Northwest **Power** and **Conservation** Council

April 4, 2017

MEMORANDUM

TO: **Council members**

FROM: **Brian Dekiep**

SUBJECT: **Transmission and Generation Resources in Montana**

BACKGROUND:

Presenters: John Leland, Consultant Northern Tier Transmission Group (NTTG), and former Northwestern Energy Transmission Planner.

Chelsea Loomis, Northwestern Energy Transmission Planner and NTTG Planning Committee Vice Chair.

Bill Pascoe: Pascoe Energy Consulting.

Brian Altman: Account Executive, Bonneville Power Administration.

Summary: This Power Committee item will have four presenters who are familiar with transmission and generation resources in Montana.

The Northern Tier Transmission Group (NTTG) is a group of transmission providers and customers that are actively involved in the sale and purchase of transmission capacity of the power grid that delivers electricity to customers in the Northwest and Mountain States. Transmission owners serving this region work in conjunction with state governments, customers,

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and other stakeholders to improve the operations of and chart the future for the grid that links all of these service territories. [1]

NTTG coordinates individual transmission systems operations, products, business practices, and planning of their high-voltage transmission network to meet and improve transmission services that deliver power to consumers. NTTG, in late December of 2016 released their draft redline 2016-2017 transmission plan. NTTG in coordination with Northwestern Energy has also conducted additional studies that look at the impacts to the regional transmission study with the potential closure of one or more plants at the Colstrip generation station in Montana.

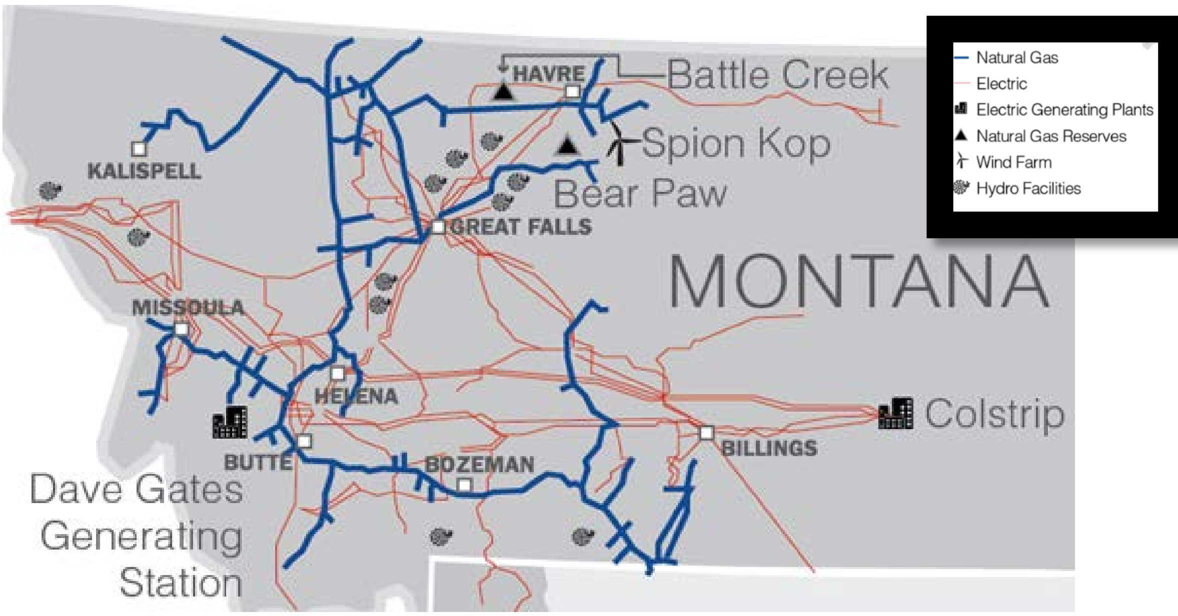
Currently, Northwestern Energy has a significant amount of wind, solar and hydro resource activity in their generation interconnect transmission queue. Some of these Montana developers are also active in the BPA transmission planning process looking to export energy out of the state, while others are looking to provide energy to Montana's native load.

Bonneville Power is currently in their Transmission System Expansion Planning Process (TSEP). The TSEP is a process under which BPA Transmission (BPAT) responds to eligible requests for transmission service on its Network. In TSEP, BPAT processes and studies transmission service requests (TSRs) collectively unless a Customer requests an individual study for a specific TSR. TSEP consists of five phases: Pre-Study, the Cluster Study, Preliminary Engineering, Environmental Review, and Project Construction. The Cluster Study allows BPAT to aggregate TSRs to assess the collective system impacts and to identify the Plan(s) of Service to meet the demand.

Following a Cluster Study, if the Customer chooses to proceed with further evaluation of the Plan(s) of Service, BPAT will perform Preliminary Engineering and Environmental Review, as necessary. Based on the outcome of the study and review of the TSRs, and based on Customers' decisions whether to proceed, BPA will determine whether to proceed with the Plan(s) of Service to provide service. BPA recently providing notice that it is extending the date for completion of the 2016 Cluster Study until May 31, 2017. The Cluster study was proponed due to the overlapping commercial impacts of the cluster studies and the I-5 corridor reinforcement project. The BPA Administrator has not yet made a decision on this project. The I-5 Corridor Reinforcement Project is a proposed 500-kV transmission line between the areas near Castle Rock, Washington and Troutdale, Oregon.

[1] https://nttg.biz/site/index.php?option=com_content&view=featured&Itemid=107

Montana Generation and Transmission System: Courtesy of Northwestern Energy



Biographical Information:

Bill Pascoe

Bill Pascoe is President of Pascoe Energy Consulting, a firm located in Absarokee, Montana and specializing in electricity supply and transmission issues. His clients include companies developing generation and transmission projects in Montana and surrounding states.

Mr. Pascoe was employed by The Montana Power Company and NorthWestern Energy for 25 years and served in key leadership positions including Vice President of Energy Supply and Sr. Vice President of Transmission.

Mr. Pascoe has been active in regional utility organizations and served terms as Chairman of the Pacific Northwest Utilities Conference Committee (PNUCC), Western Electricity Coordinating Council (WECC) and RTO West Board of Directors.

Mr. Pascoe is a Montana native and holds degrees in electrical and civil engineering from Montana State University.

John Leland

John Leland is a technical consultant for the Northern Tier Transmission Group ("NTTG") regional and interregional transmission planning processes. He retired from NorthWestern Energy in 2014 after 35 plus years of resource and transmission planning for the electric utility. John was a key player in the developing the policy and compliance responses to FERC Orders 890 and 1000 local, regional and interregional planning processes for NorthWestern Energy and NTTG.

He is an accomplished professional with successful experience in policy and regulatory compliance as well as analyzing and identifying solutions to complex technical problems.

Montana vs. Pacific Northwest Wind Cost Comparison

Prepared by:

Bill Pascoe, Pascoe Energy Consulting

December 2016

This report summarizes findings of an analysis that compares the cost of Montana wind and Pacific Northwest wind delivered to utilities in Washington and Oregon.

Background

For many years, Montana wind advocates have been touting the advantages of Montana wind to potential utility purchasers in Washington and Oregon. The primary advantages of Montana wind are:

- Higher capacity factors due to the more robust wind resource in Montana.
- Wind shapes that provide relatively more output during winter daytime hours when Pacific Northwest demand for electricity is highest.
- Diversity that reduces the cost of integrating additional wind energy into Pacific Northwest power systems.

These advantages have historically been offset by the cost and uncertainty of securing transmission service between Montana wind projects and utilities in Washington and Oregon. As described later in this report, reasonable transmission solutions are available.

Recent developments have increased interest in Montana wind by Washington and Oregon utilities that will create market opportunities in the near future. These developments include:

- An agreement reached by the owners of Colstrip 1&2 (Puget Sound Energy (PSE) and Talen Energy) and environmental groups that commits to the closure of Colstrip 1&2 no later than 2022. In addition to creating a need for power to replace 600 MW of retired baseload generation, this agreement frees up 300 MW of firm transmission rights between Colstrip and the PSE system.

- Enactment of the Oregon Clean Electricity and Coal Transition Plan (SB1547) in the 2016 Oregon legislative session that increases the renewable portfolio standard for Portland General Electric (PGE) to 50% by 2040. This requirement coupled with the recent phased-out extension of the federal production tax credit (PTC) has created an incentive for early action by PGE.

These developments have led PSE and PGE to give serious consideration to Montana wind in their recent Integrated Resource Plan (IRP) processes. This may lead to a once-in-a-decade opportunity for these utilities to acquire Montana wind resources.

Models, Data Sources and Assumptions

For this analysis, delivered costs were determined using the PowerFin levelized cost model maintained by the Northwest Power and Conservation Council (NPCC)[1]. As explained below, basic inputs to the model were taken from the NPCC's Seventh Power Plan with certain assumptions specified by the author.

Resource Costs

Capital and operating costs for wind generators ($2,240/kw CapEx) and aeroderivative CTs ($1,111/kw CapEx) were taken from the Seventh Power Plan.

The capital cost of wind generation has fallen since the Seventh Power Plan with costs in the range of $1,800 to $2,000/kw commonly cited. Using lower current costs for wind generation would lower the costs for both Montana wind and Pacific Northwest wind, but would not have a significant impact on the relative cost comparisons which are the focus of this analysis.

Wind costs were developed with and without federal PTCs. Assumptions about PTCs effect the costs for Montana wind and Pacific Northwest wind, but did not have a significant impact on the relative cost comparisons which are the focus of this analysis.

The cost of capacity from aeroderivative CTs is used to calculate the capacity value of the Montana wind and Pacific Northwest wind, as discussed further below.

Wind Capacity Factors

The capacity factor for Pacific Northwest wind was assumed to be 34%. This is the capacity factor used in PSE's 2015 IRP[2] and in PGE's 2016 IRP.

Two capacity factors were tested for Montana wind – 40% and 45%. These values were selected to represent a reasonable range for fair (40%) to good (45%) Montana wind sites and to evaluate the sensitivity of the results to this important parameter.

Wind Capacity Value

Capacity value is the capability of a wind farm to contribute toward a utility system's resource adequacy or effective load carrying capability. In simple terms, increased capacity value from wind generation reduces the need for a utility to develop conventional peaking resources. For this analysis, capacity value from wind resources was assumed to reduce capacity needed from new aeroderivative CTs which is a logical choice to provide new capacity with flexibility to complement wind and other intermittent resources.

The capacity value for Pacific Northwest wind was assumed to be 10%. This is similar to the values in PSE's 2015 IRP, PGE's 2016 IRP and a recent NPCC study[3].

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[1] NPCC staff provided the PowerFin results that are the foundation of this analysis.

[2] PSE's 2017 IRP will use a 37% capacity factor to reflect improved efficiency from newer wind turbine technology. A similar improvement in capacity factor would be expected from applying new technology to Montana wind sites.

[3] System Capacity Contribution of Montana Wind Resources, presented at August 9, 2016 NPCC meeting.

A range of capacity values for Montana wind – 10%, 30% and 50% - were tested in this analysis to evaluate the sensitivity of the results to this important parameter.

- 10% was selected as a lower bookend assuming Montana wind and Pacific Northwest wind have similar capacity values.
- 30% was selected as a midrange value and is similar to the value for the first 300 MW of Montana wind in PGE's 2016 IRP.
- 50% was selected as an upper bookend and is similar to the values found in PSE's 2015 IRP and the recent NPCC study[4].

Capacity value is treated as a credit against wind generation costs in this analysis.

Transmission

Securing affordable transmission is key to making the delivered cost of Montana wind competitive with Pacific Northwest wind. It is generally understood that Montana wind delivered over newly constructed long-distance transmission lines in Montana and/or on the BPA system is too expensive to compete with Pacific Northwest wind delivered over existing BPA transmission facilities. Fortunately, lower cost transmission alternatives exist for several hundred MW of Montana wind.

For this analysis, Pacific Northwest wind is assumed to be delivered over BPA's existing transmission facilities at the current BPA Main Grid rate ($21.48/kw-year).

For Montana wind, three transmission options were considered:

> Option #1 – One wheel on the NorthWestern Energy (NWE) transmission system at current rates ($39.96/kw-year)[5] and one wheel on the BPA Main Grid ($21.48/kw-year)[6].
>
> Option #2 – A generator tie line (at a cost of $80/kw)[7] interconnecting at Broadview or Colstrip followed by three wheels on transmission rights currently used to deliver PSE's share of Colstrip 1&2 – PSE Colstrip transmission ($31.82/kw-year), BPA Montana Intertie ($7.18/kw-year) and BPA Main Grid ($21.48/kw-year).
>
> Option #3 - A generator tie line (at a cost of $80/kw)[8] interconnecting at Broadview followed by wheeling on upgraded facilities between Broadview and Garrison ($160/kw)[9] and on the BPA Main Grid ($300/kw)[10]. Note that using the financing assumptions in the NPCC levelized cost model, the annual costs of the upgrades are less

[4] See footnote 3.
[5] Transmission service studies performed by NWE for Gaelectric indicate that approximately 330 MW of transmission capacity is available between the Harlowton, MT area and the BPA Main Grid with modest upgrades that would be rolled into NWE's current transmission rate.
[6] Recent conversations with BPA staff indicate that 200 MW of transmission is available for new Montana exports with the installation of a generator tripping scheme for certain contingencies.
[7] 70 miles of 230 kV wood H-frame transmission at $500,000/mile = $35 million, 450 MW capacity
[8] See footnote 7.
[9] $73 million in upgrades from Gaelectric transmission service study, 450 MW capacity
[10] $137 million in upgrades ($115 million from BPA 2010 NOS ROD escalated 3% per year), 450 MW capacity

than the current transmission rates used in Option #2. Under current FERC and BPA pricing policies these upgrades would be rolled into current rates and Montana wind exports would pay the same transmission costs as in Option #2.

Transmission losses were applied to each option based on current tariffs:

- Gen Tie – 3% (estimated)
- NWE – 4%
- PSE Colstrip / BPA MT Intertie – 3%
- BPA Main Grid – 1.9%

Integration Costs

BPA wind integration costs from the Seventh Power Plan ($14.76/kw-year) were included for all options.

Results

Results of the analysis are summarized in the following tables. In these tables, a positive value (blue shading) indicates the percentage by which the delivered cost for Montana wind exceeds Pacific Northwest wind. A negative value (green shading) indicates the percentage by which the delivered cost for Montana wind is less than Pacific Northwest wind.

Graphical depictions of the results for different assumptions for Montana wind capacity factors, Montana and Pacific Northwest wind capacity values, PTCs and transmission costs are provided in the Appendix.

Table 1A. MT Wind vs WA/OR Wind, Delivered Cost Comparison MT 40% CF, Full PTC

		Tx Option		
WA CV	MT CV	#1	#2	#3
0%	0%	0%	4%	-5%
10%	10%	0%	5%	-4%
10%	30%	-10%	-6%	-15%
10%	50%	-20%	-16%	-25%

Table 1B. MT Wind vs WA/OR Wind, Delivered Cost Comparison MT 40% CF, No PTC

		Tx Option		
WA CV	MT CV	#1	#2	#3
0%	0%	0%	4%	-3%
10%	10%	1%	5%	-3%
10%	30%	-8%	-4%	-12%
10%	50%	-17%	-13%	-21%

Table 2A. MT Wind vs WA/OR Wind, Delivered Cost Comparison MT 45% CF, Full PTC

		Tx Option		
WA CV	MT CV	#1	#2	#3
0%	0%	-13%	-9%	-17%
10%	10%	-12%	-8%	-16%
10%	30%	-21%	-17%	-26%
10%	50%	-30%	-27%	-35%

Table 2B. MT Wind vs WA/OR Wind, Delivered Cost Comparison MT 45% CF, Full PTC

		Tx Option		
WA CV	MT CV	#1	#2	#3
0%	0%	-11%	-7%	-14%
10%	10%	-10%	-6%	-13%
10%	30%	-18%	-14%	-22%
10%	50%	-26%	-23%	-30%

High level conclusions are as follows:

<u>For Montana Wind with 40% CF and Full PTCs</u>:

- Assuming <u>no capacity value or 10% capacity value</u> for Pacific Northwest wind and Montana wind, delivered costs for Montana wind range from <u>5% higher to 5% lower</u> than Pacific Northwest wind depending on the transmission option selected.

- Assuming 10% capacity value for Pacific Northwest wind and <u>30% capacity value for Montana wind</u>, delivered costs for Montana wind range from <u>6% to 15% lower</u> than Pacific Northwest wind depending on the transmission option selected.

- Assuming 10% capacity value for Pacific Northwest wind and <u>50% capacity value for Montana wind</u>, delivered costs for Montana wind range from <u>16% to 25% lower</u> than Pacific Northwest wind depending on the transmission option selected.

<u>For Montana Wind with 45% CF and Full PTCs</u>:

- Assuming <u>no capacity value or 10% capacity value</u> for Pacific Northwest wind and Montana wind, delivered costs for Montana wind range from <u>8% to 17% lower</u> than Pacific Northwest wind depending on the transmission option selected.

- Assuming 10% capacity value for Pacific Northwest wind and <u>30% capacity value for Montana wind</u>, delivered costs for Montana wind range from <u>17% to 26% lower</u> than Pacific Northwest wind depending on the transmission option selected.

- Assuming 10% capacity value for Pacific Northwest wind and <u>50% capacity value for Montana wind</u>, delivered costs for Montana wind range from <u>27% to 35% lower</u> than Pacific Northwest wind depending on the transmission option selected.

Assuming no PTCs, the cost advantage of Montana wind is reduced slightly (from 2% to 5%) depending on the particular case being considered.

These estimates of the cost advantage of Montana wind are conservative for the following reasons:

- This analysis calculates the capacity value difference between Pacific Northwest wind and Montana wind. However, it does not capture the difference in energy value from seasonal and diurnal shapes. Relatively more Montana wind is produced during the high-value winter season and relatively more Pacific Northwest wind is produced during the low-value spring season.

- This analysis assumes wind integration costs are the same for Pacific Northwest wind and Montana wind. However, due to diversity, Montana wind will be less costly to integrate into the Pacific Northwest system, especially for the first Montana wind to be integrated.

- This analysis assumes a relatively long (70 mile) generator tie line for Transmission Options #2 and #3. Montana wind projects located nearer to Broadview or Colstrip would reduce or eliminate the tie line costs and losses which make up about 5% to 6% of the total delivered costs. These costs would also be avoided if the Gordon Butte pumped hydro project is successfully developed and the very high quality wind resources in that area access the Colstrip transmission lines through the Gordon Butte interconnection.

- Transmission Option #2 includes transmission rates for PSE Colstrip transmission and the BPA Montana Intertie. Closure of Colstrip 1&2 will free up 300 MW of transmission capacity on these facilities. The cost of this capacity will continue to be borne by PSE ratepayers unless this capacity is used for some other purpose such as delivering Montana wind. Treating these as sunk costs reduces total delivered costs for Montana wind by between 11% and 17%.

APPENDIX

Chart 1. PNW Capacity Value – 0%, MT Capacity Value – 0%, Full PTCs

Chart 2. PNW Capacity Value – 10%, MT Capacity Value – 10%, Full PTCs

Chart 3. PNW Capacity Value – 10%, MT Capacity Value – 30%, Full PTCs

Chart 4. PNW Capacity Value – 10%, MT Capacity Value – 50%, Full PTCs

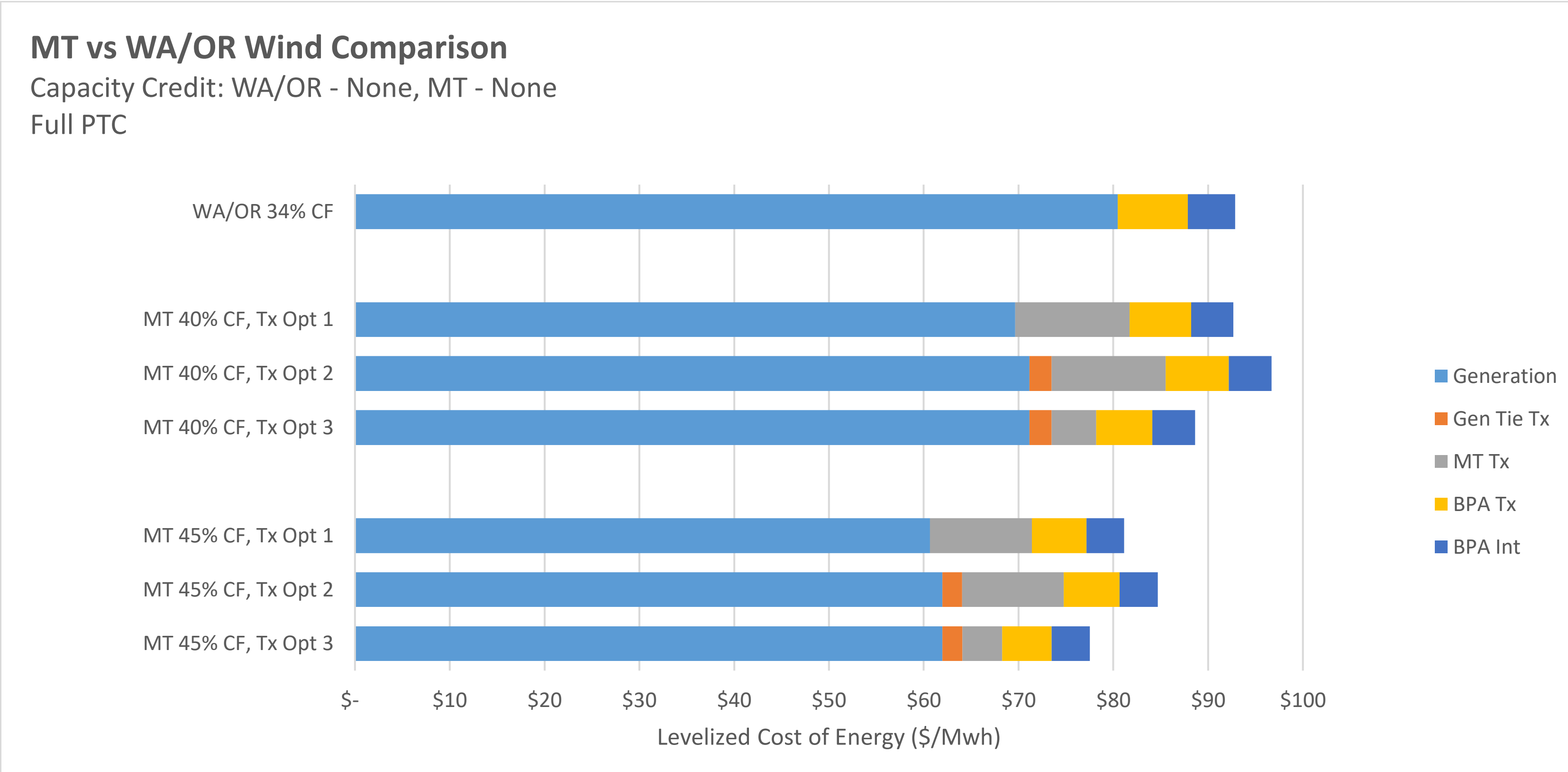
Chart 5. PNW Capacity Value – 0%, MT Capacity Value – 0%, No PTCs

Chart 6. PNW Capacity Value – 10%, MT Capacity Value – 10%, No PTCs

Chart 7. PNW Capacity Value – 10%, MT Capacity Value – 30%, No PTCs

Chart 8. PNW Capacity Value – 10%, MT Capacity Value – 50%, No PTCs

Chart 1



MT vs WA/OR Wind Comparison
Capacity Credit: WA/OR - None, MT - None
Full PTC
WA/OR 34% CF
MT 40% CF, Tx Opt 1
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MT 40% CF, Tx Opt 3
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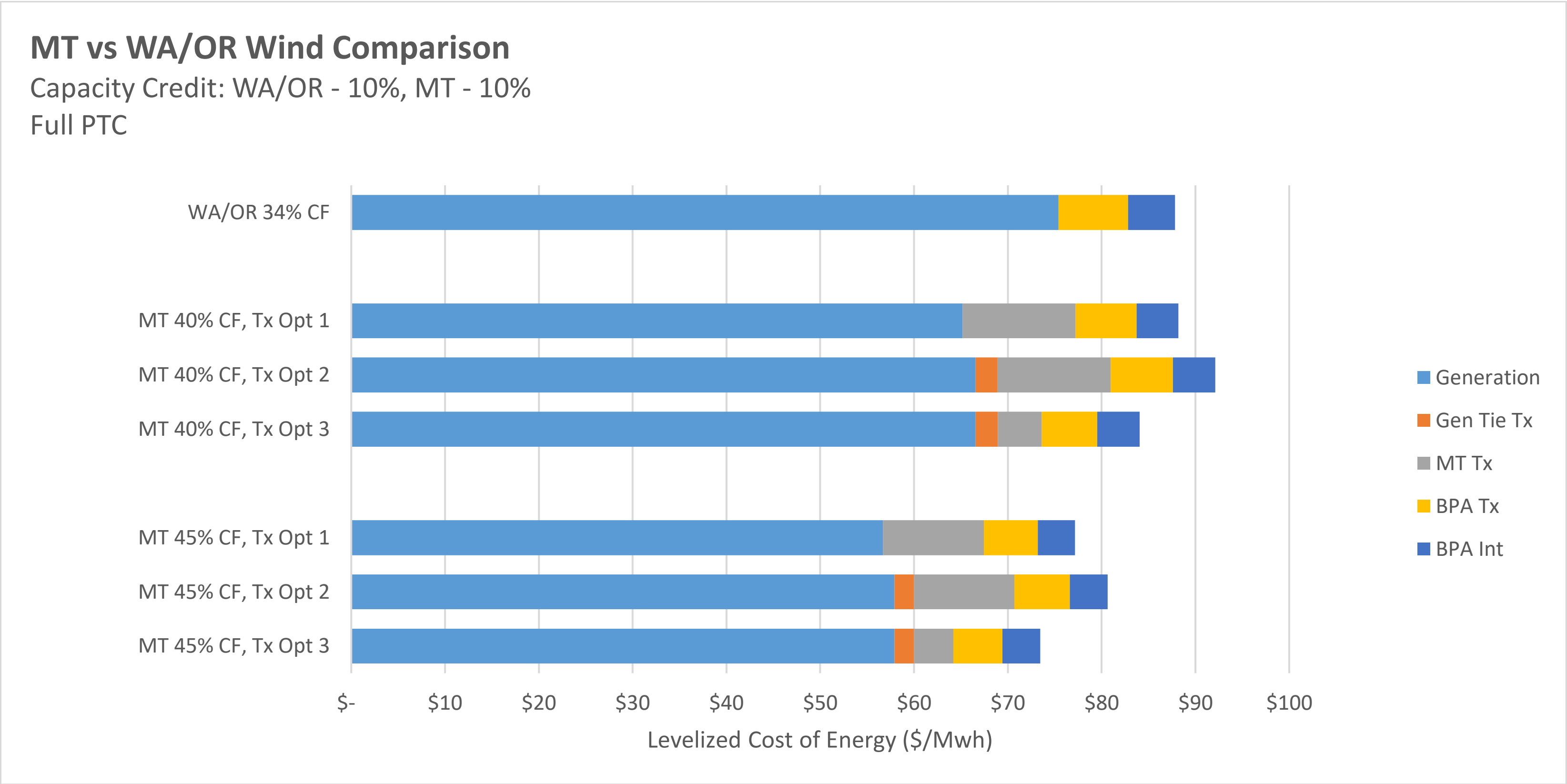
Levelized Cost of Energy ($/Mwh)
Generation
Gen Tie Tx
MT Tx
BPA Tx
BPA Int

Chart 2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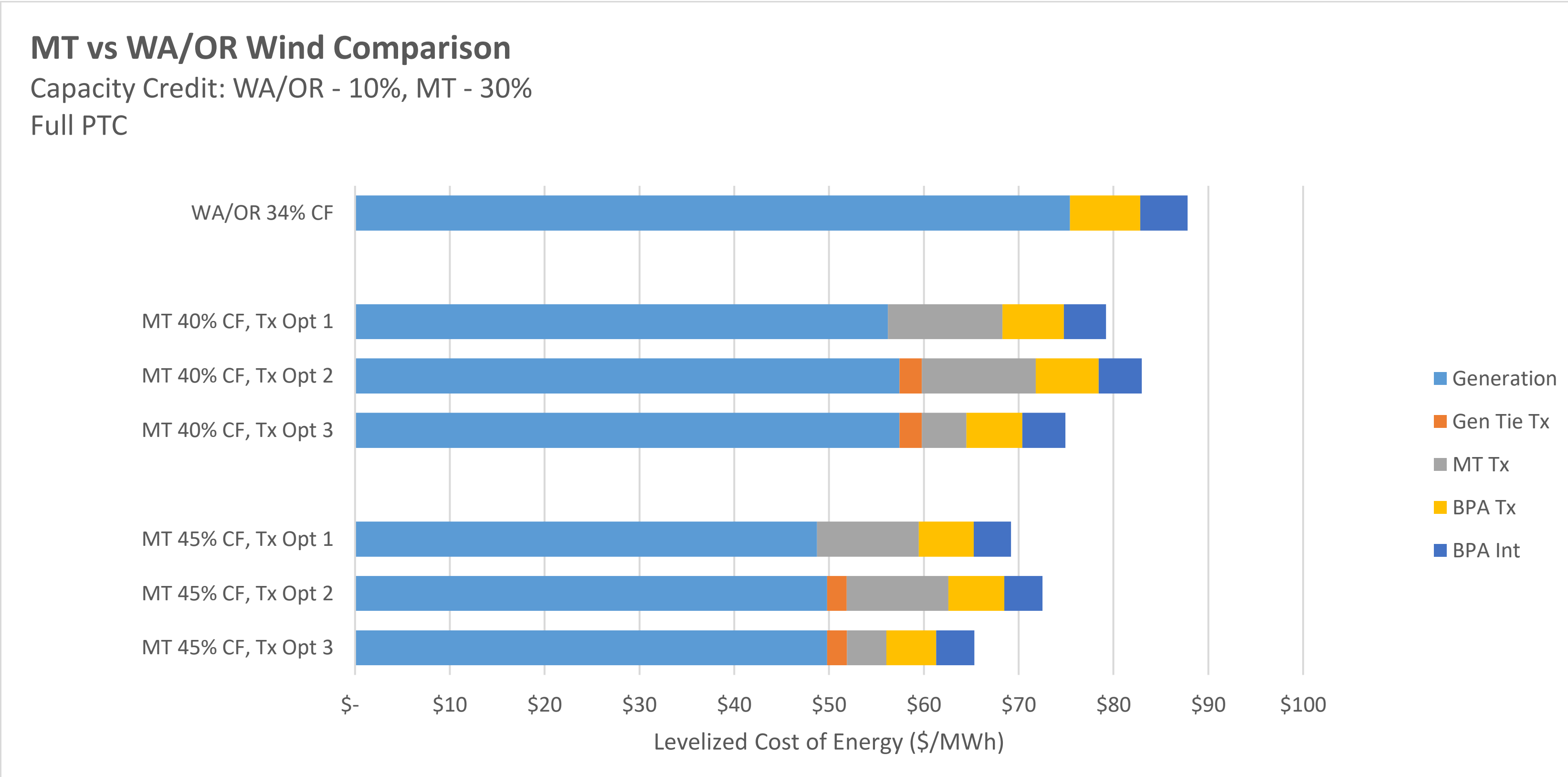
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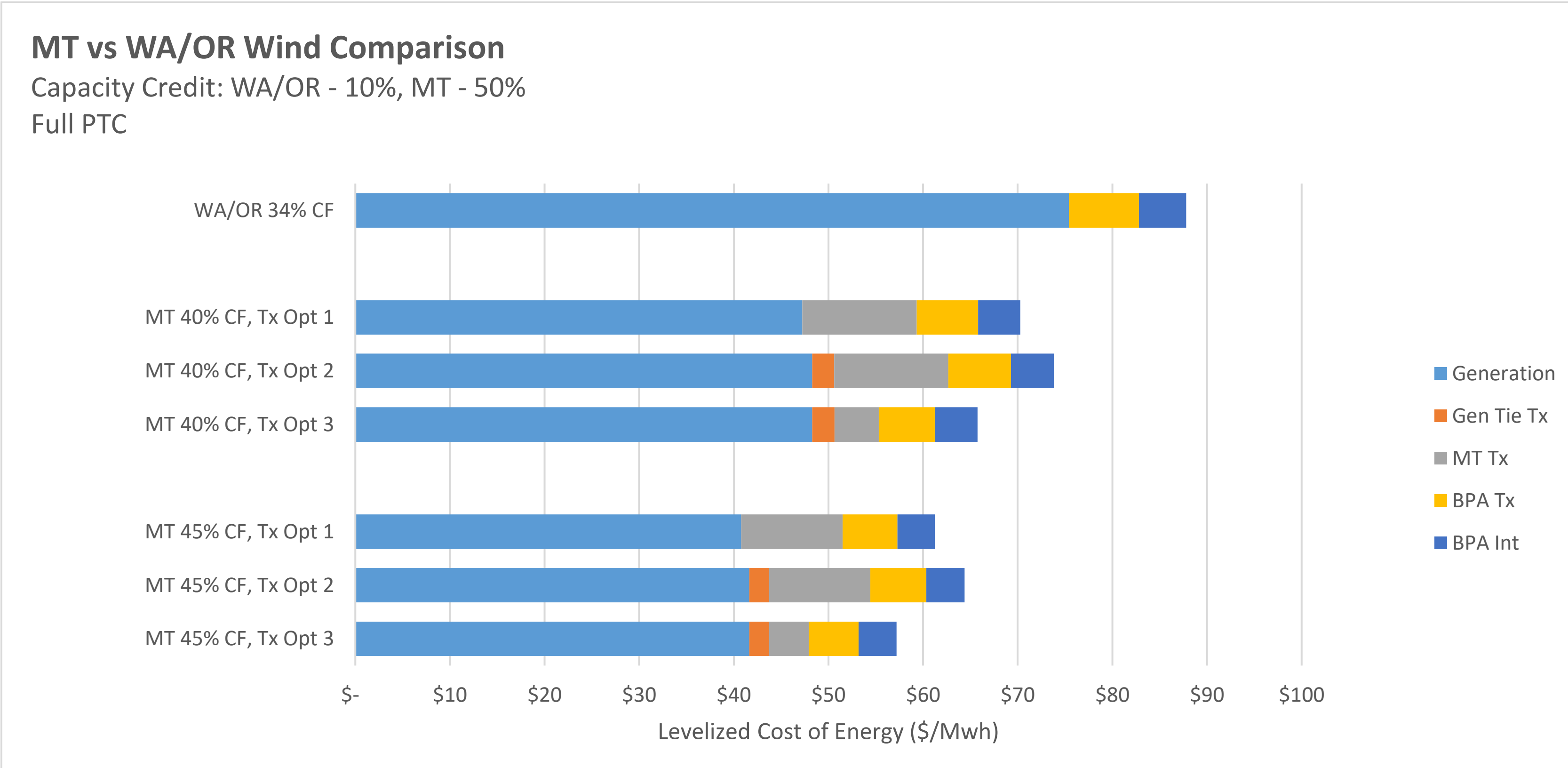
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Chart 5

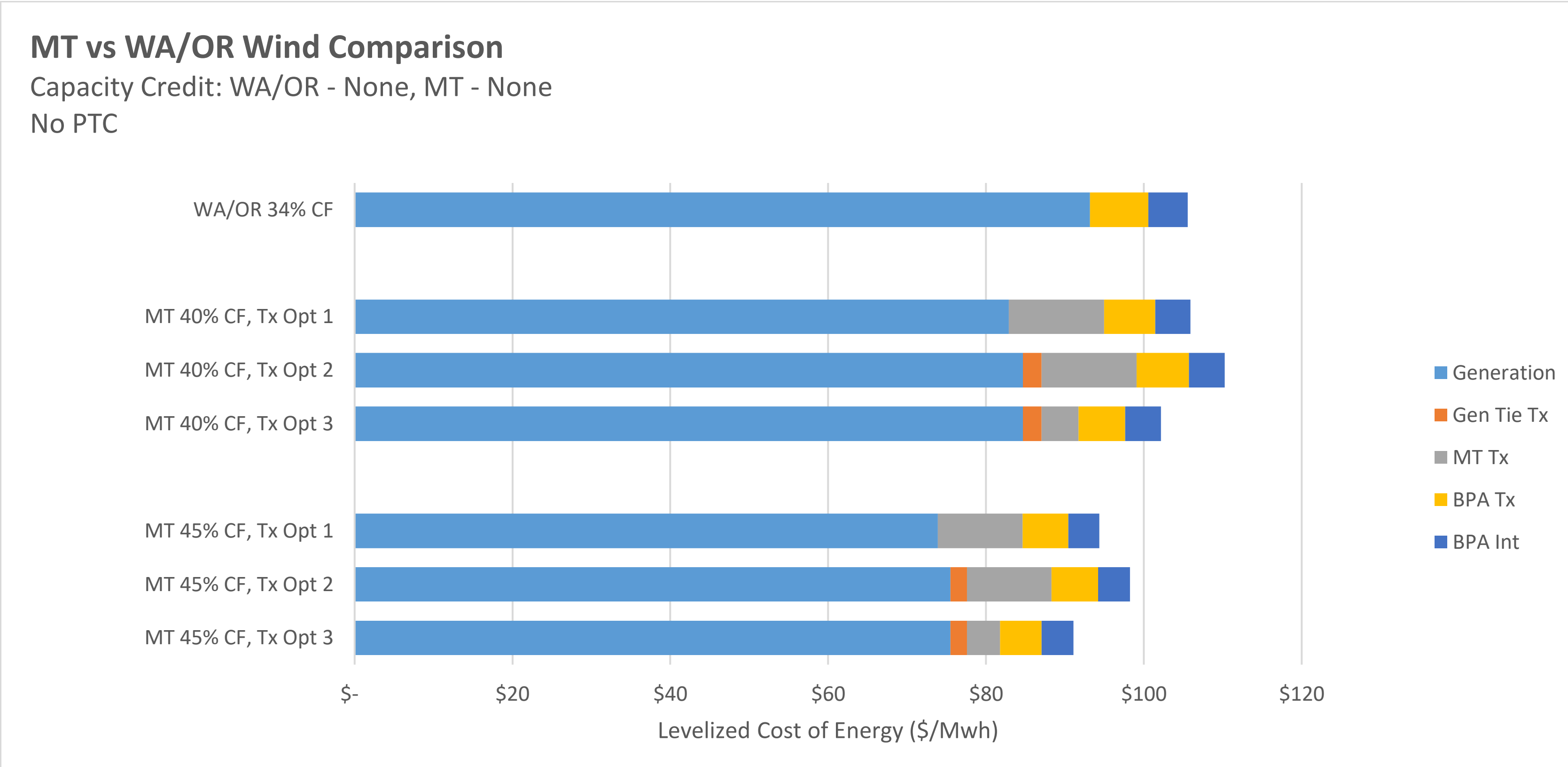

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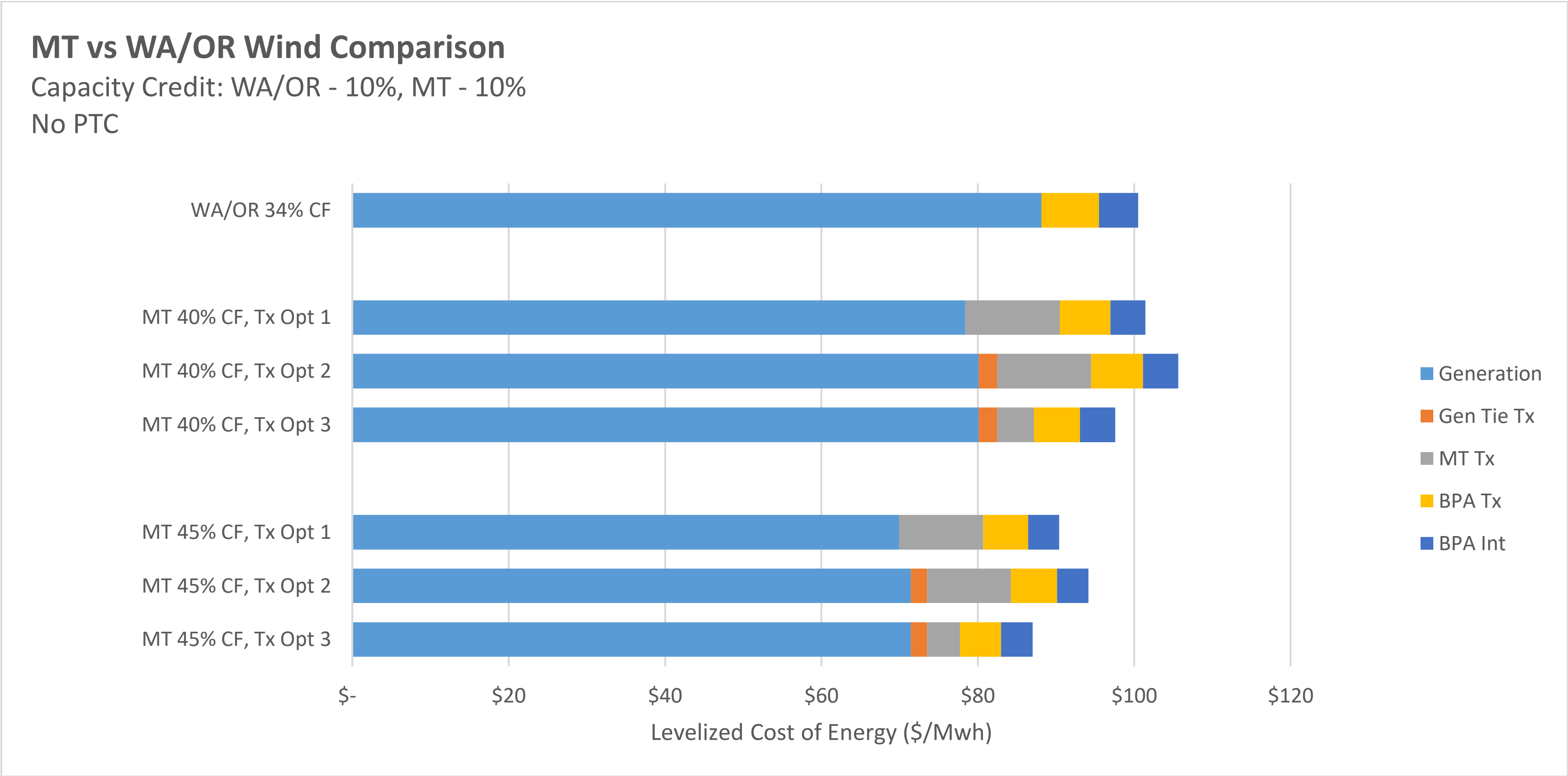
Chart 6



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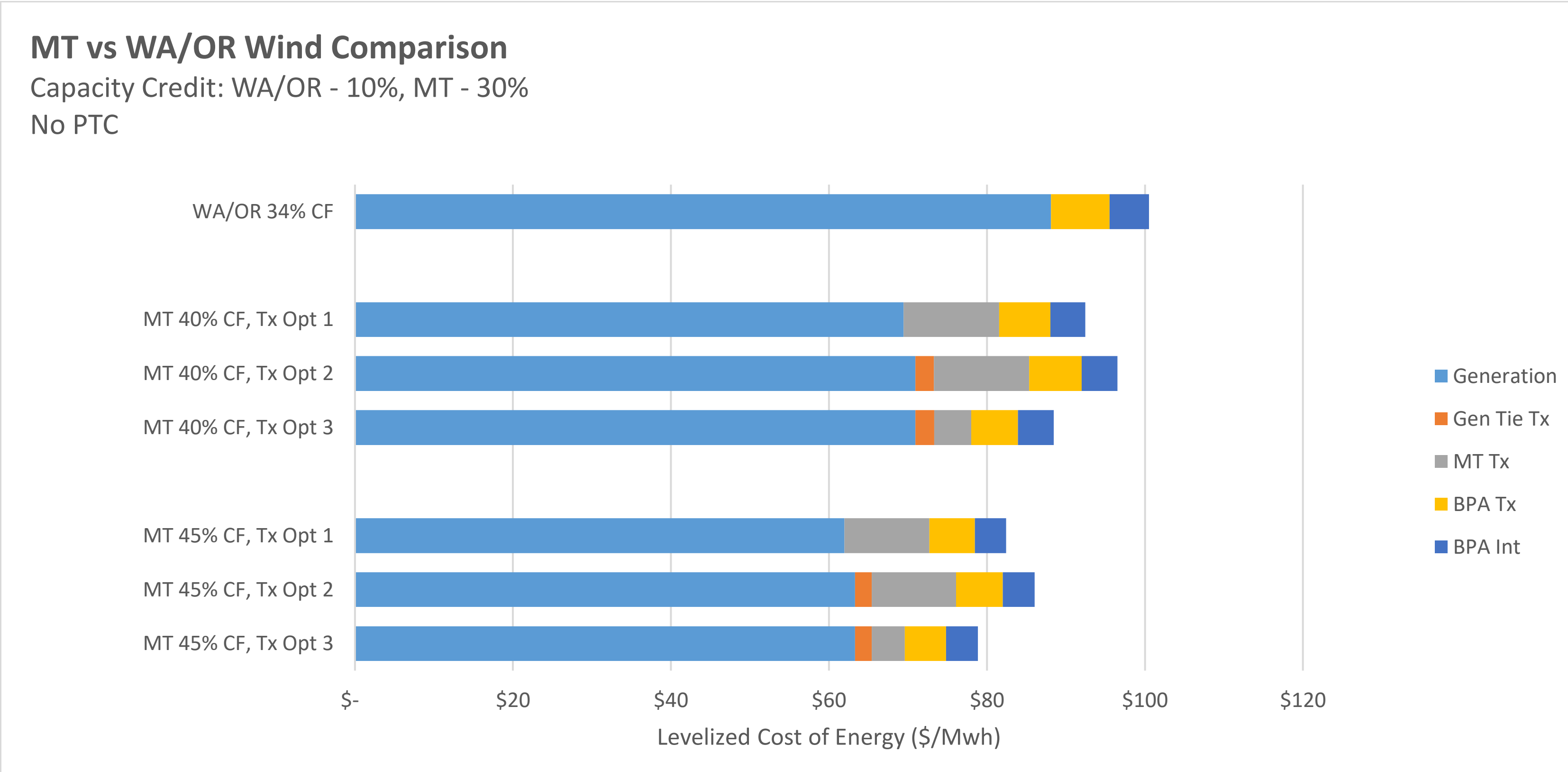

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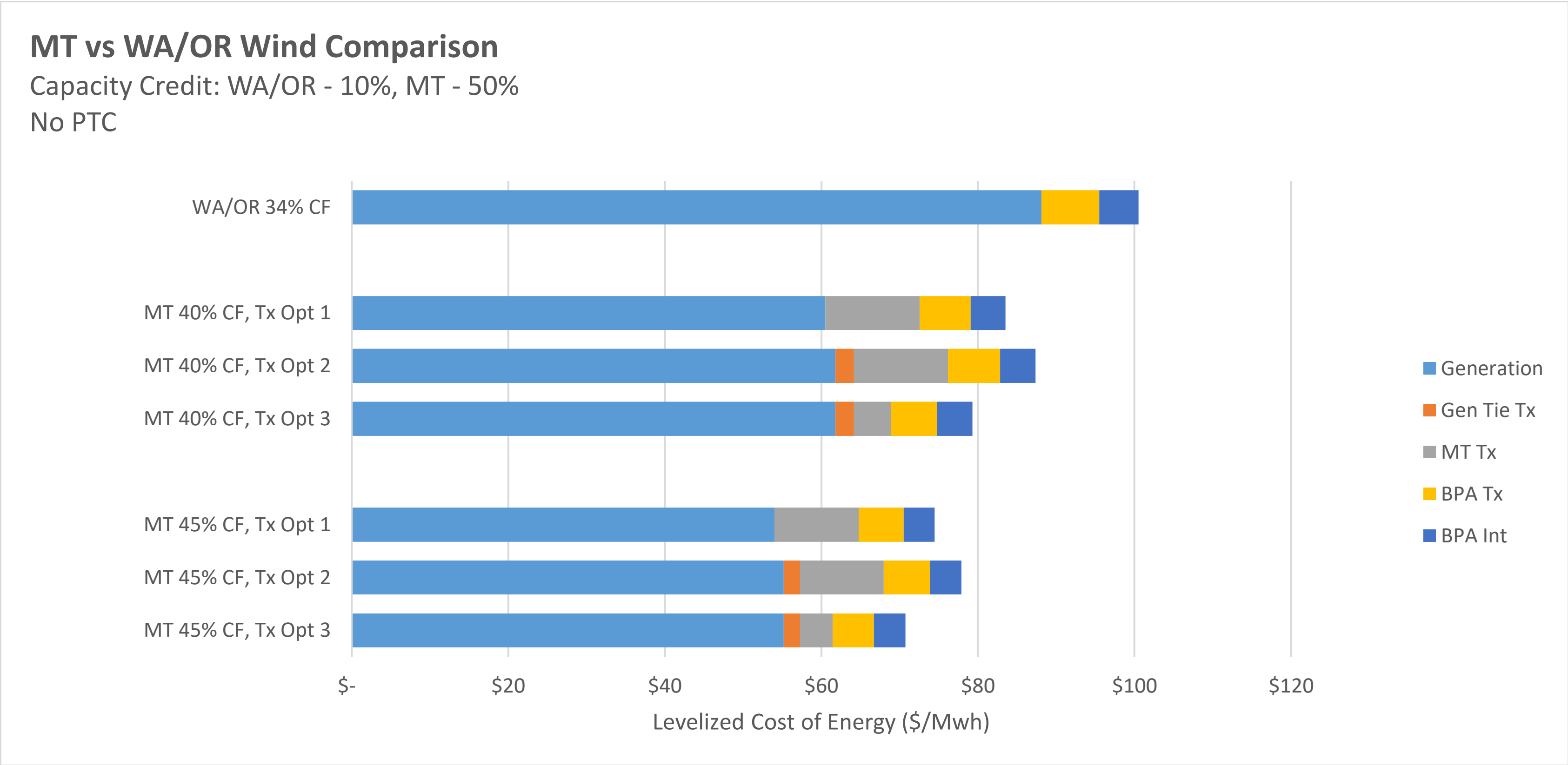

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BPA Int

Energy+Environmental Economics

Gordon Butte Pumped Storage

Colstrip 1&2 Replacement Analysis

Prepared by E3 for Absaroka Energy

December 2016

Analysis Overview

+ Absaroka Energy asked E3 to compare the cost of two alternatives for providing energy (250 aMW) and capacity (300 MW) to replace Puget Sound Energy’s share of Colstrip 1&2
  - **MT Alternative:** Gordon Butte Pumped Storage facility paired with 250 aMW of Montana wind (located at Martinsdale, MT) and 300 MW of existing long-term firm transmission rights from Montana to PSE
  - **PNW Alternative:** An Aeroderivative CT generator (located in Washington state) paired with 250 aMW of Washington wind (located at the Columbia Gorge)

Gordon Butte Overview

+ **Gordon Butte Pumped Storage Facility**
  - 400 MW pumping / generating capacity
  - Ternary units allow seamless transition between generating and pumping modes
  - 8.5 available hours of storage
  - 83% efficiency
  - Sited to allow access to transmission currently used to deliver power from Colstrip coal plants in Montana. Some of this transmission capacity will become available when Colstrip 1&2 are retired (no later than 2022).
  - FERC License issued December 14, 2016.

Analysis Scope

+ Quantified benefits of pumped storage

- Shaping of wind resource to maximize value, avoid curtailment, and increase transmission utilization
- Ability to provide firm capacity on demand (given available capacity)
- Emissions-free flexible resource helps with wind integration
- Time-based market arbitrage opportunities (given available capacity)

+ Potential benefits of pumped storage not considered here

- Ability to provide ancillary services (Load-following, Regulation, Spinning & Non-Spinning Reserves, Frequency Response)
- Sub-hourly energy dispatch savings
- Value derived from participation in the Energy Imbalance Market

MT Alternative

Year = 2030

Dispatch value of energy provided to Puget Sound is determined by market prices at Mid-C

Washington

Montana

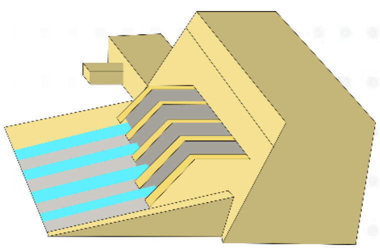
250 aMW Montana, CF ~46%

Puget Sound Energy

300 MW
(1.5% Losses)

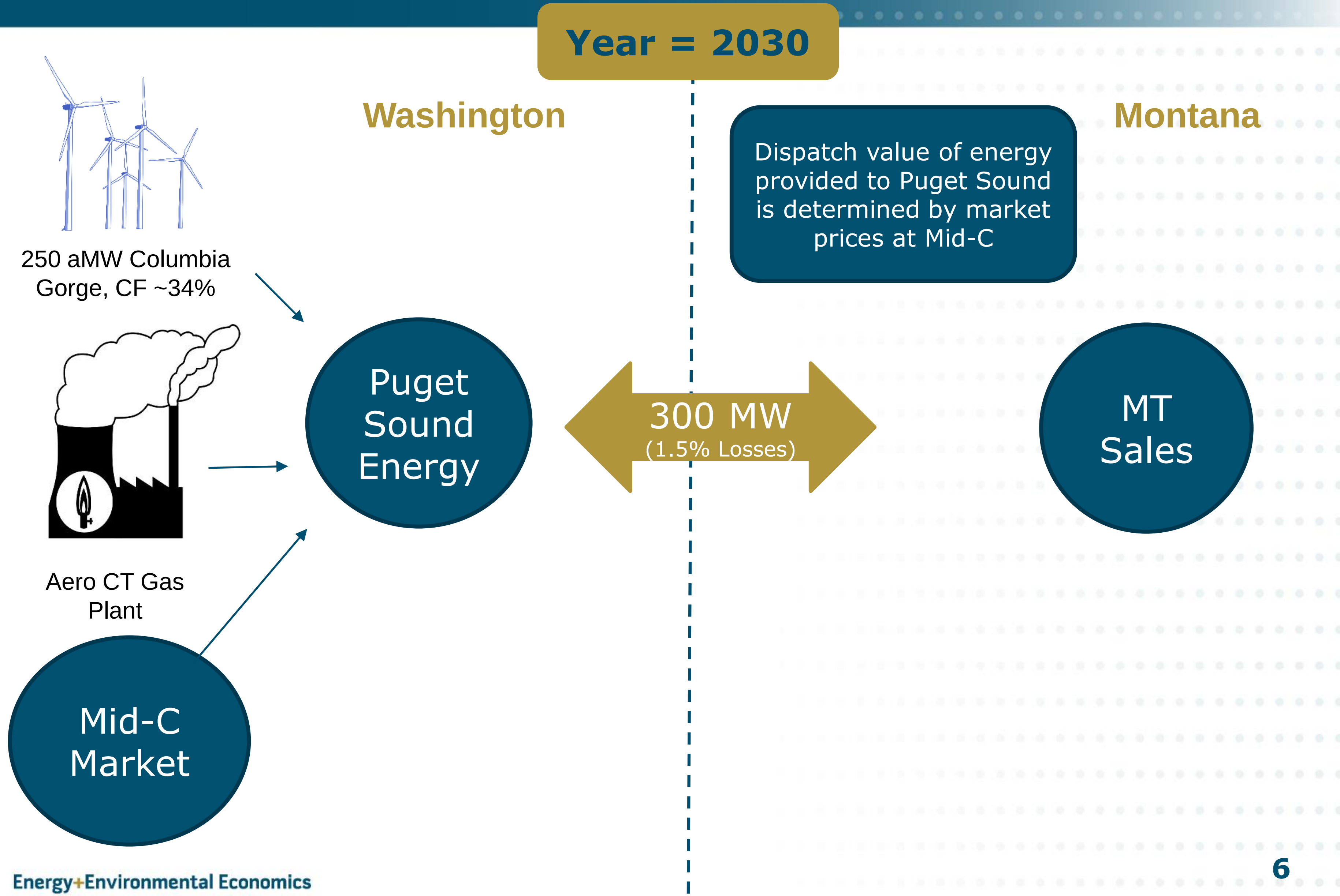
MT Sales

Mid-C Market



Gordon Butte Pumped Storage Facility

PNW Alternative



Wind Capacity Credit

+ Absaroka also asked E3 to investigate how geography-based differences in Effective Load Carrying Capability (ELCC) between wind sites might influence the results of the analysis
    - To achieve this, E3 sized both the pumped storage and Aero CT resources so that they provide 300 MW of capacity *when paired with the planning capacity assigned to wind resources*

Assumption	*WA Wind – Installed Capacity*	*WA Wind – Planning Capacity*	Aero CT Size	*MT Wind – Installed Capacity*	*MT Wind – Credited Capacity*	Pumped Storage Size
No Capacity Credit for Wind	*736 MW*	*0 MW*	**300 MW**	*548 MW*	*0 MW*	**300 MW**
Capacity Credit for Wind	*736 MW*	*37 MW (5%)*	**263 MW**	*548 MW*	*137 MW (25%)*	**163 MW**

Modeling Efforts

- **Fixed costs for the resources were calculated using E3 financial models and publicly available data sources**
- **Hourly dispatch values were calculated using an adapted version of the E3 REFLEX model**
  - REFLEX is a multi-stage production simulation model with integer variables formulated for high renewable penetrations
    - Hourly modeling of energy values and arbitrage opportunities
    - Hourly generation profiles for non-dispatchable (wind) generation
    - Priced-based dispatch of controllable resources
    - 24-hour optimization of storage resources

Data Sources – Wind Resource Characteristics

+ **Wind shapes provided by Absaroka Energy**
  - E3 adjusted to reflect most recent capacity factors
    - Washington (Columbia Gorge): 34% Capacity Factor
    - Montana (Martinsdale, MT): 46% Capacity Factor
  - Nameplate capacity sized to output 250 aMW over the course of the year
    - Columbia Gorge: 736 MW
    - Martinsdale: 548 MW
+ **Wind planning capacity based on location of wind resources**
  - Reasonable estimates based on previous E3 analysis
    - Washington (Columbia Gorge): 5% Capacity Value
    - Montana (Martinsdale, MT): 25% Capacity Value

Data Sources – Other Resource Characteristics

- **Aero CT characteristics based on generators in the TEPPC Common Case**
- **Pumped storage operational characteristics provided by Absaroka Energy** (see previous slide)
- **Transmission losses of 1.5% Montana to BPA**
  - Based on Colstrip Transmission System losses from Broadview to Garrison

Data Sources – Cost / Pricing Characteristics

- Wind capital costs based on NREL data
- Aero CT capital costs taken from Northwest Power and Conservation Council's 7th Power Plan
- Gordon Butte Pumped Hydro capital costs from Absaroka Energy
- 2030 gas prices based on Henry Hub forwards and basis spreads
  - 2030 chosen to represent "typical" future gas and power market conditions
- Cost of existing firm transmission rights treated as a sunk cost

Key Financial Assumptions

Metric	Assumption	Source
MT Wind LCOE	40 $/MWh	NREL capital costs, 46% CF, 2018 commencement (for PTC)
WA Wind LCOE	65 $/MWh	NREL capital costs, 34% CF, 2018 commencement (for PTC)
CT Levelized Fixed Cost	192 $/kW-yr.	NWPCC 7th power plan, Aero GT East**
Gordon Butte Levelized Fixed Cost	350 $/kW-yr.	E3 estimate based on GBEP Financial Model
Mid-C Prices	Vary by Hour	E3 projection for 2030 based on historical price patterns, resource mix, and gas price projection
MT Price Discount, Hours with Constrained Tx	6.9 $/MWh	Discount (buying and selling) during hours when wind exceeds capacity of 300 MW of existing firm transmission to deliver to PSE (approximates cost to wheel from MT to Mid-C on hourly nonfirm transmission)
Discount Rate	10%	Taken from GBEP Financial Model

* http://www.brattle.com/system/publications/pdfs/000/004/827/original/Resource_Adequacy_in_California_Calpine_Pfeifenberger_Spees_Newell_Oct_2012.pdf?1378772133
**https://www.nwcouncil.org/media/7149910/7thplanfinal_appdixh_gresources.pdf

Results – With Wind Capacity Value

- **MT Alternative provides substantial benefits to PSE ratepayers:**
  - **$300 million** reduction in capital costs
  - **$53 million** reduction in levelized annual costs
    - **$481 million** NPV over 25 years
  - **$24/MWh** reduction in levelized energy costs (250 aMW)

Results – Wind Provides Planning Capacity

	P-PNW	P-MT	
GENERATION SUMMARY			
Wind Energy (aMW)	**250**	**250**	
Wind Capacity (Nameplate MW)	**736**	**548**	
Wind Planning Capacity (MW)	**37**	**137**	
Aero CT Capacity (ME)	**263**	**-**	
Pumped Hydro Capacity (MW)	**-**	**163**	

	P-PNW	P-MT	MT BENEFITS
CAPITAL COSTS ($MILLIONS)			
Wind	$ 1,472	$ 1,096	
Aero CT	$ 290		
Pumped Hydro		$ 367	
Total	$ 1,622	$ 1,463	**$ 299**
	P-PNW	**P-MT**	**MT BENEFITS**
LEVELIZED FIXED COSTS ($millions)			
250 avg. MW Wind	$ 208	$ 153	
300 MW CT Capacity	$ 50	-	
300 MW Pumped Storage Capacity	-	$ 57	
Total	$ 258	$ 210	$ 48
ANNUAL DISPATCH VALUE ($millions)	$ 44	$ 49	$ 5
TOTAL ANNUAL BENEFITS ($millions)			**$ 53**
25-YEAR NPV BENEFITS ($millions)			**$ 481**
ENERGY COST BENEFIT ($/MWh)			**$24/MWh**

Results – Without Wind Capacity Value

+ **Even ignoring the superior capacity value of MT wind, the MT Alternative provides significant benefits to PSE ratepayers:**

  - **$31 million** reduction in capital costs
  - **$18 million** reduction in levelized annual costs
    - **$163 million** NPV over 25 years
  - **$8/MWh** reduction in levelized energy costs (250 aMW)

Results – No Wind Planning Capacity

	P-PNW	P-MT	
GENERATION SUMMARY			
Wind Energy (aMW)	**250**	**250**	
Wind Capacity (Nameplate MW)	**736**	**548**	
Wind Planning Capacity (MW)	**0**	**0**	
Aero CT Capacity (ME)	**300**	**-**	
Pumped Hydro Capacity (MW)	**-**	**300**	

	P-PNW	P-MT	MT BENEFITS
CAPITAL COSTS ($MILLIONS)			
Wind	$ 1,472	$ 1,096	
Aero CT	$ 330		
Pumped Hydro		$ 675	
Total	$ 1,802	$ 1,771	**$ 31**
	P-PNW	**P-MT**	**MT BENEFITS**
LEVELIZED FIXED COSTS ($millions)			
250 avg. MW Wind	$ 208	$ 153	
300 MW CT Capacity	$ 57	-	
300 MW Pumped Storage Capacity	-	$ 105	
Total	$ 265	$ 258	$ 7
ANNUAL DISPATCH VALUE ($millions)	$ 44	$ 55	$ 11
TOTAL ANNUAL BENEFITS ($millions)			**$ 18**
25-YEAR NPV BENEFITS ($millions)			**$ 163**
ENERGY COST BENEFIT ($/MWh)			**$8/MWh**

Energy+Environmental Economics

Thank You!

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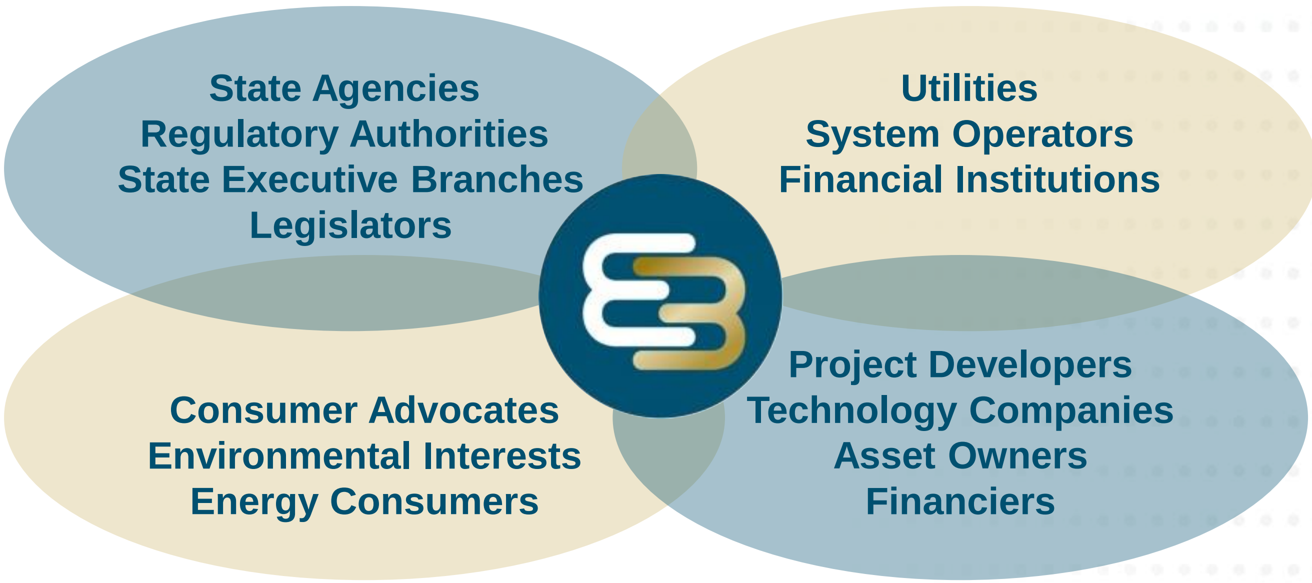
About E3

- Founded in 1989, E3 is an industry leading consultancy in North America with a growing international presence
- E3 operates at the nexus of energy, environment, and economics
- Our team employs a unique combination of economic analysis, modeling acumen, and deep institutional insight to solve complex problems for a diverse client base



Asset Valuation Overview

- E3 relies on the following key strengths to provide industry-leading consulting for asset valuation services

Reputation for high quality

Objectivity and transparency

Experience and integrity

Industry leading knowledge

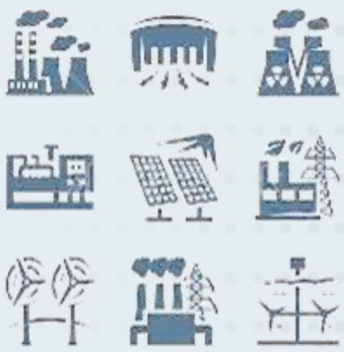
- The Asset Valuation Group focuses on short and longer-term valuation analysis that provides unique insights for the following:

Traditional Bulk System Assets

Generation Assets
Renewable & Traditional
(Bulk and Distribution Level)

Energy Storage Assets
(Bulk and Distribution Level)

Pipeline Assets



NORTHERN TIER
TRANSMISSION GROUP

NTTG

Northwest Power and Conservation Council
Chelsea Loomis and John Leland
April 11, 2017

NTTG

- Northern Tier Transmission Group
- Responsible for developing FERC Order 1000 Regional Transmission Plan for NTTG region
- Comprised of utilities and state representatives

2

NTTG

3

What NTTG Is and Is Not

- NTTG is a regional entity responsible for the coordination and development of the Regional Transmission Plan
  - Regional Planning and Cost Allocation
  - Interregional Coordination and Cost Allocation
- NTTG is not an entity responsible for Resource Planning nor does it ensure that utilities meet their Public Policy Requirements

4

NTTG Cycle

- Biannual cycle that starts every even year
- Q1: Load and Resource submittal from Transmission Providers and Stakeholders
  - Also, any Public Policy Consideration or Economic study requests are submitted
- Q2: Develop the Study Plan, get stakeholder comment and Steering committee approval
  - Initial plan comprised of committed projects and projects from previous Plan

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NTTG Cycle

- Q3: Prepare cases and perform analysis
- Q4: Continue analysis, prepare Draft Regional Transmission Plan
- Q5: Perform Economic or PPC studies, receive updated Load and Resource information. Receive and incorporate (as appropriate) comments from stakeholders

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NTTG Cycle

- Q6: Determine if any work needs to be updated per the updated Load and Resource information; perform any new analyses as necessary and conduct regional cost allocation (if appropriate)
- Q7: Improve the Draft Regional Transmission Plan
- Q8: Start on next cycle and finalize Regional Transmission Plan

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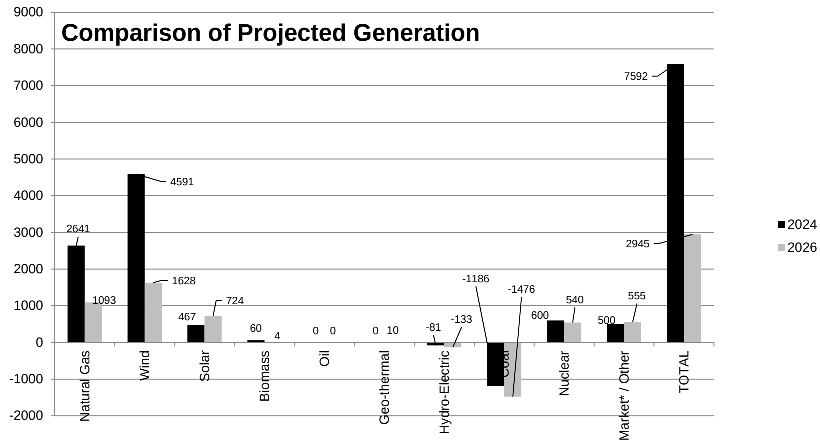
Loads submitted in Q1

SUBMITTED BY:	2015 Actual Peak Demand (MW)	2024 Summer Load Data Submitted in 2014-15 (MW)	2026 Summer Load Data Submitted in Q1 2016 (MW)	Difference (MW) 2024-2026
Idaho Power	3,730	4,193	4,346	153
NorthWestern	1,790	1,774	1,992	218
PacifiCorp	12,634	14,002	13,414	-588
Portland General	3,958	3,933	3,885	-48
TOTAL*	22,947	23,902	23,637	-265

* Loads for Deseret G&T and UAMPS are included in PacifiCorp East

8

Resources submitted in Q1



9

Base Cases

- NTTG uses the “Round Trip” Process
  - Starts with 2026 TEPPC case
  - Performs Production Cost Modeling on the case to find times of interest
  - Back-translates those resulting PCM cases to powerflow cases with dynamic capability

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Base Cases

Stressed Condition	Date	Hour	TWG Label
Max. NTTG Summer Peak	July 22, 2026	16:00	A
Max. NTTG Winter Peak	December 8, 2026	19:00	B
Max. MT to NW	September 10, 2026	Midnight	C
High Southern Idaho Import	June 11,2026	14:00	D1
High Southern Idaho Export	September 17, 2026	2:00	D2
High Tot2 Flows	November 11, 2026	17:00	E
High Wyoming Wind	September 17, 2026	2:00	F

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Selection of Projects

- Boardman to Longhorn (formerly Hemingway)
- Energy Gateway
- Antelope Transmission Project
- No Interregional projects were selected into the Plan

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Public Policy Consideration Study

- PPC study submitted to study the transmission impact of closing down Colstrip Units 1, 2 and 3 and replacing with either wind alone or a combination of wind and gas

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PPC Study

- Started with a case that had heavy Path 8 westbound transfers
- Modeled in all the possible combinations of coal-fired generation, wind and gas
  - The new wind was analyzed at three different dispatch levels, 0%, 35% and 100%
- Ran steady state and transient stability

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PPC Results

- With the high-level assumptions and the understanding that this study did not constitute an interconnection request, transmission service request or path rating, there was nothing to suggest that replacing coal with wind/gas will significantly harm the transmission system
- Any new generation will be fully analyzed

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NorthWestern Energy

- NWE currently has 36 active projects
  - Hydro, 1 project: 450 MW
  - Solar, 25 projects: 1161 MW
  - Wind, 10 projects: 1774 MW
- Total of 3385 MW in the GIA queue

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NorthWestern Energy

- NWE recently signed the following (not yet online)
  - Solar, 6 projects: 17 MW
  - Wind, 9 projects: 655 MW
- Between queued projects and signed projects, NWE has 4057 MW of new generation
- For perspective, NWE has a peak load of approximately 1800 MW and 4100 MW of existing generation (including CS 1 and 2)

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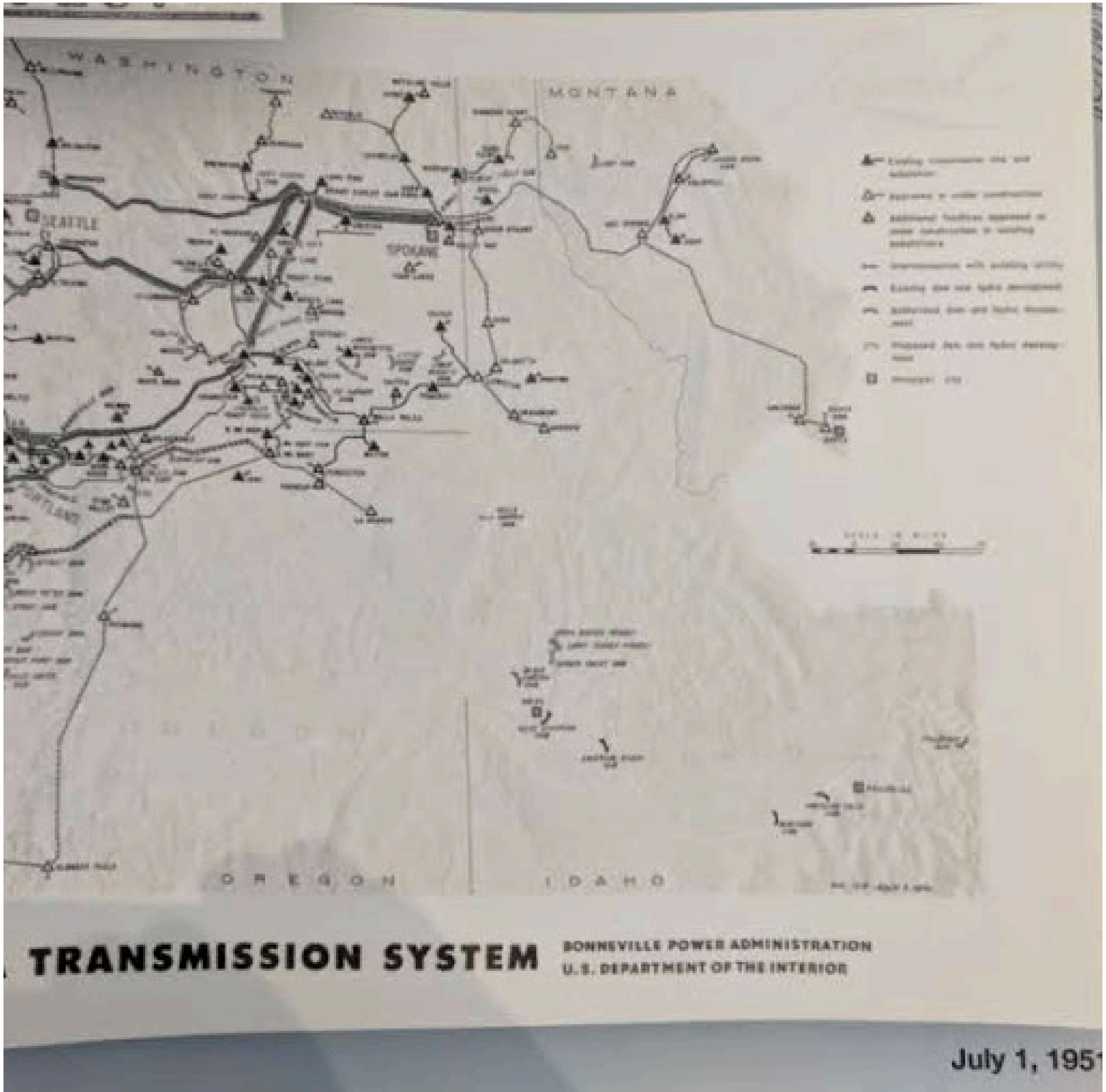
Montana Transmission BPA Perspective

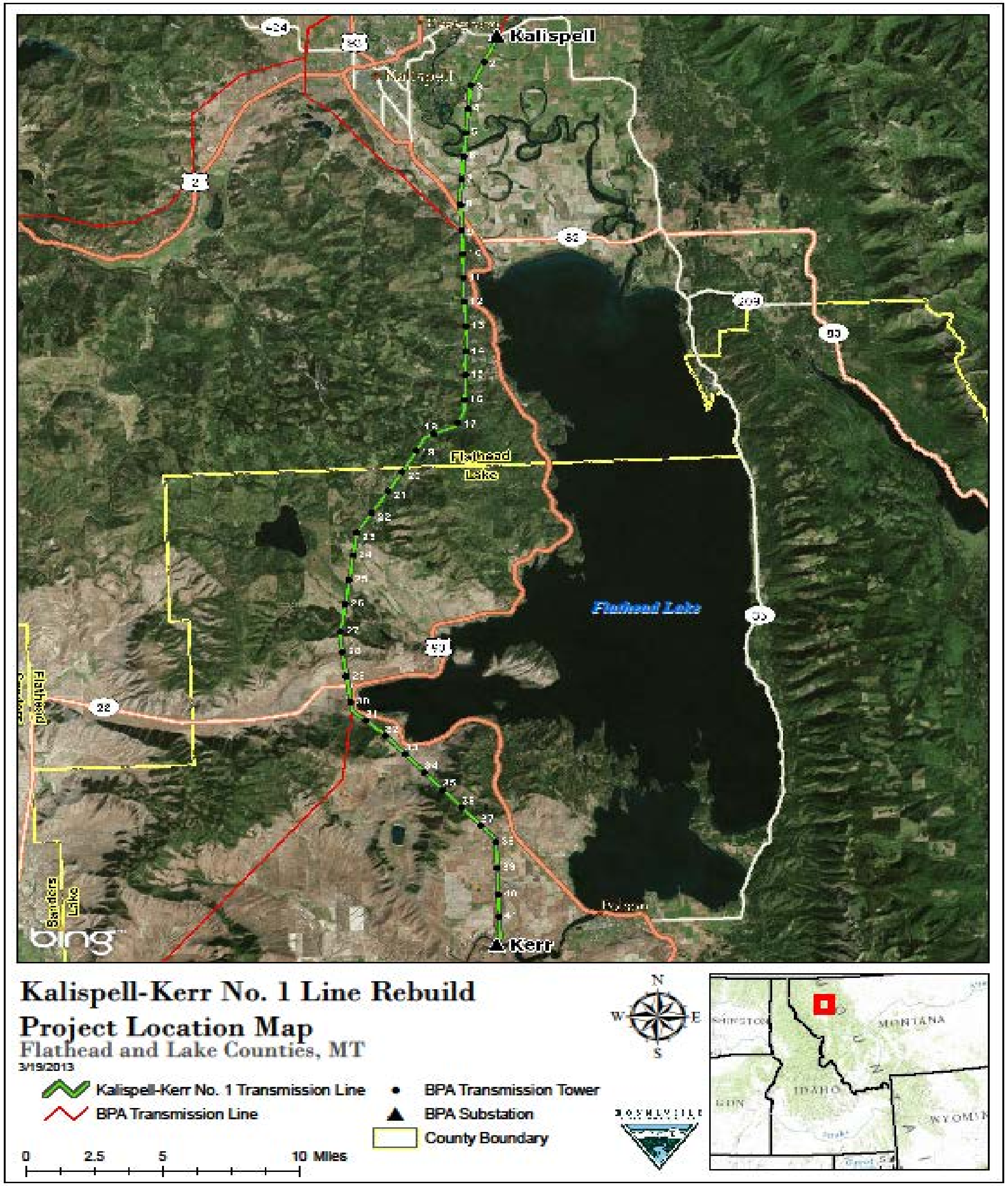
Brian Altman

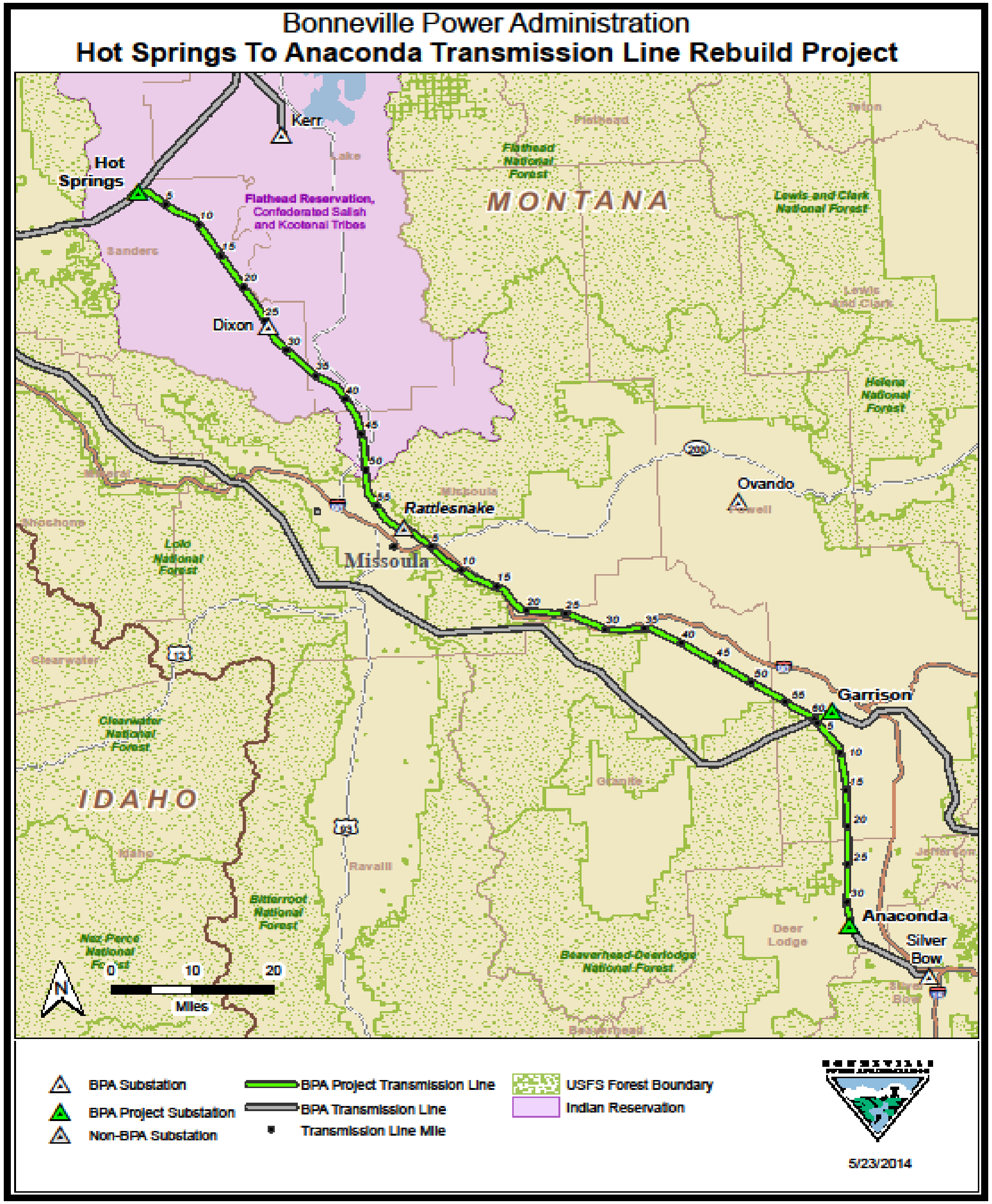
April 11, 2017

Topics

- Transmission Project Rebuilds
  - Kalispell-Kerr 115 kV
  - Hot Springs – Garrison- Anaconda 230 kV
- System Expansion
  - TSEP and BPA Transmission Queue
  - Utilizing Existing Capacity


WASHINGTON
MONTANA
SEATTLE
SPOKANE
PORTLAND
OREGON
IDAHO
TRANSMISSION SYSTEM
BONNEVILLE POWER ADMINISTRATION
U.S. DEPARTMENT OF THE INTERIOR
July 1, 195


Kalispell
Kerr
Flathead Lake
Flathead
Lake
Sanders
Kalispell-Kerr No. 1 Line Rebuild
Project Location Map
Flathead and Lake Counties, MT
3/19/2013
Kalispell-Kerr No. 1 Transmission Line
BPA Transmission Line
BPA Transmission Tower
BPA Substation
County Boundary
0 2.5 5 10 Miles
N
S
E
W
MONTANA
IDAHO


Bonneville Power Administration
Hot Springs To Anaconda Transmission Line Rebuild Project
Kerr
Hot Springs
Flathead Reservation, Confederated Salish and Kootenai Tribes
Flathead National Forest
MONTANA
Lewis and Clark National Forest
Dixon
Helena National Forest
Ovando
Rattlesnake
Missoula
Lolo National Forest
Garrison
Clearwater National Forest
IDAHO
Bitterroot National Forest
Nez Perce National Forest
Beaverhead-Deerlodge National Forest
Anaconda
Silver Bow
Miles
BPA Substation
BPA Project Substation
Non-BPA Substation
BPA Project Transmission Line
BPA Transmission Line
Transmission Line Mile
USFS Forest Boundary
Indian Reservation
5/23/2014

TSR Study & Expansion Process

Phase 1 (P1): Pre-Study

P1 - Pre-study:
- Customer TSR submittal and ATC assessment;
- Period between close of last TSR deadline and next TSR deadline for Cluster Study participation (typically June-May)
- $ - TSR deposit and processing fee

Phase 2 (P2): Cluster Study

P2 - Cluster Study:
- BPA tenders Study Agreements following TSR deadline;
- BPA commences and completes study (120-day study period);
- Results: preliminary plan of service scope, cost, and schedule;
- $ - Customer's pro rata share of costs by MW

Phase 3 (P3): Plan of Service Validation

P3 - Plan of Service Validation and Preliminary Engineering:
- Refinement of cost and scope of Cluster Study results;
- Estimation of Environmental Review scope and costs;
- $ - Customer's pro rata share of costs by MW

Phase 4 (P4): Environmental Review

P4 - Environmental Review:
- Required NEPA review of environmental impacts
- Includes Record of Decision whether to build the project;
- $ - Customer's pro rata share of costs by MW

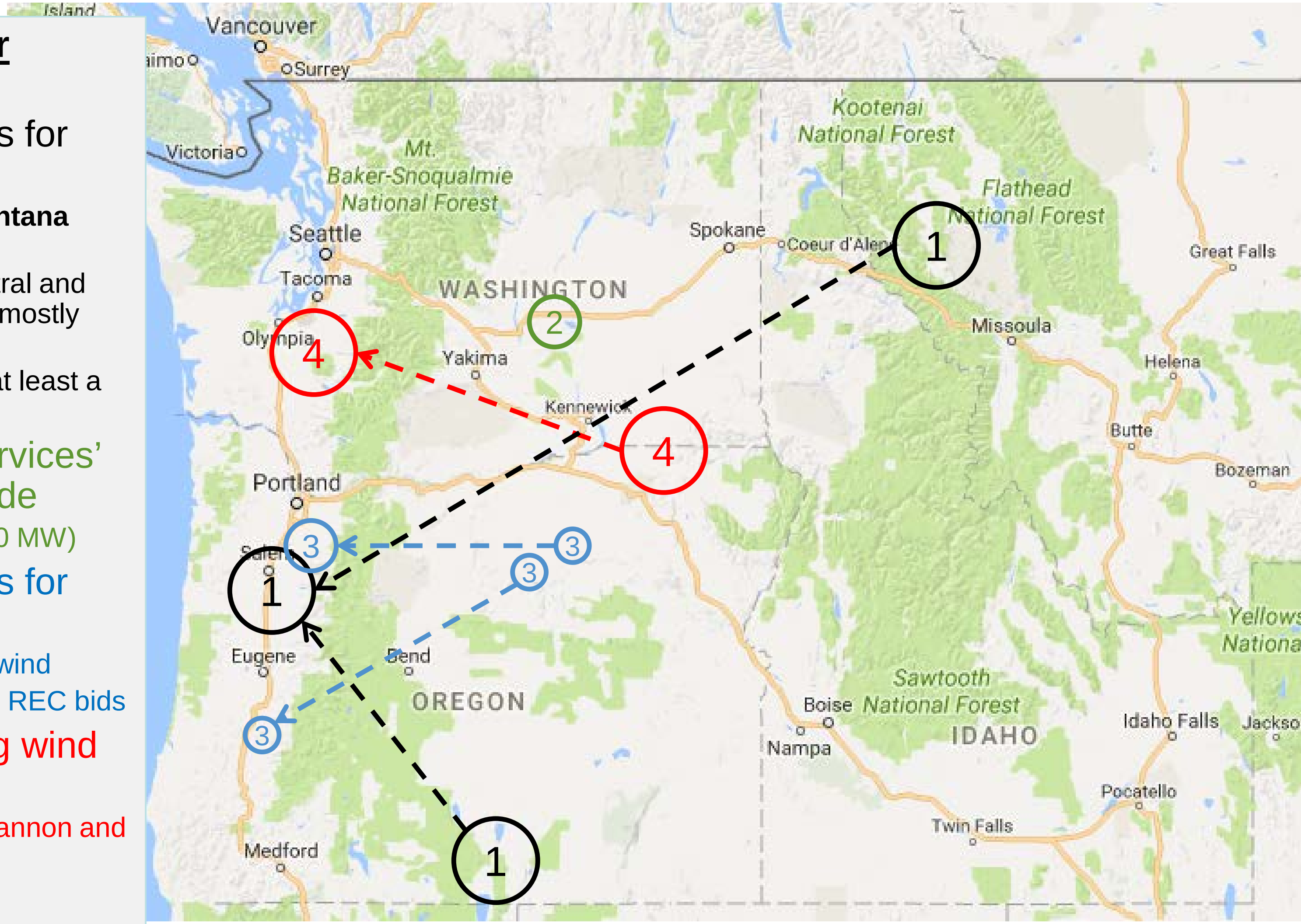
Phase 5 (P5): Project Construction

P5 - Project Construction:
- Construction and Energization of identified transmission project;
- $ - Customer secures its pro rata MW share of construction costs (letter of credit, etc.)

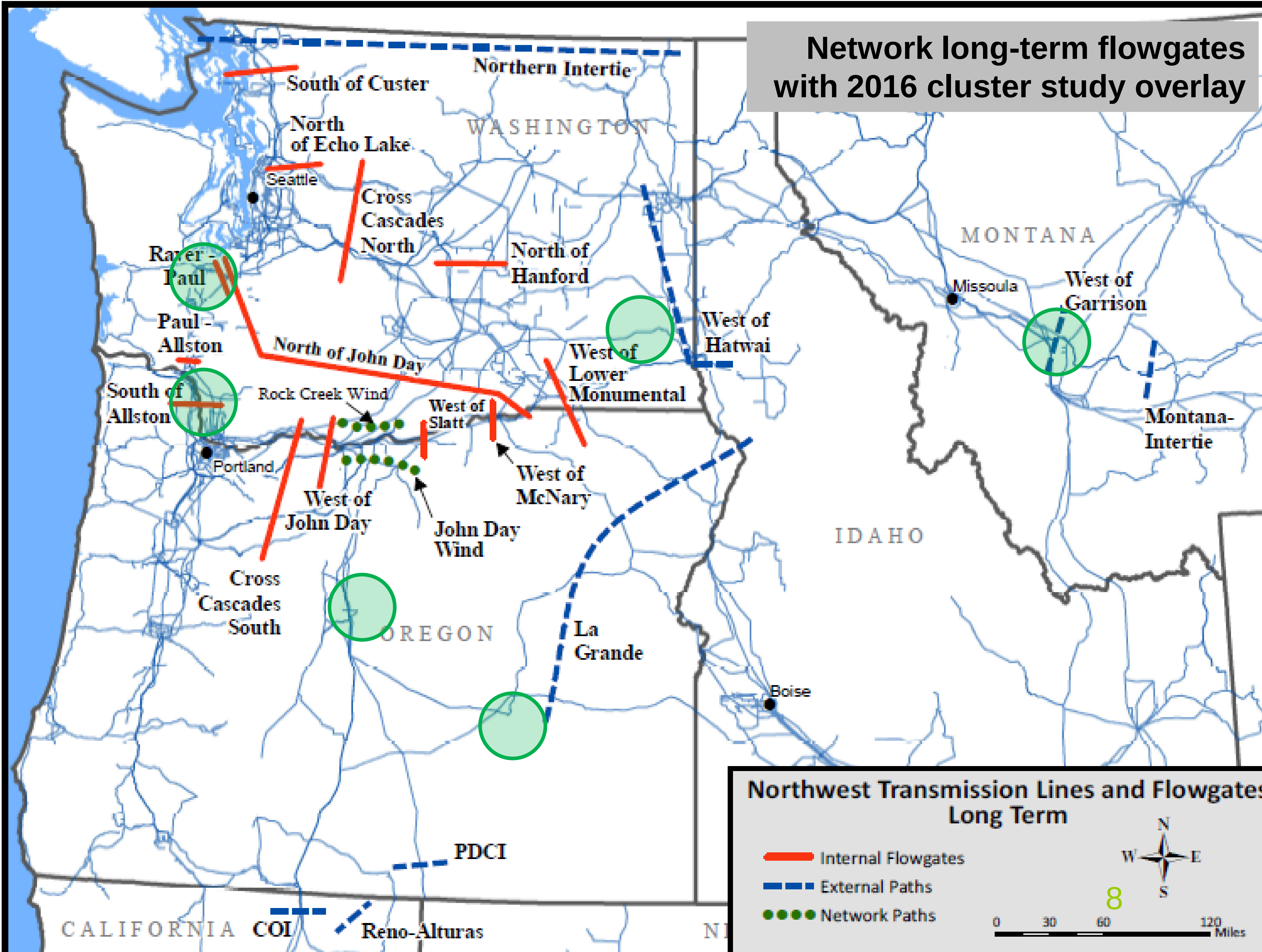
2016 Cluster Study Load and Generation Trends

Primary Customer Behaviors

1. Renewable bids for PGE's RFP
   - **850 MW from Montana wind**
   - 335 MW from central and southern Oregon (mostly solar)
   - RFP deferred for at least a year
2. BPA Power Services' potential upgrade
   - Grand Coulee (240 MW)
3. Renewable bids for PAC's RFP
   - 200 MW of gorge wind
   - PAC selected only REC bids
4. Puget importing wind resources
   - 300 MW from Tucannon and Central Ferry



Network long-term flowgates with 2016 cluster study overlay

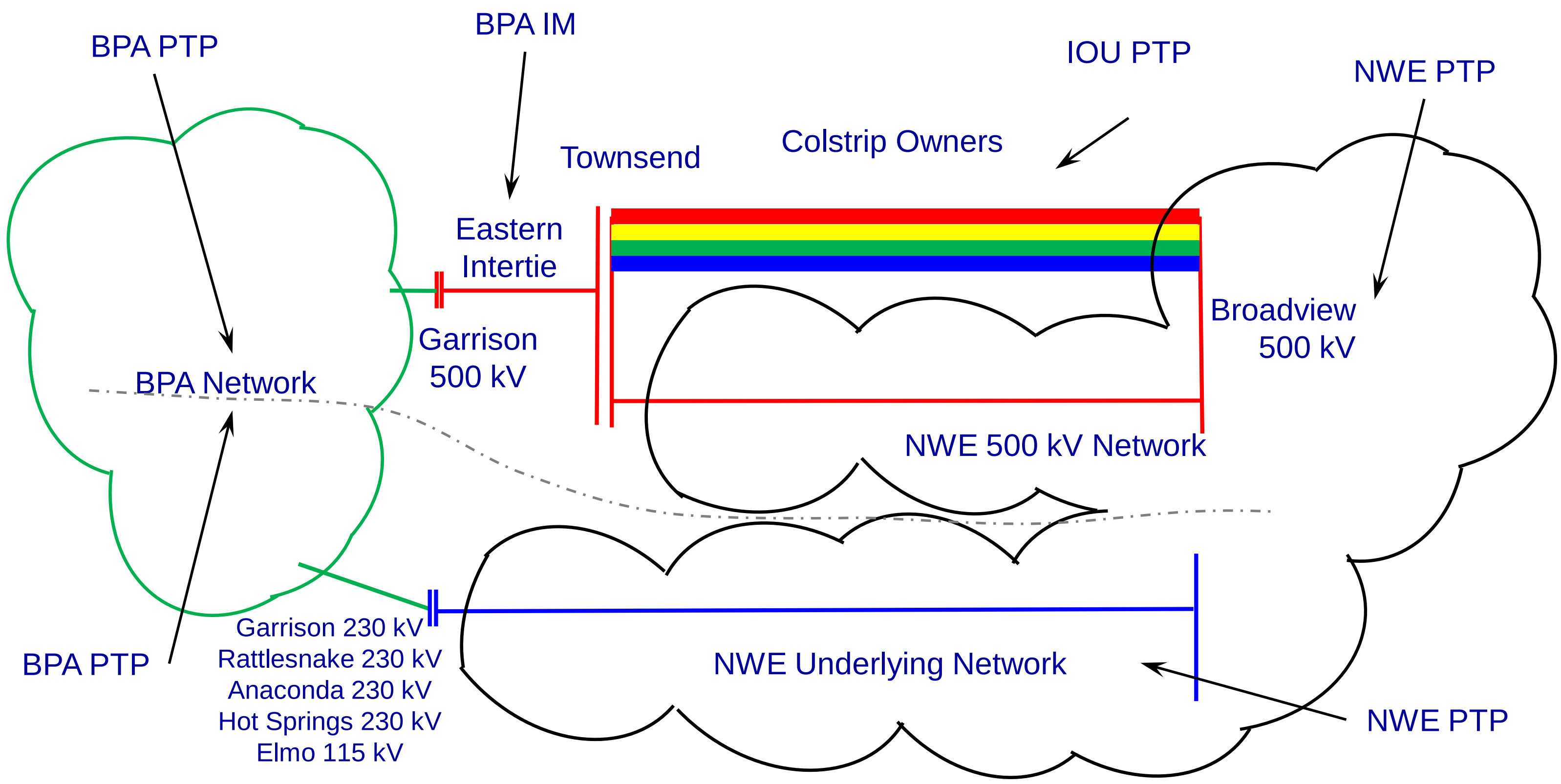


2016 TSEP Cluster Study Preliminary Observations

- 51 TSRs representing 2,042 MW of long-term firm demand
- I-5 (South of Allston flowgate) continues to be a key issue to offering commercial long-term firm transmission service
- Most TSRs require multiple plans of service
- RAS remains a requirement for all new service across the West of Garrison path

** MW values are preliminary and are subject to change based on final determinations.*

Complications with Transmission Service on Montana Intertie to the Northwest



Northwest Power and Conservation Council
Power Committee
April 11, 2017

Montana Transmission and Resources Panel

Bill Pascoe

pascoeenergy@aol.com

Montana vs. Pacific Northwest Wind Cost Comparison

- Prepared by Pascoe Energy with assistance from NPCC staff
  - Completed December 2016
- Resource costs from 7th Power Plan and PowerFin
- Levelized energy costs delivered to utilities in Washington and Oregon

Montana vs. Pacific Northwest Wind Cost Comparison

- Wind Capacity Factors
  - WA/OR: 34%
  - MT: 40% and 45%

- Wind Capacity Values
  - WA/OR: 0% and 10%
  - MT: 0%, 10%, 30% and 50%

Montana vs. Pacific Northwest Wind Cost Comparison

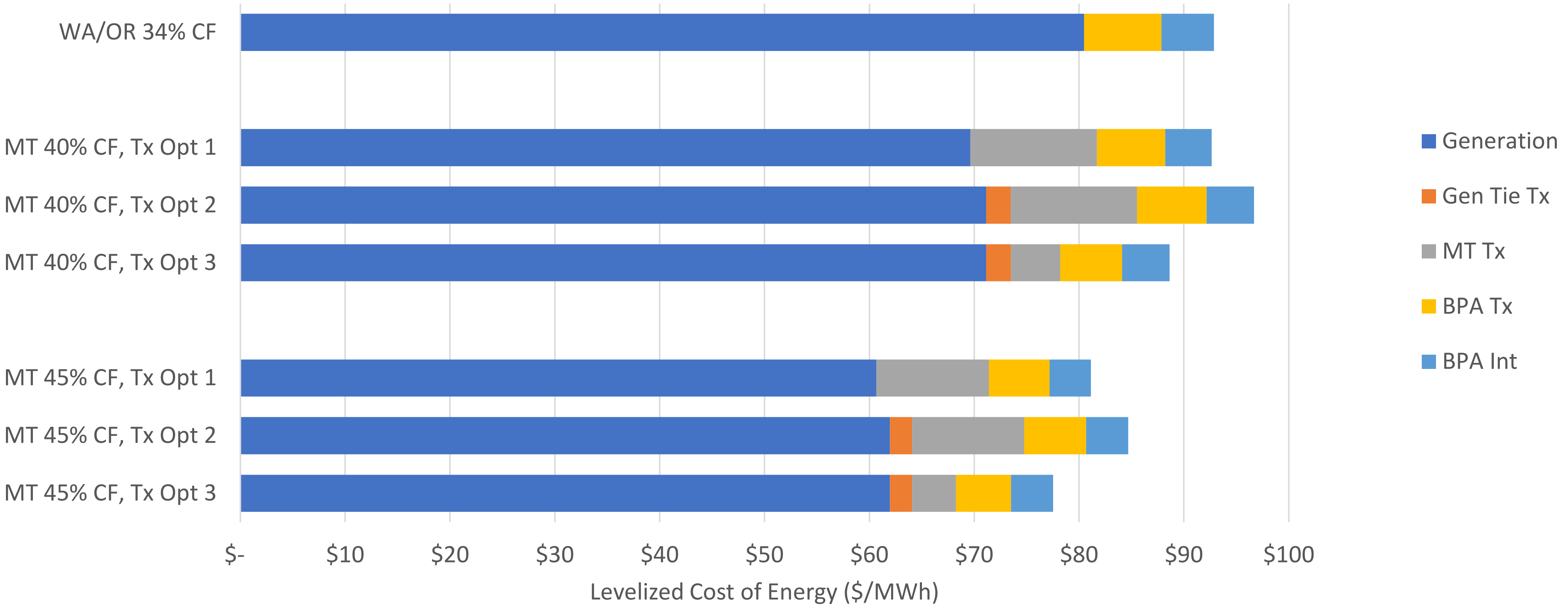
- Transmission Costs
  - WA/OR: one wheel on BPA
  - MT Opt 1: wheels on NWE and BPA
  - MT Opt 2: gen tie plus wheels on PSE CTS, BPA MT Intertie and BPA
  - MT Opt 3: gen tie plus upgrades to CTS/BPA MT Int and BPA (M2W)

- Integration Costs
  - WA/OR and MT: BPA integration charges

MT vs WA/OR Wind Cost Comparison

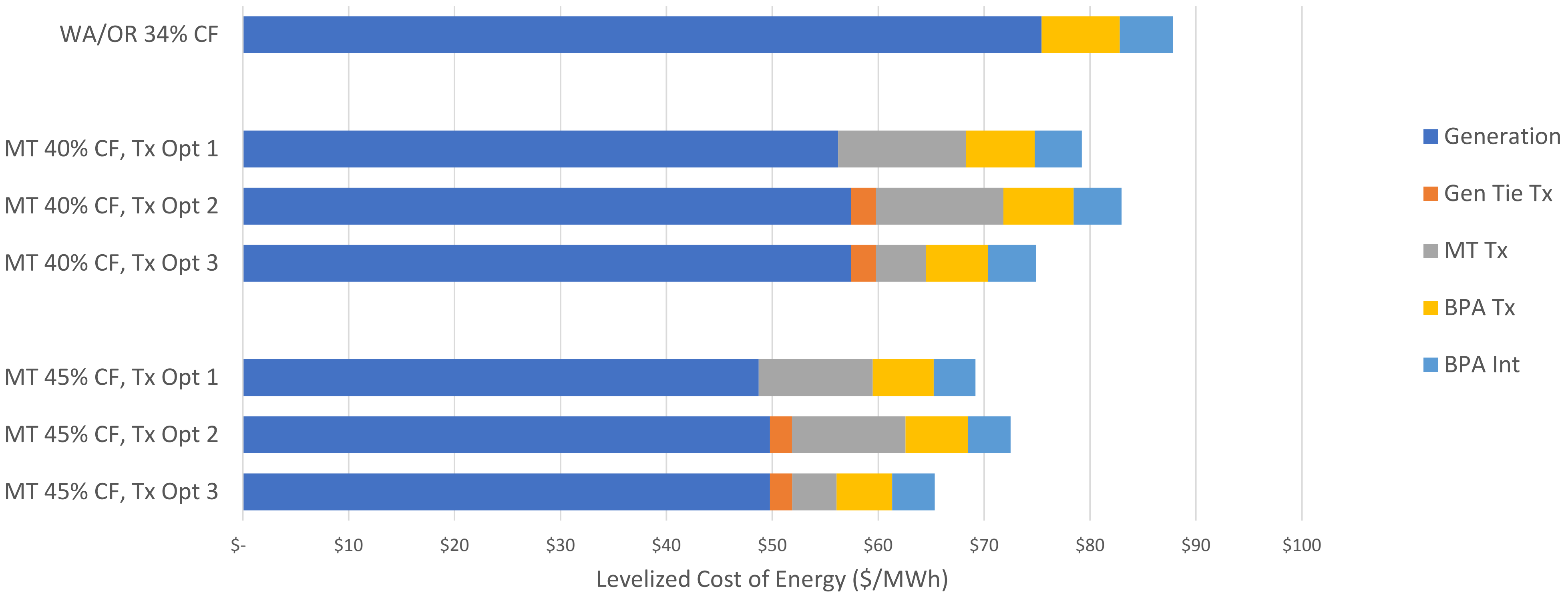
Capacity Credit: WA/OR - None, MT – None

Full PTC



MT vs WA/OR Wind Cost Comparison

Capacity Credit: WA/OR - 10%, MT – 30%
Full PTC



Colstrip 1& 2 Replacement Analysis

- Prepared by E3 Consulting for Absaroka Energy, developer of the Gordon Butte Pumped Storage Hydro (PSH) Project
  - Completed December 2016
- Two alternatives to replace PSE’s share of Colstrip 1&2 energy (250 aMW) and capacity (300 MW)
  - PNW Alternative
    - 736 MW PNW Wind for energy and some capacity (5% capacity value)
    - 263 MW Aero CT for remaining capacity
  - MT Alternative
    - 548 MW MT Wind for energy and some capacity (25% capacity value)
    - 163 MW Gordon Butte PSH for remaining capacity and shaping

Colstrip 1& 2 Replacement Analysis

MT Alternative provides substantial benefits to PSE customers:

- **$300 million** reduction in CapEx
- **$53 million** reduction in annual levelized costs
  - **$481 million** NPV over 25 years
- **$24/MWh** reduction in levelized energy costs (250 aMW)