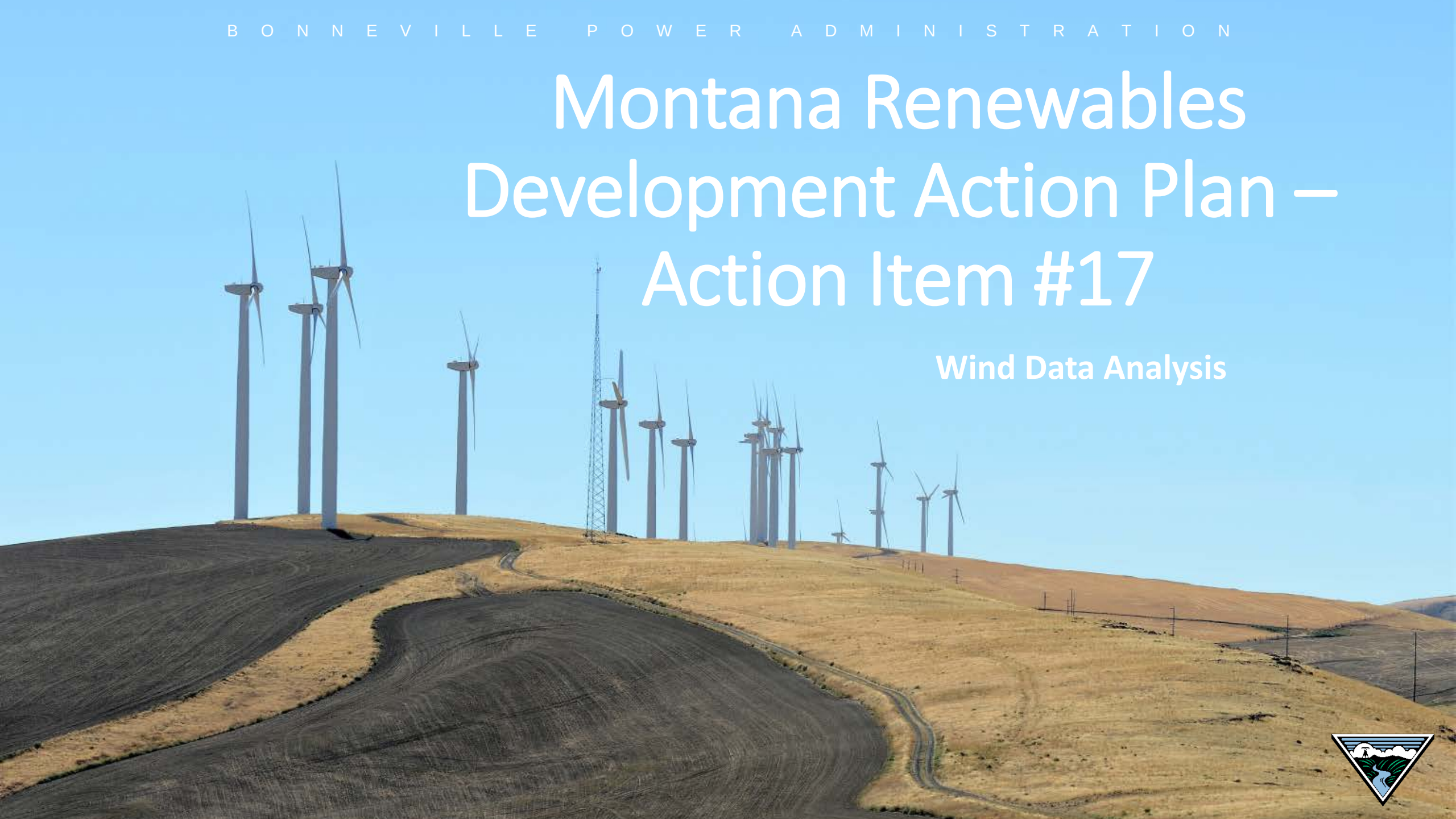
BONNEVILLE POWER ADMINISTRATION

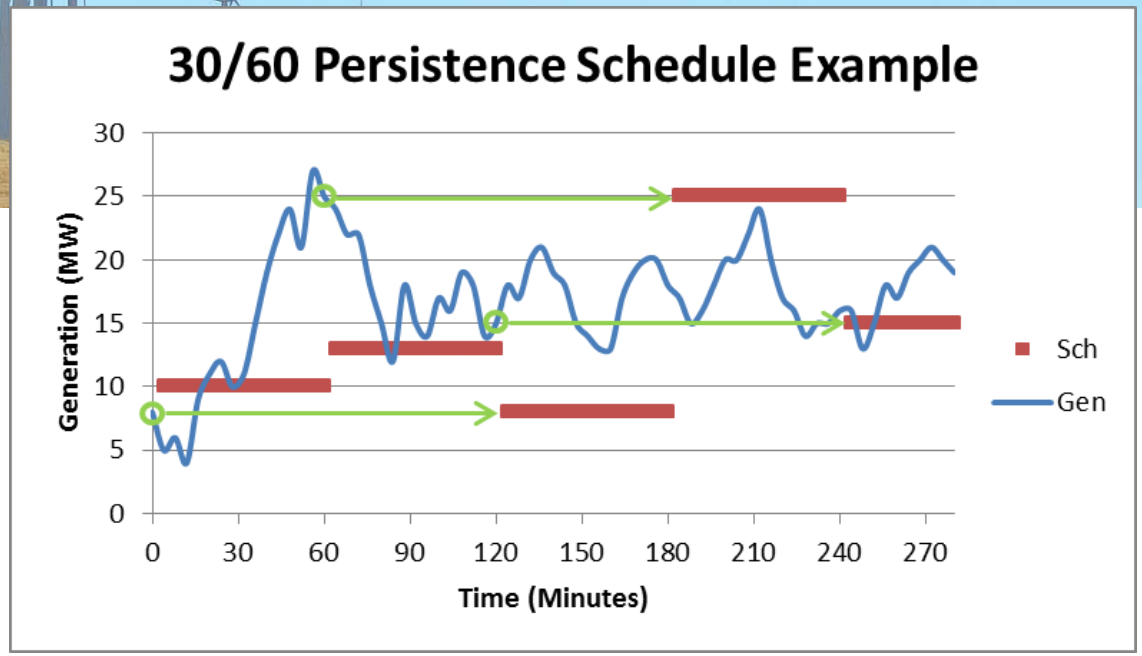
Montana Renewables Development Action Plan – Action Item #17

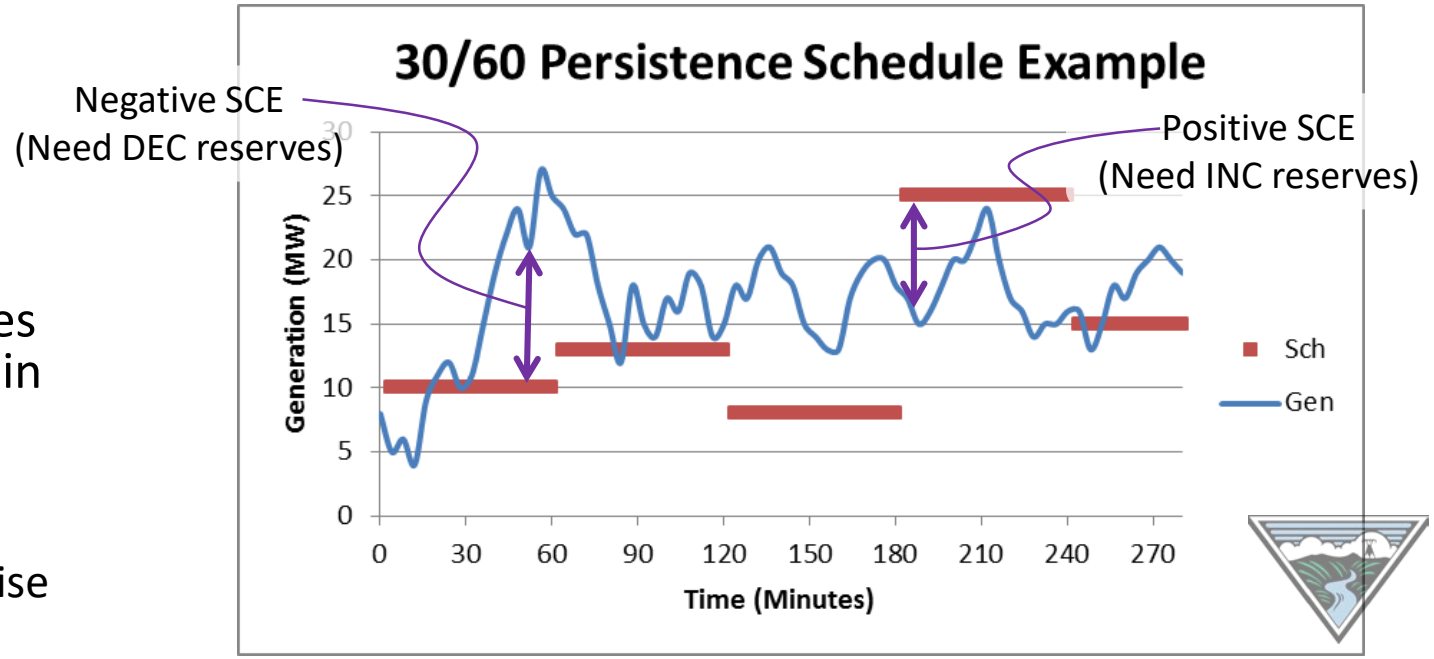
Wind Data Analysis



Analysis

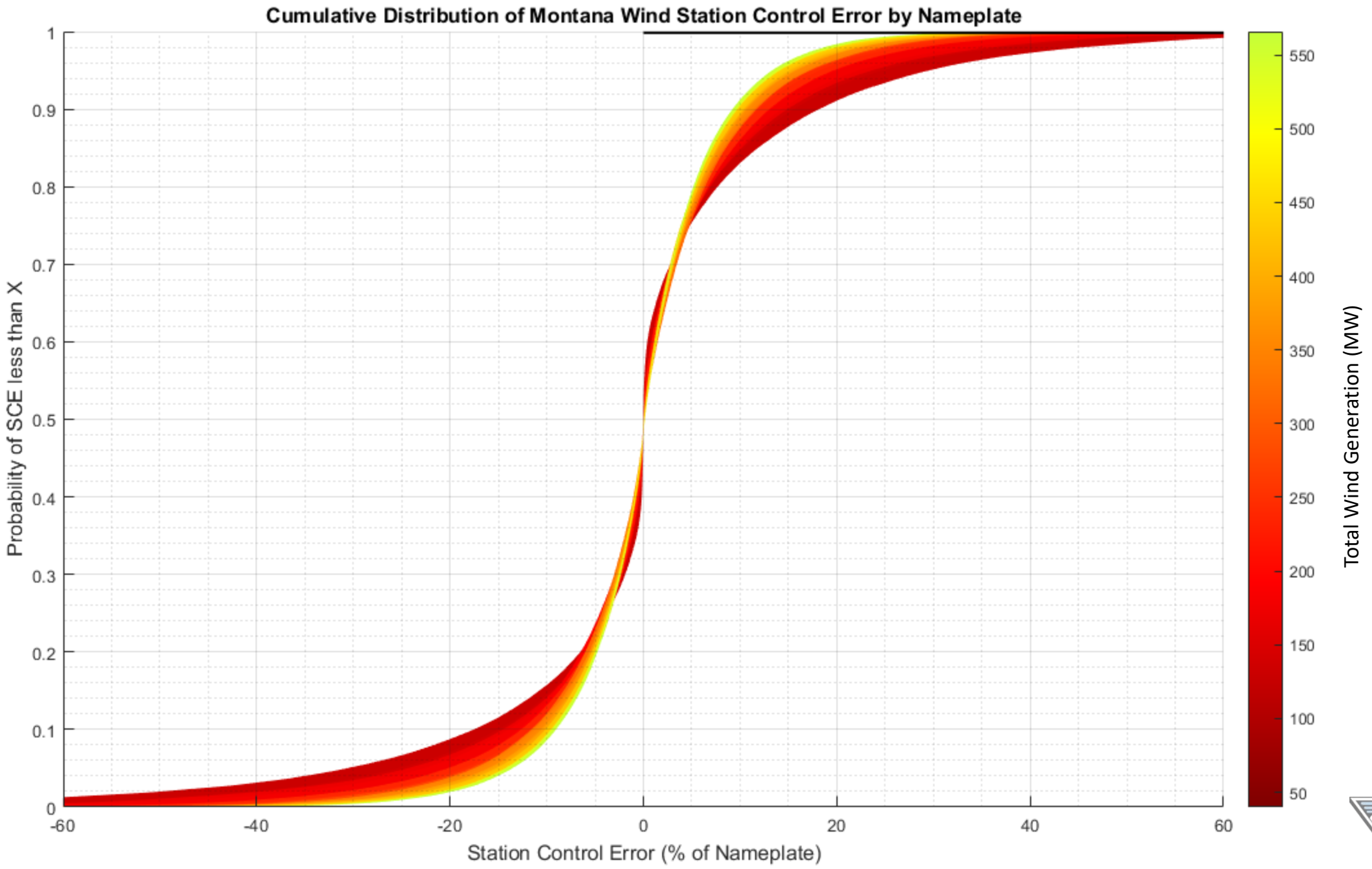
- Station Control Error (SCE): A measure of reserve need, equal to the sum of generation schedules minus the sum of generation actuals on a minute-by-minute basis.
  - For our analysis, we have used a "30/60 Persistence" schedule
  - The higher the station control error, the more reserves are needed
  - We present station control error measures as a percent of wind nameplate capacity in order to normalize measurements for comparison
    - In particular, this helps us observe the diversity benefit as wind capacity levels rise

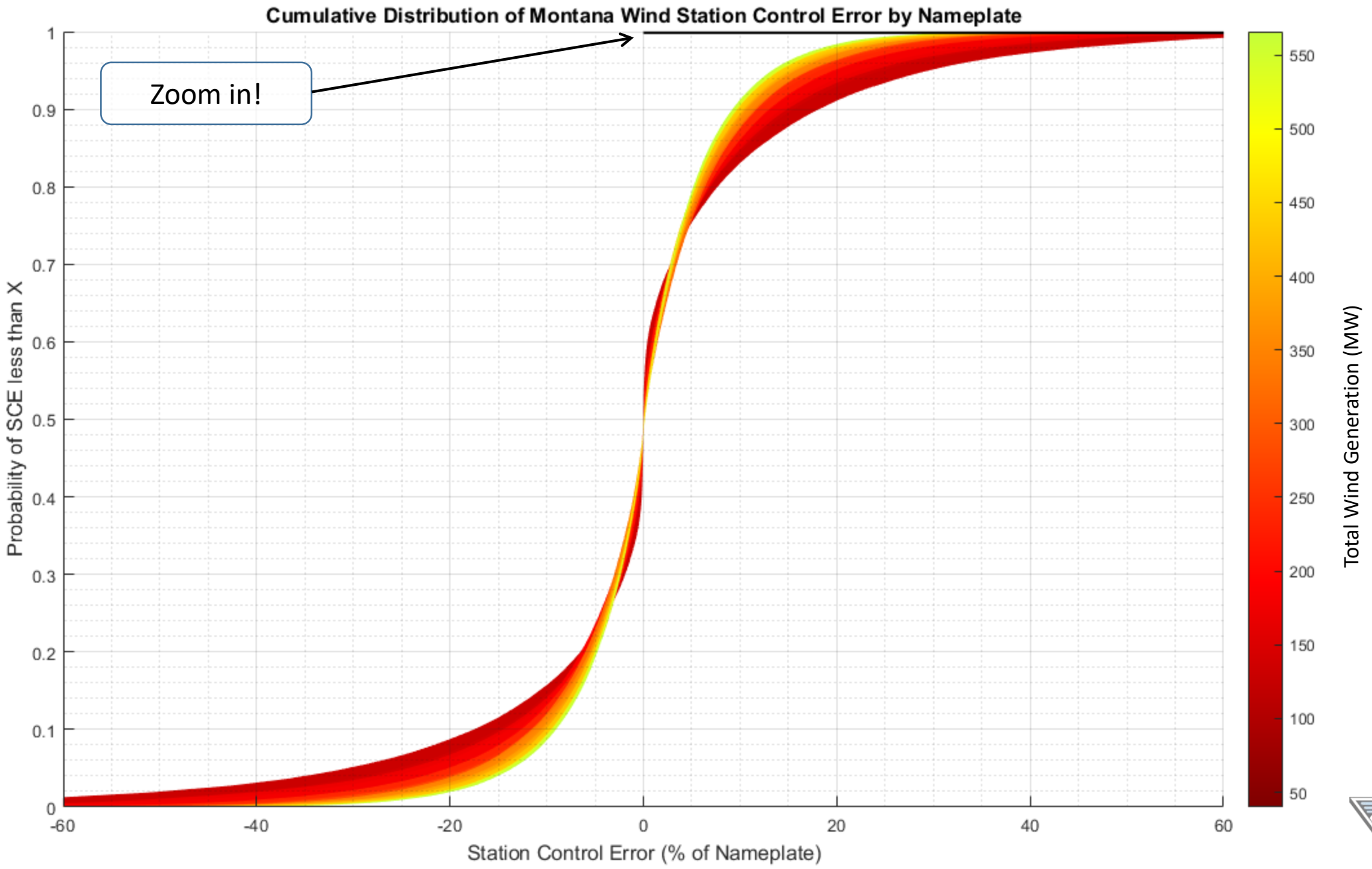


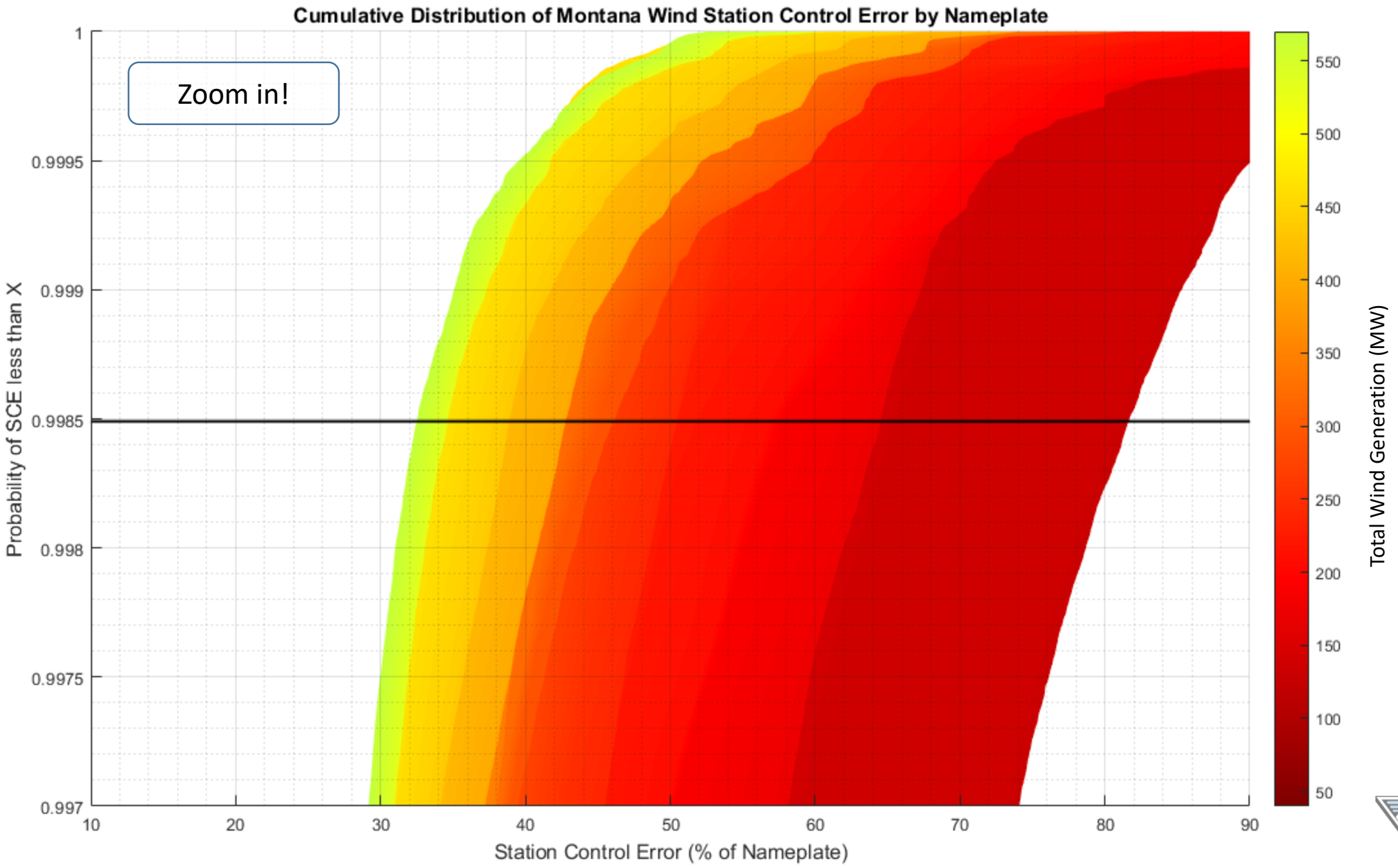


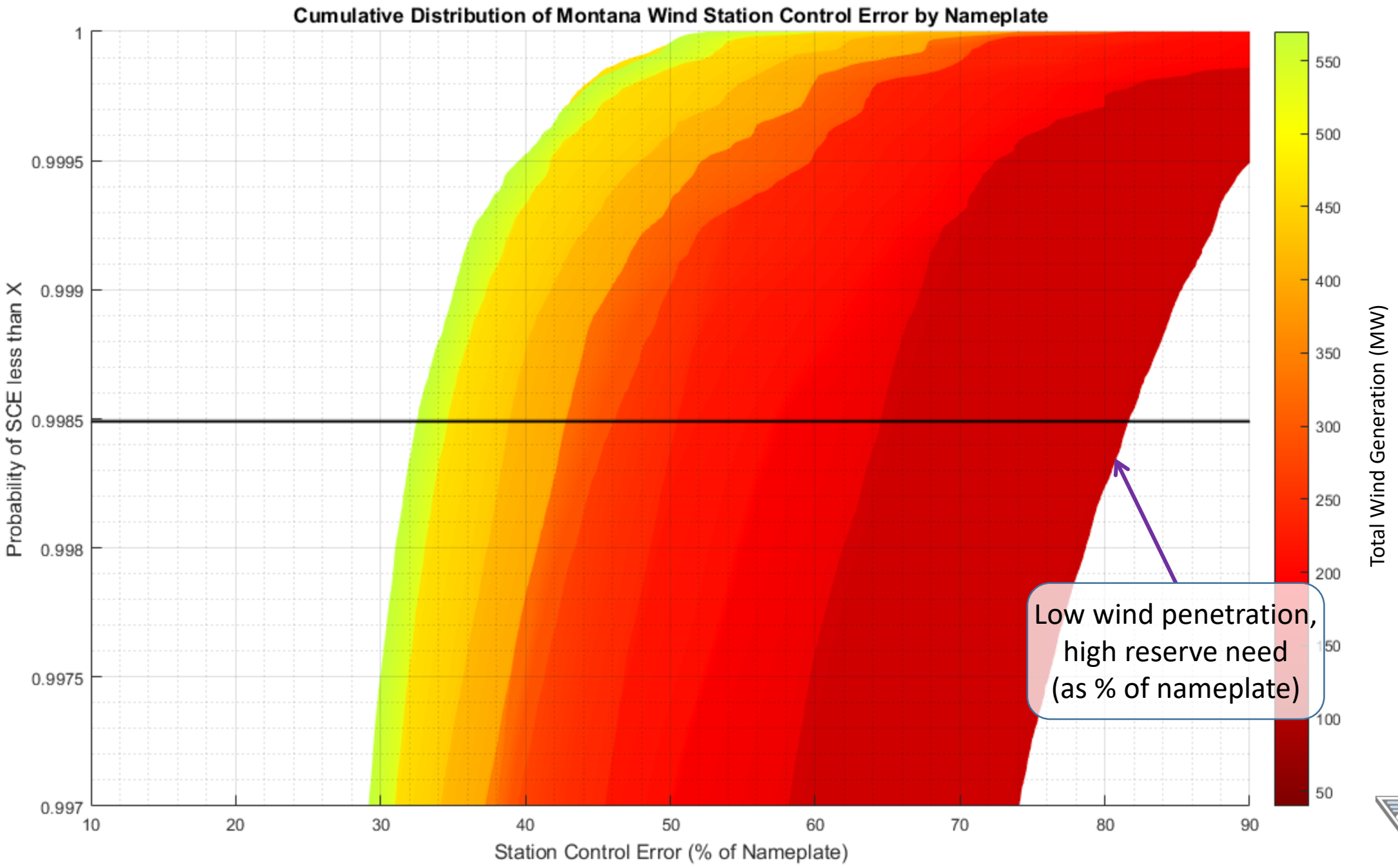
Analysis

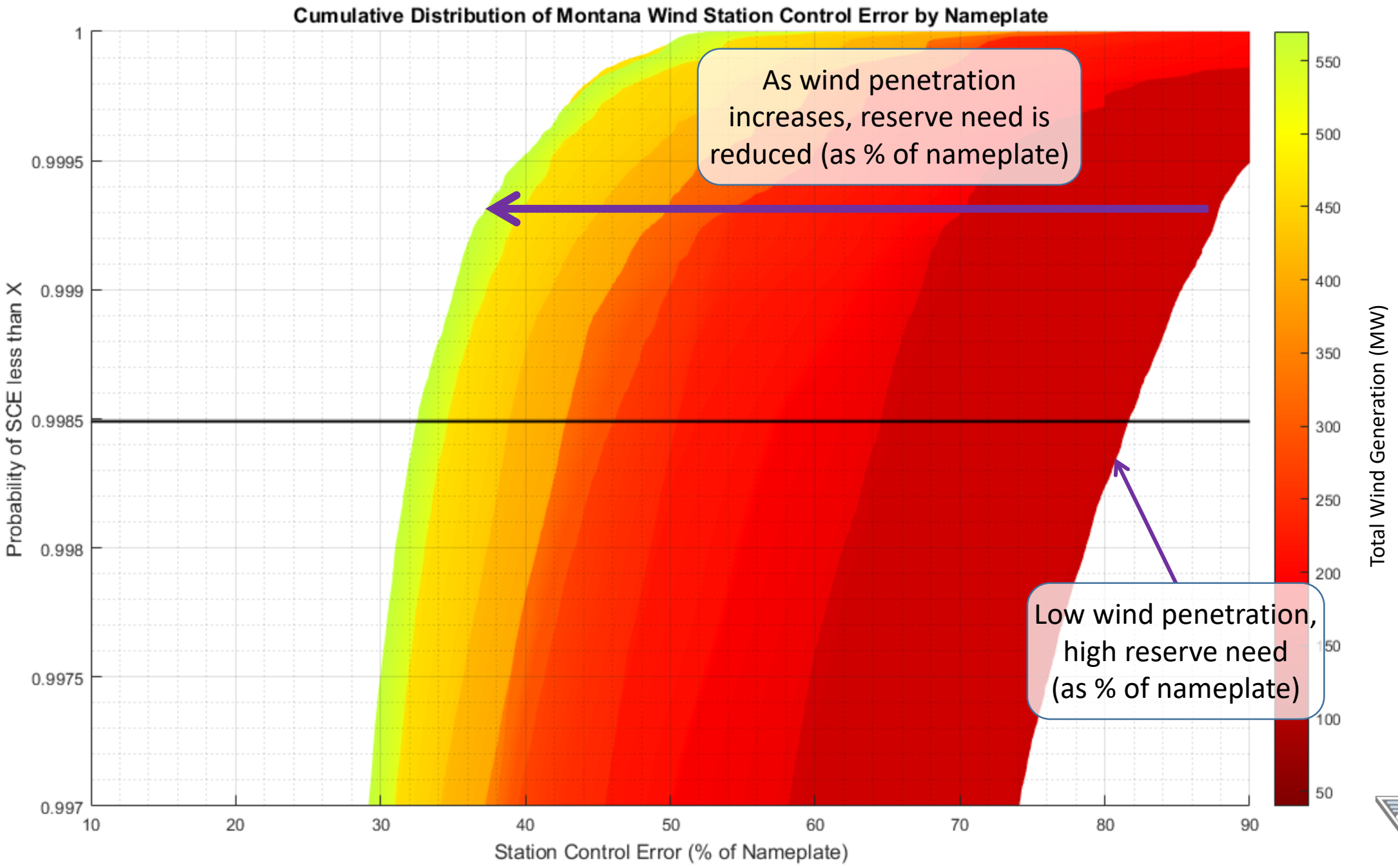
- We used all combinations of Montana wind plants for which we had generation data (ranging from ~50MW to 574MW). For each combination, we created a 30/60 Persistence schedule, and measured the station control error for each minute of the data set. We then plotted the distribution of the station control error measurements.
- We performed a similar analysis using wind plants in the BPA BA of similar nameplate capacity to each of the Montana plants, such that we can compare the reserve need of similar magnitudes of wind penetration.
- We further analyzed a larger set of BPA wind data (up to 1370MW), such that we can see the continued trend of reserve need as wind penetration continues to grow.
- We applied the trend to the smaller set of Montana data to indicate where their trend may continue.
- We lastly analyzed the combination of the full BPA BA wind fleet with the 574MW of Montana wind in order to see the comparative diversity.
  - Note: This analysis is for comparison purposes only. This is not an indication that BPA and Montana wind fleets could be treated as a combined set for reserve purposes.

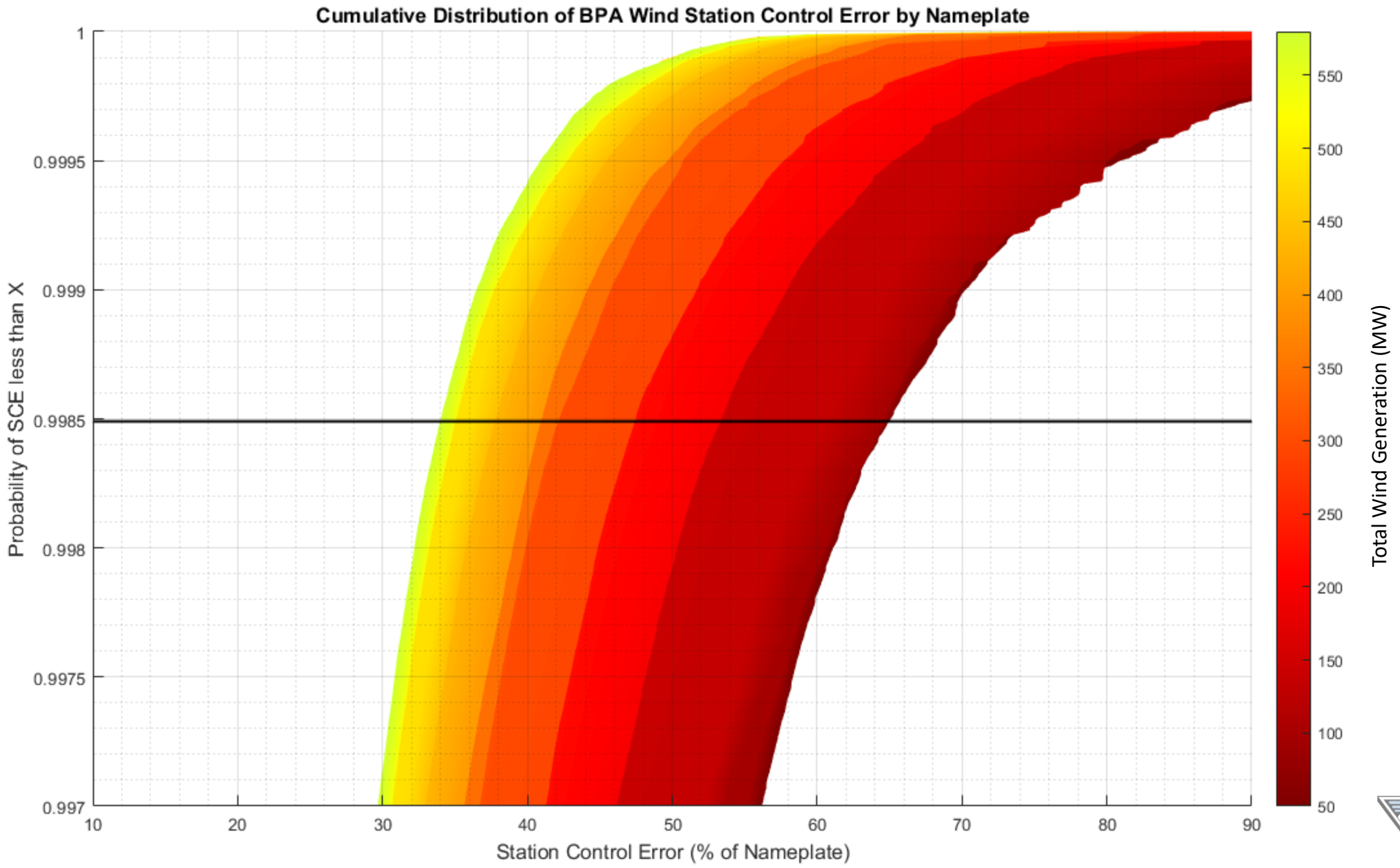

Cumulative Distribution of Montana Wind Station Control Error by Nameplate
Probability of SCE less than X
Station Control Error (% of Nameplate)
Total Wind Generation (MW)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-60
-40
-20
0
20
40
60
550
500
450
400
350
300
250
200
150
100
50

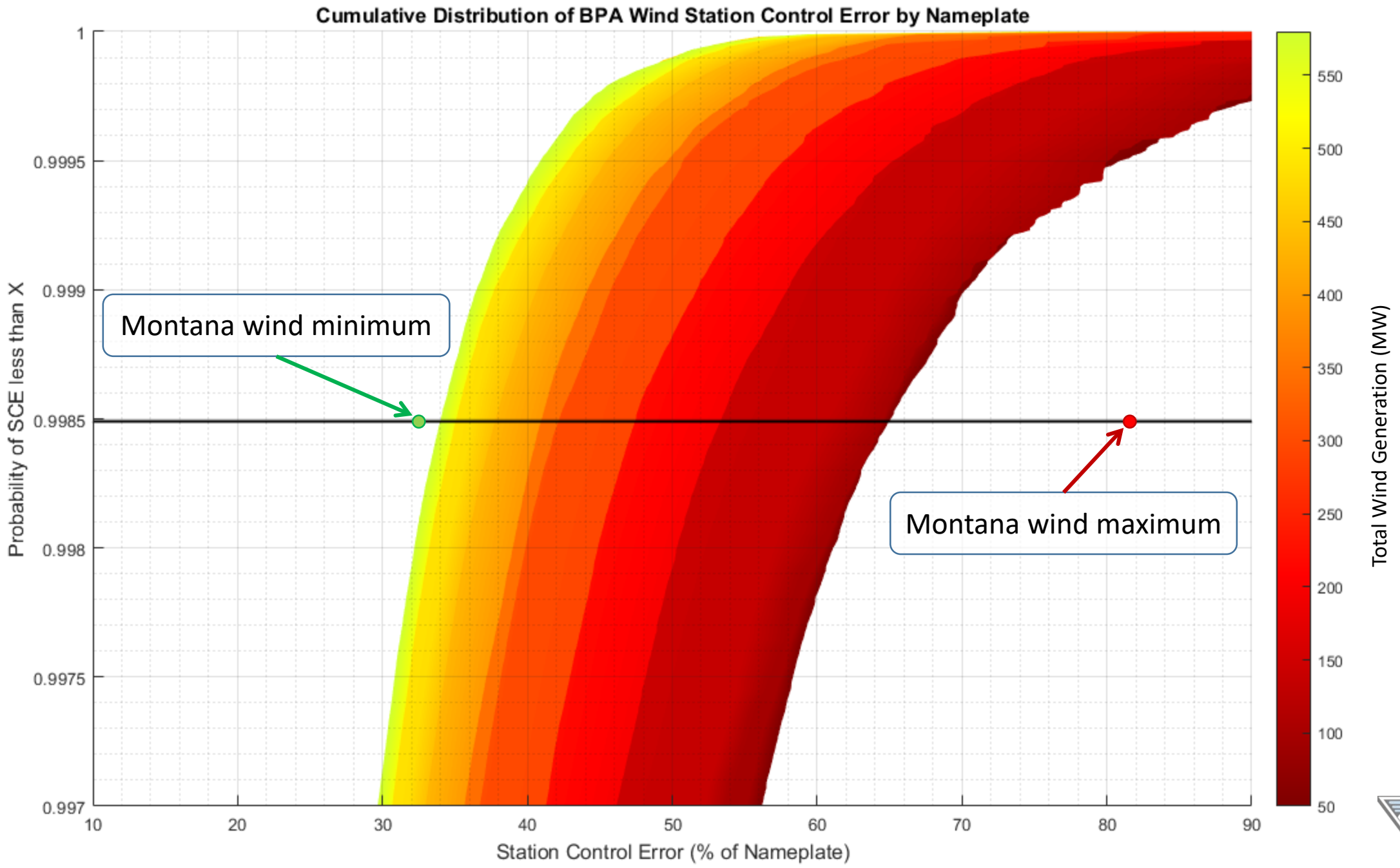

Cumulative Distribution of Montana Wind Station Control Error by Nameplate
Zoom in!
Probability of SCE less than X
Station Control Error (% of Nameplate)
Total Wind Generation (MW)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-60
-40
-20
0
20
40
60
550
500
450
400
350
300
250
200
150
100
50

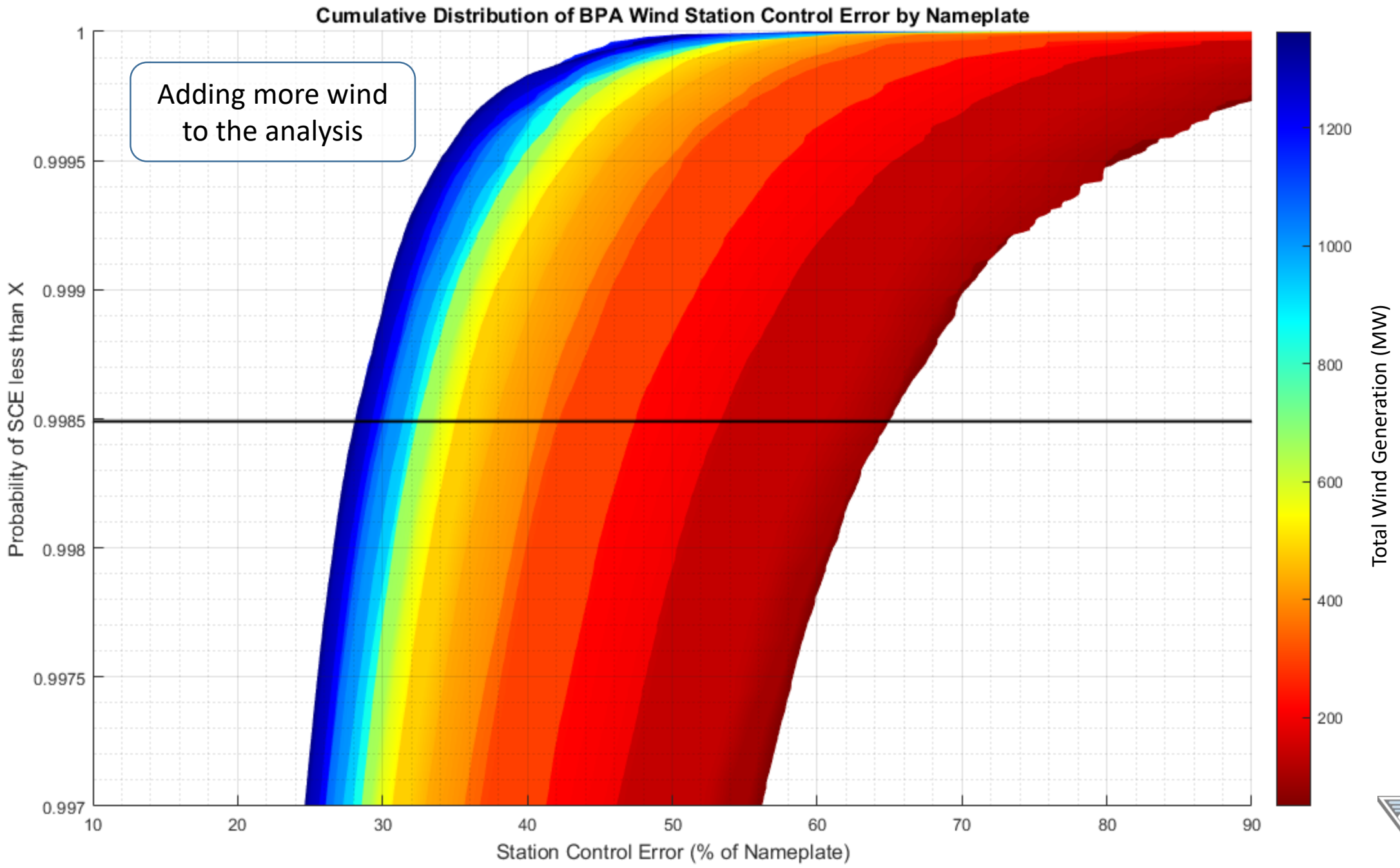

Cumulative Distribution of Montana Wind Station Control Error by Nameplate
Zoom in!
Probability of SCE less than X
1
0.9995
0.999
0.9985
0.998
0.9975
0.997
10
20
30
40
50
60
70
80
90
Station Control Error (% of Nameplate)
550
500
450
400
350
300
250
200
150
100
50
Total Wind Generation (MW)

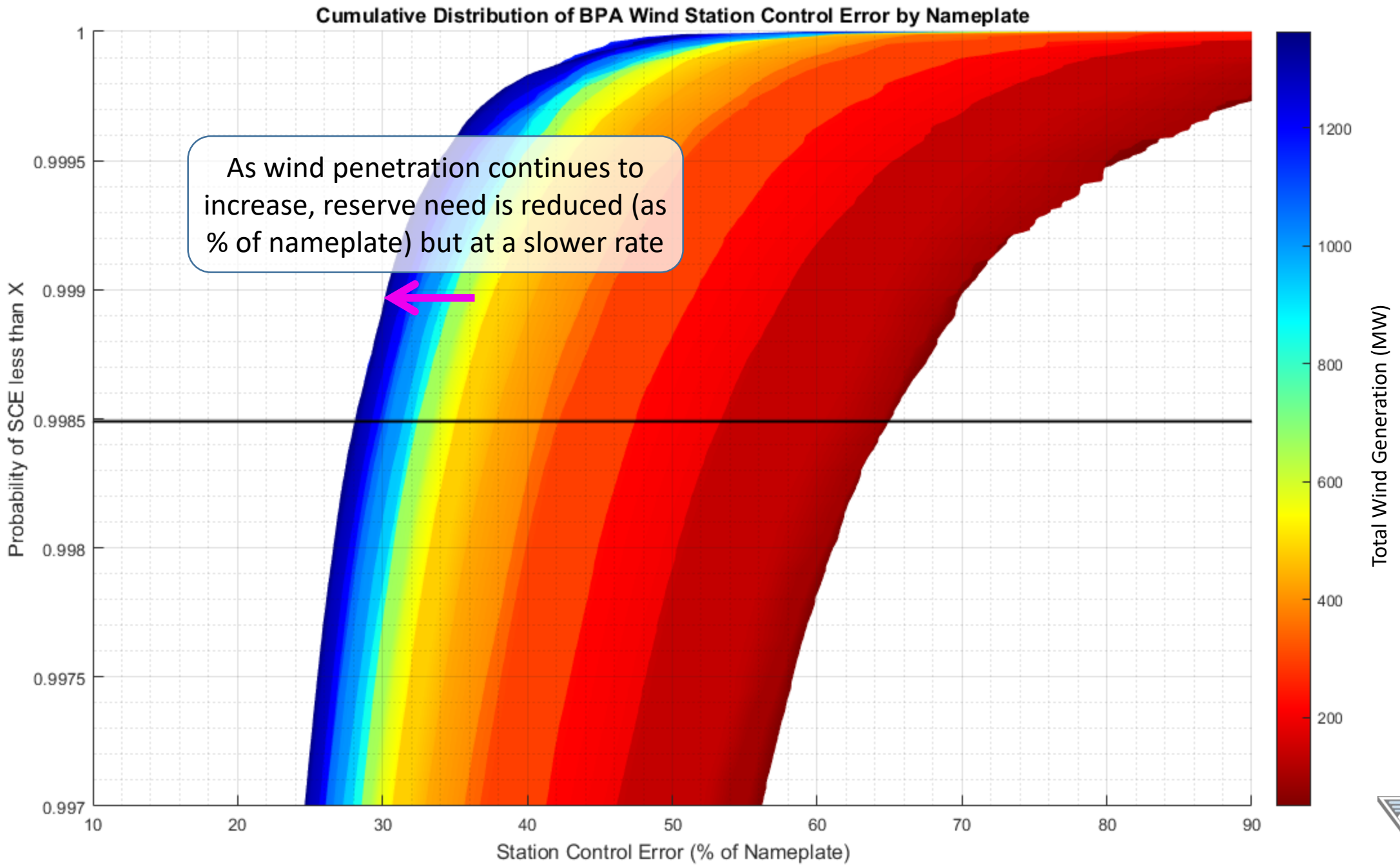

Cumulative Distribution of Montana Wind Station Control Error by Nameplate
Probability of SCE less than X
1
0.9995
0.999
0.9985
0.998
0.9975
0.997
10
20
30
40
50
60
70
80
90
Station Control Error (% of Nameplate)
550
500
450
400
350
300
250
200
150
100
50
Total Wind Generation (MW)
Low wind penetration, high reserve need (as % of nameplate)

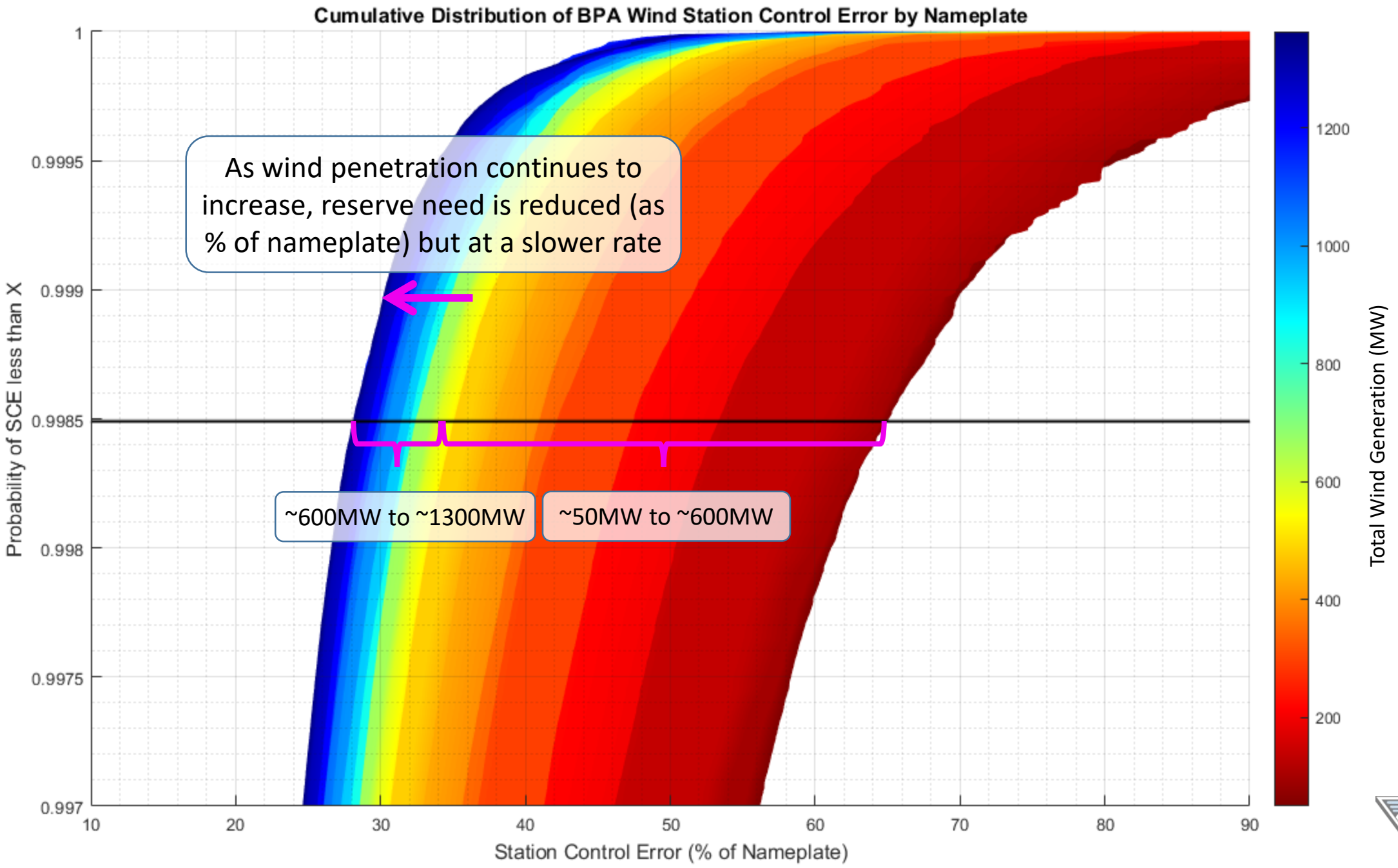

Cumulative Distribution of Montana Wind Station Control Error by Nameplate
As wind penetration increases, reserve need is reduced (as % of nameplate)
Low wind penetration, high reserve need (as % of nameplate)
Probability of SCE less than X
1
0.9995
0.999
0.9985
0.998
0.9975
0.997
10
20
30
40
50
60
70
80
90
Station Control Error (% of Nameplate)
550
500
450
400
350
300
250
200
150
100
50
Total Wind Generation (MW)

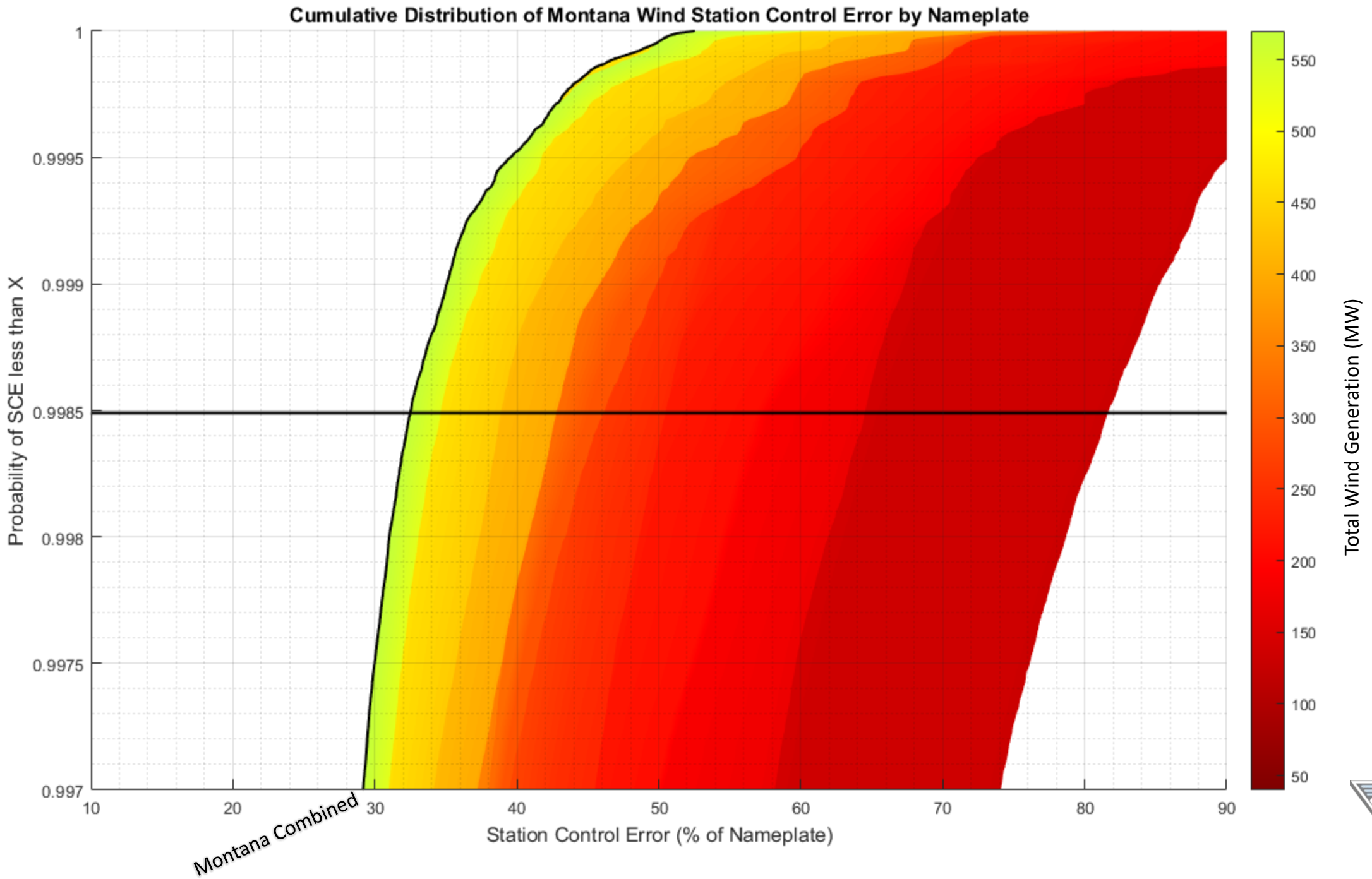

Cumulative Distribution of BPA Wind Station Control Error by Nameplate
Probability of SCE less than X
1
0.9995
0.999
0.9985
0.998
0.9975
0.997
10
20
30
40
50
60
70
80
90
Station Control Error (% of Nameplate)
550
500
450
400
350
300
250
200
150
100
50
Total Wind Generation (MW)

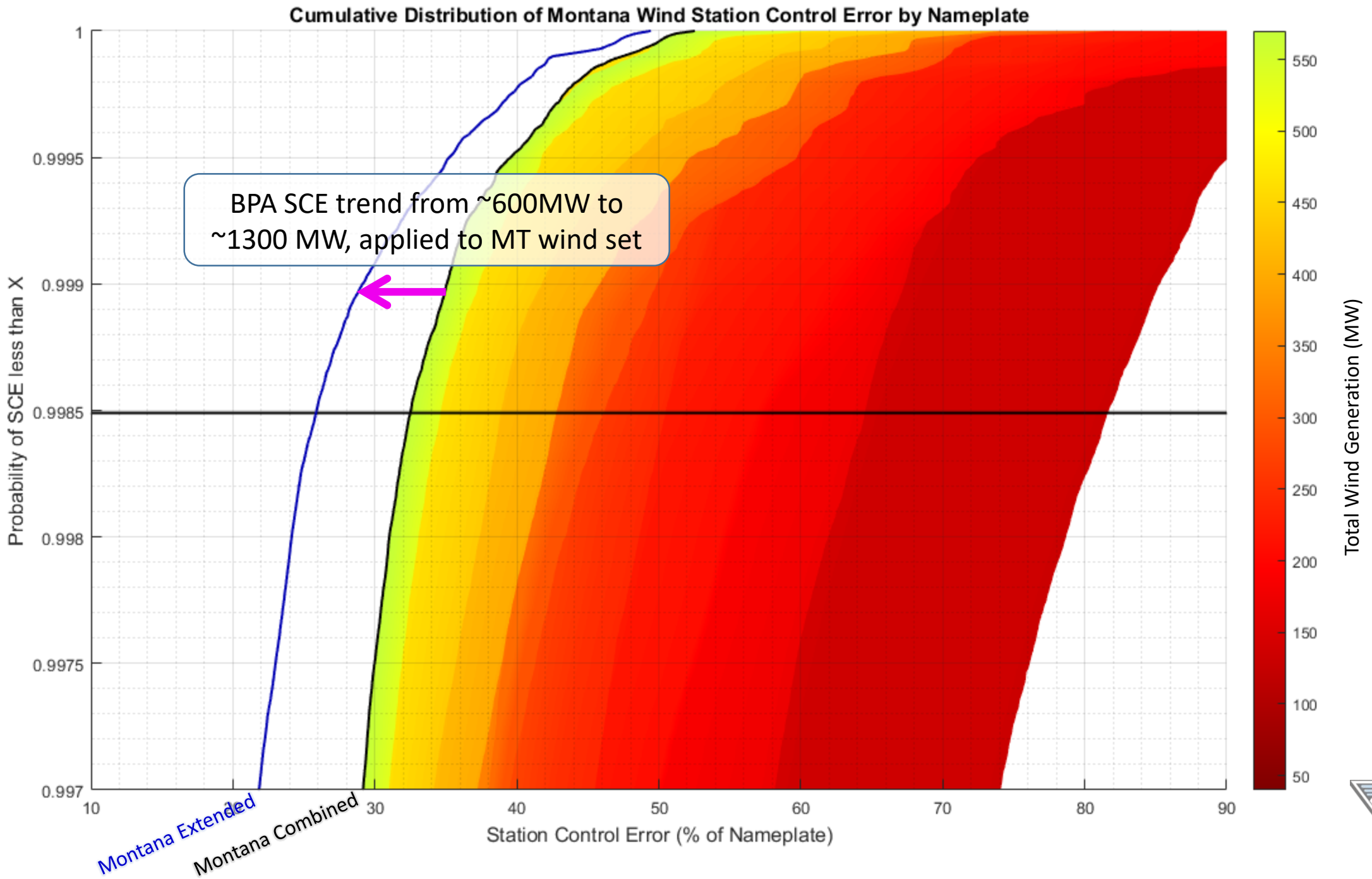

Cumulative Distribution of BPA Wind Station Control Error by Nameplate
Probability of SCE less than X
1
0.9995
0.999
0.9985
0.998
0.9975
0.997
10
20
30
40
50
60
70
80
90
Station Control Error (% of Nameplate)
Montana wind minimum
Montana wind maximum
Total Wind Generation (MW)
550
500
450
400
350
300
250
200
150
100
50

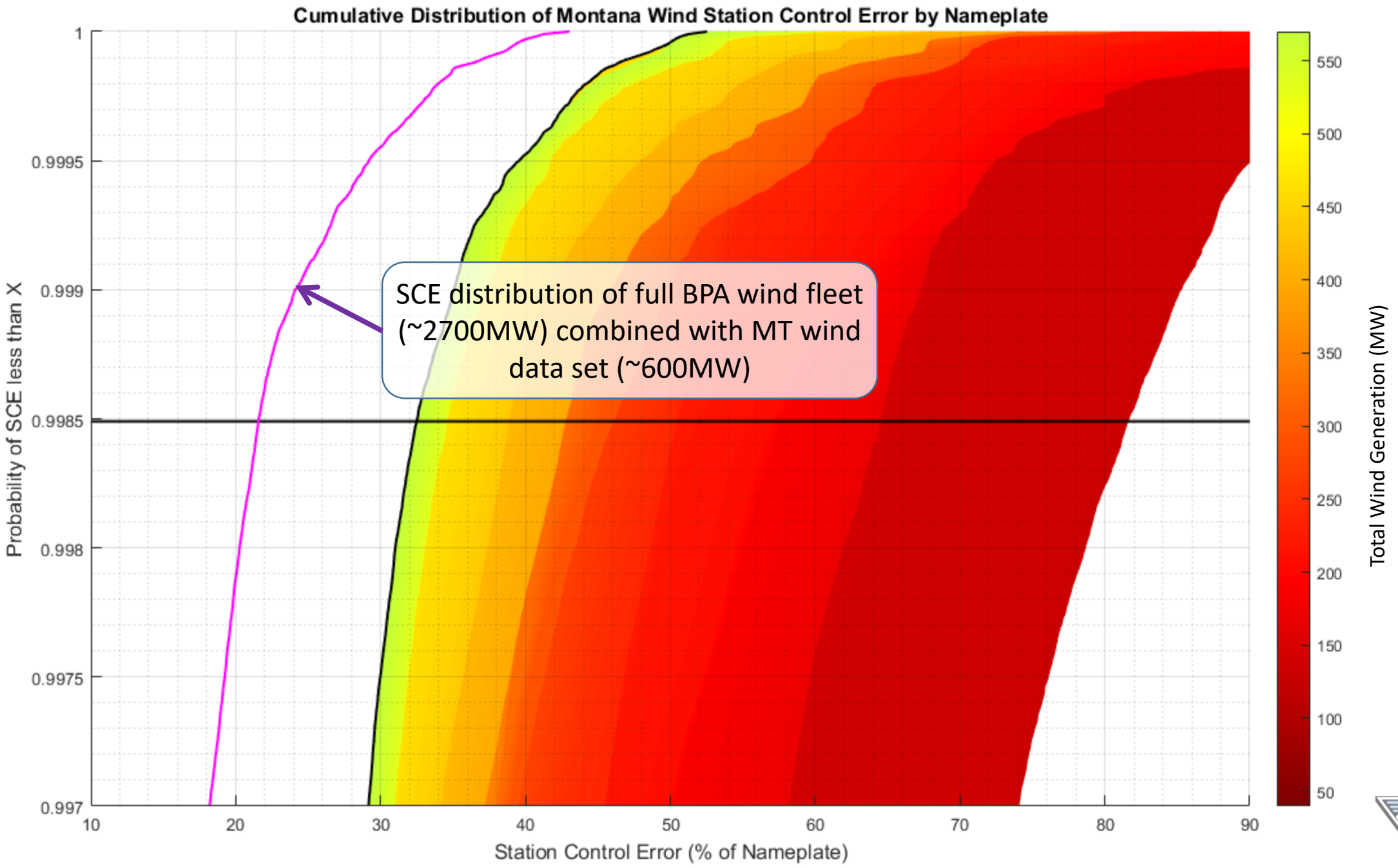

Cumulative Distribution of BPA Wind Station Control Error by Nameplate
Adding more wind to the analysis
Probability of SCE less than X
1
0.9995
0.999
0.9985
0.998
0.9975
0.997
10
20
30
40
50
60
70
80
90
Station Control Error (% of Nameplate)
1200
1000
800
600
400
200
Total Wind Generation (MW)


Cumulative Distribution of BPA Wind Station Control Error by Nameplate
As wind penetration continues to increase, reserve need is reduced (as % of nameplate) but at a slower rate
Probability of SCE less than X
1
0.9995
0.999
0.9985
0.998
0.9975
0.997
10
20
30
40
50
60
70
80
90
Station Control Error (% of Nameplate)
1200
1000
800
600
400
200
Total Wind Generation (MW)

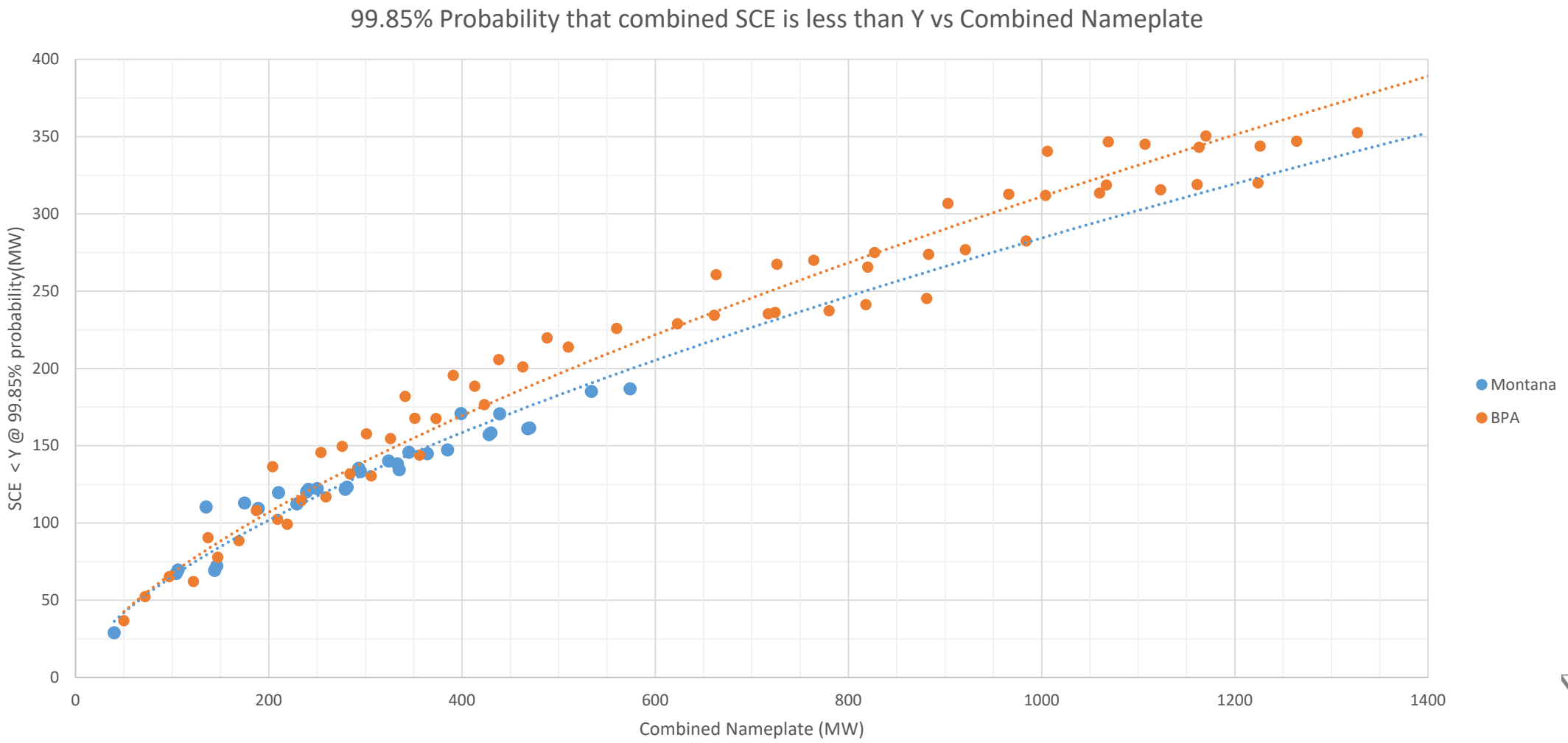

Cumulative Distribution of BPA Wind Station Control Error by Nameplate
As wind penetration continues to increase, reserve need is reduced (as % of nameplate) but at a slower rate
~600MW to ~1300MW
~50MW to ~600MW
Probability of SCE less than X
Station Control Error (% of Nameplate)
Total Wind Generation (MW)
1
0.9995
0.999
0.9985
0.998
0.9975
0.997
10
20
30
40
50
60
70
80
90
1200
1000
800
600
400
200


Cumulative Distribution of Montana Wind Station Control Error by Nameplate
Probability of SCE less than X
1
0.9995
0.999
0.9985
0.998
0.9975
0.997
10
20
30
40
50
60
70
80
90
Station Control Error (% of Nameplate)
Total Wind Generation (MW)
550
500
450
400
350
300
250
200
150
100
50
Montana Combined


Cumulative Distribution of Montana Wind Station Control Error by Nameplate
BPA SCE trend from ~600MW to ~1300 MW, applied to MT wind set
Probability of SCE less than X
1
0.9995
0.999
0.9985
0.998
0.9975
0.997
10
30
40
50
60
70
80
90
Station Control Error (% of Nameplate)
Montana Extended
Montana Combined
550
500
450
400
350
300
250
200
150
100
50
Total Wind Generation (MW)


Cumulative Distribution of Montana Wind Station Control Error by Nameplate
Probability of SCE less than X
1
0.9995
0.999
0.9985
0.998
0.9975
0.997
10
20
30
40
50
60
70
80
90
Station Control Error (% of Nameplate)
550
500
450
400
350
300
250
200
150
100
50
Total Wind Generation (MW)
SCE distribution of full BPA wind fleet (~2700MW) combined with MT wind data set (~600MW)

BONNEVILLE POWER ADMINISTRATION


99.85% Probability that combined SCE is less than Y vs Combined Nameplate
SCE < Y @ 99.85% probability(MW)
Combined Nameplate (MW)
0
50
100
150
200
250
300
350
400
0
200
400
600
800
1000
1200
1400
Montana
BPA

Conclusions

- The trend of diversity benefits for grouped wind power in Montana suggests similar or better diversity compared with benefits seen by wind in the Columbia River Basin.
- With respect to the reserve capacity held for wind in Bonneville's BA, the diversity in wind variability would require a smaller increase to accommodate a plant in Montana than would likely be required for adding an equally sized plant in the Columbia River Basin.

  *Analysis used smaller time range than normal study range