Northwest **Power** and
Conservation Council

April 28, 2015

MEMORANDUM

TO: **Council members**

FROM: **Ben Kujala, System Analysis Manager**

SUBJECT: **Discussion of Scenario Analysis Results**

BACKGROUND:

Presenter: Tom Eckman and Ben Kujala

Summary This presentation will look at the least cost and least risk resource strategies for the RPM scenario analyses. The scenarios that will be discussed are

- 1B - Current policy without any incremental cost for carbon included
- 2C - Considers uncertainty in the cost of carbon ranging from $0 to $110
- 1A - Considers deterministic approach where uncertainty is removed from the model

Staff will continue to discuss key findings and update the Council Members on feedback from the advisory committees regarding model results.

Workplan: 1. B. Develop Seventh Power Plan and maintain analytical capability

Background: The RPM or Regional Portfolio Model was recently redeveloped by Navigant for the Council. The RPM estimates the regional costs and risks associated with pursuing resource development strategies and it uses optimization to look for strategies that minimize the estimated cost and risk. The draft inputs for the starting scenarios have been finalized. This presentation will examine outputs from RPM with the initial data and discuss methods for comparison of resource strategies.

At the March Council Meeting, staff presented a list of proposed scenarios the Power Committee Members and the full Council. At the April Council Meeting, staff discussed a range of strategies under scenario 1B, which is a scenario with no changes to current policy over the course of the study. This was followed up with a webinar on April 24 where least cost and least risk resource strategies were presented for scenario 1B and scenario 2C, which is the scenario that includes a carbon price adder to the RPM market price.

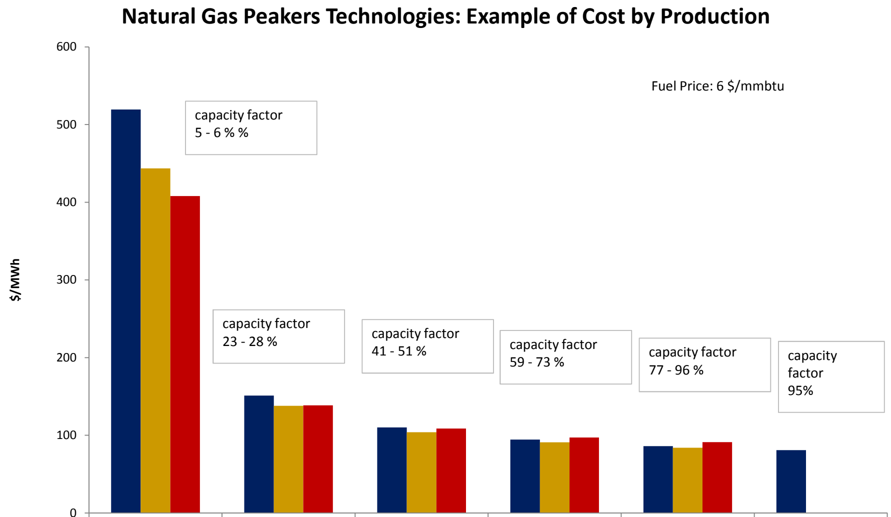
More Info: Staff will be updating the materials from the April 24th webinar with consideration of feedback received during that meeting. An updated presentation will be sent out to Council Members on Friday May 1st ahead of the Council Meeting.

Update on Scenario Analysis

May 5, 2015

Guidance on Scenario Input Assumptions

- All Scenarios – Forecast of peak hourly loads for determination of capacity needs
  - Staff responded to SAAC recommendations and adjusted peak demands
- All Scenarios – Gas Peaking Technology Assumption
  - Currently in RPM uses two basic types of gas plant options:
    - Combined Cycle Combustion Turbines for larger scale, highly efficient generation
    - Reciprocating Engines for peaking, but also flexibility (quick ramps...but not captured in RPM)
  - GRAC Recommended Use of Reciprocating Engine (currently assumed in RPM)
  - SAAC Concern – Cheapest "gas peaker" sets the value of alternative capacity resources (DR, Energy Efficiency)
  - SAAC Recommended Use of Cheapest "Peaker" (i.e., Single Cycle Gas Turbine (Frame CT)
  - Staff proposes using Aero Derivative
    - No "frames" being built in entire WECC
    - Aero is intermediate in cost between frame and "recip"
    - Can provide most of the same "ramping/flexibility" functions as "recip"



	10	50	90	130	170	210
RECIP ENG	519	151	110	94	86	81
AERO CT	444	138	104	91	84	
FRAME CT	408	139	109	97	91	

Annual Production - aMW

What We Have Today

- Comparison of two *Resource Strategies* (least cost and least risk) across 800 futures for two *Scenarios* (Current Policy and Carbon Risk)
  - Distribution of Net System Cost ($)
  - Distribution of conservation development (aMW and MW)
  - Distribution of RPS resource development (aMW and MW)
  - CO2 emissions without carbon risk uncertainty (Scenario 1B) and with carbon risk uncertainty (Scenario 2C)
  - Discussion of Gas Capacity Resource and Demand Response Resource Development Schedule Assumption and Implications

RPM Results Disclaimers

- The long-term capacity expansion logic and input assumptions for resource adequacy are still being reviewed so there is still potential for revision
- *Caveat emptor* –
  - All results in this presentation *are still preliminary*
  - The RPM test resource strategies across 800 different futures
    - Each future has a unique result
    - Staff interpretations of results, communicated with terms like "on average" or "in general," will likely not hold in one or more of those futures.
  - These qualification are missing because they wouldn't fit on every slide!

Scenario 1B – Current Policy Least Cost vs. Least Risk

- Least cost strategy already has low risk
  - Additional risk reduction comes at a high cost relative to the reduction in risk
- Least cost range is from around $50 billion to $177 billion with a mean at $79.6 billion
- Least risk range is from around $60 billion to $171 billion with a mean at $83 billion

Scenario 1B – Current Policy

- Adequacy and RPS drives builds
  - The planning period starts not meeting adequacy standards in many of the futures
- DR is optioned because it has a shorter lead time than generation options, small incremental resource size and low cost
- Economic builds are few and far between
  - Economic builds occur in less than 1% of futures in the least cost resource strategy
- Thermal build options selected for adequacy seem related to retirements of Boardman and Centralia
- Gas peaking options in 2021 lead to a build mid 2022 and combined cycle options in 2023 lead to a build in 2025
- REC banking delays the need for constructing renewables until well past the action plan period

Scenario 2C – Carbon Risk Least Cost vs. Least Risk

- Similar to 1B, reduction in risk comes at a relatively high cost
- Least cost range is from $57 billion to $257 billion with a mean at $104.7 billion
- Least risk range is from $59 billion to $249 billion with a mean at $106.1 billion

Scenario 2C – Carbon Risk Least Cost Strategy

- In the least cost strategy the thermal options selected are all combined cycle gas plants, no gas peaking plant is selected
- DR still plays a major role in the resource strategy
- Conservation by the end of the study supplies around 80% of the capacity added to the system

Comparing 1B and 2C Conservation

- Action plan period has 50 to 70 aMW more conservation purchased in 2C when comparing least cost strategies
- Over the 20-year study, 2C has around 500 aMW more conservation when comparing least cost strategies
- DR looks substantively similar in both scenarios

Comparing 1B and 2C Thermal Resources

- Thermal Options
  - In the Carbon Risk scenario more efficient combined cycle combustion turbines are selected rather than peaking units
  - In the Carbon Risk scenario Economic builds increase significantly which is likely based on market price impacts of CO2 tax
- Existing Dispatch
  - Existing units with associated carbon emissions have a much lower dispatch over the planning period

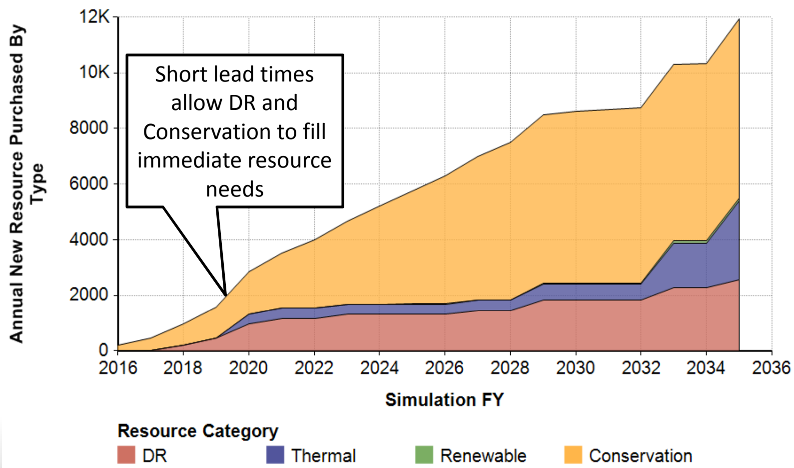
Comparing 1B and 2C Carbon Emissions

- Under Scenario 2C Carbon emissions are significantly reduced
  - Average emissions under both Scenario 1B and 2C are below EPA 111(d) proposed limits
    - However, 90^{th} percentile emissions exceed EPA's proposed limits
  - Scenario 2C emissions are around 65% of the emissions in 1B

EPA 111(d) Mass-Based Emissions Targets for NW States for Affected Existing and New Resources

	Interim Mass Equivalent (Million Metric Tons)	Final Mass Equivalent (Million Metric Tons)
Idaho	0.9	1.0
Montana	15.4	15.2
Oregon	5.3	5.3
Washington	4.4	4.8
Region	25.9	26.2

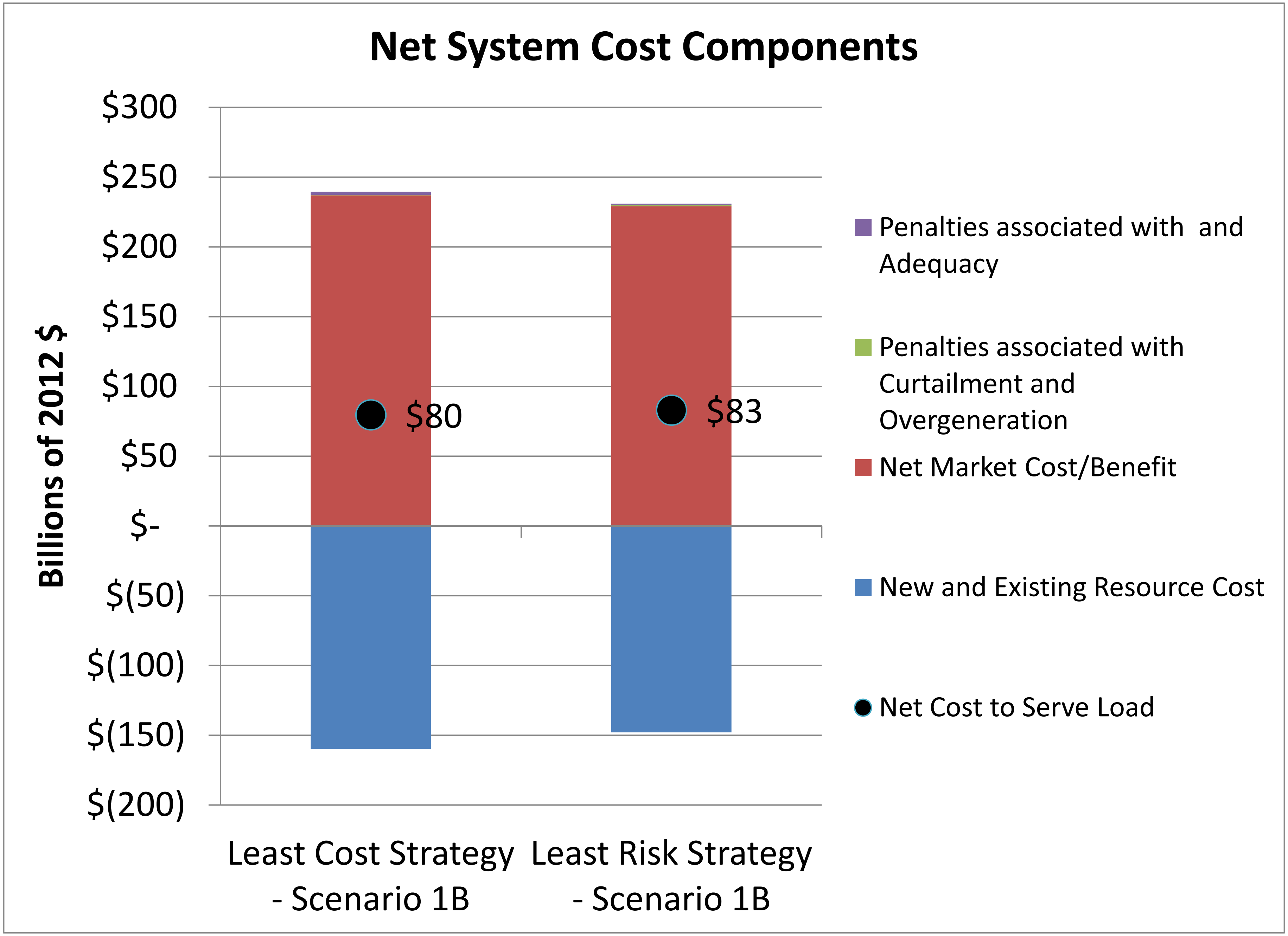
Example Future with DR



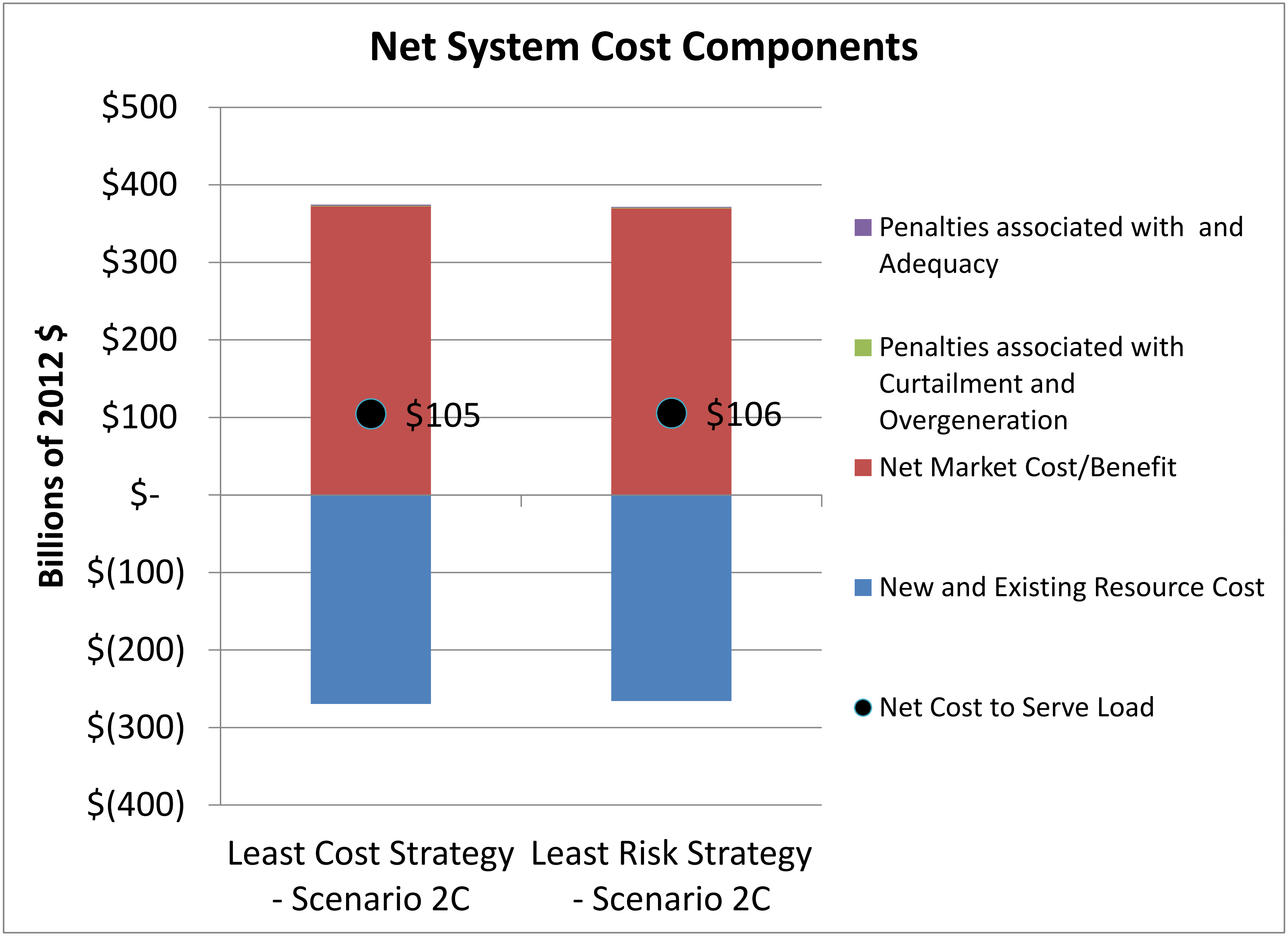
Earliest On-Line Date

Resource Type (Construction Time)	On-line Date
Conservation (3 Mo)	Jan 2016
DR (6 Mo)	Apr 2016
Gas Peaker (15 Mo)	Sept 2018
Gas Combined Cycle (30 Mo)	Jun 2020
Solar (15 Mo)	June 2018
Wind (24 Mo)	Jan 2019

QUESTIONS?

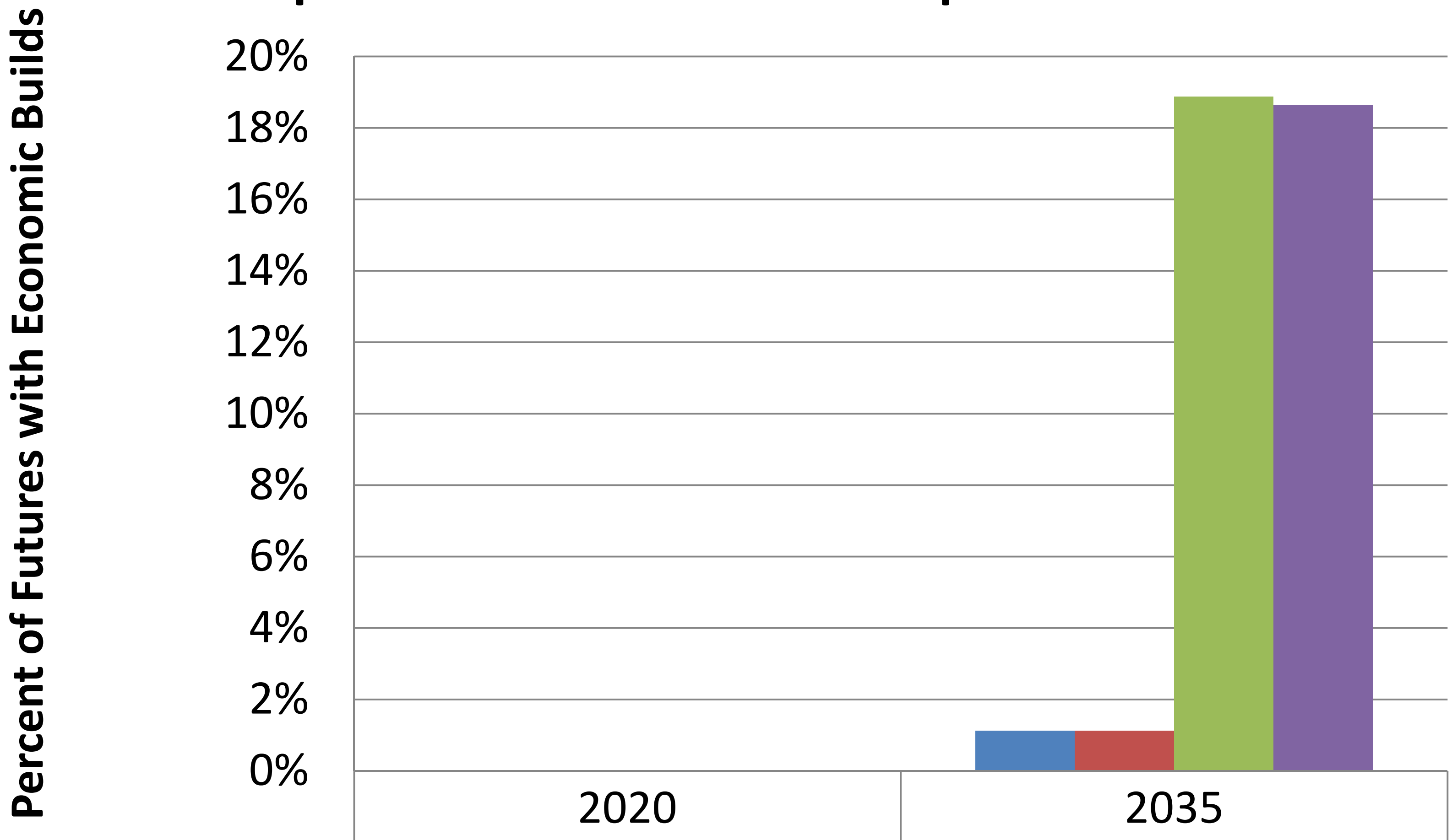


Net System Cost Components
Billions of 2012 $
$300
$250
$200
$150
$100
$50
$-
$(50)
$(100)
$(150)
$(200)
$80
$83
Least Cost Strategy - Scenario 1B
Least Risk Strategy - Scenario 1B
Penalties associated with and Adequacy
Penalties associated with Curtailment and Overgeneration
Net Market Cost/Benefit
New and Existing Resource Cost
Net Cost to Serve Load

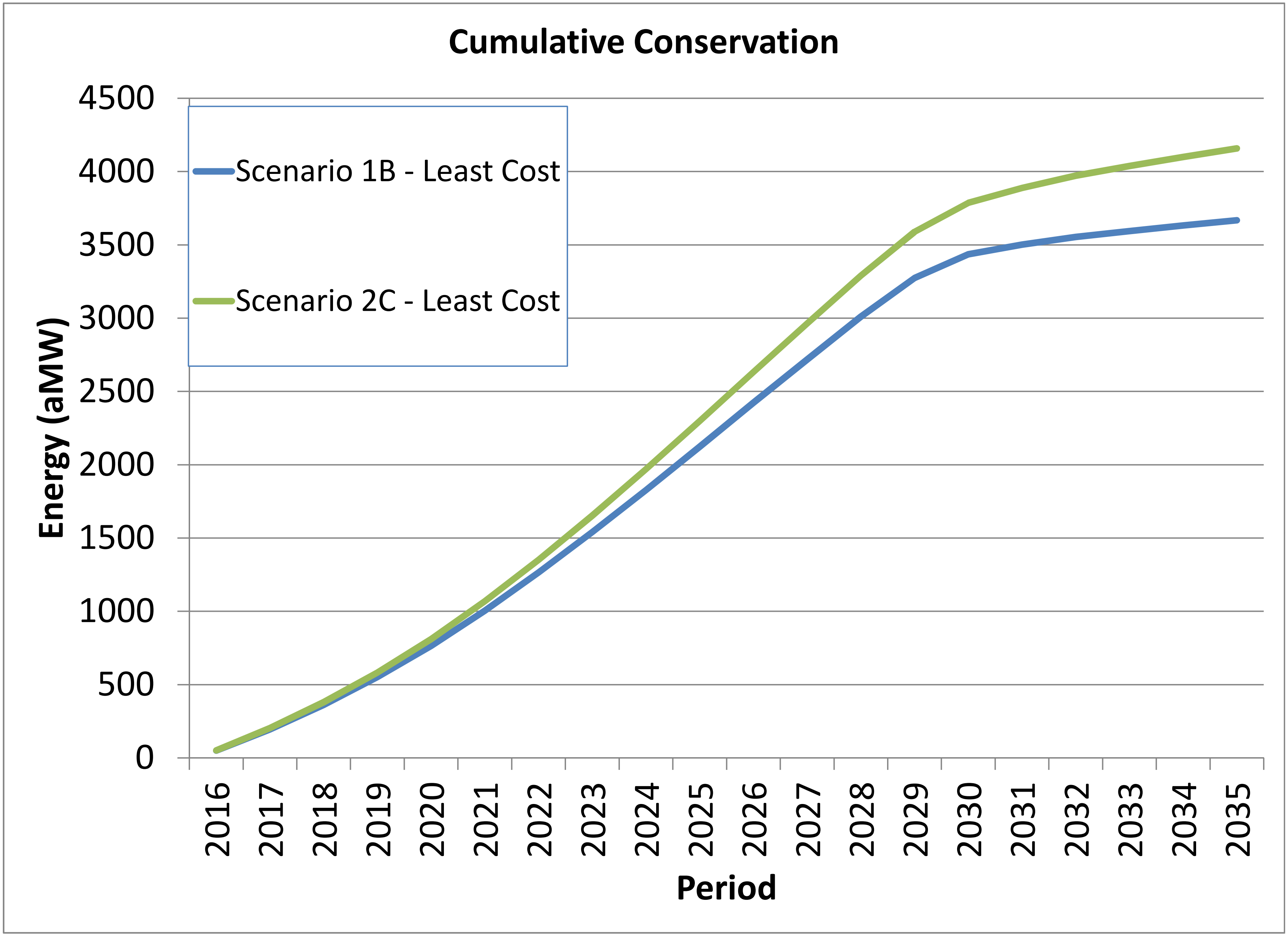


Net System Cost Components
$500
$400
$300
$200
$100
$-
$(100)
$(200)
$(300)
$(400)
Billions of 2012 $
$105
$106
Least Cost Strategy - Scenario 2C
Least Risk Strategy - Scenario 2C
Penalties associated with and Adequacy
Penalties associated with Curtailment and Overgeneration
Net Market Cost/Benefit
New and Existing Resource Cost
Net Cost to Serve Load

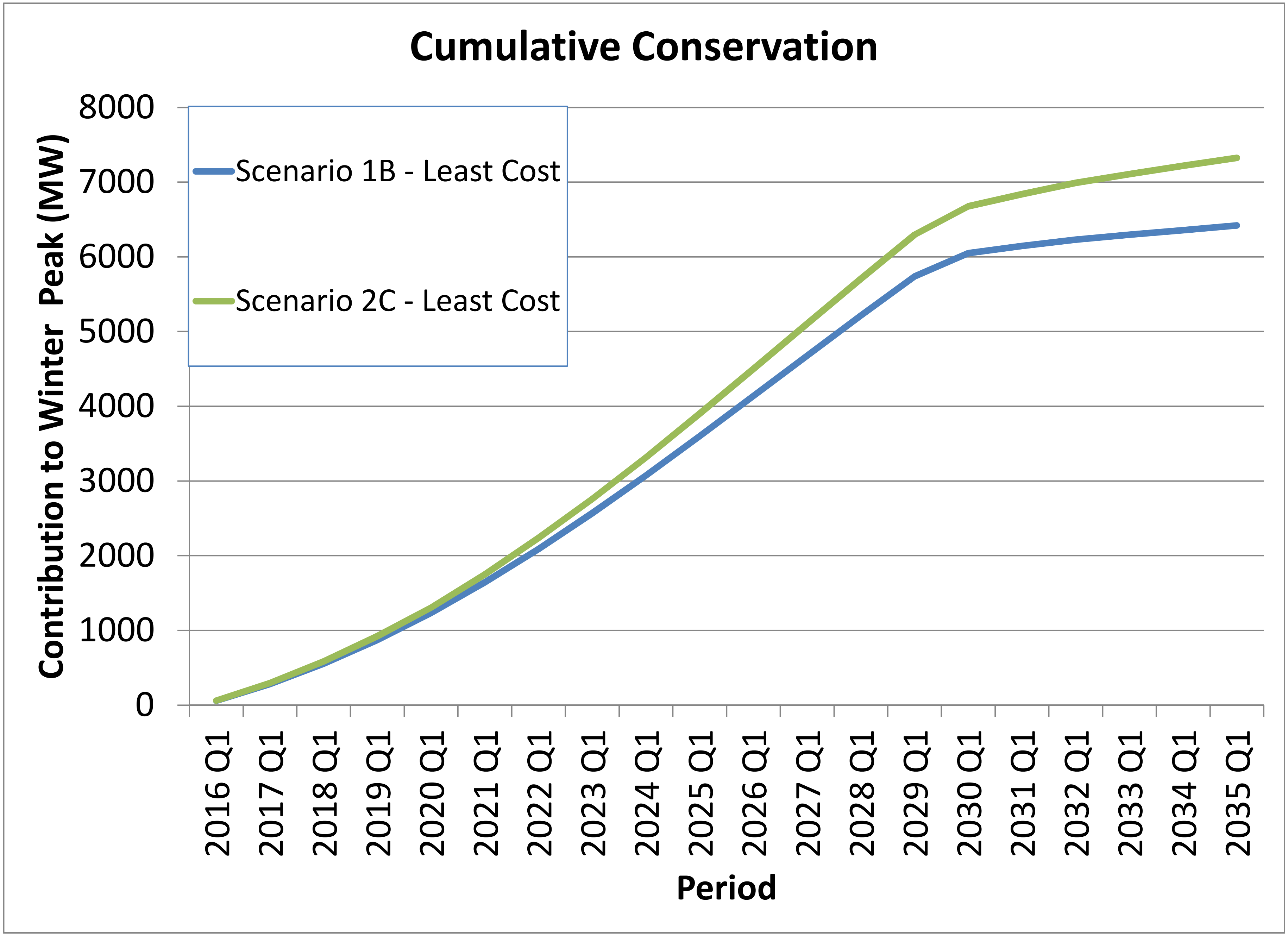
Example of Economic Build Comparison



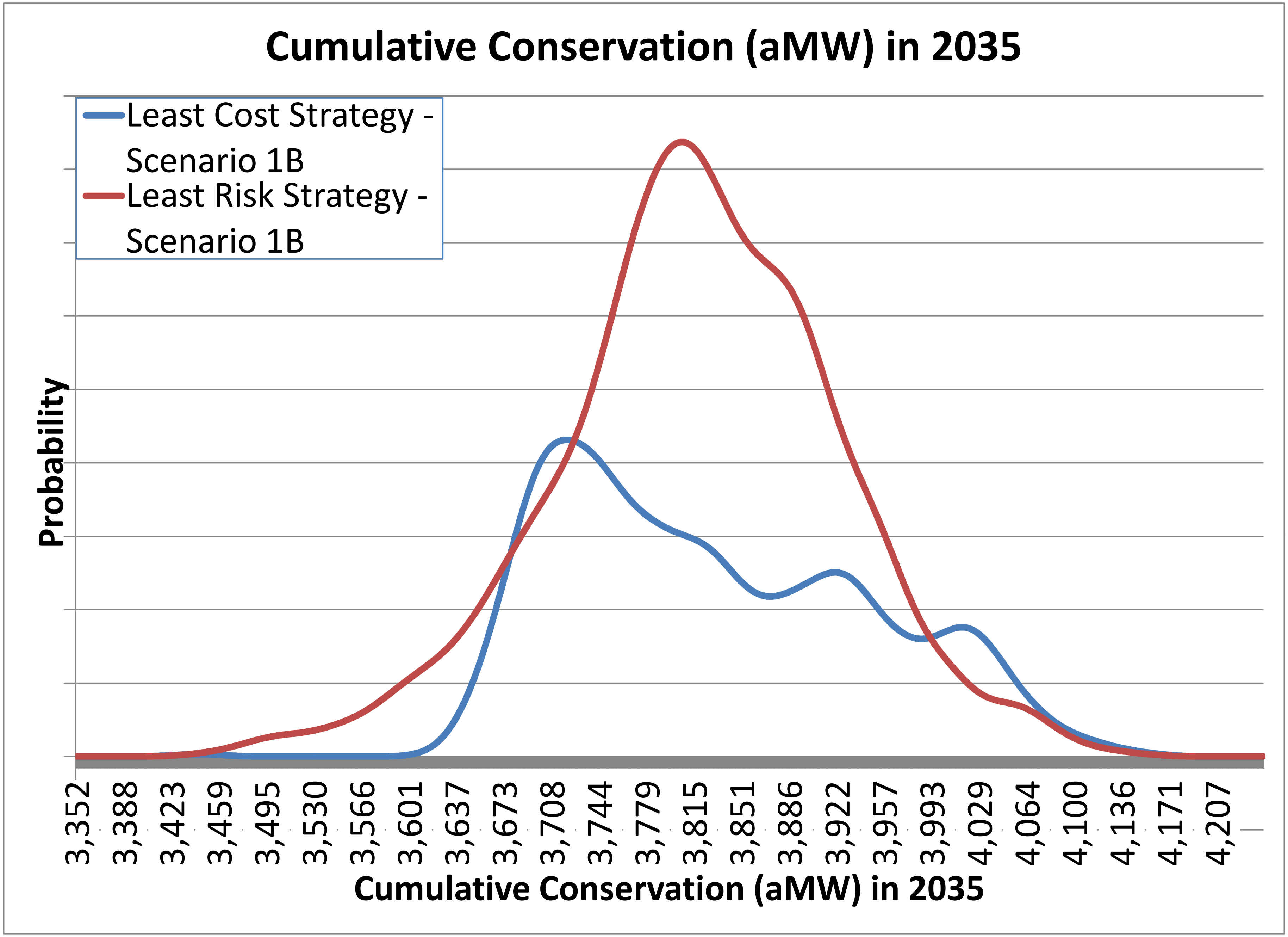
	2020	2035
Least Cost Scenario 1B	0%	1%
Least Risk Scenario 1B	0%	1%
Least Cost Scenario 2C	0%	19%
Least Risk Scenario 2C	0%	19%

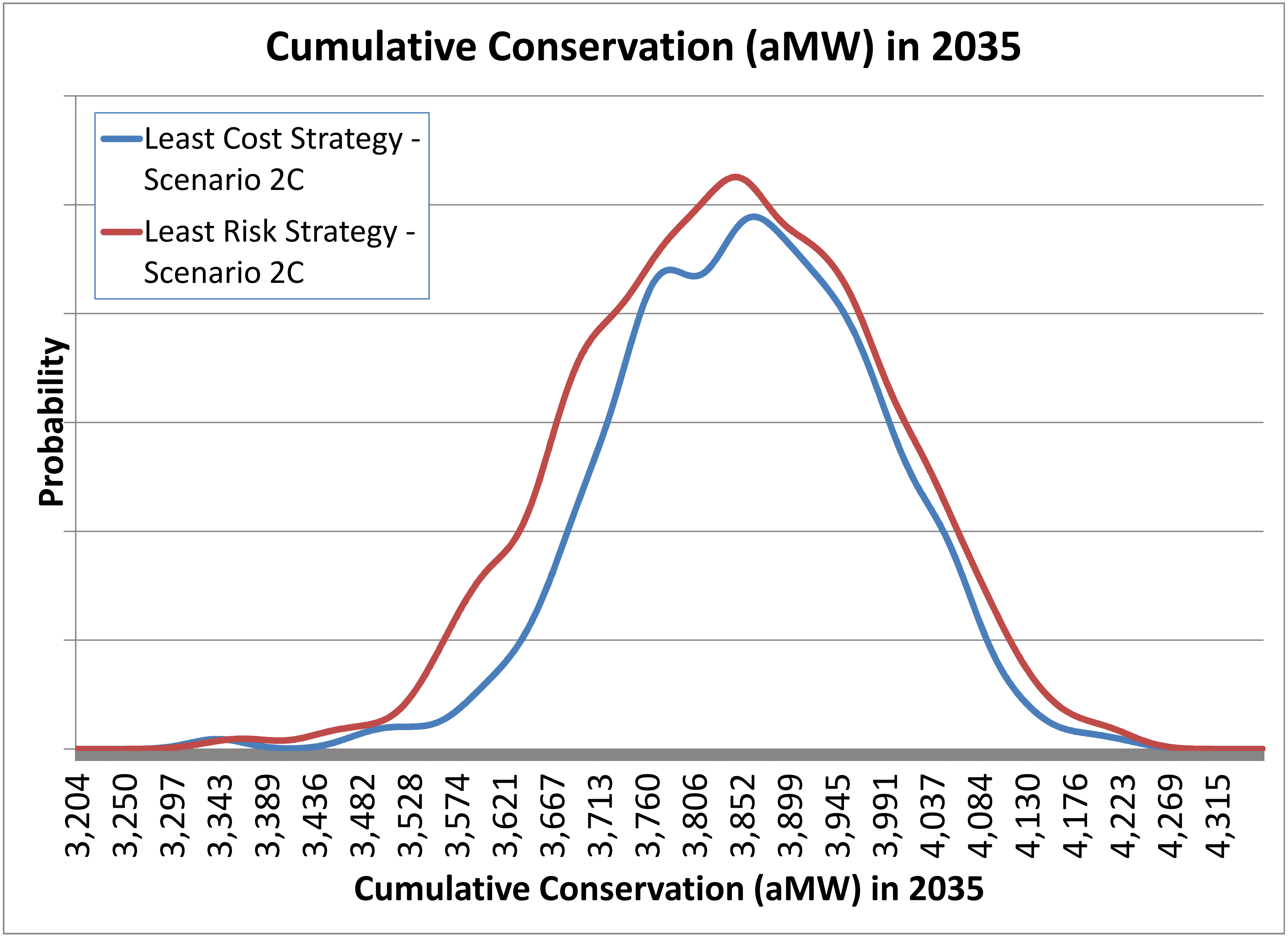


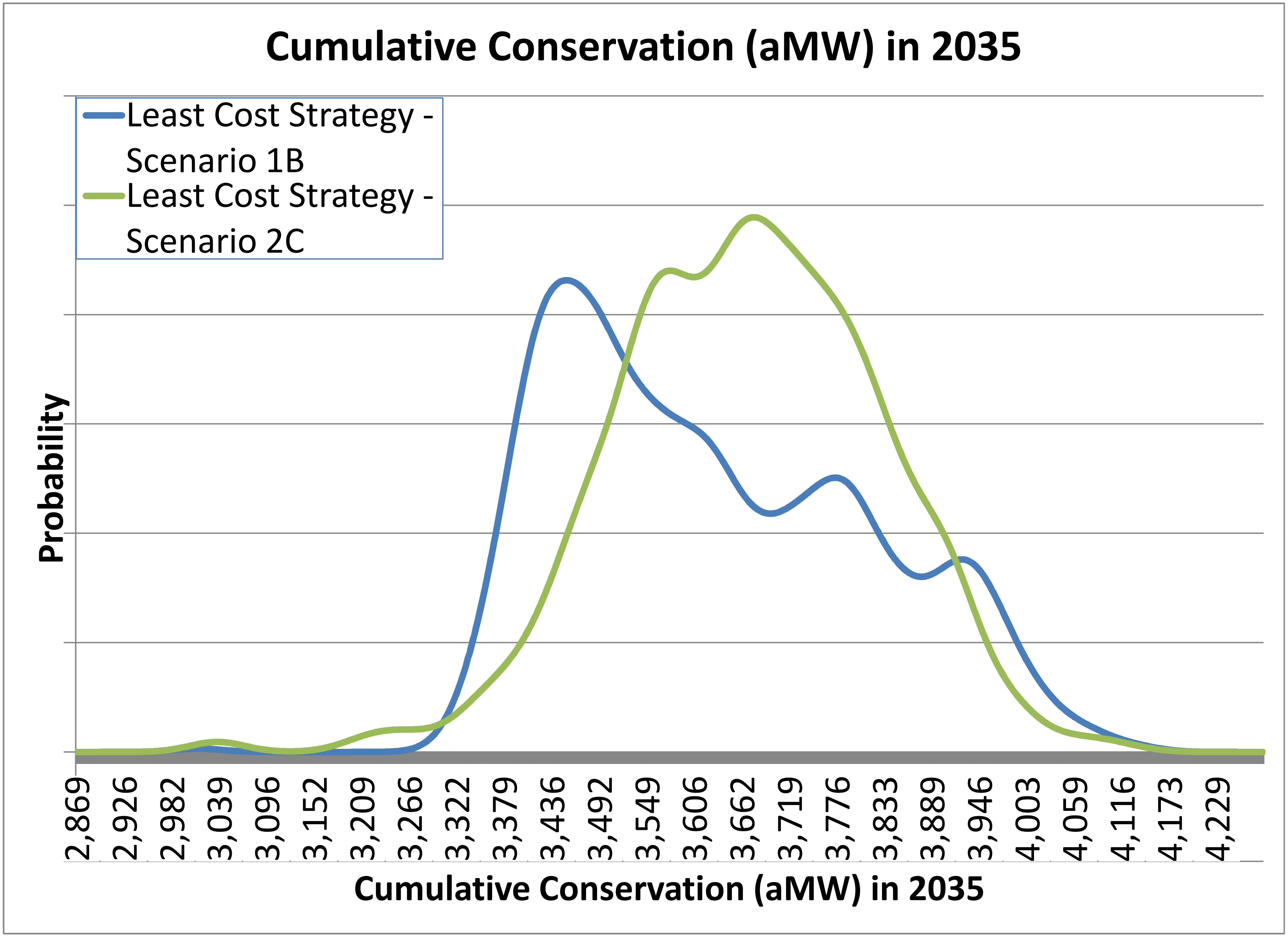
Cumulative Conservation
Energy (aMW)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Scenario 1B - Least Cost
Scenario 2C - Least Cost
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
Period



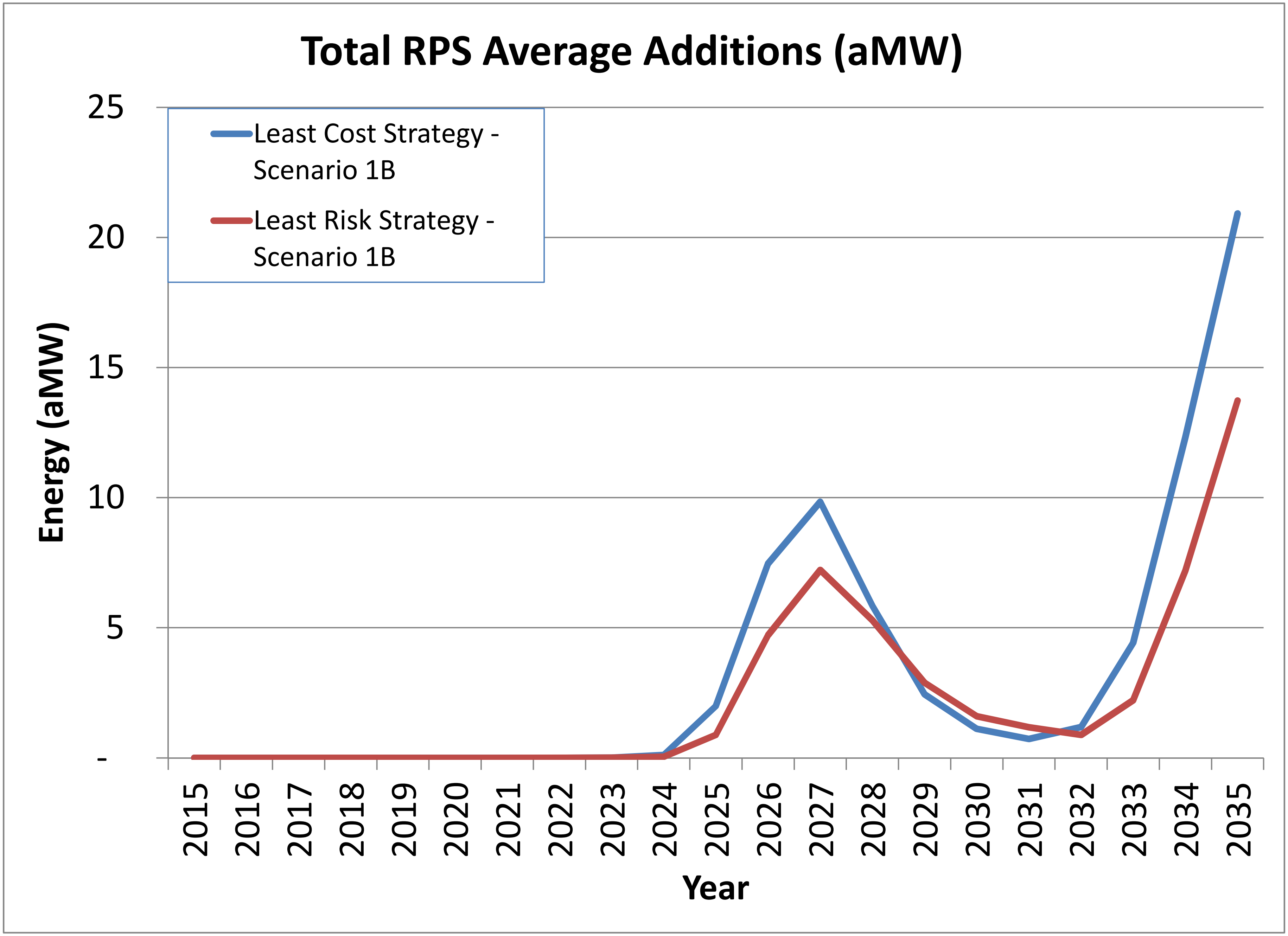
Cumulative Conservation
Contribution to Winter Peak (MW)
8000
7000
6000
5000
4000
3000
2000
1000
0
Scenario 1B - Least Cost
Scenario 2C - Least Cost
2016 Q1
2017 Q1
2018 Q1
2019 Q1
2020 Q1
2021 Q1
2022 Q1
2023 Q1
2024 Q1
2025 Q1
2026 Q1
2027 Q1
2028 Q1
2029 Q1
2030 Q1
2031 Q1
2032 Q1
2033 Q1
2034 Q1
2035 Q1
Period


Cumulative Conservation (aMW) in 2035
Least Cost Strategy - Scenario 1B
Least Risk Strategy - Scenario 1B
Probability
3,352
3,388
3,423
3,459
3,495
3,530
3,566
3,601
3,637
3,673
3,708
3,744
3,779
3,815
3,851
3,886
3,922
3,957
3,993
4,029
4,064
4,100
4,136
4,171
4,207
Cumulative Conservation (aMW) in 2035

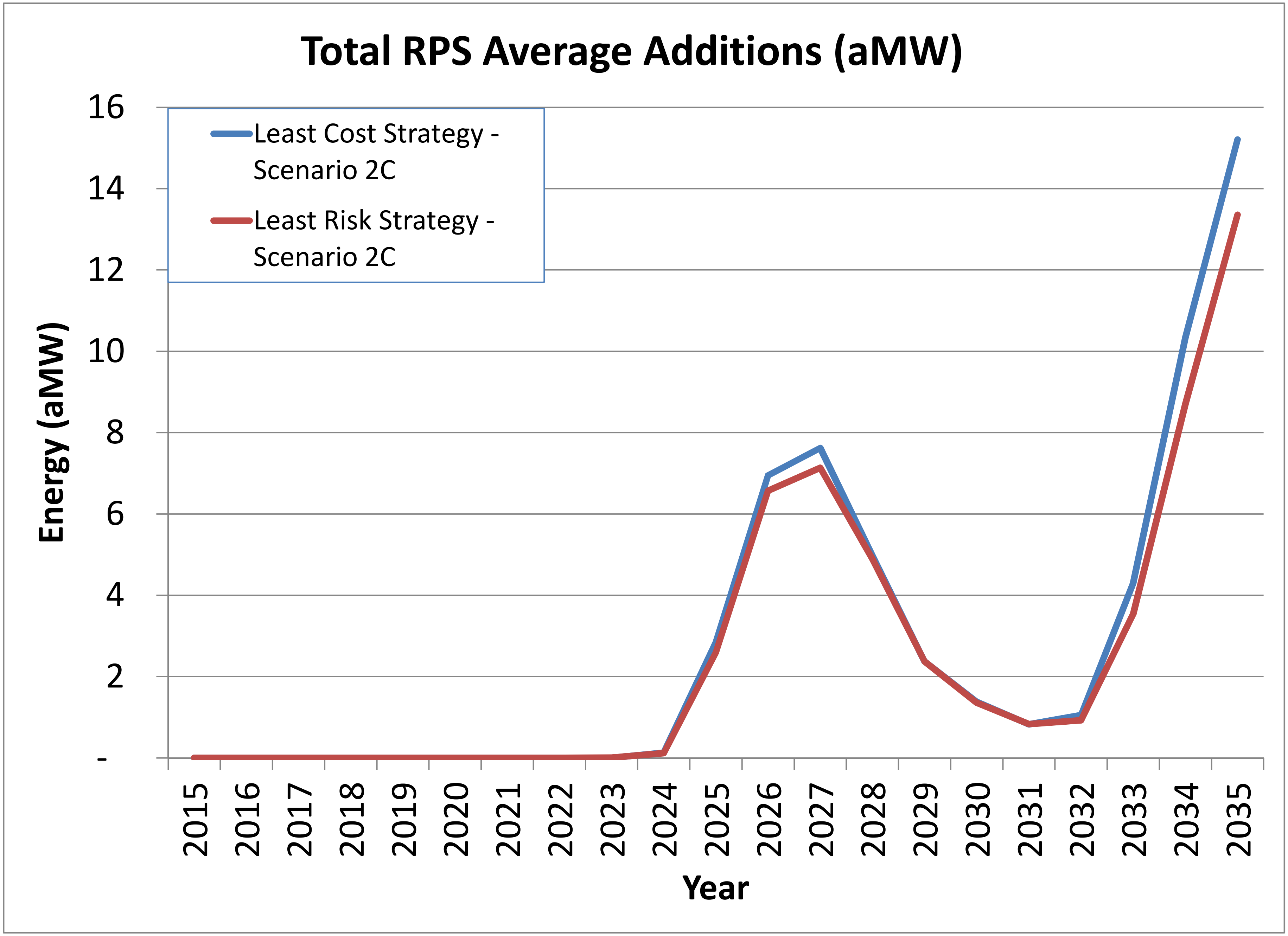

Cumulative Conservation (aMW) in 2035
Least Cost Strategy - Scenario 2C
Least Risk Strategy - Scenario 2C
Probability
3,204
3,250
3,297
3,343
3,389
3,436
3,482
3,528
3,574
3,621
3,667
3,713
3,760
3,806
3,852
3,899
3,945
3,991
4,037
4,084
4,130
4,176
4,223
4,269
4,315
Cumulative Conservation (aMW) in 2035

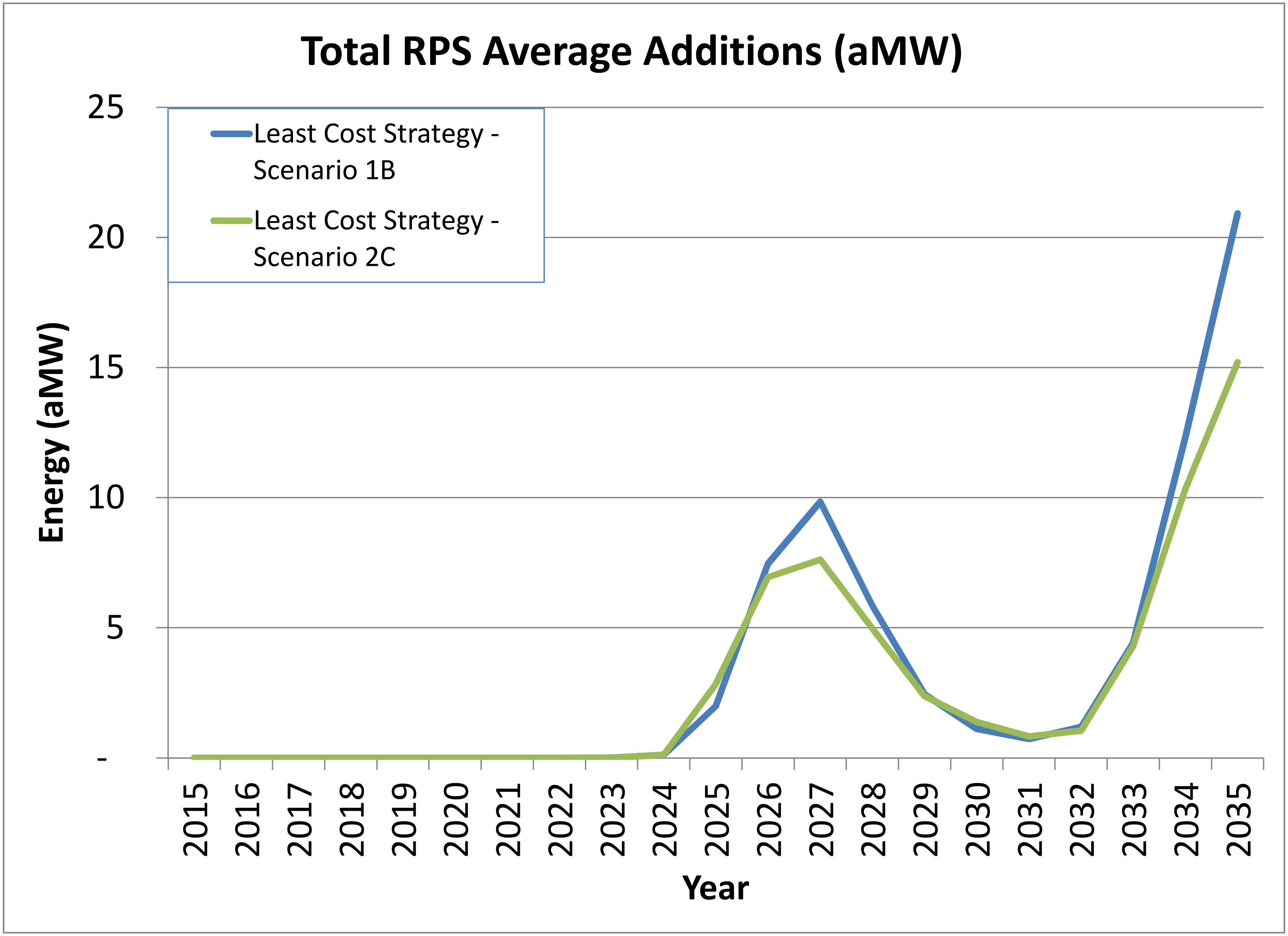


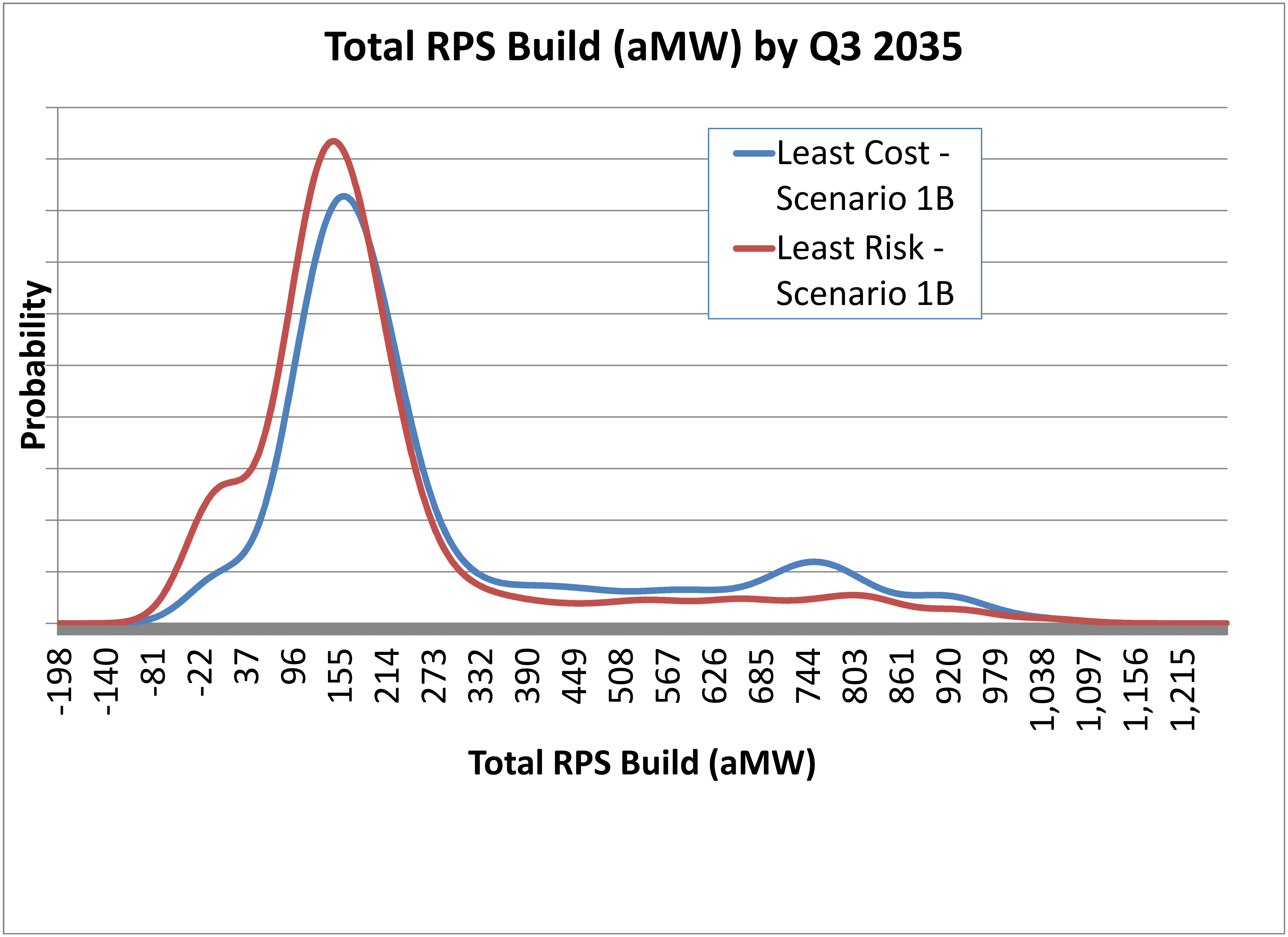
Cumulative Conservation (aMW) in 2035
Least Cost Strategy - Scenario 1B
Least Cost Strategy - Scenario 2C
Probability
2,869
2,926
2,982
3,039
3,096
3,152
3,209
3,266
3,322
3,379
3,436
3,492
3,549
3,606
3,662
3,719
3,776
3,833
3,889
3,946
4,003
4,059
4,116
4,173
4,229
Cumulative Conservation (aMW) in 2035



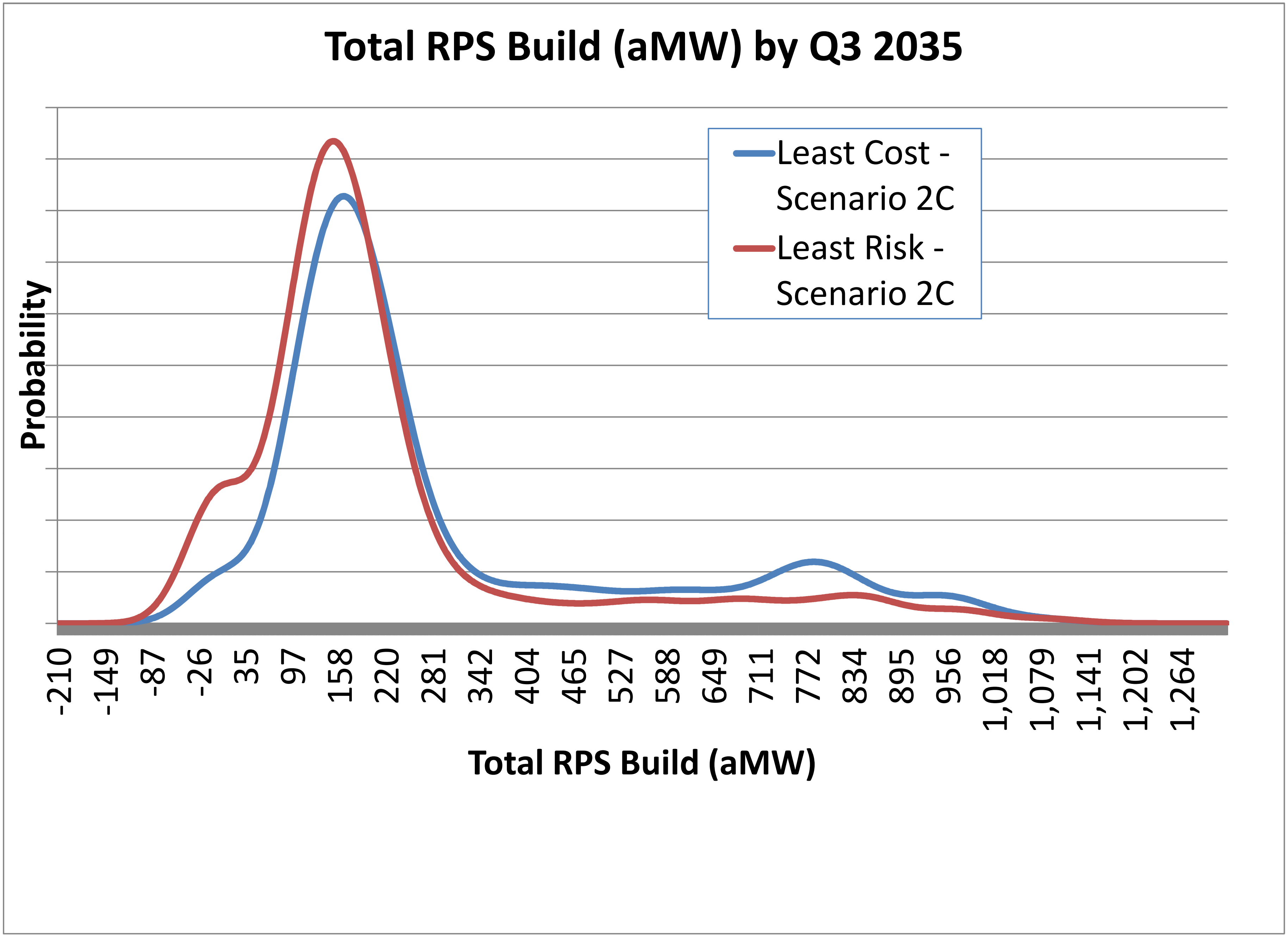
Total RPS Average Additions (aMW)
Least Cost Strategy - Scenario 1B
Least Risk Strategy - Scenario 1B
Energy (aMW)
25
20
15
10
5
-
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
Year


Total RPS Average Additions (aMW)
Least Cost Strategy - Scenario 2C
Least Risk Strategy - Scenario 2C
Energy (aMW)
16
14
12
10
8
6
4
2
-
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
Year

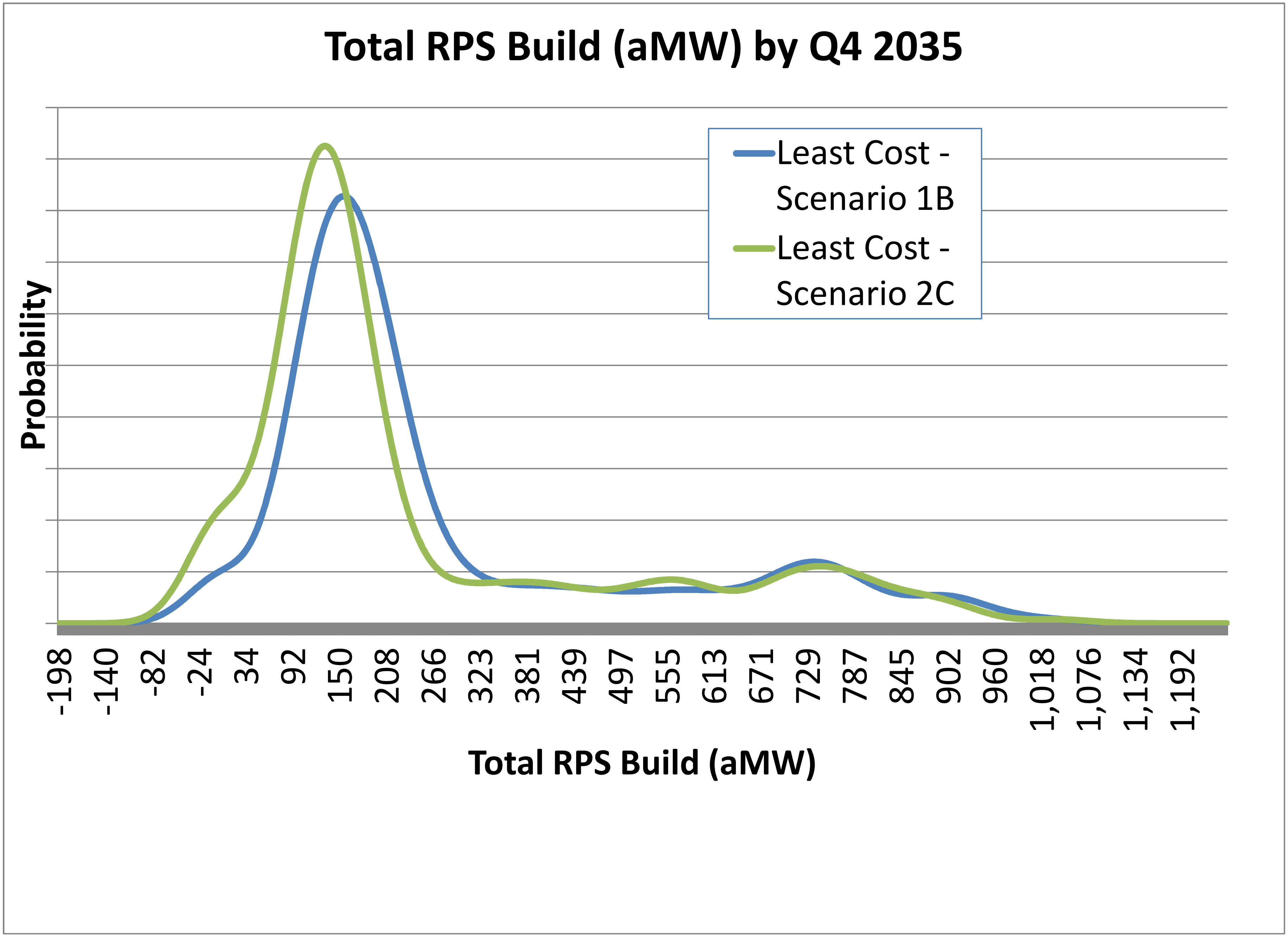

Total RPS Average Additions (aMW)
Least Cost Strategy - Scenario 1B
Least Cost Strategy - Scenario 2C
Energy (aMW)
25
20
15
10
5
-
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
Year

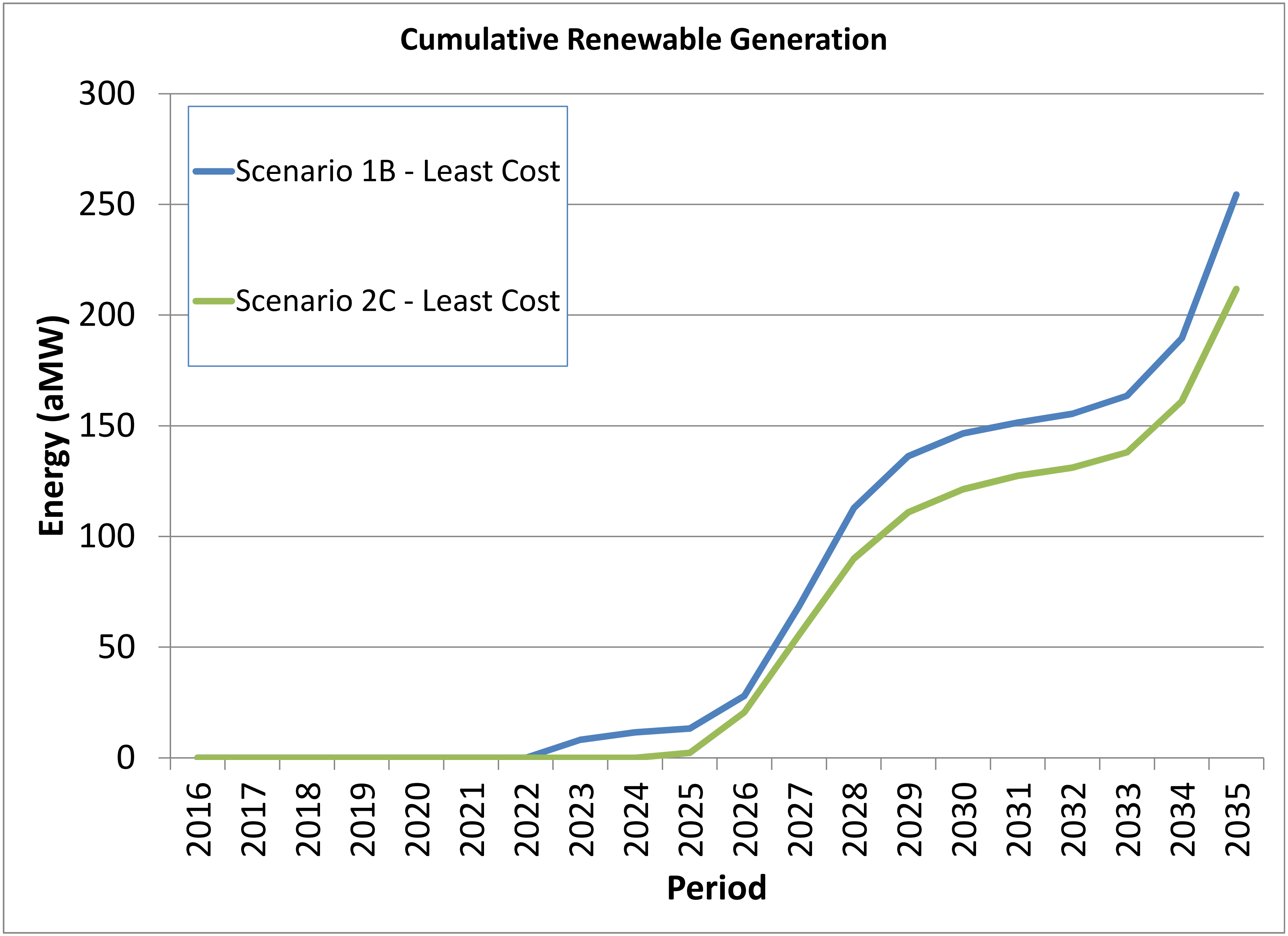


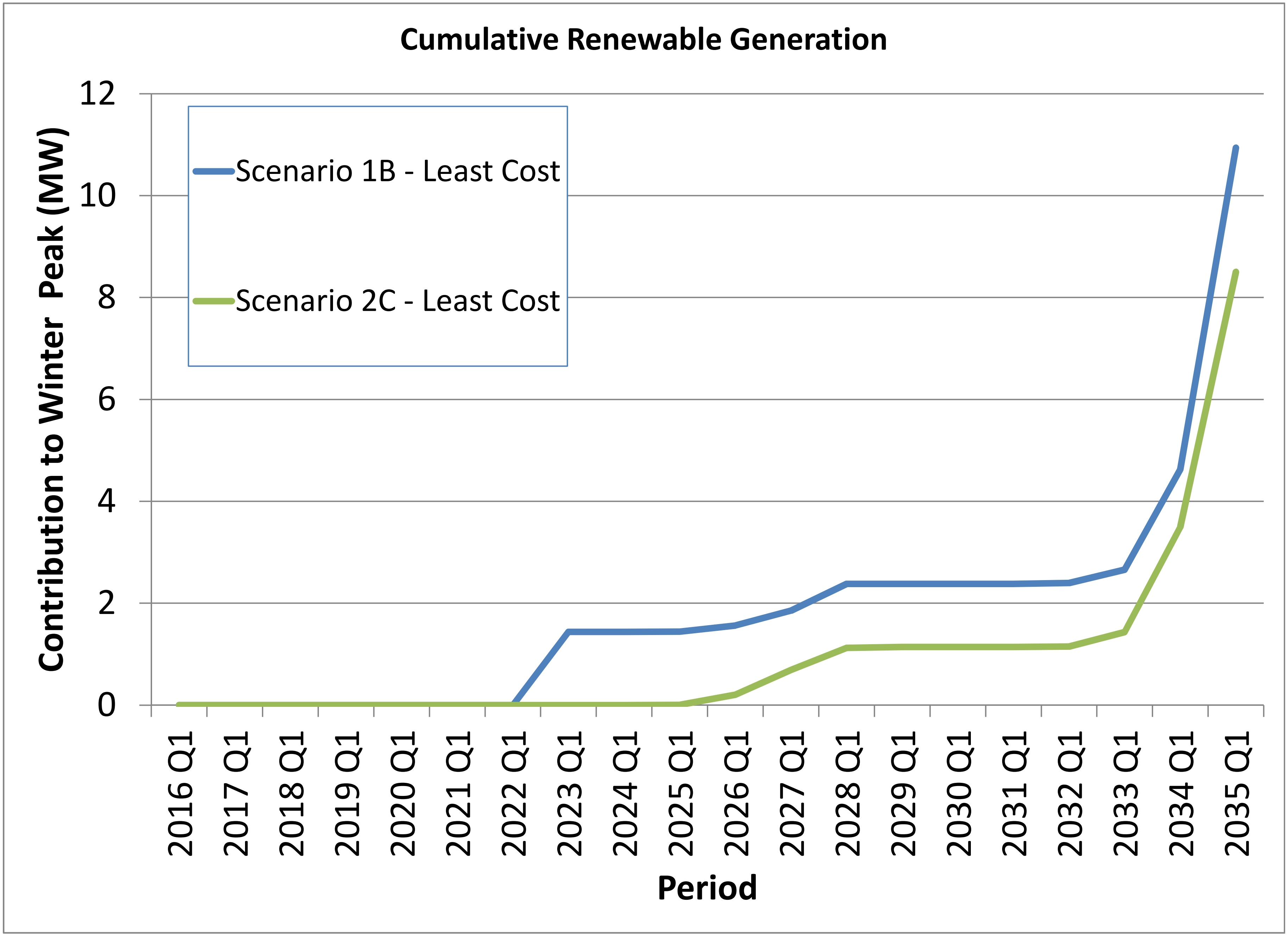
Total RPS Build (aMW) by Q3 2035
Probability
Least Cost - Scenario 1B
Least Risk - Scenario 1B
-198
-140
-81
-22
37
96
155
214
273
332
390
449
508
567
626
685
744
803
861
920
979
1,038
1,097
1,156
1,215
Total RPS Build (aMW)



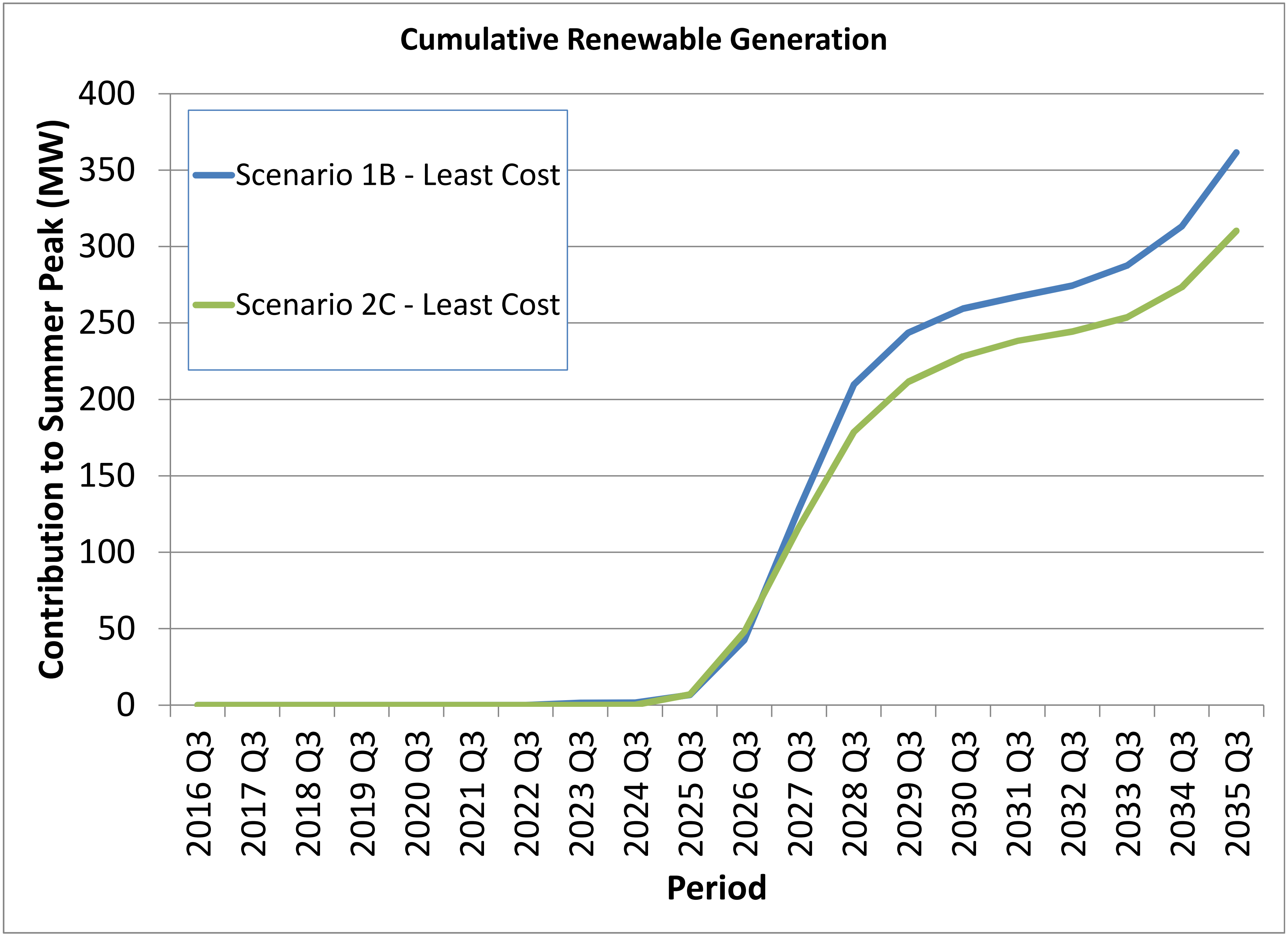
Total RPS Build (aMW) by Q3 2035
Least Cost - Scenario 2C
Least Risk - Scenario 2C
Probability
-210
-149
-87
-26
35
97
158
220
281
342
404
465
527
588
649
711
772
834
895
956
1,018
1,079
1,141
1,202
1,264
Total RPS Build (aMW)


Total RPS Build (aMW) by Q4 2035
Least Cost - Scenario 1B
Least Cost - Scenario 2C
Probability
-198
-140
-82
-24
34
92
150
208
266
323
381
439
497
555
613
671
729
787
845
902
960
1,018
1,076
1,134
1,192
Total RPS Build (aMW)

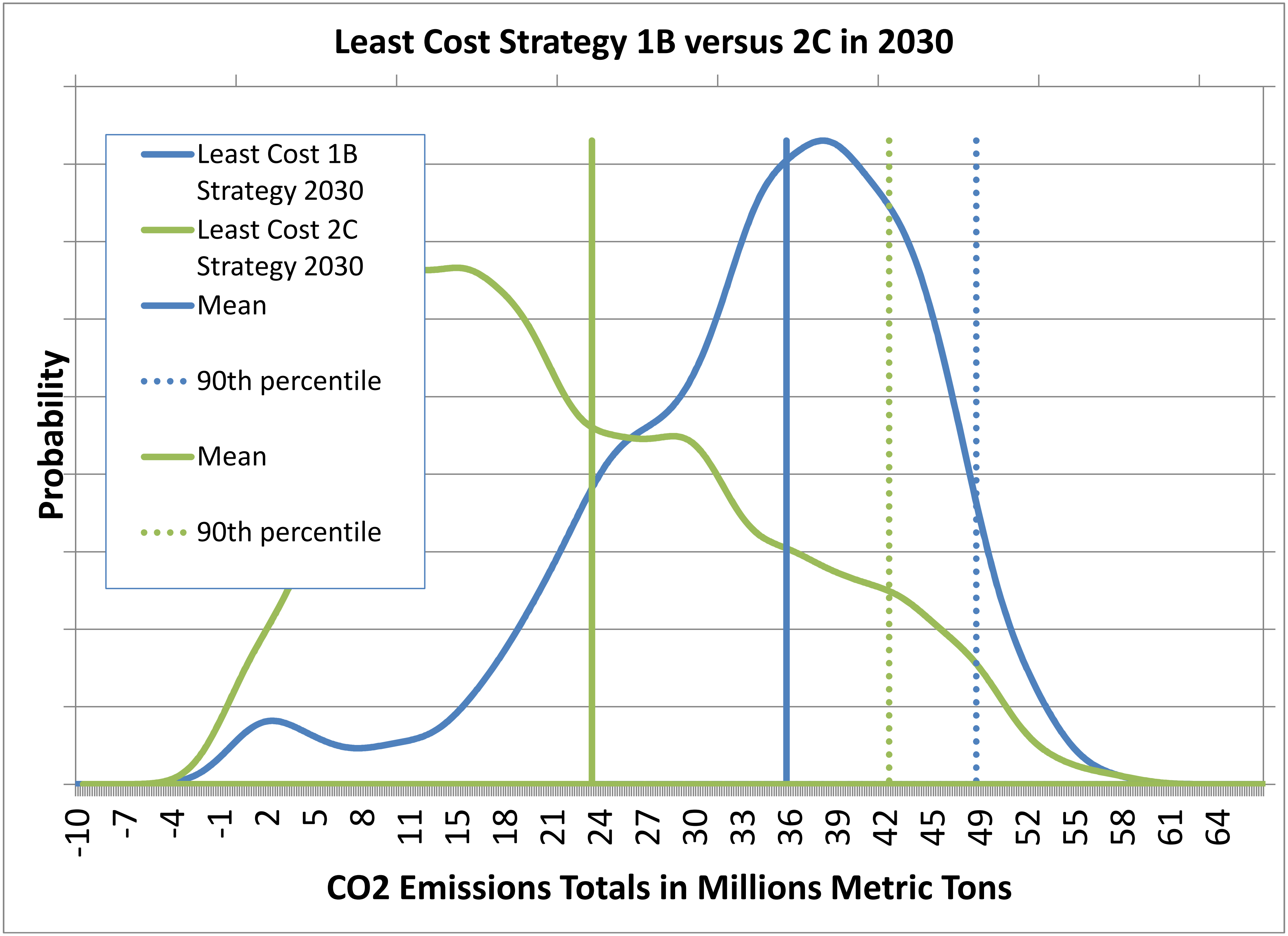

Cumulative Renewable Generation
Scenario 1B - Least Cost
Scenario 2C - Least Cost
Energy (aMW)
300
250
200
150
100
50
0
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
Period



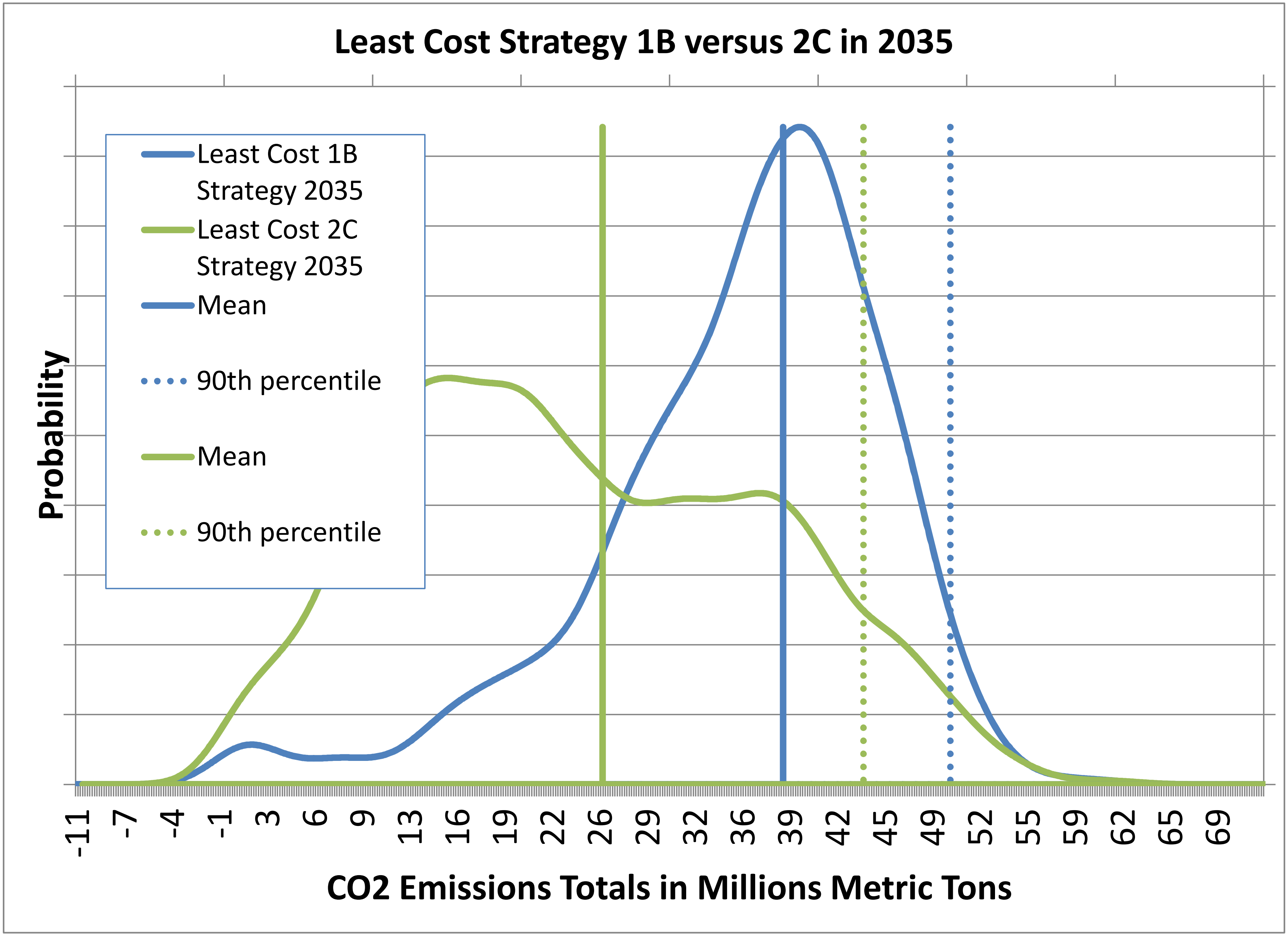
Cumulative Renewable Generation
Contribution to Winter Peak (MW)
12
10
8
6
4
2
0
Scenario 1B - Least Cost
Scenario 2C - Least Cost
2016 Q1
2017 Q1
2018 Q1
2019 Q1
2020 Q1
2021 Q1
2022 Q1
2023 Q1
2024 Q1
2025 Q1
2026 Q1
2027 Q1
2028 Q1
2029 Q1
2030 Q1
2031 Q1
2032 Q1
2033 Q1
2034 Q1
2035 Q1
Period



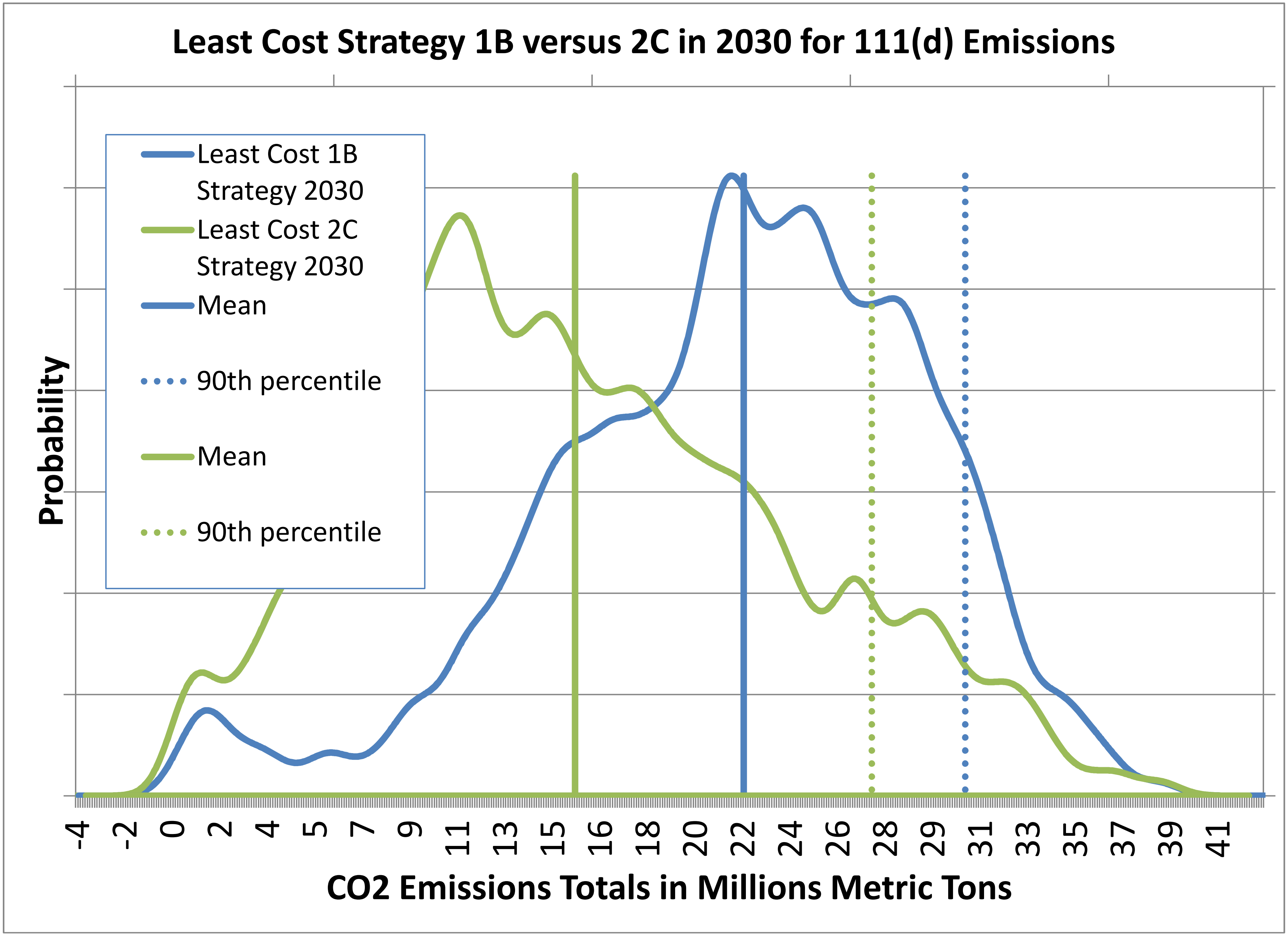
Cumulative Renewable Generation
Contribution to Summer Peak (MW)
400
350
300
250
200
150
100
50
0
Scenario 1B - Least Cost
Scenario 2C - Least Cost
2016 Q3
2017 Q3
2018 Q3
2019 Q3
2020 Q3
2021 Q3
2022 Q3
2023 Q3
2024 Q3
2025 Q3
2026 Q3
2027 Q3
2028 Q3
2029 Q3
2030 Q3
2031 Q3
2032 Q3
2033 Q3
2034 Q3
2035 Q3
Period

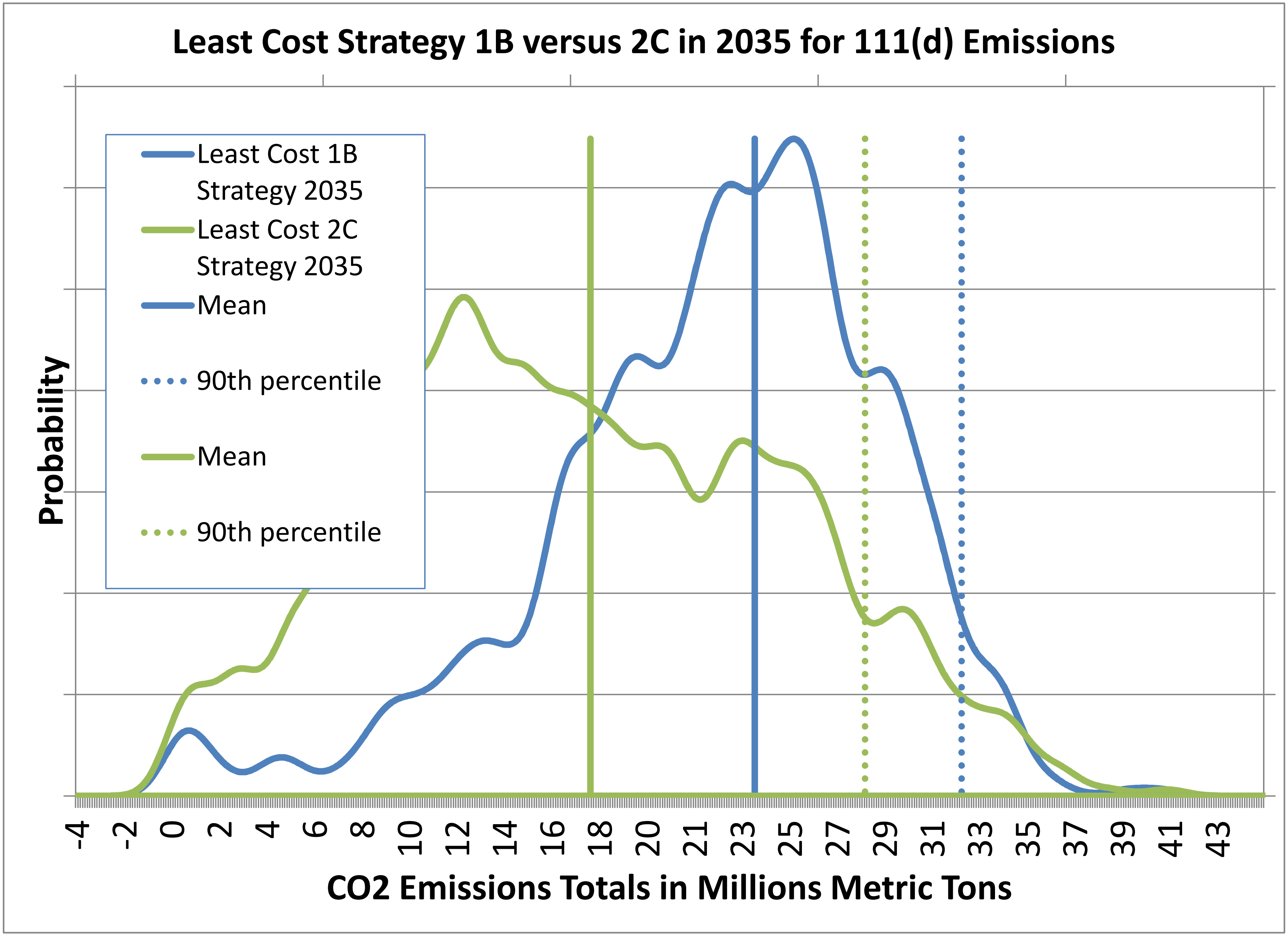


Least Cost Strategy 1B versus 2C in 2030
Least Cost 1B Strategy 2030
Least Cost 2C Strategy 2030
Mean
90th percentile
Mean
90th percentile
Probability
-10
-7
-4
-1
2
5
8
11
15
18
21
24
27
30
33
36
39
42
45
49
52
55
58
61
64
CO2 Emissions Totals in Millions Metric Tons



Least Cost Strategy 1B versus 2C in 2035
Least Cost 1B Strategy 2035
Least Cost 2C Strategy 2035
Mean
90th percentile
Mean
90th percentile
Probability
-11
-7
-4
-1
3
6
9
13
16
19
22
26
29
32
36
39
42
45
49
52
55
59
62
65
69
CO2 Emissions Totals in Millions Metric Tons


Least Cost Strategy 1B versus 2C in 2030 for 111(d) Emissions
Least Cost 1B Strategy 2030
Least Cost 2C Strategy 2030
Mean
90th percentile
Mean
90th percentile
Probability
-4
-2
0
2
4
5
7
9
11
13
15
16
18
20
22
24
26
28
29
31
33
35
37
39
41
CO2 Emissions Totals in Millions Metric Tons



Least Cost Strategy 1B versus 2C in 2035 for 111(d) Emissions
Least Cost 1B Strategy 2035
Least Cost 2C Strategy 2035
Mean
90th percentile
Mean
90th percentile
Probability
-4
-2
0
2
4
6
8
10
12
14
16
18
20
21
23
25
27
29
31
33
35
37
39
41
43
CO2 Emissions Totals in Millions Metric Tons