Power from the Prairie Project Economic Assessment

A Case Study

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HVDC Transmission

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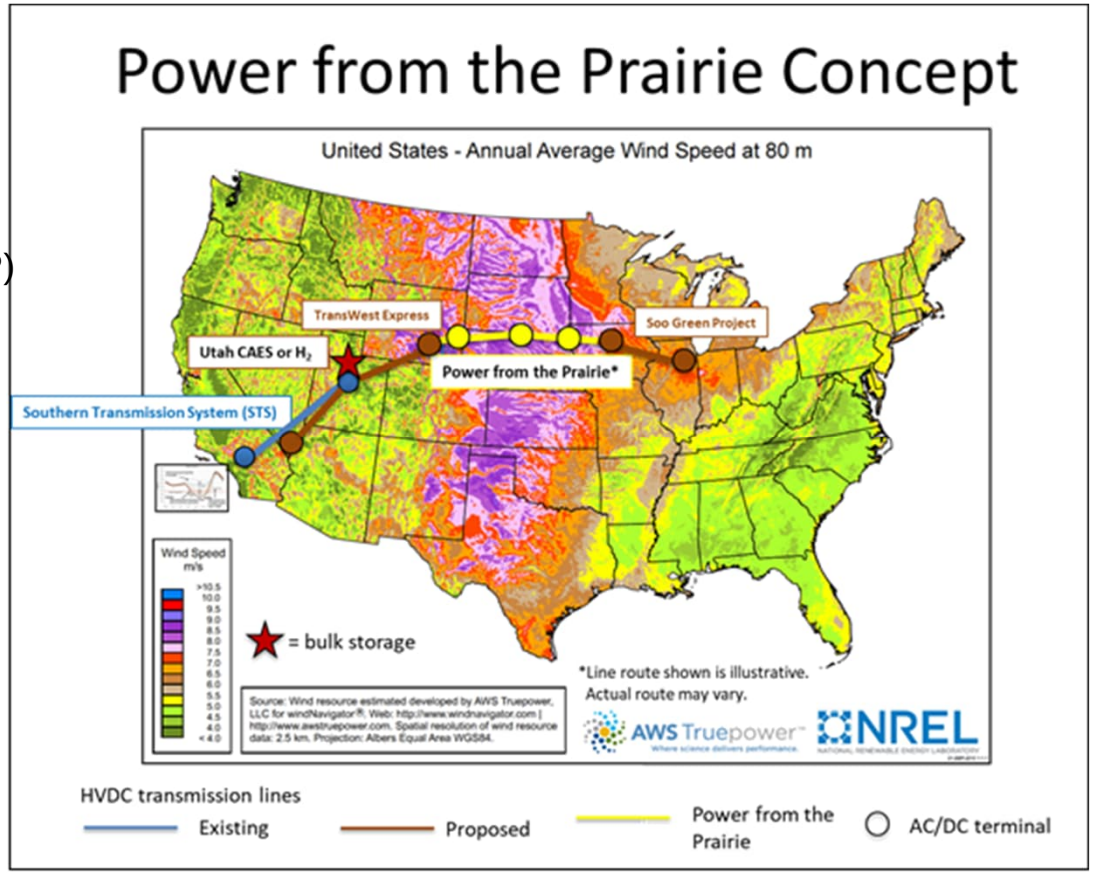
New HVDC Projects

- Delivery renewable from renewable rich region to load centers (TWE, Soo Green, Sunzia, Clean Path NY)
- Offshore wind development (NJ and NY)
- HVDC across asynchronized regions (CHPE, NECEC, PftP)

Power from the Prairie (PftP) – Concept Development Study (CDS)

- PftP crosses Eastern and Western Interconnections
- To East, connect with Soo Green project to Chicago
- To West, connect to TWE to Utah and STS to California
- HVDC connection from California to Chicago
- A Multi-terminal HVDC
- Diversified Resources (Wind,Solar,Geo,Battery,Hydro,etc.), Time-Diversified Resource, Geo-Diversified Resources (2000+ miles span)



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Concept Development Study for PftP

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- **PftP Project connects Eastern and Western Interconnections**
  - Need a study Database covering the project to assess economic transfers through PftP (MISO/SPP/PJM in PROMOD, WECC in GridView)
  - Need a merged and consistent Model for Eastern/Western Interconnection
- **MISO Planning Database to Represent for Eastern Interconnection**
  - Convert PROMOD data to GridView format and benchmark
  - Merge with WECC Database in GridView
  - Inter ties between East and West are modeled as HVDC links
  - Wind, Solar, and Load profiles reference to the same timezone and historical year
  - CO2 national emission price at $16.07, except CA, BC, AB at higher price
  - All wind and solar units can be curtailed at -25$/MWh, except for BTM

Benchmarking and Merge Databases

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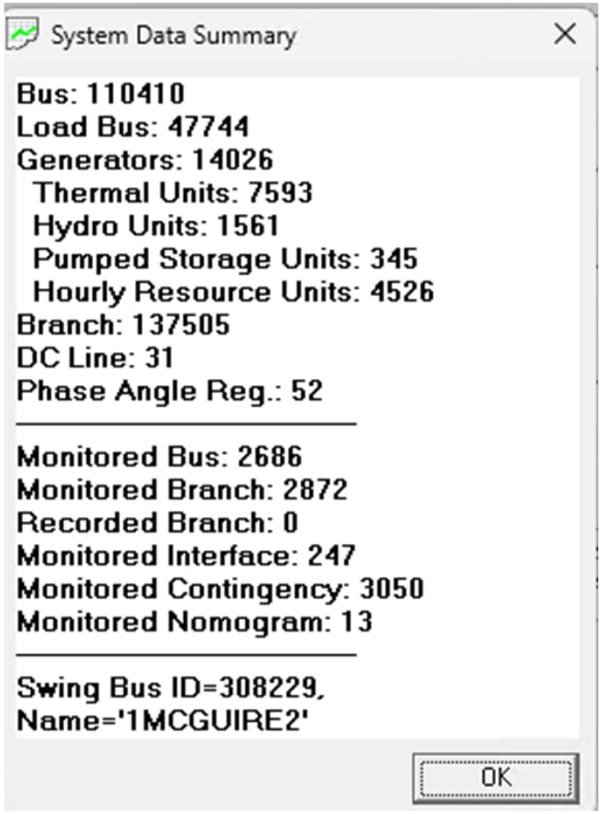
Benchmarked MISO Case

Row Labels	Sum of Promod	Sum of GridView
⊞MHEB	37,909,057	37,830,371
⊞MISO	744,720,716	744,443,479
⊞PJM Interconnection	957,879,046	998,489,548
⊞Southeast	516,307,742	527,296,978
⊟Southwest Power Pool	343,715,817	345,826,464
CC	72,714,328	70,294,862
CT Gas	31,422,325	28,992,473
CT Oil	85	599
CT Other	2,119	3,172
Geothermal	348,388	354,100
IC Gas	1,355,304	1,404,897
IC Oil	9,674	8,612
IC Renewable	45,897	29,430
Nuclear	14,909,694	14,948,775
PV + Batt	6,468,016	6,453,752
Solar PV	1,622,885	1,622,343
ST Coal	52,902,444	60,674,185
ST Gas	808,719	1,507,373
ST Other	249,814	251,033
ST Renewable	36,793	36,672
Wind	140,941,717	138,536,597
Battery Storage	1,639,712	2,741,419
Conventional Hydro	14,182,569	14,163,490
Pumped Storage Hydro	423,641	206,219
External Transaction	3,631,662	3,596,439
Interruptible Loads	32	22
⊞TVA	173,316,152	174,472,421
⊞TVA - Other	57,188,622	56,655,482
Grand Total	2,831,037,152	2,885,014,742

+ WECC Case

MISO-WECC Merged Case



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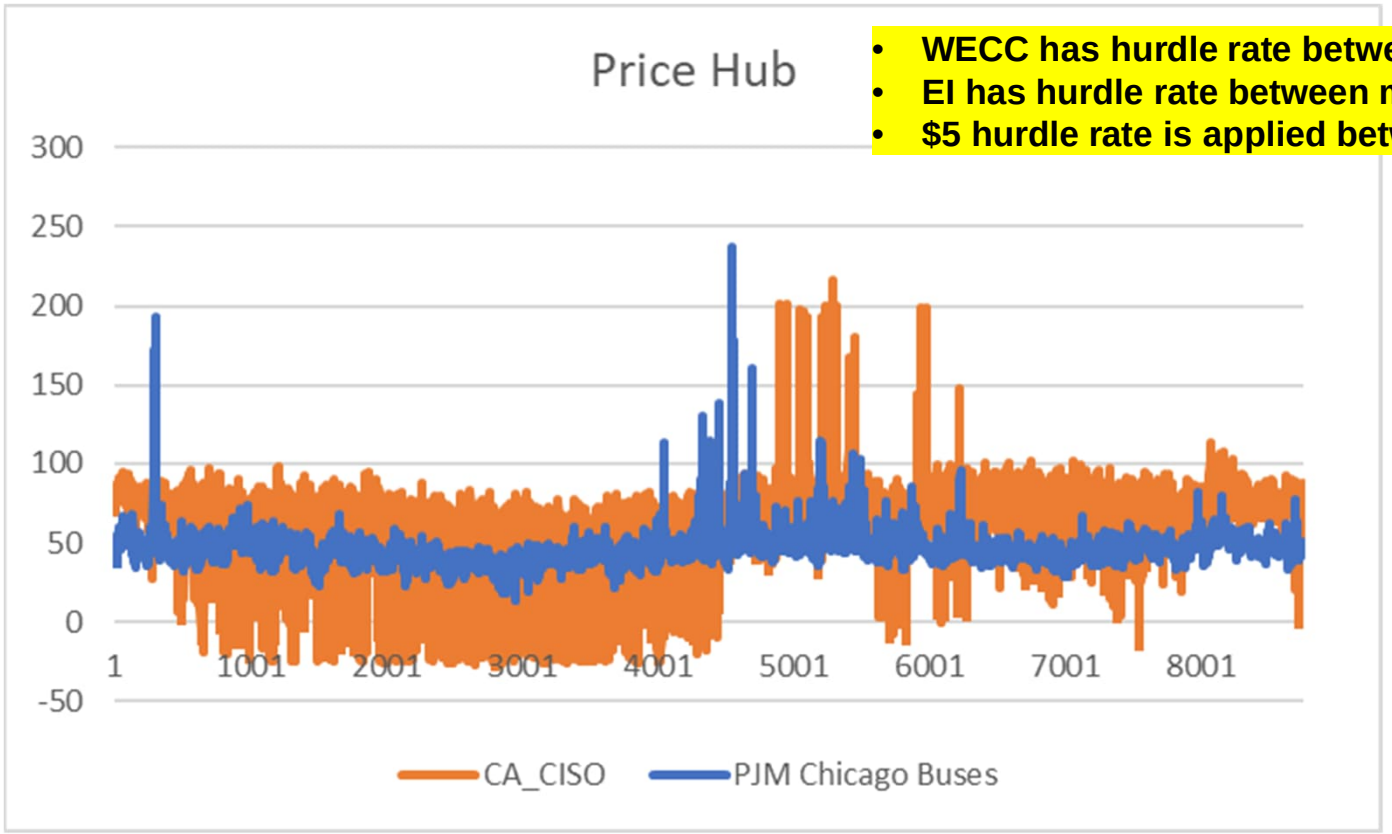
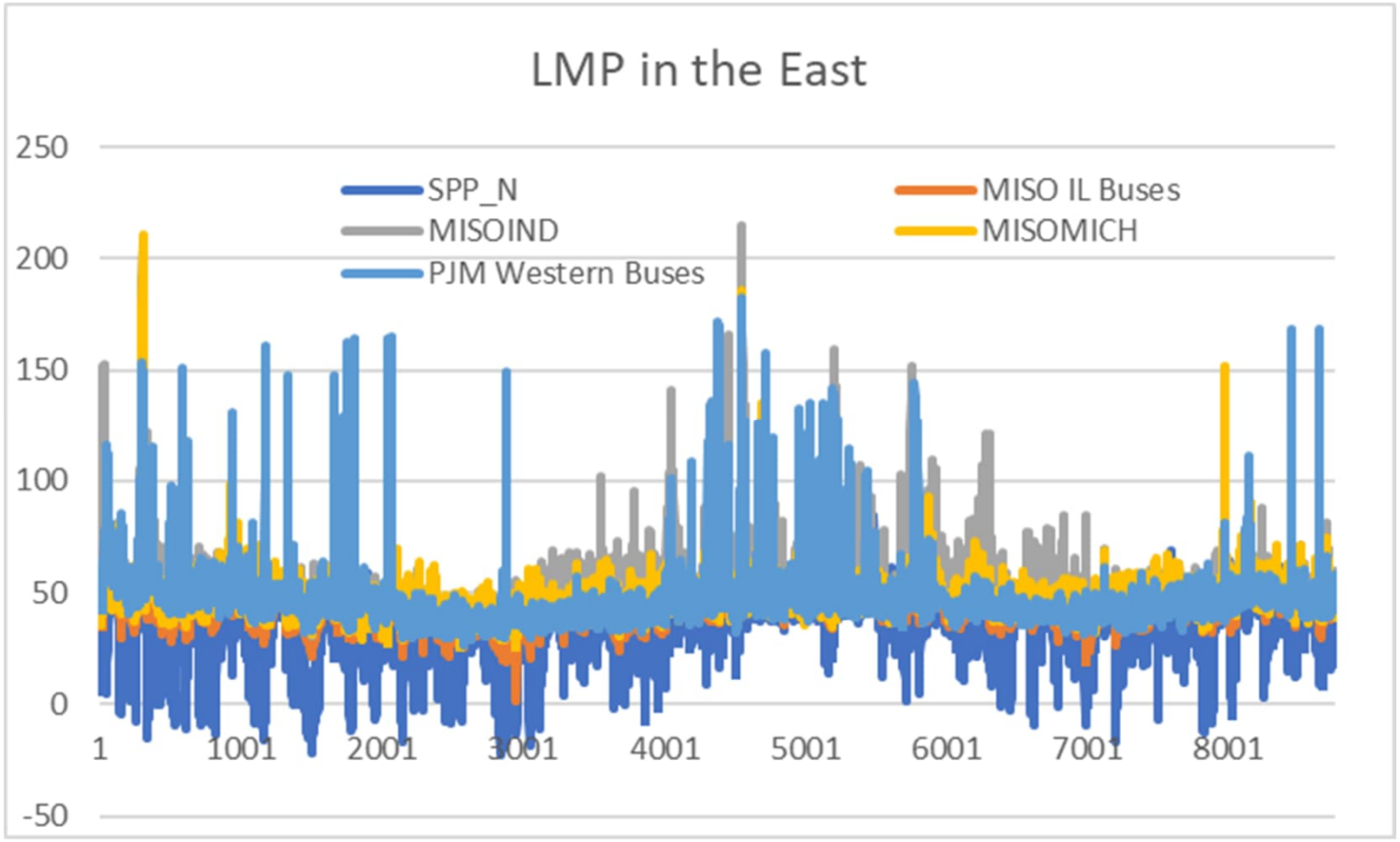
Hub Locational Marginal Price ($/MWh)



- **WECC has hurdle rate between BAAs**
- **EI has hurdle rate between markets**
- **$5 hurdle rate is applied between East and West**

Hub Locational Marginal Price ($/MWh)



Study Scenarios

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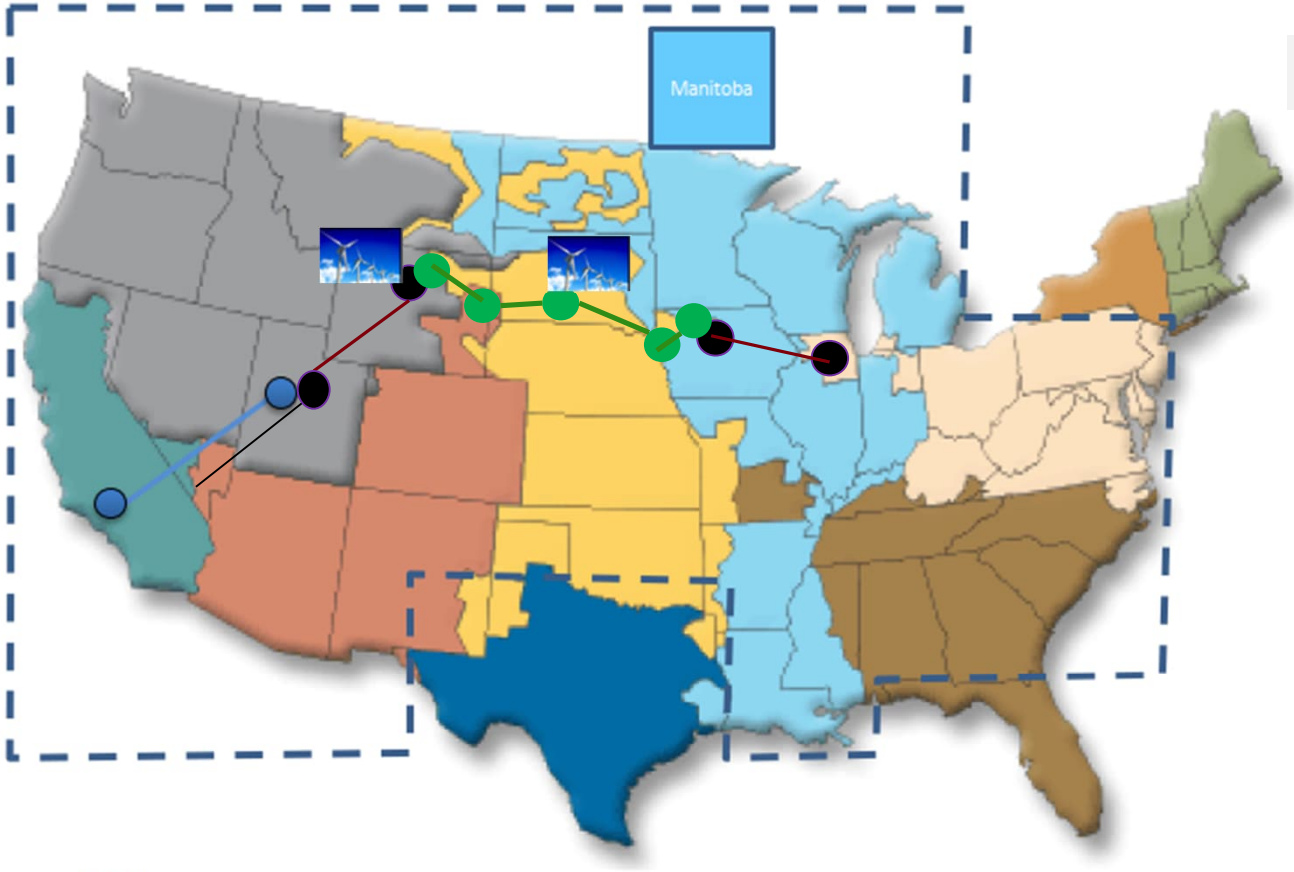

Basecase

- California (CAISO)
- MISO
- New England (ISO-NE)
- New York (NYISO)
- Northwest
- PJM
- Southeast
- Southwest
- SPP
- Texas (ERCOT)

POWER FROM THE PRAIRIE LLC

Scenario A

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- **Trans West Express (TWE)**
  - 3,000 MW, ±500 kV, high voltage direct current (HVDC) transmission system with terminals in south-central Wyoming and central Utah adjacent to the Intermountain Power Project site;
  - A 278-mile 1,500 MW 500 kV alternating current (AC) transmission line interconnected to the Utah Terminal and existing 500 kV substations in southeastern Nevada;
  - a 49-mile, 1,680 MW 500 kV AC transmission line with interconnections to existing 500 kV facilities in southeastern Nevada
  - 3300 MW Wyoming Wind are added
- **SOO Green**
  - The SOO Green HVDC Link, is a 350-mile, 2,100 MW, 525 kV underground HVDC transmission line from Iowa (KILLDEER 345kV) to Illinois (PLANO 765kV), linking low-cost, utility-scale renewable generation in MISO with customers in PJM.
  - Scenario A+ has a double SOO Green lines, 2 X 2100 MW

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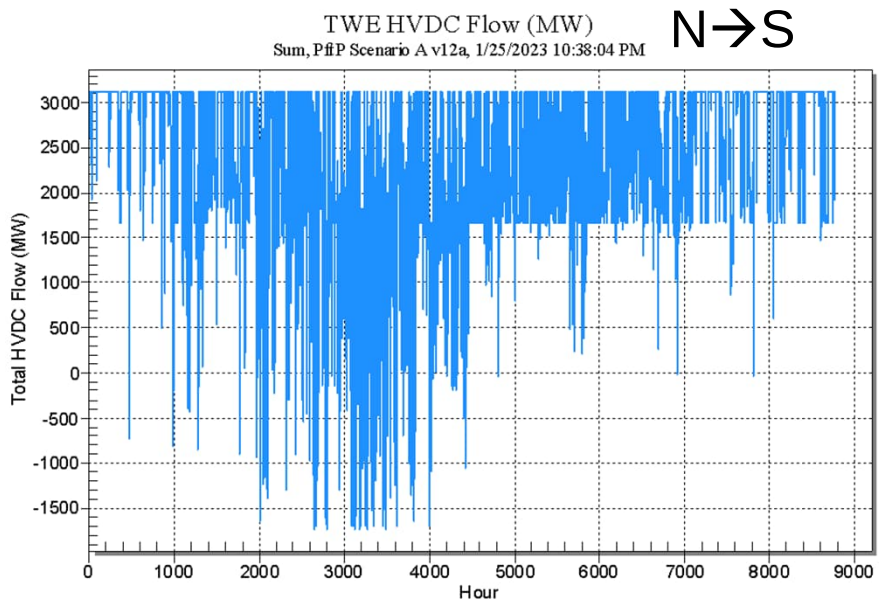
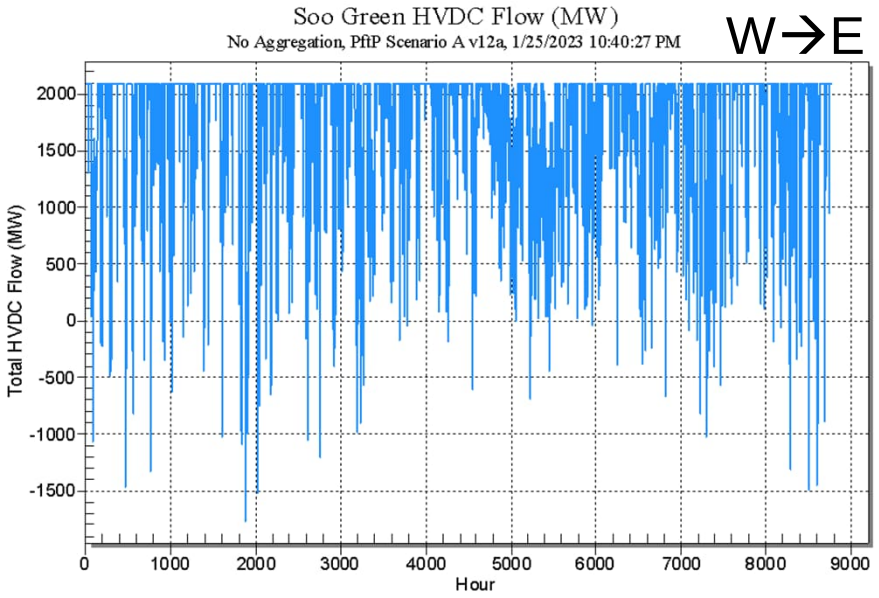
Scenario A – TWE and SOO GREEN HVDC Flows





Scenario B

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- **Power from the Prairie Multi-Terminal HVDC**
  - Referenced to Scenario A
  - ± 600kV, 4000 MW Multi-Terminal HVDC at Sinclair WY (TWE), Ault CO, Gregory County SD, Raun IA, Mason City IA (SOO Green).
  - a 972-mile ± 600 kV HVDC Grid System with Five converters, with 4000 MW capacity and 0.75% converter losses at full capacity.
  - Project transmission line losses at full capacity is estimated at 308 MWh
  - 3000 MW wind and solar capacity added

- **Scenario B+**
  - All changes in Scenario B on Scenario A+

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Scenario B – DC Converter Flows

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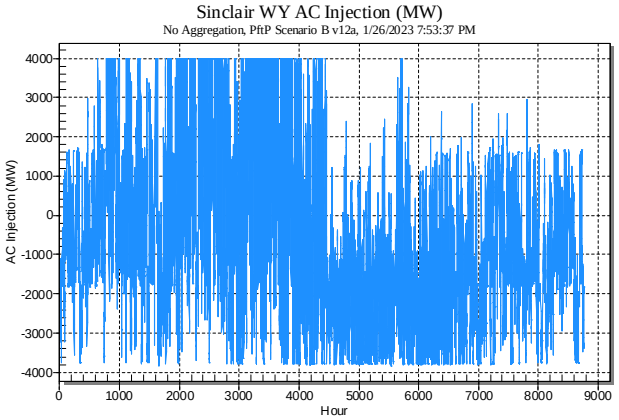
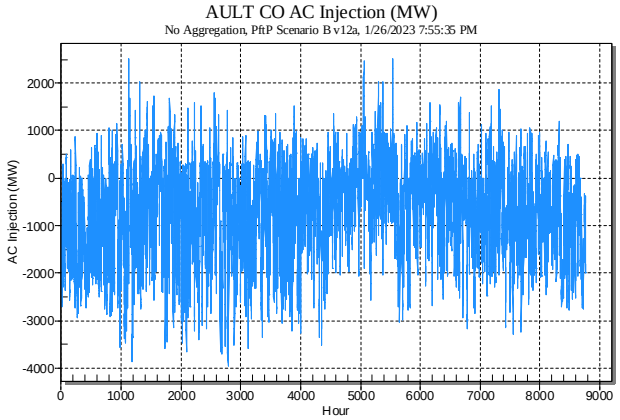
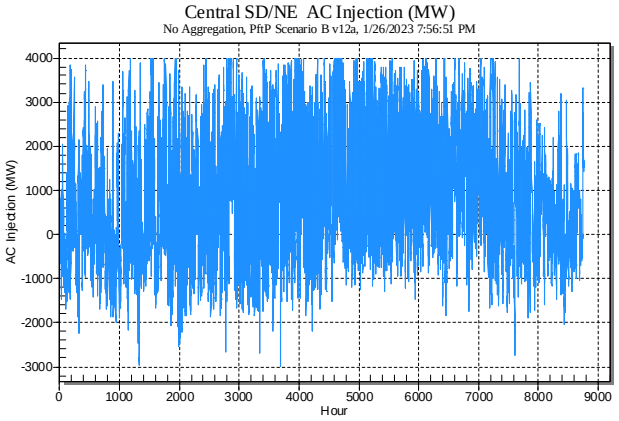
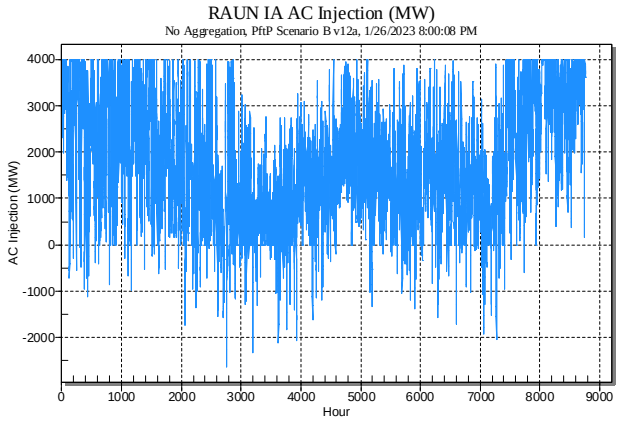
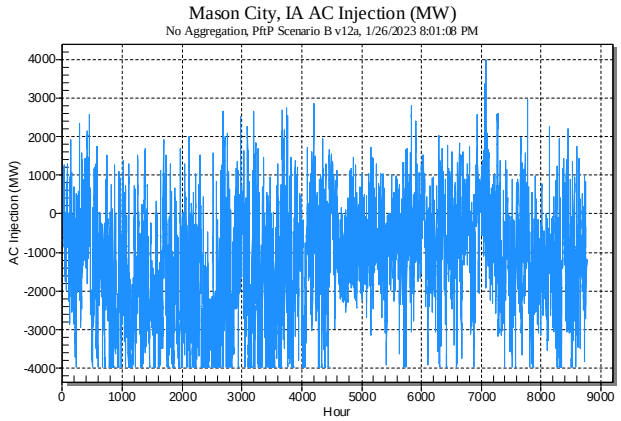




- **DC Converter**
  - +: AC to DC
  - -: DC to AC







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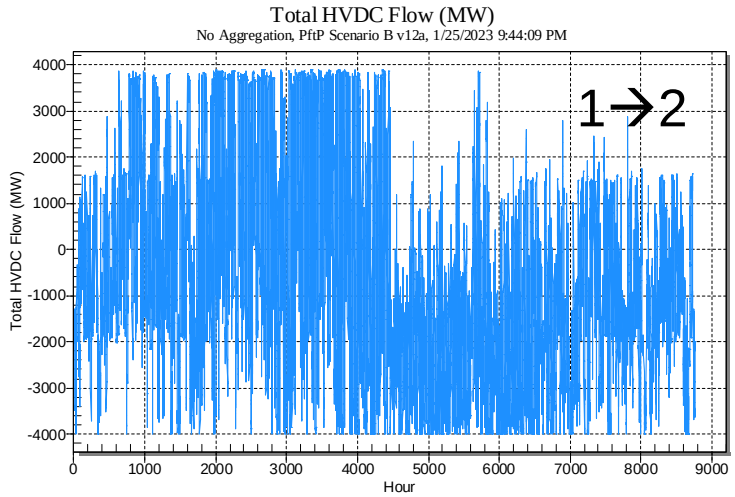
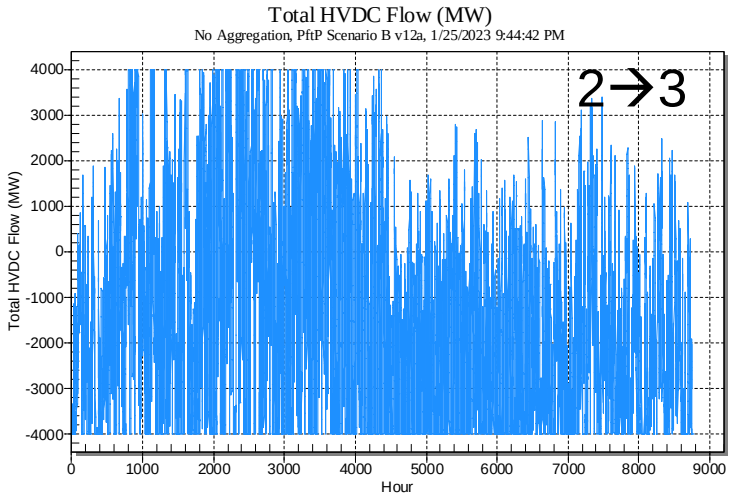
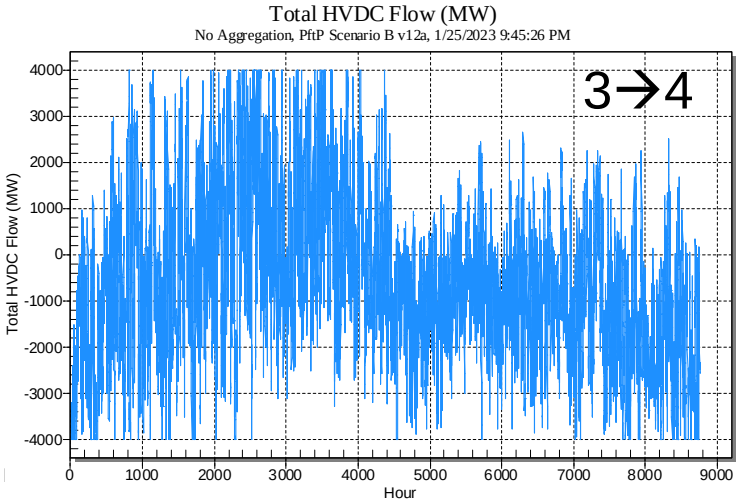
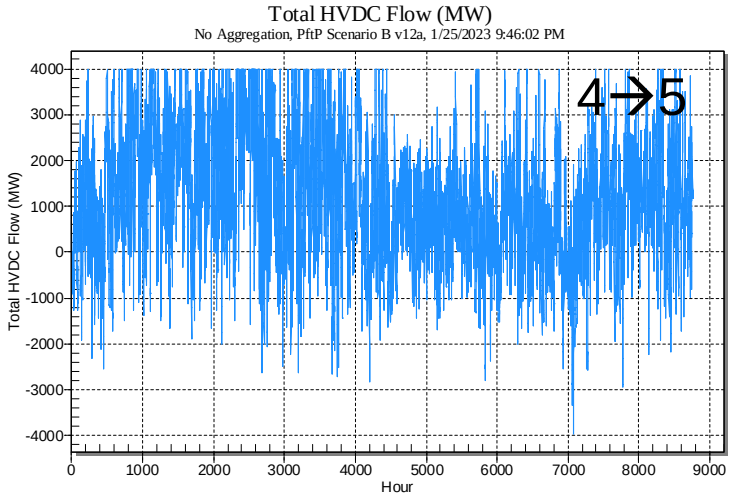
Scenario B – PftP HVDC Flows (Positive from West to East)









Scenario B – TWE and Soo Green Flows

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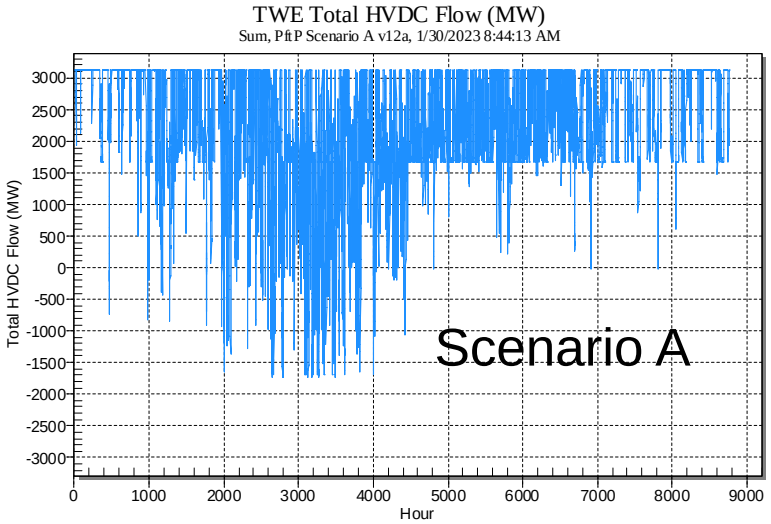

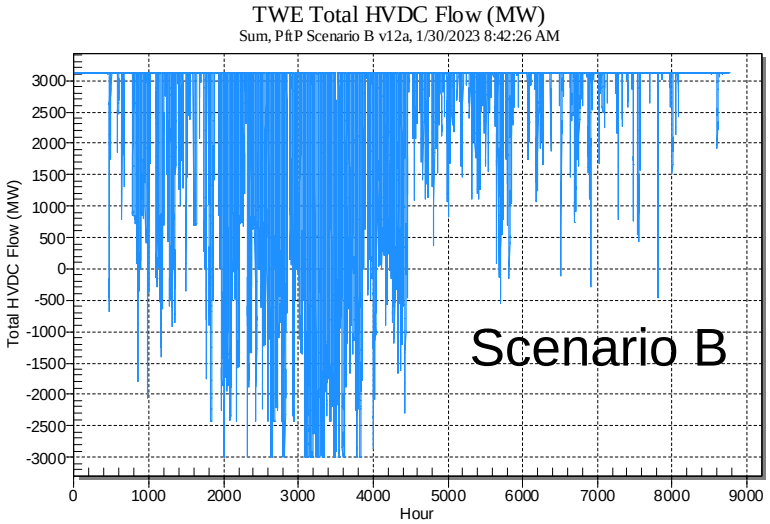

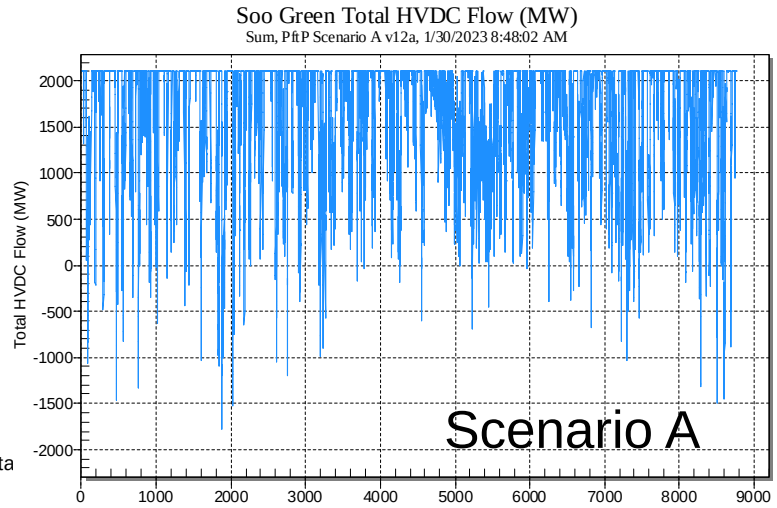

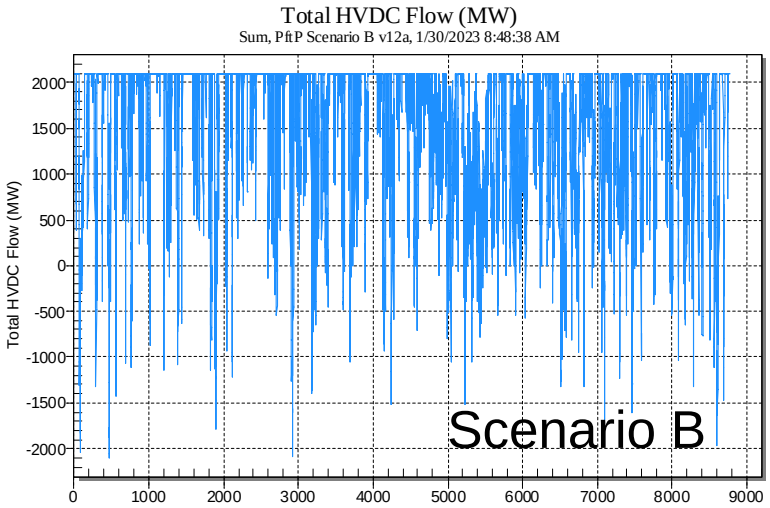

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APC and Emission Amounts

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APC	Region	Basecase	Scenario A	Scenario A+	Scenario B	Scenario B+
	reference		Basecase	Basecase	Scenario A	Scenario A+
1	MISO	16,995	16,943	16,926	16,985	16,922
2	PJM Interconnection	24,337	24,334	24,341	24,377	24,375
3	SPP	5,765	5,746	5,740	5,622	5,614
4	WECC	19,952	19,234	19,235	18,459	18,492
		67,048	66,257	66,242	65,442	65,403
			791	806	816	839

Emission	Region	Basecase	Scenario A	Scenario A+	Scenario B	Scenario B+
	reference		Basecase	Basecase	Scenario A	Scenario A+
1	MISO	179,002,619	179,201,806	179,362,107	182,500,014	182,266,144
2	PJM Interconnection	239,675,393	238,190,768	237,805,831	238,718,854	237,700,188
3	SPP	85,715,693	86,092,120	86,189,361	81,488,819	81,532,939
4	WECC	170,737,280	165,962,426	166,017,350	159,472,615	159,956,331
		675,130,984	**669,447,120**	**669,374,649**	**662,180,301**	**661,455,603**
			(5,683,865)	(5,756,336)	(7,266,819)	(7,919,046)

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Enabled Renewables and Curtailment

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Renewable Total	Region	Basecase	Scenario A	Scenario A+	Scenario B	Scenario B+
	reference		Basecase	Basecase	Scenario A	Scenario A+
1	MISO	219,312,628	219,674,796	219,694,661	229,582,457	229,640,095
2	PJM Interconnection	88,936,207	88,947,559	88,940,805	88,954,043	88,941,894
3	SPP	161,610,092	162,029,319	162,166,910	162,591,896	162,759,968
4	WECC	317,447,041	330,098,797	330,093,170	331,498,547	331,561,950
		787,305,968	800,750,471	800,895,546	812,626,943	812,903,907
			13,444,503	13,589,578	11,876,472	12,008,361

Curtailment	Region	Basecase	Scenario A	Scenario A+	Scenario B	Scenario B+
	reference		Basecase	Basecase	Scenario A	Scenario A+
1	MISO	2,683,769	2,321,602	2,301,737	1,761,907	1,704,268
2	PJM Interconnection	1,226,001	1,214,649	1,221,403	1,208,165	1,220,313
3	SPP	16,655,511	16,236,285	16,098,693	15,673,708	15,505,634
4	WECC	3,739,896	4,460,935	4,466,562	3,061,197	2,997,795
		24,305,176	24,233,471	24,088,395	21,704,977	21,428,011
			71,705	216,781	2,528,494	2,660,385

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Observations

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- TWE and Soo Green (Scenario A) are not competing project to PftP (Scenario B)
- HVDC bypassing AC congestion and deliver energy to load centers
- HVDC project may requires AC upgrades to allow power deliver to/from HVDC project
- HVDC allows long distance economic energy transfers, reserve sharing, etc.
- HVDC improves system reliability and resilience
- TWE and PftP convertors at WY may be merged to one – save big on capital cost
- Muti-terminal HVDC convertor sizing Optimization
- Muti-Terminal HVDC dispatch cannot be mimicked by Two-terminal HVDC
- Capacity Expansion for renewable resources with HVDC projects
- Transmission projects enable renewable development and mitigate curtailment

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PftP Summary

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- **The primary benefits are Adjusted Production Costs (APC) in Year 2030 and capacity value of added renewables, and storage**
  - Benefit/Cost ratio using public power financials: 1.44, while Investor financials B/C is 0.82 (with ITC)
  - The capital costs involved are in the Billions of dollars. The method of financing assets is material to the economic results
  - Additional benefits from Resilience, Reliability, Reserve sharing, Resource adequacy, and Decarbonization to be considered in the future study
- **The Benefit/Cost ratio economics of a transmission or storage project that enables* additional renewables are far better than if it merely provides access to markets and price arbitrage for existing renewables**
  - The total benefit to the regions is often much larger than the total benefits to the nine CDS Participants alone
- **A national problem requires a national solution**

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