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**BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA**

Order Instituting Rulemaking to Implement the Commission's Procurement Incentive Framework and to Examine the Integration of Greenhouse Gas Emissions Standards into Procurement Policies.

Rulemaking 06-04-009
(Filed April 13, 2006)

Order Instituting Informational Proceeding - AB-32

CEC Docket Number 07-OIP-01

**COMMENTS OF KENNETH C. JOHNSON
PERTAINING TO MODELING-RELATED ISSUES**

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December 3, 2007

**COMMENTS OF KENNETH C. JOHNSON
PERTAINING TO MODELING-RELATED ISSUES**

Kenneth C. Johnson, an unaffiliated individual, U.S. citizen, and resident of California having a personal interest in and concern about climate change, respectfully submits the following comments in response to the *Administrative Law Judge's Ruling Requesting Comments on Modeling-Related Issues* (11/09/2007).

The November 9 ALJ ruling requests comments on the Energy and Environmental Economics, Inc. (E3) modeling methodology. The ruling also seeks comment on the Public Utilities Commission Staff workpaper entitled "Greenhouse Gas Emissions Reduction Measures for the Electricity and Natural Gas Sectors Under Consideration as Part of R.06-04-009," included with the ruling as Attachment A.

Much of the E3 modeling effort is focused on issues of resource availability and costs of technology and infrastructure associated with decarbonization of California's electricity resources. Other issues of importance are the regulatory costs associated with GHG caps and standards, distributional impacts of alternative allocation methods, and the efficacy of regulatory incentives in inducing emission reductions. Regarding regulatory incentives, Attachment A to the ruling states the following:

As many of the opportunities identified on the outer margin of potential emission reduction measures are in early stages of technological development, any GHG framework's ability to stimulate innovation is particularly valuable for capturing these potential reductions. By providing an economic incentive to exceed compliance with existing regulations where possible, a cap and trade program can spur innovation to pursue potentially cost effective opportunities outside the realm of existing control measures.

Under a cap and trade program, marginal incentives for emission reductions are reflected by the emission price, but the economic and practical feasibility of imposing a stringent target and high price can be limited by distributional costs of the regulations. A variety of distributional policy objectives and allocation methodologies were discussed in the October 15 ALJ ruling on allowance allocation issues and in respondents' comments.

These include grandfathering, distribution proportionate to “economic harm”, direct distribution to the public or “in the public interest”, and output-based refunding. The discussions were primarily non-quantitative and conceptual in nature, but serious consideration of any of these proposals requires at least an estimate of the quantitative economic impacts of such policies in terms of both their cost burden and their efficacy in incentivizing decarbonization of electricity generation.

The following comments provide such an estimation for several allocation methods. The purpose of this analysis is not just to advocate a particular allocation method, but rather to propound an accounting methodology that provides a high degree of transparency, accountability, and administrative control over the distributional impacts of regulation. This approach determines not only the total regulatory cost incurred, or gain accrued, by any particular entity, but also provides a complete accounting of where that particular entity’s costs are going or where the subsidies are coming from. Individual cross-subsidies between specific industry sub-sectors can be administratively controlled to manage distributional impacts and regulatory incentives in an efficacious manner.

The analysis applies to a cap-and-trade system with 100% auctioning, but the same principles apply to administrative allowance allocation, which is substantially equivalent to a refunded auction that uses the same proportionate allocation formula for refund distribution. Three policies are modeled, including an unrefunded auction, an auction with 100% output-based refunding, and a modified output-based refunding method that is administratively modified to selectively eliminate large cross-subsidies that do not serve useful policy objectives.

In these examples, the CA 2004 electricity market is subdivided into sub-sectors defined by fuel type. The same approach could be used to further subdivide the market into individual regulated entities or geographic regions and account for cross-subsidies between specific entities or regions. If the auction revenue is not all returned to the regulated sector, then the state or any beneficiaries of the revenue should be included in the accounting, which should specify what portion of any particular entity’s regulatory cost goes to any such beneficiary.

The analysis approach can be extended to cover CHP or other types of industrial combustion, e.g., by defining a MWh-equivalent valuation metric for usable heat output.

The data for the analysis was recently provided by ARB in two spreadsheets, one that provides a breakdown of California electricity generation and emission by fuel type, and one that provides a similar breakdown of California electricity imports.¹ The data is tabulated in Appendix A.

Table 1 shows a fuel breakdown of the 2004 CA electricity market in terms of generation, emissions, and emission intensity. Table 2 shows what the regulatory costs would be for an unrefunded auction with an emission price of \$10 per MTCO₂e. Industry-average emission charges would be \$4.05/MWh, and aggregate revenue would be \$1.2 billion.

Under a refunded auction with pure output-based allocation the revenue would be distributed to regulated entities in proportion to generation output, at a refund rate (\$4.05/MWh) determined to achieve revenue neutrality. This is shown in Table 3. (The formulas underlying Table 3 are outlined in the Appendix B.) Marginal incentives for emission intensity reduction would not be affected by the refund, and the relative competitiveness of alternative fuels would not be affected, but regulatory costs would be greatly diminished (e.g. the emission charge for CA Coal would be reduced from \$11.55/MWh to \$7.50/MWh, and non-emitting sources receive subsidies of \$4.05/MWh).

The aggregate net emission charges in Table 3 can be disaggregated into individual cross-sector revenue flows, shown in Table 4. For example, there would be a \$103.31 million cross-subsidy from Import Coal to CA NG. (The disaggregation formula is outlined in Appendix B.) If the auction is not revenue-neutral within the electricity sector, then this table would be augmented with additional rows and columns to account for all additional revenue sources and sinks.

¹ This data was received from Larry Hunsaker (lhunsake@arb.ca.gov) on Nov. 27, 2007. The file names are Electricity Generation (November 27, 2007).xls
Electricity Profile for CA Imports (November 26, 2007).xls
Mr. Hunsaker noted that "This is an update to the frozen numbers on our site which we will go to the Board with, this update will make its way into future inventory improvements ..."

Sub-sector	Generation (GWh)	Emissions (MMT-CO2e)	Generation (%)	Emissions (%)	Emission Intensity (MT/MWh)
CA Coal	2244.00	2.59	0.77%	2.18%	1.16
Import Coal	57838.00	58.47	19.75%	47.56%	0.98
CA NG	100455.00	45.77	34.31%	38.55%	0.46
Import NG	9013.00	4.43	3.08%	3.73%	0.49
CA Nuclear	30268.00	0.00	10.34%	0.00%	0.00
CA Hydro	33324.00	0.00	11.38%	0.00%	0.00
Import NonEmitting	31170.00	0.00	10.64%	0.00%	0.00
CA WindSolar	4877.00	0.00	1.87%	0.00%	0.00
CA Biomass	6335.00	0.35	2.16%	0.29%	0.05
CA Geothermal	13105.00	2.07	4.48%	1.75%	0.16
CA OtherGas	1862.00	4.64	0.64%	3.91%	2.49
CA Petroleum	2310.00	2.40	0.79%	2.02%	1.04
Import Distillate	21.00	0.02	0.01%	0.01%	0.76
Total:	292822.00	118.73	100.00%	100.00%	0.41

Table 1. California 2004 electricity market.

Sub-sector	Emission Charge (\$/MWh)	Aggregate Charge (M\$)
CA Coal	11.55	25.92
Import Coal	9.76	564.65
CA NG	4.56	457.67
Import NG	4.91	44.27
CA Nuclear	0.00	0.00
CA Hydro	0.00	0.00
Import NonEmitting	0.00	0.00
CA WindSolar	0.00	0.00
CA Biomass	0.55	3.47
CA Geothermal	1.58	20.74
CA OtherGas	24.94	46.44
CA Petroleum	10.39	24.01
Import Distillate	7.62	0.16
Total:	4.05	1187.33

Table 2. Unrefunded auction at \$10/MTCO2e.

Sub-sector	Emission Charge (\$/MWh)	Refund (\$/MWh)	Net Charge (\$/MWh)	Aggregate Charge (M\$)	Aggregate Refund (M\$)	Agg.Net Charge (M\$)
CA Coal	11.55	4.05	7.50	25.92	9.10	16.82
Import Coal	9.76	4.05	5.71	564.65	234.52	330.13
CA NG	4.56	4.05	0.50	457.67	407.32	50.35
Import NG	4.91	4.05	0.86	44.27	36.55	7.72
CA Nuclear	0.00	4.05	-4.05	0.00	122.73	-122.73
CA Hydro	0.00	4.05	-4.05	0.00	135.12	-135.12
Import NonEmitting	0.00	4.05	-4.05	0.00	126.39	-126.39
CA WindSolar	0.00	4.05	-4.05	0.00	19.78	-19.78
CA Biomass	0.55	4.05	-3.51	3.47	25.69	-22.22
CA Geothermal	1.58	4.05	-2.47	20.74	53.14	-32.40
CA OtherGas	24.94	4.05	20.89	46.44	7.55	38.89
CA Petroleum	10.39	4.05	6.34	24.01	9.37	14.64
Import Distillate	7.62	4.05	3.56	0.16	0.09	0.07
Total:	4.05	4.05	0.00	1187.33	1187.33	0.00

Table 3. Pure output-based refund allocation at \$10/MTCO₂e.

Table 3 shows that Hydro and Nuclear would receive large subsidies (\$4.05/MWh), primarily from Coal and NG (cf. Table 4). Unless it is a policy objective to expand Hydro and Nuclear to replace Coal and NG, this subsidy does not serve a useful purpose – it only diverts economic resources that might be more usefully spent on sequestration or renewable energy. (For simplicity, this analysis assumes that “non-emitting” imports are Hydro or Nuclear, and no distinction is made between small and large Hydro.) Also, the cross subsidy from Coal to NG may be counterproductive because of the economic impact of NG demand on other industries that rely on NG, and because substitution of NG for Coal is not a viable long-term decarbonization strategy. Therefore, it may be advantageous to selectively eliminate these cross-subsidies, as illustrated in Table 5 (shaded cells). Alternatively, the cross-subsidies might be phased in over a period of time, gradually evolving toward pure output-based allocation.

Table 6 shows the effect of the cross-subsidy elimination on regulatory costs. The net charges per MWh (middle column) are reduced substantially for both Coal and NG. (Compare Net Charge columns in Tables 3 and 6.) Hydro and Nuclear subsidies are eliminated, there is no change for Wind/Solar, and the net subsidies for Biomass and Geothermal are slightly increased because they are not subsidizing Hydro and Nuclear.

	CA Coal	Import Coal	CA NG	Import NG	CA Nuclear	CA Hydro	Import Non-Emitting	CA Wind-Solar	CA Biomass	CA Geothermal	CA OtherGas	CA Petroleum	Import Distillate
CA Coal	0.00	0.79	5.38	0.46	2.68	2.95	2.76	0.43	0.53	1.00	-0.19	0.02	0.00
Import Coal	-0.79	0.00	103.31	8.64	58.37	64.26	60.11	9.40	11.53	21.17	-5.58	-0.29	0.01
CA NG	-5.38	-103.31	0.00	-1.10	47.31	52.08	48.72	7.62	8.71	13.37	-13.02	-4.63	-0.02
Import NG	-0.46	-8.64	1.10	0.00	4.58	5.04	4.71	0.74	0.85	1.34	-1.15	-0.39	0.00
CA Nuclear	-2.68	-58.37	-47.31	-4.58	0.00	0.00	0.00	0.00	-0.36	-2.14	-4.80	-2.48	-0.02
CA Hydro	-2.95	-64.26	-52.08	-5.04	0.00	0.00	0.00	0.00	-0.39	-2.36	-5.29	-2.73	-0.02
Import NonEmitting	-2.76	-60.11	-48.72	-4.71	0.00	0.00	0.00	0.00	-0.37	-2.21	-4.94	-2.56	-0.02
CA WindSolar	-0.43	-9.40	-7.62	-0.74	0.00	0.00	0.00	0.00	-0.06	-0.35	-0.77	-0.40	0.00
CA Biomass	-0.53	-11.53	-8.71	-0.85	0.36	0.39	0.37	0.06	0.00	-0.29	-0.98	-0.49	0.00
CA Geothermal	-1.00	-21.17	-13.37	-1.34	2.14	2.36	2.21	0.35	0.29	0.00	-1.95	-0.91	-0.01
CA OtherGas	0.19	5.58	13.02	1.15	4.80	5.29	4.94	0.77	0.98	1.95	0.00	0.21	0.00
CA Petroleum	-0.02	0.29	4.63	0.39	2.48	2.73	2.56	0.40	0.49	0.91	-0.21	0.00	0.00
Import Distillate	0.00	-0.01	0.02	0.00	0.02	0.02	0.02	0.00	0.00	0.01	0.00	0.00	0.00

Table 4. Cross-sector revenue flows (M\$) for pure output-based refund allocation.

	CA Coal	Import Coal	CA NG	Import NG	CA Nuclear	CA Hydro	Import Non-Emitting	CA Wind-Solar	CA Biomass	CA Geothermal	CA OtherGas	CA Petroleum	Import Distillate
CA Coal	0.00	0.79						0.43	0.53	1.00	-0.19	0.02	0.00
Import Coal	-0.79	0.00						9.40	11.53	21.17	-5.58	-0.29	0.01
CA NG			0.00	-1.10				7.62	8.71	13.37	-13.02	-4.63	-0.02
Import NG			1.10	0.00				0.74	0.85	1.34	-1.15	-0.39	0.00
CA Nuclear					0.00	0.00	0.00						
CA Hydro					0.00	0.00	0.00						
Import NonEmitting					0.00	0.00	0.00						
CA WindSolar	-0.43	-9.40	-7.62	-0.74				0.00	-0.06	-0.35	-0.77	-0.40	0.00
CA Biomass	-0.53	-11.53	-8.71	-0.85				0.06	0.00	-0.29	-0.98	-0.49	0.00
CA Geothermal	-1.00	-21.17	-13.37	-1.34				0.35	0.29	0.00	-1.95	-0.91	-0.01
CA OtherGas	0.19	5.58	13.02	1.15				0.77	0.98	1.95	0.00	0.21	0.00
CA Petroleum	-0.02	0.29	4.63	0.39				0.40	0.49	0.91	-0.21	0.00	0.00
Import Distillate	0.00	-0.01	0.02	0.00				0.00	0.00	0.01	0.00	0.00	0.00

Table 5. Cross-sector revenue flows (M\$) for modified output-based refund allocation.

Sub-sector	Agg. Net Charge (M\$)	Net Charge (\$/MWh)	Refund (\$/MWh)
CA Coal	2.59	1.15	10.40
Import Coal	35.45	0.61	9.15
CA NG	10.93	0.11	4.45
Import NG	2.49	0.28	4.64
CA Nuclear	0.00	0.00	0.00
CA Hydro	0.00	0.00	0.00
Import NonEmitting	0.00	0.00	0.00
CA WindSolar	-19.78	-4.05	4.05
CA Biomass	-23.34	-3.68	4.23
CA Geothermal	-39.11	-2.98	4.57
CA OtherGas	23.86	12.81	12.13
CA Petroleum	6.87	2.98	7.42
Import Distillate	0.02	1.10	6.52
Total:	0.00	0.00	4.05

Table 6. Modified output-based allocation at \$10/MTCO_{2e}.

All of the dollar-dimensioned values in the above tables scale in proportion to the emission price, assumed here to be \$10/MTCO_{2e}. By mitigating the distributional impacts of regulation, it becomes possible to apply a more stringent cap (or higher price floor) consistent with the 2020 emission target and with the AB 32 mandate requiring “the maximum technologically feasible and cost-effective greenhouse gas emission reductions”.

Respectfully submitted,

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Appendix A: California Electricity Sector Data

November 27, 2007 Generation Source	Generation for CA (GWh)														
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Imports (ARB Method)	109,035	102,392	94,659	88,559	89,468	92,233	96,110	102,528	102,366	104,181	78,557	80,905	94,766	93,249	98,043
Specified	41,209	41,435	44,037	42,430	42,866	40,763	41,319	44,536	47,262	46,571	47,347	48,276	47,337	46,680	47,930
Unspecified	67,826	60,956	40,622	46,128	46,602	51,470	54,791	57,992	55,104	57,610	31,210	32,629	47,430	46,569	50,113
In-State (EIA Data)	165,785	158,948	177,155	186,991	186,192	181,463	175,263	172,798	189,601	188,319	208,083	198,586	184,210	192,789	194,780
Wind/Solar	3,126	3,386	3,263	3,446	3,873	3,583	3,600	3,648	3,260	3,725	4,011	4,042	4,357	4,429	4,877
Biomass	6,148	6,500	6,949	6,663	6,777	5,297	5,203	5,332	5,462	5,793	6,172	5,610	6,349	6,373	6,335
Geothermal	14,521	14,785	14,771	14,948	13,660	11,450	12,340	12,716	12,840	13,046	12,309	12,181	13,074	12,982	13,105
Hydroelectric	24,779	22,057	20,163	40,775	23,947	50,540	46,946	42,068	50,757	40,350	39,272	25,192	30,900	35,458	33,324
Nuclear	32,693	31,542	35,244	31,581	33,752	30,246	34,097	30,512	34,594	33,372	35,176	33,220	34,352	35,594	30,268
Natural Gas	74,168	74,006	88,705	79,644	94,432	72,579	64,414	71,002	75,132	85,099	103,219	111,932	89,624	91,432	100,455
Other Gases	2,147	1,978	2,715	3,097	2,959	2,595	3,217	2,984	3,077	2,418	2,687	1,130	1,240	1,759	1,862
Petroleum	5,565	2,061	2,045	3,706	3,519	2,386	2,918	2,203	2,320	2,220	2,873	3,056	1,987	2,435	2,310
Coal	2,638	2,632	3,300	3,130	3,272	2,787	2,529	2,332	2,159	2,296	2,364	2,233	2,328	2,326	2,244

Generation Source	Emissions (MMTCO2E)														
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Imports (ARB Method)	61,910	57,581	50,226	55,878	56,487	54,979	50,791	57,639	60,684	57,574	42,632	50,857	50,955	57,558	60,908
Specified	29,605	28,496	31,168	29,901	30,247	27,474	26,859	28,645	30,312	30,061	30,732	32,838	31,349	31,983	33,179
Unspecified	32,305	29,085	19,058	25,978	26,240	27,505	23,932	28,994	30,371	27,513	11,900	18,019	19,606	25,575	27,729
In-State (EIA Data)	47,489	44,911	53,172	49,744	56,991	44,009	40,876	42,919	46,685	50,602	60,141	64,274	50,566	49,219	57,824
Wind/Solar	0.439	0.391	0.417	0.404	0.406	0.364	0.364	0.357	0.355	0.374	0.375	0.379	0.396	0.378	0.347
Biomass	2.307	2.338	2.326	2.354	2.151	1.803	1.948	2.007	2.032	2.065	1.948	1.928	2.069	2.054	2.074
Geothermal															
Hydroelectric															
Nuclear															
Natural Gas	36.591	36.721	43.872	38.799	46.050	34.744	30.980	34.370	35.654	39.793	48.744	54.569	41.374	39.271	45.767
Other Gases	0.923	1.000	1.456	1.790	2.059	1.839	2.074	1.723	4.105	3.738	3.907	2.064	1.536	2.694	4.644
Petroleum	4.697	1.912	1.978	3.298	3.152	2.471	3.076	2.315	2.501	2.983	2.897	3.196	2.790	2.647	2.401
Coal	2.531	2.550	3.122	3.099	3.173	2.787	2.433	2.148	2.038	2.250	2.271	2.138	2.401	2.174	2.592

<u>Imported Power (November 26, 2007)</u>		Imported Power Generation (GWh)															
Import Type	Region	Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Specified	PNW	Coal	1,160	1,510	1,701	1,546	1,688	1,236	1,007	896	1,560	1,154	747	706	601	684	564
Specified	PNW	Natural Gas															
Specified	PNW	Distillate	2	3	2	2	2	3	2	3	2	1	1	0	1	2	1
Specified	PNW	Residual Fuel Oil															
Specified	PNW	Non-Emitting															
Unspecified	PNW	Coal	7,126	6,458	4,327	3,397	3,346	4,404	6,680	5,695	4,303	5,926	4,333	3,742	5,799	8,406	6,942
Unspecified	PNW	Natural Gas												1,247	1,883	2,151	2,597
Unspecified	PNW	Non-Emitting												8,004	22,209	14,460	14,072
Specified	PSW	Coal	28,505	25,834	17,310	13,589	13,386	17,616	26,720	22,781	17,211	23,704	17,330	32,046	33,826	32,967	34,564
Specified	PSW	Natural Gas	29,612	27,991	30,525	30,429	29,823	27,086	26,722	29,291	30,608	30,795	224	217	253	205	131
Specified	PSW	Distillate	258	221	215	257	234	196	173	213	212	224	217	253	205	131	135
Specified	PSW	Residual Fuel Oil	35	32	25	22	17	13	18	19	19	16	29	48	24	31	20
Specified	PSW	Non-Emitting	1	0	0	0	0	3	0	0							
Specified	PSW	Non-Emitting	10,142	11,678	11,568	10,174	11,101	12,230	13,394	14,114	14,862	14,381	14,306	13,443	14,117	12,865	12,646
Unspecified	PSW	Coal	23,824	21,212	14,049	21,565	22,104	21,793	15,829	21,841	24,856	20,705	7,065	11,486	10,611	13,255	15,768
Unspecified	PSW	Natural Gas												3,416	3,367	4,224	6,281
Unspecified	PSW	Non-Emitting	8,371	7,453	4,936	7,577	7,766	7,657	5,562	7,674	8,733	7,275	2,482	4,732	3,560	4,073	4,452
Total Generation			109,035	102,392	84,659	88,559	89,468	92,233	96,110	102,528	102,366	104,181	78,557	80,905	94,766	93,249	98,043
			Imported Power Emissions (MMTCO2E)														
Import Type	Region	Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Specified	PNW	Coal	1,208	1,546	1,666	1,538	1,739	1,304	1,045	0,906	1,616	1,155	0,744	0,674	0,570	0,675	0,545
Specified	PNW	Natural Gas															
Specified	PNW	Distillate	0,002	0,002	0,001	0,002	0,002	0,002	0,002	0,002	0,002	0,001	0,001	0,000	0,001	0,002	0,001
Specified	PNW	Residual Fuel Oil															
Specified	PNW	Non-Emitting															
Unspecified	PNW	Coal	7,673	6,981	4,534	3,623	3,526	4,756	7,382	6,238	4,661	6,356	4,696	3,904	6,244	8,944	7,436
Unspecified	PNW	Natural Gas												0,646	0,947	1,034	1,309
Unspecified	PNW	Non-Emitting															
Specified	PSW	Coal	28,216	26,797	29,356	28,200	28,358	26,045	25,691	27,596	28,551	28,757	29,807	31,951	30,634	31,200	32,531
Specified	PSW	Natural Gas	0,153	0,126	0,126	0,147	0,134	0,112	0,104	0,126	0,129	0,135	0,152	0,167	0,127	0,083	0,087
Specified	PSW	Distillate	0,025	0,024	0,019	0,015	0,013	0,010	0,014	0,015	0,014	0,012	0,030	0,045	0,017	0,024	0,015
Specified	PSW	Residual Fuel Oil	0,001	0,000	0,000	0,000	0,000	0,003	0,000	0,000							
Specified	PSW	Non-Emitting															
Unspecified	PSW	Coal	24,632	22,104	14,524	22,354	22,714	22,748	16,550	22,756	25,710	21,157	7,203	11,590	10,745	13,407	15,953
Unspecified	PSW	Natural Gas												1,876	1,670	2,190	3,031
Unspecified	PSW	Non-Emitting															
Total Emissions			61,910	57,581	50,226	55,878	58,487	54,979	50,791	57,639	60,684	57,574	42,632	50,857	50,955	57,558	60,908

Appendix B: Calculation formulas for output-based refund allocation.

A conceptual overview of the output-based allocation method is provided in my November 12, 2007 reply comments (Appendix) responding to the October 15 ALJ ruling on allowance allocation issues. Following the same notation conventions, the electricity sector is segmented into sub-sectors Coal, NG, etc. which will be indicated by the symbol S . During a particular compliance period, sub-sector S generates emissions $E^{[S]}$ in connection with generation output $Q^{[S]}$. The auction effectively imposes a tax $T^{[S]}$ on the emissions from S , and the refund to S is $R^{[S]}$. Aggregate quantities over the entire electricity sector are indicated without the superscript,

$$\begin{aligned} E &= \sum_S E^{[S]}, & Q &= \sum_S Q^{[S]} \\ T &= \sum_S T^{[S]}, & R &= \sum_S R^{[S]} \end{aligned}$$

For simplicity, it is assumed that a uniform emission price p applies to all emissions; and a uniform refund rate c applies to generation output,

$$\begin{aligned} T^{[S]} &= p E^{[S]} \\ R^{[S]} &= c Q^{[S]} \end{aligned}$$

(As noted in my November 12 reply comments, the refund rate should be prorated to the price if the latter is nonuniform.) Based on the revenue-neutrality condition, the refund rate is equal to the price times the electricity sector's aggregate emission intensity,

$$R = T \rightarrow c = p \frac{E}{Q}$$

The Refund (\$/MWh) column in Table 3 is based on the above equation.

The net emission charge aggregated over sub-sector S , denoted as $F^{[S]}$, is

$$F^{[S]} = T^{[S]} - R^{[S]} = p E^{[S]} - c Q^{[S]}$$

Substituting the preceding equations for c , E and Q , the emission charge $F^{[S]}$ can be represented as a sum of cross-subsidies $F^{[S \rightarrow S']}$ between sub-sectors S and S' ,

$$F^{[S]} = \sum_{S'} F^{[S \rightarrow S']}$$

wherein

$$F^{[S \rightarrow S']} = p \left(\frac{E^{[S]}}{Q^{[S]}} - \frac{E^{[S']}}{Q^{[S']}} \right) \frac{Q^{[S]} Q^{[S']}}{Q}$$

Table 4 is based on this equation. (Note that the above cross-subsidy is proportionate to the difference in emission intensity between sub-sectors S and S' , with the direction of revenue flow depending on which sub-sector has better emission performance.)

After the highlighted modifications in Table 5 are made, the redefined $F^{[S \rightarrow S']}$ terms in each table row are summed over S' to determine $F^{[S]}$. This is the Aggregate Net Charge (M\$) in Table 6. The Net Charge (\$/MWh) is $F^{[S]} / Q^{[S]}$. A revised refund rate $c^{[S]}$ for sub-sector S is defined according to the relation,

$$F^{[S]} = p E^{[S]} - c^{[S]} Q^{[S]}$$

This yields

$$c^{[S]} = \frac{p E^{[S]} - F^{[S]}}{Q^{[S]}}$$

This is the Refund (\$/MWh) column in Table 6.

CERTIFICATE OF SERVICE

I hereby certify that I have this day served a copy of COMMENTS OF KENNETH C. JOHNSON PERTAINING TO MODELING-RELATED ISSUES on the service list for CPUC Docket No. R.06-04-009 and CEC Docket No. 07-OIIP-01 by serving a copy to each party by electronic mail and/or by mailing a properly addressed copy by first-class mail with postage prepaid.

Executed on December 3, 2007, at Santa Clara, California.

/s/ Kenneth C. Johnson

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