Technical Analysis of a 100% Renewable or Clean Energy Standard:

Results Discussion with Stakeholder Advisory Group

November 14, 2023

Presented by: Sustainable Energy Advantage, LLC

Sustainable Energy Advantage, LLC

Overview

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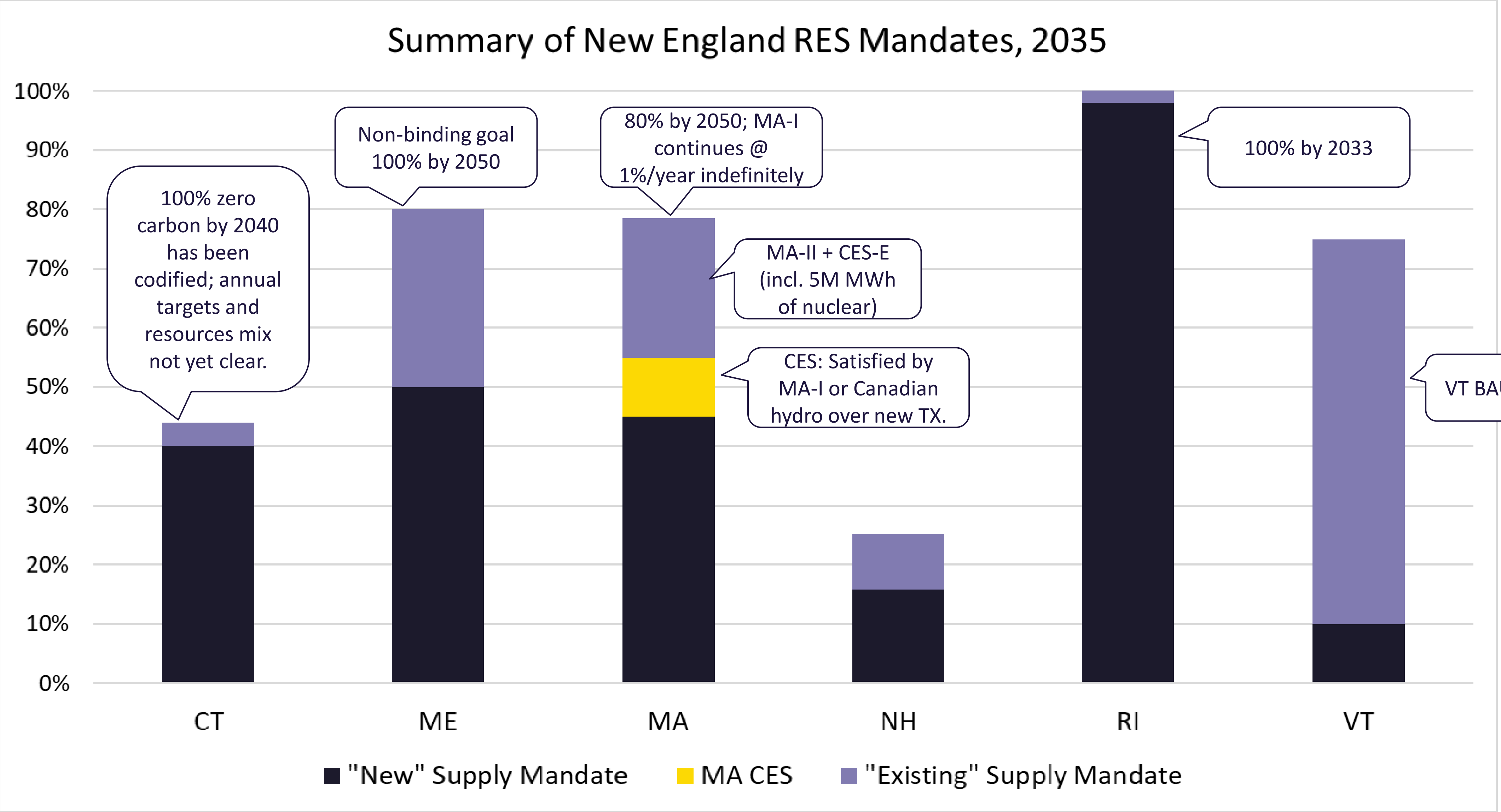
Scope, Approach, & Purpose

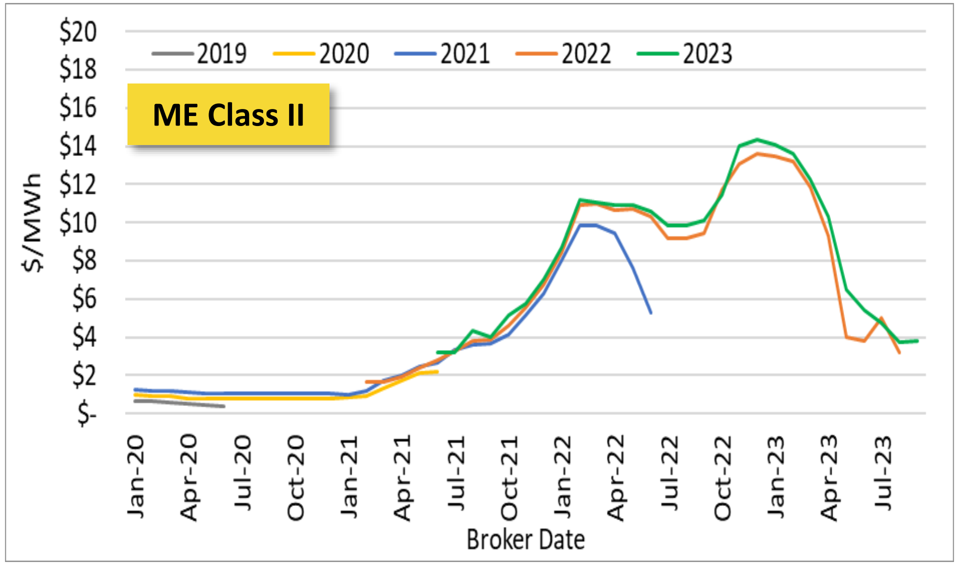
- Scope:
  - "Provide quantitative technical analysis for expanding Vermont's current Renewable Energy Standard to 100% renewable or clean"
- Purpose:
  - Support informed discussion and decision-making regarding potential revisions to Vermont's Renewable Energy Standard (RES)
- Approach:
  - Conduct scenario and sensitivity analyses to explore a range of RES policy designs and potential outcomes
    - The design of policies other than the RES, while related, are not the focus of this analysis
  - Each scenario is evaluated relative to the current RES policy
  - Results are expressed (primarily) as incremental to the current RES policy
  - Selected results also show cumulative benefits and costs, including for BAU

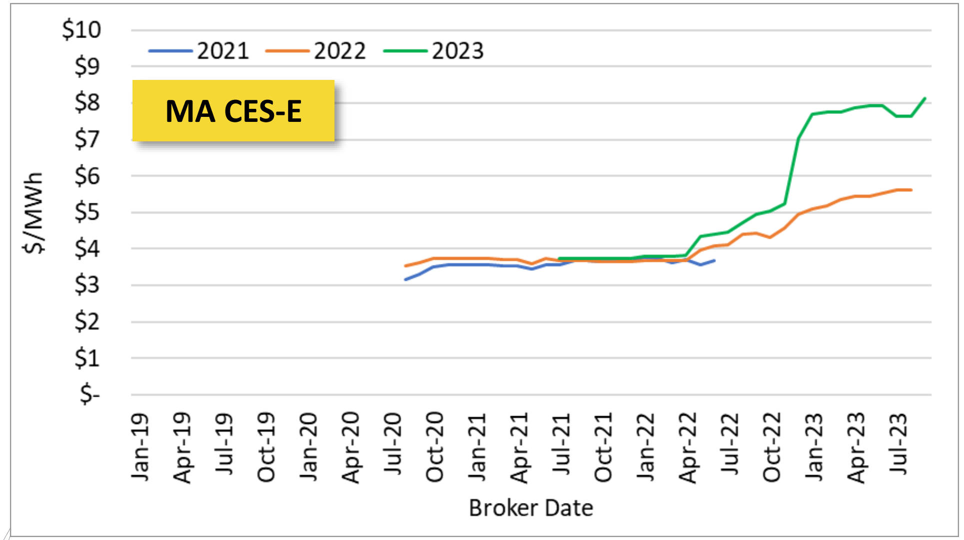
Regional Context: Current RES/RPS Targets, 2035



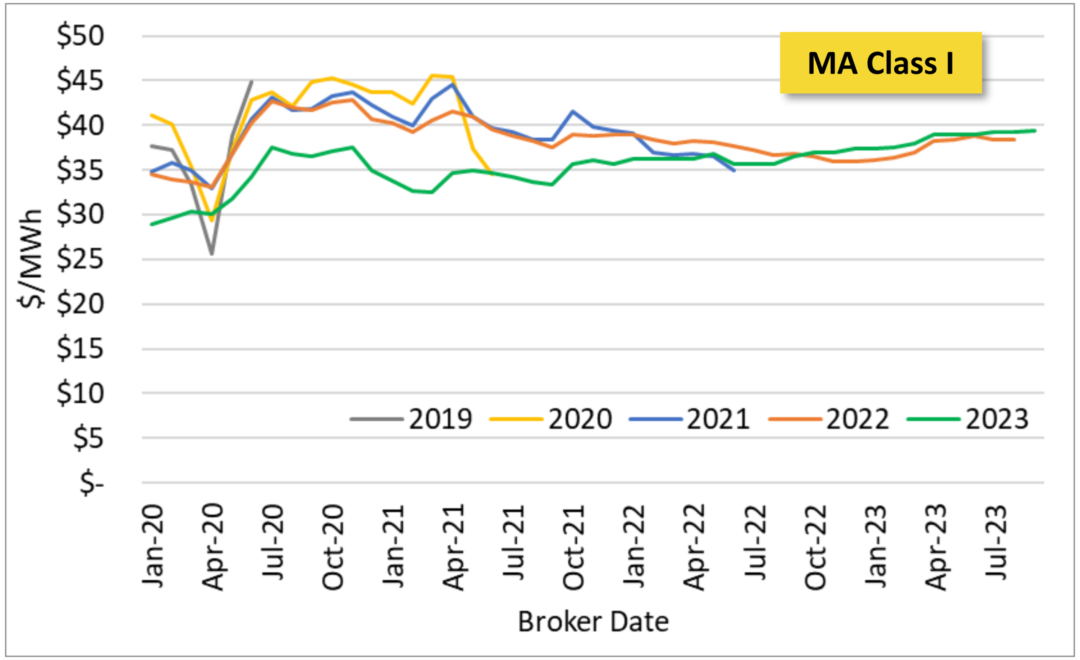
Regional Context: Recent Cost of RES/RPS Compliance

Existing Market Examples: ME-II and MA CES-E





New Market Example: MA Class I



Using the model and interpreting results

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RES Policy Modeling: Issues & Options

- The model is a tool to help explore possible policy design changes and potential outcomes, but the most important question is: *What are we trying to accomplish?*
  - Common renewable energy policy objectives:
    - Achieve targets at least cost,
    - Incentivize in-state development for job/economic development benefits,
    - Build new resources throughout the region,
    - Achieve greenhouse gas emissions targets, and
    - Combinations of the above.
- RES Policy Design issues/options include (but are not limited to):
  1. Total target: 100% or other (consider relationship to progress in other sectors)
  2. Tier allocation and annual targets for each Tier (new v. existing, and pace of deployment)
  3. RES or CES (i.e., should nuclear be eligible for Tier I? If yes, in what quantity?)
  4. Long-term role of existing resources
  5. Role of new, regional resources
  6. RES Exemptions, near-term and long-term
- **Interpreting Results:** How do the results align with what we are trying to accomplish? Leverage modeling choices to inform the discussion.

Modeling Scope and Capability

- Model architecture characterized by scenario and sensitivity needs
  - Objective = maximum flexibility for combining policy design options
- Modeling outcomes consider both costs and benefits
  - Incremental Costs
    - Tier I, II and Regional Tier → varying combinations
    - Rate impact
  - Benefits and Costs by…
    - Scenario
    - Tier
    - Consider both societal and rate impact (i.e., VT bill) perspective
- What is *not* included?
  - Localized optimization of supply, flexibility mechanisms (e.g., storage, price-responsive demand, etc.), and grid infrastructure.

Scenario Definitions

This analysis focuses on six **(6) core scenarios**, which were designed jointly by the Department of Public Service and Stakeholder Advisory Group. Scenario definitions are provided below:

Scenarios → Design Element ↓		BAU	Scenario 1: 100% RES	Scenario 2: 100% RES, incl. Regional Tier	Scenario 3: 100% CES	Scenario 4: 100% CES, incl. Regional Tier	Scenario 5: 100% RES, no biomass	Scenario 6: 100% CES, no biomass, Reg + T-II combo
Tier I, Net	Target	65%	70%	40%	70%	40%	50%	40%
	Target Date	2032	2035	2035	2035	2035	2035	2035
	Eligibility Changes	N/A	None	None	Add nuclear	Add nuclear	Remove biomass	Add nuclear; remove biomass
Tier II	Target	10%	30%	30%	30%	30%	20%	Combined with Regional Tier
	Target Date	2032	2035	2035	2035	2035	2035	
	Eligibility Changes	N/A	None	None	None	None	None	
Regional Tier	Target	N/A	N/A	30%	N/A	30%	30%	60%
	Target Date	N/A	N/A	2035	N/A	2035	2035	2035
	Eligibility*	N/A	N/A	2010+	N/A	2010+	2010+	2010+

In all Scenarios (other than BAU), the RES (or CES) reaches 100% by 2030; Tier-specific targets drive reallocation of supply through 2035 while maintaining 100% total standard.

Sensitivity Analyses

- Driven by Stakeholder and Department feedback and preferences, the analysis includes 69 total case runs → comprised of a BAU and 68 combinations of the following policy and market drivers:

Tier II: 0%, 10%, 20%, 30%	**Regional Tier**: 0%, 20%, 30%, 40%, 50% (Scenario 6 only)
Tier I Eligibility: Nuclear: Yes/No Biomass: Yes/No	**Load Forecast**: Base Case High Electrification Case

Sensitivities = 68 combinations of these variables

All 68 cases available to support future policy deliberation

*In each sensitivity, **Tier I is set as the remainder** after Tier II and Regional Tier are defined*

Summary of Results

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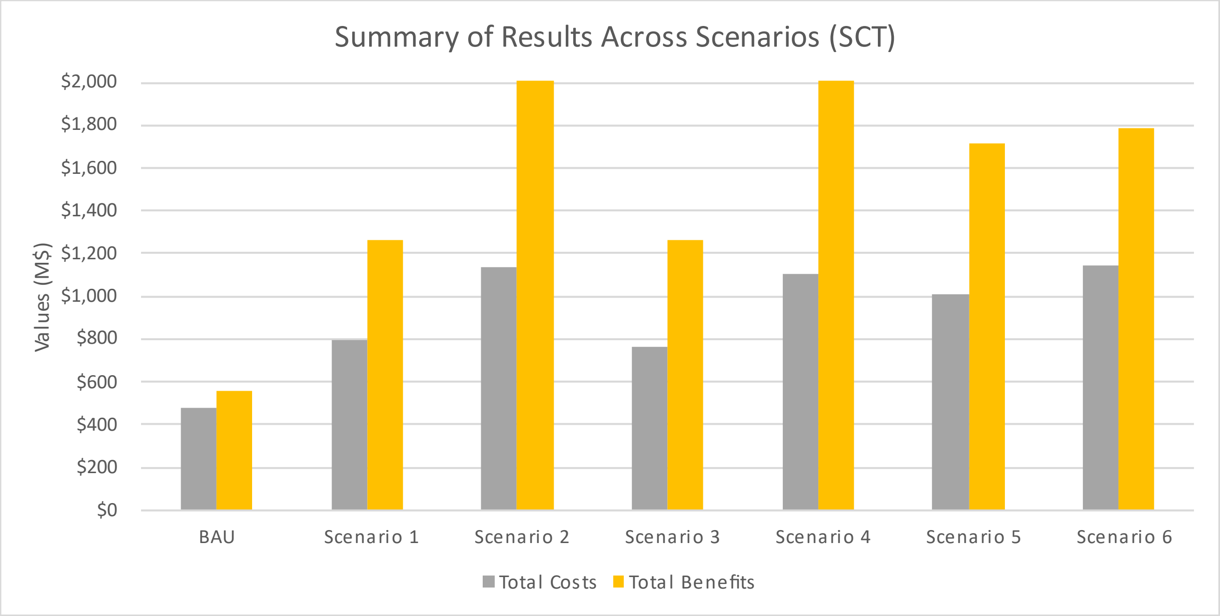
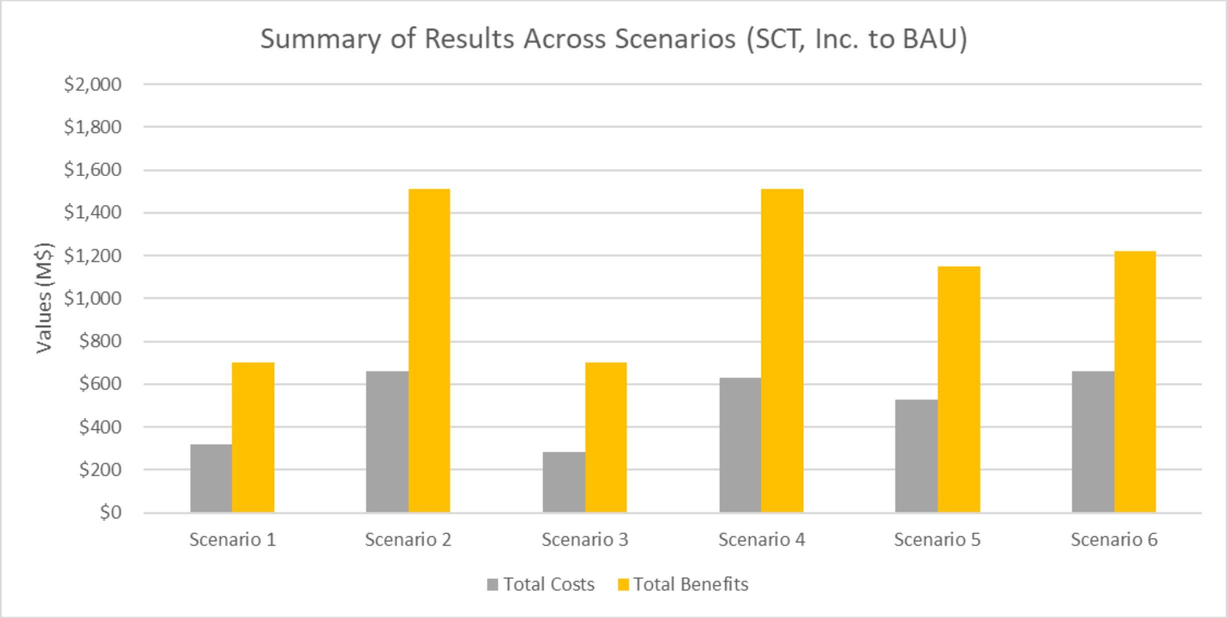
Costs & Benefits: Cumulative vs Incremental
Societal Cost Test (SCT), M$

Cumulative Results

Scenario results *minus* BAU results

Incremental Results





- Total Benefits exceed Total Costs in all Scenarios (for Societal Cost Test (SCT)).
- Benefits by category, rate impact, and deployment by technology shown on following slides.

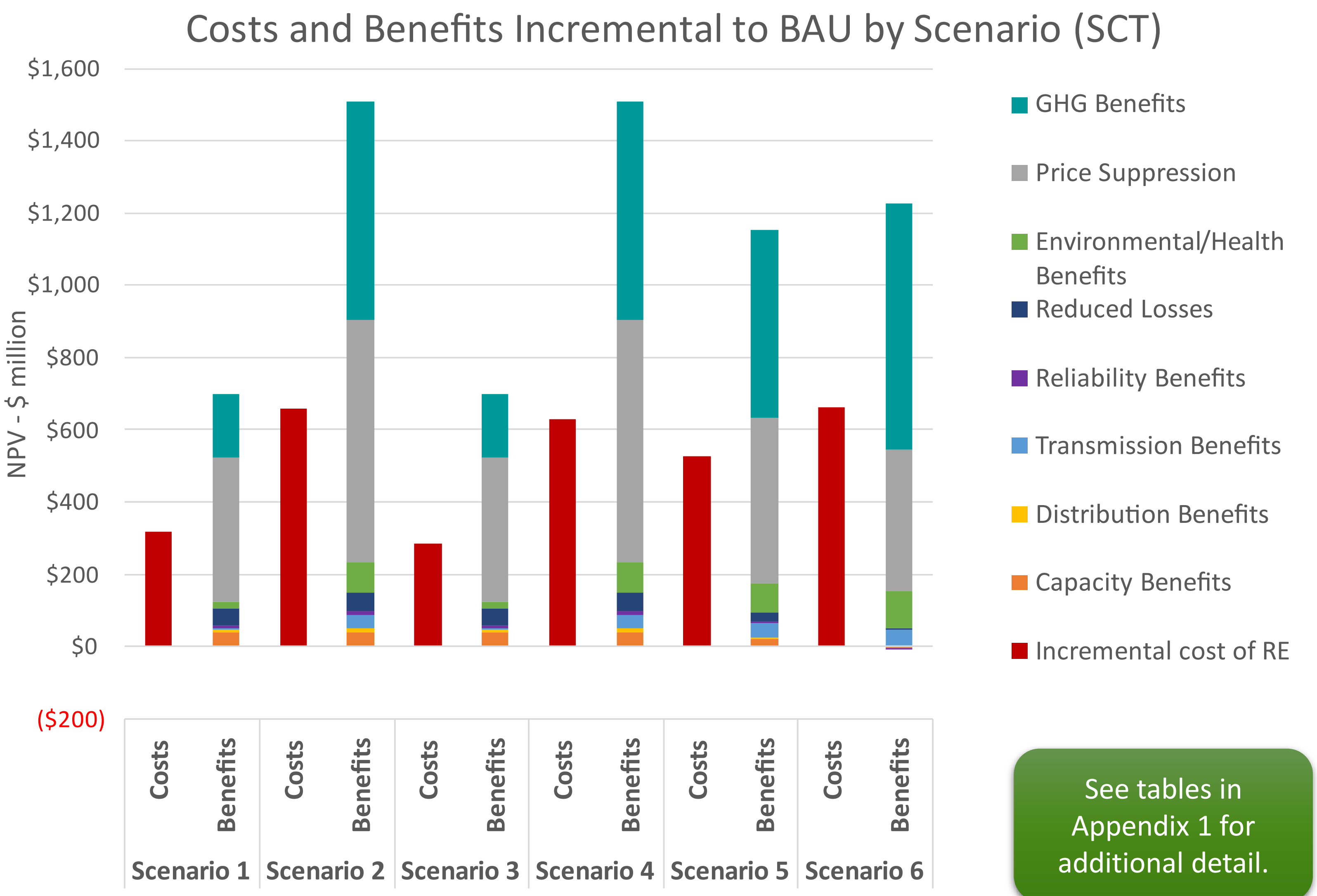
Costs & Benefits by Scenario: Incremental, SCT

Observations:

- Positive net benefits in all scenarios
- GHG and price suppression (all types) drive majority of benefit stack
- Tier I is not assigned any benefits, given absence of "additionality" for legacy resources

Scenario Definitions

	Reg. Tier Target	Tier II Target	Tier I Target	Target Date	Nuclear Tier I Eligible	Biomass Tier I Eligible
BAU	0%	10%	BAU	2032	No	Yes
Scenario 1	0%	30%	100% by 2030	2035	No	Yes
Scenario 2	30%	30%	100% by 2030	2035	No	Yes
Scenario 3	0%	30%	100% by 2030	2035	Yes	Yes
Scenario 4	30%	30%	100% by 2030	2035	Yes	Yes
Scenario 5	30%	20%	100% by 2030	2035	No	No
Scenario 6	50%	10%	100% by 2030	2035	Yes	No



See tables in Appendix 1 for additional detail.

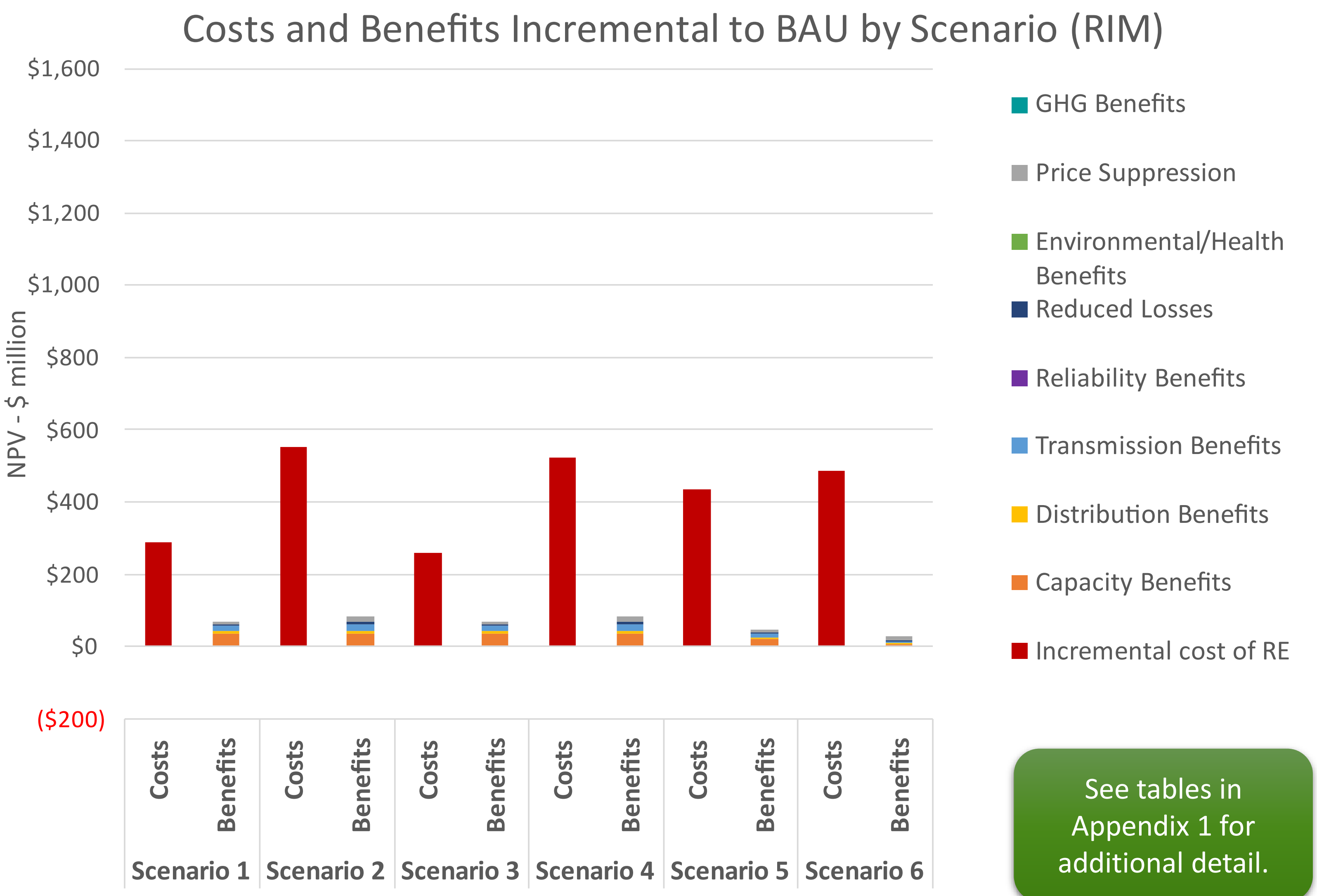
Costs & Benefits by Scenario: Incremental, RIM

Observations:

- RIM focuses exclusively on items impacting VT bills
- Excludes GHG benefits
- Price suppression benefits limited to in-state (~4% of regional benefits)
- RIM approach yields net costs under every scenario

Scenario Definitions

	Reg. Tier Target	Tier II Target	Tier I Target	Target Date	Nuclear Tier I Eligible	Biomass Tier I Eligible
BAU	0%	10%	BAU	2032	No	Yes
Scenario 1	0%	30%	100% by 2030	2035	No	Yes
Scenario 2	30%	30%	100% by 2030	2035	No	Yes
Scenario 3	0%	30%	100% by 2030	2035	Yes	Yes
Scenario 4	30%	30%	100% by 2030	2035	Yes	Yes
Scenario 5	30%	20%	100% by 2030	2035	No	No
Scenario 6	50%	10%	100% by 2030	2035	Yes	No

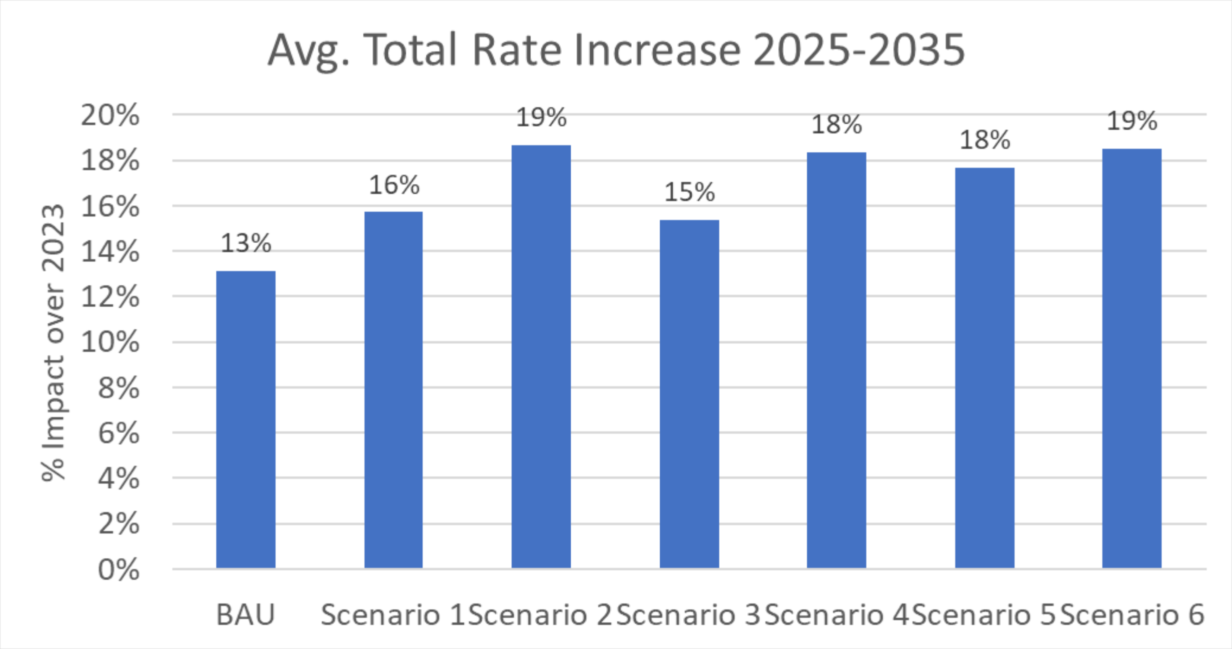


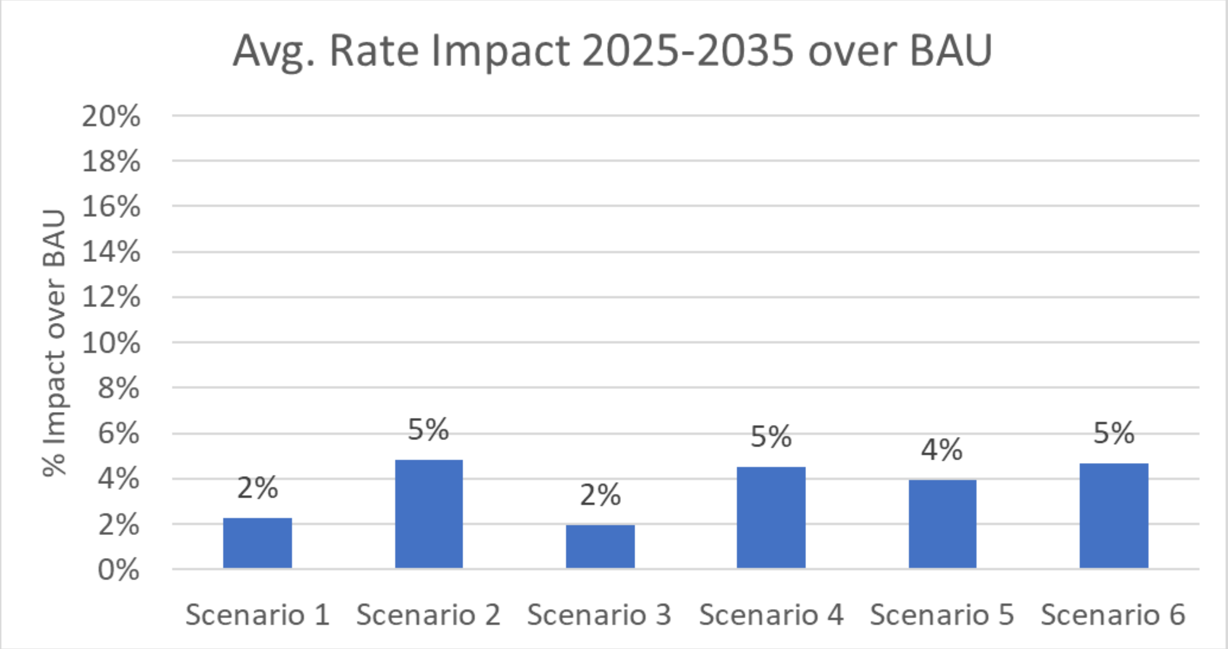
See tables in Appendix 1 for additional detail.

Rate Impact: Average Rate Increase, %

- Rate impact reflects net costs or benefits on VT bills
- Impact increases over time as RES targets increase
- Cumulative average total rate impact, including BAU, shown on the left.
- Rate impact incremental to BAU shown on the right
- Scenario 2, depicted below, has the highest net cost of the six scenarios summarized in this report.

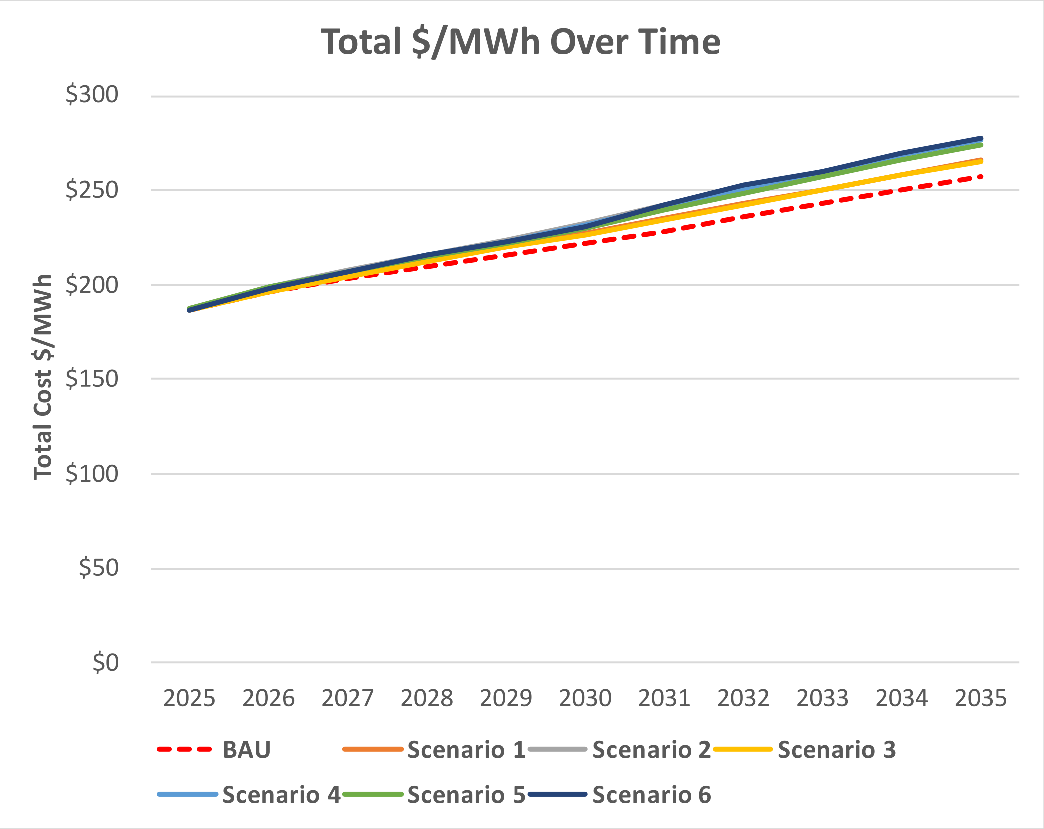
$10/MWh = 1 cent/kWh

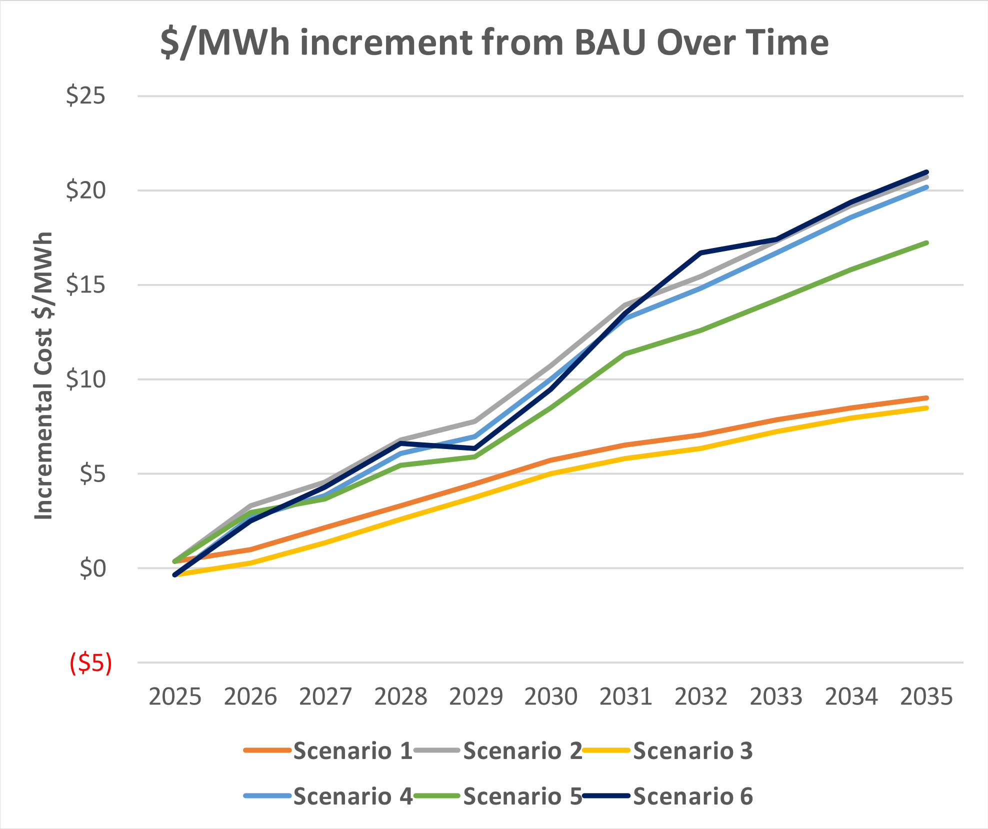




Rate Impact: $/MWh

- Annual results demonstrate that cost increases tracking with target increases
- The forecast of total $/MWh over time (left-hand chart) demonstrates that market cost drivers embedded in the current RES policy (BAU) explain much of the total cost increase through 2035.
- Incremental cost increases from BAU are shown in the right-hand chart





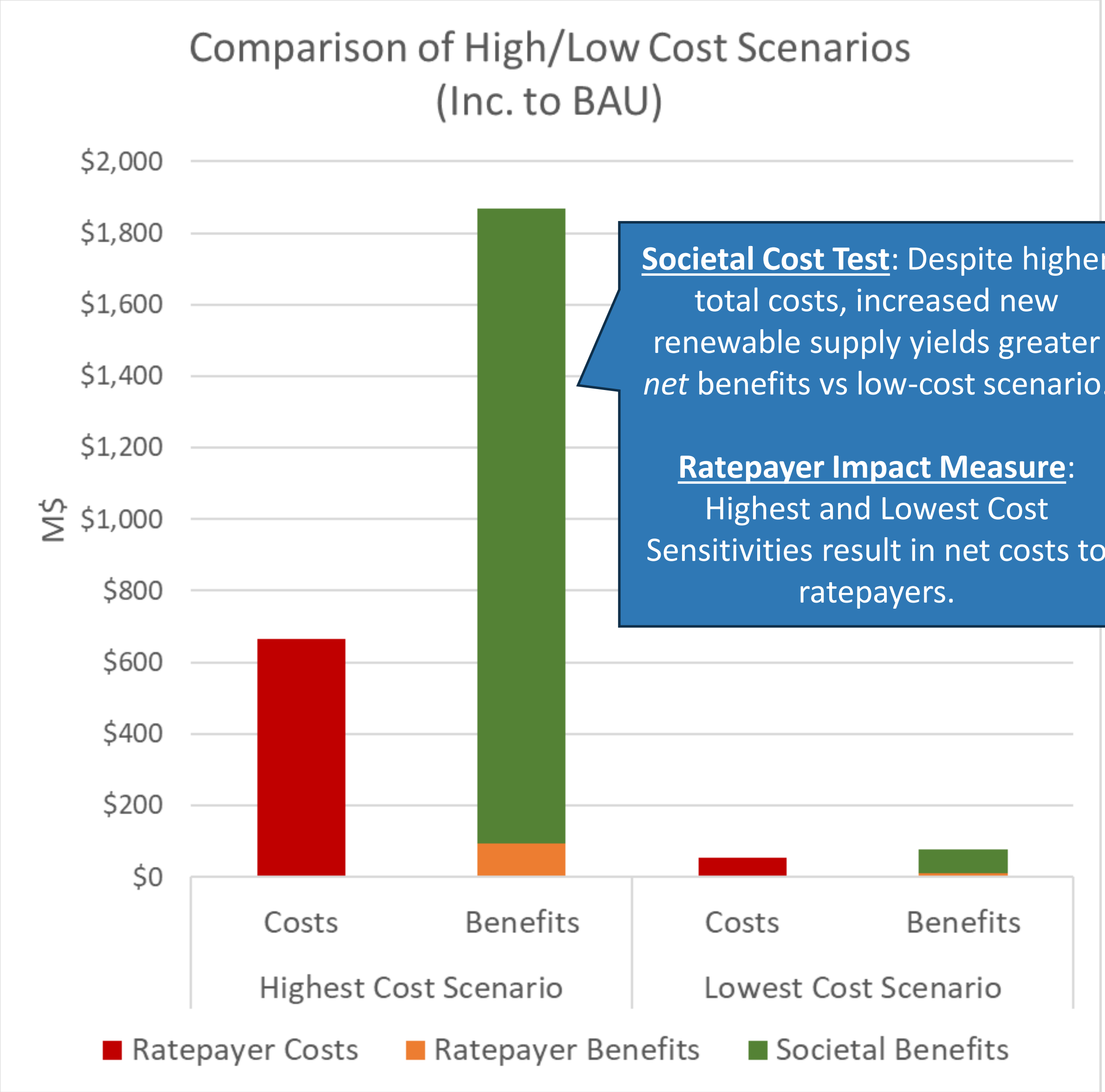
Bounding Ratepayer Impact, *Incremental* to BAU

- To explore the bounds of potential ratepayer impact, results from highest- and lowest-cost sensitivities (incremental to BAU) are compared:

Scenario Definitions	Highest-Cost Sensitivity	Lowest-Cost Sensitivity
Scenario Name	**Scenario 5 Variant 13**	**Scenario 3 – Variant 5**
Regional Tier Target	40%	0%
Tier II Target	30%	10%
Tier I Target	100% by 2030	100% by 2030
Target Date	2035	2035
Load Forecast	Base Load, High Electrification	Base Load, High Electrification
Nuclear Tier I Eligible?	Yes	Yes
Biomass Tier I Eligible?	Yes	Yes

Electrification and Tier I eligibility are held constant to provide apples-to-apples comparison

Scenario	Rate Impact, *Incremental* to BAU (Avg. % impact 2025-2035)
Highest Cost Sensitivity	5%
Lowest Cost Sensitivity	<1%

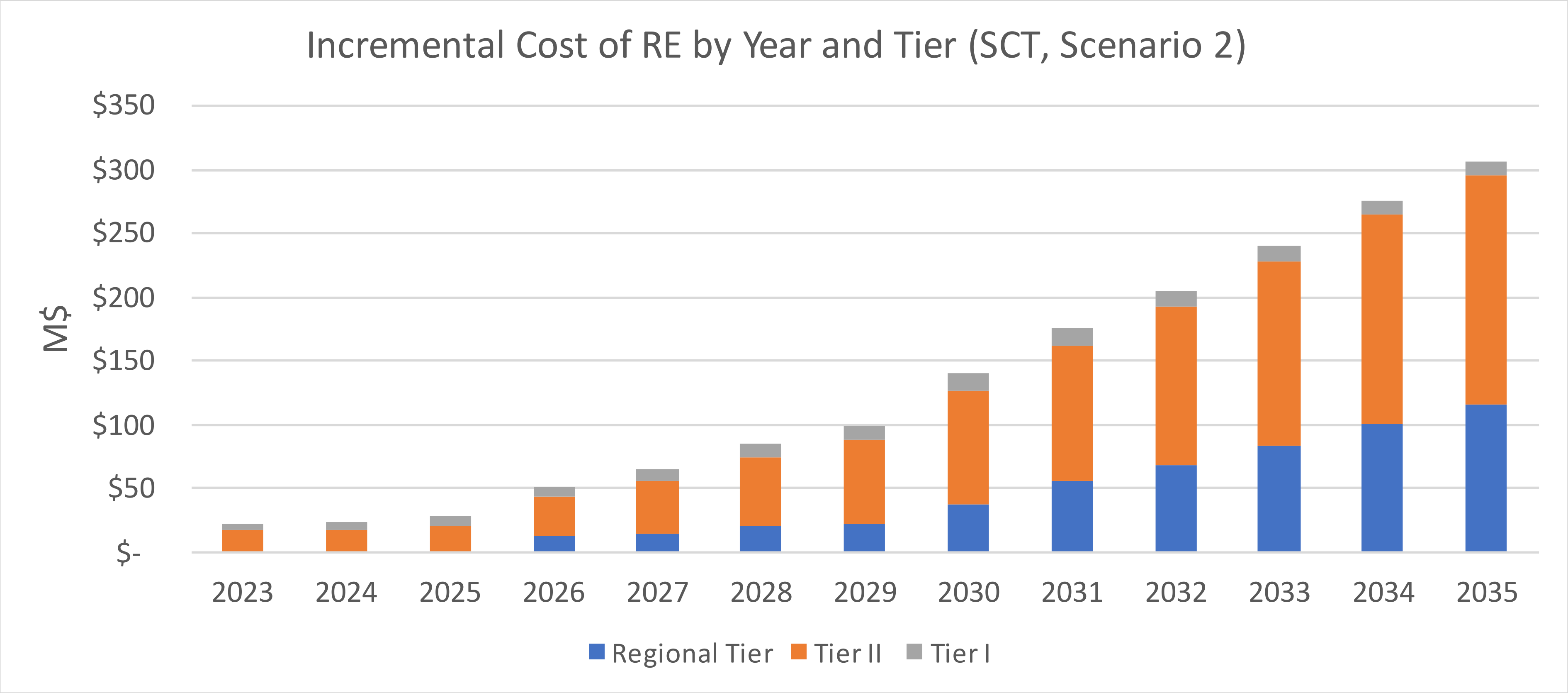


Societal Cost Test: Despite higher total costs, increased new renewable supply yields greater *net* benefits vs low-cost scenario.

Ratepayer Impact Measure: Highest and Lowest Cost Sensitivities result in net costs to ratepayers.

Incremental Costs by Year, M$

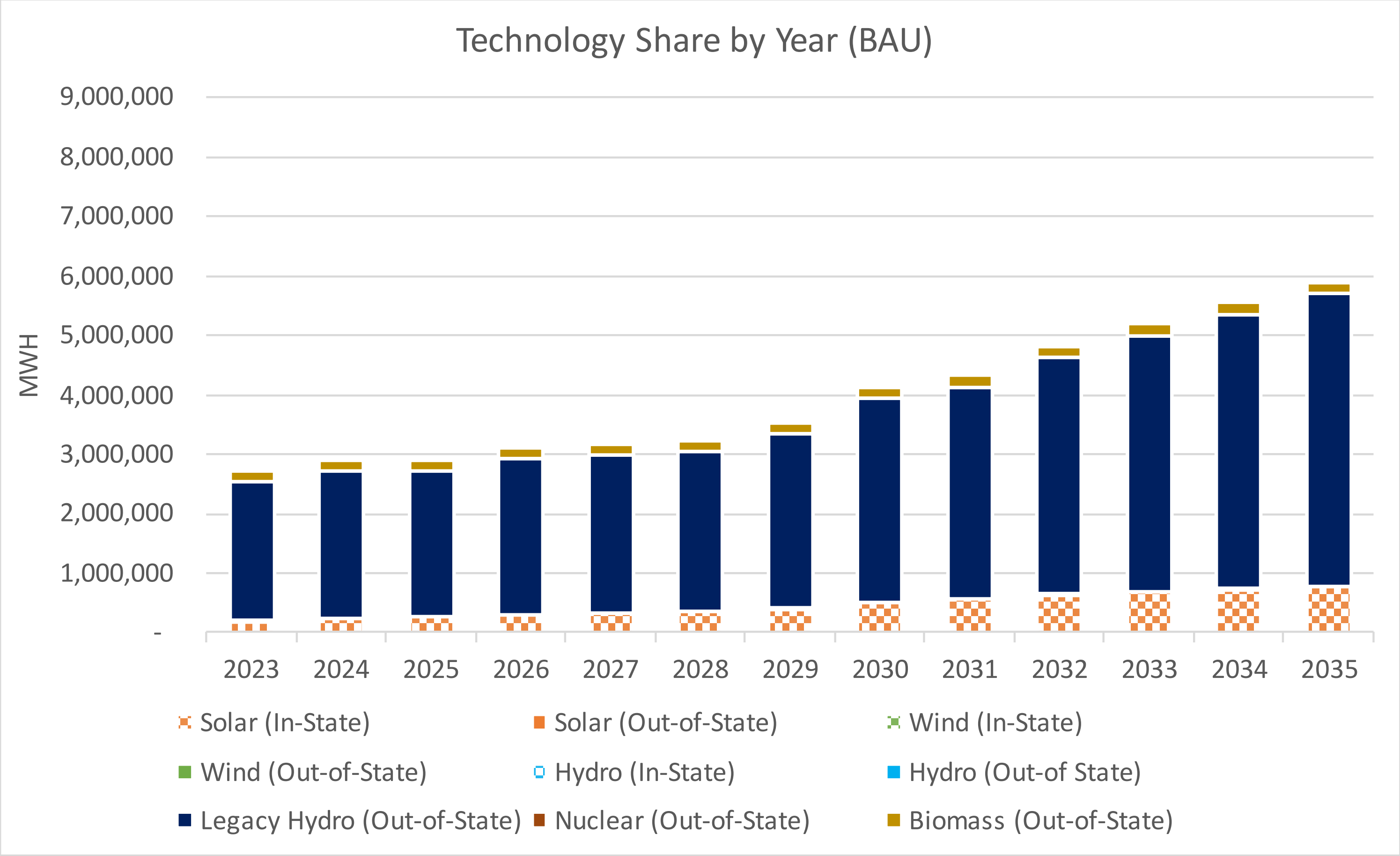
- Scenario 2 has the highest total cost
- Annual incremental costs by tier are shown below



About this Scenario	
Regional Tier Target	30%
Tier II Target	30%
Tier I Target	100% by 2030
Target Date	2035
Load Forecast	Base Load, Base Electrification
Nuclear Tier I Eligible?	No
Biomass Tier I Eligible?	Yes

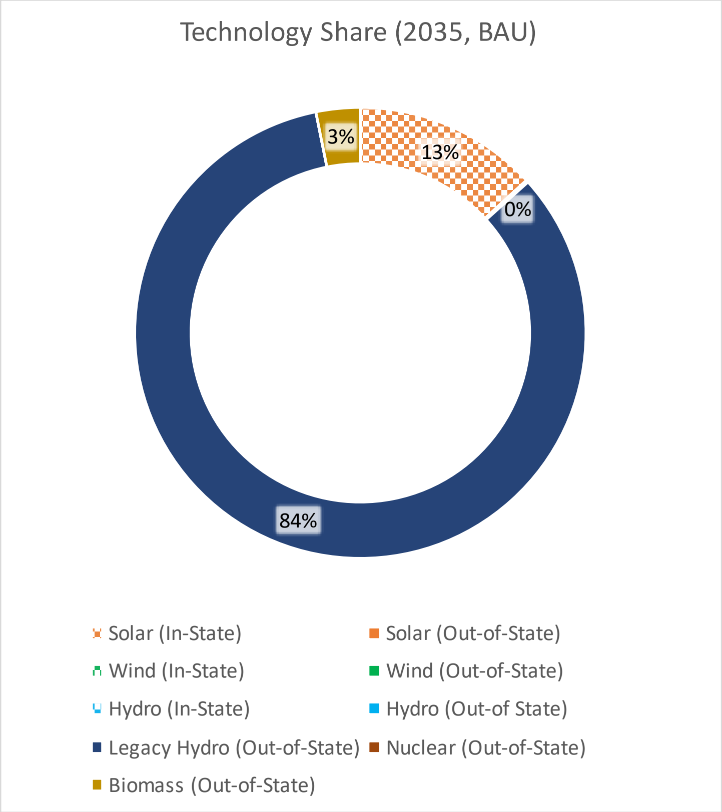
See tables in Appendix 2 for other Scenarios.

RES-Eligible Technology Deployment, BAU



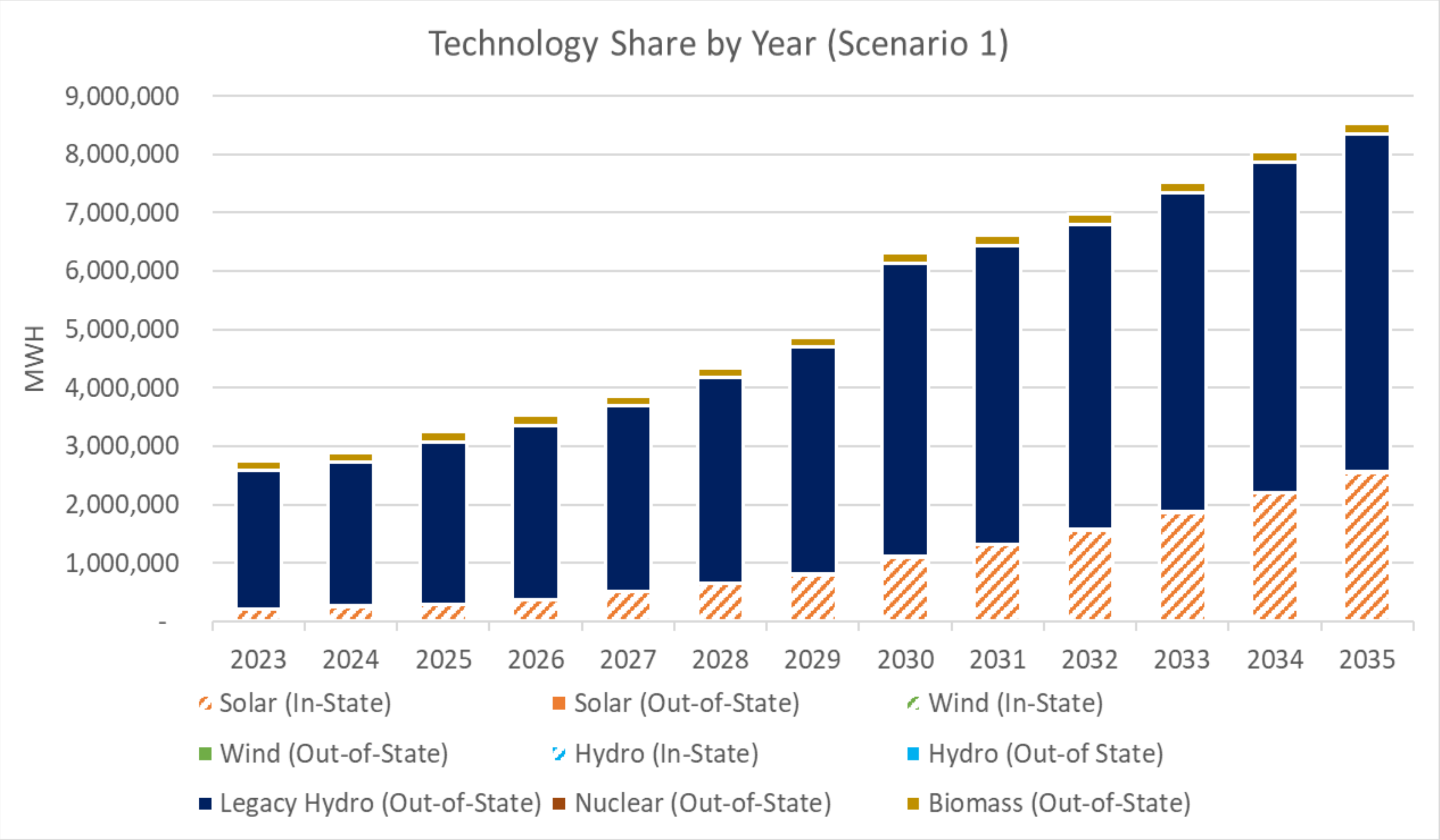
About this Scenario

Regional Tier Target	0%
Tier II Target	10%
Tier I Target	BAU
Target Date	2032
Load Forecast	Base Load, Base Electrification
Nuclear Tier I Eligible?	No
Biomass Tier I Eligible?	Yes



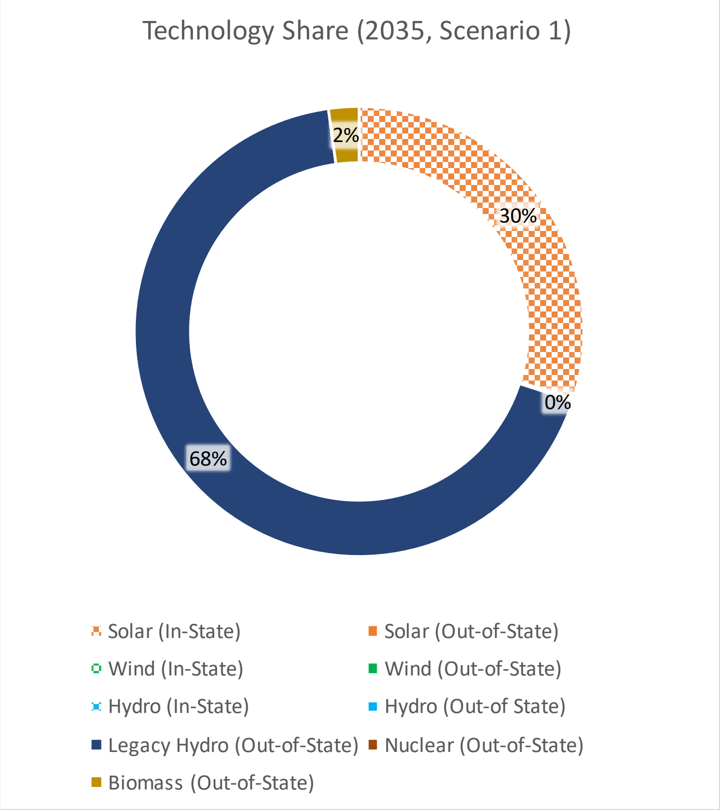
BAU has no regional tier ➔ in-state Solar used to meet Tier II; majority of Tier I met with Hydro

RES-Eligible Technology Deployment, Scenario 1



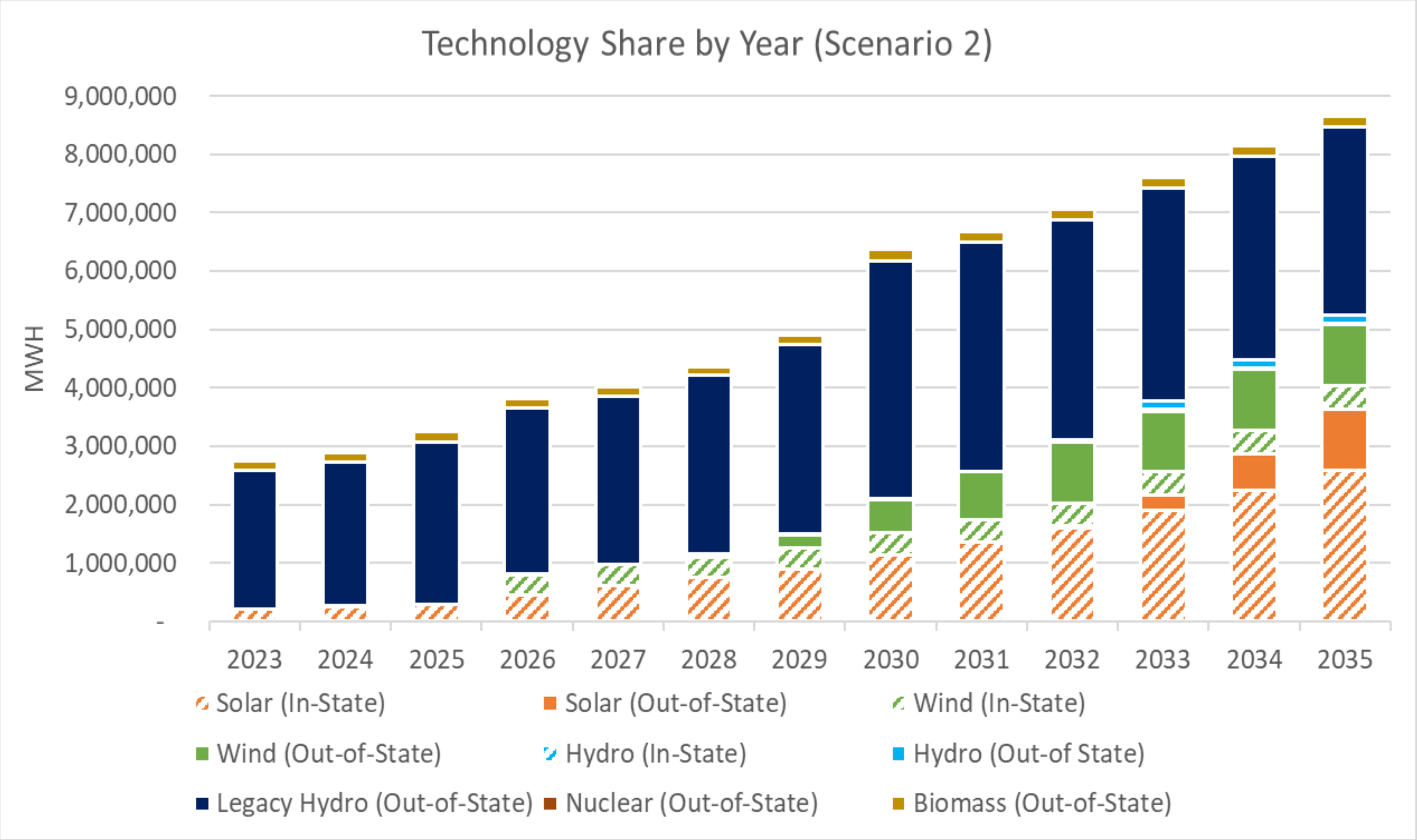
About this Scenario

Regional Tier Target	0%
Tier II Target	30%
Tier I Target	100% by 2030
Target Date	2035
Load Forecast	Base Load, Base Electrification
Nuclear Tier I Eligible?	No
Biomass Tier I Eligible?	Yes



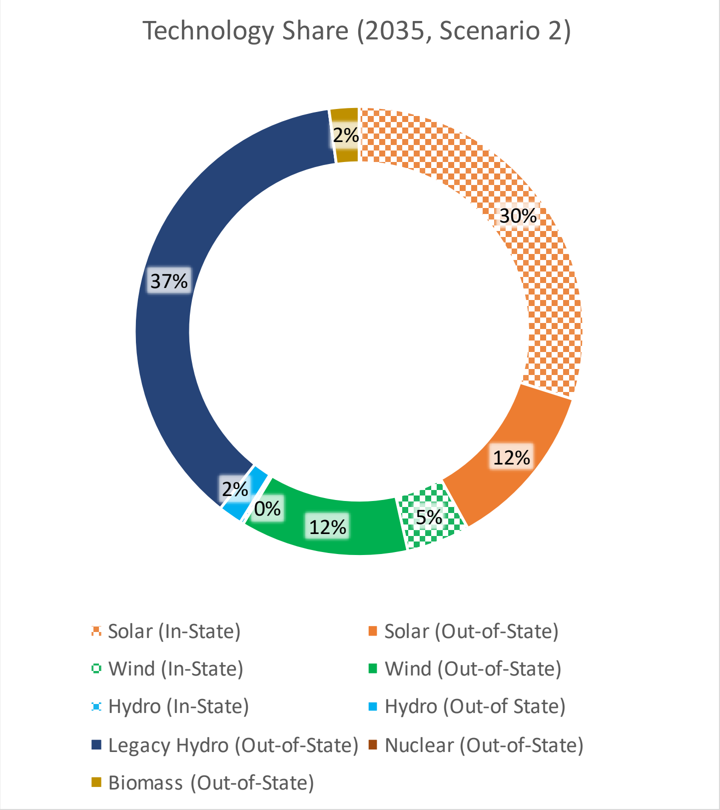
Scenario 1 has increases Tier II deployment and reaches 100% RES by 2035

RES-Eligible Technology Deployment, Scenario 2



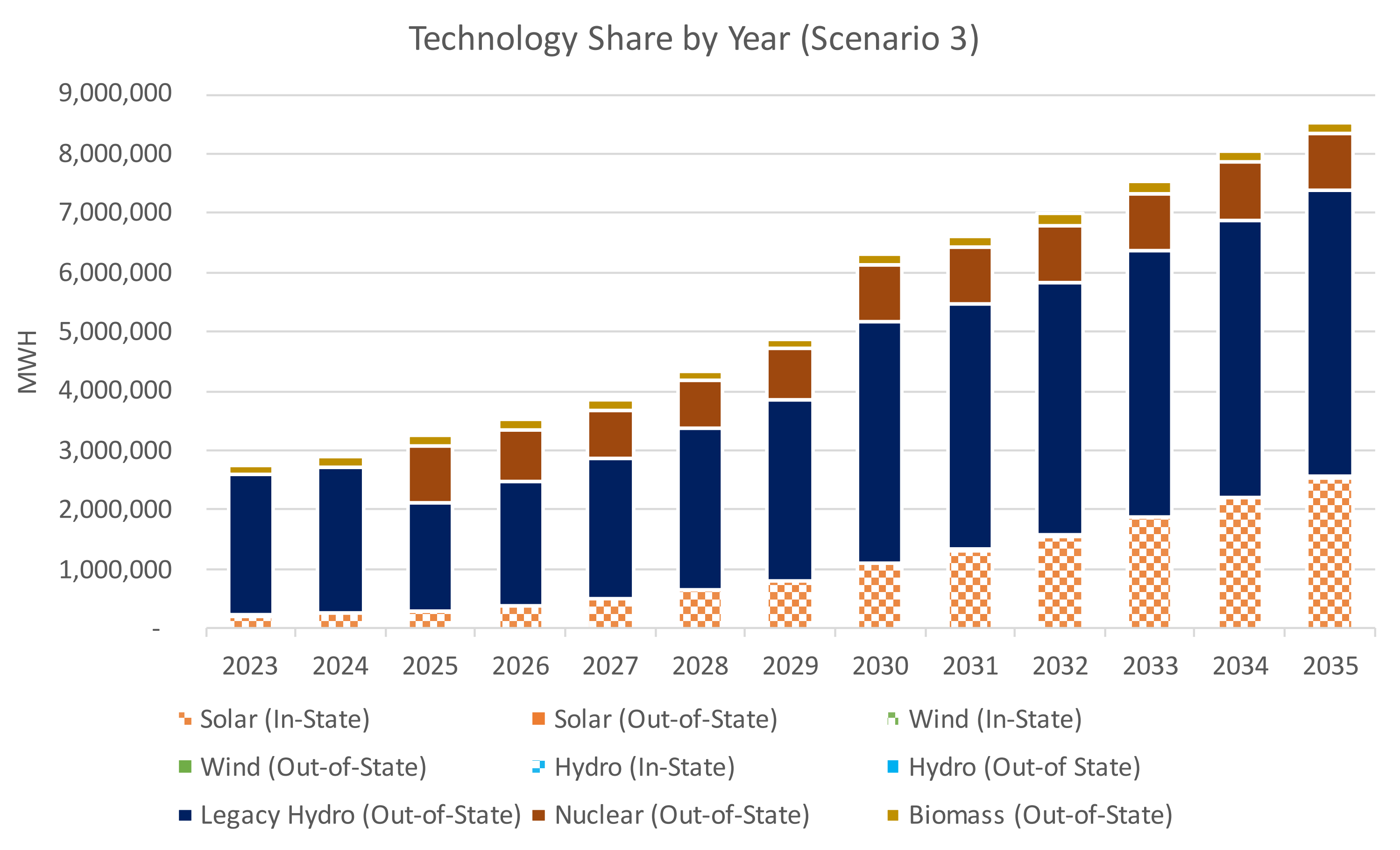
About this Scenario

Regional Tier Target	30%
Tier II Target	30%
Tier I Target	100% by 2030
Target Date	2035
Load Forecast	Base Load, Base Electrification
Nuclear Tier I Eligible?	No
Biomass Tier I Eligible?	Yes



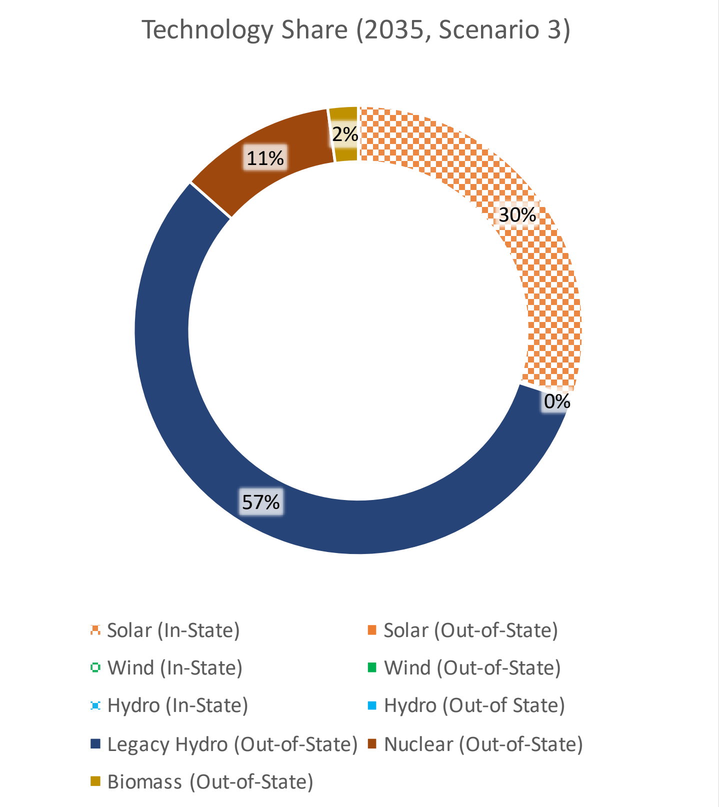
Scenario 2 introduces regional tier ➔ Addition of out-of-state RE

RES-Eligible Technology Deployment, Scenario 3



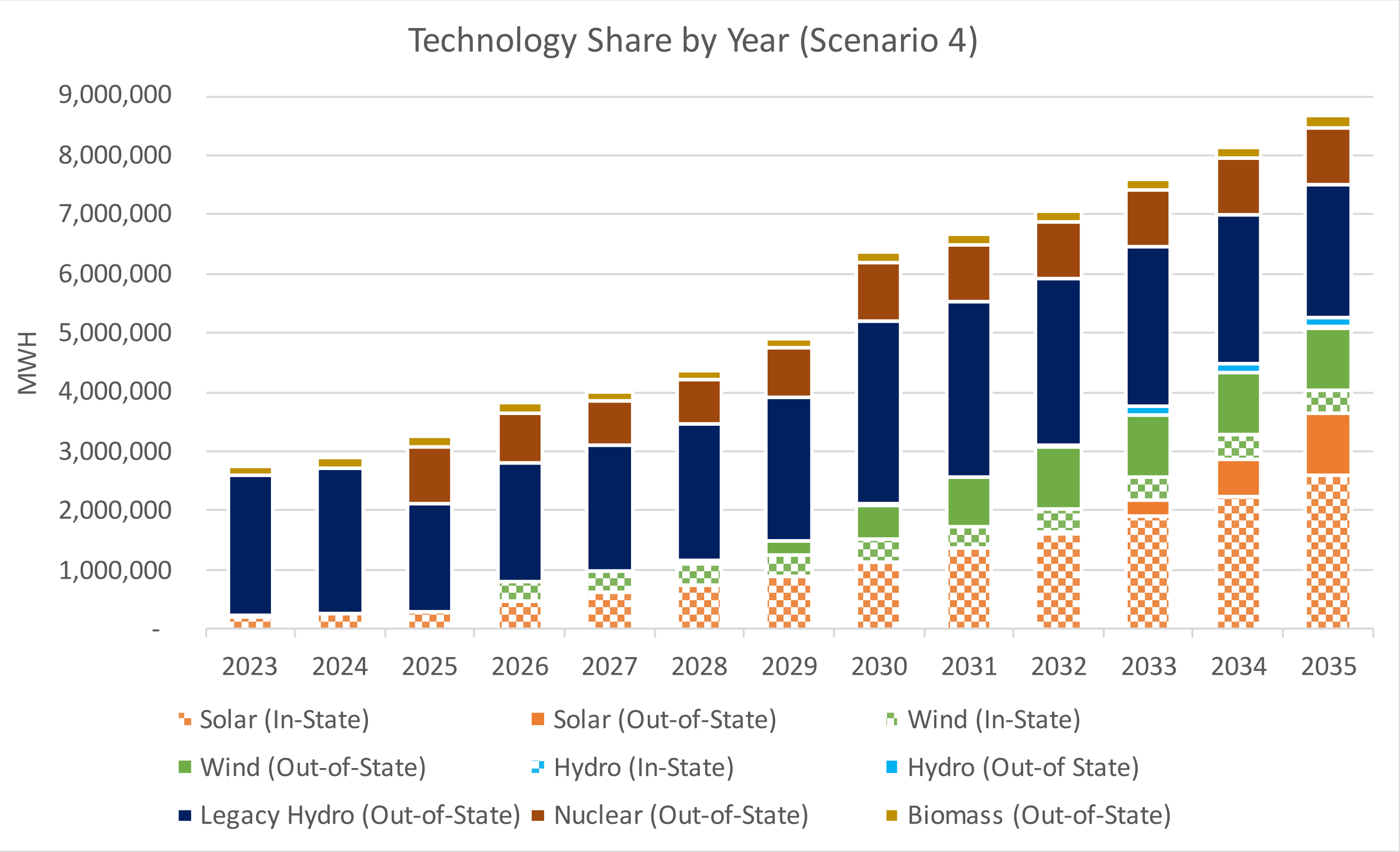
About this Scenario

Regional Tier Target	0%
Tier II Target	30%
Tier I Target	100% by 2030
Target Date	2035
Load Forecast	Base Load, Base Electrification
Nuclear Tier I Eligible?	Yes
Biomass Tier I Eligible?	Yes



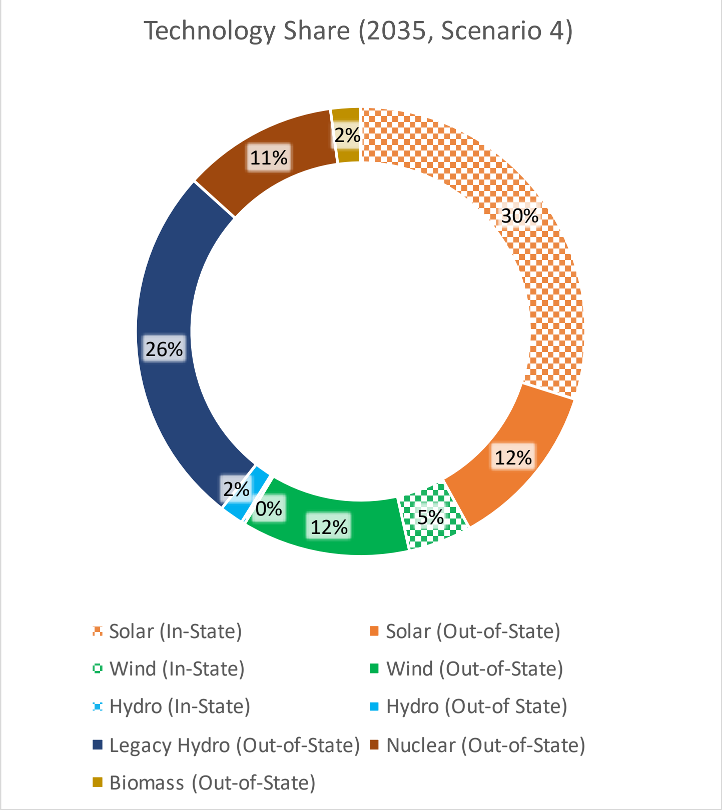
Scenario 3 removes regional tier, but adds Nuclear Eligibility to Tier I

RES-Eligible Technology Deployment, Scenario 4



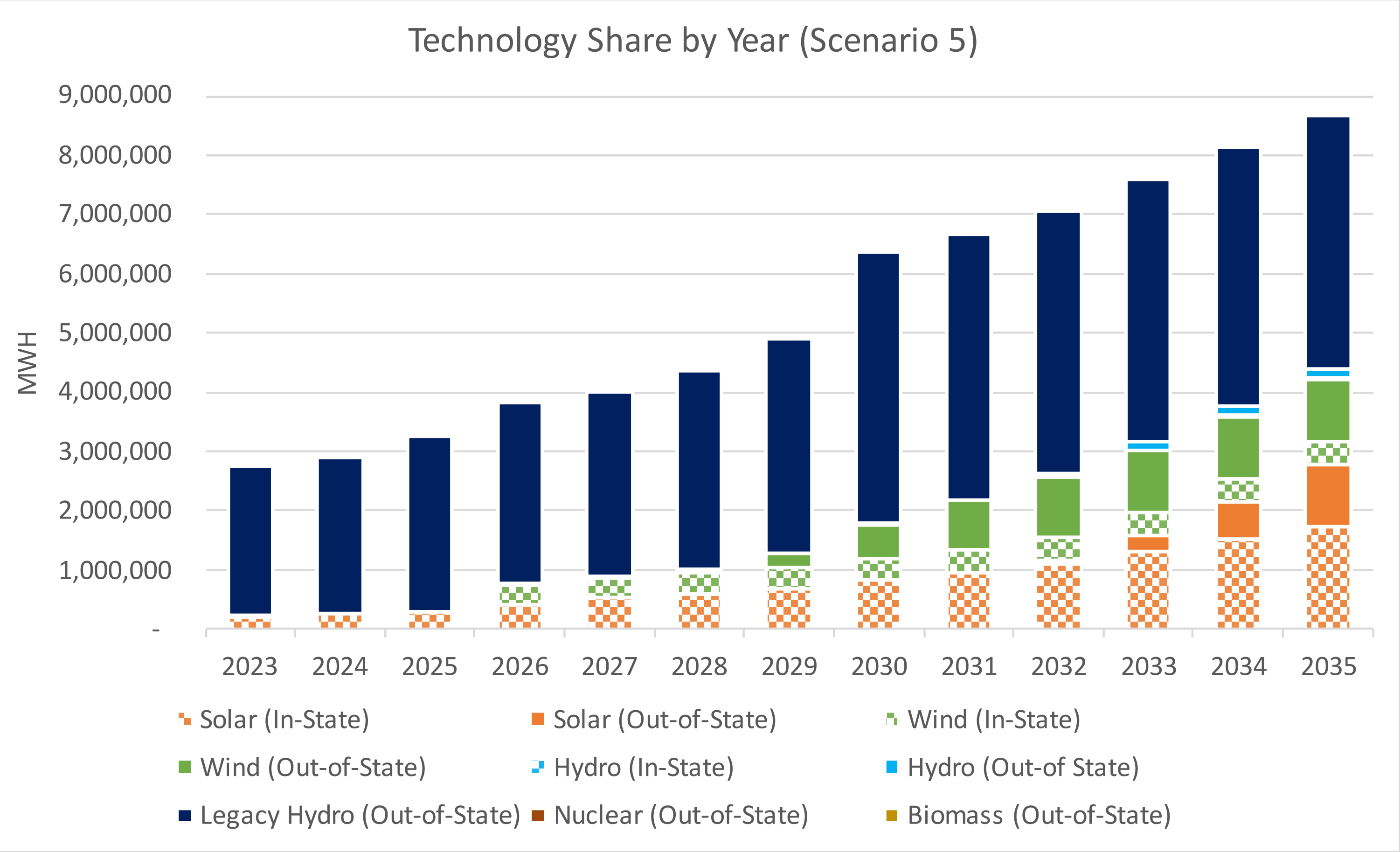
About this Scenario

Regional Tier Target	30%
Tier II Target	30%
Tier I Target	100% by 2030
Target Date	2035
Load Forecast	Base Load, Base Electrification
Nuclear Tier I Eligible?	Yes
Biomass Tier I Eligible?	Yes



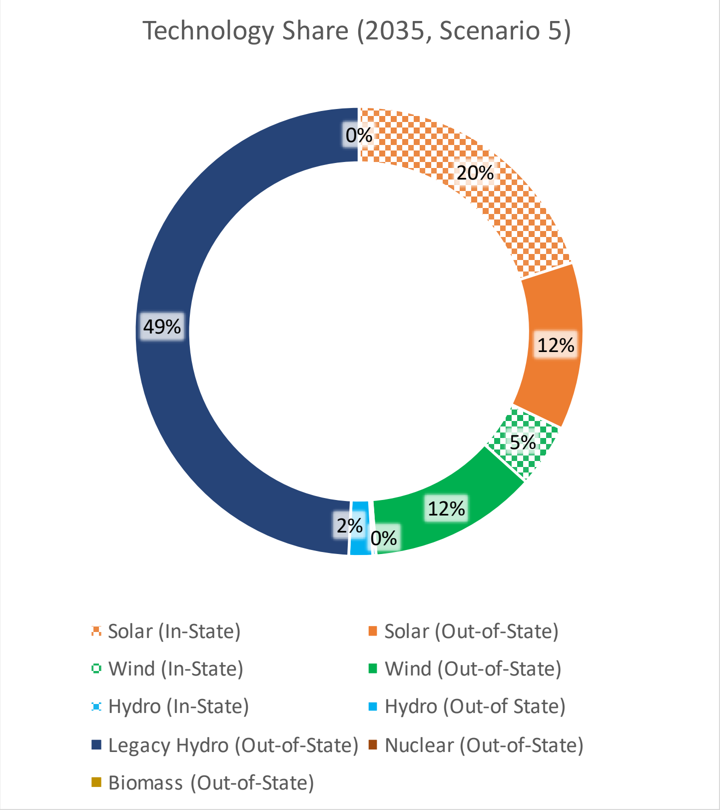
Scenario 4 includes regional tier, and adds Nuclear Eligibility to Tier I

RES-Eligible Technology Deployment, Scenario 5



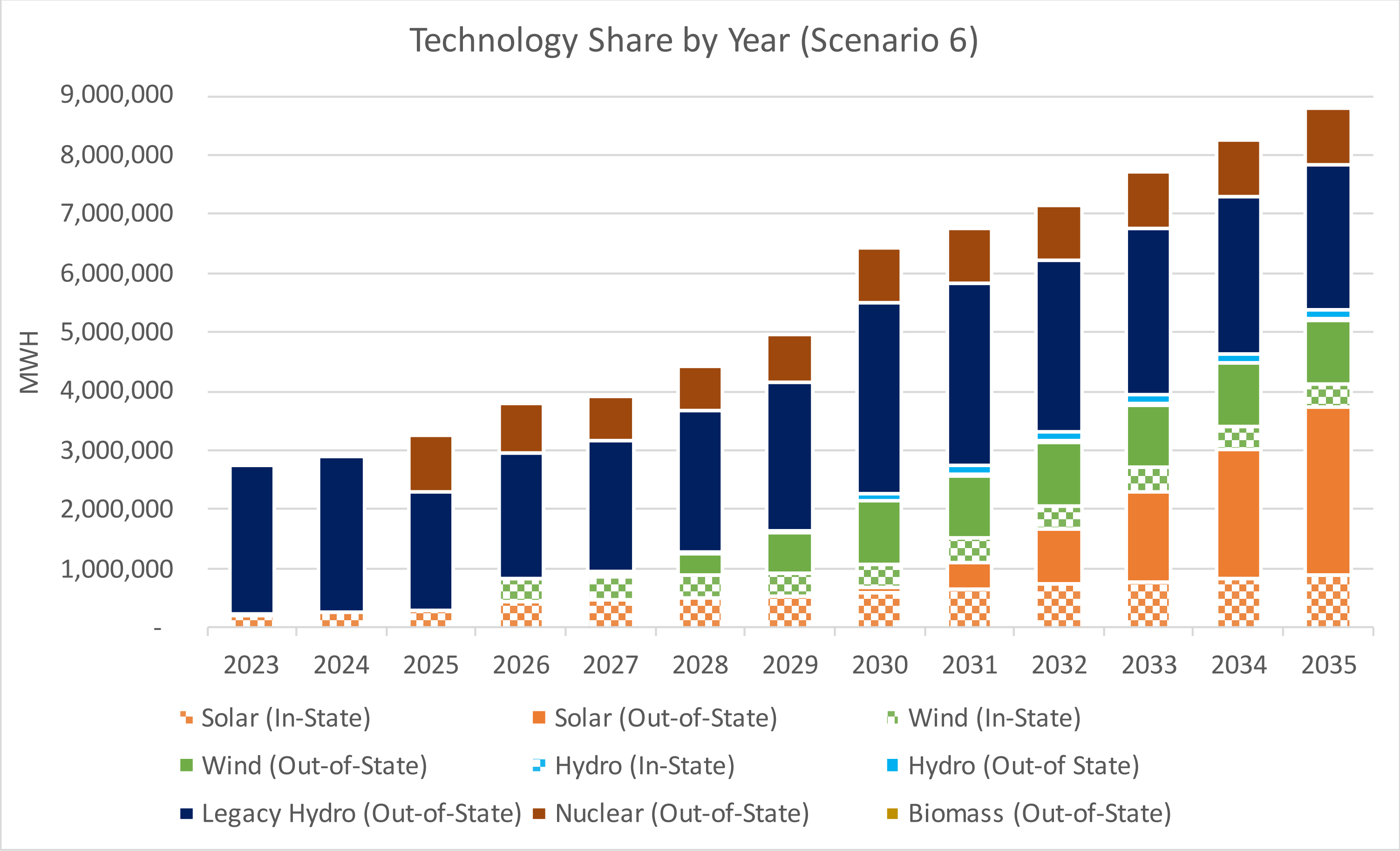
About this Scenario

Regional Tier Target	30%
Tier II Target	20%
Tier I Target	100% by 2030
Target Date	2035
Load Forecast	Base Load, Base Electrification
Nuclear Tier I Eligible?	No
Biomass Tier I Eligible?	No



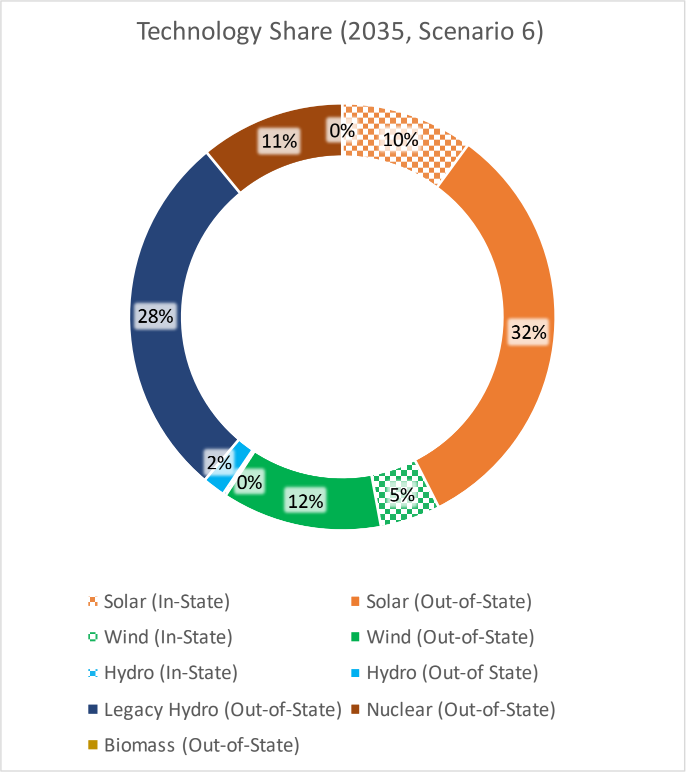
Scenario 5 scales back Tier II to 20% and removes Nuclear/Biomass Eligibility to Tier I

RES-Eligible Technology Deployment, Scenario 6



About this Scenario

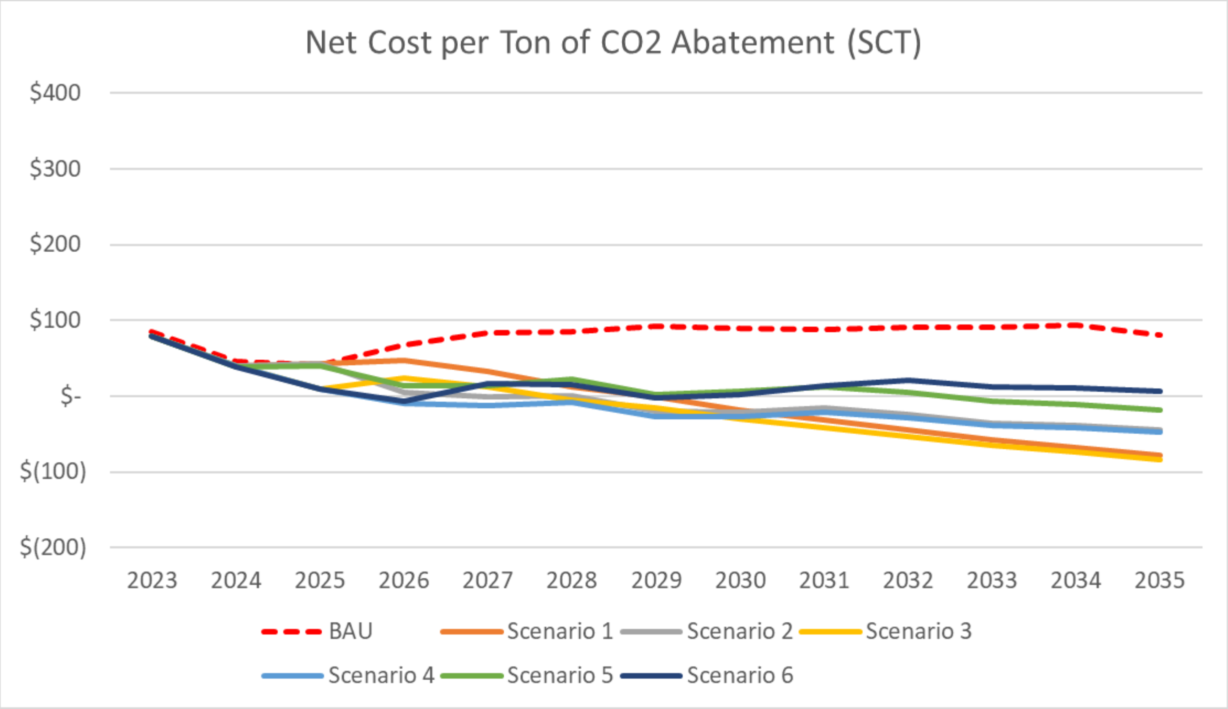
Regional Tier Target	50%
Tier II Target	10%
Tier I Target	100% by 2030
Target Date	2035
Load Forecast	Base Load, Base Electrification
Nuclear Tier I Eligible?	Yes
Biomass Tier I Eligible?	No

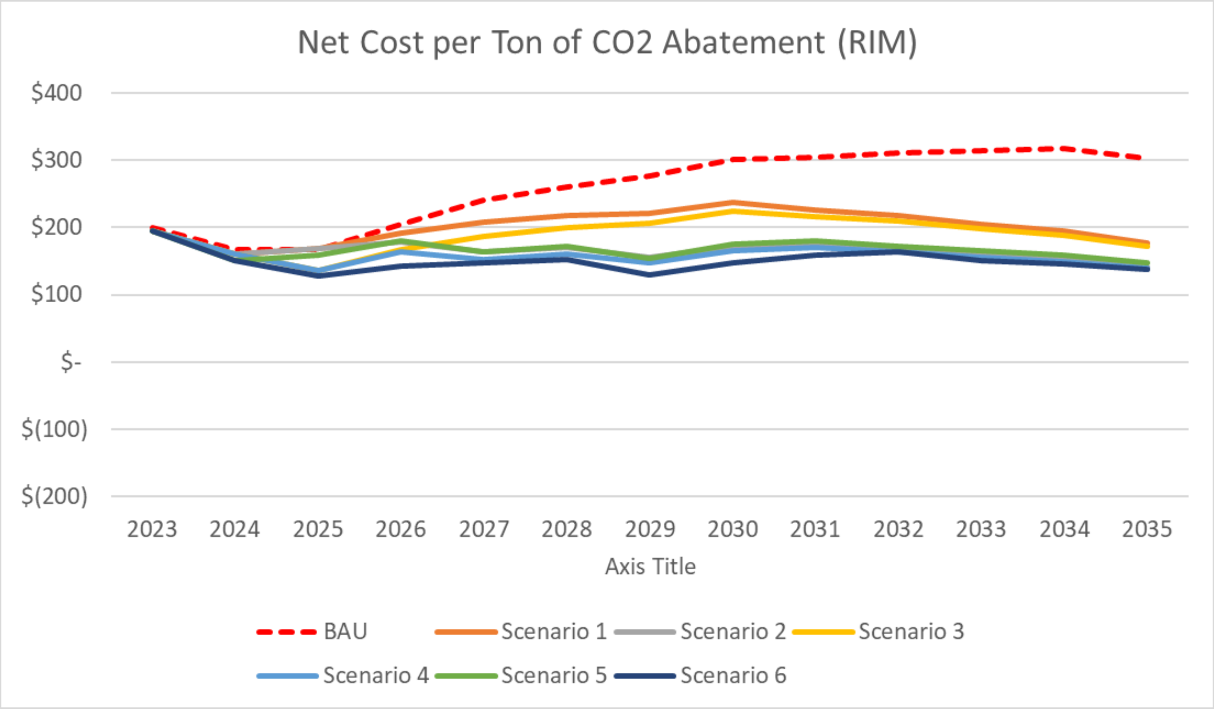


Scenario 6 has max Regional Tier → results in more out-of-state RE; also includes nuclear as eligible for Tier I, while removing Biomass

Cost of Carbon Abatement, by Scenario

- CO2 abatement reflects carbon emission reductions resulting from Tier II and Regional Tier resources (there is no reduction from Tier I resources)
- Results depict scenario-wide costs *net of benefits* for each test (but <u>excludes</u> GHG benefits for the SCT)
- As targets increase, net metering assumed to represent a smaller portion of the Tier II portfolio over time, resulting in a lower weighted average cost relative to BAU. This results in a lower cost of carbon abatement relative to BAU, for all scenarios
- Graphs below depict the unit-cost of a ton of CO2 abatement, by scenario



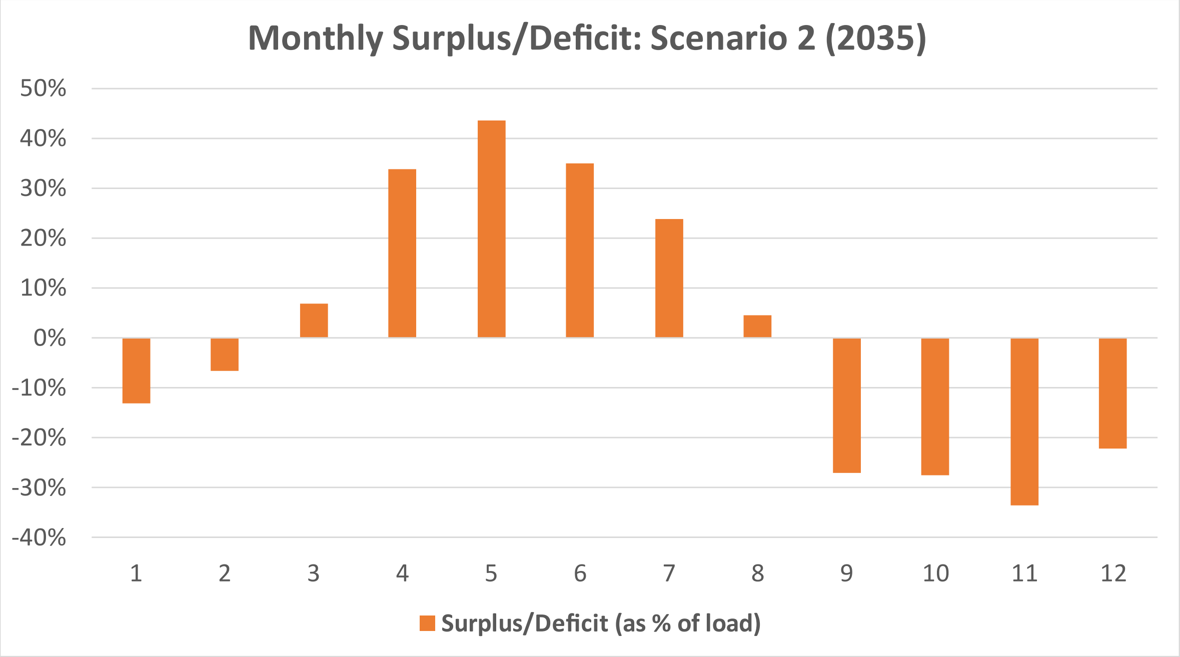


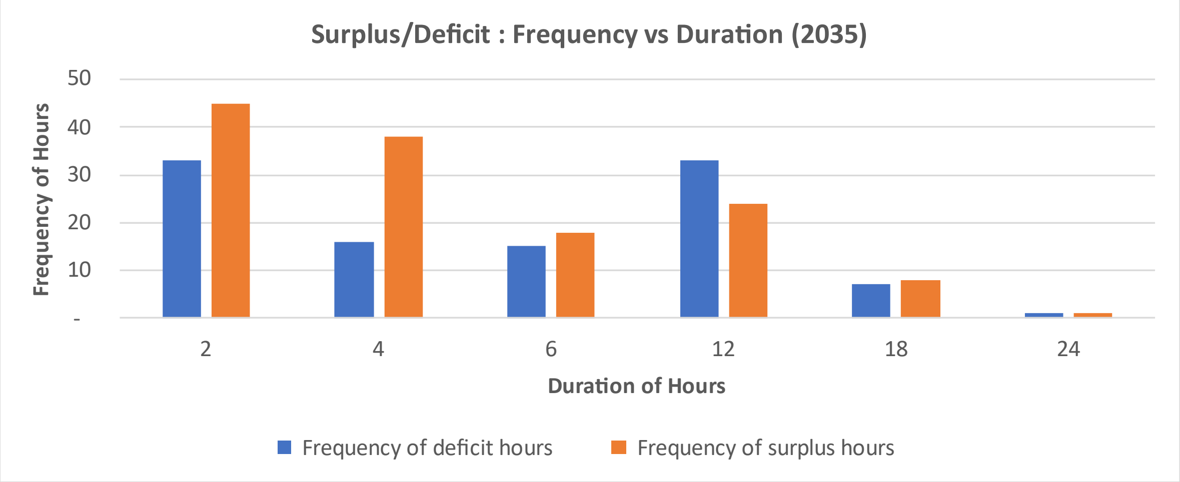
Variability of Load and Generation Underscores need for flexibility mechanisms to achieve 100% RES: **Scenario 2**

- VT RES (and all regional RPS) compliance is currently demonstrated on an annual basis.
- As policymakers consider quarterly, monthly, or hourly compliance, storage and load management options will be required to align generation and load

Surplus/Deficit Metrics, by Month, Scenario 2, 2035

Month	Total Surplus or Deficit (MWh)	Max hourly surplus (MW)	Surplus/ load during max surplus	Max hourly deficit (MW)	Deficit/ load during max deficit
1	(116,101)	1,121	103%	(1,165)	-73%
2	(51,153)	1,254	103%	(1,086)	-72%
3	54,234	1,666	180%	(1,408)	-95%
4	225,102	1,765	233%	(872)	-71%
5	276,164	1,956	272%	(1,138)	-99%
6	218,231	1,647	181%	(778)	-67%
7	161,586	1,801	226%	(1,279)	-98%
8	30,901	1,241	139%	(1,083)	-96%
9	(160,048)	1,042	123%	(1,166)	-92%
10	(186,464)	1,439	183%	(1,253)	-98%
11	(255,759)	1,022	102%	(1,447)	-99%
12	(196,692)	946	83%	(1,423)	-98%





Summary of Key Inputs & Assumptions

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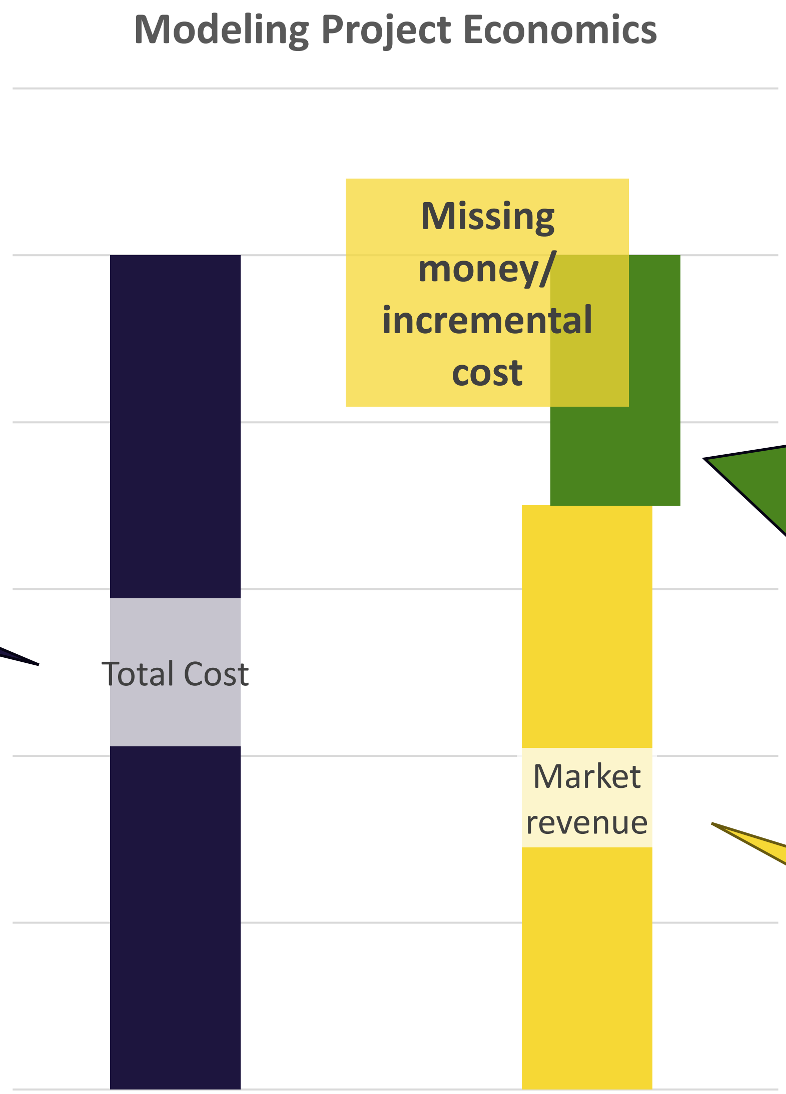
Approach to Modeling Incremental Cost of RE

Includes capital cost, development, O&M, financing, etc.



Missing Money = Difference between levelized costs and levelized market revenues.

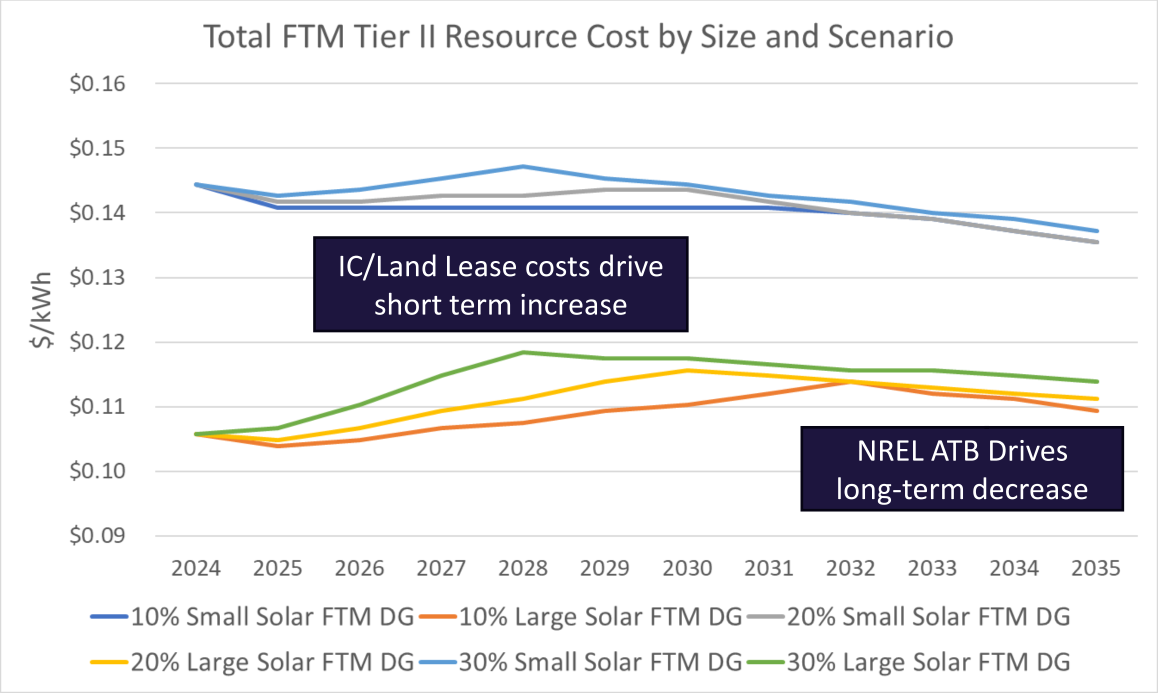
Represents the incremental cost (above ISO-NE system mix) of RES compliance.

For **Tier I and Regional Tier** the incremental cost is **equal to the forecasted, Tier-specific REC price**. For Tier II, incremental cost is calculated through resource-specific, bottom-up analysis (see following slides).

Technology production-weighted value of energy

Approach to Tier II Cost Modeling

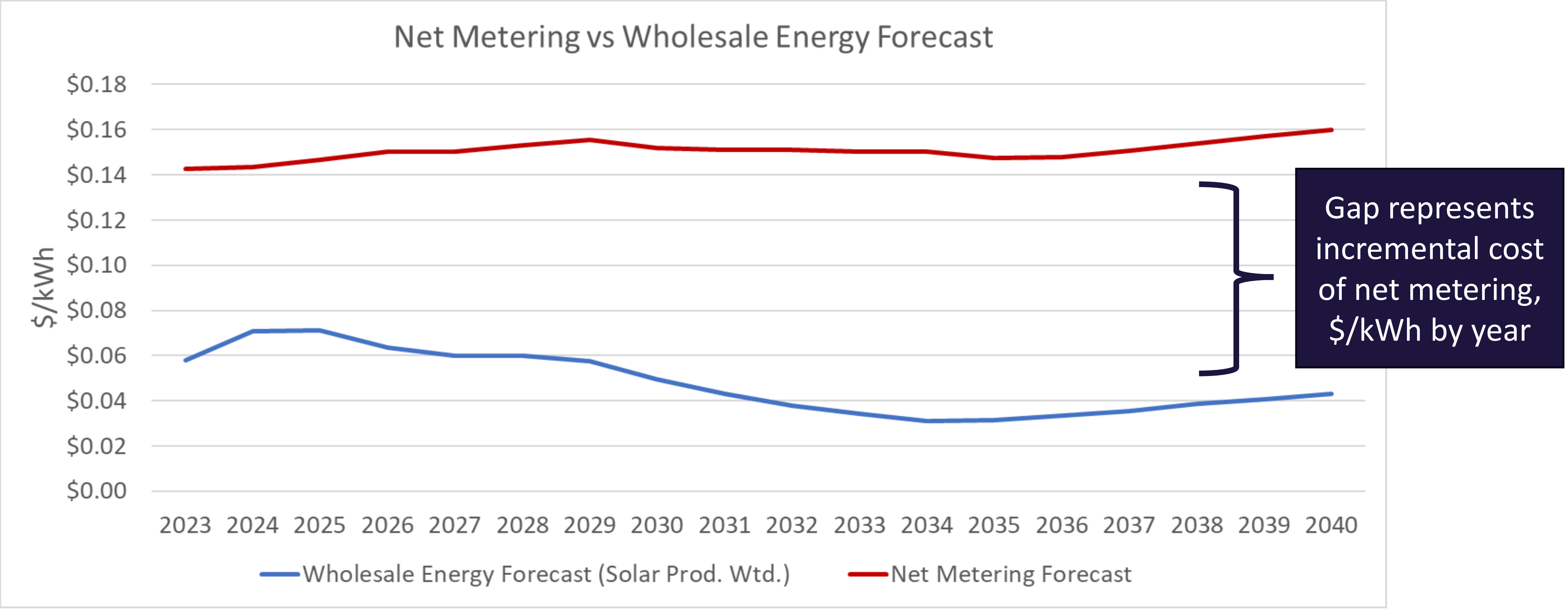
- Tier II incremental costs are modeled based on assumed policy incentives and trajectory:
  - Behind-the-meter (BTM) resources are assumed to participate in the net metering program ➔ Total Cost = forecasted net metering rate
  - Front-of-meter (FTM) resources are assumed subject to market competition (including utility procurement) ➔ Total cost = resource/year-specific revenue requirement derived from cash flow modeling
    - For historical deployment under the Standard Offer program, SEA models costs based on the weighted average bid price for each technology/program year
    - Net cost is constrained to the 95% of the Tier II ACP (implies project owners may need to take lower return in some cases)
- Total FTM resource cost ($/LCOE) is shown in the graph to the right (% in legend represents Tier II Target options modeled)
  - Capital cost assumptions informed by regional installed cost databases with focus on VT-adjacent areas (upstate NY, western MA)
  - Operating expense assumptions are informed by SEA's market research
- Resource cost over time is a function of the balance between:
  - NREL ATB cost curves (reflecting ***reductions*** in cost over time as technology matures)
  - Assumed ***increases*** in interconnection and land lease costs as DG reaches higher penetration in VT
    - Tier II scenarios with more aggressive deployment schedules ➔ faster ramp up of IC and land costs



Small Solar = 2.2 MW, Large Solar = 5 MW

Approach to Net Metering Cost Modeling

- Incremental cost = net metering rate forecast minus solar production-weighted wholesale value of energy
- See chart below. The ‘gap’ represents incremental cost of RES compliance via net metering.



Approach to Tier I and Regional Tier Cost Modeling

- **Tier I**
  - Incremental cost based on weighted average cost of certificates for eligible supply.
  - Existing (pre-RES) contracts for HQ and NYPA hydro supply assumed at $0 incremental costs.
  - When eligible, nuclear contributes to RES at $0 incremental cost, at quantity equal to existing contracts (including assumed expiration dates, by contract).
  - Weighted average Tier I incremental cost varies by case and year. The range of outcomes across all scenarios is summarized below for 2025, 2030, and 2035.

Tier I Range, $/MWh	2025	2030	2035
Min	$0.60	$1.88	$0.70
Max	$2.30	$3.75	$4.00

- **Regional Tier**
  - Regional Tier incremental cost varies by case and year. The range of outcomes across all scenarios is summarized below for 2025, 2030, and 2035.

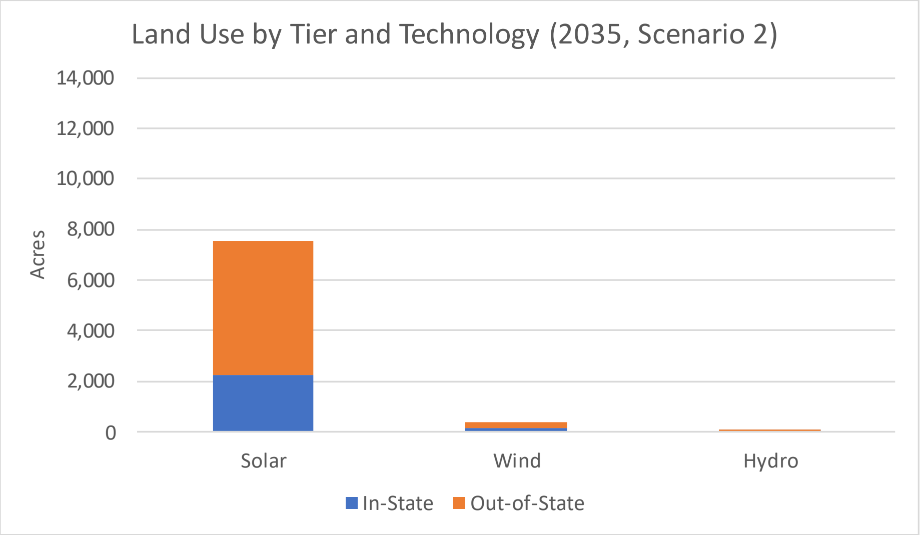
Regional Tier Range, $/MWh	2025	2030	2035
Min	$31.50	$37.00	$43.00
Max	$37.00	$37.00	$43.50

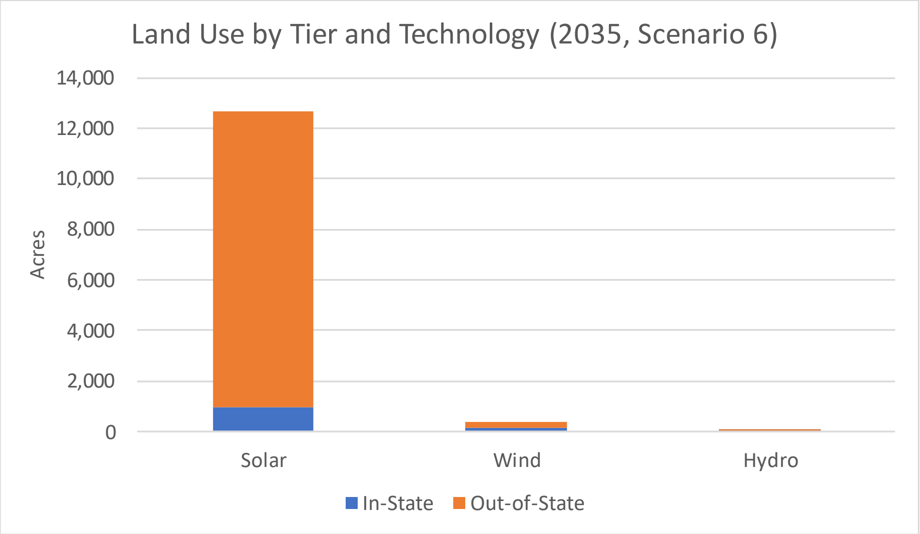
Land Use: Intensity by Technology & Impact by Scenario

- Assumed land use ‘capacity density’ by technology, acres per MW:

	Acre/MW	Source
Wind	10.00	PSD - Generation Scenarios Planning Tool
Solar	6.18	PSD - Generation Scenarios Planning Tool, adjusted for solar assumed roof-mounted (<50 kW)
Hydro	1.00	PSD - Generation Scenarios Planning Tool

- New resource deployment, and therefore land use impacts, vary by Scenario.
- Results shown at right are a function of both the *volume* of resources deployed and the *capacity density* of each resource
  - Since all scenarios involve significant solar deployment, and very modest deployment of other resources, most land use is associated with solar development
  - Results for Scenarios 2 and 6 are shown to the right.
- In practice, renewable energy siting will be shaped by state and local policy which will incent beneficial siting on already disturbed parcels





See tables in Appendix 4 for other Scenarios.

Assumptions Applied to All Scenarios/Sensitivities

- All targets reached by 2035
- RES-obligated load to include losses (required for a 100% target)
- For ‘100% renewable utilities,’ Tier I, Tier II, and Regional Tier RES requirements will be applied to load above 2019 “baseline”
- CES defined as “Tier I with Nuclear eligible”:
  - When eligible, quantity of nuclear contribution assumes equal to sum of all existing contracts for energy and certificates
  - Annual contribution of nuclear aligns with existing contract end dates
- Regional Tier Eligibility
  - All post-2010 solar and wind
  - Hydro currently certified for MA Class I
  - Biomass ineligible
  - Eligible supply under existing contractual commitments is assumed retained and retired for VT RES.
- Alternative Compliance Payments
  - Tier I and Tier II: methodology unchanged
  - Regional Tier: same as Tier II

Summary of Other Inputs & Assumptions

Category	Value	Unit	Source	Notes
Transmission integration costs	$5.71	$/MWh of gen.	NREL, Gorman	Applies to regional Tx-connected systems
VT load shape forecast	AESC		AESC	Used in calc of benefits re VT coincident peak.
Portion of Dx IC as benefit	25.00%	%	Estimate	Limited data available
Value of avoided distribution upgrades	$67.00	$/kW-year	Allocation of $87.40 T&D benefit used by VT in EE screening	2023 base year
Value of avoided transmission upgrades	$20.00	$/kW-year		2023 base year
RNS charge	$154.35	$/kW-year	2024 RNS rate sheet	Used to calculate reduced share of capacity costs
VT share of Regional MWh	4.00%	%	ISO-NE	Based on % of regional MWh
VT Share of Transmission Costs	4.10%	%	ISO-NE	Based on VT's highest MW as % of sum of other state's highest MW (used in RNS calcs)
VT share of Regional Annual System Peak	2.89%	%	ISO-NE	Based on share of annual system coincident peak
Marginal T&D Energy Losses	4.50%	%	AESC	
Marginal T&D Capacity Losses	8.00%	%	AESC	
Social cost of carbon	$128.00	$/Short Ton	AESC	
Inflation	3%	%/year		

Appendix 1

Comparative Results Tables: Societal Cost Test

Sustainable Energy Advantage, LLC

Scenario 1 : SCT (Incremental Costs & Benefits)

	Scenario Total	Regional Tier	Tier II	Tier I
BCR	2.20	0.00	2.36	0.00
Net Benefits (Total Benefits - Total Costs)	$381.32	$0.00	$402.39	($21.06)
Total Costs	$317.51	$0.00	$296.44	$21.06
Total Benefits	$698.83	$0.00	$698.83	$0.00
Incremental cost of RE	$317.51	$0.00	$296.44	$21.06
Transmission integration costs (Intrastate)	$0.00	$0.00	$0.00	$0.00
Transmission integration costs (ROP)	$0.00	$0.00	$0.00	$0.00
Interconnection upgrade benefits	$2.58	$0.00	$2.58	$0.00
Uncleared capacity value (Intrastate)	$1.11	$0.00	$1.11	$0.00
Uncleared capacity value (ROP)	$37.27	$0.00	$37.27	$0.00
Reduced Share of Capacity Costs	$0.00	$0.00	$0.00	$0.00
Price suppression - energy (Intrastate)	$1.92	$0.00	$1.92	$0.00
Price suppression - energy (ROP)	$72.76	$0.00	$72.76	$0.00
Price suppression - capacity (Intrastate)	$7.30	$0.00	$7.30	$0.00
Price suppression - capacity (ROP)	$283.38	$0.00	$283.38	$0.00
Price suppression - electric-gas (Intrastate)	$0.03	$0.00	$0.03	$0.00
Price suppression - electric-gas (ROP)	$1.44	$0.00	$1.44	$0.00
Price suppression - electric-gas-electric (Intrastate)	$0.68	$0.00	$0.68	$0.00
Price suppression - electric-gas-electric (ROP)	$31.22	$0.00	$31.22	$0.00
Reduced transmission costs (Intrastate)	$0.08	$0.00	$0.08	$0.00
Reduced transmission costs (ROP)	$1.91	$0.00	$1.91	$0.00
Reduced Share of Transmission Costs	$0.00	$0.00	$0.00	$0.00
Reduced distribution costs	$5.21	$0.00	$5.21	$0.00
Reduced T&D losses - capacity (Intrastate)	$4.85	$0.00	$4.85	$0.00
Reduced T&D losses - capacity (ROP)	$25.80	$0.00	$25.80	$0.00
Reduced T&D losses - energy (Intrastate)	$0.35	$0.00	$0.35	$0.00
Reduced T&D losses - energy (ROP)	$13.60	$0.00	$13.60	$0.00
Improved generation reliability (Intrastate)	$0.46	$0.00	$0.46	$0.00
Improved generation reliability (ROP)	$9.96	$0.00	$9.96	$0.00
Non-embedded GHG emissions	$177.19	$0.00	$177.19	$0.00
NOx emissions	$2.59	$0.00	$2.59	$0.00
Local pollutants	$17.14	$0.00	$17.14	$0.00

	Regional Tier Target	Tier II Target	Tier I Target	Target Date	Nuclear Tier I Eligible?	Biomass Tier I Eligible?
Scenario 1	0%	30%	100% by 2030	2035	No	Yes

Scenario 2 : SCT (Incremental Costs & Benefits)

	Scenario Total	Regional Tier	Tier II	Tier I
BCR	2.29	2.17	2.36	0.00
Net Benefits (Total Benefits - Total Costs)	$851.30	$437.21	$402.39	$11.70
Total Costs	$658.88	$374.13	$296.44	($11.70)
Total Benefits	$1,510.18	$811.35	$698.83	$0.00
Incremental cost of RE	$605.35	$320.60	$296.44	($11.70)
Transmission integration costs (Intrastate)	$2.18	$2.18	$0.00	$0.00
Transmission integration costs (ROP)	$51.35	$51.35	$0.00	$0.00
Interconnection upgrade benefits	$2.69	$0.11	$2.58	$0.00
Uncleared capacity value (Intrastate)	$1.14	$0.03	$1.11	$0.00
Uncleared capacity value (ROP)	$38.29	$1.02	$37.27	$0.00
Reduced Share of Capacity Costs	$0.00	$0.00	$0.00	$0.00
Price suppression - energy (Intrastate)	$6.34	$4.42	$1.92	$0.00
Price suppression - energy (ROP)	$243.86	$171.10	$72.76	$0.00
Price suppression - capacity (Intrastate)	$8.06	$0.77	$7.30	$0.00
Price suppression - capacity (ROP)	$323.28	$39.90	$283.38	$0.00
Price suppression - electric-gas (Intrastate)	$0.12	$0.08	$0.03	$0.00
Price suppression - electric-gas (ROP)	$4.68	$3.25	$1.44	$0.00
Price suppression - electric-gas-electric (Intrastate)	$1.92	$1.24	$0.68	$0.00
Price suppression - electric-gas-electric (ROP)	$81.23	$50.01	$31.22	$0.00
Reduced transmission costs (Intrastate)	$1.59	$1.51	$0.08	$0.00
Reduced transmission costs (ROP)	$37.47	$35.56	$1.91	$0.00
Reduced Share of Transmission Costs	$0.00	$0.00	$0.00	$0.00
Reduced distribution costs	$5.86	$0.65	$5.21	$0.00
Reduced T&D losses - capacity (Intrastate)	$6.57	$1.72	$4.85	$0.00
Reduced T&D losses - capacity (ROP)	$27.06	$1.25	$25.80	$0.00
Reduced T&D losses - energy (Intrastate)	$0.51	$0.16	$0.35	$0.00
Reduced T&D losses - energy (ROP)	$14.56	$0.96	$13.60	$0.00
Improved generation reliability (Intrastate)	$0.50	$0.04	$0.46	$0.00
Improved generation reliability (ROP)	$10.91	$0.95	$9.96	$0.00
Non-embedded GHG emissions	$606.88	$429.69	$177.19	$0.00
NOx emissions	$10.12	$7.52	$2.59	$0.00
Local pollutants	$76.53	$59.39	$17.14	$0.00

	Regional Tier Target	Tier II Target	Tier I Target	Target Date	Nuclear Tier I Eligible?	Biomass Tier I Eligible?
Scenario 2	30%	30%	100% by 2030	2035	No	Yes

Scenario 3 : SCT (Incremental Costs & Benefits)

	Scenario Total	Regional Tier	Tier II	Tier I
BCR	2.44	0.00	2.36	0.00
Net Benefits (Total Benefits - Total Costs)	$412.97	$0.00	$402.39	$10.58
Total Costs	$285.86	$0.00	$296.44	($10.58)
Total Benefits	$698.83	$0.00	$698.83	$0.00
Incremental cost of RE	$285.86	$0.00	$296.44	($10.58)
Transmission integration costs (Intrastate)	$0.00	$0.00	$0.00	$0.00
Transmission integration costs (ROP)	$0.00	$0.00	$0.00	$0.00
Interconnection upgrade benefits	$2.58	$0.00	$2.58	$0.00
Uncleared capacity value (Intrastate)	$1.11	$0.00	$1.11	$0.00
Uncleared capacity value (ROP)	$37.27	$0.00	$37.27	$0.00
Reduced Share of Capacity Costs	$0.00	$0.00	$0.00	$0.00
Price suppression - energy (Intrastate)	$1.92	$0.00	$1.92	$0.00
Price suppression - energy (ROP)	$72.76	$0.00	$72.76	$0.00
Price suppression - capacity (Intrastate)	$7.30	$0.00	$7.30	$0.00
Price suppression - capacity (ROP)	$283.38	$0.00	$283.38	$0.00
Price suppression - electric-gas (Intrastate)	$0.03	$0.00	$0.03	$0.00
Price suppression - electric-gas (ROP)	$1.44	$0.00	$1.44	$0.00
Price suppression - electric-gas-electric (Intrastate)	$0.68	$0.00	$0.68	$0.00
Price suppression - electric-gas-electric (ROP)	$31.22	$0.00	$31.22	$0.00
Reduced transmission costs (Intrastate)	$0.08	$0.00	$0.08	$0.00
Reduced transmission costs (ROP)	$1.91	$0.00	$1.91	$0.00
Reduced Share of Transmission Costs	$0.00	$0.00	$0.00	$0.00
Reduced distribution costs	$5.21	$0.00	$5.21	$0.00
Reduced T&D losses - capacity (Intrastate)	$4.85	$0.00	$4.85	$0.00
Reduced T&D losses - capacity (ROP)	$25.80	$0.00	$25.80	$0.00
Reduced T&D losses - energy (Intrastate)	$0.35	$0.00	$0.35	$0.00
Reduced T&D losses - energy (ROP)	$13.60	$0.00	$13.60	$0.00
Improved generation reliability (Intrastate)	$0.46	$0.00	$0.46	$0.00
Improved generation reliability (ROP)	$9.96	$0.00	$9.96	$0.00
Non-embedded GHG emissions	$177.19	$0.00	$177.19	$0.00
NOx emissions	$2.59	$0.00	$2.59	$0.00
Local pollutants	$17.14	$0.00	$17.14	$0.00

	Regional Tier Target	Tier II Target	Tier I Target	Target Date	Nuclear Tier I Eligible?	Biomass Tier I Eligible?
Scenario 3	0%	30%	100% by 2030	2035	Yes	Yes

Scenario 4: SCT (Incremental Costs & Benefits)

	Scenario Total	Regional Tier	Tier II	Tier I
BCR	2.40	2.17	2.36	0.00
Net Benefits (Total Benefits - Total Costs)	$882.21	$437.21	$402.39	$42.61
Total Costs	$627.97	$374.13	$296.44	($42.61)
Total Benefits	$1,510.18	$811.35	$698.83	$0.00
Incremental cost of RE	$574.44	$320.60	$296.44	($42.61)
Transmission integration costs (Intrastate)	$2.18	$2.18	$0.00	$0.00
Transmission integration costs (ROP)	$51.35	$51.35	$0.00	$0.00
Interconnection upgrade benefits	$2.69	$0.11	$2.58	$0.00
Uncleared capacity value (Intrastate)	$1.14	$0.03	$1.11	$0.00
Uncleared capacity value (ROP)	$38.29	$1.02	$37.27	$0.00
Reduced Share of Capacity Costs	$0.00	$0.00	$0.00	$0.00
Price suppression - energy (Intrastate)	$6.34	$4.42	$1.92	$0.00
Price suppression - energy (ROP)	$243.86	$171.10	$72.76	$0.00
Price suppression - capacity (Intrastate)	$8.06	$0.77	$7.30	$0.00
Price suppression - capacity (ROP)	$323.28	$39.90	$283.38	$0.00
Price suppression - electric-gas (Intrastate)	$0.12	$0.08	$0.03	$0.00
Price suppression - electric-gas (ROP)	$4.68	$3.25	$1.44	$0.00
Price suppression - electric-gas-electric (Intrastate)	$1.92	$1.24	$0.68	$0.00
Price suppression - electric-gas-electric (ROP)	$81.23	$50.01	$31.22	$0.00
Reduced transmission costs (Intrastate)	$1.59	$1.51	$0.08	$0.00
Reduced transmission costs (ROP)	$37.47	$35.56	$1.91	$0.00
Reduced Share of Transmission Costs	$0.00	$0.00	$0.00	$0.00
Reduced distribution costs	$5.86	$0.65	$5.21	$0.00
Reduced T&D losses - capacity (Intrastate)	$6.57	$1.72	$4.85	$0.00
Reduced T&D losses - capacity (ROP)	$27.06	$1.25	$25.80	$0.00
Reduced T&D losses - energy (Intrastate)	$0.51	$0.16	$0.35	$0.00
Reduced T&D losses - energy (ROP)	$14.56	$0.96	$13.60	$0.00
Improved generation reliability (Intrastate)	$0.50	$0.04	$0.46	$0.00
Improved generation reliability (ROP)	$10.91	$0.95	$9.96	$0.00
Non-embedded GHG emissions	$606.88	$429.69	$177.19	$0.00
NOx emissions	$10.12	$7.52	$2.59	$0.00
Local pollutants	$76.53	$59.39	$17.14	$0.00

	Regional Tier Target	Tier II Target	Tier I Target	Target Date	Nuclear Tier I Eligible?	Biomass Tier I Eligible?
Scenario 4	30%	30%	100% by 2030	2035	Yes	Yes

Scenario 5: SCT (Incremental Costs & Benefits)

	Scenario Total	Regional Tier	Tier II	Tier I
BCR	2.18	2.17	2.21	0.00
Net Benefits (Total Benefits - Total Costs)	$624.39	$437.21	$186.47	$0.71
Total Costs	$527.48	$374.13	$154.05	($0.71)
Total Benefits	$1,151.87	$811.35	$340.52	$0.00
Incremental cost of RE	$473.95	$320.60	$154.05	($0.71)
Transmission integration costs (Intrastate)	$2.18	$2.18	$0.00	$0.00
Transmission integration costs (ROP)	$51.35	$51.35	$0.00	$0.00
Interconnection upgrade benefits	$1.36	$0.11	$1.25	$0.00
Uncleared capacity value (Intrastate)	$0.58	$0.03	$0.55	$0.00
Uncleared capacity value (ROP)	$19.50	$1.02	$18.47	$0.00
Reduced Share of Capacity Costs	$0.00	$0.00	$0.00	$0.00
Price suppression - energy (Intrastate)	$5.37	$4.42	$0.95	$0.00
Price suppression - energy (ROP)	$207.42	$171.10	$36.32	$0.00
Price suppression - capacity (Intrastate)	$4.17	$0.77	$3.41	$0.00
Price suppression - capacity (ROP)	$172.33	$39.90	$132.43	$0.00
Price suppression - electric-gas (Intrastate)	$0.10	$0.08	$0.02	$0.00
Price suppression - electric-gas (ROP)	$3.95	$3.25	$0.71	$0.00
Price suppression - electric-gas-electric (Intrastate)	$1.58	$1.24	$0.34	$0.00
Price suppression - electric-gas-electric (ROP)	$65.35	$50.01	$15.34	$0.00
Reduced transmission costs (Intrastate)	$1.55	$1.51	$0.04	$0.00
Reduced transmission costs (ROP)	$36.54	$35.56	$0.97	$0.00
Reduced Share of Transmission Costs	$0.00	$0.00	$0.00	$0.00
Reduced distribution costs	$3.98	$0.65	$3.33	$0.00
Reduced T&D losses - capacity (Intrastate)	$4.18	$1.72	$2.46	$0.00
Reduced T&D losses - capacity (ROP)	$13.40	$1.25	$12.15	$0.00
Reduced T&D losses - energy (Intrastate)	$0.37	$0.16	$0.21	$0.00
Reduced T&D losses - energy (ROP)	$7.79	$0.96	$6.83	$0.00
Improved generation reliability (Intrastate)	$0.28	$0.04	$0.23	$0.00
Improved generation reliability (ROP)	$6.00	$0.95	$5.05	$0.00
Non-embedded GHG emissions	$518.83	$429.69	$89.14	$0.00
NOx emissions	$8.85	$7.52	$1.33	$0.00
Local pollutants	$68.38	$59.39	$8.99	$0.00

	Regional Tier Target	Tier II Target	Tier I Target	Target Date	Nuclear Tier I Eligible?	Biomass Tier I Eligible?
Scenario 5	30%	20%	100% by 2030	2035	No	No

Scenario 6: SCT (Incremental Costs & Benefits)

	Scenario Total	Regional Tier	Tier II	Tier I
BCR	2.22	2.09	1.66	0.00
Net Benefits (Total Benefits - Total Costs)	$749.32	$686.19	$19.66	$43.47
Total Costs	$615.12	$628.91	$29.68	($43.47)
Total Benefits	$1,364.44	$1,315.10	$49.33	$0.00
Incremental cost of RE	$531.38	$545.17	$29.68	($43.47)
Transmission integration costs (Intrastate)	$3.41	$3.41	$0.00	$0.00
Transmission integration costs (ROP)	$80.33	$80.33	$0.00	$0.00
Interconnection upgrade benefits	$0.30	$0.14	$0.16	$0.00
Uncleared capacity value (Intrastate)	$0.14	$0.05	$0.09	$0.00
Uncleared capacity value (ROP)	$4.58	$1.67	$2.91	$0.00
Reduced Share of Capacity Costs	$0.00	$0.00	$0.00	$0.00
Price suppression - energy (Intrastate)	$7.74	$7.57	$0.17	$0.00
Price suppression - energy (ROP)	$300.37	$293.72	$6.65	$0.00
Price suppression - capacity (Intrastate)	$1.74	$1.42	$0.32	$0.00
Price suppression - capacity (ROP)	$83.79	$71.31	$12.48	$0.00
Price suppression - electric-gas (Intrastate)	$0.14	$0.13	$0.00	$0.00
Price suppression - electric-gas (ROP)	$5.51	$5.39	$0.12	$0.00
Price suppression - electric-gas-electric (Intrastate)	$2.24	$2.19	$0.05	$0.00
Price suppression - electric-gas-electric (ROP)	$90.19	$87.95	$2.24	$0.00
Reduced transmission costs (Intrastate)	$1.91	$1.90	$0.01	$0.00
Reduced transmission costs (ROP)	$45.09	$44.90	$0.19	$0.00
Reduced Share of Transmission Costs	$0.00	$0.00	$0.00	$0.00
Reduced distribution costs	$2.43	$0.99	$1.44	$0.00
Reduced T&D losses - capacity (Intrastate)	$3.62	$3.17	$0.45	$0.00
Reduced T&D losses - capacity (ROP)	$3.54	$2.29	$1.25	$0.00
Reduced T&D losses - energy (Intrastate)	$0.36	$0.29	$0.07	$0.00
Reduced T&D losses - energy (ROP)	$2.89	$1.65	$1.25	$0.00
Improved generation reliability (Intrastate)	$0.12	$0.08	$0.03	$0.00
Improved generation reliability (ROP)	$2.56	$1.81	$0.75	$0.00
Non-embedded GHG emissions	$699.65	$683.35	$16.30	$0.00
NOx emissions	$11.84	$11.57	$0.27	$0.00
Local pollutants	$93.69	$91.57	$2.13	$0.00

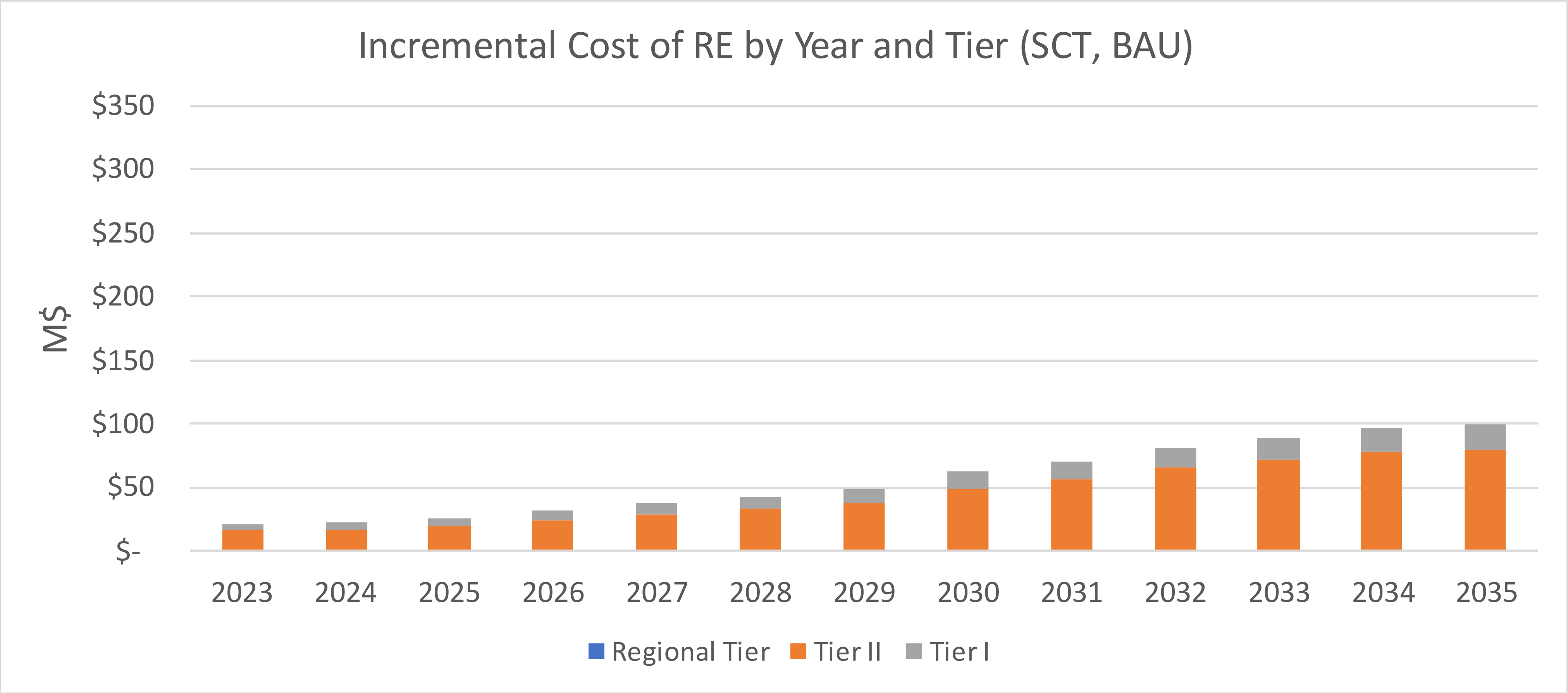
	Regional Tier Target	Tier II Target	Tier I Target	Target Date	Nuclear Tier I Eligible?	Biomass Tier I Eligible?
Scenario 6	50%	10%	100% by 2030	2035	Yes	No

Appendix 2

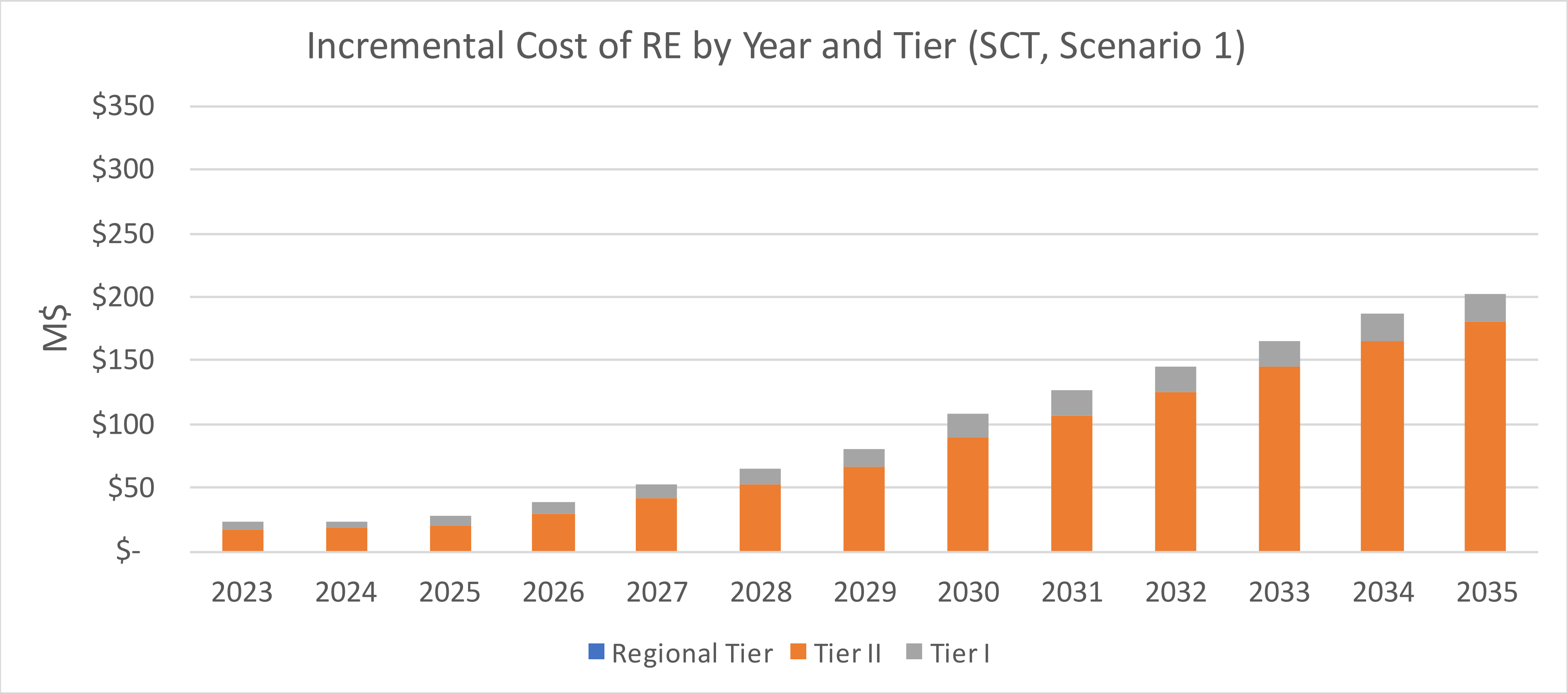
Incremental Costs by Year/Scenario

Sustainable Energy Advantage, LLC

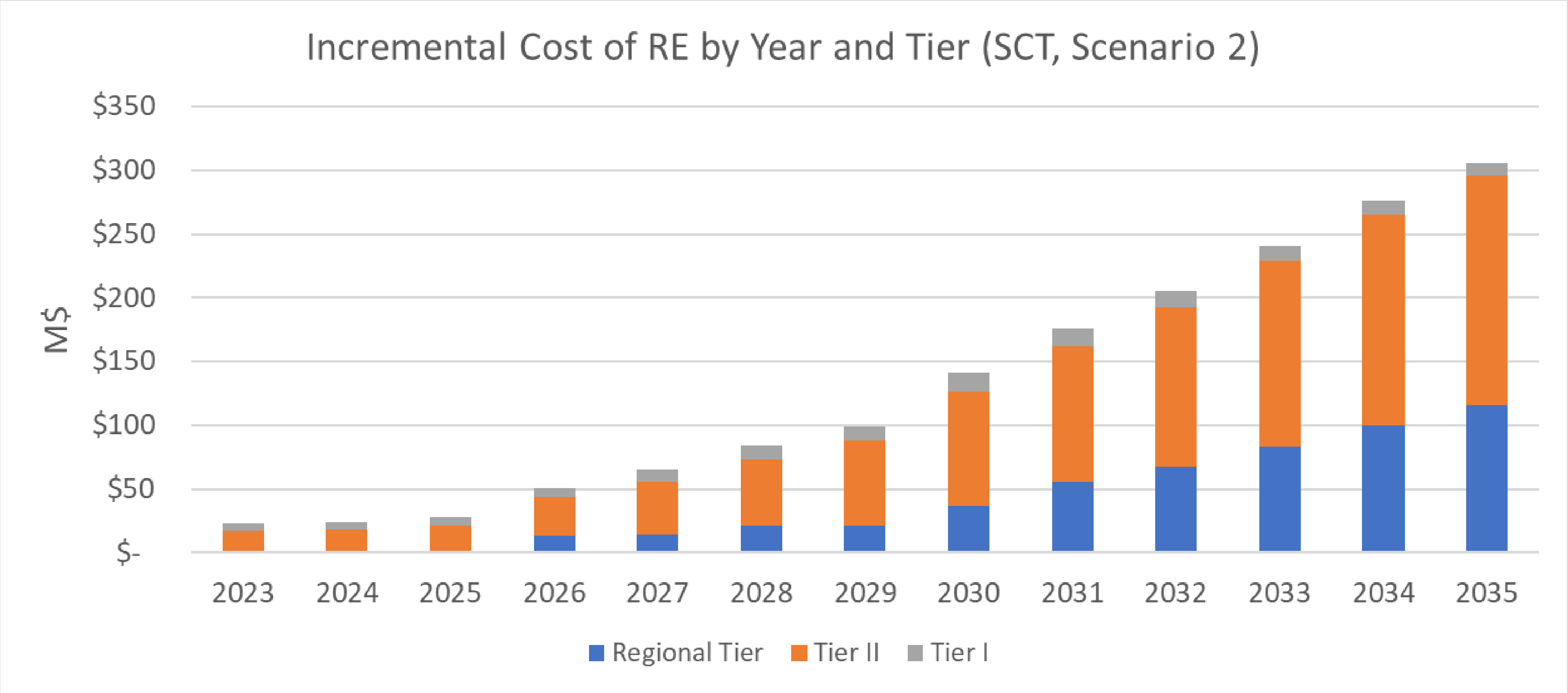
Incremental Costs by Year – BAU



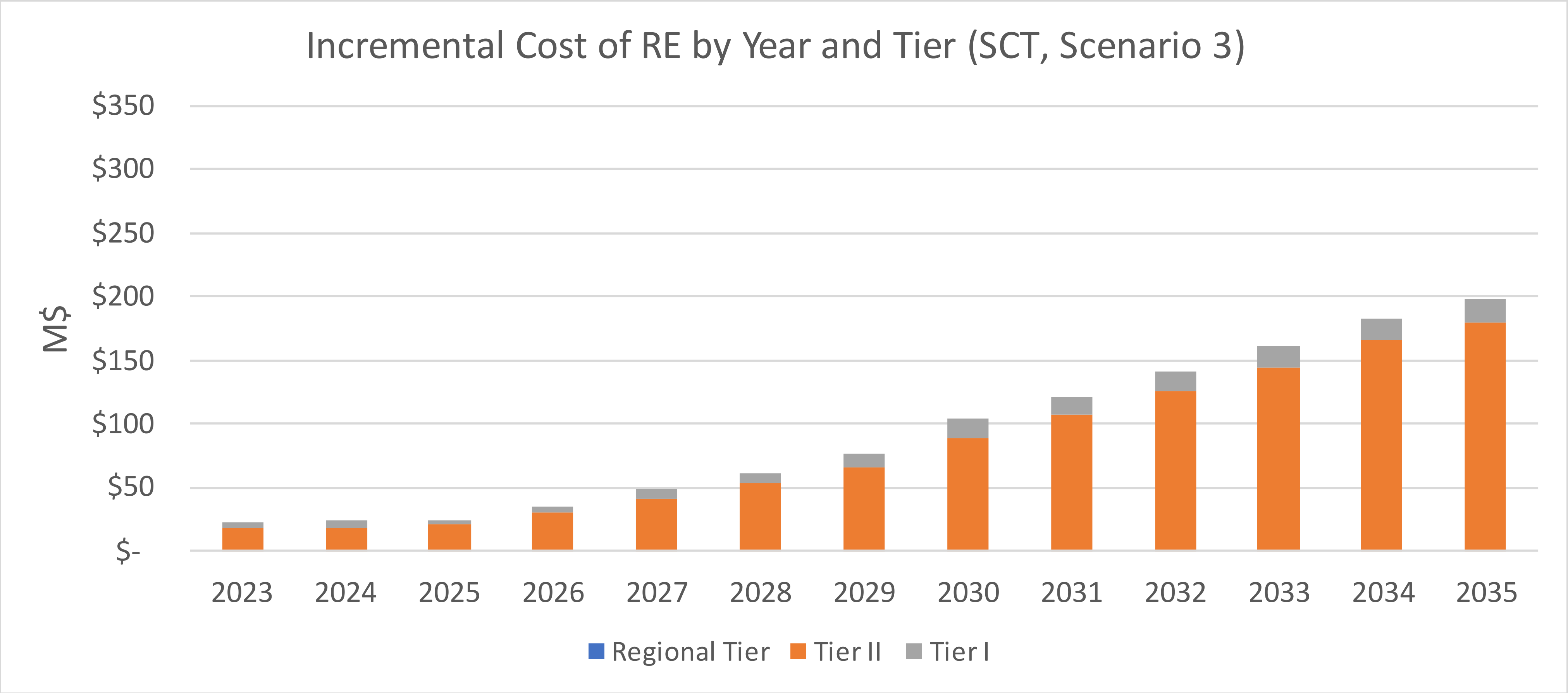
Incremental Costs by Year – Scenario 1



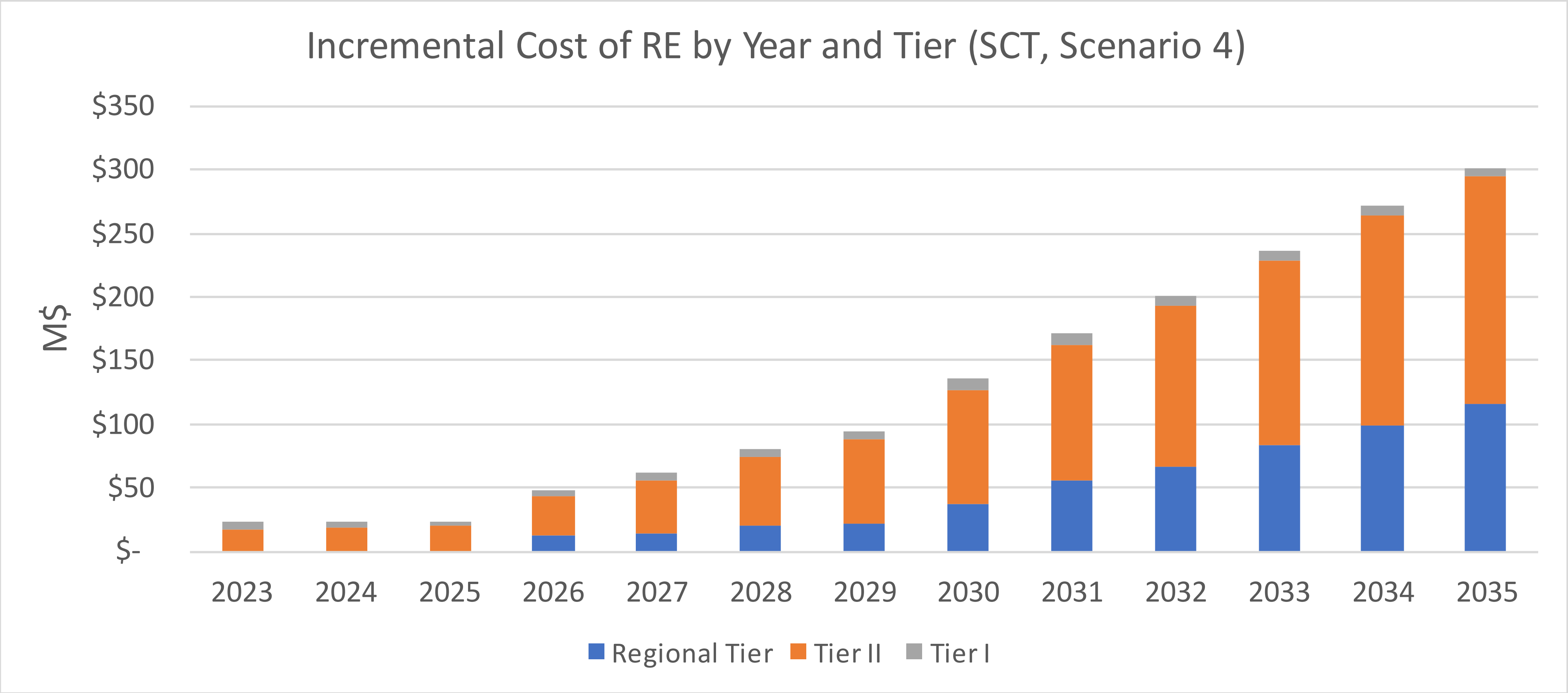
Incremental Costs by Year – Scenario 2



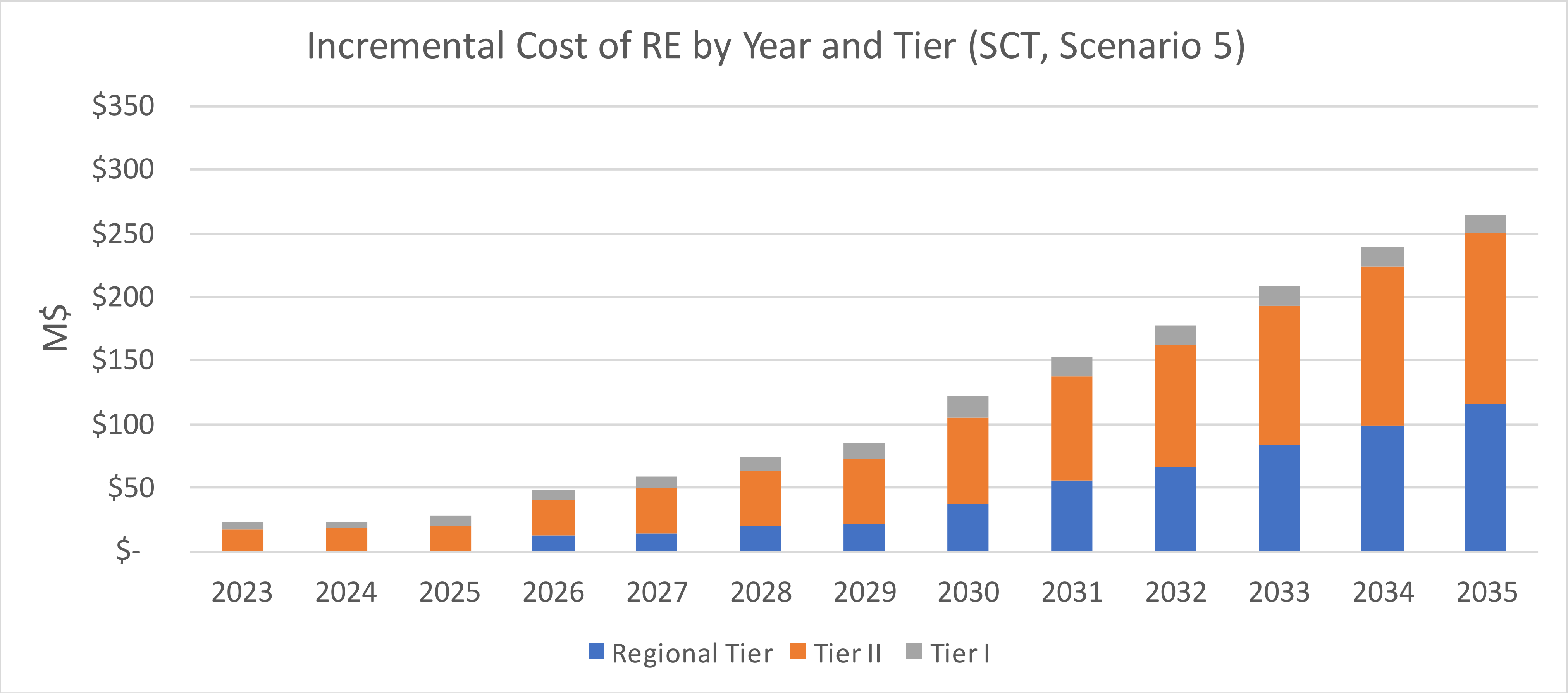
Incremental Costs by Year – Scenario 3



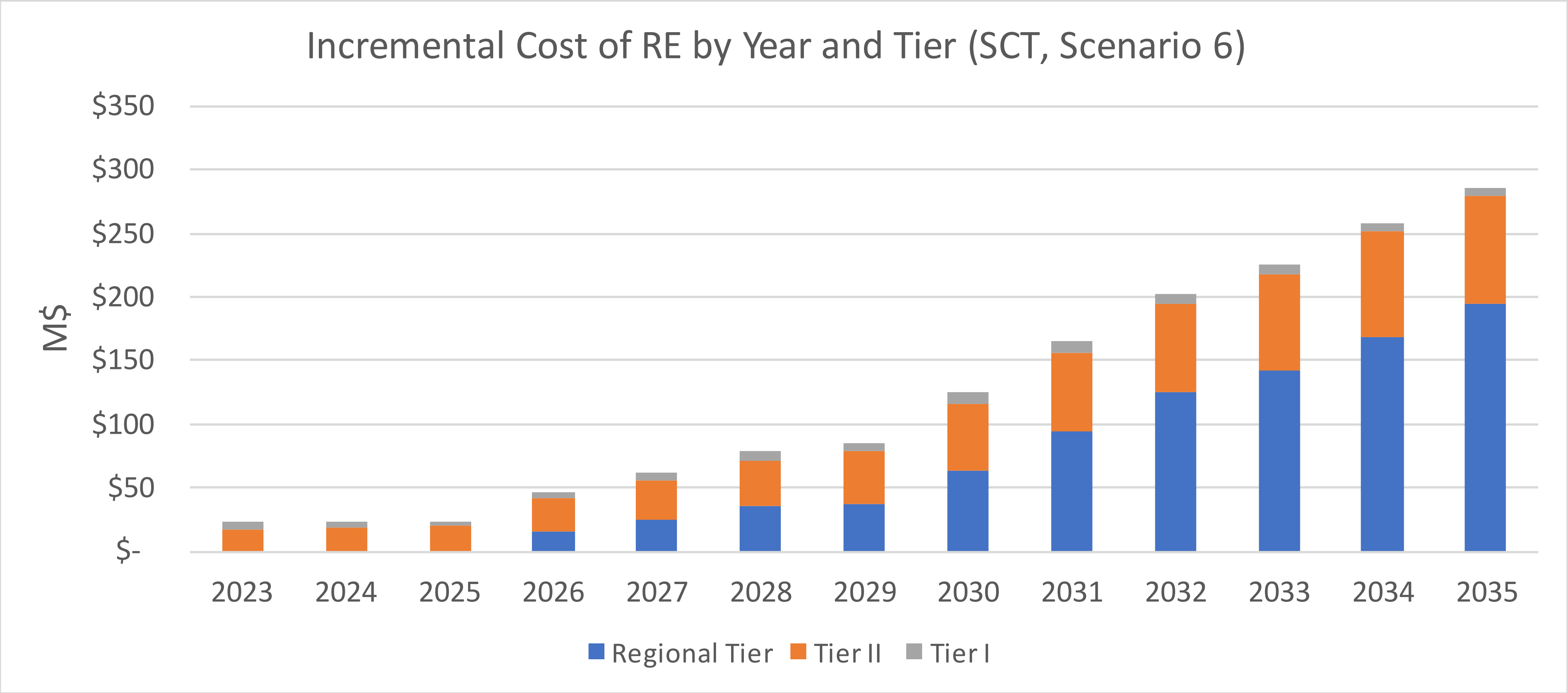
Incremental Costs by Year – Scenario 4



Incremental Costs by Year – Scenario 5



Incremental Costs by Year – Scenario 6



Appendix 3

Need for Flexibility Mechanisms: Surplus/Deficit Metrics, by Scenario

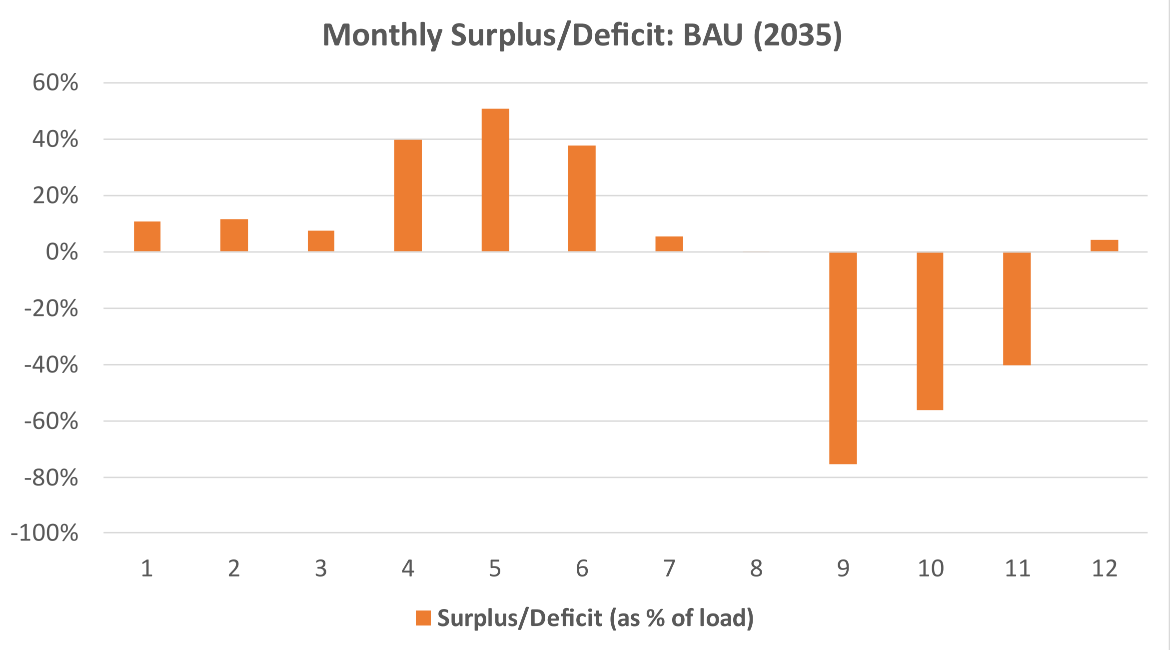
Sustainable Energy Advantage, LLC

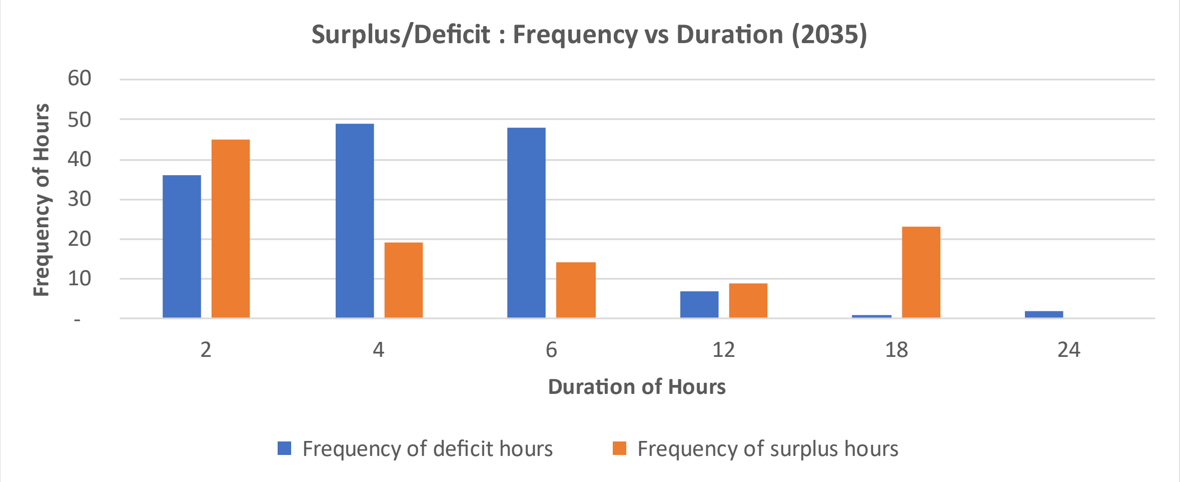
Variability of Load and Generation Underscores need for flexibility mechanisms to achieve 100% RES: **BAU**

- VT RES (and all regional RPS) compliance is currently demonstrated on an annual basis.
- As policymakers consider quarterly, monthly, or hourly compliance, storage and load management options will be required to align generation and load

Surplus/Deficit Metrics, by Month, BAU, 2035

Month	Total Surplus or Deficit (MWh)	Max hourly surplus (MW)	Surplus/ load during max surplus	Max hourly deficit (MW)	Deficit/ load during max deficit
1	64,728	493	69%	(568)	-50%
2	61,250	571	90%	(469)	-47%
3	39,563	666	102%	(978)	-97%
4	179,499	829	176%	(352)	-40%
5	218,258	880	205%	(769)	-98%
6	160,268	774	139%	(266)	-34%
7	25,059	878	214%	(863)	-98%
8	(137)	601	92%	(752)	-90%
9	(303,972)	487	78%	(848)	-98%
10	(259,808)	682	128%	(906)	-99%
11	(210,039)	526	81%	(980)	-99%
12	25,330	484	97%	(958)	-97%



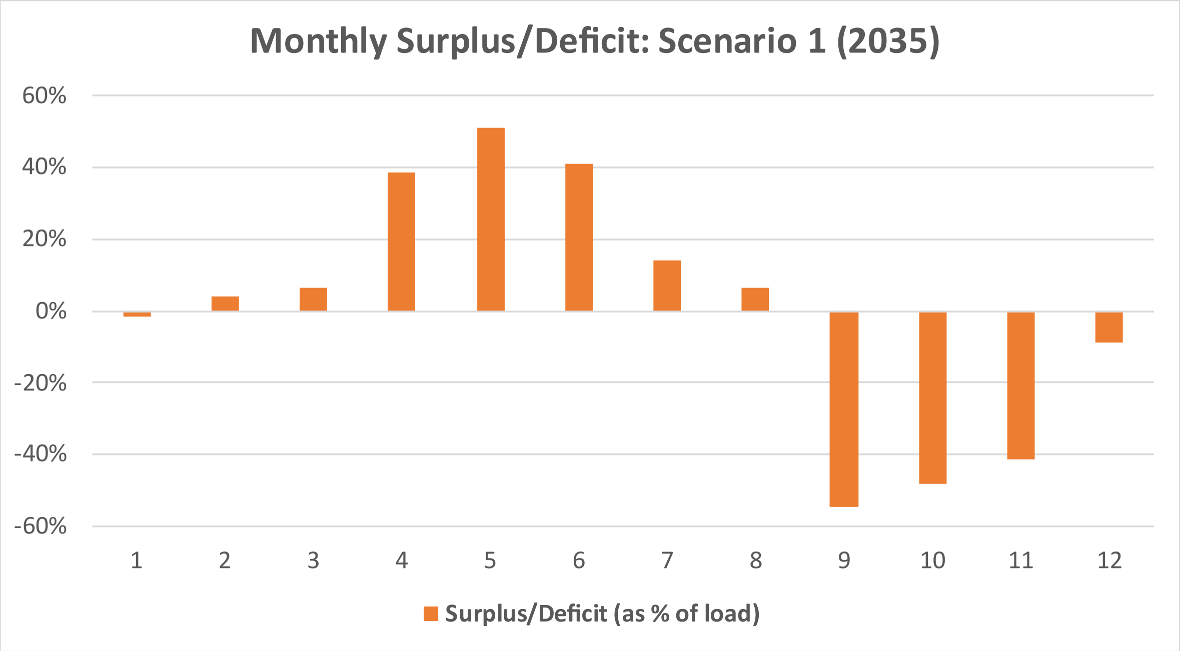


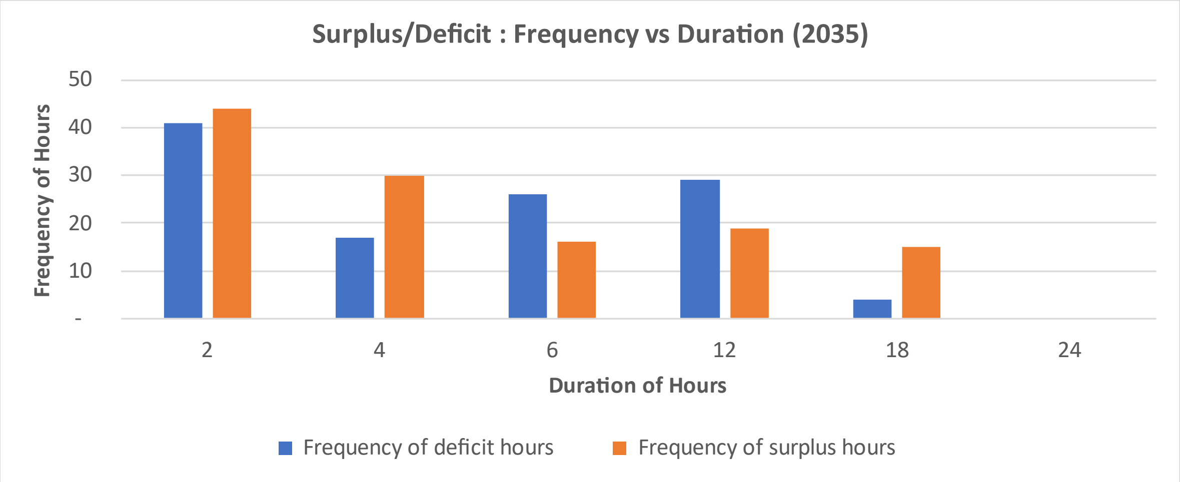
Variability of Load and Generation Underscores need for flexibility mechanisms to achieve 100% RES: **Scenario 1**

- VT RES (and all regional RPS) compliance is currently demonstrated on an annual basis.
- As policymakers consider quarterly, monthly, or hourly compliance, storage and load management options will be required to align generation and load

Surplus/Deficit Metrics, by Month, Scenario 1, 2035

Month	Total Surplus or Deficit (MWh)	Max hourly surplus (MW)	Surplus/ load during max surplus	Max hourly deficit (MW)	Deficit/ load during max deficit
1	(12,834)	918	77%	(983)	-60%
2	30,583	1,088	90%	(830)	-57%
3	51,366	1,341	141%	(1,432)	-98%
4	253,025	1,539	196%	(653)	-52%
5	317,307	1,597	226%	(1,121)	-99%
6	252,367	1,438	178%	(530)	-47%
7	93,701	1,543	259%	(1,260)	-98%
8	43,333	1,188	126%	(1,115)	-93%
9	(319,380)	917	101%	(1,235)	-99%
10	(321,555)	1,255	162%	(1,319)	-99%
11	(311,671)	878	93%	(1,427)	-99%
12	(76,242)	826	75%	(1,402)	-98%



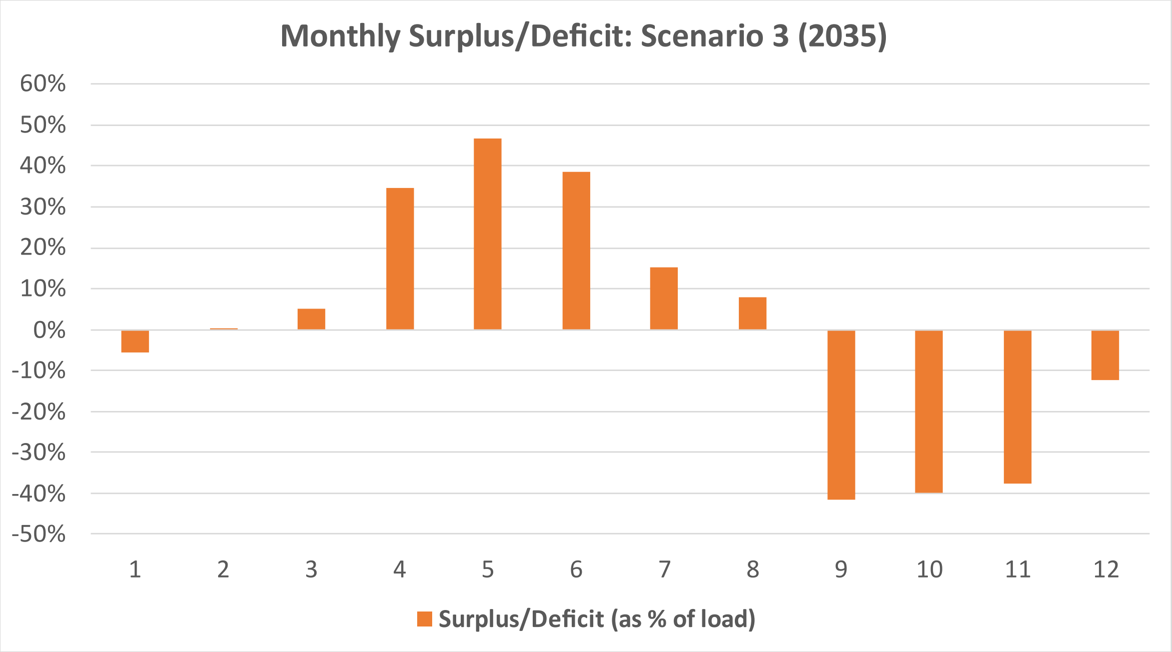


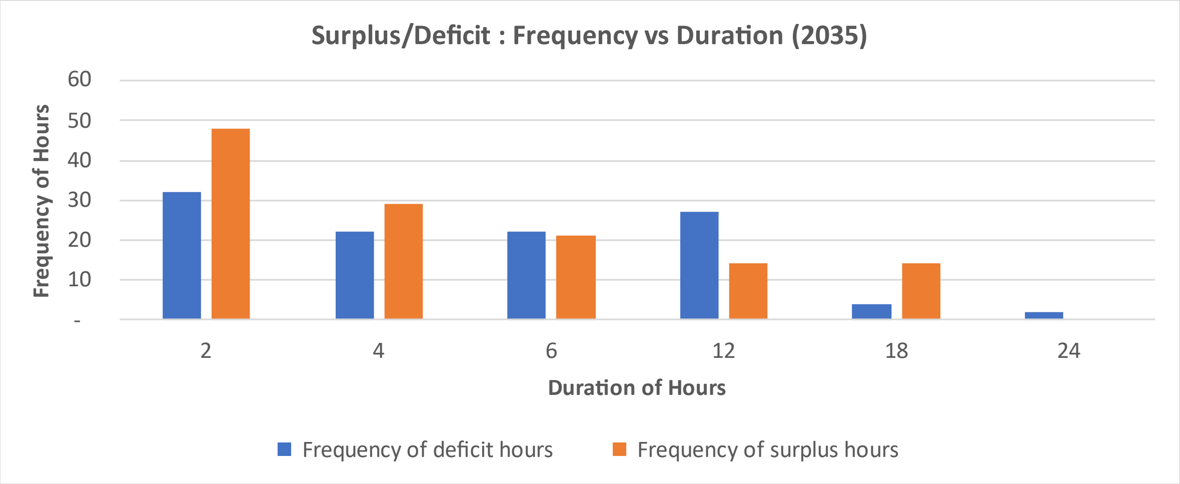
Variability of Load and Generation Underscores need for flexibility mechanisms to achieve 100% RES: **Scenario 3**

- VT RES (and all regional RPS) compliance is currently demonstrated on an annual basis.
- As policymakers consider quarterly, monthly, or hourly compliance, storage and load management options will be required to align generation and load

Surplus/Deficit Metrics, by Month, Scenario 3, 2035

Month	Total Surplus or Deficit (MWh)	Max hourly surplus (MW)	Surplus/ load during max surplus	Max hourly deficit (MW)	Deficit/ load during max deficit
1	(50,020)	842	71%	(978)	-59%
2	2,446	1,011	84%	(818)	-56%
3	40,179	1,268	134%	(1,322)	-90%
4	226,314	1,462	186%	(641)	-51%
5	290,916	1,519	223%	(1,012)	-88%
6	236,934	1,355	168%	(528)	-42%
7	101,290	1,462	246%	(1,150)	-90%
8	53,505	1,138	129%	(1,017)	-84%
9	(243,617)	860	94%	(1,125)	-90%
10	(266,735)	1,186	153%	(1,209)	-91%
11	(283,649)	801	85%	(1,317)	-91%
12	(107,563)	744	68%	(1,292)	-90%



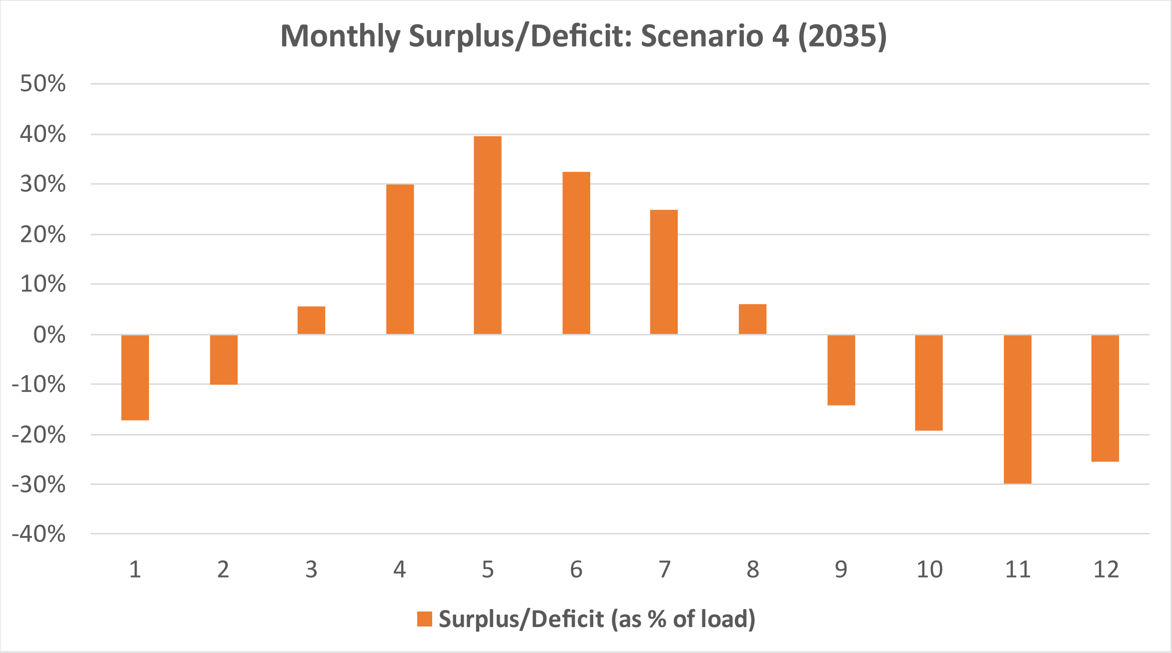


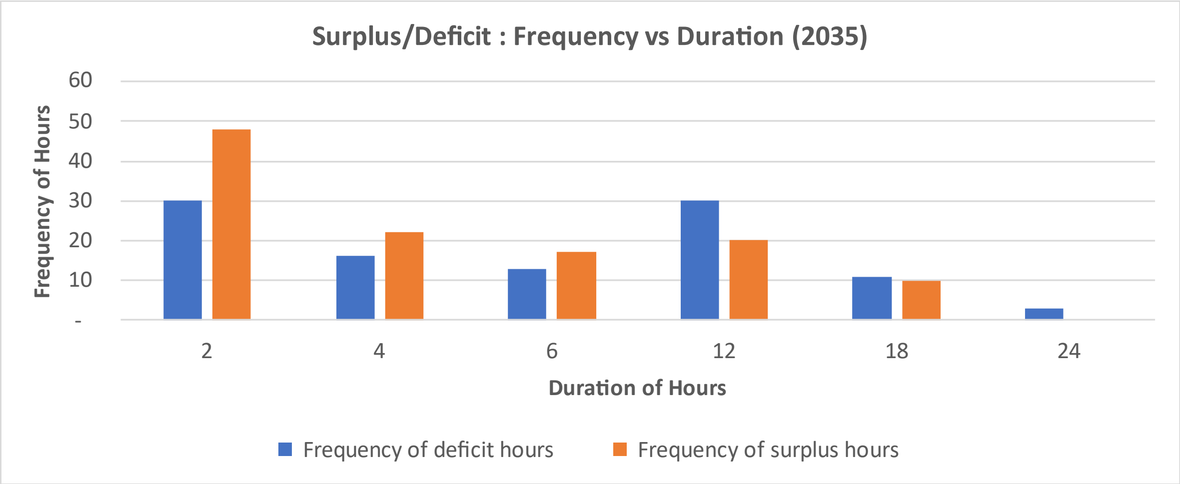
Variability of Load and Generation Underscores need for flexibility mechanisms to achieve 100% RES: **Scenario 4**

- VT RES (and all regional RPS) compliance is currently demonstrated on an annual basis.
- As policymakers consider quarterly, monthly, or hourly compliance, storage and load management options will be required to align generation and load

Surplus/Deficit Metrics, by Month, Scenario 4, 2035

Month	Total Surplus or Deficit (MWh)	Max hourly surplus (MW)	Surplus/ load during max surplus	Max hourly deficit (MW)	Deficit/ load during max deficit
1	(153,287)	1,046	96%	(1,164)	-73%
2	(79,290)	1,180	97%	(1,088)	-70%
3	43,047	1,613	175%	(1,298)	-87%
4	198,391	1,688	223%	(859)	-70%
5	249,773	1,875	261%	(1,028)	-89%
6	202,798	1,607	176%	(766)	-66%
7	169,175	1,727	217%	(1,169)	-90%
8	41,072	1,301	196%	(972)	-86%
9	(84,285)	1,152	136%	(1,056)	-83%
10	(131,643)	1,370	175%	(1,146)	-90%
11	(227,737)	950	95%	(1,337)	-92%
12	(228,013)	870	76%	(1,313)	-90%



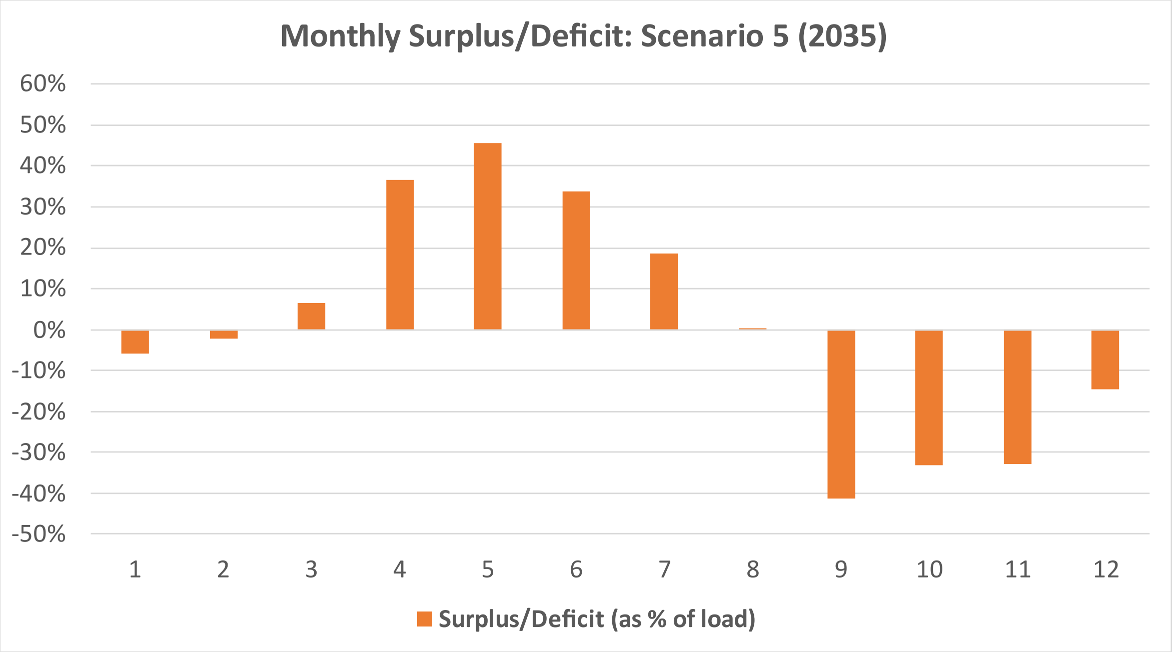


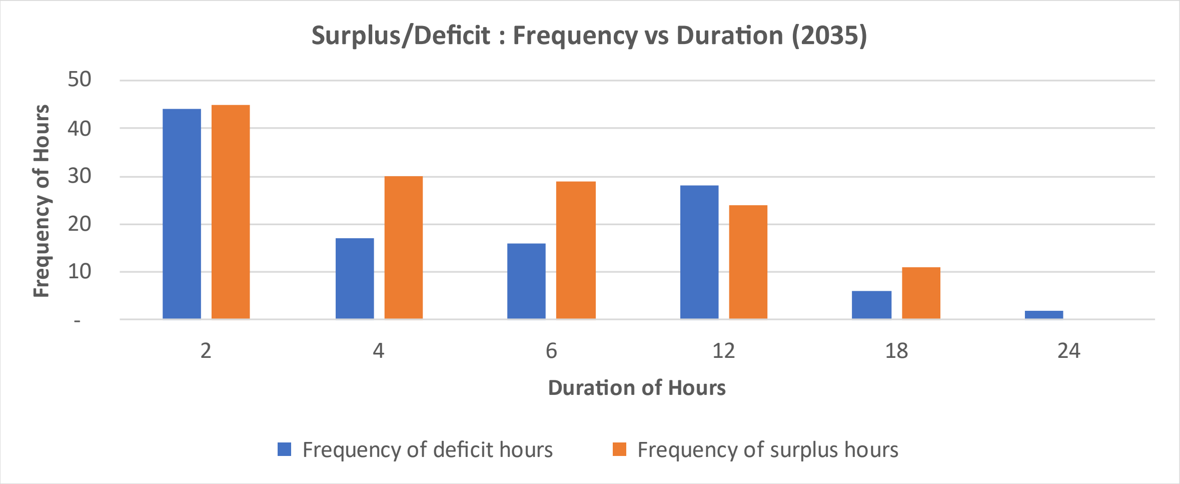
Variability of Load and Generation Underscores need for flexibility mechanisms to achieve 100% RES: **Scenario 5**

- VT RES (and all regional RPS) compliance is currently demonstrated on an annual basis.
- As policymakers consider quarterly, monthly, or hourly compliance, storage and load management options will be required to align generation and load

Surplus/Deficit Metrics, by Month, Scenario 5, 2035

Month	Total Surplus or Deficit (MWh)	Max hourly surplus (MW)	Surplus/ load during max surplus	Max hourly deficit (MW)	Deficit/ load during max deficit
1	(52,376)	1,019	94%	(1,078)	-68%
2	(17,767)	1,106	101%	(999)	-66%
3	51,307	1,428	155%	(1,439)	-97%
4	242,717	1,567	207%	(781)	-64%
5	289,072	1,766	246%	(1,152)	-100%
6	210,485	1,396	153%	(694)	-60%
7	125,890	1,610	202%	(1,300)	-100%
8	2,868	1,027	115%	(1,103)	-98%
9	(244,344)	781	85%	(1,180)	-93%
10	(225,771)	1,306	166%	(1,263)	-99%
11	(251,457)	971	101%	(1,461)	-100%
12	(130,623)	865	76%	(1,454)	-100%



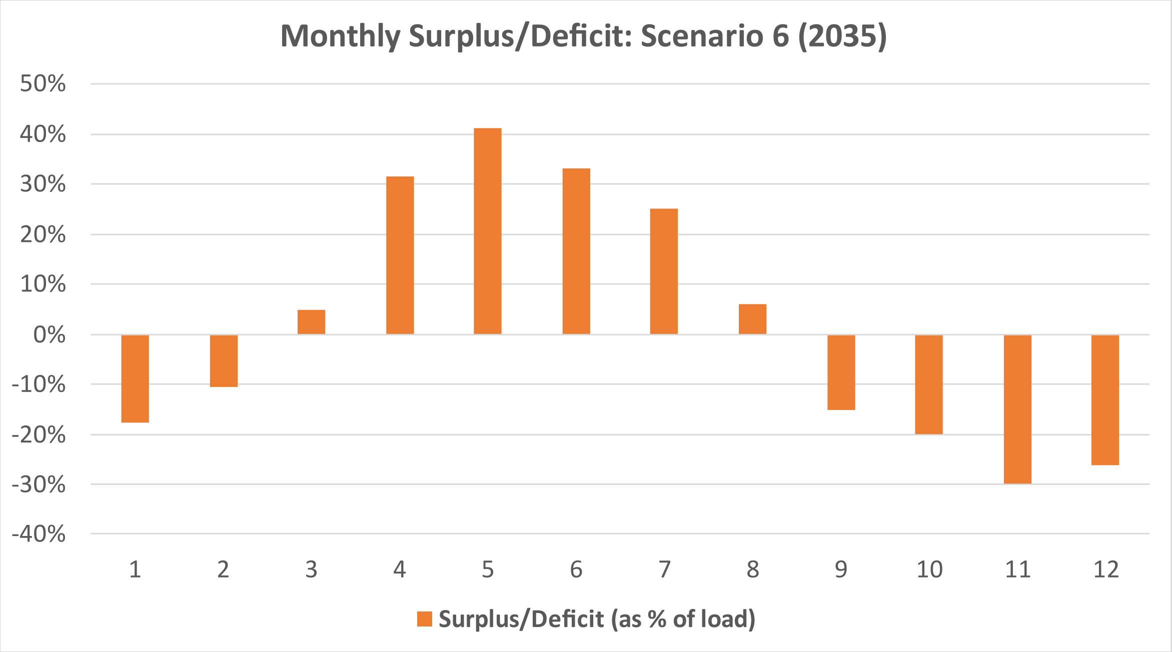


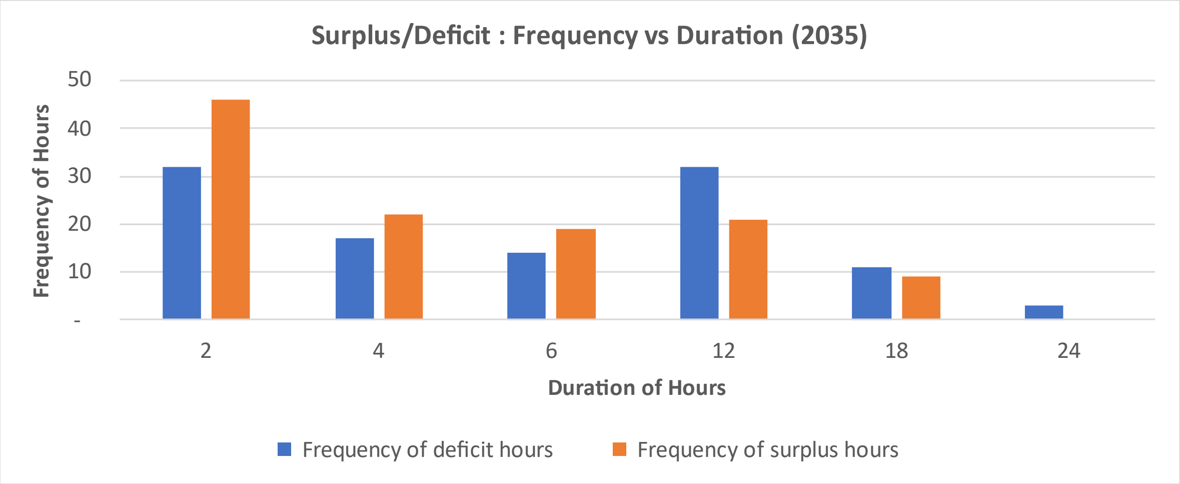
Variability of Load and Generation Underscores need for flexibility mechanisms to achieve 100% RES: **Scenario 6**

- VT RES (and all regional RPS) compliance is currently demonstrated on an annual basis.
- As policymakers consider quarterly, monthly, or hourly compliance, storage and load management options will be required to align generation and load

Surplus/Deficit Metrics, by Month, Scenario 6, 2035

Month	Total Surplus or Deficit (MWh)	Max hourly surplus (MW)	Surplus/ load during max surplus	Max hourly deficit (MW)	Deficit/ load during max deficit
1	(158,880)	1,073	98%	(1,197)	-74%
2	(83,272)	1,214	98%	(1,117)	-73%
3	38,512	1,652	176%	(1,350)	-90%
4	211,912	1,749	227%	(872)	-70%
5	264,427	1,940	266%	(1,058)	-91%
6	210,027	1,655	179%	(784)	-67%
7	172,531	1,780	220%	(1,208)	-92%
8	41,482	1,318	196%	(1,009)	-88%
9	(91,517)	1,175	137%	(1,087)	-85%
10	(137,368)	1,421	178%	(1,178)	-91%
11	(231,713)	991	97%	(1,372)	-93%
12	(236,143)	894	77%	(1,365)	-93%





Appendix 4

Land Use Impact by Scenario

Sustainable Energy Advantage, LLC

Appendix 4: Land Use Impact by Scenario (Acres)

Tech (Location)	BAU	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Solar (In-State)	873.9	2197.8	2232.6	2197.8	2232.6	1582.0	937.0
Wind (In-State)	5.4	5.4	152.4	5.4	152.4	152.4	154.7
Hydro (In-State)	0.0	0.0	3.5	0.0	3.5	3.5	3.5
Total In-State	**879**	**2,203**	**2,388**	**2,203**	**2,388**	**1,738**	**1,095**
Solar (Out-of-State)	0.0	0.0	5301.2	0.0	5301.2	5007.3	11736.9
Wind (Out-of-State)	0.0	0.0	208.9	0.0	208.9	208.9	212.2
Hydro (Out-of-State)	0.0	0.0	63.0	0.0	63.0	63.0	64.1
Total Out-of-State	**-**	**-**	**5,573**	**-**	**5,573**	**5,279**	**12,013**

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