Appendix K: Regional Haze Control Measures Selected

DRAFT

Kanoelehua-Hill Power Plant

Highest Emission Reduction with Control Measure Below $5,800/Ton Threshold in Green							
Unit	Control Measure	Cost per Ton	Emission Reduction (Tons)				Notes
			NO_X	SO_2	PM_{10}	Total Reduction	
Boiler Hill 5	Fuel Switch from Fuel Oil No. 6 to ULSD	$4,319	113.2	819.9	21.0	954	Boilers Hill 5 and Hill 6 shall be fired only on ULSD with a maximum fuel sulfur content not to exceed 0.0015% by weight.
Boiler Hill 6	Fuel Switch from Fuel Oil No. 6 to ULSD	$4,684	70.7	1,345.5	27.5	1,444	
				Total Combined Reduction for Switching Fuel---->		2,398	
Boiler Hill 5	LNB w/OFA and/or FGR for fuel oil No. 6	$1,051	119.7			120	
Boiler Hill 6	LNB w/OFA and/or FGR for fuel oil No. 6	$598	209.4			209	
				Total Combined Reduction for Combustion Controls---->		329	
Boiler Hill 5	Fuel Switch to ULSD + Combustion Controls	$4,147	183.2	819.9	21.0	1,024	Combustion controls are economically feasible after fuel switch from fuel oil No. 6 to ULSD since control cost is below $5,800/ton threshold. See Notes a, b, d, e, f, and g.
Boiler Hill 6	Fuel Switch to ULSD + Combustion Controls	$4,345	212.2	1,345.5	27.5	1,585	
				Total Combined Reduction for Fuel Switch and Combustion Controls---->		2,609	
Boiler Hill 5	SCR for Fuel Oil No. 6	$1,733	207.6			208	
Boiler Hill 6	SCR for Fuel Oil No. 6	$1,858	281.5			282	
				Total Combined Reduction for SCR---->		489	
Boiler Hill 5	Fuel Switch to ULSD + SCR	$4,152	238.2	819.9	21.0	1,079	SCR is economically feasible after fuel switch from fuel oil No. 6 to ULSD since control cost is below $5,800/ton threshold. See Notes a, c, d, e, h, and i.
Boiler Hill 6	Fuel Switch to ULSD + SCR	$4,290	325.4	1,345.5	27.5	1,698	
				Total Combined Reduction for Fuel Switch + SCR---->		2,778	
Boiler Hill 5	SCR + Combustion Controls for Fuel Oil No. 6	$2,116	229.5			230	
Boiler Hill 6	SCR + Combustion Controls for Fuel Oil No. 6	$2,041	317.6			318	
				Total Combined Reduction for SCR + Combustion Controls---->		547	
Boiler Hill 5	SCR + Combustion Controls + ULSD	$4,242	245.3	819.9	21.0	1,086	SCR and combustion controls are economically feasible after fuel switch to ULSD since control cost is below $5,800/ton threshold. See Notes a, b, c, d, e, f, h, k, l, and m.
Boiler Hill 6	SCR + Combustion Controls + ULSD	$4,326	339.6	1,345.5	27.5	1,713	
				Total Combined Reduction for SCR +Combustion Controls + ULSD-------->		**2,799**	
Boiler Hill 5	SNCR for Fuel Oil No. 6	$1,884	119.7			120	SNCR was not evaluated after fuel switch sinced SCR provides greater control for NO_X than SNCR. See Note d.
Boiler Hill 6	SNCR for Fuel Oil No. 6	$1,522	209.4			209	
				Total Combined Reduction for SNCR---->		329	
Boiler Hill 5	SNCR + Combustion Controls for Fuel Oil No. 6	$2,147	163.7			164	SNCR + combustion controls was not evaluated after fuel switch since SCR provides greater control for NO_X than SNCR. See Note d.
Boiler Hill 6	SNCR + Combustion Controls for Fuel Oil No. 6	$1,597	245.5			246	
				Total Combined Reduction for SNCR plus Combustion Controls---->		409	

Footnotes:

a. Annual cost of fuel switch from fuel oil No. 6 to ULSD for Hill 5 and Hill 6 is $4,120,758 and $6,762,141, respectively.

b: Annual cost of combustion controls for Hill 5 and Hill 6 is $125,823 and $125,184, respectively.

c: Annual cost of SCR for Hill 5 and Hill 6 is $359,776 and $522,986, respectively.

d. Control efficieny for control equipment is based on AP-42 Chapter 1.3 Fuel Oil Combustion, Table 1.3-14 Control Options for Oil-Fired Boilers, 2010.

e: Total 2017 NO_X after fuel switch is 252 tpy - 113 tpy = 139 tpy for Hill 5 and 354 tpy - 71 tpy = 283 tpy for Hill 6.

f. Assuming 50% control efficiency for combustion controls, after fuel switch an additional 70 tpy of NO_X reduced for Hill 5 and 142 tpy of NO_X reduced for Hill 6.

g: Cost of combustion controls after fuel switch is $4,246,581/1,024 tons = $4,147/ton for Hill 5 and $6,887,325/1,585 = $4,345/ton of pollutant removed for Hill 6.

h: Assuming 90% control efficiency for SCR, after fuel switch an additional 125 tpy of NO_X reduced for Hill 5 and a 254.7 tpy of NO_X reduced for Hill 6.

i: Total cost of fuel switch + SCR is $4,480,534/1,079 tons = $4,152/ton for Hill 5 and $7,285,127/1,698 tons = $4,290/ton for Hill 6.

j: Total NO_X after fuel switch and combustion controls is 252 tpy - 113 tpy - 70 tpy = 69 tpy for Hill 5 and 354 tpy - 71 tpy - 142 tpy= 141 tpy for Hill 6.

k: Assuming 90% control efficiency for SCR after fuel switch and combustion controls, an additional 62.1 tpy of NO_X is reduced for Hill 5 and 126.9 tpy of NO_X reduced for Hill 6.

l: Cost of fuel switch + combustion controls + SCR is $4,606,357/1,086 tons of pollutant removed = $4,242/ton of pollutant removed for Hill 5.

m: Cost of fuel switch + combustion controls + SCR is $7,410,311/1,713 tons of pollutant removed = $4,326/ton of pollutant removed for Hill 6.

Kahului Power Plant

Kahului Power Plant and Highest Emission Reduction from Control Measures Below $5,800/Ton Threshold in Green							
Unit	Control Measure	Cost per Ton	Emission Reduction (Tons)				Notes
			NO_X	SO_2	PM_{10}	Total Reduction	
K-1	Fuel switch to ULSD	$4,935	40.1	292.9	12.4	345	
K-2	Fuel switch to ULSD	$4,910	38	253.1	8.9	300	Boilers K-1, K-2, K-3, and K-4 shall be fired only on ULSD with a maximum fuel sulfur content not to exceed 0.0015% by weight.
K-3	Fuel switch to ULSD	$4,920	131.7	897.8	32.6	1,062	
K-4	Fuel switch to ULSD	$5,156	82.2	775.2	17.6	875	
					Total Combined Reduction for Fuel Switch to ULSD---->	2,582	
K-1	LNB w/OFA and/or FGR for Fuel Oil No. 6	$3,723	18.8			19	
K-2	LNB w/OFA and/or FGR for Fuel Oil No. 6	$3,239	21.7			22	
K-3	LNB w/OFA and/or FGR for Fuel Oil No. 6	$803	148.5			149	
K-4	LNB w/OFA and/or FGR for Fuel Oil No. 6	$2,050	58.2			58	
					Total Combined Reduction for Combustion Controls---->	247	
K-1	Fuel switch to ULSD + combustion controls	$4,956	52.9	292.9	12.4	358	
K-2	Fuel switch to ULSD + combustion controls	$4,946	69.5	253.1	8.9	332	Combustion controls are economically feasible after fuel switch to ULSD since control cost is below $5,800/ton threshold. See notes a through l.
K-3	Fuel switch to ULSD + combustion controls	$4,676	223.1	897.8	32.6	1,154	
K-4	Fuel switch to ULSD + combustion controls	$5,006	132.5	775.2	17.6	925	
					Total Combined Reduction for Fuel Switch to ULSD + Combustion Controls---->	2,769	
K-1	SCR for Fuel Oil No. 6	$3,719	50.1			50	
K-2	SCR for Fuel Oil No. 6	$3,795	48.8			49	
K-3	SCR for Fuel Oil No. 6	$1,456	244.6			245	
K-4	SCR for Fuel Oil No. 6	$2,381	141.2			141	
					Total Combined Reduction for SCR---->	485	
K-1	Fuel Switch to ULSD + SCR	$5,124	63.2	292.9	12.4	369	
K-2	Fuel Switch to ULSD + SCR	$5,149	59.9	253.1	8.9	322	SCR is economically feasible after fuel switch to ULSD since control cost is below $5,800/ton threshold. See notes a through l.
K-3	Fuel Switch to ULSD + SCR	$4,624	276.5	897.8	32.6	1207	
K-4	Fuel Switch to ULSD + SCR	$5,018	172.7	775.2	17.6	966	
					Total Combined Reduction for Fuel Switch + SCR---->	2,863	
K-1	SCR + Combustion Controls for Fuel Oil No. 6	$4,422	58.0			58	
K-2	SCR + Combustion Controls for Fuel Oil No. 6	$4,595	55.5			56	
K-3	SCR + Combustion Controls for Fuel Oil No. 6	$1,769	268.6			269	
K-4	SCR + Combustion Controls for Fuel Oil No. 6	$2,813	162.0			162	
					Total Combined Reduction for SCR + Combustion Controls---->	544	
K-1	SCR + Combustion Controls + ULSD	$5,300	64.5	292.9	12.4	370	
K-2	SCR + Combustion Controls + ULSD	$5,350	61.1	353.1	8.9	423	SCR + combustion controls + ULSD is economically feasible since control cost is below $5,800/ton threshold. See notes a through l
K-3	SCR + Combustion Controls + ULSD	$4,692	284.6	897.8	32.6	1,215	
K-4	SCR + Combustion Controls + ULSD	$5,120	177.7	775.2	17.6	970	
					Total Combined Reduction for SCR + Combustion Controls---->	**2,978**	
K-1	SNCR	$6,359	18.8			19	
K-2	SNCR	$6,178	21.7			22	SNCR was not evaluated after fuel switch because SCR provides greater control for NO_X than SNCR. See Note l.
K-3	SNCR	$1,549	148.5			149	
K-4	SNCR	$3,195	58.2			58	
					Total Combined Reduction for SNCR---->	247	
K-1	SNCR + Combustion Controls	$5,495	34.5			35	
K-2	SNCR + Combustion Controls	$5,794	35.2			0	SNCR + combustion controls was not evaluated after fuel switch because SCR provides greater control for NO_X than SNCR. See Note l.
K-3	SNCR + Combustion Controls	$1,777	196.5			197	
K-4	SNCR + Combustion Controls	$3,195	99.7			100	
					Total Combined Reduction for SNCR + Combustion Controls---->	331	

Kahului Power Plant

Footnotes:

a: Annual cost for fuel switch from fuel switch for fuel oil No. 6 to ULSD for K-1, K-2, K-3, and K-4 is $1,704,479; 1,473,028; $5,225,092; and $4,511,548, respectively.

b: Annual cost for combustion controls is $69,914; $70,168; $119,191; and $119,394 for K-1, K-2, K-3, and K-4, respectively.

c: Annual cost for SCR is $186,428; $185,001; $356,020; and $336,163 for K-1, K-2, K-3, and K-4, respectively.

d. Control efficieny for control equipment is based on AP-42 Chapter 1.3 Fuel Oil Combustion, Table 1.3-14 Control Options for Oil-Fired Boilers, 2010.

e: Total NO_X after fuel switch is 65.8 tpy - 40.1 tpy = 25.7 for K-1; 62.3 tpy - 38.0 = 24.3 tpy for K-2; 292.6 tpy - 131.7 tpy = 160.9 tpy for K-3; and 182.7 tpy - 82.2 tpy = 100.5 tpy for K-4.

f: Assuming 50% control efficiency for combustion controls after fuel switch, an additional 12.85 tpy, 12.15 tpy, 80.45 tpy, and 50.25 tpy of NOx is removed for K-1, K-2, K-3, and K-4, respectively.

g: Cost for combustion controls after fuel switch, is $1,774,393/358 ton = $4,956/ ton for K-1; $1,543,196/312 ton = $4,946/ton for K-2; $5,344,283/1,143 ton =$4,676/ton for K-3; $4,630,942/925 ton = $5,006/ton for K

h: Assuming a 90% control efficiency for SCR after fuel switch, an additional 23.1 tpy, 21.9 tpy, 144.8 tpy, and 90.5 tpy of NO_X is removed for K-1, K-2, K-3, and K-4, respectively.

i: Cost for SCR after fuel switch is $1,890,907/369 ton = $5,124/ ton for K-1; $1,658,029/322 ton = $5,149/ton for K-2; $5,581,112/1,207 ton =$4,624/ton for K-3; $4,847,711/966 ton = $5,018/ton for K-4.

j: Total NO_X after fuel switch and combustion controls is 25.7 tpy - 12.85 tpy = 12.85 for K-1; 24.3 tpy -12.15 tpy = 12.15 tpy for K-2; 160.9 tpy - 80.45 tpy for K-3; and 1005 tpy - 50.25 tpy = 50.25 tpy for K-4.

k: Assuming a 90% control efficiency for SCR after fuel switch and combustion controls, an additional 11.57 tpy, 10.94 tpy, 72.41 tpy, and 45.23 tpy of NO_X is removed from K-1, K-2, K-3, and K-4, respectively.

l: Cost for SCR + combustion controls after fuel switch is $1,960,821/370 ton = $5,300/ton for K-1; $1,728,197/323 ton = $5,350/ton for K-2; $5,700,303/1,215 ton = $4,692/ton for K-3; $4,967,105/970 ton = $5,120/to

Puna Power Plant

Highest Emission Reduction from Control Measure Below $5,800/Ton Threshold in Green							
Unit	Control Measure	Cost per Ton	Emission Reduction (Tons)				Emissions limit
			NO_X	SO_2	PM_{10}	Total Reduction	
Boiler	Fuel Switch to ULSD	$4,697	18.2	183.9	8.3	**210**	The boilers shall be fired only on ULSD with a maximum fuel sulfur content not to exceed 0.0015% by weight.

Maalaea Power Plant

Highest Emission Reduction from Control Measures Below $5,800/Ton Threshold in Green							
Unit	Control Measure	Cost per Ton	Emission Reduction (Tons)				Notes
			NO_X	SO_2	PM_{10}	Total Reduction	
M1	FITR	$3,030	5.0			5	
M2	FITR	$5,225	2.9			3	
M3	FITR	$3,030	5.0			5	
Total Combined Reduction for FITR---->						**13**	
M7	SCR	$5,530	110.6			111	
Total Reduction for SCR---->						**111**	
Total Combined Reduction for FITR and SCR---->						**124**	

The Effect of Emission Controls on Q/d Metric - Haleakala NP Big Island

Facility: Before Controls	d (Km)	2014				2017			
		Q (tpy)			Q/d	Q (tpy)			Q/d
		NOx	SO2	PM10		NOx	SO2	PM10	
HELCO - Kanoelehua-Hill	147.01	611	1852	56	**17**	609	2167	57	**19**
MECO - Kahului	26.49	483	1634	60	**82**	603	2221	84	**110**
MECO - Maalaea	25.52	2114	549	148	**110**	2786	235	144	**124**

Facility: After Single Control Method Applied	d (Km)	Fuel-Switch to ULSD				SCR				SNCR				Combustion Controls				FITR			
		Q (tpy)			Q/d	Q (tpy)			Q/d	Q (tpy)			Q/d	Q (tpy)			Q/d	Q (tpy)			Q/d
		NOx	SO2	PM10		NOx	SO2	PM10		NOx	SO2	PM10		NOx	SO2	PM10		NOx	SO2	PM10	
HELCO - Kanoelehua-Hill	147.01	421	1.73	8.6	**3**	116	2167	57	**16**	276	2167	57	**17**	333	2167	57	**17**	N/A	N/A	N/A	**NA**
MECO - Kahului	26.49	314	1.78	12.7	**12**	119	2221	84	**92**	356	2221	84	**100**	247	2221	84	**96**	N/A	N/A	N/A	**NA**
MECO - Maalaea	25.52	N/A	N/A	N/A	**N/A**	456	235	144	**33**	N/A	N/A	N/A	**N/A**	N/A	N/A	N/A	**N/A**	2773	235	144	**124**

Facility: After All Control Methods within Control Cost Threshold Are Applied	d (Km)	Control Methods within Cost Threshold					Q (tpy)			Final Q/d
		ULSD	SCR	SNCR	Comb. Cntrls.	FITR	NOx	SO2	PM10	
HELCO - Kanoelehua-Hill: Hill 5 and Hill 6	147.01	✓	✓		✓		24	2	8	**0.2**
MECO - Kahului: K-1, K-2, K-3, K-4	26.49	✓	✓		✓		15	2	12	**1.1**
MECO - Maalaea: FITR for M1, M2, M3; SCR for M7	25.52		✓			✓	2662	N/A	N/A	**104.3**

The Effect of Emission Controls on Q/d Metric - Haleakala NP Small Island

Facility: Before Controls	d (Km)	2014				2017			
		Q (tpy)			Q/d	Q (tpy)			Q/d
		NOx	SO2	PM10		NOx	SO2	PM10	
HELCO - Kanoelehua-Hill	147.66	611	1852	56	**17**	609	2167	57	**19**
MECO - Kahului	50.16	483	1634	60	**43**	603	2221	84	**58**
MECO - Maalaea	48.49	2114	549	148	**58**	2786	235	144	**65**

Facility: After Single Control Method Applied	d (Km)	Fuel-Switch to ULSD				SCR				SNCR				Combustion Controls				FITR			
		Q (tpy)			Q/d	Q (tpy)			Q/d	Q (tpy)			Q/d	Q (tpy)			Q/d	Q (tpy)			Q/d
		NOx	SO2	PM10		NOx	SO2	PM10		NOx	SO2	PM10		NOx	SO2	PM10		NOx	SO2	PM10	
HELCO - Kanoelehua-Hill	147.66	421	1.73	8.6	**3**	116	2167	57	**16**	276	2167	57	**17**	333	2167	57	**17**	N/A	N/A	N/A	**NA**
MECO - Kahului	50.16	314	1.78	12.7	**7**	119	2221	84	**48**	356	2221	84	**53**	247	2221	84	**51**	N/A	N/A	N/A	**NA**
MECO - Maalaea	48.49	N/A	N/A	N/A	**N/A**	456	235	144	**17**	N/A	N/A	N/A	**N/A**	N/A	N/A	N/A	**N/A**	2773	235	144	**65**

Facility: After All Control Methods within Control Cost Threshold Are Applied	d (Km)	Control Methods within Cost Threshold					Q (tpy)			Final Q/d
		ULSD	SCR	SNCR	Comb. Cntrls.	FITR	NOx	SO2	PM10	
HELCO - Kanoelehua-Hill: Hill 5 and Hill 6	147.66	✓	✓		✓		24	2	8	**0.2**
MECO - Kahului: K-1, K-2, K-3, K-4	50.16	✓	✓		✓		15	2	12	**0.6**
MECO - Maalaea: FITR for M1, M2, M3; SCR for M7	48.49		✓			✓	2662	N/A	N/A	**54.9**

The Effect of Emission Controls on Q/d Metric - Volcanoes NP

Facility: Before Controls	d (Km)	2014				2017			
		Q (tpy)			Q/d	Q (tpy)			Q/d
		NOx	SO2	PM10		NOx	SO2	PM10	
HELCO - Kanoelehua-Hill	34.53	611	1852	56	**73**	609	2167	57	**82**
HELCO - Puna	27.46	70	524	29	**23**	23	187	11	**8**
MECO - Kahului	176.82	483	1634	60	**12**	603	2221	84	**16**
MECO - Maalaea	169.61	2114	549	148	**17**	2786	235	144	**19**

Facility: After Single Control Method Applied	d (Km)	After Fuel-Switch to ULSD				After SCR				After SNCR				Combustion Controls				FITR			
		Q (tpy)			Q/d	Q (tpy)			Q/d	Q (tpy)			Q/d	Q (tpy)			Q/d	Q (tpy)			Q/d
		NOx	SO2	PM10		NOx	SO2	PM10		NOx	SO2	PM10		NOx	SO2	PM10		NOx	SO2	PM10	
HELCO - Kanoelehua-Hill	34.53	421	1.73	8.6	**12**	116	2167	57	**68**	276	2167	57	**72**	333	2167	57	**74**	N/A	N/A	N/A	**N/A**
HELCO - Puna	27.46	4.8	0.15	1.65	**0.2**	9.8	187	11	**8**	15	187	11	**8**	15	187	11	**8**	N/A	N/A	N/A	**N/A**
MECO - Kahului	176.82	314	1.78	12.7	**2**	119	2221	84	**14**	356	2221	84	**15**	247	2221	84	**14**	N/A	N/A	N/A	**N/A**
MECO - Maalaea	169.61	N/A	N/A	N/A	**N/A**	456	235	144	**5**	N/A	N/A	N/A	**N/A**	N/A	N/A	N/A	**N/A**	2773	235	144	**19**

Facility: After All Control Methods within Control Cost Threshold Are Applied	d (Km)	Control Methods within Cost Threshold					Q (tpy)			Final Q/d
		ULSD	SCR	SNCR	Comb. Cntrls.	FITR	NOx	SO2	PM10	
HELCO - Kanoelehua-Hill: Hill 5 and Hill 6	34.53	✓	✓		✓		24	2	8	**1.0**
HELCO - Puna	27.46	✓					4.8	0.15	1.65	**0.2**
MECO - Kahului: K-1, K-2, K-3, K-4	176.82	✓	✓		✓		15	2	12	**0.2**
MECO - Maalaea: FITR for M1, M2, M3; SCR for M7	169.61		✓			✓	2662	N/A	N/A	**15.7**

The Effect of Emission Controls on Q/d Metric - Volcanoes NP Olaa Tract

Facility: Before Controls	d (Km)	2014				2017			
		Q (tpy)			Q/d	Q (tpy)			Q/d
		NOx	SO2	PM10		NOx	SO2	PM10	
HELCO - Kanoelehua-Hill	25.69	611	1852	56	**98**	609	2167	57	**110**
HELCO - Puna	23.01	70	524	29	**27**	23	187	11	**10**
MECO - Kahului	197.82	483	1634	60	**11**	603	2221	84	**15**
MECO - Maalaea	191.85	2114	549	148	**15**	2786	235	144	**16**

Facility: After Single Control Method Applied	d (Km)	After Fuel-Switch to ULSD				After SCR				After SNCR				Combustion Controls				FITR			
		Q (tpy)			Q/d	Q (tpy)			Q/d	Q (tpy)			Q/d	Q (tpy)			Q/d	Q (tpy)			Q/d
		NOx	SO2	PM10		NOx	SO2	PM10		NOx	SO2	PM10		NOx	SO2	PM10		NOx	SO2	PM10	
HELCO - Kanoelehua-Hill	25.69	421	1.73	8.6	**17**	116	2167	57	**91**	276	2167	57	**97**	333	2167	57	**100**	N/A	N/A	N/A	**N/A**
HELCO - Puna	23.01	4.8	0.15	1.65	**0.3**	9.8	187	11	**9**	15	187	11	**9**	15	187	11	**9**	N/A	N/A	N/A	**N/A**
MECO - Kahului	197.82	314	1.78	12.7	**2**	119	2221	84	**12**	356	2221	84	**13**	247	2221	84	**13**	N/A	N/A	N/A	**N/A**
MECO - Maalaea	191.85	N/A	N/A	N/A	**N/A**	456	235	144	**4**	N/A	N/A	N/A	**N/A**	N/A	N/A	N/A	**N/A**	2773	235	144	**16**

Facility: After All Control Methods within Control Cost Threshold Are Applied	d (Km)	Control Methods within Cost Threshold					Q (tpy)			Final Q/d
		ULSD	SCR	SNCR	Comb. Cntrls.	FITR	NOx	SO2	PM10	
HELCO - Kanoelehua-Hill: Hill 5 and Hill 6	25.69	✓	✓		✓		24	2	8	**1.3**
HELCO - Puna	23.01	✓					4.8	0.15	1.65	**0.3**
MECO - Kahului: K-1, K-2, K-3, K-4	197.82	✓	✓		✓		15	2	12	**0.1**
MECO - Maalaea: FITR for M1, M2, M3; SCR for M7	191.85		✓			✓	2662	N/A	N/A	**13.9**