Market Efficiency Update

Transmission Expansion Advisory Committee

October 17, 2019

2018/19 Market Efficiency Window

Modeling Update

- Posted modeling data for the First Energy withdrawn deactivations
  - Affected units are Davis Besse 1, Perry 1, Sammis 5-7
  - Link to Generator Deactivation information: https://www.pjm.com/planning/services-requests/gen-deactivations.aspx

- Posted as PROMOD XML file on the Market Efficiency Secure Page
  - https://www.pjm.com/planning/rtep-development/market-efficiency/economic-planning-process.aspx

- To be used as sensitivity for the current Market Efficiency Long-Term Window

2018/19 Market Efficiency Window Interregional Analysis

PJM Interregional Proposals Analysis

- Market Efficiency Analysis performed on a base case that includes all previously approved PJM RTEP enhancements and expansions.
- Base Case corrected for the Maple – LNG line rating.
- Completed PROMOD runs
  - Projects modeled using the submitted assumptions
  - Simulated years 2019, 2023, 2026, 2029
- Results coordinated with MISO and interregional benefit allocation determined (see 9/20 IPSAC).
- Completed Cost/Constructability Analysis for all Interregional proposals.

Bosserman – Trail Creek Analysis Overview

- Initial results presented at August 2019 TEAC (slide 6).
- Two lower cost proposals, BT_481 and BT_129, substantially relieve congestion on the driver without shifting congestion.
- Both projects meet all criteria to qualify as an IMEP under the JOA and each regional Tariff.
- RPM benefit analysis found there are no RPM benefits for either BT_481 or BT_129 proposals.
- Cost updated based on PJM's Independent Cost/Constructability Review.
- PJM benefits, cost split, and BC Ratios are shown on the next slide.
- Sensitivity results in Appendix A

Bosserman-Trail Creek Proposal Final Results

Proposal ID	BT_481	BT_129
Proposal Description	**Rebuild Michigan City-Trail Creek-Bosserman 138 kV (10.7mi)**	**New Kuchar station and new Kutchar-Luchtman 138kV line (10.5mi)**
Project Type	Upgrade	Greenfield
B/C Ratio Metric	Lower Voltage	Lower Voltage
In-Service Cost ($MM)*	$24.69	$29.51 (Independent Cost Review) $26.3 (Proposer's Cost Containment)
Cost Containment	No	Yes
In-Service Month	Jan 2023	Dec 2023
% Cong Driver Mitigated	100%	95%
2023 Shifted Cong ($MM)	$0.04	-
PJM Benefit Metric ($MM)	69.16	60.01
PJM Base Case B/C Ratio	2.63	1.91 (with Independent Cost Review) 2.14 (with Proposer's Cost Containment)
PJM Interregional Cost Allocation %**	89.1 %	86.7%

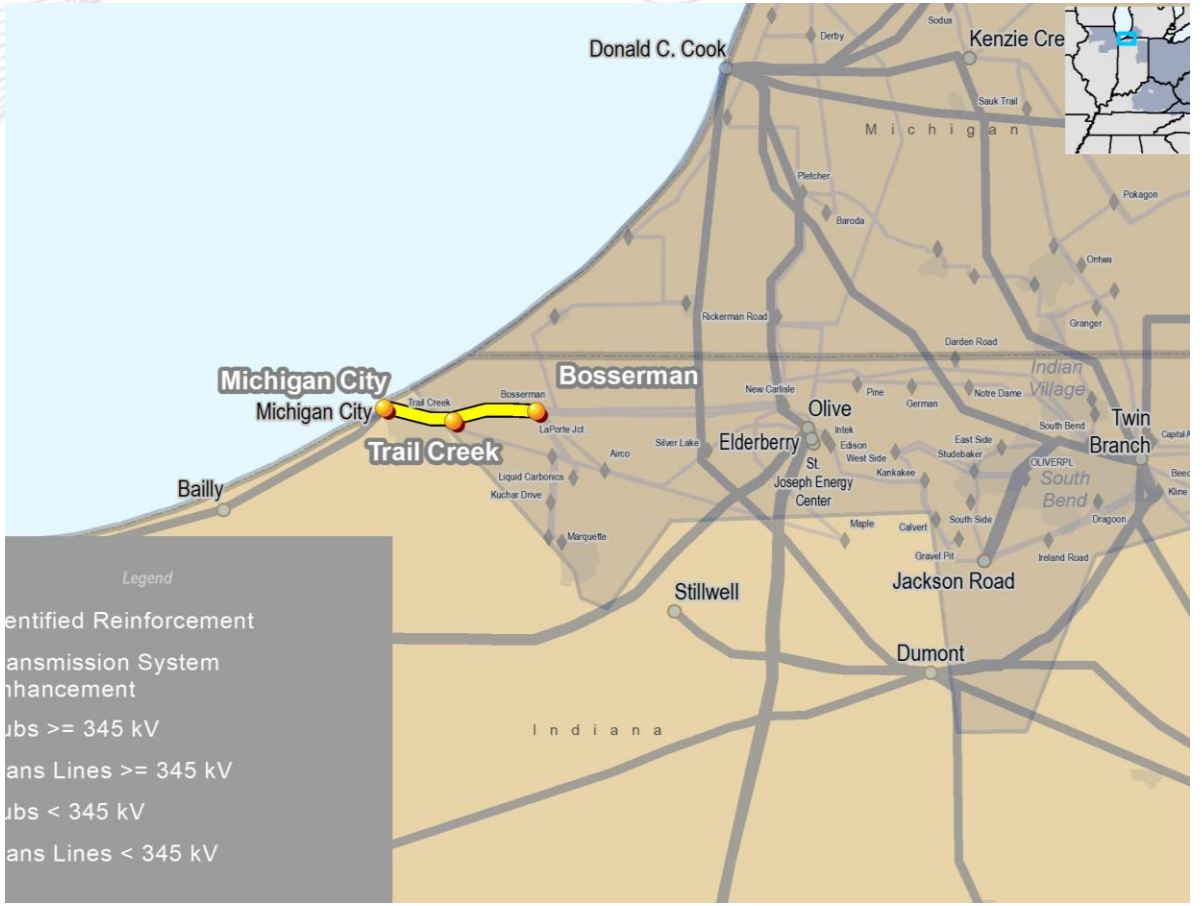
** Costs based on PJM's Independent Cost/Constructability Review*

*** Cost split based on September 20 IPSAC Presentation :*

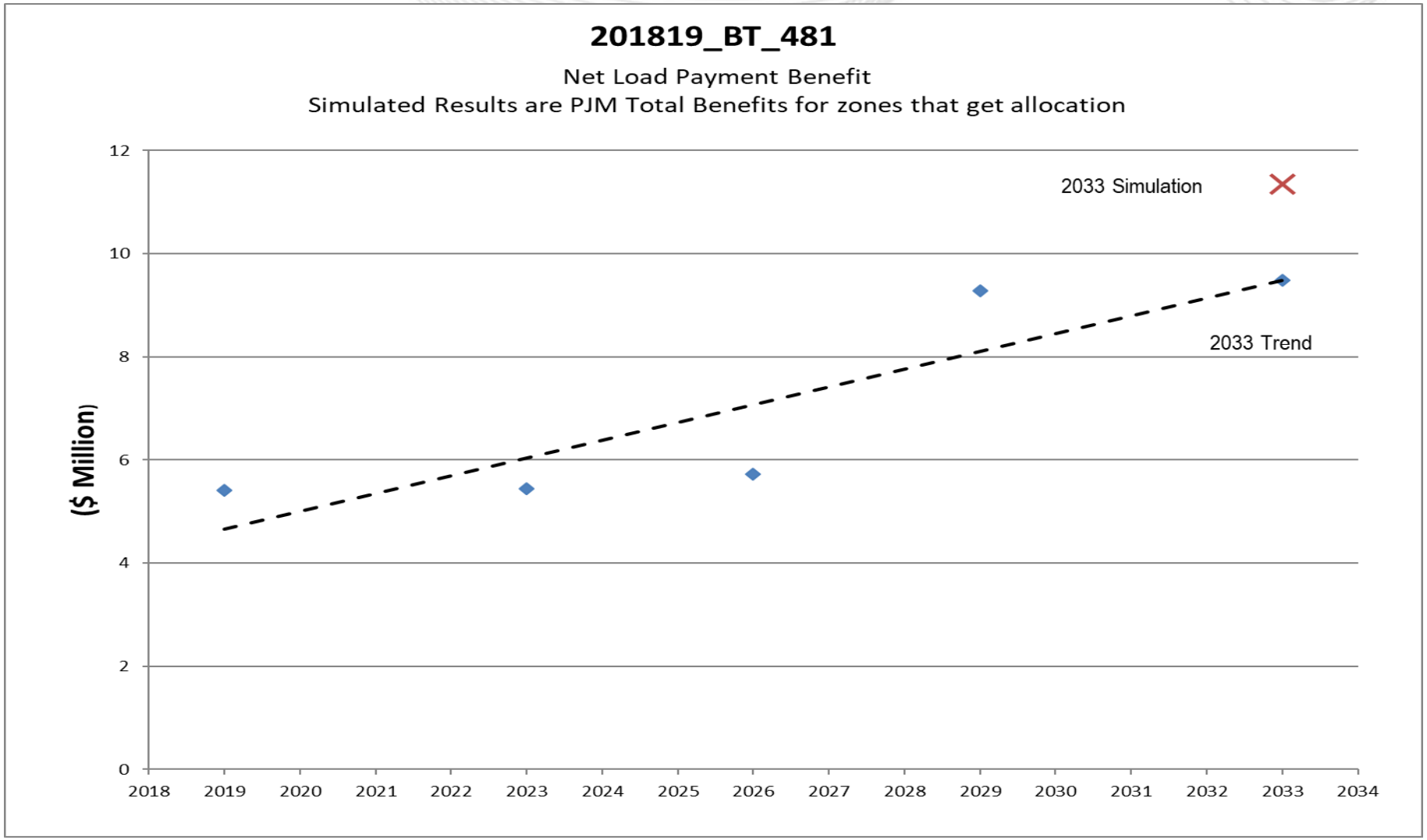
https://www.pjm.com/-/media/committees-groups/stakeholder-meetings/ipsac/20190920/20190920-ipsac-presentation.ashx

Bosserman –Trail Creek 138 kV

- BT_481, rebuilding Michigan City to Trail Creek to Bosserman 138 kV lines:
  - Highest B/C ratio
  - Robustly addresses congestion on identified issue
  - Passed reliability no-harm test
- Recommended as Interregional Market Efficiency Project
- MISO similarly recommends project



Trend for Net Load Benefits of Proposal BT_481



Marblehead Transformer Analysis Overview

- Results presented at Aug 2019 TEAC (slide 7) and Sept 2019 TEAC (slide 14)
- Cost updated based on PJM's Independent Cost/Constructability Review
- PJM benefits and B/C Ratios are shown on the next slide
- Neither proposal addressing Marblehead North Transformer 161/138kV congestion meets the 1.25 B/C threshold
- MH_322 and MH_506 will not be recommended for Board Approval

Marblehead Transformer Proposal Final Results

Proposal ID	MH_322	MH_506
Proposal Description	**Rebuild Palmyra-Marblehead 161 kV and Marblehead-Herleman 138 kV lines (12mi). New 345 kV ring bus at the Palmyra substation.**	**Rebuild Palmyra-Marblehead 161 kV and Marblehead-Herleman 138 kV lines. New Maywood-Palmyra 345 kV line (15mi).**
Project Type	Upgrade	Greenfield
B/C Ratio Metric	Lower Voltage	Lower Voltage
In-Service Cost ($MM)*	$35.95	$36.02
Cost Containment	No	No
In-Service Year	2023	2023
% Cong Driver Mitigated	100%	100%
2023 Shifted Cong ($MM)	$0.11	$0.13
PJM Benefit Metric ($MM)	13.90	25.86
PJM Base Case B/C Ratio	0.36 (FAIL)	0.68 (FAIL)
PJM Interregional Cost Allocation %**	62.7%	76.9%

** Costs based on PJM's Independent Cost/Constructability Review*

*** Cost split based on September 20 IPSAC Presentation :* https://www.pjm.com/-/media/committees-groups/stakeholder-meetings/ipsac/20190920/20190920-ipsac-presentation.ashx

Monroe – Wayne 345 kV Analysis Overview

- None of the Monroe – Wayne proposals significantly decrease the total congestion around the Monroe bus
- Analysis results presented at June 2019 TEAC (slide 11)
- None of the Monroe – Wayne 345 kV proposals will be recommended for Board Approval

Conclusion of Interregional Market Efficiency Analysis

- Analysis is complete, concluding 2019 PJM-MISO Coordinated System Plan

- Three drivers identified:
  - Marblehead N 161/138kV Transformer
    - No proposed project met B/C criteria in either region
  - Monroe – Wayne 345kV
    - No proposed project effectively resolved congestion
  - Bosserman – Trail Creek 138kV
    - Rebuilding Michigan City to Trail Creek to Bosserman 138kV to be recommended in both regional processes

Interregional Market Efficiency Analysis Next Steps

- 2nd read for proposal BT_481, Bosserman-Trail Creek 138kV, at November TEAC
- Recommend BT_481 for provisional* approval at the December Board meeting
- Continue to coordinate with MISO

**Dependent on MISO Board approval of same project*

2018/19 Market Efficiency Window
Hunterstown – Lincoln Proposals

Status Update: Hunterstown – Lincoln

- Preliminary results presented at July 2019 TEAC
  - Calculated preliminary benefits and determined preliminary B/C ratios

- Three lower cost proposals fully relieve congestion on the driver with minimal shift in congestion
  - HL_469: Install SmartWire** power flow control series device
  - HL_622: Rebuild the Hunterstown-Lincoln 115 kV line
  - HL_960: Build new Hunterstown-Lincoln 115 kV line

- Proposals currently under Cost/Constructability Analysis

Hunterstown-Lincoln Analysis Next Steps

- Complete Cost/Constructability Analysis for all proposals
- Hunterstown – Lincoln Proposals
  - Focus on more efficient/cost effective candidates that address congestion

Note: PJM is currently monitoring on-going developments relating to the Hunterstown-Lincoln congestion driver. The outcome of these developments may impact the market efficiency analysis for this driver. Further updates will be provided as they become available.

2019 Annual Reevaluation of Market Efficiency Projects

Reminder: FERC Order regarding Annual Reevaluation

- On June 28, 2019, pursuant to section 205 of the Federal Power Act (FPA), PJM filed revisions to the Operating Agreement (OA), Schedule 6, section 1.5.7(f).
- On August 22, 2019 FERC accepted PJM's proposed OA revisions, effective August 28, 2019:
  - The Office of the Interconnection will not be required to review annually the costs and benefits of constructing Economic-based Enhancements or Expansions with capital costs less than $20 million if, based on updated cost estimates and the original benefits, the Benefit/Cost Ratio remains at or above 1.25.
  - The Office of the Interconnection shall no longer be required to review costs and benefits of constructing Economic-based Enhancements and Expansions once: (i) a certificate of public convenience and necessity or its equivalent is granted by the state or relevant regulatory authority in which such enhancements or expansions will be located; or (ii) if a certificate of public convenience and necessity or its equivalent is not required by the state or relevant regulatory authority in which an economic-based enhancement or expansion will be located, once construction activities commence at the project site.

Reevaluation Overview

- Applies to Market Efficiency projects approved during the 2014/15 and 2016/17 RTEP Windows.
- Using the most recent Market Efficiency case available:
  - Base case version 2019-07-26 (posted on 08/02/2019)
  - With First Energy generator deactivations withdrawn
- Projects already in-service, under construction or cancelled are no longer required to be reevaluated.
- Projects must continue to meet the B/C criterion of 1.25.
- Reevaluation Process to be completed by December 2019.

In-Service, Under Construction or Cancelled Projects

PJM Window Project ID	Baseline#	Type	Area	Constraint	Status	Description
201415_1-2B	b2691	Upgrade	ME/PPL	Brunner Island to Yorkana 230 kV	In Service	Reconductor three spans limiting Brunner Island - Yorkana 230 kV line, add 1 breaker to Brunner Island switchyard, upgrade associated terminal equipment
201415_1-4J	b2698	Upgrade	AEP	Jacksons Ferry to Cloverdale 765 KV	In Service	Replace relays at Cloverdale and Jackson's Ferry substations
201415_1-10B	b2693	Upgrade	COMED	Wayne to South Elgin 138 kV	In Service	Replace L7915 B phase line trap at Wayne substation
201415_1-10D	b2728	Upgrade	COMED	Loretto to Wilton 345 kV (RPM)	In Service	Mitigate sag limitations on Loretto - Wilton Center 345 kV Line and replace station conductor at Wilton Center
201415_1-12A	b2689.1-3	Upgrade	DUQ	Dravosburg to West Mifflin 138 kV	In Service	Reconductor ~7 miles of the Woodville - Peters 138 kV circuit. Reconfigure West Mifflin-USS Clairton 138 kV circuit. Upgrade terminal equipment
201415_1-13E	b2695	Upgrade	DPL	Worcester to Ocean Pines (I) 69 kV	In Service	Rebuild Worcester - Ocean Pine 69 kV ckt. 1
201415_1-18G	b2688.1-3	Upgrade	APS	Taneytown to Carroll 138 kV	In Service	Upgrade terminal equipment on the Lincoln - Carroll 115/138kV path.
201415_1-2A	b2690	Upgrade	PPL/BGE	Safe Harbor to Graceton 230 kV	In Service	Reconductor two spans of the Graceton - Safe Harbor 230 kV transmission line
201415_1-18I	b2696	Upgrade	APS/ATSI	Krendale to Shanor Manor 138 kV	In Service	Upgrade 138 kV substation equipment at Butler, Shanor Manor and Krendale substations
201415_1-10J	b2692.1-2	Upgrade	COMED	Cordova to Nelson 345 kV	In Service	Replace station equipment at Nelson, ESS H-471 and Quad Cities. Upgrade conductor ratings of Cordova - Nelson, Quad Cities - ESS H-471 and ESS H-471 - Nelson 345 kV lines and mitigating sag limitations
201415_1-11H	b2694	Upgrade	PECO	Peach Bottom 500 kV	In service	Increase ratings of Peach Bottom 500/230 kV transformer
Optimal Caps	b2729	Upgrade	DOM	AP-South	Under Construction	New capacitor banks at Brambleton, Ashburn, Shelhorn and Liberty substations
201617_1-3A	b2930 AC1-223	Upgrade	COMED	E. Frankfort to University Park 345 kV	Cancelled	Upgrade capacity on E. Frankford-University Park 345kV

EP Status Projects Under $20 Million

- The following projects have costs under $20 million.
- Therefore they will be reevaluated using the original benefits and updated costs.
- Cost for these projects currently under PJM review.
- Updated B/C ratios to be presented at upcoming TEAC meetings.

PJM Window Project ID	Baseline#	Type	Area	Constraint	Capital Cost* ($ million)	Status	Projected ISD	Description
201415_1-4I	b2697.1-2	Upgrade	AEP	Fieldale to Thornton 138 kV	**$0.80**	EP	1: 06/01/2019 2: 12/31/2019	Mitigate violations identified by sag study to operate Fieldale-Thornton-Franklin 138 kV overhead line conductor at its max. operating temperature Replace terminal equipment at Danville and East Danville substations
201617_1A_RPM_DEOK	b2976 (RPM)	Upgrade	DEOK	Tanners Creek to Dearborn 345 kV	**$0.60**	EP	06/01/2021	Upgrade terminal equipment at Tanners Creek 345kV station. Upgrade 345kV Bus and Risers at Tanners Creek for the Dearborn circuit.
201617_1-3B	b2931 (RPM)	Upgrade	COMED	Pontiac to Brokaw 345 kV	**$5.62**	EP	06/01/2021	Upgrade substation equipment at Pontiac Midpoint station

*Capital costs under annual review by PJM
EP – Engineering Procurement

B/C Reevaluation Candidates

PJM Window Project ID	Baseline#	Type	Area	Constraint	Capital Cost ($ million)	Status	Projected ISD	Description
201415_1-9A*	b2743.**2-8**, b2752.**1-9**	Greenfield	APS/ BGE	AP-South	**$383.63**	EP	11/01/2020	New double-circuit Rice – Ringgold 230 kV. New double-circuit Furnace Run - Conastone 230 kV. Reconductor Conastone – NWest 230 kV.
201617_1-5E	b2992.1-4	Upgrade	BGE	Conastone - Graceton - Bagley 230 kV	Under review	EP	06/01/2021	Reconductor the Conastone to Graceton 230 kV 2323 & 2324 circuits Add Bundle conductor on the Graceton-Bagley-Raphael Road 2305 & 2313 230kV circuits Reconductor Raphael Road - Northeast 2315 & 2337 circuits

EP – Engineering Procurement

Reevaluation Status and Next Steps

- Completed September 2019 Reevaluation of Transource 201415_1-9A (b2743, b2752) project
  - Updated Capital Cost: $383.63 Million
  - Updated Benefits (15-years PV Net Load Payments): $855.19 Million
  - Updated Benefit/Cost Ratio: **2.10**
- Reevaluation of 201617_1-5E (b2992.1-4) project in-progress
- Next steps (for projects b2697, b2976, b2931 and b2992)
  - Finalize cost review
  - Present reevaluated B/C Ratios at upcoming TEAC meetings

2019 Acceleration Analysis

Acceleration Analysis of Reliability Upgrades

- Scope
  - Determine which Reliability upgrades, if any, have an economic benefit if accelerated or modified
- Study Years
  - 2020 and 2024 set of economic input assumptions used to study impacts of approved RTEP projects
- Process
  - Compare market congestion for near term vs. future topology
  - Estimate economic impact of accelerating planned reliability upgrades

Acceleration Analysis Status

- Finalized PROMOD modeling work for 2020 and 2024 (AS-IS topology) cases

- Completed PROMOD simulations
  - 2020 and 2024 study years with 2020 Topology (AS-IS Topology)
  - 2020 and 2024 study years with 2024 Topology (RTEP Topology)

- Compared the board approved reliability upgrades with the congestion reductions between the AS-IS and the RTEP Base cases

Acceleration Analysis: 2020 Load, Generation and Economic Assumptions

Congestion Decreases Associated With Approved Reliability Projects - 2020 Study Year			2020 Study Year		
			2020 Topology	2024 Topology	Congestion Savings ($ Millions)
Constraint Name	AREA	TYPE	Year 2020 Congestion ($ Millions)	Year 2020 Congestion ($ Millions)	
05CAPITOLH138-05CHEM 2138	AEP	LINE	$36.9	$0.0	$36.9
05TANNER345-08M.FORT345	AEP/DEOK	LINE	$1.7	$0.0	$1.7

Upgrade Associated with Congestion Reduction	ISD
B2834:Reconductor and string open position and sixwire 6.2 miles of the Chemical - Capitol Hill 138 kV circuit	2022
B2831:Upgrade/Rebuild Tanner Creek to Miami Fort 345 kV line	2021

Note: For a particular flowgate, the congestion savings for the 2020 study year are calculated as the difference in simulated congestion between the PROMOD case with AS-IS topology and the PROMOD case with the RTEP topology.

Acceleration Analysis: 2024 Load, Generation and Economic Assumptions

Congestion Decreases Associated With Approved Reliability Projects - 2024 Study Year			2024 Study year		
			2020 Topology	2024 Topology	Congestion Savings ($ Millions)
Constraint Name	AREA	TYPE	Year 2024 Congestion ($ Millions)	Year 2024 Congestion ($ Millions)	
05CAPITOLH138-05CHEM 2138	AEP	LINE	$3.4	$0.0	$3.4
05TANNER345-08M.FORT345	AEP/DEOK	LINE	$1.6	$0.0	$1.6

Upgrade Associated with Congestion Reduction	ISD
B2834:Reconductor and string open position and sixwire 6.2 miles of the Chemical - Capitol Hill 138 kV circuit	2022
B2831:Upgrade/Rebuild Tanner Creek to Miami Fort 345 kV line	2021

Note: For a particular flowgate, the congestion savings for the 2024 study year are calculated as the difference in simulated congestion between the PROMOD case with AS-IS topology and the PROMOD case with the RTEP topology.

Acceleration Analysis Results

- No reliability upgrades were selected for acceleration*
  - did not provide significant congestion benefits in the acceleration analysis, or
  - ISD is in near future

**Update will be provided if any facilities may be accelerated*

Appendix A
Bosserman – Trail Creek Sensitivities

B/C Ratio Sensitivities: Bosserman – Trail Creek

Sensitivity	BT_481	BT_129
Base Case	2.63	1.91
FSA Included	5.13	4.40
High Load	3.12	3.19
Low Load	3.73	2.78
High Gas	3.62	3.03
Low Gas	2.26	1.96
Outage Library 1	4.62	3.78
Outage Library 2	3.87	3.38
Outage Library 3	4.21	3.25
Outage Library 4	4.62	3.94
Outage Library 5	3.62	3.50
FE Reactivations	4.62	3.95

Note: B/C ratios computed using Independent Cost / Constructability Review

Revision History

- V1 – 10/14/2019 – Original slides posted