Wind and Solar-Induced Coal Plant Cycling and Curtailment Costs

on the

Public Service Company of Colorado System

Prepared by

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Executive Summary

This report presents the results of a Wind and Solar Induced Coal Cycling study completed on the Public Service Company of Colorado ("Public Service" or the "Company") electrical generation system. A previous Wind Induced Coal Cycling study was completed in August 2011. The purpose of that study was to define and quantify the integration costs directly associated with: 1) cycling baseload coal generator output as a result of wind generation levels, and 2) curtailing wind generation at times to avoid certain excessive system bottoming events.

The current study has the same purpose but also evaluates the potential impacts to coal cycling and curtailment from the effects of wind and solar, both combined and individually. At the time of the original study in 2011, the Company had approximately 130 MW of solar capacity. By the end of 2016, the Company will have about 550 MW of solar and anticipates that several more hundred MW will be installed in the next few years.

The previous study examined wind levels of 2 GW and 3 GW; levelized annual costs from coal cycling and curtailments were estimated at $4.8 million and $8.3 million respectively over a 15-year study period (2011-2025). In this study, over a similar length period (2016-2030), estimated levelized annual coal cycling and curtailment costs are $2.6 million; estimated levelized costs over a 25-year period are $2.0 million. Solar generation was found to contribute to coal cycling and curtailment costs but, at the penetrations studied here, wind continues to be the primary driver. Significant reductions in future estimates of coal cycling costs are attributable to fewer coal units in the fleet, older wind purchased power contracts that can be curtailed without requiring PTC compensation, and ultimate termination of existing wind contracts.

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Introduction

Wind and solar generation ("variable generation") create additional electrical system costs that are not captured or reflected in traditional resource planning models. These costs are one set of additional costs imposed by variable generation known as integration costs.

The objective of this study is to update the integration costs associated with: 1) cycling baseload coal unit output as a result of wind and solar generation levels, and 2) curtailing variable generation at times to maintain balance between load and generation during system bottoming events.[1] Coal cycling cost from this study are included in the Company's Phase I alternate plans included as part of its Electric Resource Plan ("ERP") filings and also for evaluation of various portfolios of generation resources submitted in a Phase II ERP acquisition process.

Coal Plant Cycling Costs

Cycling is the operation of thermal electric generators at varying load levels, including on/off and low load variations, in response to system load requirements. Some generators (e.g., natural gas-fired combustion turbines and pumped hydro units) are designed for cyclical operation in order to follow, or balance, variations in load. In contrast, coal-fired generating units were principally designed for baseload operation. The inclusion of greater levels of variable generation sources such as wind and solar has forced a movement from the designed non-varying operation of the coal-fired generating units which can result in increased cycling-induced plant wear.

Curtailment Costs

In addition to cycling coal-fired generators in order to balance load and generation, system operators can choose to reduce/curtail the amount of variable generation on the system. While such actions can avoid additional coal cycling and cycling costs, curtailing variable generation results in its own set of costs including replacement fossil fuel costs, potential carbon mitigation costs, Renewable Energy Credit ("REC") opportunity costs, and payments/opportunity costs for the value of lost Production Tax Credits ("PTC").[2]

Prior Coal Plant Cycling Studies

The Company completed a previous coal cycling study in 2011.[3] The previous study evaluated the impacts of wind generation at two levels of installed capacity: 2 GW and 3 GW.[4] That study had two purposes: 1) estimate the costs associated with wind induced coal cycling and with wind curtailments, and 2) evaluate an appropriate coal plant operating protocol with significant amounts of wind generation. Table 1 below shows a summary of results from the prior study.

[1] The term "cycling" in this document refers to variations in the electric output of coal units from their maximum output to their minimum output (while remaining synchronized to the grid).
[2] Wind generators are only eligible for PTCs during the first 10 years of production. After the first 10 year period is over for a wind facility, there are no more "make whole" PTC payments or opportunity costs associated with curtailing wind generation from that facility.
[3] The study report was filed as Attachment 2.12-1 in the 2011 Electric Resource Plan (Docket No. 11A-869E).
[4] In this study report, all references to MW, GW, and MWh refer to MW_{AC}, GW_{AC}, and MWh_{AC} unless otherwise noted.

Table 1: Summary of Scenario Results from 2011 to 2025 (2010 Present Value)

Scenario	Installed Wind	Cycling Protocol	Cycling Cost Component ($Million)	Curtailment Cost Component ($/Million)	Total Levelized Annual Cost ($Million)	Total Levelized Cost ($/MWh)
1	2GW	Curtail	$3.6	$1.2	$4.82	$0.77
2	2GW	Deep Cycle	$5.1	$0.1	$5.21	$0.83
3	3GW	Curtail	$5.0	$3.3	$8.30	$1.03
4	3GW	Deep Cycle	$8.2	$0.6	$8.75	$1.08

The two operating protocols evaluated were: "Curtail" meaning cycling coal plants down to their economic minimum generation levels (shallow cycle) to accommodate wind and then curtailing wind in excess of the level needed to meet system load, and "Deep Cycle" meaning cycling coal plants down to their lower emergency minimum levels (deep cycle) to accommodate wind and then curtailing in excess of the level needed to meet system load. Because the 2011 study did not find a significant cost difference between the two operating protocols (and because there is a greater risk of reduced system reliability in the Deep Cycle protocol), the Curtail protocol was determined to be—and continues to be—the preferred operational protocol for the Company's system.[5]

Solar as a Source of Coal Cycling and Curtailments

At the time of the original study in 2011, the Public Service system had approximately 130 MW of solar capacity. Given these low solar levels and the observation that system load is typically higher during daylight hours, the prior study did not include solar generation as a variable generator. By the end of 2016, however, the Company estimates it will have ~ 550 MW of solar and anticipates the acquisition of several hundred MW more in the near future.

At current wind and solar penetration levels, solar generation can impact coal cycling and curtailments. Figure 1 is an illustration of how net load is impacted by projected wind and solar production over a two-day period in 2016.[6] As can be seen in the figure, solar may be affecting coal cycling and curtailments during early morning hours on days with relatively low system load and high wind generation.

[5] The Company will also place some coal units in reserve shutdown during extended periods of time when high levels of wind generation and low levels of customer load are forecast. Such actions serve to lower the system bottom ("Fleet Minimum Output") and reduce wind curtailments.

[6] Net load is defined here as total customer load less wind and solar generation.

Figure 1: Illustrative Coal Cycling and Curtailments - 2016 Summer

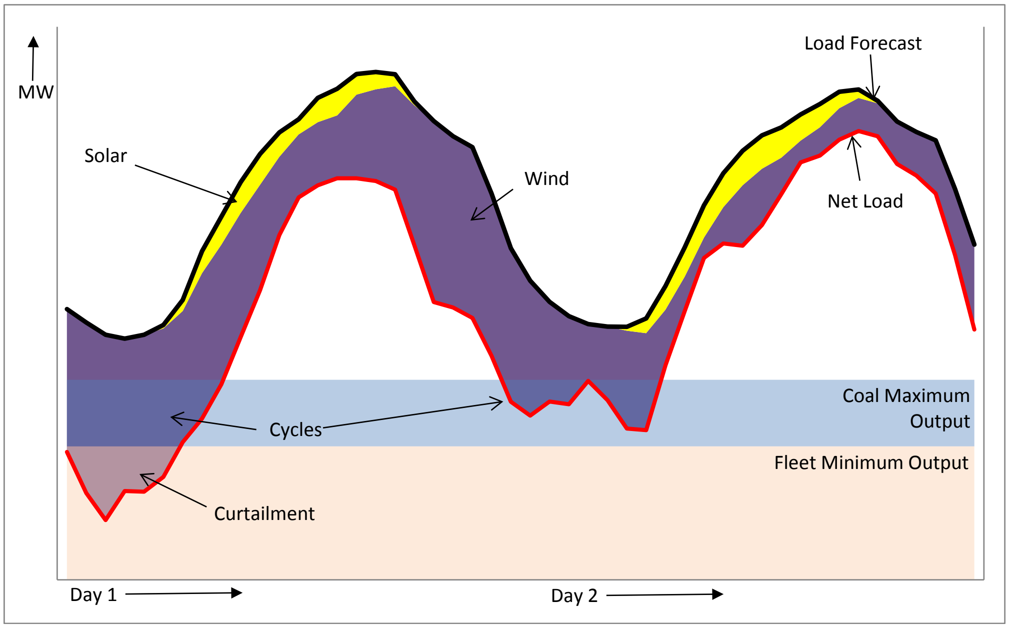
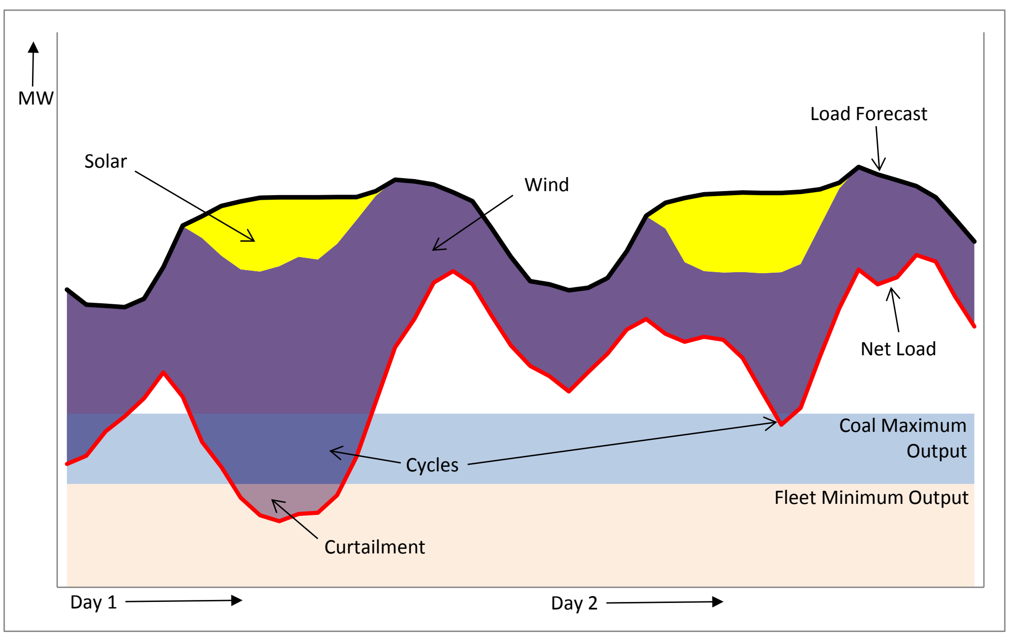


Figure 2 shows that as incremental solar and wind generation are added to the system these affects will be magnified and solar could become a more significant contributor to coal cycling and curtailment costs during daytime hours.[7]

Figure 2: Illustrative Coal Cycling and Curtailments - 2020 Spring



[7] Figure 2 was obtained from hourly data utilized in the analysis of an incremental 600 MW of wind and 450 MW of solar from Scenario 6 described in Table 3.

Study Methodology

In order to determine the plant-cycling cost component attributable to variable generation it is necessary to: 1) estimate the number of coal unit cycles that are directly attributable to a given level of wind and solar generation on the system, and 2) determine the cost per coal-unit cycle.

A spreadsheet model was developed for the prior study in order to estimate the number of coal-unit cycles attributable to variable generation. This model utilized a forecast of load before and net load after the addition of a user-specified level of wind generation to estimate the frequency and intensity of coal-unit cycles. In the spreadsheet model, coal units are stacked by operating cost to meet forecast net load and the number of cycles, by coal unit, are estimated. Plant cycling costs are then calculated as costs per cycle multiplied by the number of cycles estimated in the model.

Within the spreadsheet model, coal-unit generation is reduced until all operating coal units have been reduced to their economic minimum; this point is illustrated in Figures 1 and 2 as "Fleet Minimum Output". In order to balance load and generation, variable generation is curtailed if net load would otherwise fall below Fleet Minimum Output. Curtailment costs are then calculated based on existing coal plant variable and fuel cost forecasts, REC price forecasts, and PTC cost forecasts. These curtailment costs are added to the plant cycling costs to calculate the total costs.

In order to remove cycling and curtailment costs that would have occurred due to reductions in demand alone, cycling and curtailment costs are calculated twice for each scenario; once with variable generation in the generation portfolio and second under a control scenario which excludes variable generation. The cost difference between the variable generation calculation and the control calculation represents the cycling and curtailment cost attributable to the level of variable generation evaluated. Appendix A contains a more detailed description of the modeling assumptions and methodology used.

Study Goals

The Company's goals in this study were to estimate coal cycling and curtailment costs over the 25-year period from 2016-2040 for:

1. The existing system including assumptions for: ongoing customer choice solar programs, coal plant retirements, and expiring wind and solar purchase power agreements.[8] These existing system costs are referred to as "baseline costs" and set the level of costs against which incremental additions of wind and/or solar generation are measured.
2. Incremental portfolios of wind and/or solar generation at multiple locations to support the Company's 2016 Phase I ERP filing which requires various alternative generation plans. These are referred to in this study report as "Portfolio Addition" cases.
3. Incremental wind or solar generation at individual locations to support a 2016 ERP Phase II acquisition process. These location-specific cases could be used to estimate proposal-specific coal cycling costs for individual proposals. These are referred to in this study report as "Individual Addition" cases.

[8] Customer choice solar programs are assumed to add an incremental 110 MW each year over the study period. Customer choice solar is modeled with a 0.5% annual degradation in capacity and energy and with an expected 20-year life expectancy.

Model Updates to Support the Study Goals

As indicated earlier, the coal cycling spreadsheet model developed for the 2011 study was designed to examine the impacts of wind generation only. In order to support the current study goals, the following changes were made to the spreadsheet model:

- The 2011 model only included generic wind generation curves for two locations: "North" (the geographic region along the Colorado-Wyoming border) and "South" (the geographic region near Lamar, CO). For this study, another generic wind generation curve was added for a "Central" region (the geographic region near Limon, CO).
- Generic wind generation curves were utilized in the 2011 model for both existing and incremental generation. For this study, existing wind farms were modeled with plant-specific typical meteorological year ("TMY") profiles.[9] Incremental wind generation was modeled with a generic TMY curve specific to each of the three wind regions.
- Generic solar TMY generation curves were added for both fixed and tracking solar generation profiles at four broad geographic regions: Northern Front Range ("NFR"), Southern Front Range ("SFR"), San Luis Valley ("SLV"), and Western Slope ("WS"). Site-specific solar TMY generation curves were utilized for the Company's existing large-scale solar generators. Incremental solar generation was modeled with the generic solar TMY curves.
- Coal-unit cycle-counting logic was changed to accommodate the possibility that coal units would cycle more than once per day given the impacts of solar generation on system net load.
- The model was expanded from a maximum 15-year study period to a maximum 40-year period.

Other minor changes made to the spreadsheet model are noted in Appendix A.

Baseline Study Results

Table 2 below shows the levels of coal, wind and solar assumed in the baseline model. As mentioned previously, these levels are calculated assuming planned retirement dates for existing coal-fired generators along with terminations in currently existing coal, wind, and solar purchased power contracts. Installed Solar grows over time given the assumptions made for ongoing annual additions of customer choice solar.

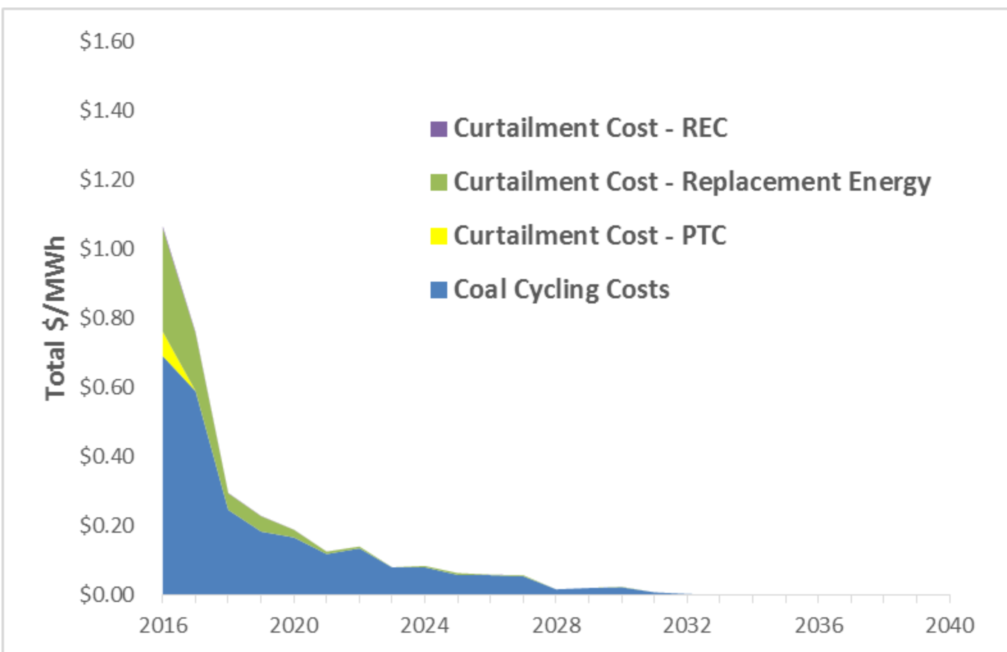
[9] A TMY curve is based on historical generation and is intended to capture typical variations in generation as observed over a multi-year period. Hourly generation for each month of the annual curve comes from the same historical monthly period; however, historical generation for each month can be based on historical generation from different years. The goal is to select hourly generation for each month from historical years in which the data are most typical of all years in the data set for that month. For example, in the TMY curve January data could come from 2012 whereas February data could come from 2014.

Table 2: Coal Economic Minimums and Installed Levels of Wind and Solar in Baseline Model

Year	Coal Economic Minimums (MW)	Installed Wind (MW)	Installed Solar (MW)[10]
2016	1,480	2,560	400
2020	1,150	2,360	870
2025	1,150	2,360	1,330
2030	1,150	1,700	1,720
2035	880	1,100	1,920
2040	620	250	2,050

Figure 3 below shows the costs of coal cycling and curtailments in the Baseline case. Total $/MWh costs are calculated in the figure as total coal cycling and curtailment costs divided by total wind and solar generation. A table of annual results for the Baseline case is included in Appendix B as Table B.1.

Figure 3: Baseline Case Cost of Coal Cycling and Curtailments years 2016-2040



In the Baseline case, the level of curtailments and the number of coal unit cycles decrease over time, eventually dropping to zero due to load growth and changes in the generation supply mix. The large drop

[10] Installed Solar interconnected or assumed to connect at voltages below transmission voltage is grossed up to a transmission-level MW equivalent to compensate for assumed line losses.

in costs that occurs between 2016 and 2018 is driven primarily by the retirement of the 184 MW Valmont 5 coal-fired unit at the end of 2017 and the continued operation of the 352 MW Cherokee 4 coal-fired unit on natural gas past the end of 2017 as part of the Clean Air Clean Jobs Act. In addition, 500 MW of wind generation will lose PTC payments at the end of 2016 and by 2019 over 50% of the existing wind portfolio will not be receiving PTC payments. The result of these changes is that the PTC cost of curtailment, while important in the 2011 Coal Cycling study, is not particularly material in the Baseline case here. REC costs of curtailment are negligible due primarily to the low forecasted price of wind RECs.[11]

Figure 3 shows no Curtailment Costs for incremental carbon dioxide emissions assumed for the replacement energy resources when variable generation is curtailed. The characteristics of pending carbon dioxide regulation for new and existing generation units (i.e., the final version of the EPA's Clean Power Plan released in August 2015) suggest that each state (and the affected generation units within each state) would be required to lower carbon dioxide emissions to a certain level rather than incurring carbon taxes (e.g., the implementation of a $/ton emissions cost). Accordingly, the Company currently assumes a baseline, zero cost of carbon dioxide emissions in its planning efforts; reductions in regulated emissions are modeled separately and assumed emissions costs can be calculated outside of the models. Therefore, the Company assumed no incremental carbon dioxide emission costs resulting from variable generation curtailment in this study.

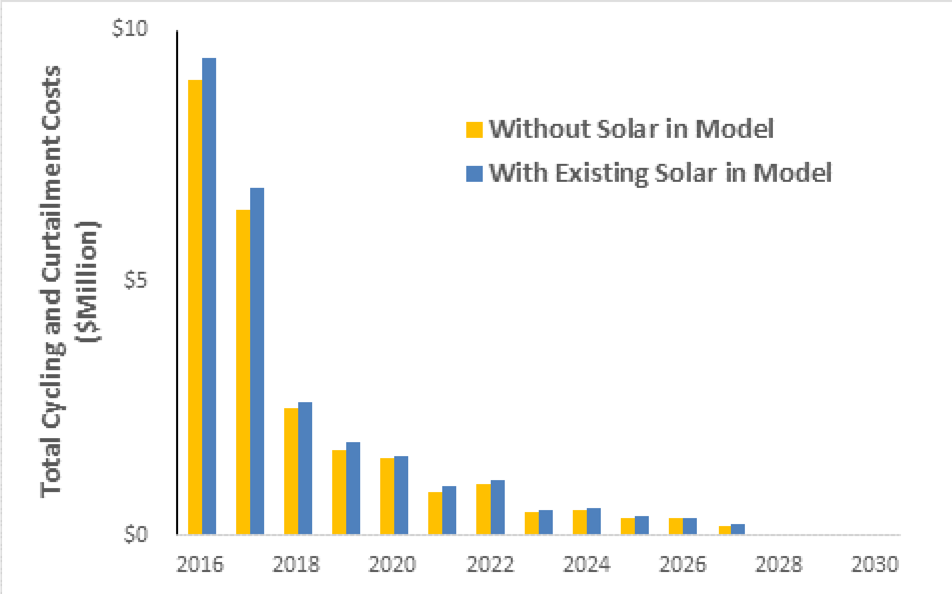
Current Impacts of Solar

As stated earlier, solar generation was examined in this study because it is an increasingly important contributor to the Company's generation mix. To explore whether solar is a factor in coal cycling at current levels, the coal cycling and curtailment spreadsheet model was run with and without solar. Figure 4 shows the total cycling and curtailments costs for these two runs.

Figure 4 indicates that current (2016) levels of installed solar do appear to have an impact on coal cycling and curtailment costs. However the impact is small compared to the costs due to current levels of installed wind generation.

[11] A flat REC price of $0.40/MWh of wind or solar generation was assumed. See Appendix A for further discussion.

Figure 4: Total Coal Cycling and Curtailment Costs with and without Solar



Portfolio Addition Study Results

As indicated previously, the Portfolio Addition study assumptions were designed for use in the development of alternate plan portfolios for Phase I of the Company's ERP. The Company evaluated the incremental additions of a geographic-diverse portfolio of 600 MW and 1,200 MW of wind and 450 MW and 900 MW of solar on top of the Baseline portfolio as shown in Table 3.[12] In order to facilitate the use of the study results in the Company's planning models all incremental generators were assumed to be operational at the start of 2019.

Table 3: Portfolio Wind and Solar Additions by Resource Zones

Scenario	Wind Additions (MW)				Solar Additions (MW)				
#	North	Central	South	Total	NFR	SFR	SLV	WS	Total
1				0					0
2	250	250	100	600					0
3	500	500	200	1,200					0
4				0	100	170	150	30	450
5				0	200	340	300	60	900
6	250	250	100	600	100	170	150	30	450
7	500	500	200	1,200	200	340	300	60	900

[12] The distribution of incremental wind and solar generation assumed in Table 3 is roughly equal to the current distribution of wind and solar generation for these broad geographic areas. All incremental solar generation was assumed to be tracking.

Baseline Scenario Results

Table 4 shows the levelized annual costs of the 25-year coal cycling and curtailment costs from the Baseline run (Scenario 1) as well as those from Scenarios 2-7 with increasing levels of wind and solar. Results are provided in Table 4 on both a levelized annual dollar and $/MWh basis. Tables of annual results for Scenarios 2-7 are included in Appendix B as Tables B.2 through B.7 respectively.

Table 4: Summary of Portfolio Addition Scenario Results for 2016-2040 (2016 present value)

Scenario #	**Added Wind** (MW)	**Added Solar** (MW AC)	**Cycling Cost Component** ($Million)	**Curtailment Cost Component** ($/Million)	**Total Levelized Annual Cost** ($Million)	**Total Levelized Cost** ($/MWh)
1	---	---	$1.55	$0.46	$2.01	$0.23
2	600	---	$2.39	$0.93	$3.32	$0.31
3	1,200	---	$3.43	$2.91	$6.33	$0.52
4	---	450	$1.75	$0.54	$2.29	$0.24
5	---	900	$2.14	$0.77	$2.92	$0.28
6	600	450	$2.68	$1.28	$3.96	$0.35
7	1,200	900	$4.18	$5.23	$9.41	$0.69

Incremental Wind Scenario Results

Figures 5 and 6 below show the Coal Cycling and Curtailment costs (in nominal $/MWh) for Scenarios 2 and 3 which add 600 and 1,200 MW of wind respectively.

**Figure 5: Scenario 2 Total Cycling and Curtailment Costs
600 MW Incremental Wind**

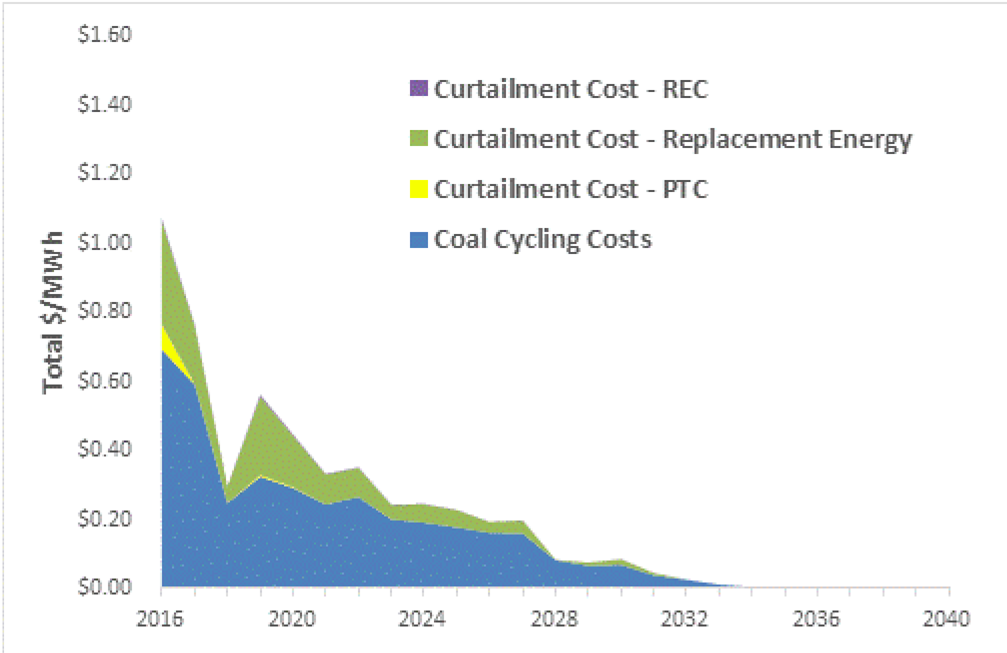
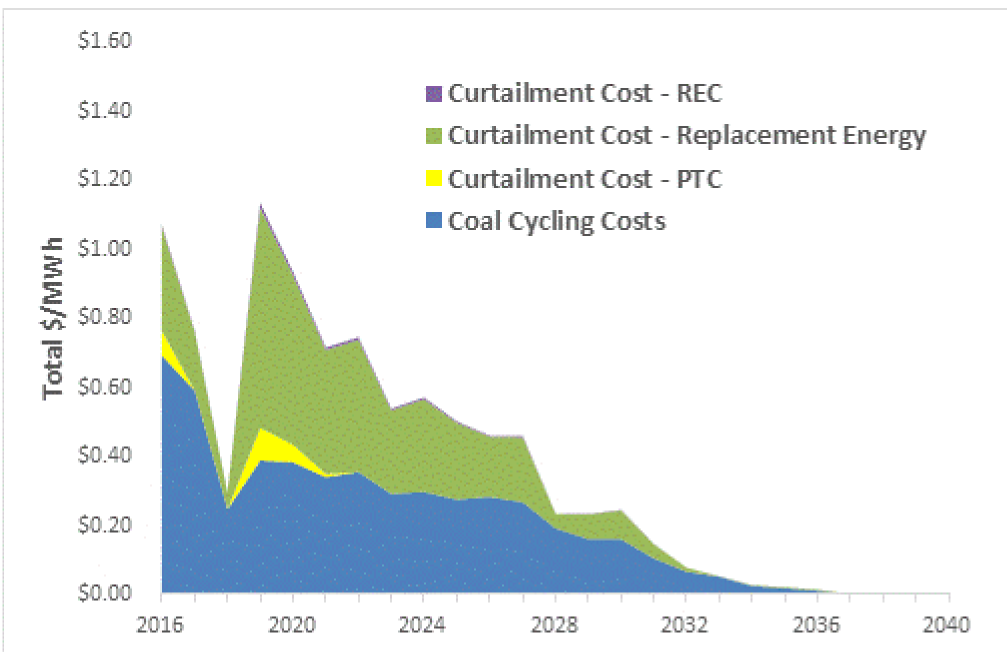


**Figure 6: Scenario 3 Total Cycling and Curtailment Costs
1,200 MW Incremental Wind**

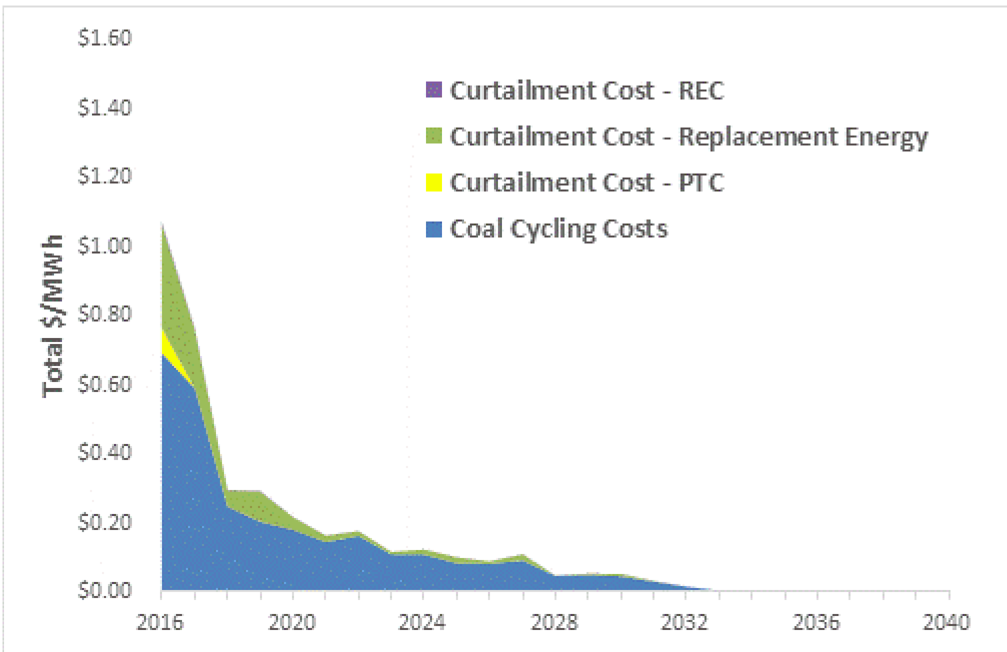


With the addition of 1,200 MW of wind generation, combined coal cycling and curtailment costs increase temporarily, on a $/MWh basis, to current levels; however replacement energy costs represent a larger portion of the costs in 2019 as compared to 2016. PTC curtailment costs become a minor factor again for a few years as a larger portion of wind generation subject to PTC costs would be curtailed.[13]

Incremental Solar Scenario Results

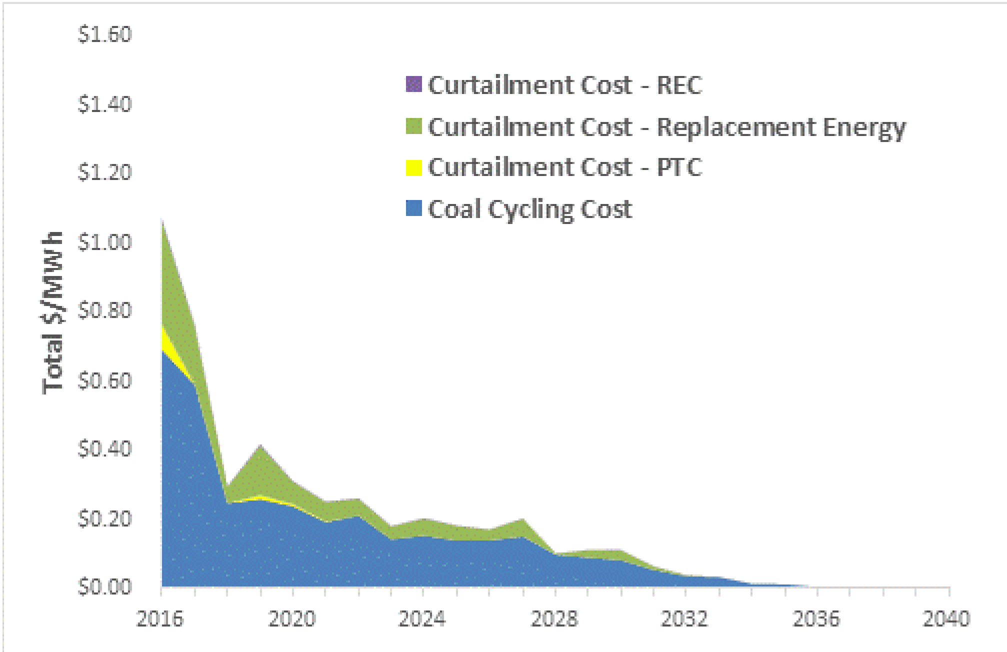
Figures 7 and 8 show the Coal Cycling and Curtailment costs (in nominal $/MWh) for Scenarios 4 and 5 which add 450 and 900 MW of solar respectively. The coal cycling and curtailment impacts for solar are smaller than that of wind but they do impact the total $/MWh costs. Again, the costs eventually drop to zero due to resource and contract retirements over time.

Figure 7: Scenario 4 Total Cycling and Curtailment Costs
450 MW Incremental Solar



[13] The spreadsheet model curtails wind generation before any other variable generation. If solar generation from purchased power contracts is curtailed ahead of PTC-eligible wind, the levelized cost of curtailment shown in Figure 6 for Scenario 3 would be reduced by an insignificant $0.04 million.

**Figure 8: Scenario 5 Total Cycling and Curtailment Costs
900 MW Incremental Solar**



Incremental Wind and Solar Scenario Results

Figures 9 and 10 show the Coal Cycling and Curtailment costs (in nominal $/MWh) for Scenarios 6 and 7. Scenario 6 adds the 600 MW of wind and 450 MW of solar examined separately in Scenarios 2 and 4. Scenario 7 adds the 1,200 MW of wind and 900 MW of solar examined separately in Scenarios 3 and 5.

Figure 9: Scenario 6 Total Cycling and Curtailment Costs
Incremental 600 MW Wind and 450 MW Solar

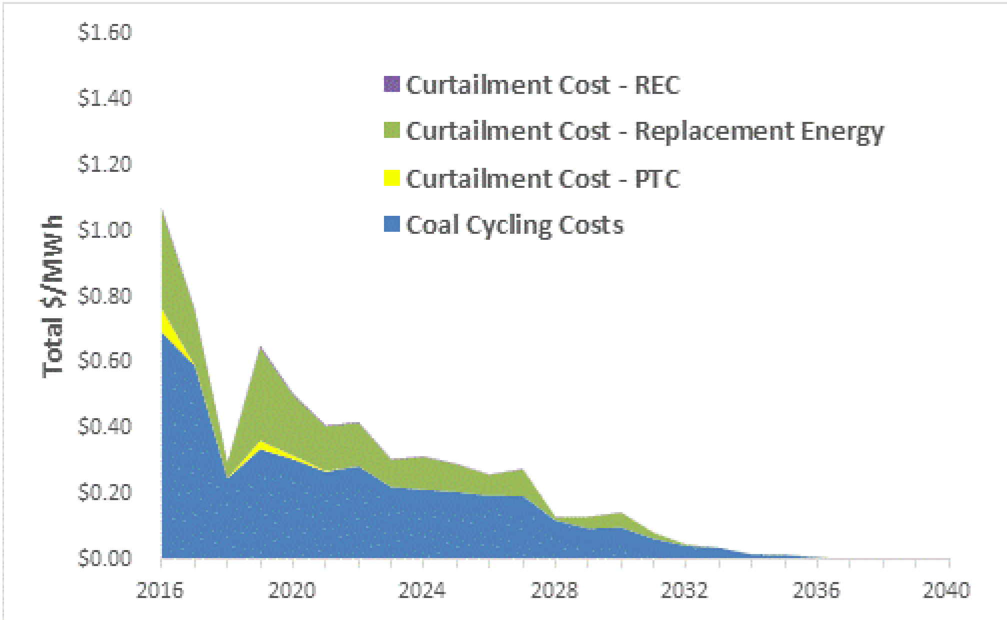
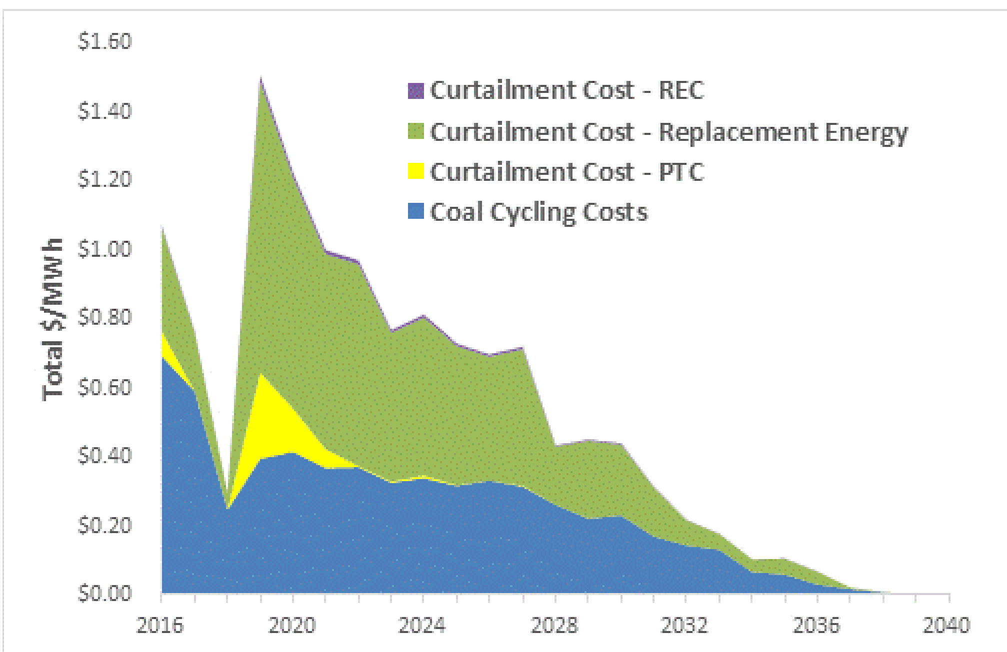


Figure 10: Scenario 7 Total Cycling and Curtailment Costs
Incremental 1,200 MW Wind and 900 MW Solar



A comparison of the results for Scenario 2 (600 MW incremental wind only) with the results for Scenario 6 (600 MW incremental wind and 450 MW incremental solar) shows that the incremental solar causes a relatively low level of incremental coal cycling and curtailment costs. However, a similar comparison of

Scenarios 3 and 7 (comparing 1,200 MW of wind only with 1,200 MW of wind and 900 MW of solar) shows that the incremental solar causes a noticeably higher level of incremental costs.

PTC Curtailment Costs shown in Figure 10 for Scenario 7 could likely be reduced through the curtailment of utility-scale solar in lieu of PTC-funded wind curtailment. The model shows that if solar generation from purchased power contracts were curtailed ahead of PTC-eligible wind the levelized cost of curtailment would be reduced $0.34 Million and the levelized Total Cost would decrease by $0.02/MWh.

Individual Additions Study Results

In order to examine the impacts of individual, location-specific additions of wind and solar generation, the Company studied the impacts of 300 MW, 600 MW, and 900 MW of wind at each of the three resource zones (North, Central, South) and the impacts of 100 MW and 200 MW of solar at each of the four resource zones (NFR, SFR, SLV, WS) and for fixed or tracking additions. These results can be used to estimate the impact that individual projects would have on coal cycling and curtailment costs when evaluated as part of a competitive acquisition.

Table 5 shows the incremental levelized costs of adding individual increments of 300 MW, 600 MW, and 900 MW of wind at three resource zones. All of the costs shown are incremental above the Baseline case costs. Annual $/MWh costs for Scenarios 8-16 are shown in Tables B.8 through B.16 in Appendix B.

Table 5: Incremental Levelized Costs over the Baseline Scenario of Individual Additions of Wind by Resource Zone 2019 to 2040

			Incremental over Baseline				
Scenario	Added Wind	Resource Zone	Wind Production (GWh/yr)	Cycling Cost Component ($Million)	Curtailment Cost Component ($/Million)	Total Levelized Annual Cost ($Million)	Total Levelized Cost ($/MWh)
8	300 MW	North	1,070	$0.51	$0.18	$0.68	$0.64
9	600 MW	North	2,140	$1.19	$0.65	$1.84	$0.86
10	900 MW	North	3,211	$1.97	$1.69	$3.66	$1.14
11	300 MW	Central	1,022	$0.49	$0.18	$0.67	$0.66
12	600 MW	Central	2,043	$1.12	$0.64	$1.75	$0.86
13	900 MW	Central	3,065	$1.84	$1.66	$3.49	$1.14
14	300 MW	South	1,181	$0.47	$0.16	$0.64	$0.54
15	600 MW	South	2,363	$1.13	$0.62	$1.75	$0.74
16	900 MW	South	3,544	$1.96	$1.66	$3.62	$1.02

Table 6 shows the incremental levelized costs of adding individual increments of 100 MW and 200 MW of fixed orientation solar at four resource zones. Table 7 shows similar incremental costs for tracking solar. The costs for incremental solar are small relative to wind additions both in $/MWh and total dollars; note that wind incremental costs in Table 5 are reported in millions of dollars while solar incremental costs in Tables 6 and 7 are reported in thousands of dollars. Annual $/MWh costs for Scenarios 17-24 are shown in Tables B.17 through B.24 in Appendix B.

Table 6: Incremental Levelized Costs over the Baseline Scenario of Individual Additions of Fixed Solar by Resource Zone 2019 to 2040

			Incremental over Baseline				
Scenario	Added Solar	Resource Zone	1st Year Solar Production (GWh)	Cycling Cost Component ($000)	Curtailment Cost Component ($000)	Total Levelized Annual Cost ($000)	Total Levelized Cost ($/MWh)
17	100 MW	NFR	137	$34	$9	$43	$0.33
18	200 MW	NFR	274	$69	$21	$90	$0.34
19	100 MW	SFR	161	$41	$11	$52	$0.34
20	200 MW	SFR	322	$84	$26	$109	$0.35
21	100 MW	SLV	169	$38	$10	$49	$0.30
22	200 MW	SLV	338	$72	$23	$95	$0.29
23	100 MW	WS	147	$28	$8	$37	$0.26
24	200 MW	WS	293	$62	$19	$81	$0.29

Table 7: Incremental Levelized Costs over the Baseline Scenario of Individual Additions of Tracking Solar by Resource Zone 2019 to 2040

			Incremental over Baseline				
Scenario	Added Solar	Resource Zone	1st Year Solar Production (GWh)	Cycling Cost Component ($000)	Curtailment Cost Component ($000)	Total Levelized Annual Cost ($000)	Total Levelized Cost ($/MWh)
25	100 MW	NFR	167	$41	$13	$53	$0.33
26	200 MW	NFR	334	$85	$29	$115	$0.36
27	100 MW	SFR	197	$49	$16	$65	$0.34
28	200 MW	SFR	393	$99	$36	$135	$0.36
29	100 MW	SLV	224	$46	$14	$60	$0.28
30	200 MW	SLV	448	$92	$32	$124	$0.29
31	100 MW	WS	181	$36	$12	$48	$0.28
32	200 MW	WS	361	$72	$28	$100	$0.29

Conclusions

The Public Service system currently has about 2,550 MW of wind and it expects ~ 550 MW of solar at the end of 2016. These variable generation resources cause incremental integration costs as a result of interactions with the Company's existing coal-fired units. Current integration costs are front loaded; absent incremental variable generation, coal cycling costs are expected to decrease over time with load growth, coal unit retirements, and changes to existing wind generation resources including loss of PTC eligibility and contract termination. Incremental wind and solar generation resources will tend to delay cost reductions or increase coal cycling and curtailment costs depending upon the level of assumed additions.

Coal cycling costs and the replacement energy components of the curtailment costs are the primary drivers of the total costs. Production Tax Credit curtailment costs stop being a significant contributor to curtailment costs by the end of 2017 with the exception of scenarios with large additions of new PTC-funded wind. Even in those cases, however, the impact is minor and only lasts for a few years after assumed installation in 2019. Similarly, Renewable Energy Credit curtailment costs are negligible due to the low assumed price of RECs.

Appendix A – Assumptions and Methodology

This study estimated wind and solar (variable resources) induced cycling costs for a Baseline scenario as well as various levels of added solar and wind resources. The total cycling costs are the sum of the plant cycling component and the curtailment component. The study determined cycling costs and curtailment costs as follows:

Plant Cycling Component Calculation

This study used current resource expansion plans, unit operating characteristics, load forecasts and cost per cycle metrics to estimate variable generation-induced cycling costs using a method that applies a cost per cycle to the forecast number of wind and solar-induced cycles to determine annual cycling costs.

Plant cycling costs are calculated as the number of variable resource-induced cycles multiplied by the cost per cycle. In the original study, three types of cycles were considered: 1) on/off cycling, 2) shallow cycling, and 3) deep cycling. On/off cycling is decommitting the coal unit. In the first study, on/off cycling was not determined to be a viable choice for routine cycling due to its high cost. Deep cycling assumes cycling the coal units down to their emergency minimums while shallow cycling assumes cycling down to economic minimums. Deep cycling increases potential reliability risks and in the first study the cycling costs were estimated to be similar to shallow cycling costs. In that study, shallow cycling was determined to be the recommended operating protocol. Therefore, in this study update, shallow cycling was used for all scenarios.

Estimating the Number of Cycles

To estimate the number of coal unit cycles attributable to wind, the Company developed a spreadsheet tool that forecasts cycles based on hourly obligation load, wind and solar generation forecasts and its baseload unit generation profiles and used this information to estimate the frequency and intensity of cycles. Inputs needed to calculate cycles are as follows:

Load Forecast

The hourly obligation load forecast based upon the typical year hourly load shape used in the Company's planning models. The base year data is scaled to meet forecast energy and peak load.

Generating Unit Characteristics

Unit level detail of baseload and must-take units including: unit minimum and maximum output levels, typical outage schedules, expected forced outage rates and planned capacity changes (additions and retirements). The resource mix used in the analysis includes all coal plant retirements at their scheduled dates, all must-take contract expirations and the planned expansion of the Cabin Creek Pumped Storage Generation Station.

Wind Generation Forecasts and Profiles

Individual plant-specific hourly profiles were used for each of the existing wind contracts. Typical Wind Year ("TWY") hourly profiles for each existing facility plus the three generic profiles (North, Central, and South) are based on historical data or, when unavailable, best available data (wind speeds and generation from geographically proximate sources). The three generic wind profiles were used for incremental wind additions.

In this study, all existing wind contracts are forecasted to expire at the contract termination dates and all generic wind additions are assumed to have 25-year lives.

Solar Generation Profiles

Individual plant-specific hourly profiles were used for each of the existing large-scale solar generating facilities. Typical Solar Year ("TSY") hourly profiles for the existing facilities and customer choice solar facilities were based on historical solar generation data. In addition, eight "generic" TSY profiles were used for future additions. These generic profiles represent four solar resource zones: Northern Front Range, Southern Front Range, San Luis Valley and the Western Slope and either fixed or tracking installations. The generic profiles were also based on historic generation data.

In this study, all existing solar contracts are forecasted to expire at the contract termination dates and all generic solar additions are assumed to have 30-year lives. Incremental customer choice solar is assumed to be added at approximately 110 MW per year in the Baseline scenario. In addition, a single 50 MW facility is also assumed in the Baseline scenario starting in 2018.

Counting the Cycles

The model estimates the number of coal unit load follow cycles directly attributable to wind and solar generation using the following methodology:

- An hourly net load forecast is created for each year. The net load is the difference between the forecast obligation load and the sum of the forecast wind and solar generation.
- For each hour of the year, the net load is compared to the maximum aggregate generation capacity of the baseload plants for that hour. If the net load is lower than the maximum aggregate baseload capacity, then it is assumed that one or more baseload units will have to decrease output, or cycle, to follow load. Unit maintenance schedules, scheduled power purchase contracts and estimated forced outages ("EFOR") are accounted for in the calculation. Therefore the maximum baseload capacity for a given hour is the sum of the expected online units only.
- In the 2011 study, for each day of the year the maximum MW load follow was determined based on the hourly calculations above. This method assumed baseload units cycle a maximum of once per day. Because solar has a different diurnal nature, the potential for multiple coal unit cycles occurring during any given day is higher versus if only wind is modeled. In the current model, for each individual cycle (that is, any time the coal plants are calculated to have reduced generation due to wind and solar generation) the maximum MW reduced generation for that cycle was determined. The model then determines which coal units would reduce their generation in each cycle based on each of their maximum and economic minimum MWs and economic dispatch order.

These calculations are repeated assuming there is no wind or solar generation on the system; i.e., the net load is equal to obligation load so as to count cycles that would have occurred absent any wind or solar. The difference between these two cycle counts (with and without variable energy) is the estimate of the number of cycles attributable to wind and solar.

Calculating the Cost per Cycle

The Company retained APTECH Engineering Inc. in the fall of 2008 to study cycling costs for its baseload units. In March 2009, APTECH completed drafts for the Phase 1 study for Pawnee. These costs were extrapolated to the rest of the coal-fired fleet using data from an earlier study[14] which calculated cycling costs for a number of plants. In the previous study, cycling costs were found to be correlated to plant size. The Phase 1 costs for Pawnee were extrapolated to other coal-fired generating units using the correlation data for the rest of the coal-fired plants. These costs were inflated to 2016 dollars based on the change in the Bureau of Labor Statistic's Producer Price Index-Commodities Finished Goods index.

Calculating the Curtailment Cost Component

In addition to load following by baseload units to accommodate wind and solar generation, curtailment may be required when the cycling capabilities of the baseload fleet have been maximized. Curtailment costs are calculated by multiplying the quantity of variable energy curtailed (MWh) by the cost per MWh of curtailment. The costs are calculated on an annual basis and divided by the total MWh of annual variable energy generation (including curtailed hours) resulting in a dollar per Megawatt-hour metric for ease of discussion and consistency with how wind integration costs have been presented in previous studies.

Forecasting Variable Energy Curtailment

The model estimates the MWhs of curtailed generation by determining, for each hour of the year, the quantity of excess wind and solar remaining on the system after all baseload coal units have cycled down to their minimum loads. This quantity of energy must be curtailed to balance load and generation. In the 2011 study, wind was assumed to be curtailed in 50 MW blocks. Since the 2011 study, the Company now requires wind facilities to have AGC capabilities allowing for more discrete levels of wind curtailment. Therefore, variable energy can now be curtailed by the MW and the 50 MW block requirement was removed from the model.

Per MWh Curtailment Costs

Costs per MWh of curtailed energy are comprised of the following four components:

Avoided Energy Cost

Avoided energy or replacement energy cost is the cost of the coal generation that would have been avoided if not for the curtailment. This cost is based on the annual average coal dispatch costs for the fleet. While this method is a simplification and does not explicitly capture the reduced coal plant efficiencies caused by operating at lower output levels when cycling, it does capture some of these effects of cycling in as much as typical cycles are captured in the dispatch models. Avoided energy costs are multiplied by all curtailed MWhs.

Production Tax Credits

PTC uplift payments may be paid to a wind developer when production is curtailed. PTCs are available for the first 10 years of operations of a wind facility. In the model, it is assumed that the tax credit will be available to wind facilities that begin commercial operations by the end of 2019. The PTC is $23/MWh in 2016 and grows at an assumed inflation rate of 2% annually. To make the developer whole, the PTC is grossed-up for taxes using a composite tax rate of 38%.

[14]APTECH Engineering Services, Inc.; Total Cost of Cycling Fossil Power Plants: Phase 2, January 1997 (PSCo Source Data: 1985-1994).

Energy that is curtailed in the model is identified on an hourly basis as “PTC wind” or “non-PTC wind”: a wind facility is generally PTC wind for 10 years then moves to non-PTC wind. The model subtracts “free curtailment wind” (i.e., certain purchase power contracts allow the Company to curtail specified amounts of wind on an annual basis with no make-whole payments) and non-PTC wind from the curtailed wind; only the remaining curtailed PTC wind is used to calculate the total cost of the annual PTC payments.

Carbon Dioxide Emissions Cost

Carbon dioxide emissions costs are assumed to be zero in this updated study consistent with other recent Company studies and filings.

Renewable Energy Credit Opportunity Cost

The opportunity cost of RECs not generated as a result of curtailment is applied to all curtailed wind. This assumes the REC has value either for compliance or for sale into a market. The forecast REC price of $1.00/MWh is discounted to $0.40/MWh to account for the fact that not every REC is available for sale. This price is held constant for all years.

Model Expansion

The updated model used in this study was expanded from 15-years to 40-years which corresponds to the Company’s maximum resource planning period.

Appendix B – Annual Results

Table B.1: Scenario 1
Baseline Annual Results
(<u>Total</u> Nominal $/MWh)

Year	Total Variable Energy	Curtailed Energy	Cycling Cost	Curtailment Cost			Total Cost
				PTC Gross Up	Replacement Energy	REC	
	(GWh)	(GWh)	($/MWh)	($/MWh)	($/MWh)	($/MWh)	($/MWh)
2016	8,885	134	$0.69	$0.07	$0.30	$0.01	$1.07
2017	9,199	75	$0.59	$0.00	$0.17	$0.00	$0.76
2018	9,337	25	$0.25	$0.00	$0.05	$0.00	$0.30
2019	9,151	21	$0.18	$0.00	$0.04	$0.00	$0.23
2020	9,312	11	$0.17	$0.00	$0.02	$0.00	$0.19
2021	9,473	3	$0.12	$0.00	$0.01	$0.00	$0.13
2022	9,633	3	$0.14	$0.00	$0.01	$0.00	$0.14
2023	9,793	0	$0.08	$0.00	$0.00	$0.00	$0.08
2024	9,953	2	$0.08	$0.00	$0.00	$0.00	$0.08
2025	10,111	2	$0.06	$0.00	$0.01	$0.00	$0.06
2026	10,069	1	$0.06	$0.00	$0.00	$0.00	$0.06
2027	10,224	1	$0.05	$0.00	$0.00	$0.00	$0.06
2028	8,704	0	$0.02	$0.00	$0.00	$0.00	$0.02
2029	8,832	0	$0.02	$0.00	$0.00	$0.00	$0.02
2030	8,868	0	$0.02	$0.00	$0.00	$0.00	$0.02
2031	8,921	0	$0.01	$0.00	$0.00	$0.00	$0.01
2032	8,093	0	$0.00	$0.00	$0.00	$0.00	$0.00
2033	7,554	0	$0.00	$0.00	$0.00	$0.00	$0.00
2034	7,647	0	$0.00	$0.00	$0.00	$0.00	$0.00
2035	7,304	0	$0.00	$0.00	$0.00	$0.00	$0.00
2036	7,414	0	$0.00	$0.00	$0.00	$0.00	$0.00
2037	6,734	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	5,401	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	5,407	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	4,579	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.2: Scenario 2
600 MW Added Wind
(<u>Incremental</u> over Baseline Nominal $/MWh)

Year	Total Variable Energy	Curtailed Energy	Cycling Cost	Curtailment Cost			Total Cost
				PTC Gross Up	Replacement Energy	REC	
	(GWh)	(GWh)	($/MWh)	($/MWh)	($/MWh)	($/MWh)	($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	2,137	114	$0.92	$0.03	$1.01	$0.02	$1.98
2020	2,137	78	$0.83	$0.01	$0.70	$0.01	$1.56
2021	2,137	48	$0.79	$0.00	$0.44	$0.01	$1.24
2022	2,137	46	$0.85	$0.00	$0.44	$0.01	$1.30
2023	2,137	24	$0.75	$0.00	$0.23	$0.00	$0.99
2024	2,137	29	$0.70	$0.00	$0.28	$0.01	$0.99
2025	2,137	25	$0.74	$0.00	$0.26	$0.00	$1.00
2026	2,137	16	$0.65	$0.00	$0.17	$0.00	$0.82
2027	2,137	19	$0.66	$0.00	$0.20	$0.00	$0.86
2028	2,137	0	$0.35	$0.00	$0.00	$0.00	$0.35
2029	2,137	4	$0.25	$0.00	$0.05	$0.00	$0.30
2030	2,137	7	$0.26	$0.00	$0.08	$0.00	$0.33
2031	2,137	3	$0.16	$0.00	$0.03	$0.00	$0.20
2032	2,137	0	$0.11	$0.00	$0.00	$0.00	$0.11
2033	2,137	0	$0.05	$0.00	$0.00	$0.00	$0.05
2034	2,137	0	$0.02	$0.00	$0.00	$0.00	$0.02
2035	2,137	0	$0.02	$0.00	$0.00	$0.00	$0.02
2036	2,137	0	$0.01	$0.00	$0.00	$0.00	$0.01
2037	2,137	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	2,137	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	2,137	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	2,137	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.3: Scenario 3
1,200 MW Added Wind
(Incremental over Baseline Nominal $/MWh)

Year	Total Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replace ment Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	4,274	432	$0.82	$0.30	$1.90	$0.04	$3.06
2020	4,274	336	$0.85	$0.16	$1.50	$0.03	$2.55
2021	4,274	246	$0.83	$0.03	$1.14	$0.02	$2.02
2022	4,274	258	$0.85	$0.00	$1.23	$0.02	$2.11
2023	4,274	163	$0.78	$0.00	$0.80	$0.02	$1.59
2024	4,274	179	$0.80	$0.00	$0.89	$0.02	$1.70
2025	4,274	143	$0.79	$0.00	$0.74	$0.01	$1.54
2026	4,274	112	$0.81	$0.00	$0.58	$0.01	$1.40
2027	4,274	120	$0.78	$0.00	$0.63	$0.01	$1.42
2028	4,274	23	$0.55	$0.00	$0.13	$0.00	$0.68
2029	4,274	39	$0.45	$0.00	$0.22	$0.00	$0.67
2030	4,274	46	$0.44	$0.00	$0.25	$0.00	$0.70
2031	4,274	22	$0.31	$0.00	$0.12	$0.00	$0.43
2032	4,274	6	$0.18	$0.00	$0.03	$0.00	$0.22
2033	4,274	0	$0.14	$0.00	$0.00	$0.00	$0.14
2034	4,274	1	$0.07	$0.00	$0.01	$0.00	$0.07
2035	4,274	1	$0.05	$0.00	$0.01	$0.00	$0.06
2036	4,274	1	$0.03	$0.00	$0.01	$0.00	$0.04
2037	4,274	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	4,274	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	4,274	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	4,274	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.4: Scenario 4
450 MW Added Solar
(Incremental over Baseline Nominal $/MWh)

Year	Total Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replace ment Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	891	24	$0.40	$0.01	$0.51	$0.01	$0.93
2020	887	8	$0.32	$0.00	$0.18	$0.00	$0.50
2021	882	7	$0.41	$0.00	$0.15	$0.00	$0.56
2022	878	4	$0.46	$0.00	$0.10	$0.00	$0.56
2023	874	3	$0.44	$0.00	$0.07	$0.00	$0.51
2024	869	6	$0.42	$0.00	$0.14	$0.00	$0.56
2025	865	6	$0.37	$0.00	$0.15	$0.00	$0.53
2026	861	3	$0.36	$0.00	$0.07	$0.00	$0.43
2027	856	7	$0.53	$0.00	$0.19	$0.00	$0.72
2028	852	0	$0.35	$0.00	$0.00	$0.00	$0.35
2029	848	1	$0.35	$0.00	$0.04	$0.00	$0.39
2030	844	2	$0.28	$0.00	$0.06	$0.00	$0.35
2031	839	1	$0.26	$0.00	$0.02	$0.00	$0.28
2032	835	0	$0.13	$0.00	$0.00	$0.00	$0.13
2033	831	0	$0.04	$0.00	$0.00	$0.00	$0.04
2034	827	0	$0.01	$0.00	$0.00	$0.00	$0.01
2035	823	0	$0.03	$0.00	$0.00	$0.00	$0.03
2036	819	0	$0.02	$0.00	$0.00	$0.00	$0.02
2037	814	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	810	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	806	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	802	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.5: Scenario 5
900 MW Added Solar
(Incremental over Baseline Nominal $/MWh)

Year	Total Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replacement Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	1,783	62	$0.64	$0.07	$0.66	$0.01	$1.38
2020	1,774	27	$0.61	$0.03	$0.29	$0.01	$0.95
2021	1,765	29	$0.59	$0.01	$0.32	$0.01	$0.92
2022	1,756	25	$0.62	$0.00	$0.29	$0.01	$0.92
2023	1,747	20	$0.49	$0.00	$0.24	$0.00	$0.74
2024	1,739	26	$0.57	$0.00	$0.31	$0.01	$0.88
2025	1,730	21	$0.61	$0.00	$0.26	$0.00	$0.87
2026	1,721	16	$0.62	$0.00	$0.20	$0.00	$0.82
2027	1,713	26	$0.72	$0.00	$0.34	$0.01	$1.07
2028	1,704	1	$0.51	$0.00	$0.02	$0.00	$0.53
2029	1,696	10	$0.45	$0.00	$0.14	$0.00	$0.59
2030	1,687	12	$0.39	$0.00	$0.17	$0.00	$0.57
2031	1,679	5	$0.29	$0.00	$0.06	$0.00	$0.36
2032	1,670	1	$0.19	$0.00	$0.01	$0.00	$0.20
2033	1,662	0	$0.18	$0.00	$0.00	$0.00	$0.18
2034	1,654	0	$0.07	$0.00	$0.00	$0.00	$0.07
2035	1,645	0	$0.06	$0.00	$0.00	$0.00	$0.06
2036	1,637	0	$0.02	$0.00	$0.00	$0.00	$0.02
2037	1,629	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	1,621	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	1,613	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	1,605	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.6: Scenario 6
600 MW Added Wind + 450 MW Added Solar
(Incremental over Baseline Nominal $/MWh)

Year	Total Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replacement Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	3,028	162	$0.80	$0.10	$1.01	$0.02	$1.93
2020	3,024	108	$0.73	$0.05	$0.69	$0.01	$1.48
2021	3,019	82	$0.73	$0.01	$0.54	$0.01	$1.29
2022	3,015	79	$0.76	$0.00	$0.54	$0.01	$1.31
2023	3,011	51	$0.68	$0.00	$0.35	$0.01	$1.04
2024	3,006	59	$0.65	$0.00	$0.42	$0.01	$1.07
2025	3,002	48	$0.70	$0.00	$0.35	$0.01	$1.06
2026	2,998	37	$0.65	$0.00	$0.27	$0.00	$0.93
2027	2,993	46	$0.67	$0.00	$0.35	$0.01	$1.02
2028	2,989	5	$0.41	$0.00	$0.04	$0.00	$0.45
2029	2,985	18	$0.31	$0.00	$0.14	$0.00	$0.45
2030	2,980	22	$0.32	$0.00	$0.18	$0.00	$0.50
2031	2,976	9	$0.23	$0.00	$0.07	$0.00	$0.30
2032	2,972	2	$0.14	$0.00	$0.01	$0.00	$0.16
2033	2,968	0	$0.12	$0.00	$0.00	$0.00	$0.12
2034	2,964	0	$0.05	$0.00	$0.00	$0.00	$0.05
2035	2,960	0	$0.05	$0.00	$0.00	$0.00	$0.05
2036	2,955	0	$0.02	$0.00	$0.00	$0.00	$0.02
2037	2,951	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	2,947	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	2,943	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	2,939	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.7: Scenario 7
1,200 MW Added Wind + 900 MW Added Solar
(<u>Incremental</u> over Baseline Nominal $/MWh)

Year	Total Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replacement Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	6,057	657	$0.71	$0.63	$2.05	$0.04	$3.43
2020	6,048	526	$0.80	$0.32	$1.66	$0.03	$2.81
2021	6,039	440	$0.76	$0.14	$1.44	$0.03	$2.37
2022	6,030	446	$0.75	$0.01	$1.51	$0.03	$2.29
2023	6,021	325	$0.72	$0.01	$1.13	$0.02	$1.88
2024	6,012	343	$0.77	$0.02	$1.20	$0.02	$2.01
2025	6,004	293	$0.75	$0.01	$1.07	$0.02	$1.85
2026	5,995	259	$0.79	$0.00	$0.96	$0.02	$1.77
2027	5,986	283	$0.76	$0.01	$1.07	$0.02	$1.85
2028	5,978	108	$0.62	$0.00	$0.42	$0.01	$1.04
2029	5,969	141	$0.52	$0.00	$0.56	$0.01	$1.09
2030	5,961	128	$0.54	$0.00	$0.51	$0.01	$1.06
2031	5,953	89	$0.41	$0.00	$0.35	$0.01	$0.77
2032	5,944	43	$0.33	$0.00	$0.17	$0.00	$0.51
2033	5,936	25	$0.30	$0.00	$0.10	$0.00	$0.40
2034	5,927	19	$0.15	$0.00	$0.08	$0.00	$0.24
2035	5,919	23	$0.13	$0.00	$0.10	$0.00	$0.23
2036	5,911	18	$0.07	$0.00	$0.08	$0.00	$0.15
2037	5,903	2	$0.04	$0.00	$0.01	$0.00	$0.04
2038	5,895	0	$0.01	$0.00	$0.00	$0.00	$0.01
2039	5,887	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	5,878	0	$0.01	$0.00	$0.00	$0.00	$0.01

Table B.8: Scenario 8
300 MW Wind (<u>North</u> Resource Zone)
(<u>Incremental</u> over Baseline Nominal $/MWh)

Year	Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replacement Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	1,070	40	$0.95	$0.00	$0.71	$0.02	$1.68
2020	1,070	27	$0.87	$0.00	$0.48	$0.01	$1.37
2021	1,070	11	$0.78	$0.00	$0.20	$0.00	$0.98
2022	1,070	11	$0.88	$0.00	$0.21	$0.00	$1.09
2023	1,070	5	$0.64	$0.00	$0.09	$0.00	$0.73
2024	1,070	8	$0.67	$0.00	$0.15	$0.00	$0.83
2025	1,070	7	$0.67	$0.00	$0.15	$0.00	$0.82
2026	1,070	4	$0.52	$0.00	$0.08	$0.00	$0.60
2027	1,070	5	$0.61	$0.00	$0.10	$0.00	$0.71
2028	1,070	0	$0.23	$0.00	$0.00	$0.00	$0.23
2029	1,070	1	$0.18	$0.00	$0.02	$0.00	$0.20
2030	1,070	1	$0.22	$0.00	$0.03	$0.00	$0.25
2031	1,070	0	$0.13	$0.00	$0.00	$0.00	$0.13
2032	1,070	0	$0.06	$0.00	$0.00	$0.00	$0.06
2033	1,070	0	$0.01	$0.00	$0.00	$0.00	$0.01
2034	1,070	0	$0.00	$0.00	$0.00	$0.00	$0.00
2035	1,070	0	$0.01	$0.00	$0.00	$0.00	$0.01
2036	1,070	0	$0.00	$0.00	$0.00	$0.00	$0.00
2037	1,070	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	1,070	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	1,070	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	1,070	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.9: Scenario 9
600 MW Wind (<u>North</u> Resource Zone)
(<u>Incremental</u> over Baseline Nominal $/MWh)

Year	Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replacement Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	2,140	122	$0.99	$0.02	$1.08	$0.02	$2.11
2020	2,140	88	$0.95	$0.01	$0.78	$0.02	$1.75
2021	2,140	51	$0.90	$0.00	$0.47	$0.01	$1.38
2022	2,140	52	$0.95	$0.00	$0.50	$0.01	$1.45
2023	2,140	27	$0.82	$0.00	$0.26	$0.01	$1.09
2024	2,140	33	$0.75	$0.00	$0.32	$0.01	$1.07
2025	2,140	27	$0.78	$0.00	$0.28	$0.01	$1.06
2026	2,140	19	$0.74	$0.00	$0.19	$0.00	$0.93
2027	2,140	19	$0.73	$0.00	$0.20	$0.00	$0.94
2028	2,140	0	$0.38	$0.00	$0.00	$0.00	$0.39
2029	2,140	4	$0.27	$0.00	$0.05	$0.00	$0.32
2030	2,140	8	$0.25	$0.00	$0.08	$0.00	$0.34
2031	2,140	3	$0.15	$0.00	$0.03	$0.00	$0.18
2032	2,140	0	$0.11	$0.00	$0.00	$0.00	$0.11
2033	2,140	0	$0.06	$0.00	$0.00	$0.00	$0.06
2034	2,140	0	$0.02	$0.00	$0.00	$0.00	$0.02
2035	2,140	0	$0.02	$0.00	$0.00	$0.00	$0.02
2036	2,140	0	$0.01	$0.00	$0.00	$0.00	$0.01
2037	2,140	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	2,140	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	2,140	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	2,140	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.10: Scenario 10
900 MW Wind (North Resource Zone)
(Incremental over Baseline Nominal $/MWh)

Year	Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replacement Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	3,211	264	$0.97	$0.09	$1.55	$0.03	$2.64
2020	3,211	203	$1.00	$0.04	$1.21	$0.03	$2.27
2021	3,211	137	$0.99	$0.00	$0.84	$0.02	$1.85
2022	3,211	148	$0.98	$0.00	$0.94	$0.02	$1.94
2023	3,211	83	$0.89	$0.00	$0.54	$0.01	$1.44
2024	3,211	93	$0.88	$0.00	$0.61	$0.01	$1.51
2025	3,211	75	$0.86	$0.00	$0.51	$0.01	$1.38
2026	3,211	55	$0.84	$0.00	$0.38	$0.01	$1.23
2027	3,211	59	$0.79	$0.00	$0.41	$0.01	$1.21
2028	3,211	7	$0.48	$0.00	$0.05	$0.00	$0.53
2029	3,211	17	$0.35	$0.00	$0.12	$0.00	$0.48
2030	3,211	22	$0.36	$0.00	$0.17	$0.00	$0.53
2031	3,211	9	$0.25	$0.00	$0.07	$0.00	$0.32
2032	3,211	2	$0.16	$0.00	$0.02	$0.00	$0.18
2033	3,211	0	$0.12	$0.00	$0.00	$0.00	$0.12
2034	3,211	0	$0.05	$0.00	$0.00	$0.00	$0.05
2035	3,211	0	$0.04	$0.00	$0.00	$0.00	$0.04
2036	3,211	0	$0.02	$0.00	$0.00	$0.00	$0.02
2037	3,211	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	3,211	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	3,211	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	3,211	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.11: Scenario 11
300 MW Wind (Central Resource Zone)
(Incremental over Baseline Nominal $/MWh)

Year	Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replacement Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	1,022	40	$0.95	$0.00	$0.74	$0.02	$1.71
2020	1,022	25	$0.88	$0.00	$0.47	$0.01	$1.35
2021	1,022	13	$0.78	$0.00	$0.25	$0.01	$1.03
2022	1,022	11	$0.90	$0.00	$0.21	$0.00	$1.12
2023	1,022	5	$0.72	$0.00	$0.10	$0.00	$0.83
2024	1,022	8	$0.70	$0.00	$0.17	$0.00	$0.87
2025	1,022	7	$0.64	$0.00	$0.16	$0.00	$0.80
2026	1,022	3	$0.57	$0.00	$0.07	$0.00	$0.64
2027	1,022	6	$0.56	$0.00	$0.13	$0.00	$0.69
2028	1,022	0	$0.22	$0.00	$0.00	$0.00	$0.22
2029	1,022	1	$0.21	$0.00	$0.02	$0.00	$0.23
2030	1,022	1	$0.21	$0.00	$0.03	$0.00	$0.25
2031	1,022	0	$0.16	$0.00	$0.01	$0.00	$0.16
2032	1,022	0	$0.05	$0.00	$0.00	$0.00	$0.05
2033	1,022	0	$0.00	$0.00	$0.00	$0.00	$0.00
2034	1,022	0	$0.00	$0.00	$0.00	$0.00	$0.00
2035	1,022	0	$0.01	$0.00	$0.00	$0.00	$0.01
2036	1,022	0	$0.00	$0.00	$0.00	$0.00	$0.00
2037	1,022	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	1,022	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	1,022	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	1,022	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.12: Scenario 12
600 MW Wind (Central Resource Zone)
(Incremental over Baseline Nominal $/MWh)

Year	Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replacement Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	2,043	119	$0.97	$0.06	$1.10	$0.02	$2.15
2020	2,043	80	$0.89	$0.04	$0.75	$0.02	$1.69
2021	2,043	50	$0.88	$0.00	$0.49	$0.01	$1.38
2022	2,043	47	$0.90	$0.00	$0.47	$0.01	$1.37
2023	2,043	24	$0.81	$0.00	$0.25	$0.00	$1.06
2024	2,043	30	$0.82	$0.00	$0.31	$0.01	$1.13
2025	2,043	27	$0.81	$0.00	$0.29	$0.01	$1.10
2026	2,043	17	$0.70	$0.00	$0.18	$0.00	$0.88
2027	2,043	22	$0.69	$0.00	$0.25	$0.00	$0.94
2028	2,043	1	$0.36	$0.00	$0.01	$0.00	$0.37
2029	2,043	5	$0.28	$0.00	$0.06	$0.00	$0.34
2030	2,043	8	$0.28	$0.00	$0.09	$0.00	$0.38
2031	2,043	3	$0.19	$0.00	$0.04	$0.00	$0.23
2032	2,043	0	$0.10	$0.00	$0.00	$0.00	$0.10
2033	2,043	0	$0.06	$0.00	$0.00	$0.00	$0.06
2034	2,043	0	$0.02	$0.00	$0.00	$0.00	$0.02
2035	2,043	0	$0.03	$0.00	$0.00	$0.00	$0.03
2036	2,043	0	$0.01	$0.00	$0.00	$0.00	$0.01
2037	2,043	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	2,043	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	2,043	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	2,043	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.13: Scenario 13
900 MW Wind (Central Resource Zone)
(Incremental over Baseline Nominal $/MWh)

Year	Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replacement Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	3,065	257	$0.93	$0.26	$1.58	$0.03	$2.80
2020	3,065	189	$0.91	$0.15	$1.18	$0.02	$2.25
2021	3,065	128	$0.91	$0.03	$0.83	$0.02	$1.79
2022	3,065	127	$0.93	$0.00	$0.85	$0.02	$1.79
2023	3,065	73	$0.88	$0.00	$0.50	$0.01	$1.39
2024	3,065	85	$0.86	$0.00	$0.58	$0.01	$1.46
2025	3,065	68	$0.85	$0.00	$0.49	$0.01	$1.35
2026	3,065	51	$0.85	$0.00	$0.37	$0.01	$1.22
2027	3,065	60	$0.82	$0.00	$0.44	$0.01	$1.26
2028	3,065	7	$0.54	$0.00	$0.05	$0.00	$0.59
2029	3,065	20	$0.43	$0.00	$0.15	$0.00	$0.58
2030	3,065	24	$0.39	$0.00	$0.18	$0.00	$0.58
2031	3,065	10	$0.26	$0.00	$0.07	$0.00	$0.33
2032	3,065	1	$0.15	$0.00	$0.01	$0.00	$0.15
2033	3,065	0	$0.12	$0.00	$0.00	$0.00	$0.12
2034	3,065	0	$0.04	$0.00	$0.00	$0.00	$0.05
2035	3,065	0	$0.04	$0.00	$0.00	$0.00	$0.04
2036	3,065	0	$0.02	$0.00	$0.00	$0.00	$0.02
2037	3,065	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	3,065	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	3,065	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	3,065	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.14: Scenario 14
300 MW Wind (South Resource Zone)
(Incremental over Baseline Nominal $/MWh)

Year	Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replacement Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	1,181	38	$0.78	$0.00	$0.61	$0.01	$1.41
2020	1,181	24	$0.76	$0.00	$0.39	$0.01	$1.15
2021	1,181	12	$0.69	$0.00	$0.20	$0.00	$0.89
2022	1,181	10	$0.76	$0.00	$0.18	$0.00	$0.94
2023	1,181	5	$0.58	$0.00	$0.09	$0.00	$0.67
2024	1,181	7	$0.58	$0.00	$0.12	$0.00	$0.70
2025	1,181	6	$0.55	$0.00	$0.11	$0.00	$0.66
2026	1,181	3	$0.46	$0.00	$0.06	$0.00	$0.52
2027	1,181	4	$0.48	$0.00	$0.08	$0.00	$0.57
2028	1,181	0	$0.14	$0.00	$0.00	$0.00	$0.14
2029	1,181	1	$0.13	$0.00	$0.02	$0.00	$0.15
2030	1,181	1	$0.17	$0.00	$0.03	$0.00	$0.19
2031	1,181	0	$0.12	$0.00	$0.00	$0.00	$0.12
2032	1,181	0	$0.05	$0.00	$0.00	$0.00	$0.05
2033	1,181	0	$0.00	$0.00	$0.00	$0.00	$0.00
2034	1,181	0	$0.00	$0.00	$0.00	$0.00	$0.00
2035	1,181	0	$0.01	$0.00	$0.00	$0.00	$0.01
2036	1,181	0	$0.00	$0.00	$0.00	$0.00	$0.00
2037	1,181	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	1,181	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	1,181	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	1,181	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.15: Scenario 15
600 MW Wind (South Resource Zone)
(Incremental over Baseline Nominal $/MWh)

Year	Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replacement Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	2,363	117	$0.90	$0.04	$0.93	$0.02	$1.89
2020	2,363	80	$0.82	$0.02	$0.64	$0.01	$1.50
2021	2,363	49	$0.78	$0.00	$0.41	$0.01	$1.19
2022	2,363	49	$0.80	$0.00	$0.42	$0.01	$1.23
2023	2,363	25	$0.65	$0.00	$0.22	$0.00	$0.88
2024	2,363	28	$0.69	$0.00	$0.25	$0.00	$0.95
2025	2,363	25	$0.68	$0.00	$0.23	$0.00	$0.91
2026	2,363	17	$0.63	$0.00	$0.16	$0.00	$0.80
2027	2,363	18	$0.62	$0.00	$0.17	$0.00	$0.80
2028	2,363	1	$0.30	$0.00	$0.00	$0.00	$0.30
2029	2,363	6	$0.22	$0.00	$0.06	$0.00	$0.27
2030	2,363	7	$0.22	$0.00	$0.07	$0.00	$0.29
2031	2,363	2	$0.15	$0.00	$0.02	$0.00	$0.17
2032	2,363	0	$0.09	$0.00	$0.00	$0.00	$0.09
2033	2,363	0	$0.03	$0.00	$0.00	$0.00	$0.03
2034	2,363	0	$0.01	$0.00	$0.00	$0.00	$0.01
2035	2,363	0	$0.03	$0.00	$0.00	$0.00	$0.03
2036	2,363	0	$0.01	$0.00	$0.00	$0.00	$0.01
2037	2,363	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	2,363	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	2,363	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	2,363	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.16: Scenario 16
900 MW Wind (South Resource Zone)
(Incremental over Baseline Nominal $/MWh)

Year	Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replacement Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	3,544	256	$0.93	$0.19	$1.36	$0.03	$2.52
2020	3,544	190	$0.87	$0.11	$1.03	$0.02	$2.02
2021	3,544	129	$0.84	$0.02	$0.72	$0.01	$1.59
2022	3,544	137	$0.87	$0.00	$0.79	$0.02	$1.67
2023	3,544	79	$0.79	$0.00	$0.47	$0.01	$1.26
2024	3,544	84	$0.79	$0.00	$0.50	$0.01	$1.31
2025	3,544	70	$0.79	$0.00	$0.43	$0.01	$1.23
2026	3,544	56	$0.76	$0.00	$0.35	$0.01	$1.12
2027	3,544	55	$0.73	$0.00	$0.35	$0.01	$1.08
2028	3,544	7	$0.46	$0.00	$0.04	$0.00	$0.50
2029	3,544	19	$0.37	$0.00	$0.13	$0.00	$0.50
2030	3,544	21	$0.35	$0.00	$0.14	$0.00	$0.50
2031	3,544	7	$0.23	$0.00	$0.05	$0.00	$0.28
2032	3,544	1	$0.16	$0.00	$0.01	$0.00	$0.17
2033	3,544	0	$0.08	$0.00	$0.00	$0.00	$0.08
2034	3,544	0	$0.03	$0.00	$0.00	$0.00	$0.03
2035	3,544	0	$0.03	$0.00	$0.00	$0.00	$0.03
2036	3,544	0	$0.02	$0.00	$0.00	$0.00	$0.02
2037	3,544	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	3,544	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	3,544	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	3,544	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.17: Scenario 17
100 MW Solar (Northern Front Range Fixed)
(<u>Incremental</u> over Baseline Nominal $/MWh)

Year	Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replacement Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	137	3	$0.38	$0.00	$0.38	$0.01	$0.77
2020	136	1	$0.22	$0.00	$0.15	$0.00	$0.37
2021	135	0	$0.43	$0.00	$0.05	$0.00	$0.49
2022	135	0	$0.39	$0.00	$0.01	$0.00	$0.40
2023	134	0	$0.53	$0.00	$0.01	$0.00	$0.54
2024	133	0	$0.32	$0.00	$0.07	$0.00	$0.39
2025	133	1	$0.33	$0.00	$0.13	$0.00	$0.46
2026	132	0	$0.39	$0.00	$0.03	$0.00	$0.43
2027	131	1	$0.41	$0.00	$0.09	$0.00	$0.50
2028	131	0	$0.05	$0.00	$0.00	$0.00	$0.05
2029	130	0	$0.28	$0.00	$0.01	$0.00	$0.28
2030	129	0	$0.20	$0.00	$0.03	$0.00	$0.24
2031	129	0	$0.23	$0.00	$0.00	$0.00	$0.23
2032	128	0	$0.04	$0.00	$0.00	$0.00	$0.04
2033	128	0	$0.00	$0.00	$0.00	$0.00	$0.00
2034	127	0	$0.00	$0.00	$0.00	$0.00	$0.00
2035	126	0	$0.00	$0.00	$0.00	$0.00	$0.00
2036	126	0	$0.00	$0.00	$0.00	$0.00	$0.00
2037	125	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	124	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	124	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	123	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.18: Scenario 18
200 MW Solar (Northern Front Range Fixed)
(<u>Incremental</u> over Baseline Nominal $/MWh)

Year	Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replacement Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	274	6	$0.38	$0.00	$0.41	$0.01	$0.80
2020	272	2	$0.29	$0.00	$0.15	$0.00	$0.45
2021	271	1	$0.39	$0.00	$0.07	$0.00	$0.47
2022	270	0	$0.42	$0.00	$0.02	$0.00	$0.44
2023	268	0	$0.45	$0.00	$0.02	$0.00	$0.47
2024	267	1	$0.37	$0.00	$0.08	$0.00	$0.45
2025	265	2	$0.29	$0.00	$0.14	$0.00	$0.43
2026	264	1	$0.30	$0.00	$0.04	$0.00	$0.35
2027	263	1	$0.44	$0.00	$0.13	$0.00	$0.57
2028	262	0	$0.15	$0.00	$0.00	$0.00	$0.15
2029	260	0	$0.27	$0.00	$0.01	$0.00	$0.28
2030	259	0	$0.23	$0.00	$0.04	$0.00	$0.27
2031	258	0	$0.23	$0.00	$0.00	$0.00	$0.23
2032	256	0	$0.07	$0.00	$0.00	$0.00	$0.07
2033	255	0	$0.01	$0.00	$0.00	$0.00	$0.01
2034	254	0	$0.00	$0.00	$0.00	$0.00	$0.00
2035	253	0	$0.00	$0.00	$0.00	$0.00	$0.00
2036	251	0	$0.00	$0.00	$0.00	$0.00	$0.00
2037	250	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	249	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	248	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	246	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.19: Scenario 19
100 MW Solar (Southern Front Range Fixed)
(<u>Incremental</u> over Baseline Nominal $/MWh)

Year	Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replacement Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	161	3	$0.39	$0.00	$0.39	$0.01	$0.79
2020	160	1	$0.23	$0.00	$0.15	$0.00	$0.38
2021	159	0	$0.39	$0.00	$0.05	$0.00	$0.45
2022	159	0	$0.46	$0.00	$0.01	$0.00	$0.48
2023	158	0	$0.51	$0.00	$0.01	$0.00	$0.52
2024	157	1	$0.32	$0.00	$0.07	$0.00	$0.39
2025	156	1	$0.35	$0.00	$0.13	$0.00	$0.48
2026	155	0	$0.38	$0.00	$0.04	$0.00	$0.41
2027	155	1	$0.46	$0.00	$0.10	$0.00	$0.55
2028	154	0	$0.10	$0.00	$0.00	$0.00	$0.10
2029	153	0	$0.30	$0.00	$0.01	$0.00	$0.31
2030	152	0	$0.24	$0.00	$0.03	$0.00	$0.27
2031	152	0	$0.27	$0.00	$0.00	$0.00	$0.27
2032	151	0	$0.03	$0.00	$0.00	$0.00	$0.03
2033	150	0	$0.00	$0.00	$0.00	$0.00	$0.00
2034	149	0	$0.00	$0.00	$0.00	$0.00	$0.00
2035	149	0	$0.00	$0.00	$0.00	$0.00	$0.00
2036	148	0	$0.00	$0.00	$0.00	$0.00	$0.00
2037	147	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	146	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	146	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	145	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.20: Scenario 20
200 MW Solar (Southern Front Range Fixed)
(<u>Incremental</u> over Baseline Nominal $/MWh)

Year	Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replacement Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	322	7	$0.37	$0.00	$0.42	$0.01	$0.80
2020	320	3	$0.29	$0.00	$0.15	$0.00	$0.45
2021	319	1	$0.36	$0.00	$0.08	$0.00	$0.44
2022	317	0	$0.48	$0.00	$0.02	$0.00	$0.50
2023	315	0	$0.45	$0.00	$0.02	$0.00	$0.47
2024	314	1	$0.37	$0.00	$0.09	$0.00	$0.46
2025	312	2	$0.32	$0.00	$0.14	$0.00	$0.47
2026	311	1	$0.32	$0.00	$0.05	$0.00	$0.37
2027	309	2	$0.44	$0.00	$0.14	$0.00	$0.58
2028	308	0	$0.23	$0.00	$0.00	$0.00	$0.23
2029	306	0	$0.28	$0.00	$0.02	$0.00	$0.29
2030	305	1	$0.26	$0.00	$0.04	$0.00	$0.31
2031	303	0	$0.25	$0.00	$0.00	$0.00	$0.25
2032	302	0	$0.08	$0.00	$0.00	$0.00	$0.08
2033	300	0	$0.01	$0.00	$0.00	$0.00	$0.01
2034	299	0	$0.00	$0.00	$0.00	$0.00	$0.00
2035	297	0	$0.00	$0.00	$0.00	$0.00	$0.00
2036	296	0	$0.00	$0.00	$0.00	$0.00	$0.00
2037	294	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	293	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	291	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	290	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.21: Scenario 21
100 MW Solar (San Luis Valley Fixed)
(Incremental over Baseline Nominal $/MWh)

Year	Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replacement Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	169	3	$0.40	$0.00	$0.35	$0.01	$0.76
2020	168	1	$0.20	$0.00	$0.14	$0.00	$0.34
2021	167	0	$0.34	$0.00	$0.03	$0.00	$0.38
2022	166	0	$0.44	$0.00	$0.01	$0.00	$0.45
2023	166	0	$0.46	$0.00	$0.01	$0.00	$0.48
2024	165	0	$0.23	$0.00	$0.06	$0.00	$0.29
2025	164	1	$0.28	$0.00	$0.12	$0.00	$0.40
2026	163	0	$0.33	$0.00	$0.03	$0.00	$0.36
2027	162	0	$0.36	$0.00	$0.07	$0.00	$0.43
2028	161	0	$0.10	$0.00	$0.00	$0.00	$0.10
2029	161	0	$0.25	$0.00	$0.00	$0.00	$0.26
2030	160	0	$0.24	$0.00	$0.03	$0.00	$0.27
2031	159	0	$0.21	$0.00	$0.00	$0.00	$0.21
2032	158	0	$0.03	$0.00	$0.00	$0.00	$0.03
2033	157	0	$0.00	$0.00	$0.00	$0.00	$0.00
2034	157	0	$0.00	$0.00	$0.00	$0.00	$0.00
2035	156	0	$0.00	$0.00	$0.00	$0.00	$0.00
2036	155	0	$0.00	$0.00	$0.00	$0.00	$0.00
2037	154	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	154	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	153	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	152	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.22: Scenario 22
200 MW Solar (San Luis Valley Fixed)
(Incremental over Baseline Nominal $/MWh)

Year	Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replacement Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	338	7	$0.34	$0.00	$0.38	$0.01	$0.73
2020	336	2	$0.21	$0.00	$0.14	$0.00	$0.35
2021	334	1	$0.36	$0.00	$0.05	$0.00	$0.42
2022	333	0	$0.38	$0.00	$0.01	$0.00	$0.39
2023	331	0	$0.34	$0.00	$0.02	$0.00	$0.36
2024	329	1	$0.30	$0.00	$0.07	$0.00	$0.38
2025	328	2	$0.26	$0.00	$0.12	$0.00	$0.38
2026	326	1	$0.24	$0.00	$0.04	$0.00	$0.28
2027	324	1	$0.38	$0.00	$0.10	$0.00	$0.48
2028	323	0	$0.11	$0.00	$0.00	$0.00	$0.11
2029	321	0	$0.22	$0.00	$0.01	$0.00	$0.23
2030	320	0	$0.24	$0.00	$0.03	$0.00	$0.28
2031	318	0	$0.21	$0.00	$0.00	$0.00	$0.21
2032	316	0	$0.06	$0.00	$0.00	$0.00	$0.06
2033	315	0	$0.00	$0.00	$0.00	$0.00	$0.00
2034	313	0	$0.00	$0.00	$0.00	$0.00	$0.00
2035	312	0	$0.00	$0.00	$0.00	$0.00	$0.00
2036	310	0	$0.00	$0.00	$0.00	$0.00	$0.00
2037	309	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	307	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	306	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	304	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.23: Scenario 23
100 MW Solar (Western Slope Fixed)
(Incremental over Baseline Nominal $/MWh)

Year	Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replacement Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	147	3	$0.31	$0.00	$0.33	$0.01	$0.64
2020	146	1	$0.24	$0.00	$0.13	$0.00	$0.37
2021	145	0	$0.30	$0.00	$0.03	$0.00	$0.33
2022	144	0	$0.32	$0.00	$0.01	$0.00	$0.32
2023	144	0	$0.51	$0.00	$0.01	$0.00	$0.52
2024	143	0	$0.20	$0.00	$0.05	$0.00	$0.25
2025	142	1	$0.19	$0.00	$0.11	$0.00	$0.30
2026	142	0	$0.26	$0.00	$0.03	$0.00	$0.29
2027	141	0	$0.27	$0.00	$0.06	$0.00	$0.33
2028	140	0	$0.09	$0.00	$0.00	$0.00	$0.09
2029	139	0	$0.24	$0.00	$0.00	$0.00	$0.25
2030	139	0	$0.13	$0.00	$0.02	$0.00	$0.16
2031	138	0	$0.17	$0.00	$0.00	$0.00	$0.17
2032	137	0	$0.04	$0.00	$0.00	$0.00	$0.04
2033	137	0	$0.00	$0.00	$0.00	$0.00	$0.00
2034	136	0	$0.00	$0.00	$0.00	$0.00	$0.00
2035	135	0	$0.00	$0.00	$0.00	$0.00	$0.00
2036	135	0	$0.00	$0.00	$0.00	$0.00	$0.00
2037	134	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	133	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	133	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	132	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.24: Scenario 24
200 MW Solar (Western Slope Fixed)
(Incremental over Baseline Nominal $/MWh)

Year	Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replacement Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	293	5	$0.36	$0.00	$0.35	$0.01	$0.72
2020	292	2	$0.23	$0.00	$0.14	$0.00	$0.37
2021	290	1	$0.35	$0.00	$0.05	$0.00	$0.40
2022	289	0	$0.35	$0.00	$0.01	$0.00	$0.36
2023	287	0	$0.35	$0.00	$0.01	$0.00	$0.36
2024	286	1	$0.30	$0.00	$0.06	$0.00	$0.36
2025	285	1	$0.25	$0.00	$0.12	$0.00	$0.37
2026	283	0	$0.27	$0.00	$0.03	$0.00	$0.30
2027	282	1	$0.33	$0.00	$0.09	$0.00	$0.42
2028	280	0	$0.12	$0.00	$0.00	$0.00	$0.12
2029	279	0	$0.24	$0.00	$0.01	$0.00	$0.25
2030	278	0	$0.20	$0.00	$0.03	$0.00	$0.23
2031	276	0	$0.22	$0.00	$0.00	$0.00	$0.22
2032	275	0	$0.05	$0.00	$0.00	$0.00	$0.05
2033	273	0	$0.00	$0.00	$0.00	$0.00	$0.00
2034	272	0	$0.00	$0.00	$0.00	$0.00	$0.00
2035	271	0	$0.00	$0.00	$0.00	$0.00	$0.00
2036	269	0	$0.00	$0.00	$0.00	$0.00	$0.00
2037	268	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	267	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	265	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	264	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.25: Scenario 25
100 MW Solar (Northern Front Range Tracking)
(Incremental over Baseline Nominal $/MWh)

Year	Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replacement Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	167	4	$0.41	$0.00	$0.42	$0.01	$0.85
2020	166	1	$0.18	$0.00	$0.16	$0.00	$0.35
2021	165	0	$0.46	$0.00	$0.06	$0.00	$0.52
2022	165	0	$0.43	$0.00	$0.03	$0.00	$0.46
2023	164	0	$0.42	$0.00	$0.02	$0.00	$0.45
2024	163	1	$0.36	$0.00	$0.08	$0.00	$0.45
2025	162	1	$0.36	$0.00	$0.13	$0.00	$0.50
2026	161	0	$0.18	$0.00	$0.04	$0.00	$0.22
2027	160	1	$0.44	$0.00	$0.09	$0.00	$0.54
2028	160	0	$0.13	$0.00	$0.00	$0.00	$0.13
2029	159	0	$0.24	$0.00	$0.01	$0.00	$0.26
2030	158	0	$0.24	$0.00	$0.04	$0.00	$0.28
2031	157	0	$0.23	$0.00	$0.00	$0.00	$0.23
2032	156	0	$0.05	$0.00	$0.00	$0.00	$0.05
2033	156	0	$0.00	$0.00	$0.00	$0.00	$0.00
2034	155	0	$0.00	$0.00	$0.00	$0.00	$0.00
2035	154	0	$0.00	$0.00	$0.00	$0.00	$0.00
2036	153	0	$0.00	$0.00	$0.00	$0.00	$0.00
2037	153	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	152	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	151	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	150	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.26: Scenario 26
200 MW Solar (Northern Front Range Tracking)
(Incremental over Baseline Nominal $/MWh)

Year	Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replacement Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	334	8	$0.33	$0.00	$0.46	$0.01	$0.80
2020	332	3	$0.25	$0.00	$0.17	$0.00	$0.42
2021	331	1	$0.43	$0.00	$0.08	$0.00	$0.51
2022	329	1	$0.47	$0.00	$0.04	$0.00	$0.52
2023	327	1	$0.49	$0.00	$0.03	$0.00	$0.52
2024	326	2	$0.36	$0.00	$0.10	$0.00	$0.46
2025	324	2	$0.28	$0.00	$0.14	$0.00	$0.43
2026	323	1	$0.32	$0.00	$0.05	$0.00	$0.37
2027	321	2	$0.45	$0.00	$0.12	$0.00	$0.58
2028	319	0	$0.23	$0.00	$0.00	$0.00	$0.23
2029	318	0	$0.27	$0.00	$0.03	$0.00	$0.30
2030	316	1	$0.25	$0.00	$0.04	$0.00	$0.30
2031	315	0	$0.20	$0.00	$0.00	$0.00	$0.20
2032	313	0	$0.09	$0.00	$0.00	$0.00	$0.09
2033	311	0	$0.01	$0.00	$0.00	$0.00	$0.01
2034	310	0	$0.00	$0.00	$0.00	$0.00	$0.00
2035	308	0	$0.00	$0.00	$0.00	$0.00	$0.00
2036	307	0	$0.00	$0.00	$0.00	$0.00	$0.00
2037	305	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	304	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	302	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	301	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.27: Scenario 27
100 MW Solar (Southern Front Range Tracking)
(Incremental over Baseline Nominal $/MWh)

Year	Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replacement Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	197	4	$0.37	$0.00	$0.43	$0.01	$0.81
2020	196	2	$0.19	$0.00	$0.16	$0.00	$0.36
2021	195	1	$0.43	$0.00	$0.06	$0.00	$0.49
2022	194	0	$0.48	$0.00	$0.03	$0.00	$0.51
2023	193	0	$0.47	$0.00	$0.03	$0.00	$0.49
2024	192	1	$0.40	$0.00	$0.09	$0.00	$0.49
2025	191	1	$0.35	$0.00	$0.13	$0.00	$0.48
2026	190	0	$0.23	$0.00	$0.04	$0.00	$0.27
2027	189	1	$0.42	$0.00	$0.09	$0.00	$0.52
2028	188	0	$0.17	$0.00	$0.00	$0.00	$0.17
2029	187	0	$0.28	$0.00	$0.01	$0.00	$0.29
2030	186	0	$0.26	$0.00	$0.04	$0.00	$0.30
2031	185	0	$0.21	$0.00	$0.00	$0.00	$0.21
2032	184	0	$0.07	$0.00	$0.00	$0.00	$0.07
2033	183	0	$0.00	$0.00	$0.00	$0.00	$0.00
2034	182	0	$0.00	$0.00	$0.00	$0.00	$0.00
2035	181	0	$0.00	$0.00	$0.00	$0.00	$0.00
2036	180	0	$0.00	$0.00	$0.00	$0.00	$0.00
2037	180	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	179	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	178	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	177	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.28: Scenario 28
200 MW Solar (Southern Front Range Tracking)
(Incremental over Baseline Nominal $/MWh)

Year	Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replacement Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	393	10	$0.30	$0.00	$0.47	$0.01	$0.78
2020	391	3	$0.27	$0.00	$0.17	$0.00	$0.45
2021	389	2	$0.33	$0.00	$0.09	$0.00	$0.42
2022	387	1	$0.47	$0.00	$0.05	$0.00	$0.52
2023	385	1	$0.52	$0.00	$0.04	$0.00	$0.55
2024	383	2	$0.39	$0.00	$0.10	$0.00	$0.49
2025	381	2	$0.29	$0.00	$0.14	$0.00	$0.43
2026	379	1	$0.30	$0.00	$0.05	$0.00	$0.36
2027	378	2	$0.48	$0.00	$0.13	$0.00	$0.61
2028	376	0	$0.23	$0.00	$0.00	$0.00	$0.23
2029	374	0	$0.31	$0.00	$0.03	$0.00	$0.33
2030	372	1	$0.25	$0.00	$0.05	$0.00	$0.29
2031	370	0	$0.20	$0.00	$0.00	$0.00	$0.20
2032	368	0	$0.08	$0.00	$0.00	$0.00	$0.08
2033	366	0	$0.01	$0.00	$0.00	$0.00	$0.01
2034	365	0	$0.00	$0.00	$0.00	$0.00	$0.00
2035	363	0	$0.00	$0.00	$0.00	$0.00	$0.00
2036	361	0	$0.00	$0.00	$0.00	$0.00	$0.00
2037	359	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	357	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	356	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	354	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.29: Scenario 29
100 MW Solar (San Luis Valley Tracking)
(<u>Incremental</u> over Baseline Nominal $/MWh)

				Curtailment Cost			
Year	Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	PTC Gross Up ($/MWh)	Replacement Energy ($/MWh)	REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	224	4	$0.35	$0.00	$0.34	$0.01	$0.70
2020	223	2	$0.24	$0.00	$0.13	$0.00	$0.38
2021	222	1	$0.36	$0.00	$0.05	$0.00	$0.41
2022	221	0	$0.37	$0.00	$0.02	$0.00	$0.38
2023	220	0	$0.41	$0.00	$0.02	$0.00	$0.43
2024	218	1	$0.27	$0.00	$0.06	$0.00	$0.33
2025	217	1	$0.25	$0.00	$0.11	$0.00	$0.36
2026	216	0	$0.12	$0.00	$0.03	$0.00	$0.16
2027	215	1	$0.35	$0.00	$0.08	$0.00	$0.42
2028	214	0	$0.11	$0.00	$0.00	$0.00	$0.11
2029	213	0	$0.24	$0.00	$0.01	$0.00	$0.25
2030	212	0	$0.21	$0.00	$0.03	$0.00	$0.24
2031	211	0	$0.19	$0.00	$0.00	$0.00	$0.19
2032	210	0	$0.02	$0.00	$0.00	$0.00	$0.02
2033	209	0	$0.00	$0.00	$0.00	$0.00	$0.00
2034	208	0	$0.00	$0.00	$0.00	$0.00	$0.00
2035	207	0	$0.00	$0.00	$0.00	$0.00	$0.00
2036	206	0	$0.00	$0.00	$0.00	$0.00	$0.00
2037	205	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	204	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	203	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	202	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.30: Scenario 30
200 MW Solar (San Luis Valley Tracking)
(<u>Incremental</u> over Baseline Nominal $/MWh)

				Curtailment Cost			
Year	Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	PTC Gross Up ($/MWh)	Replacement Energy ($/MWh)	REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	448	9	$0.27	$0.00	$0.37	$0.01	$0.65
2020	446	3	$0.20	$0.00	$0.14	$0.00	$0.34
2021	444	2	$0.32	$0.00	$0.07	$0.00	$0.40
2022	441	1	$0.38	$0.00	$0.03	$0.00	$0.41
2023	439	1	$0.40	$0.00	$0.03	$0.00	$0.42
2024	437	2	$0.32	$0.00	$0.08	$0.00	$0.40
2025	435	2	$0.24	$0.00	$0.11	$0.00	$0.36
2026	433	1	$0.23	$0.00	$0.04	$0.00	$0.27
2027	430	2	$0.35	$0.00	$0.10	$0.00	$0.45
2028	428	0	$0.17	$0.00	$0.00	$0.00	$0.17
2029	426	0	$0.23	$0.00	$0.02	$0.00	$0.25
2030	424	1	$0.22	$0.00	$0.03	$0.00	$0.26
2031	422	0	$0.17	$0.00	$0.00	$0.00	$0.17
2032	420	0	$0.06	$0.00	$0.00	$0.00	$0.06
2033	418	0	$0.00	$0.00	$0.00	$0.00	$0.00
2034	416	0	$0.00	$0.00	$0.00	$0.00	$0.00
2035	414	0	$0.00	$0.00	$0.00	$0.00	$0.00
2036	411	0	$0.00	$0.00	$0.00	$0.00	$0.00
2037	409	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	407	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	405	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	403	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.31: Scenario 31
100 MW Solar (Western Slope Tracking)
(<u>Incremental</u> over Baseline Nominal $/MWh)

Year	Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replacement Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	181	3	$0.32	$0.00	$0.37	$0.01	$0.70
2020	180	1	$0.19	$0.00	$0.16	$0.00	$0.35
2021	179	0	$0.33	$0.00	$0.05	$0.00	$0.38
2022	178	0	$0.33	$0.00	$0.02	$0.00	$0.35
2023	177	0	$0.42	$0.00	$0.02	$0.00	$0.43
2024	176	1	$0.29	$0.00	$0.07	$0.00	$0.36
2025	175	1	$0.24	$0.00	$0.13	$0.00	$0.38
2026	175	0	$0.23	$0.00	$0.04	$0.00	$0.27
2027	174	1	$0.32	$0.00	$0.07	$0.00	$0.39
2028	173	0	$0.12	$0.00	$0.00	$0.00	$0.12
2029	172	0	$0.23	$0.00	$0.01	$0.00	$0.24
2030	171	0	$0.15	$0.00	$0.04	$0.00	$0.18
2031	170	0	$0.22	$0.00	$0.00	$0.00	$0.22
2032	169	0	$0.04	$0.00	$0.00	$0.00	$0.04
2033	168	0	$0.00	$0.00	$0.00	$0.00	$0.00
2034	168	0	$0.00	$0.00	$0.00	$0.00	$0.00
2035	167	0	$0.00	$0.00	$0.00	$0.00	$0.00
2036	166	0	$0.00	$0.00	$0.00	$0.00	$0.00
2037	165	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	164	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	163	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	163	0	$0.00	$0.00	$0.00	$0.00	$0.00

Table B.32: Scenario 32
200 MW Solar Western Slope Tracking)
(<u>Incremental</u> over Baseline Nominal $/MWh)

Year	Variable Energy (GWh)	Curtailed Energy (GWh)	Cycling Cost ($/MWh)	Curtailment Cost: PTC Gross Up ($/MWh)	Curtailment Cost: Replacement Energy ($/MWh)	Curtailment Cost: REC ($/MWh)	Total Cost ($/MWh)
2016	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2017	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2018	0	0	$0.00	$0.00	$0.00	$0.00	$0.00
2019	361	8	$0.31	$0.00	$0.39	$0.01	$0.71
2020	360	3	$0.20	$0.00	$0.16	$0.00	$0.37
2021	358	1	$0.30	$0.00	$0.07	$0.00	$0.37
2022	356	1	$0.38	$0.00	$0.03	$0.00	$0.41
2023	354	0	$0.37	$0.00	$0.02	$0.00	$0.39
2024	353	1	$0.24	$0.00	$0.08	$0.00	$0.32
2025	351	2	$0.20	$0.00	$0.14	$0.00	$0.35
2026	349	1	$0.24	$0.00	$0.04	$0.00	$0.28
2027	347	2	$0.35	$0.00	$0.10	$0.00	$0.45
2028	346	0	$0.23	$0.00	$0.00	$0.00	$0.23
2029	344	0	$0.23	$0.00	$0.02	$0.00	$0.25
2030	342	1	$0.20	$0.00	$0.04	$0.00	$0.24
2031	340	0	$0.17	$0.00	$0.00	$0.00	$0.17
2032	339	0	$0.05	$0.00	$0.00	$0.00	$0.05
2033	337	0	$0.00	$0.00	$0.00	$0.00	$0.00
2034	335	0	$0.00	$0.00	$0.00	$0.00	$0.00
2035	334	0	$0.00	$0.00	$0.00	$0.00	$0.00
2036	332	0	$0.00	$0.00	$0.00	$0.00	$0.00
2037	330	0	$0.00	$0.00	$0.00	$0.00	$0.00
2038	329	0	$0.00	$0.00	$0.00	$0.00	$0.00
2039	327	0	$0.00	$0.00	$0.00	$0.00	$0.00
2040	325	0	$0.00	$0.00	$0.00	$0.00	$0.00