Supplementary data

Table 6 (S1): Mass Fractions of Induction Blends for Engine Fueling Using Port Injection with Natural Gas-Hydrogen Blends at Various Air-Fuel Ratios.

Species	Stoichiometric				Rich				Lean			
	O_2%	N_2%	CH_4%	H_2%	O_2%	N_2%	CH_4%	H_2%	O_2%	N_2%	CH_4%	H_2%
+ 10% H_2	19.73	74.23	5.49	0.55	19.56	73.56	6.25	0.63	19.9	74.86	4.76	0.476
+ 15% H_2	19.67	74.02	5.49	0.82	19.49	73.32	6.25	0.94	19.85	74.68	4.76	0.71
+ 20% H_2	19.62	73.79	5.49	1.10	19.43	73.07	6.25	1.25	19.8	74.5	4.76	0.95
+ 25% H_2	19.56	73.58	5.49	1.37	19.36	72.83	6.25	1.56	19.75	74.3	4.76	1.19
+ 30% H_2	19.50	73.36	5.49	1.65	19.30	72.57	6.25	1.88	19.7	74.11	4.76	1.43
+ 35% H_2	19.44	73.14	5.49	1.93	19.2	72.37	6.25	2.18	19.65	73.92	4.76	1.67
+ 40% H_2	*	*	*	*	*	*	*	*	19.6	73.74	4.76	1.9
+ 45% H_2	*	*	*	*	*	*	*	*	20.0	73.04	4.76	2.2
+ 50% H_2	*	*	*	*	*	*	*	*	19.5	73.36	4.76	2.38

Table 7 (S2) : Performance and Pollution Values When Fueled with Pure Gasoline for Various Air-Fuel Ratios.

Species	Stoichiometric				Rich				Lean			
	Gross ISFC per kW.hr [g]	Gross Indicated Power [kW]	CO @ EVO [g]	EINOX @ EVO [g]	Gross ISFC per kW.hr [g]	Gross Indicated Power [kW]	CO @ EVO [g]	EINOX @ EVO [g]	Gross ISFC per kW.hr [g]	Gross Indicated Power [kW]	CO @ EVO [g]	EINOX @ EVO [g]
100% C_8H_{18}	573	4.53	9.2E-3	3.5E-4	594	5.03	2.3E-2	7.8E-5	487	4.68	1.6E-4	2.4E-3

Table 8 (S3) : Engine Performance and Emissions When Fueled with Pure Natural Gas at Various Air-Fuel Ratios.

Species	Stoichiometric				Rich				Lean			
	Gross ISFC per kW.hr [g]	Gross Indicated Power [kW]	CO @ EVO [g]	EINOX @ EVO [g]	Gross ISFC per kW.hr [g]	Gross Indicated Power [kW]	CO @ EVO [g]	EINOX @ EVO [g]	Gross ISFC per kW.hr [g]	Gross Indicated Power [kW]	CO @ EVO [g]	EINOX @ EVO [g]
100% CH_4^{320}	457	4.53	6.2E-3	3.6E-4	485	4.84	1.5E-2	7.4E-5	393	4.60	6.6E-5	2.7E-3
100% CH_4^{330}	295	7.01	6.2E-3	3.8E-4	318	7.39	1.5E-2	7.6E-5	256	7.05	7.9E-5	2.5E-3
100% CH_4^{340}	235	8.81	6.4E-3	3.6E-4	270	8.70	1.6E-2	7.1E-5	209	8.63	1.4E-4	2.0E-3
100% CH_4^{350}	223	9.29	6.4E-3	3.5E-4	260	9.01	1.6E-2	6.7E-5	200	9.02	1.8E-4	1.6E-3
100% CH_4^{360}	230	9.0	6.6E-3	3.6E-4	269	8.71	6.5E-2	1.6E-5	207	8.74	2.9E-4	1.3E-3
100% CH_4^{370}	252	8.22	6.9E-3	3.9E-4	299	7.85	1.6E-2	6.7E-5	228	7.92	7.1E-4	1.1E-3

Table 9 (S4) : Engine Performance and Emissions When Fueled with Pure Hydrogen at Various Air-Fuel Ratios

Species	Stoichiometric				Rich				Lean			
	Gross ISFC per kW.hr [g]	Gross Indicated Power [kW]	CO @ EVO [g]	EINOX @ EVO [g]	Gross ISFC per kW.hr [g]	Gross Indicated Power [kW]	CO @ EVO [g]	EINOX @ EVO [g]	Gross ISFC per kW.hr [g]	Gross Indicated Power [kW]	CO @ EVO [g]	EINOX @ EVO [g]
100% H_2^{320}	406	2.00	7.7E-5	1.8E-4	591	1.54	1.6E-4	2.9E-5	310	2.4	1.0E-6	1.7E-3
100% H_2^{330}	310	2.61	7.5E-5	1.7E-4	370	2.47	1.6E-4	3.1E-5	209	3.56	4.5E-7	1.7E-3
100% H_2^{340}	203	4.00	7.1E-5	1.9E-4	224	4.08	1.6E-4	3.6E-5	187	4.00	9.2E-8	1.7E-3
100% H_2^{350}	153	5.31	7.7E-5	2.3E-4	184	5.00	1.7E-4	4.4E-5	140	5.32	2.1E-7	1.8E-3
100% H_2^{360}	135	6.0	7.8E-5	3.0E-4	153	5.98	1.7E-4	6.1E-5	127	5.89	5.1E-7	1.8E-3
100% H_2^{370}	136	5.94	8.2E-5	4.2E-4	153	5.96	1.7E-4	9.2E-5	126	5.93	1.5E-6	1.8E-3

Table 10 (S5) : Performance and pollution of the engine when fueled with various blends of gasoline and Hydrogen.

Species	Stoichiometric				Rich				Lean			
	Gross ISFC per kW.hr [g]	Gross Indicated Power [kW]	CO @ EVO [g]	EINOX @ EVO [g]	Gross ISFC per kW.hr [g]	Gross Indicated Power [kW]	CO @ EVO [g]	EINOX @ EVO [g]	Gross ISFC per kW.hr [g]	Gross Indicated Power [kW]	CO @ EVO [g]	EINOX @ EVO [g]
100% C_8H_{18}	573	4.53	9.2E-3	3.5E-4	594	5.03	2.3E-2	7.8E-5	487	4.68	1.6E-4	2.4E-3
+ 1% H_2	449	5.93	2.5E-2	2.1E-5	430	6.93	3.2E-2	1.0E-5	475	5.0	1.9E-2	4.4E-5
+ 2% H_2	406	6.66	2.5E-2	4.6E-6	463	6.47	2.8E-2	2.3E-6	358	6.83	2.3E-2	9.2E-6
+ 3% H_2	449	6.09	2.2E-2	1.4E-6	512	5.87	2.5E-2	5.2E-7	405	6.18	2.0E-2	2.8E-6

Table 11 (S6) : Engine Performance and Emissions with Various Natural Gas and Hydrogen Blends at Different Air-Fuel Ratios.

Species	Stoichiometric				Rich				Lean			
	Gross ISFC per kW.hr [g]	Gross Indicated Power [kW]	CO @ EVO [g]	EINOX @ EVO [g]	Gross ISFC per kW.hr [g]	Gross Indicated Power [kW]	CO @ EVO [g]	EINOX @ EVO [g]	Gross ISFC per kW.hr [g]	Gross Indicated Power [kW]	CO @ EVO [g]	EINOX @ EVO [g]
+ 10% H_2	444	4.82	1.5E-2	4.8E-5	420	5.72	2.1E-2	1.8E-5	430	4.37	7.3E-3	1.9E-4
+ 15% H_2	417	5.19	1.7E-2	2.8E-5	386	6.27	2.2E-2	1.0E-5	424	4.50	1.1E-2	8.6E-5
+ 20% H_2	387	5.67	1.8E-2	1.7E-5	385	6.36	2.2E-2	5.5E-6	414	4.68	1.3E-2	4.7E-5
+ 25% H_2	366	6.06	1.9E-2	1.1E-5	406	6.07	2.1E-2	3.7E-6	394	5.00	1.4E-2	2.9E-5
+ 30% H_2	351	6.39	1.9E-2	6.7E-6	423	5.87	2.0E-2	2.4E-6	370	5.40	1.5E-2	2.0E-5
+ 35% H_2	375	6.03	1.8E-2	4.7E-6	435	5.75	2.0E-2	1.5E-6	354	5.72	1.6E-2	1.4E-5
+40% H_2	*	*	*	*	*	*	*	*	332	6.17	1.6E-2	9.5E-6
+45% H_2	*	*	*	*	*	*	*	*	328	6.35	1.6E-2	7.8E-6
+50% H_2	*	*	*	*	*	*	*	*	350	5.99	1.5E-2	5.1E-6