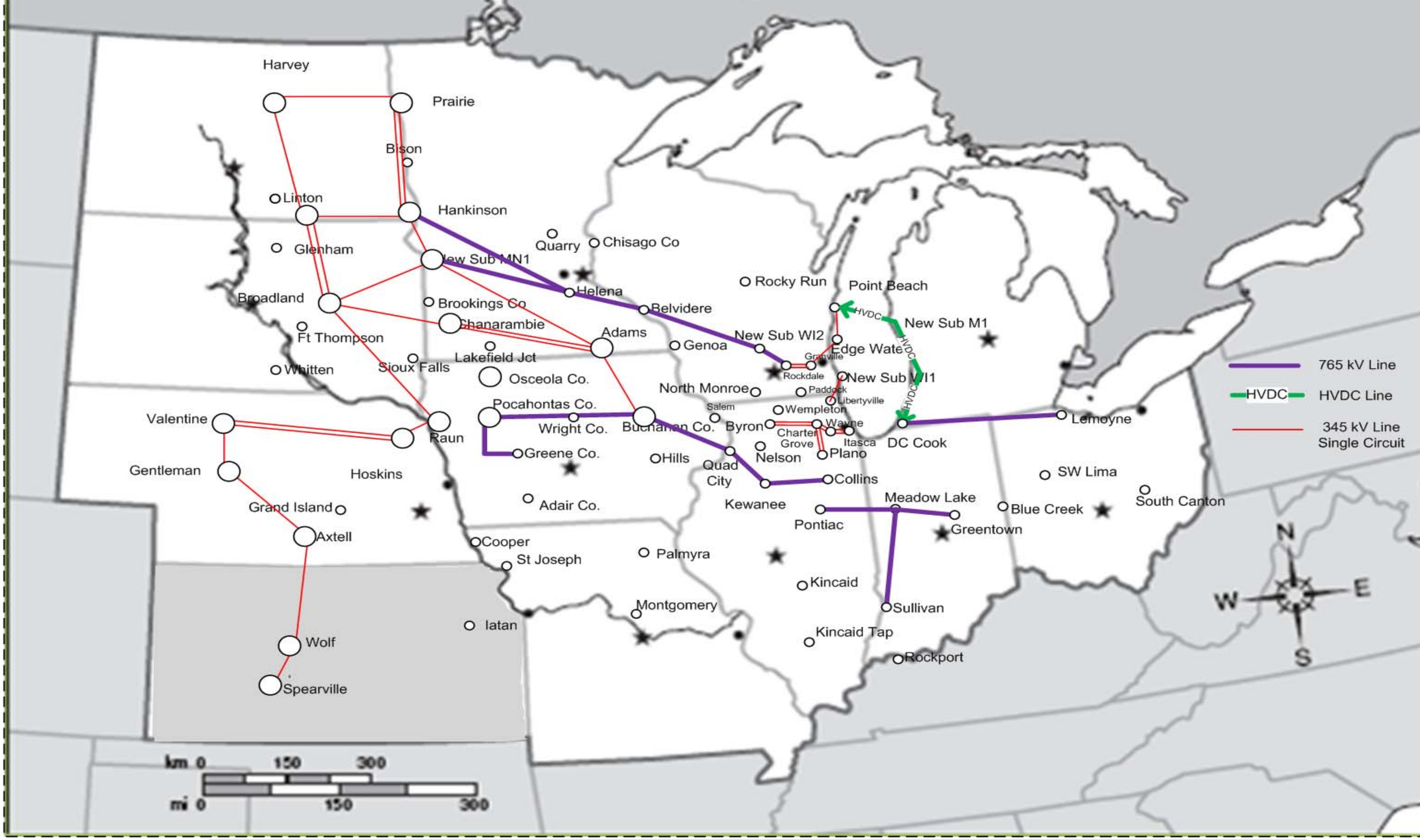
Notes:

1. Ref 1-5 reflect the results directly related to the proposed EHV alternative
2. Ref 3 for the sensitivities of High Wind and Imports from SPP show a number of contingencies that would not solve. Also Ref 4 indicates there are thermal violations. These results indicate that the system is stressed and that we are seeing the capability limits of the proposed alternatives.
3. Ref 6-9 reflect the results of the facilities other than the proposed EHV alternative. Violations in Ref 6-9 are shown for completeness and are generally a function of load growth or where the wind resources are located. Those violations are expected to be picked up during the annual planning studies. Ref 8 gives an indication of the impact on the underlying system from contingencies on the EHV alternatives. However, solutions for those violations are not proposed because the uncertainty of the underlying system for 2024.

2019 Lines removed from 2024 Topology Alternative 2- 345 kV and 765 kV



2019 Revised Conceptual Alternative 2- 345 kV and 765 kV

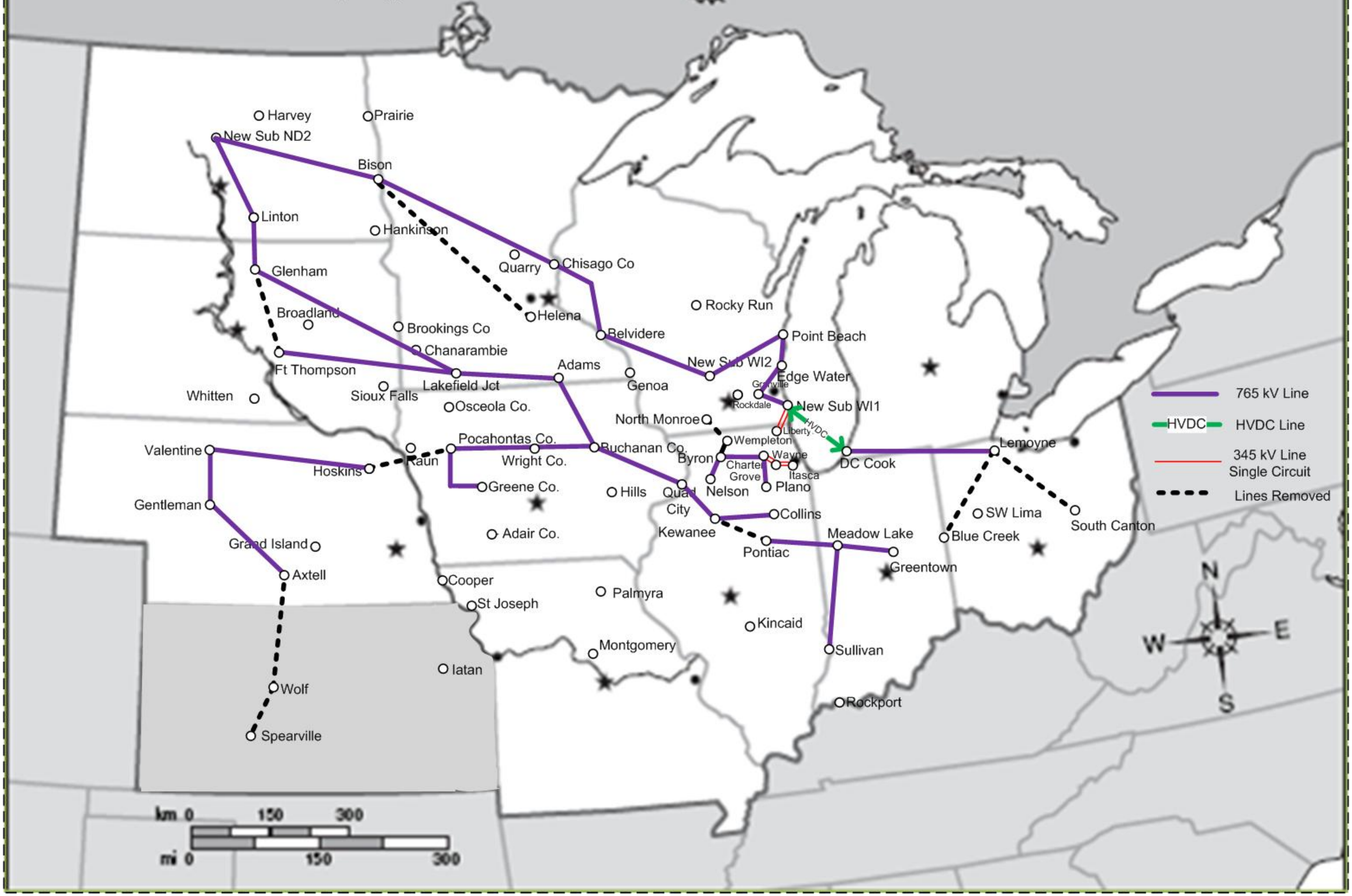


Based on performance results, a number of 345kV and 765kV lines were removed

- Removed 765kV South Canton – Lemoyne - Blue Creek, Kewanee - Pontiac
- Removed 345kv Harvey – Linton
- Removed 345kV NS MN1 – Adams – Buchanan Co - Hills
- Removed 345kV Raun – Pocahontas
- Removed 345kV Valentine – Ft Thompson, 345kV Valentine – Gentleman – Axtell – Wolf – Spearville

QUANTA TECHNOLOGY

2019 Lines removed from 2024 topology Alternative 5- 765 kV



2019 Revised Conceptual Alternative 5- 765 kV

Based on performance results, a number of 765kV lines were removed

- Removed 765kV Bison – Helena
- Removed 765kV Hoskins – Pocahontas
- Removed 765kV Glenham – Ft Thompson
- Removed 765kV Axtell – Wolf – Spearville
- Removed 765kV Pontiac – Kewanee
- Removed 765kV North Monroe – Byron
- Removed 765kV South Canton – Lemoyne – Blue Creek

QUANTA TECHNOLOGY

2019 Base Case Wind

Ref	2019 Base Case Wind	Off Peak		On Peak	
		Alt 2	Alt 5	Alt 2	Alt 5
1	Number of EHV voltage violations-Basecase	0	1	0	0
2	Number of EHV Thermal violations- Basecase	0	0	0	0
3	Number of EHV unsolvable-contingency	0	0	0	0
4	Number of EHV thermal violations-contingency	0	0	0	0
5	Number of EHV voltage violations-contingency	4	0	0	0
6	Number of other Line Thermal violations-Basecase	2	2	0	0
7	Number of other unsolvable-contingency	3	3	5	5
8	Number of other element thermal violations resulting from EHV contingency	5	20	0	0
19	Number of other thermal violations resulting from other contingencies	34	13	31	44

Notes:

1. Ref 1-5 reflect the results directly related to the proposed EHV alternative
2. Ref 1 for the Off Peak Base Wind Alt 2 there was a voltage concern at Lakefield Junction (1.06).
3. Voltage violations in Ref 5 can be fixed with the addition of capacitors or reactors.
4. Ref 6-9 reflect the results of the facilities other than the proposed EHV alternative. Violations in Ref 6-9 are shown for completeness and are generally a function of load growth or where the wind resources are located. Those violations are expected to be picked up during the annual planning studies. Ref 8 gives an indication of the impact on the underlying system from contingencies on the EHV alternatives. However, solutions for those violations are not proposed because the uncertainty of the underlying system for 2019.

2019 Base Case Wind - Sensitivities

Ref	2019 Base Case Wind Sensitivities	High Wind		Imports SPP		Low Wind		High Load	
		Alt 2	Alt 5	Alt 2	Alt 5	Alt 2	Alt 5	Alt 2	Alt 5
1	Number of EHV voltage violations-Basecase	0	0	0	1	0	1	0	0
2	Number of EHV Thermal violations- Basecase	0	0	0	0	0	0	0	0
3	Number of EHV unsolvable-contingency	1	4	0	1	0	0	0	0
4	Number of EHV thermal violations-contingency	1	2	0	0	0	0	0	0
5	Number of EHV voltage violations-contingency	3	4	3	1	7	0	0	0
6	Number of other Line Thermal violations-Basecase	2	3	2	2	2	0	0	0
7	Number of other unsolvable-contingency	4	7	4	5	3	2	5	6
8	Number of other element thermal violations resulting from EHV contingency	0	2	4	7	0	1	0	0
9	Number of other thermal violations resulting from other contingencies	11	21	30	17	16	15	34	53

Notes:

1. Ref 1-5 reflect the results directly related to the proposed EHV alternative
2. Ref 3 for the sensitivities of High Wind and Imports from SPP show a number of contingencies that would not solve. Also Ref 4 indicates there are thermal violations. These results indicate that the system is stressed and that we are seeing the capability limits of the proposed alternatives.
3. Ref 6-9 reflect the results of the facilities other than the proposed EHV alternative. Violations in Ref 6-9 are shown for completeness and are generally a function of load growth or where the wind resources are located. Those violations are expected to be picked up during the annual planning studies. Ref 8 gives an indication of the impact on the underlying system from contingencies on the EHV alternatives. However, solutions for those violations are not proposed because the uncertainty of the underlying system for 2019.

Summary of Phase 1

- Eight alternatives were evaluated: one 345kV only; two 345kV/765kV; and five 765 kV alternatives.
- After evaluating all the alternatives from a cost and performance perspective, modified versions of Alternative 2 (345 kV/765 kV), Alternative 5 (765 kV), and Alternative 5A (765 kV with HVDC) were chosen for additional analysis using futures and sensitivities. They were chosen based on their cost and reliability performance in the base case which contained a total of 56.8 GW of nameplate wind generation within the study area. This amount of wind generally reflects the current RPS requirements for those states that have an RPS requirement or goal.
  - The 345 kV alternative solves for the low wind case only and the cost of that alternative is higher than the other alternatives so it was not analyzed further.
- Alternatives 2, 5, and 5a all work technically in the futures and sensitivity analysis with manageable contingencies and mitigations. Because HVDC options may not provide local benefits by offering low cost on and off ramps for energy in southern Iowa, northeastern Missouri, and Illinois Alternatives 2 and 5 were chosen for “sequencing” – developing and testing interim-year plans toward the ultimate 2029 build out.
  - Based on the Study’s assumptions, the SMART Study team developed workable solutions for 2019 and 2024 for Alternatives 2 and 5.
  - This effort provides a potential scenario for a phased build out. Actual sequencing of the transmission overlay will be dependent on where and when wind generation is developed as well as the magnitude and distribution of load growth.
- Alternatives 2 and 5 will be further studied in Phase 2 to evaluate their relative economic performance.
- Coordination with the ISOs / RTOs and appropriate regulatory approvals will be required to get the EHV overlay in place since they will ultimately decide what and when projects get built.
- The study does not address cost allocation.

Phase 2 Update

Phase 2 Objectives

- Develop the needs assessment for the economic study.
- Identify the key assumptions used in the economic study.
- Identify a better performing alternative between Alternative 2 and Alternative 5 identified in Phase I.
- Develop the report.

Production Model Key Assumptions

- Study Years: 2019, 2024, 2029
- Production Model: RGOS model from MISO
- Underlying input data contained in PROMOD Powerbase
  - Updated fuel and emission costs on November 2009 PROMOD Powerbase update.
- PROMOD Study Footprint
  - MISO, MAPP, and partial PJM area (AEP and ComEd)
- Powerflow Cases
  - MTEP09 2019 power flow case to represent future system
- Wind Hourly Profile
  - Hourly wind profile as collected by NREL for new wind power development in 2004 – 2006

Key Assumptions for Economic Model Development

Uncertainty		Unit	RGOS Study Value (in 2010 $)	SMART Study Value
Demand and Energy	Demand Growth Rate	%	1.60	Varying[1]
	Energy Growth Rate	%	2.19	Varying[1]
Fuel Prices (Starting Values)	Gas	($/MBtu)	6.22[2]	Same[3]
	Oil	($/Mbtu)	PowerBase Default	Same[3]
	Coal	($/Mbtu)	PowerBase Default (by unit)	Same[3]
	Uranium	($/Mbtu)	1.12	Same[3]
Fuel Prices (Escalation Rates)	Gas	%	2.91	Same[3]
	Oil	%	2.91	Same[3]
	Coal	%	2.91	Same[3]
	Uranium	%	2.91	Same[3]
Emission Costs	SO_2	($/ton)	PowerBase Default[4,6]	Same[3]
	NOx	($/ton)	PowerBase Default[5,6]	Same[3]
	CO_2	($/ton)	0[7]	Same[3]
Economic Parameters	Discount Rate	%	8.39	Same[3]
	Inflation Rate	%	2.91	Same[3]
O&M for New Wind	Variable O&M	($/MWh)	5.46[8]	Same[3]
Reserve Target		%	15 for MISO	Same[3]

1. Demand growth rate and energy growth rate in the SMART PROMOD model will be different for different regions as specified in the Phase I.
2. Henry Hub 2010 price.
3. Same as used in the RGOS model.
4. PowerBase default values of SO2 annual are: $564.66 in 2019, $574.37 in 2024, $626.94 in 2029.
5. PowerBase default values of NOx annual are: $525.72 in 2019, $466.22 in 2024, $274.80 in 2029.
6. Ventyx uses a proprietary emission forecast model (EFM) to simulate emission control decisions and results simultaneously in the three cap-and-trade markets (SO2, NOX Annual, and NOX Seasonal).
7. None-zero carbon tax values will be used in the sensitivity runs.
8. Variable O&M value used in the RGOS study for the new wind farms came from the Eastern Wind Integration and Transmission Study (EWITS).

PROMOD Cases

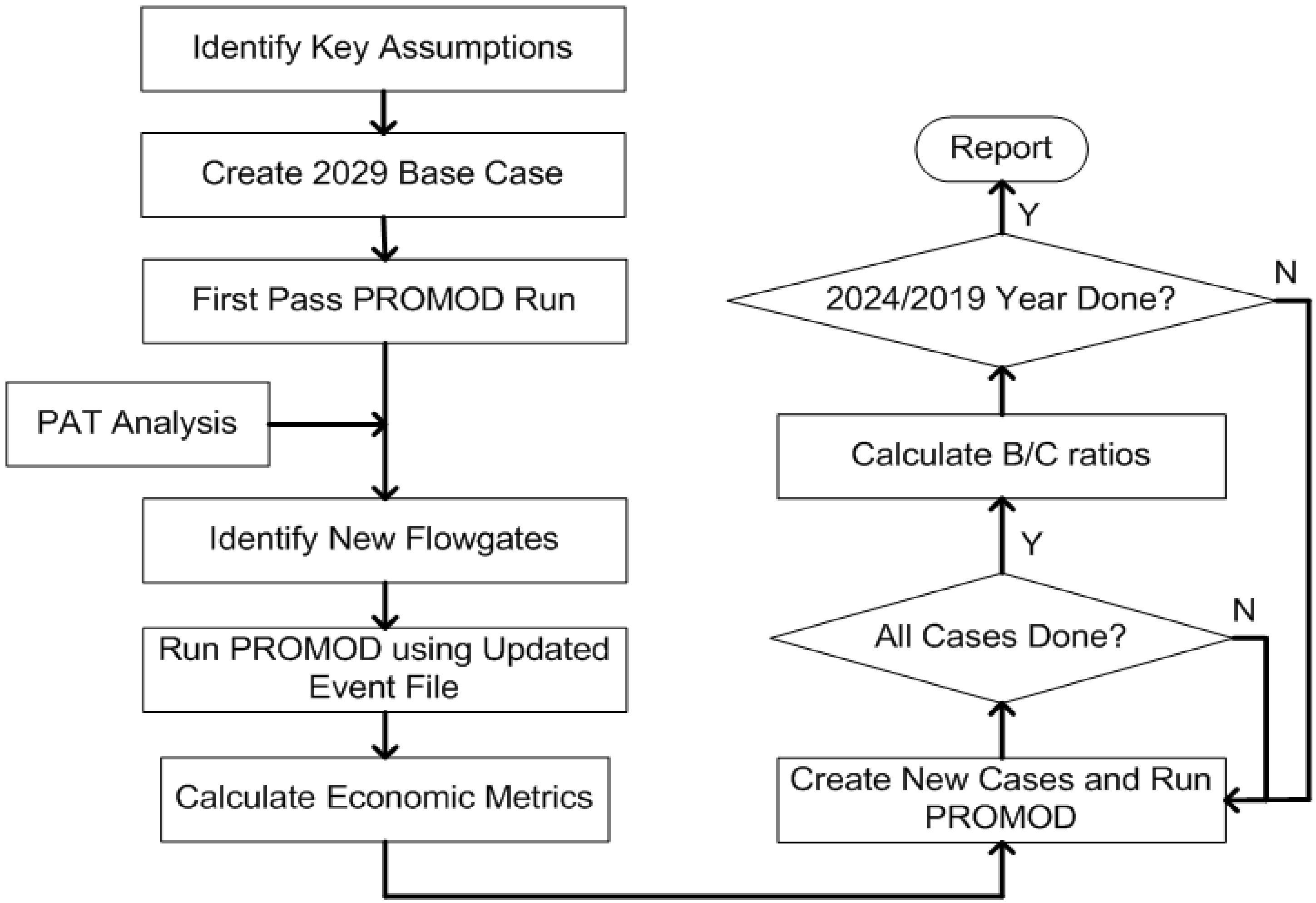
Table 1: Change Cases

Year	Generation Future	Transmission Upgrade	
		Alt 2	Alt 5
2019	Base Case Wind	√	√
2024	Base Case Wind	√	√
2029	Base Case Wind	√	√
	High Gas Future	√	√
	Low Carbon Future	√	√

Table 2: Sensitivity Cases for Each Transmission Alternative

Year	Generation Future	Carbon Tax	
		High ($90/ton)	Low ($20/ton)
2024	Base Case Wind	√	√
2019	Base Case Wind	√	√
2029	Base Case Wind	√	√
	High Gas Future	√	√
	Low Carbon Future	√	√

SMART Phase II Work Process

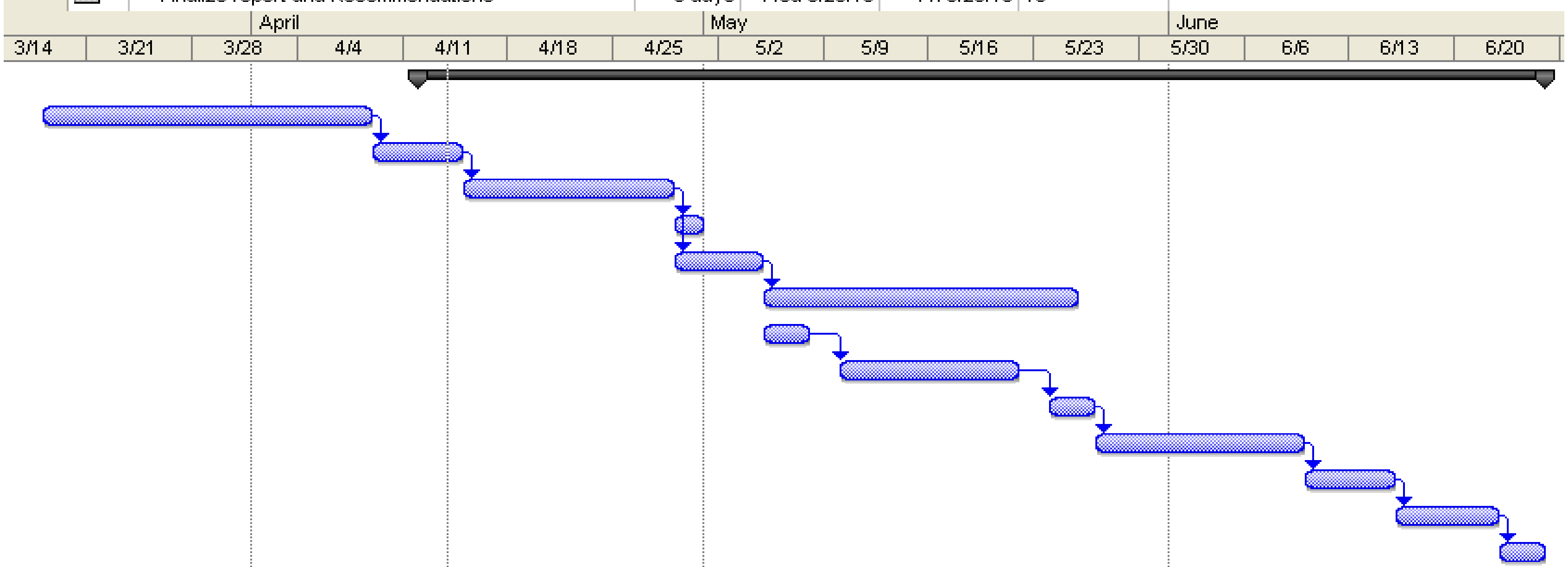


Savings resulting from PROMOD are only a component of the savings used in the calculation of the benefits. The Sponsor group will be reviewing other savings.

Schedule & Next Steps

SMART Phase II Gantt Chart

		Task Name	Duration	Start	Finish	Predecessors	Resource Names
1		Phase 2 - Economic Assessment	2.75 mons	Mon 4/12/10	Fri 6/25/10		
2		Develop Economic Assumptions and Metrics	0.8 mons	Thu 3/18/10	Thu 4/8/10		
3		Stakeholder Meeting - Assumptions and Metrics	0.8 wks	Fri 4/9/10	Wed 4/14/10	2	
4		Develop Economic Base Case for 2029	10 days	Thu 4/15/10	Wed 4/28/10	3	
5		Identify new flowgates using PAT	2 days	Thu 4/29/10	Fri 4/30/10	4	
6		Model Generation Futures for Alternatives	4 days	Thu 4/29/10	Tue 5/4/10	4	
7		Model Sensitivities for Alternatives (30 Cases)	15 days	Wed 5/5/10	Tue 5/25/10	6	
8		Model Base Case for 2024	3 days	Wed 5/5/10	Fri 5/7/10		
9		Model Sensitivities for 2024 Alternatives (5 cases)	10 days	Mon 5/10/10	Fri 5/21/10	8	
10		Model Base Case for 2019	3 days	Mon 5/24/10	Wed 5/26/10	9	
11		Model Sensitivities for 2019 Alternatives (5 cases)	10 days	Thu 5/27/10	Wed 6/9/10	10	
12		Score Alternatives per metrics	4 days	Thu 6/10/10	Tue 6/15/10	11	
13		Draft Phase 2 Report	5 days	Wed 6/16/10	Tue 6/22/10	12	
14		Finalize report and Recommendations	3 days	Wed 6/23/10	Fri 6/25/10	13	



Next Steps

- Receive input from Stakeholders and update results - info@smartstudy.biz
- Draft Report of Phase 1
- Continue with Phase 2

QUESTIONS?