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Hydrogen Co-firing Demonstration at New York Power Authority Brentwood Site: GE LM6000 Gas Turbine

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ABSTRACT

The New York Power Authority (NYPA), EPRI, and General Electric (GE) developed and executed a pilot project focused on hydrogen-fueled power generation. As part of the Low-Carbon Resources Initiative (LCRI), the companies jointly conducted a hydrogen blending project at NYPA's Brentwood Power Station. This collaborative effort demonstrated the burning of a hydrogen-natural gas blend on an LM6000 gas turbine (GT) to identify the resulting impact on combustion emissions (CO2, NOx, CO) and GT operation. The GT was operated on hydrogen blends ranging from 5 to 44% by volume. The successful test represents the first utility-scale hydrogen blending project in the state of New York, which is mandating a zero-emission electricity sector by 2040 and calling for an orderly and just transition to clean energy for a economy-wide carbon neutrality through the Climate Leadership and Community Protection Act.

NOMENCLATURE

CLCPA	Climate Leadership and Community Protection Act
CO	Carbon Monoxide
CO_2	Carbon Dioxide
EPRI	Electric Power Research Institute
GC	Gas Chromatograph
GE	General Electric
GT	Gas Turbine
H_2	Hydrogen
LCRI	Low Carbon Resource Initiative
LHV	Lower Heating Value
MW	Megawatt
MWg	Gross Megawatts
NG	Natural Gas
NO_2	Nitrogen Dioxide
NOx	Nitrogen oxides
NYPA	New York Power Authority
O_2	Oxygen
OEM	Original Equipment Manufacturer
OH	Oxygen Hydrogen
ppm	part per million
SAC	Single Annular Combustor
SCR	Selective Catalytic Reduction
SPRINT	Spray Intercooler
WIM	Wobbe Index Meter

2. INTRODUCTION

The New York Power Authority (NYPA) conducted a pilot project beginning in 2021 to advance low-carbon technologies for power generation at the Brentwood Power Station, located near the Pilgrim State Hospital in Suffolk County on Long Island, New York. The 48MW Brentwood plant was commissioned in the summer of 2001 and consists of a GE LM6000 gas turbine (GT) firing natural gas. The GT is equipped with a single annular combustion (SAC) system, which is not a dry- low emissions technology and requires water injection for NOx control. The plant is also equipped with post-combustion catalyst systems for NOx and CO control. The plant was established in 2001 as part of New York's Power Now! Initiative to increase local power generation capacity for Long Island and New York City in anticipation of potential summer power shortages. The Brentwood plant's location and layout, combined with its relatively low capacity factor as a peaking unit, facilitated the temporary modifications required for this demonstration project.

The project aligned with NYPA's strategic VISION2030 priority to decarbonize and was designed to test and demonstrate the feasibility of using new low-to-zero carbon technologies to help achieve zero-carbon emissions by 2035 (NYPA's goal) and 100% zero emission electricity sector by 2040. New York's Climate Leadership and Community Protection Act (CLCPA) calls for an orderly and just transition to clean energy and economy-wide carbon neutrality. Blending of hydrogen with NG is a positive step in this transition away from fossil fuels. This proof-of-concept demonstration enabled collaborators to learn how blending hydrogen adjacent to a turbine may help generate electricity in a low-to-no carbon way.

NYPA, partnering with EPRI, General Electric (GE) and other industry collaborators, led the project to investigate the potential of substituting hydrogen for a portion of NG for power generation for the purpose of reducing carbon emissions. The Brentwood GT was operated on a 5–44% (by volume) blend of hydrogen and NG to specifically examine the impact on GT operation and emissions (CO2, NOx, and CO). An upper hydrogen limit of 35% was first defined by GE, however, following the success of the first series of testing, it was agreed to test hydrogen over 40%.

3. MATERIALS AND METHODS

The NYPA Brentwood Hydrogen Demo used a 48MW aeroderivative turbine to complete this test. The equipment and methods utilized are described below.

3.1. Brentwood Site Technical Specifications

- Operational since 2001
- GE LM6000 PC (CF6-80C aircraft engine)
- Simple Cycle Gas Turbine, 48 MW output
- Utilization: ~10-15% annual capacity factor
- Emissions Control: Water injection, CO oxidation catalyst, selective catalytic reduction (SCR).
- NOx Emissions ~100ppm burner uncontrolled, less than 25 ppm burner w/$H_2$0 injection, and less than 2.5ppm post SCR system.

3.2. Overall Site Layout

The overall site layout consisted of five major systems, as listed below, and illustrated in Figure 1.

- Hydrogen supply system
- Natural Gas supply system
- Hydrogen blending system
- Fuel gas analyzer
- Gas turbine package

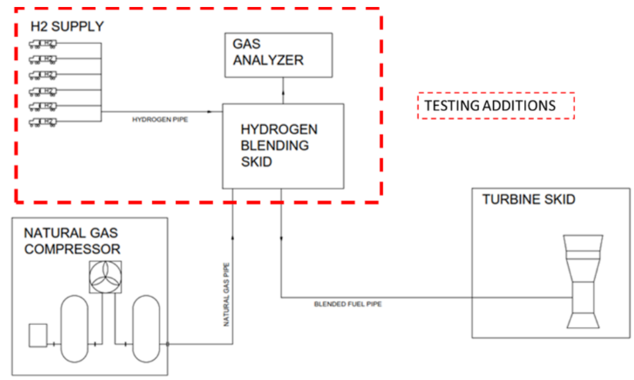

Figure 1. Blending skid site layout.

3.3. Hydrogen Supply System

The system consisted of three stanchions; each stanchion connected to two hydrogen trucks The stanchions used two pressure control valves, one for each truck, to regulate the pressure received from the trucks to the desired working pressure of the hydrogen system. These stanchions fed the hydrogen into a supply header, which fed the hydrogen to the fuel blending system and eventually into the turbine.

3.4. Blending Skid System

The hydrogen blending skid was designed to mix varying percentages of hydrogen and NG for use in the GT. The blending skid used an advanced hydrogen flow control valve to meter and control the flow of hydrogen being introduced into the NG supply. After the two fuels were combined in the same pipeline, the blending skid was configured to ensure a well-mixed blended fuel was sent to the turbine. A separate fuel analyzer was used to verify the mixture of hydrogen and NG. If there was any deviation from the target fuel blend ratio, it was then corrected by the system feedback controls.

The blending system included new controls allowing the operator to adjust the NG-to-hydrogen ratio. When all hydrogen permissives were met, the hydrogen was admitted through a sequence to establish a minimum flow. The controls then adjusted the hydrogen percentage until the target NG-to-hydrogen ratio was reached. When steady-state operation was achieved, the hydrogen blending skid managed the hydrogen fuel flow, allowing for standard unit operation.

3.5. Fuel Analyzer System

The fuel analyzer system, fabricated by Hobré, included two gas chromatographs (GCs) to measure the constituents of the blended fuel, a Wobbe Index Meter (WIM) to measure the low heating value (LHV), and a specific gravity sensor.

3.6. Test Plan

3.6.1 Objectives

The primary objective of the project was to confirm that the LM6000 PC Sprint GT could operate under normal operating regimes (12.5–48 MW ambient dependent) with hydrogen/NG fuel mixtures up to 35% hydrogen by volume. Since the blending system allowed a higher hydrogen maximum capacity, the test team agreed to test up to 44% hydrogen after 35% hydrogen was successfully demonstrated. An additional objective was to determine how hydrogen might impact the operational flexibility of the overall plant as renewable power generation variability sources become more integrated with the grid.

Other objectives for this test were as follows:

- Demonstrate the ability to remain in emissions compliance at approximately 25%, 50%, 75%, and 100% (as measured at the generator terminals) rated load with various ratios of hydrogen and NG.
- Measure the required derate of the GT (if any) to meet emissions while operating on hydrogen.
- Evaluate trade-offs between NOx and CO emissions and define turbine inlet temperature with various blends of NG and hydrogen.
- Evaluate the behavior of the SCR/CO catalysts when subjected to GT exhaust flow resulting from burning hydrogen– NG blends in the GT.
- Demonstrate the ability to follow a defined load ramp at a defined blended hydrogen ratio to ensure hydrogen stability during ramping of the GT.
- Evaluate any changes in combustion and gas path characteristics while operating on hydrogen.
- Evaluate challenges with the hydrogen supply chain.

3.6.2 Constraints

- GE restricted operational time while burning hydrogen was not to exceed total 150 hours. The hours limit was imposed to reduce risk to the equipment such as hydrogen embrittlement. The original package was not designed with the intent of operating on hydrogen fuel. The demonstration was to be completed on the existing package equipment and GT hardware with only additional test instrumentation added.
- Hydrogen was provided by the commercial gas company in groups of five or six tube trailers for each site delivery. Hydrogen was to be used until the overall supply pressure fell below 750 psi. A usable volume of 75,000 SCF of hydrogen was estimated for each tube trailer.
- Water flow setpoints for each load/hydrogen setpoint:
  - Water flow rate was maintained as the baseline NG flow reference to understand the effects of various blends of NG and H_2 on GT outlet NOx emissions.
  - As hydrogen levels were increased, water flow was to increase to the biased level for the purpose of returning NOx emissions to baseline NG levels.
- Test protocol points were to be repeated at least once to confirm consistency and repeatability.
- Installed equipment was to be disconnected from the plant at the end of the testing and the plant returned to its pretest configuration.
- Existing NG equipment sizing (compressor and piping) was to be adequate to support the higher volumetric flow rates at target volume ratios.
- The ambient air inlet temperatures were to be above 50°F to allow uninterrupted operation with GT SPRINT which boosts power and represents the typical operational profile.

3.6.3 Exclusions

- Testing the GT's ability to start and stop on a hydrogen blended fuel
- Long-term impact on equipment with hydrogen blended fuels
- Explore upper co-firing limit without any gas turbine capital investment
- Explore uncontrolled NOx/CO emissions at the engine outlet

4. RESULTS AND DISCUSSION

4.1. Conversion of Volumetric Measurements to Mass Rate

For the unique conditions of this test program, it is extremely important to note that dry ppm volumetric (ppmv dry) analyzer readings of exhaust components, such as NOx or CO, either at the actual O_2 level or corrected to 15% O_2, should not be directly used for comparison purposes across different natural gas and hydrogen fuel blend ratios. This is because fundamental combustion excess air requirements and exhaust gas moisture levels change as the hydrogen fuel fraction changes. As moisture is removed from the exhaust gas through the sample conditioning process at a given hydrogen fuel blend ratio, the resulting dry sample will have a different volumetric component concentration compared to another fuel blend condition. This change in volumetric concentration is artificial, ultimately caused by the exhaust gas conditioning (moisture removal) process. Taking the additional step of correcting the ppm-dry reading to 15% O_2 further compounds the artificial difference. These effects are described in more detail in a recent ASME paper authored by Georgia Tech and EPRI [1].

An approach that removes this artificial difference is to convert the ppm-dry analyzer readings to a mass rate incorporating the change in the fuel components. Consequently, the results reported in the following section were converted to lb/hr units. An accepted methodology for converting the NOx and CO ppm-dry analyzer readings to mass rates is given in EPA Method 19 [2].

For the gas turbine outlet emission analyzers, multi-point calibrations for were performed for each instrument (NOx, CO, CO_2, O_2) by introducing calibration gases to the system at the sample probe. This verified the response for each parameter through the entire sample system and demonstrated linearity of the analyzers. Calibrations were performed using EPA Protocol 1 calibration gases at the beginning and end of each test period.

4.2. GT Performance

Two acoustic sensors were placed in the engine combustor casing to monitor the acoustic pressure within the GT. During the test, the engine acoustic dynamics were monitored to see what impact hydrogen had, if any, on the turbine, and to ensure the addition of hydrogen did not create any risk to the engine by inducing a new resonant frequency or an increase in peak-to-peak pressure within the combustor.

Periodic borescope inspections of the combustor between test runs revealed no increased deterioration or damage due to an addition of hydrogen to the fuel blend. Constant monitoring of the T48 temperature probes, located at the first stage of the inlet of the low-pressure turbine, revealed no change or shift in the circumferential temperature profile due to the addition of hydrogen. The T48 temperatures were monitored and evaluated for variations and deviations at all load conditions and hydrogen percentages for each test point.

4.3. GT Outlet NOx and CO Mass Emissions Data

Table 1 and Table 2 provide summaries of the GT outlet NOx and CO mass emissions data for constant water injection and increasing water injection conditions, respectively. The testing occurred in April-May, 2022, over six test days totally 12 hours.

Table 1. GT Outlet NOx and CO Mass Emissions Data with Constant Water Injection

12-Apr-22

Time	Load, MWg	Water, GPM	Fuel H_2, % vol	CO_2, ton/hr	O2, % dry	NOx, lb/hr	NO_2/NOx	CO, lb/hr
10:03	46.8	42.2	0.0	26.4	14.2	35.4	0.24	39.2
11:18	46.9	42.5	5.5	26.0	14.2	35.1	0.21	31.0
11:32	46.8	42.3	16.4	25.1	14.2	37.2	0.17	16.9
11:48	46.8	42.3	27.3	23.9	14.3	40.2	0.15	11.1
11:59	46.8	42.3	32.8	23.3	14.3	42.0	0.14	8.9
12:09	46.8	42.1	35.0	22.7	14.3	43.3	0.14	7.6
10:16	40.3	37.9	0.0	23.6	14.7	26.2	0.39	72.5
13:09	40.3	38.1	5.5	23.2	14.6	28.7	0.27	37.7
12:58	40.3	38.1	16.4	22.4	14.7	29.7	0.21	20.5
12:43	40.3	38.0	27.3	21.4	14.8	30.7	0.19	13.0
12:29	40.3	37.9	35.0	20.4	14.9	31.8	0.19	8.9
10:42	26.3	28.2	0.0	17.6	15.5	19.6	0.41	58.6
13:24	26.2	28.0	5.5	17.2	15.5	21.4	0.29	29.3
13:35	26.2	28.0	16.4	16.7	15.6	21.7	0.24	17.2
13:50	26.2	27.9	27.3	15.9	15.6	22.9	0.21	10.6
14:02	26.2	27.9	35.0	15.2	15.6	23.4	0.19	6.9
10:53	12.7	16.8	0.0	11.9	16.4	12.4	0.68	79.1
15:07	12.6	17.2	5.5	11.7	16.4	12.9	0.51	50.3
14:56	12.6	17.1	16.4	11.2	16.4	13.4	0.40	30.3
14:40	12.6	17.0	27.3	10.7	16.5	13.9	0.32	16.7
14:27	12.7	16.8	35.0	10.3	16.5	14.4	0.27	9.3

3-May-22

Time	Load, MWg	Water, GPM	Fuel H_2, % vol	CO_2, ton/hr	O2, % dry	NOx, lb/hr	NO_2/NOx	CO, lb/hr
10:00	46.7	42.3	0.0	25.7	14.3	35.1	0.22	38.9
10:11	46.4	42.6	16.4	24.3	14.4	35.9	0.17	19.0
11:34	45.7	42.0	38.3	21.5	14.6	38.3	0.15	9.4
11:45	45.6	42.5	43.7	20.8	14.7	38.5	0.15	8.1
9:47	40.3	37.9	0.0	22.9	14.8	25.5	0.37	72.1
12:21	40.3	37.9	16.4	21.6	14.8	27.8	0.23	26.1
12:07	40.3	37.6	38.3	19.6	15.0	31.0	0.18	9.8
11:57	40.4	38.0	43.7	19.0	15.1	31.7	0.18	8.4

Table 2. GT Outlet NOx and CO Mass Emissions Data with Increasing Water Injection

12-Apr-22

Time	Load, MWg	Water, GPM	Fuel H_2, % vol	CO_2, ton/hr	O2, % dry	NOx, lb/hr	NO_2/NOx	CO, lb/hr
10:03	46.8	42.2	0.0	26.4	14.2	35.4	0.24	39.2
11:22	46.8	44.0	5.5	26.0	14.2	33.8	0.24	38.0
11:36	46.9	45.3	16.4	25.1	14.2	34.3	0.21	24.8
11:52	46.9	47.2	27.3	23.9	14.2	33.2	0.20	17.9
12:03	46.9	46.2	32.8	23.3	14.3	34.9	0.19	14.0
12:13	46.9	47.9	35.0	22.7	14.3	34.9	0.18	12.2
10:16	40.3	37.9	0.0	23.6	14.7	26.2	0.39	72.5
13:12	40.3	38.9	5.5	23.2	14.6	27.1	0.32	49.1
13:01	40.2	41.1	16.4	22.4	14.6	26.8	0.27	36.4
12:47	40.3	41.2	27.3	21.4	14.7	25.6	0.25	24.3
12:33	40.3	43.6	35.0	20.4	14.8	25.6	0.24	16.9
10:42	26.3	28.2	0.0	17.6	15.5	19.6	0.41	58.6
13:27	26.2	29.3	5.5	17.2	15.5	20.5	0.32	39.3
13:39	26.2	29.5	16.4	16.7	15.5	19.7	0.31	28.6
13:54	26.2	31.8	27.3	15.9	15.5	18.9	0.29	19.4
14:06	26.1	32.3	35.0	15.2	15.6	19.0	0.27	13.2
10:53	12.7	16.8	0.0	11.9	16.4	12.4	0.68	79.1
15:11	12.6	18.0	5.5	11.7	16.4	12.4	0.59	60.9
15:00	12.6	18.5	16.4	11.2	16.4	12.2	0.49	40.8
14:47	12.7	19.4	27.3	10.7	16.5	11.8	0.43	30.0
14:31	12.6	19.5	35.0	10.3	16.5	12.2	0.35	16.8

3-May-22

Time	Load, MWg	Water, GPM	Fuel H_2, % vol	CO_2, ton/hr	O2, % dry	NOx, lb/hr	NO_2/NOx	CO, lb/hr
10:00	46.7	42.3	0.0	25.7	14.3	35.1	0.22	38.9
10:15	46.7	46.1	16.4	24.3	14.3	31.8	0.22	29.7
11:39	46.0	48.3	38.3	21.5	14.6	30.6	0.20	16.1
-	-			-	-	-	-	-
9:47	40.3	37.9	0.0	22.9	14.8	25.5	0.37	72.1
12:30	40.3	40.8	16.4	21.6	14.8	24.2	0.30	45.1
12:11	40.3	43.2	38.3	19.6	15.0	25.0	0.23	18.6
12:01	40.3	44.0	43.7	19.0	15.0	25.1	0.23	16.2

Figure 2 through Figure 5 show how GT outlet NOx and CO mass emissions (lb/hr) changed as the volumetric hydrogen fuel percentage was varied at 100% (47 MW) and 25% (12.7MW) load conditions. Key findings from these plots are summarized below:

- At steady water injection conditions, GT outlet NOx levels increased as the hydrogen fuel fraction increased. At 35–45% hydrogen, NOx generally increased by 20–25% relative to the 0% hydrogen baseline condition. It is important to note that this NOx increase observation is specific to LM6000 SAC technology and may not apply to dry-low emissions combustors. Potential implication for the industry: When firing higher percentages of hydrogen, LM6000 operators may need to increase water injection to maintain steady GT outlet NOx levels. If this is not an option and GT outlet NOx levels increase, LM6000 owners may need to modify the existing SCR system design and/or adjust catalyst replacement intervals to maintain stack permit compliance (potentially increasing capital and operations and maintenance [O&M] costs).

- At steady water injection conditions, GT outlet CO levels decreased as the hydrogen fuel fraction increased. At 35–45% hydrogen, CO generally decreased by over 80% from the 0% hydrogen baseline condition. Even at lower hydrogen levels of 15%, CO emissions were reduced by more than 50%. Potential implication for the industry: This was a significant positive impact when firing hydrogen. Depending on stack permit requirements, hydrogen cofiring could allow some LM6000 units to operate across a wider load range (improved turndown capability) without CO oxidation catalysts or with reduced volumes of catalyst (potentially lowering capital and O&M costs).

- GT Outlet NOx and CO trends were repeatable when comparing overlapping conditions between the April and May hydrogen tests. Figures 2 through 5 illustrate this consistency at full load and low load. Although the trends are consistent, note the deviation in the NOx curves for the full load tests in May compared to April as hydrogen levels increased (Figure 2). During the May tests, the load dropped slightly from 47 to 46 MWg (due to different ambient conditions on different test days) and this appeared to lower the baseline NOx levels below the original conditions. The result was artificially lower NOx levels for these tests at higher hydrogen levels (~10% increase rather than >20% as seen in April).

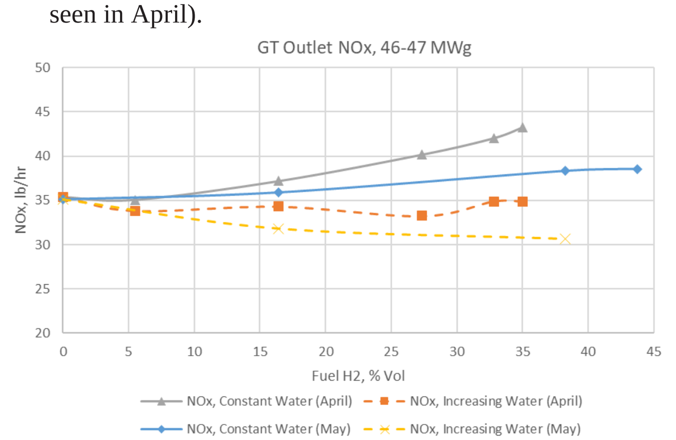

Figure 2. Full load GT outlet NOx mass emissions with increasing hydrogen percentage at constant and increasing water injection flow

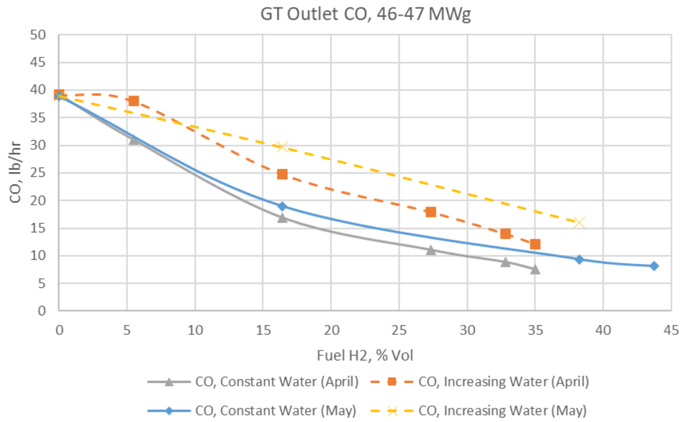

Figure 3. Full load GT outlet CO mass emissions with increasing hydrogen percentage at constant and increasing water injection flow

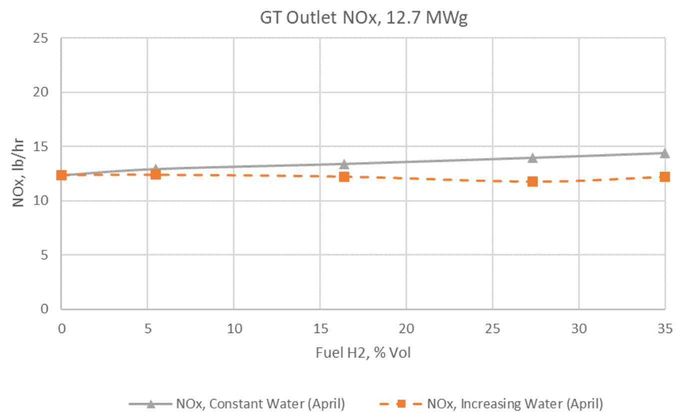

Figure 4. Low load GT outlet NOx mass emissions with increasing hydrogen percentage at constant and increasing water injection

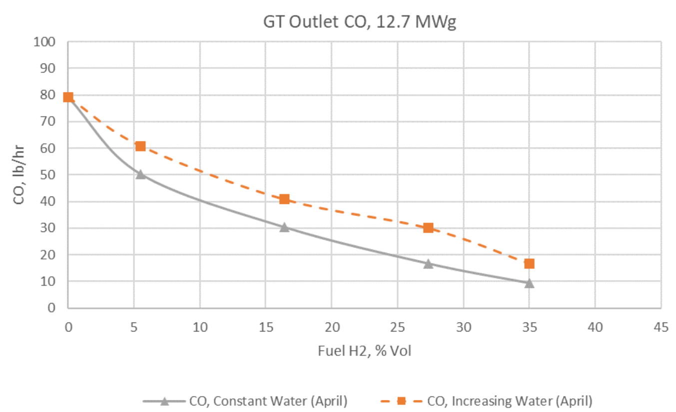

Figure 5. Low load GT outlet CO mass emissions with increasing hydrogen percentage at constant and increased water injection flow

Figure 6 shows the water injection flow rate required to keep NOx levels constant across the hydrogen blend range at different GT load conditions. At a given GT load, the required water increase remained below 20% at the highest hydrogen blend conditions compared to the NG baseline. The water increase was approximately linear with the hydrogen fuel percentage increase.

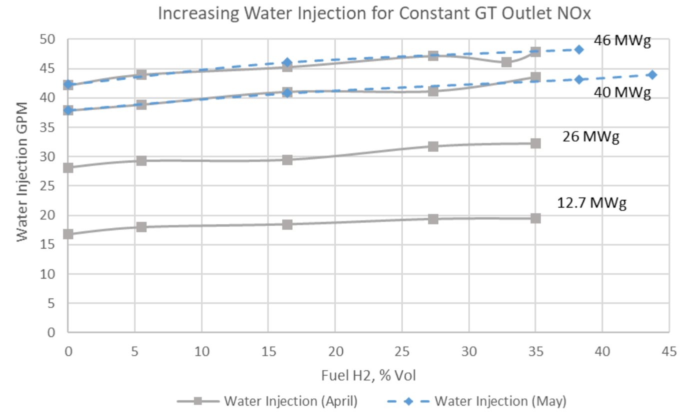

Figure 6. Increasing water injection flow for constant GT outlet NOx mass emissions at all load conditions

Figure 7 illustrates the change in molar NO2/NOx with hydrogen variation. The plot shows that without hydrogen, the NO2/NOx fraction increased from 0.25 to nearly 0.7 as load decreased from 47 MWg to 12.7 MWg. As the hydrogen fuel percentage was increased, the NO2/NOx fraction decreased so that at hydrogen fuel levels above 35%, the NO2/NOx fraction was below 0.3 for all load conditions. Potential implication for the industry: This may benefit LM6000 turndown capability since NO2/NOx levels above 0.5 at lower load temperature conditions could have a detrimental impact on the efficiency and performance of some SCR catalyst formulations.

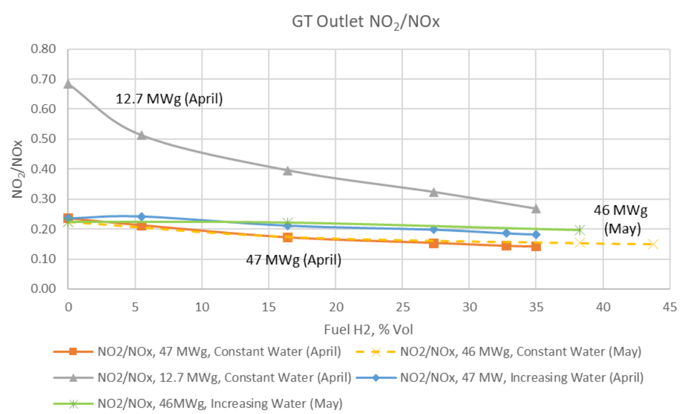

Figure 7. GT outlet NO2/NOx (molar basis) with increasing hydrogen fuel percentage at 100 and 25% load conditions

4.4. Stack NOx, CO, and Ammonia Slip Emissions Data

Figure 8 and Figure 9 show GT outlet and stack emission data at full load conditions during the May 2022 test program. This data set shows the ability of the current SCR and CO catalyst systems to keep the stack NOx, CO, and ammonia slip levels below the regulatory permit limits (based on the current NG fuel permit), using increased water injection rates at the higher range of hydrogen fuel percentages. The ability to increase water injection was needed for maintaining constant GT outlet NOx levels as the fuel hydrogen levels increased. Under normal conditions while firing NG, additional water injection would result in higher CO levels. However, with increasing hydrogen fuel levels, the GT outlet CO levels decreased even as water injection was increased. This reduced the amount of CO oxidation required from catalyst at this condition, with the implication that less CO catalyst material would be needed to reach the stack permit requirement.

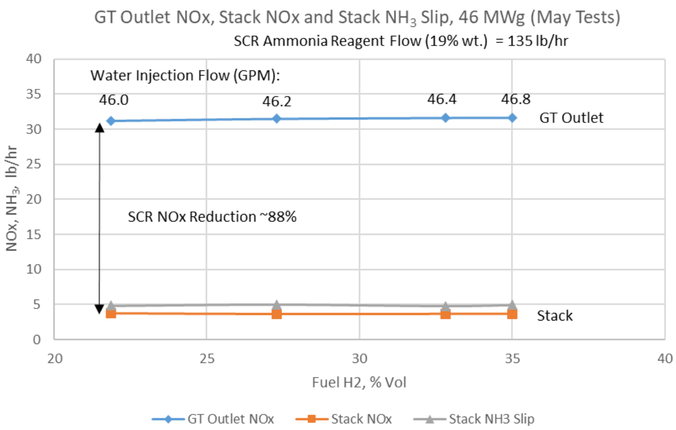

Figure 8. Full load GT outlet NOx, stack NOx, and stack NH3 slip mass emissions

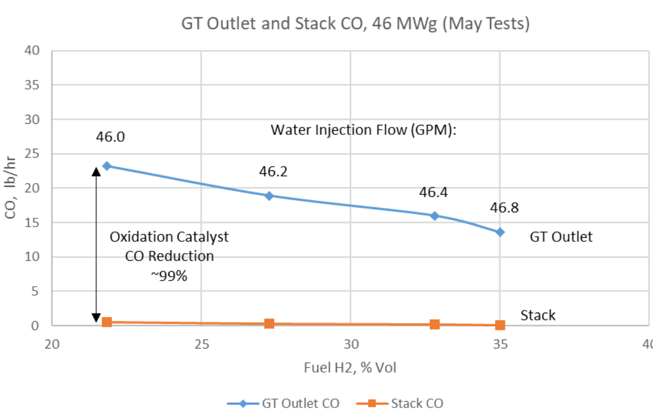

Figure 9. Full load GT outlet and stack CO mass emissions

4.5. CO_2 Mass Emissions Data

The curve in Figure 10 shows the expected reduction in CO2 mass emissions (using an assumed and constant NG composition) with increasing hydrogen content in a NG blend along with calculated values from the April and May 2022 hydrogen cofiring tests. The calculated values from the tests (based on the actual fuel analyses) closely follow the expected curve. The reduction in CO2 emissions was directly proportionally to the reduction of carbon as a fuel source.

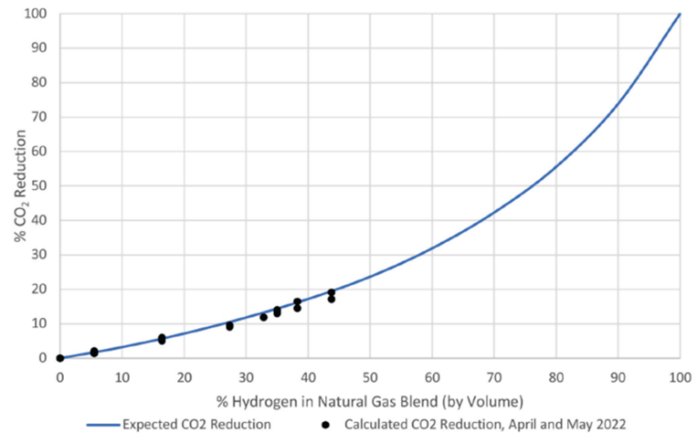

Figure 10. Expected and calculated CO2 mass emission reductions for natural gas/hydrogen blends

4.6. Key Findings

The results of the test confirmed that blending hydrogen with natural gas results in a reduction in carbon emissions. This test also showed that it was possible to manage NOx on existing equipment that is currently in operation.

- At steady-state conditions, the current SCR and CO catalyst systems were able to control the stack NOx, CO, and ammonia slip levels below the plant's regulatory permit limits (based on the current NG fuel permit) with hydrogen cofiring.
- Reductions in the calculated CO_2 mass emission rates (ton/hr) with increasing hydrogen fuel percentages followed the expected trends. At 47 MWg, CO_2 mass emission rates were reduced by approximately 14% at 35% hydrogen cofiring.
- At steady water injection conditions, NOx levels increased by up to 24% as the hydrogen fuel fraction increased. It is important to note that this NOx increase observation is specific to LM6000 SAC technology and may not apply to dry-low emissions combustors. At the same GT load, maintaining a constant GT outlet NOx level while increasing the hydrogen fuel percentage required almost a linear increase in the NOx water injection flow rate. A key implication is that hydrogen cofiring could require LM6000 operators to increase water injection to maintain steady GT outlet NOx levels. If this is not an option and GT outlet NOx levels increase, owners may need to modify the existing SCR system design and/or adjust catalyst replacement intervals to maintain stack permit compliance, potentially increasing capital and O&M costs.
- At steady water injection conditions, CO levels decreased by up to 88% as the hydrogen fuel fraction

increased. Even with increasing water injection rates for NOx control, CO levels decreased with increasing hydrogen percentages theorizing due to the enhanced CO oxidation in the presence of OH radicals from hydrogen combustion. Depending on stack permit requirements, hydrogen cofiring could allow some LM6000 units to operate across a wider load range (improved turndown capability) without CO oxidation catalysts or with reduced volumes of catalyst, potentially lowering capital and O&M costs.

- As the hydrogen fuel percentage was increased with steady water conditions, the NO_2/NOx fraction decreased by up to 61%. This may also benefit LM6000 turndown capability since higher NO_2/NOx levels (above 0.5) at lower load temperature conditions could have a detrimental impact on the efficiency and performance of some SCR catalyst formulations.
- NOx and CO trends were repeatable when comparing overlapping conditions between the April and May hydrogen tests.
- Vibrometer and dynamic pressure sensor measurements (GT test equipment installed for test) showed that combustion dynamics pressure (amplitude) did not increase with increasing hydrogen fuel levels, indicating that the flame remained stable.
- GT control was stable without experiencing any trips during variations in fuel composition, provided the LHV and specific gravity were transmitted to control software at the appropriate time.
- Periodic borescope inspection of combustor between the tests showed no apparent damage due to hydrogen testing.

5. SUMMARY AND CONCLUSIONS

NYPA successfully conducted a pilot project to advance low-carbon technologies for power generation at the Brentwood Power Station. Partnering with EPRI, GE, and other industry collaborators, NYPA demonstrated the burning of a 5–44% hydrogen blend on an LM6000 GT with SAC technology to identify the resulting impact on stack emissions (CO2, NOx, CO) and GT operation.

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7. REFERENCES

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