Montana vs. Pacific Northwest Wind
Cost Comparison

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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:

For Montana Wind with 40% CF and Full PTCs:

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

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

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

For Montana Wind with 45% CF and Full PTCs:

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

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

- Assuming 10% capacity value for Pacific Northwest wind and 50% capacity value for Montana wind, delivered costs for Montana wind range from 27% to 35% lower 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

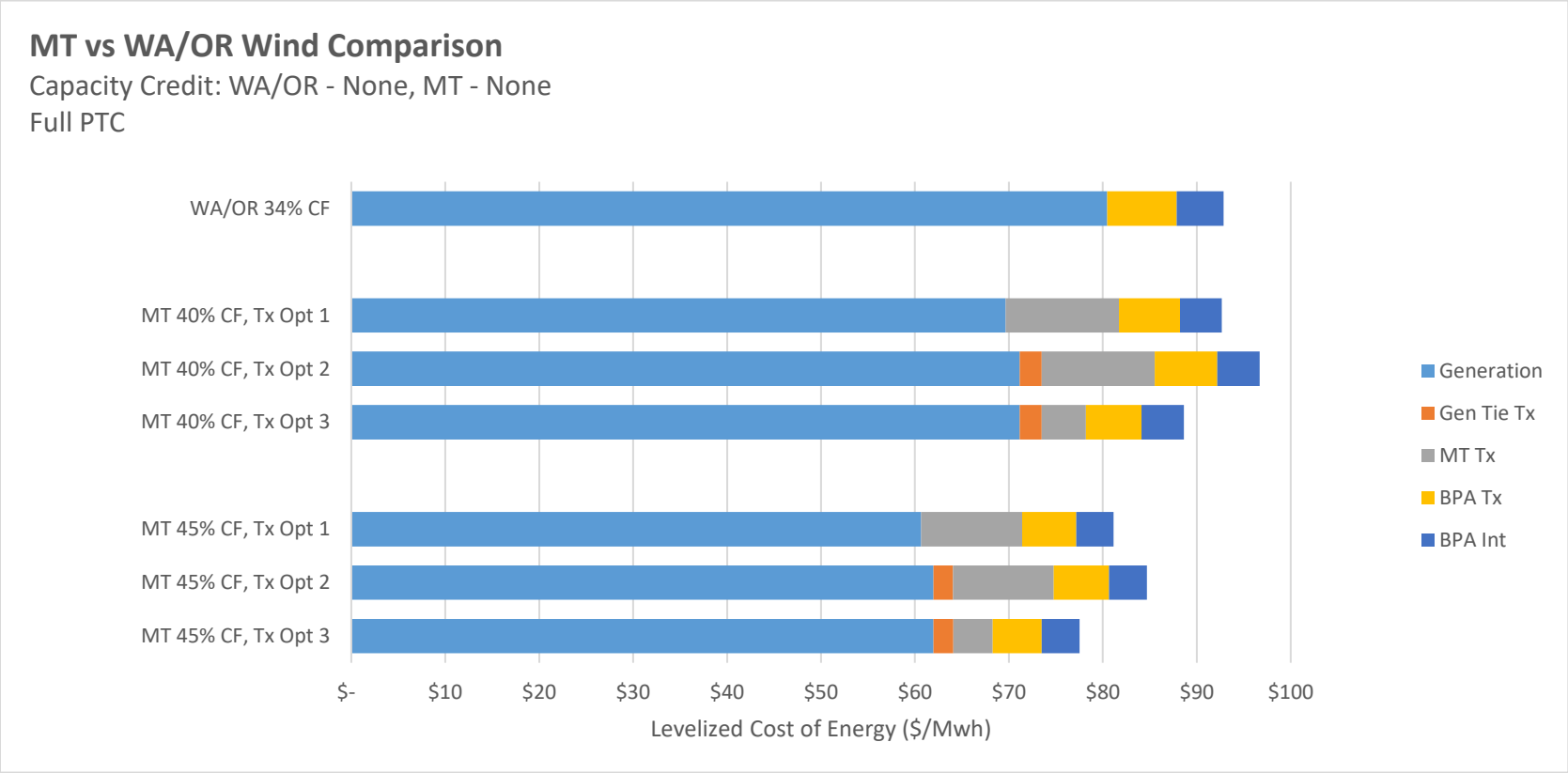
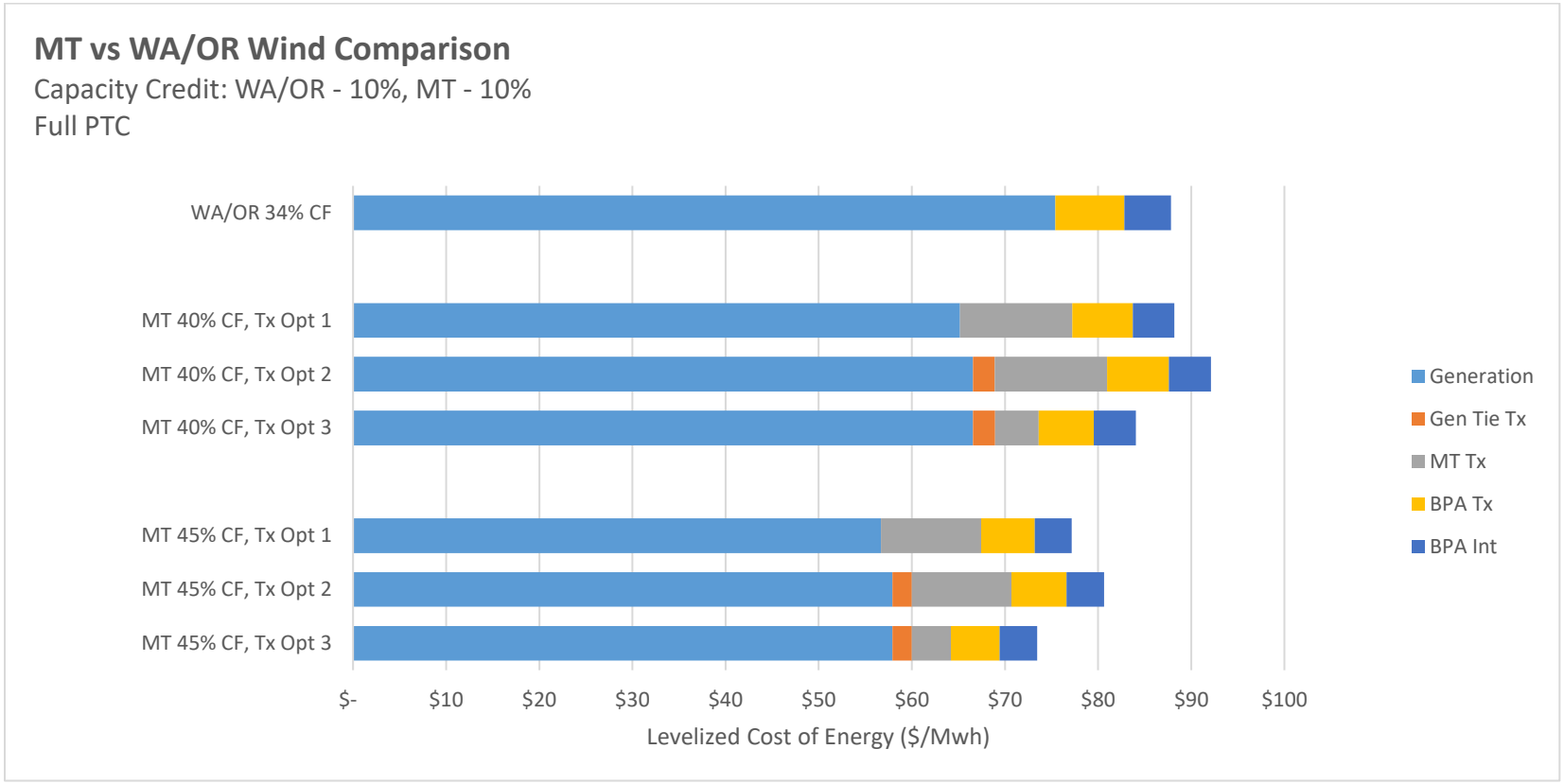

MT vs WA/OR Wind Comparison
Capacity Credit: WA/OR - None, MT - None
Full PTC
WA/OR 34% CF
MT 40% CF, Tx Opt 1
MT 40% CF, Tx Opt 2
MT 40% CF, Tx Opt 3
MT 45% CF, Tx Opt 1
MT 45% CF, Tx Opt 2
MT 45% CF, Tx Opt 3
$- $10 $20 $30 $40 $50 $60 $70 $80 $90 $100
Levelized Cost of Energy ($/Mwh)
Generation
Gen Tie Tx
MT Tx
BPA Tx
BPA Int

Chart 2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Full PTC
WA/OR 34% CF
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MT 40% CF, Tx Opt 2
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MT 45% CF, Tx Opt 3
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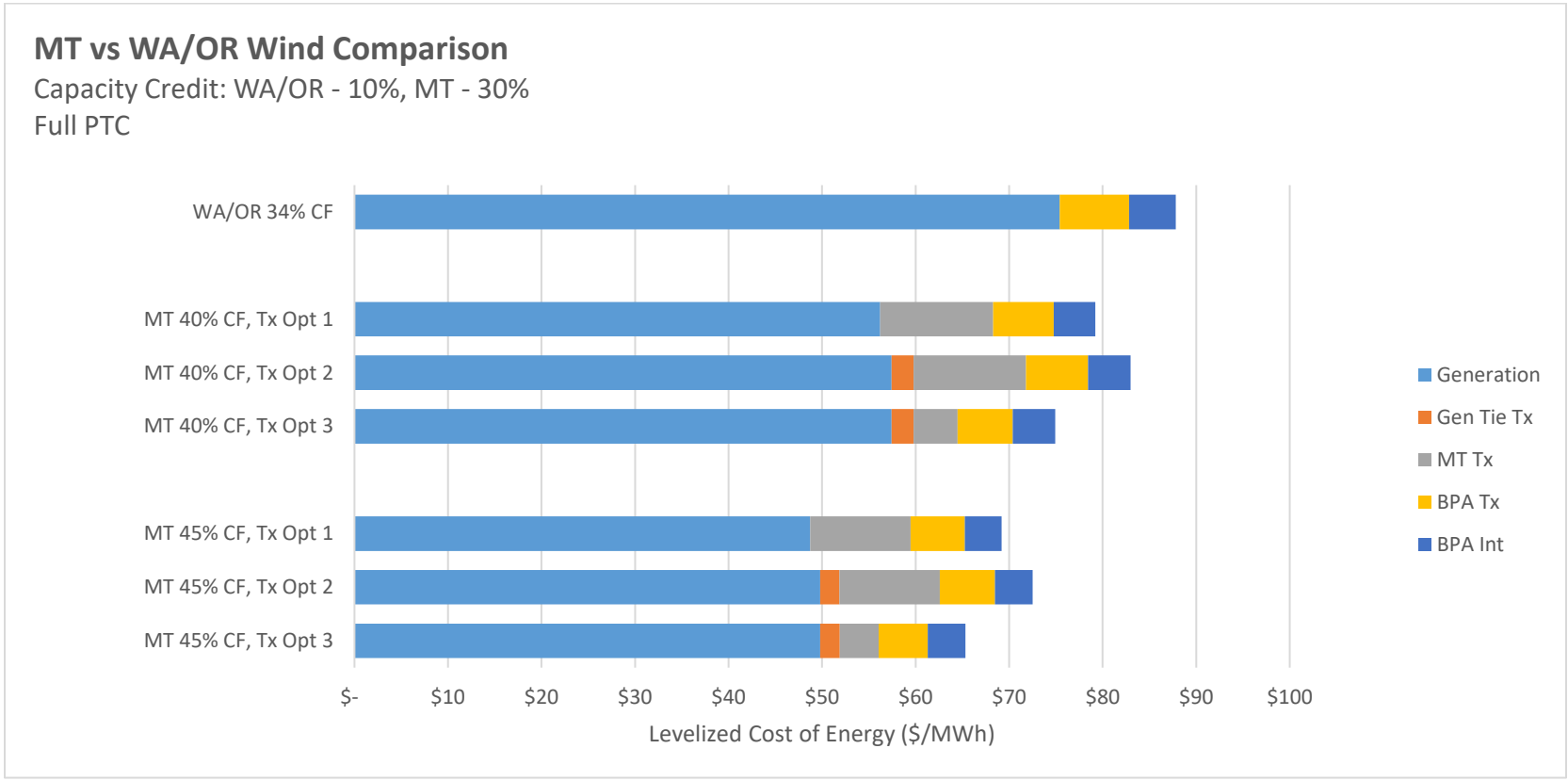
Levelized Cost of Energy ($/Mwh)
Generation
Gen Tie Tx
MT Tx
BPA Tx
BPA Int

Chart 3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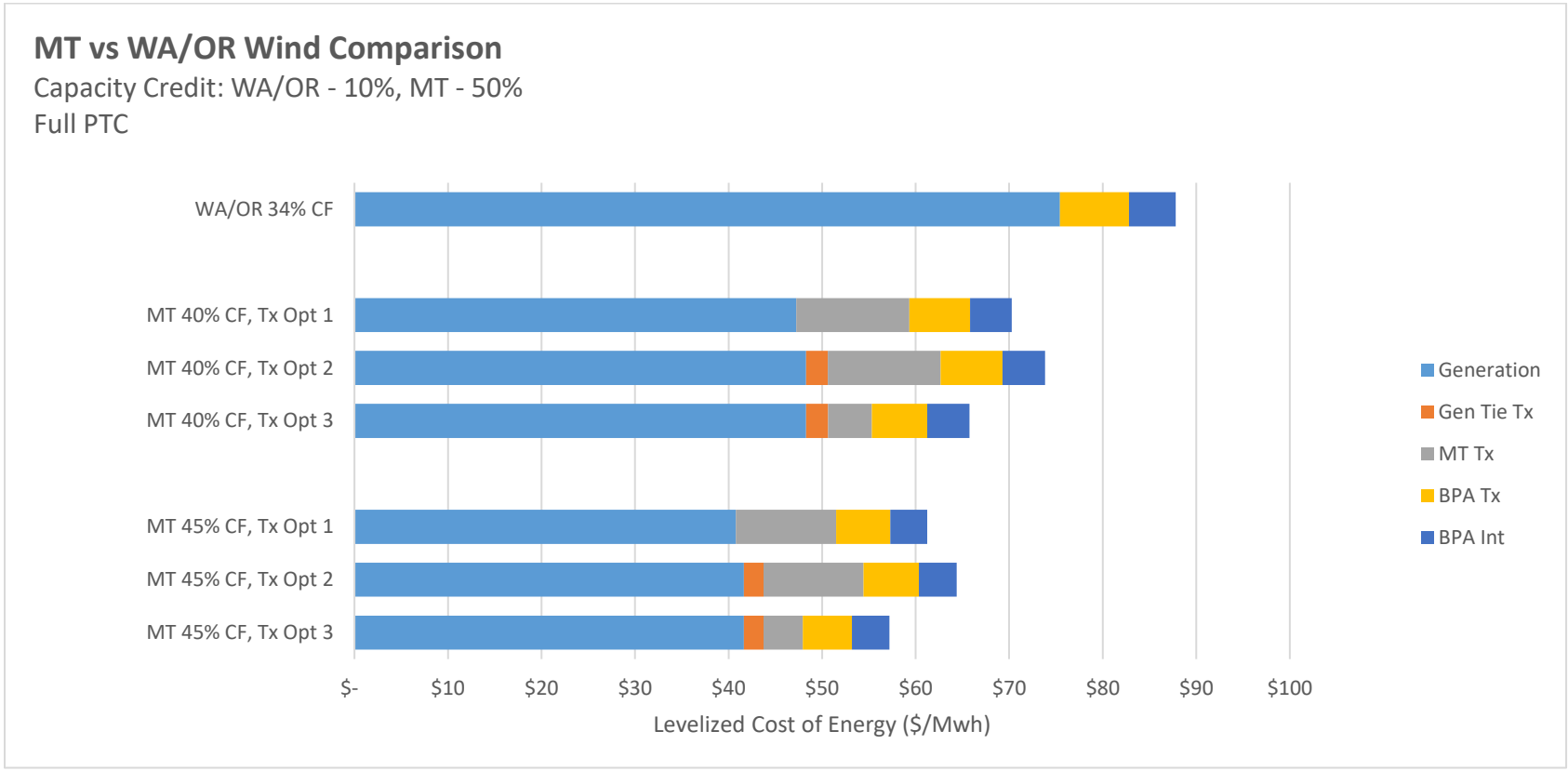
$- $10 $20 $30 $40 $50 $60 $70 $80 $90 $100
Levelized Cost of Energy ($/MWh)
Generation
Gen Tie Tx
MT Tx
BPA Tx
BPA Int

Chart 4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WA/OR 34% CF
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MT 45% CF, Tx Opt 2
MT 45% CF, Tx Opt 3
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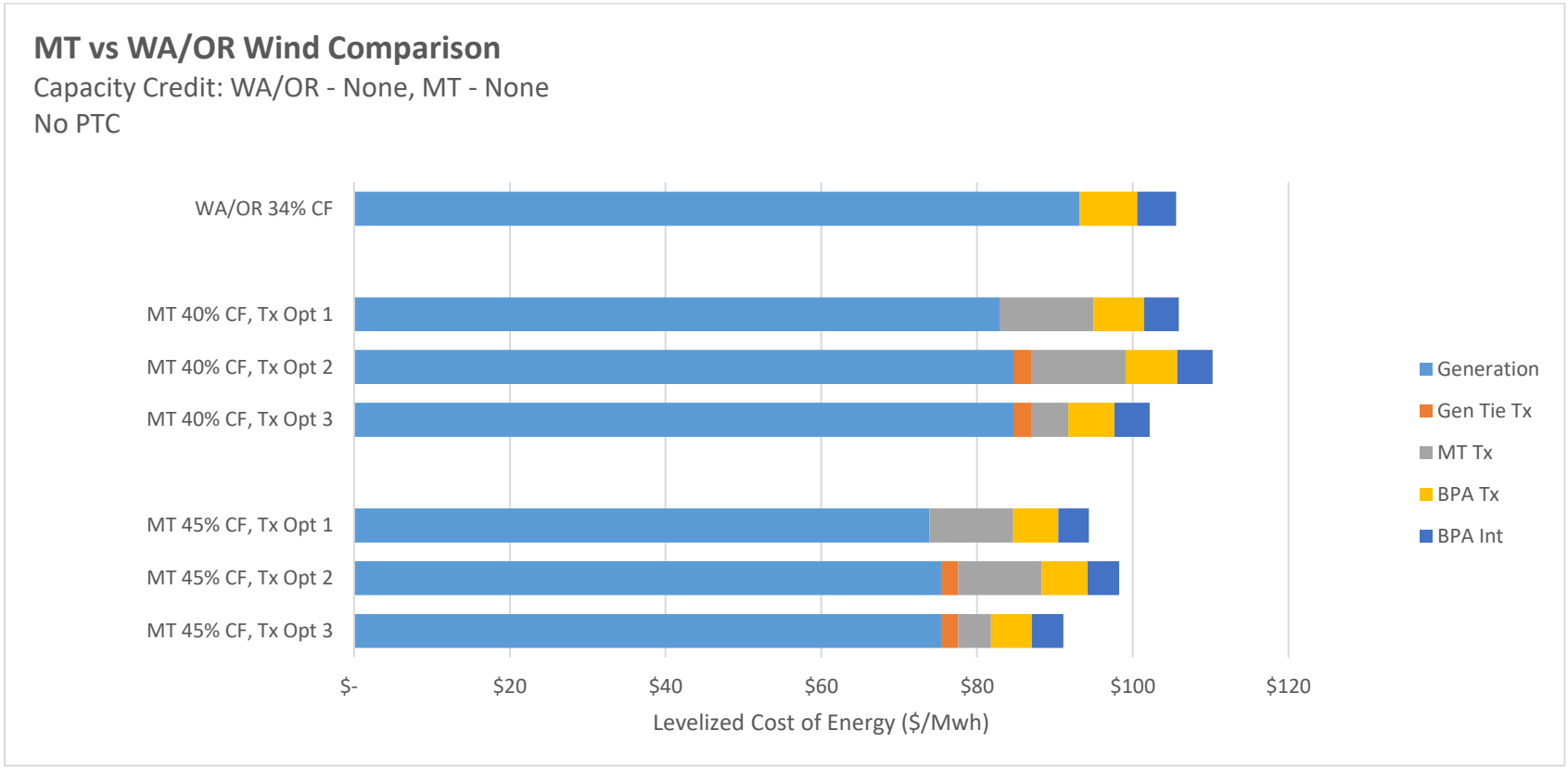
Levelized Cost of Energy ($/Mwh)
Generation
Gen Tie Tx
MT Tx
BPA Tx
BPA Int

Chart 5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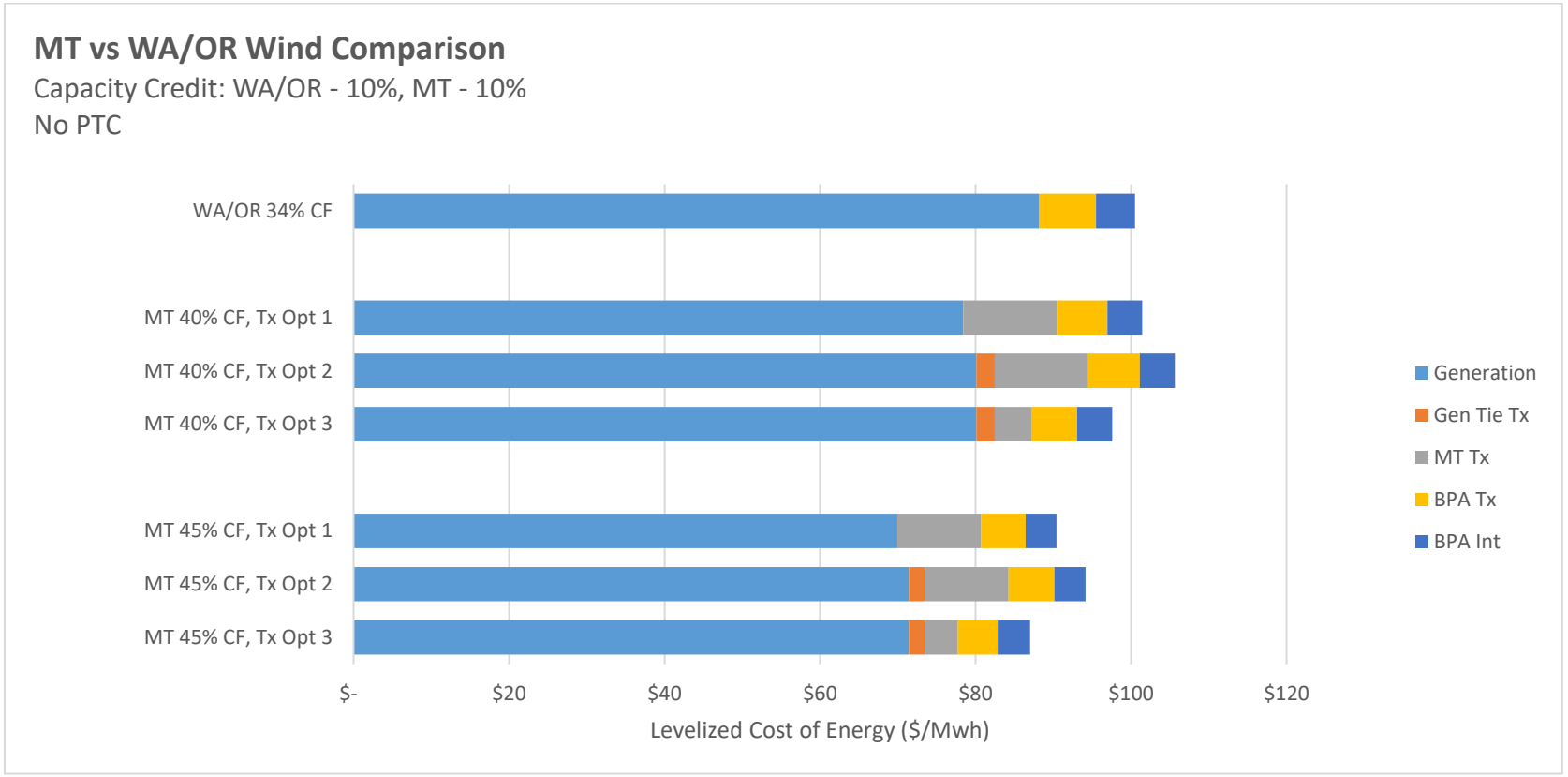
$-
$20
$40
$60
$80
$100
$120
Levelized Cost of Energy ($/Mwh)
Generation
Gen Tie Tx
MT Tx
BPA Tx
BPA Int

Chart 6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MT 45% CF, Tx Opt 3
$-
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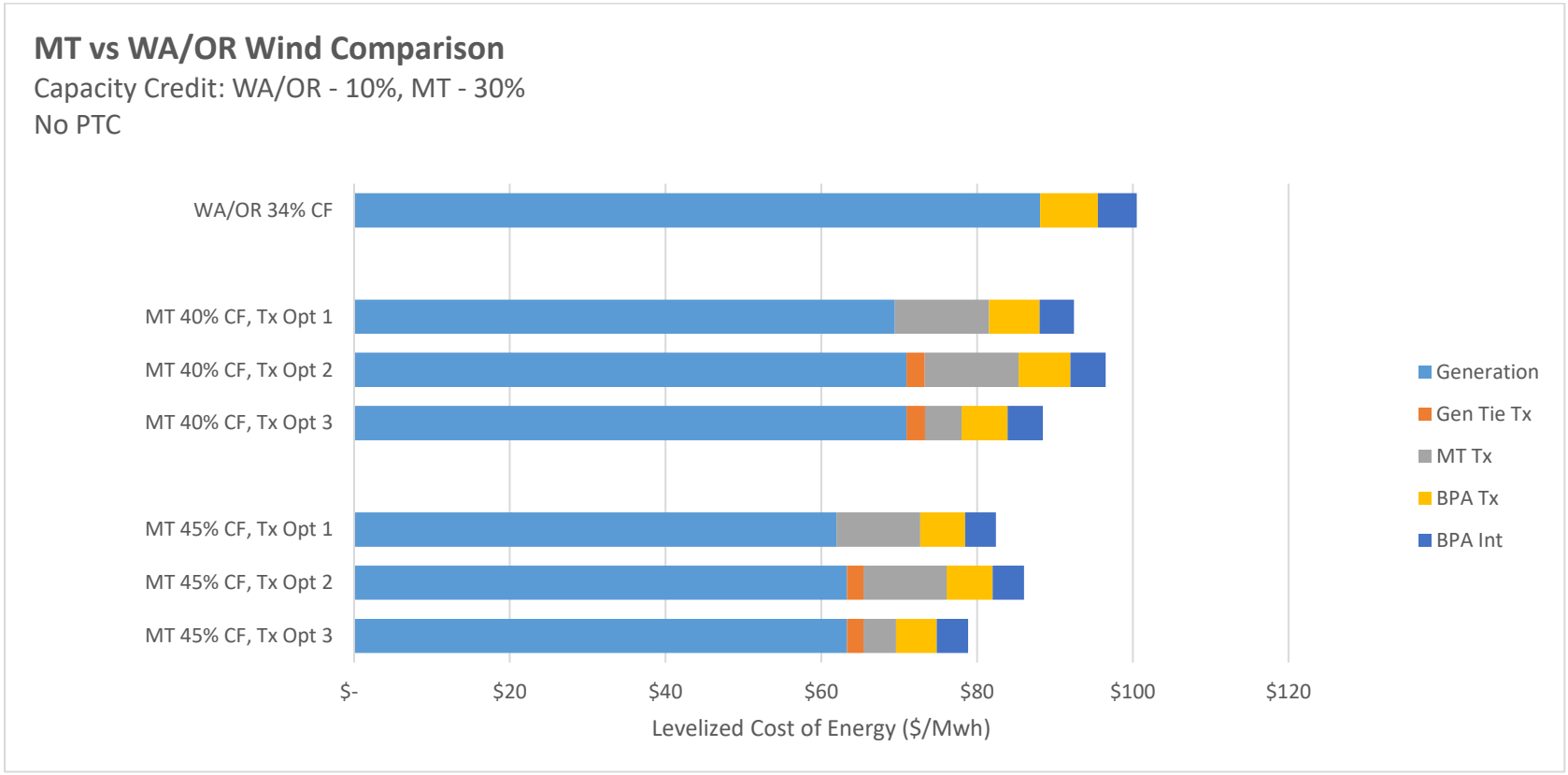
$40
$60
$80
$100
$120
Levelized Cost of Energy ($/Mwh)
Generation
Gen Tie Tx
MT Tx
BPA Tx
BPA Int

Chart 7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Levelized Cost of Energy ($/Mwh)
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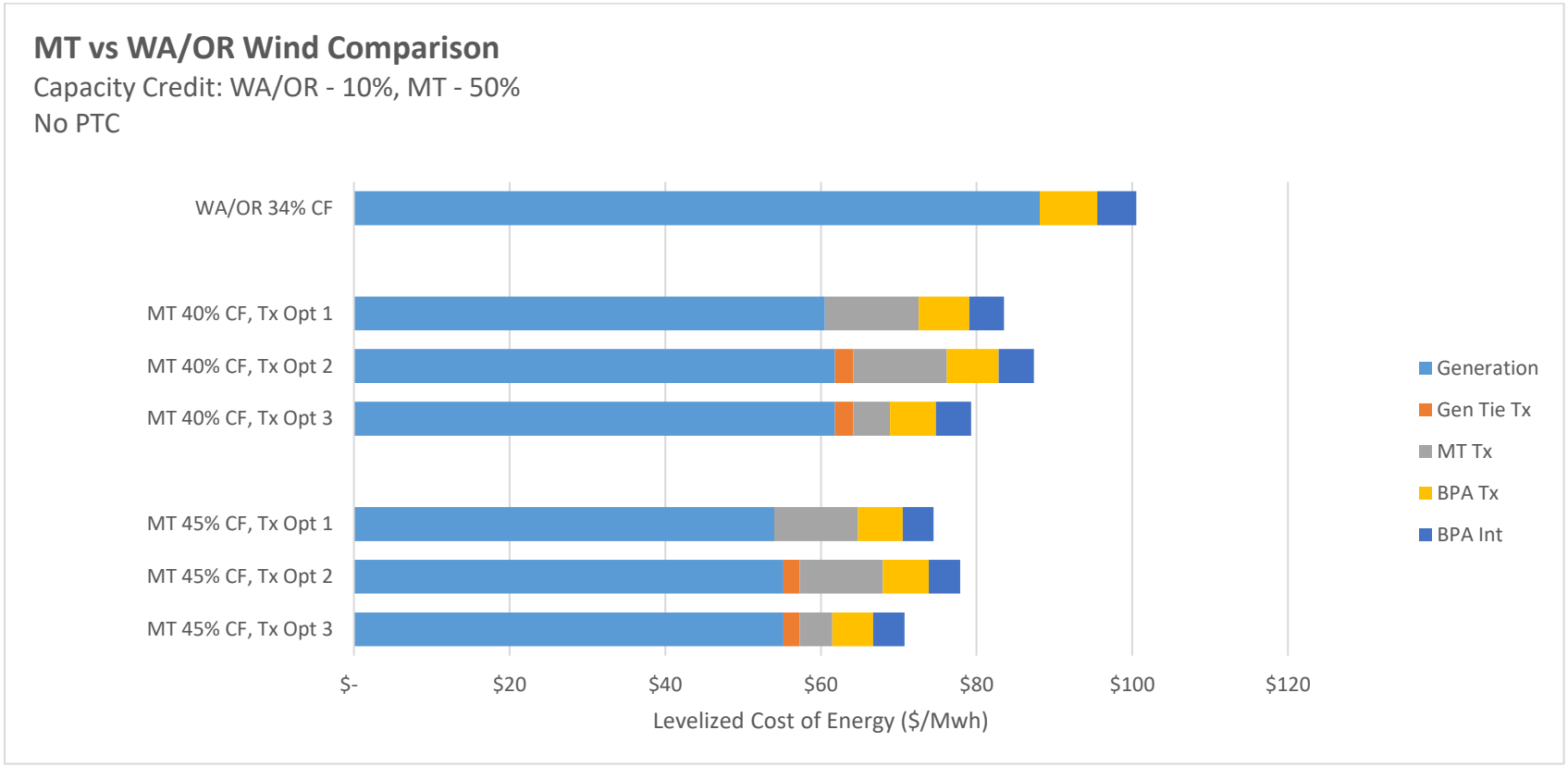
MT Tx
BPA Tx
BPA Int

Chart 8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$120
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BPA Tx
BPA Int