CHAPTER 6
CARBON IMPACTS

Carbon Scenarios Included in Modeled Portfolios

Carbon Costs

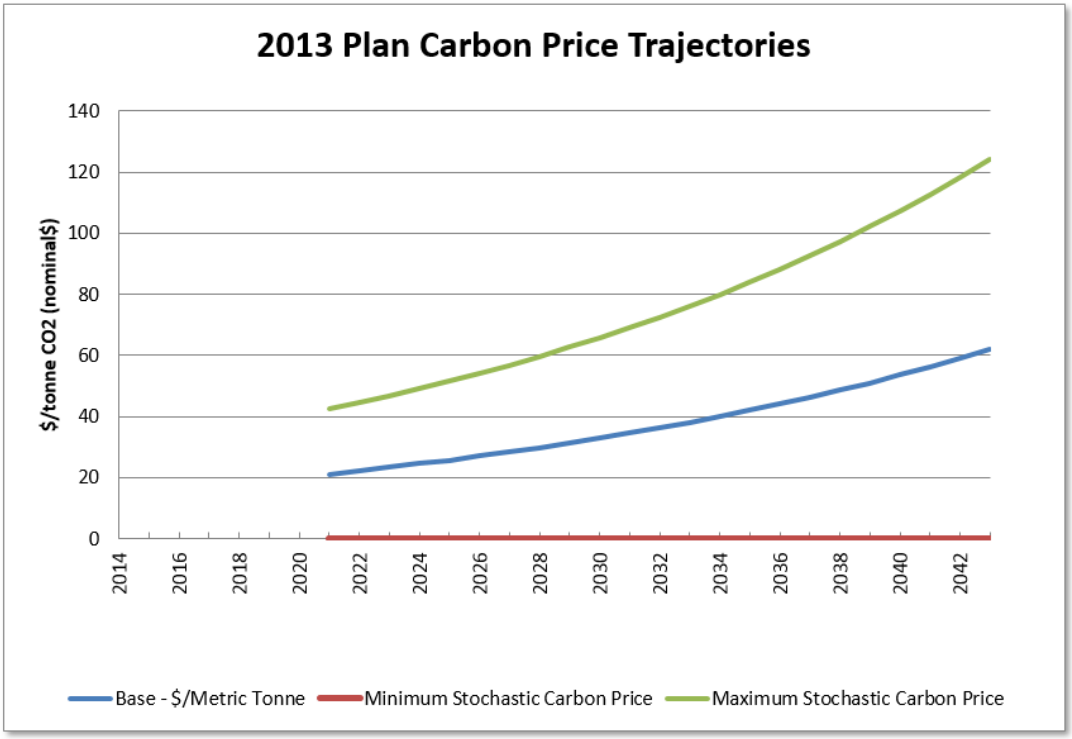
Estimates of future costs associated with regulation of CO_2 emissions from thermal power plants is an important consideration in terms of analyzing potential changes to resource costs, electricity market prices, and portfolio risk. Most electric utilities, including NorthWestern, consider future carbon cost uncertainty as a significant risk variable that should be considered and assessed through modeling. NorthWestern incorporates carbon risk in the evaluation of resource alternatives.

NorthWestern does not know the future costs of carbon emissions, as they will be largely dependent on what regulatory measures might be imposed as a means of controlling them. However, carbon cost estimates can be formulated from a diverse range of analytically supported opinions that are found in other utility resource plans, government proposals, and academic literature. The best approach to estimating the effects of carbon risks is to evaluate current and potential resource portfolios over a range of plausible futures to determine which resource portfolio(s) achieve a balance of acceptable cost and risk.

The 2013 Plan considered carbon costs in the context of the information provided in the 2013 EIA Annual Energy Outlook and in advance of the EPA 111(d) proposed rules for existing CO_2 emitting sources. In selecting the EIA GHG15 carbon case as the base carbon assumption, NorthWestern derived a base set of carbon pricing assumptions of $21.22/tonne ($/metric tonne - nominal) starting in 2021 and escalating annually at 5% over the 20-year planning horizon and through 2043. For stochastic modeling purposes, carbon price was varied above and below the annual base value according to a triangular

distribution in recognition of the high degree of uncertainty associated with the carbon price variable and how it might actually materialize over time (Figure 6-1). One hundred iterations of the model were executed to create a distribution of total portfolio cost where carbon cost, like other stochastic variables such as electricity and natural gas price, varied above and below the starting value defined by the forecast schedule. Values never went below zero.

Figure 6-1 2013 Plan Carbon Price Trajectories



The final EPA rules for implementation of the CPP were published August 3, 2015, and the schedule for states to submit implementation plans was set. States were required to submit initial plans for achieving GHG emission standards to EPA by September 2016. However, the U.S. Supreme Court recently issued a stay of the final rule to remain in effect until the challenge to the rule is either appealed and decided by the U.S. Supreme Court or

the U.S. Supreme Court declines to hear the appeal (see Volume 2, Chapter 4 for final CPP goals and NorthWestern's Motion to Stay).

NorthWestern relies on outside sources of carbon cost estimates to inform its planning and modeling. Prior resource planning cycles have recognized the Annual Energy Outlook as a guiding source of carbon cost planning information. The 2015 Annual Energy Outlook excluded projections of carbon prices, however. This left NorthWestern, its advisors, and its advisory group to identify and select carbon cost estimates without the use of information from EIA. The following sources were reviewed to inform NorthWestern's 2015 Plan:

- CO_2 Price Report, January, 2016 (Synapse Energy Economics, Inc.)
- PacifiCorp 2015 Integrated Resource Plan
- Xcel Energy 2015 IRP (Preferred PF)
- Puget Sound Energy 2015 IRP (low, mid, and high case)
- Portland General Electric 2015 Update

The carbon cost values from the reference list above plus NorthWestern's three projections of carbon costs are presented in Table 6-1.

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Table 6-1 CO_2 Cost Forecasts

Forecast Source	$/Short Ton CO_2 (Nominal $)																
	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
NWE - Base				20.00	20.83	21.69	22.59	23.53	24.51	25.53	26.59	27.69	28.84	30.03	31.28	32.58	33.93
NWE - Low				0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NWE - High				40.00	41.66	43.39	45.19	47.06	49.02	51.05	53.17	55.38	57.68	60.07	62.56	65.16	67.86
PacifiCorp - 2015		22.39	26.20	30.02	33.83	37.64	41.45	45.27	49.08	52.89	56.71	60.52	64.33	68.14	71.96	75.77	79.58
PGE - 2015 Update		12.04	12.78	13.66	14.68	15.84	17.13	18.57	20.14	21.85	23.69	25.68	27.80	30.06	32.46	34.99	37.67
PSE - 2015 Low	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PSE - 2015 Mid	16.59	17.85	19.22	20.68	22.26	23.96	25.78	27.75	29.86	32.14	34.59	37.23	40.07	43.12	46.41	49.95	53.76
PSE - 2015 High		34.79	37.80	41.07	44.62	48.48	52.68	57.23	62.18	67.56	73.41	79.76	86.65	94.15	102.29	111.14	120.76
Synapse - 2016 High				28.72	30.46	32.27	34.13	36.06	38.05	44.31	50.80	57.54	64.52	71.76	79.27	87.04	95.10
Synapse - 2016 Med				22.97	24.31	25.69	27.12	28.60	30.12	31.69	33.32	34.99	39.81	44.81	49.99	55.36	60.92
Synapse - 2016 Low				17.23	18.45	19.72	21.03	22.38	23.78	25.23	26.72	28.26	29.86	31.51	33.21	34.96	36.78
Xcel - 2015	21.50	22.15	22.81	23.49	24.20	24.92	25.67	26.44	27.24	28.05	28.89	29.76	30.65	31.57	32.52	33.50	34.50

To aid in the comparison of NorthWestern's three carbon price cases to other utility values, the pricing information from several recent utility planning documents shown in Table 6-1 has been plotted in Figure 6-2. NorthWestern has supplied three carbon price trajectories with carbon costs beginning in 2022 (Table 6-2). Each year after 2022 non-zero values were escalated using the same escalation rate that has been employed for other commodities in this Plan. The purpose of three pricing cases is to evaluate cost and risk over a plausible range of potential carbon price futures. Figure 6-2 illustrates the forecasted trajectories of NorthWestern's three pricing cases (in black) in comparison to other utility and non-utility values.

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Figure 6-2 CO_2 Cost Forecast Comparison

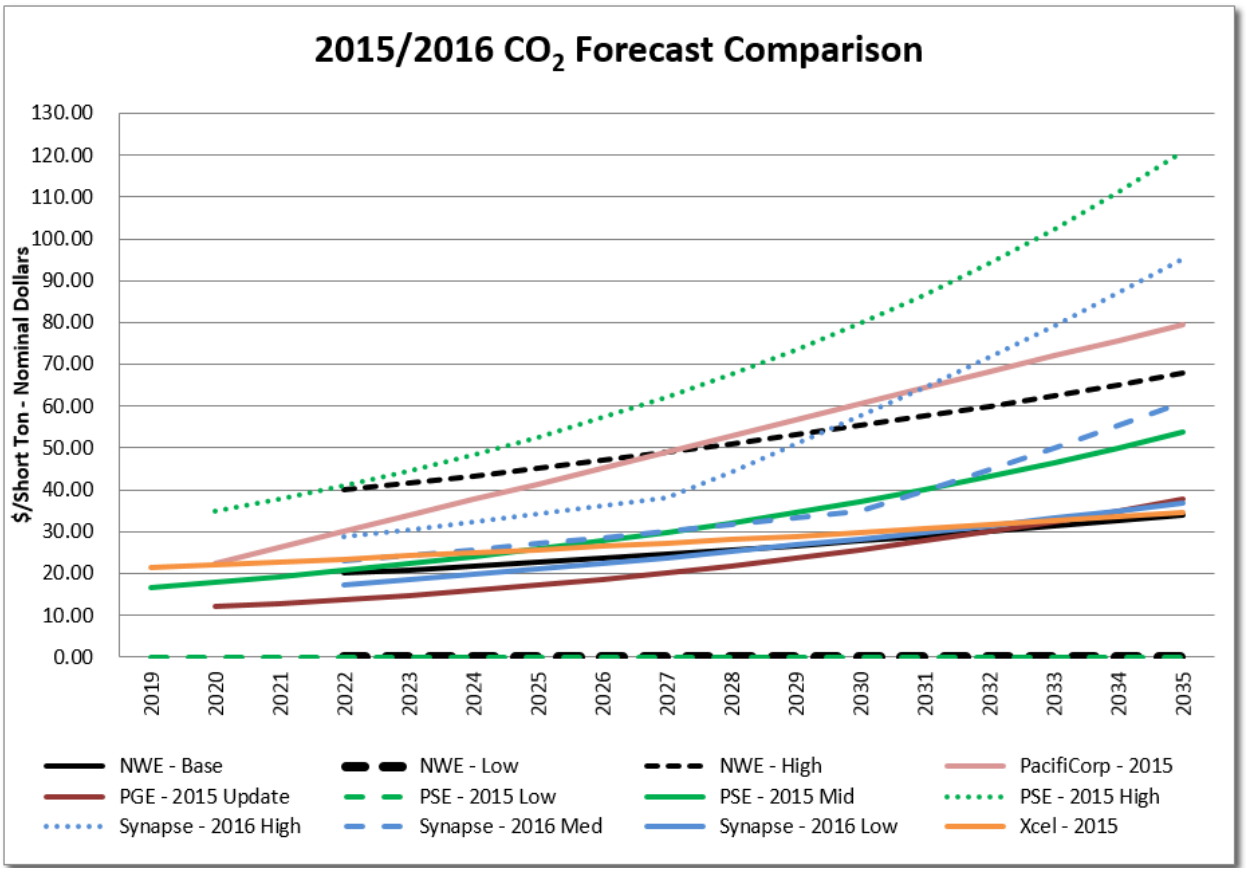

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Table 6-2 2015 Plan Carbon Price Forecast

2015 Plan Carbon Price Forecast			
	Carbon Penalty ($/ton - Nominal)	Carbon Penalty ($/ton - Nominal)	Carbon Penalty ($/ton - Nominal)
Year	base case	high case	low case
2016	$0.00	$0.00	$0.00
2017	$0.00	$0.00	$0.00
2018	$0.00	$0.00	$0.00
2019	$0.00	$0.00	$0.00
2020	$0.00	$0.00	$0.00
2021	$0.00	$0.00	$0.00
2022	$20.00	$40.00	$0.00
2023	$20.83	$41.66	$0.00
2024	$21.69	$43.39	$0.00
2025	$22.59	$45.19	$0.00
2026	$23.53	$47.06	$0.00
2027	$24.51	$49.02	$0.00
2028	$25.53	$51.05	$0.00
2029	$26.59	$53.17	$0.00
2030	$27.69	$55.38	$0.00
2031	$28.84	$57.68	$0.00
2032	$30.03	$60.07	$0.00
2033	$31.28	$62.56	$0.00
2034	$32.58	$65.16	$0.00
2035	$33.93	$67.86	$0.00
20 -Year Levelized:	$13.87	$27.75	$0.00

The application of the carbon cost adder in modeling is again defined as a stochastic variable in the PowerSimm software using a triangular distribution. Recognition of the uncertainty associated with carbon value is captured in the Monte Carlo routine which stresses the carbon value above and below the annual price projection over the 20-year simulation horizon. This allows us to observe portfolio performance over a plausible set of carbon price paths to evaluate a range of outcomes rather than simply choosing a single set of prices.

The carbon price trajectories shown in Table 6-2 are one of many possible price paths that could materialize. Carbon pricing is included as a risk variable in the portfolio simulations presented in Chapter 12 and is considered a base assumption in the 2015 Plan. In order to better understand the impact of this carbon pricing variable, two alternative carbon pricing cases have been included for comparison purposes to the base case. They include a zero carbon cost adder "low case" and a doubling of the base case value as a "high" carbon cost case. Specialty case portfolio runs were performed using the zero and high case carbon prices, and the results of these models are presented in Chapter 12.

In its comments to the 2013 Plan, the Commission directed NorthWestern to make changes to its methods and scope of evaluation of future carbon costs. Specifically, the Commission requested the following:

- A more rigorous evaluation of potential CO_2 costs in future filings;
- Evaluation of alternative CO_2 price trajectories;
- Alternative ways of defining the CO_2 price distribution; and
- Receipt of specific guidance on CO_2 from ETAC.

Based on these comments NorthWestern did the following:

1. NorthWestern solicited input from ETAC during 2015 for CO_2 pricing including the cost, timing, and methods of including carbon costs and received comments to address the use of a triangular distribution in the stochastic simulations;
2. NorthWestern identified and considered additional sources of price forecasts for CO_2 and shared them with ETAC;
3. NorthWestern employed a base case carbon pricing assumption and two alternatives including a zero carbon cost case and a high carbon cost case in the 2015 Plan; and
4. NorthWestern completed portfolio simulations for the base capacity plan using all three carbon pricing trajectories.

It should be noted that neither NorthWestern nor Ascend Analytics nor ETAC identified an appropriate alternative to the triangular distribution of carbon price in the stochastic models. However, the use of multiple pricing scenarios provides modeling results that allow an understanding of the impacts under different carbon price assumptions.