NV Energy Distributed Energy Resources Market Potential Study

May 2024

Acknowledgements

This study was prepared for NV Energy by the following organizations.

- Energy and Environmental Economics, Inc. (E3): Michaela Levine, Jessie Knapstein, Eric Cutter, Dyami Andrews, Michael Sontag, Sean Smillie, Molly Bertolacini, Hayden Dahmm, Rawley Loken, Caitlin McMahon, Aneri Shaw, Mandy Kim
- Tierra Resource Consultants: Floyd Keneipp, David Alspector, Gregory Brown, Tom Hines
- Integral Analytics: Darrin Kinney, Tim Bagwell, Kenneth Skinner, Julie Penning, Shawn Flanagan, Scott Smith, Alex Telford, Sarah Szewczyk, Jason Crabtree
- ADM Associates, Inc.: Robert Oliver

Table of Contents

List of Figures

List of Tables

Acronym Definitions

Acronym	Definition
AEO	Annual Energy Outlook
AHRI	Air-Conditioning, Heating, Refrigeration Institute
BEV	Battery Electric Vehicle
BNEF	Bloomberg New Energy Finance
BTM	Behind-the-Meter
CBECS	Commercial Building Energy Consumption Survey
CPUC	California Public Utilities Commission
DER	Distributed Energy Resource
DR	Demand Response
DRP	Distributed Resources Plan
DSM	Demand-Side Management
E3	Energy and Environmental Economics
EE	Energy Efficiency
EIA	Energy Information Administration
EPA	Environmental Protection Agency
EV	Electric Vehicle
EVO	Electric Vehicle Outlook
FA	Forecasting Anywhere
H3	Hexagonal Hierarchical Spatial Index
IA	Integral Analytics
IECC	International Energy Conservation Code
IRP	Integrated Resource Plan
LBNL	Lawrence Berkeley National Laboratory
LDV	Light-Duty Vehicle
LMI	Low and Moderate Income
ML	Machine Learning
MPS	Market Potential Study
MHDV	Medium Heavy-Duty Vehicle
NPC	Nevada Power Company
NPV	Net Present Value
NREL	National Renewable Energy Laboratory
nTRC	Non-Energy Benefits Total Resource Cost Test
NVE	NV Energy
PCT	Participant Cost Test
RASS	Residential Appliance Saturation Survey
RECS	Residential Energy Consumption Survey

SPPC	Sierra Pacific Power Company
VGI	Vehicle-Grid Integration
ZEV	Zero-Emission Vehicle

Executive Summary

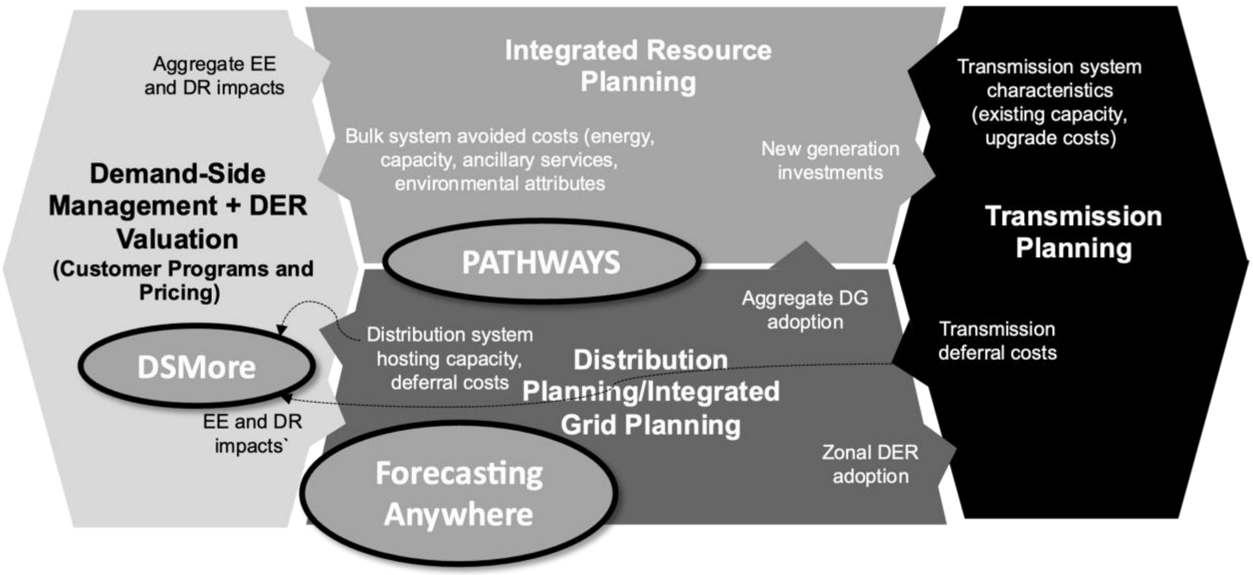
Purpose and Objectives

NV Energy (NVE) contracted with Integral Analytics (IA) and IA's subcontractors Energy and Environmental Economics (E3), Tierra Resource Consultants (Tierra), and ADM Associates, Inc. (ADM), collectively referred to as the analysis team, to develop a comprehensive distributed energy resource (DER) Market Potential Study (MPS). This report documents the study which assessed potential for energy efficiency, building electrification, transportation electrification, behind-the-meter (BTM) solar, BTM storage, and demand response adoption from 2024 to 2054 in NVE's two service territories—Nevada Power Company (NPC) and Sierra Pacific Power Company (SPPC).

This study of market potential was conducted to inform the development of NVE's demand-side management (DSM) portfolio and to support other planning activities, including the development of its Integrated Resource Plan (IRP) and Distributed Resources Plan (DRP). Additionally, this study discusses DSM portfolio design metrics that are aligned with the needs of NVE's customers and the utility's strategic initiatives.

The framework of this MPS study was created to support NVE in the development of an Integrated System Planning (ISP) framework, which aims to unify, coordinate, and optimize utility planning functions, including bulk system integrated resource planning, distribution planning/integrated grid planning, transmission planning, and customer programs (or demand-side management) to cost-effectively meet customer needs and strategic goals of the utility. This study establishes a framework to utilize ISP concepts in NVE's IRP, DRP, and DSM plans, and leverages several new tools, discussed in the following section, that can bridge the gaps among utility planning functions. Figure 1 illustrates the concept of Integrated System Planning. For example, customer programs influence the adoption of energy efficiency and demand response, which influences Integrated Resource Planning and Distribution Planning/Integrated Grid Planning. The DER adoption scenarios generated by PATHWAYS help to inform the potential range of futures for each of these planning functions.

Figure 1. Integrated System Planning and MPS models



As this Market Potential Study is the first step in implementing the new framework, the priority of this study is to establish new modeling pathways; in future cycles, continued progress can be made to advance ISP and expand upon scenario-specific data. The implementation of this framework can be described as a “walk-jog-run” approach in moving toward an ISP framework. At each subsequent iteration of planning cycles, NVE should take the opportunity to improve upon its modeling and planning process coordination. This MPS represents NVE entering the “walk” phase.

Study Approach and Methodology

To accomplish these objectives, the DER MPS considers a wide range of potential futures with respect to DER and new electric end-use adoption to identify the potential contributions from DER technologies in NVE’s service territory. In this first phase, E3 used its economy-wide greenhouse gas (GHG) and energy demand accounting and stock rollover model, PATHWAYS, to assess several scenarios of DER adoption. Additionally, E3 developed a feasibility screen to rank the qualitative plausibility of scenarios, based on key metrics related to cost, customer disruption, and progress toward decarbonization. Next, E3 used its Forecasting Anywhere model to apply the systems impacts from the broader scenarios to more granular geospatial levels to be incorporated into NVE’s DRP, along with impacts in Low- and Moderate-Income (LMI) communities. Lastly, E3 developed portfolio evaluation metrics to better evaluate the implications of measures and portfolios on strategic concerns such as energy efficiency, load management, and greenhouse gas reduction.

As a second phase, the study narrows in on the cost-effective and achievable DER market potential under current conditions. In this phase, the analysis team used IA’s DSMore tool to model the Economic, Maximum Achievable, and Realistically Achievable potential for energy efficiency (EE) and demand response (DR) adoption for the Mid scenario with various DSM portfolio-building strategies.

For the PATHWAYS-based scenario analysis, E3 developed six different scenarios to explore a range of DER adoption scenarios that reflect varying economic and policy landscapes. PATHWAYS is an economy-wide stock rollover model, providing a comprehensive representation of the cumulative impact of a variety of DER types and demand-side options. PATHWAYS does not model DER adoption at the utility program or measure level (e.g. a direct install energy efficiency measure) and is agnostic to the administration of DER programs at the utility, state, or federal program level. Rather, it models the adoption of categories of devices and demand changes as scenarios, representing the cumulative impact of various policy and economic conditions. This approach differs from a 'traditional' bottom-up MPS as a means of calculating Technical Potential for a utility DSM program, and instead enables more rapid and efficient modeling of potential DSM impacts across the six scenarios presented in this report and allows for exploration of a range of policy and market futures. The multiple DER scenarios from PATHWAYS were leveraged to understand what additional types, and the potential scale, of measures/programs that could be considered in the development of NVE's DSM portfolio. These additional measures were then considered in the portfolio design as the analysis moved into the second phase to model the Economic, Maximum Achievable, and Realistically Achievable Potential.

To link this analysis to NVE's DRP, the analysis team leveraged Forecasting Anywhere (FA), a geospatial DER adoption model developed by IA and E3 to add geospatial granularity to the broader PATHWAYS scenarios and to identify where DER adoption is likely to occur. This analysis was conducted to support NVE's DRP activities, identifying areas where DERs can be leveraged as non-wires alternatives, and to evaluate the impact of DER adoption in Low- and Moderate- Income (LMI) communities in the MPS. FA is a lighter-weight version of IA's LoadSEER distribution system forecasting tool, which is a tailored platform setup and integrated directly into utility operations for use by NVE distribution planners. While LoadSEER is being setup for future use by NVE staff, FA was customized and run by E3 to provide planning inputs for the distribution level analysis given its ability to nimbly consider multiple scenarios and provide geographic granularity of impacts. The scenarios from FA used in this study will be ported into the NVE LoadSEER instance once that setup is complete. FA supports NVE in the "walk" phase of integrated system planning, while LoadSEER will support the "jog" and "run" phases.

For the second phase, Tierra developed DSM potentials with different portfolio-building strategies:

+ **Traditional**: Focuses primarily on all measures that generate energy savings and is consistent with historical metrics determining annualized first year energy (kWh) savings (e.g. % of sales-based target).
+ **Grid Value**: Prioritizes measures that support renewable energy integration and reduce energy and demand during grid peaks and during hours with higher marginal costs and higher emissions from fossil-fuel generating plant.
+ **Strategic Decarbonization (To be considered in future iterations)**: Similar to Grid Value priorities, but layers in fuel neutral measures that further improve demand flexibility,

reduce site emissions, and complement state and federal funding opportunities (e.g. gas hot water heater to grid-interactive heat pump hot water heater).

The exploration of three portfolio strategies reflects the present and emerging challenges faced by NVE. Designing portfolios around the Traditional strategy, and setting DSM goals based on annual retail sales, will become increasingly difficult for NVE as the utility is expected to experience significant load growth driven by transportation electrification and data centers, which present very little energy efficiency opportunities to the utility. At the same time, a Traditional strategy may miss higher-impact opportunities by keeping a narrow focus on annual energy reductions. The Grid Value strategy prioritizes reducing peak load, avoiding fossil-fuel generation, minimizing curtailment of renewable generation, and reducing load during generally high-cost hours. This strategy is intended to drive cost savings as it focuses on managing peak load growth, which will be increasingly important with electrification, and optimizing the utilization of NVE's generation fleet. Finally, the Strategic Decarbonization portfolio acknowledges the role of demand-side resources and DERs in driving economy-wide decarbonization while also driving cost savings as it targets measures that reduce energy usage during carbon intensive hours which also tend to be high-cost hours. Note that in this study, the analysis team focused on the Traditional and Grid Value strategies and did not develop a portfolio based on the Strategic Decarbonization strategy at this time.

To develop these strategy-specific potentials, Tierra calculated potential at the utility measure level using Integral Analytics' DSMore tool to model the Technical, Economic, Maximum Achievable, and Realistically Achievable Potential for energy efficiency and demand response adoption. In this phase, Technical Potential was defined for each measure, based on data from PATHWAYS on equipment stock and annual sales. Next, Economic Potential was calculated based on measures that are cost-effective according to Nevada's Non-Energy Benefits Total Resource Cost Test (nTRC). Next, Maximum Achievable Potential was calculated for each measure based on market acceptance curves, and participant-focused economics. Lastly, Realistically Achievable Potential was calculated through assumed impacts of additional constraints and qualitative market limitations, based on NVE's program implementation experience.

To support portfolio development and target setting, E3 developed evaluation metrics aligned with each portfolio type and its strategic objective and NVE's broader priorities and goals. These metrics can be considered along with cost-benefit analysis to guide measure-level portfolio building decisions and serve as a basis for assessing performance. Ultimately, E3 developed two new hourly metrics—marginal source energy from fossil fuel–based generation, and grid marginal emissions—that can estimate the marginal impact for a given change in electricity consumption and are correlated with high cost and high emissions grid conditions as well a grid peaks. These metrics can be used to determine the alignment between savings load profiles for different DSM measures and hours of higher grid stress or cost, and support achievement of portfolio design strategies, including Grid Value and Strategic Decarbonization. Note that discussions between NVE and stakeholders on metrics to support Strategic Decarbonization portfolio design are on pause due to uncertainty in state policy as to the scope of emissions reductions that can be considered. If emissions reductions from avoided on-site fossil fuel combustion can be considered, additional metrics that consider those impacts, would be needed to support the development of a Strategic Decarbonization portfolio.

While this study outlines a framework for evaluating detailed portfolios across additional combinations of future scenarios (ex. Mid, High, Deep Decarbonization) and portfolio-design strategies (Traditional, Grid Value, Strategic Decarbonization), this iteration of the MPS presents results for the Mid scenario, with Traditional and Grid Value portfolio design strategies. Based on this framework, future iterations and cycles of the MPS can consider expanded scenarios and portfolio strategies.

Summary of Key Results

DER Adoption Scenarios

E3 used its PATHWAYS model to explore six future scenarios of DER adoption, including energy efficiency, building electrification, transportation electrification, BTM solar, BTM storage, and demand response. The scenarios were designed to explore a wide range of potential futures and reflect varying policy and market landscapes. The core themes of each scenario are summarized in Figure 2.

The Reference scenario is intended to reflect DER adoption assuming no change to existing federal, state, and utility policy and no dramatic shifts in market trends, and thus is a business-as-usual type scenario. The Mid scenario is intended to reflect a continuation of existing policies and market conditions in the near term but higher policy ambition and market transformation starting around 2030 which accelerates the deployment of DERs. The Low scenario reflects lower DER adoption due to market forces or policy changes that result in a deceleration of historical adoption rates. The Deep Decarbonization and High scenarios were developed to achieve GHG reduction targets outlined by the state of Nevada. These scenarios explore varying levels of adoption of all DER types. In the Deep Decarbonization and High scenarios, the high rates of building and transportation electrification needed to meet the GHG targets in the scenarios were coupled with aggressive energy efficiency and demand response adoption. Additionally, the team developed the Technical Potential scenario to explore the theoretical maximum potential for energy efficiency. This scenario assumes that there is no electrification incremental to what is assumed in the Reference scenario and did not analyze adoption of other DER types (BTM solar and storage, and DR).

Figure 2. PATHWAYS Scenario Design Overview

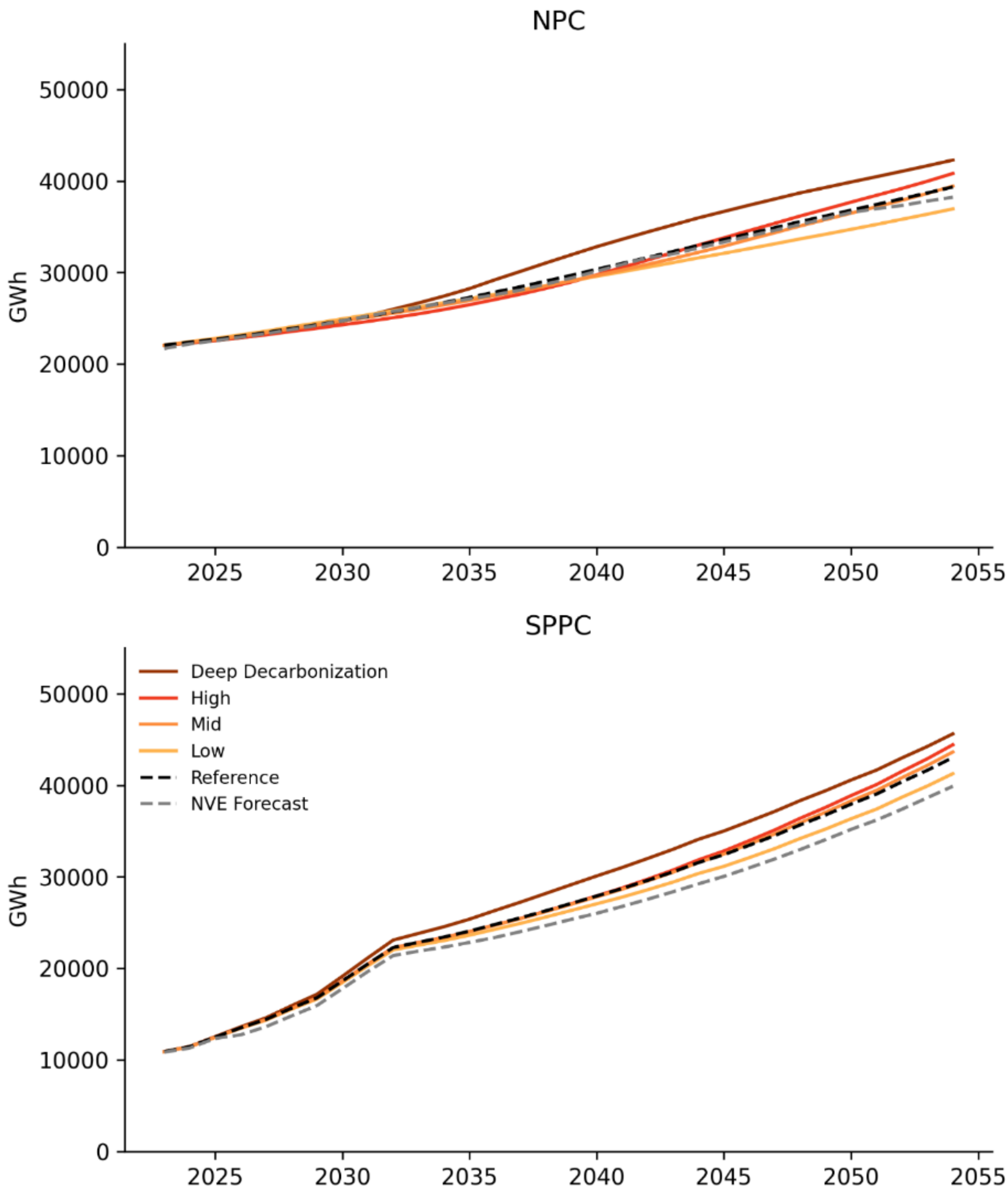
Deep Decarbonization	**Meets GHG reductions goals of 28% by 2025, 45% by 2030 and net-zero emissions by 2050**
High	**Represents achievement of 2050 carbon goal, but not interim goals**
Mid	**Aligned with existing policies and current trends in the near-term, but higher policy ambition and market transformation starting in 2030.**
Low	**Assumes a slow down in historical adoption rates due to head winds to DER adoption.**
Technical Potential	**Maximum adoption of efficient appliances and behavioral EE assuming no electrification**
Reference	**Aligned with existing policy and market trends.**

Total Net Electricity Growth

Although each scenario represents a very different vision of the future in terms of the pace and scale of electrification, decarbonization, and DER deployment, all PATHWAYS scenarios produce similar levels of net electricity demand[1] through the study period. The decarbonization scenarios that emphasize both building and transportation electrification also pursue ambitious levels of energy efficiency, which offsets load growth from fuel switching. The scenarios also produce similar levels of electricity demand because two of the largest sources of load growth—light duty vehicle electrification and data centers—are similar across scenarios. In 2040, battery electric vehicles account for 72% of light duty vehicles sales in the Reference scenario and 100% in the Deep Decarbonization scenarios, reflecting rapid transportation electrification in both scenarios. In the Reference scenario, incremental load growth from major projects, or data centers, accounts for 16% and 78% of net load growth by 2054 in NPC and SPPC, respectively. The Mid, High, and Deep Decarbonization scenarios assume only modest potential for energy efficiency in data centers leading to similar trajectories in major projects growth.

[1] Net electricity demand is defined as gross electricity demand minus BTM solar generation.

Figure 3. Total net electricity demand across PATHWAYS scenarios



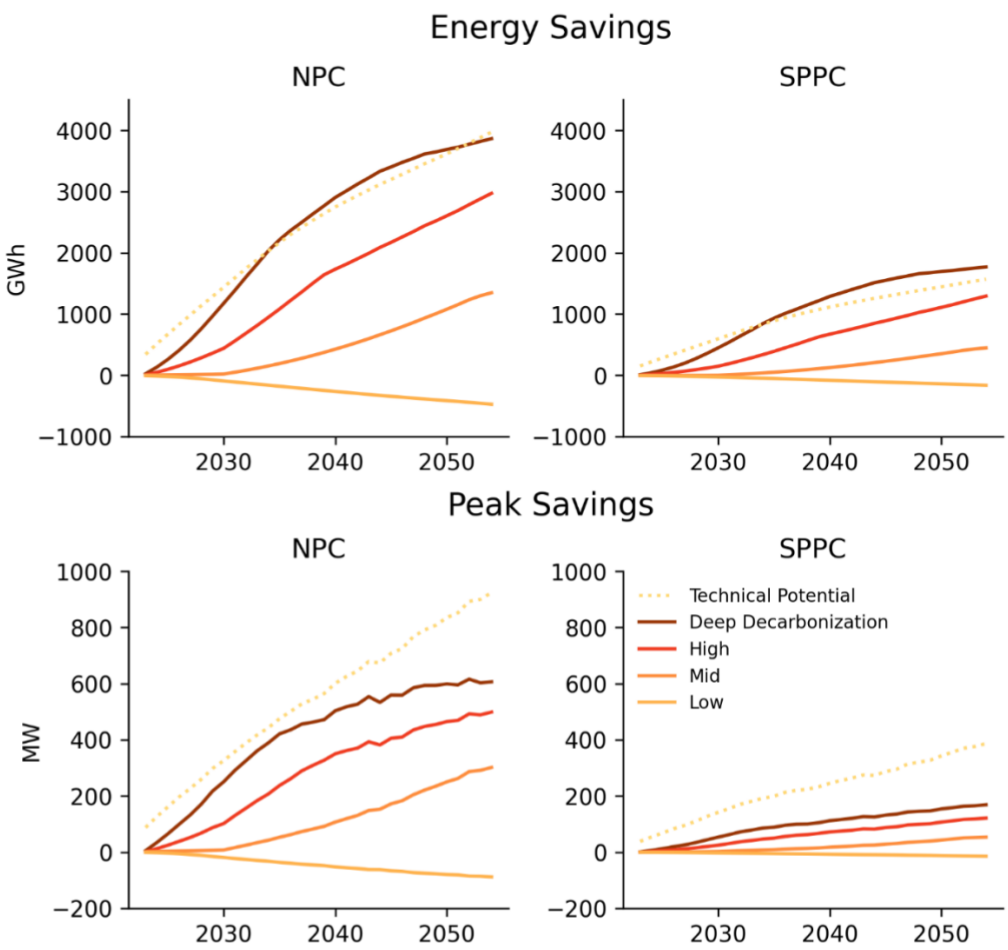
Notes: "NVE Forecast" is a load forecast developed by NVE's load forecasting team. Other scenarios presented are from PATHWAYS.

Energy Efficiency

Figure 4 shows the cumulative programmatic energy and peak savings from energy efficiency across PATHWAYS scenarios. In PATHWAYS, programmatic energy efficiency savings are defined as the energy efficiency impacts incremental to those achieved in the Reference scenario. As the Reference scenario reflects a continuation of existing market trends, code and standards, and policy, programmatic energy efficiency is driven by incremental changes in state and federal policy, utility programs, and market forces.

The programmatic energy efficiency savings range from –91 to 1,176 GWh in NPC and –27 to 420 GWh in SPPC in 2030 between the Low and Technical Potential scenarios. The peak load impacts range from –19 MW to 326 MW in NPC and –3 to 142 MW in SPPC. In 2054, the energy savings range from –471 to 3,971 GWh in NPC and –162 to 1,750 GWh in SPPC, and the peak savings range from –88 to 924 MW in NPC and –15 to 386 MW in SPPC.

Figure 4. Cumulative programmatic energy and peak impacts of energy efficiency across PATHWAYS scenarios



Notes: Programmatic energy efficiency is the energy efficiency achieved incremental to that of the Reference scenario. Negative values indicate that less energy efficiency is achieved in that scenario than in Reference.

The top PATHWAYS subsectors for energy savings from efficiency ranked according to their cumulative programmatic impact in the Mid scenario by 2030 are shown in Table 1. While subsectors are ranked according to their cumulative potential as of 2030, the table also shows the programmatic impact beyond that year in 2040 and 2054. In both NPC and SPPC, air conditioning in the residential and commercial buildings and commercial linear lighting are top subsectors.[2,3] Commercial space heating is a top subsector as well due to the phase-out of electric resistance heating and replacement with more efficient heat pumps.

The top subsectors for peak savings from energy efficiency in the Mid scenario are shown in Table 1. Many of the subsectors that produce the most system net peak savings[4] also produce significant energy savings. Air conditioning subsectors produce the most system net peak savings as space cooling end uses are highly coincident with NVE system load. In the PATHWAYS model, peak savings are defined as the average load impact in the top 150 hours of NVE (NPC + SPPC) system load net of must-take renewables.

Table 1. Top 10 subsectors for cumulative programmatic energy efficiency, ranked by 2030 values - Mid scenario (GWh)

Subsector	2025	2026	2027	2030	2040	2054
NPC						
Residential Central Air Conditioning	7,645	9,379	11,212	18,286	276,908	762,360
Non-Equipment Residential HVAC	374	714	1,142	2,358	823	263
Commercial Space Heating	116	165	222	546	8,484	34,820
Commercial Linear Lighting	-	-	-	173	14,171	70,312
Commercial Air Conditioning	12	18	24	134	5,695	25,470
Residential Behavioral EE	89	97	105	129	208	319
Commercial Ventilation	-	-	-	120	8,525	27,408
Residential Refrigeration	-	-	-	110	8,117	35,831
Residential Room Air Conditioning	6	12	20	92	6,061	18,059
Residential General Service Lighting	-	-	-	90	2,378	9,475
SPPC						
Residential Central Air Conditioning	795	990	1,202	2,034	33,046	95,146
Commercial Space Heating	69	98	133	325	5,004	20,283
Residential Behavioral EE	110	111	112	116	127	143
Commercial Linear Lighting	-	-	-	101	8,093	38,790

[2] The analysis team did not explicitly model the impacts of the Assembly Bill 144 in the Reference scenario, which at the time of developing this report was only proposed legislation to ban the sale of fluorescent light bulbs starting in 2025.
[3] This analysis was conducted before the U.S. Department of Energy finalized its latest standards for residential and commercial general service lamps (on April 12, 2024), and therefore the impact of those standards is not incorporated in the Reference scenario.
[4] System net peak, here, is defined as the peak period of system load, net of must-take renewable generation. These periods serve as a proxy for periods of highest grid need for incremental generation capacity on the grid.

Commercial Ventilation	-	-	-	75	4,971	15,579
Residential Room Air Conditioning	4	7	12	58	4,010	12,478
Commercial Air Conditioning	5	7	10	55	2,560	12,643
Commercial General Service Lighting	-	-	-	36	922	3,713
Residential Clothes Washing	-	-	-	26	1,726	6,054
Residential Refrigeration	-	-	-	23	1,579	6,550

Additional DER Adoption Modeled in PATHWAYS

In addition to programmatic efficiency, PATHWAYS included scenarios and load impacts from several additional DERs. Impacts from these load forecasts are included in the geospatial impacts modeled in Forecasting Anywhere and can be brought into NVE's DRP framework.

+ **Building Electrification:** The rate of building electrification varies significantly between scenarios with the Deep Decarbonization and High scenarios having high rates of heat pump adoption to meet decarbonization goals and the Mid scenario having more modest heat pump adoption. The analysis showed that in the Deep Decarbonization and High scenarios, building electrification with high efficiency heat pumps rather than standard performance heat pumps can significantly mitigate load growth. Additionally, energy efficiency from other end-uses can offset load growth from building electrification.
+ **Transportation Electrification:** Transportation electrification is expected to increase load in NVE significantly across scenarios, adding incremental load equivalent to 28–71% of NPC's and 26–64% of SPCC's current system load by 2054. In all scenarios, light duty electric vehicles reach 100% of sales shares during the study period, while the trajectory for medium- and heavy-duty vehicle adoptions is more variable across scenarios.
+ **Behind the Meter Solar and Storage:** For BTM solar, the Deep Decarbonization scenario shows faster adoption in the near-term than the Mid and High scenarios, but all three scenarios tend to converge in the long-term. The Reference scenario is intended to reflect NVE's internal solar adoption forecast, and the Low scenario represents a trajectory with lower realized adoption. For BTM storage, the range of adoption varies more significantly across scenarios as they reflect a broad range of policies and market futures that could encourage the coupling of BTM solar adoption with storage.
+ **Demand Response from Building End-Uses:** Scenarios varied substantially by DR participation across several device types considered. The DR capacity from residential HVAC, one of the device types of primary focus, ranged from 165 to 258 MW in NPC and 27 to 32 MW in SPPC in 2028 across scenarios. In the long-term, the analysis incorporated the impacts of energy efficiency reducing potential for DR response per participating device. Scenarios with high rates of DR participation also had aggressive energy efficiency adoption.

+ **Demand Response from Managed EV Charging:** Managed charging was found to significantly mitigate the peak load impacts of transportation electrification. For example, in NPC in 2054, the peak load impacts of transportation electrification in the Deep Decarbonization scenario are 2,203 MW before charging management and 436 MW with charging management. Scenarios varied both in their rates of transportation electrification as well as participation in managed charging, such that some scenarios that had higher levels of electric vehicle adoption had lower peak impacts than scenarios with lower adoption and less participation in managed charging.

In future iterations of the methodology, scenario inputs can be further refined to incorporate higher levels of load management or load flexibility, based on greater adoption of advanced retail rate design (such as Time-of-use rates or critical peak pricing), or generally more grid-conscious consumer behavior. Further, for impacts from DERs on system net peaks, outputs from NVE's IRP modeling should be considered to inform the shifting timing of system net peak hours, and how well-aligned those shifting periods are with resource availability for capacity-focused DER impacts. For example, if system net peak hours move later into evening hours, this will generally be more coincident with residential loads, and less coincident with commercial loads.

Feasibility Screen

Judging the relative feasibility or plausibility of realizing a specific DER adoption scenario in the long-term is inherently uncertain and challenging, given the vast number of factors that affect energy demand and purchasing decisions, especially on a multi-decade time frame. For this analysis, a handful of metrics were developed to express the technical, economic, or societal challenges associated with decarbonization, which were used to compare these long-term scenarios. These screening metrics include:

1. **Total direct costs**: The total amount of spending on energy-consuming devices, fuels, and electricity in each scenario.
2. **Average household costs**: The average change in household energy costs due to spending on appliances, vehicles, fuel, and electricity costs.
3. **Capital investment:** The total amount of capital expenditures on energy-consuming devices alone. This captures the differences in upfront costs that consumers will face in each scenario.
4. **Customer behavioral changes:** The difference in pace of adoption for new and potentially disruptive technologies not yet widely adopted in Nevada like heat pumps.
5. **Achievement of GHG emissions reductions:** The extent to which each scenario achieves GHG emissions reductions that will support the state of Nevada's economy-wide GHG targets.

For all screening metrics, the costs and emissions are calculated for the buildings, vehicles, and electricity generation sectors within NVE's service territory.

Table 2 shows how each scenario ranks according to the five metrics with lower values indicating better performance (i.e. lower cost, more GHG reduction). The Reference scenario ranks highly in terms of having the lowest total direct costs and low impacts for the other cost metrics, but it has the second highest GHG emissions. The Low scenario ranks highest for capital investment and customer behavior since it assumes virtually no change in current adoption practices, but as a result it both misses out on cost-effective new technologies, like passenger electric vehicles, and has the highest GHG emissions of any scenario. The Mid scenario has the second lowest total direct costs and ranks highly on cost per household, since there is high adoption of cost-effective electric vehicles and slower adoption of relatively expensive building electrification technologies. Finally, the High and Deep Decarbonization scenarios understandably rank the highest on GHG emissions due to their deeper reductions, but those scenarios pose the largest challenges in terms of higher direct costs, upfront investments for households and businesses, and rapid adoption of new technologies.

Table 2. DER Scenarios Feasibility Metric Rankings

Scenario	Total Direct Cost Ranking	Cost per Household Ranking	Capital Investment Ranking	Customer Behavior Ranking	GHG Emissions Ranking
Reference	1	2	2	2	4
Low	3	5	1	1	5
Mid	2	1	3	3	3
High	4	3	4	4	2
Deep	5	4	5	5	1

Forecasting Anywhere and Low- and Moderate- Income Customer Impact

Using Forecasting Anywhere (FA), the analysis team studied the distributional impacts of DER adoption in LMI communities. First, the team geospatially downscaled the results of the Mid scenario to identify where DER adoption would occur in that scenario, then identified census block groups considered to be home to LMI communities and isolated adoption occurring in those block groups. Consistent with the definition in SB448,[5] the analysis team identified LMI communities as census block groups where the median income is 80% or less than that of the median income of the county the block group is in.

In both NPC and SPPC, there is lower energy efficiency adoption in LMI communities than non-LMI communities overall and per capita. In the FA model, it is assumed that income is a driver of participation in energy efficiency, particularly for AC, amongst other factors. As a result, lower adoption and therefore load impacts occur in LMI communities. Table 3 and Table 4 summarize the cumulative programmatic energy efficiency impacts in non-LMI and LMI communities.

[5] SB448, https://www.leg.state.nv.us/App/NELIS/REL/81st2021/Bill/8201/Overview

Table 3. LMI community energy efficiency impacts in the Mid Scenario (NPC)

Energy Efficiency Types	Year	GWh		kWh per capita	
		Non-LMI	LMI	Non-LMI	LMI
Residential AC Energy Efficiency	2027	-233.83	-14.20	-147.08	-24.74
	2030	-331.51	-20.34	-208.52	-35.43
	2034	-535.04	-34.00	-336.55	-59.24
	2039	-786.34	-52.07	-494.63	-90.72
	2044	-1034.87	-69.70	-650.96	-121.43
Residential Clothes Drying Energy Efficiency	2027	-3.37	-0.22	-2.12	-0.38
	2030	-4.74	-0.31	-2.98	-0.53
	2034	-6.43	-0.42	-4.05	-0.73
	2039	-8.47	-0.57	-5.33	-0.99
	2044	-11.13	-0.75	-7.00	-1.31
Residential Lighting Energy Efficiency	2027	-249.92	-17.05	-157.20	-29.70
	2030	-264.42	-18.73	-166.33	-32.63
	2034	-311.38	-22.93	-195.87	-39.95
	2039	-386.65	-29.60	-243.21	-51.57
	2044	-454.72	-36.01	-286.03	-62.73
Residential Refrigeration Energy Efficiency	2027	-45.35	-2.94	-28.53	-5.12
	2030	-64.67	-4.31	-40.68	-7.52
	2034	-91.32	-6.30	-57.44	-10.97
	2039	-117.26	-8.36	-73.76	-14.57
	2044	-133.99	-9.79	-84.29	-17.06
Residential Building Electrification	2027	41.63	4.59	26.19	8.00
	2030	58.20	6.29	36.61	10.95
	2034	92.02	9.49	57.88	16.53
	2039	153.80	15.72	96.74	27.38
	2044	243.07	25.02	152.90	43.58

Table 4. LMI community energy efficiency impacts in the Mid Scenario (SPPC)

Energy Efficiency Types	Year	GWh		kWh per capita	
		Non-LMI	LMI	Non-LMI	LMI
Residential AC Energy Efficiency	2027	-25.01	-6.14	-49.30	-31.81
	2030	-36.09	-9.10	-71.14	-47.16
	2034	-59.11	-14.88	-116.52	-77.11
	2039	-89.01	-22.32	-175.47	-115.65
	2044	-119.39	-30.06	-235.36	-155.74
Residential Clothes Drying Energy Efficiency	2027	-1.01	-0.25	-2.00	-1.30
	2030	-1.41	-0.37	-2.78	-1.91
	2034	-1.90	-0.48	-3.75	-2.51
	2039	-2.44	-0.62	-4.80	-3.20
	2044	-3.11	-0.79	-6.13	-4.08
Residential Lighting Energy Efficiency	2027	-49.77	-11.68	-98.11	-60.50
	2030	-51.66	-12.24	-101.85	-63.40
	2034	-59.74	-14.30	-117.77	-74.07

	2039	-72.67	-17.51	-143.25	-90.70
	2044	-83.22	-20.17	-164.05	-104.51
Residential Refrigeration Energy Efficiency	2027	-7.97	-1.95	-15.72	-10.13
	2030	-11.35	-2.86	-22.38	-14.84
	2034	-16.02	-4.01	-31.59	-20.80
	2039	-20.23	-5.09	-39.88	-26.35
	2044	-22.47	-5.67	-44.30	-29.36
Residential Building Electrification	2027	61.38	13.80	121.00	71.52
	2030	91.76	21.37	180.89	110.72
	2034	139.67	33.72	275.33	174.69
	2039	209.89	50.56	413.75	261.95
	2044	284.16	67.30	560.15	348.70

DSM Planning: Economic, Maximum Achievable, and Realistically Achievable Potential

From the Economic, Maximum Achievable, and Realistically Achievable Potential analysis, energy savings potentials results are summarized in Figure 5, and demand savings potentials results are summarized in Figure 5, below.

Figure 5. Comparison of Energy Savings Potentials Across NVE Portfolios

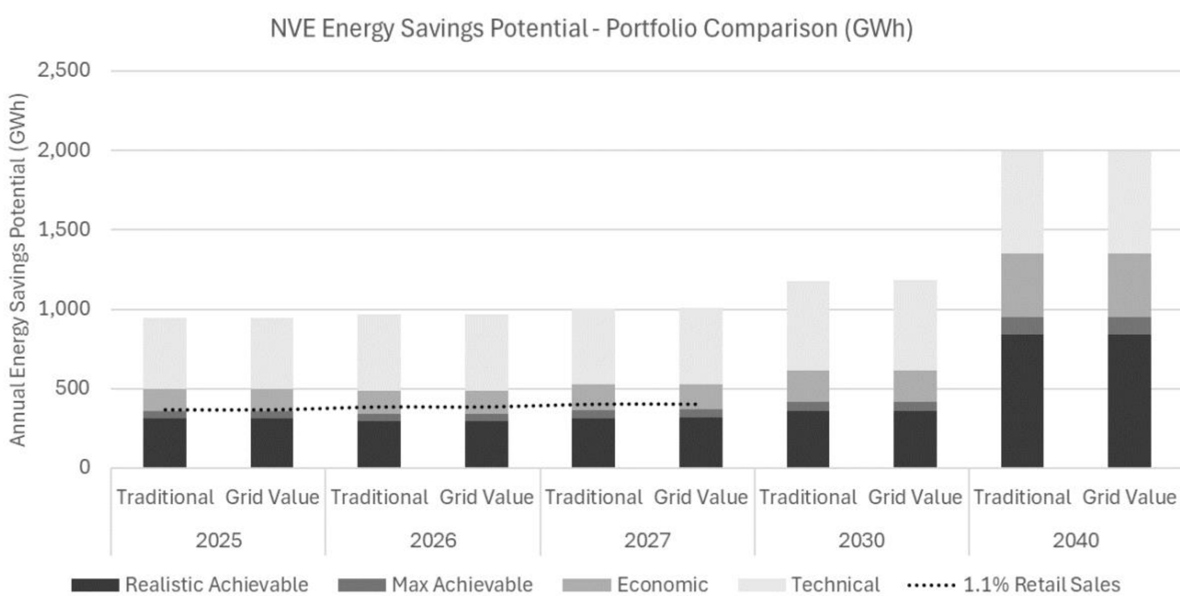
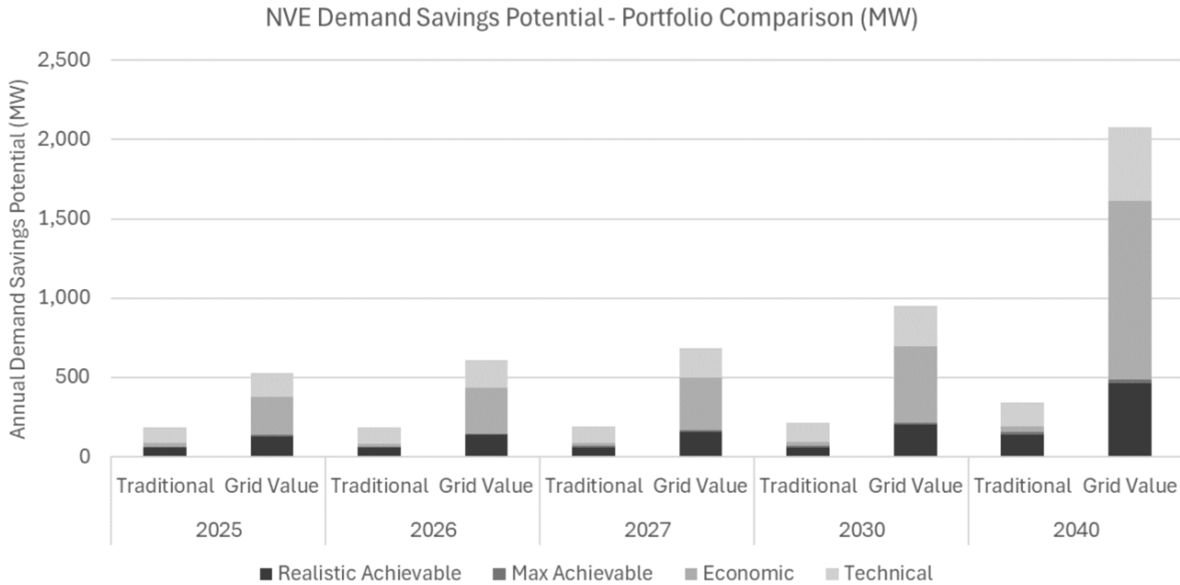


Figure 6. Comparison of Demand Savings Potentials Across NVE Portfolios



Several key takeaways emerged from the analysis of Economic and Maximum Achievable Potential for NVE's DSM portfolio in the near and long-term. The results of this analysis are presented in detail later in this report, but high-level conclusions include:

- **Economic Potential calculations screened out the majority of measures and savings from Technical Potential**. This screen is based on a measure having an nTRC that is at least 1.0. In total, approximately 68% of measures and 47% of Technical Potential for energy savings (75% of Technical Potential for demand savings) did not pass this screen and were not included in Economic Potential across both NPC and SPPC.
- **Commercial measures were more likely to be included in Economic Potential**, owing to the diminishing list of cost-effective energy efficiency measures in the residential sector, and the historic implementation of the Business Energy Services program in the commercial sector.
- **Significant categories of measures and end-uses that did pass the economic screen and are included in economic potential include**:
    - Residential single family and multi-family new construction
    - HVAC tune-up and control measures
    - Home Energy Reports
    - Most commercial measures, with a particular focus on upgrading non-GSL and commercial lighting
    - Thermostat demand response measures
    - Bring-Your-Own-Battery demand response programs
- **Considerations of Source Energy and Lifecycle Greenhouse Gas Emissions Metrics**

  - HVAC and thermostat measures generally outperform other top measures in the source energy and lifecycle greenhouse gas emissions metrics, offering more impact per kWh of energy saved. This is driven by the coincidence of HVAC savings shapes with hours of high source energy, emissions, and by correlation, high costs.
  - Lighting measures typically had lower impact in these metrics per unit of energy saved.
  - Residential measures typically have a higher impact per unit of energy saved compared to commercial measures, likely due to higher savings in the evening.
  - The source energy and emissions metrics are reflective of a "Grid Value" portfolio strategy and appear to encourage energy savings in peak hours.
  - The source energy and emissions metrics, additionally, would be reflective of electric grid emissions, and could guide design of a "Strategic Decarbonization" portfolio.
- **Portfolio Design Strategies (Traditional vs Grid Value)**
  - Within the three-year study period, through 2027, the Traditional and Grid Value only showed minor differences.
  - As loads continue to grow and as future controllable technologies come online – such as smart thermostats, managed EV charging, and battery storage – the incremental benefit of a Grid Value approach over a Traditional approach will increase.
  - Adding in additional grid benefits into a Grid Value approach, such as location value in distribution planning, would cause further divergence in total portfolio benefits between Grid Value and Traditional strategies.
- **More conversation is needed to develop a Strategic Decarbonization portfolio.** Given uncertainty in state policy regarding the scope (i.e. electric sector only or economy-wide) of emissions reduction NVE can consider in developing DSM portfolios, a Strategic Decarbonization portfolio was not developed in this study. If NVE can consider avoided emissions from on-site fossil fuel combustion, additional metrics would be needed to support portfolio development and prioritize measures that support efficient electrification.
- **Variations in program implementation and avoided costs between NPC and SPPC territory led to differences in the list of measures included in Economic Potential calculations**. In particular, residential HVAC tune-up measures were less cost effective in SPPC territory, as compared to NPC.
- **Out of the potential savings included in Economic Potential for energy savings, 72% is considered to be part of the Maximum Achievable Potential given practical constraints to consumer marketing and customer adoption curves, and 63% is considered to be Realistically Achievable Potential given historical and typical customer rebate amounts.** For demand savings, 37% of economic potential is determined to be the Maximum Achievable Potential, while 35% is Realistically Achievable.

Importantly, measures being screened out of Economic Potential does not preclude NVE from including these measures in its DSM portfolio. As long as the portfolio as a whole exceeds an nTRC of 1.0, individual measures that are not cost-effective can be included if they help to achieve other strategic priorities of the utility, such as energy equity or demand flexibility.

Conclusions, Recommendations, and Future Research

The results of the PATHWAYS DER adoption scenarios and DSM planning analysis support enablement of DSM/DER programs as a resource to meet grid needs. The resource potential for energy efficiency is changing in NVE's service territory, driven by the success of codes and standards. This reduces the remaining, achievable levels of energy efficiency for certain measures, such as lighting, as well as increased adoption of electric vehicles and new high-efficiency data centers entering the service territories. Simultaneously, the electric resource mix serving NVE is evolving, with higher levels of rooftop and utility-scale solar PV and other renewable resources, increasing the value of distributed energy resources that can reduce demand during system net peak periods. Given these changes, enabling NVE's energy efficiency program design to support overall Grid Value is prudent.

The analysis of Maximum Achievable and Realistically Achievable Potentials in both the Traditional and Grid Value portfolios revealed challenges in achieving the historic goal of energy savings equivalent to 1.1% of annual retail sales. This is due to the success of codes and standards in reducing the region's remaining energy efficiency opportunities and significant load growth in sectors that have fewer opportunities for incremental energy efficiency savings, including data centers and transportation electrification.

A shift toward a new DSM valuation framework that considers other key benefits to NVE's customers, such as those embodied in the Grid Value portfolio, could maximize overall benefits to the grid and to NVE customers, including: the ability to proactively manage peak demand increases and defer or avoid grid upgrades, increased flexibility in the face of policy and market uncertainty, reduced greenhouse gas emissions, and bolstered ability to manage increasing loads. Several jurisdictions across the US have augmented their energy efficiency programs and targets to enable transitions that maximize these benefits for customers.

Lastly, as this iteration of the MPS represents the "walk" phase of a "walk-jog-run" approach, several key improvements can be made in future iterations. First, measure analysis was performed at the end use level; in the future this can be performed at a more granular level that includes specific end-use technologies with varying efficiency specifications, thus providing further insight into variations of certain measures that may be cost-effective or provide greater grid value to NVE. Additionally, results can be generated with more awareness of locational benefit, leveraging the linkage between DSMore, Forecasting Anywhere, and LoadSEER; modeling results from this linkage can be applied both to Distribution Resource Planning, and Demand Side Management cost effectiveness. Lastly, additional underlying scenarios can be considered for evaluation of economic, maximum achievable, and realistically achievable potential. Important scenario considerations include level of adoption for Distributed Energy Resources and other load forecasts, upfront measure cost implications of different future scenarios, and underlying avoided costs and source energy/emissions metrics that are tied to relevant IRP scenarios or DER technology penetration. Continuing to improve and refine this process over time will further coordinate modeling and planning across NVE and help achieve truly integrated systems planning.

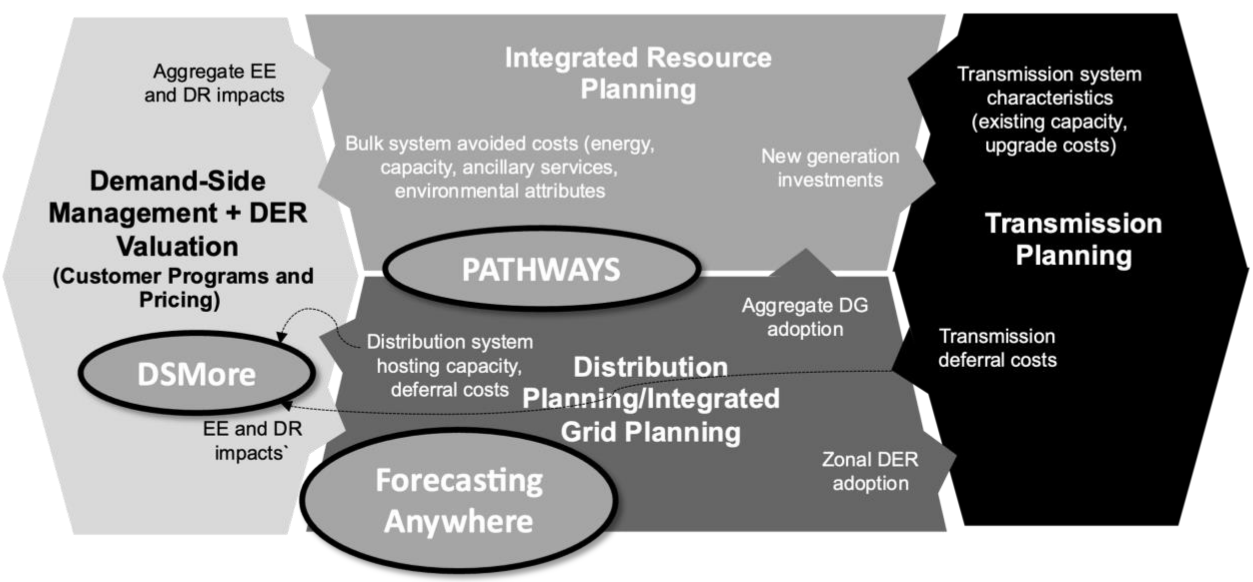
Introduction

This report documents the comprehensive distributed energy resource (DER) Market Potential Study (MPS), which assessed the potential for energy efficiency, building electrification, transportation electrification, behind-the-meter (BTM) solar, BTM storage, and demand response adoption from 2024 to 2054 in NVE's two service territories—Nevada Power Company (NPC) and Sierra Pacific Power Company (SPPC).

This study of market potential was conducted to inform NVE's demand-side management (DSM) portfolio and support other planning activities, including the development of its Integrated Resource Plan (IRP) and Distributed Resources Plan (DRP). Additionally, this study discusses DSM portfolio design metrics that are better aligned with the needs of NVE's customers and the utility's strategic initiatives.

The framework of this MPS study was created to support NVE in the development of an Integrated System Planning (ISP) framework, which aims to unify, coordinate, and optimize utility planning functions, including transmission planning, bulk system resource planning, distribution/distributed resource planning, and customer programs (or demand-side management) to cost-effectively meet customer needs and strategic goals of the utility. This study establishes a framework to utilize ISP concepts in NVE's IRP, DRP, and DSM plans, and leverages several new tools, that can bridge the gaps among utility planning functions. Figure 7 illustrates the concept of Integrated System Planning. For example, customer programs influence the adoption of energy efficiency and demand response, which influences Bulk System Resource Planning and Distribution Planning. The DER adoption scenarios generated by PATHWAYS help to inform the potential range of futures for each of these planning functions.

Figure 7. Integrated System Planning and MPS models



As this Market Potential Study is the first step in implementing the new framework, the priority of this study is to establish the new modeling pathways; in future cycles, continued progress can be made to advance ISP and expand upon scenario-specific data. It is recommended that NVE take a "walk-jog-run" process in moving toward an ISP framework in which the utility takes the opportunity at each iteration to improve upon its modeling and planning process coordination. This MPS represents NVE entering the "walk" phase.

The study was completed in two phases. In the first phase, E3 used its economy-wide greenhouse gas (GHG) and energy demand accounting and stock rollover model, PATHWAYS, to assess several scenarios of DER adoption. In the second phase, the analysis team focused on modeling the Economic, Maximum Achievable, and Realistically Achievable Potential for energy efficiency (EE) and demand response (DR) adoption.

For the first phase, E3 developed six different scenarios in PATHWAYS to explore a range of DER adoption scenarios that reflect varying economic and policy landscapes scenarios as well as the Technical Potential[6] for energy efficiency. PATHWAYS is agnostic to the administrator of DER programs, and scenarios represent the cumulative impact of various policy and economic conditions. As an economy-wide stock rollover model, PATHWAYS provides a comprehensive representation of the cumulative impact of a variety of DER types and demand-side options. PATHWAYS does not model DER adoption at the utility program or measure level and does not attribute adoption to specific utility, state, or federal programs. This approach differs from a 'traditional' bottom-up MPS as a means of calculating Technical, Economic, Maximum Achievable, and Realistically Achievable Potential for a utility DSM program, but enables more rapid and efficient modeling of potential DSM impacts across the six scenarios presented in this report.

To accompany the DER adoption scenarios produced in PATHWAYS, E3 characterized the types of supporting policy from the federal and state governments and the utility that can support DER adoption and produced a feasibility screen to rank each scenario according to metrics related to cost, customer disruption, and progress toward decarbonization. The supporting policy characterization lists potential policies that can support the level of DER adoption projected in each scenario but does not attempt to quantify the impacts of any of these potential policies nor to assign attribution for program administration to the federal government, states, or local actors, like utilities. Given that it is highly uncertain which DER adoption scenario is mostly likely to be realized, E3 developed a feasibility screen to provide an indication of the social, technical, and economic challenges of realizing each scenario. The metrics developed to reflect those challenges include total direct costs, average household costs, capital investment, customer behavior change, and achievement of GHG reductions. The screen is intended to provide an indication of the social, technical, and economic challenges of realizing each scenario.

The multiple DER scenarios from PATHWAYS were leveraged to understand what additional types and the potential scale of measures and programs that could be considered in the development of NVE's DSM portfolio. These additional measures were then considered in portfolio design as the

[6] Technical potential is the theoretical upper limit of adoption of a certain technology assuming that customers adopt regardless of cost-effectiveness or preference.

analysis moved into the second phase to model the Economic, Maximum Achievable, and Realistically Achievable Potential.

In addition to developing the DER scenarios in PATHWAYS, which take a service-territory wide view of DER adoption, the analysis team leveraged Forecasting Anywhere (FA), a geospatial DER adoption model developed by IA and E3 to identify where DER is likely to occur. This analysis was conducted to support NVE's DRP activities, identifying areas where DERs can be leveraged as non-wires alternatives, and to evaluate the impact of DER adoption in Low- and Moderate- Income (LMI) communities in the MPS. Note that FA is a lighter-weight version of IA's LoadSEER, a distribution system forecasting tool, which is a tailored platform setup and integrated directly into utility operations for use by NVE distribution planners. While LoadSEER is being set up for future use by NVE staff, FA was customized and run by E3 to conduct the distribution level analysis given its ability to nimbly consider multiple scenarios and to provide geographic granular DER impacts. The scenarios from FA used in this study will be ported into the NVE LoadSEER instance once that setup is complete.

In the second phase, the analysis team modeled the Technical, Economic, Maximum Achievable, and Realistically Achievable Potential (see Methodology section for discussion of potential definitions) for energy efficiency and demand response adoption. Technical potential was first estimated using assumptions from the PATHWAYS model, most notably the annual stock turnover rate of commercial and residential technologies. These annual turnover rates, combined with unit energy savings from the most recent NVE M&V analyses (or other sources, as needed) defined the annual Technical Potential available to NVE if all stock were replaced with efficient technologies upon turnover.

Based on Technical Potential representing the upper bound to annual measure adoption through NVE DSM programs, Economic, Maximum Achievable, and Realistically Achievable were then assessed using IA's DSMore tool, which evaluates DSM measures, programs, and portfolios for cost-effectiveness. For each individual measure administered through a separate DSM program, DSMore was utilized to calculate its nTRC inclusive of measure level incremental costs and pro-rated program administration and implementation costs. The sum of savings from measures with an nTRC above 1.0 accounts for the Economic Potential. A compilation of the inputs, outputs, and data sources utilized in these DSMore runs is included in an appendix to this report.

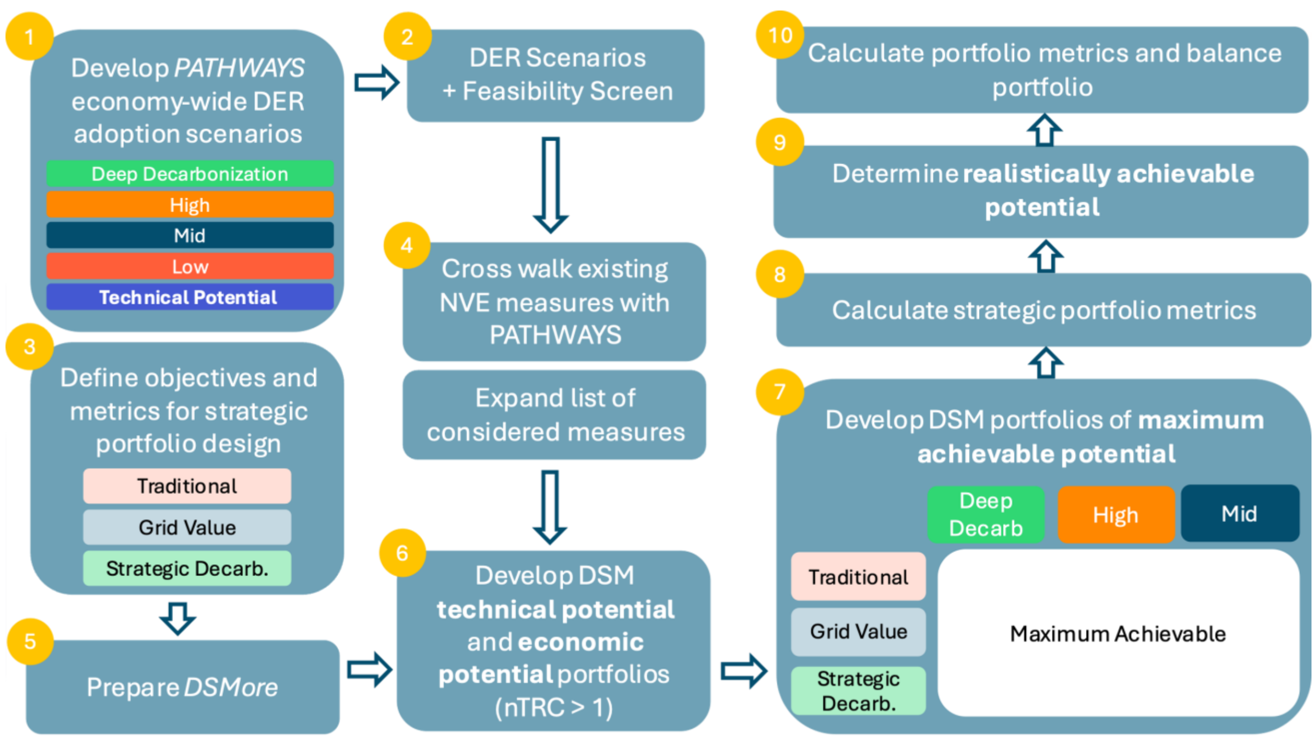
The last step in the second phase was the determination of achievable savings. Maximum Achievable savings is presumed to include most of the Economic Potential but recognizes that some customers will not participate in an NVE program no matter how generous the rebates or how aggressive the marketing campaigns. For programs that did not include a customer rebate, it is estimated that 85% of annual turnovers could be captured in an NVE DSM program with a Herculean outreach effort. For measures that comprise a customer rebate, DSMore was utilized to estimate the Maximum Achievable Potential if 90% of the participant costs were covered by program rebates. Lastly, after assessing the Maximum Achievable Potential, Realistically Achievable savings were determined accounting for additional considerations—such as supply chain constraints, capital availability, the operational capacity of community partners, etc.— that regularly impact the annual operation and reach of DSM programs. Similar to the assessment of Maximum Achievable Potential, programs were estimated differently depending on whether there was a participant rebate. When there is a rebate, DSMore was combined with customer payback acceptance curves to estimate potential under multiple rebate levels, including 50% of participant costs, as well as the historical rebate level provide by NVE or similar utility DSM programs. For measures without a participant rebate, the analysis team performed a literature review to arrive at estimates of the percentage of annual turnover that could be captured in a DSM program with a realistic customer outreach and marketing campaign.

Methodology

The MPS was conducted in two phases. In the first phase (steps 1 – 4 below), DER adoption scenarios were developed using E3's PATHWAYS model to assess a wide range of futures of policy support and market conditions supporting varying levels of DER adoption. Economy-wide PATHWAYS results were then translated and scaled to map to demand-side measures, to be leveraged in portfolio planning. In the second phase (steps 5 – 10 below), to support the DSM Planning Process directly, DSMore was used to assess the cost-effectiveness of energy efficiency and demand response measures and programs to evaluate Economic, Maximum Achievable, and Realistically Achievable Potential.

Market Potential Study Process Flow

Figure 8. Market Potential Study and DSM Planning Process Flow Diagram



This section describes the overall process of developing this MPS. Note that the process flow diagram shown in Figure 8 has been simplified from the version shown to stakeholders previously on March 4th, 2024 (see Appendix D). The modeling process has been modified slightly, based on modeling and data limitations found after the stakeholder meeting.

The primary modification was in the calculation of maximum achievable potential. The previous approach looked at adjusting program cost levels to achieve a target result in the participant cost test; given current data and modeling capabilities this exercise did not produce meaningful results. The updated process for calculating maximum achievable potential includes the use of a market acceptance curve based on measure-levels participant economics, which is a widely used convention.

1) **DER Adoption Scenarios and Technical Potential**

In the DER adoption scenarios phase, E3 and Tierra used PATHWAYS to model a range of DER adoption. The following section describes the PATHWAYS model, the development of DER scenarios, and underlying modeling assumptions. Through the PATHWAYS modeling, E3 and Tierra produced an assessment of the economy-wide Technical Potential for energy efficiency which was used as a basis in the DSM planning process to define NVE Technical Potential. In addition to the adoption trajectories, E3 and Tierra produced a narrative on the range of policies and market conditions that could support the achievement of the scenarios. Finally, the analysis team produced a feasibility screen to characterize the challenges of achieving each scenario.

2) Feasibility Screen

The relative feasibility of the PATHWAYS scenarios was estimated using five metrics designed to reflect the technical, societal, and economic challenges associated with each scenario: total direct costs, average household costs, capital investment, customer behavioral changes, and achievement of GHG emissions reductions.

3) Define Objectives and Metrics

In the metrics definition phase, E3 and NVE explored the use of several metrics to evaluate potential portfolios, in lieu of energy impacts in units of kWh. While additional stakeholder engagement is anticipated to define the final metrics that will be used to set binding targets for NVE's portfolios, E3 developed two preliminary metrics: Hourly Marginal Source Energy, and Hourly Marginal Emissions. These metrics inform portfolio design by identifying higher impact DSM measures.

4) Cross-Walking NVE Measures with PATHWAYS & Comprehensive List of Measures

In this step, the existing NVE DSM portfolio of measures was cross-walked with the PATHWAYS outputs. This shows how the existing measures contribute to the overall economy-wide goals by end-use, subsector, and sector. This information is supportive of the translation to DSMore and provides additional information to support future portfolio design and NVE Achievable Potential relative to the MPS.

Tierra developed new measures in addition to NVE's existing portfolio to be more comprehensive of measures aligned with each end-use, subsector, and sector of the MPS, specifically focusing on the full range of utility-supported programs. These new measures cover energy efficiency and demand response measures aligned with the MPS scenarios. This list was compiled through current programs, measures lists from other studies, new and emerging technologies, and feedback from stakeholders. All DSM portfolio measures were then mapped to PATHWAYS devices on an end-use basis to prepare for calculation of the DSM Technical Potential.

5) Prepare DSMore

In this step, the analysis team prepared inputs for DSMore. These inputs included utility-level inputs for NPC and SPPC, such as avoided costs, and program/measure-level inputs, such as per-unit savings and implementation costs. For existing NVE DSM offerings, these measure characterization input values were based on existing data provided by NVE. For new measures added into DSMore for consideration, inputs were based on measure characterizations performed in geographically similar jurisdictions. Input sheets containing all measure and utility-level inputs were reviewed by IA to ensure the functionalities being used within DSMore were achieving the desired aim of characterizing the modeled measures and assessing their cost-effectiveness with the assumed inputs. Additionally, in collaboration with NVE, the analysis team created a framework for building portfolios of different DSM program offerings being evaluated in DSMore, each designed around NVE's strategic goals.

6) DSM Technical & Economic Potential

To define the Technical Potential to be used as the basis for portfolio planning, stocks and sales from the PATHWAYS Technical Potential scenario were used. Technical Potential was determined as the number of devices reaching their end of life in any given year or the maximum number of new sales per device in any year. No early retirements of technology were assumed before their end of life. To translate Technical Potential into energy terms, the maximum sales by end-use was multiplied by the energy savings potential per measure.

Economic Potential is calculated at the measure level and is based on historical cost and savings numbers from NVE programs, where such data is available. To be included in Economic Potential, a measure must have an nTRC that is at least 1.0. The calculation of nTRC is similar to the industry standard Total Resource Cost test (TRC), with an additional percentage multiplier applied to the benefits for each measure to account for non-energy benefits to the State of Nevada.

Note that the nTRC criterion that is applied to determine Economic Potential screens out the majority of measures from consideration in subsequent calculations of Maximum Achievable and Realistically Achievable Potential. Though it varies from year to year, approximately one-third of measures achieve an nTRC greater than 1.0. Importantly, this does not preclude NVE from including measures that do not pass the Economic Potential screen in their DSM portfolio. As long as the portfolio as a whole exceeds an nTRC of 1.0, individual measures that are not cost-effective can be included if they help to achieve other strategic priorities of the utility, such as energy equity or demand flexibility.

7) Maximum Achievable Potential

Maximum Achievable Potential is calculated using adoption curves that are based on simple payback periods (SPPs) that show how many years it would take for a customer to recoup their costs when rebates and/or incentives are set at 90% of the incremental cost of the measures to customers. Maximum Achievable Potential for portfolios was developed based on three different portfolio design options for each of the PATHWAYS scenarios:[7]

- **Traditional**: Focuses primarily on all measures that generate energy savings and is consistent with historical metrics determining annualized first year energy (kWh) savings (e.g. % of sales-based target).
- **Grid Value**: Prioritizes measures that support renewable energy integration and reduce energy and demand during grid peaks and during hours with higher marginal costs and higher emissions from fossil-fuel generating plant.
- **Strategic Decarbonization (To be considered in future iterations)**: Similar to Grid Value priorities, but layers in fuel neutral measures that further improve demand flexibility, reduce site emissions, and complement state and federal funding opportunities (e.g. gas hot water heater to grid-interactive heat pump hot water heater).

8) Calculate Strategic Portfolio Metrics

Portfolios designed in the previous step are quantified against the specific metrics aligned with the strategic initiative (e.g. GHG impacts). This allows for quantification of how each portfolio performs relative to the strategic initiatives.

9) Realistically Achievable Potential

Leveraging the outputs from the strategic initiative quantification and information coming out of DSMore on the portfolio and measure cost-effectiveness (nTRC and PCT), NVE developed the Realistically Achievable Potential. NVE considered several factors that could constrain their ability to realize the Achievable Potential calculated in Step 7. These factors include program budget availability, program ramp-up time, supply chain constraints, local constraints, capital availability, and community partners' operational constraints. Realistically Achievable Potential is the basis for developing NVE's DSM portfolio for the next 3-year period.

10) Calculate Metrics and Balance Portfolio

Calculated portfolio metrics of the Realistically Achievable portfolio and balanced cost-effectiveness with strategic initiatives.

PATHWAYS Model

E3 developed PATHWAYS, an economy-wide energy, stock rollover, and emissions accounting model. Among other features, the model can estimate future annual energy demand and GHG

[7] Note that results for Maximum Achievable Potential shown in this report only include portfolios built off of the Mid PATHWAYS scenario and designed for Traditional and Grid Value strategic objectives.

emissions over time, as well as annual sales and stocks of energy-consuming devices (equipment, appliances, motor vehicles etc.). The PATHWAYS model includes 15 residential subsectors, 9 commercial subsectors, and 6 transportation subsectors, or 30 total subsectors captured in the stock rollover section of the model. Together, these sectors include 117 technologies. This study used the PATHWAYS model framework to project future adoption of additional DER types, including BTM solar, BTM storage, demand response in residential and commercial buildings, managed electric vehicle (EV) charging, and non-equipment and behavioral energy efficiency.

Crucially, PATHWAYS is not an optimization model, nor does it endogenously model adoption. Rather, it evaluates user-defined scenarios based on underlying drivers of demand for energy services (such as population growth) and interventions that affect final energy consumption (such as increased sales of efficient or electrified devices). When scenarios are designed to reach a set target, such as a decarbonization goal, the results should be viewed as “backcasts” of requisite action.

To prepare a PATHWAYS model specific to NVE, E3 first benchmarked the tool to the entire state of Nevada. U.S. Energy Information Administration’s (EIA) State Energy Data System (SEDS) has published aggregated energy demands by economic sector and fuel type for Nevada as of 2020, and the energy demands calculated by PATHWAYS were aligned with this reference. Initial subsector estimates were developed by combining government data on device stocks, device shares, device efficiency, and service demands from various sources, most importantly AEO, EIA’s Residential Energy Consumption Survey (RECS), EIA’s Commercial Building Energy Consumption Survey (CBECS), and National Renewable Energy Laboratory (NREL). Default assumptions were updated with NVE specific data when available. EIA data on proportional electricity demand by end-use was also incorporated.

SEDS does not provide energy demand data by subsector or device, so E3 assembled default data on the use, rates of ownership, and efficiency of major technologies to arrive at a bottom-up estimate of sectoral energy demands. Default values were then adjusted with data from NVE and other supplemental sources until demands aligned with SEDS.

E3 then adapted the model of Nevada to describe the NPC and SPPC service territories. These models were first scaled down from the Nevada model using customer counts and population data for each territory. The model description of energy technology in the two territories was refined with data from NVE’s 2016 Residential Appliance Saturation Survey (RASS), its 2017 Market Potential Study, and its load forecast. Finally, model outputs were benchmarked against historic electricity consumption data.

Scenario Design

The study explored six future scenarios of DER adoption, including energy efficiency, building electrification, transportation electrification, BTM solar, BTM storage, and demand response. The scenarios were designed to explore a wide range of potential futures and reflect varying policy and market landscapes. There were many considerations that went into the development of key

PATHWAYS inputs, including annual sales shares of DERs, which are discussed further in subsequent sections of this report.

Scenario Summary

The Deep Decarbonization and High scenarios were developed to achieve greenhouse gas reduction targets outlined by the state of Nevada in 2019 Senate Bill 254.[8] The Deep Decarbonization scenario achieves interim goals of 28% reduction below 2005 levels by 2025, 45% reduction by 2030, and net-zero by 2050. The High scenario does not achieve the interim targets, but it achieves the mid-century net-zero goal. The Reference case is intended to reflect DER adoption assuming no change to existing federal, state, and utility policy and no dramatic shifts in market trends. The Mid scenario is intended to reflect a continuation of existing policies and market conditions in the near term but higher policy ambition and market transformation starting around 2030 which accelerates the deployment of DERs. The Low scenario reflects lower DER adoption due to unfavorable market forces or policy changes. These scenarios explore varying levels of adoption of all DER types. The Deep Decarbonization and High scenarios, which were designed around decarbonization targets, have high rates of building and transportation electrification which were coupled with ambitious energy efficiency and demand response adoption.

The Technical Potential scenario was developed to explore the maximum energy efficiency potential. This scenario assumes that customers choose the most efficient device option available on the market upon burnout of existing equipment and in new construction and there is no fuel switching in retrofit applications. The scenario also assumes that all customers participate in non-equipment energy efficiency programs such as home energy reports and smart thermostats. This scenario was developed to explore only the technical potential for energy efficiency and not the technical potential for other DERs evaluated in this study.

[8] State of Nevada Priority Climate Action Plan (2024) https://www.epa.gov/system/files/documents/2024-03/state-of-nevada-priority-climate-action-plan.pdf

Figure 9. PATHWAYS Scenario Design Overview

Deep Decarbonization	**Meets GHG reductions goals of 28% by 2025, 45% by 2030 and net-zero emissions by 2050**
High	**Represents achievement of 2050 carbon goal, but not interim goals**
Mid	**Aligned with existing policies and current trends in the near-term, but higher policy ambition and market transformation starting in 2030.**
Low	**Assumes a slow down in historical adoption rates due to head winds to DER adoption.**
Technical Potential	**Maximum adoption of efficient appliances and behavioral EE assuming no electrification**
Reference	**Aligned with existing policy and market trends.**

Scenario Considerations

To develop inputs to the PATHWAYS model that are differentiated by scenario, the analysis team considered several policy, economic, and market factors that influence the adoption rate of DERs. Those factors include:

+ Fossil fuel prices,
+ Electricity rates,
+ Upfront equipment/device costs,
+ Federal, state, and utility incentives,
+ Customer preferences and attitudes,
+ Supply chain constraints,
+ Codes and standards,
+ And other federal, state, and utility policy.

PATHWAYS scenarios were developed considering how a combination of these factors at varying scales (i.e. range of gas prices, magnitudes of incentives) could influence adoption. Given the uncertain nature of how economic conditions and the policy environment will evolve, PATHWAYS does not model how a specific factor spurs adoption. Instead, the scenarios are designed to capture a wide range of possible policy and economic futures. There are many possible combinations of factors that could lead to the adoption rates modeled in PATHWAYS for each scenario. For example, high levels of energy efficiency adoption could be driven by varying combinations of market conditions, such as high electricity prices and low equipment costs, and new incentives provided by the federal or state government. The scenarios do assume that these factors generally differ between scenarios, but the model does not quantify nor specify by how much. For example, for the Deep Decarbonization scenario to be achieved, there would need to be no supply chain constraints and technology costs would need to decline or new incentives from the federal/state government or utility would be needed to encourage adoption. In the Low scenario, supply chain constraints limit adoption rates and higher technology costs are a barrier to adoption for customers.

Further discussion of the types of supporting policies and market conditions that could support the levels of DER adoption modeled in each scenario is provided in the Supporting Policy for the DER Scenarios section of this report. The analysis team describes various policies that could contribute to spurred adoption across scenarios. Where possible, the team notes known policies that would generate the levels of adoption seen in a scenario. For example, the teams notes that if Nevada were to adopt a regulation like the California Air Resources Board (CARB) Advanced Clean Cars II (ACC II), the levels of light-duty vehicle transportation electrification in the Deep Decarbonization scenario would be achieved. More often, the analysis team notes policies and market conditions that would most likely be in effect to varying degrees across scenarios contributing to adoption. For example, all scenarios would include investments in building out public EV charging infrastructure by the federal, state, utility, and/or private market to accelerate transportation electrification. Higher levels of investment in the public charging network are needed to realize and support greater EV adoption, which varies across scenarios.

Reference Scenario

As described above, the Reference scenario is intended to reflect a business-as-usual case with no new policy or market transformation. To develop that scenario, the analysis team benchmarked the scenario to what is observed today and, for the future forecast, relied upon historical adoption rates of energy efficiency and extrapolated those forward. The data sources used for assessing those historical adoption rates include the impacts of utility programs. Thus, the Reference scenario reflects the current scale of NVE’s DSM programs, and the forward trajectory could capture some inertia from those programs, even though no NVE DSM program was explicitly considered.

Adoption Inputs

PATHWAYS takes as inputs expected annual sales shares of each energy consuming device in the economy.[9] These sales shares determine the pace of DER deployment and are different in each scenario. This section discusses the consideration and research that influenced the development of those sales shares.

Energy Efficiency

Sales shares of efficient technologies among each subsector in the Reference scenario are held constant based on their current, business-as-usual rates based on sales data from the most recent

[9] Solar and storage deployment was modeled by user driven assumptions about the trajectory of installed capacity.

ENERGY STAR Unit Shipment report[10] or Current Practice market technology shares from measure analyses performed at the Regional Technical Forum. In the Deep Decarbonization scenario, sales shares increase linearly from their current market shares to 100% by 2030. In the High scenario, adoption increases are based on the results of surveys fielded to residential, commercial and industrial utility customers conducted by the California Public Utilities Commission (CPUC).[11] The study identified the most significant barriers to the adoption of efficient technologies based on survey responses. The top three barriers were assigned numerical values of importance for each end use technology based on professional judgment. These values, meant to signify the level of effort needed in overcoming adoption barriers, were used in the calculation of the sales rate increases through 2030. From then on, sales rates are assumed to increase linearly to 100% by the end of the analysis period. In the Mid scenario, sales rates are assumed to remain constant through 2030, and then increase linearly through the remaining analysis period to the same rate assumed for 2030 in the High scenario based on the CPUC Study surveys. The Low scenario assumes a slight or moderate decrease in efficient sales shares through 2030 and 2054 based on the same survey results.

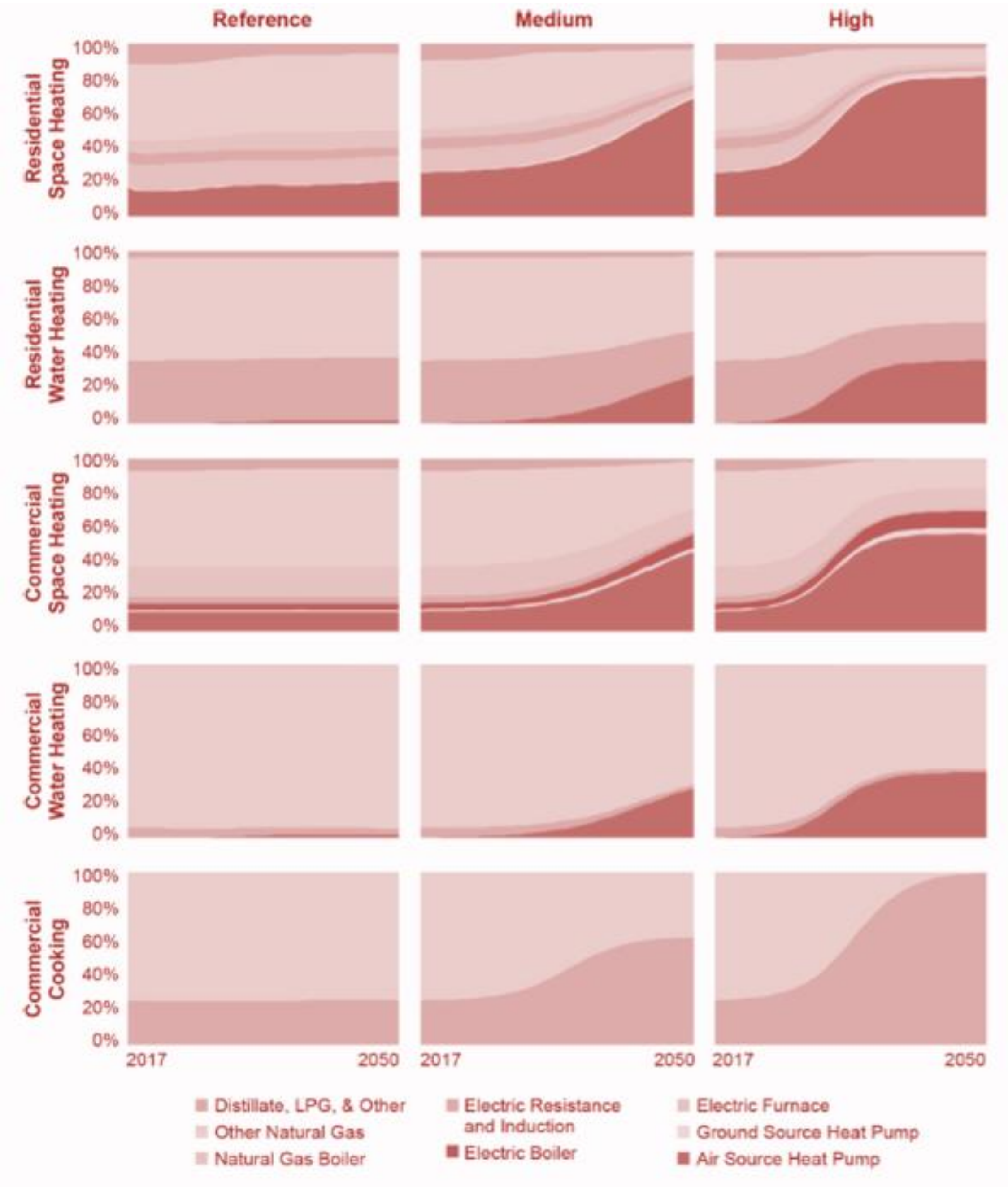
For some end use technology groups, such as residential heating, the analysis also required an assumption of changes in fuel shares, generally electricity versus natural gas. In these cases, the current fuel splits are based on Current Practice Baseline calculations performed by the Regional Technical Forum or current Reference case technology and fuel splits from NREL's recent "Electrification Futures Study" (EFS), reproduced as Figure 10 below (originally Figure 4.2 on page 28 of EFS[12]). In the Deep Decarbonization scenario, technologies are assumed to transition to all electric by 2030 and by the end of the analysis period in the High scenario. Fuel shares from the NREL study are also used in the High Scenario for 2030 and in the Mid scenario for the end of the analysis period. The Mid scenario also assumes business as usual fuel shares continue through 2030. In the Low scenario, natural gas sales rates are expected to increase slightly to moderately, depending on end use technology, over the analysis period.

---

[10] "ENERGY STAR Unit Shipment and Market Penetration Report, Calendar Year 2022 Summary," United States Department of Energy, 2022. Available at: https://www.energystar.gov/sites/default/files/2022%20Unit%20Shipment%20Data%20Summary%20Report.pdf?itid=lk_inline_enhanced-template

[11] "California Energy Efficiency Market Adoption Characteristics Study," prepared for California Public Utility Commission by Guidehouse and Opinion Dynamics, April 2021. Available at: https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/energy-efficiency/2021-potential-goals-study/market-adoption-report-final.pdf?sc_lang=en&hash=131848F75C4A50EB35D9247F45FB4257

Figure 10. NREL Electrification Futures Study - Buildings technology sales shares by electrification scenario



PATHWAYS leverages several public data sources to establish the energy efficiency of each device for both the efficient and standard options. The model considers that both the efficient and standard options improve over time. Table 5 summarizes the data sources considered in developing device efficiency assumptions by counterfactual fuel and subsector.

Table 5. PATHWAYS Device Efficiency Data Sources

Subsector	Fuel	Efficiency Data Source
Residential Central Air Conditioning	Electricity	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
Residential Clothes Drying	Electricity	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
	Natural Gas	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
Residential Clothes Washing	Electricity	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
Residential Cooking	Electricity	ACEEE Induction Cooking Technology Design and Assessment, 2014
	LPG	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
	Natural Gas	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
Residential Dishwashing	Electricity	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
Residential Freezing	Electricity	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
Residential General Service Lighting	Electricity	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix C
Residential Reflector Lighting	Electricity	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix C
Residential Linear Lighting	Electricity	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix C
Residential Exterior Lighting	Electricity	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix C
Residential Refrigeration	Electricity	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
Residential Room Air Conditioning	Electricity	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
Residential Multi Family Space Heating	Electricity	NREL Electrification Futures Study Technology Data
		EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
	Natural Gas	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
	Distillate	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
	LPG	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
	Wood	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A

Residential Single Family Space Heating	Electricity	NREL Electrification Futures Study Technology Data
		EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
	Natural Gas	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
	Distillate	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
	LPG	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
	Wood	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
Residential Water Heating	Electricity	NREL Electrification Futures Study Technology Data
		EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
	Distillate	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
	Natural Gas	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
	LPG	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
Commercial Air Conditioning	Electricity	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
	Natural Gas	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
Commercial Cooking	Electricity	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
	Natural Gas	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
	Electricity	ACEEE Induction Cooking Technology Design and Assessment, 2014
Commercial General Service Lighting	Electricity	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix C
Commercial HID Lighting	Electricity	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix C
Commercial Linear Lighting	Electricity	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix C
Commercial Refrigeration	Electricity	NEMS input file ktex.txt
Commercial Space Heating	Electricity	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
	Distillate	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
	Natural Gas	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A

	LPG	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
Commercial Ventilation	Electricity	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix C
Commercial Water Heating	Electricity	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
	Natural Gas	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
	Distillate	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A
	LPG	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiency Appendix A

Data Center Energy Efficiency

Energy efficiency savings potential for data centers were calculated by extrapolating historical project- and measure-level savings to NVE-adjusted capacity requests from existing customers. Forecasted savings were segmented by project utility, project vintage (i.e., existing, new construction), and facility type (e.g., large tech, small tech). Savings were further calibrated to reflect Nevada's recent code update from the 2018 to 2021 International Energy Conservation Code (IECC). The analysis generally took a conservative approach to assessing data center energy efficiency potential as most data centers are built as efficiently as possible. It is recommended that NVE continue to study the potential for data center energy efficiency as data centers represent a new and large source of load growth.

Building Electrification

To estimate adoption patterns for building electrification, the analysis team reviewed trends in data from two sources: the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) report of monthly shipments by equipment type and the EIA's RECS estimate of regional equipment saturations. AHRI issues a monthly report of combined U.S. manufactured shipments of central air conditioning, air-source heat pumps systems, gas furnaces, and gas and electric tank water heaters. Annual cumulative shipment data was reviewed for 2018 through 2023 for gas warm air furnaces compared to unitary heat pump systems as well as residential gas storage water heaters compared to electric storage water heaters. The table below shows an annual compounded decline rate in shipments of approximately –2.4% for both types of natural gas appliances over the 6-year period reviewed.

Table 6. AHRI Shipment data informing energy efficiency assumptions

AHRI Shipments	2018	2019	2020	2021	2022	2023	CAGR
NG HWH	51.7%	51.0%	49.6%	50.4%	47.5%	44.6%	-2.4%
NG Furnaces	53.7%	52.5%	49.5%	49.5%	49.5%	46.7%	-2.3%

The AHRI data represents national trends while the EIA's RECS database provides regional saturation estimates. To establish if national trends defined by AHRI are also occurring in Nevada, the analysis team reviewed the most recent RECs data for the Mountain South region, which includes Arizona, New Mexico, and Nevada. The table below shows natural gas hot water heater saturation declining at an annual compounded rate of –2.6% over the 12-year period of the EIA reports, while the saturation of natural gas furnace declined at an annual compound rate of –1.4%.

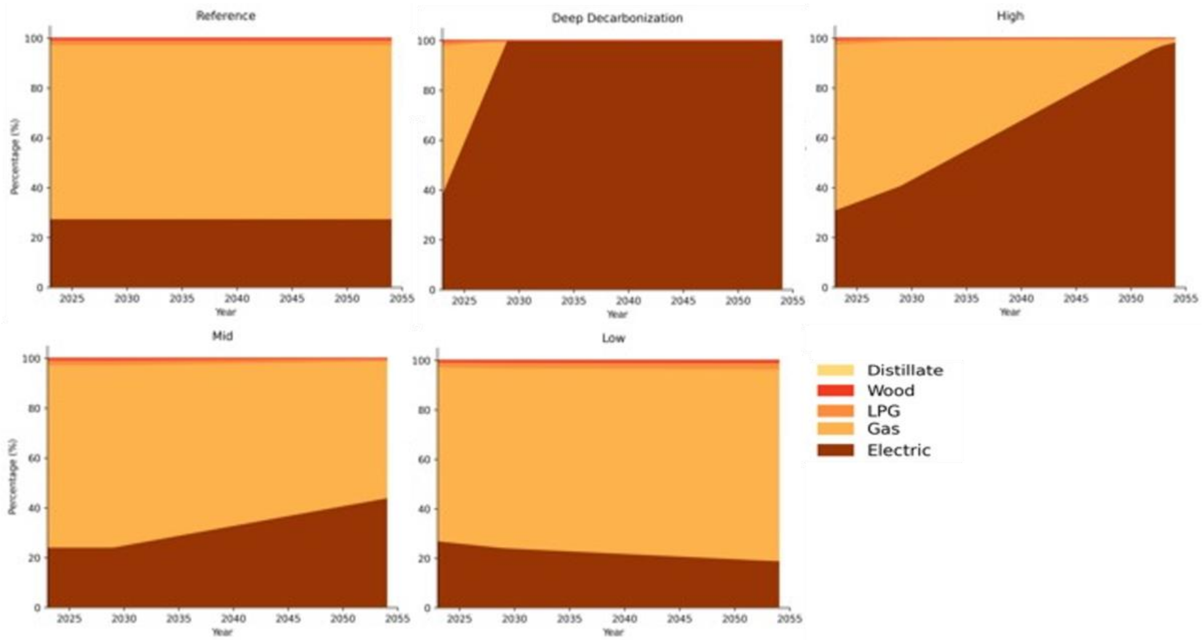
Table 7. RECS Mountain South Space Heating Fuel Saturation Data

RBEC Saturations	2009	2015	2020	CAGR
NG HWH	75%	62%	55%	-2.6%
NG Furnaces	60%	53%	51%	-1.4%

The analysis team concluded that AHRI and EIA data could be used as a reference forecast for trends in residential building electrification in Nevada, though could not be used to verify the efficiency of electric appliances being installed.

As discussed in the energy efficiency inputs section, in the Deep Decarbonization scenario, technologies are assumed to transition to all-electric by 2030, and by the end of the analysis period in the High scenario to meet the decarbonization goals defining those scenarios. Fuel shares from the NREL EFS are also used in the High Scenario for 2030 and in the Mid scenario for the end of the analysis period. The Mid scenario also assumes business-as-usual fuel shares continue through 2030. In the Low scenario, natural gas sales rates are expected to increase slightly to moderately, depending on end use technology, over the analysis period.

Figure 11. Residential Space Heating Equipment Sales Shares by Fuel in NPC



Transportation Electrification

In the Reference scenario, light duty zero-emissions vehicle (ZEV) sales shares were developed based on Bloomberg New Energy Finance (BNEF)'s *Long-Term Electric Vehicle Outlook 2023 (EVO).*[13,14] The Mid scenario represents a continuation of the growth rates modeled in BNEF before 2035 through the end of the analysis period. The sales shares in the Deep Decarbonization scenario are equivalent to those required to comply with California's Advanced Clean Car II regulations.[15] The High scenario is designed to achieve the GHG net-zero 2050 goal. To meet that goal, it is assumed that ZEV sales shares must reach 100% by 2040. The sales shares in the High scenario are equivalent to the reference case until 2027 and then show accelerated market transformation. The ZEV sales shares in the Low scenario were drawn from the Environmental Protection Agency's (EPA) report, *Electric Sector Emissions Impacts of the Inflation Reduction Act: Assessment of Projected CO_2 Emission Reductions from Changes in Electricity Generation and Use.* [16]

---

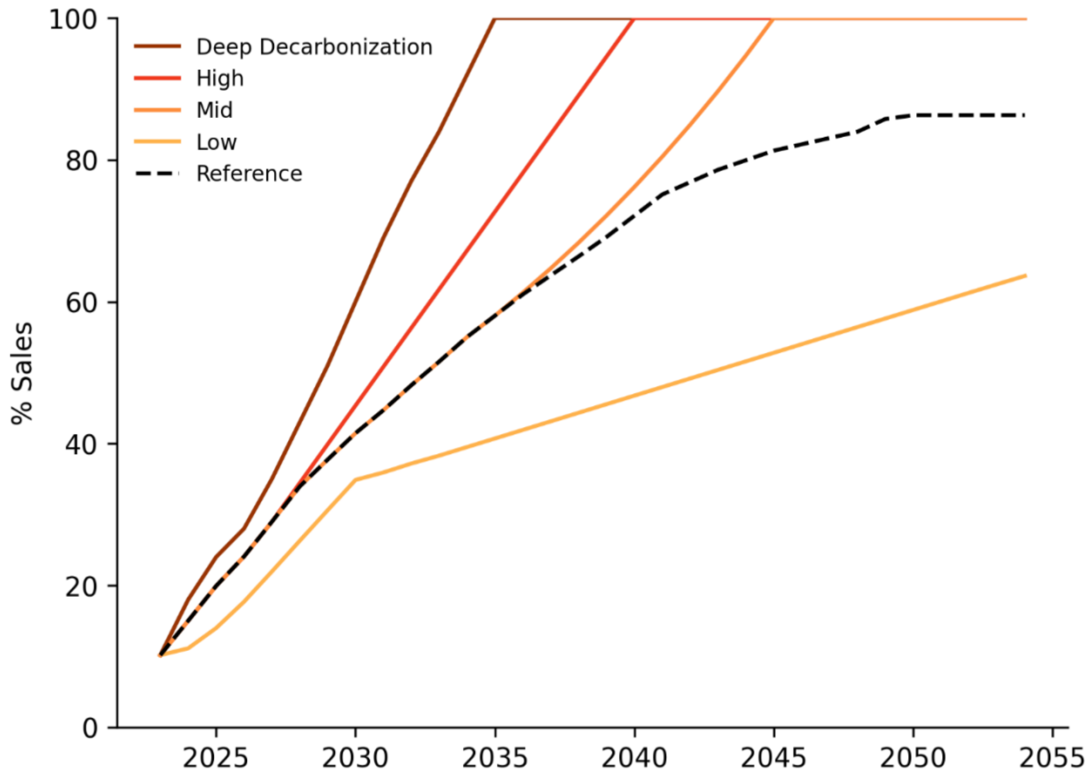
[13] Bloomberg New Energy Finance, Electric Vehicle Outlook 2023, https://about.bnef.com/electric-vehicle-outlook/.

[14] Note that this analysis was conducted prior to the finalization of the "Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles" by the U.S. EPA.

[15] California Air Resources Board, https://ww2.arb.ca.gov/our-work/programs/low-emission-vehicle-program

[16] Environmental Protection Agency, *Electric Sector Emissions Impacts of the Inflation Reduction Act: Assessment of Projected CO_2 Emission Reductions from Changes in Electricity Generation and Use*, 2023, https://www.epa.gov/system/files/documents/2023-09/Electricity_Emissions_Impacts_Inflation_Reduction_Act_Report_EPA-FINAL.pdf

Figure 12. Light Duty Zero Emissions Vehicle Sales Share

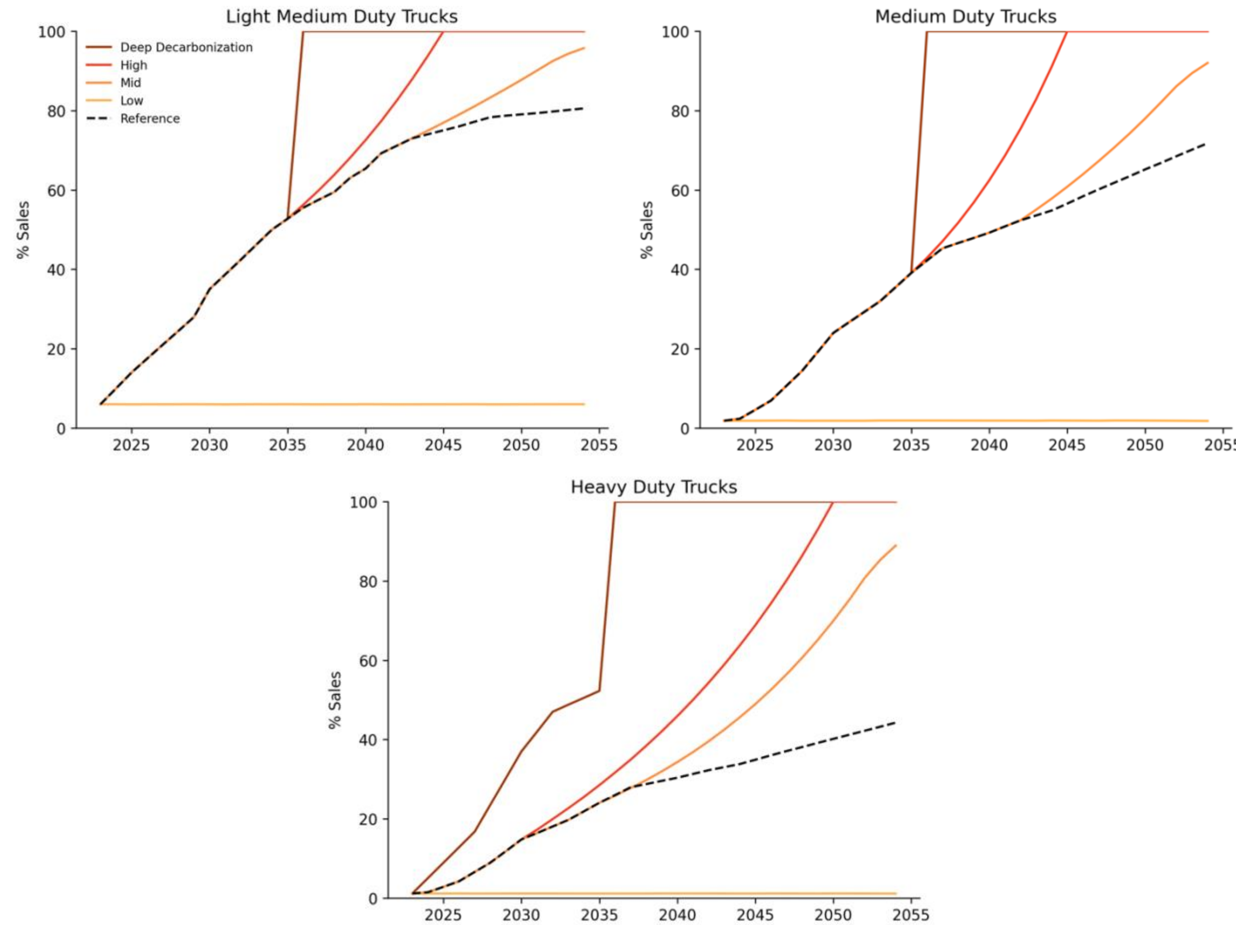


In the Reference scenario, medium- and heavy-duty zero-emissions vehicle sales shares were developed based on BNEF's *EVO 2023 (EVO).*[17,18] The Mid scenario represents a continuation of the growth rates modeled in BNEF before 2040 through the end of the analysis period. The sales shares in the Deep Decarbonization scenario are equivalent to those required to comply with California's Advanced Clean Trucks and Advanced Clean Fleet regulations.[19,20] The High scenario is designed to achieve the GHG net-zero 2050 goal. To meet that goal, it is assumed that ZEV sales shares must reach 100% by 2045. The sales shares in the High scenario are equivalent to the Reference case until 2035 and then show accelerated market transformation. The sales shares in the Low scenario are based on EIA's AEO 2023.[21] In all scenarios, it is assumed that a majority of ZEVs are battery electric vehicles (BEVs), but the share of hydrogen fuel cell vehicles varies by scenario. In the Low scenarios, all medium- and heavy-duty trucks sales are assumed to be BEVs. In all other scenarios, BEVs make up 84–90% of light medium duty truck, 78–84% of medium duty truck, and 75–79% of heavy-duty truck ZEV sales in 2054.

---

[17] Bloomberg New Energy Finance, Electric Vehicle Outlook 2023, https://about.bnef.com/electric-vehicle-outlook/.
[18] This analysis was conducted prior to the finalization of the "Greenhouse Gas Emissions Standards for Heavy-Duty Vehicles – Phase 3" by the U.S. EPA.
[19] California Air Resources Board, https://ww2.arb.ca.gov/our-work/programs/advanced-clean-trucks
[20] California Air Resources Board, https://ww2.arb.ca.gov/our-work/programs/advanced-clean-fleets
[21] U.S. Energy Information Administration, Annual Energy Outlook 2023, Table 49, https://www.eia.gov/outlooks/aeo/

Figure 13. Medium and Heavy-Duty ZEV Sales Share



Behind-the-Meter Solar

The reference case BTM solar forecast is aligned with NVE's internal storage forecast developed in support of the base case IRP load forecast. The forecast of installed capacity for the Deep Decarbonization, High, Mid, and Low scenarios were developed based on the relative growth rates of solar across scenarios modeled by the California Energy Commission (CEC) in their 2021 Integrated Energy Policy Report (IEPR).

Behind-the-Meter Storage

The adoption trajectory of BTM storage was determined based on projections of what share of solar installations would be coupled with storage, or the storage attachment rate. In the Reference scenario, storage attachment rates are assumed to increase from the current rate observed in NVE's territory (2%) to the attachment rate observed nationally in 2020 (4%)[22] by 2025 and remain constant from 2025–2054. In the Deep Decarbonization scenario, the storage attachment rate reaches 80%

[22] Barbose et al. (2021) https://eta-publications.lbl.gov/sites/default/files/btm_solarstorage_trends_final.pdf

in 2040, which is the attachment rate currently observed in states with highly supportive storage policies.[23] The attachment rates in the High and Mid scenario were informed by modeling in the NREL Storage Futures Study. In the High scenario, the storage attachment rate reaches 16% in 2040 and in the Mid scenario the attachment rate reaches 6% in 2040. In the Low scenario, there is no change to the current storage attachment rate.

These attachment rates are applied to the incremental new solar customers projected in each scenario to determine the number of new storage customers. The total installed capacity of BTM storage was calculated by multiplying the number of storage customers by the assumptions of average storage installation size per customer, as summarized in Table 8.

Table 8. Average BTM solar and storage installation size per customer

kW/Customer	Residential		Commercial	
	Solar	Storage	Solar	Storage
SPPC	5.9	5.8	22.8	15
NPC	7.4	7.4	56.4	15

Demand Response

This study primarily explores demand response applications from managing loads in residential and commercial buildings as well as EV charging. Growth in demand response participation in the Reference and Low scenarios was determined based on stated goals and historical performance, as reported in Measurement and Verification Reports, of NVE's existing demand response programs and existing time-of-use rate enrollment rates. NREL's *Electrification Futures Study*,[24] U.S. DOE's *A National Roadmap for Grid-Interactive Efficient Buildings,*[25] and professional judgement informed the growth DR participation in the Deep Decarbonization, High, and Mid scenarios. Increases in demand response in buildings was tied to stock rollover modeled in PATHWAYS. Table 9 summarizes the device types in the PATHWAYS model that are assumed eligible for DR participation. Figure 14 shows the share of new and retrofit devices each year that enroll in DR.

[23] Ibid.
[24] Sun et al. (2020) https://www.nrel.gov/docs/fy20osti/73336.pdf
[25] U.S. DOE (2021) https://connectedcommunities.lbl.gov/sites/default/files/2021-07/1.%20A%20National%20Roadmap%20for%20GEBs-20210712.pdf

Figure 14. DR enrollment with stock rollover in residential and commercial buildings in NPC

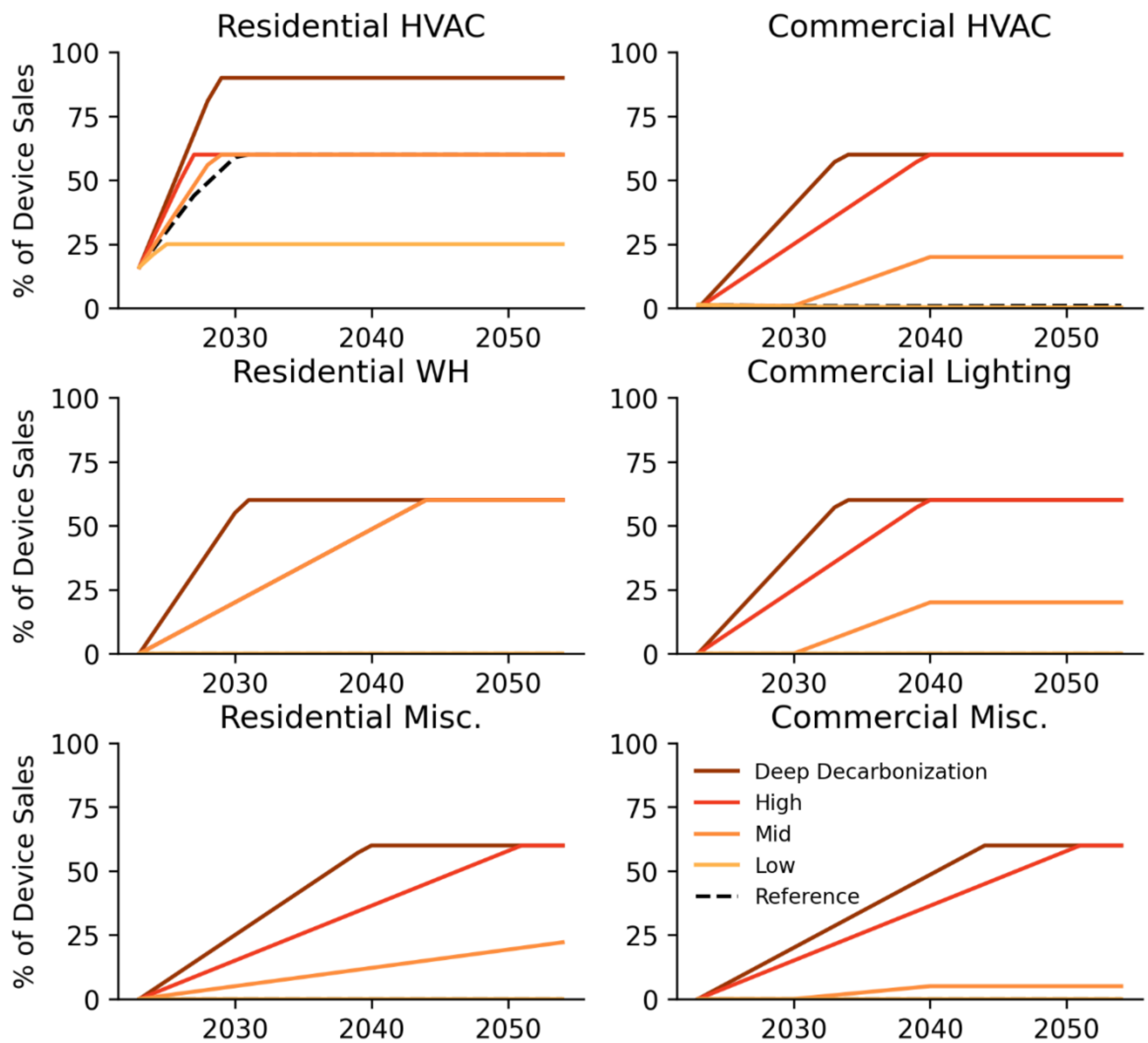


Table 9. PATHWAYS devices participating in DR

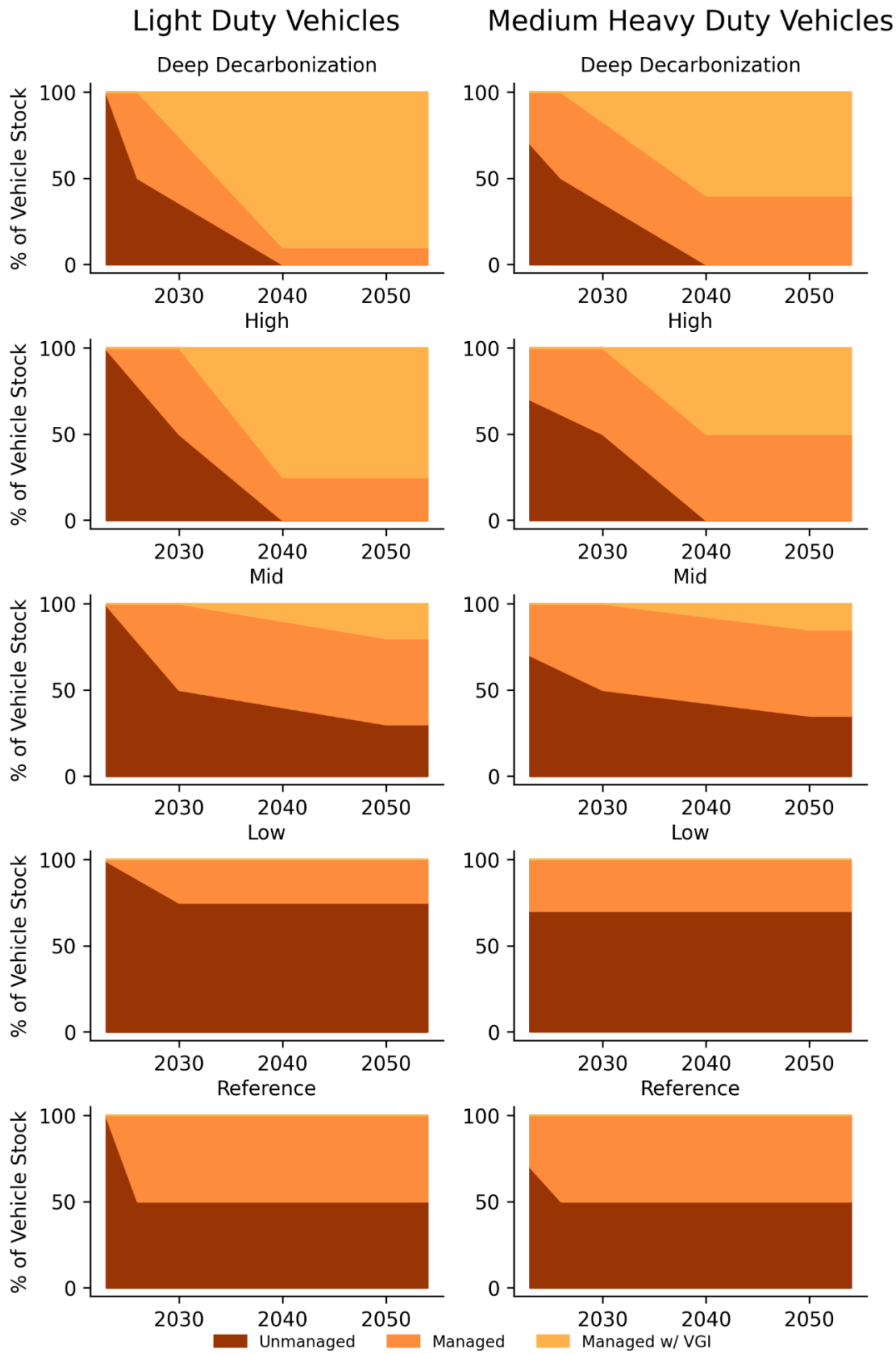
Device	DR Category
Commercial Air Conditioning Air Source Heat Pump - Cooling	Commercial HVAC
Commercial Air Conditioning Centrifugal Chiller	Commercial HVAC
Commercial Air Conditioning Commercial Central AC	Commercial HVAC
Commercial Air Conditioning Efficient Centrifugal Chiller	Commercial HVAC
Commercial Air Conditioning Efficient Commercial Central AC	Commercial HVAC
Commercial Air Conditioning Efficient Air Source Heat Pump - Cooling	Commercial HVAC
Commercial Air Conditioning Efficient Rooftop AC	Commercial HVAC
Commercial Air Conditioning Efficient WallRoom AC	Commercial HVAC
Commercial Air Conditioning Gas Absorption Chiller	Commercial HVAC
Commercial Air Conditioning Gas Driven AC	Commercial HVAC
Commercial Air Conditioning Ground Source Heat Pump - Cooling	Commercial HVAC

Commercial Air Conditioning Reciprocating Chiller	Commercial HVAC
Commercial Air Conditioning Rooftop AC	Commercial HVAC
Commercial Air Conditioning WallRoom AC	Commercial HVAC
Commercial General Service Lighting CFL	Commercial Lighting
Commercial General Service Lighting GSL LED	Commercial Lighting
Commercial General Service Lighting Halogen	Commercial Lighting
Commercial General Service Lighting Halogen Infrared Reflector	Commercial Lighting
Commercial General Service Lighting Halogen Par38	Commercial Lighting
Commercial General Service Lighting Incandescent	Commercial Lighting
Commercial HID Lighting HID LED	Commercial Lighting
Commercial HID Lighting High Pressure Sodium	Commercial Lighting
Commercial HID Lighting Mercury Vapor	Commercial Lighting
Commercial HID Lighting Metal Halide	Commercial Lighting
Commercial Linear Fluorescent Lighting High Efficiency Linear Fluorescent	Commercial Lighting
Commercial Linear Fluorescent Lighting LFL LED	Commercial Lighting
Commercial Linear Fluorescent Lighting reference Linear Fluorescent	Commercial Lighting
Commercial Refrigeration Beverage Merchandisers	Commercial Misc.
Commercial Refrigeration Compressor Rack Systems	Commercial Misc.
Commercial Refrigeration Condensers	Commercial Misc.
Commercial Refrigeration Efficient Beverage Merchandisers	Commercial Misc.
Commercial Refrigeration Efficient Compressor Rack Systems	Commercial Misc.
Commercial Refrigeration Efficient Condensers	Commercial Misc.
Commercial Refrigeration Efficient Ice Machines	Commercial Misc.
Commercial Refrigeration Efficient Reach-In Freezers	Commercial Misc.
Commercial Refrigeration Efficient Reach-In Refrigerators	Commercial Misc.
Commercial Refrigeration Efficient Refrigerated Vending Machines	Commercial Misc.
Commercial Refrigeration Efficient Supermarket Display Cases	Commercial Misc.
Commercial Refrigeration Efficient Walk-In Freezers	Commercial Misc.
Commercial Refrigeration Efficient Walk-In Refrigerators	Commercial Misc.
Commercial Refrigeration Ice Machines	Commercial Misc.
Commercial Refrigeration Reach-In Freezers	Commercial Misc.
Commercial Refrigeration Reach-In Refrigerators	Commercial Misc.
Commercial Refrigeration Refrigerated Vending Machines	Commercial Misc.
Commercial Refrigeration Supermarket Display Cases	Commercial Misc.
Commercial Refrigeration Walk-In Freezers	Commercial Misc.
Commercial Refrigeration Walk-In Refrigerators	Commercial Misc.
Commercial Water Heating Electric Heat Pump Storage	Commercial Misc.
Commercial Water Heating Electric Resistance Storage	Commercial Misc.
Residential Central Air Conditioning Central AC	Residential HVAC
Residential Central Air Conditioning Central Air Source Heat Pump - Cooling	Residential HVAC
Residential Central Air Conditioning Efficient Central AC	Residential HVAC
Residential Central Air Conditioning Ground Source Heat Pump - Cooling	Residential HVAC
Residential Clothes Drying Efficient Electric	Residential Misc.
Residential Clothes Drying Electric	Residential Misc.
Residential Clothes Washing Efficient Electric	Residential Misc.

Residential Clothes Washing Electric	Residential Misc.
Residential Dishwashing Efficient Electric	Residential Misc.
Residential Dishwashing Electric	Residential Misc.
Residential Room Air Conditioning Efficient Room AC	Residential HVAC
Residential Room Air Conditioning Room AC	Residential HVAC
Residential Water Heating Electric Heat Pump Storage	Residential WH
Residential Water Heating Electric Resistance Storage	Residential WH
Transportation Buses Battery Electric	HDVs - Unmanaged
Transportation Buses Battery Electric	HDVs - Managed
Transportation Buses Battery Electric	HDVs - Managed w/ VGI
Transportation Heavy Duty Trucks Battery Electric	HDVs - Unmanaged
Transportation Heavy Duty Trucks Battery Electric	HDVs - Managed
Transportation Heavy Duty Trucks Battery Electric	HDVs - Managed w/ VGI
Transportation Light Duty Cars BEV	LDVs - Managed
Transportation Light Duty Cars BEV	LDVs - Managed w/ VGI
Transportation Light Duty Trucks BEV	LDVs - Managed
Transportation Light Duty Trucks BEV	LDVs - Managed w/ VGI
Transportation Light Medium Duty Trucks Battery Electric	MDVs - Managed
Transportation Light Medium Duty Trucks Battery Electric	MDVs - Managed w/ VGI
Transportation Medium Duty Trucks Battery Electric	MDVs - Managed
Transportation Medium Duty Trucks Battery Electric	MDVs - Managed w/ VGI

Managed charging participation was modeled as a share of the vehicle stock and considers three different types of potential charging behavior: unmanaged, managed, and managed with VGI. In the unmanaged behavior, customers are responsive to the average cost to charge in each location (e.g. at home, at their workplace, or at public locations) but are not responsive to any time-varying price signal. In the managed scenario, drivers manage their charging on time-of-use rates to minimize their cost to charge. In the managed with VGI scenario, an aggregator or the utility helps customers manage their charging according to hourly price signals from the grid while still meeting the driving needs of the customer.

Figure 15. Managed charging participation rates



Load Shapes and Peak Load Impacts

The PATHWAYS model produces expected annual energy demand projections for every device and subsector. Those energy demands are coupled with normalized load shapes (see Appendix B for source of load shapes) to determine hourly and peak impacts of DER adoption. Peak load impacts for energy efficiency, building electrification, and transportation electrification are calculated based on the average load impact of DERs during the top 150 hours of NVE's net system load (net of must-take renewables).

For demand response, the PATHWAYS model produces the expected number of devices participating each year which was paired with metrics of expected load impact per device to determine the available DR capacity. The expected load impact per device values were derived from NVE M&V reports for DR categories where NVE has historically run programs. For DR from end-uses that NVE's programs have not addressed, load impacts were determined based on end-use load shapes, annual energy consumption per device (as derived from PATHWAYS), the hours in which DR events are likely called, and the fraction of load that is flexible as characterized in Lawrence Berkeley National Laboratory's (LBNL) California Demand Response Potential Studies.[26] Additionally, the DR load impact analysis accounts for improving device efficiency over time as projected in each scenario. The table below summarizes the DR capacity per participating device in the base year[27].

[26] Alstone et al. (2017) https://buildings.lbl.gov/publications/2025-california-demand-response

[27] E3 Notes that long-term future conditions may impact the future per-device impacts of Demand Response. For example, with growing levels of renewables, grid net peaks (peak load, net of non-dispatchable renewable generation) may shift to hours where baseline end use load profiles have a different level of coincidence. Similarly, as participation broadens to mass market levels, impact per device may change.

Table 10. Demand response load impacts per participating device

Subsector	Device	kW/device	Source
NPC			
Commercial DR	HVAC	0.91	2023 M&V report
Commercial DR	Lighting	0.06	E3 analysis supported by ADM load curves and LBNL DR Potential Studies
Commercial DR	Misc.	0.28	E3 analysis supported by ADM load curves and LBNL DR Potential Studies
Residential DR	HVAC	1.03	2023 M&V report
Residential DR	Misc.	0.07	E3 analysis supported by ADM load curves and LBNL DR Potential Studies
Residential DR	WH	0.22	Draft 2023 NVE M&V Report
SPPC			
Commercial DR	HVAC	0.61	2022 M&V Report
Commercial DR	Lighting	0.09	E3 analysis supported by ADM load curves and LBNL DR Potential Studies
Commercial DR	Misc.	0.40	E3 analysis supported by ADM load curves and LBNL DR Potential Studies
Residential DR	HVAC	1.03	2023 NVE M&V Report
Residential DR	Misc.	0.07	E3 analysis supported by ADM load curves and LBNL DR Potential Studies
Residential DR	WH	0.22	Draft 2023 NVE M&V Report

Forecasting Anywhere

Forecasting Anywhere is a geospatial DER adoption model developed by E3 and IA. FA was used to provide NV Energy with a geospatial DER adoption forecast to inform the development of their DRP and to support the analysis of DER adoption impacts in LMI communities for the MPS. As noted previously, FA is a nimbler version of IA's LoadSEER, which will be used by NVE in future geospatial DER and distribution system studies.

The first step in FA is to determine geospatial technical potential, which defines how much DER adoption can occur at a given location. Several datasets are used to define technical potential including data on parcels, businesses, and the location of parking lots. Technical potential for residential and commercial energy efficiency, building electrification, and DR are defined in units of building square footage. The technical potential for BTM solar and storage is defined in units of installed capacity. The units of technical potential for transportation electrification are number of chargers.

The next step in FA is to calculate the propensity, or likelihood, of DER adoption in every location in which there is technical potential for adoption. E3 and IA use a combination of heuristic and machine learning (ML) propensities. ML propensities were developed by training regression models on geospatial demographic variables predicting historical adoption. To develop an ML model, a large amount of geospatial data on historical adoption is needed, and therefore, ML propensities were only developed for DER types where that data was available. Heuristic propensities are developed by considering factors that are known to influence DER adoption, such as income, current electricity usage, neighbor participation, business type, business size, etc., to develop a score that represents the likelihood of adoption. The heuristic methodologies are not necessarily less robust than ML methodologies as the heuristic approach allows for consideration of how DER adoption patterns may evolve in the future rather than rely solely on historical adoption patterns.

Technical potential and propensity are geospatially defined using hexagonal hierarchical spatial index system (H3), which maps the world into hexagonal grids of varying spatial resolution. FA uses the H3 system to map all datasets used to define technical potential and propensity to an H3 cell or hexagon, which allows for the consideration of multiple data sources. Technical potential and propensity are defined at level 11 cell and are approximately 2,100 square meters allowing technical potential and propensity to be defined with a high level of spatial resolution.

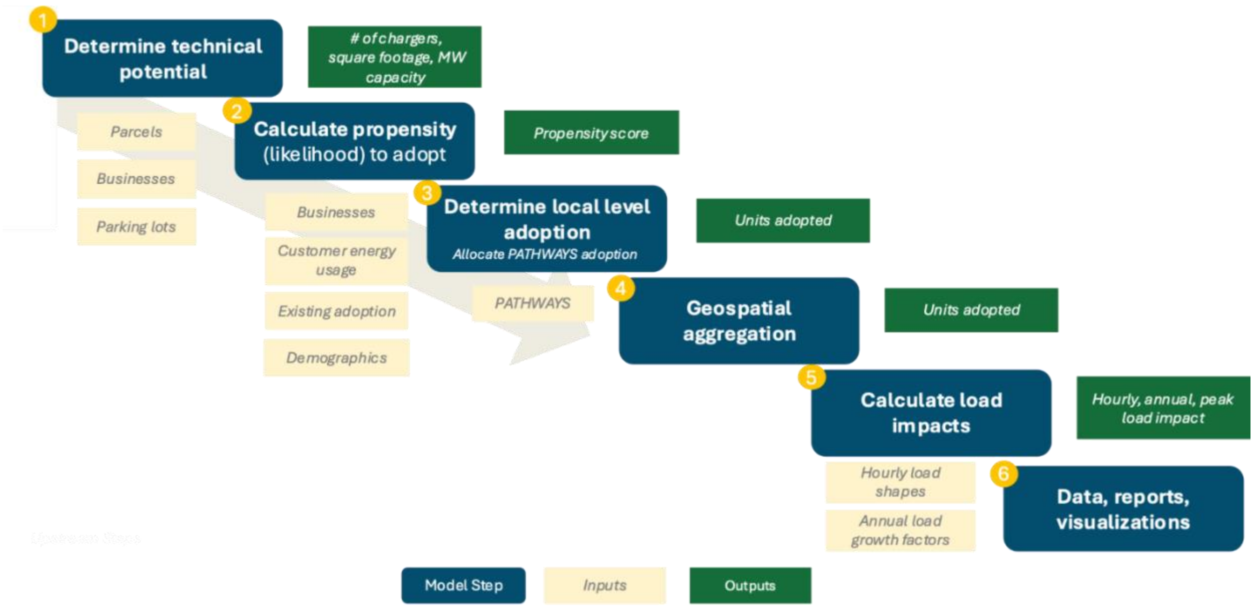
After defining technical potential and propensity, the FA model takes a regional adoption forecast—developed by PATHWAYS modeling in the MPS—and geospatially allocates DER adoption to places where adoption can occur considering the likelihood of adoption in those locations. The geospatial allocation is aggregated up from the level 11 H3 cells to the census block group level as a meaningful level of spatial resolution for FA. The output of the spatial allocation is adoption in units consistent with how technical potential is defined (e.g. square footage, chargers, kW installed capacity).

Next, the spatially allocated adoption is multiplied by per-unit load shapes to calculate the load impacts of DERs. The load impact calculation considers how the load impact per unit of DER evolves over time. For example, if the efficient device options on the market improve over time, the load impacts of energy efficiency scale accordingly.

Finally, E3 and IA generate data visualizations and tables that can be incorporated into NVE's distribution system planning tools and support LMI impact analyses.

FA's methodology is described in further detail in Appendix E.

Figure 16. Forecasting Anywhere Model Overview



Low-Moderate Income Community Impacts

After geospatially downscaling the Mid DER scenario with FA, the analysis team identified census block groups considered to be home to LMI communities. Consistent with the definition in SB448,[28] the analysis team identified LMI communities as census block groups where the median income is 80% or less than that of the median income of the county the block group is in. FA results for select years and DER types are summarized in terms of kWh impact and devices adopted in LMI communities only versus all areas.

DSM Planning Process

In the second phase of the MPS, the analysis team assessed Economic Maximum Achievable, and Realistically Achievable energy efficiency and demand response potential for a combination of scenarios and portfolio design options. At a high level, this was performed by first translating energy, stock, and sales impact data from PATHWAYS into more specific measure-level data and cost effectiveness in DSMore. Next, DSMore was used to define the Economic, Maximum Achievable, and Realistically Achievable Potential for portfolios based on three different portfolio design options:

- **Traditional**: Focuses primarily on all measures that generate energy savings and is consistent with historical metrics determining annualized first year energy (kWh) savings (e.g. % of sales-based target).

[28] SB448, https://www.leg.state.nv.us/App/NELIS/REL/81st2021/Bill/8201/Overview

- **Grid Value**: Prioritizes measures that support renewable energy integration and reduce energy and demand during grid peaks and during hours with higher marginal costs and higher emissions from fossil-fuel generating plant.
- **Strategic Decarbonization (To be considered in future iterations)**: Similar to Grid Value priorities, but layers in fuel neutral measures that further improve demand flexibility, reduce site emissions, and complement state and federal funding opportunities (e.g. gas hot water heater to grid-interactive heat pump hot water heater).

The exploration of three portfolio strategies reflects the present and emerging challenges faced by NVE. Designing portfolios around the Traditional strategy, and setting DSM goals based on annual retail sales, will become increasingly difficult for NVE as the utility is expected to experience significant load growth driven by transportation electrification and data centers, which present very little energy efficiency opportunities to the utility. At the same time, a Traditional strategy may miss higher-impact opportunities by keeping a narrow focus on annual energy reductions. The Grid Value strategy prioritizes reducing peak load, avoiding fossil-fuel generation, minimizing curtailment of renewable generation, and reducing load during generally high-cost hours. This strategy is intended to drive cost savings as it focuses on managing peak load growth, which will be increasingly important with electrification, and optimizing the utilization of NVE's generation fleet. Finally, the Strategic Decarbonization portfolio acknowledges the role of demand-side resources and DERs in driving economy-wide decarbonization while also driving cost savings as it targets measures that reduce energy usage during carbon intensive hours which also tend to be high-cost hours. Note that in this study, the analysis team focused on the Traditional and Grid Value strategies and did not develop a portfolio based on the Strategic Decarbonization strategy at this time.

Portfolios were designed to meet design criteria, and portfolio metrics were developed to both inform portfolio design and summarize high level benefits.

Results of each portfolio are presented alongside NVE's historical DSM goal (kWh savings equivalent of 1.1% of retail sales) for context. The historical DSM target applied to the study years is summarized in the table below.

Table 11. NPC and SPPC 2025-2027 Retail Sales and Historical DSM Goal (GWh)

GWh	2025	2026	2027
NPC			
Retail Sales	22,370	22,966	23,566
1.1% of Retail Sales	246	253	259
SPPC			
Retail Sales	11,210	12,258	13,211
1.1% of Retail Sales	123	135	145

DSMore

To conduct the cost tests necessary to assess Economic, Maximum Achievable, and Realistically Achievable Potential, the analysis team leveraged Integral Analytics' DSMore application.

DSMore is a model developed by IA and is used for valuing the cost-effectiveness of energy efficiency and demand response programs. IA develops accurate valuations by capturing all avoided costs and the covariance between prices and loads, and values these impacts across 30 years of actual hourly weather patterns, which ensures accuracy in quantifying avoided costs.

The DSMore tool is an award-winning modeling software that is nationally recognized and has been used in 30 states to determine cost-effectiveness of energy efficiency programs. Developed and licensed by IA, the DSMore cost-effectiveness modeling tool takes hourly prices and hourly energy savings from the specific measures/technologies being considered for each energy efficiency program and then correlates both to weather. The algorithm used by the modeling software looks at over 30 years of historic weather variability to fully capture the weather variances. In turn, this allows the model to capture the low probability but consequence weather events and apply appropriate value to them. Thus, a more accurate view of the value of the efficiency measure can be captured in comparison to other alternative supply options.

DSMore calculates various test results including:

- **Utility Cost Test**: ratio of the benefits of the programs to the program costs incurred by the utility for the programs;
- **Total Resource Cost Test**: total avoided cost divided by the program costs plus the participant's costs. Participant costs are the incremental costs over the baseline technology;
- **Non-Energy Benefits Total Resource Cost Test (nTRC)**: adds additional non-energy benefits to the Total Resource Cost Test;
- **Societal Test**: adds additional environmental benefits to the Total Resource Cost Test;
- **Rate Impact Measure**: avoided cost benefits divided by the program costs and lost revenues; and
- **Participant Test**: participant's benefits in energy savings from their bill plus their incentives divided by their costs to participate.

Each cost-effectiveness test shares a common structure. Each test compares the total benefits and the total costs in dollars from a certain point of view to determine whether the overall benefits exceed the costs. A test passes cost-effectiveness if the benefit-to-cost ratio is greater than one and fails if it is less than one.

$$Benefit - Cost\ Ratio = \frac{Benefits}{Costs} = \frac{NPV\ \sum benefits\ (\$)}{NPV\ \sum costs\ (\$)}$$

Inputs into the model include participation rates, incentives paid, energy savings of the measure, life of the measure, implementation costs, administrative costs, and any incremental costs incurred by participants when installing an efficiency measure. Certified energy savings and participation amounts are provided by measures from third-party independent evaluators. Participation results multiplied by the certified savings number over the life of the measure yields the lifetime savings results used in the DSMore model. For the calculation of peak demand savings, DSMore utilizes assumed 8,760 hour savings shapes from independent evaluators specific to each measure being modeled. These savings shapes are combined with the assumption, provided by NVE, of the system peak hour occurring during hour ending 18 on a July afternoon to determine the peak demand savings for each measure. Program costs and incentives paid are based on actual payments from past implementation programs. Additional information such as measure life and incremental cost are taken from past implementation programs. For utility information, DSMore utilizes utility rates, escalation rates, avoided costs, and discount rates for the utility, society, and participant tests.

The avoided electric benefits utilize historic hourly price data and hourly weather data to determine the value of the saved electricity. The electric savings by measure are applied at specific hours over the year since prices vary by hour. These prices are weighted based on the probability of weather variations over 30 years of weather history so that the full range of weather and prices are properly captured. Each hour has a unique price, which is then escalated over time. This ensures that the savings reflect the value you would expect to see in the market over time from the avoided energy sales.

The avoided benefits for natural gas are calculated using weather-adjusted prices, similar to electric, but are based on natural gas prices from the Henry Hub sales market. Natural gas prices are based on daily natural gas prices, versus hourly prices for electric. Again, the purpose is to best represent the expected value of the energy savings in the marketplace.

The following figure provides an overview of the DSMore application and how the key inputs are related to the application engine.

Figure 17. DSMore application engine

Wherever possible, DSMore follows the precepts of the California Standard Practice Manual in the derivation of benefit-cost ratios and calculations. The California Manual was developed during the 1980s and 1990s, prior to the advent of more powerful computing resources. The Standard Practice Manual is recognized as the industry standard for determining cost-effectiveness and DSMore follows the underlying procedures laid out in the manual. However, IA also recognizes that new methods and new approaches to cost-effectiveness measurement have, and will, emerge within the industry, given new processing capabilities, the advent of new microgrid resources, and changes in marginal cost estimation. As such, IA encourages users to think more broadly about the valuation of energy efficiency than what is portrayed in the California Manual, where appropriate. For example, DSMore's Option Value Test values EE and DR programs over several forward curves and over several hourly weather scenarios, to arrive at an overall long run test result expectation for the program.

DSMore vs AceGuru: Differences and Similarities

While AceGuru and DSMore both follow best practices for calculating cost tests, consistent with the California Standard Practice Manual, DSMore includes several additional features that improve functionality and integration with the broader modeling framework proposed in this study. Consistent with the overall "walk-jog-run" approach of this framework, many of these advanced features have not yet been employed; the focus on this step of the modeling was to establish a framework that is starting from a point that is consistent with familiar and established conventions from NVE's past analyses. Thus, the DSMore functionality used in this study includes only what is needed to perform cost test calculations for the kinds of measures typically considered in NVE's DSM portfolio (energy efficiency and demand response) in a manner similar to how AceGuru operates. This section describes key features of DSMore that were not used in this analysis but could be leveraged in subsequent studies and DSM plans to consider additional cost and benefit streams such as locational value, expand the universe of demand-side technologies considered, and incorporate weather uncertainty. A summary of key DSMore features is provided in Table 12.

Table 12. Summary of DSMore Features Used in This Study or Planned for Future Use

DSMore Features	Used in 2024 MPS	Used in 2025-27 Planning	Planned for Future Use
Cost-Effectiveness Calculations			
TRC Calculations		X	X
(n)TRC Calculations	X	X	X
PCT Calculations		X	X
SCT Calculations		X	X
UCT Calculations		X	X
RIM Test Calculations		X	X
Cost Categories			
O&M Cost Impacts			X
Additional Cost Components TBD			X
Impact Adjustments			
Free-Riders	X	X	X
Code Changes			X
Water Savings			X
Emissions Reductions	X	X	X
Other Externalities			X
Historical Weather Data	X	X	X
Supplemental Reserve Margin			X
Evaluation Methods			
Cost-based Evaluation Method	X	X	X
Option Value Results			X
Stochastic Risk and Sensitivity Analysis			X
Locational Grid Value			X

Locational Grid Value

Coded in C# and linked to the LoadSEER distribution planning software, DSMore is designed to integrate more seamlessly with big data sources. Hundreds of thousands of cost-effectiveness calculations are able to be run with actual AMI and SCADA data, specific customer demographic data and utility location specific avoided costs. Locational Grid Value is identified for each local area, substation, circuit or customer location and used in program planning to allocate resources to specific needs.

Additional Demand Side Technologies

Additionally, DSMore is designed to value the full range of potential integrated demand side technologies including backup generation, local renewable generation, electric vehicles, electrification, fuel switching, demand response, energy efficiency and other disruptive technologies. As such, DSMore allows users to think more broadly about the valuation of demand side resources than what is portrayed in the Standard Practice Manual and AceGuru.

Only expected values of baseload resources are able to be valued in AceGuru. In addition to these, DSMore values emergency resources like demand response or backup generation and other weather sensitive resources.

Weather Uncertainty "Option Value"

DSMore explicitly measures the value of weather uncertainty on program savings and avoided cost. An example of the value of using DSMore to value weather uncertainty was introduced to the NV PUC in 2014, “The DSMore Option value for DR Programs”[29]. The DSMore “Option Value” result takes into account the "intrinsic value" of weather sensitive measures due to the flexibility they provide in response to changes in weather. DSMore calculates the intrinsic value from actual facility load shapes, regional energy prices and weather covariance by measuring the impact and value of extreme weather variance.

By retaining the full variance of program results as observed from historic data, DSMore is able to calculate the program impacts during extreme conditions and resulting actuarial or “insurance value” benefits. AceGuru only retains the weather normal variance derived from the expected value of prices and savings (the Standard Error) from a weather normalized deterministic simulation. Thus, the impact of extreme weather, price, and measure savings are underrepresented. Table 13 below, demonstrates the effects of considering weather impacts in DSMore on annual average energy prices (in $/kWh), and shows that, although the average energy prices may be consistent with historic observations, AceGuru data significantly differs in the range, standard deviation and skew.

Table 13. Comparison of DSMore and AceGuru Annual Energy Price Distribution Statistics ($/kWh)

Annual $/kWh	2021	2022	2023	AceGuru 2022
Average	**$ 52.00**	**$ 87.41**	**$ 76.04**	**$ 59.13**
Median	$ 42.04	$ 62.50	$ 60.00	$ 54.90
Skew	9.09	4.19	5.47	1.25
Min	5.00	3.57	-	0.01
Max	$ 1,000	$ 1,016	$ 1,000	$ 185
Stdev	$ 53	$ 93	$ 58	$ 24

[29] See: PUCN Docket No. 14-07007, Technical Appendix DSM-16, available at: https://pucweb1.state.nv.us/PDF/AxImages/DOCKETS_2010_THRU_PRESENT/2014-7/39345.pdf”.

PATHWAYS – DSMore Connection

Tierra, with input from E3, mapped PATHWAYS outputs to DSMore measure inputs and the process of portfolio design. This step aligns the technology/end-use level calculations in PATHWAYS with the measure- and program-level calculations used in DSMore to facilitate portfolio design. This fills the gap between models and translates PATHWAYS outputs into more specific DSM measures that either already exist in NVE's portfolio or could be incorporated into NVE's portfolio in the future.

Mapping between PATHWAYS and DSMore does not always yield a direct, one-to-one match. For example, a single technology in PATHWAYS may be reflected in multiple NVE program offerings. E.g., Efficient Residential Clothes Dryers has two efficient measures in NVE portfolio (ENERGY STAR and ENERGY STAR heat pump) and is offered in two different programs. Some measures are offered by NVE, but are not included in PATHWAYS, often because the NVE savings mechanism is indirect, such as HVAC tune-ups or residential advanced power strips. The mapping exercise facilitates the matching of savings potential in the MPS and portfolio design work to avoid double counting or omissions in instances where there is not a one-to-one match between PATHWAYS and DSMore. Some results from PATHWAYS are not included in the mapping as they are not a component of the DSMore work for the EE/DR portfolio design, such as efficient Transportation technologies.

Overall, this process ensures that the savings potential identified by PATHWAYS is accounted for in portfolio design and preliminary cost-effectiveness calculations. Note that while there is a mapping exercise performed, it does not necessarily imply that all measures in PATHWAYS will be present in the final NVE portfolio, or that the PATHWAYS will contain all measures that are in the final portfolio.

Table 14 and Table 15 below summarize the mapping of PATHWAYS outputs to DSMore inputs for the Residential and Commercial sectors, respectively.

Table 14. Residential Measures Mapped from PATHWAYS to DSMore Inputs

PATHWAYS Outputs (Efficient Electric Only)		EE/DR/ Both	Existing NVE Portfolio		
End Use	Technology		Sector	Program Name	Measure
Behavioral EE	Behavioral EE	EE	Education Services Programs	Home Energy Education	Events
Behavioral EE	Behavioral EE	EE	Education Services Programs	Home Energy Education	Kits
Behavioral EE	Behavioral EE	EE	Education Services Programs	Home Energy Reports	Home Energy Reports
Behavioral EE	Behavioral EE	EE	Education Services Programs	Online Energy Assessment	Online Energy Assessment
Behavioral EE	Behavioral EE	EE	Residential Services Programs	In-Home Energy Assessment	In-Home Energy Assessment
Central Air Conditioning	Central Air Source Heat Pump - Cooling	EE	Residential Services Programs	Residential Equipment and Plug Loads	Retrofit - HP Replacement
Central Air Conditioning	Ground Source Heat Pump - Cooling	EE	Residential Services Programs	Residential Equipment and Plug Loads	Retrofit - HP Replacement
Central Air Conditioning	Efficient Central AC	EE	Residential Services Programs	Residential Equipment and Plug Loads	Retrofit - AC Replacement
Clothes Drying	Efficient Electric	EE	Residential Services Programs	Residential Equipment and Plug Loads	ENERGY STAR® Clothes Dryer
Clothes Drying	Efficient Electric	EE	Residential Services Programs	Residential Equipment and Plug Loads	ENERGY STAR® Heat Pump Dryer
Clothes Drying	Efficient Electric	EE	Residential Services Programs	Low Income	Dryer (QAR)
Clothes Washing	Efficient Electric	EE	Residential Services Programs	Residential Equipment and Plug Loads	ENERGY STAR® Clothes Washer
Freezing	Efficient Electric	EE	Residential Services Programs	Residential Equipment and Plug Loads	ENERGY STAR® Freezer
General Service Lighting Reflector Lighting Linear Fluorescent Lighting Exterior Lighting	LED	EE	Residential Services Programs	Direct Install	LED Lighting
General Service Lighting Reflector Lighting Linear Fluorescent Lighting Exterior Lighting	LED	EE	Residential Services Programs	Direct Install	Photocell / LED Photocell Combo
General Service Lighting Reflector Lighting Linear Fluorescent Lighting Exterior Lighting	LED	EE	Residential Services Programs	Low Income	LED Lighting (QAR)
General Service Lighting Reflector Lighting Linear Fluorescent Lighting Exterior Lighting	LED	EE	Residential Services Programs	Low Income	LEDs - Food Bank Distribution
Refrigeration	Efficient Electric	EE	Residential Services Programs	Residential Equipment and Plug Loads	ENERGY STAR® Refrigerator
Refrigeration	Efficient Electric	EE	Residential Services Programs	Low Income	Refrigerator (QAR)
Room Air Conditioning	Efficient Room AC	EE	Residential Services Programs	Residential Equipment and Plug Loads	ENERGY STAR® Room Air Conditioner
Multi Family Space Heating	Air Source Heat Pump with Electric Backup	EE	Residential Services Programs	Residential Equipment and Plug Loads	Retrofit - HP Replacement
Multi Family Space Heating	Ground Source Heat Pump	EE	Residential Services Programs	Residential Equipment and Plug Loads	Retrofit - HP Replacement
Single Family Space Heating	Air Source Heat Pump with Electric Backup	EE	Residential Services Programs	Residential Equipment and Plug Loads	Retrofit - HP Replacement
Single Family Space Heating	Ground Source Heat Pump	EE	Residential Services Programs	Residential Equipment and Plug Loads	Retrofit - HP Replacement
Water Heating	Electric Heat Pump Storage	EE	Residential Services Programs	Residential Equipment and Plug Loads	ENERGY STAR Heat Pump Water Heaters

PATHWAYS Outputs (Efficient Electric Only)		EE/DR/ Both	Existing NVE Portfolio		
End Use	Technology		Sector	Program Name	Measure
	Solar Water Heater				ENERGY STAR Heat Pump Water Heaters
Non-Equipment HVAC	Non-Equipment HVAC	EE/DR/ Both	Residential Services Programs	Residential DR Build - Thermostats	Thermostats
				Residential DR Manage - Thermostats	Thermostats
BTM Storage	BTM Storage	DR	Residential Services Programs	Residential DR Build - Batteries	Batteries
DR	HVAC	DR	Residential Services Programs	Residential DR Build - Thermostats	Thermostats
				Residential DR Manage - Thermostats	Thermostats
	Water Heating			Residential DR Build - Thermostats	Grid interactive plug loads
	Misc.			Residential DR Build - Thermostats	Grid interactive plug loads
Building Shell	Construction	EE	Residential Services Programs	Residential Codes & New Construction	New Construction
	Retrofit	EE	No Known Existing Portfolio measure		
Cooking	Induction Stove	EE	No Known Existing Portfolio measure		
Dishwashing	Efficient Electric	EE	No Known Existing Portfolio measure		

Table 15. Commercial Measures Mapped from PATHWAYS to DSMore

PATHWAYS Outputs (Efficient Electric Only)		EE/DR/ Both	Existing NVE Portfolio			
End Use	**Technology**		**Sector**	**Program Name**	**Measure**	**Sub-Measure**
Air Conditioning	Air Source Heat Pump - Cooling Ground Source Heat Pump - Cooling Efficient Commercial Central AC Efficient Rooftop AC	EE	Non-Residential Services Programs	Business Energy Services	High-Efficiency HVAC	-
				Energy Smart School	NPC CEI	HVAC upgrades
				Energy Smart School	Capital Projects	HVAC upgrades
	Efficient Reciprocating Chiller			Business Energy Services	Chillers	-
	Efficient Centrifugal Chiller					
Cooking	Induction Range Oven	EE	No Known Existing Portfolio measure			-
General Service Lighting HID Lighting Linear Lighting	GSL LED HID LED HE Linear Fluorescent LFL LED	EE	Non-Residential Services Programs	Business Energy Services	Lighting (Interior)	-
				Business Energy Services	Lighting (Exterior)	-
				Energy Smart School	NPC CEI	Lighting and occupancy sensors LED gym lighting
				Energy Smart School	Capital Projects	Lighting and occupancy sensors LED gym lighting

Refrigeration	Efficient Beverage Merchandisers	EE	Non-Residential Services Programs	Business Energy Services	Vending Machine Controls	-
				Energy Smart School	NPC CEI	Vending machine sensor
				Energy Smart School	Capital Projects	Vending machine sensor
	Efficient Compressor Rack Systems		No Known Existing Portfolio measure			-
	Efficient Condensers		No Known Existing Portfolio measure			-
	Efficient Ice Machines		Non-Residential Services Programs	Business Energy Services	Commercial Ice Machine	-
	Efficient Refrigerated Vending Machines		Non-Residential Services Programs	Business Energy Services	Vending Machine Controls	-
				Energy Smart School	NPC CEI	Vending machine sensor
				Energy Smart School	Capital Projects	Vending machine sensor
	Efficient Supermarket Display Cases		No Known Existing Portfolio measure			-
	Efficient Reach-In Freezers Efficient Reach-In Refrigerators Efficient Walk-In Freezers Efficient Walk-In Refrigerators		Non-Residential Services Programs	Business Energy Services	Refrigerator	SD/GD; ENERGY STAR
Space Heating	Air Source Heat Pump with Electric Backup Air Source Heat Pump with Electric Backup ER Replacement Air Source Heat Pump with Gas Backup Ground Source Heat Pump	EE	Non-Residential Services Programs	Business Energy Services	High-Efficiency HVAC	-
				Energy Smart School	NPC CEI	HVAC upgrades
				Energy Smart School	Capital Projects	HVAC upgrades
Ventilation	Efficient Variable Flow	EE	Non-Residential Services Programs	Business Energy Services	Variable Frequency Drives	Cooling Tower Fans
						Centrifugal Chillers
						Air-Moving Fans/Industrial Blowers
Water Heating	Electric Heat Pump Storage	EE	No Known Existing Portfolio measure			-
	Solar with Electric Backup					
Behavioral EE	Behavioral EE	EE	Non-Residential Services Programs	Energy Education Kits	-	-
Non-Equipment HVAC	Non-Equipment HVAC	EE/DR/ Both	Non-Residential Services Programs	Commercial DR Manage	Manage	-
				Commercial DR build - Thermostats	Thermostats	
BTM Storage	BTM Storage	DR	Non-Residential Services Programs	Commercial DR Build - Batteries	Batteries	-
						Small Energy Storage Program
						Standalone Small Energy Storage Program
						Large Energy Storage Program
DR	HVAC			Commercial DR Manage	Manage	-

		EE/DR/ Both	Non-Residential Services Programs	Commercial DR build - Thermostats	Thermostats	
	Lighting	DR	No Known Existing Portfolio measure			
	Misc.	DR	No Known Existing Portfolio measure			
Building Shell	Retrofit	EE	Non-Residential Services Programs	Business Energy Services	Whole Building	
	New Construction	EE				

Technical Potential Methodology

To define the Technical Potential to be used as the basis for portfolio planning, stocks and sales from the PATHWAYS Technical Potential scenario were used. Given the PATHWAYS model is a stock rollover model, this means that Technical Potential was determined as the number of devices reaching their end of life in any given year, or the maximum number of new sales per device in any given year. No early retirements of technology were assumed before their end of life. DSM portfolio measures were mapped to PATHWAYS devices on an end-use basis. To calculate the total Technical Potential in energy savings terms, this mapping was leveraged to multiply the end-use stock/sales Technical Potential by the energy savings per measure.

Economic Potential Methodology

The first step in determining Economic Potential is to generate cost-effectiveness results per measure using DSMore. Next, application of Non-Energy Benefits Total Resource Cost test (nTRC) adders were included in the TRC benefits to calculate the new nTRC ratios and net benefits per measure. The nTRC compares the benefits of avoided electricity supply costs and non-energy benefits to the incremental cost of the measure relative to the baseline condition and the utility's cost to deliver a program that implements the measure. If the cost-benefit ratio of a measure's nTRC is greater than or equal to 1, the measure is considered to contribute to Economic Potential.

Maximum Achievable Potential Methodology

The Maximum Achievable Potential is calculated by starting from the Economic Potential and adjusting down with several factors. First, it is assumed that 15% of the population will not be responsive to any program marketing, and therefore will not participate in a program and contribute to Achievable Potential.

Next, Achievable Potential is then calculated as the fraction of that Economic Potential that can be achieved based on offering incentives and/or rebates that cover 90% of the incremental cost to customers. Market acceptance curves from a recent potential study conducted in the desert Southwest[30] are leveraged to determine participation for cost-effective measures and therefore the adoption fraction; market acceptance curves by customer type are shown in Figure 18. This adoption fraction is applied to the scaled Economic Potential by measure to calculate Achievable Potential for these measures. For non-cost-based programs[31], historic program performance was used to

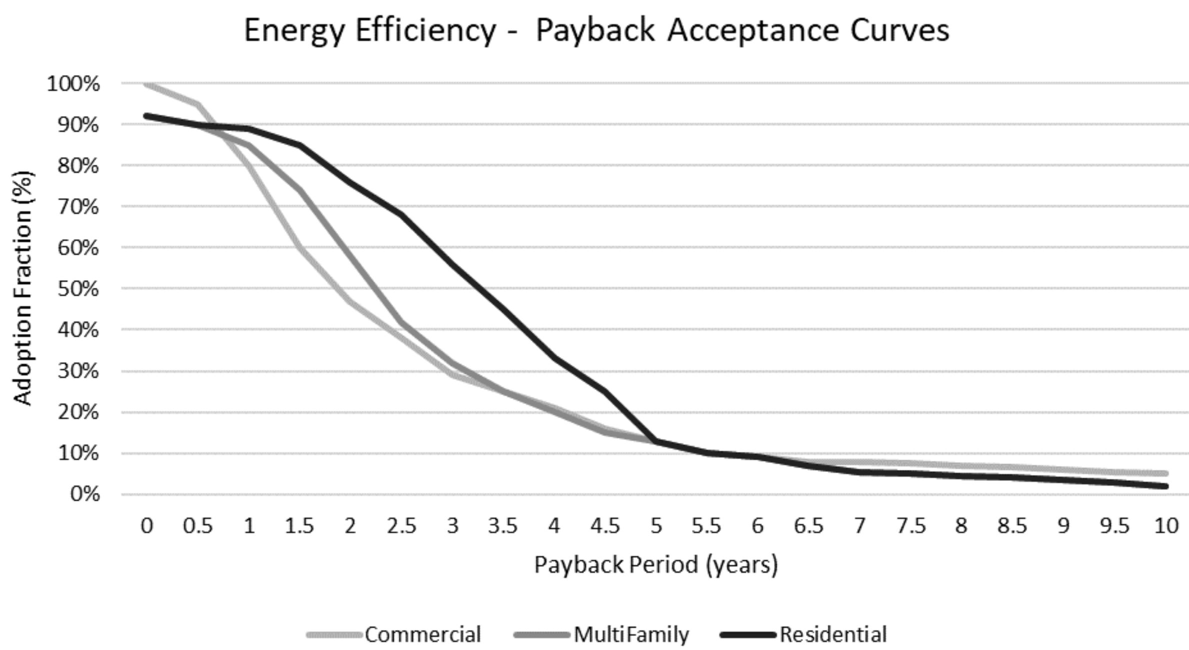
---

[30] Guidehouse Consulting, Tierra Consulting, "Arizona Public Service Company: 2023 Integrated Resource Plan. November 2023." See Figure 5 within embedded 2023 EEDRPS Appendix, pg. 19. Available at: https://www.aps.com/-/media/APS/APSCOM-PDFs/About/Our-Company/Doing-business-with-us/Resource-Planning-and-Management/APS_IRP_2023_PUBLIC.pdf?la=en&sc_lang=en&hash=DF34B49033ED43FF0217FC2F93A0BBE6

[31] Non-cost based programs are defined as programs where all customer costs for installing EE are covered by the program. This includes Direct Install, Home Energy Reports, and Low-income programs.

determine Maximum and Realistically Achievable participation levels. The sum of the potential and budgets for these two program types designates total Achievable Potential.

Figure 18. Market acceptance curves



Realistically Achievable Potential

As the final step of calculating portfolio potential, Realistically Achievable Potential is determined as a gauge for what level of reductions could actually be achieved through a program implemented by the company. Realistically Achievable Potential leverages the professional judgement and program implementation experience of NVE and accounts for the change in the willingness of customers to install energy efficient technologies given a change in their payback period brought on as program rebates are adjusted downward from the 90% of incremental costs assumed in the calculation of Maximum Achievable Potential. For this adjustment, the same payback curves shown in Figure 18 were utilized, by participant sector, to estimate the expected drop in program participation as program rebates are decreased, leading to an increase in net participant costs and an elongation of the payback period. Several participant rebate levels were tested, including 75%, 50%, 33% and 25% of measure incremental costs, as well as specific participant rebate provided per measure in the 2023 NVE DSM portfolio, when available. Ultimately, this last modeled option was determined to be the most Realistically Achievable Potential, as prior NVE rebate levels are assumed to be a reasonable proxy for what is budgetarily realistic in the near-term, given our current environment of rising efficient incremental costs.

For programs without a participant rebate or a readily calculatable participant payback period, Realistically Achievable Potential is intended to account for the following constraining factors:

+ **Program budget availability**: What level overall program budget is feasible for the utility
+ **Program ramp-up time:** How quickly new programs can reach maturity after they begin, or how quickly existing programs can expand, given marketing and education across customers and installers
+ **Supply chain constraints**: If a sufficient level of efficient equipment is able to be supplied to a given region or locality, given broader industry trends and availability
+ **Local constraints:** Considerations of local workforce and markets
+ **Capital availability:** Capital at the customer or installer level needed to overcome any upfront cost barriers
+ **Operational constraints from community partners:** Bandwidth of critical community partners to be implementing programs, performing customer outreach, or generally supporting programs

In these instances, potential as a percentage of Maximum Achievable Potential uses customer awareness of and willingness to participate in programs based on previously fielded surveys to NVE customers, with responses aggregated separately based on residential sector (single family versus multi-family) and service territory. In addition to customers' willingness to participate, their awareness of NVE programs historically is presumed to be a combined proxy for several of the constraints cited above, such as program budget availability, and supply/operational constraints that would feed into the determination of the appropriate level of customer outreach. Realistically Achievable Potential is the basis for developing NVE's DSM portfolio for the next 3-year period.

Portfolio Performance Metrics – Hourly Grid Marginal Source Energy and Marginal Emissions

As a proposed improvement over evaluating DSM portfolio only on a basis of energy savings in kWh, E3 explored several portfolio metrics that could align portfolios with broader goals of better targeting DSM measures that reduce system cost and/or reduce greenhouse gas emissions. Table 16 below includes a summary of potential metrics reported in typical units, as well as potential units of energy, if a kWh-based metric is required by state policy.

Table 16. Summary of metrics considered for each portfolio. Preliminary results for the bolded metrics below have been calculated for demonstrative purposes.

	Traditional	*Grid Value & Electric Grid Decarb*	Strategic Decarbonization
Potential Targets	Current target for current metric is 1.1% of annual weather-adjusted forecasted electricity sales for first-year of energy savings measures	Targets can be expressed on a gross kWh basis, or as a percent of retail sales Targets can also focus on first-year savings, or lifecycle savings	Targets can be expressed on a gross kWh basis, or as a percent of retail sales Targets can also focus on first-year savings, or lifecycle savings
Potential Metrics (any type/units)	Annual energy sales	Annual peak demand reduced (kW) Hourly Source Energy reductions from fossil-fuel based generation (expressed in kWh or Btu) Hourly CO2 emissions reduced, based on hourly grid emissions Hourly Total System Benefit (based on hourly Avoided Costs)	CO2 reduced, based on hourly grid emissions, and CO2 emissions of non-electric energy sources GHGs reduced for electric and non-electric energy sources, along with other reduction of other local air pollutants Total System Benefit (based on hourly avoided costs, and costs for non-electric fuels)
Potential Metrics (expressed as Energy Savings in kWh compliant with NRS 704.7834)	Annual weather-adjusted forecasted electricity sales per year for 1st year measure savings Cumulative electricity sales by a target year for lifetime measure savings Adjusted electricity sales (non-EV, no DOS customers, or other logical and required adjustments)	Reduction in fossil-fuel generated electricity expressed in kWh Reduction in renewable energy curtailed expressed in kWh (i.e. energy saved from being wasted) Reduction in source energy of fossil-fuel generated electricity expressed in kWh;	Reduction in fossil-fuel generated electricity expressed in kWh Reduction in renewable energy curtailed expressed in kWh (i.e. energy saved from being wasted); plus, Reduction in site gas consumption saved (as proxy for CO2 reduction) converted from therms to kWh equivalent

While discussions between NVE and stakeholders are still ongoing to reach a final proposed set of metrics and targets, E3 developed two interim metrics to guide portfolio design considerations, for the Grid Value and Strategic Decarbonization portfolio: hourly marginal source energy and hourly marginal emissions. These metrics were selected based on availability of data, along with being able to provide a signal correlated both with high-emissions hours on the grid, grid peaks, and generally high-cost hours on the grid. While these two new metrics are developed to inform Grid Value, specifically, it is important to consider that hourly avoided costs, which are already available, provide an additional insights on Grid Value.

For metrics for a "Strategic Decarbonization" portfolio, discussions between NVE and stakeholders are currently on pause, due to uncertainties about state policy among stakeholders on the scope of decarbonization that should be considered for emissions reductions; effectively, whether metrics should only consider grid emissions, or if emissions from other on-site fossil fuel combustion (ex. natural gas) should also be considered. These metrics can inform electric system emissions, but further discussion is necessary to determine what else is in scope. In either case, a metric based on site fossil fuel reductions would be in alignment with efforts to ensure more efficient building electrification over standard efficiency levels, that customers may pursue absent other interventions.

E3 notes, in general, that for future metric discussions, it is most efficient for the selected metric to directly translate to the ultimate goals of a given DSM portfolio. For example, if reducing system costs is the primary goal of a DSM portfolio, hourly avoided costs should be considered, potentially internalizing the costs of greenhouse gas emissions. If greenhouse gas emissions reductions are considered the primary goals of a DSM portfolio, the guiding metric should be greenhouse gas emissions reductions.

While these metrics extend through 2052 and are evaluated over the lifetime of a measure, the developed metrics are considered *Short Run Marginal* metrics. In this context, the short run denotation means that any changes in the electric generation resource mix resulting from changes in load are not considered; only the change in dispatch of existing electrical generation. Conversely, a *Long Run* metric, in this context, would mean that changes in annual energy consumption must be met to some extent by changes in renewable build, as driven by Renewable Portfolio Standards or similar policies. Long run metrics are more applicable for load-building measures such as transportation or building electrification.[32,33] Short run metrics were selected for this process, given the desire to emphasize grid peaks; peaks are more pronounced in short run metrics.

The first metric, ***hourly marginal source energy***, is defined as the marginal change in fossil fuel energy input into the marginal electricity generator, per unit of site energy consumed, to meet a marginal change in site energy consumption. This metric is calculated, as follows, based on forecasted hourly marginal energy prices. Forecasted hourly marginal energy prices were provided by NVE from a production simulation model run, consistent with NVE's 5th amendment IRP.

---

[32] See Gagnon, Cole, "Planning for the evolution of the electric grid with a long-run marginal emission rate", iScience, Volume 25, Issue 3, 2022, 103915, ISSN 2589-0042, https://doi.org/10.1016/j.isci.2022.103915. (https://www.sciencedirect.com/science/article/pii/S2589004222001857)

[33] NYSERDA, E3, "Projected Emission Factors for New York State Grid Electricity", 2022.. https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/Energy-Analysis/22-18-Projected-Emission-Factors-for-New-York-Grid-Electricity.pdf

Forecasts were provided through 2052. Note that these metrics, as reported, do not include impacts of line losses; those are incorporated in the DSMore parts of the analysis.

To calculate source energy, first, Implied Hourly Marginal Heat Rate is calculated based on hourly electricity prices and forecasted wholesale natural gas prices. In this formulation, it is assumed that marginal electric generators in NVE's service territory will either be gas generators or renewable generation. As a further step in this equation, it is recognized that reasonable bounds of heat rates for gas generators are 6,5000 Btu/kWh on the low end and 14,000 Btu/kWh on the high end. Any calculated values below this range are assumed to be a result of renewable generation, and therefore were set to 0. Any calculated values above this range are assumed to be driven by market dynamics and are set at the maximum heat rate of 14,000 Btu/kWh.

$$Hourly\ Implied\ Marginal\ Heat\ Rate\ \left(\frac{Btu}{kWh}\right)\ \frac{Electricity\ Price\ \left(\frac{\$}{kWh}\right) - Variable\ O\&M\ \left(\frac{\$}{kWh}\right)}{Fuel\ Cost\ \left(\frac{\$}{Btu}\right)}$$

Next, to create a metric that is based in kWh units to potentially comply with state policy, units are converted from Btu/kWh to kWh_source/kWh_site. This measures the amount of fossil fuel input at the generator level (source) per unit of energy consumed at the meter (site).

$$Hourly\ Marginal\ Source\ Energy\ \left(\frac{kWh_{source}}{kWh_{site}}\right) = Implied\ Marginal\ Heat\ Rate\ \left(\frac{Btu}{kWh}\right) * Conversion\ Factor\ \left(\frac{kWh}{Btu}\right)$$

To control for differences in calendar year and weather year between forecasted hourly energy price data and hourly demand side measure load profiles, these metrics are converted to month-hour averages before being applied to demand side data. Figure 19 below shows month-hour heat maps for 2025, 2035, and 2050 for the hourly marginal source energy metric. Low values in the middle of the day are driven by increasing levels of renewable energy over time.

Figure 19. Hourly Marginal Source Energy Heat Maps [kWh_source/kWh_site]

2025

Month \ Hour	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	2.51	2.53	2.43	2.41	2.47	2.54	3.33	2.39	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	2.54	2.63	2.63	2.63	2.63	2.63	2.63	2.61
2	2.60	2.56	2.52	2.48	2.51	2.51	2.30	1.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.19	3.04	3.10	3.09	3.04	3.04	3.04	2.84
3	3.26	2.98	2.89	2.89	2.94	3.20	2.37	1.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	1.09	2.95	3.23	3.14	2.99	2.98	2.97	2.90
4	2.82	2.60	2.53	2.45	2.52	2.42	1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.61	1.17	2.79	3.65	3.57	3.18	3.10	3.13	3.06
5	3.28	3.05	2.67	2.63	2.63	2.31	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.26	0.77	1.09	1.85	2.57	3.65	3.44	3.12	3.11	3.29	3.19
6	3.40	3.10	3.06	2.95	3.03	2.27	0.22	0.08	0.15	0.23	0.62	1.01	1.87	2.34	2.60	2.84	3.06	3.25	4.00	4.10	3.98	3.87	3.70	3.46
7	4.08	4.08	4.05	4.03	4.03	3.98	2.96	1.63	2.46	2.85	3.27	3.78	3.93	3.99	3.99	4.02	4.05	4.05	4.08	4.08	4.10	4.08	4.08	4.08
8	4.01	3.99	3.94	3.95	3.91	3.93	3.28	1.91	1.61	1.92	2.49	2.99	3.51	3.64	3.82	3.86	3.90	4.02	4.10	4.10	4.10	4.10	4.03	4.02
9	3.43	3.30	3.24	3.21	3.17	3.29	2.53	0.78	0.59	0.78	0.94	1.03	1.15	1.57	2.32	2.78	3.35	3.71	3.78	3.74	3.71	3.71	3.65	3.52
10	2.90	2.72	2.63	2.62	2.56	2.73	2.56	0.45	0.23	0.23	0.23	0.23	0.16	0.23	0.31	0.84	2.80	3.30	3.29	3.29	3.29	3.29	3.28	3.02
11	0.19	0.19	0.19	0.19	0.19	0.19	2.54	2.63	2.63	2.63	0.13	0.13	0.13	0.13	0.13	1.60	3.21	3.22	3.26	3.23	3.24	3.22	2.89	2.81
12	2.63	2.63	2.63	2.61	2.72	2.77	3.07	2.08	1.26	1.33	1.33	1.33	1.33	1.33	1.33	1.87	2.93	2.94	2.94	2.98	2.98	2.94	2.79	2.71

2035

Month \ Hour	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	2.88	2.92	2.90	2.84	3.03	3.31	3.30	1.90	0.44	0.00	0.06	0.00	0.06	0.06	0.13	0.07	2.78	2.81	2.86	2.78	2.78	2.63	2.78	2.73
2	2.64	2.70	2.70	2.60	2.51	2.17	1.01	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	1.50	2.77	2.86	2.76	2.67	2.49	2.66	2.63
3	2.38	2.26	2.36	2.41	2.41	2.32	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71	0.67	0.66	0.66	0.65	1.42	1.35
4	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	1.96	1.64	0.44	0.20	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.07	0.14	0.14	0.14	0.14	0.14	0.14
6	2.20	1.82	0.89	0.86	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.14	0.22	0.55	0.52	1.44	1.61	1.48	1.47	1.44	1.44
7	2.60	2.66	2.72	2.82	2.95	2.40	0.00	0.00	0.00	0.06	0.00	0.00	0.38	0.32	1.34	1.75	2.21	2.65	2.66	2.68	2.64	2.64	2.66	2.65
8	2.96	3.13	3.43	3.68	3.75	3.29	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.21	1.05	1.60	1.68	3.03	3.08	2.99	2.90	2.88	2.92	2.94
9	2.55	2.60	2.83	3.13	3.27	3.12	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.32	0.47	2.15	2.91	3.03	2.72	2.64	2.64	2.65	2.62
10	2.64	2.53	2.51	2.55	2.62	3.02	2.11	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	2.53	2.96	2.94	2.94	2.89	2.86	2.94	2.89
11	0.06	0.00	0.06	0.06	0.13	0.07	2.78	2.81	2.86	2.78	0.00	0.00	0.00	0.00	0.00	0.55	2.79	2.86	2.81	2.79	2.79	2.77	2.65	2.64
12	2.78	2.63	2.78	2.73	3.06	2.85	2.67	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	2.75	2.75	2.75	2.75	2.76	2.75	2.75	2.75

2050

Month \ Hour	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	2.24	2.24	2.19	2.17	2.18	2.19	2.21	1.80	0.31	0.21	0.16	0.14	0.14	0.15	0.21	0.28	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
2	1.52	1.52	1.51	1.51	1.50	1.43	0.99	0.08	0.00	0.08	0.00	0.00	0.08	0.00	0.08	0.16	0.15	0.23	0.23	0.23	0.23	0.23	0.23	0.23
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.08	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.91	0.84	0.78	0.74	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	2.44	2.24	2.04	2.13	1.84	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	3.26	2.91	2.73	2.66	2.54	0.37	0.00	0.00	0.09	0.11	0.00	0.00	0.08	0.15	0.06	0.25	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
8	2.93	2.69	2.69	2.85	2.86	2.55	0.06	0.08	0.08	0.08	0.06	0.06	0.06	0.06	0.07	0.08	0.08	0.42	0.42	0.42	0.42	0.42	0.42	0.42
9	2.32	1.62	1.82	2.09	2.15	2.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.00	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
10	2.25	2.22	2.18	2.20	2.26	2.32	1.39	0.20	0.07	0.06	0.00	0.00	0.00	0.00	0.00	0.13	0.13	0.28	0.28	0.28	0.28	0.28	0.28	0.28
11	0.16	0.14	0.14	0.15	0.21	0.28	0.38	0.38	0.38	0.38	0.13	0.07	0.07	0.07	0.14	0.21	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
12	0.38	0.38	0.38	0.38	2.68	2.74	2.77	1.56	0.28	0.34	0.14	0.20	0.20	0.20	0.22	0.35	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45

Notes: Dark colors indicate higher values and lighter colors indicate lower values.

The second metric, ***hourly marginal emissions,*** is defined as the marginal change in greenhouse gas emitted per unit of site energy consumed to meet a marginal change in site energy consumed. It is calculated based on the same hourly implied marginal heat rate, but heat rate is converted to CO_2-equivalent emissions, based on the carbon intensity of combusting natural gas.

$$Hourly\ Marginal\ Emission\ Factor\ \left(\frac{Metric\ ton\ CO_2}{kWh}\right) =$$
$$= Implied\ Marginal\ Heat\ Rate\ \left(\frac{Btu}{kWh}\right) * Fuel\ Emission\ Rate\ \left(\frac{Metric\ ton\ CO_2}{Btu}\right)$$

Figure 20, below, shows month-hour heat maps for 2025, 2035, and 2050 for the hourly marginal emissions metric. Under the formulation used for source energy and marginal emissions, these metrics are highly correlated with each other.

Figure 20. Hourly Marginal Emissions Heat Maps [tCO_2-e/MWh]

2025

Month \ Hour	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	0.45	0.46	0.44	0.43	0.45	0.46	0.60	0.43	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.46	0.47	0.47	0.47	0.47	0.47	0.47	0.47
2	0.47	0.46	0.46	0.45	0.45	0.45	0.42	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.55	0.56	0.56	0.55	0.55	0.55	0.51
3	0.59	0.54	0.52	0.52	0.53	0.58	0.43	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.20	0.53	0.58	0.57	0.54	0.54	0.54	0.52
4	0.51	0.47	0.46	0.44	0.45	0.44	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.11	0.21	0.50	0.66	0.64	0.57	0.56	0.57	0.55
5	0.59	0.55	0.48	0.48	0.47	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.14	0.20	0.33	0.46	0.66	0.62	0.56	0.56	0.59	0.58
6	0.61	0.56	0.55	0.53	0.55	0.41	0.04	0.01	0.03	0.04	0.11	0.18	0.34	0.42	0.47	0.51	0.55	0.59	0.72	0.74	0.72	0.70	0.67	0.62
7	0.74	0.74	0.73	0.73	0.73	0.72	0.53	0.29	0.44	0.51	0.59	0.68	0.71	0.72	0.72	0.73	0.73	0.73	0.74	0.74	0.74	0.74	0.74	0.74
8	0.72	0.72	0.71	0.71	0.71	0.71	0.59	0.35	0.29	0.35	0.45	0.54	0.63	0.66	0.69	0.70	0.70	0.73	0.74	0.74	0.74	0.74	0.73	0.73
9	0.62	0.59	0.58	0.58	0.57	0.59	0.46	0.14	0.11	0.14	0.17	0.19	0.21	0.28	0.42	0.50	0.60	0.67	0.68	0.68	0.67	0.67	0.66	0.64
10	0.52	0.49	0.48	0.47	0.46	0.49	0.46	0.08	0.04	0.04	0.04	0.04	0.03	0.04	0.06	0.15	0.50	0.60	0.59	0.59	0.59	0.59	0.59	0.54
11	0.03	0.03	0.03	0.03	0.03	0.03	0.46	0.47	0.47	0.47	0.02	0.02	0.02	0.02	0.02	0.29	0.58	0.58	0.59	0.58	0.59	0.58	0.52	0.51
12	0.47	0.47	0.47	0.47	0.49	0.50	0.55	0.37	0.23	0.24	0.24	0.24	0.24	0.24	0.24	0.34	0.53	0.53	0.53	0.54	0.54	0.53	0.50	0.49

2035

Month \ Hour	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	0.52	0.53	0.52	0.51	0.55	0.60	0.60	0.34	0.08	0.00	0.01	0.00	0.01	0.01	0.02	0.01	0.50	0.51	0.52	0.50	0.50	0.47	0.50	0.49
2	0.48	0.49	0.49	0.47	0.45	0.39	0.18	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.27	0.50	0.52	0.50	0.48	0.45	0.48	0.48
3	0.43	0.41	0.43	0.43	0.44	0.42	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.12	0.12	0.12	0.12	0.26	0.24
4	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.35	0.30	0.08	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.03	0.03	0.03	0.03	0.03
6	0.40	0.33	0.16	0.16	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.10	0.09	0.26	0.29	0.27	0.26	0.26	0.26
7	0.47	0.48	0.49	0.51	0.53	0.43	0.00	0.00	0.00	0.01	0.00	0.00	0.07	0.06	0.24	0.32	0.40	0.48	0.48	0.48	0.48	0.48	0.48	0.48
8	0.53	0.56	0.62	0.66	0.68	0.59	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.19	0.29	0.30	0.55	0.56	0.54	0.52	0.52	0.53	0.53
9	0.46	0.47	0.51	0.57	0.59	0.56	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.06	0.08	0.39	0.52	0.55	0.49	0.48	0.48	0.48	0.47
10	0.48	0.46	0.45	0.46	0.47	0.54	0.38	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.46	0.54	0.53	0.53	0.52	0.52	0.53	0.52
11	0.01	0.00	0.01	0.01	0.02	0.01	0.50	0.51	0.52	0.50	0.00	0.00	0.00	0.00	0.00	0.10	0.50	0.52	0.51	0.50	0.50	0.50	0.48	0.48
12	0.50	0.47	0.50	0.49	0.55	0.51	0.48	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50

2050

Month \ Hour	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	0.40	0.40	0.40	0.39	0.39	0.39	0.40	0.33	0.06	0.04	0.03	0.03	0.03	0.03	0.04	0.05	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
2	0.28	0.27	0.27	0.27	0.27	0.26	0.18	0.01	0.00	0.01	0.00	0.00	0.01	0.00	0.01	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.16	0.15	0.14	0.13	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.44	0.40	0.37	0.39	0.33	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.59	0.53	0.49	0.48	0.46	0.07	0.00	0.00	0.02	0.02	0.00	0.00	0.02	0.03	0.01	0.04	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
8	0.53	0.49	0.49	0.52	0.52	0.46	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.08	0.08	0.08	0.08	0.08	0.08	0.08
9	0.42	0.29	0.33	0.38	0.39	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
10	0.41	0.40	0.39	0.40	0.41	0.42	0.25	0.04	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.05	0.05	0.05	0.05	0.05	0.05	0.05
11	0.03	0.03	0.03	0.03	0.04	0.05	0.07	0.07	0.07	0.07	0.02	0.01	0.01	0.01	0.02	0.04	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
12	0.07	0.07	0.07	0.07	0.48	0.49	0.50	0.28	0.05	0.06	0.03	0.04	0.04	0.04	0.04	0.06	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08

Notes: Dark colors indicate higher values and lighter colors indicate lower values.

DER Scenario Results

PATHWAYS Results

Total Net Electricity Demand

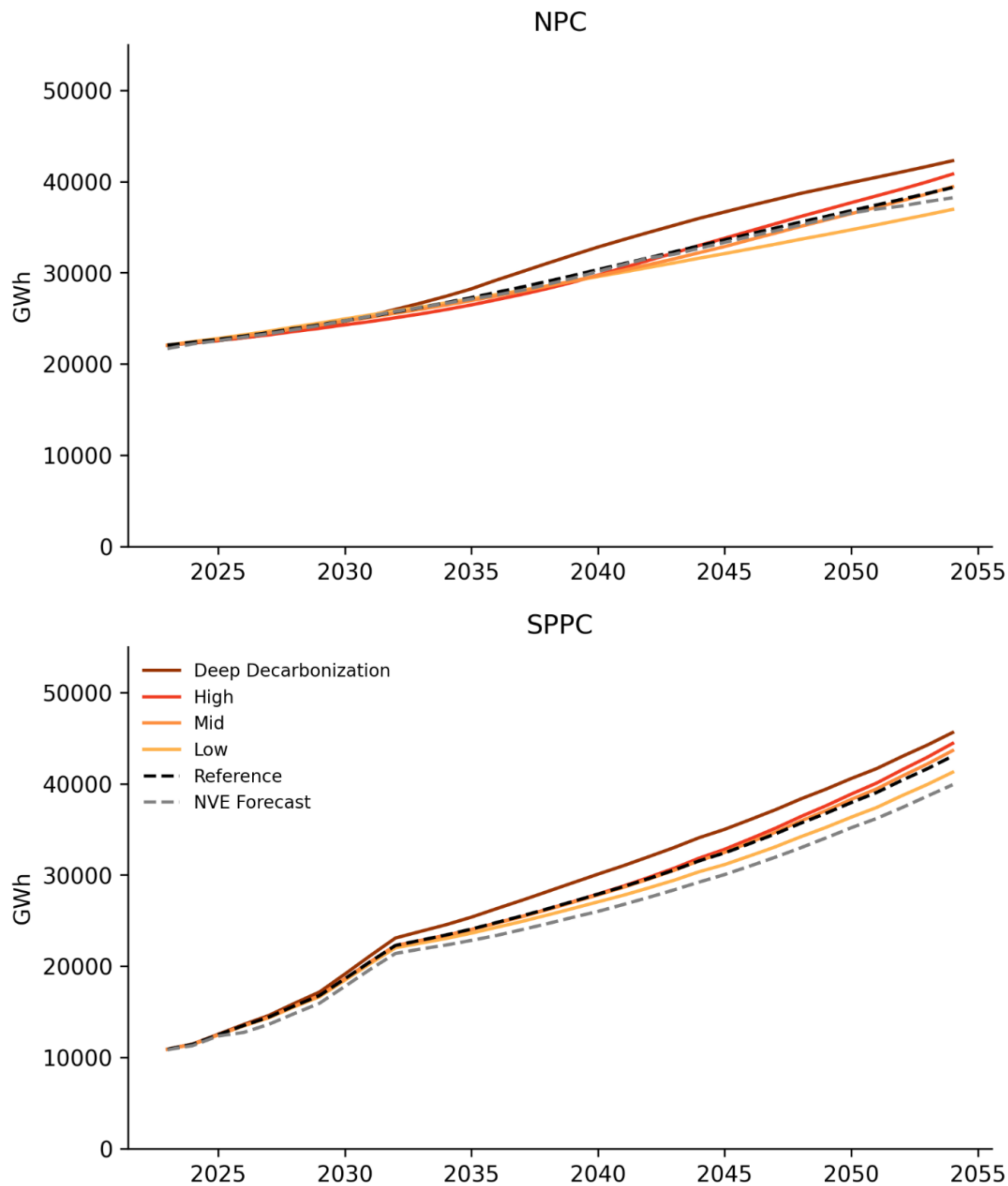
Although the PATHWAYS scenarios reflect very different visions of the future in terms of the extent of electrification and decarbonization, the scenarios produce similar net electricity demand [34] forecasts, as shown in Figure 21. By 2054, the Deep Decarbonization scenario has 7% higher net electricity demand than the Reference scenario in NPC and 6% higher net electricity demand in SPPC.

[34] Net electricity demand is defined as gross electricity demand minus BTM solar generation.

The scenarios that emphasize electrification as a decarbonization strategy also have ambitious levels of energy efficiency and higher BTM solar adoption, offsetting incremental electricity demand. In NPC, the *gross* electricity demand increases 87% by 2054 in the Refence scenario compared to today and the *gross* demand in the Deep Decarbonization scenario increases 103%. In contrast, the relative difference in growth in *net* electricity demand by 2054 between the Reference (78%) and Deep Decarbonization (92%) scenarios is smaller, indicating that higher solar adoption offsets additional load growth from electrification. Energy efficiency also offsets incremental electricity growth. The Deep Decarbonization and High scenarios assume a significant portion of heat pumps adopted to meet decarbonization targets are high efficiency models. In the Deep Decarbonization scenario, in NPC, the incremental electricity demand from residential and commercial space and water heating is 2,819 GWh in 2054 but gross energy efficiency savings (in non-space heating and water heating subsectors) are 4,893 GWh, which more than offsets the incremental load growth from building electrification. In SPPC, which has a colder climate, incremental load from building electrification is not entirely offset by energy efficiency, but the load growth is still mitigated by efficiency.

The scenarios also produce similar levels of electricity demand because two of the largest sources of load growth—light duty vehicle electrification and data centers—are similar across scenarios. In 2040, battery electric vehicles account for 72% of light duty vehicles sales in the Reference scenario and 100% in the Deep Decarbonization scenarios, reflecting rapid transportation electrification in both scenarios. Transportation electrification—from light, medium, and heavy-duty vehicles—adds an incremental 11,197 GWh in the Reference scenario and 15,700 GWh in the Deep Decarbonization by 2054 in NPC, which is equivalent to 26 and 33% of the respective gross electricity demand growth. In SPPC, transportation electrification accounts for 12-15% of incremental gross electricity demand in the Reference and Deep Decarbonization scenarios. In all scenarios, major projects, including data centers, add significantly to NVE's system load. In the Reference scenario, incremental load growth from data centers drives 16% of net load growth by 2054 in NPC and 78% of load growth in SPPC.

Figure 21. Total Net Electricity Demand across PATHWAYS Scenarios



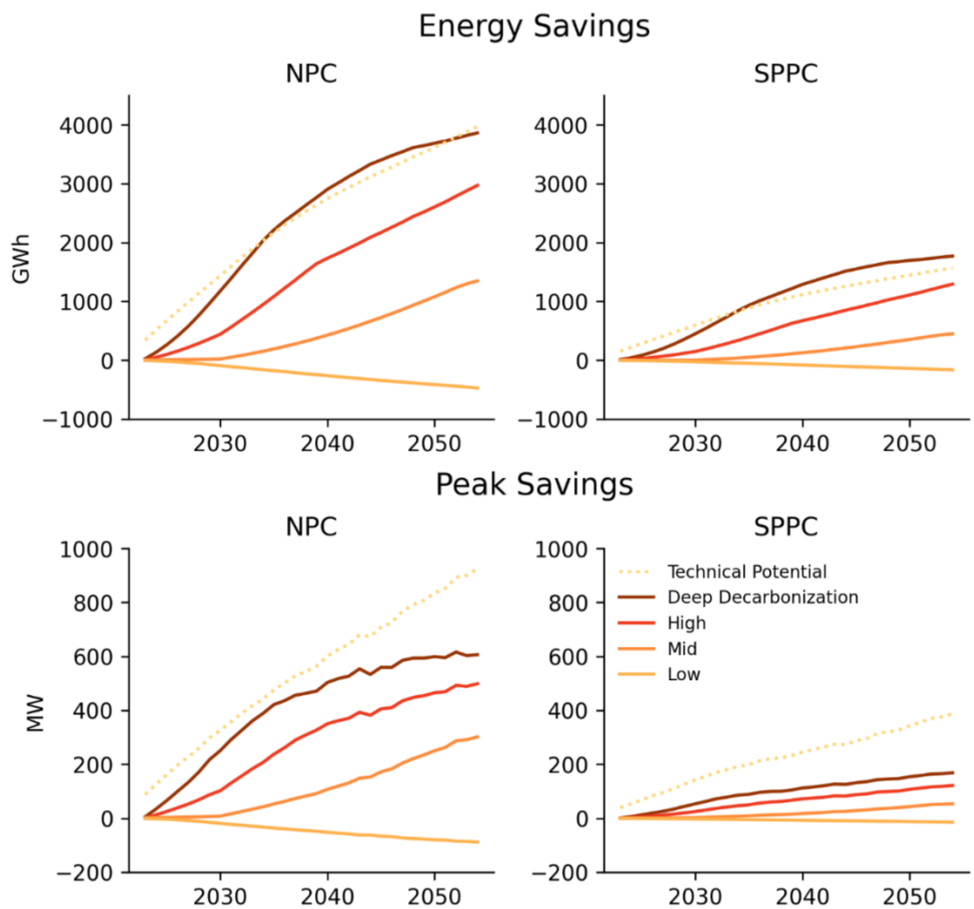
Notes: “NVE Forecast” is a load forecast developed by NVE’s load forecasting team. Other scenarios presented are from PATHWAYS.

Energy Efficiency

Figure 22 shows the cumulative programmatic energy and peak savings from energy efficiency across PATHWAYS scenarios. Programmatic energy efficiency savings are defined as the energy efficiency impacts incremental to those achieved in the Reference scenario. As the Reference scenario reflects a continuation of existing market trends, code and standards, and policy, programmatic energy efficiency is driven by incremental changes in state and federal policy, utility programs, and market forces.

The programmatic energy efficiency savings range from –91 to 1,176 GWh in NPC and –27 to 420 GWh in SPPC in 2030 between the Low and Technical Potential scenarios. The peak load[35] impacts range from –19 MW to 326 MW in NPC and –3 to 142 MW in SPPC (see Figure 22). In 2054, the energy savings range from –471 to 3,971 GWh in NPC and –162 to 1,750 GWh in SPPC, and the peak savings range from –88 to 924 MW in NPC and –15 to 386 MW in SPPC.

Figure 22. Cumulative programmatic energy (GWh) and peak (MW) impacts of energy efficiency across PATHWAYS scenarios



Notes: Programmatic energy efficiency is the energy efficiency achieved incremental to that of the Reference scenario. Negative values indicate that less energy efficiency is achieved in that scenario than in Reference.

[35] Peak load impacts are calculation as the average load impact during the top 150 hours of NVE's system load net of must take renewables.

Table 17. Programmatic energy efficiency energy impact (GWh) across PATHWAYS scenarios

Annual Energy (GWh)	2025	2026	2027	2028
NPC				
Technical Potential	672	830	983	1,139
Deep Decarbonization	261	408	575	763
High	98	154	218	287
Mid	8	10	12	14
Low	-19	-29	-42	-57
SPPC				
Technical Potential	284	347	409	474
Deep Decarbonization	85	136	199	274
High	30	48	68	93
Mid	0	0	1	1
Low	-6	-9	-13	-17

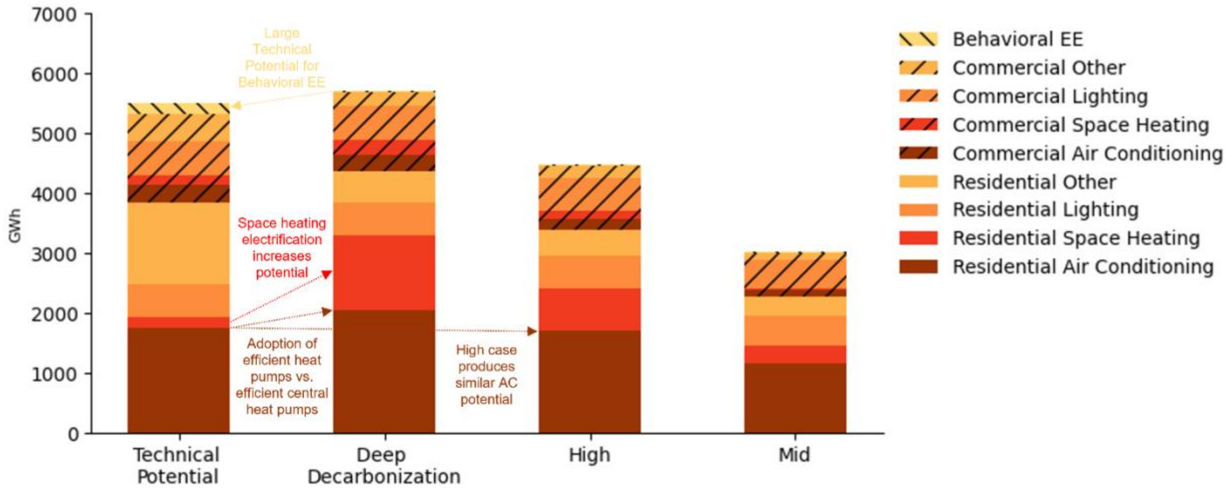
Table 18. Programmatic peak impacts (MW) of energy efficiency across PATHWAYS scenarios

Peak Impact (MW)	2025	2026	2027	2028
NPC				
Technical Potential	161	196	227	260
Deep Decarbonization	65	99	132	171
High	25	38	52	68
Mid	3	4	5	6

Low	-4	-6	-8	-12
SPPC				
Technical Potential	68	83	95	110
Deep Decarbonization	12	19	26	34
High	5	9	12	16
Mid	1	1	1	1
Low	-1	-1	-1	-2

In the near term, the Technical Potential scenario has the most energy efficiency potential followed by the Deep Decarbonization, High, and Mid scenarios, but in the 2040s, the Deep Decarbonization scenario shows more energy efficiency potential that the Technical Potential scenario. The Technical Potential scenario assumes no electrification or fuel switching for space and water heating while the Deep Decarbonization scenario deploys heat pumps to achieve high levels of electrification. As illustrated Figure 23, electrifying space heating presents an opportunity to drive efficiency benefits by installing high-performance heat pumps rather than minimum standard heat pumps. Using high performance heat pumps for cooling rather than standard heat pumps produces more energy savings than installing high efficiency central air conditioners rather than standard central air conditioners as modeled in the Technical Potential scenario. Fuel switching produces larger energy efficiency gains in space heating sectors in the Deep Decarbonization scenario compared to the Technical Potential scenario and is the primary driver of the higher energy savings in the 2040s. Space heating electrification is modeled as having no impact on NVE's existing system peak, and therefore, the Technical Potential scenario has consistently higher peak load impacts than the Deep Decarbonization scenario.

Figure 23. Gross energy savings by subsector in 2045 in NPC across select PATHWAYS scenarios



The top subsectors for energy savings from efficiency ranked according to their programmatic impact in the Mid scenario in 2030 are shown in Table 19. In both NPC and SPPC, air conditioning in the residential and commercial buildings and commercial lighting [36, 37] are top subsectors. Commercial space heating is a top subsector as well due to the phase out of electric resistance heating and replacement with more efficient heat pumps.

The top subsector for peak savings from energy efficiency in the Mid scenario are shown in Table 20. Many of the subsectors that produce the most peak savings also produce significant energy savings. Air conditioning subsectors produce the most peak savings as space cooling end uses are highly coincident with NVE system load.

[36] The analysis team did not explicitly model the impacts of the Assembly Bill 144 in the Reference scenario, which at the time of developing this report was only proposed legislation to ban the sale of fluorescent light bulbs starting in 2025.

[37] This analysis was conducted before the U.S. Department of Energy latest standards for residential and commercial general service lamps that were finalized as of April 12, 2024, and therefore the impact of those standards is not incorporated in the Reference scenario.

Table 19. Top 10 subsectors ranked for cumulative programmatic energy efficiency potential, ranked by 2030 values - Mid scenario (GWh)

Subsector	2025	2026	2027	2030	2040	2054
NPC						
Residential Central Air Conditioning	7,645	9,379	11,212	18,286	276,908	762,360
Non-Equipment Residential HVAC	374	714	1,142	2,358	823	263
Commercial Space Heating	116	165	222	546	8,484	34,820
Commercial Linear Lighting	-	-	-	173	14,171	70,312
Commercial Air Conditioning	12	18	24	134	5,695	25,470
Residential Behavioral EE	89	97	105	129	208	319
Commercial Ventilation	-	-	-	120	8,525	27,408
Residential Refrigeration	-	-	-	110	8,117	35,831
Residential Room Air Conditioning	6	12	20	92	6,061	18,059
Residential General Service Lighting	-	-	-	90	2,378	9,475
SPPC						
Residential Central Air Conditioning	795	990	1,202	2,034	33,046	95,146
Commercial Space Heating	69	98	133	325	5,004	20,283
Residential Behavioral EE	110	111	112	116	127	143
Commercial Linear Lighting	-	-	-	101	8,093	38,790
Commercial Ventilation	-	-	-	75	4,971	15,579
Residential Room Air Conditioning	4	7	12	58	4,010	12,478
Commercial Air Conditioning	5	7	10	55	2,560	12,643
Commercial General Service Lighting	-	-	-	36	922	3,713
Residential Clothes Washing	-	-	-	26	1,726	6,054
Residential Refrigeration	-	-	-	23	1,579	6,550

Table 20. Top 10 subsectors for cumulative programmatic energy efficiency potential, ranked by 2030 values - Mid scenario (MW)[38]

Subsector	2025	2026	2027	2030	2040	2054
NPC						
Residential Central Air Conditioning	2.96	3.59	4.16	6.75	95.97	260.98
Non-Equipment Residential HVAC	0.11	0.21	0.33	0.67	0.23	0.07
Residential Room Air Conditioning	0.00	0.00	0.01	0.03	2.10	6.18
Behavioral EE	0.02	0.02	0.03	0.03	0.05	0.08
Commercial Air Conditioning	0.00	0.00	0.00	0.02	0.93	4.33
Residential General Service Lighting	-	-	-	0.02	0.49	1.93
Residential Reflector Lighting	-	-	-	0.02	0.70	2.40
Commercial Ventilation	-	-	-	0.01	0.99	3.22
Commercial Linear Lighting	-	-	-	0.01	1.09	5.48
Residential Refrigeration	-	-	-	0.01	0.93	4.09
SPPC						
Residential Central Air Conditioning	0.32	0.39	0.45	0.76	9.95	30.35
Behavioral EE	0.03	0.03	0.03	0.03	0.03	0.04
Residential Room Air Conditioning	0.00	0.00	0.00	0.02	1.21	3.98
Commercial Air Conditioning	0.00	0.00	0.00	0.01	0.53	2.74
Commercial Linear Lighting	-	-	-	0.01	0.70	3.36
Commercial Ventilation	-	-	-	0.01	0.56	1.77
Residential General Service Lighting	-	-	-	0.00	0.09	0.36
Residential Reflector Lighting	-	-	-	0.00	0.14	0.45
Residential Clothes Washing	-	-	-	0.00	0.24	0.85
Commercial General Service Lighting	-	-	-	0.00	0.08	0.32

Building Electrification

Figure 24 shows the annual electricity demand from residential and commercial space heating and water heating. The charts show the upper and lower range of electricity demand growth expected under each scenario if the forecasted electrification occurs with the efficient heat pumps assumed in the scenario (lower end) or all standard performance heat pumps (upper end). The scenarios vary

[38] Analysis excludes Major Projects

both by the rate of heat pump adoption as well as the share of those heat pumps that are high efficiency (reflected in the lower end). The range between upper and lower bounds shows there is significant potential to manage load growth from electrification through efficiency. Scenarios that have higher rates of electrification show a broader range of load impacts. While the lower end of the areas shows the expected load from residential and commercial space and water heating with electrification and efficiency, the large ranges in the Deep Decarbonization and High scenarios indicate that load growth could be higher without energy efficiency in these subsectors.

In the Deep Decarbonization scenario, building electrification will add 2,870 GWh to NPC's system and 1,560 GWh to SPPC's with energy efficiency by 2054. Without the energy efficiency investments in the Deep Decarbonization scenario, load growth from building electrification would be 68% and 92% higher in NPC and SPPC, respectively. In the Mid scenarios, incremental load growth from building electrification (with energy efficiency) is modest, adding 772 GWh and 260 GWh to NPC and SPPC by 2054.

Figure 24. Annual Electricity Demand from Residential and Commercial Space Heating and Water Heating across PATHWAYS scenarios

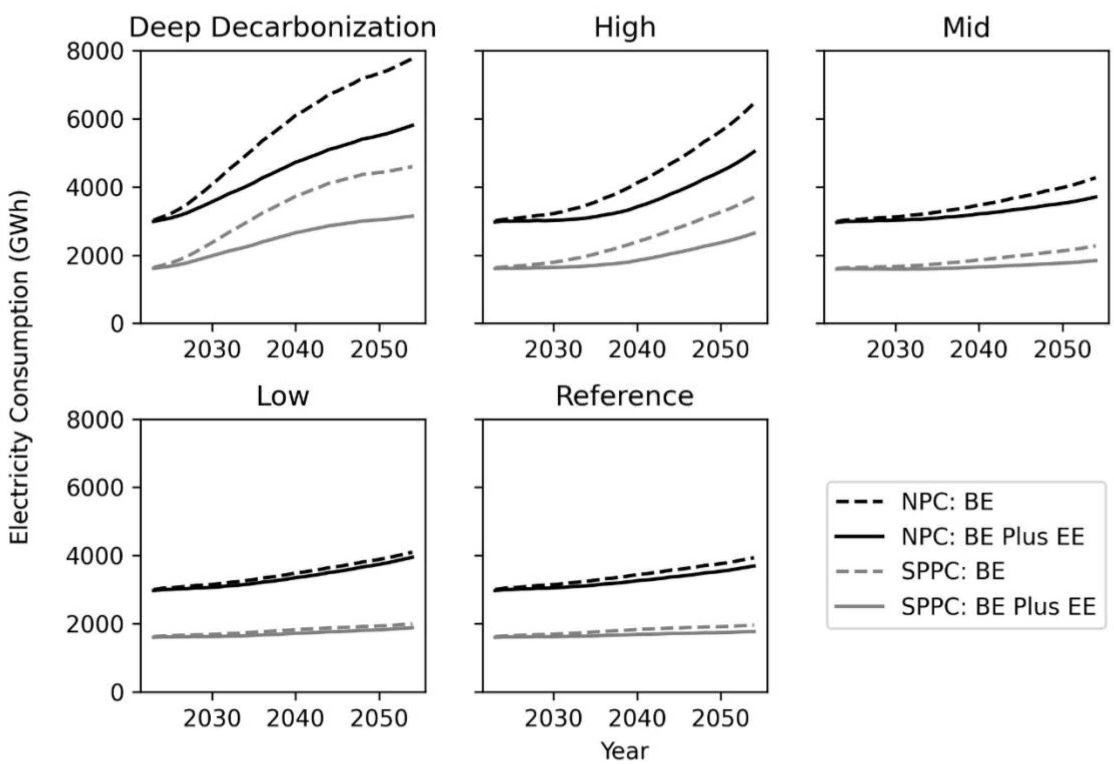


Table 21. Annual Electricity Demand from Residential and Commercial Space Heating and Water Heating with and without energy efficiency across PATHWAYS scenarios

Electricity (GWh)	BE or BE + EE	2025	2026	2027	2028
NPC					
Reference	BE	3054	3074	3092	3120
	BE + EE	3003	3014	3022	3040
Deep Decarbonization	BE	3212	3339	3489	3678
	BE + EE	3086	3155	3238	3347
High	BE	3069	3096	3123	3162
	BE + EE	2997	3002	3005	3017
Mid	BE	3039	3056	3072	3097
	BE + EE	2988	2997	3003	3018
Low	BE	3053	3074	3092	3120
	BE + EE	3006	3018	3028	3048
SPPC					
Reference	BE	1649	1659	1667	1681
	BE + EE	1611	1613	1614	1619
Deep Decarbonization	BE	1768	1856	1960	2090
	BE + EE	1676	1721	1774	1844
High	BE	1670	1691	1712	1741
	BE + EE	1617	1621	1624	1632
Mid	BE	1635	1641	1647	1658
	BE + EE	1597	1596	1594	1597
Low	BE	1647	1656	1664	1676
	BE + EE	1611	1613	1615	1621

Transportation Electrification

Across scenarios, the outlook for light-duty vehicle adoption is high. In the Deep Decarbonization, High, and Mid scenarios, battery electric vehicles (BEVs) reach 100% of light-duty (LDV) sales shares during the analysis period. Across scenarios, LDV BEVs compose between 52–100% of the light-duty vehicle stock in 2054. The adoption trajectories for zero-emissions medium- and heavy-duty vehicles (MHDV) varies more substantially than the LDV trajectories. In the Deep Decarbonization and High scenarios, the sales shares of MHDV zero-emissions vehicles reach 100% to meet decarbonization goals, but the Low scenario presents a worldview where decarbonizing this sector remains a challenge over the study horizon. In all scenarios, light-duty vehicles account for >70% of incremental electricity demand from transportation electrification. By 2054, the incremental load added to NVE's system from transportation electrification is equivalent to 28–71% of NPC's current system load and 26–64% of SPPCs. The figure below shows the annual load from the transportation sector expected during the modeling horizon for each scenario.

Figure 25. Transportation electrification annual load impact (GWh) across PATHWAYS scenarios

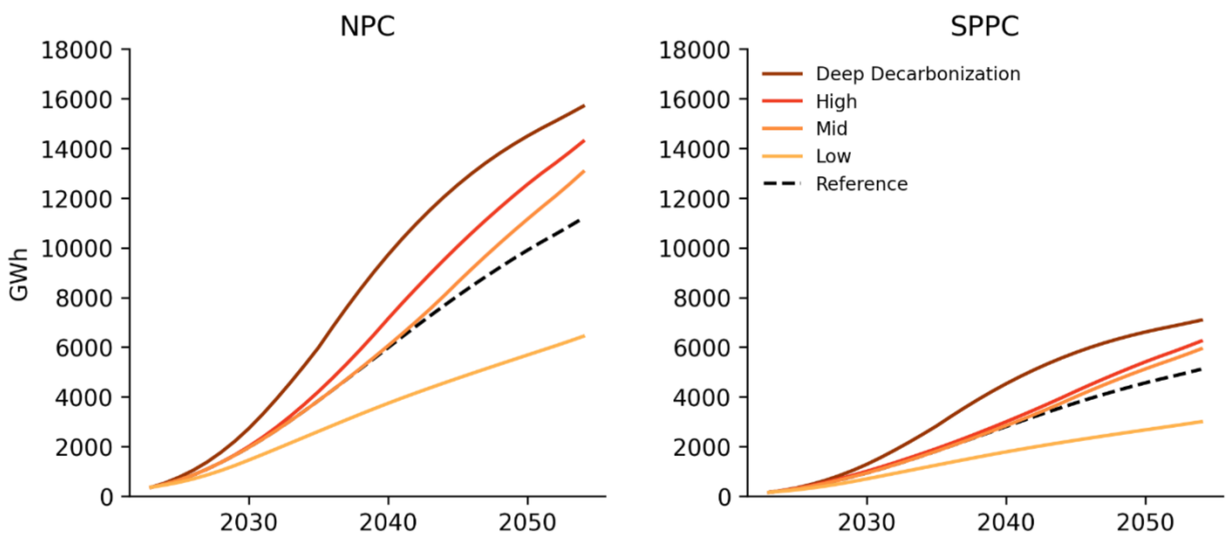


Table 22. Transportation electrification annual load (all vehicle types) (GWh) across PATHWAYS scenarios

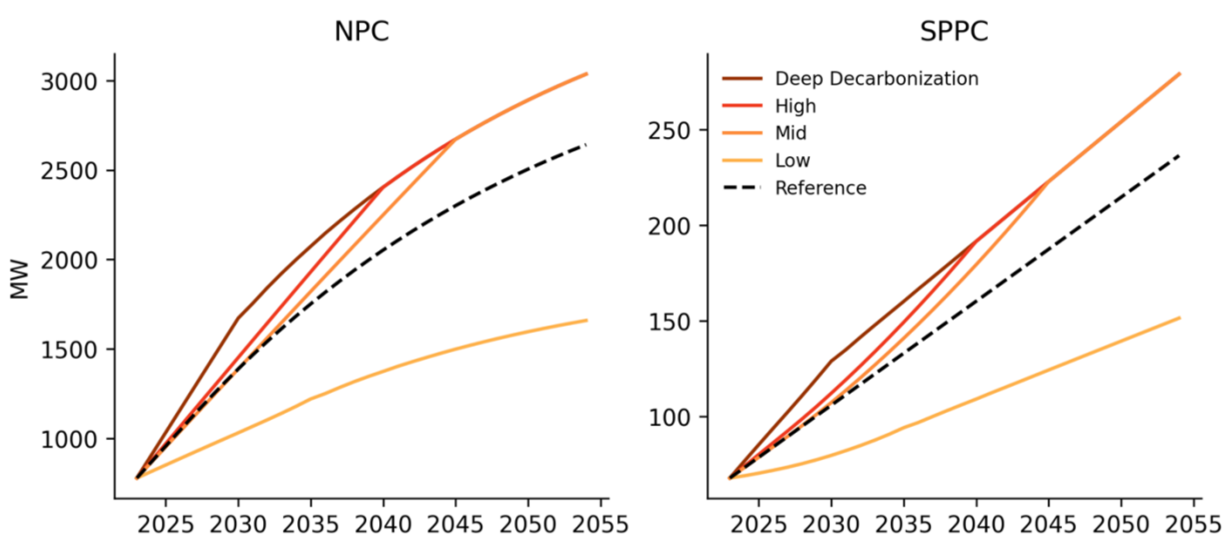
GWh	2025	2026	2027	2028
NPC				
Deep Decarbonization	760	1,034	1,365	1,757
High	648	847	1,082	1,353
Mid	648	847	1,082	1,350
Low	554	688	846	1,028
Reference	648	847	1,082	1,350
SPPC				
Deep Decarbonization	332	467	627	816

High	312	422	549	689
Mid	299	398	511	640
Low	253	320	399	488
Reference	299	398	511	640

Behind-the-Meter Solar and Storage

The Deep and High scenarios show higher near-term growth in BTM residential and commercial solar (see Figure 26) than the Reference and Mid scenarios. The Deep Decarbonization, High, and Mid scenarios adoption trajectories converge in the 2040s reflecting market saturation. In 2054, the Deep Decarbonization, High, and Mid scenario have 15% higher installed capacity in NPC and 18% higher installed capacity in SPPC. The Low scenario has much slower growth rate in solar adoption resulting in 36–37% lower adoption in 2054.

Figure 26. Residential and Commercial Behind-the-Meter Installed Solar Capacity across PATHWAYS scenarios



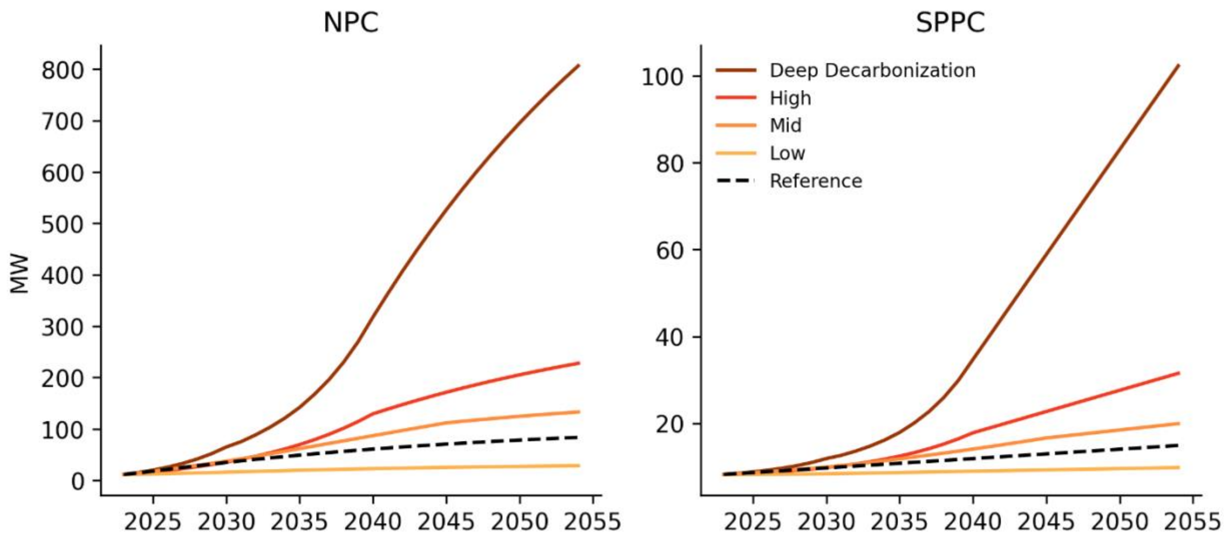
Notes: Both charts show installed capacity in MW. Note different axes scales.

Table 23. Residential and Commercial Behind-the-Meter Installed Solar Capacity (MW) across PATHWAYS scenarios

MW	2025	2026	2027	2028
NPC				
Deep Decarbonization	1,034	1,161	1,289	1,417
High	971	1,067	1,163	1,260
Mid	953	1,040	1,127	1,214
Low	851	888	924	960
Reference	957	1,047	1,136	1,223
SPPC				
Deep Decarbonization	85	94	102	111
High	80	86	93	99
Mid	79	84	90	95
Low	70	72	74	75
Reference	79	84	90	95

As described in the methodology section, the projections of BTM storage adoption are connected to BTM solar but reflect a range of storage attachment rate on solar installations. In NPC, the Deep Decarbonization scenario has 86% higher installed capacity compared to the Reference scenario and the Low scenario has 54% lower installed capacity than the Reference in 2030. In SPPC, the installed storage capacity is 22% higher in the Deep Decarbonization compared to the Reference in 2030 and the Low scenario is 14% lower than the Reference.

Figure 27. Residential and Commercial Behind-the-Meter Installed Storage Capacity across PATHWAYS scenarios



Notes: Both charts show installed capacity in MW. Note different axes scales.

Table 24. Residential and Commercial Behind-the-Meter Installed Storage Capacity (MW) across PATHWAYS scenarios

MW	2025	2026	2027	2028
NPC				
Deep Decarbonization	20	26	33	41
High	16	19	23	27
Mid	18	21	25	29
Low	12	13	14	15
Reference	18	22	25	28
SPPC				
Deep Decarbonization	9	9	10	10
High	9	9	9	9
Mid	9	9	9	9

Low	8	8	8	8
Reference	9	9	9	9

Demand Response

The number of devices participating in demand response in residential and commercial buildings is shown in Figure 28 and Figure 29. The scenarios emphasize enrollment of residential and commercial HVAC systems, expanding upon NVE's existing DR programs, because managing cooling loads presents a large resource with availability coincident with periods of system need. Note that the units of participating devices for HVAC systems are smart thermostats. The Deep Decarbonization, High, and Mid scenarios also assume a ramping up of DR programs addressing commercial lighting, residential water heating, and miscellaneous end uses.

Figure 28. Commercial demand response participation (devices) across PATHWAYS scenarios

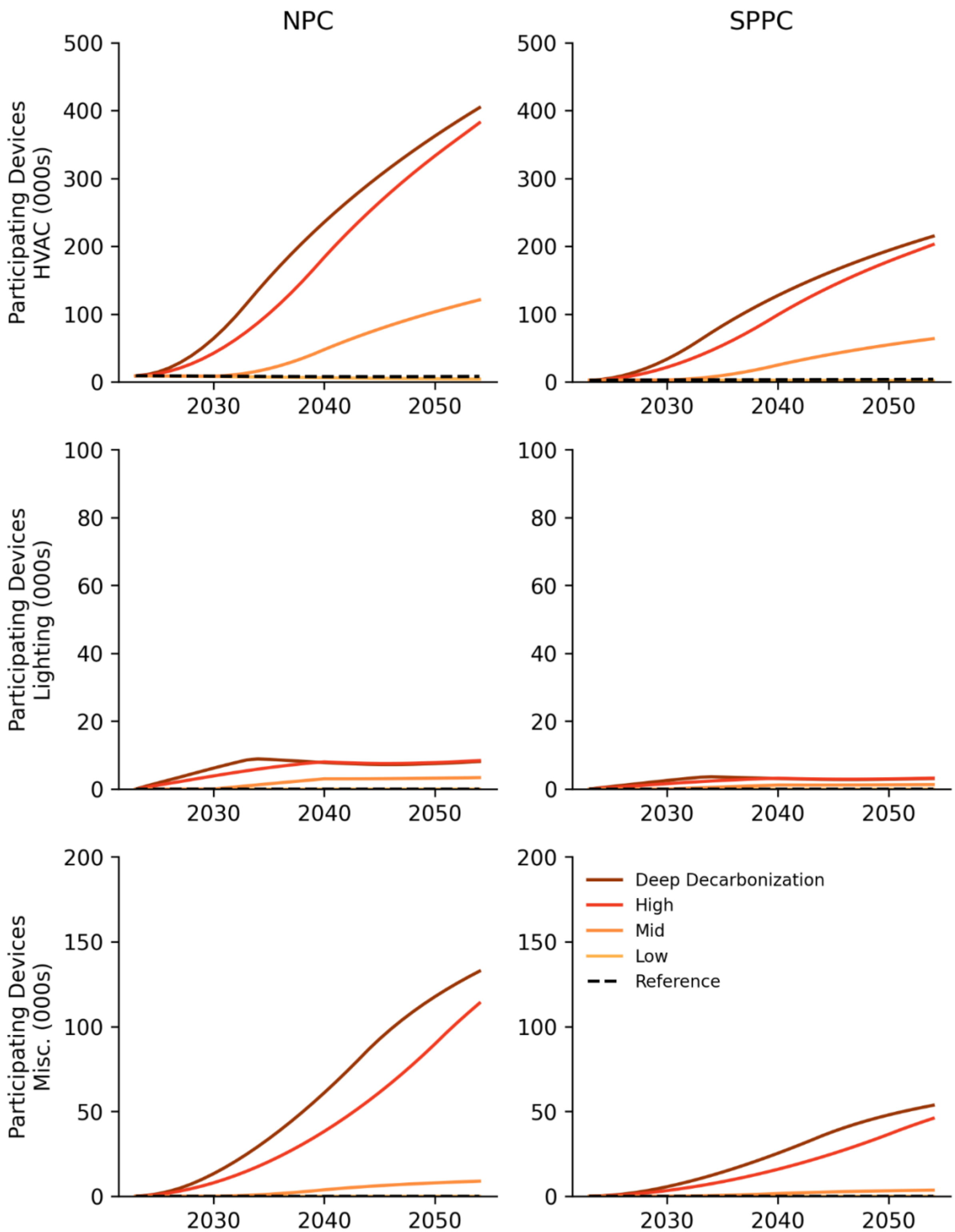


Figure 29. Residential demand response participation (devices) across PATHWAYS scenarios

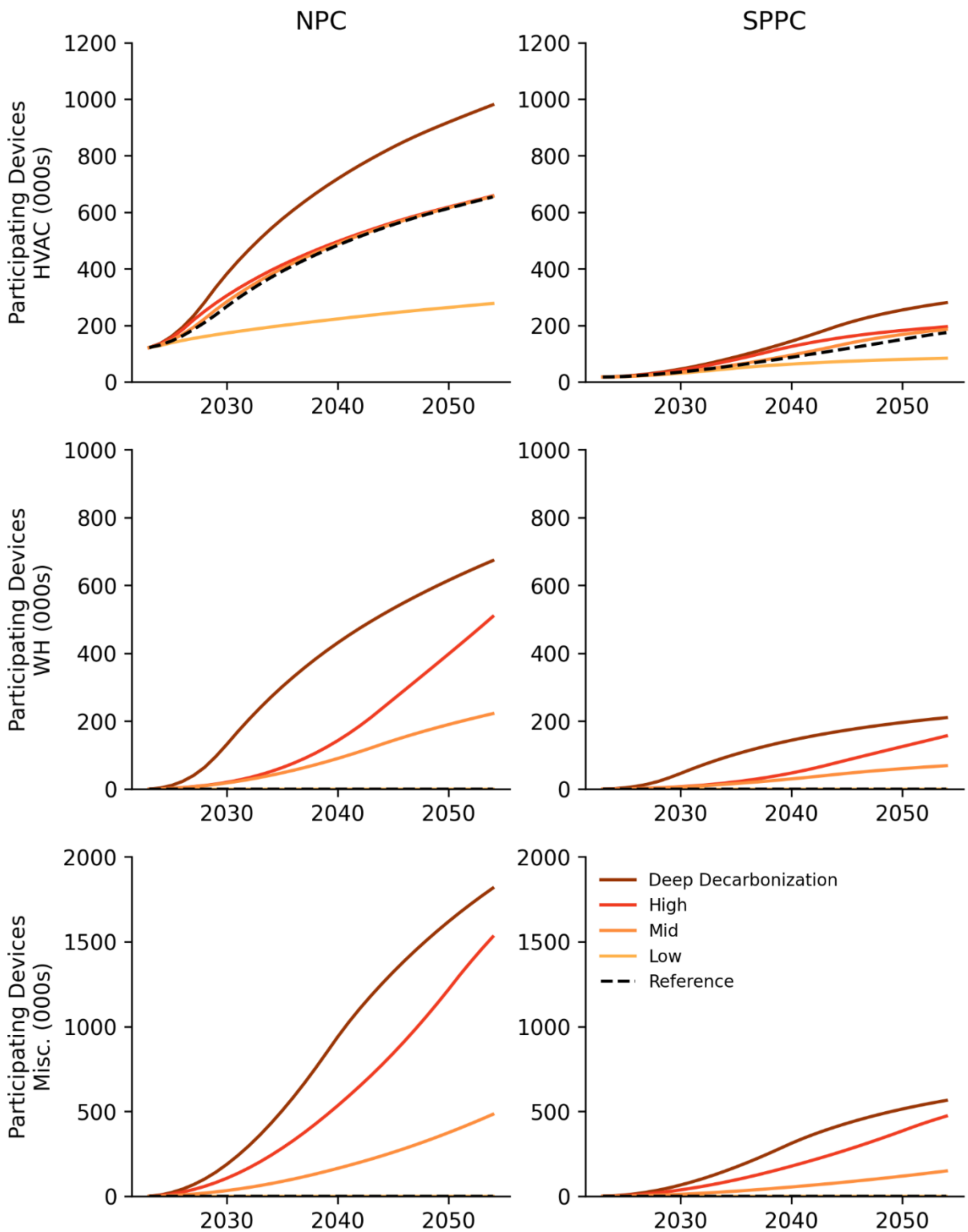


Table 25. Residential and Commercial HVAC DR participating devices (Thermostats) across PATHWAYS scenarios

Thermostats	Residential				Commercial			
	2025	2026	2027	2028	2025	2026	2027	2028
NPC								
Deep Decarbonization	160	193	233	282	15	20	28	38
High	156	185	219	250	12	16	20	26
Mid	147	168	193	223	9	9	9	9
Low	138	147	154	161	9	9	9	8
Reference	144	163	185	210	9	9	9	9
SPPC								
Deep Decarbonization	21	24	28	33	6	9	14	19
High	20	23	26	31	4	7	9	13
Mid	19	21	24	27	3	3	3	3
Low	19	21	23	25	3	3	3	3
Reference	19	22	24	28	3	3	3	3

As shown in Figure 30, the peak load impacts of residential HVAC DR in NPC range from 176–330 MW between scenarios in 2030 and 308–717 MW between scenarios in 2054. While participation rates are higher in the High scenario, the peak load impacts from demand response are slightly higher in the Reference scenario. Peak load impacts of demand response are a function of both the number of customers participating and the amount of load participating customers can shift or shed. In the Deep Decarbonization and High scenarios, energy efficiency reduces residential and commercial air conditioning load substantially, lowering the potential load response from demand response, relative to the Reference scenario. Figure 31 shows the contribution to peak load reductions from residential air conditioning energy efficiency (hatched area) and residential HVAC demand response (solid area) for the Deep Decarbonization and Reference scenarios. In 2054, 52%

(792 MW) of peak load reduction in the Deep Decarbonization scenario comes from energy efficiency while 31% (309 MW) of peak load reduction in the Reference case comes from energy efficiency. Thus, the much more aggressive load reductions from energy efficiency reduce the demand response potential in the scenarios with higher efficiency adoption. The Low scenario shows lower peak impact from DR compared to the Reference due to lower participation rates and not from efficiency in the end uses participating in DR. This highlights the opportunity to optimize investments in energy efficiency and demand response that address end use loads highly coincident with NVE system peaks to produce grid value.

Figure 30. Peak load impacts of HVAC demand response across PATHWAYS scenarios

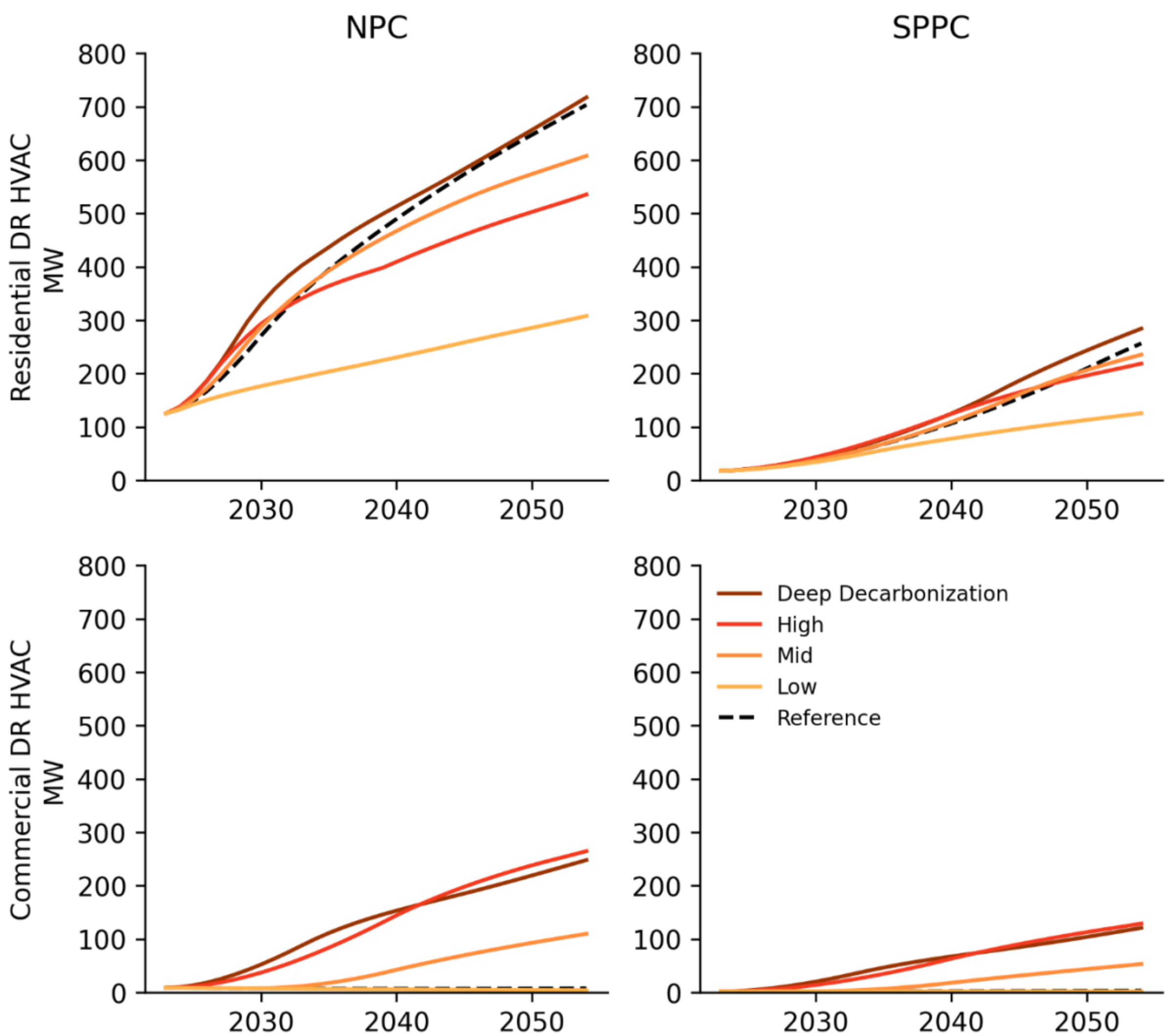
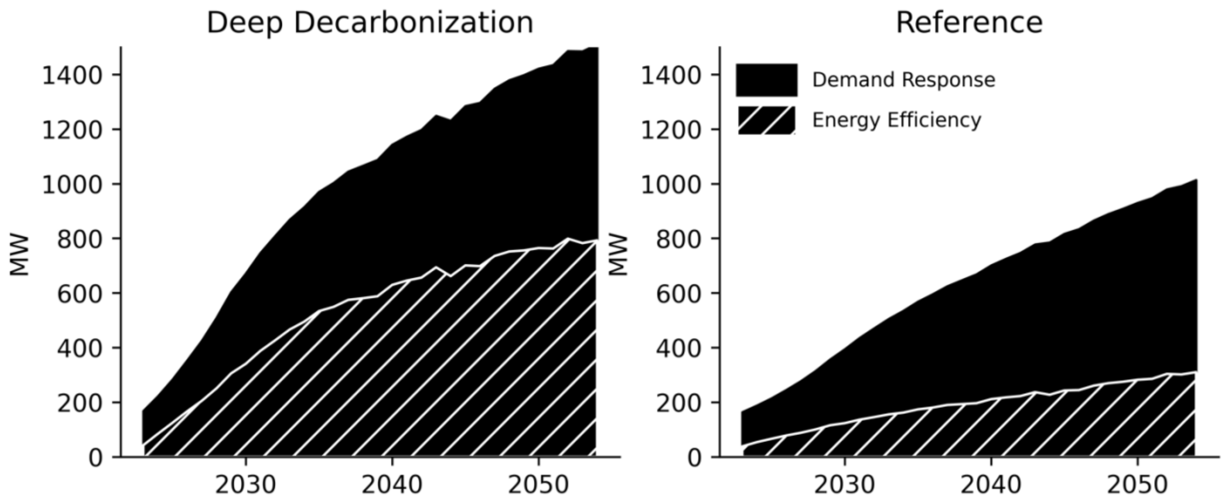


Table 26. Residential and Commercial HVAC DR Capacity (MW) across PATHWAYS scenarios

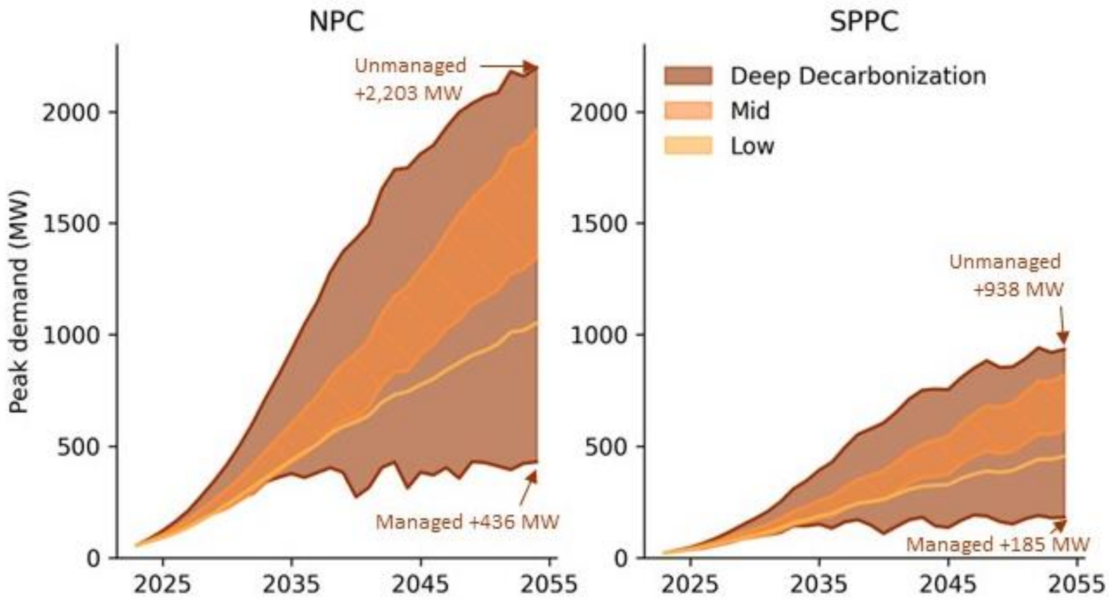
MW	Residential				Commercial			
	2025	2026	2027	2028	2025	2026	2027	2028
NPC								
Deep Decarbonization	158	186	220	258	13	18	25	33
High	158	185	217	245	11	14	18	24
Mid	151	171	197	227	8	8	8	8
Low	142	150	157	164	8	8	8	8
Reference	148	166	189	214	8	8	8	8
SPPC								
Deep Decarbonization	21	24	28	32	4	6	8	12
High	21	24	27	32	3	4	6	8
Mid	20	22	25	29	2	2	2	2
Low	20	22	24	27	2	2	2	2
Reference	20	23	26	30	2	2	2	2

Figure 31. Contribution of residential HVAC energy efficiency and demand response to peak load reductions fin NPC in the Deep Decarbonization and Reference scenarios



Charging management can play a significant role in mitigating the peak impact of transportation electrification. With the amount of transportation electrification projected in the Deep Decarbonization scenario, EV charging is expected to increase NPC's system peak by 2,203 MW if charging occurs in an unmanaged fashion. With the rates of managed charging described in the Methodology section, the Deep Decarbonization scenario is expected to only add 436 MW to NPC's system peak. This is lower than the 1,345 MW of expected transportation peak impacts with managed charging projected in the Mid scenario. The Deep Decarbonization scenario has 20% higher annual energy consumption from the transportation sector in 2054 compared to the Mid scenario, but due to the much more ambitious projections for managed charging participation, the Deep Decarbonization scenario projects lower peak impacts. NVE should continue to evaluate the potential for managed charging to mitigate system load impacts as electrification at scale will present new challenges around ensuring consistent and reliable responses as well as mitigating rebound peaks.

Figure 32. Transportation electrification peak load impact with unmanaged charging and with charging management based on electric vehicle adoption and DR participation in the Deep Decarbonization, Mid, and Low scenarios



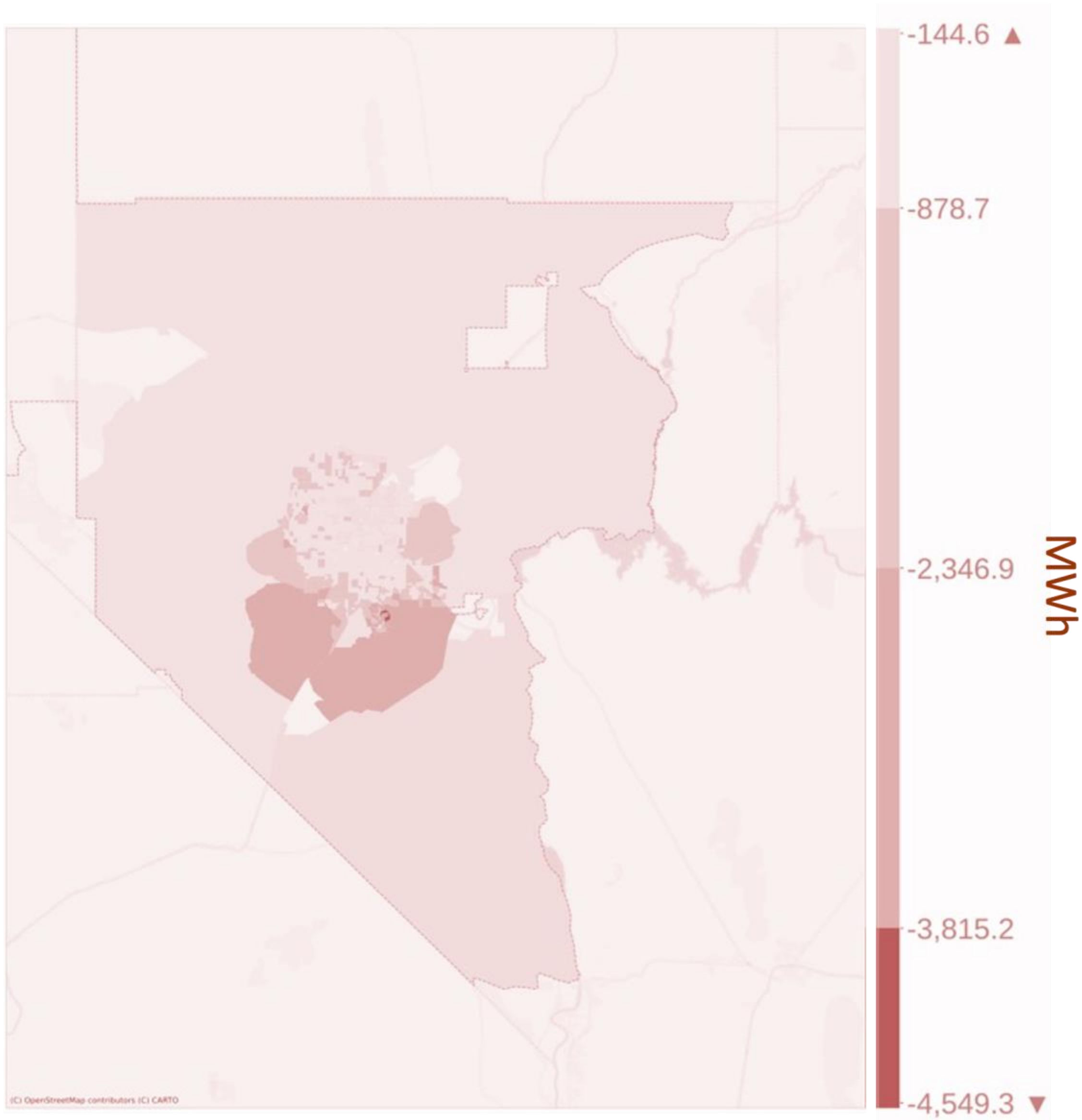
Forecasting Anywhere

As discussed in the Methodology section, the analysis team geospatially downscaled the results of the Mid scenario to support the development of the DRP and to evaluate the impact of DER adoption in LMI communities for the MPS. All DER types (excluding behavioral and non-equipment energy efficiency) were geospatially downscaled. A select set of results from the FA analysis are shown here and the LMI analysis is presented in detail in the following section.

Figure 33 and Figure 34 show the cumulative programmatic energy impacts of residential energy efficiency by block group in NPC and SPPC by 2030 for the Mid scenario (note that energy efficiency is presented using negative values). In 2030, the FA model shows higher energy efficiency impacts in suburban communities surrounding Las Vegas and Reno than in those urban centers. FA analysis of the long-term geospatial impacts of the Mid scenario shows energy efficiency adoption spreading to more rural and urban communities in the 2040s.

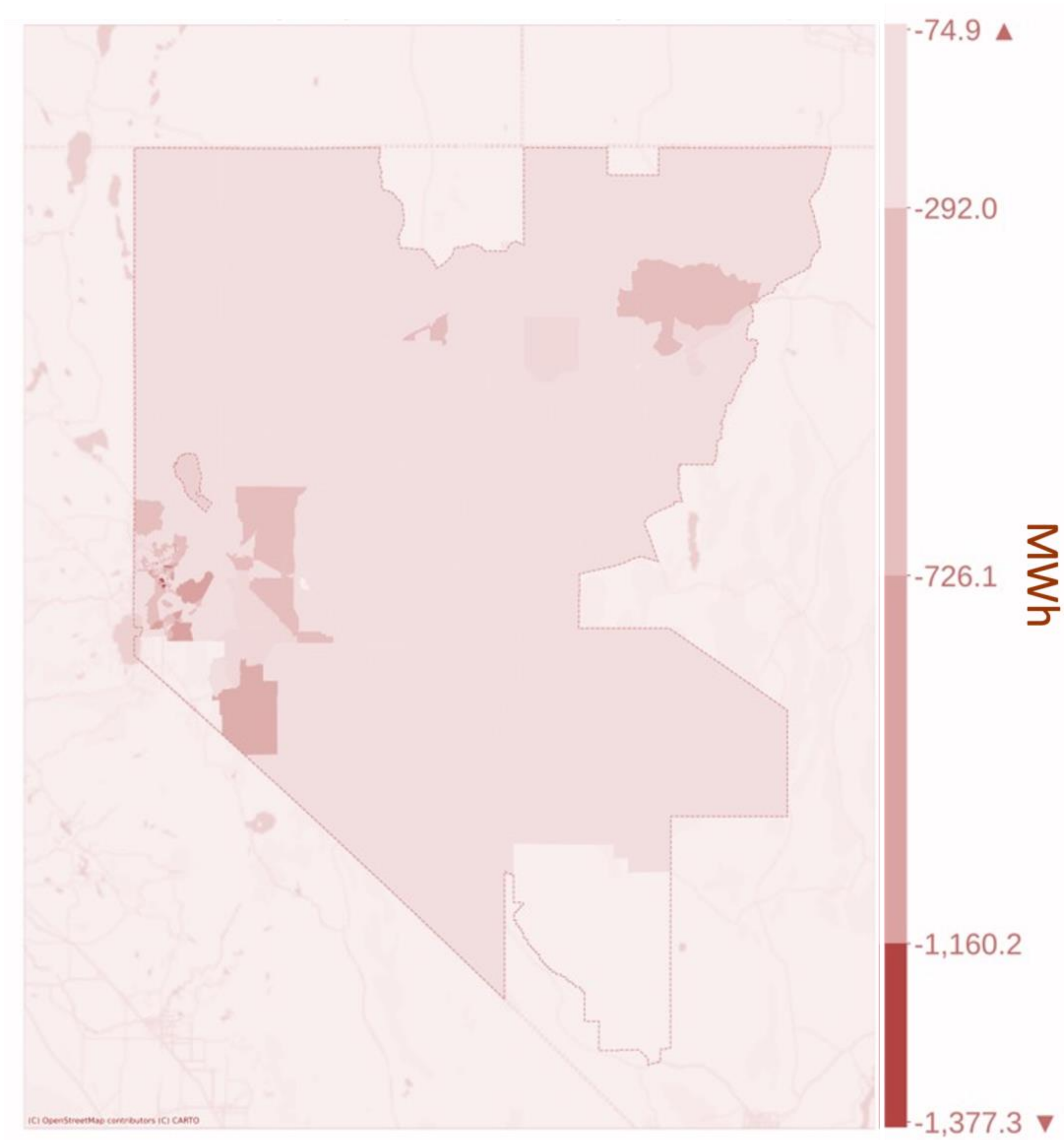
As noted above, the analysis team provided NVE with a geospatial forecast for other DER types including building and transportation electrification. The complete suite of downscaled DERs can provide NVE with insight into how both loading building and reducing DERs will impact their distribution system and can be leveraged for non-wires alternatives to distribution system upgrades.

Figure 33. NPC Cumulative Annual Programmatic Residential Energy Efficiency Impacts in 2030 in the Mid scenario (GWh)



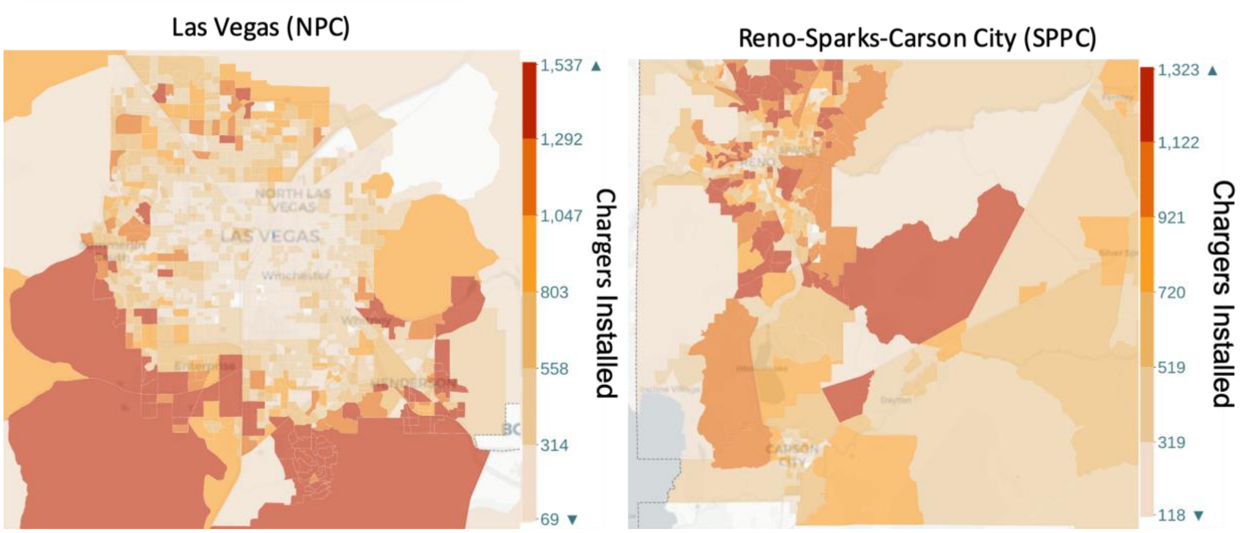
Notes: The top of the scale shown indicates the 95th percentile and the bottom indicates the 5th percentile. Energy efficiency is shown as a negative load impact.

Figure 34. SPPC Cumulative Annual Programmatic Residential Energy Efficiency Impacts in 2030 in the Mid scenario (GWh)



Notes: The top of the scale shown indicates the 95th percentile and the bottom indicates the 5th percentile. Energy efficiency is shown as a negative load impact.

Figure 35. Home L2 charger adoption by 2044 by Census Block Group to support Light Duty Vehicle Electrification in the Mid scenario in Las Vegas area (NPC) and Reno-Sparks-Carson City area (SPPC)



Notes: The top of the scale shown indicates the 95th percentile and the bottom indicates the 5th percentile.

Low- and Moderate-Income Community Impacts

DER adoption and load impacts in LMI and non-LMI communities are summarized in the following tables. Table 27 and Table 28 show cumulative residential energy efficiency and building electrification load impacts in GWh and GWh per capita (note that efficiency is shown as negative values while building electrification is shown as positive values). Per capita impacts were calculated relative to today's population and do not incorporate the assumption of population growth embedded in the PATHWAYS model. They are provided for additional context on the proportional deployment of DERs in LMI and non-LMI communities.

In both NPC and SPPC, there is lower energy efficiency adoption in LMI communities than non-LMI communities overall and per capita. In the FA model, it is assumed that income is a driver of participation in energy efficiency, particularly for AC, among other factors. As a result, lower adoption and therefore load impacts occur in LMI communities.

Table 27. LMI community energy efficiency impacts in the Mid Scenario (NPC)

Energy Efficiency Types	Year	GWh		kWh per capita	
		Non-LMI	LMI	Non-LMI	LMI
Residential AC Energy Efficiency	2027	-233.83	-14.20	-147.08	-24.74
	2030	-331.51	-20.34	-208.52	-35.43
	2034	-535.04	-34.00	-336.55	-59.24
	2039	-786.34	-52.07	-494.63	-90.72
	2044	-1034.87	-69.70	-650.96	-121.43
Residential Clothes Drying Energy Efficiency	2027	-3.37	-0.22	-2.12	-0.38
	2030	-4.74	-0.31	-2.98	-0.53
	2034	-6.43	-0.42	-4.05	-0.73
	2039	-8.47	-0.57	-5.33	-0.99
	2044	-11.13	-0.75	-7.00	-1.31
Residential Lighting Energy Efficiency	2027	-249.92	-17.05	-157.20	-29.70
	2030	-264.42	-18.73	-166.33	-32.63
	2034	-311.38	-22.93	-195.87	-39.95
	2039	-386.65	-29.60	-243.21	-51.57
	2044	-454.72	-36.01	-286.03	-62.73
Residential Refrigeration Energy Efficiency	2027	-45.35	-2.94	-28.53	-5.12
	2030	-64.67	-4.31	-40.68	-7.52
	2034	-91.32	-6.30	-57.44	-10.97
	2039	-117.26	-8.36	-73.76	-14.57
	2044	-133.99	-9.79	-84.29	-17.06
Residential Building Electrification	2027	41.63	4.59	26.19	8.00
	2030	58.20	6.29	36.61	10.95
	2034	92.02	9.49	57.88	16.53
	2039	153.80	15.72	96.74	27.38
	2044	243.07	25.02	152.90	43.58

Table 28. LMI community energy efficiency impacts in the Mid Scenario (SPPC)

Energy Efficiency Types	Year	GWh		kWh per capita	
		Non-LMI	LMI	Non-LMI	LMI
Residential AC Energy Efficiency	2027	-25.01	-6.14	-49.30	-31.81
	2030	-36.09	-9.10	-71.14	-47.16
	2034	-59.11	-14.88	-116.52	-77.11
	2039	-89.01	-22.32	-175.47	-115.65
	2044	-119.39	-30.06	-235.36	-155.74
Residential Clothes Drying Energy Efficiency	2027	-1.01	-0.25	-2.00	-1.30
	2030	-1.41	-0.37	-2.78	-1.91
	2034	-1.90	-0.48	-3.75	-2.51
	2039	-2.44	-0.62	-4.80	-3.20
	2044	-3.11	-0.79	-6.13	-4.08
Residential Lighting Energy Efficiency	2027	-49.77	-11.68	-98.11	-60.50
	2030	-51.66	-12.24	-101.85	-63.40
	2034	-59.74	-14.30	-117.77	-74.07
	2039	-72.67	-17.51	-143.25	-90.70

	2044	-83.22	-20.17	-164.05	-104.51
Residential Refrigeration Energy Efficiency	2027	-7.97	-1.95	-15.72	-10.13
	2030	-11.35	-2.86	-22.38	-14.84
	2034	-16.02	-4.01	-31.59	-20.80
	2039	-20.23	-5.09	-39.88	-26.35
	2044	-22.47	-5.67	-44.30	-29.36
Residential Building Electrification	2027	61.38	13.80	121.00	71.52
	2030	91.76	21.37	180.89	110.72
	2034	139.67	33.72	275.33	174.69
	2039	209.89	50.56	413.75	261.95
	2044	284.16	67.30	560.15	348.70

Table 29 and Table 30 show adoption of home L2 chargers overall and per capita. Note that FA assumes the number of home L2 chargers installed per vehicle on the road changes over time as more EVs are adopted. The tables provided show the ratio of chargers per vehicle in each snapshot year, but it should be noted that in between the snapshot years, the ratio changes. As stated above, the per capita values are calculated relative to today's population.

There are more home L2 chargers adopted in non-LMI than LMI communities for both NPC and SPPC. The likeliness of a household to adopt an L2 charger is based on historical trends. The main driver is income, with a smaller weight placed on residential square footage (as a proxy for whether a home has a garage). Given that income is the driving factor, it is expected that there would be less adoption of home L2 chargers in areas with lower income.

Table 29. Home L2 charger adoption in LMI communities in the Mid Scenario (NPC)

	Home L2 Chargers		Home L2 Chargers Per Capita		Conversion
	Non-LMI	LMI	Non-LMI	LMI	Home L2 per EV
2027	87,493	6,847	0.06	0.01	0.69
2030	171,068	13,817	0.11	0.02	0.61
2034	296,270	25,337	0.19	0.04	0.55
2039	455,985	42,991	0.29	0.07	0.46
2044	607,865	68,400	0.38	0.12	0.42

Table 30. Home L2 charger adoption in LMI communities in the Mid Scenario (SPPC)

	Home L2 Chargers		Home L2 Chargers Per Capita		Conversion
	Non-LMI	LMI	Non-LMI	LMI	Home L2 per EV
2027	36,058	10,643	0.07	0.06	0.69
2030	69,695	20,843	0.14	0.11	0.61
2034	119,427	36,483	0.24	0.19	0.55
2039	184,385	55,490	0.36	0.29	0.46
2044	249,954	72,951	0.49	0.38	0.42

DER Scenario Feasibility Screen

Overview

The relative feasibility of the PATHWAYS scenarios was estimated using five metrics designed to reflect the technical, societal, and economic challenges associated with each scenario:

- **Total direct costs**: The total amount of spending on energy-consuming devices, fuels, and electricity in each scenario.
- **Average household costs**: The average change in household energy costs due to spending on appliances, vehicles, fuel, and electricity costs.
- **Capital investment:** The total amount of capital expenditures on energy-consuming devices alone. This captures the differences in upfront costs that consumers will face in each scenario.
- **Customer behavioral changes:** The difference in pace of adoption for new and potentially disruptive technologies not yet widely adopted in Nevada like heat pumps.
- **Achievement of GHG emissions reductions:** The extent to which each scenario achieves GHG emissions reductions that will support the state of Nevada's economy-wide GHG targets.

For all metrics, the costs and emissions are calculated for the buildings, vehicles, and electricity generation sectors within NVE's service territory. See Table 71 for the assumptions around capital costs, fuel prices, and electricity prices.

Results

The total direct costs for each scenario include all capital and maintenance costs for energy-consuming equipment in buildings and on-road vehicles in addition to their fuel and electricity costs. Table 31 below shows the net present value (NPV) of these costs for each scenario over the study period (2021-2054) using a societal discount rate of 2%. In addition, the incremental cost of each scenario relative to the Reference is shown to compare the magnitude of increased spending. The Mid scenario has the lowest cost premium relative to the Reference scenario, while the Deep Decarbonization scenario has the highest, although its incremental cost of $23B is still only around 3% of total costs in the Reference scenario.

Table 31. Total direct costs of PATHWAYS scenarios

Scenario	NPV of Total Direct Costs (Billion 2021$)	NPV of Incremental Direct Costs (Billion 2021$)	Rank
Reference	$674	$0	1
Low	$677	$3.3	3
Mid	$677	$2.6	2
High	$686	$12	4
Deep Decarbonization	$697	$23	5

The average household costs are calculated using total spending on residential building equipment and personal light duty vehicles and averaging these over the total number of households in NVE's service territories for each year. The values are not meant to represent an example customer in NVE's service territory, but instead are meant to capture general trends in household energy spending on appliances, utility bills, and personal transportation. Household costs reflect changes in utility bills and gasoline purchases due to energy efficiency and electrification investments modeled in each scenario. This metric assumes that building equipment and upfront vehicle costs do not vary between scenarios even though achieving the scenarios with higher levels of electrification will likely require policies that reduce upfront equipment and vehicles costs. Table 32 shows the NPV of increased spending per household over the study period (2021-2054). Here, the Mid scenario has lower spending per household relative to the Reference scenario, while the Low scenario has the highest since the low amount of vehicle electrification means households will continue to spend significantly on gasoline into the 2050s.

Table 32. Average household energy spending in PATHWAYS scenarios

Scenario	NPV of Incremental Energy Spending per Household (2021$ per household)	Rank
Reference	$0	2
Low	$3,852	5
Mid	-$813	1
High	$654	3
Deep Decarbonization	$1,195	4

While the previous two metrics look at total spending on energy-consuming equipment and fuels, the capital investment metric compares only the upfront capital costs for energy-consuming devices, as these may be higher for electrified technologies than they are for fossil-powered devices, even if their higher efficiency may lead to lower lifetime costs. Table 33 below shows the total and incremental NPV of capital expenditures on building appliances and vehicles over the study period. The Low scenario has the lowest incremental costs, as there is little investment in new technologies that may be more expensive, while the Deep Decarbonization scenario has the highest incremental cost. As noted on the household spending metric, the capital investment metric assumes the same upfront costs across scenarios. This metric better reflects capital costs from a societal perspective rather than the perspective of consumers. Policy interventions may be needed in the scenarios with high levels of DER adoption that lower the upfront cost for consumers.

Table 33. Capital investment cost in PATHWAYS scenarios

Scenario	NPV of Capital Investment Costs (Billion 2021$)	NPV of Incremental Capital Investment Costs (Billion 2021$)	Rank
Reference	$371	$0	2
Low	$369	-$1	1
Mid	$378	$7	3
High	$392	$21	4
Deep Decarbonization	$402	$32	5

One of the challenges to widespread electrification that must be managed during the energy transition is customer readiness to adopt new technologies. For this analysis, residential heat pumps were used as an example technology because existing penetration in Nevada is low (only around 7% of households) and the market share for heat pumps has not increased as rapidly in recent years as other electrification technologies like EVs. Table 34 below shows the heat pump share of residential space heaters in NVE service territories in 2050. In the Deep Decarbonization scenario, almost all residential buildings are heated with a heat pump, while the Reference and Low scenarios show very little increase above current levels.

Table 34. Residential heat pump stock share 2050 in PATHWAYS scenarios

Scenario	Heat Pump Share of Residential Space Heating Stock in 2050	Rank
Reference	16%	2
Low	10%	1
Mid	23%	3
High	54%	4
Deep Decarbonization	98%	5

A final societal component that must be considered is the extent to which each scenario achieves the state's GHG emissions targets. While Nevada's GHG targets are based on economy-wide emissions from all sectors, this analysis focused primarily on emissions from buildings, vehicles, and electricity generation. As a result, the total GHG emissions from these sectors in 2021 and 2050 is shown in Table 35. The 2021-2050 reductions in emissions range from 48% in the Low scenario to 83% in the Deep Decarbonization scenario. While Nevada has a statewide target of net zero emissions by 2050, the 83% reductions modeled here for the Deep Decarbonization scenario can be consistent with this target since we are only modeling a subset of sectors with emissions in the state, and there are additional decarbonization measures for these sectors that were not modeled since they do not directly impact final electricity demands (e.g., drop-in renewable fuels).

Table 35. Emissions from buildings, vehicles, and electricity generation in PATHWAYS scenarios

Scenario	GHG Emissions from Buildings, Vehicles, Electricity in 2021 (MMT CO2e)	GHG Emissions from Buildings, Vehicles, Electricity in 2050 (MMT CO2e)	Rank
Reference	26	11	4
Low		14	5
Mid		9	3
High		7	2
Deep Decarbonization		4	1

Judging the relative feasibility or probability of a specific scenario is inherently uncertain and challenging given the vast number of factors that affect energy demand and purchasing decisions, especially on a multi-decade time frame. For this analysis, a handful of metrics that are helpful in expressing the technical, economic, or societal challenges associated with decarbonization were selected to provide a comparison between these long-term scenarios. The final step of this feasibility screening is to compare the scenario rankings across the selected metrics.

The Reference scenario ranks highly in terms of having the lowest total direct costs and low impacts for the other cost metrics, but it has the second highest GHG emissions. The Low scenario ranks highest for capital investment and customer behavior since it assumes virtually no change in current adoption practices, but as a result it both misses out on cost-effective new technologies like passenger electric vehicles and has the highest GHG emissions of any scenario. The Mid scenario has the second lowest total direct costs and ranks highly on cost per household since there is high adoption of cost-effective electric vehicles while slower adoption of relatively expensive building electrification technologies. Finally, the High and Deep Decarbonization scenarios understandably rank the highest on GHG emissions due to their deeper reductions, but those scenarios pose the largest challenges in terms of higher direct costs and upfront investments for households and businesses and rapid adoption of new technologies.

Table 36. Feasibility metric rankings

Scenario	Total Direct Cost Ranking	Cost per Household Ranking	Capital Investment Ranking	Customer Behavior Ranking	GHG Emissions Ranking
Reference	1	2	2	2	4
Low	3	5	1	1	5
Mid	2	1	3	3	3
High	4	3	4	4	2
Deep	5	4	5	5	1

Supporting Policy for the DER Scenarios

In E3's PATHWAYS model, user-defined scenarios can be designed to reflect specific policy options (e.g. all-electric new construction mandates, zero-emissions vehicle sales requirements), or scenarios can be designed to reflect a future where a suite of unspecified policies drive infrastructure and energy sector transformation, oftentimes to support a larger goal or policy (e.g. greenhouse gas mitigation goals, low-carbon fuel standards, etc.). In this study, scenarios were designed using the latter methodology by assuming a suite of federal, state, and utility policies drive different levels of DER adoption and influence electricity demand. The Reference case was designed to reflect active policies on the books and/or business-as-usual trajectories.

This section provides a summary of potential policies that can support the level of DER adoption projected in each scenario but does not make an attempt to quantify the impacts of any of these potential policies nor to assign attribution for program administration to the federal government, states, or local actors like utilities. In most cases, the same supporting policy could apply in multiple scenarios and potentially only vary between scenarios by level of ambition or adoption. For example, contractor engagement programs could support the higher levels of energy efficiency observed in the Deep Decarbonization, High, and Mid scenarios compared to the Reference scenario. Occasionally, we note policies that would ensure the achievement of the level of DER adoption modeled in each sector and scenario. For example, if Nevada were to adopt Advance Clean Cars II regulations similar to other states, the level of light-duty electric vehicle adoption projected in the Deep Decarbonization scenario would be achieved.

The following policy outlines are only indicative of possible developments and should not be taken as policy prescriptions.

Energy Efficiency

The analysis team made several high-level assumptions about the range of possible environments that could materialize in the future that would influence the rate of adoption for efficient appliances and end-uses in each scenario. As a baseline, the Reference scenario assumes the continuation of existing policies at the local, state, and federal level and utility programs. Additionally, the Reference scenario assumes a general increase in the price of electricity and fossil fuels that is in line with inflation. In contrast, the Low scenario reflects a future where the market share of efficient sales backslides. As mentioned, specific policies were not modeled so this change could be due to meaningful reductions in the inflation-adjusted price of fossil fuels relative to electricity and/or a political or policy environment that leads to the repeal of local or state building codes, federal efficiency standards, or significant portions of existing federal legislation promoting energy efficiency and/or electrification.

The Deep Decarbonization, High, and Mid scenarios all reflect additional policy or programmatic interventions into the market beyond the Reference scenario. Adoption rates in the Deep Decarbonization scenario could be supported by immediate and aggressive requirements that all sales and installations be both efficient and electric powered (as opposed to fossil fuel powered) by 2030. These requirements would almost certainly include the immediate adoption of state or federal mandates regarding the types and efficiency of new equipment sold, as well as constraints on secondary market transactions combined with intense coordination with manufacturers and education of contractors and trade allies to meet the massive surge in demand for these products.

By not assuming full electrification, represented by 100% sales of all-electric end-uses, until the end of the analysis time frame, the High scenario could allow for more gradual adoption of the efficiency and electrification mandates than that described in the Deep Decarbonization scenario. In the meantime, faster adoption of efficient technologies could be catalyzed through a combination of several methods, including:

- A progressively higher valuation of avoided GHG emissions in the Nevada TRC benefit-cost test;
- NV Energy EE/DSM programs that include significant point-of-sale incentives that reduce or eliminate the incremental costs of efficient technologies and reduce frictions in the adoption of these technologies;
- Ongoing and aggressive increases in federal or state efficiency standards, and state/local building codes; and
- Intensive customer outreach and contractor education campaigns organized by NV Energy, federal or state agencies.

The Mid scenario assumes a collection of market advances that are similar in nature to the High scenario, but less aggressive or immediate. For example, instead of widespread point-of-sale incentives from utility DSM programs, incentive values could be less significant, but still meaningful, and delivery mechanisms could continue to include a direct install, but not capture all customer sales interactions.

Building Electrification

In the Reference scenario, it is assumed that any existing Nevada state codes related to electrification would remain unchanged and that no new state or federal codes would be introduced. The Mid scenario projections could represent a more aggressive federal code. The sales shares in the Deep Decarbonization scenario projections could reflect local codes requiring equipment that exceeds Federal requirements, no benefit-cost constraints on market support programs targeting fuel switching, and/or aggressive market interventions designed to encourage early adoption of emerging technologies related to electrification. The High scenario projections represent codes and standards and benefit-cost criteria that are less restrictive than the Mid scenario, but more stringent than the Deep Decarbonization scenario. Sales shares in the Low scenario reflect codes and are more restrictive for fuel switching projects, and benefit cost criteria that severely limit the application of public purpose funds for electrification projects. Additionally, the Low scenario could represent an energy market where natural gas prices make the economics for electrification projects unfavorable for building owners and operators.

Light Duty Vehicles

Under the Reference scenario, LDV sales shares were projected forward assuming existing policies and techno-economic drivers continue to hold. The Deep Decarbonization, High, and Mid scenarios assume a comprehensive set of new policies are introduced, including but not limited to additional incentives for EV purchases, support for single and multi-family charger installations, make-ready programs, special EV utility rates, robust investments in the public charging network, low carbon fuel standards, and outreach and education for fleet vehicle operators. Market forces that would contribute to the realization of the Deep Decarbonization, High, and Mid scenarios include higher gasoline prices, declining upfront vehicle costs, and limited or no supply chain constraints. The Deep Decarbonization scenario would be achieved with adoption of ACC II ZEV sales requirements. The Low scenario provides the counter-narrative of a world with EV supply chain constraints and low gasoline prices that curtail prospects for LDV electrification.

Medium and Heavy-Duty Vehicles

As with LDVs, the Reference scenario for MDV and HDV sales shares was built around a continuation of existing policies and trends. The Deep Decarbonization scenario could be achieved with the adoption of the Advanced Clean Trucks and Advanced Clean Fleets standard, plus the requirement of 100% ZEV sales by 2040. Adoption rates projected in the Deep Decarbonization, High, and Mid scenario would require a suite of supportive policies including but not limited to favorable EV rates, large scale investments in the public charging network, outreach and education for MDV and HDV fleet operators, low carbon fuel standards, and rebates/incentives for vehicles and chargers. Market forces that would contribute to the realization of the Deep Decarbonization, High, and Mid scenarios include higher gasoline prices, declining upfront vehicle costs, and limited or no supply chain constraints. As with LDVs, the Low scenario assumes supply chain constraints and low gasoline prices that limit EV adoption.

Behind-the-Meter Solar

The Reference scenario assumes there is no change in NEM policy for BTM solar and that technology costs hold at expected levels. The Deep Decarbonization, High, and Mid scenarios reflect continued tax incentives, supportive tariffs and programs, high customer interest, and technology cost declines. The Low scenario, meanwhile, represents the pessimistic assumptions of declining customer interest, higher technology costs, and bottlenecks to interconnection.

Behind-the-Meter Storage

The Reference scenario assumes there is no change to existing policies, tariffs, or customer preferences with regards to BTM storage, and that technology costs hold at expected levels. The Deep Decarbonization, High, and Mid scenarios represent a range of adoption that can be achieved with strong tariffs and programs that incentivize the coupling of storage with solar, technology cost declines, continuation of tax incentives for storage, and increased customer interest. The Low scenario assumes no change to existing policy, tariffs, or customer preferences but with higher-than-expected technology costs.

Demand Response

The Reference scenario is taken to represent continued growth of existing DR programs at expected rates with no new significant advancements in enabling technology. Potential policies that could support the adoption levels modeled in the Deep Decarbonization, High, and Mid scenarios include full implementation of FERC Order 2222 and regionalization, peak demand mandates, load flexibility goals, loading order legislation, improved Integrated System Planning processes, attractive programs, more robust partnerships with DR aggregators and DERMS providers, codes and standards, customer outreach and education, and declining costs for DR compatible technologies. Finally, the Low scenario assumes no new significant policy or investment expanding existing DR programs.

DSM Planning: Economic, Maximum Achievable, and Realistically Achievable Potential

The following section presents the results of the calculation of Economic, Maximum (Max) Achievable, and Realistically Achievable Savings Potentials for NPC and SPPC. These results are based on the PATHWAYS economy-wide Mid scenario for energy efficiency and demand response adoption in NPC and SPCC territories. In this section, all savings results, both energy and demand, are presented in net terms, and at the generator rather than behind-the-meter.

The results are presented for two portfolios, Traditional and Grid Value. The Traditional portfolio is designed to focus NV Energy's DSM investments on its historic goal of achieving annual energy (kWh) savings, without preference for when during the day or year those savings occur. In addition to maintaining high-value peak focused energy efficiency and addressing historically underserved customers, the Grid Value portfolio shifts NV Energy's DSM investments toward programs and measures that deliver greater peak demand savings or incentivizes the adoption of technologies and controls that enable greater demand flexibility. This is done by adding greater focus and investment in scaling dispatchable flexible capacity with connected DERS, including smart thermostats, batteries, water heater controls, pool pumps and greater options for C&I customers to participate in DR programs. The long-term aim with this portfolio is to develop both static and flexible shifts in the times during which energy is used by NV Energy customers to economically balance the temporal supply and demand for electricity.

Both of the proposed portfolios deliver significant savings and benefits for NV Energy customers, but the implication of the different portfolio motivations is that the Technical, Economic, and Max Achievable Potential energy (kWh) savings are relatively similar across both portfolios. The primary differentiation occurs when viewing demand savings, and Realistically Achievable energy savings, where NVE DSM portfolio and budgetary constraints come into play. While impact results between the Traditional and Grid Value scenarios will take some time to scale as new programs and technology are introduced, the Grid Value scenario already shows better results in key source energy and emissions metrics as well as greater peak demand savings and higher net benefits for customers, with potential to significantly increase impacts as participation grows, additional grid service values can be developed and modeled, and as program offerings can be better bundled with appropriate customer rate structures or value streams. It is also worth noting that due to limitations in this iteration of the MPS as analytical tools continue to be developed for NVE, these results may not be capturing all benefits that will accrue to NVE customers and stakeholders when utilizing the Grid Value paradigm. The comparative potentials for the Traditional and Grid Value portfolios are shown at a high level in Figure 36 and Figure 37.

Figure 36. Comparison of Energy Savings Potentials Across NV Energy Portfolios (GWh)

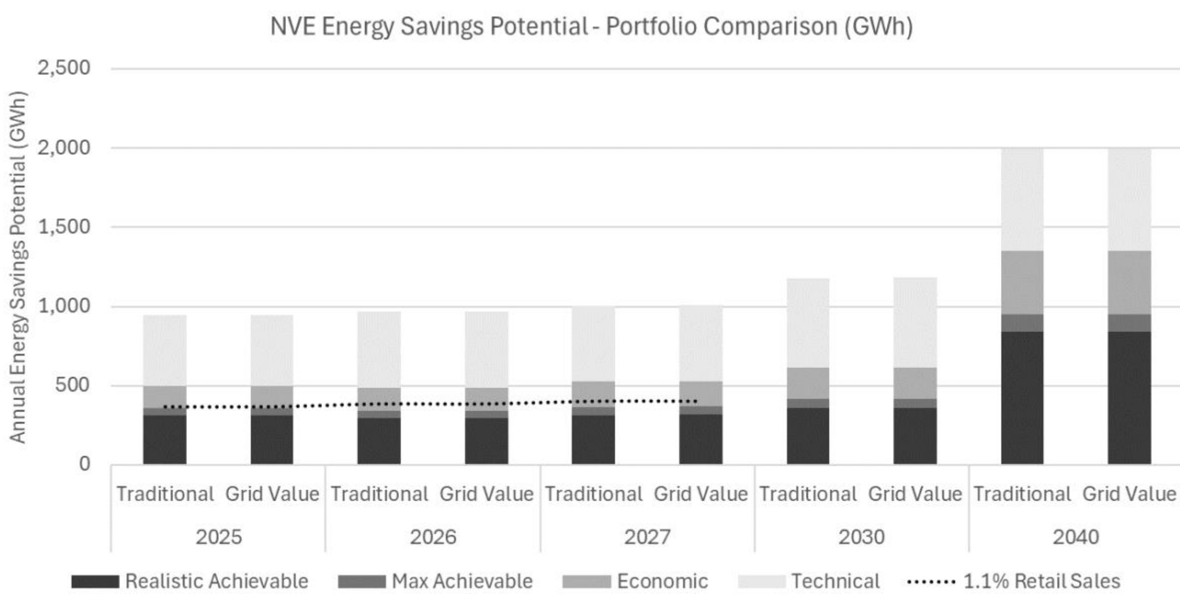
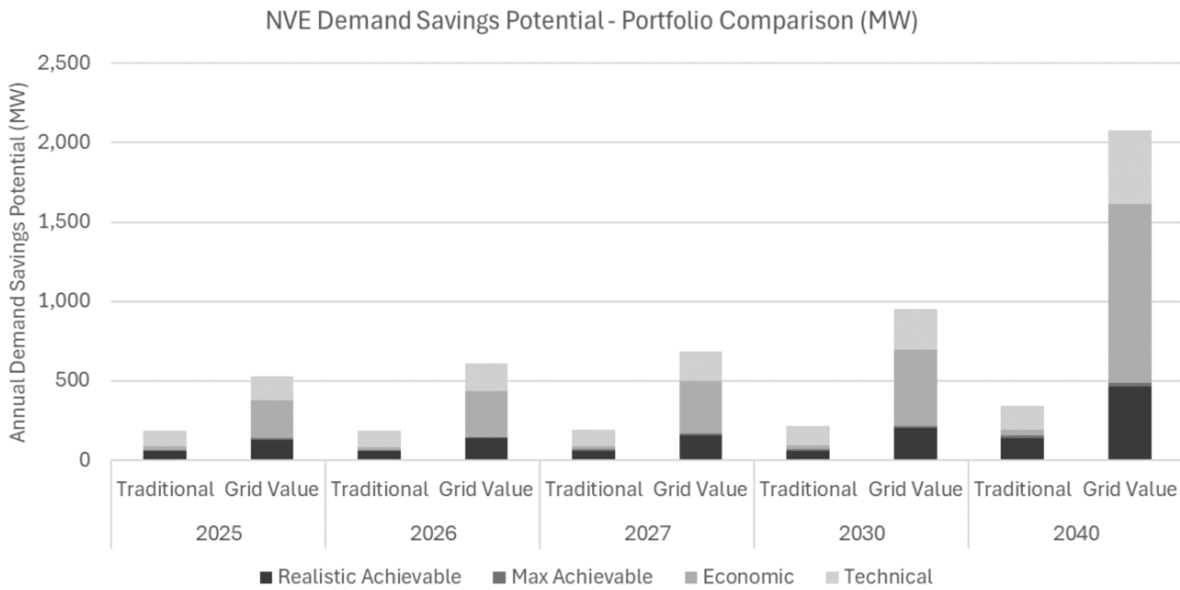


Figure 37. Comparison of Demand Savings Potentials Across NV Energy Portfolios (MW)



As was described earlier in this report, Technical Potential in this study is defined as the energy and demand savings that could be achieved if *all* equipment in the regional stock that turns over in a given year were replaced with efficient equipment. For this reason, this potential calculation could alternatively be referred to as the Annual Stock Turnover Technical Potential, though this report shortens the term to Technical Potential throughout. This calculation does not necessarily account for all opportunities that are available for energy and demand savings in a market. With the right program design or incentives, customers may be induced to retrofit inefficient equipment that is still in working order. However, these early retirements are frequently cost prohibitive due to incremental labor and installation costs, and participant uptake in such programs is frequently limited. Therefore, the definition of Technical Potential used in this study is expected to capture the vast majority of savings potential.

Using Technical Potential as the starting point, Economic Potential is calculated at the measure level and is based on historical cost and savings numbers from NVE programs, where such data are available. To be included in Economic Potential, a measure must have an nTRC that is at least 1.0. The calculation of nTRC is similar to the industry standard Total Resource Cost test (TRC), with an additional percentage multiplier applied to the benefits for each measure to account for non-energy benefits to the State of Nevada.

The nTRC criterion applied to determine economic potential screens out the majority of measures from consideration in subsequent calculations of Maximum Achievable and Realistically Achievable Potential. Though it varies from year to year, approximately one-third of measures achieve an nTRC greater than 1.0. The measures that pass this screen include:

- Residential Home Energy Reports

- Residential New Construction
- Residential Air Conditioner and Heat Pump Tune-Ups
- School and Commercial Energy Efficiency measures across most end-use categories
- Thermostat and Pool Pump Demand Response measures
- Bring-Your-Own-Battery Demand Response measures
- Data Center energy efficiency

Importantly, this does not preclude NV Energy from including measures that do not pass the Economic Potential screen in their DSM portfolio. As long as the portfolio as a whole exceeds an nTRC of 1.0, individual measures that are not cost-effective can be included to generate additional energy and demand savings and to achieve other strategic priorities of the utility, such as energy equity or demand flexibility.

Maximum Achievable potential is then calculated based on 1) an assumed maximum participation rate of 85% that is based on similar assumptions used in NVE's 2018 Market Potential Study and 2) a rebate cost that is equal to 90% of the measure's incremental cost of installation, where applicable and paid by the customer. Realistically Achievable potential was then calculated by lowering the customer rebates to historical NV Energy program levels, where applicable, and applying customer adoption curves based on the resulting simple payback period. The details of how these maximum participation rates and rates of customer adoption based on payback periods were calculated are provided in an appendix.

Results for NPC

Following are various presentations and discussion of the potential calculations modeled separately for 2025, 2026, 2027, 2030, and 2040. Results for NPC are presented here, with energy efficiency first followed by demand response. These results are followed by similar results for SPPC.

Energy Efficiency

Figure 38 below shows the differentiation between the various defined potential calculations year over year for NPC. For all versions of potential, actual figures are modeled in years 2025-27, 2030, and 2040. In the figure, the intervening years are interpolated using a linear regression. All values in this graph as well as in subsequent tables and figures in this section are presented on a net basis, opposed to a gross basis, due to net savings being a better representation of the actual potential levels available to NV Energy DSM programs. Table 37 presents the numbers underlying Figure 38 in tabular form.

Figure 38. NPC Cumulative Net Efficiency Potential for Mid Scenario (GWh)

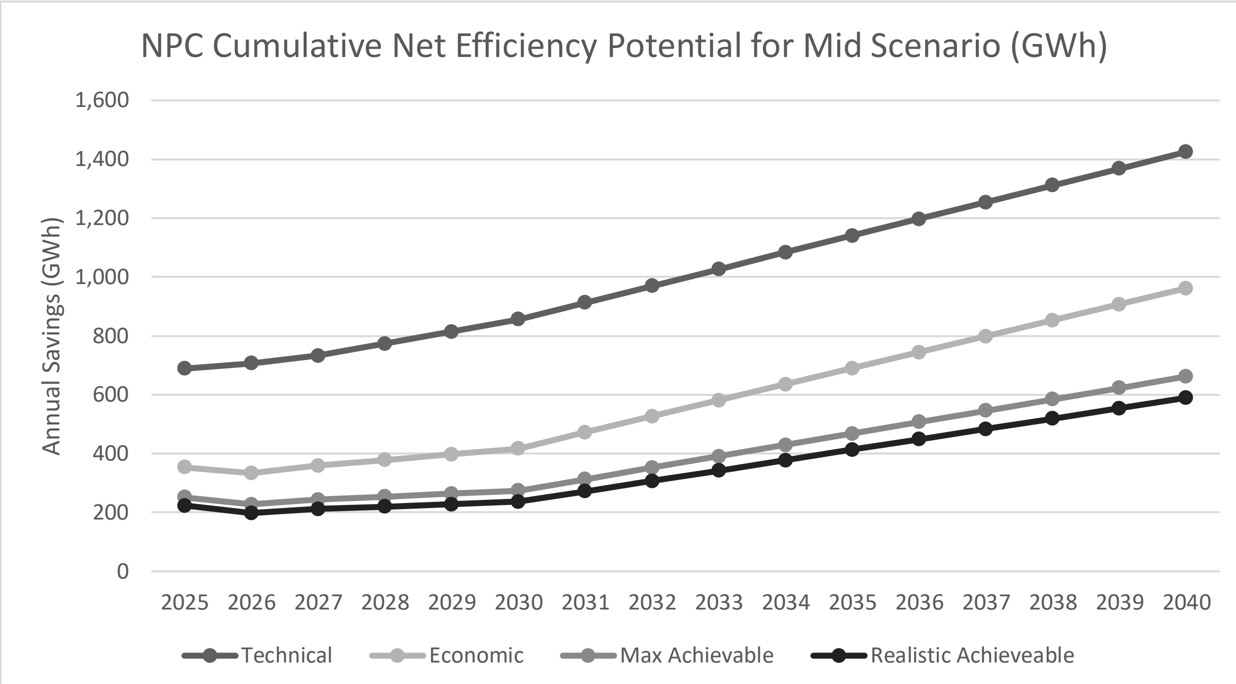


Table 37. NPC Cumulative Net Efficiency Potential (GWh)

Scenario	2025	2026	2027	2030	2040
Mid					
Technical Potential					
Traditional	688.4	706.6	732.3	855.3	1,423.8
Grid Value	688.5	706.8	732.6	855.7	1,425.0
Economic Potential					
Traditional	353.8	333.4	358.4	416.9	961.0
Grid Value	353.8	333.5	358.6	417.2	961.8
Maximum Achievable Potential					
Traditional (% Retail Sales)	251.1 (1.12%)	227.7 (0.99%)	243.1 (1.03%)	274.1	661.9
Grid Value (% Retail Sales)	251.1 (1.12%)	227.7 (0.99%)	243.1 (1.03%)	274.2	662.1
Realistically Achievable Potential					
Traditional (% Retail Sales)	231.3 (1.03%)	206.4 (0.90%)	220.0 (0.93%)	245.3	599.9
Grid Value (% Retail Sales)	231.3 (1.03%)	206.5 (0.90%)	220.0 (0.93%)	245.4	600.1
Historical DSM Goal (1.1% of retail sales)	246	253	259		

As stated previously, all results in this table (and all tables in this section) are presented as net savings at the generator, while retail sales can be construed as gross. Table 37 shows energy savings between the Traditional and Grid Value portfolios and demonstrates the similarity. In contrast, Table 38 shows more differentiation in demand savings based on the priorities of a Grid Value portfolio. These differences become more pronounced when flexible loads from demand response are reviewed later. For the calculation of peak savings, DSMore primarily utilized an assumed 8,760 hour savings shapes that were specific to each measure being modeled. These savings shapes were combined with the assumption, provided by NVE, of the system peak hour occurring during hour ending 18 on a July afternoon to determine the peak demand savings for each measure.

Table 38. NPC Cumulative Net Energy Efficiency Peak Savings (MW)

Scenario	2025	2026	2027	2030	2040
Mid					
Technical Potential					
Traditional	180.1	182.0	186.1	205.5	296.8
Grid Value	479.3	542.8	604.2	821.5	1,726.6
Economic Potential					
Traditional	69.1	63.9	66.9	65.2	136.2
Grid Value	333.4	376.8	427.5	589.3	1,343.1
Maximum Achievable Potential					
Traditional	52.7	48.2	50.7	49.8	109.6
Grid Value	118.9	125.8	139.5	177.3	400.8
Realistically Achievable Potential					
Traditional	49.6	44.9	47.0	45.3	99.6
Grid Value	115.8	122.5	135.8	172.8	390.9

Residential

This section presents the same information, but specific to NPC's Residential sector. Figure 39 shows that even though there is a moderate uptrend in Residential Technical potential over time, Economic, Maximum Achievable, and Realistically Achievable Potentials remain comparatively flat, largely due to limited cost-effectiveness. As we saw for the entire NPC portfolio, energy savings in Table 39 are nearly identical across all potential calculations, while Table 40 shows greater differentiation between demand savings in the Traditional and Grid Value portfolios that grows over time.

Figure 39. NPC Residential Cumulative Net Efficiency Potential (GWh)

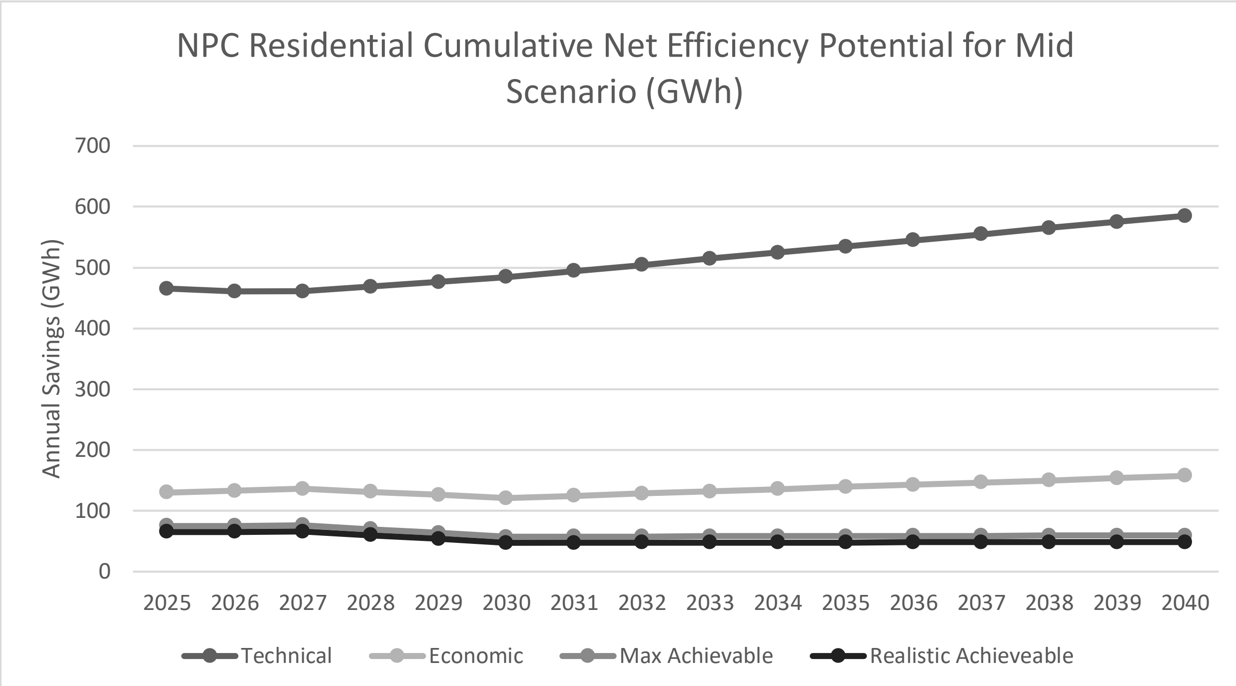


Table 39. NPC Residential Cumulative Net Efficiency Potential (GWh)

Scenario	2025	2026	2027	2030	2040
Mid					
Technical Potential					
Traditional	464.9	460.7	460.7	483.8	583.9
Grid Value	465.0	460.9	460.9	484.3	585.0
Economic Potential					
Traditional	130.3	132.6	135.9	120.6	156.6
Grid Value	130.3	132.8	136.1	120.9	157.4
Maximum Achievable Potential					
Traditional	75.2	75.3	76.1	57.3	59.3
Grid Value	75.2	75.4	76.2	57.4	59.5
Realistically Achievable Potential					
Traditional	73.7	73.9	74.7	56.5	59.0
Grid Value	73.8	73.9	74.8	56.6	59.2

Table 40. NPC Residential Cumulative Net Energy Efficiency Peak Savings (MW)

Scenario	2025	2026	2027	2030	2040
Mid					
Technical Potential					
Traditional	151.4	150.3	150.7	155.9	178.9
Grid Value	431.3	477.0	521.1	680.6	1,362.7
Economic Potential					
Traditional	40.4	40.0	40.1	28.5	23.7
Grid Value	286.8	321.6	356.7	468.4	1,006.4
Maximum Achievable Potential					
Traditional	28.5	28.2	28.2	19.0	14.7
Grid Value	91.5	100.2	109.2	131.5	266.1
Realistically Achievable Potential					
Traditional	27.8	27.5	27.5	18.5	14.5
Grid Value	90.8	99.5	108.5	131.1	265.9

Table 41 lists the Residential measures that have the most Achievable energy savings for NPC during the 2025-2027 period. Programs and measures that facilitate the construction of energy efficient single and multi-family residences and behavioral savings from Home Energy Reports take primary roles. HVAC measures also contribute a meaningful portion of Achievable Potential, including HVAC tune-ups, as well as the energy savings component of installed smart thermostats present in Residential demand response programs.

Table 41. NPC Residential Top Energy Efficiency Measures for Achievable Potential (Incremental Net MWh)

Program / Measure	Traditional / Grid Value			
	Rank	2025	2026	2027
MF - New Construction BOP	1	24,294	23,770	23,537
HER – Home Energy Reports	2	21,186	21,398	21,828
Residential New Construction	3	14,159	13,854	13,718
DR Manage - Thermostats	4	6,436	7,197	7,931
HES - Retrofit - AC Tune Up	5	4,534	4,535	4,536
DR Build - Thermostats	6	2,306	2,344	2,378

Commercial

Unlike the Residential sector, Figure 40 shows that all forms of energy savings potentials are expected to grow significantly in the NPC Commercial sector over time. As previously mentioned, the primary reason for this difference is the relative cost-effectiveness of many commercial measures, as defined by the nTRC and by the analysis inputs that are primarily based on recent NPC DSM programs. Just like for Residential NPC, the analysis of Commercial NPC shows very similar energy savings in the Traditional and Grid Value portfolios over time, as shown in Table 42, while Table 43 shows more differentiation in demand savings, though less so than for the Residential sector.

Figure 40. NPC Commercial Cumulative Net Efficiency Potential (GWh)

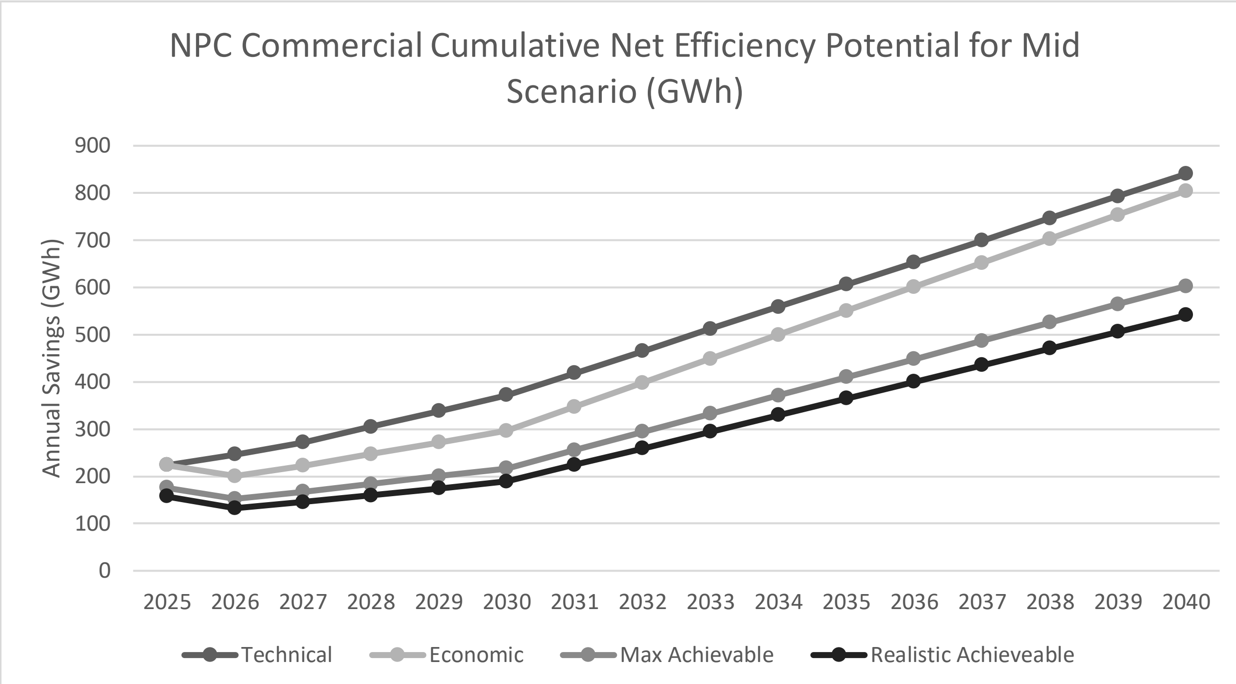


Table 42. NPC Commercial Cumulative Net Efficiency Potential (GWh)

Scenario	2025	2026	2027	2030	2040
Mid					
Technical Potential					
Traditional	223.5	245.9	271.7	371.4	839.9
Grid Value	223.5	245.9	271.7	371.5	839.9
Economic Potential					
Traditional	223.5	200.7	222.5	296.3	804.4
Grid Value	223.5	200.7	222.5	296.3	804.4
Maximum Achievable Potential					
Traditional	175.9	152.4	166.9	216.8	602.6
Grid Value	175.9	152.4	166.9	216.8	602.6
Realistically Achievable Potential					
Traditional	157.5	132.5	145.3	188.9	540.9
Grid Value	157.5	132.5	145.3	188.9	540.9

Table 43. NPC Commercial Cumulative Net Energy Efficiency Peak Savings (MW)

Scenario	2025	2026	2027	2030	2040
Mid					
Technical Potential					
Traditional	28.6	31.7	35.4	49.6	117.9
Grid Value	48.0	65.8	83.0	140.9	363.9
Economic Potential					
Traditional	28.6	23.8	26.8	36.7	112.5
Grid Value	46.6	55.2	70.8	120.9	336.8
Maximum Achievable Potential					
Traditional	24.2	20.0	22.5	30.8	94.8
Grid Value	27.4	25.6	30.3	45.8	134.7
Realistically Achievable Potential					
Traditional	21.8	17.4	19.5	26.8	85.1
Grid Value	25.0	23.0	27.4	41.7	125.0

Table 44 lists the Commercial measures that contribute the most Achievable energy savings for NPC during the 2025-2027 period, largely grouped at the end-use level due to the greater diversity of commercial products and program participants. In the near-term, Achievable Potential is primarily found in Commercial lighting measures that target lamps and settings that do not conform to the recently updated Federal General Service Lamp (GSL) definitions, such as the replacement of linear fluorescent lamps with TLEDs. However, the greatest growth in potential comes from Commercial HVAC measures and controls for both heating and cooling. Efficient motors and variable frequency drives (VFDs) also contribute to savings potential, though some of these savings are diminished by recent improvements in codes and standards. Notably, Schools CEI is also a significant contributor to energy savings potential, but is borderline cost-effective. Based on the MPS analysis, this measure passes the economic screen with an nTRC of 1.01 in 2025, but then falls just below 1.0 in 2026 and thus is not included in Economic or Achievable Potential.

Table 44. NPC Commercial Top Energy Efficiency Measures for Achievable Potential (Incremental Net MWh)

Program / Measure	Traditional / Grid Value			
	Rank	2025	2026	2027
BES - Commercial Measures - Lighting	1	108,409	111,661	116,499
Schools - CEI, Schools	2	35,687	-	-
BES - Commercial Measures - HVAC	3	17,720	22,921	28,684
BES - Commercial Measures - Motors	4	2,656	3,487	4,382
BES - Commercial Measures - VFD	5	2,656	3,487	4,382
DR Build - Thermostats	6	2,493	2,521	2,549

Demand Response

While the previous section looked at energy and demand savings potentials from the entire NPC DSM portfolio, this section focuses specifically on potential demand savings from demand response programs in NPC territory. This is where the differentiation between the Traditional and Grid Value portfolios becomes readily apparent. With the Traditional portfolio's focus ***on*** energy savings, limited DSM resources are not allocated to demand response programs that create flexibility during times of grid need. Energy savings from smart thermostats and other devices previously installed for demand response programs remain, but without the recurring incentives and investments in demand response programs that are present in the Grid Value portfolio, no flexible demand savings are available from demand response programs in the Traditional portfolios, as shown in Table 45.

Table 45. NPC Cumulative Net Peak[39] Demand Response Savings (MW)

Scenario	2025	2026	2027	2030	2040
Mid					
Technical Potential					
Traditional	-	-	-	-	-
Grid Value	299.3	360.8	418.1	616.0	1,429.8
Economic Potential					
Traditional	-	-	-	-	-
Grid Value	264.3	312.9	360.6	524.1	1,206.9
Maximum Achievable Potential					
Traditional	-	-	-	-	-
Grid Value	66.2	77.6	88.8	127.5	291.3
Realistically Achievable Potential					
Traditional	-	-	-	-	-
Grid Value	66.2	77.6	88.8	127.5	291.3

It is worth noting that the amount of Achievable demand response potential calculated as part of this analysis likely does not capture the entirety of what is available to NVE. There are several reasons for this dichotomy. First, the MPS analysis focuses primarily on devise-based demand response potential. This does not include interruptible/curtailable demand response, which historically has been focused on commercial and industrial customers and has represented the majority of achievable demand response. However, this form of DR is generally not directly controllable by NVE, requiring actions to be taken by individual customers at the behest of NVE during called events.

Second, in order to be included in the calculation of Economic, Maximum Achievable, and Realistically Achievable Potential, demand response technologies must have an nTRC of at least 1.0. As discussed previously, NVE can create a portfolio of measures and programs that includes EE or DR measures that do not have an nTRC greater than 1.0, but these are not included in the calculation of Achievable Potential due to the economic screening criteria. In the first year of deploying demand response infrastructure (historically performed by NVE's DR Build programs), installation costs combined with necessary customer incentive costs and program overhead costs can limit the cost-

[39] Note, in these Demand Response potential output charts, "Net Peak Savings" does not necessarily refer to potential relative with system net peaks, but instead presents "net" savings, as opposed to "gross" savings.

effectiveness of DR measures. However, in subsequent years where installation costs are not incurred, the cost-effectiveness of DR measures is improved.

And last, many of the device-based demand response opportunities require the installation of new technologies or control mechanisms at individual customer sites. This is a time-intensive process that requires a significant amount of program administration and customer outreach. Additionally, some controllable technologies, such as communicating heat pump water heaters, are limited by the growth rate in their saturation within NVE territory, either through DSM programs or natural adoption. Though there may be a large number of devices that could be controlled for DR purposes in NVE territory, there are logistical, budgetary, and other constraints that limit the number of devices that can be enrolled (and retrofitted, when necessary) in a given amount of time. This is reflected in the drop from Economic to Achievable DR potential.

Residential

Table 46 shows that the majority of potentials from demand response programs in the Grid Value portfolio come from the Residential sector. Table 47 shows that thermostats that control residential HVAC technologies provide the bulk of demand response potential, while newer controlled technologies, such as pool pumps, batteries, and water heaters (not shown in the table) begin to emerge.

Table 46. NPC Residential Cumulative Net Peak Demand Response Savings (MW)

Scenario	2025	2026	2027	2030	2040
Mid					
Technical Potential					
Traditional	-	-	-	-	-
Grid Value	279.9	326.7	370.4	524.6	1,183.8
Economic Potential					
Traditional	-	-	-	-	-
Grid Value	246.4	281.5	316.6	439.8	982.6
Maximum Achievable Potential					
Traditional	-	-	-	-	-
Grid Value	63.0	72.0	81.0	112.5	251.4
Realistically Achievable Potential					
Traditional	-	-	-	-	-
Grid Value	63.0	72.0	81.0	112.5	251.4

Table 47. NPC Residential Top Demand Response Measures for Achievable Potential (Incremental Net MW)

Program / Measure		Traditional			Grid Value		
	Rank	2025	2026	2027	2025	2026	2027
DR Manage - Thermostats	1	51.3	57.4	63.2	51.3	57.4	63.2
DR Build - Thermostats	2	9.1	9.3	9.4	9.1	9.3	9.4

DR Build - Pool Pump Controls	3	-	-	-	1.8	1.9	1.9
DR Build - Batteries	4	-	-	-	0.7	0.8	1.0
DR Manage - Batteries	5	-	-	-	0.0	0.8	1.7
DR Manage - Pool Pump Controls	6	-	-	-	0.0	1.9	3.7

Commercial

While commercial demand response does not provide the same magnitude of potential as Residential demand response, meaningful potentials are still present and grow significantly over time if the necessary resources are placed and investments made, as is shown in Table 48. As on the Residential side, Table 49 shows that the near-term potential lies in controlling commercial HVAC systems, but batteries and other controlled technologies are beginning to emerge as a source of potential.

Table 48. NPC Commercial Cumulative Net Peak Demand Response Savings (MW)

Scenario	2025	2026	2027	2030	2040
Mid					
Technical Potential					
Traditional	-	-	-	-	-
Grid Value	19.4	34.1	47.7	91.3	246.0
Economic Potential					
Traditional	-	-	-	-	-
Grid Value	17.9	31.4	44.0	84.2	224.3
Maximum Achievable Potential					
Traditional	-	-	-	-	-
Grid Value	3.2	5.6	7.8	15.0	39.8
Realistically Achievable Potential					
Traditional	-	-	-	-	-
Grid Value	3.2	5.6	7.8	15.0	39.8

Table 49. NPC Commercial Top Demand Response Measures for Achievable Potential (Incremental Net MW)

Program / Measure		Traditional			Grid Value		
	Rank	2025	2026	2027	2025	2026	2027
DR Manage - Thermostats	1	1.8	4.0	6.1	1.8	4.0	6.1
DR Build - Thermostats	2	1.2	1.2	1.2	1.2	1.2	1.2
DR Build - Batteries	3	-	-	-	0.2	0.1	0.1

Results for SPPC

The following section presents similar results for SPPC territory. Though the overarching potential story is similar to what is presented for NPC, there are some meaningful differences, such as the measure mix that passes the Economic Potential cost-effectiveness screen, and the substantial expected growth in energy demands from data centers, which presents both a challenge and an opportunity. As stated previously, all results below are presented as net savings at the generator.

Energy Efficiency

Figure 41 below shows the differentiation between the various defined potential calculations year over year for SPPC. For all versions of potential, actual figures are modeled in years 2025-27, 2030, and 2040. In the figure, the intervening years are interpolated using a linear regression. Table 50 presents the numbers underlying Figure 41 in tabular form, while Table 51 presents demand potential numbers, which are not graphically displayed.

Figure 41. SPPC Cumulative Net Efficiency Potential for Mid Scenario (GWh)

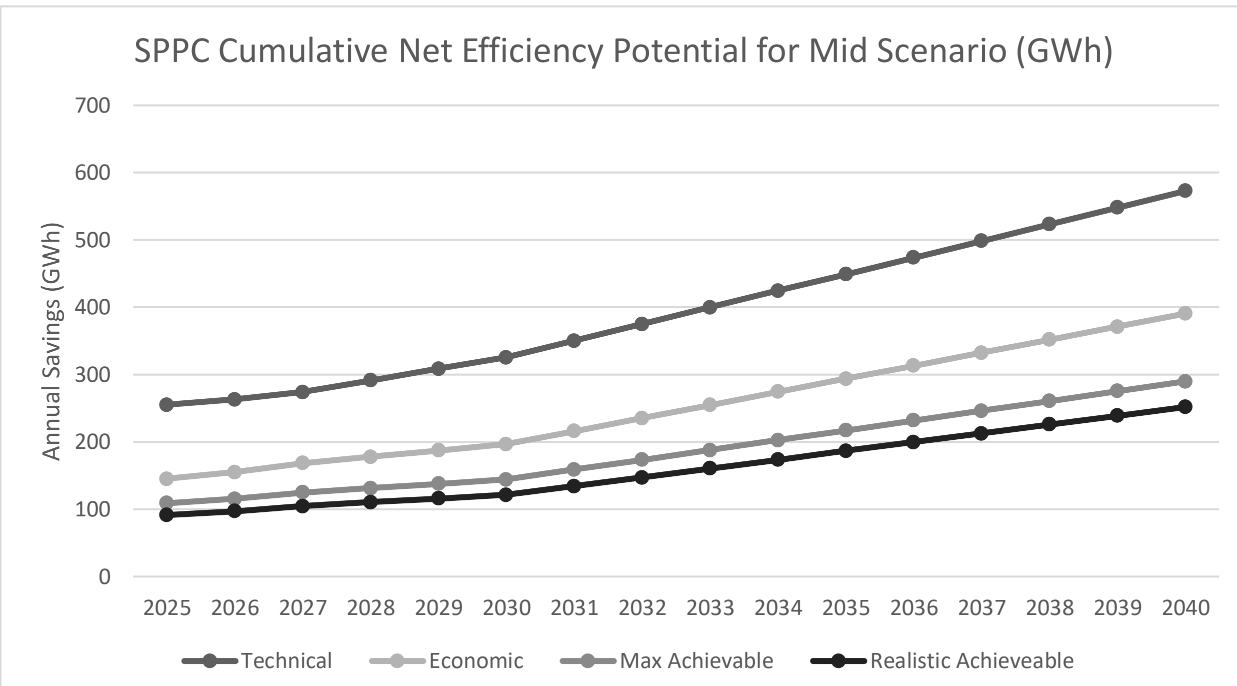


Table 50. SPPC Cumulative Net Efficiency Potential (GWh)

Scenario	2025	2026	2027	2030	2040
Mid					
Technical Potential					
Traditional	255.3	262.8	273.9	325.2	571.6
Grid Value	255.4	263.0	274.2	325.7	572.7
Economic Potential					
Traditional	145.4	155.0	168.5	196.8	390.4
Grid Value	145.4	155.0	168.5	196.8	390.5
Maximum Achievable Potential					
Traditional (% Retail Sales)	108.9 (0.97%)	115.5 (0.94%)	125.1 (0.95%)	144.4	290.0
Grid Value (% Retail Sales)	108.9 (0.97%)	115.5 (0.94%)	125.1 (0.95%)	144.4	290.0
Realistically Achievable Potential					
Traditional (% Retail Sales)	84.3 (0.75%)	90.1 (0.73%)	97.4 (0.74%)	113.6	242.9
Grid Value (% Retail Sales)	84.4 (0.75%)	90.1 (0.73%)	97.4 (0.74%)	113.6	242.9
Historical DSM Goal (1.1% of retail sales)	123	135	145		

Table 51. SPPC Cumulative Net Energy Efficiency Peak Savings (MW)

Scenario	2025	2026	2027	2030	2040
Mid					
Technical Potential					
Traditional	63.5	64.7	66.9	76.7	122.9
Grid Value	109.8	126.9	142.5	198.2	423.8
Economic Potential					
Traditional	30.4	32.1	36.6	40.3	75.6
Grid Value	58.6	70.1	83.9	122.3	286.2
Maximum Achievable Potential					
Traditional	22.0	23.3	26.9	30.1	59.3
Grid Value	27.0	29.9	35.0	43.8	94.1
Realistically Achievable Potential					
Traditional	15.2	16.4	18.0	20.3	46.1
Grid Value	20.3	23.0	26.0	34.1	81.0

Residential

This section presents information specific to SPPC's Residential sector. Similar to NPC, Figure 42 shows that even though there is a moderate uptrend in Residential Technical potential over time, Economic, Maximum Achievable, and Realistically Achievable Potentials remain comparatively flat, largely due to limited cost-effectiveness. As with the SPPC DSM portfolio as a whole, energy savings in Table 52 is nearly identical across all potential calculations, while Table 53 shows significant differentiation between demand savings in the Traditional and Grid Value portfolios that grows over time.

Figure 42. SPPC Residential Cumulative Net Efficiency Potential (GWh)

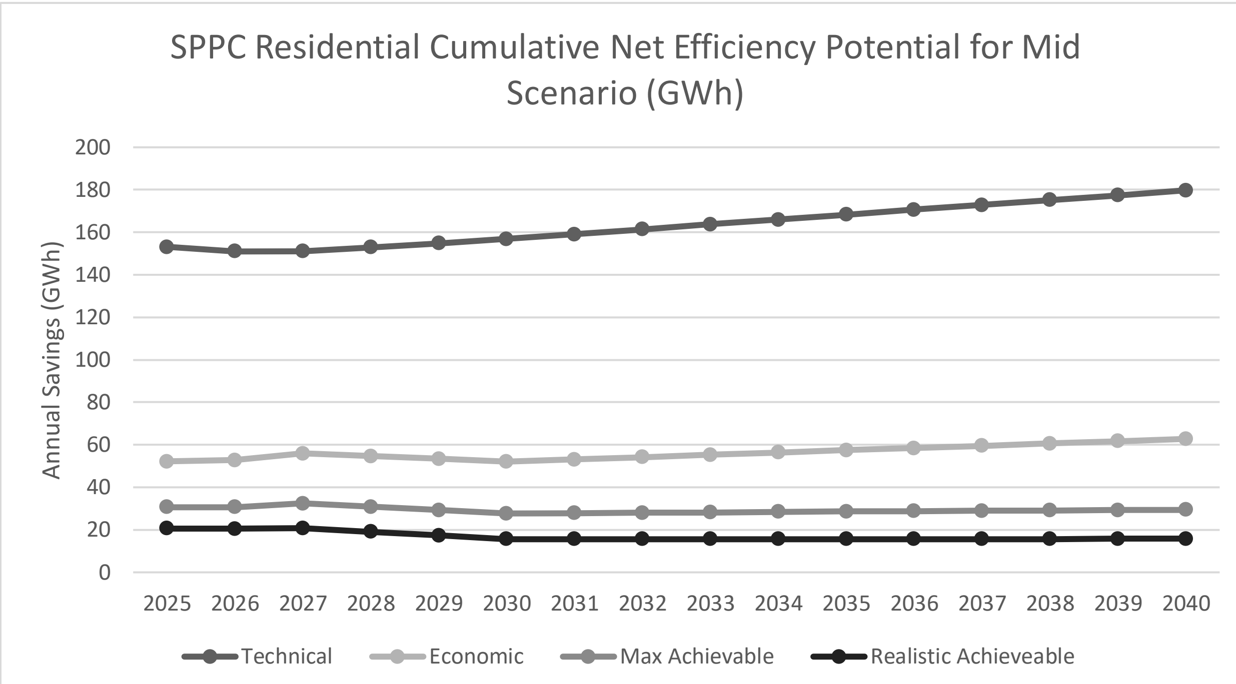


Table 52. SPPC Residential Cumulative Net Efficiency Potential (GWh)

Scenario	2025	2026	2027	2030	2040
<u>Mid</u>					
Technical Potential					
Traditional	153.0	151.1	151.0	156.8	179.7
Grid Value	153.0	151.1	151.1	156.8	179.8
Economic Potential					
Traditional	52.2	52.9	55.9	52.1	62.7
Grid Value	52.2	52.9	55.9	52.1	62.8
Maximum Achievable Potential					
Traditional	30.7	30.7	32.5	27.7	29.5
Grid Value	30.7	30.7	32.5	27.7	29.5
Realistically Achievable Potential					
Traditional	13.5	13.3	13.4	7.9	6.8
Grid Value	13.5	13.3	13.5	7.9	6.8

Table 53. SPPC Residential Cumulative Net Energy Efficiency Peak Savings (MW)

Scenario	2025	2026	2027	2030	2040
Mid					
Technical Potential					
Traditional	49.1	48.6	48.7	50.1	56.0
Grid Value	88.2	97.9	106.4	138.0	268.9
Economic Potential					
Traditional	17.3	17.3	19.9	17.2	18.3
Grid Value	43.1	47.8	54.9	72.6	153.9
Maximum Achievable Potential					
Traditional	10.9	10.9	12.8	10.6	10.9
Grid Value	15.7	16.5	19.3	20.8	36.0
Realistically Achievable Potential					
Traditional	5.1	5.0	5.0	2.5	1.7
Grid Value	9.8	10.6	11.4	12.7	26.8

Table 54 lists the Residential measures that have the most Achievable energy savings for SPPC during the 2025-2027 period. Programs and measures that facilitate the construction of energy efficient single and multi-family residences and behavioral savings form Home Energy Reports take primary roles. Smart thermostats contribute a meaningful portion of Achievable Potential, but the contribution of HVAC tune-ups is more muted than in NPC territory due to only air conditioner tune-ups in the HES program having an nTRC greater than 1.0 and thus contributing to Economic, Maximum Achievable, and Realistically Achievable Potential.

Table 54. NPC Residential Top Energy Efficiency Measures for Achievable Potential (Incremental Net MWh)

Program / Measure	Traditional / Grid Value			
	Rank	2025	2026	2027
HER - Energy Reports	1	19,392	19,586	19,979
MF - New Construction BOP	2	6,643	6,456	6,389
RNC - Codes and New Construction	3	3,871	3,762	3,723
DR Manage - Thermostats	4	569	694	813
DR Build - Thermostats	5	192	194	195

Commercial

Figure 43 shows that all forms of energy savings potentials are expected to grow significantly in the SPPC Commercial sector over time. As previously mentioned, the primary reason for this difference is the relative cost-effectiveness of many commercial measures, as defined by the nTRC and by the analysis inputs that are primarily based on recent SPPC DSM programs. Just like in the Residential sector, the analysis of Commercial potentials shows very similar energy savings in the Traditional and Grid Value portfolios over time, as shown in Table 55, while Table 56 shows more differentiation in demand savings, though less so than for the Residential sector.

Figure 43. SPPC Commercial Cumulative Net Efficiency Potential (GWh)

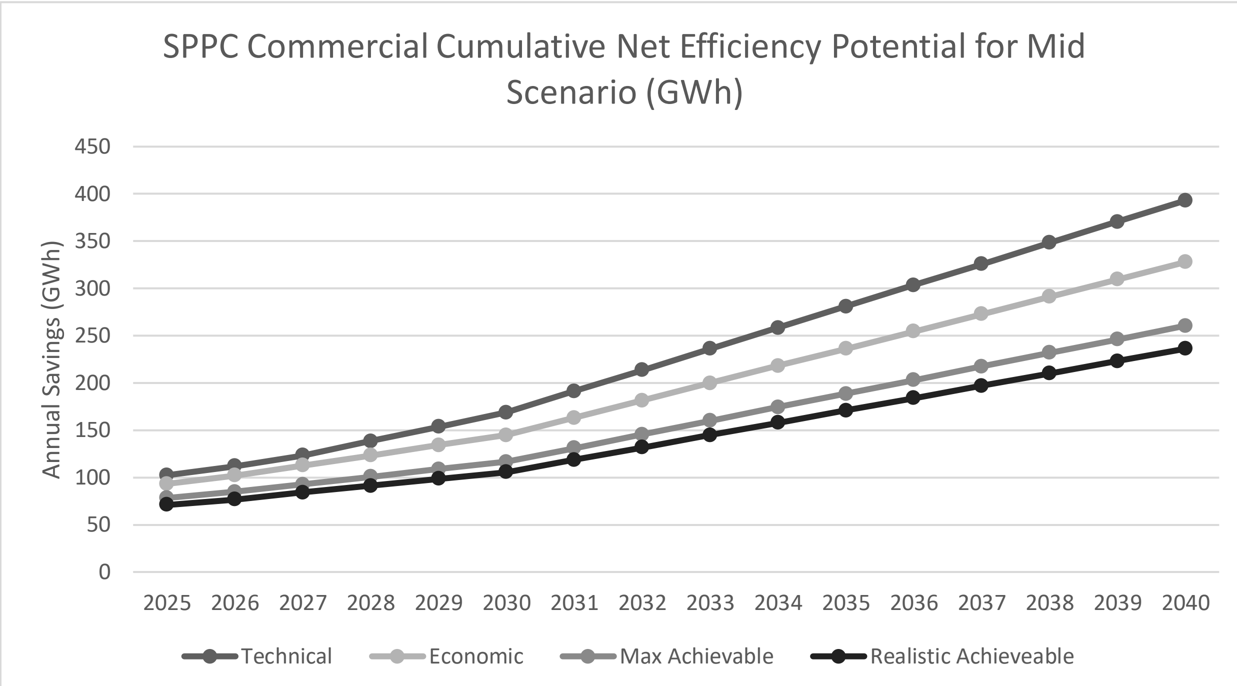


Table 55. SPPC Commercial Cumulative Net Efficiency Potential (GWh)

Scenario	2025	2026	2027	2030	2040
Mid					
Technical Potential					
Traditional	102.3	111.7	122.9	168.5	391.9
Grid Value	102.4	111.9	123.1	168.9	392.9
Economic Potential					
Traditional	93.2	102.2	112.6	144.7	327.7
Grid Value	93.2	102.2	112.6	144.8	327.8
Maximum Achievable Potential					
Traditional	78.3	84.8	92.6	116.7	260.5
Grid Value	78.3	84.8	92.6	116.7	260.5
Realistically Achievable Potential					
Traditional	70.9	76.8	84.0	105.7	236.1
Grid Value	70.9	76.8	84.0	105.8	236.1

Table 56. SPPC Commercial Cumulative Net Energy Efficiency Peak Savings (MW)

Scenario	2025	2026	2027	2030	2040
Mid					
Technical Potential					
Traditional	14.4	16.2	18.3	26.5	66.9
Grid Value	21.6	29.0	36.1	60.1	154.9
Economic Potential					
Traditional	13.1	14.8	16.8	23.1	57.4
Grid Value	15.5	22.3	29.0	49.7	132.2
Maximum Achievable Potential					
Traditional	11.0	12.5	14.1	19.5	48.4
Grid Value	11.3	13.4	15.7	23.0	58.2
Realistically Achievable Potential					
Traditional	10.1	11.4	13.0	17.9	44.4
Grid Value	10.4	12.4	14.6	21.4	54.2

Table 57 lists the Commercial measures that contribute the most Achievable energy savings for SPPC during the 2025-2027 period, largely grouped at the end-use level due to the greater diversity of commercial products and program participants. Like for NPC, Achievable Potential is primarily found in Commercial lighting measures that target lamps and settings that do not conform to the recently updated Federal General Service Lamp (GSL) definitions, such as the replacement of linear fluorescent lamps with TLEDs. In future years, significant relative growth in potential comes from Commercial HVAC measures and controls for both heating and cooling. Efficient motors and variable frequency drives (VFDs) also contribute to savings potential, along with Refrigeration opportunities.

Table 57. SPPC Commercial Top Energy Efficiency Measures for Achievable Potential (Incremental Net MWh)

Program / Measure	Traditional / Grid Value			
	Rank	2025	2026	2027
BES - Commercial Measures - Lighting	1	58,287	59,764	62,103
BES - Commercial Measures - HVAC	2	7,502	9,734	12,225
Schools - Capital Projects	3	4,946	5,296	5,734
BES - Commercial Measures - Motors	4	2,864	3,754	4,709
BES - Commercial Measures - VFDs	5	2,864	3,754	4,709
BES - Commercial Measures - Refrigeration	6	1,010	1,175	1,345

Demand Response

This section focuses specifically on potential demand savings from demand response programs in SPPC territory. As was also true for the NPC analysis, this is where the differentiation between the Traditional and Grid Value portfolios becomes readily apparent. With the Traditional portfolio's focus upon energy savings, limited DSM resources are not allocated to demand response programs that create flexibility during times of grid need. Energy savings from smart thermostats and other devices previously installed for demand response programs remain, but without the recurring incentives and investments in demand response programs that are present in the Grid Value portfolio, no flexible demand savings are available from demand response programs in the Traditional portfolios, as shown in Table 58.

Table 58. SPPC Cumulative Net Peak Demand Response Savings (MW)

Scenario	2025	2026	2027	2030	2040
Mid					
Technical Potential					
Traditional	-	-	-	-	-
Grid Value	46.4	62.2	75.5	121.5	300.9
Economic Potential					
Traditional	-	-	-	-	-
Grid Value	28.2	38.0	47.2	82.0	210.5
Maximum Achievable Potential					
Traditional	-	-	-	-	-
Grid Value	5.1	6.6	8.1	13.7	34.8
Realistically Achievable Potential					
Traditional	-	-	-	-	-
Grid Value	5.1	6.6	8.1	13.7	34.8

Residential

Table 59 shows that the majority of potentials from demand response programs in the Grid Value portfolio come from the Residential sector. Table 60 shows that thermostats controlling residential HVAC technologies provide the bulk of demand response potential, while new opportunities related to controlled charging and discharging of residential batteries are beginning to emerge.

Table 59. SPPC Residential Cumulative Net Peak Demand Response Savings (MW)

Scenario	2025	2026	2027	2030	2040
Mid					
Technical Potential					
Traditional	-	-	-	-	-
Grid Value	39.2	49.3	57.7	87.9	212.9
Economic Potential					
Traditional	-	-	-	-	-
Grid Value	25.8	30.5	35.0	55.4	135.6
Maximum Achievable Potential					
Traditional	-	-	-	-	-
Grid Value	4.8	5.6	6.5	10.2	25.0
Realistically Achievable Potential					
Traditional	-	-	-	-	-
Grid Value	4.8	5.6	6.5	10.2	25.0

Table 60. SPPC Residential Top Demand Response Measures for Achievable Potential (Incremental Net MW)

Program / Measure	Rank	Traditional			Grid Value		
		2025	2026	2027	2025	2026	2027
DR Manage - Thermostats	1	3.4	4.2	4.9	3.4	4.2	4.9
DR Build - Thermostats	2	1.2	1.2	1.2	1.2	1.2	1.2
DR Build - Batteries	3	-	-	-	0.1	0.1	0.1
DR Manage - Batteries	4	-	-	-	0.0	0.1	0.3

Commercial

While Commercial demand response does not provide the same magnitude of potential as Residential demand response, meaningful potentials are still present and grow significantly over time if the necessary resources are placed and investments made, as is shown in Table 61. Like on the Residential side, Table 62 shows that the near-term potential lies in controlling commercial HVAC systems, but batteries and other controlled technologies are beginning to emerge as an additional source of potential.

Table 61. SPPC Commercial Cumulative Net Peak Demand Response Savings (MW)

Scenario	2025	2026	2027	2030	2040
Mid					
Technical Potential					
Traditional	-	-	-	-	-
Grid Value	7.2	12.8	17.8	33.6	88.0
Economic Potential					
Traditional	-	-	-	-	-
Grid Value	2.4	7.5	12.2	26.6	74.9
Maximum Achievable Potential					
Traditional	-	-	-	-	-
Grid Value	0.3	1.0	1.6	3.5	9.8
Realistically Achievable Potential					
Traditional	-	-	-	-	-
Grid Value	0.3	1.0	1.6	3.5	9.8

Table 62. SPPC Commercial Top Demand Response Measures for Achievable Potential (Incremental Net MW)

Program / Measure	Rank	Traditional			Grid Value		
		2025	2026	2027	2025	2026	2027
DR Manage - Thermostats	1	0.2	0.7	1.2	0.2	0.7	1.2
DR Build - Batteries	2	-	-	-	0.1	0.1	0.1

Portfolio Metrics

In addition to calculating energy savings and demand reductions at the portfolio level, Table 63 and Table 64 show the source energy and emissions reductions metrics for each portfolio over the study period and with additional points in 2030 and 2040. Further analysis and stakeholder engagement is needed to determine final methodologies and future roles of these metrics, but they can be used to better tune portfolios to goals beyond direct energy or demand savings.

Table 63. NPC Portfolio Metrics for Achievable Potentials

Scenario	2025	2026	2027	2030	2040
Maximum Achievable Potential					
Traditional					
Lifetime Emissions Reductions (tCO2)	745,716	761,277	804,552	773,471	1,550,987
First Year Source Energy Savings (GWh)	658	593	631	689	1,656
Lifetime Source Energy Savings (GWh)	4,131	4,217	4,456	4,284	8,591
Grid Value					
Lifetime Emissions Reductions (tCO2)	745,780	761,382	804,701	773,696	1,551,565
First Year Source Energy Savings (GWh)	658	593	631	689	1,656
Lifetime Source Energy Savings (GWh)	4,131	4,217	4,457	4,286	8,594
Realistically Achievable Potential					
Traditional					
Lifetime Emissions Reductions (tCO2)	682,438	693,521	731,252	687,497	1,367,716
First Year Source Energy Savings (GWh)	612	543	577	622	1,509
Lifetime Source Energy Savings (GWh)	3,780	3,841	4,050	3,808	7,576
Grid Value					
Lifetime Emissions Reductions (tCO2)	682,503	693,627	731,401	687,722	1,368,294
First Year Source Energy Savings (GWh)	612	543	577	622	1,510
Lifetime Source Energy Savings (GWh)	3,780	3,842	4,051	3,809	7,579

Table 64. SPPC Portfolio Metrics for Achievable Potentials

Scenario	2025	2026	2027	2030	2040
Maximum Achievable Potential					
Traditional					
Lifetime Emissions Reductions (tCO2)	341,781	362,798	393,135	410,400	852,570
First Year Source Energy Savings (GWh)	280	297	323	367	734
Lifetime Source Energy Savings (GWh)	1,893	2,010	2,178	2,273	4,722
Grid Value					
Lifetime Emissions Reductions (tCO2)	341,784	362,802	393,140	410,417	852,627
First Year Source Energy Savings (GWh)	280	297	323	367	734
Lifetime Source Energy Savings (GWh)	1,893	2,010	2,178	2,273	4,723
Realistically Achievable Potential					

Traditional					
Lifetime Emissions Reductions (tCO2)	306,087	325,051	349,465	361,096	759,439
First Year Source Energy Savings (GWh)	212	227	245	281	606
Lifetime Source Energy Savings (GWh)	1,695	1,800	1,936	2,000	4,207
Grid Value					
Lifetime Emissions Reductions (tCO2)	306,090	325,055	349,470	361,113	759,496
First Year Source Energy Savings (GWh)	212	227	245	281	606
Lifetime Source Energy Savings (GWh)	1,695	1,800	1,936	2,000	4,207

Additionally, the analysis team calculated the first-year source energy savings and lifetime emissions savings metrics for the top measures contributing to Achievable energy efficiency potential to compare how each performs on these potential metrics. The source energy intensity of each measure is also reported to indicate which measures have higher source energy savings when normalized on an energy basis. As discussed in the report methodology, the source energy intensity serves as a guide for measure selection for a Grid Value portfolio, as it reflects measures with higher impact per unit of energy saved. Measures with a higher intensity have a higher coincidence of load savings shape with hours of high grid costs or grid emissions.

As shown in Table 65, HER – Energy Reports, the second and first largest measure in NPC and SPPC, respectively, has significant first year source energy savings, but lower source energy intensity than the other top measures. This suggests that while the HER – Energy Reports save a lot of energy, they do so at periods of time when NVE's generation is lower in carbon intensity relative to when other measures save energy. The lower source energy intensity of the HER – Energy Reports measure is reflected in the lower lifetime emissions reductions of that measures ranked lower by Achievable energy savings, but lifetime emissions savings are also a function of measure life.

Table 65. Portfolio Metrics for the Top NPC and SPPC Residential Energy Efficiency Measures Ranked by Achievable Potential

Program / Measure		1st Year Source Energy Savings (MWh)			Source Energy Intensity			Lifetime Emissions Reductions (tCO2)		
	Rank	2025	2026	2027	2025	2026	2027	2025	2026	2027
NPC										
MF - New Construction BOP NEW	1	79,727	78,080	77,371	3.28	3.28	3.29	178.9	175.0	173.3
HER - Energy Reports	2	65,317	65,972	67,298	3.08	3.08	3.08	11.8	11.9	12.1
RNC - New Construction	3	46,463	45,503	45,096	3.28	3.28	3.29	77.0	75.4	74.6
DRManage - Thermostats	4	20,270	22,664	24,977	3.15	3.15	3.15	12.5	14.0	15.4
HES - Retrofit - AC Tune Up	5	15,418	15,427	15,390	3.40	3.40	3.39	10.7	10.7	10.7

DRBuild - Thermostats	6	7,262	7,381	7,490	3.15	3.15	3.15	8.9	9.0	9.2
SPPC										
HER - Energy Reports	1	57,126	57,697	58,856	2.95	2.95	2.95	10.3	10.4	10.6
MF - New Construction BOP NEW	2	21,802	21,206	21,003	3.28	3.28	3.29	48.9	47.5	47.0
RNC - Codes and New Construction	3	12,703	12,357	12,240	3.28	3.28	3.29	21.1	20.5	20.3
DRManage - Thermostats	4	1,638	1,998	2,339	2.88	2.88	2.88	1.4	1.8	2.1
DRBuild - Thermostats	5	553	557	562	2.88	2.88	2.88	0.7	0.7	0.7

Table 66 summarizes the portfolio metrics for the top commercial measures for Achievable potential. Measures with the highest source energy intensity generally apply to cooling end uses. The measure with the highest source energy intensity is DRBuild – Thermostats in NPC and BES – Commercial Measures - HVAC in SPPC. As cooling loads are highly coincident with peak periods in both NPC and SPPC, the source energy factors are generally higher when these measures save energy. This data also shows that Commercial loads generally have lower coincidence with high source energy and high emissions hours. In NPC, the source energy intensity of the BES– Commercial Measures - Lighting (2.17) is about 35% lower than the HES - Retrofit - AC Tune Up measure (3.4).

Table 66. Portfolio Metrics for the Top NPC and SPPC Commercial Energy Efficiency Measures Ranked by Achievable Potential

Program / Measure		1st Year Source Energy Savings (MWh)			Source Energy Intensity			Lifetime Emissions Reductions (tCO2)		
	Rank	2025	2026	2027	2025	2026	2027	2025	2026	2027
NPC										
BES - Commercial Measures - Lighting	1	235,545	242,639	253,163	2.17	2.17	2.17	320.6	330.2	344.5
Schools - CEI, Schools	2	96,071	-	-	2.69	-	-	17.3	-	-
BES - Commercial Measures - HVAC	3	46,850	60,634	75,845	2.64	2.65	2.64	51.0	66.0	82.5
BES - Commercial Measures - Motors	4	6,453	8,474	10,648	2.43	2.43	2.43	14.2	18.6	23.4
BES - Commercial Measures - VFD	5	6,453	8,474	10,648	2.43	2.43	2.43	14.2	18.6	23.4
DRBuild - Thermostats	6	9,137	9,237	9,339	3.66	3.66	3.66	10.5	10.6	10.7
SPPC										
BES - Commercial Measures - Lighting	1	134,237	137,646	143,032	2.30	2.30	2.30	188.7	193.5	201.1

BES - Commercial Measures - HVAC	2	21,739	28,256	35,523	2.90	2.90	2.91	23.4	30.4	38.2
Schools - Capital Projects	3	11,658	12,476	13,489	2.36	2.36	2.35	15.8	16.9	18.3
BES - Commercial Measures - Motors	4	7,284	9,547	11,978	2.54	2.54	2.54	16.8	22.0	27.6
BES - Commercial Measures - VFDs	5	7,284	9,547	11,978	2.54	2.54	2.54	16.8	22.0	27.6
BES - Commercial Measures - Refrigeration	6	2,698	3,141	3,593	2.67	2.67	2.67	3.5	4.1	4.7

Coordination of Portfolio Evaluation Metrics and Portfolio Strategies

Based on the measures that are favorable in the evaluation metric results, the source energy and emissions metrics are shown to be reasonable proxies to prioritize measures under a Grid Value portfolio strategy. Measures that have high savings during evening hours have higher impact on emissions and source energy, and by correlation would have high impact on avoided utility costs as well.

Lastly, while the Traditional and Grid Value portfolios in the three-year study period of this analysis only show minor differences, significant load growth in NVE's system will drive greater future need for Grid Value prioritization. At the same time, future controllable technologies will come online to greater extents, such as smart thermostats, managed EV charging, and battery storage. Prioritizing Grid Value metrics will place more emphasis on managing the hourly timing of these loads, decreasing grid emissions and utility costs. Additionally, leveraging a location-specific value, potentially in distribution system planning, would cause further divergence in total portfolio benefits between Grid Value and Traditional strategies.

Conclusions

The results of the PATHWAYS analysis and DSM Planning analysis support enablement of energy efficiency programs as a resource to meet grid needs. As successes are achieved to enshrine traditional energy efficiency into codes and standards, as the grid evolves to be predominantly clean variable energy resources, and as policies shift toward electrification of already efficient end-uses, enabling energy efficiency program design to support overall Grid Value is prudent.

The portfolios considered in this analysis were measured against the current cost-effectiveness standards for Nevada. To enable a transition toward maximizing other grid benefits such as Grid Value and Decarbonization, other portfolio performance metrics such as hourly grid marginal source energy and marginal emissions have been included for comparison. Several jurisdictions across the US have started incorporating these and similar metrics into their energy efficiency screening to enable transitions that maximize these benefits for customers.

The analysis of Maximum Achievable and Realistically Achievable Potentials in both portfolios demonstrates the significant challenges present in achieving the historic goal of energy savings equivalent to 1.1% of annual retail sales. None of the analysis scenarios modeled achieve this goal, even with Maximum Achievable Potential. This is likely due to the confluence of several factors:

- Prior successes in increasing the efficiency of codes and standards, increasing the market saturation of efficient products, and other market advancements, have raised baseline efficiencies and reduced the remaining potential savings.
- Significant current and future load growth from transportation electrification, data centers and other emerging end uses, such as indoor agriculture, has increased the absolute GWh savings required to meet a 1.1% target.
- New electric end uses, such as EVs and data centers, represent very large increases in load but are already very efficient. They drastically improve overall efficiency when viewed at the energy source level but offer minimal incremental opportunities for cost effective utility DSM program savings.
- Recent supply chain challenges have resulted in persistently higher incremental upfront costs associated with many key EE technologies, such as HVAC units and heat pump water heaters. This reduces the portfolio of measures that passes the cost-effectiveness screen required for Economic Potential.

Rather than seeing the difficulties of achieving a 1.1% reduction in annual retail energy sales through DSM programs as an obstacle, this could also be perceived as a by-product of a series of prior successes in promoting energy efficiency throughout the State of Nevada historically. This may allow NVE the opportunity to begin pivoting from a Traditional portfolio to one that places more emphasis on Grid Value or Strategic Decarbonization and accommodates broader economic changes toward decarbonization including electrification. This transition is reflective of several characteristics of today's grid, economy, and customer usage patterns, including:

- Changing resource needs have reduced the value of EE savings, particularly during times when the abundance of solar energy regionally available may result in the need to curtail these renewable resources. Instead, there may be higher value in dispatching additional energy use during these times to better integrate this solar, take advantage of low of negative priced clean energy in wholesale markets, reduce grid emissions, and solve operational challenges associated with low load conditions.
- Grid Value measures provide greater value from flexible distributed capacity in the form of energy storage, load management, and demand response in addition to efficiency, thus producing high peak demand savings and higher net benefits for customers with a lower revenue requirement.
- A gradual transition to a Grid Value approach begins to directly address ways to manage expected load growth and potential peak demand impacts of emerging C&I and residential electrical loads for EVs, data centers, building electrification, and indoor agricultural. This provides an opportunity to be more proactive in addressing emerging loads and could delay costly grid upgrades.
- Laying the groundwork early to build new programs that manage expanding loads more efficiently and economically will facilitate the scaling of these resources as electrification

adoption increases. The value of this early investment will only increase if electric load growth occurs at a rate faster than is currently forecasted (i.e., due to Federal or State policies or other outside market influences and policy changes), thus reducing risk to NVE.

Further Research

Consistent with this analysis being in the "walk" phase of a "walk-jog-run" approach, there are several additional avenues for data analysis that could benefit future decision making and portfolio evolution in NVE's service territory. Potential areas for further research or refinement of the study methodology are listed below.

- The current analysis largely utilizes measure data at the end-use level. Performing a more granular analysis that includes specific end-use technologies with varying efficiency specifications could provide further insight into variations of certain measures that may be cost-effective or provide greater grid value to NVE.
- More fully exploring the ability to pair 'devices with prices' via dynamic time-of-use rates may reveal additional opportunities for demand savings at the customer level. These are enabled by connected DR technology that can also be optimized for daily load shifting around rates. This additional flex capacity potential (which is much greater in the Grid Value portfolio) has not been factored into the demand savings or cost effectiveness of the measures considered.
- Some measures supporting end-uses such as batteries could offer additional future EE potential by providing higher upfront incentives for energy storage products with the highest round-trip efficiencies. These products would be compared against an average market baseline efficiency level and the incremental efficiency savings could be claimed toward EE goals.
- Measures such as EV load management, managed charging, and demand response offer significant potential for scaling flexible distributed capacity. These are shown in the Transportation Electrification Plan and are additive to what is in the DSM plan.
- Additional opportunities for energy efficiency and demand savings from the Industrial and Agricultural sectors, or demand flexibility from Data Centers, were not meaningfully investigated as part of this analysis. Significant opportunities may be identified in these sectors given further analysis.
- Expansion of scenarios reflected in the DSM potential analysis, including avoided costs and scenario inputs consistent with the additional PATHWAYS scenarios defined in this study.

Appendix A: PATHWAYS Model

Model Overview

PATHWAYS is an economy-wide energy and greenhouse gas (GHG) emissions accounting model. E3 created the PATHWAYS model to help policymakers, businesses, and other stakeholders analyze paths to achieving deep decarbonization of the economy. PATHWAYS is not an optimization or general equilibrium model, but instead allows for comparison of user-defined scenarios of future energy demand and emissions to explore the impacts and implications of potential climate and energy policies. Variables that impact final energy demand in the model (e.g., customer adoption of electric vehicles, amount of space heating demanded per household), are specified by the user. The PATHWAYS model accounts for annual energy demands and greenhouse gas emissions from the following final energy demand and non-energy and/or non-combustion sources:

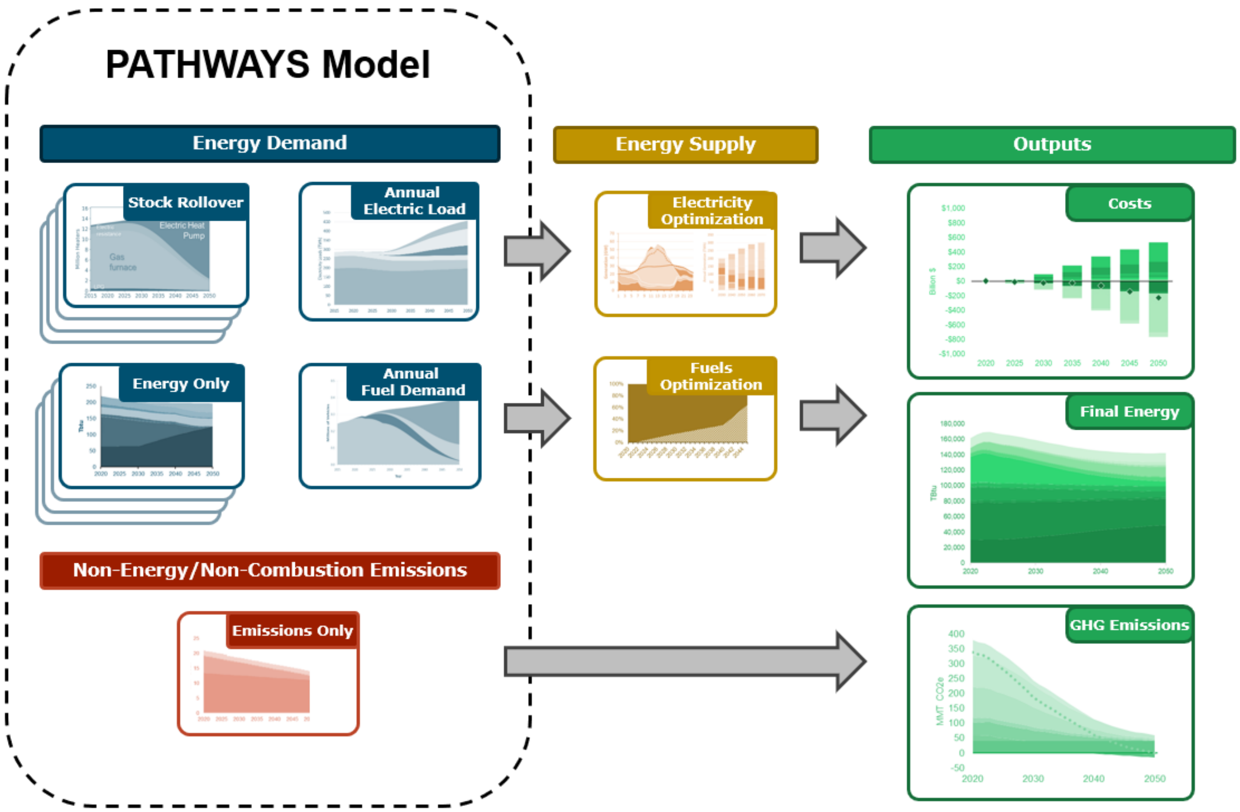
- Energy Demand Sectors
  - Residential
  - Commercial
  - Industrial
  - Transportation
- Non-Energy, Non-Combustion Sectors
  - Agriculture
  - Coal Mining
  - Natural Gas & Oil Systems
  - Industrial Processes & Product Use (IPPU)
  - Waste
  - Land-use, Land-use Change, & Forestry (LULUCF)

The sources from these sectors are categorized into one of three subsector types:

1. **Stock Rollover** – Subsectors where PATHWAYS accounts for the stock rollover of energy-consuming devices in the economy. Here, final energy demands and direct emissions are calculated based on demand for energy services (e.g., vehicle miles travelled, delivered heat), the fuel type of devices, and the efficiency of devices.
2. **Energy Only** – Subsectors where PATHWAYS accounts for annual energy demands and direct emissions but does not model stock rollover of devices due to a lack of high-quality, comprehensive data on device stocks, service demands, and efficiencies (e.g., industrial process heat).
3. **Emissions Only** – Subsectors where emissions are generated from sources other than energy demand and/or fuel combustion, so only the annual direct emissions are tracked (e.g., landfill methane leakage).

The final energy demands from PATHWAYS are typically passed to energy supply models like the E3 RESOLVE model for electricity sector capacity expansion and the E3 fuels optimization module to determine the cost and emissions associated with meeting final energy demands under various resource and emissions constraints. Figure 44 below shows the process flow for a typical economy-wide analysis using PATHWAYS in conjunction with these other tools. Using energy supply models to optimize electricity sector costs and emissions rates and fuel prices and blend levels is not required to generate economy-wide outputs using PATHWAYS, as users also have the option to input pre-determined emissions rates and prices for all fuels within PATHWAYS itself.

Figure 44. Flow chart of PATHWAYS model used in conjunction with energy supply tools



Stock Rollover Subsectors

Overview

PATHWAYS models 31 distinct stock rollover subsectors across the Residential, Commercial, and Transportation sectors. For each subsector, the total stock of devices and the share for each technology type is benchmarked in the base year using historical data. For future years, the total stock is determined using growth rates for various key indicators (e.g., population). Table 67 below shows the default stock rollover subsectors in PATHWAYS and the growth rates used to determine total device stocks in future years.

Table 67. Stock rollover subsectors in PATHWAYS

Subsector	Growth Rate
Residential Central Air Conditioning	Households
Residential Clothes Drying	Households
Residential Clothes Washing	Households
Residential Cooking	Households
Residential Dishwashing	Households
Residential Freezing	Households
Residential Exterior Lighting	Households
Residential General Service Lighting	Households
Residential Linear Fluorescent Lighting	Households
Residential Reflector Lighting	Households
Residential Refrigeration	Households
Residential Room Air Conditioning	Households
Residential Single Family Space Heating	Households
Residential Multi Family Space Heating	Households
Residential Water Heating	Households
Commercial Air Conditioning	Commercial Square Footage
Commercial Cooking	Commercial Square Footage
Commercial General Service Lighting	Commercial Square Footage
Commercial HID Lighting	Commercial Square Footage
Commercial Linear Lighting	Commercial Square Footage
Commercial Refrigeration	Commercial Square Footage
Commercial Space Heating	Commercial Square Footage
Commercial Ventilation	Commercial Square Footage
Commercial Water Heating	Commercial Square Footage
Transportation Light Duty Cars	Population
Transportation Light Duty Trucks	Population
Transportation Light Medium Duty Trucks	Population
Transportation Medium Duty Trucks	Population
Transportation Heavy Duty Trucks (Short-haul)	Population
Transportation Heavy Duty Trucks (Long-haul)	Population
Transportation Buses	Population

The final energy demand from stock rollover subsectors is a function of the total number of devices, the service demands per device, the share of various technologies among the total number of devices, and the average efficiencies of these devices. Each year, the model retires devices based on survival profiles that determine the fraction of devices retired from year to year, and then sells new devices so that the total number of devices equals the amount calculated using the base year stocks and top down growth rates.

Users have the option of changing the market share for new device sales as a scenario input. Examples of user inputs are measures that lead to an increase in sales of more efficient devices with the same fuel type or measures that lead to an increase in sales of devices with a different fuel type (e.g., shifting sales of gasoline vehicles to battery electric vehicles). In addition, users can input service demand modifiers that change the underlying amount of energy services required, which in turn change the final energy demand (e.g., reducing vehicle miles travelled). One unique service demand modifier available for buildings is the deployment of more efficient building shells that reduce space heating and cooling needs. Unlike other service demand modifiers like behavioral conservation or VMT reductions, the model accounts for the capital costs of building shell measures that reduce service demands, although the user must specify the cost and percent reduction in heating and/or cooling demand associated with each efficient shell type. The section below walks through the calculations for stock rollover and energy demand.

Calculations

Stock Rollover Calculations

Stock rollover calculations are performed for each stock rollover subsector. The goal of the stock rollover calculations is to calculate the 3-dimensional stock array, A_{ijk}, which represents the number of devices that exist in year i of vintage j and device type k (e.g. for the light duty vehicles subsector in the year 2024, how many 2002 vintage gasoline internal combustion engine cars are on the road).

Key model inputs for the calculation of the stock array, A_{ijk}, include:

- A_{0jk}, the base year stock share
- r_i, the total number of devices that exist in year i across the entire subsector
- S_{ijk}, the survival profile matrix, which represents the percentage of devices that will survive from year $(i-1)$ to year i
- B_{ijk}, the natural retirement sales share, which represents the fraction of natural retirements in year i of vintage j that will be replaced with device type k. The value is typically the same across all vintages for a given year i.
- D_{ijk}, the early retirement sales share, which represents the fraction of early retirements in year i of vintage j that will be replaced with device type k. The value is typically the same across all vintages for a given year i.
- X_{ik}, the early retirement stock fraction, which represents the fraction of devices of type k that will be retired early in year i. Note: the vintage is not specified. The calculations assume that the oldest devices will be retired first.

Key intermediate calculated quantities include:

- P_{ijk}, the array of natural retirements occurring in year i of vintage j and device type k
- Q_{ijk}, the array of early retirements occurring in year i of vintage j and device type k
- Y_{ijk}, the array of sales occurring in year i of vintage j and device type k
- $\hat{A}_{ijk}$, the stock array in year i of vintage j and device type k after accounting for natural retirements, but **before** accounting for early retirements and sales
- $\tilde{A}_{ijk}$, the stock array in year i of vintage j and device type k after accounting for both natural and early retirements but **before** accounting for sales

The stock rollover calculations occur iteratively from years $(i = 1 \ldots n)$, assuming that stocks in year 0, A_{0jk}, are known. The following steps are performed for each successive year:

Step 1: subtract natural retirements

The first step is calculating the number of devices that will naturally retire given the starting stocks and the survival profile. The number of natural retirements, P_{ijk}, and the intermediate stock array, $\hat{A}_{ijk}$, are calculated as shown in Equations 1 and 2 below:

$$P_{ijk} = A_{(i-1)jk} * S_{ijk} \quad (1)$$

$$\hat{A}_{ijk} = A_{(i-1)jk} - P_{ijk} \quad (2)$$

Step 2: subtract early retirements

The second step is calculating the number of early retirements. Devices are retired from oldest to youngest, until the specified early retirement fraction, X_{ik} , is reached. The number of early retirements, Q_{ijk}, are thus calculated such that Equation 3 is satisfied:

$$\sum_{j} Q_{ijk} = X_{ik} * \sum_{j} \hat{A}_{ijk} \quad (3)$$

Intermediate stock array, $\tilde{A}_{ijk}$, represents the stock array **after** accounting for both natural and early retirements but **before** accounting for sales. $\tilde{A}_{ijk}$ is calculated as shown in Equation 4:

$$\tilde{A}_{ijk} = \hat{A}_{ijk} - Q_{ijk} \quad (4)$$

Step 3: add sales

After both natural and early retirements have been accounted for to produce the intermediate stock array, $\tilde{A}_{ijk}$, the third and final step in the calculation of the final stock array, A_{ijk}, is to add the anticipated sales. This is achieved by replacing natural and early retirements, as well as adding new devices to meet the total number of devices specified for the subsector, r_i. The sales, Y_{ijk}, are calculated as shown in Equation 5:

$$Y_{ijk} = \left(P_{ijk} * B_{ijk}\right) + \left(Q_{ijk} * D_{ijk}\right) + \left(r_i - \sum_{jk} \tilde{A}_{ijk}\right) * B_{ijk} \quad (5)$$

where

- P_{ijk} is the array of natural retirements occurring in year i of vintage j and device type k,

- B_{ijk} is the natural retirement sales share, which represents the fraction of natural retirements in year i of vintage j that will be replaced with device type k,
- Q_{ijk} is the array of early retirements occurring in year i of vintage j and device type k,
- D_{ijk} is the early retirement sales share, which represents the fraction of early retirements in year i of vintage j that will be replaced with device type k, and
- r_i is the total number of devices that exist in year i across the entire subsector.

The final stock array, A_{ijk}, is calculated by adding the sales, Y_{ijk}, to $\tilde{A}_{ijk}$ (the intermediate stock array coming out of the previous step), as shown in Equation 6:

$$A_{ijk} = \tilde{A}_{ijk} + Y_{ijk} \qquad 6$$

Energy Demand Calculations for Stock Rollover Subsectors

Once the stock rollover has been calculated, energy demands are calculated for each year i, device type k, and fuel type f. Key inputs for the energy demand calculations include:

- A_{ijk}, the final stock array defining the number of devices that exist in year i of vintage j and device type k. This is the main output of the stock rollover calculations.
- X_{ijkf}, the fuel share of service demand for fuel type f for devices in year i of vintage j and device type k. This represents the percentage of service demand that is served by a particular fuel type.
- F_{ijkf}, the efficiency of devices in year i of vintage j and device type k and fuel type f (in units of (MMBtu out)/(MMBtu in)).
- d_{ik}, the service demand in year i for device type k (in units of MMBtu/year)

The resulting energy demand, E^s_{ikf}, represents the energy demand year i for device type k and fuel type f. E^s_{ikf} is calculated as shown in Equation 7:

$$E^s_{ikf} = d_{ik} * \sum_j X_{ijkf} * (A_{ijk} \div F_{ijkf}) \qquad 2$$

The final energy demands are aggregated over all devices in the subsector to yield E^s_{if}, the total final energy demand for each year i and fuel type f as shown in Equation 8:

$$E^s_{if} = \sum_k E^s_{ikf} \qquad 8$$

Emissions resulting from these energy demands are dependent on the energy supply and are described in a subsequent section.

Costs for Stock Rollover Subsectors

Three types of costs are calculated for devices within a stock rollover subsector:

1. **Device costs:** capital costs to purchase new devices. Overnight capital costs are calculated by multiplying annual device sales by the capital cost for each device. Annual levelized costs are calculated from the overnight costs assuming a financing rate and financing lifetime specified for each subsector.
2. **Operation and maintenance (O&M) costs:** annual costs associated with O&M for a specified device type. O&M costs are calculated by multiplying the total number of devices operating in a given year by the annual O&M cost for each individual device type.
3. **Fuel costs:** annual costs associated with fuel consumption for each device. Fuel costs are calculated by multiplying the energy demand for each device by the fuel price per MMBtu for the fuel it consumes.

Energy Only Subsectors

Overview

Energy only subsectors represent the final energy demands and direct GHG emissions for categories where comprehensive data on equipment stock, efficiencies, and service demands are not readily available. These include manufacturing and non-manufacturing industrial sectors, off-road transportation and aviation, and miscellaneous energy end-uses in residential and commercial buildings. For all energy only subsectors, starting year energy demands are benchmarked to historical consumption. For industrial subsectors, business-as-usual changes in future year energy demand are applied by subsector and fuel type based on changes forecasted in EIA Annual Energy Outlook 2023. Changes in future year aviation energy demand are also taken from Annual Energy Outlook, while energy demand growth for miscellaneous residential and commercial end-uses is projected using the households and commercial square footage growth rates, respectively. Table 68 below lists the default energy only subsectors used in PATHWAYS.

Table 68. Energy only subsectors in PATHWAYS

Subsector	Growth Rate
Residential Other	Households
Commercial Other	Commercial Square Footage
Transportation Aviation	EIA AEO23 Demand Growth for Jet Fuel
Transportation Other	N/A
Industry Aluminum	EIA AEO23 Demand Growth by Individual Fuel and Subsector
Industry Cement and Lime	
Industry Chemicals	
Industry Food	
Industry Glass	
Industry Iron and Steel	
Industry Metal Based Durables	
Industry Other	
Industry Paper	
Industry Plastics	
Industry Refining	
Industry Wood Products	
Industry Agriculture	
Industry Construction	
Industry Mining and Upstream Oil and Gas	

Once the baseline growth in energy demand is determined, users can specify either energy efficiency measures to reduce final energy consumption or fuel-switching measures to convert energy demand from one fuel to another. A third option for some stationary sources of CO_2 emissions is to apply CCS. The share of final emissions from a specific fuel and subsector that will be captured annually is specified by the user along with the technical characteristics of the CCS equipment like capital and operating costs, capture rate, and energy demands. The section below walks through the calculations for final energy demands in the energy only subsectors.

Calculations

Energy Demand Calculations for Energy Only Subsectors

As mentioned in the overview, the final energy demands in energy only subsectors account for both fuel-switching measures to convert energy demand from one fuel to another, and energy efficiency measures to reduce the final energy consumption. The final result is E_{if}^{I}, the final energy demand in year i for fuel type f across the subsector.

Key inputs for the energy demand calculations in energy only subsectors include:

- E_{if}^{I0}, the default energy demand in year i for fuel type f
- W_{ifg}, the percentage of energy demand in year i to be converted from fuel type f to fuel type g
- V_{ifg}, the energy efficiency factor in year i when converting from fuel type f to fuel type g (e.g. if switching from a natural gas boiler to an electric heat pump that is 3X more efficient, this value would be 300%)

- R_{if}, the energy efficiency reduction fraction for energy efficiency measures. This represents the % of final energy demand that will be reduced as a result of the measure

Intermediate calculated values include:

- $\hat{E}^{I}_{if}$, the energy demand in year i for fuel type f **after** fuel switching has been accounted for but **before** energy efficiency measures have been applied

Step 1: account for fuel-switching

First, fuel-switching is applied to the default energy demand trajectories for each fuel. This calculation:

1. starts with the default energy demand trajectory, E^{I0}_{if},
2. subtracts energy demands that will be switching from fuel type f to other fuel types, and then
3. adds fuel demands that will be switching from other fuel types to fuel type f, accounting for the conversion efficiency.

The intermediate energy demand accounting for fuel switching, $\hat{E}^{I}_{if}$, is calculated as shown in Equation 9:

$$\hat{E}^{I}_{if}, = E^{I0}_{if} - \sum_g \left(E^{I0}_{if} * W_{ifg}\right) + \sum_g \left(E^{I0}_{if} * W_{igf} \div V_{igf}\right) \qquad 0$$

Step 2: account for energy-efficiency measures

After fuel-switching has been accounted for, energy efficiency measures are applied to the intermediate energy demands, $\hat{E}^{I}_{if}$, to produce the final energy demands, E^{I}_{if}. The energy efficiency reduction fraction, R_{if}, is applied to calculate the final energy demands, E^{I}_{if}, as shown in Equation 10:

$$E^{I}_{if}, = \hat{E}_{if} * (1 - R_{if}) \qquad 10$$

Emissions resulting from these energy demands are dependent on the energy supply. In cases where CCS is applied within a subsector, energy demands associated with CCS operations are also accounted for.

Costs for Energy Only Subsectors

Although device stocks are not explicitly modeled for energy only subsectors, the capital costs that would be associated with equipment upgrades are represented as levelized annual costs on a dollars per MMBtu basis. These include:

- **Fuel-switching costs:** annual levelized costs representing capital investments needed to purchase equipment associated with fuel-switching (e.g. the levelized incremental capital cost of an industrial heat pump replacing a natural gas boiler).
- **Efficiency costs:** annual levelized costs representing capital investments needed to purchase equipment associated with energy efficiency measures (e.g. the levelized incremental capital cost of efficient boilers relative to conventional boilers).

Annual costs that are accounted for in energy only subsectors include:

- **Fuel costs:** annual costs associated with fuel consumption in the subsector. Fuel costs are calculated by multiplying the final energy demand by the fuel cost per MMBtu of the fuel consumed.

If CCS is applied in the subsector, additional CCS costs will also be accounted for.

Emissions Only Subsectors

Overview

Emissions only subsectors represent GHG emissions from non-energy and/or non-combustion related sources and emissions sinks from land use and forestry. For these sources, annual emissions are entered into the model directly as metric tons by pollutant type. The four pollutant types represented in PATHWAYS are CO_2, CH_4, N_2O, and CO_2e (CO_2e is used for fluorinated gases like HFCs, PFCs, SF_6, and NF_3). Base year emissions sources and sinks are benchmarked to state-level data from EPA[40]. Table 69 below lists the default emissions only sectors and subsectors used in PATHWAYS.

Table 69. Emissions only subsectors in PATHWAYS

Sector	Subsector	Pollutant
Agriculture	Liming	CO2
	Urea Fertilization	CO2
	Enteric Fermentation	CH4
	Manure Management CH4	CH4
	Rice Cultivation	CH4
	Residue Burning CH4	CH4
	Manure Management N2O	N2O
	Soil Management	N2O
	Residue Burning N2O	N2O
Coal Mining	Active Coal Mines	CH4
	Abandoned Coal Mines	CH4
Natural Gas and Oil Systems	Natural Gas Systems CO2	CO2
	Petroleum Systems CO2	CO2

[40] U.S. Environmental Protection Agency. (2023). *Inventory of U.S. Greenhouse Gas Emissions and Sinks by State: 1990-2021*; https://www.epa.gov/ghgemissions/state-ghg-emissions-and-removals

	Abandoned Oil and Gas Wells CO2	CO2
	Natural Gas Systems CH4	CH4
	Petroleum Systems CH4	CH4
	Abandoned Oil and Gas Wells CH4	CH4
	Natural Gas Systems N2O	N2O
	Petroleum Systems N2O	N2O
Industrial Processes and Product Use (IPPU)	Cement Production	CO2
	Lime Production	CO2
	Other Process Uses of Carbonates	CO2
	Glass Production	CO2
	Soda Ash Production	CO2
	Carbon Dioxide Consumption	CO2
	Titanium Dioxide Production	CO2
	Aluminum Production CO2	CO2
	Iron and Steel Production CO2	CO2
	Ferroalloy Production CO2	CO2
	Ammonia Production	CO2
	Urea Consumption	CO2
	Phosphoric Acid Production	CO2
	Petrochemical Production CO2	CO2
	Carbide Production and Consumption CO2	CO2
	Lead Production	CO2
	Zinc Production	CO2
	Magnesium Production and Processing CO2	CO2
	Petrochemical Production CH4	CH4
	Carbide Production and Consumption CH4	CH4
	Iron and Steel Production CH4	CH4
	Ferroalloy Production CH4	CH4
	Adipic Acid Production	N2O
	Nitric Acid Production	N2O
	N2O from Product Uses	N2O
	Caprolactam and Others Production	N2O
	Electronics Industry N2O	N2O
	ODS Substitutes	CO2e
	HCFC-22 Production	CO2e
	Magnesium Production and Processing	CO2e
	Aluminum Production	CO2e
	Electronics Industry	CO2e
	Electrical Transmission and Distribution	CO2e
Waste	Waste Combustion CO2	CO2
	Landfills	CH4
	Wastewater Treatment CH4	CH4
	Composting CH4	CH4
	Anaerobic Digestion	CH4

	Waste Combustion CH4	CH4
	Wastewater Treatment N2O	N2O
	Waste Combustion N2O	N2O
	Composting N2O	N2O
Land-Use, Land-Use Change, and Forestry (LULUCF)	LULUCF CH4 Sources	CH4
	LULUCF N2O Sources	N2O
	LULUCF Carbon Stock Change	CO2

After the baseline trend for future year non-energy and/or non-combustion emissions has been determined, the user can specify annual emissions reductions as a percentage below the baseline trend for individual sources along with measure costs on a $/ton of pollutant basis.

Calculations

Emissions Calculations for Emissions Only Subsectors

The final emissions for an emissions only subsector, γ_{ip}, are calculated for each year i and pollutant p. Tracked pollutants typically include the most common greenhouse gases (i.e. CO2, CH4, and N2O). The final emissions, γ_{ip}, are calculated as shown in Equation 11:

$$\gamma_{ip} = \gamma_{ip}^{0} - \alpha_{ip} \qquad 0$$

where:

- γ_{ip}^{0} is the default emission value for year i and pollutant p, and
- α_{ip} is the quantity of emissions to be reduced via mitigation measures for year i and pollutant p.

In some cases, CCS may be applied to an emissions only subsector (e.g. cement production). Impacts from CCS are described further in subsequent sections.

Cost Calculations for Emissions Only Subsectors

Annual costs associated with emissions reductions in emissions only subsectors are tracked within the model. These **emissions only reduction costs** are calculated by multiplying the annual emissions reductions, α_{ip}, by the input cost on a $/ton basis.

If CCS is applied in the subsector, additional CCS costs will also be accounted for. These are described further in subsequent sections.

Energy Supply

PATHWAYS generates annual energy demands by fuel type, stocks and sales of energy consuming devices, and GHG emissions from non-energy/non-combustion sources. The energy demands by fuel type from PATHWAYS can be passed to a set of energy supply optimization tools like E3's RESOLVE electricity sector capacity expansion model and E3's fuels optimization module. RESOLVE calculates optimal long-term electricity generation and transmission investments subject to reliability, policy, and technical constraints. The fuels optimization module calculates what production and allocation of low carbon fuels like biofuels, electrolytic fuels, and fossil fuels with negative emissions technology, provides the lowest cost portfolio that meets final energy demands and economy-wide emissions targets. Both RESOLVE and the fuels optimization tool provide emissions rates and prices for electricity and fuels, respectively, that are used to calculate final economy-wide emissions and costs.

PATHWAYS can still be used to calculate economy-wide results on its own without the use of energy supply optimization models, but requires the user to enter predetermined annual emissions rates and prices for electricity and emissions rates, prices, and fuel blends for all liquid and gaseous fuel types. The default assumptions for fuel prices in PATHWAYS are taken from the Reference case forecast in EIA AEO23.

Calculation of Economy-wide Emissions

Once the economy-wide energy supply has been determined for a scenario, economy-wide emissions can be calculated within the PATHWAYS model. Economy-wide emissions include direct emissions from combusted fuels, indirect emissions from electricity, non-energy/non-combustion emissions, and any negative emissions that occur through CCS or negative emissions technologies (e.g. direct air capture). Emissions are calculated for each subsector that is modeled. Non-energy/non-combustion emissions are also calculated. Other types of modeled emissions and their calculations are described in the subsequent sections.

Calculation of Emissions from Fuels

The final energy demands for stock rollover subsectors and energy only subsectors are represented by E_{if}^{S} and E_{if}^{I} respectively for each year i for fuel type f. The final energy demand for a general subsector year i for fuel type f will henceforth be denoted by E_{if}.

Energy demands for each fuel type f can potentially be served by a number of different candidate fuels c (e.g. energy demands for the "Natural Gas" fuel type might be served by candidate fuels "Fossil Natural Gas" or "Renewable Natural Gas"). The share of fuel demand in year i for fuel type f that is served by each candidate fuel c is denoted by ρ_{ifc}, and may be determined by either the user directly as an input or by an optimization calculation in a subsequent energy supply tool. For many candidate fuels, ρ_{ifc} does not change over time. However, in some instances, it may vary with time (e.g. a declining emissions factors for grid electricity). The subsector energy demands for each final fuel are translated to subsector energy demands for each candidate fuel as shown in Equation 12:

$$E_{ic} = \sum_{f} (E_{if} * \rho_{ifc}) \qquad 02$$

The emissions factors, β_{icp}, are known for each year i, candidate fuel c, and pollutant p (i.e. each GHG modeled). Subsector emissions, γ_{ip}, for each year i pollutant p are calculated as shown below:

$$\gamma_{ip} = \sum\nolimits_{c} (E_{ic} * \beta_{icp}) \tag{13}$$

Captured Emissions from CCS and Negative Emissions Technologies

Final subsector emissions account for any negative emissions that are captured through CCS. CCS can be applied to both energy only subsectors and emissions only subsector as specified by the user. CCS is assumed to capture CO2. Key CCS inputs for energy only subsectors include:

- E_{if}, final energy demand for a general subsector year i for fuel type f (output of prior model calculations)
- τ_{if}, the percentage of operations that CCS will be applied to in year i for the combustion of fuel type f (e.g. for an energy only subsector, CCS might be applied to 90% of operations where coal is being combusted)
- μ_{if}, the capture rate for CCS applied to in year i for the combustion of fuel type f
- β_f, the gross CO2 emission factor for fuel type f (i.e. the metric tons of CO2 emitted per MMBtu of fuel type f consumed)

The emissions captured in year i, γ_i^{CCS}, are calculated as shown in Equation 14:

$$\gamma_i^{CCS} = \sum\nolimits_{f} (E_{if} * \beta_f * \tau_{if} * \mu_{if}) \tag{14}$$

For emissions only subsectors, the CCS will be applied to a fraction of the subsector emissions. In this case, the CCS will not be capturing emissions from combusted fuels. The captured emissions are instead calculated as shown in Equation 15:

$$\gamma_i^{CCS} = \gamma_i * \tau_i * \mu_i \tag{15}$$

where:

- γ_i are the CO2 emissions for the emissions only subsector in year i absent any CCS,
- τ_i is the percentage of operations that CCS will be applied to in year i, and
- μ_i is the capture rate for CCS applied to in year i

CCS equipment also demands energy to operate. Emissions associated with these energy demands are accounted for in the subsector where the CCS is applied.

In some cases, other negative emissions technologies (NETs) may also be represented (e.g. direct air capture). NETs are treated in the same way as CCS, except that the captured emissions from NETs are specified directly as a model input rather than being calculated, as they are not tied directly to emissions from other subsectors. Energy demands and costs for NETs are calculated using the same methodology as described for CCS.

Additional CCS Energy Demands

If CCS is applied in the subsector, then the additional energy demands associated with running the CCS equipment will also be accounted for. Key inputs to calculate these energy demands are:

- ε_{if}^{CCS}, the energy demand required to operate any CCS equipment in year i of fuel type f per metric ton of captured CO2
- γ_i^{CCS}, the metric tons of captured CO2 in year i across the subsector

The additional energy demand to run the CCS equipment, E_{if}^{CCS} is calculated as shown in Equation 16:

$$E_{if}^{CCS} = \varepsilon_{if}^{CCS} * \gamma_i^{CCS} \qquad 06$$

Additional CCS Costs

If CCS is applied in the subsector, then the additional costs associated with purchasing and running the CCS equipment will also be accounted for. These include:

- **CCS capital costs:** the annual levelized cost of incremental CCS capacity. This is calculated by levelizing the overnight capital cost of the equipment based on an assumed financing rate and financing lifetime.
- **CCS operation and maintenance (O&M) costs:** the annual variable costs associated with operating and maintaining the CCS equipment.
- **Fuel costs:** annual costs associated with fuel consumption in the by the CCS equipment.

Appendix B: Load Shaping Methodology

Table 70 summarizes all electricity consuming or producing devices in the PATHWAYS analysis and the name of the load shape used to evaluate its peak impacts. Often, there is a many to one relationship between the PATHWAYS devices and load shape database. The third column of Table 70 reports the source of the load shape.

Table 70. PATHWAYS devices and load shapes

PATHWAYS Default Devices	Shape Group	Source
Commercial Air Conditioning Air Source Heat Pump - Cooling	Commercial Central Air Conditioning	ADM
Commercial Air Conditioning Efficient Air Source Heat Pump - Cooling	Commercial Central Air Conditioning	ADM
Commercial Air Conditioning Centrifugal Chiller	Commercial Central Air Conditioning	ADM
Commercial Air Conditioning Commercial Central AC	Commercial Central Air Conditioning	ADM

Commercial Air Conditioning Efficient Commercial Central AC	Commercial Central Air Conditioning	ADM
Commercial Air Conditioning Ground Source Heat Pump - Cooling	Commercial Central Air Conditioning	ADM
Commercial Air Conditioning Reciprocating Chiller	Commercial Central Air Conditioning	ADM
Commercial Air Conditioning Rooftop AC	Commercial Room Air Conditioning	ADM
Commercial Air Conditioning WallRoom AC	Commercial Room Air Conditioning	ADM
Commercial Cooking Electric Range Oven	Commercial Cooking	ADM
Commercial Cooking Induction Range Oven	Commercial Cooking	ADM
Commercial General Service Lighting CFL	Commercial General Service Lighting	ADM
Commercial General Service Lighting GSL LED	Commercial General Service Lighting	ADM
Commercial General Service Lighting Halogen	Commercial General Service Lighting	ADM
Commercial General Service Lighting Halogen Infrared Reflector	Commercial General Service Lighting	ADM
Commercial General Service Lighting Halogen Par38	Commercial General Service Lighting	ADM
Commercial General Service Lighting Incandescent	Commercial General Service Lighting	ADM
Commercial HID Lighting HID LED	Commercial HID Lighting	ADM
Commercial HID Lighting High Pressure Sodium	Commercial HID Lighting	ADM
Commercial HID Lighting Mercury Vapor	Commercial HID Lighting	ADM
Commercial HID Lighting Metal Halide	Commercial HID Lighting	ADM
Commercial Linear Lighting High Efficiency Linear Fluorescent	Commercial Linear Lighting	ADM
Commercial Linear Lighting LFL LED	Commercial Linear Lighting	ADM
Commercial Linear Lighting reference Linear Fluorescent	Commercial Linear Lighting	ADM
Commercial Refrigeration Beverage Merchandisers	Commercial Refrigeration	ADM
Commercial Refrigeration Efficient Beverage Merchandisers	Commercial Refrigeration	ADM
Commercial Refrigeration Efficient Ice Machines	Commercial Refrigeration	ADM
Commercial Refrigeration Efficient Reach-In Freezers	Commercial Refrigeration	ADM
Commercial Refrigeration Efficient Reach-In Refrigerators	Commercial Refrigeration	ADM
Commercial Refrigeration Efficient Refrigerated Vending Machines	Commercial Refrigeration	ADM
Commercial Refrigeration Efficient Walk-In Freezers	Commercial Refrigeration	ADM
Commercial Refrigeration Efficient Walk-In Refrigerators	Commercial Refrigeration	ADM
Commercial Refrigeration Ice Machines	Commercial Refrigeration	ADM
Commercial Refrigeration Reach-In Freezers	Commercial Refrigeration	ADM
Commercial Refrigeration Reach-In Refrigerators	Commercial Refrigeration	ADM
Commercial Refrigeration Refrigerated Vending Machines	Commercial Refrigeration	ADM
Commercial Refrigeration Walk-In Freezers	Commercial Refrigeration	ADM
Commercial Refrigeration Walk-In Refrigerators	Commercial Refrigeration	ADM
Commercial Space Heating Efficient Air Source Heat Pump with Electric Backup	Commercial Space Heating Efficient Air Source Heat Pump with Electric Backup	E3
Commercial Space Heating Air Source Heat Pump with Electric Backup	Commercial Space Heating Air Source Heat Pump with Electric Backup	E3
Commercial Space Heating Electric Boiler	Commercial Resistance	E3
Commercial Space Heating Electric Resistance	Commercial Resistance	E3
Commercial Space Heating Ground Source Heat Pump	Commercial Ground Source Heat Pump	E3
Commercial Ventilation Constant Flow	Commercial Ventilation Constant Flow	ADM
Commercial Ventilation Efficient Constant Flow	Commercial Ventilation Constant Flow	ADM
Commercial Ventilation Efficient Variable Flow	Commercial Ventilation Variable Flow	ADM
Commercial Ventilation Variable Flow	Commercial Ventilation Variable Flow	ADM
Commercial Water Heating Electric Heat Pump Storage	Commercial Electric Heat Pump Storage	E3
Commercial Water Heating Electric Resistance Storage	Commercial Electric Resistance Storage	E3
Commercial Water Heating Solar with Electric Backup	Commercial Electric Resistance Storage	E3
Residential Central Air Conditioning Central AC	Residential Central Air Conditioning	ADM
Residential Central Air Conditioning Central Air Source Heat Pump - Cooling	Residential Central Air Conditioning	ADM

Residential Central Air Conditioning Efficient Central Air Source Heat Pump - Cooling	Residential Central Air Conditioning	ADM
Residential Central Air Conditioning Efficient Central AC	Residential Central Air Conditioning	ADM
Residential Central Air Conditioning Ground Source Heat Pump - Cooling	Residential Central Air Conditioning	ADM
Residential Clothes Drying Efficient Electric	Residential Clothes Drying	ADM
Residential Clothes Drying Electric	Residential Clothes Drying	ADM
Residential Clothes Washing Efficient Electric	Residential Clothes Washing	ADM
Residential Clothes Washing Electric	Residential Clothes Washing	ADM
Residential Cooking Electric Resistance Stove	Residential Electric Cooking	ADM
Residential Cooking Induction Stove	Residential Electric Cooking	ADM
Residential Dishwashing Efficient Electric	Residential Dishwashing	ADM
Residential Dishwashing Electric	Residential Dishwashing	ADM
Residential Exterior Lighting CFL	Residential Exterior Lighting	ADM
Residential Exterior Lighting Halogen	Residential Exterior Lighting	ADM
Residential Exterior Lighting LED	Residential Exterior Lighting	ADM
Residential Freezing Efficient Electric	Residential Freezing	ADM
Residential Freezing Electric	Residential Freezing	ADM
Residential General Service Lighting CFL	Residential General Service Lighting	ADM
Residential General Service Lighting Halogen	Residential General Service Lighting	ADM
Residential General Service Lighting Incandescent	Residential General Service Lighting	ADM
Residential General Service Lighting LED	Residential General Service Lighting	ADM
Residential Linear Fluorescent Lighting LED	Residential Linear Fluorescent Lighting	ADM
Residential Linear Fluorescent Lighting T12	Residential Linear Fluorescent Lighting	ADM
Residential Linear Fluorescent Lighting T5	Residential Linear Fluorescent Lighting	ADM
Residential Linear Fluorescent Lighting T8	Residential Linear Fluorescent Lighting	ADM
Residential Multi Family Space Heating Efficient Air Source Heat Pump with Electric Backup	Residential Space Heating Efficient Air Source Heat Pump with Electric Backup	E3
Residential Multi Family Space Heating Air Source Heat Pump with Electric Backup	Residential Space Heating Air Source Heat Pump with Electric Backup	E3
Residential Multi Family Space Heating Electric Resistance	Residential Resistance	E3
Residential Multi Family Space Heating Ground Source Heat Pump	Residential Ground Source Heat Pump	E3
Residential Reflector Lighting CFL	Residential Reflector Lighting	ADM
Residential Reflector Lighting Halogen	Residential Reflector Lighting	ADM
Residential Reflector Lighting Incandescent	Residential Reflector Lighting	ADM
Residential Reflector Lighting LED	Residential Reflector Lighting	ADM
Residential Refrigeration Efficient Electric	Residential Refrigeration	ADM
Residential Refrigeration Electric	Residential Refrigeration	ADM
Residential Room Air Conditioning Efficient Room AC	Residential Room Air Conditioning	ADM
Residential Room Air Conditioning Room AC	Residential Room Air Conditioning	ADM
Residential Single Family Space Heating Efficient Air Source Heat Pump with Electric Backup	Residential Space Heating Efficient Air Source Heat Pump with Electric Backup	E3
Residential Single Family Space Heating Air Source Heat Pump with Electric Backup	Residential Space Heating Air Source Heat Pump with Electric Backup	E3
Residential Single Family Space Heating Electric Resistance	Residential Resistance	E3
Residential Single Family Space Heating Ground Source Heat Pump	Residential Ground Source Heat Pump	E3
Residential Water Heating Electric Heat Pump Storage	Residential Electric Heat Pump Storage	E3
Residential Water Heating Electric Resistance Storage	Residential Electric Resistance Storage	E3
Transportation Buses Battery Electric	Residential Electric Resistance Storage	E3
Transportation Heavy Duty Trucks Battery Electric	Heavy Duty Vehicle	E3
Transportation Light Duty Cars BEV	Light Duty Vehicle	E3
Transportation Light Duty Cars PHEV	Light Duty Vehicle	E3
Transportation Light Duty Trucks BEV	Light Duty Vehicle	E3

Transportation Light Duty Trucks PHEV	Light Duty Vehicle	E3
Transportation Light Medium Duty Trucks Battery Electric	Medium Duty Vehicle	E3
Transportation Medium Duty Trucks Battery Electric	Medium Duty Vehicle	E3
Residential Solar PV	Residential PV	NVE
Commercial Solar PV	Commercial PV	NVE
Residential Storage	Residential BTM Storage	E3-NVE
Commercial Storage	Commercial BTM Storage	E3-NVE
Transportation Heavy Duty DR Unmanaged	Unmanaged HDV	E3
Transportation Heavy Duty DR Managed	Managed HDV	E3
Transportation Heavy Duty DR Managed w/ VGI	VGI HDV	E3
Transportation Light Duty DR Unmanaged	Unmanaged LDV	E3
Transportation Light Duty DR Managed	Managed LDV	E3
Transportation Light Duty DR Managed w/ VGI	VGI LDV	E3
Medium Heavy Duty DR Unmanaged	Unmanaged MDV	E3
Medium Heavy Duty DR Managed	Managed MDV	E3
Medium Heavy Duty DR Managed w/ VGI	VGI MDV	E3
Major Projects	Major Projects	E3
Behavioral EE	Behavioral EE	ADM
Non-Equipment Residential HVAC	Non-Equipment Residential HVAC	ADM
Non-Equipment Commercial HVAC	Non-Equipment Commercial HVAC	ADM
Commercial DR HVAC	Commercial HVAC DR	E3-NVE
Commercial DR Lighting	Commercial Lighting DR	E3-NVE
Commercial DR Misc.	Commercial Misc. DR	E3-NVE
Residential DR HVAC	Residential HVAC DR	E3-NVE
Residential DR Misc.	Residential Misc. DR	E3-NVE
Residential DR WH	Residential WH DR	E3-NVE

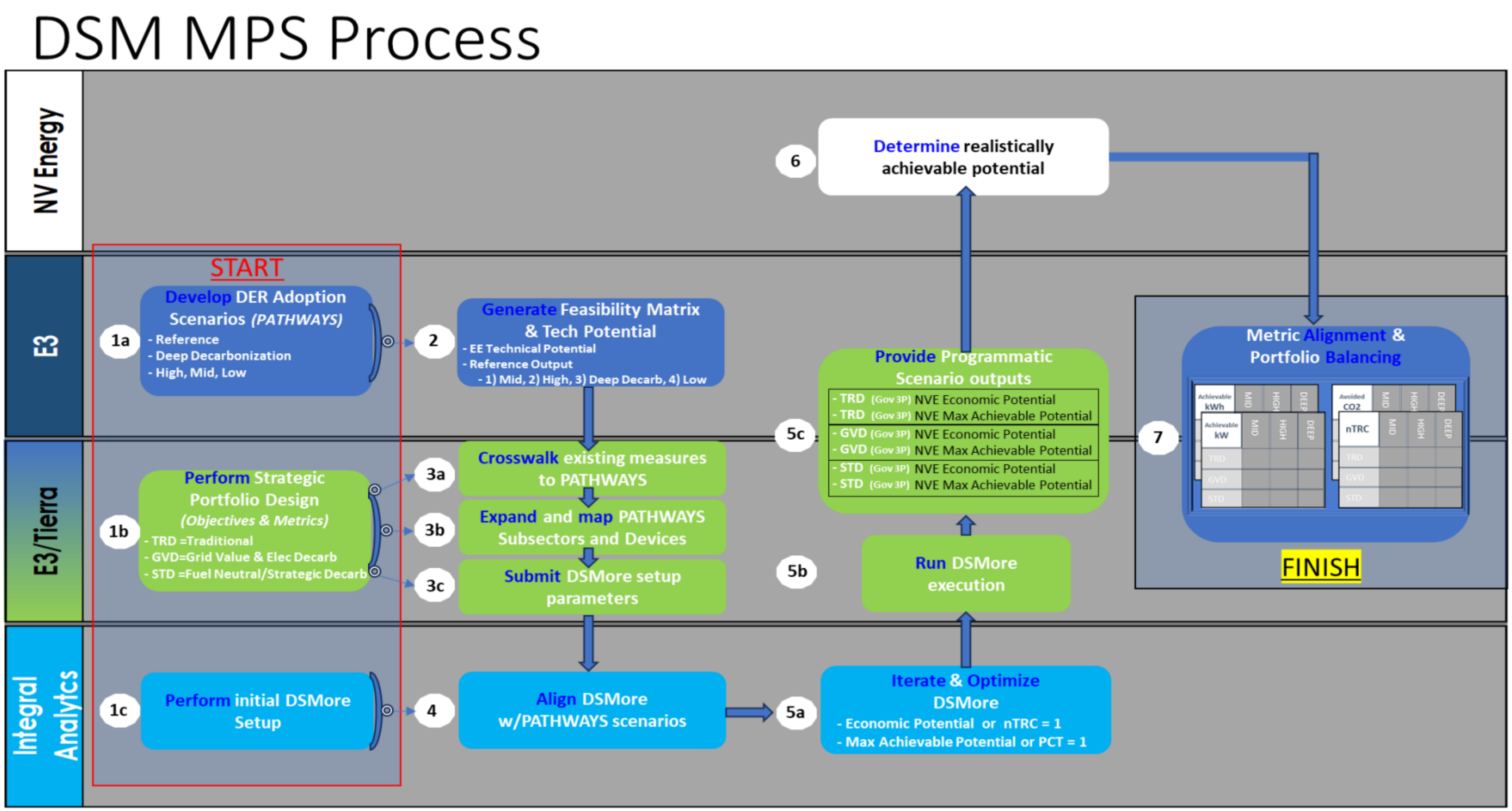
Appendix C: Data Sources for Feasibility Screen

Table 71. Feasibility screen data inputs

Sector	Cost Category	Sources
Buildings	Capital and maintenance costs of appliances	• Energy & Environmental Economics. (2019). Residential Building Electrification in California. • U.S. Energy Information Administration. (2023). Updated Buildings Sector Appliance and Equipment Costs and Efficiencies. • TRC. (2016). Palo Alto Electrification Final Report.
Transportation	Capital and maintenance costs of vehicles	• International Council on Clean Transportation. (2019). Update on electric vehicle costs in the United States through 2030. • Argonne National Laboratory. (2021). Comprehensive Total Cost of Ownership Quantification for Vehicles with Different Size Classes and Powertrains.

Sector	Cost Category	Sources
Electricity Generation	Capital and maintenance costs of electricity generation and T&D	• National Renewable Energy Laboratory. (2023). 2022 Standard Scenarios Report: A U.S. Electricity Sector Outlook • National Renewable Energy Laboratory. (2022). 2022 Annual Technologies Baseline • U.S. Energy Information Administration. (2023). 2022 Standard Scenarios Report: A U.S. Electricity Sector Outlook
All Sectors	Non-electric fuel prices	• U.S. Energy Information Administration. (2023). 2022 Standard Scenarios Report: A U.S. Electricity Sector Outlook

Appendix D: Process Flow Diagram Presented on March 4, 2024, Stakeholder Meeting



Appendix E: Forecasting Anywhere Methodology

Introduction

This document summarizes the methodology of Forecasting Anywhere (FA), a geospatial distributed energy resources (DER) adoption model developed by Energy and Environmental Economics (E3) and Integral Analytics (IA). FA was used to provide NV Energy (NVE) with a geospatial adoption forecast consistent with the Mid DER adoption scenario developed using E3's PATHWAYS model in support of NVE's DER Market Potential Study (MPS). The NVE MPS explored the potential for adoption of energy efficiency, building electrification, transportation electrification, demand response (DR), managed charging, and behind-the-meter (BTM) solar and storage.

Model Overview

The first step in FA is to determine technical potential, which defines how much DER adoption can occur at a given location. Several datasets are used to define technical potential including data on parcels, businesses, and the location of parking lots. Technical potential for residential and commercial energy efficiency, building electrification, and DR are defined in units of building square footage. The technical potential for BTM solar and storage is defined in units of installed capacity. The units of technical potential for transportation electrification are number of chargers.

The next step in FA is to calculate the propensity, or likelihood, of DER adoption in every location in which there is technical potential for adoption. E3 and IA use a combination of heuristic and machine learning (ML) propensities. ML propensities were developed by training regression models on geospatial demographic variables predicting historical adoption. To develop an ML model, a large amount of geospatial data on historical adoption is needed, and therefore, ML propensities were only developed for DER types where that data was available. Heuristic propensities are developed by considering factors that are known to influence DER adoption such as income, current electricity usage, neighbor participation, business type, business size, etc. to develop a score that represents the likelihood of adoption. The heuristic methodologies are not necessarily less robust than ML methodologies as the heuristic approach allows for consideration of how DER adoption patterns may evolve in the future rather than rely solely on historical adoption patterns.

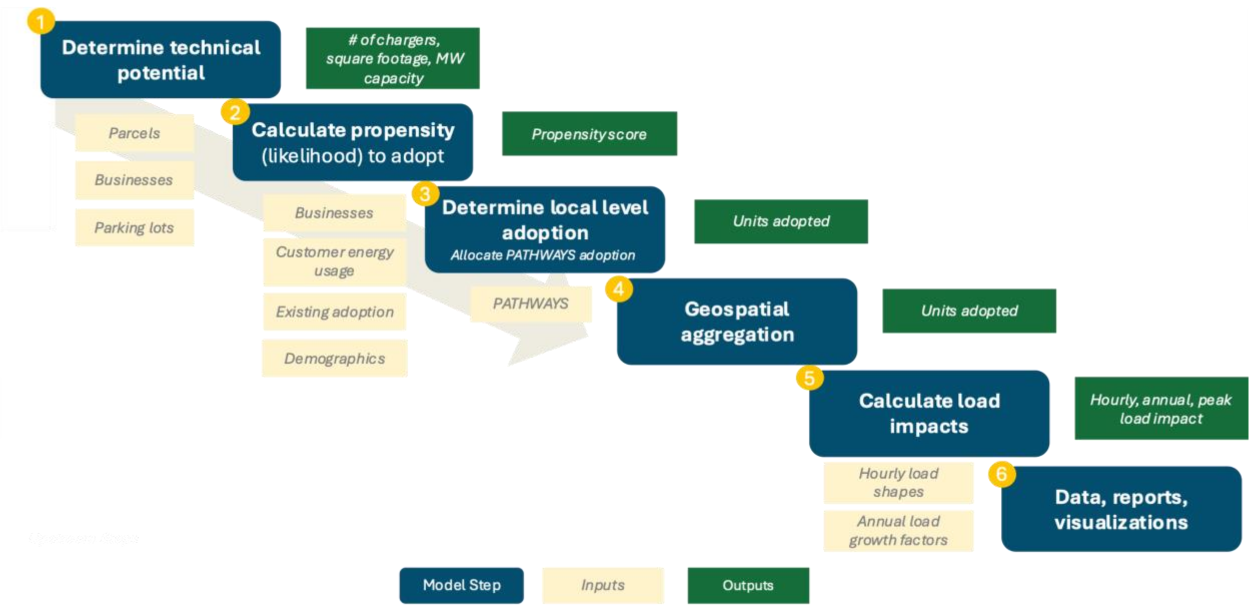
Technical potential and propensity are geospatially defined using hexagonal hierarchical spatial index system (H3), which maps the world into hexagonal grids of varying spatial resolution. FA uses the H3 system to map all datasets used to define technical potential and propensity to an H3 cell or hexagon, which allows for the consideration of multiple data sources. Technical potential and propensity are defined at level 11 cell and are approximately 2,100 square meters allowing technical potential and propensity to be defined with a high level of spatial resolution.

After defining technical potential and propensity, the FA model takes a regional adoption forecast—developed by PATHWAYS modeling in the MPS—and geospatially allocates DER adoption to places where adoption can occur considering the likelihood of adoption in those locations. The geospatial allocation is aggregated up from the level 11 H3 cells to the census block group level as a meaningful level of spatial resolution for FA. The output of the spatial allocation is adoption in units consistent with how technical potential is defined (e.g. square footage, chargers, kW installed capacity).

Next, the spatially allocated adoption is multiplied by per unit load shapes to calculate the load impacts of DERs. The load impact calculation considers how the load impact per unit of DER evolves over time. For example, if the efficient device options on the market improve over time, the load impacts of energy efficiency scale accordingly.

Finally, E3 and IA generate data visualizations and tables that can be incorporated into NVE's distribution system planning tools.

Figure 45. Forecasting Anywhere Model Overview



Technical Potential

Technical potential is the upper bound on the amount of DER adoption that can occur in a location. This section summarizes how technical potential was developed for each of the DER types modeled in FA.

Building Electrification, Energy Efficiency, and Demand Response

The technical potential for most of FA's building-related agents is in the form of building square footage. The geospatial distribution of this square footage is determined using ReGrid parcel data. This dataset includes detailed information about the size and number of buildings on each parcel for the entire U.S.

Behind-the-Meter Solar and Storage

We use data from Google Sunroof on technical potential for rooftop solar. The Google Sunroof data is publicly available at the census tract level, which we allocated down to the H3 cells using the building data. We allocate the census tract level capacity based on the roof areas of buildings ranked by ideal orientation according to the direction of their major axis. We assign the technical potential in a census tract based on ideal orientation until the technical potential in the areas is exhausted. This produces the PV technical potential for all buildings in the region.

Using this BTM solar technical potential, we assume that a building can have N battery systems in it of size 5 kW. This N value is determined by the size of the PV system relative to the average solar size of the region (base on technical potential). For example, if a building can have a PV system that is 2 times larger than the average solar size of the region, it is assumed to have a BTM storage technical potential of 10 kW (2 x 5kW).

Home L2

The technical potential for home level 2 (L2) chargers is determined based on the square footage of residential buildings. For residential buildings larger than 10,000 square feet, we assume 1 home L2 charger per 3,000 square feet. For buildings smaller than, 10,000 square feet, we assume 1 home L2 charger. The technical potential in a cell is capped at 50 chargers.

Public L2 and DCFC

The technical potential for public chargers is determined by available parking spaces. We use data from OpenStreetMap on the parking area in each location. We assume that parking lots provide 1 space per 28 square meters of area and that at most 1 out of every 10 spaces in a parking lot can be dedicated to direct current fast chargers (DCFCs). For public L2 chargers, we determined the technical potential as the of the number of parking spaces. Additionally, we subtract existing public chargers from our calculations of technical potential to avoid over saturation.

Work L2

To determine the technical potential for workplace charging, we use the parking area data and divide by the assumption that a parking space requires 28 square meters and that 1 charger can installed per parking space.

Fleet L2 and MHDV Chargers

The technical potential for light-duty vehicle (LDV) fleet L2, medium-duty vehicle (MDV) L2, and heavy-duty vehicle (HDV) DCFC chargers is determined by the number of employees at certain business types in the area. Employment and business data is from Environmental Systems Research Institute, Inc. (ESRI). We apply ratios that reflect how the number of vehicles at a business scale by its size, using employees as a proxy for size. The ratios are chargers per employee considering the maximum number of chargers needed to serve full fleet electrification of that business. Ratios are differentiated by business type.

Propensities

In FA, every location identified to have technical potential for DER adoption receives a propensity score, which is a value between 0 and 1 representing the relative likelihood of adoption in that location. The methodology for developing propensity scores for each DER types is discussed in this section.

Building Electrification

Residential

The propensity to adopt a heat pump for space or water heating is determined by the size of the home and the presence of the homes using electricity for heating in the area. Data from the California Energy Commission's (CEC) Residential Appliance Saturation Survey (RASS)[41] suggests that smaller homes are more likely to have electric heating than larger homes although the correlation is weak. RASS data did not suggest a relationship between home heating fuel and income or vintage. The propensity scoring for residential building electrification considers the residential building square footage in a cell as a proxy for home size as well as the share of existing homes using either electric resistance or heat pumps for heating as reported by the ResStock analysis tool, developed by the National Renewable Energy Laboratory (NREL), which reports fuel mix at the county level.[42]

A detailed distribution of existing heating fuel mix within counties that are served by NVE is provided in the table below.

---

[41] California Energy Commission, 2019 Residential Appliance Saturation Survey, https://www.energy.ca.gov/data-reports/surveys/2019-residential-appliance-saturation-study

[42] National Renewable Energy Laboratory, ResStock, https://resstock.nrel.gov/datasets

Table 72. Existing Heating Fuel Mix at County Level (Source: ResStock, NREL)

	Electricity	Natural Gas	Other
Washoe County	21%	71%	6%
Clark County	30%	69%	1%
Nye County	48%	28%	25%
Douglas County	9%	74%	18%
Carson City	18%	72%	10%
Elko County	38%	21%	42%
Humboldt County	35%	52%	13%
Pershing County	47%	17%	34%
White Pine County	14%	33%	54%
Lyon County	11%	81%	8%
Churchill County	35%	42%	23%
Lander County	56%	26%	18%
Lincoln County	43%	11%	46%
Esmeralda County	0%	100%	0%
Mineral County	45%	29%	28%
Storey County	0%	53%	47%
Eureka County	100%	0%	0%

Commercial

The propensity to adopt a heat pump for space heating for commercial buildings is determined by the sales of the businesses and business types, as defined by the North American Industry Classification System (NAICS). Data from the California Commercial End-Use Survey (CEUS)[43], prepared by Itron for the California Energy Commission (CEC), was utilized to understand the share of either electric resistance or heat pumps for heating across the different commercial building types. CEUS data did not suggest a relationship between building heating fuel and size. The propensity scoring for commercial building electrification considers the NAICS code for businesses with higher sales value in a cell as a proxy for higher financial flexibility to invest in heat pump adoption.

Energy Efficiency

Residential

The propensity to adopt energy efficiency measures in residential buildings is based on household income and electricity consumption. Data on the average electricity consumption by rate class and zip code was used to geospatially characterize variations in residential electricity consumption. For the efficiency measure related to air conditioning, only the average electricity consumption during

[43] California Energy Commission, California Commercial Energy -Use Survey, 2006, https://planning.lacity.gov/eir/CrossroadsHwd/deir/files/references/C19.pdf

the summer months was utilized to accurately capture the consumption pattern during months of peak cooling, while for the other efficiency measures, the annual average electricity consumption was employed. The approach for propensity scoring for residential buildings assumes households with higher income to have greater flexibility for capital investment in energy efficiency measures and that residential customers currently exhibiting higher electricity consumption have increased motivation to adopt energy efficiency measures to lower their bills. Greater emphasis was placed on income than current electricity consumption in determining propensity, particularly for air conditioning.

Commercial

The propensity to adopt energy efficiency measures for commercial buildings is based on annual electricity consumption. The annual electricity consumption data broken down by rate class and zip code was used to characterize geospatial differences in commercial energy consumption. For the efficiency measure related to air conditioning, only the average electricity consumption during the summer months was utilized to accurately capture the consumption pattern during months of peak cooling, while for the other efficiency measures, the annual average electricity consumption was employed. The approach for propensity scoring assumes the existing share of businesses exhibiting higher electricity use in a cell correlates with increased motivation to adopt energy efficiency measures to lower the costs associated with electricity consumption.

Demand Response

The propensity to participate in DR programs is based on the share of existing DR customers in a neighborhood, income level (referenced for residential buildings only), and annual electricity consumption. The existing customers participating in DR programs are classified by commercial and residential type to avoid mischaracterization of existing participation. The annual electricity consumption is characterized by rate class and zip code. The study titled "*Determinants of Willingness to Participate in Urban Incentive-Based Energy Demand-Side Response: An Empirical Micro-Data Analysis*" by Wang et. al suggests that existing DR customers are more likely to adopt and influence neighboring customers to participate in DR programs[44]. This study also suggests that low-income customers are more likely to participate in DR programs with a motivation to lower the proportion of household expenditure on electricity, with a relatively weak correlation. Additionally, the propensity scoring approach used for this project, assumes the existing share of residential and commercial customers with higher electricity consumption in a cell correlates with increased willingness to participate in DR programs, although the emphasis on this factor is relatively low.

[44] Wang, B.; Cai, Q.; Sun, Z. Determinants of Willingness to Participate in Urban Incentive-Based Energy Demand-Side Response: An Empirical Micro-Data Analysis. Sustainability 2020, 12, 8052. https://doi.org/10.3390/su12198052

Behind-the-Meter Solar and Storage

We generated propensity scores for BTM solar and storage using NVE's existing net-energy metering (NEM) customer data. To conduct granular location analysis and propensity modeling, we geocoded the list of addresses and obtained latitude/longitude coordinates. We then combined these points with a comprehensive set of geographic, demographic, and parcel-level attributes to build ML and regression models. This included geographic data such as proximity to roads, schools, hospitals, etc. as well as Census data on household income, median house value, percentage of ownership vs renter, and level of education, among others. We also matched these solar customers with parcel-level characteristics, such as property value and square footage of house. We used NVE's NEM locations of existing solar customers to train the model and provide a relative propensity score for all customers in the NVE service area.

We developed a simple logistic regression approach and a more complex decision tree regression, both yielding satisfactory results. Please refer to the FA appendix for model performance metrics. The MLmodels were balanced to use the least amount of input variables while still providing acceptable predictive score, using factor analysis and feature importance selection methods to prevent overfitting. The key explanatory variables in the final models were median house value, aggregate household income, owner-occupied housing units, parcel land value, and building square footage. Overall, the adoption rate of BTM solar in NVE was sufficient to train a model and confidently provide propensity scores. However, BTM storage is a recent technology and is not yet widely adopted enough to train and develop a statistically significant model. Nonetheless, we created a simple approach for batter storage that highlights the growing connection between solar customers who are adopting storage.

Home L2

The propensity to adopt a home L2 charger is based on income (US Census) and household size, in order of importance. Homes with higher income are more likely to adopt a charger due to greater potential for capital investment and known historical adoption trends. A smaller portion of the propensity score is based on square footage. Homes with higher square footage are assumed more likely to have a garage, which is known to be correlated with electric vehicle (EV) adoption. In the absence of data on square footage per home, technical potential of residential square footage divided by total population (US Census) is used as an estimate.

Public L2 and DCFC

The likelihood of a location to adopt public L2 chargers is determined by proximity to certain locations (Open Street Maps) in which drivers are likely to park their car or seek charging away from home. In the propensity formula, high emphasis is placed on proximity to shopping, schools, business sales volume (ESRI), and parks. A lower emphasis is placed on proximity to points of interest.

For DCFC, proximity to highway exits is the most significant driving factor of propensity since that is where drivers are likely to need to charge quickly. A medium importance is placed on proximity to shopping, parks, points of interest. Proximity to schools and business sales volume has a low emphasis. These locations are where cars will likely park in public and charge their vehicles.

Fleet L2

The propensity of a location to adopt a fleet L2 charger is determined by the sales volume of businesses in the surrounding area, since businesses with higher sales are more likely to have the capital to spend on fleet electrification. Sales and business data is from ESRI. The sales are weighted based on the relative likelihood of business type (defined by NAICS code) to have a light-duty fleet and electrify it. Work L2

Similar to the fleet L2 propensity methodology, the propensity of a location to adopt a work L2 charger is based on sales and business type. Business sales volume in the surrounding area is weighted by a scalar based on business type, since businesses with higher sales are more likely to have the capital to purchase work chargers, but only certain types of businesses (defined by NAICS code) are likely to offer workplace charging.

Medium and Heavy-Duty Vehicle Chargers

The propensities for MDV L2 and HDV DCFC fleet chargers are calculated similarly to fleet L2 and work L2 propensities. They are determined by sales volume in the surrounding area weighted based on the likeliness of each business type (defined by NAICS code) to have fleet charging for medium and heavy-duty vehicles.

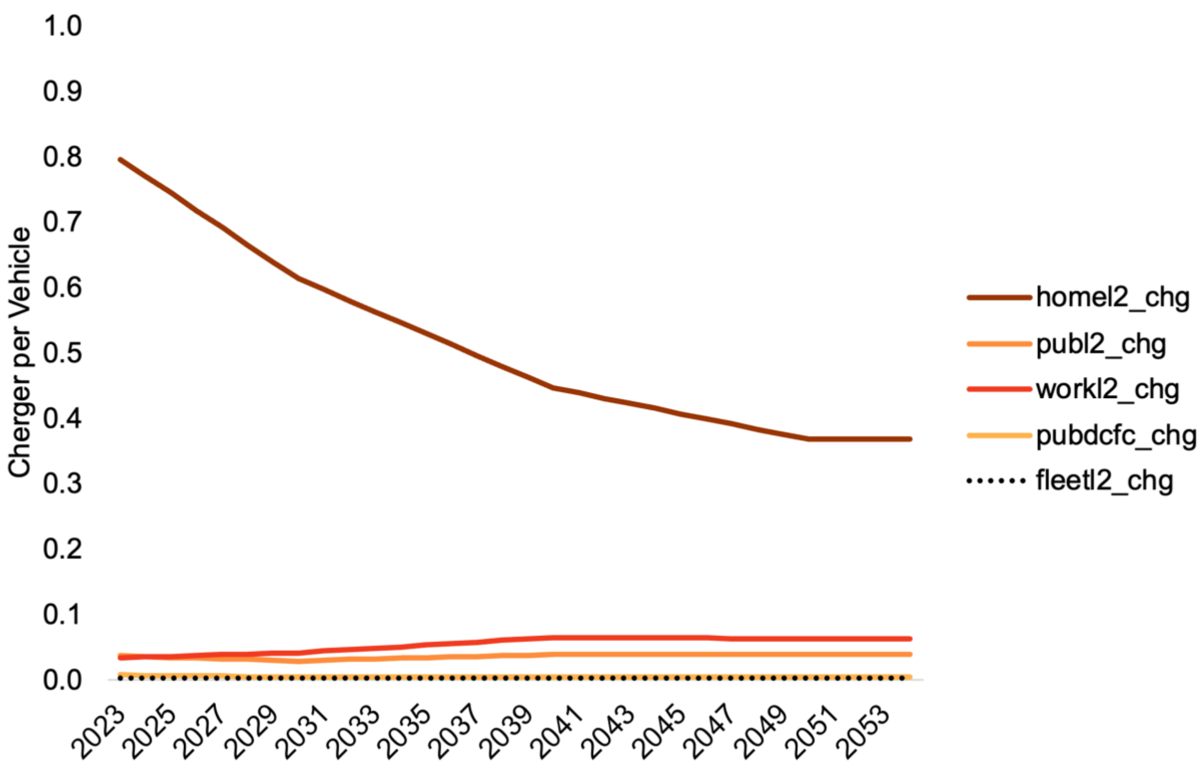
Adoption Forecast

To calculate the adoption forecast used in FA, the PATHWAYS stock forecast is first converted into the units required for FA. While the PATHWAYS model projects adoption in units of devices or system capacity for energy efficiency, building electrification, and DR, the technical potential for those DER types in FA is defined in units of square feet and therefore a translation of units is required between the models. Similarly, PATHWAYS projects the number of electric vehicles, but from the lens of geospatial adoption forecasts, determining the location of charging points serving those vehicles is most relevant for distribution system planning so we convert vehicle adoption forecasts into forecasts of the number of home, workplace, public and fleet chargers needed to support the expected population of EVs. Next, the PATHWAYS stock forecast is filtered down to remove devices (e.g. internal combustion engine vehicles, natural gas furnaces) not relevant to assessing the adoption of DERs. Once we have the correct units for the forecast, we convert the cumulative stock to incremental adoption, and divide each year's adoption by 12 to change from annual to monthly. This incremental, monthly adoption forecast is called our "guarantees." FA will ensure that the guarantees from each month are geospatially allocated. The mapping of PATHWAYS subsector to FA agent ID is described in the FA Appendix.

Electric Vehicle Chargers

For transportation electrification, the PATHWAYS electrification outputs are in units of EVs. To convert the EV forecast into a charger forecast, we run NREL's EVI-Pro Lite[45] tool for a handful of years in the model horizon to estimate the number of chargers needed to support the EV stock. Then we divide the resulting number of chargers by the number of vehicles in each year to get the chargers-to-EV ratios, illustrated in Figure 46. Note that these agents are the only ones with conversion factors that vary annually, the rest described below are all constant.

Figure 46. Annually varying chargers per EV ratios (chargers/vehicle)



[45] US Department of Energy, Alternative Fuels Data Center, https://afdc.energy.gov/evi-x-toolbox#/evi-pro-ports

EVI-Pro Lite does not output fleet chargers for LDV, MDV or HDVs. Instead, a constant chargers per EV ratio based on literature review.[46],[47] These ratios are applied to the EV stock, PATHWAYS Light Duty Vehicles and Light Duty Trucks, to get the EV charger stock.

Commercial Electrification

For commercial building electrification and energy efficiency, PATHWAYS outputs stock in units of capacity. This is divided by the average system capacity per square foot in commercial buildings according to National Energy Modeling System (NEMS) to convert the forecast to square footage.

For commercial lighting, the stock is multiplied by the ratio of the region's total commercial square footage divided by the region's sum of subsector lighting devices. Assumptions about the number of lighting devices are drawn from Energy Information Administration's (EIA) Commercial Building Energy Consumption Survey (CBECS).

Residential Electrification

For residential building electrification and energy efficiency, PATHWAYS outputs stock in units of devices. To convert the forecast to square footage, it is multiplied by the average square footage for a home in Nevada from EIA's Residential Energy Consumption Survey (RECS) and divided by the number of devices per household.

Demand Response

DR agents are post-processed from their corresponding subsectors and devices in the PATHWAYS results. The output units are the number of participating customers or number of thermostats. For residential DR, the DR forecast is converted to square footage by multiplying by the average residential square footage from RECS. For commercial DR, the number of customers is multiplied by square footage per customer from EIA's CBECs and EIA's Annual Energy Outlook. For DR that is modeled in terms of number of thermostats, we apply the PATHWAYS assumptions around thermostats per customer to first convert the stock units to customers.

Solar and Storage

Solar PV and storage agents are forecasted in PATHWAYS in the same units of FA's technical potential (kW) therefore no conversion is required.

---

[46] EIA Annual Energy Outlook 2019 Table 50, https://www.eia.gov/outlooks/aeo/data/browser/#/?id=60-AEO2023&cases=ref2023&sourcekey=0

[47] Federal Highway Administration, Highway Statistics 2018, https://www.fhwa.dot.gov/policyinformation/statistics.cfm

Spatial Allocation

With information about where DERs could be adoption in the form of technical potential, and where adoption is likely to go in the form of propensities, and a total regional adoption forecast in our guarantees, the spatial allocation step of FA generates the geospatially discrete results. This is done using a probabilistic method, where the propensity is used as the likelihood for a site to adopt in any particular iteration. At each iteration a probabilistic sample of all available sites is produced. If the total adopted sites for that sample is too low, then a new sample is taken from the remaining sites until the guarantee is reached. If the total adoption is too high, then a new sample is taken from all available sites. Once the guarantee is reached, the sites that have adopted have their technical potential reduced to account for the new adoption, and the process repeats for the next iteration. In this manner, the spatial allocation retains the general trends encapsulated in the propensity distribution while also maintaining the inherent uncertainty associated with forward looking forecasts.

Load Impacts

After spatially allocating the adoption of guarantees, FA combines the spatial allocation with raw 8760 load shapes to calculate incremental load profiles. Load shape sources by agent or DER type are listed in the table below. Additionally, the load shapes were multiplied by scaling factors that vary over time to reflect changes in device efficiency and energy demand overtime as modeled in PATHWAYS. We reported annual load and non-coincident peak impacts based on the incremental load profiles.

Table 73. Load Shape Sources

DER Type	Load Shape Source
Energy Efficiency	ADM
Transportation Electrification (and Managed Charging)	E3 RESHAPE-EV tool
Building Electrification	E3 RESHAPE tool
DR	NVE-E3 Plexos ST Study
BTM Storage	NVE-E3 Plexos ST Study
BTM Solar	NVE Load Forecasting Analysis

Appendix E1: Forecasting Anywhere Appendix

Forecasting Anywhere Agent ID - PATHWAYS Subsector Mapping

Forecasting Anywhere		PATHWAYS
Type	Agent ID	Subsector
Commercial HVAC EE	comac_eesqft	Commercial Air Conditioning
Commercial Cooking EE	comcook_eesqft	Commercial Cooking
HVAC DR	comac_drsqft	Commercial DR
Commercial Lighting DR	comlght_drsqft	
Commercial Misc. DR	commisc_drsqft	
Commercial Lighting EE	comlght_eesqft	Commercial General Service Lighting, Commercial Linear Fluorescent Lighting, Commercial HID Lighting
Commercial Refrigeration EE	comrefr_eesqft	Commercial Refrigeration
Solar	comres_pvkw	Commercial Solar, Residential Solar
Commercial Heat Pumps	comgen_bsqft	Commercial Space Heating
Storage	comres_battkw	Commercial Storage, Residential Storage
Commercial Ventilation EE	comvent_eesqft	Commercial Ventilation
Commercial HPWH	comhpwh_bsqft	Commercial Water Heating
Residential HVAC EE	resac_eesqft	Residential Central Air Conditioning, Residential Room Air Conditioning
Residential Clothes Drying EE	rescd_eesqft	Residential Clothes Drying
Residential Clothes Washing EE	rescw_eesqft	Residential Clothes Washing
Residential Cooking EE	rescook_eesqft	Residential Cooking
Residential Dishwashing EE	resdw_eesqft	Residential Dishwashing
Residential HVAC DR	resac_drsqft	Residential DR
Residential Misc. DR	resmisc_drsqft	
Residential WH DR	reswh_drsqft	
Residential Freezing EE	resfrz_eesqft	Residential Freezing
Residential Lighting EE	reslght_eesqft	Residential General Service Lighting, Residential Reflector Lighting, Residential Linear Fluorescent Lighting, Residential Exterior Lighting
Residential Heat Pumps	resgen_bsqft	Residential Multi Family Space Heating, Residential Single Family Space Heating
Residential Refrigeration EE	resrefr_eesqft	Residential Refrigeration
Residential HPWH	reshpwh_bsqft	Residential Water Heating
HDV DCFC	hdvdcfc_chg	Transportation Buses, Transportation Heavy Duty Trucks
Public L2	publ2_chg	Transportation Light Duty Cars, Transportation Light Duty Trucks
Fleet L2	fleetl2_chg	
Home L2	homel2_chg	
Public DCFC	pubdcfc_chg	
Work L2	workl2_chg	
MDV L2	mdvl2_chg	Transportation Light Medium Duty Trucks, Transportation Medium Duty Trucks

Machine Learning Model Performance

- **Model Performance**:
    - **Logistic Regression**:
        - Accuracy: 74.9%
        - Precision: 75.2%
        - Recall: 94.7%
    - **Decision Tree**:
        - Accuracy: 80.9%
        - Precision: 83.8%
        - Recall: 89.5%
- **Key Explanatory Variables**: Parcel Land Value, Median House Value, Aggregate Household Income, Owner-Occupied Housing Units, Building Sq Ft.

Appendix F: DSMore Inputs and Outputs

As described in this report, DSMore is a model developed by IA, and used for valuing the cost-effectiveness of energy efficiency and demand response programs. The model develops accurate valuations by capturing all avoided costs and the covariance between prices and loads, and values these impacts across 30 years of actual hourly weather patterns, which ensures accuracy in quantifying avoided costs.

For this MPS, the analysis team combined DSMore's analytical power with utility-level inputs (see Table 74), program-level inputs, and measure-level inputs (see Table 75) to achieve cost-effectiveness results that are specific to NPC's and SPPC's circumstances. In the compilation of these inputs, the analysis team utilized a wide range of sources. Whenever possible, the team utilized actual data from the most recent program year during which efficiency measures were delivered in NVE territory. However, in instances where potential new measures were being modeled for the MPS, or NVE-specific data was otherwise unavailable, the team looked to other regional jurisdiction for appropriate data, including Arizona Public Service (APS), the Regional Technical Forum (RTF), and California's Electronic Technical Reference Manual (eTRM). To improve the robustness of the measure-level cost-effectiveness calculations, the team allocated program costs among the individual measures that may be delivered in a given DSM program. These program administration and implementation costs were based on the existing NVE DSM portfolio and distributed among program measures proportionately on a $/kWh savings basis. The tables below contain a list of the data inputs utilized and a general description of the sources utilized for each data point. The actual values utilized for each input can be seen within the attached DSMore Template and Batch Input files, utilized as part of the MPS.

Table 74. DSMore Utility-level Inputs and Sources

DSMore Input Field	DSMore Input Sheet	Data Source
Line Loss – Energy	Utility Input	NVE
Line Loss – Demand	Utility Input	NVE
Tax Rate (%)	Utility Input	NVE
Discount Rate	Utility Input	NVE
Coincident Month	Utility Input	NVE
Coincident Hour	Utility Input	NVE
Avoided Energy Costs ($/kWh)	Utility Input	NVE
Avoided Capacity ($/kW Annualized)	Utility Input	NVE
Avoided Electric T&D ($/kW)	Utility Input	NVE
Retail Rates ($/kWh)	Utility Input	NVE
Supplemental Reserve Margin (%)	Utility Input	NVE
Base CCF Charge ($/CCF)	Utility Input	NVE
Electric Price Files	Utility Input	NVE
Inflation Rate	Notes	NVE

Table 75. DSMore Program/Measure-level Inputs and Sources

DSMore Input Field	DSMore Input Sheet	Data Source(s)
Mode	Program Input	MPS Analysis Team

Measure Life	Program Input	NVE M&V Reports, or Measure Characterizations from eTRM, RTF, and APS
Initial Calendar Year	Program Input	MPS Analysis Team
Sector	Program Input	MPS Analysis Team
Category	Program Input	MPS Analysis Team
Program	Program Input	NVE
Utility	Program Input	NVE
Free Riders	Program Input	NVE M&V Reports, or Measure Characterizations from eTRM, RTF, and APS
Unit Energy Savings	Program Input / End Use	NVE M&V Reports, or Measure Characterizations from eTRM, RTF, and APS
Annual Target Gas CCF	Program Input / Loadshapes	NVE M&V Reports, or Measure Characterizations from eTRM, RTF, and APS
Annual Summer Coincident Target kW	Program Input / Loadshapes	NVE M&V Reports, or Measure Characterizations from eTRM, RTF, and APS
Coincident Hour	Utility Input	NVE
Participants / Installs	Program Input	NVE M&V Reports; Technical Potential Analysis
One-time Participant Costs	Program Input	NVE M&V Reports, or Measure Characterizations from eTRM, RTF, and APS
Participant Rebates	Program Input	NVE M&V Reports
Up-stream Incentives	Program Input	NVE M&V Reports
Implementation Costs	Program Input	NVE M&V Reports
Administration Costs	Program Input	NVE M&V Reports
End Use 8,760 Loadshape	End Use	NVE M&V Reports, or Measure Characterizations from California, RTF, and APS

Table 76 shows the specific DSMore outputs that were utilized as part of this MPS analysis. These outputs can be recreated using the attached DSMore Template and Batch files. DSMore also contains many other data outputs that are available to users but were not utilized as a component of this MPS analysis.

Table 76. DSMore Outputs Utilized in Potential Calculations

DSMore Output Field	DSMore Sheet	Utilization
Annual Energy Savings w/ Losses (kWh)	Financial Reports	nTRC, Technical, Economic, and Achievable Potential
Net Annual Energy Savings w/ Losses (kWh)	Financial Reports	nTRC, Technical, Economic, and Achievable Potential
Lifetime Energy Savings w/ Losses (kWh)	Financial Reports	nTRC, Economic Potential
Net Lifetime Energy Savings w/ Losses (kWh)	Financial Reports	nTRC, Economic Potential
Coincident Summer Demand Savings w/ Losses (kW)	Financial Reports	nTRC, Technical, Economic, and Achievable Potential
Net Coincident Summer Demand Savings w/ Losses (kW)	Financial Reports	nTRC, Technical, Economic, and Achievable Potential
TRC Total Benefits	Test Results	nTRC, Economic Potential
TRC Total Costs	Test Results	nTRC, Economic Potential
TRC Benefit Cost Ratio	Test Results	nTRC, Economic Potential
TRC Avoided Electric Production	Test Results	nTRC, Economic Potential
TRC Avoided Electric Production Adders	Test Results	nTRC, Economic Potential
TRC Avoided Electric Capacity	Test Results	nTRC, Economic Potential
TRC Avoided Electric T&D	Test Results	nTRC, Economic Potential
TRC Avoided Gas Production	Test Results	nTRC, Economic Potential
TRC Administration Costs	Test Results	nTRC, Economic Potential
TRC Implementation / Participation Costs	Test Results	nTRC, Economic Potential
TRC Other / Miscellaneous Costs	Test Results	nTRC, Economic Potential
TRC Incentives	Test Results	nTRC, Economic Potential
TRC Participant or Unit Costs (Net)	Test Results	nTRC, Economic Potential
Total tCO2 Emissions	Loadshapes	Portfolio Metrics
Total kWh Source	Loadshapes	Portfolio Metrics
Utility Program Costs - Administration - 1st Year	Financial Reports	nTRC, Economic Potential
Utility Program Costs - Implementation - 1st Year	Financial Reports	nTRC, Economic Potential
Utility Program Costs - Incentives - 1st Year	Financial Reports	nTRC, Economic Potential, Achievable Potential
Utility Program Costs - Other - 1st Year	Financial Reports	nTRC, Economic Potential
Utility Program Costs - Total - 1st Year	Financial Reports	nTRC, Economic Potential
Utility Program Costs - Administration - Total	Financial Reports	nTRC, Economic Potential
Utility Program Costs - Implementation - Total	Financial Reports	nTRC, Economic Potential
Utility Program Costs - Incentives - Total	Financial Reports	nTRC, Economic Potential, Achievable Potential
Utility Program Costs - Other - Total	Financial Reports	nTRC, Economic Potential
Utility Program Costs - Total - Total	Financial Reports	nTRC, Economic Potential
Undiscounted Payback	Financial Reports	Achievable Potential
Rebate for 90% of Cost	Financial Reports	Achievable Potential
Custom Adoption Fraction Undiscounted	Notes	Achievable Potential
90% Rebate % Adoption Fraction Undiscounted	Notes	Achievable Potential