
Senate Bill 350 Study

Addendum Report: Additional Sensitivities to the Ratepayer Impact Analysis

PREPARED FOR



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A. INTRODUCTION AND SUMMARY

This report is an addendum to the Senate Bill 350 Study: The Impacts of a Regional ISO-Operated Power Market on California, published on July 12, 2016 on www.aiso.com.¹ In this report we present two additional sensitivities on ratepayer impacts, in response to stakeholder comments we received on June 22, 2016. The sensitivities include:

1. 2030 High Energy Efficiency: 2030 regionalization with an expanded Regional ISO including all of the U.S. WECC except for the federal Power Marketing Agencies (“PMAs”) (BPA and WAPA) (“WECC without PMAs”), assuming a significant amount of additional energy efficiency achieved in California (in addition to the energy efficiency already assumed in our baseline scenarios in the July 22, 2016 report).
2. 2030 60% RPS: 2030 regionalization with WECC without PMAs, assuming California reaches a 60% Renewables Portfolio Standard (“RPS”), rather than the 50% RPS assumed in our baseline scenarios.

Supporting data will be posted on www.aiso.com following release of this report.²

B. RENEWABLE ENERGY PORTFOLIO ANALYSIS

Figure 1 and Figure 2 summarize the results of the renewable energy portfolio analysis. The renewable portfolio cost savings for the High Energy Efficiency sensitivity were already included in the main report; they are provided again here for convenience. In our baseline scenarios, a regional market in 2030 results in renewable portfolio investment cost savings of \$680–799 million per year for the State of California. In the High Energy Efficiency sensitivity this savings decreases slightly to \$576–692 million per year. In the 60% RPS sensitivity savings more than double, reaching \$1,578–2,048 million per year, due primarily to a relatively high degree of curtailment under 2030 Current Practice 1.

¹ <https://www.aiso.com/Pages/documentsbygroup.aspx?GroupID=4C17574F-73AE-40E3-942C-59C3A13BBDF1>. Last accessed July 2016.

² <https://www.aiso.com/informed/Pages/RegionalEnergyMarket/BenefitsofaRegionalEnergyMarket.aspx>. Last accessed July 2016.

**Figure 1: California State Annual Renewable Portfolio Investment Cost Savings from Regional Market Implementation (\$million)³
2030 Baseline Scenarios vs. Sensitivities**

	Regional 2 vs. Current Practice 1	Regional 3 vs. Current Practice 1
Baseline Scenarios	\$680	\$799
High Energy Efficiency Sensitivity	\$576	\$692
60% RPS Sensitivity	\$1,578	\$2,048

**Figure 2: Renewable Curtailment Results for CAISO Area
(% of annual RPS generation curtailed)
2030 Baseline Scenarios vs. Sensitivities**

	Current Practice 1	Regional 2	Regional 3
Baseline Scenarios	4.5%	1.6%	1.2%
High Energy Efficiency Sensitivity	4.8%	1.7%	1.2%
60% RPS Sensitivity	7.8%	2.9%	1.4%

1. 2030 High Energy Efficiency

Our baseline scenarios assume California achieves its committed energy efficiency and Additional Achievable Energy Efficiency (“AAEE”) as projected by the California Energy Commission in its 2015 Integrated Energy Policy Report. In the High Energy Efficiency sensitivity we assume the projected AAEE for the California Investor-Owned Utilities (“IOUs”) is doubled by 2030 to meet goals outlined in SB 350. This additional energy efficiency is assumed cost-effective to the state, but it will be up to the state’s utilities and regulatory agencies to determine how much of the doubled AAEE can realistically be achieved. Our assumed double AAEE is consistent with the assumption made by the California Public Utilities Commission in its 2016 Long-Term Procurement Plan process.

The additional EE lowers California’s electric retail sales and thus lowers the amount of renewables required to meet the state’s RPS goal. Compared to our baseline scenarios, this results in less solar procurement in Current Practice 1, and less renewable integration (oversupply) challenges. As a result, we estimate a slightly lower benefit from a Regional ISO’s ability to alleviate these integration challenges through load and resource diversification.

³ Note that the results for California’s municipal utilities are held constant in the additional sensitivity cases.

Figure 3 and Figure 4 summarize the resulting 50% RPS portfolio and renewables investment costs under the 2030 High Energy Efficiency sensitivity. It should be noted that the sensitivities, like the other renewable procurement sensitivities described in the main report, were implemented for the currently-defined CAISO service area (including three IOU service areas) only.

**Figure 3: Renewable Portfolio Additions in MW of Installed Capacity
(Incremental to Resources to Meet CA’s 33% RPS)
2030 High Energy Efficiency Sensitivity**

New Resources (MW)	Current Practice 1	Regional 2	Regional 3
California Solar	2,875	3,580	-
California Wind	3,000	1,900	1,480
California Geothermal	500	500	500
Northwest Wind, Existing Transmission	697	-	-
Northwest Wind RECs	1,000	364	-
Utah Wind, Existing Transmission	-	-	-
Wyoming Wind, Existing Transmission	500	500	500
Wyoming Wind, New Transmission	-	-	1,500
Southwest Solar, Existing Transmission	-	500	500
Southwest Solar RECs	1,000	1,000	1,000
New Mexico Wind, Existing Transmission	1,000	1,000	1,000
New Mexico Wind, New Transmission	-	-	1,500
Total CA Resources	6,375	5,980	1,980
Total Out-of-State Resources	4,197	3,364	6,000
Total Renewable Resources	10,572	9,344	7,980
Batteries	388	-	-
Pumped Hydro	500	500	500

**Figure 4: Impact of the Regional ISO on California’s Renewables Investment Cost
(Incremental to Resources to Meet CA’s 33% RPS)
2030 High Energy Efficiency Sensitivity**

Costs and REC Revenue (\$MM)	Current Practice 1	Regional 2	Regional 3
Annualized Investment Costs	\$2,128	\$1,776	\$1,367
Transmission Costs (new construction and wheeling)	\$188	\$0	\$207
Energy Credit for REC Resources*	-\$240	-\$240	-\$127
Net Total Costs - CAISO	\$2,076	\$1,536	\$1,446
Net Total Costs - Statewide (incl. Munis)	\$2,790	\$2,214	\$2,098
Statewide Procurement Savings Relative to Current Practice 1		\$576	\$692

2. 2030 60% RPS

Our baseline scenarios assume all of California achieves 50% renewables penetration by 2030. In the 60% RPS sensitivity, the RPS goal is increased from 50% to 60% by 2030 for the CAISO area, which increases the total required renewable generation procurement in the ISO from 101,488 GWh to 121,785 GWh. The RPS requirements for all other modeled years (2016, 2020, and 2025 in the RESOLVE model) remain unchanged.

In order to ensure that there are sufficient renewable resources available in the 60% RPS sensitivity, additional solar resources are made available in the state, as shown in Figure 5. In

order to improve model run-times, only a portion of in-state solar resources, as represented in the California Public Utilities Commission’s RPS Calculator, were made available for selection in RESOLVE. With a higher RPS goal, the solar resource was increased by about 10,000 MW to ensure that the in-state solar resource potential was not understated.

Figure 5: Overview of Changes in Available Renewable Resources to Meet California’s RPS 2030 Baseline Scenarios vs. 60% RPS Sensitivity

Resource	Zone	Baseline Scenarios Potential (MW)	60% RPS Sensitivity Potential (MW)
Geothermal	Greater Imperial	1,384	1,384
	Northern California	424	424
	Subtotal	1,808	1,808
Solar PV	Central Valley & Los Banos	1,000	2,000
	Greater Carrizo	570	1,140
	Greater Imperial	1,317	2,633
	Kramer & Inyokern	375	750
	Mountain Pass & El Dorado	-	-
	Northern California	1,702	3,404
	Riverside East & Palm Springs	2,459	3,000
	Solano	551	551
	Southern California Desert	-	-
	Tehachapi	2,500	2,500
	Westlands	1,450	5,800
	Subtotal	11,924	21,778
Wind	Central Valley & Los Banos	150	150
	Greater Carrizo	500	500
	Greater Imperial	400	400
	Riverside East & Palm Springs	500	500
	Solano	600	600
	Tehachapi	850	850
	Subtotal	3,000	3,000
Total California Renewable Potential		16,732	26,586

In Current Practice 1, a 60% RPS results in relatively high in-state solar procurement, as the out-of-state resources and the in-state wind resources are developed to their maximum assumed potential. In addition, RESOLVE selects around 1,000 MW of in-state biomass and geothermal resources. Even though these resources are at a higher cost than solar (or wind), their flat generation profile results in less marginal curtailment and a cheaper overall procurement cost as compared to procuring additional solar. The renewable integration challenges in this sensitivity also result in the economical procurement of almost 3,000 MW of battery storage.

Under Regional 2, these integration challenges are partly alleviated, resulting in lower curtailment and consequently less over-procurement to offset those curtailments. This allows

the model to avoid procuring expensive geothermal, biomass and battery storage resources. Under Regional 3 we see similar results. Also, under Regional 3 a large fraction of the in-state solar is substituted with out-of-state wind resources which are lower-cost and do not exacerbate solar-driven oversupply.

The resulting savings from regional integration in this scenario increase significantly compared to the baseline scenarios. Figure 6 and Figure 7 summarize the resulting 50% RPS portfolio and renewables investment costs under the 2030 60% RPS sensitivity.

**Figure 6: Renewable Portfolio Additions in MW of Installed Capacity
(Incremental to Resources to Meet CA’s 33% RPS)
2030 60% RPS Sensitivity**

New Resources (MW)	Current Practice 1	Regional 2	Regional 3
California Solar	11,656	11,561	5,598
California Wind	3,000	3,000	2,400
California Biomass	535	-	-
California Geothermal	924	500	500
Northwest Wind, Existing Transmission	1,000	1,000	1,000
Northwest Wind RECs	1,000	1,000	393
Utah Wind, Existing Transmission	-	-	-
Wyoming Wind, Existing Transmission	500	500	500
Wyoming Wind, New Transmission	-	-	3,000
Southwest Solar, Existing Transmission	500	500	500
Southwest Solar RECs	1,000	1,000	1,000
New Mexico Wind, Existing Transmission	1,000	1,000	1,000
New Mexico Wind, New Transmission	-	-	1,500
Total CA Resources	16,115	15,061	8,498
Total Out-of-State Resources	5,000	5,000	8,893
Total Renewable Resources	21,115	20,061	17,391
Batteries	2,840	99	-
Pumped Hydro	500	500	500

**Figure 7: Impact of the Regional ISO on California’s Renewables Investment Cost
(Incremental to Resources to Meet CA’s 33% RPS)
2030 60% RPS Sensitivity**

Costs and REC Revenue (\$MM)	Current Practice 1	Regional 2	Regional 3
Annualized Investment Costs	\$4,953	\$3,629	\$2,734
Transmission Costs (new construction and wheeling)	\$218	\$0	\$338
Energy Credit for REC Resources*	-\$240	-\$240	-\$127
Net Total Costs	\$4,931	\$3,389	\$2,945
Net Total Costs -Statewide (incl. Munis)	\$5,645	\$4,067	\$3,597
Procurement Savings Relative to Current Practice 1		\$1,578	\$2,048

C. PRODUCTION COST ANALYSIS

We performed a production cost analysis on the High Energy Efficiency sensitivity previously described, in order to estimate California’s annual net power production, purchases, and sales

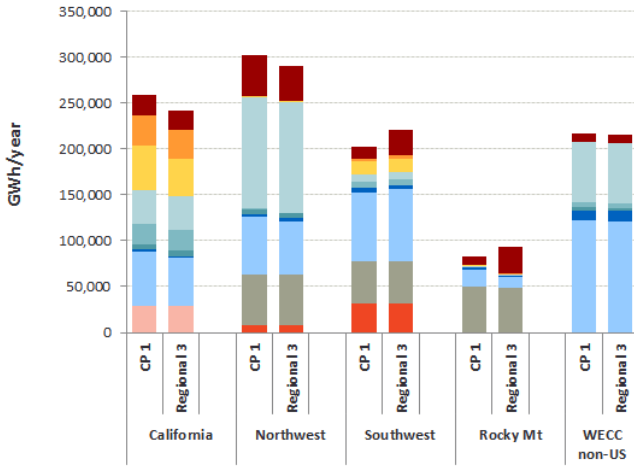
costs under that scenario. We did not perform a production cost analysis on the 60% RPS sensitivity.

1. 2030 High Energy Efficiency

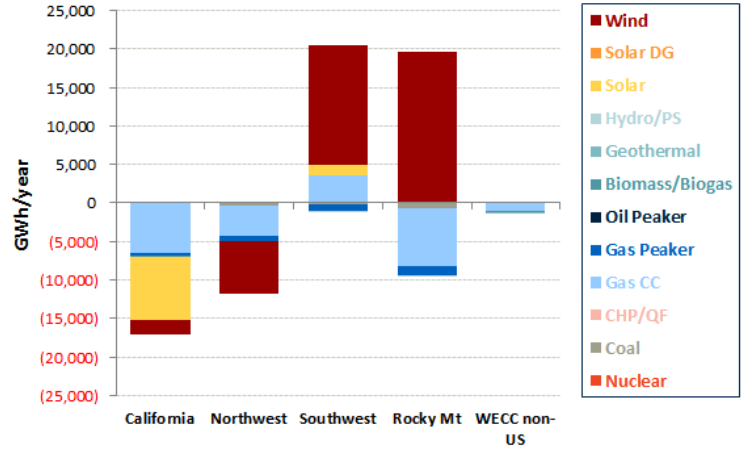
Figure 8 compares the generation results in the baseline scenarios in panels (a) and (b), and in the High Energy Efficiency sensitivity in panels (c) and (d). Absolute generation levels shown in panel (c) are lower in California compared to panel (a), indicating lower state loads due the additional energy efficiency. Generation levels in all other geographic areas are nearly identical in the two sets of cases. The impacts of regionalization—shown in panels (b) and (d)—are also nearly identical.

**Figure 8: Generation Impacts of an Expanded Regional ISO in 2030
Baseline Scenarios vs. High Energy Efficiency Sensitivity**

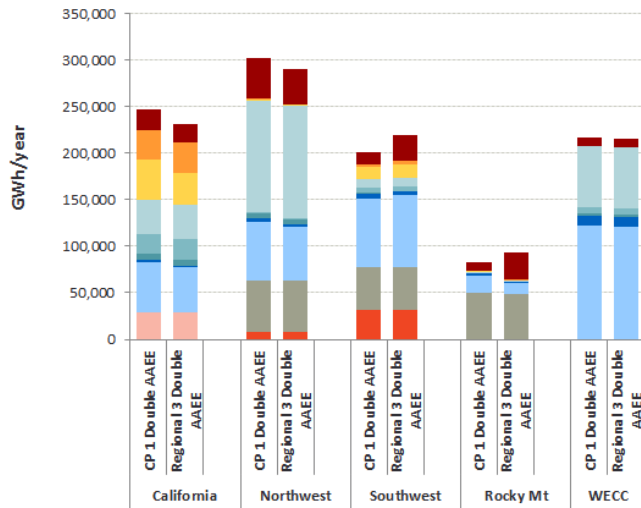
(a) Baseline Scenarios: CP1 vs. Regional 3



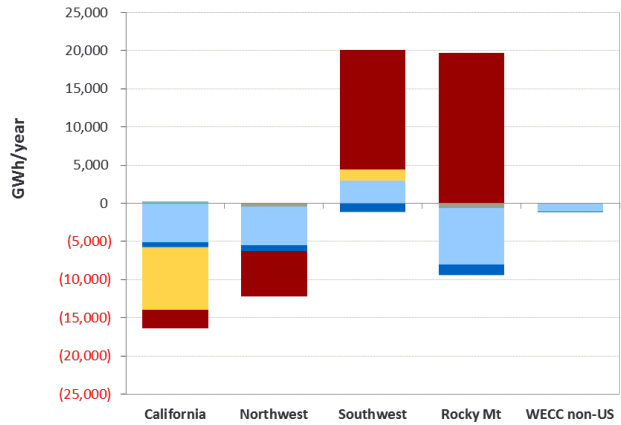
(b) Difference



(c) High EE Sensitivity: CP1 vs. Regional 3



(d) Difference



In the baseline scenarios a regional market reduces WECC-wide production costs by \$980 million per year.⁴ With higher energy efficiency, we see nearly the same result with a slightly higher savings of \$990 million per year, as shown in panel (a) of Figure 9. Similarly, higher

⁴ See Volume 5: Production Cost Analysis, Figure 37.

energy efficiency in California has a relatively small impact on system-wide CO₂ emissions. In the baseline scenarios a regional market reduces WECC-wide CO₂ emissions by 9.8 million metric tons (“MMT”).⁵ In the High Energy Efficiency sensitivity this increases slightly to 9.9 MMT CO₂ as shown at the bottom of panel (b) of Figure 9. The reduction in CO₂ emissions associated with serving California’s load changes slightly from a reduction of 4.6 MMT CO₂ in the baseline scenarios to a reduction of 4.8 MMT CO₂ in the High Energy Efficiency sensitivity.

Figure 9: Production Cost and CO₂ Emission Impacts of the Regional Market 2030 High Energy Efficiency Sensitivity

(a) Annual WECC-Wide Production Cost in 2016 \$million/yr

	2030 Current Practice 1 Double AAEE	2030 Regional ISO 3 Double AAEE
Fuel cost	\$17,389	\$16,577
Start-up cost	\$719	\$565
Variable O&M cost	\$1,182	\$1,159
TOTAL	\$19,290	\$18,300
Impact of Regionalization		(\$990) (5.1%)

(b) Annual CO₂ Emissions in million tonnes/yr

	2030 Current Practice 1 Double AAEE	2030 Regional ISO 3 Double AAEE
CA In-State	44.1	41.7
CA Imports Contracted	5.9	3.0
CA Imports Generic	1.7	1.3
CA Exports Generic	(4.6)	(3.8)
CA Emissions for Load	47.0	42.2
Impact of Regionalization		(4.8) (10.2%)
WECC TOTAL	305.1	295.2
Impact of Regionalization		(9.9) (3.2%)

In the baseline scenarios a Regional ISO results in a savings of \$523 million per year for California net production, purchase, and sales costs.⁶ With higher energy efficiency, these savings increase slightly to \$569 million per year, as shown in Figure 10.

⁵ See Volume 5: Production Cost Analysis, Figure 42.

⁶ See Volume 5: Production Cost Analysis, Figure 40.

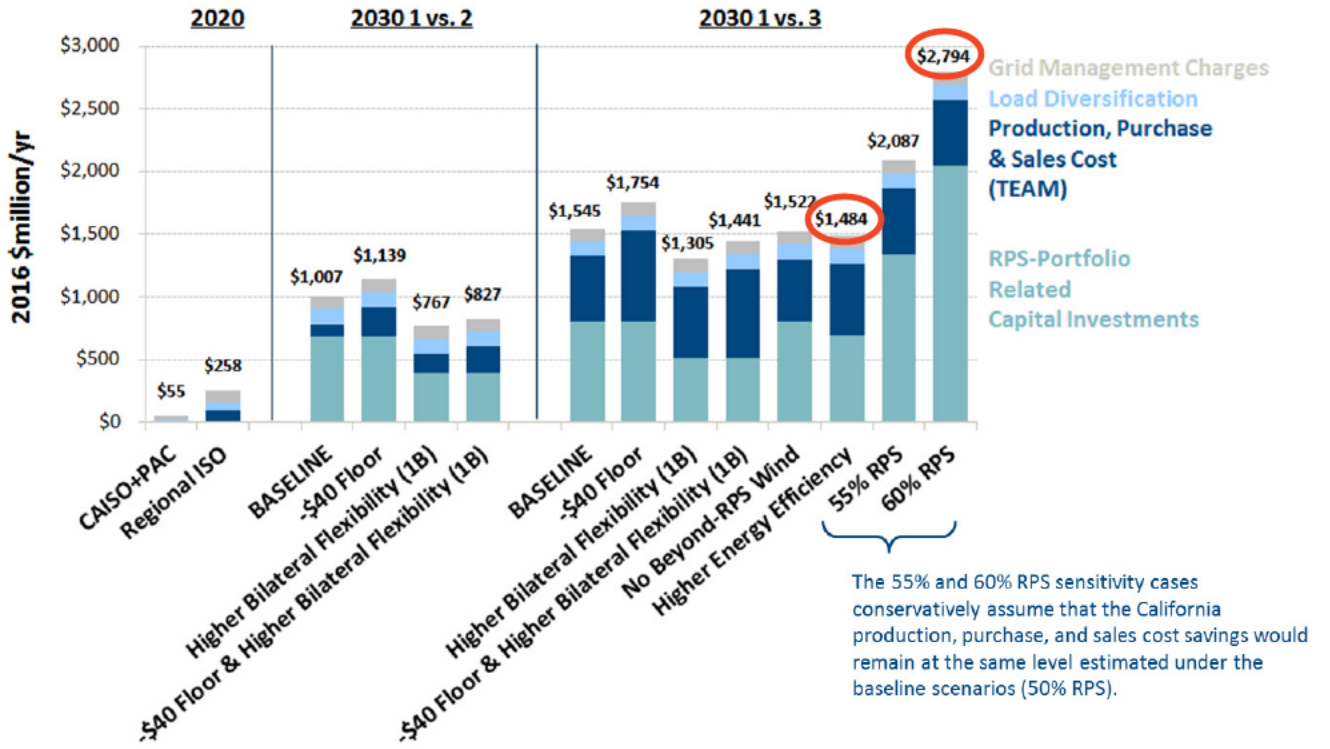
**Figure 10: California Annual Net Power Production, Purchases, and Sales Costs
2030 High Energy Efficiency Sensitivity**

	GWh		\$/MWh		\$/MM/yr	
	2030	2030	2030	2030	2030	2030
	CP 1 with Double AAEE	Regional 3 with Double AAEE	CP 1 with Double AAEE	Regional 3 with Double AAEE	CP 1 with Double AAEE	Regional 3 with Double AAEE
CAISO TEAM Ratepayer Impacts						
Production Cost of Owned and Contracted Gen	190,774	195,388	\$16.9	\$16.5	\$3,227	\$3,214
Cost of CAISO-Internal Market Purchases	43,468	34,524	\$59.2	\$58.9	\$2,574	\$2,034
Cost of CAISO Market Imports	3,493	11,116	\$58.0	\$52.8	\$203	\$587
Revenues from Exports of Owned and Contracted Gen	(8,801)	(12,093)	\$5.3	\$24.7	(\$46)	(\$299)
Cong. Revenues from Export of Merchant Gen					\$1	\$3
Total Load (excludes curtailments adjustment)	228,934	228,934				
TOTAL	228,934	228,934	\$26.0	\$24.2	\$5,959	\$5,539
Impact of Regionalization						(\$420) (7.0%)
Rest of California Adjusted Production Cost Ratepayer Impacts						
Production Cost of Owned and Contracted Gen	52,808	48,882	\$21.4	\$17.9	\$1,129	\$876
Cost of Market Purchases	15,384	18,934	\$56.8	\$52.0	\$873	\$985
Revenues from Market Sales	(6,397)	(6,021)	\$30.1	\$33.4	(\$193)	(\$201)
TOTAL	61,795	61,795	\$29.3	\$26.9	\$1,809	\$1,660
Impact of Regionalization						(\$149) (8.2%)
Total California Ratepayer Impacts						
Production Cost of Owned and Contracted Gen	243,583	244,270	\$17.9	\$16.7	\$4,355	\$4,090
Cost of Market Purchases	62,345	64,574	\$58.5	\$55.8	\$3,650	\$3,606
Revenues from Market Sales	(15,198)	(18,114)	\$15.6	\$27.4	(\$238)	(\$497)
TOTAL	290,730	290,730	\$26.7	\$24.8	\$7,768	\$7,199
Impact of Regionalization						(\$569) (7.3%)

D. RATEPAYER IMPACT ANALYSIS

The two values circled in red in Figure 11 show the resulting annual California ratepayer impacts for the High Energy Efficiency and 60% RPS sensitivities. As previously discussed, the High Energy Efficiency sensitivity reflects slightly lower renewable investment cost savings relative to our baseline scenarios and slightly higher production, purchase, and sales cost savings. Combined, the High Energy Efficiency sensitivity results in \$1,484 million per year in ratepayer benefits, which is \$61 million per year lower compared to the baseline scenarios (\$1,545 million per year). The 60% RPS sensitivity results in more than doubled renewable investment cost savings relative to our baseline scenarios, which increases overall ratepayer benefits from \$1,545 million per year to \$2,794 million per year. Due to increases renewable integration challenges under the 60% RPS sensitivity—which would be alleviated by the regional market—we believe the California production, purchase, and sales cost savings would also increase. However, this additional benefit is not shown in our results as we conservatively assume the same baseline values for the California production, purchase, and sales cost savings.

Figure 11: Annual California Ratepayer Impacts
Baseline Scenarios and Sensitivities



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