
SPP
Southwest
Power Pool
HELPING OUR MEMBERS WORK TOGETHER
TO KEEP THE LIGHTS ON... TODAY AND IN THE FUTURE.

Interconnection Seams Study Update

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Jay Caspary
Director – Research, Development & Tariff Services
jcaspary@spp.org

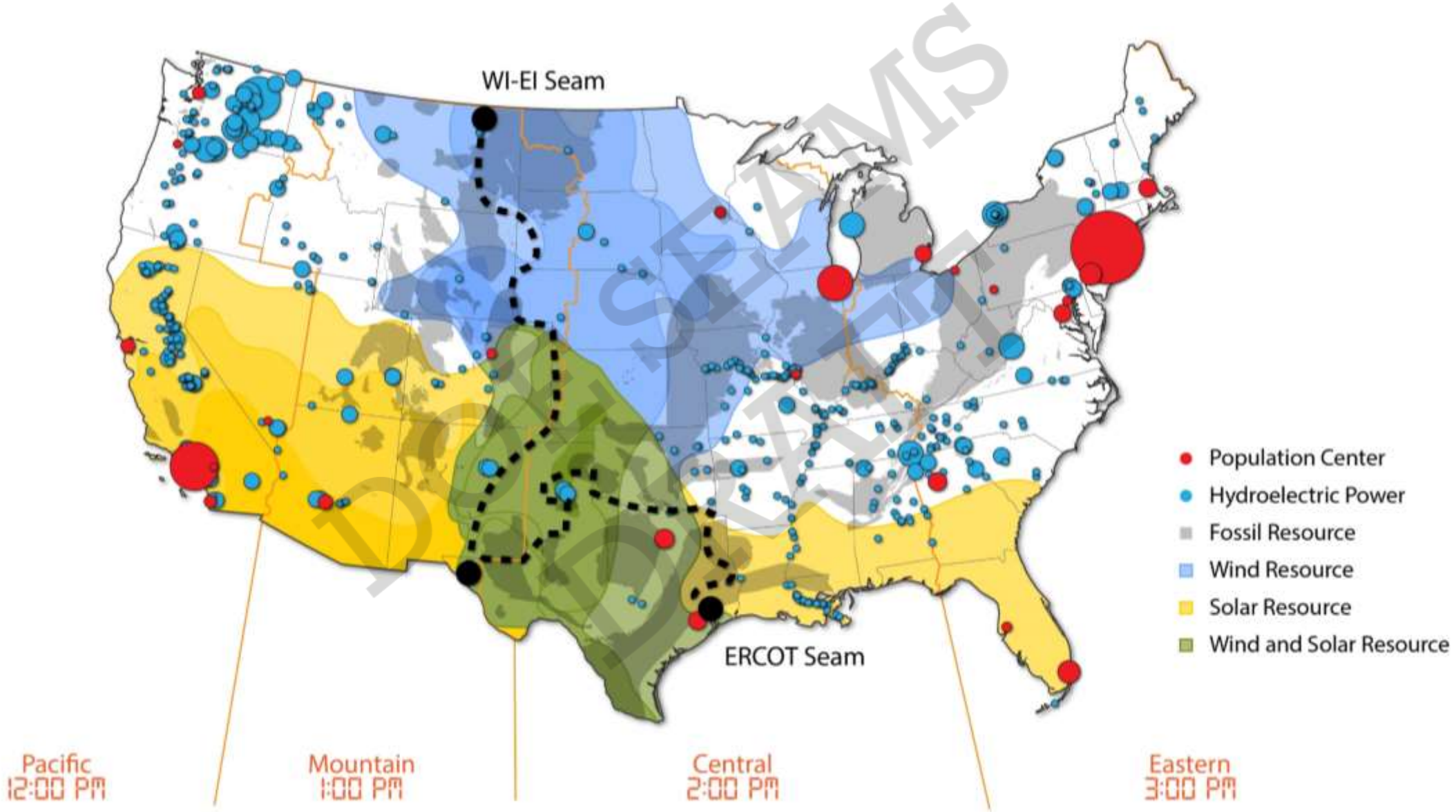
Disclaimer

- This deck includes materials which were presented at the TRC meeting 5/17 and NARIS Update 9/12 in Mexico City and are subject to change as this project is concluded. While the models and inputs have been vetted on several occasions with stakeholders, caution needs to be exercised in drawing conclusions and sharing results…

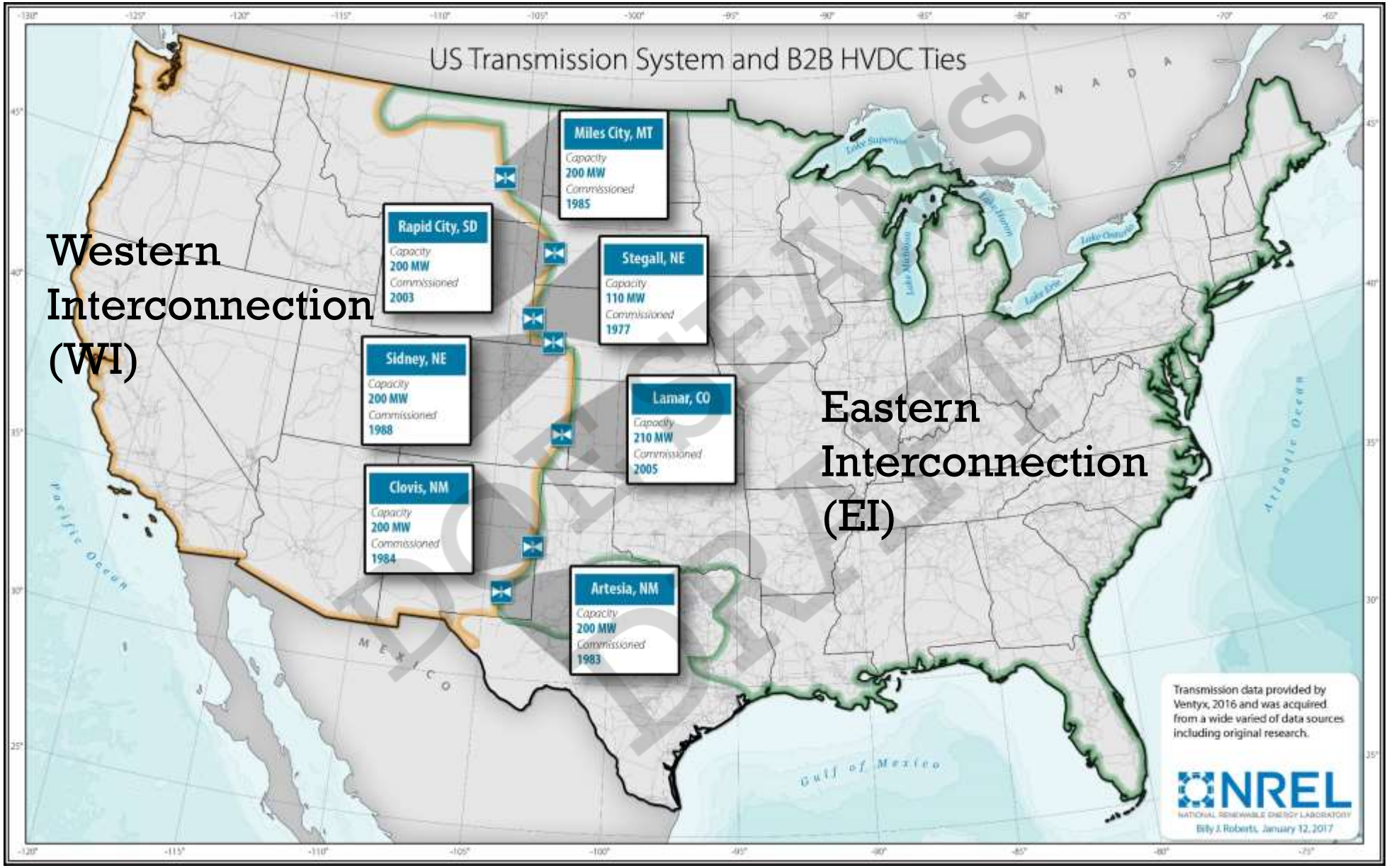
DOE-funded, NREL-led Interconnection Seams Study

- $1.2M, 18 month EI-WECC Seams and HVDC Overlay Study approved as part of DOE's Grid Modernization Laboratory Collaborative (GMLC)
  - Strong industry support
  - Opportunity to not just replace in-kind the aging B2B HVDC Ties between EI and WECC
  - Four DC Scenarios
    - Status Quo
    - Modernized/Optimized Seam with Rightsized/Relocated B2B and/or Links
    - Macrogrid Overlay
- Promising preliminary results
- Additional analyses being discussed

Diversity in Resources and Load Centers

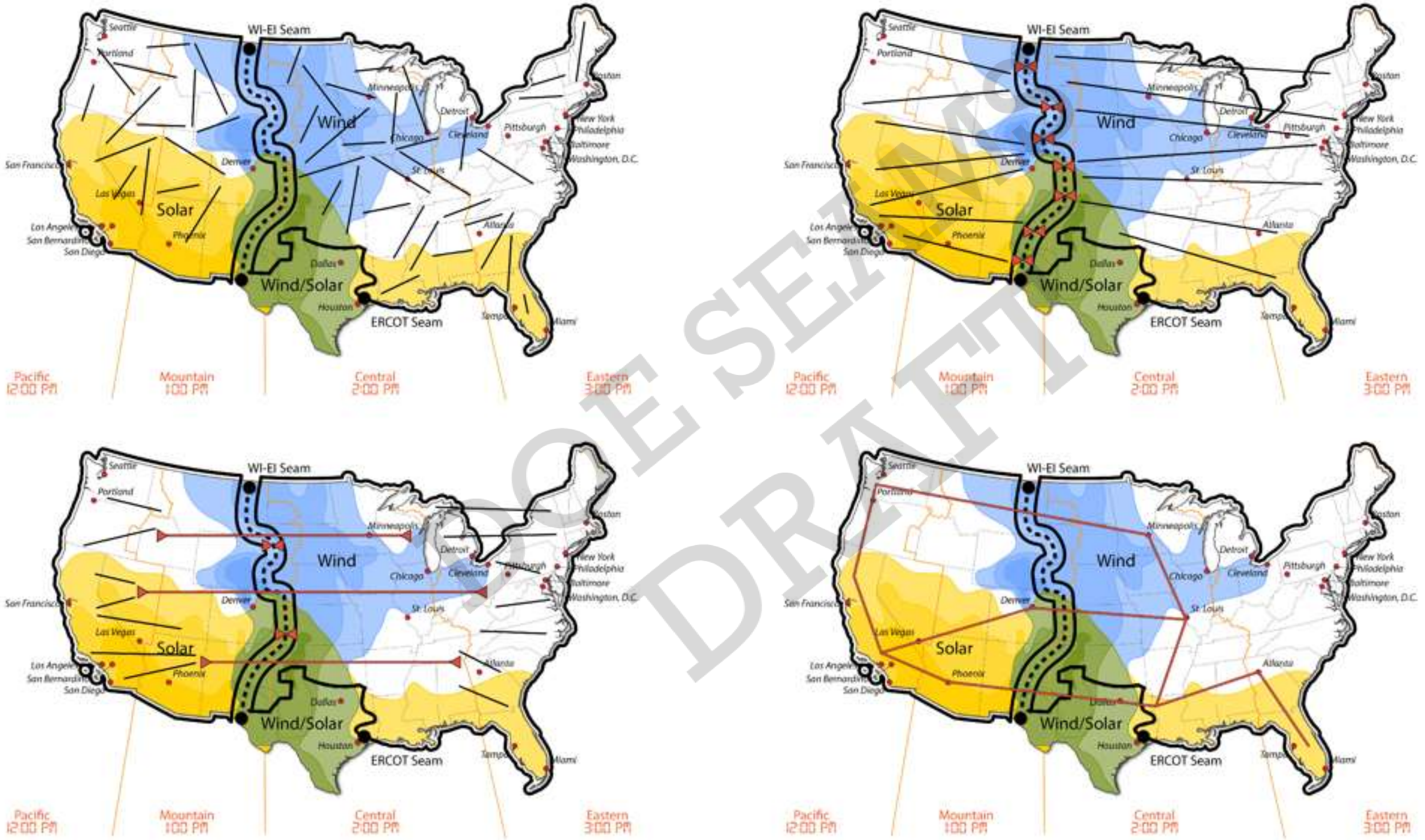


WI & EI Back-to-Back HVDC Ties



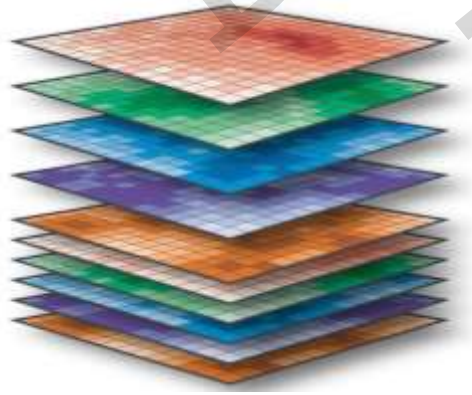
- http://www.nrel.gov/analysis/seams.html
- Seams TRC 4 v7 Final.pptx

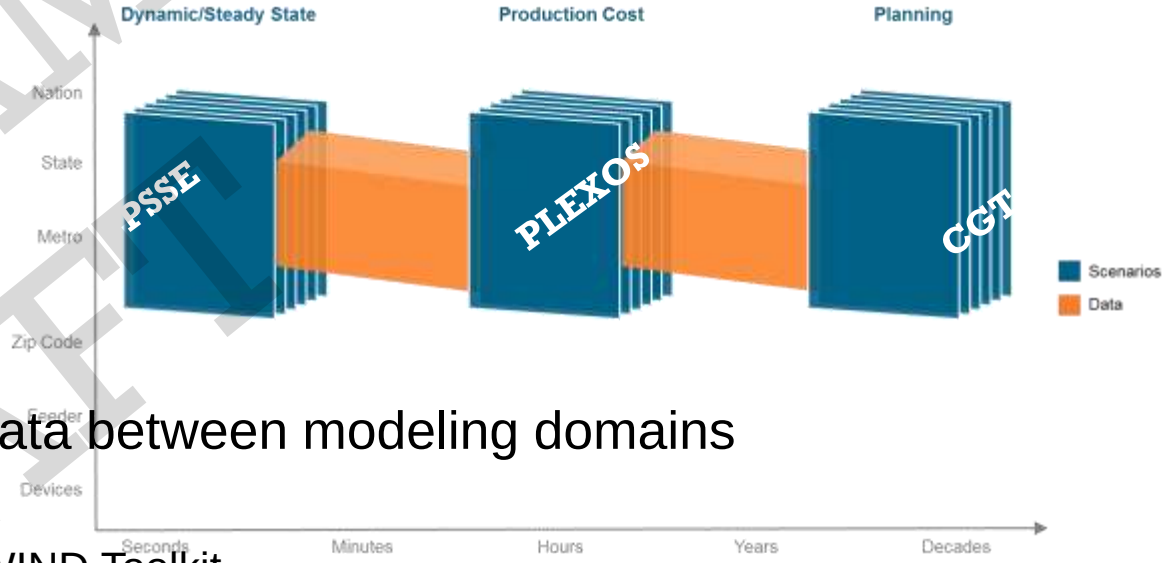
Conceptual Scenarios



Comprehensive Economic and Reliability Analysis with Integrated Data

- Models are chosen to ask a specific set of questions
  - CGT-Plan
    - Capital and operating costs 2024-2038
    - Generation and transmission system for 2038
  - PLEXOS
    - Operating costs 2038
    - Hourly unit commitment and 5 minute economic dispatch
  - PSSE
    - Steady state AC power flow
    - N-1 contingency

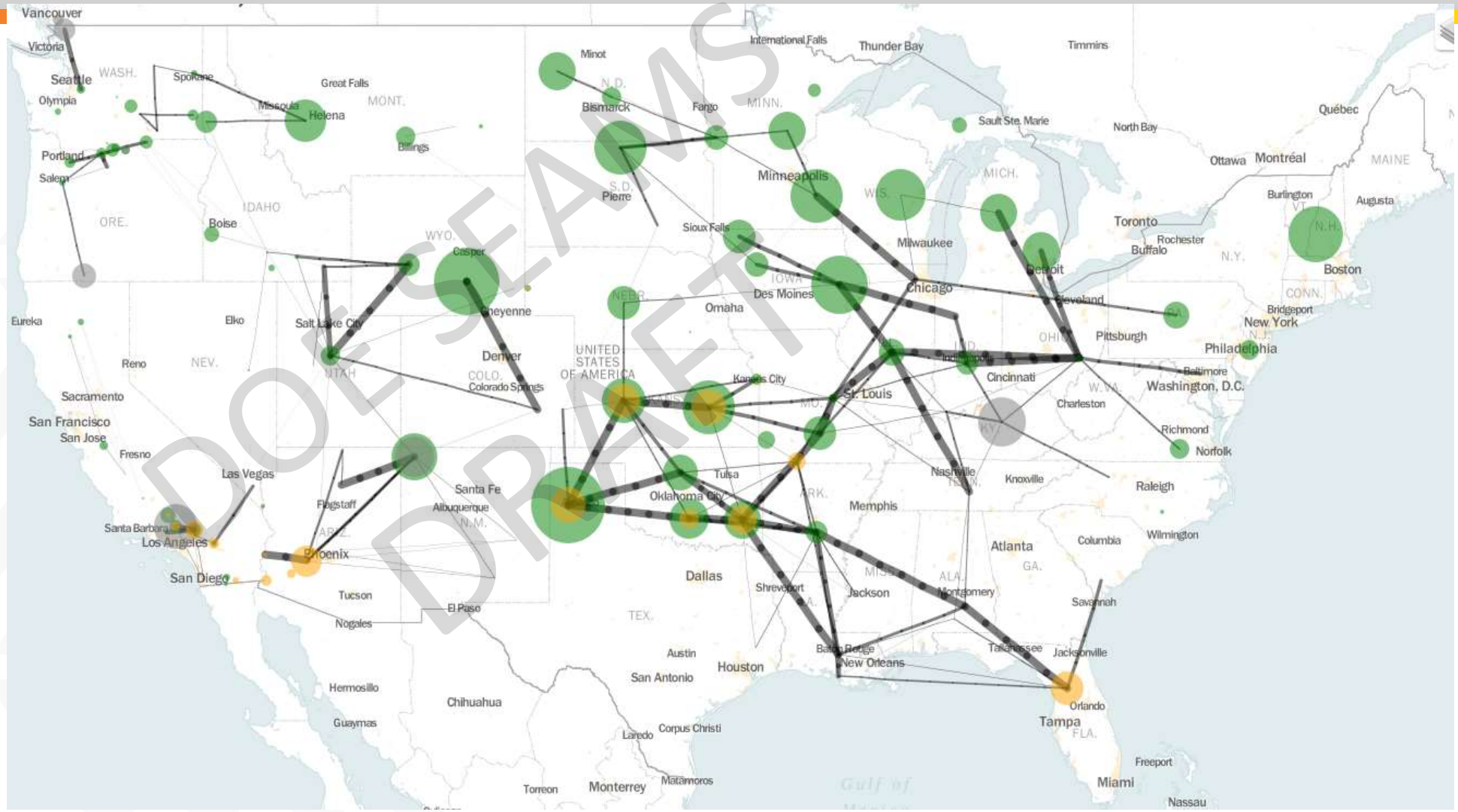




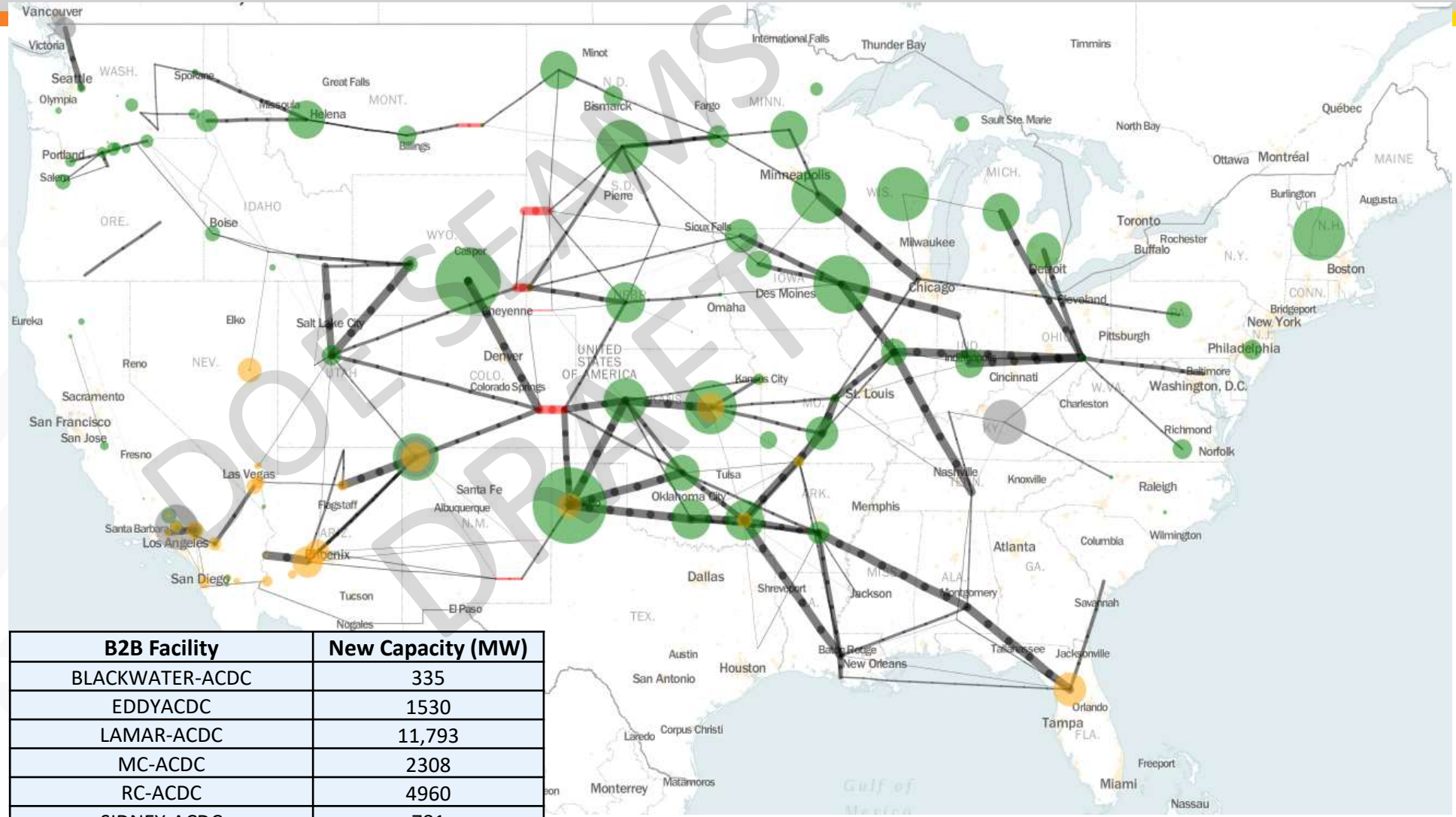
- Consistent data between modeling domains
  - Wind
    - 2012 WIND Toolkit
  - Solar
    - 2012 NSRDB
  - Transmission and Generation
    - WECC TEPPC 2026-Western Interconnection
    - MMWG 2024-Eastern Interconnection
  - Load
    - 2012 FERC

Co-optimization of Generation and Transmission Expansion Planning Results

Design 1: No Upgrades

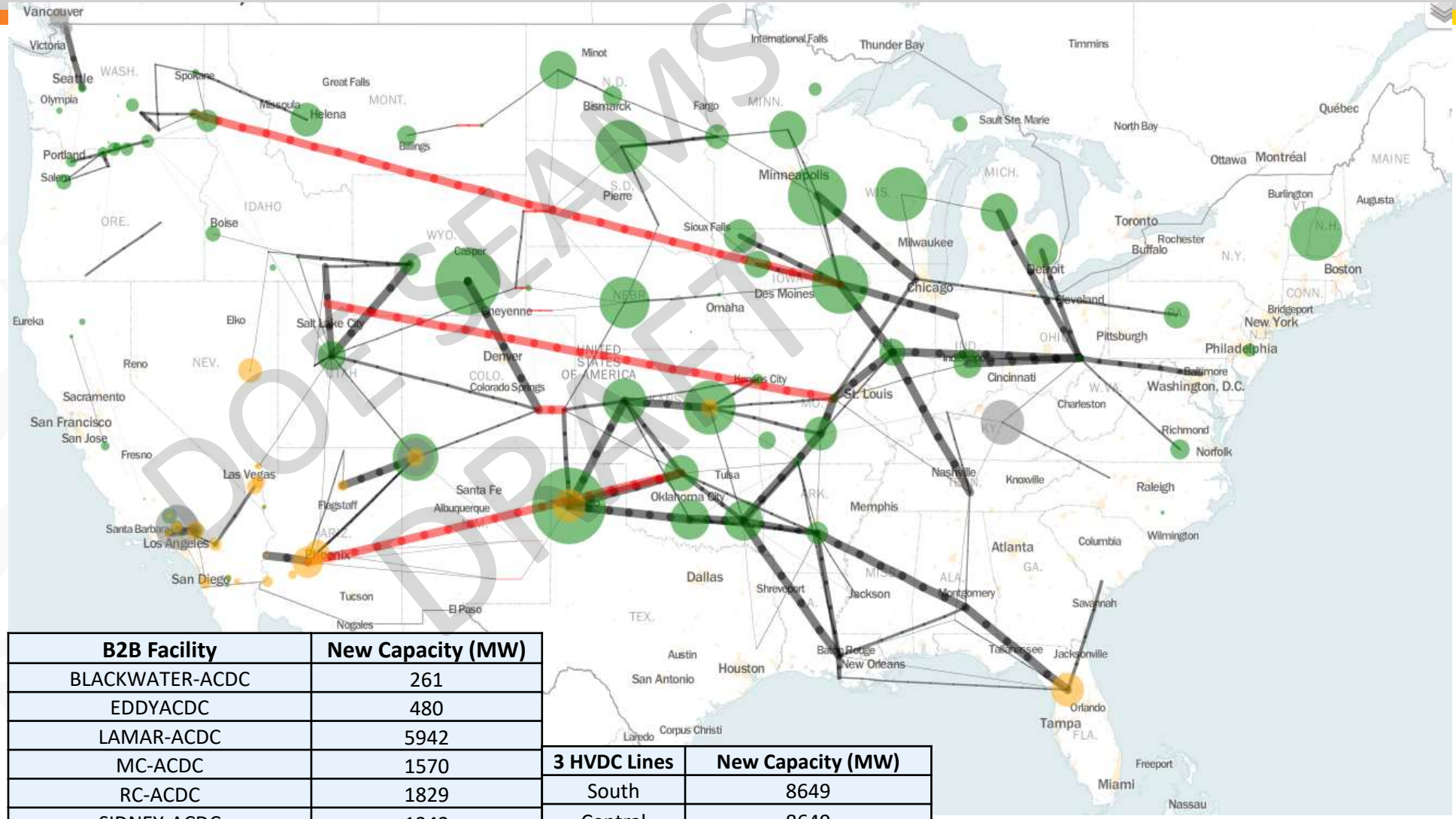


Design 2A: B2B Upgrades



B2B Facility	New Capacity (MW)
BLACKWATER-ACDC	335
EDDYACDC	1530
LAMAR-ACDC	11,793
MC-ACDC	2308
RC-ACDC	4960
SIDNEY-ACDC	781
STEGAL-ACDC	7484
TOTAL B2B	**29,191**

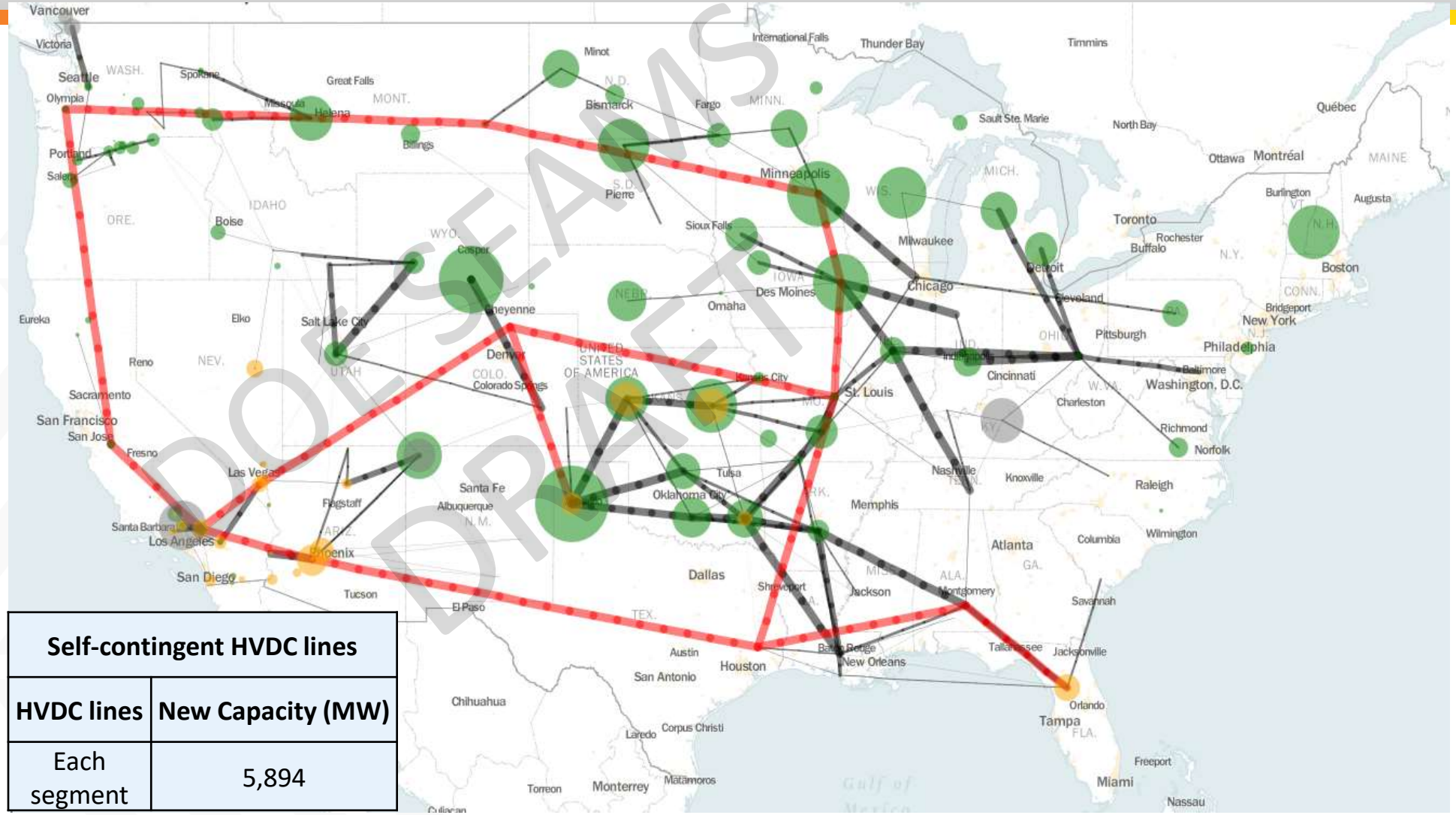
Design 2B: B2B Upgrades + HVDC Lines



B2B Facility	New Capacity (MW)
BLACKWATER-ACDC	261
EDDYACDC	480
LAMAR-ACDC	5942
MC-ACDC	1570
RC-ACDC	1829
SIDNEY-ACDC	1243
STEGAL-ACDC	1422
TOTAL B2B	**12,747**

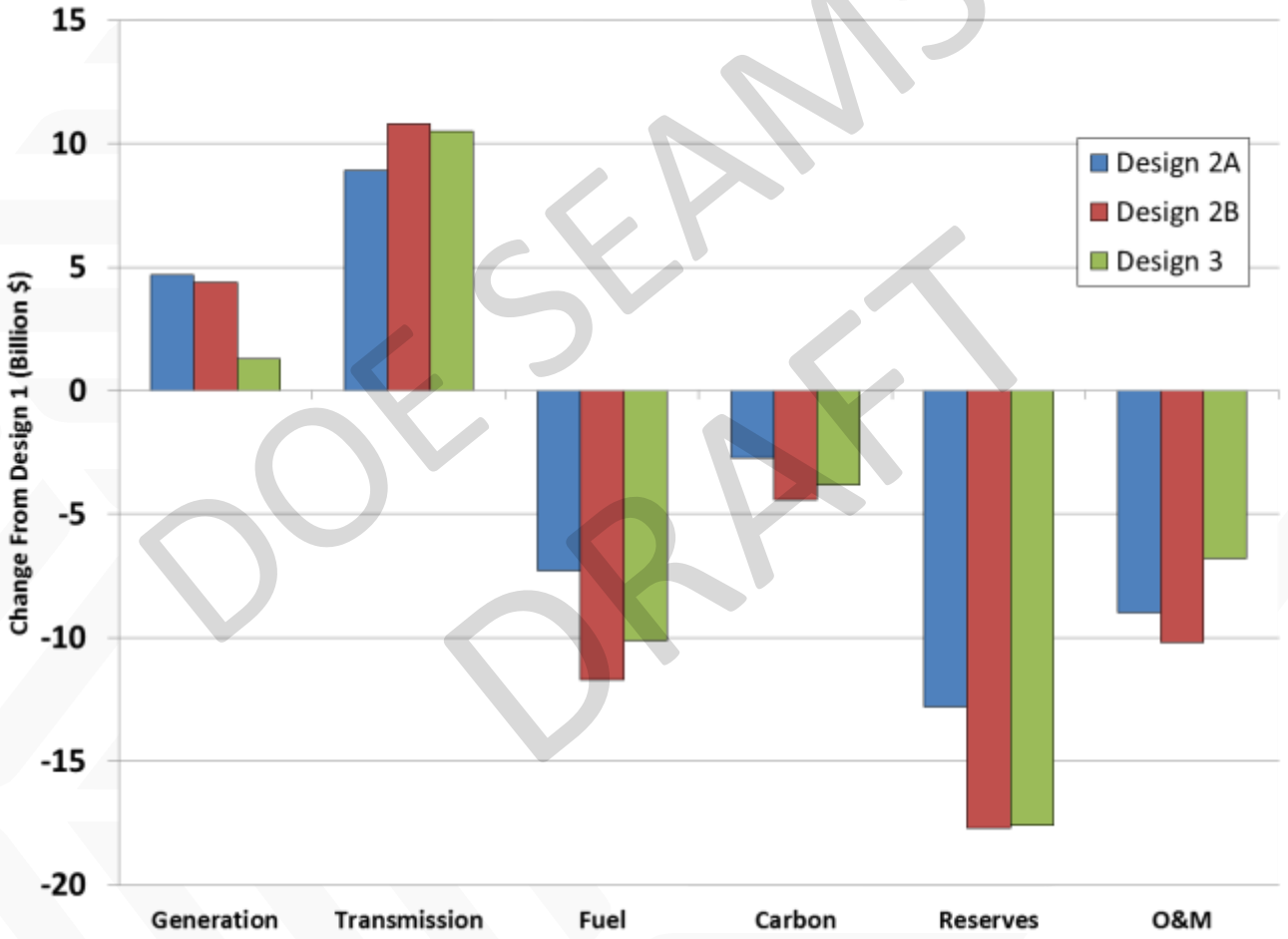
3 HVDC Lines	New Capacity (MW)
South	8649
Central	8649
North	8649
TOTAL DC LINE	**25,947**

Design 3: Macrogrid



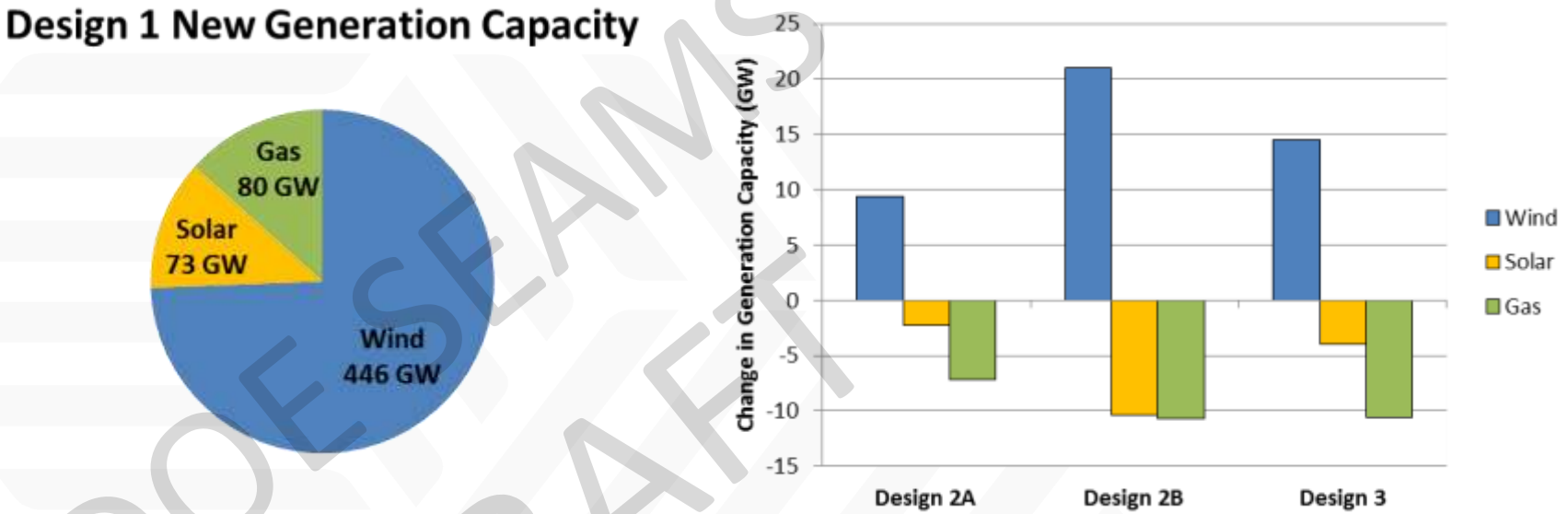
Self-contingent HVDC lines	
HVDC lines	**New Capacity (MW)**
Each segment	5,894

Economic Results



- All Designs pay for themselves
- Ability to share reserves (regulation and contingency) provides largest value
- While benefits of Designs 2A and 2B are driven by energy, Design 3 is driven by capacity sharing during peak periods

Generation Results



- Wind and Solar account for 45% of all energy in all designs
- 75% decrease in CO2 emissions compared to 2024
  - Wind and solar have no emissions
  - New gas is efficient
  - Retirements of less efficient coal, gas, and oil based units

2024-2038 NPV Results

	D1	D2a	Delta	D2b	Delta	D3	Delta
Generation	722.2	726.9	4.7	726.6	4.4	723.5	1.3
Transmission	78.2	87.1	8.9	89	10.8	88.7	10.5
Fuel	792.6	785.3	-7.3	780.9	-11.7	782.5	-10.1
Carbon	176.3	173.6	-2.7	171.9	-4.4	172.5	-3.8
Regulation-up	46.2	42.5	-3.7	40	-6.2	39.2	-7
Regulation-down	19.8	15.2	-4.6	12.3	-7.5	12.2	-7.6
Contingency	97.7	93.2	-4.5	93.7	-4	94.7	-3
FOM	443	434.3	-8.7	433.2	-9.8	436.6	-6.4
VOM	64.9	64.6	-0.3	64.5	-0.4	64.5	-0.4
Total	2440.9	2422.7	-18.2	2412.1	-28.8	2342	-26.5
B/C			2.04		2.67		2.52

Transmission Expansion in SPP

- CEP runs assumed that Transmission Expansion for Base Designs are limited by existing prominent EHV voltage, e.g., 345kV in SPP, 500kV in MISO South, etc.
- Single Circuit 345kV is Base Design for SPP
- Cursory analyses follow which show Transmission Expansion within SPP, as well as with neighboring regions if we consider upsizing new AC backbone lines up to Double Circuit 345kV, 500kV or 765kV
- EHV Transmission Design Assumptions regarding EHV/UHV AC transmission capabilities/costs follow:

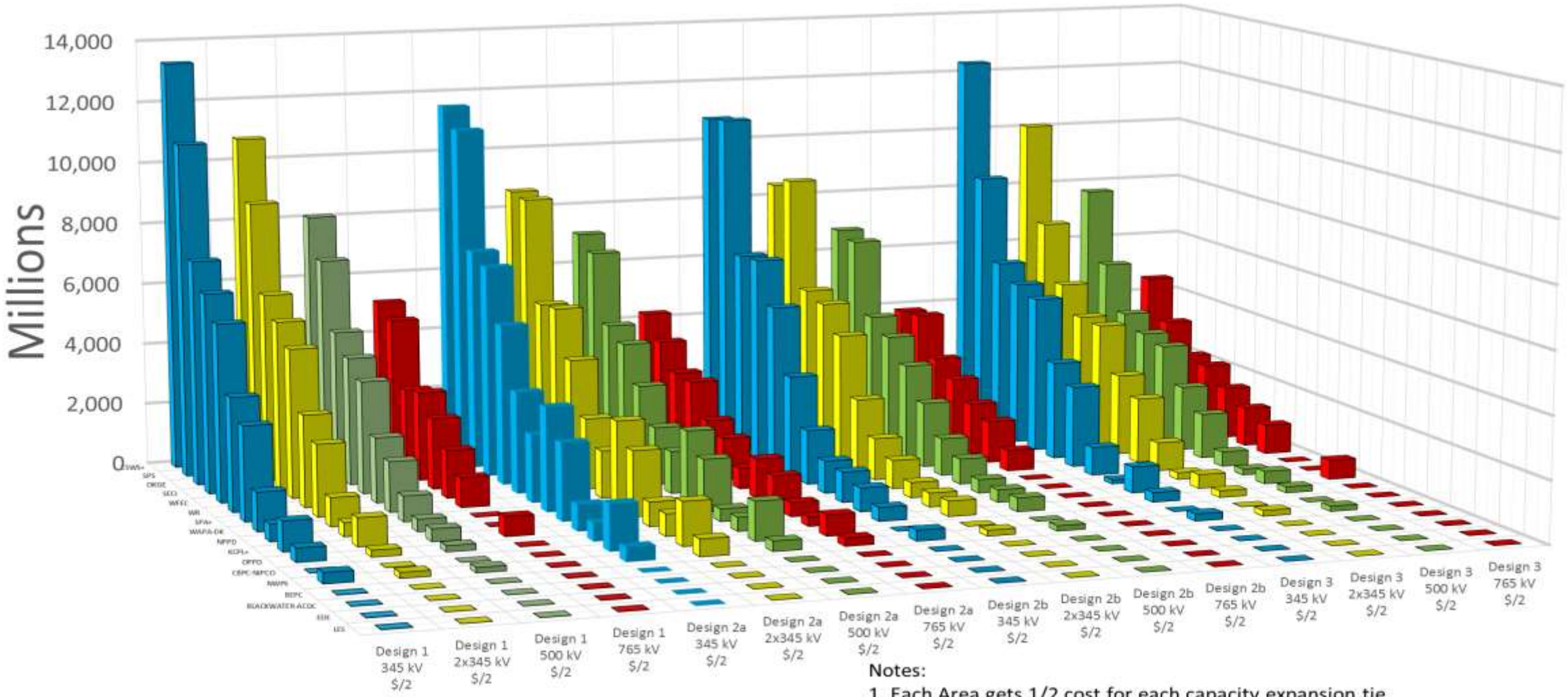
EHV/UHV AC Transmission Design Assumptions

Circuit Type	kV	Emergency Rating (Amps)	Emergency Rating (MVA)	Estimated Cost ($/mile)	[1] Loadability (MW) @300 Miles
Single	345	3000	1,793	1,300,000	400
Double	345	6000	3,585	2,200,000	800
Single	500	3000	2,598	1,900,000	900
Single	765	4000	5,300	3,000,000	2300

[1] American Electric Power Transmission Facts,

https://web.ecs.baylor.edu/faculty/grady/_13_EE392J_2_Spring11_AEP_Transmission_Facts.pdf

SPP Areas Capacity Expansion AC Transmission Line $M



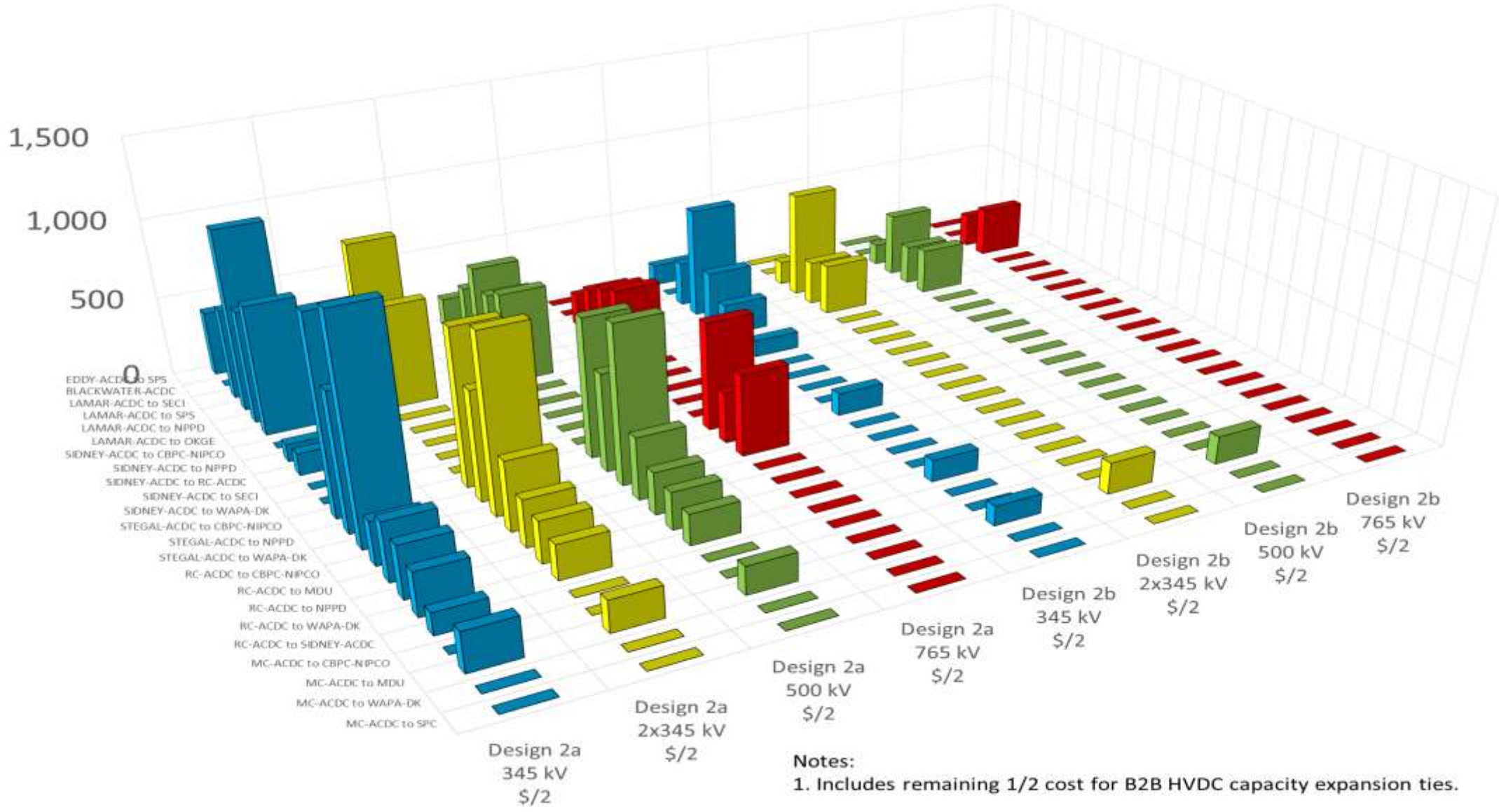
Notes:

1. Each Area gets 1/2 cost for each capacity expansion tie.
2. Includes 1/2 cost for each B2B HVDC capacity expansion ties.
3. Excludes remaining 1/2 cost for B2B HVDC capacity expansion ties.

SPP Areas Capacity Expansion AC Transmission Lines $M

	Design 1 345 kV $/2	Design 1 2x345 kV $/2	Design 1 500 kV $/2	Design 1 765 kV $/2	Design 2a 345 kV $/2	Design 2a 2x345 kV $/2	Design 2a 500 kV $/2	Design 2a 765 kV $/2	Design 2b 345 kV $/2	Design 2b 2x345 kV $/2	Design 2b 500 kV $/2	Design 2b 765 kV $/2	Design 3 345 kV $/2	Design 3 2x345 kV $/2	Design 3 500 kV $/2	Design 3 765 kV $/2
CSWS+	13,317	10,762	8,081	5,115	11,563	8,633	7,083	4,245	10,791	8,440	6,785	3,855	12,350	10,085	7,707	4,530
SPS	10,865	8,838	6,852	4,755	10,965	8,558	6,660	3,540	10,918	8,773	6,603	3,945	8,553	6,881	5,365	3,225
OKGE	7,290	6,075	4,731	2,700	7,156	5,290	4,463	2,745	6,564	5,279	4,261	2,700	5,852	5,010	3,887	2,295
SECI	6,470	5,440	4,136	2,880	6,867	5,387	4,088	2,700	6,632	5,053	3,820	2,250	5,362	4,129	3,436	2,205
WFEC	5,745	4,817	3,637	2,295	5,194	3,935	2,956	1,680	5,295	4,236	3,100	1,680	5,093	4,075	3,244	1,680
WR	3,669	2,967	2,102	1,545	3,286	2,290	1,862	1,365	3,252	2,365	2,111	1,365	3,185	2,634	2,111	1,260
SPA+	3,044	2,322	1,622	960	2,184	1,527	1,363	675	1,760	1,355	1,209	675	2,641	2,118	1,459	960
WAPA-DK	1,250	925	825	0	3,353	2,774	2,313	1,260	1,048	925	825	0	914	925	480	0
NPPD	551	441	393	0	2,493	2,107	1,689	1,005	981	495	441	0	134	215	192	0
KCPL+	961	903	403	630	847	774	403	450	766	452	403	0	847	452	403	630
OPPD	443	215	192	0	578	710	441	300	443	495	441	0	309	215	192	0
CBPC-NIPCO	0	0	0	0	1,478	1,398	1,248	675	0	0	0	0	0	0	0	0
NWPS	343	183	163	0	457	548	326	255	343	183	163	0	228	183	163	0
BEPC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLACKWATER-ACDC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EDE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

AC Transmission Expansion $M to B2B HVDC Ties



Notes:
1. Includes remaining 1/2 cost for B2B HVDC capacity expansion ties.

AC Transmission Expansion $M to HVDC B2B Ties

	Design 2a 345 kV $/2	Design 2a 2x345 kV $/2	Design 2a 500 kV $/2	Design 2a 765 kV $/2	Design 2b 345 kV $/2	Design 2b 2x345 kV $/2	Design 2b 500 kV $/2	Design 2b 765 kV $/2
EDDY-ACDC to SPS	403	215	192	0	134	0	0	0
BLACKWATER-ACDC	0	0	0	0	0	0	0	0
LAMAR-ACDC to SECI	564	452	403	210	282	151	134	210
LAMAR-ACDC to SPS	1,129	903	605	315	705	677	403	315
LAMAR-ACDC to NPPD	699	559	499	390	349	280	250	0
LAMAR-ACDC to OKGE	806	645	576	450	202	323	288	0
SIDNEY-ACDC to CBPC-NIPCO	0	0	0	0	0	0	0	0
SIDNEY-ACDC to NPPD	108	0	0	0	108	0	0	0
SIDNEY-ACDC to RC-ACDC	134	0	0	0	0	0	0	0
SIDNEY-ACDC to SECI	0	0	0	0	0	0	0	0
SIDNEY-ACDC to WAPA-DK	0	0	0	0	0	0	0	0
STEGAL-ACDC to CBPC-NIPCO	1,209	968	864	675	0	0	0	0
STEGAL-ACDC to NPPD	847	677	605	315	141	0	0	0
STEGAL-ACDC to WAPA-DK	1,371	1,097	979	510	0	0	0	0
RC-ACDC to CBPC-NIPCO	269	430	384	0	0	0	0	0
RC-ACDC to MDU	363	290	259	0	0	0	0	0
RC-ACDC to NPPD	323	258	230	0	0	0	0	0
RC-ACDC to WAPA-DK	269	215	192	0	134	0	0	0
RC-ACDC to SIDNEY-ACDC	134	0	0	0	0	0	0	0
MC-ACDC to CBPC-NIPCO	0	0	0	0	0	0	0	0
MC-ACDC to MDU	242	194	173	0	121	194	173	0
MC-ACDC to WAPA-DK	0	0	0	0	0	0	0	0
MC-ACDC to SPC	0	0	0	0	0	0	0	0

Observations

- Further analyses are warranted since status quo appears to be least desirable scenario among HVDC alternative futures
- Significant AC expansion is needed 2024-2038 absent any changes to EI-WECC Seams facilities.
- Further analysis of EHV AC voltages for backbone facilities is warranted
- Transmission expansion costs are understated since they are based on equivalized EHV models and don't consider substations as well as integration to underlying existing AC systems. Significant system reconfiguration would be required for any of these futures.
- Harmonized models and datasets are an important and valuable step in shaping future dialogue and assessments

Next Steps

- Sensitivity analyses to demonstrate robustness of solutions
- Production Costing and Reliability Assessments
- Conclude DOE-funded HVDC alternative assessments as part of Interconnections Seams Study and publish report in December 2017
- Need to investigate relocated B2B ties and HVDC terminals, as well as potential AC, as well as Hybrid, Seam scenarios
- Need to scope supplemental analyses to inform regional planning and shape dialogue about next steps