Preliminary Transmission Sensitivities & Nodal Results

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Workshop #5 Transmission Office Hour

Agenda:

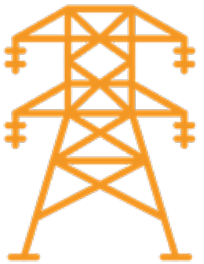
- Transmission cost adder discussion from Wednesday
  - Cost adders impact least cost portfolios.

- Transmission sensitivities - largely informational
  - Zonal transmission sensitivities
  - Nodal transmission sensitivities
    - Main focus is curtailments

Transmission Considerations

April 15th zonal results have not considered resource location. Results are location neutral.

- Most selected resources do not require transmission (EE, DR) or could be located to have minimum transmission expense (solar, short duration storage).
- Pumped hydro storage (PHS) is selected in the HEG future and would be expected to be remote to PNM service territory. Since storage largely utilizes transmission when renewables are not generating, new transmission is not likely required to accommodate some level of pump storage.
- Nuclear is selected in later years of the study period. It is expected that location would be remote so additional analysis with transmission costs was performed to determine implications.



Transmission Cost Adders For Zonal Analysis

Cost Adder Determination for Four Corners location (4C-PV-SJ)

- Four Corners-Albuquerque Line Addition ($448M)
- Capacity Added – 700 MW
- Transmission Cost Adder - $448M/700 MW = $640,000/MW

Adder increases the capital cost applied to the candidate resources utilizing the new transmission capacity:

- Amount of adder = Candidate resource capacity in MW times the Transmission Cost Adder.
- Example: 100 MW Pumped Storage times $640,000/MW = $64M

CTP and HEG Portfolio Composition

New Installed Capacity (MW)

CTP															
CTP	Nuclear	Coal	GasCC	GasCT	GasST	GasLG	SD Storage	LD Storage	PHS	DR	Solar	Wind	Geo	Energy Efficiency	Total
Total	1,022	-	-	212	-	120	1,195	200	-	88	1,508	800	-	377	5,522

New Installed Capacity (MW)

HEG															
HEG	Nuclear	Coal	GasCC	GasCT	GasST	GasLG	SD Storage	LD Storage	PHS	DR	Solar	Wind	Geo	Energy Efficiency	Total
Total	1,460	-	-	212	-	280	1,063	400	200	95	1,762	876	-	377	6,725

CTP with Cost Adder

CTP Cost Adder minus CTP															
	Firm Generating Resources							Dynamic Balancing Resources				Carbon-Free Energy Resources			
	Nuclear	Coal	GasCC	GasCT	GasST	GasLG	Geothermal	SD Storage	LD Storage	PHS	DR	Solar	Wind	Energy Efficiency	Total
Year	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)
2026	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2027	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2028	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2029	-	-	-	-	-	-	-	(0)	-	-	-	-	-	-	(0)
2030	-	-	-	-	-	-	-	-	-	-	-	0	-	-	0
2031	-	-	-	-	-	-	-	(0)	-	-	-	-	-	-	(0)
2032	-	-	-	-	-	-	-	-	-	-	-	0	-	-	0
2033	-	-	-	-	-	-	-	(71)	-	-	-	(55)	38	-	(89)
2034	-	-	-	-	-	-	-	-	-	B	-	(6)	-	-	(6)
2035	-	-	-	-	-	-	-	-	-		-	(59)	39	-	(20)
2036	-	-	-	-	-	-	-	-	-	-	-	(33)	17	-	(16)
2037	-	-	-	-	-	-	-	-	-	-	-	2	-	-	2
2038	-	-	-	-	-	-	-		-	-	-	(5)	-	-	(5)
2039	-	-	-	-	-		-	51	-	-	-	(6)	-	-	45
2040	(146)	-	-	-	-	120	-	19	-	C	-	-	-	-	(7)
2041	146	-	-	-	-	(40)	-	(65)	-		-	-	-	-	41
2042	-		-	-	-	-	-	(56)	-	-	-	(1)	-	-	(57)
2043	(146)	A	-	-	-	-	-	8	-	-	-	300	-	-	162
2044	-	-	-	-	-	-	-	174	-	-	-	103	-	-	277
2045	-	-	-	-	-	-	-	19	-	-	-	(16)	-	-	(1)
Total	(146)	-	-	-	-	80	-	74	-	-	-	223	94	-	325

Key Observations

A Nuclear additions reduced (15%)

B Reductions to storage, solar and additions to wind in focus period (2033-2036)

C Adding more gas, short duration storage and solar beyond the focus period.

HEG with Cost Adders

HEG Cost Adder minus HEG															
	Firm Generating Resources							Dynamic Balancing Resources				Carbon-Free Energy Resources			
	Nuclear	Coal	GasCC	GasCT	GasST	GasLG	Geothermal	SD Storage	LD Storage	PHS	DR	Solar	Wind	Energy Efficiency	Total
Year	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)
2026	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2027	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2028	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2029	-	-	-	-	-	-	-	0	-	-	-	0	-	-	0
2030	-	-	-	-	-	-	-	-	-	-	-	0	-	-	0
2031	-	-	-	-	-	-	-	0	-	-	-	0	-	-	0
2032	-	-	-	-	-	-	-	1	-	-	-	(14)	-	-	(14)
2033	-	-	-	-	-	-	-	-	100	-	-	(4)	83	-	179
2034	-	-	-	-	-	-	-	-	-	(200)	-	(203)	13	-	(391)
2035	-	-	-	-	-	-	-	-	-	-	-	(195)	178	-	(17)
2036	-	-	-	-	-	(40)	-	-	-	-	-	44	49	-	53
2037	-	-	-	-	-	-	-	-	-	-	-	30	36	-	66
2038	-	-	-	-	-	40	-	-	-	-	-	(51)	-	-	(11)
2039	-	-	-	-	-	40	-	-	-	-	-	(42)	-	-	(2)
2040	(146)	-	-	-	-	80	-	27	-	-	(8)	49	68	-	70
2041	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2042	-	-	-	-	-	40	-	-	-	-	-	122	-	-	162
2043	(146)	-	-	-	-	80	-	29	-	-	-	208	-	-	171
2044	(146)	-	-	-	-	-	-	260	-	-	-	300	-	-	414
2045	-	-	-	-	-	-	-	(59)	100	-	-	35	-	-	76
Total	(438)	-	-	-	-	240	-	258	200	(200)	(8)	278	428	-	758

A

B

C

Key Observations

A PHS (24-hr) is eliminated in the portfolio, iron-air long- duration storage (100 hr) comes in focus period. (2033-2036)

B Nuclear amount reduced as with CTP (30%)

C Adding more gas (linear generator), short duration storage, solar and wind beyond the focus period.

Summary

- Cost Adders change the timing and size of resource types in the capacity portfolio optimization.
- This is seen the previous slides in the trade-offs the optimization is making to minimize cost of the portfolio.
- In both examples, adding cost adder increased total build-out of the portfolio.

Zonal Questions

Questions?

2026 IRP Transmission Sensitivities

No	Current Trends & Policy (CTP)	High Economic Growth (HEG)	Low Economic Growth (LEG)
1	None	None	None
2	High Electric Vehicles	TOU	TOU
3	TOU	Extreme Economic Development	ETA 400 thru 2044, Zero CO2 by 2045
4	Transmission Project - Rio Sol	Transmission Project - Rio Sol	No ETA
5	Transmission Project - SunZia	Transmission Project - SunZia	
6	Transmission Project - Blackwater DC Tie	Transmission Project - Blackwater DC Tie	
7	Transmission Project - Four Corners	Transmission Project - Four Corners	
8	Late Long-Duration Storage	Late Long-Duration Storage	
9	No New Natural Gas Resources	ETA 400 thru 2044, Zero CO2 by 2045	
10	No ETA	No ETA	
11	ETA 400 thru 2044, Zero CO2 by 2045		
12	Federal CO2 tax beginning 2030		

Sensitivities subject to change or modification

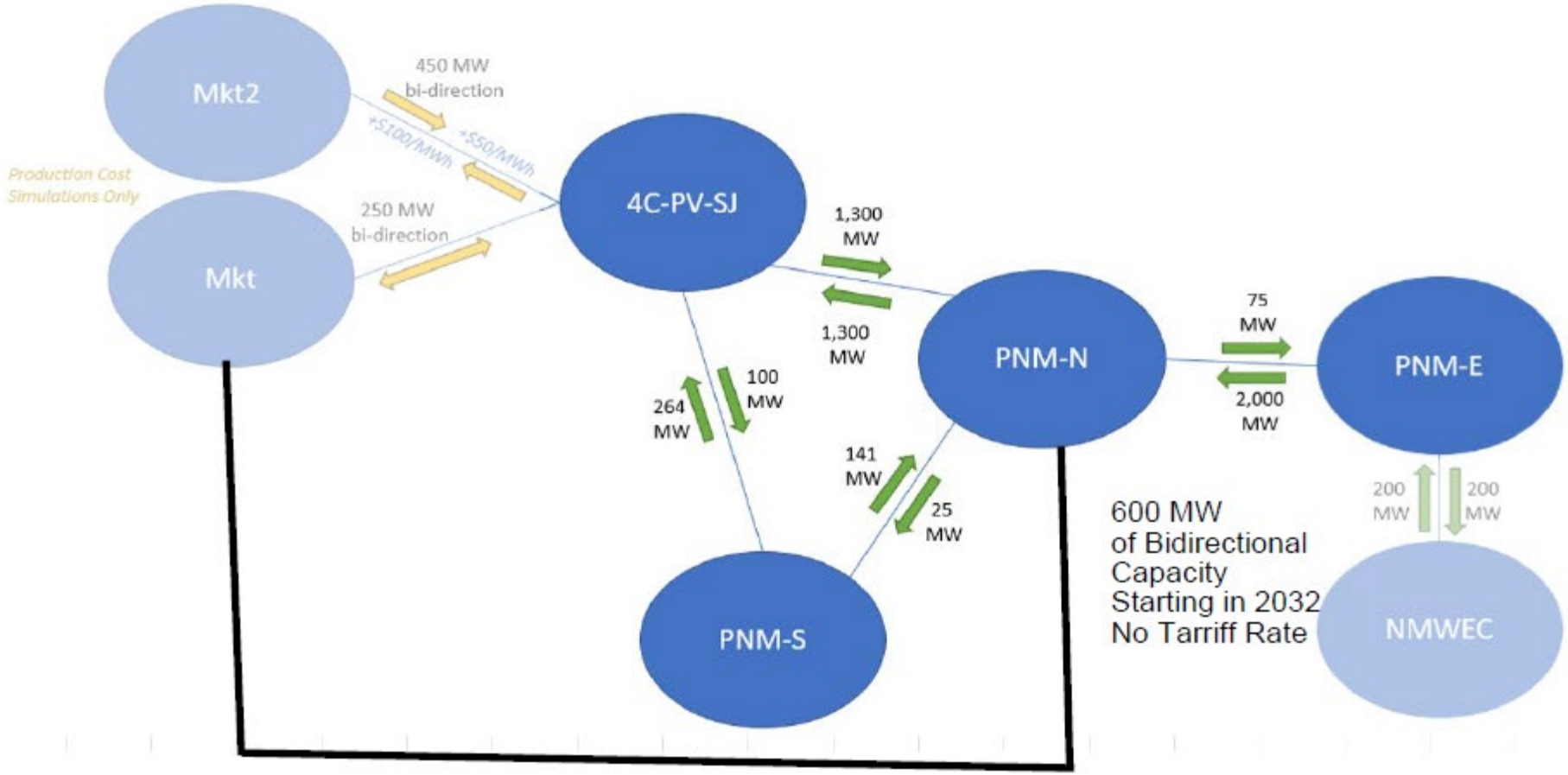
CTP = Current Trends & Policies, HEG = High Economic Growth
LEG = Low Economic Growth

Zonal Transmission Sensitivity Analysis

- Transmission sensitivities in this analysis are exploratory using conceptual projects that have been discussed in New Mexico.
  - PNM has made simplifying assumptions based on available data for modeling purposes (line distance, impedance, cost)
  - Quantifies impacts on portfolio value
  - Results serve as guidance for future transmission development which will require further analysis

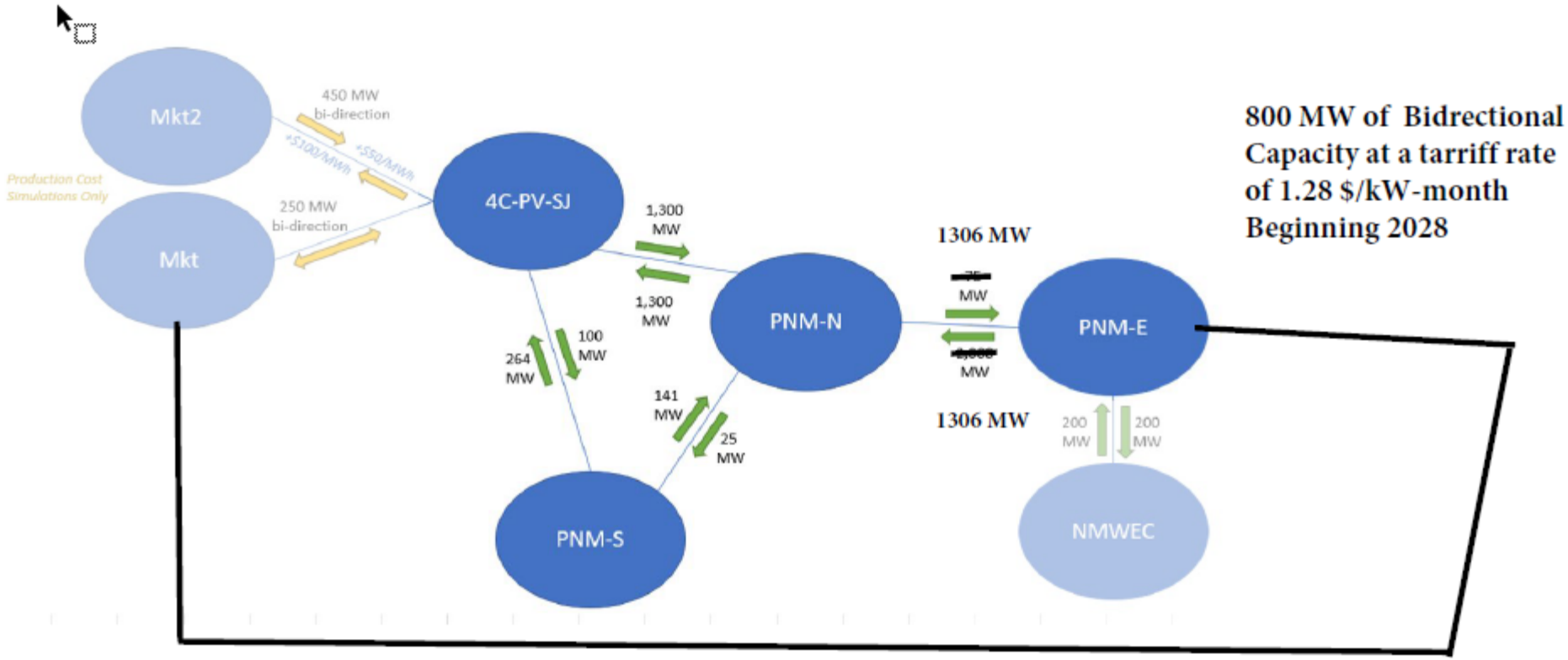
Zonal Transmission project – Rio Sol

- Rio Sol Transmission Alternative



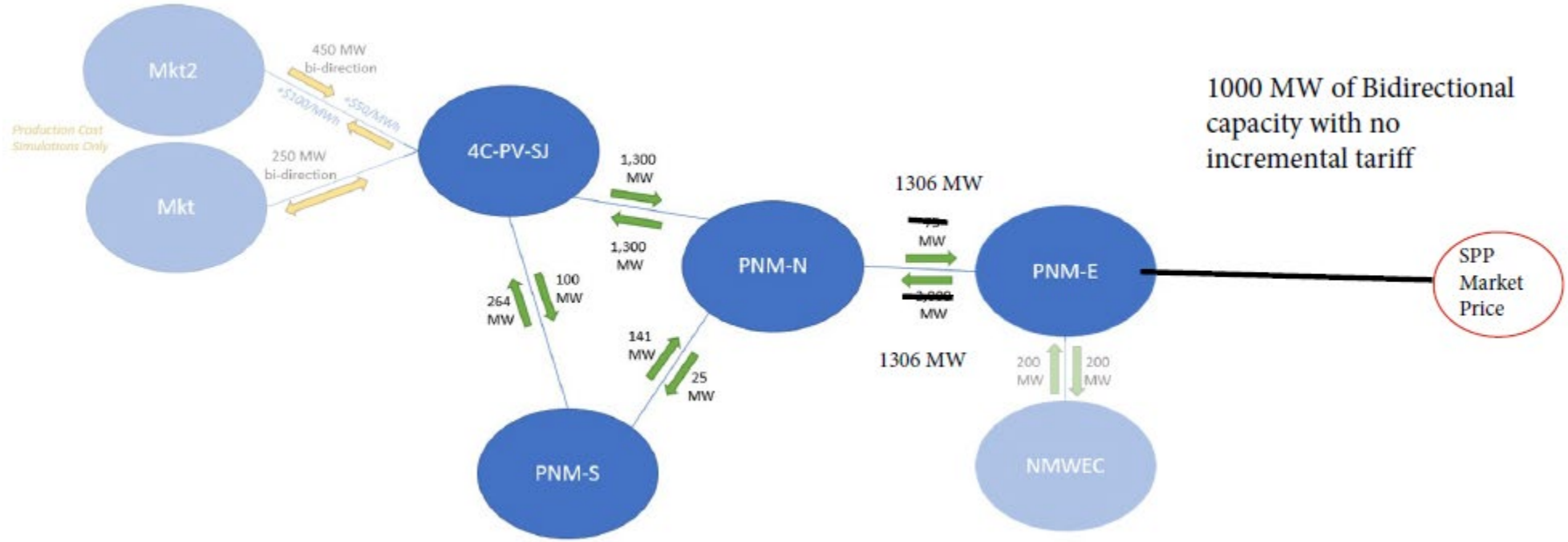
Zonal Transmission project – Sun Zia

- Sun Zia Transmission Alternative



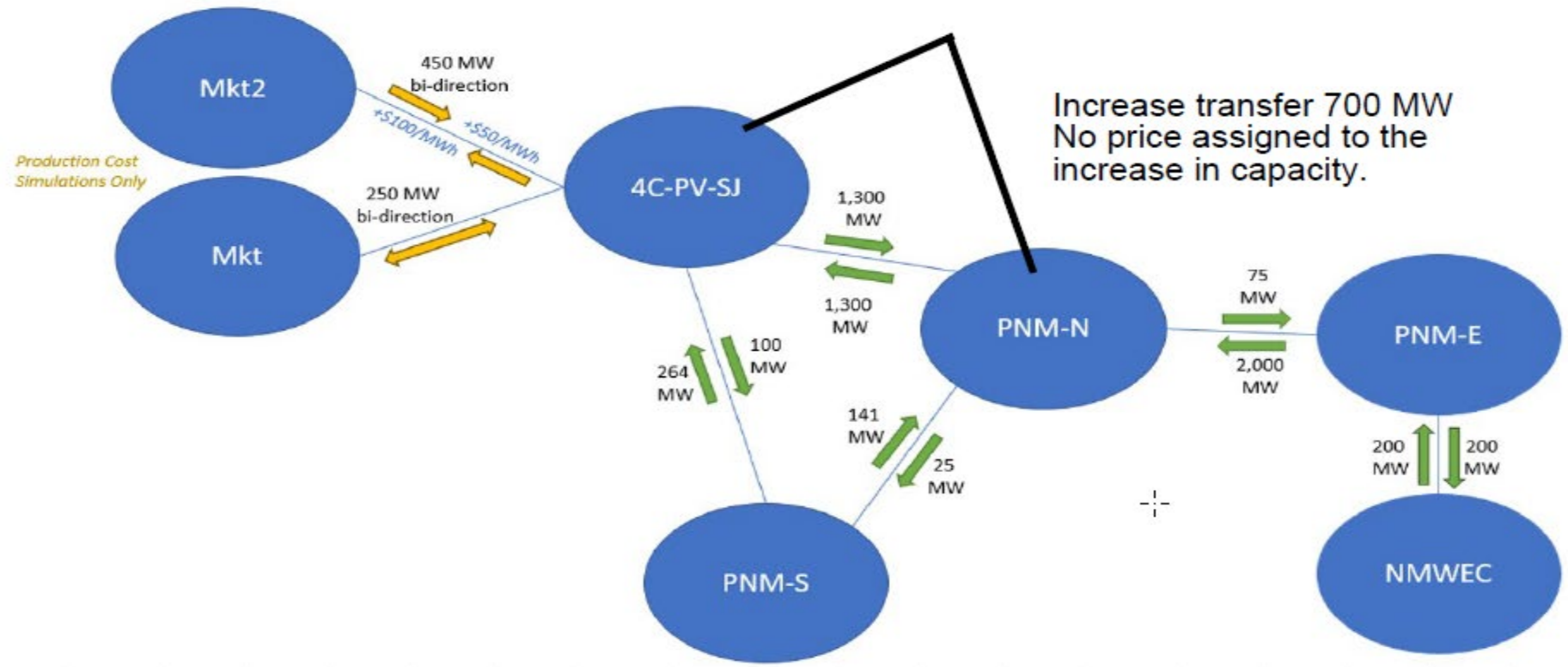
Zonal Transmission project – Black Water

- Black Water Transmission Alternative

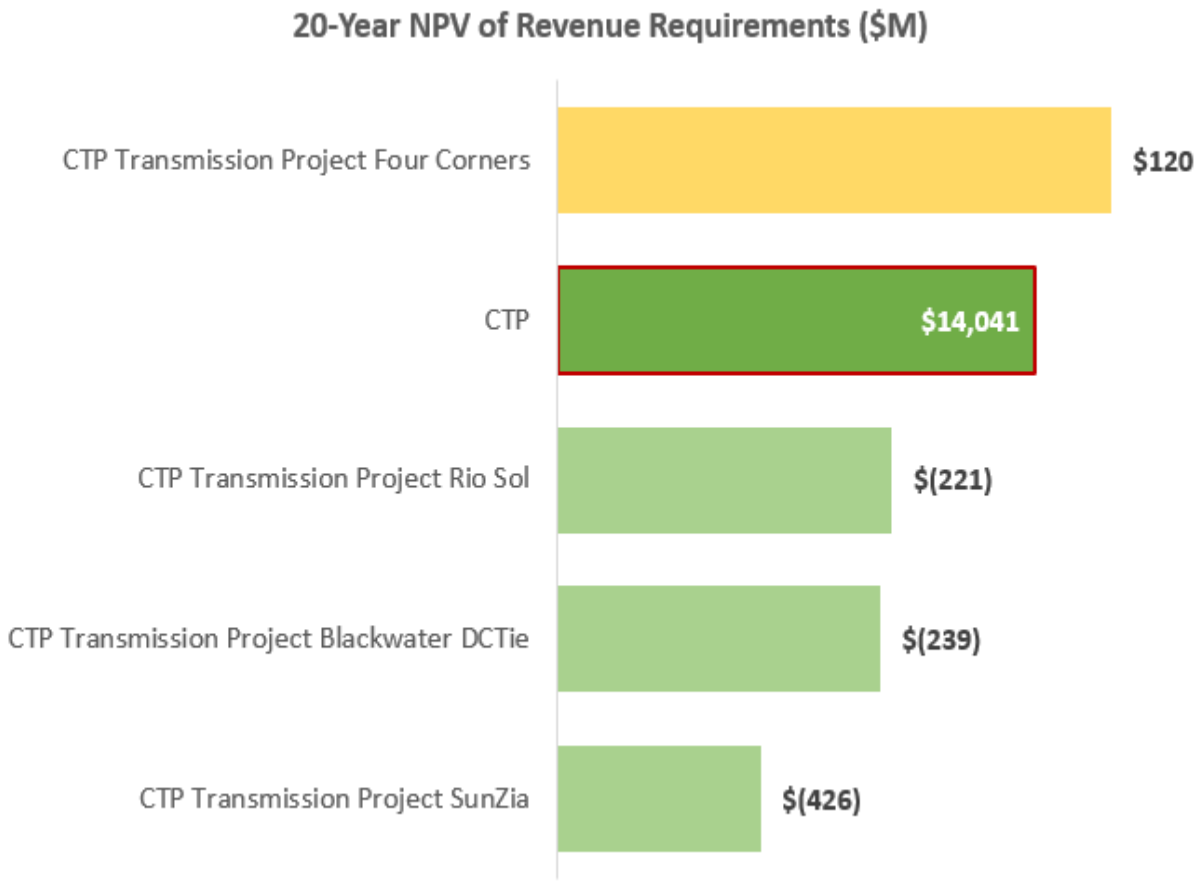


Zonal Transmission project – Four Corners

- Four Corners Alternative

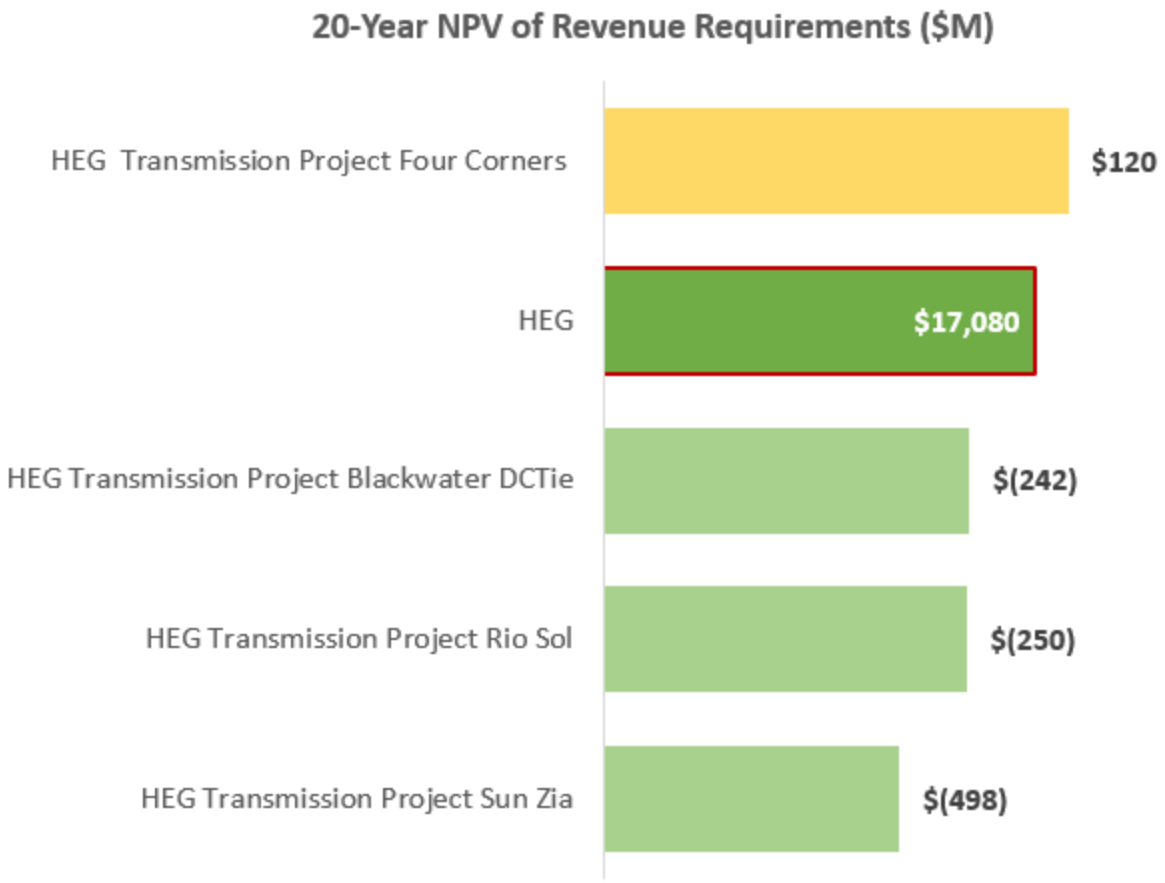


Transmission Scenario NPV results CTP



- Rio Sol, Blackwater and Sun Zia projects offer net present value less than the CTP plan with the same resource portfolio.
- Market access would need to be increased to see value from Four Corners – Albuquerque line addition.

Transmission Scenario NPV results HEG



- Similar Results to CTP.

Zonal Transmission Project Sensitivities

- Zonal model runs are effectively increasing capacity between PNM and a market except for Four Corners sensitivity
- Expanding transmission connections to external markets provides savings to PNM by optimizing the resource portfolio
- Expansion may be required outside of PNM's system to utilize the capacity of the transmission additions.
- 20 Year Transmission Outlook examined other configurations for expanding the transmission system and can be seen here:

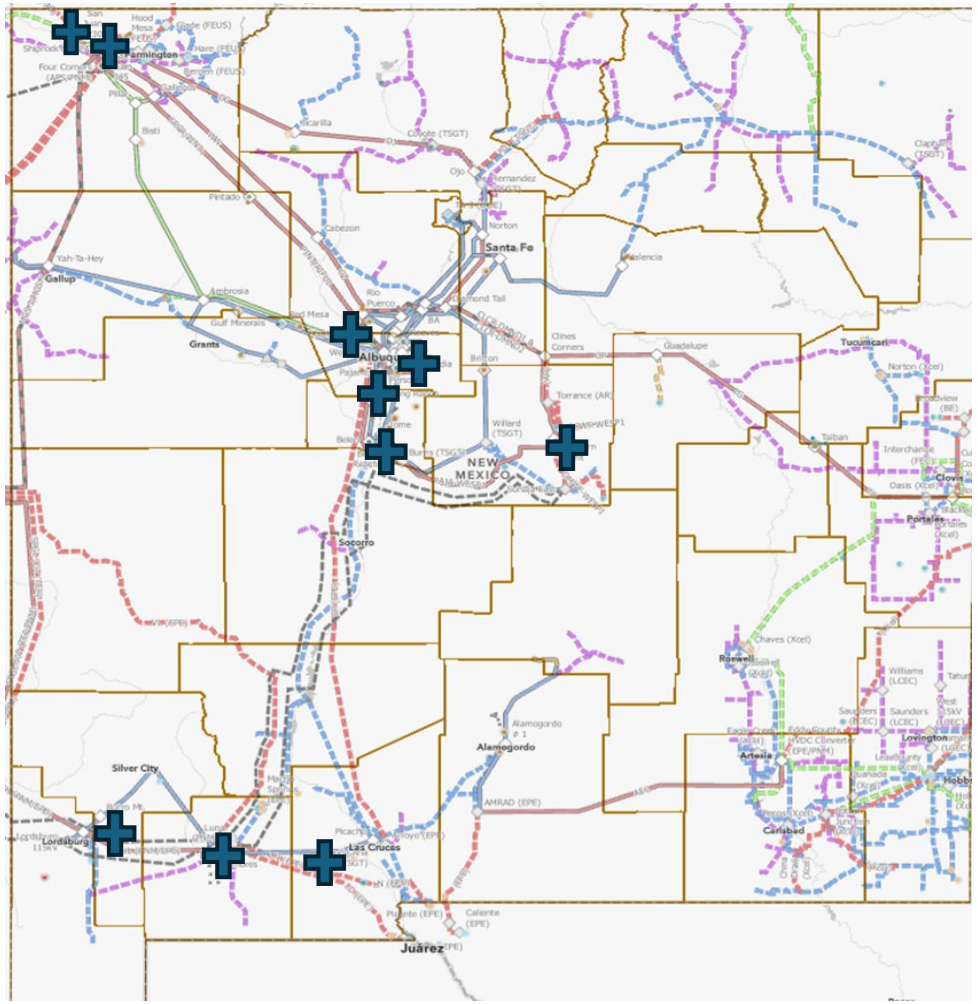
https://www.pnm.com/documents/d/pnm.com/pnm_20-year-transmission-outlook_92025

Transmission Nodal Analysis - Assumptions

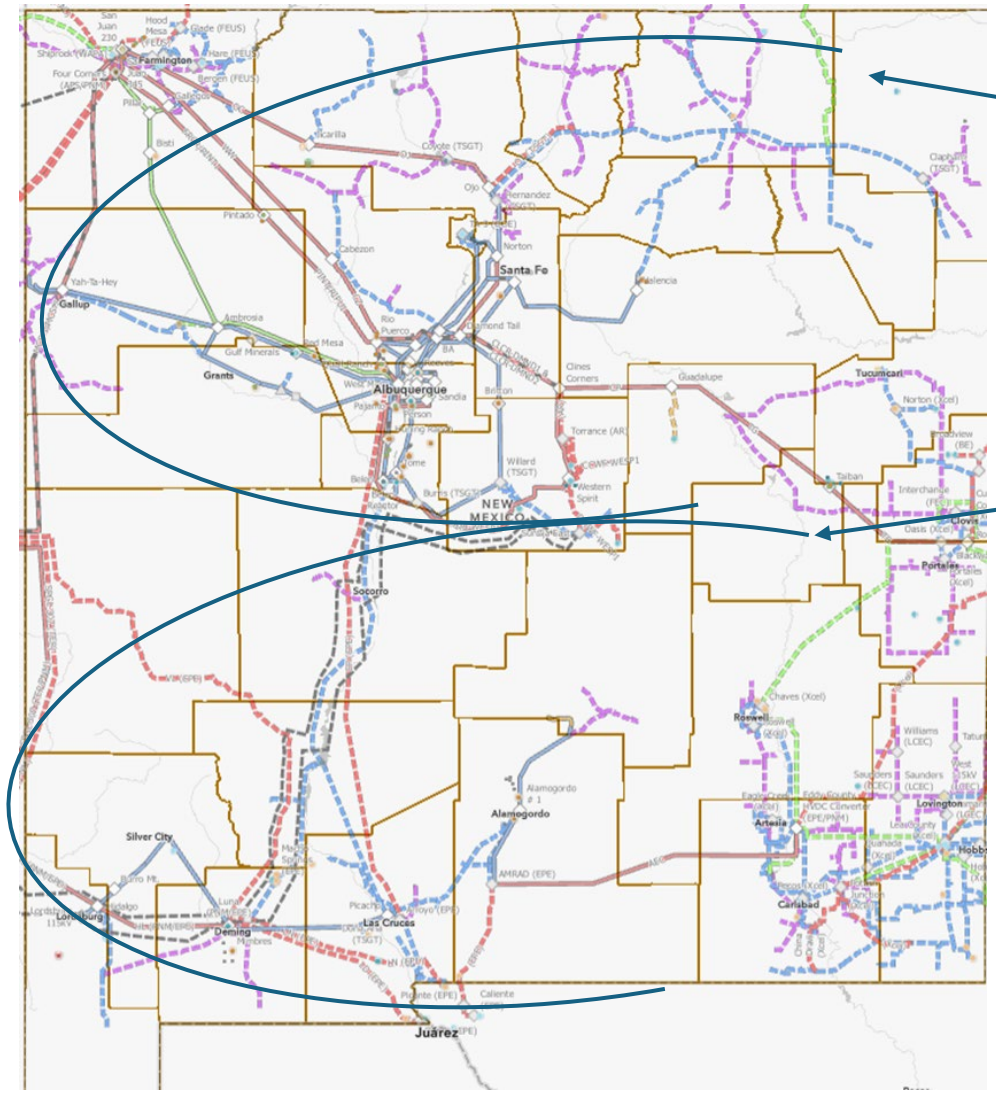
Resource Alternative Name	Mapped Switching Station	CTP	HEG	LEG
CC-CCS-FClass	Hidden Mountian Switching Station			
CC-FClass	Hidden Mountian Switching Station			
Iron A.E.S	Pajarito Switching Station			
Pumped Hydro	San Juan Switching Station			
SMNR	San Juan Switching Station			
TZN-GT-Frame7	Belen Switching Station			
TZN-GT-Frame7 172MW	Rattle Snake Switching Station			
TZN-GT-LM6000 40MW	Belen Switching Station			
TZN-Li-Ion 4Hr	Hidden Mountian Switching Station			
TZN-Li-Ion 4Hr	Prosperity Switching Station			
TZN-Li-Ion 8Hr	Near Person Switching Station			
TZN-Linear Generator	Hidden Mountian Switching Station			
TZN-Solar Generic	La Luz Switching Station			
TZN-Solar Generic	Sandia Switching Station			
TZN-Solar Generic	Petroglyph Switchign Station			
TZN-Solar Generic	Prosperity Switching Station			
TZN-Solar Generic	Pajarito Switching Station			
TZN-Solar Generic	Hidden Mountian Switching Station			
TZS-GT-Frame7	Luna Switching Station			
TZS-Li-Ion 4Hr	Afton Generationing Station			
TZS-Li-Ion 4Hr	Hidalgo Switching Station			
TZS-Linear Generator	Luna Switching Station			
TZS-Solar Generic	Luna Switching Station			
TZS-Solar Generic	Afton Generationing Station			
Wind Generic	Western Spirit Switching Station			
TZE-Wind Generic	Western Spirit Switching Station			

In nodal analysis, resources have to be mapped to the Transmission system so that flows and transmission congestion can be observed.

All 3rd party transmission uses are included in the model.



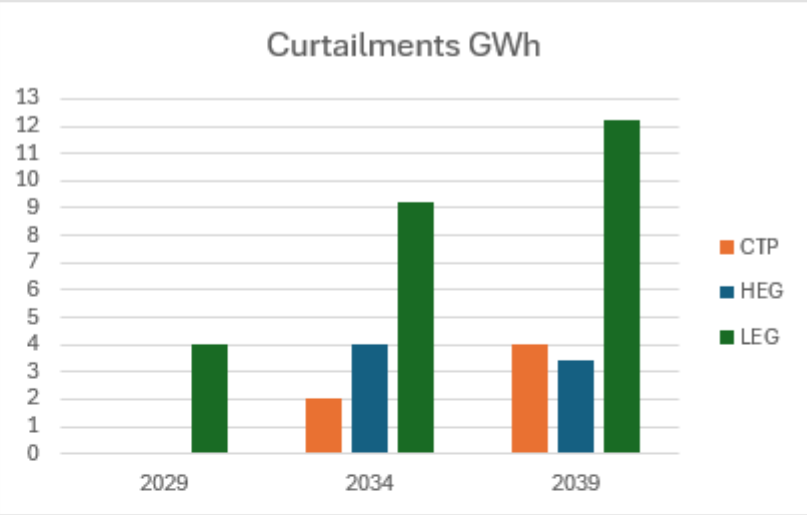
Transmission Nodal Analysis – Assumptions

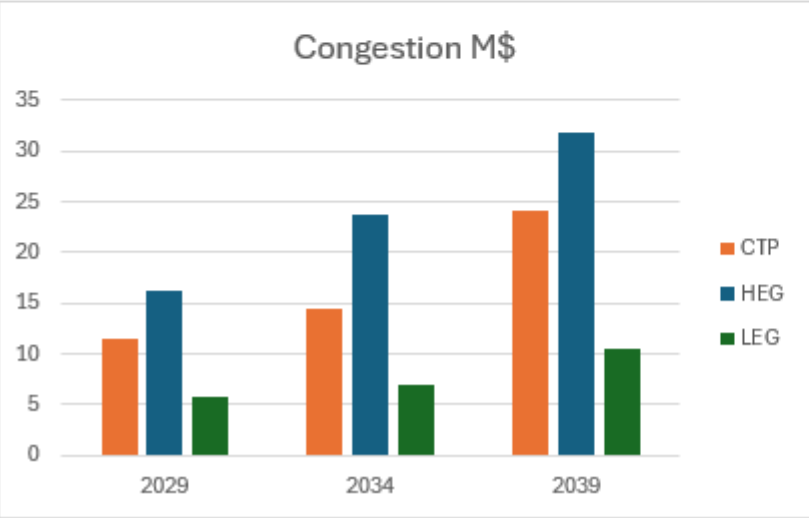


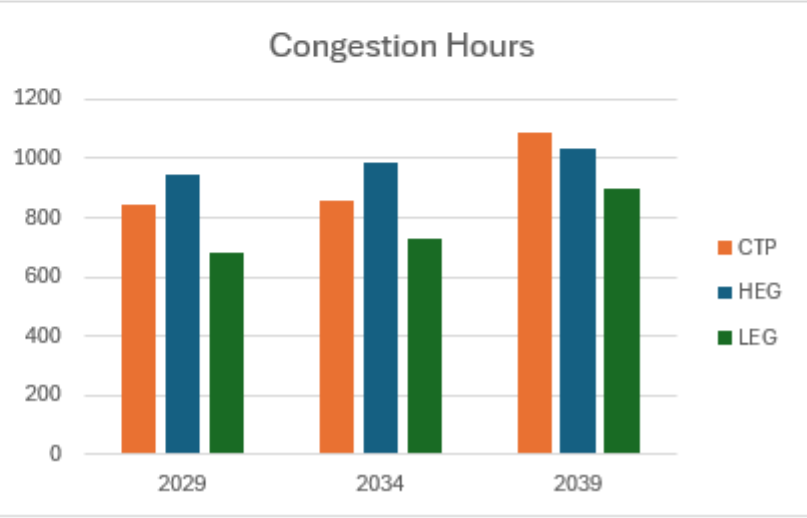
Contingencies simulated in Nodal Analyisis

Contingecies Modeled in Nodal
BA-Rio Puerco 345 kV line ck 1 - CJ
Cabezon - Rio Puerco 345 kV line - CZ
Clines Corners - Western Spirit 345 kV Line - CLCR - WESP1
Four Corners - Pintado 345 kV Line - FCCR-PINT1
Gallup-Yah-Ta-Hey 115 kV Line - GYTH
Pajarito-Sandia 345 kV line - PAJA - SAND1
Pajarito-West Mesa 345 kV Line - PAJA - WSMS1
Rio Puerco - West Mesa ckt 2 - BJ
San Juan - Cabezon 345 kV Line - WW
Sandia-KAFB 115 kV Line - KS
Transformer West Mesa 345/115 kV #2
West Mesa - Arroyo 345 kV Line - EP
West Mesa - Central 115 kV Line - WJ
West Mesa - Person 115 kV Line - PM
RioPuerc - Westmesa Circuit 2
Clines Corners - Blackwater

Transmission Nodal Results on Path 48



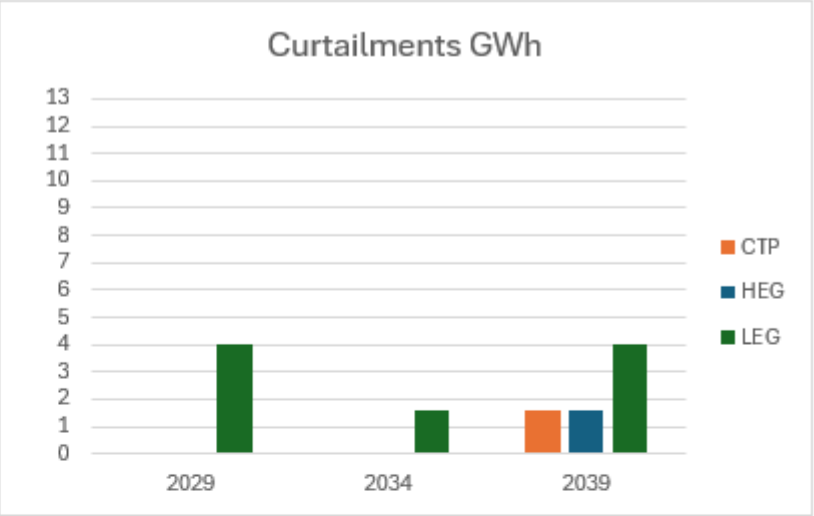


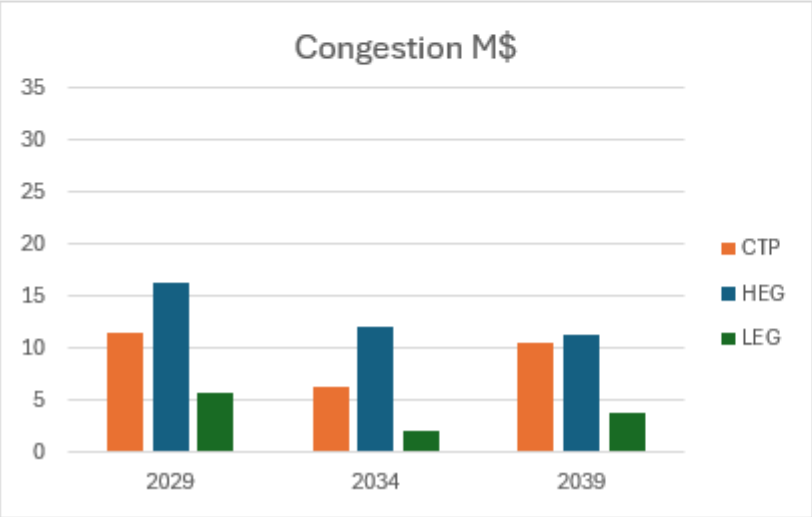


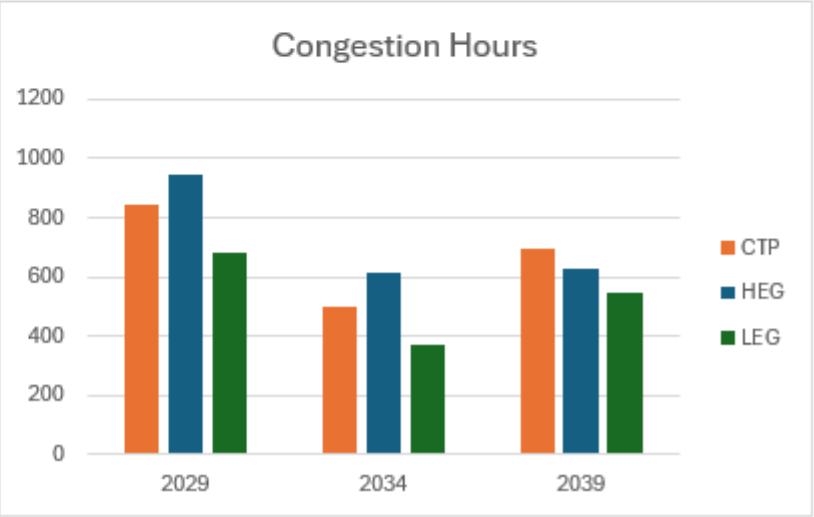
From the CTP, HEG, LEG:

- Increase in loads, losses increase
- Congestion $ increase or decrease with load
- Curtailments are very low in the model and as such the graph is misleading
- Congestion hours follow load except for the HEG case.

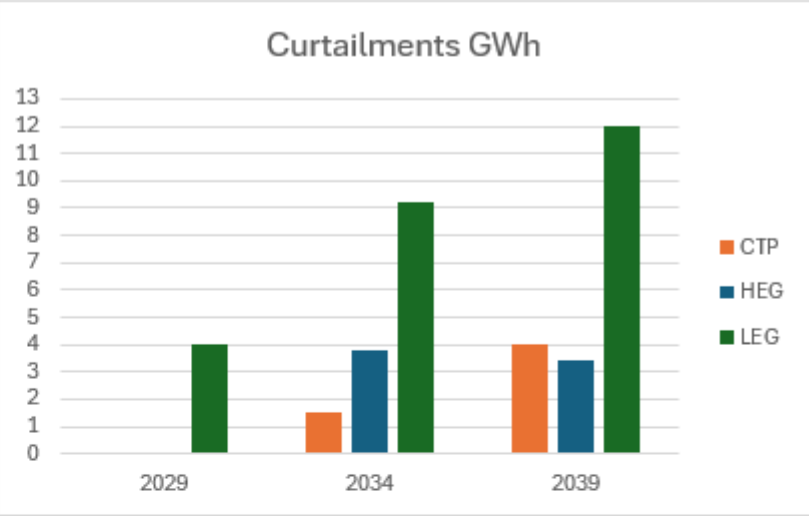
Transmission Nodal Results on Path 48 – Rio Sol

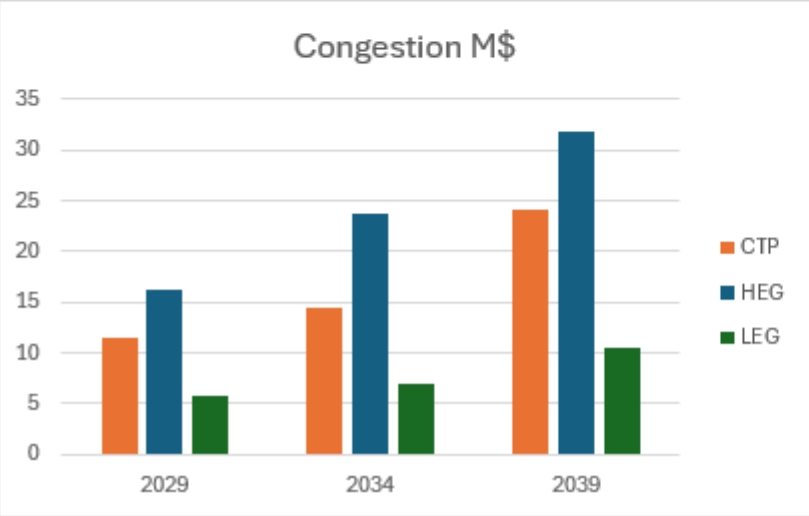


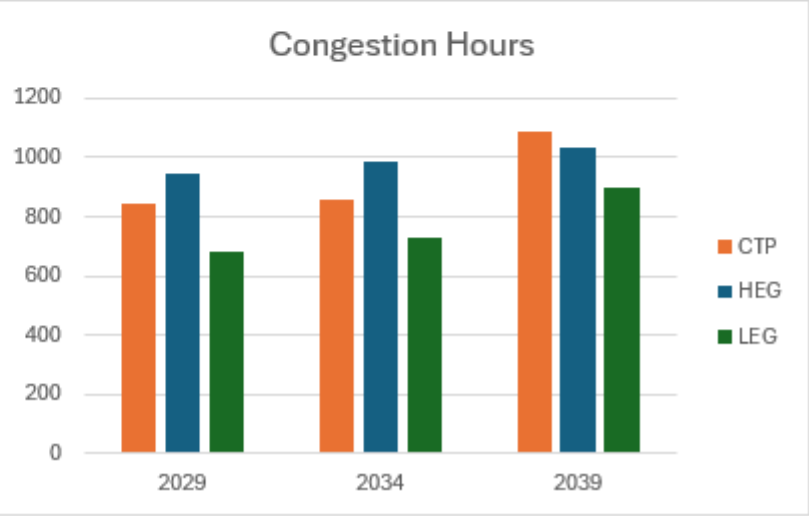




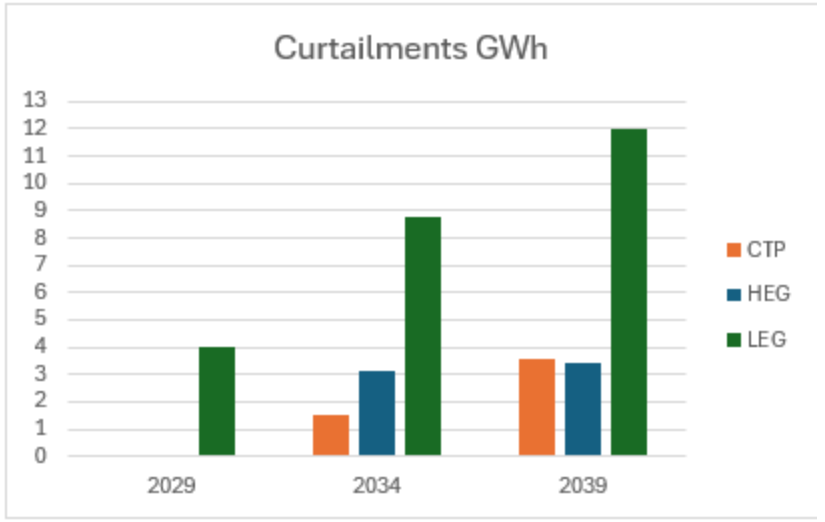
Transmission Nodal Analysis Three futures Path 48 – Sun Zia

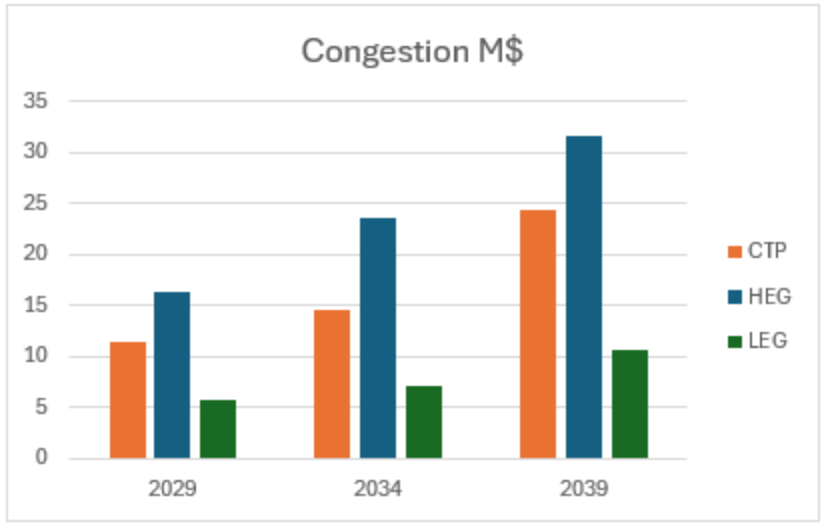


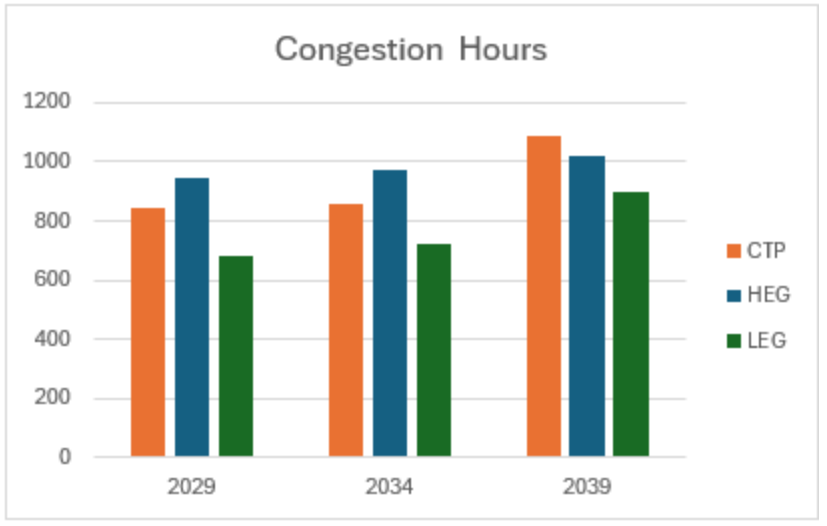




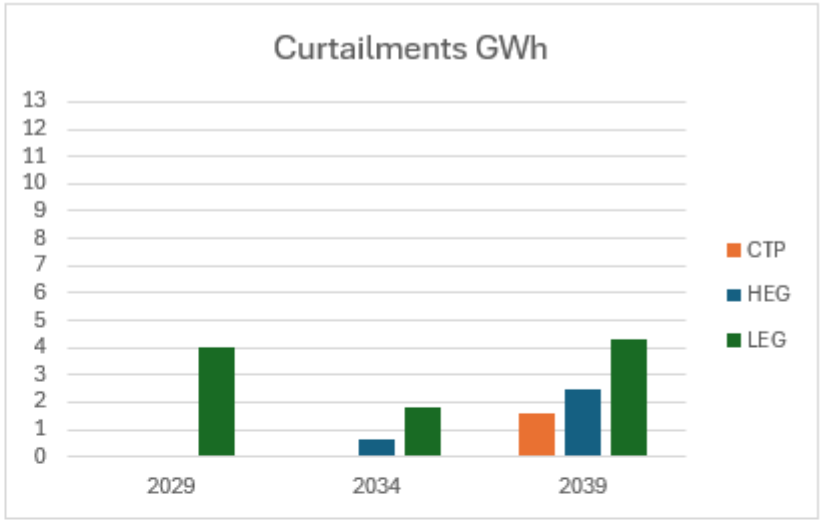
Transmission Nodal Analysis Three futures Path 48 – Blackwater

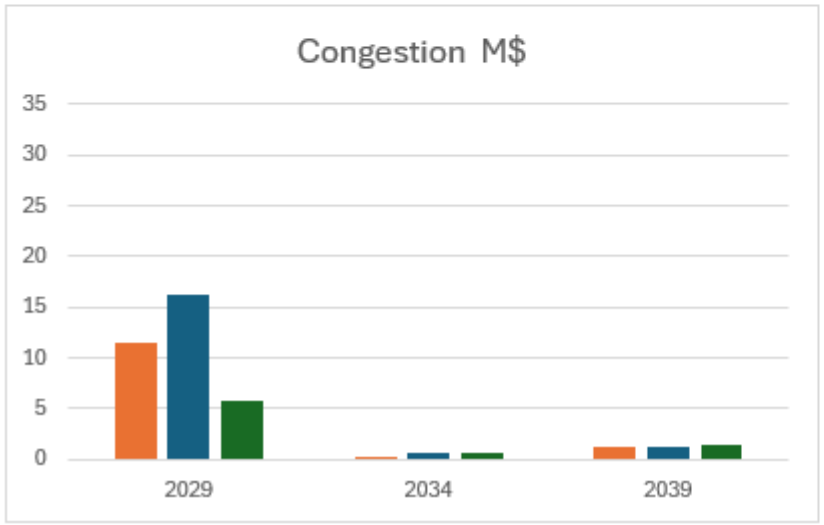


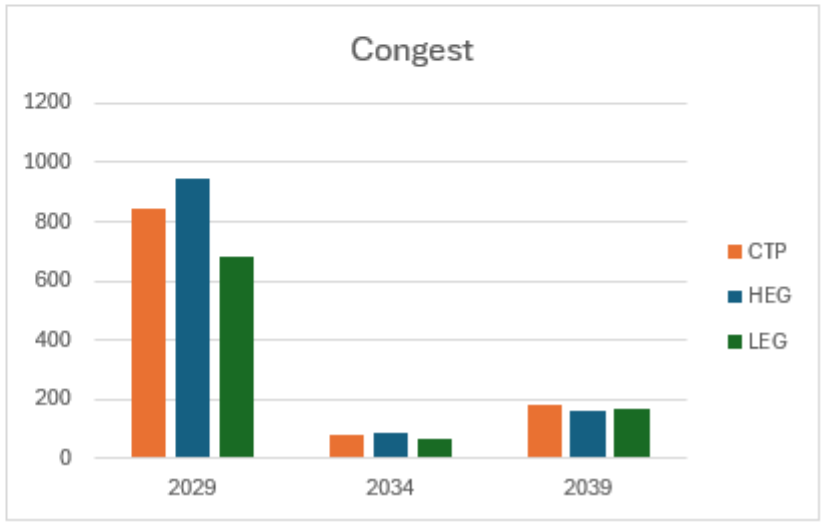




Transmission Nodal Analysis Three futures Path 48 – Four Corners







Takeaways

- Curtailment of renewables is the focus of nodal modeling in this IRP.
  - Significant curtailment results were not identified.
- Remote resources should consider both the potential cost and schedule for transmission enhancements.
- Transmission adders may not be warranted for all technologies in the same location.
  - Storage technologies tend to use the system when renewable sources are not available.
  - Some curtailment may be the more economical solution over a transmission addition provided the system can be redispatch to meet reliability requirements.
- Candidate portfolios will be adjusted based on curtailment impacts.