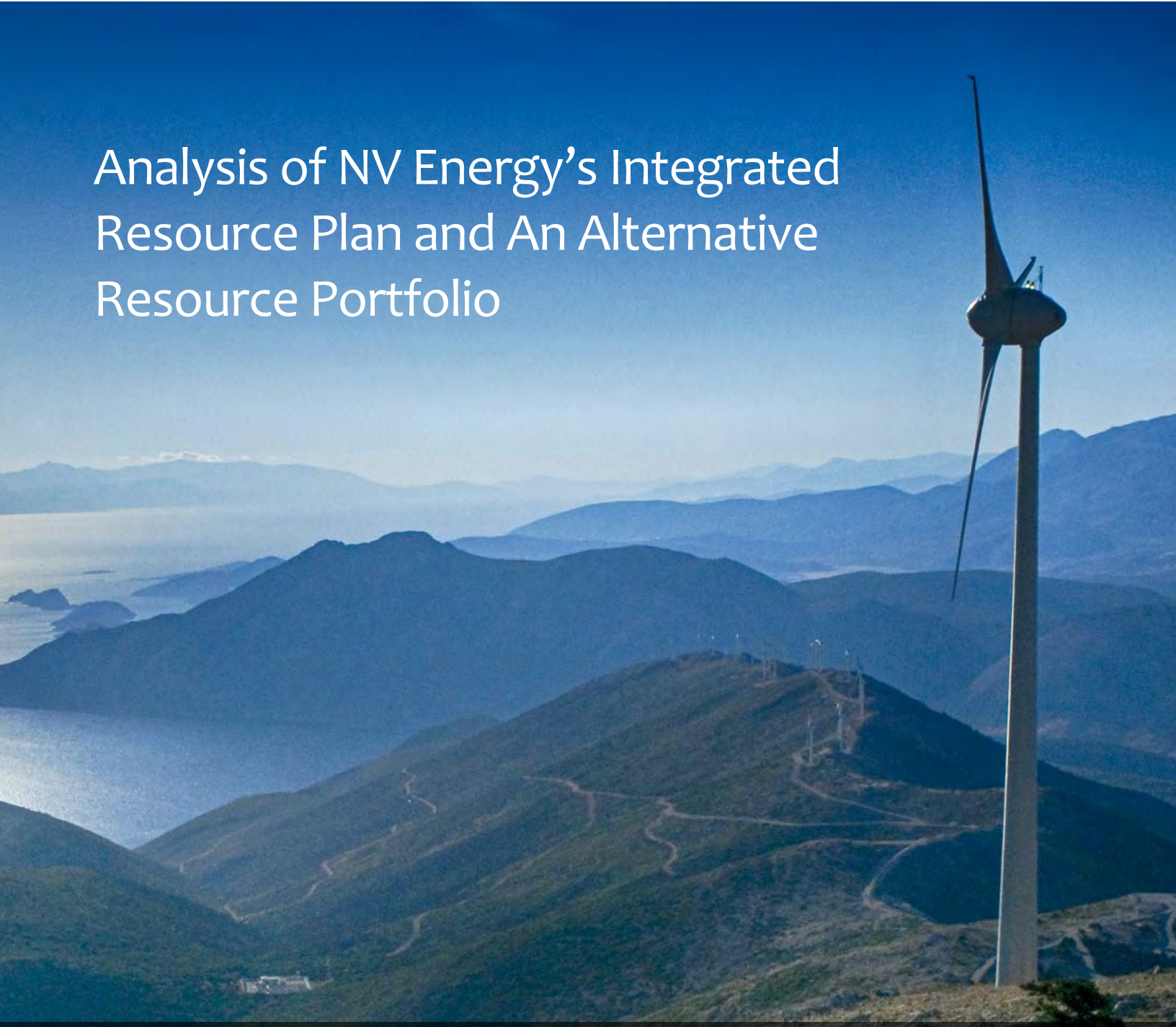
Analysis of NV Energy's Integrated Resource Plan and An Alternative Resource Portfolio



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Prepared For:

Western Resource Advocates

December 19, 2018

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Contents

Introduction

The following analysis was commissioned by Western Resource Advocates (WRA), in consultation with the Southwest Energy Efficiency Project (SWEEP), regarding the 2018 Integrated Resource Plan (IRP) filed by NV Energy (NVE). The overarching objective of this analysis is to develop a portfolio of resources that meets NV Energy's capacity needs and energy needs, while adding additional clean energy resources beyond the Action Plan period and continuing to reduce carbon emissions. A secondary goal of the analysis was to evaluate a resource mix that would enable NVE to comply with a 50% renewable energy standard, a policy consistent with Question 6, the Renewable Energy Promotion Initiative, which will be on the ballot in the 2018 general election.

NV Energy's Preferred IRP Portfolio, the Low Carbon case, adds over 1 GW of renewable resources and battery storage during the Action Plan period. However, beyond the Action Plan, the portfolio includes significant amounts of new natural gas, which would contribute to rising carbon emissions over the long term, as well as additional fuel and capital costs. The Alternative Portfolio developed here would reduce future investments in natural gas and replace those resources with increased levels of energy efficiency, renewables, and battery storage. Specifically, over the next 20 years, the Alternative Portfolio

- Eliminates the need for over 1,600 MW of new natural gas additions, which are included in NVE's Low Carbon case;
- Reduces peak demand by over 2,000 MW through energy efficiency programs and demand response;
- Adds over 5,000 MW of new solar, wind, and geothermal resources (inclusive of the 1 GW of renewables in the Low Carbon Action Plan); and
- Adds 700 MW of new energy storage resources.

The Alternative Portfolio would put NVE on a path to meet a 50% renewable energy standard by 2030, and could save customers over $192 million, compared to the Low Carbon portfolio selected by NVE.[1]

Given limited budget and time constraints, the analysis presented here does not provide the full suite of technical modeling that could be pursued in developing an IRP. Nevertheless, we believe the analysis presented is sufficient to provide insight into the viability of the Alternative Portfolio and we recommend that it or a similar portfolio be thoroughly examined between now and the next IRP cycle. We believe this provides a valuable "proof of concept" for what could be achieved while providing reasonable estimates of the potential costs and operational issues that may be encountered along the way.

[1] This value reflects the difference in the present worth revenue requirements (PWRR) 2019-2038 of the two resource portfolios under a No Carbon price scenario.

Summary of the Resource Portfolio Selected by NVE

In its 2018 IRP, NVE selected a resource portfolio (the "Low Carbon Case" or "Preferred Portfolio") that includes significant utility-scale renewable resources in the near-term, significant natural gas resource additions over the long-term, moderate demand-side management efforts, and some near-term battery storage resources additions. Specifically, the plan includes the following:

- Over 2,200 MW of natural gas resource additions by 2038. This includes more than 1,600 MW of new build gas resources and 600 MW of summer tolling agreements.[2] Over the 30-year horizon (2019-2048), NVE's portfolio includes over 7,200 MW of new-build natural gas additions.
- Over 2,400 MW of new solar PV resources by 2038, including 1,300 MW within the next 5 years.[3]
- 56 MW of geothermal resource additions by 2038.
- 100 MW of near-term battery storage additions; however, these additions are retired and not replaced over the 20-year time horizon.
- Over 1,300 MW in cumulative peak demand reduction from energy efficiency by 2038 (approximately 65-70 MW per year) and over 300 MW of demand response by 2038.
- The expiration of several renewable energy resource contracts in the 20-year timeframe that are not replaced or renewed, including 150 MW of wind and over 400 MW of geothermal.

[2] Up to 865 MW of summer tolling resources are initially included, however only 600 MW remain in the 2038 timeframe.

[3] Net additions of solar PV are less than 2,400 MW, since ~325 MW of existing solar PV PPA contracts expire by 2038.

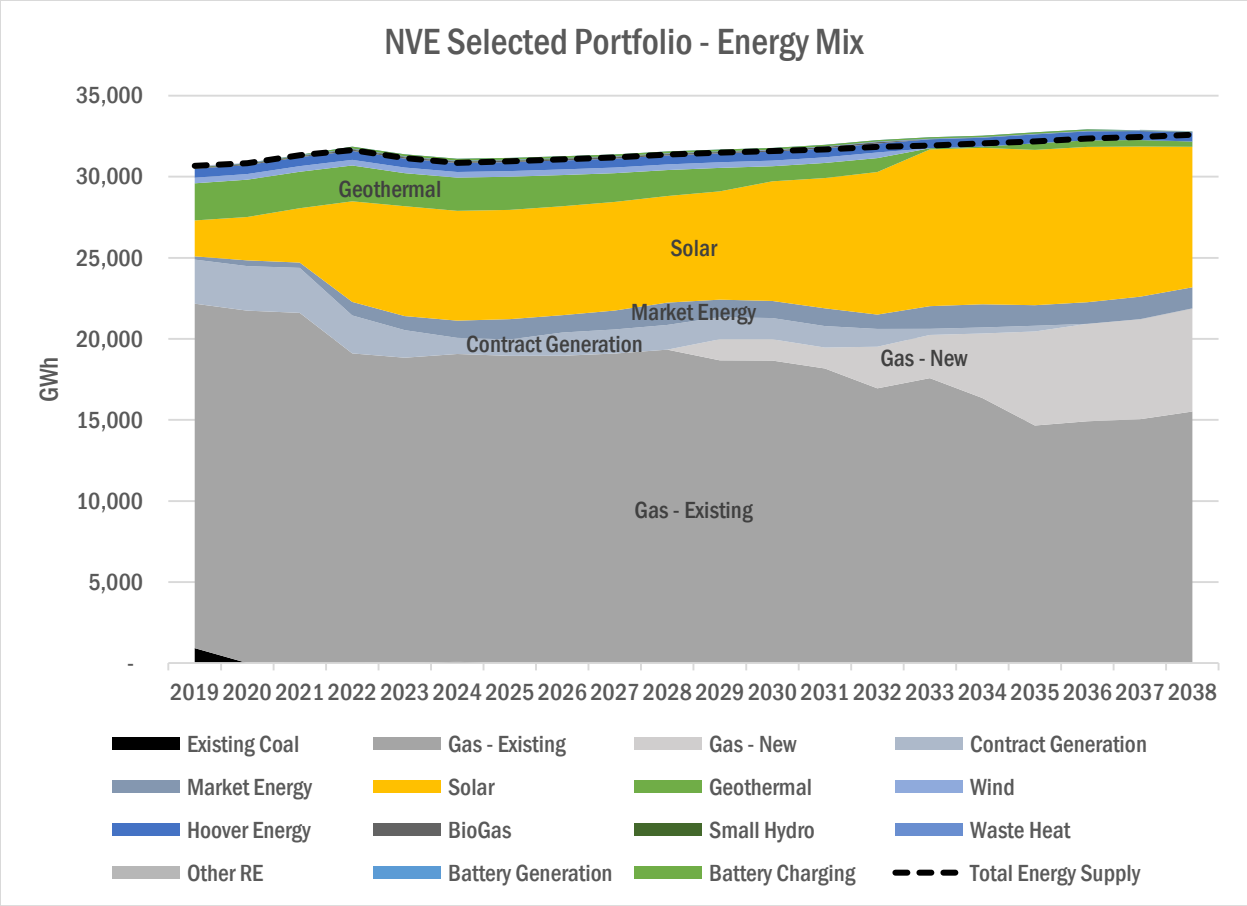

Figure 1. Illustration of the energy mix under NVE's Preferred Plan resource portfolio. Source: NVE IRP Vol 16, ECON-4

As shown in Figure 1 after 2022, the amount of energy from fossil fuels planned by NVE remains roughly constant each year.

In addition to the Low Carbon case, NVE evaluated additional portfolios as part of their IRP analysis, including a "Renewable Case" which the company identifies as its "Alternative Plan." This portfolio is very similar to the Preferred Plan in terms of the proposed resource additions and energy mix. Both portfolios are identical in terms of renewable energy additions, demand side management, and energy storage. As NVE states in its testimony, "The only difference in the Low Carbon Case and the Renewable Case relates to the operation of North Valmy Unity 1."[4] Additionally, NVE studied a "Development Case" which includes 300 MW of additional solar PV, however these incremental renewable resources are relatively modest compared to the amount of incremental gas-fired generation included in the portfolio (>2,200 MW). Therefore, neither the Renewable case nor the Development case enable stakeholders to evaluate the long-term performance of a portfolio that adds substantial clean energy resources and achieves significant carbon emission reductions.

As stated earlier, NVE's Low Carbon Case shows significant near-term efforts to invest in clean energy resources such as renewable energy, demand-side management, and energy storage. However, the plan's consideration of these resources over the long-term is much more limited. Beyond the Action

[4] Direct Testimony of S. Elicegui, p 9, line 23.

Plan period, NVE models "placeholder resources". These placeholder resources are natural gas plants except when additional renewable resources are needed to comply with the existing Renewable Portfolio Standard (RPS). The Preferred Plan, therefore, indicates plans to expand natural gas resources beginning in the late 2020s. This represents a substantial increase in risk borne by NVE customers due to significant capital investments, uncertainty of future fuel commodity prices and the fact that fuel costs (and associated price risk) are directly passed through to customers.

Moreover, the inclusion of new gas-fired resources (i.e. "conventional placeholders") was not derived from any form of economic analysis or optimization. As NVE states, "Conventional placeholders were the same in all plans. These resources were chosen to be the same type as existing generating units which are expected to retire. No specific cost analysis was made to select the resources ultimately included."[5]

To manage the cost and risk associated with natural gas additions, and to meet long-term climate and clean energy goals, we developed an Alternative Portfolio. The Alternative Portfolio is the result of a detailed analysis of the information provided in NVE's IRP, with specific modifications as described below.

Summary of the Proposed Alternative Portfolio for NVE

The Alternative Portfolio models continued investment in clean energy resources over the 20-year period, from 2019 – 2038. The additional clean energy resources – and the reductions in pollution they achieve – are in line with the resource investments NVE has made over the past 13 years. In addition to the environmental benefits, the portfolio generates cost savings for customers, and reduces the risk of future costs associated with volatile natural gas prices and carbon regulation. Specifically, the Alternative Portfolio would reduce the addition of natural gas resources over the next 20 years from over 2,240 MW to just 865 MW – the remaining portion consisting of summer tolling agreements. This would eliminate the need for over 1,648 MW of new-build natural gas additions when compared to NVE's Preferred Plan. The Alternative Portfolio would also include the following new resource additions (or contract renewals):

- 2,500 MW of new large-scale renewable energy resources over the next 10 years, ultimately reaching more than 5,000 MW of new renewables by 2038. The total 2038 additions would include 350 MW of wind, 3,917 MW of solar PV, and 770 MW of geothermal.
- New battery storage resources totaling 300 MW over the next 10 years and 920 MW by 2038.
- Incremental energy efficiency resources totaling 828 MW of cumulative peak demand reduction over the next 10 years and nearly 1,616 MW by 2038
- Demand response and demand management resources totaling 340 MW over the next 10 years and over 404 MW by 2038.

As a result of these changes and others described herein, we estimate that the total revenue requirement (present worth) for the NVE Alternative Portfolio could be up to $192 M less costly to customers over the 20-year period than the portfolio selected by NVE.

[5] NVE Response to NCARE 6-01.

Additionally, we estimate that the Alternative Portfolio would still meet basic peak demand (MW) and energy (MWh) needs in each year of the planning horizon. More specifically, the remaining "Open Position" capacity need would actually be reduced relative to the Preferred Portfolio in every year and approximately 220 MW less, on average, through 2038. This leads to reduced costs in the form of reduced market capacity purchases.

Table 1. Comparison of resource additions and retirements in the NVE Preferred Portfolio and the WRA Alternative

Resource Additions	**NVE Preferred (low carbon)**		**WRA Alternative Portfolio**	
MW (nameplate, cumulative)	**2028**	**2038**	**2028**	**2038**
Natural Gas	865	2,248	600	865
Summer Tolling	865	600	600	865
New Build	0	1,648	0	0
Wind	0	0	-	350
Solar PV	1,313	2,475	2,104	3,917
Battery Storage	100	0	300	920
Geothermal	0	56	400	770
DSM	678	1,366	828	1,616
NEM	172	221	172	221
DR	305	319	340	404
Existing Resource Retirements/ Contracts Ended	**NVE Preferred (low carbon)**		**WRA Alternative Portfolio**	
MW (nameplate, cumulative)	**2028**	**2038**	**2028**	**2038**
Coal	-516	-516	-516	-516
Natural Gas	-439	-1,907	-439	-1,907
PPA	-439	-451	-439	-451
NVE Owned	0	-1,456	0	-1,456
Wind	0	-150	0	-150
Solar PV	0	-325	0	-325
Geothermal	-147	-464	-147	-464

We believe operational issues associated with this high level of renewables will be manageable. For example, overgeneration and evening ramp events would continue to occur especially on low load days throughout the year but could be managed through a combination of energy storage, modest renewable resource curtailment, and continued participation in regional markets.

Alternative Portfolio Construction

The development of the Alternative Portfolio used the Preferred Portfolio (i.e. Low Carbon Case) developed by NVE as a starting point. We relied on the same energy and peak demand forecasts (prior to customer resources) presented in the IRP. We also relied on the same forecasts for distributed energy

(i.e. NEM resources) included in the utility portfolios. Additional energy efficiency and demand response savings beyond those shown in the Preferred Portfolio were also included; specifically, we modelled a 30% increase in savings in the near term, and 15% over the long term, relative to the Preferred Portfolio.

We then removed several of the natural gas plant placeholder additions included in the portfolio, including major plant additions in 2029, 2032, 2034, and 2035.

Next, sufficient additional resources were included to ensure that that the portfolios met both annual peak demand (MW) needs and annual energy (MWh) needs for each year through 2038. To ensure a reasonable buildout, we limited additions of certain resources to a finite amount in each year. Additional timing adjustments were also made, such as the extension of one summer tolling agreement. Retirements of existing coal and natural gas units were consistent with the Preferred Plan.

Energy output from each resource type was initially determined by applying the capacity factors that corresponded with the energy supply mix and resource tables in the IRP.[6] Adjustments were then made to the energy output from some thermal units to more closely match overall energy needs. In each year, this led to a reduction in output, reflecting the fact that additional energy efficiency and renewable resources led to reduced overall energy need from thermal generation, thereby yielding additional fuel cost savings (or higher levels of off-system sales). Curtailment of renewable energy due to overgeneration was also estimated and accounted for when estimating total energy supply. Detailed assumptions related to each resource type are described in the following sections, and complete load and resource tables and energy mixes for Alternative Portfolio are presented in Appendices A & B.

[6] See Vol. 16, ECON-4 and ECON-6.

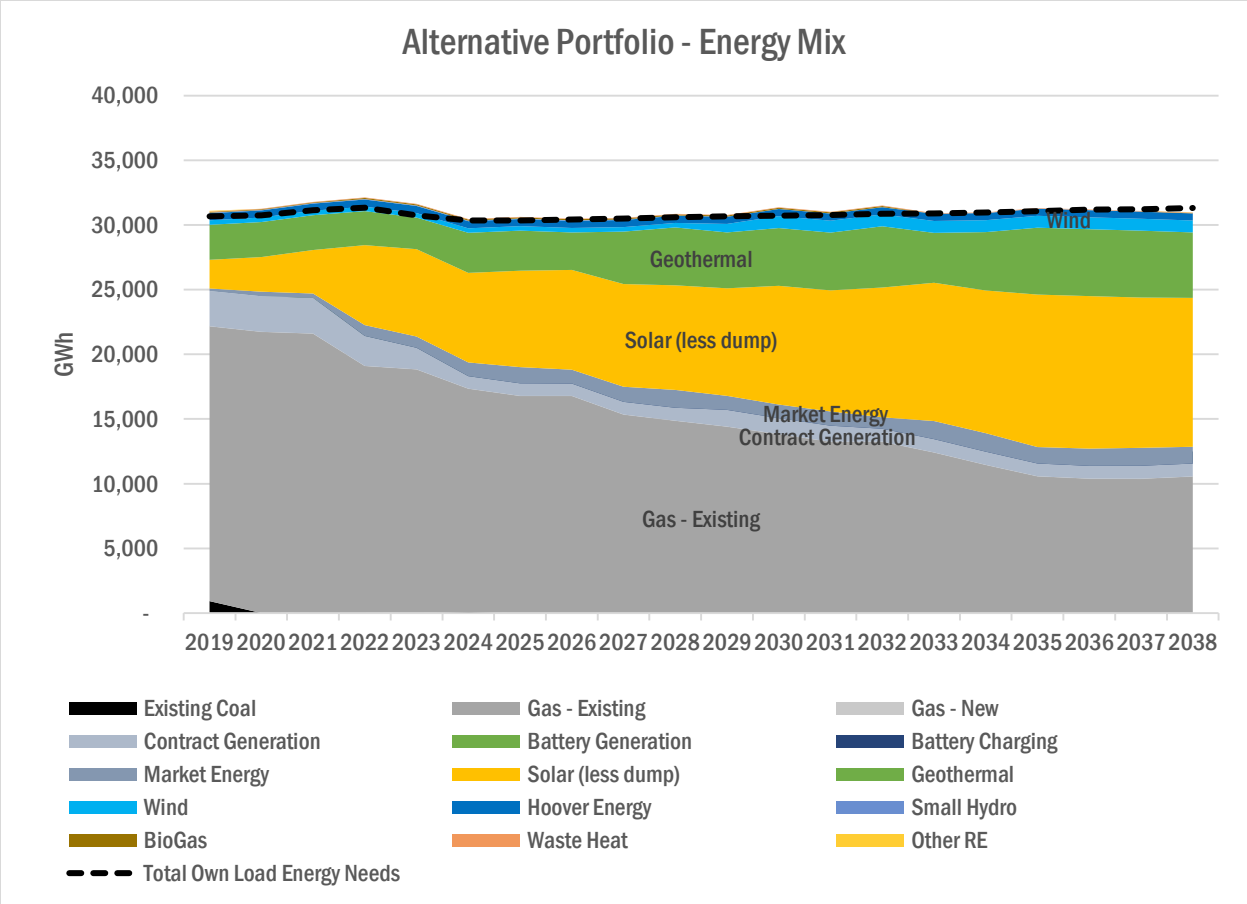

Figure 2. Illustration of the energy mix under the Alternative Portfolio

Renewable Energy Resource Additions

Additional renewable energy resources were included in the Alternative Portfolio beyond what NVE included in its Preferred Plan. Specifically, over the next 10 years, the Alternative Portfolio includes an additional 790 MW of large-scale solar PV resources, and an additional 400 MW of geothermal resources, beyond what was included in the Preferred Plan. By 2038, the Alternative Portfolio include an additional 1,440 MW of solar PV, 700 MW of geothermal, and 350 MW of wind – all of which would be incremental to the Preferred Plan. For distributed resources we incorporated the same projections of customer adoption included in NVE's IRP, recognizing that there is some uncertainty in the rate of customer adoption for NEM resources. Overall, we estimate that these additions (excluding DG) would result in renewable energy accounting for approximately 50% of NVE's retail sales by 2030.

Hourly energy output profiles for solar PV and wind resources were developed using the System Advisor Model developed by NREL, using representative data for Nevada (solar) and southern Idaho (wind). These profiles were used to calculate net load for estimating potential overgeneration and curtailment on an hourly basis for each year on NVE's system.

Although renewable resources are intermittent, they still provide a capacity contribution to the system that is less than their nameplate values. To the extent possible, we relied upon information provided in NVE's IRP on the capacity value of renewable resources. We recognize that for solar PV, the capacity

value declines as penetration increases. As part of its IRP analysis, NVE commissioned a study titled "Capacity Value of Solar Photovoltaic Resources in NV Energy's System."[7] This analysis shows that the capacity value (i.e. the effective load carrying capability, or ELCC) of solar PV declines from approximately 34% for near-term additions, to approximately 18% as total solar PV capacity approaches 3,000 MW. The assumed capacity value for solar PV declines along a similar trajectory in the Alternative Portfolio, reaching 18% in 2027 when 2,690 MW of solar PV are online. Under the Alternative Portfolio, total solar PV capacity ultimately exceeds 3,000 MW by 2030. Further analysis is needed to confirm the capacity contribution of solar PV beyond 3,000 MW. However, for the purpose of this analysis, we assume the capacity value further declines to 15% beginning in 2031.

Table 2. Capacity values for renewable resources included in the Alternative Portfolio.

Resource Type	Capacity Value (peak coincidence)
Geothermal	42%
Wind	10%
Solar PV	34% declining to 15%

We estimate the renewable energy resources included in the Alternative Portfolio would contribute over 1,150 MW towards meeting NVE peak demand requirements in 2038, after accounting for the unique capacity value of each renewable resource type. Additionally, as discussed below, some of these resources could be paired with storage to provide additional system benefits while leveraging the federal investment tax credit.

For new solar resources, we assumed annual energy output similar to outputs reported in NVE's plan (i.e. 32% capacity factor for solar). For new wind we assumed a 30% capacity factor for wind. For new geothermal resources we assumed a capacity factor of 75%.

For renewable resource costs, we assumed PPA prices for solar PV and geothermal equal to those included NVE's IRP.[8] For new wind we assumed a PPA price of $45/MWh, which is consistent with wind PPA prices in the West reported by Lawrence Berkeley Lab.[9] We recognize that recent bid prices in wind-rich areas (e.g. Colorado, New Mexico) have been lower than $20/MWh, but believe $45 is reasonable estimate to reflect the expiration of federal production tax credits and/or potential transmission wheeling charges.

According to NVE's Preferred Plan, additional transmission upgrades were needed to accommodate approximately 1,300 MW in near-term renewable additions. Based on information supplied by NVE, we estimate the PWRR of these upgrades to be approximately $22 M through 2038.[10] Since the Alternative Plan includes approximately 1,440 MW of incremental renewable resources beyond those in the Preferred Plan, we presume there would be incremental transmission network upgrades needed to accommodate these resources. While it is impossible to know the exact cost of these upgrades without

[7] See Vol. 17, Exhibit ECON-11.
[8] See Vol. 12, Exhibit REN-3 (confidential).
[9] See https://emp.lbl.gov/sites/default/files/2017_wind_technologies_market_report.pdf
[10] Based on cumulative PWRR for CER analysis provided in Staff 1-02.

performing an interconnection study, we conservatively assume these additional costs increase the PWRR by approximately $40 M.

Energy Storage Resource Additions

The Alternative Portfolio includes significant new additions of energy storage resources beyond what NVE included in its plan. These resources are included both to help meet peak demand and to help meet operational challenges associated with daytime overgeneration and evening ramping as solar penetration increases. Beyond these functions, the energy storage systems can also provide economic value through energy arbitrage, by charging during times when energy is inexpensive, and discharging when it is more expensive. They may also provide fast ramping capabilities that can be used for frequency regulation and frequency response.

The storage facilities were assumed to be 4-hour battery energy storage facilities. We modeled the addition of 300 MW of battery energy storage facilities over the next 10 years (compared to 100 MW currently being proposed), ultimately reaching 920 MW by 2038. This is consistent with recent estimates suggesting that deployment of 700-1000 MW of energy storage in NV by 2030 could be cost effective.[11]

Energy storage costs were based on The Economic Potential for Energy Storage in Nevada report, released on October 1, 2018.[12] This report estimates a levelized cost of storage ranging from $136/kW-yr to $204/kW-yr for a 4-hour duration battery (including financing) installed in 2020. This is based on an estimated capital cost between $1,200/kW and$1,800/kW. For comparison, Xcel Energy's recent RFP received bids for over 1,600 MW of stand-alone battery storage, with a median price of $11.30/kW-month, which, if available year-round, translates to $136/kW-yr.[13] We conservatively assumed a cost of $170/kW-yr for a 2023 installation. We also conservatively estimate a 3% annual cost decline for new energy storage resources, while noting that some recent studies have projected decline rates in the 8-10% range.[14]

Furthermore, as demonstrated by NVE's proposed PPAs, battery storage systems are increasingly being paired with renewable resource additions, which offers many potential synergies. For example, storage systems primarily charged from solar PV can take advantage of the federal investment tax credits, as well as enhanced performance via DC-coupling. These hybrid systems are also increasingly cost competitive. The solicitation recently conducted by Xcel Energy in Colorado received bids for over 10,000 MW of solar PV with battery storage projects, with a median bid price of $36/MWh. It also received over 5,000 MW of wind plus battery storage projects, with a median bid price of $21/MWh. These prices are consistent with the proposed additions in NVE's IRP; for example, the Dodge Flat solar PV project has a levelized cost of energy of $29.23/MWh (i.e. for solar only), and $34.87/MWh with the inclusion of the battery storage.[15] For the purposes of this analysis, we assumed all battery storage

[11] http://files.brattle.com/files/14618_economic_potential_for_storage_in_nevada_-_final.pdf

[12] http://files.brattle.com/files/14618_economic_potential_for_storage_in_nevada_-_final.pdf

[13] Public Service Company of Colorado, December 28, 2017. 2016 Electric Resource Plan, 2017 All Source Solicitation 30-Day Report (Public Version).

[14] See for example:

Lazard Levelized Cost of Storage 2017: https://www.greentechmedia.com/research/report/us-front-of-the-meter-energy-storage-system-prices-2018-2022#gs.SXZLAcc

GTM Research 2018: https://www.lazard.com/perspective/levelized-cost-of-storage-2017/

[15] See D. Ulozas Direct Testimony at p 19.

systems were paired with renewables and were therefore eligible to receive the federal investment tax credit.

Energy Efficiency and Demand Response Resource Additions

The energy efficiency and demand response resource additions in the Alternative Portfolio are based on the resource additions included in the NVE Preferred Portfolio. The Preferred Portfolio generally reflects an increase in demand-side management efforts from previous years. For example, in 2017 NVE achieved approximately 31 MW of peak demand savings from energy efficiency (annual incremental), and 242 MW of peak demand savings from demand response.[16] Under the Preferred Plan, NVE anticipates approximately 65-70 MW in peak demand savings from energy efficiency (annual incremental) in each year through 2038 for a total cumulative savings of 1366 MW. NVE also plans for annual demand response savings reaching 319 MW over the same time period.[17]

While the Preferred Portfolio demonstrates an increase in savings over recent years, it does not necessarily reflect the full potential of demand side management measures that NVE could pursue. For example, NVE's DSM Potential Study shows a maximum achievable potential of 1,992 MW by 2038, or about 100 MW of incremental peak savings in each year.[18] As such, and in consultation with SWEEP, we included additional energy efficiency measures beyond those proposed in NVE's Preferred Plan. We included an additional 20 MW of annual incremental energy efficiency in each year through 2025 and an additional 10 MW in each year thereafter. This yields a total additional peak demand savings (additional to the preferred plan) from energy efficiency of 150 MW (cumulative) by 2028 and 250 MW (cumulative) by 2038. Energy savings from DSM measures were computed based on an assumed 55% average load factor, which is approximates the energy savings and peak demand reductions projected in NVE's IRP.

Similarly, demand response resources were scaled up by an additional 5 MW each year, reaching 85 MW of additional DR by 2038 above the Preferred Plan. Energy efficiency resource costs were estimated based on NVE's recent portfolios. In 2017, NVE demonstrated incremental first-year costs of $147/MWh.[19] Similarly, NVE demonstrated demand response annual program costs of $79/kw-yr in 2017. Costs for procuring incremental energy efficiency and annual demand response were assumed to increase from 2017 levels at a rate of 3% annually and were presumed to be expensed during the year they were implemented.

Cost Analysis

We evaluated the Alternative Portfolio for its impact in terms of overall cost to customers relative to the NVE's Preferred Plan.[20] While some of the resource changes in the Alternative Portfolio led to increased

[16] See Vol. 6, Table DSM-9C.
[17] See Load and Resource tables in Vol. 16, ECON-6.
[18] See table 4-4 of DSM Market Potential Study (Vol. 10).
[19] Based on NVE recent portfolio cost (IRP Vol 6, Table DSM-9C)
[20] We recognize that federal tax legislation passed in December 2017 may have an impact on overall utility resource portfolio costs. We did not attempt to account for this in our analysis since the effects are still being

costs due to incremental resource additions, other changes let to substantial cost savings to customers. Notably, cost savings in the Alternative Portfolio were achieved from the following: 1) reduced fixed costs associated with avoided new natural gas additions and 2) reduced fuel and operating costs at existing fossil resources (or increased off-system sales). The net impact of these changes is summarized in Table 3 below. The customer savings for the Alternative Portfolio were computed in terms of the Present Worth of Revenue Requirement (PWRR) using a discount rate of 7.5%.[21]

Table 3. Estimated difference in revenue requirements between the NVE Alternative Portfolio and the NVE Preferred Portfolio. PWRR based on NVE Preferred Portfolio (BLBFNC case) as reported in NVE IRP Vol. 17, ECON-8, p 8. This analysis compares the PWRR of the two portfolios under the "No Carbon" price scenario. Thus, reductions in fuel costs to not reflect potential CO_2 market prices. If CO_2 prices were included, this would significantly increase customer bill savings under the Alternative Portfolio.

Changes Relative to Preferred Portfolio:	**PWRR, $M (2019-2038)**	**% Diff**
NVE Preferred Portfolio (BLBFNC), Total PWRR	**$17,119**	
Additional Renewables	$1,635	9.5%
Additional DSM	$128	0.7%
Additional Battery Storage	$275	1.6%
Additional Transmission Upgrades	$40	0.2%
Reduced Fixed Costs for New Gas	($680)	-4.0%
Reduced Fuel & VOM Costs	($1,590)	-9.3%
Total Change vs Preferred Portfolio	**($192)**	**-1.1%**
WRA Alternative Portfolio, Total PWRR	**$16,927**	

Additional costs for renewable energy, energy storage, energy efficiency, and demand response were only calculated for the incremental resources procured above the Preferred Portfolio.

The avoided fixed costs of deferred new natural gas additions were readily determined from the estimated revenue requirements for these resources provided by NVE in the CER model results.[22] It is not readily apparent whether these costs account for additional incremental new gas pipeline costs, which may also be significant.

In addition to reduced fixed costs for new plant additions, we also estimated the savings from reduced capacity purchases resulting from a reduced open position in the Alternative Portfolio. Capacity prices for open position purchases were based on estimates provided by NVE.[23] The reduced capacity purchase costs are reflected in the "Reduced Fixed Costs for New Gas."

determined. We believe the comparison presented here is sound, even if more nuanced tax rate analysis would change costs for all portfolios (both Alternative and Selected).

[21] Based on a WACC of 7.95% for NPC and 6.65% for SPPC, we estimated that the load-weighted average would be approximately 7.5%, which was used as the discount rate for NVE.

[22] See response to Staff 1-2

[23] NCARE 3-06.

Additional avoided fuel costs under the Alternative Portfolios were also estimated. To do so, we first determined the total annual energy production (in MWh) from both new and existing resources based on information provided by NVE and the assumptions described in previous sections. Next, we determined the annual MWh load obligation, after accounting for energy efficiency and distributed generation. The initial MWh supply of the Alternative Portfolio was generally found to exceed the load obligation in most years. Thus, we assumed that the output at certain existing gas generators could be reduced, yielding corresponding savings in fuel and O&M. In other words, the incremental renewable energy and demand side management under the Alternative Portfolio were assumed to displace energy from gas-fired generation. The output from existing gas generators was adjusted to more closely match the remaining load obligation. We then calculating the reduction in fuel costs based on the specific performance characteristics of a proxy-generator which was based on information provided by NVE.[24] It was assumed that in most cases a natural gas combined cycle unit was the marginal generator on NVE's system. Natural gas fuel prices were based on NVE's forecast for the Rockies delivery point.[25]

In addition to operational savings from reduced fuel consumption at NVE plants, we also estimated the cost savings that would result from operation of battery storage due to arbitrage. A battery dispatch schedule was determined for each month based on the results of NVE's PROMOD simulation runs, which provide hourly marginal costs for electricity.[26] Daily charging was set to occur when average marginal costs for the month were low, while daily discharging was set to occur when average marginal costs for the month were high. This dispatch schedule was then applied to determine the arbitrage value in each year through the operation of the battery storage resources.

We recognize that a full production cost simulation would be more precise way of quantifying the fuel cost savings from existing resources; however, this was not possible given the limited time and resources available. Nevertheless, we believe this method provides a reasonable first order approximation of the savings achievable through the Alternative Portfolio.

Societal Costs/Externalities

In addition to changes in direct customers costs (i.e. the revenue requirement), the Alternative Portfolio would lead to reduced societal costs in the form of CO_2 emissions, conventional pollutants, and water consumption. Of these, CO_2 emissions represent the largest source of societal costs, and therefore were the primary focus of our analysis. For this analysis we estimated the difference in CO_2 emissions associated with the Alternative Portfolio versus the Preferred Portfolio. We then computed the difference in the present worth of societal costs (PWSC) for both cases using a Social Cost of Carbon (SCC).[27] The SCC values used in this analysis were provided by NVE and reflects an average SCC value

[24] For this analysis, we conservatively assumed an efficient combined cycle plant on NVE's system (i.e. Harry Allen CC) was the marginal generator and used corresponding plant performance characteristics provided in GEN-1. We recognize that there are likely times when less efficient generators are on the margin and that the actual avoided fuel costs under the Alternative Portfolio may be higher than what we have estimated.

[25] Based on Chart PF-2

[26] We relied on the 2018 IRP Low Carbon BLBFMC PROM_OUT36 model run for this analysis.

[27] This PWSC analysis was done assuming the initial PWRR for a "No Carbon" price scenario. This was done for simplicity to demonstrate the full CO_2 costs, including any potential future market prices. It should be noted that if

with a real discount rate of 3%.[28] Under these assumptions, the SCC value increases from approximately $52/ton in 2019 to $74/ton in 2038.

The Alternative Portfolio yields substantial annual CO_2 emissions reductions relative to the Preferred Portfolio in each year from 2024 through 2038. Emissions reductions grow from approximately 2,000 MMT in 2028 to 4,000 MMT in 2038. As such, the Alternative Portfolio would reduce the PWSC by approximately $1.6 billion over the 20-year planning period, relative to the Preferred Plan.[29] The Alternative Portfolio would also yield additional PWSC savings beyond this due to reduced water use and conventional pollutants, but these savings were not directly estimated.

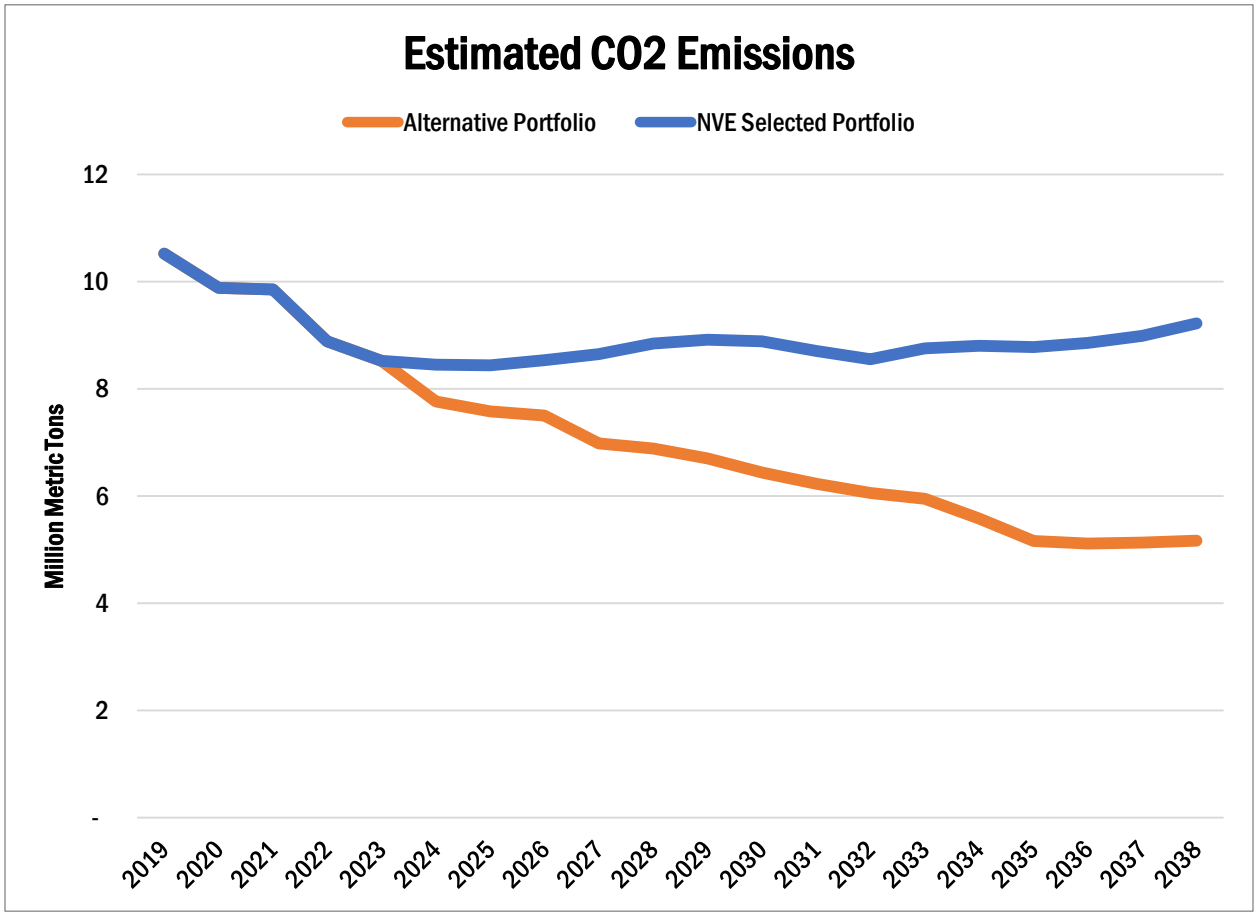

Figure 3. Comparison of the annual CO_2 emissions of the NVE Preferred Portfolio and the Alternative Portfolio.

some or all of the SCC is monetized through a market price in the future, this portion would be reflected in the PWRR analysis shown in the previous section.

[28] NCARE 2-04, SCC Values.

[29] Assumes a 3% societal discount rate.

Renewable Energy and Portfolio Diversity

In addition to cost, the Alternative Portfolio performs well in terms of increasing resource diversity and overall share of renewable energy.

The Alternative Portfolio reflects a more diverse energy mix, and, as described above, reduced emissions of air pollutants. The fuel diversity reduces utilities' and customers' risk exposure to rising fuel prices or environmental regulations. Under NVE's Selected Portfolio, the utility would be reliant on natural gas to meet approximately 67% of energy demands in 2038, excluding market purchases, and only 29% of the energy mix would be renewables; under the Alternative Portfolio, 36% of NVE's energy needs would be met with natural gas, and 60% of demand is met with renewables (both utility scale renewables, hydroelectric power, and distributed generation) (Figure 4).

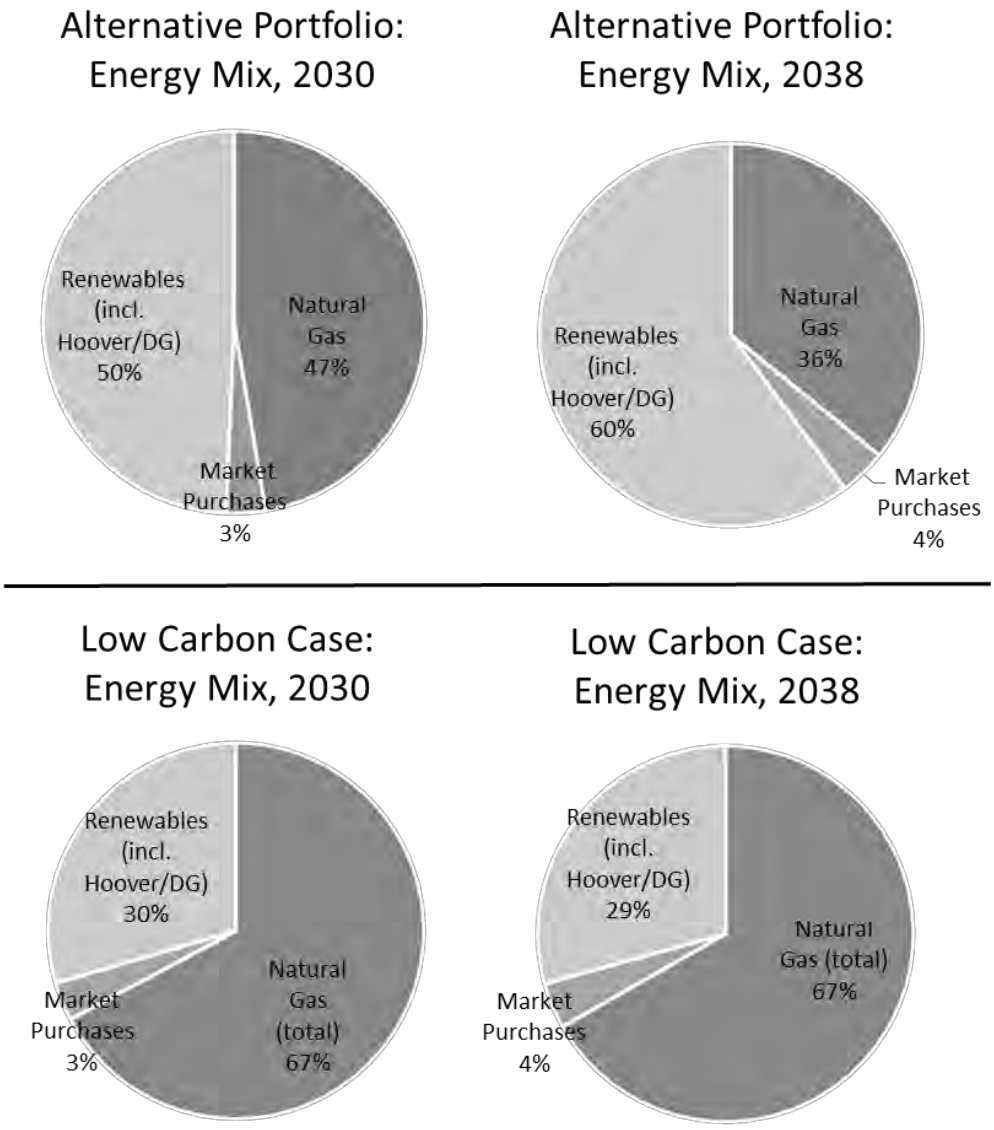

Figure 4. Graphs show the peak capacity and energy mix for the Low Carbon case and the Alternative Portfolio.

As illustrated below, the Alternative Portfolio would also put NVE on a path to meet the requirements of the Question 6 (Q6) Ballot Initiative if passed (i.e. 50% renewable energy by 2030).

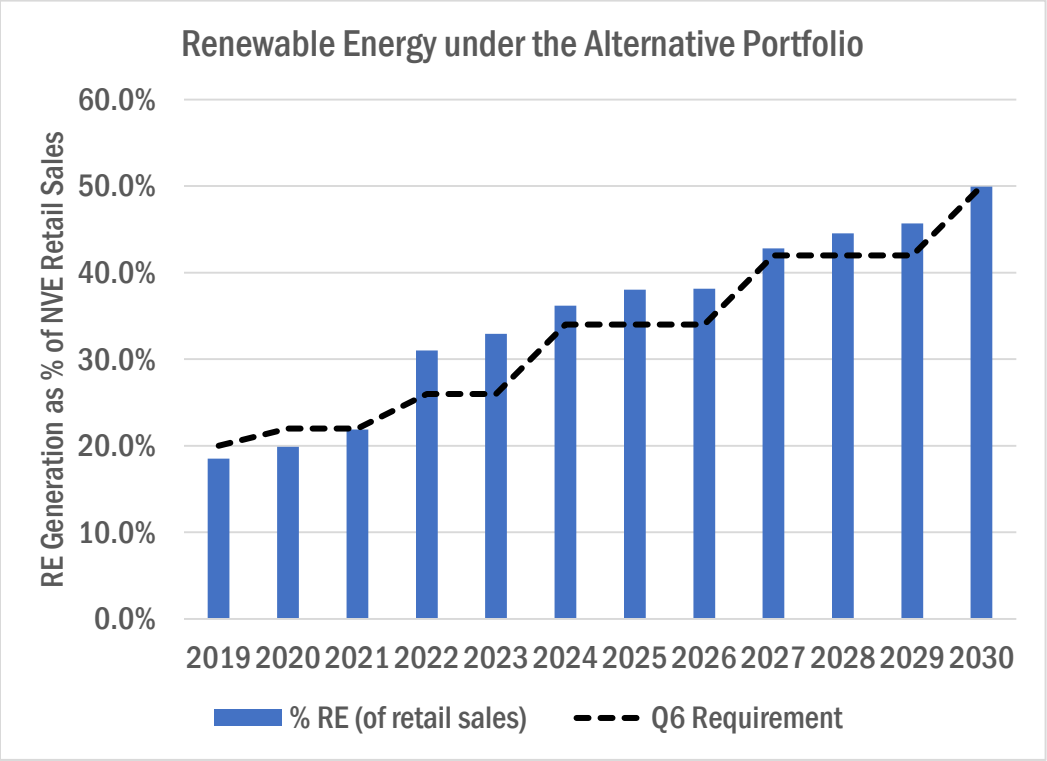

Figure 5. Comparison of the Renewable Energy portion of the WRA Alternative Portfolio to the 50% Ballot Initiative requirement.

Operational Issues

Beyond meeting peak demand and energy needs, the increased penetration of renewable energy leads to new system challenges. For example, flexible ramping resources may be needed to accommodate certain ramping events, such as when solar PV generation declines in the evening. Additionally, the abundance of solar energy during midday in certain low-load months may lead to overgeneration events in which there is more renewable energy being generated than the system can accommodate.

We discuss some of these challenges below and how they were considered in this analysis. Beyond this high-level assessment, a more detailed modeling effort using production cost simulations would be valuable in better understanding these operational challenges, and in particular, to understand the overall annual and multiyear impact on system cost and reliability.

Overgeneration

The potential for overgeneration conditions leading to curtailment or "dump energy" was considered as part of our analysis. To evaluate this potential, we examined 8760 hourly load data for NVE from a

recent year.[30] Simulated hourly solar PV and wind output was used to determine the hourly net load based on the amount of each resource on the system in each year of the Alternative Portfolio. Additionally, we took into account the effects of battery storage charging and discharging as described previously. Finally, we assumed that a minimum amount of generation must be committed at any given time to provide operating reserves. We assumed this would be about 10% of NVE's average load, or about 420 MW. Each hour was examined to determine if the amount of generation available from wind and solar exceeded the load while accounting for the minimum generation for operating reserves. This was used to determine the total amount of curtailment or dump energy that could be expected over the course of each year. This curtailed energy estimate was also accounted for when considering the overall energy supply available, and subtracted from the renewable energy contribution. We recognize that this analysis is simplistic in nature and does not take into account potential exports, imports or transmission constraints which may have a significant effect on the prevalence of overgeneration conditions. A more complete production cost simulation is needed to understand these effects in more detail. However, we believe it provides some preliminary insight into the potential timing and magnitude of overgeneration conditions.

Ramping

NVE also faces potential operational challenges in the form of the need for ramping capability. As stated in testimony, NVE's net load currently experiences a 700 MW average ramp within 3 hours during the month of February.[31] However, NVE also identifies potential solutions for meeting these needs, including battery storage and the use of clean energy resources to provide ancillary services.[32] The Alternative Portfolio also includes significant battery storage that, in addition to NVE existing gas fleet, and other measures (e.g. integration with regional markets) can help support the ramping needs described.

Concluding Observations

NV Energy's Preferred IRP Portfolio, the Low Carbon case, adds significant renewable and battery storage resources over the near-term Action Plan period. Beyond that period, however, NVE's portfolio includes significant new natural gas resources which, if adopted, would increase the utility's carbon emissions and increase costs for customers. To demonstrate the potential benefits of long-term, sustained investments in clean energy resources, we developed an Alternative Portfolio for NVE. This portfolio shifts the emphasis of new resource investments from natural gas to renewable energy, energy storage, energy efficiency, and demand management.

Our analysis shows that the Alternative Portfolio is capable of meeting both utilities' energy and peak demand needs, and we expect that NVE will be able to manage other operating needs such as flexible ramping and overgeneration. Finally, the portfolios appear to outperform the utilities' selected portfolios on a variety of metrics including cost (i.e. present worth of revenue requirements), resource

[30] 2017 hourly load data for both NPC and SPPC was obtained from S&P Global.
[31] See Vol 2, Geraghty Direct at page 9.
[32] Geraghty at p 12.

diversity, and carbon emissions. Given those benefits, the Alternative Portfolio merits further evaluation and analysis by NV Energy, the Commission, and key stakeholders.

Appendix A: Loads and Resources

WRA Alternative Portfolio

Year	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
MW (peak)																				
Load Requirements																				
NVE Gross Peak Demand	7,616	7,796	7,969	8,100	8,110	8,251	8,368	8,483	8,617	8,732	8,858	8,985	9,114	9,252	9,380	9,492	9,619	9,754	9,870	10,009
Customer Resources - Base	380	486	587	683	767	847	921	993	1,079	1,155	1,228	1,297	1,369	1,453	1,524	1,601	1,676	1,747	1,821	1,906
DSM	86	150	215	281	346	411	478	543	611	678	745	813	881	950	1,018	1,087	1,156	1,226	1,296	1,366
Net Metering	68	91	109	125	141	152	155	160	166	172	176	181	185	192	196	200	206	213	216	221
Demand Response	226	245	263	277	280	284	288	290	302	305	307	303	303	311	310	314	314	308	309	319
Customer Resources - Incremental	0	20	40	65	90	115	140	155	170	185	200	215	230	245	260	275	290	305	320	335
DSM	0	20	40	60	80	100	120	130	140	150	160	170	180	190	200	210	220	230	240	250
Distributed Energy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Demand Response	0	0	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85
Peak Adjustment	19	7	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NET System Peak	7,217	7,283	7,330	7,352	7,253	7,289	7,307	7,335	7,368	7,392	7,430	7,473	7,515	7,554	7,596	7,616	7,653	7,702	7,729	7,768
Reserve Requirements	920	926	934	936	920	924	926	929	933	937	941	946	951	956	961	964	968	974	978	983
Total Resource Requirement	**8,137**	**8,209**	**8,264**	**8,288**	**8,173**	**8,213**	**8,233**	**8,264**	**8,301**	**8,329**	**8,371**	**8,419**	**8,466**	**8,510**	**8,557**	**8,580**	**8,621**	**8,676**	**8,707**	**8,751**
Exisitng Resources																				
Coal	516	261	261	134	134	134	134	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural Gas - Owned	5,475	5,475	5,475	5,475	5,475	5,475	5,475	5,475	5,475	5,475	5,141	5,093	5,039	4,725	4,725	4,510	4,163	4,091	4,019	4,019
PPA Conventional	710	710	710	620	271	271	271	271	271	271	271	271	271	259	259	259	259	259	259	259
Gas	451	451	451	361	12	12	12	12	12	12	12	12	12	0	0	0	0	0	0	0
Hoover	259	259	259	259	259	259	259	259	259	259	259	259	259	259	259	259	259	259	259	259
Renewable Energy	614	614	646	566	554	554	554	541	531	484	471	380	380	376	296	296	292	292	272	205
Solar PV	5	5	5	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	3	3
PPA Solar PV	270	270	303	228	228	193	193	193	166	166	166	162	135	135	135	135	132	132	117	71
PPA GEO	173	173	172	168	156	156	156	143	133	118	108	67	67	63	7	7	7	7	7	0
PPA CSP	128	128	128	128	128	128	128	128	128	100	100	100	100	100	100	100	100	100	100	100
PPA Wind	15	15	15	15	15	15	15	15	15	15	15	15	15	15	0	0	0	0	0	0
PPA WH	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
PPA LFG	9	9	9	9	9	9	9	9	9	9	9	9	9	9	0	0	0	0	0	0
PPA Hydro	9	9	9	9	9	9	9	9	9	5	3	3	3	3	3	3	3	3	3	3
Total Existing Resources	7,315	7,060	7,092	6,795	6,434	6,434	6,434	6,287	6,277	6,230	5,883	5,744	5,690	5,360	5,280	5,065	4,714	4,642	4,550	4,483
Future Resources																				
Placeholder Natural Gas	0	0	0	0	600	600	600	600	600	600	865	865	865	865	865	865	865	865	865	865
PPA Gas Tolling	0	0	0	0	600	600	600	600	600	600	865	865	865	865	865	865	865	865	865	865
NVE-owned Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Placeholder Renewable Energy	0	0	0	25	75	148	190	211	307	367	395	491	479	539	599	671	788	788	788	803
PPA Wind	0	0	0	0	0	0	0	0	0	0	10	20	20	20	35	35	35	35	35	35
PPA Solar PV	0	0	0	25	75	106	148	169	181	199	217	253	240	279	325	355	430	430	430	445
PPA GO	0	0	0	0	0	42	42	42	126	168	168	218	218	239	239	281	323	323	323	323
Placeholder BESS	0	0	0	0	50	50	100	125	175	200	225	275	325	390	465	515	895	895	895	920
Proposed Resources	0	0	76	348	348	310	310	310	280	280	280	271	218	218	218	218	218	218	143	143
PPA Solar PV	0	0	51	248	248	210	210	210	180	180	180	171	143	143	143	143	143	143	143	143
PPA BESS	0	0	25	100	100	100	100	100	100	100	100	100	75	75	75	75	75	75	0	0
Total Future Resources	0	0	76	373	1,073	1,108	1,200	1,246	1,362	1,447	1,765	1,902	1,887	2,012	2,147	2,269	2,766	2,766	2,691	2,731
Total Resources	**7,315**	**7,060**	**7,168**	**7,168**	**7,507**	**7,542**	**7,634**	**7,533**	**7,639**	**7,677**	**7,648**	**7,646**	**7,577**	**7,372**	**7,427**	**7,334**	**7,480**	**7,408**	**7,241**	**7,214**
Open Position (MW)	**822**	**1,149**	**1,096**	**1,120**	**666**	**672**	**599**	**732**	**663**	**652**	**723**	**773**	**889**	**1,138**	**1,130**	**1,246**	**1,141**	**1,268**	**1,466**	**1,537**
Δ,537Position (MW)rcesEnergyn	**0**	**-23**	**-46**	**-71**	**-149**	**-212**	**-333**	**-130**	**-263**	**-365**	**-329**	**-501**	**-483**	**-217**	**-309**	**-45**	**-9**	**-291**	**-307**	**-349**

Appendix B: Energy Mix

Year	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Load Forecast (GWh)																				
Sales Prior to Customer Resources	30,064	30,599	31,437	32,096	31,993	32,039	32,462	32,909	33,362	33,860	34,311	34,746	35,193	35,677	36,106	36,565	37,036	37,549	37,995	38,474
Demand Side Management (cumulative)	-447	-849	-1,252	-1,660	-2,067	-2,473	-2,879	-3,244	-3,609	-3,976	-4,348	-4,719	-5,093	-5,467	-5,845	-6,221	-6,600	-6,982	-7,364	-7,748
NEM/Distributed Generation	-164	-231	-282	-325	-368	-396	-413	-430	-447	-464	-480	-497	-514	-531	-548	-564	-581	-598	-615	-632
Demand Response	-57	-65	-72	-79	-86	-92	-97	-102	-106	-110	-114	-117	-121	-126	-129	-132	-135	-138	-142	-144
Losses	1,271	1,282	1,293	1,299	1,274	1,270	1,271	1,278	1,284	1,294	1,297	1,302	1,300	1,308	1,312	1,325	1,332	1,342	1,346	1,353
Total Own Load Energy Needs	30,667	30,736	31,124	31,331	30,746	30,348	30,344	30,412	30,485	30,603	30,667	30,715	30,765	30,861	30,896	30,973	31,052	31,173	31,220	31,304
Supply-side Resources (GWh)																				
Coal	926	8	41	38	10	82	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Natural Gas (incl. tolling contracts)	23,962	24,479	24,337	21,405	20,527	18,260	17,798	17,786	16,384	15,931	15,772	15,141	14,565	14,341	13,554	12,594	11,712	11,529	11,523	11,699
Renewables (excl. DG/Hoover)	5,447	5,855	6,525	9,317	9,704	10,528	11,058	11,115	12,497	13,057	13,426	14,737	14,939	15,994	15,909	17,108	19,121	19,121	18,864	18,451
Market Purchases	201	354	327	835	867	1,063	1,253	1,071	1,166	1,377	1,083	1,054	1,096	885	1,397	1,430	1,269	1,334	1,386	1,297
Hoover	551	551	551	551	551	551	551	551	551	551	551	551	551	551	551	551	551	551	551	551
Energy Storage (round trip losses)	-	-	(5)	(20)	(30)	(30)	(40)	(45)	(54)	(59)	(64)	(74)	(79)	(92)	(107)	(117)	(192)	(192)	(177)	(182)
Dump Energy/Curtailment	-	-	-	-	-	-	-	-	-	(0)	(2)	(43)	(60)	(178)	(396)	(598)	(1,087)	(1,087)	(1,010)	(800)
Total Supply	31,087	31,247	31,776	32,127	31,629	30,454	30,621	30,479	30,543	30,856	30,766	31,365	31,013	31,501	30,908	30,969	31,374	31,256	31,136	31,014
Resource Mix																				
Coal	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Natural Gas (incl. tolling contracts)	77%	78%	77%	67%	65%	60%	58%	58%	54%	52%	51%	48%	47%	46%	44%	41%	37%	37%	37%	38%
Renewables (excl. DG/Hoover)	18%	19%	21%	29%	31%	35%	36%	36%	41%	42%	44%	47%	48%	51%	51%	55%	61%	61%	61%	59%
Market Purchases	1%	1%	1%	3%	3%	3%	4%	4%	4%	4%	4%	3%	4%	3%	5%	5%	4%	4%	4%	4%
Hoover	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
Energy Storage (round trip losses)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%	-1%	-1%
Dump Energy/Curtailment	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%	-2%	-3%	-3%	-3%	-3%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
RE (minus dump), % of total supply	18%	19%	21%	29%	31%	35%	36%	36%	41%	42%	44%	47%	48%	50%	50%	53%	57%	58%	57%	57%
RE (minus dump), % of sales	19%	20%	22%	31%	33%	36%	38%	38%	43%	45%	46%	50%	50%	54%	52%	56%	61%	60%	60%	59%