Appendix O
Air Emissions Rates and Costs

The purpose of this appendix is to provide information about the assumptions and methodology used to estimate environmental costs of air emissions from the portfolios evaluated in the 2010 Integrated Resource Plan. More information about the portfolios and the IRP process can be found in the IRP document. This appendix contains background data and information, and is meant to be used as a reference for understanding the environmental emissions calculations and as a record of the process and assumptions.

An important part of the IRP analysis process involves the assumptions that are made about availability and costs of future resources, and there is uncertainty in these factors. This uncertainty is also reflected in the estimation of environmental costs, so the analysis shown here is meant to be representative, and conservative in avoiding uncounted emissions. The environmental calculations will be updated every two years along with the IRP.

The goal of evaluating the air emissions and estimating their cost is to help understand the overall impact of choices that can be made to meet increased demand for electricity from City Light customers. While it is not possible to know with certainty how the choices City Light makes will affect the choices of other utilities and the overall power marketplace, and associated emissions, there are some basic assumptions that can be made to help understand the potential impacts. In general, avoiding increased energy production through conservation and efficiency measures avoids impacts associated with energy resources almost entirely. Renewables have fewer impacts than traditional thermal resources (fossil fuel, nuclear), but depending upon the technology, can have air emissions, or other environmental impacts. Meeting increased City Light load by using more of an existing resource, such as a contract for hydropower from an existing facility that is not increasing its output, means that power is no longer available to other customers, and they will have to find a new source of power. The treatment of various types of power choices is described in more detail below.

In the 2010 IRP analysis, environmental costs were estimated using air emissions and proxies for the costs of these emissions. The calculation of environmental costs that are not captured as actual costs of operation of power plants and delivery of electricity are referred to as externality costs. There are a number of approaches that can be taken to calculating environmental externality costs. City Light uses best estimates of the forecast of costs to comply with existing or potential new regulations on air emissions.

The air pollutants that were evaluated were carbon dioxide (CO_2), nitrogen oxides (NO_X), sulfur oxides (SO_X), mercury (Hg) and particulates (PM).

The first step in determining an estimate of environmental externality costs is determining the amount of each of the air pollutants emitted in each portfolio, over the 20-year planning period.

For each resource in the portfolios, emission rates per unit of electricity were assigned. Figure 1 shows the emission rates for the different resource technologies included in the portfolios.

Figure 1. Resource Emission Rates

	CO_2 Lbs/MWh	NO_x Lbs/MWh	SO_x Lbs/MWh	Hg Lbs/MWh	PM Lbs/MWh
Conservation	0	0	0	0	0
Exchange	0	0	0	0	0
Short Term Market	WECCMarket Tables	WECCMarket Tables	WECCMarket Tables	WECCMarket Tables	WECCMarket Tables
Priest Rapids Option	WECCMarket Tables	WECCMarket Tables	WECCMarket Tables	WECCMarket Tables	WECCMarket Tables
Landfill Gas	0	0.66	0	0	0.1067
Gorge Tunnel 2	0	0	0	0	0
CHP/DG	685.6	0.173	0.00346	0	0.00403
Geothermal	0	0	0	0	0
Biomass - Wood	0	0.80	0	0	0.259
Wind	0	0	0	0	0
RECs	0	0.80	0	0	0.259

Short-Term Market transactions cannot be assumed to have no net emissions. Instead, they are treated as being a market purchase like any other, and those emissions rates are shown below. Note that market emissions rates are determined by the model used in the IRP analysis and represent the power sources that are used to meet loads in the western power market where City Light buys and sells power. An important feature of the power market in future years will be the addition of renewable resources to meet demand through voluntary green programs and regulatory requirements in some states, and potentially in the future, federal regulations. However, simply because it is expected that a significant amount of new renewable resources will be brought into the power generation mix does not mean that generation from the market should be considered as having low emissions. In fact, the renewable generation will be in high demand and claimed by utilities that need it for voluntary or regulatory purposes. This will leave the "unclaimed," higher emission resources on the margin.

The Priest Rapids Option would increase the amount of electricity City Light receives from an existing contract for the output of a hydropower facility. The facility would not increase its output, since as a hydropower plant it runs at maximum output for the water available. Therefore, the net result of City Light taking more power from this plant would be that some other entity that otherwise would have used that electricity will be forced to find another source. In the environmental analysis in previous Integrated Resource Plans, the increased use of existing hydropower plants has been treated as having the same overall impact as purchasing power from the short-term market. This simplifying assumption is for purposes of emissions accounting within the context of this analysis. City Light is interested in secondary impacts to emissions it believes result from its own choices and actions. Therefore, the Priest Rapids Option is treated as having the same emissions rates as the short-term market. The impact of this assumption on tallying total western market emissions below is negligible.

Gorge Tunnel 2 will be a new source of hydropower from a City Light facility and will therefore have negligible air pollution emissions during operation.

The CHP/DG (combined heat and power/ distributed generation) resource is assumed to be a natural gas combustion turbine producing electricity and steam that is used in space or water heating or an industrial process. It is assumed that the steam use increases overall efficiency of the natural gas fuel use by 20%. So, the emissions of this resource are estimated to be the same as a natural gas turbine, discounted by 20% to account for the valuable use of the steam.

The RECs (Renewable Energy Credits) category is unique, since they represent only the environmental attributes associated with renewable electricity, and City Light will not receive the associated power. RECs can be used to meet City Light's regulatory obligation to have a certain percentage of renewable electricity meeting load. There are several types of renewable resources that can be used to create RECs to meet the state of Washington's requirements, including wind, solar, geothermal, landfill gas, and biomass. The IRP does not specify which type of renewable the RECs are from. Therefore, for the purpose of being conservative, it is assumed that they have the emissions rates of a biomass plant. As in the case of the Market Resource, there is uncertainty in the source of the REC, and the actual emissions may be lower. On the other hand, the addition of a resource that supplies RECs to City Light will displace Market electricity. This is guaranteed because RECs are only produced when electricity from a renewable resource is generated, and that electricity must be used to serve a load somewhere. So, the amount of RECs are subtracted from the Portfolio resources category that includes Market and Priest Rapids, to capture the reduction in emissions.

The tables below show the emissions rates for market purchases, under the base case and the six scenarios. Note that the CO_2, NO_X, and SO_X values are based on the output of the Aurora model for the 2010 IRP. Data for Hg and PM were not included in the 2010 Aurora modeling, so the values that were used in the 2008 IRP are used for this analysis. The Hg and PM emissions rates were based on 2006 IRP data from Ventyx (formerly Global Energy Decisions), and are the same for the base case and all other scenarios.

The market purchase emissions rates data is also shown here in graph form to illustrate the differences between the scenarios and the base case. The data is presented in tabular form at the end of this appendix. The emission rates for CO_2, NO_X, and SO_X all trended together, as expected, since resources with lower rates for one of those pollutants are also likely to have lower rates for the others, and vice versa. The LoGas and HiCO_2 scenarios were similar in their emission rates, but it is interesting to note that LoGas had a lower CO_2 rate than HiCO_2, indicating that, in the Aurora model, low gas prices were a larger driver in reducing high emission resources in the market place than high CO_2 prices. In the West, there is excess capacity for natural gas-fired turbines, suggesting that with prolonged low natural gas prices they could displace a larger amount of higher-emitting generation (e.g., coal-fired generation) than would be displaced by the "high" carbon tax. Emission rates for the base case and Hi and Lo Demand were very close, diverging only slightly in the years after 2022. Low CO_2 prices resulted in the highest emission rates, even higher than in the HiGas price scenario.

Note that the WECC market emission rates for CO_2, NO_X, and SO_X in the base case, HiDemand, and LoDemand scenarios are almost identical, so do not show up separately on the accompanying graphs.

Figure 2. CO_2 Emission Rate – WECC Market

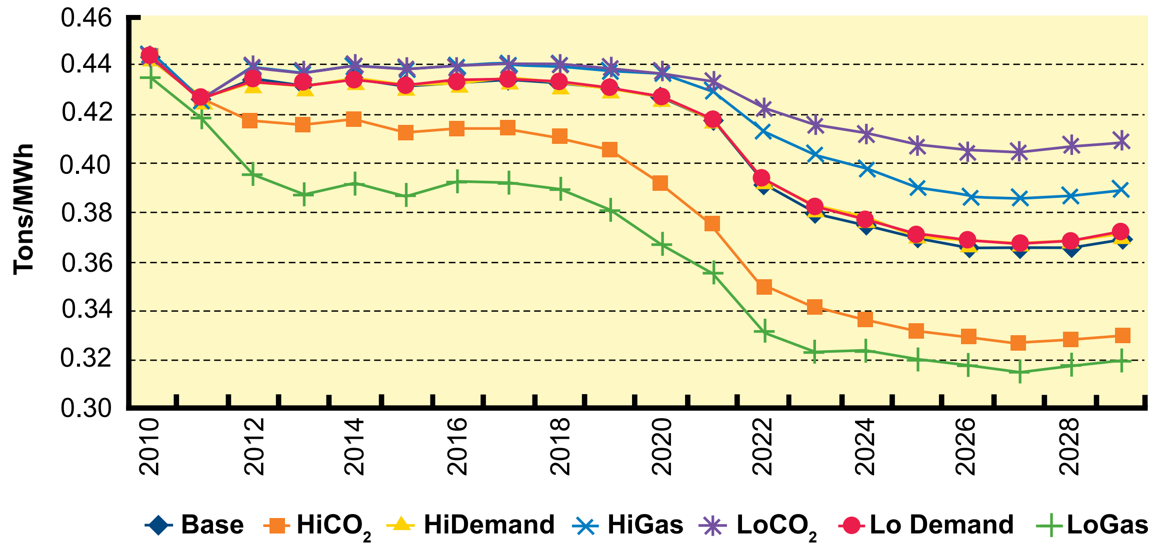


Figure 3. NO_X Emission Rates - WECC Market

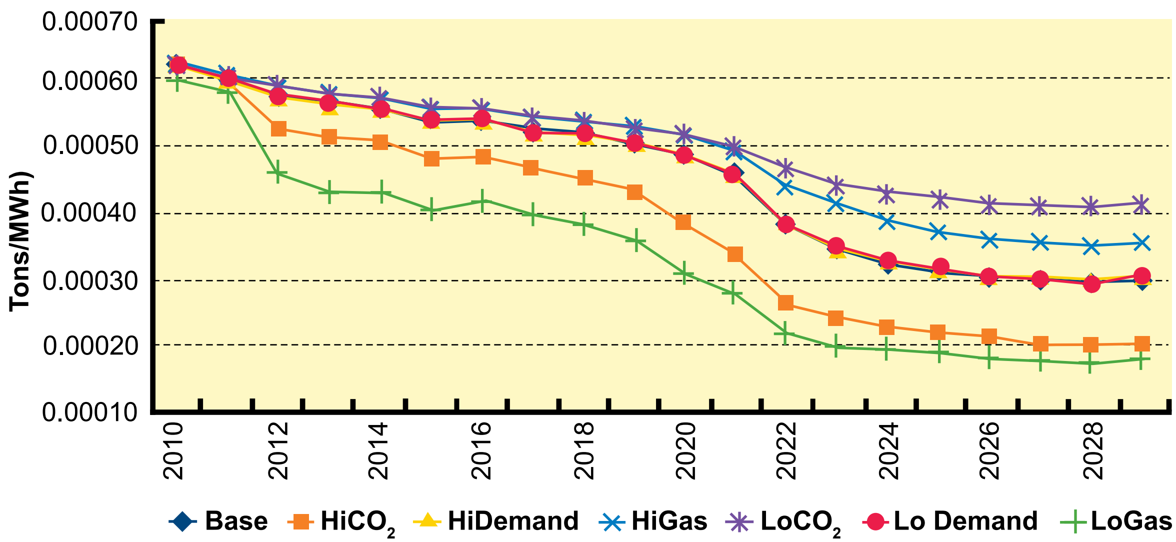


Figure 4. SO_x Emission Rates - WECC Market

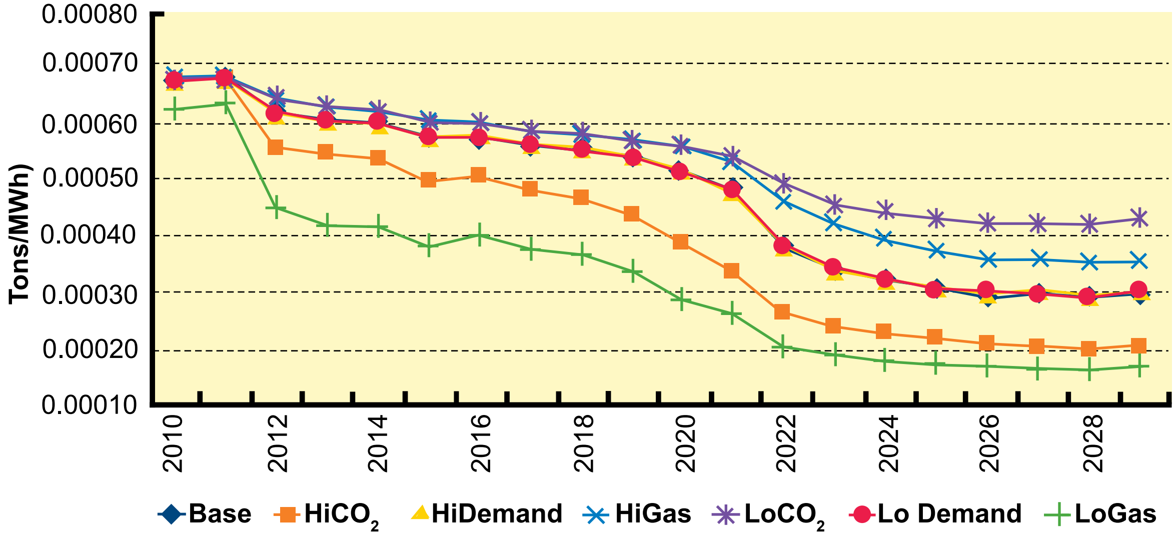
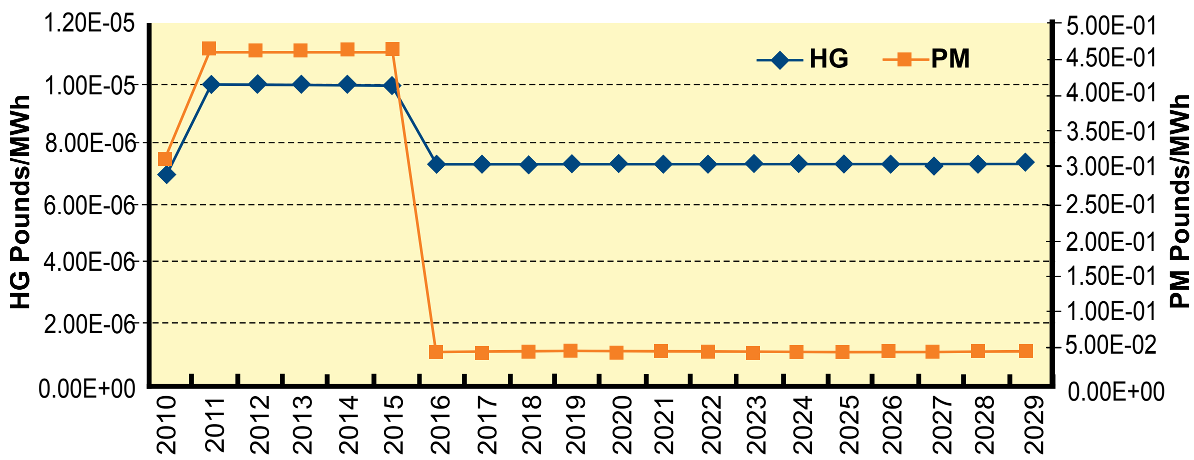


Figure 5. HG and PM Emission Rates – WECC Market



Calculating Pollution Amounts

Once the emission rates have been described, above, the next step in determining the environmental externality costs is to apply those rates to the resources in the portfolios under the base case and each scenario in order to find the amount of each pollutant in each of the years in the planning period.

The three portfolios analyzed for the 2010 IRP are the same in the base case and under all scenarios. They are described in the accompanying figures, by year and resource type. The methodology for their creation and the reasoning behind their structure is described in Appendix L – Analysis of Candidate Resource Portfolios. For the purposes of environmental costs analysis, it is important to note that the amounts of electricity shown for each year and each resource were assumed to be “must run” in the Aurora model, and therefore are energy, not capacity, amounts. The generation amounts may vary slightly from the portfolios listed in Appendix L due to rounding in the calculations.

Figure 6. Lo-RECs Portfolio

Lo-RECs	aMW Conservation	aMW Exchange	aMW Market	aMW Priest Rapids	aMW Landfill	aMW Gorge Tunnel	aMW CHP/DG	aMW Geothermal	aMW Biomass	aMW Wind	aMW RECS
2010	10	0	0	0	5.95	0	0	0	0	0	0
2011	23	25	25	0	5.95	0	0	0	0	0	0
2012	37	42.5	42.5	0	5.95	0	0	0	0	0	0
2013	51	42.5	42.5	0	5.95	0	0	0	0	0	0
2014	65	42.5	42.5	0	5.95	0	0	0	0	0	0
2015	79	42.5	42.5	0	5.95	5.04	0	0	0	0	0
2016	93	42.5	42.5	0	5.95	5.04	0	0	27	0	-5
2017	107	50	50	0	5.95	5.04	0	0	27	0	-7
2018	112	50	50	0	5.95	5.04	0	0	27	0	-9
2019	114	50	50	0	5.95	5.04	0	0	27	0	-10
2020	116	50	50	24	5.95	5.04	0	18.4	27	62.4	-4
2021	118	50	50	24	5.95	5.04	0	18.4	27	92.8	-11
2022	120	50	50	24	5.95	5.04	0	18.4	27	116.8	0
2023	122	50	50	24	5.95	5.04	0	18.4	27	116.8	-2
2024	124	50	50	24	5.95	5.04	0	18.4	27	116.8	-4
2025	12	50	50	24	5.95	5.04	0	18.4	27	116.8	-6
2026	128	50	50	24	5.95	5.04	0	18.4	27	116.8	-7
2027	130	50	50	24	5.95	5.04	0	18.4	27	116.8	-9
2028	132	50	50	24	5.95	5.04	0	18.4	27	116.8	-11
2029	134	50	50	24	5.95	5.04	0	18.4	27	116.8	-7
20 Yr aMW	1941	887.5	887.5	240	119	75.6	0	184	378	1089.6	-92

Figure 7. Hi-RECs Portfolio

Hi-RECs	aMW	aMW	aMW	aMW	aMW	aMW	aMW	aMW	aMW	aMW	aMW
	Conservation	Exchange	Market	Priest Rapids	Landfill	Gorge Tunnel	CHP/DG	Geothermal	Biomass	Wind	RECS
2010	10	0	0	0	6	0	0	0	0	0	0
2011	23	25	25	0	5.95	0	0	0	0	0	0
2012	37	42.5	42.5	0	5.95	0	0	0	0	0	0
2013	51	42.5	42.5	0	5.95	0	0	0	0	0	0
2014	65	42.5	42.5	0	5.95	0	0	0	0		0
2015	79	42.5	42.5	0	5.95	0	0	0	0	0	0
2016	93	42.5	42.5	0	5.95	0	0	0	0	0	-37
2017	107	50	50	0	5.95	0	0	0	0	0	-39
2018	112	50	50	24	5.95	0	0	0	0	0	-41
2019	114	50	50	24	5.95	5.04	6	0	0	0	-31
2020	116	50	50	24	5.95	5.04	6	0	13.5	0	-93
2021	118	50	50	24	5.95	5.04	6	0	13.5	32	-97
2022	120	50	50	24	5.95	5.04	6	18.4	13.5	32	-93
2023	122	50	50	24	5.95	5.04	6	18.4	13.5	32	-95
2024	124	50	50	24	5.95	5.04	6	18.4	27	32	-83
2025	126	50	50	24	5.95	5.04	6	18.4	27	56	-61
2026	128	50	50	24	5.95	5.04	6	18.4	27	56	-62
2027	130	50	50	24	5.95	5.04	6	18.4	27	56	-16
2028	132	50	50	24	5.95	5.04	6	18.4	27	56	-18
2029	134	50	50	24	5.95	5.04	6	18.4	27	65.6	-10
20 Yr aMW	1941	887.5	887.5	288	119.05	55.44	66	147.2	216	417.6	-775

Figure 8. High Conservation Portfolio

Hi-Cons	aMW Conservation	aMW Exchange	aMW Market	aMW Priest Rapids	aMW Landfill	aMW Gorge Tunnel	aMW CHP/DG	aMW Geothermal	aMW Biomass	aMW Wind	aMW RECS
2010	14	0	0	0	5.95	0	0	0	0	0	0
2011	30	25	25	0	5.95	0	0	0	0	0	0
2012	46	35	35	0	5.95	0	0	0	0	0	0
2013	61	35	35	0	5.95	0	0	0	0	0	0
2014	74	35	35	0	5.95	0	0	0	0	0	0
2015	87	35	35	0	5.95	5.04	0	0	0	0	0
2016	100	35	35	0	5.95	5.04	0	0	13.5	0	-17
2017	113	35	35	24	5.95	5.04	0	0	13.5	0	-19
2018	124	35	35	24	5.95	5.04	0	0	13.5	0	-22
2019	127	35	35	24	5.95	5.04	0	18.4	13.5	0	-4
2020	130	35	35	24	5.95	5.04	0	18.4	27	56	-9
2021	131	50	50	24	5.95	5.04	0	18.4	27	104	0
2022	132	50	50	24	5.95	5.04	0	18.4	27	104	-11
2023	133	50	50	24	5.95	5.04	6	18.4	27	104	-7
2024	134	50	50	24	5.95	5.04	6	18.4	27	104	-9
2025	135	50	50	24	5.95	5.04	6	18.4	27	104	-11
2026	136	50	50	24	5.95	5.04	6	18.4	27	104	-13
2027	138	50	50	24	5.95	5.04	6	18.4	27	104	-15
2028	139	50	50	24	5.95	5.04	6	18.4	27	104	-17
2029	140	50	50	24	5.95	5.04	6	18.4	27	128	0
20 Yr aMW	2124	790	790	312	119	75.6	42	202.4	324	1016	-155

WECC Market Sales and Purchases – Balancing Portfolio Resources to Meet Load

The new resources in the portfolios, along with City Light's existing resources, must meet load at all times of the year. Given the variability in loads and resources output, particularly hydropower, City Light buys electricity from the WECC market during some periods, and sells surplus electricity into the WECC market during other periods, to make sure that loads and resources balance throughout the year. For the IRP analysis of air emissions, the amount of sales and purchases from the WECC market is compared to what City Light would have sold and purchased if no candidate portfolio resources were added. The emissions from the difference between the two are included in the figures below as sales and purchases.

In all three portfolios, sales and purchases can result in reductions in emissions of all pollutants. This is because the addition of portfolio resources reduces the amount of purchases City Light needs to make to meet load, and it increases the amount of surplus power City Light has, thus increasing its sales to the WECC market. It is not the purchases that decrease emissions, rather it is the amount that the purchases decrease. Decreasing purchases means that less WECC market power is needed, and this results in reduced emissions. Increasing sales also reduces the amount of WECC market resources that are needed to meet demand throughout the region, also decreasing emissions. The emissions from the portfolio resources, and reductions from sales and purchases are shown in Figure 11.

Figure 8 illustrates how the 20-year total of CO_2 emissions vary between portfolios, in the base case. It is clear that CO_2 emissions from the portfolio resources associated with market electricity, as well as market purchases and surplus sales are the largest component of these emissions.

Emissions from purchases and sales are incremental, compared to the "business as usual" situation in which City Light does not acquire any new portfolio resources, but instead meets all future load growth with market purchases. This is an important point, because the goal of evaluating emissions in the IRP for the portfolios of resources is to determine how they would change compared to the current portfolio of resources. That is, what is the result of the choices City Light makes in meeting load in the future.

So, in each of the portfolios, sales and purchases are shown as incremental to "business as usual" amounts. Since resources were added in each of the portfolios, purchases went down, and sales went up, compared to "business as usual." When purchases go down, that is represented as a reduction in the emissions, as the market resources are not needed to meet City Light load. When sales go up, this is also represented as a reduction in emissions, as market resources are displaced by City Light's new portfolio resources that are surplus to its load. (Note that the emissions from the new resources City Light acquires in the portfolios are also accounted for, as shown in the table above.)

Now consider the differences between portfolios. In the Hi-RECs portfolio, both CO_2 emissions from purchases and "reductions" from Sales are smaller in magnitude compared to the LoRECS and Hi-Cons portfolios. That is because in the Hi-RECs portfolio, City Light meets its I-937 requirements through the acquisition of RECs rather than renewable electricity. Therefore, there is less surplus electricity that City Light can sell into the market. Also note that the "Market+Priest Rapids-RECs" emissions are also lower. That is because RECs are included in this category as resulting in a reduction of CO_2 emissions, as the associated electricity must be consumed somewhere, thus displacing market resources. Hi-Cons shows a higher amount of reductions of CO_2 emissions from sales, since load is reduced compared to the other portfolios.

Figure 9. CO_2 (Tons) 20-Year Totals by Portfolio – Base Case

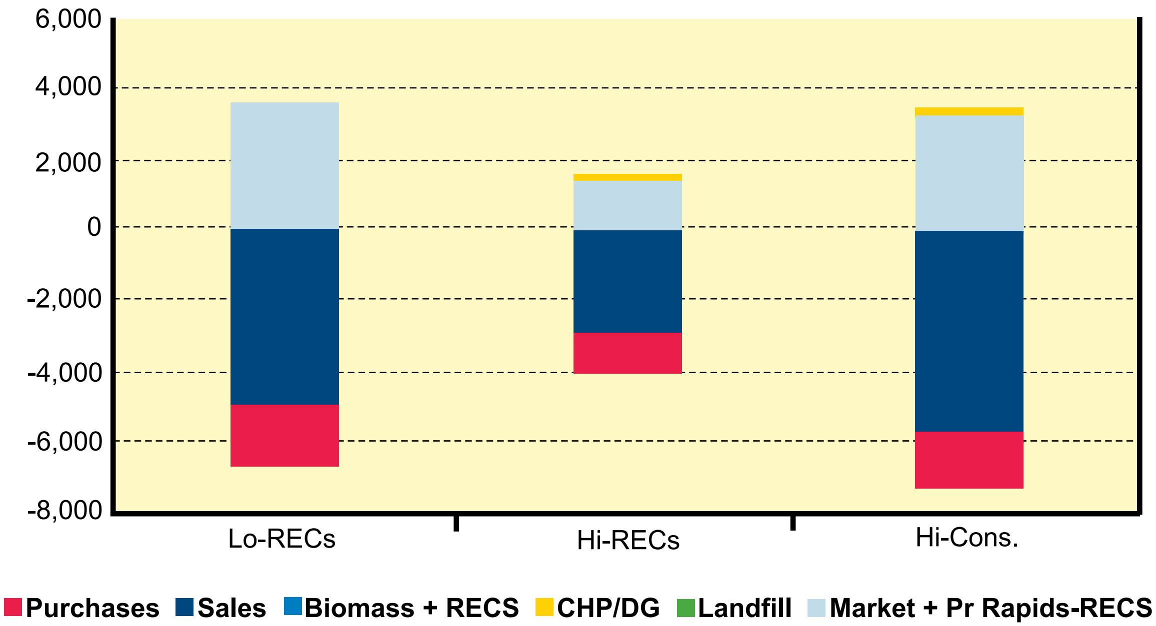


Figure 9 shows the 20-year total of NO_x emissions, by source category, for the three portfolios in the base case. Unlike the CO_2 emissions, there are several portfolio resources that emit NO_x, including landfill gas and biomass/RECs (which, for analysis, are considered to be from a biomass plant). That assumption about RECs as biomass is a worst case assumption, given the high emission factor for biomass NO_x. If, instead, the RECs were from a resource with lower emissions, for example landfill gas or wind with zero NO_x, the NO_x emissions would actually be lower. The market category of portfolio resources is the significant source of NO_x emissions.

Comparing the NO_x emissions between portfolios, Hi-RECs has the highest overall, due to the large number of RECs in this portfolio, assumed to be from a biomass plant, and lower reductions from sales and purchases. Since the amount of landfill gas is the same across all portfolios, the NO_x emissions are the same for that resource category.

Figure 10 shows the 20-year total SO_x emissions for the portfolios in the base case. For SO_x, the sources of emissions or reductions are similar to CO_2, but smaller in magnitude.

Figure 10. NO_x (Tons) – 20-Year Total

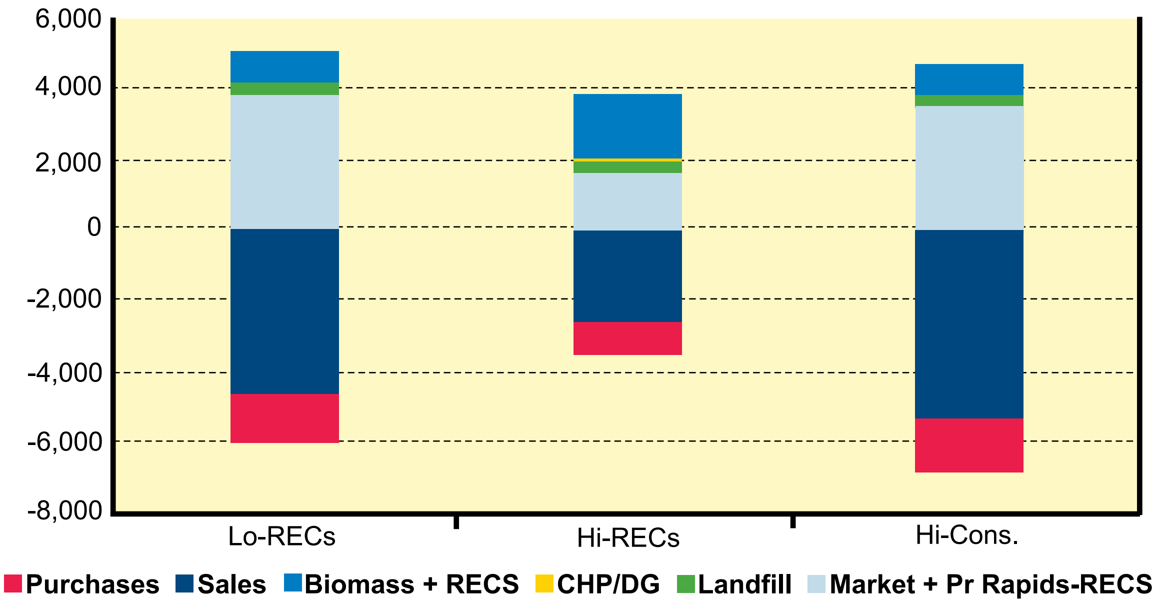
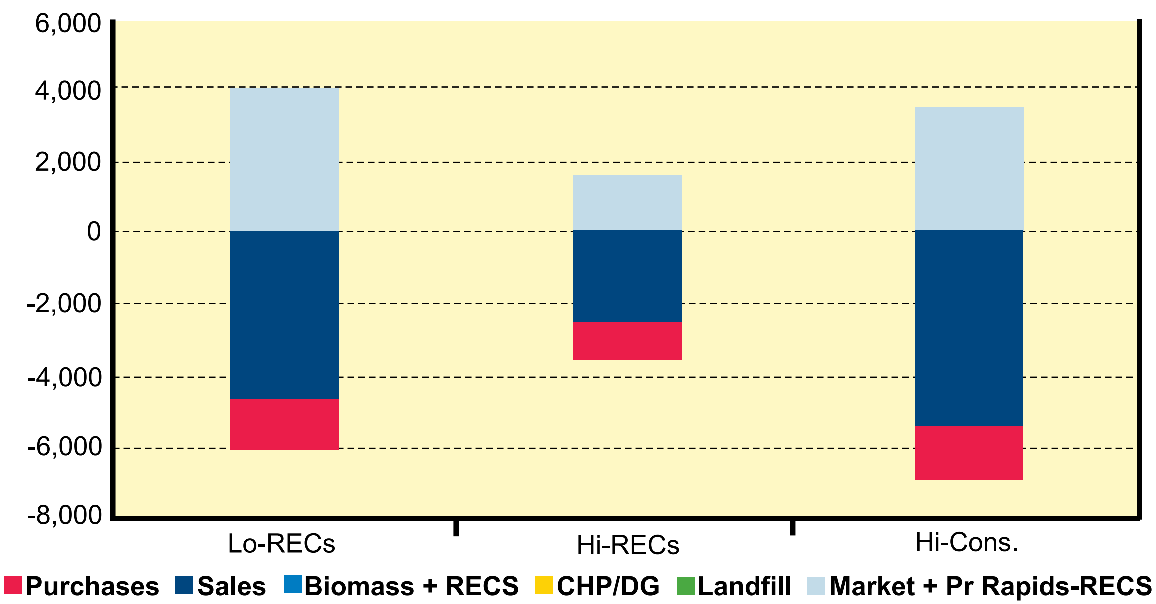


Figure 11. SO_x (Tons) – 20-Year Total



Emissions from Portfolio Resources – Base Case

This table contains the data graphed above for CO_2, NO_x, and SO_x. It also contains Hg and PM emissions. The numbers are 20-year totals, in units of tons for CO_2, NO_x, and SO_x, and pounds (lbs) for Hg and PM.

Figure 12. Emissions from Portfolio Resources - 20-Year Totals

	Lo-RECs				
	CO_2 (Tons)	NO_x (Tons)	SO_x (Tons)	Hg (Lbs)	PM (Lbs)
Market+Pr Rapids-RECs	3,627,691	3,788	3,917	71	1,086,168
Landfill	0	344	0	0	111,228
CHP/DG	0	0	0	0	0
Biomass+RECs	0	864	0	0	559,431
Sales	-4,900,308	-4,593	-4,630	-93	-537,040
Purchases	-1,572,959	-1,384	-1,376	-30	-110,728
TOTAL	-2,845,576	-981	-2,090	-52	1,109,059

	Hi-RECs				
	CO_2 (Tons)	NO_x (Tons)	SO_x (Tons)	Hg (Lbs)	PM (Lbs)
Market+Pr Rapids-RECs	1,425,836	1,589	1,680	30	860,722
Landfill	0	344	0	0	111,275
CHP/DG	198,193	50	1	0	2,331
Biomass+RECs	0	1,821	0	0	1,179,172
Sales	-2,818,900	-2,567	-2,573	-54	-306,935
Purchases	-980,787	-816	-801	-19	-45,351
TOTAL	-2,175,657	422	-1,694	-43	1,801,214

	Hi-Cons				
	CO_2 (Tons)	NO_x (Tons)	SO_x (Tons)	Hg (Lbs)	PM (Lbs)
Market+Pr Rapids-RECs	3,308,251	3,428	3,540	64	944,118
Landfill	0	344	0	0	111,228
CHP/DG	126,123	32	1	0	1,483
Biomass+RECs	0	881	0	0	570,475
Sales	-5,528,330	-5,304	-5,380	-105	-748,767
Purchases	-1,613,861	-1,422	-1,415	-31	-126,882
TOTAL	-3,707,817	2,042	-3,254	-71	751,656

Figure 13. Portfolio Resource Emissions – Lo-RECs Portfolio – Base Case

Market Emissions (Market+Pr. Rapid minus RECs)

Year	CO_2 (Tons)	NO_x (Tons)	SO_x (Tons)	HG (Lbs)	PM (Lbs)
2010	0	0	0	0	0
2011	93,272	132	148	2	100,975
2012	161,436	214	229	4	171,658
2013	160,800	210	225	4	171,658
2014	161,779	207	222	4	171,658
2015	160,775	200	213	4	171,658
2016	142,325	177	189	2	13,321
2017	163,370	197	210	3	15,274
2018	155,407	186	198	3	14,564
2019	150,869	177	189	3	14,209
2020	261,734	299	317	4	24,865
2021	230,197	253	264	4	22,379
2022	254,324	249	246	5	26,286
2023	239,532	217	211	5	25,576
2024	229,921	200	196	4	24,865
2025	220,009	186	182	4	24,155
2026	214,695	177	173	4	23,800
2027	208,180	170	169	4	23,089
2028	202,236	162	161	4	22,379
2029	216,831	176	175	4	23,800
20 Yr	3,627,691	3,788	3,917	71	1,086,168

Figure 13. Portfolio Resource Emissions – Lo-RECs Portfolio – Base Case (continued)

Landfill Emissions

Year	CO_2 (Tons)	NO_x (Tons)	SO_x (Tons)	HG (Lbs)	PM (Lbs)
2010	0	17	0	0	5,561
2011	0	17	0	0	5,561
2012	0	17	0	0	5,561
2013	0	17	0	0	5,561
2014	0	17	0	0	5,561
2015	0	17	0	0	5,561
2016	0	17	0	0	5,561
2017	0	17	0	0	5,561
2018	0	17	0	0	5,561
2019	0	17	0	0	5,561
2020	0	17	0	0	5,561
2021	0	17	0	0	5,561
2022	0	17	0	0	5,561
2023	0	17	0	0	5,561
2024	0	17	0	0	5,561
2025	0	17	0	0	5,561
2026	0	17	0	0	5,561
2027	0	17	0	0	5,561
2028	0	17	0	0	5,561
2029	0	17	0	0	5,561
20 Yr	0	344	0	0	111,228

Figure 13. Portfolio Resource Emissions – Lo-RECs Portfolio – Base Case (continued)

CHP/DG Emissions

Year	CO_2 (Tons)	NO_x (Tons)	SO_x (Tons)	HG (Lbs)	PM (Lbs)
2010	0.00	0.00	0.00	0.00	0.00
2011	0.00	0.00	0.00	0.00	0.00
2012	0.00	0.00	0.00	0.00	0.00
2013	0.00	0.00	0.00	0.00	0.00
2014	0.00	0.00	0.00	0.00	0.00
2015	0.00	0.00	0.00	0.00	0.00
2016	0.00	0.00	0.00	0.00	0.00
2017	0.00	0.00	0.00	0.00	0.00
2018	0.00	0.00	0.00	0.00	0.00
2019	0.00	0.00	0.00	0.00	0.00
2020	0.00	0.00	0.00	0.00	0.00
2021	0.00	0.00	0.00	0.00	0.00
2022	0.00	0.00	0.00	0.00	0.00
2023	0.00	0.00	0.00	0.00	0.00
2024	0.00	0.00	0.00	0.00	0.00
2025	0.00	0.00	0.00	0.00	0.00
2026	0.00	0.00	0.00	0.00	0.00
2027	0.00	0.00	0.00	0.00	0.00
2028	0.00	0.00	0.00	0.00	0.00
2029	0.00	0.00	0.00	0.00	0.00
20 Yr	0	0	0	0	0

Figure 13. Portfolio Resource Emissions – Lo-RECs Portfolio – Base Case (continued)

Biomass and RECs Emissions

Year	CO_2 (Tons)	NO_x (Tons)	SO_x (Tons)	HG (Lbs)	PM (Lbs)
2010	0	0	0	0	0
2011	0	0	0	0	0
2012	0	0	0	0	0
2013	0	0	0	0	0
2014	0	0	0	0	0
2015	0	0	0	0	0
2016	0	59	0	0	38,089
2017	0	63	0	0	40,469
2018	0	66	0	0	42,850
2019	0	68	0	0	44,040
2020	0	57	0	0	36,899
2021	0	70	0	0	45,231
2022	0	50	0	0	32,138
2023	0	53	0	0	34,518
2024	0	57	0	0	36,899
2025	0	61	0	0	39,279
2026	0	63	0	0	40,469
2027	0	66	0	0	42,850
2028	0	70	0	0	45,231
2029	0	63	0	0	40,469
20 Yr	0	864	0	0	559,431

Figure 14. Portfolio Resource Emissions – Hi-RECs Portfolio – Base Case

	Market Emissions (Market+Pr. Rapid minus RECs)				
Year	CO_2 (Tons)	NO_x (Tons)	SO_x (Tons)	HG (Lbs)	PM (Lbs)
2010	0	0	0	0	0
2011	93,272	132	148	2	100,975
2012	161,436	214	229	4	171,658
2013	160,800	210	225	4	171,658
2014	161,779	207	222	4	171,658
2015	160,775	200	213	4	171,658
2016	21,978	27	29	0	2,057
2017	42,778	52	55	1	4,000
2018	124,420	149	159	2	11,660
2019	161,407	189	202	3	15,201
2020	-69,912	-80	-85	-1	-6,642
2021	-85,408	-94	-98	-1	-8,303
2022	-64,534	-63	-62	-1	-6,670
2023	-68,601	-62	-60	-1	-7,325
2024	-29,287	-25	-25	-1	-3,167
2025	43,249	37	36	1	4,748
2026	37,531	31	30	1	4,160
2027	185,992	152	151	4	20,628
2028	180,771	145	144	4	20,004
2029	207,390	168	167	4	22,763
20 Yr	1,425,836	1,589	1,680	30	860,722

Figure 14. Portfolio Resource Emissions – Hi-RECs Portfolio – Base Case (continued)

Landfill Emissions

Year	CO_2 (Tons)	NO_x (Tons)	SO_x (Tons)	HG (Lbs)	PM (Lbs)
2010	0	17	0	0	5,608
2011	0	17	0	0	5,561
2012	0	17	0	0	5,561
2013	0	17	0	0	5,561
2014	0	17	0	0	5,561
2015	0	17	0	0	5,561
2016	0	17	0	0	5,561
2017	0	17	0	0	5,561
2018	0	17	0	0	5,561
2019	0	17	0	0	5,561
2020	0	17	0	0	5,561
2021	0	17	0	0	5,561
2022	0	17	0	0	5,561
2023	0	17	0	0	5,561
2024	0	17	0	0	5,561
2025	0	17	0	0	5,561
2026	0	17	0	0	5,561
2027	0	17	0	0	5,561
2028	0	17	0	0	5,561
2029	0	17	0	0	5,561
20 Yr	0	344	0	0	111,275

Figure 14. Portfolio Resource Emissions – Hi-RECs Portfolio – Base Case (continued)

CHP/DG Emissions

Year	CO_2 (Tons)	NO_x (Tons)	SO_x (Tons)	HG (Lbs)	PM (Lbs)
2010	0.00	0.00	0.00	0.00	0.00
2011	0.00	0.00	0.00	0.00	0.00
2012	0.00	0.00	0.00	0.00	0.00
2013	0.00	0.00	0.00	0.00	0.00
2014	0.00	0.00	0.00	0.00	0.00
2015	0.00	0.00	0.00	0.00	0.00
2016	0.00	0.00	0.00	0.00	0.00
2017	0.00	0.00	0.00	0.00	0.00
2018	0.00	0.00	0.00	0.00	0.00
2019	18,017.57	4.54	0.09	0.00	211.92
2020	18,017.57	4.54	0.09	0.00	211.92
2021	18,017.57	4.54	0.09	0.00	211.92
2022	18,017.57	4.54	0.09	0.00	211.92
2023	18,017.57	4.54	0.09	0.00	211.92
2024	18,017.57	4.54	0.09	0.00	211.92
2025	18,017.57	4.54	0.09	0.00	211.92
2026	18,017.57	4.54	0.09	0.00	211.92
2027	18,017.57	4.54	0.09	0.00	211.92
2028	18,017.57	4.54	0.09	0.00	211.92
2029	18,017.57	4.54	0.09	0.00	211.92
20 Yr	198,193	50	1	0	2,331

Figure 14. Portfolio Resource Emissions – Hi-RECs Portfolio – Base Case (continued)

Biomass and RECs Emissions

Year	CO_2 (Tons)	NO_x (Tons)	SO_x (Tons)	HG (Lbs)	PM (Lbs)
2010	0	0	0	0	0
2011	0	0	0	0	0
2012	0	0	0	0	0
2013	0	0	0	0	0
2014	0	0	0	0	0
2015	0	0	0	0	0
2016	0	67	0	0	43,694
2017	0	71	0	0	46,112
2018	0	76	0	0	49,010
2019	0	57	0	0	37,144
2020	0	195	0	0	126,405
2021	0	204	0	0	131,971
2022	0	195	0	0	126,499
2023	0	199	0	0	128,694
2024	0	202	0	0	130,831
2025	0	161	0	0	104,307
2026	0	164	0	0	106,277
2027	0	79	0	0	51,096
2028	0	82	0	0	53,190
2029	0	68	0	0	43,942
20 Yr	0	1,821	0	0	1,179,172

Figure 15. Portfolio Emissions – Hi-Cons Portfolio – Base Case

	Market Emissions (Market+Pr. Rapid minus RECs)				
Year	CO_2 (Tons)	NO_x (Tons)	SO_x (Tons)	HG (Lbs)	PM (Lbs)
2010	0	0	0	0	0
2011	93,272	132	148	2	100,975
2012	132,948	176	189	3	141,365
2013	132,423	173	185	3	141,365
2014	133,230	171	183	3	141,365
2015	132,403	165	176	3	141,365
2016	66,936	83	89	1	6,265
2017	150,095	181	193	3	14,033
2018	140,124	167	179	2	13,132
2019	205,574	241	257	3	19,361
2020	187,185	214	226	3	17,783
2021	270,390	297	310	5	26,286
2022	215,600	211	208	4	22,284
2023	222,031	201	196	4	23,707
2024	212,819	185	182	4	23,016
2025	203,597	172	169	4	22,353
2026	195,772	161	157	4	21,702
2027	189,881	155	154	4	21,060
2028	184,486	148	147	4	20,415
2029	239,485	194	193	5	26,286
20 Yr	3,308,251	3,428	3,540	64	944,118

Figure 15. Portfolio Emissions – Hi-Cons Portfolio – Base Case (continued)

Landfill Emissions

Year	CO_2 (Tons)	NO_x (Tons)	SO_x (Tons)	HG (Lbs)	PM (Lbs)
2010	0	17	0	0	5,561
2011	0	17	0	0	5,561
2012	0	17	0	0	5,561
2013	0	17	0	0	5,561
2014	0	17	0	0	5,561
2015	0	17	0	0	5,561
2016	0	17	0	0	5,561
2017	0	17	0	0	5,561
2018	0	17	0	0	5,561
2019	0	17	0	0	5,561
2020	0	17	0	0	5,561
2021	0	17	0	0	5,561
2022	0	17	0	0	5,561
2023	0	17	0	0	5,561
2024	0	17	0	0	5,561
2025	0	17	0	0	5,561
2026	0	17	0	0	5,561
2027	0	17	0	0	5,561
2028	0	17	0	0	5,561
2029	0	17	0	0	5,561
20 Yr	0	344	0	0	111,228

Figure 15. Portfolio Emissions – Hi-Cons Portfolio – Base Case (continued)

CHP/DG Emissions

Year	CO_2 (Tons)	NO_x (Tons)	SO_x (Tons)	HG (Lbs)	PM (Lbs)
2010	0.00	0.00	0.00	0.00	0.00
2011	0.00	0.00	0.00	0.00	0.00
2012	0.00	0.00	0.00	0.00	0.00
2013	0.00	0.00	0.00	0.00	0.00
2014	0.00	0.00	0.00	0.00	0.00
2015	0.00	0.00	0.00	0.00	0.00
2016	0.00	0.00	0.00	0.00	0.00
2017	0.00	0.00	0.00	0.00	0.00
2018	0.00	0.00	0.00	0.00	0.00
2019	0.00	0.00	0.00	0.00	0.00
2020	0.00	0.00	0.00	0.00	0.00
2021	0.00	0.00	0.00	0.00	0.00
2022	0.00	0.00	0.00	0.00	0.00
2023	18,017.57	4.54	0.09	0.00	211.92
2024	18,017.57	4.54	0.09	0.00	211.92
2025	18,017.57	4.54	0.09	0.00	211.92
2026	18,017.57	4.54	0.09	0.00	211.92
2027	18,017.57	4.54	0.09	0.00	211.92
2028	18,017.57	4.54	0.09	0.00	211.92
2029	18,017.57	4.54	0.09	0.00	211.92
20 Yr	126,123	32	1	0	1,483

Figure 15. Portfolio Emissions – Hi-Cons Portfolio – Base Case (continued)

	Biomass and RECs Emissions				
Year	CO_2 (Tons)	NO_x (Tons)	SO_x (Tons)	HG (Lbs)	PM (Lbs)
2010	0	0	0	0	0
2011	0	0	0	0	0
2012	0	0	0	0	0
2013	0	0	0	0	0
2014	0	0	0	0	0
2015	0	0	0	0	0
2016	0	57	0	0	36,736
2017	0	61	0	0	39,272
2018	0	65	0	0	42,293
2019	0	33	0	0	21,421
2020	0	66	0	0	42,776
2021	0	50	0	0	32,138
2022	0	70	0	0	45,549
2023	0	63	0	0	40,780
2024	0	67	0	0	43,096
2025	0	70	0	0	45,317
2026	0	73	0	0	47,498
2027	0	77	0	0	49,651
2028	0	80	0	0	51,812
2029	0	50	0	0	32,138
20 Yr	0	881	0	0	570,475

Emission Price Forecasts

The prices for NO_x, SO_x, Hg and PM are based on the 2008 IRP data, converted to 2009 dollars. The 2008 data were based on 2006 and 2007 forecasts by Global Energy Decisions of costs of complying with the Clean Air Interstate Rule, the Clean Air Mercury Rule, and other regulations in place at the time. This approach uses the cost of complying with air emissions restrictions as a proxy for the actual costs of emissions. It is not a "damage cost assessment," nor a "willingness to pay" assessment, and does not attempt to actually estimate the costs of the environmental impacts of air emissions to human health, wildlife, land, and water resources directly.

Recently, there have been a number of new regulations proposed by the EPA that would limit the emissions of NO_x, SO_x, Hg, and PM, and the EPA has announced that it plans to increase the stringency of some of the regulations on these pollutants over the next few years. More information about these regulations can be found in Appendix B –The Planning Environment. Therefore, City Light will seek updated price forecasts for these pollutants in the 2012 IRP.

The CO_2 prices are from a study of the potential costs of the federal Waxman-Markey bill (HR 2454) which passed in June 2009. The Waxman-Markey bill would have created a cap-and-trade program for many sectors of the economy, included incentives for renewables and energy efficiency, and would have allowed for a significant number of greenhouse gas offsets, from both domestic and international projects, to be used for compliance with the cap.

A number of bills have been proposed in the U.S. Senate that would result in cap-and-trading programs, or auctions, for greenhouse gases, but it is unclear as of early autumn 2010, which of the potential designs might move forward into actual legislation, or if a bill that would include a cost for CO_2 will pass at all in 2010. In order to evaluate a number of potential price levels, the IRP uses the three EIA CO_2 price forecast series for the Waxman-Markey bill as a proxy.

The price forecasts are from a study, done by the Energy Information Agency (EIA) and released August 3, 2009, that evaluated a number of potential scenarios of future supply and demand for electricity, as well as the availability of alternative fuels and technologies for controlling CO_2, and the availability of offsets. The table below shows the EIA "Basic Case" forecast of CO_2 prices, which was used in the 2010 IRP to evaluate all the portfolios in the base case and all scenarios except the Lo-CO_2 scenario, which used the EIA "High Offsets" CO_2 price forecast, and the Hi-CO_2 scenario, which used the "No International" CO_2 price forecast.

Figure 16. Emissions Costs – By Pollutant
CO_2 Prices are in 2007$ per Ton, NO_x/SO_x/Hg/PM are in 2009$ per Ton

Year	CO_2 "Basic"	CO_2 "High Offsets"	CO_2 "No International"	SO_2	NO_x	Hg	PM
2010				$1,302	$1,490	$7,065	$3,805
2011				$1,302	$1,490	$7,065	$3,805
2012	$20.00	$15.00	$30.00	$1,302	$1,490	$7,065	$3,805
2013	$21.46	$15.69	$32.76	$1,302	$1,490	$7,065	$3,805
2014	$22.93	$16.38	$35.53	$1,302	$1,490	$7,065	$3,805
2015	$24.39	$17.06	$38.29	$2,063	$2,328	$7,065	$3,805
2016	$25.85	$17.75	$41.05	$2,063	$2,328	$7,065	$3,805
2017	$27.31	$18.44	$43.81	$2,063	$2,328	$7,065	$3,805
2018	$28.78	$19.13	$46.58	$2,063	$2,328	$7,065	$3,805
2019	$30.24	$19.81	$49.34	$2,063	$2,328	$7,065	$3,805
2020	$31.70	$20.50	$52.10	$2,063	$2,328	$7,065	$3,805
2021	$35.01	$22.64	$57.53	$2,063	$2,328	$7,065	$3,805
2022	$38.32	$24.78	$62.96	$2,063	$2,328	$7,065	$3,805
2023	$41.63	$26.92	$68.39	$2,063	$2,328	$7,065	$3,805
2024	$44.94	$29.06	$73.82	$2,063	$2,328	$7,065	$3,805
2025	$48.25	$31.20	$79.25	$2,063	$2,328	$7,065	$3,805
2026	$51.56	$33.34	$84.68	$2,063	$2,328	$7,065	$3,805
2027	$54.87	$35.48	$90.11	$2,063	$2,328	$7,065	$3,805
2028	$58.18	$37.62	$95.54	$2,063	$2,328	$7,065	$3,805
2029	$61.49	$39.76	$100.97	$2,063	$2,328	$7,065	$3,805
2030	$64.80	$41.90	$106.40	$2,063	$2,328	$7,065	$3,805

Scenarios

Emissions from Portfolio Resources

The base case emissions described in the previous sections are representative of the "most likely" set of conditions (demand for electricity, price of natural gas, price for CO_2, etc.) that the utility might face in the future, based upon current information and industry and economic conditions. However, there are a number of ways that key variables could change in the coming years, and it is useful to evaluate the performance of the portfolios under a range of these conditions. Each of the scenarios tests one aspect of future conditions. The changes in emissions under the scenarios are described below.

The portfolios contain the same amounts of resources across all the scenarios, but the market emissions rates of CO_2, NO_X, and SO_X differ across the scenarios, as shown in Figure 11. The market emissions rates for Hg and PM are assumed to be the same across all scenarios, as shown in Figure 11. So, Figures 16-18 only show the CO_2, NO_X, and SO_X emissions for the market sources (Market plus Priest Rapids, minus RECs).

For CO_2, there is little variation between scenarios in the early years of the planning period, with greater differences in later years. The Hi-RECs portfolio shows negative emissions in the first half of the 2020s due to the large number of "credits" they are given against the other market resources in the portfolio.

Figure 17. CO_2 Emissions – LoRECS Portfolio

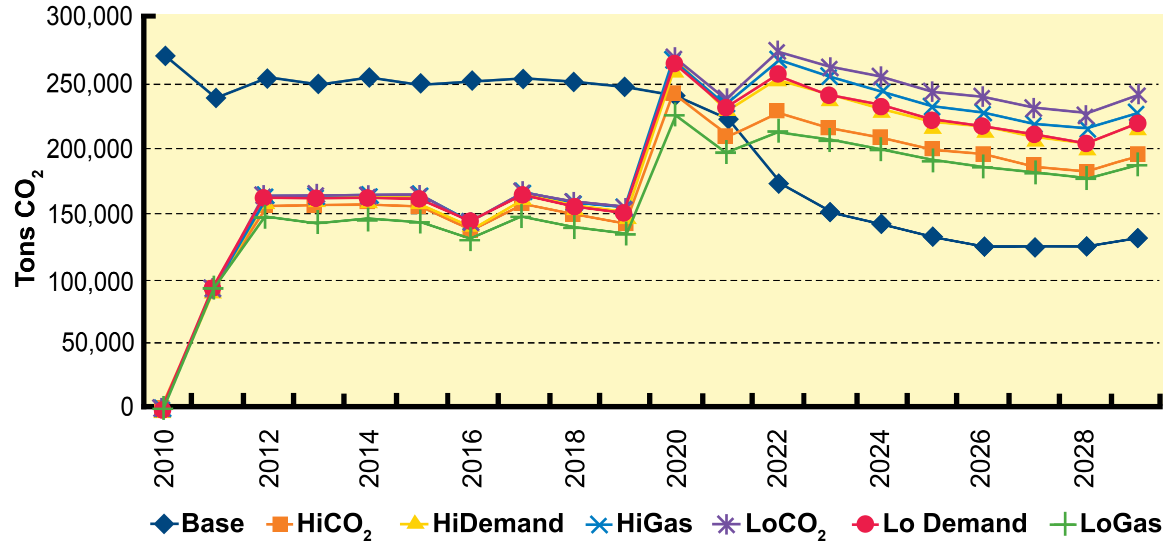


Figure 18. CO_2 Emissions – HiRECS Portfolio

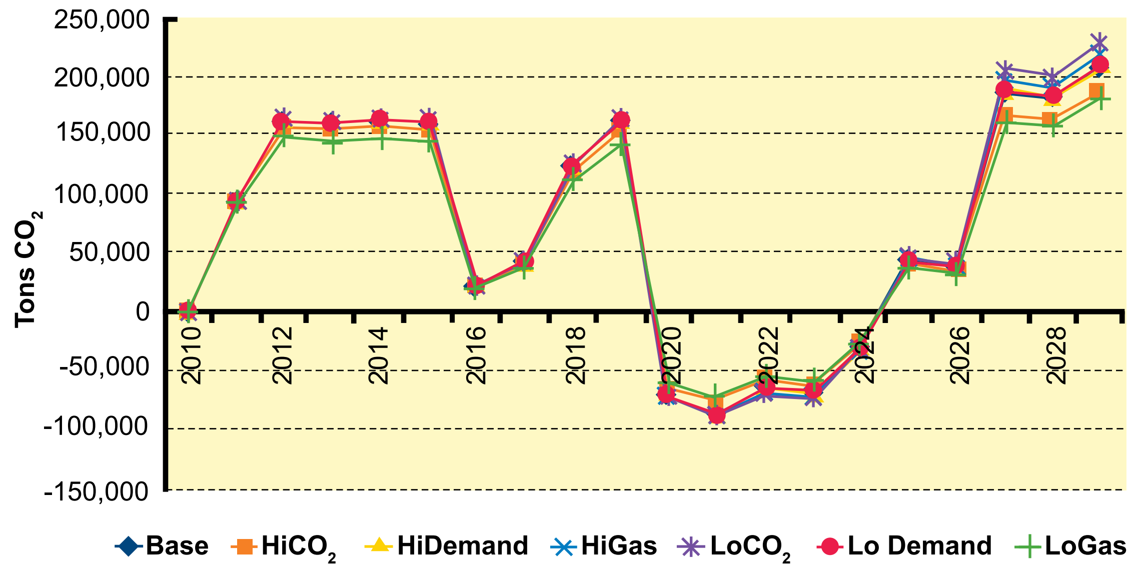
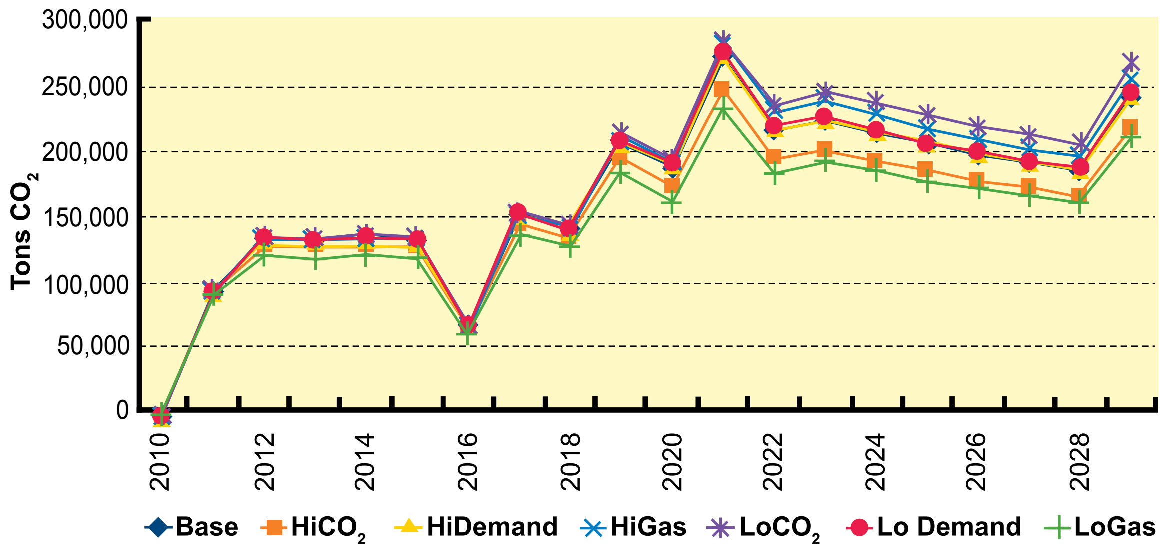


Figure 19. CO_2 Emissions – HiCons Portfolio



NO_x emissions also show variation between scenarios that are fairly significant in later years of the planning period. The variation between years is also more pronounced than for CO_2. The NO_x emissions in the Hi-RECs portfolio, like CO_2 for that portfolio, actually become negative in years 2020-2024 as RECs are "credited" with displacing higher-emissions western market resources.

SO_x emissions vary widely across scenarios in all years, likely due to changes in the amount of coal-fired generation in the WECC market under different scenarios. While natural gas does emit NO_x, it emits very low SO_x. Therefore, differences in NO_x emission rates between scenarios may not be as pronounced as differences in SO_x emission rates. SO_x emissions are negative in the Hi-RECs Portfolio, as seen for CO_2 and NO_x, but they are also negative in years 2016-2019 under the Hi-Cons portfolio.

Figure 20. NO_x Emissions – LoRECS Portfolio

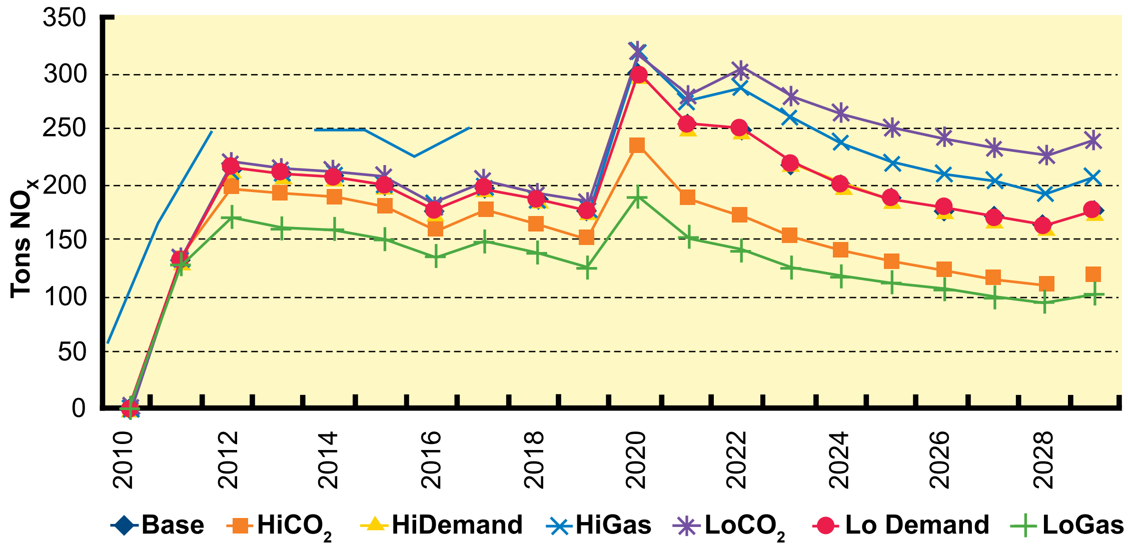


Figure 21. NO_x Emissions – HiRECS Portfolio

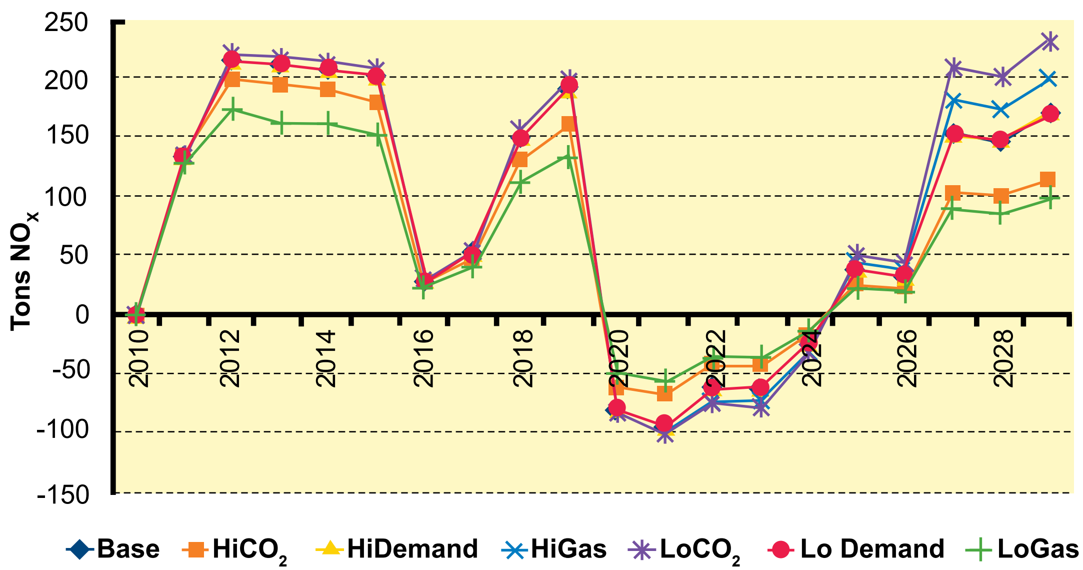


Figure 22. NO_x Emissions – HiCons Portfolio

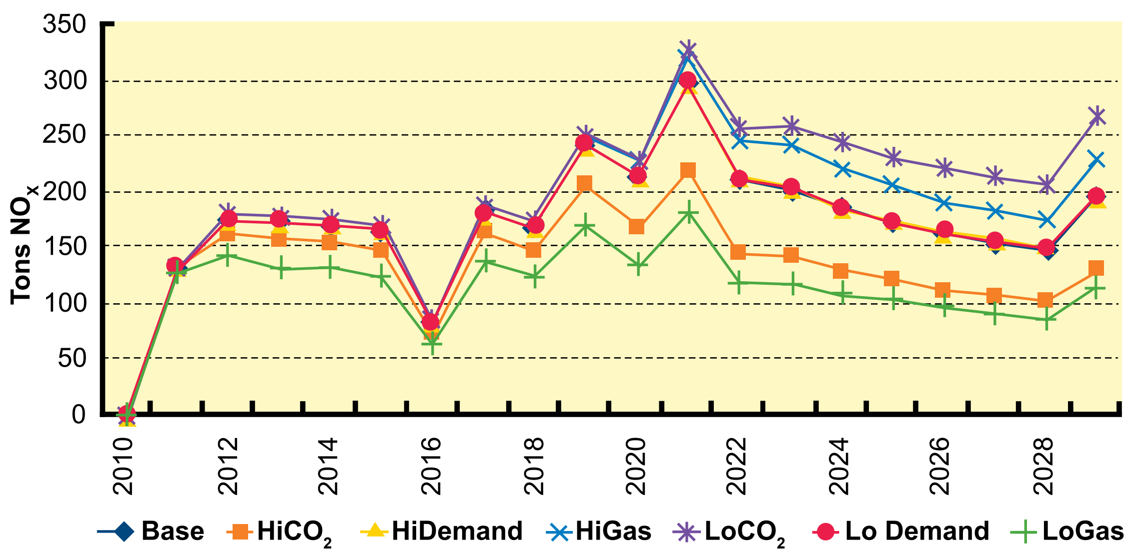


Figure 23. SO_x Emissions – LoRECS Portfolio

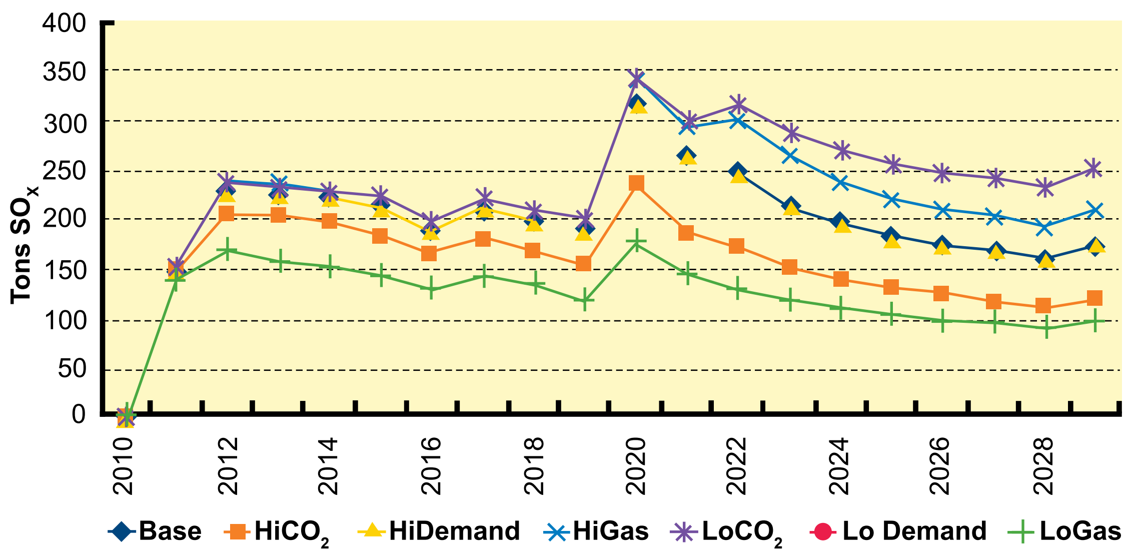


Figure 24. SO_x Emissions – HiRECS Portfolio

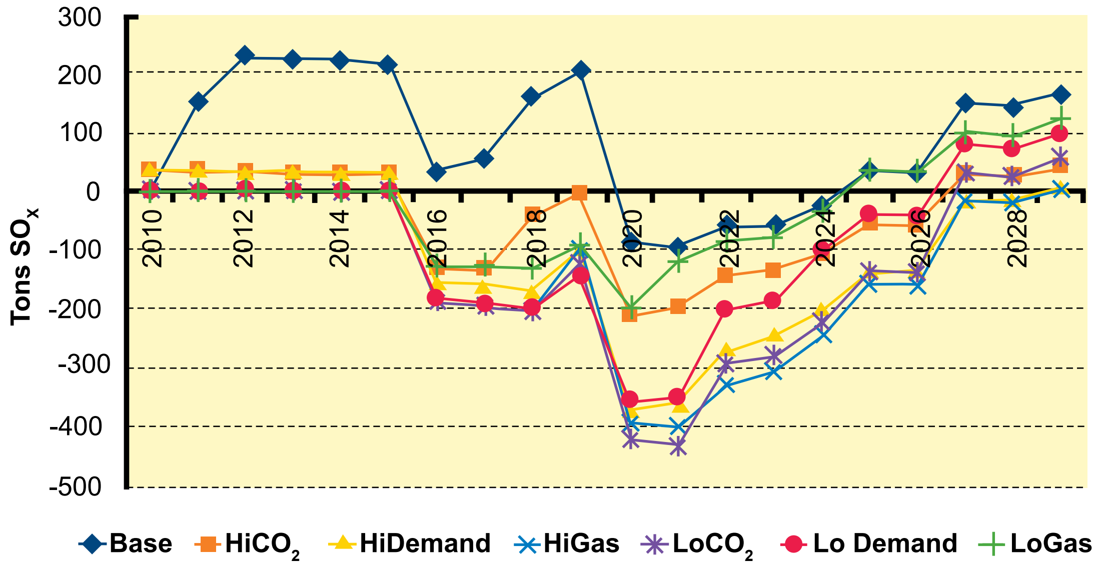


Figure 25. SO_x Emissions – HiCons Portfolio

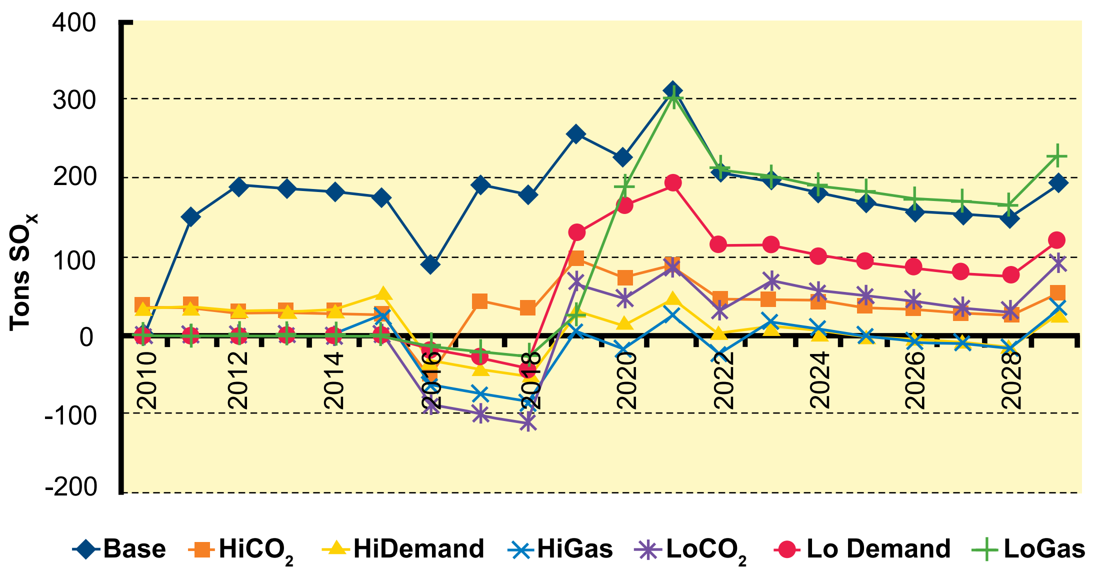


Figure 26. CO_2 Emission Rate – WECC Market (Tons/MWh)

	Base	$HiCO_2$	HiDemand	HiGas	$LoCO_2$	LoDemand	LoGas
2010	0.44	0.44	0.44	0.44	0.44	0.44	0.44
2011	0.43	0.43	0.43	0.43	0.43	0.43	0.42
2012	0.43	0.42	0.43	0.44	0.44	0.43	0.40
2013	0.43	0.41	0.43	0.44	0.44	0.43	0.39
2014	0.43	0.42	0.43	0.44	0.44	0.43	0.39
2015	0.43	0.41	0.43	0.44	0.44	0.43	0.39
2016	0.43	0.41	0.43	0.44	0.44	0.43	0.39
2017	0.43	0.41	0.43	0.44	0.44	0.43	0.39
2018	0.43	0.41	0.43	0.44	0.44	0.43	0.39
2019	0.43	0.40	0.43	0.44	0.44	0.43	0.38
2020	0.43	0.39	0.43	0.44	0.44	0.43	0.37
2021	0.42	0.38	0.42	0.43	0.43	0.42	0.36
2022	0.39	0.35	0.39	0.41	0.42	0.39	0.33
2023	0.38	0.34	0.38	0.40	0.41	0.38	0.32
2024	0.37	0.34	0.38	0.40	0.41	0.38	0.32
2025	0.37	0.33	0.37	0.39	0.41	0.37	0.32
2026	0.37	0.33	0.37	0.39	0.41	0.37	0.32
2027	0.37	0.33	0.37	0.39	0.40	0.37	0.32
2028	0.37	0.33	0.37	0.39	0.41	0.37	0.32
2029	0.37	0.33	0.37	0.39	0.41	0.37	0.32

Figure 27. NO_x Emission Rate – WECC Market (Tons/MWh)

	Base	$HiCO_2$	HiDemand	HiGas	$LoCO_2$	LoDemand	LoGas
2010	0.00063	0.00063	0.00063	0.00063	0.00063	0.00063	0.00060
2011	0.00060	0.00060	0.00060	0.00061	0.00060	0.00060	0.00058
2012	0.00057	0.00053	0.00057	0.00059	0.00059	0.00057	0.00046
2013	0.00056	0.00051	0.00056	0.00058	0.00058	0.00056	0.00043
2014	0.00056	0.00051	0.00056	0.00057	0.00057	0.00056	0.00043
2015	0.00054	0.00048	0.00054	0.00056	0.00056	0.00054	0.00040
2016	0.00054	0.00048	0.00054	0.00055	0.00055	0.00054	0.00042
2017	0.00052	0.00047	0.00052	0.00054	0.00054	0.00052	0.00040
2018	0.00052	0.00045	0.00052	0.00054	0.00054	0.00052	0.00039
2019	0.00051	0.00043	0.00051	0.00053	0.00053	0.00051	0.00036
2020	0.00049	0.00038	0.00049	0.00052	0.00052	0.00049	0.00031
2021	0.00046	0.00034	0.00046	0.00049	0.00050	0.00046	0.00028
2022	0.00038	0.00026	0.00039	0.00044	0.00047	0.00039	0.00022
2023	0.00034	0.00024	0.00035	0.00041	0.00044	0.00035	0.00020
2024	0.00033	0.00023	0.00033	0.00039	0.00043	0.00033	0.00019
2025	0.00031	0.00022	0.00032	0.00037	0.00042	0.00031	0.00019
2026	0.00030	0.00021	0.00030	0.00036	0.00041	0.00030	0.00018
2027	0.00030	0.00020	0.00030	0.00035	0.00041	0.00030	0.00018
2028	0.00029	0.00020	0.00030	0.00035	0.00041	0.00030	0.00017
2029	0.00030	0.00020	0.00030	0.00035	0.00041	0.00030	0.00018

Figure 28. SO_2 Emission Rate – WECC Market (Tons/MWh)

	Base	$HiCO_2$	HiDemand	HiGas	$LoCO_2$	LoDemand	LoGas
2010	0.00067	0.00067	0.00067	0.00068	0.00067	0.00067	0.00062
2011	0.00068	0.00068	0.00068	0.00068	0.00068	0.00068	0.00063
2012	0.00062	0.00055	0.00062	0.00064	0.00064	0.00062	0.00045
2013	0.00060	0.00054	0.00061	0.00063	0.00063	0.00060	0.00042
2014	0.00060	0.00053	0.00060	0.00062	0.00062	0.00060	0.00042
2015	0.00057	0.00049	0.00057	0.00060	0.00060	0.00057	0.00038
2016	0.00058	0.00050	0.00058	0.00060	0.00060	0.00058	0.00040
2017	0.00056	0.00048	0.00056	0.00058	0.00058	0.00056	0.00038
2018	0.00055	0.00047	0.00055	0.00058	0.00058	0.00055	0.00037
2019	0.00054	0.00044	0.00054	0.00057	0.00057	0.00054	0.00034
2020	0.00052	0.00038	0.00052	0.00055	0.00056	0.00052	0.00029
2021	0.00048	0.00034	0.00048	0.00053	0.00054	0.00048	0.00026
2022	0.00038	0.00026	0.00038	0.00046	0.00049	0.00038	0.00020
2023	0.00033	0.00024	0.00034	0.00042	0.00046	0.00034	0.00019
2024	0.00032	0.00023	0.00032	0.00039	0.00044	0.00032	0.00018
2025	0.00031	0.00022	0.00031	0.00037	0.00043	0.00031	0.00017
2026	0.00029	0.00021	0.00030	0.00036	0.00042	0.00030	0.00017
2027	0.00030	0.00020	0.00030	0.00036	0.00042	0.00030	0.00017
2028	0.00029	0.00020	0.00029	0.00035	0.00042	0.00029	0.00016
2029	0.00030	0.00020	0.00030	0.00036	0.00043	0.00030	0.00017

Figure 29. Hg and PM Emission Rate – WECC Market (Tons/MWh)

	HG	PM
2010	6.98E-06	3.09E-01
2011	9.98E-06	4.61E-01
2012	9.98E-06	4.61E-01
2013	9.98E-06	4.61E-01
2014	9.98E-06	4.61E-01
2015	9.98E-06	4.61E-01
2016	7.29E-06	4.06E-02
2017	7.29E-06	4.06E-02
2018	7.29E-06	4.06E-02
2019	7.29E-06	4.06E-02
2020	7.29E-06	4.06E-02
2021	7.29E-06	4.06E-02
2022	7.29E-06	4.06E-02
2023	7.29E-06	4.06E-02
2024	7.29E-06	4.06E-02
2025	7.29E-06	4.06E-02
2026	7.29E-06	4.06E-02
2027	7.29E-06	4.06E-02
2028	7.29E-06	4.06E-02
2029	7.29E-06	4.06E-02