

Docket No.: A.25-12-009
Exhibit No.: UCAN-05-G
ALJ: Camille Watts-Zagha
Witness: Tyson Siegele

Exhibit UCAN-05-G

SDG&E Response to UCAN Data Request 01, Question 33 – Attachment
“LM6000 Hydrogen Blending Design SDG&E”

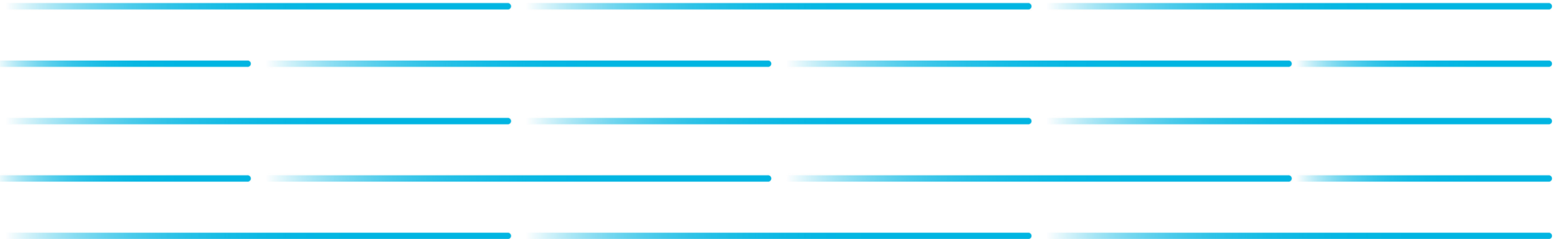


SDG&E LM6000 PC Hydrogen Blending CM&U Design

September 24, 2020

Presenters: Brian Hockman

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High Level Modifications*

- Will require Natural Gas or an alternate fuel for GT starting & shutting down
- Higher NOx water flow rates than NG as H2 has a much greater NOx scalar, thus generating more NOx relative to NG
- Reduced combustor maintenance interval
- For the use of natural gas to startup and shutdown - N2 purge is required to clear the gas manifold of any oxygen and hydrogen in emergency shutdown scenario

*H2 blend assumed to be greater than 5% and less than 35% Hydrogen



Performance Impact

Engine Performance 32F at 50% Relative Humidity								
	100% NG	5% H2	10% H2	15% H2	20% H2	25% H2	30% H2	35% H2
Generator Output, kW	51202	51202	51201	51200	51199	51198	51197	51196
Delta Power, %	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.01%	-0.01%	-0.01%
Heat Rate, Btu/kW-hr	8510.00	8513.00	8518.00	8522.00	8528.00	8533.00	8539.00	8546.00
Delta Heat Rate, %	0.00%	-0.04%	-0.09%	-0.14%	-0.21%	-0.27%	-0.34%	-0.42%
NOx Water Injection, lb/sec	6.53	6.62	6.72	6.84	6.96	7.09	7.23	7.38
Delta NOx Water Injection, %	0.00%	1.38%	2.91%	4.75%	6.58%	8.58%	10.72%	13.02%
CO_lb/hr	42.6	46.5	51.4	57.5	64.9	73.5	83.6	96.7
Delta CO_lb/hr, %	0.00%	9.15%	20.66%	34.98%	52.35%	72.54%	96.24%	127.00%
CO2_lb/hr	56941	56096	55183	54189	53117	51958	50668	49285
Delta CO2_lb/hr, %	0.00%	-1.48%	-3.09%	-4.83%	-6.72%	-8.75%	-11.02%	-13.45%

Engine Performance 50F at 50% Relative Humidity								
	100% NG	5% H2	10% H2	15% H2	20% H2	25% H2	30% H2	35% H2
Generator Output, kW	49701	49784	49881	49987	50100	50220	50345	50492
Delta Power, %	0.00%	0.17%	0.36%	0.58%	0.80%	1.04%	1.30%	1.59%
Heat Rate, Btu/kW-hr	8579	8583	8587	8592	8597	8602	8608	8616
Delta Heat Rate, %	0.00%	-0.04%	-0.09%	-0.15%	-0.21%	-0.27%	-0.33%	-0.43%
NOx Water Injection, lb/sec	5.74	5.85	5.98	6.12	6.27	6.42	6.59	6.79
Delta NOx Water Injection, %	0.00%	1.84%	4.09%	6.53%	9.14%	11.85%	14.70%	18.20%
CO_lb/hr	23.7	25.8	28.7	32.2	36.3	41.1	46.7	54.7
Delta CO_lb/hr, %	0.00%	8.96%	21.16%	35.82%	53.30%	73.57%	97.07%	130.98%
CO2_lb/hr	55745	55013	54229	53373	52442	51428	50285	49071
Delta CO2_lb/hr, %	0.00%	-1.31%	-2.72%	-4.26%	-5.93%	-7.75%	-9.79%	-11.97%



Performance Impact (cont.)

Engine Performance 75F at 50% Relative Humidity								
	100% NG	5% H2	10% H2	15% H2	20% H2	25% H2	30% H2	35% H2
Generator Output, kW	45428	45528	45634	45746	45865	45993	46145	46297
Delta Power, %	0.00%	0.22%	0.45%	0.70%	0.96%	1.24%	1.58%	1.91%
Heat Rate, Btu/kW-hr	8690	8692	8695	8697	8699	8702	8706	8711
Delta Heat Rate, %	0.00%	-0.03%	-0.06%	-0.08%	-0.11%	-0.13%	-0.18%	-0.24%
NOx Water Injection, lb/sec	4.90	5.01	5.13	5.25	5.38	5.52	5.69	5.88
Delta NOx Water Injection, %	0.00%	2.30%	4.73%	7.22%	9.89%	12.72%	16.29%	20.02%
CO_lb/hr	10.3	11.4	12.7	14.1	15.8	17.8	20.8	24.3
Delta CO_lb/hr, %	0.00%	10.79%	23.27%	37.26%	53.86%	73.41%	102.00%	136.54%
CO2_lb/hr	51632	50977	50261	49473	48615	47684	46659	45544
Delta CO2_lb/hr, %	0.00%	-1.27%	-2.65%	-4.18%	-5.84%	-7.65%	-9.63%	-11.79%

Engine Performance 90F at 50% Relative Humidity								
	100% NG	5% H2	10% H2	15% H2	20% H2	25% H2	30% H2	35% H2
Generator Output, kW	42095	42093	42091	42089	42086	42084	42081	42078
Delta Power, %	0.00%	0.00%	-0.01%	-0.02%	-0.02%	-0.03%	-0.03%	-0.04%
Heat Rate, Btu/kW-hr	8808	8811	8813	8816	8820	8825	8830	8836
Delta Heat Rate, %	0.00%	-0.03%	-0.06%	-0.10%	-0.13%	-0.19%	-0.25%	-0.31%
NOx Water Injection, lb/sec	4.25	4.32	4.40	4.47	4.57	4.68	4.81	4.94
Delta NOx Water Injection, %	0.00%	1.71%	3.51%	5.36%	7.52%	10.30%	13.24%	16.36%
CO_lb/hr	5.2	5.6	6.1	6.7	7.4	8.5	9.8	11.4
Delta CO_lb/hr, %	0.00%	8.71%	18.58%	29.62%	43.87%	64.93%	90.23%	121.35%
CO2_lb/hr	48507	47788	47009	46161	45248	44272	43184	42018
Delta CO2_lb/hr, %	0.00%	-1.48%	-3.09%	-4.84%	-6.72%	-8.73%	-10.97%	-13.38%



Performance Impact (cont.)

Engine Performance								
	100% NG	5% H2	10% H2	15% H2	20% H2	25% H2	30% H2	35% H2
Generator Output, kW	42095 to 51202	42093 to 51202	42091 to 51201	42089 to 51200	42086 to 51199	42084 to 51198	42081 to 51197	42078 to 51196
Delta Power, %	0% to 0%	0% to 0.22%	-0.01% to 0.45%	-0.02% to 0.7%	-0.02% to 0.96%	-0.03% to 1.24%	-0.03% to 1.58%	-0.04% to 1.91%
Heat Rate, Btu/kW-hr	8510 to 8808	8513 to 8811	8518 to 8813	8522 to 8816	8528 to 8820	8533 to 8825	8539 to 8830	8546 to 8836
Delta Heat Rate, %	0% to 0%	-0.04% to -0.03%	-0.09% to -0.06%	-0.14% to -0.08%	-0.21% to -0.11%	-0.27% to -0.13%	-0.34% to -0.18%	-0.42% to -0.24%
NOx Water Injection, lb/sec	4.25 to 6.53	4.32 to 6.62	4.4 to 6.72	4.47 to 6.84	4.57 to 6.96	4.68 to 7.09	4.81 to 7.23	4.94 to 7.38
Delta NOx Water Injection, %	0% to 0%	1.38% to 2.3%	2.91% to 4.73%	4.75% to 7.22%	6.58% to 9.89%	8.58% to 12.72%	10.72% to 16.29%	13.02% to 20.02%
CO_lb/hr	5.17 to 42.6	5.62 to 46.5	6.13 to 51.4	6.7 to 57.5	7.44 to 64.9	8.53 to 73.5	9.84 to 83.6	11.45 to 96.7
Delta CO_lb/hr, %	0% to 0%	8.71% to 10.79%	18.58% to 23.27%	29.62% to 37.26%	43.87% to 53.86%	64.93% to 73.41%	90.23% to 102%	121.35% to 136.54%
CO2_lb/hr	48507 to 56941	47788 to 56096	47009 to 55183	46161 to 54189	45248 to 53117	44272 to 51958	43184 to 50668	42018 to 49285
Delta CO2_lb/hr, %	0% to 0%	-1.48% to -1.27%	-3.09% to -2.65%	-4.84% to -4.18%	-6.72% to -5.84%	-8.73% to -7.65%	-10.97% to -9.63%	-13.38% to -11.79%

- Slight **Increase** in Power
- Slight **Decrease** in Heat Rate
- **Increase** in NOx Water Injection (to maintain 25 ppm)
- **Increase** in CO emissions
- **Decrease** in CO2 emissions



