Applied Economics Clinic
Economic and Policy Analysis of Energy, Environment and Equity

Comments on Astoria Gas Turbine Power LLC's Proposed Gas-Fired Combustion Turbine

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Bryndis Woods, PhD
Elizabeth A. Stanton, PhD

Introduction

Astoria Gas Turbine Power LLC's ("Astoria" or "the Company") proposes to build a 437 MW gas-fired simple cycle combustion turbine generator (CTG) (referred to as the "proposed Project" throughout these comments) at the Astoria Generating Facility—located in Astoria, New York. On behalf of Earthjustice for their engagement in the New York State Title V and Environmental Impact Statement processes before the New York Department of Environmental Conservation (NYSDEC), these comments assess the proposed Project's consistency with the electric sector goals set forth in New York's 2019 Climate Leadership and Community Protection Act (CLCPA).[1] These comments are informed by our review of Astoria's 2021 Draft Supplemental Environmental Impact Statement (DSEIS) and its appendices.[2] We specifically consider the Company's claims regarding the potential use of hydrogen fuel at the proposed plant.

Astoria Gas Turbine Power LLC incorrectly claims that the proposed Project is CLCPA-consistent

New York State's CLCPA requires 70 percent renewable electric generation by 2030 and zero emissions electricity by 2040, which means any remaining fossil fuel-powered generation can no longer operate beginning in 2040 (see Figure 1 below). These so-called "stranded assets" would lose all value by January 1, 2040 at the latest. By 2030, New York must reduce its share of oil, gas, and coal-fired generation from 63 percent in 2020 (gas-fired generation alone accounted for 37 percent of all generation in 2020) to 30 percent,[3] and increase its share of renewable generation from 26 percent in 2020 to 70 percent in 2030.[4] After 2040, a gas simple cycle CTG may no longer operate in New York State—this would include the proposed Project unless it has been converted to run entirely on a zero-emissions fuel. Hydrogen is not a

[1] New York State Climate Leadership and Community Protection Act, S.B. 6599, 242d Sess. (N.Y. 2019), https://www.nysenate.gov/legislation/bills/2019/s6599. ("CLCPA").
[2] AECOM, *Draft Supplemental Environmental Impact Statement: Astoria Replacement Project* (June 2021), https://www.nrg.com/assets/documents/legal/astoria/00_2021/astoria-draft-dseis-06-30-2021.pdf. ("DSEIS"); DSEIS Appendices A–D (June 2021), https://www.nrg.com/assets/documents/legal/astoria/00_2021/appendices-a-d-06-30-21.pdf; DSEIS Appendices E–M, https://www.nrg.com/assets/documents/legal/astoria/00_2021/appendices-e-m-06-30-21.pdf.
[3] U.S. Environmental Information Administration. 2020. Form EIA 923. Detailed data with previous form data: Electricity. US Energy Information Administration. Available at: https://www.eia.gov/electricity/data/eia923/.
[4] Ibid.

zero-emission fuel, as is discussed in detail in Section 2 below.

Figure 1. CLCPA Requirements

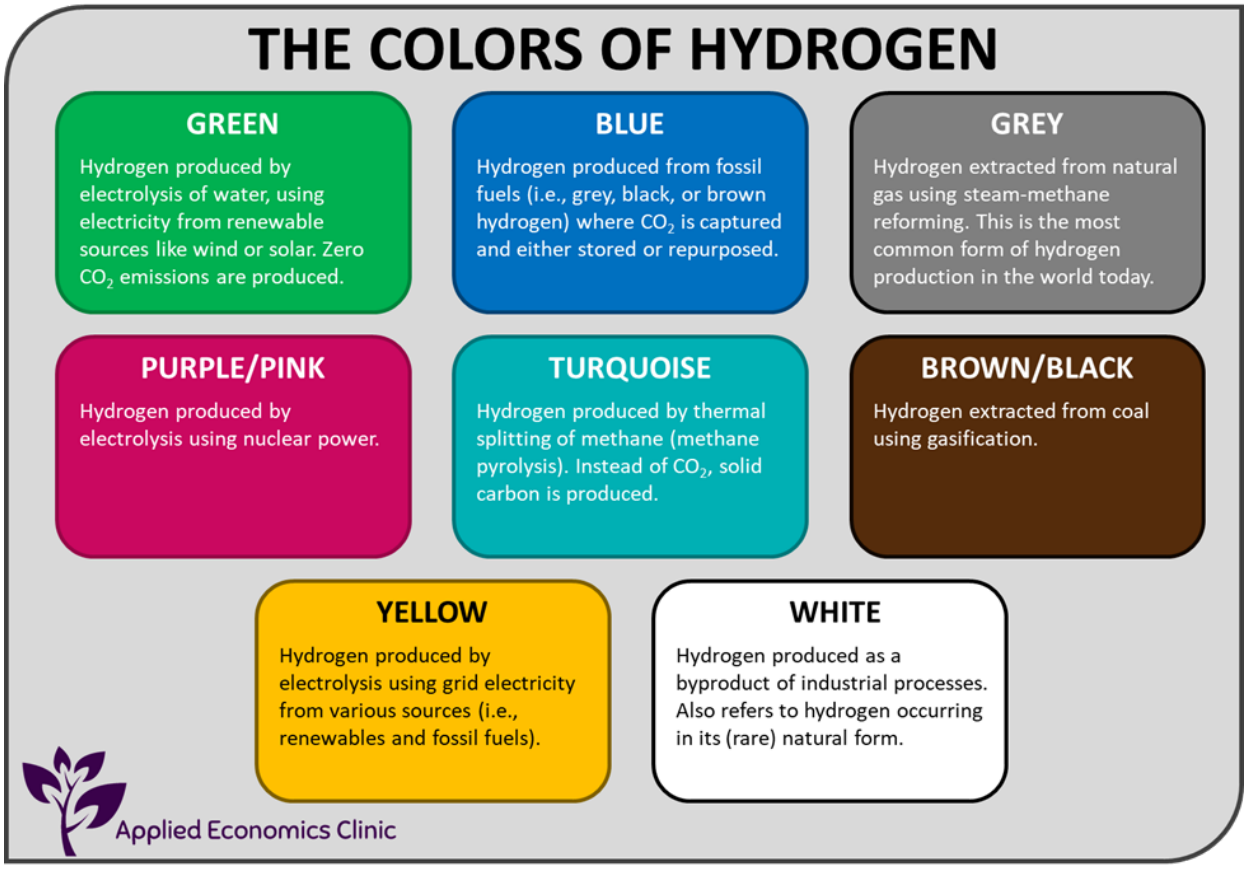
Category	Goal
Renewables	Achieve: ▪70% renewable electric generation by 2030 ▪100% zero-emissions electricity by 2040
Rooftop Solar	Install 6 GW by 2025
Offshore Wind	Install 9 GW by 2035
Battery	Install 3 GW by 2030
Energy Efficiency	Increase cumulative savings to reach 23% of 2030 total demand by 2030
Statewide Emissions	Reduce: ▪40% from 1990 levels by 2030 ▪85% from 1990 levels by 2050

Data source: CLCPA, see note 1.

In its 2021 DSEIS, Astoria asserts that the proposed gas-fired Project is consistent with CLCPA requirements **without** converting from gas to "green" hydrogen fuel (that is, hydrogen produced from 100 percent renewable energy sources and therefore with less emissions than other kinds of hydrogen, see Figure 2) or an—as yet unidentified—zero-emission fuel.[5] Hydrogen produced with anything less than 100 percent renewable energy does not qualify as green hydrogen. The Company concedes as much, stating in its DSEIS that "GHG emission reduction benefits from the use of hydrogen are only achieved if the fuel is produced using renewable energy (green hydrogen)."[6]

[5] DSEIS. Page 3-52.
[6] Ibid. Page 3-50.

Figure 2. The colors of hydrogen



Despite this disclaimer, Astoria repeatedly describes the proposed Project's ability to switch to a zero-emitting fuel in the context of 2030 and 2040 CLCPA goals, but omits any explanation of why a switch to zero-emitting fuel would be necessary if the proposed Project were already consistent with the CLCPA.[7][8] The Company also notes that if a zero-emission fuel is not available by the time the CLCPA ends all operation of gas-fired resources in 2040 (including the proposed Project), then the proposed Project will be retired.[9]

[7] DSEIS Appendix F.1: Air Emissions Supporting Information. Page 2.
[8] DSEIS Appendix D.5: Final Scoping Document. Page 2-1.
[9] Ibid. Page 2-1, Footnote 1.

Astoria does not have a coherent explanation of how the proposed Project is consistent with the CLCPA. Instead, the Company offers multiple, mutually exclusive explanations, none of which are adequately demonstrated. According to Astoria's DSEIS the proposed Project is simultaneously:

- "already consistent with the CLCPA",[10] despite the fact that gas-fired resources must decrease their share of New York's electric generation to be consistent with CLCPA goals;
- "well positioned to transition to renewable hydrogen fuel in place of natural gas or fuel oil to satisfy [the CLCPA]",[11] despite the wholly speculative nature of this conversion; and/or
- in the absence of a zero-emissions fuel—to "comply with the CLCPA…it will cease operating",[12] clearly demonstrating the proposed Project's inconsistency with CLCPA's 2040 electric sector goal.

Should the proposed Project be approved and built, the Company projects the power plant to come online in 2023[13] and is expected to have a lifetime of 30 years—operating economically through 2053.[14] The proposed Project is forecasted to emit 713,000 tons of carbon dioxide equivalent per year,[15] which means that—from 2023 through 2039—the proposed Project would emit over 8.5 million tons of carbon dioxide equivalent. In 2040, if zero-emission fuels are unavailable, infeasible, or prohibitively costly, the proposed Project will retire 13 years ahead of schedule.

To be clear, the Company claims that the proposed Project—which will produce up to 713,000 tons of greenhouse gas emissions every year it operates—is nevertheless CLCPA-consistent, even without converting to a speculative zero-emission source, because it could retire 13 years early.

Contrary to the Company's claims, the proposed Project interferes with the pre-2040 and 2040 goals of the CLCPA because it is fossil fuel-fired.

New fossil fuel resources like the proposed Project interfere with the CLCPA and must retire early unless they can be converted to as-yet-hypothetical zero-emissions fuels. By 2030, New York's electric sector must achieve 70 percent renewables and the state as a whole must achieve a 40 percent reduction in greenhouse gas emissions. The addition of new fossil-fuel infrastructure interferes with this statutory mandate and should be rejected on this basis.

DEC must also consider that a decision to grant a permit for Astoria's proposed Project may influence other gas generation owners to argue that their individual generators, like Astoria's, should be approved because, individually, gas generators have a small effect on the electric sector's total emissions. For this reason, if each application to build a new fossil-fueled power plant is considered only in isolation and not as part of a larger, integrated, legally-mandated renewable transition, New York State is at serious risk of overshooting

[10] DSEIS. Page 3-52.
[11] DSEIS Appendix D.5: Final Scoping Document, Page 2-1.
[12] Ibid. Page 2-1. Footnote 1.
[13] DSEIS. Page 3-13.
[14] Ibid. Page 3-109.
[15] Ibid. Table 3.17: Maximum Potential Combustion Turbine Air Emissions -Comparison of Current Configuration of the Project to Previously Approved Configuration of the Project.

its 2030 and 2040 emission limits.

Hydrogen is not zero emissions and does not meet CLCPA requirements

Astoria's claim that the proposed Project is "well positioned to transition to renewable hydrogen fuel"[16] is unpersuasive for three main reasons: first, because it is not technically feasible for the proposed Project to use more than 10 percent hydrogen fuel, which would only reduce emissions by 3 percent; second, because the Company admits that there is insufficient hydrogen fuel supply (of any type, see Figure 2 above) and research indicates that, even if the proposed Project can be modified at great cost to accommodate hydrogen, the existing gas pipeline system cannot ensure its safe transport; and third, because hydrogen fuel combustion causes both greenhouse gas and conventional air emissions, no matter the share of hydrogen in question and regardless of how the hydrogen is produced (in other words, regardless of hydrogen's source materials).

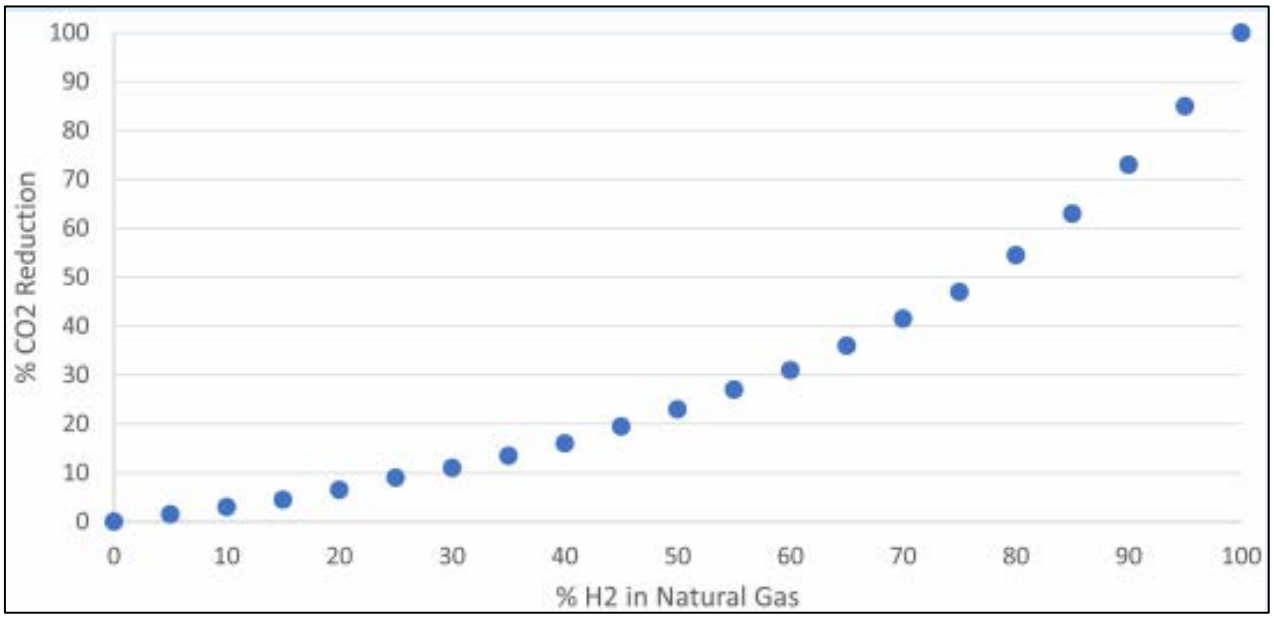
1. *The proposed Project's transition to green hydrogen fuel would not result in meaningful greenhouse gas emission reductions*

As proposed, the proposed Project can only use up to 10 percent hydrogen fuel (of any type)—with modifications—a share that would only deliver emission reductions of 3 percent.

The emission reductions achieved from blending hydrogen (from any source material) with gas are non-linear; that is, 10 percent hydrogen in a fuel blend does not lead to a 10 percent emission reduction because the difference between gas and hydrogen's volumetric density leads to less hydrogen in the fuel blend on a heat input basis.[17] According to the Company, "with the addition of several balance of plant systems it is technically feasible for the Astoria Replacement Project to immediately use a blend of hydrogen fuel up to 10 percent."[18] Assuming that the proposed Project installs the "balance of plant systems" needed to blend 10 percent hydrogen into its fuel, that would only result in 3 percent emissions savings (see Figure 3).

[16] DSEIS Appendix D.5: Final Scoping Document. Page 2-1.
[17] GE Power. February 2019. "Power to Gas: Hydrogen for Power Generation." Available at: https://www.ge.com/content/dam/gepower/global/en_US/documents/fuel-flexibility/GEA33861%20Power%20to%20Gas%20-%20Hydrogen%20for%20Power%20Generation.pdf.
[18] DSEIS Appendix L: Information from General Electric Regarding Use of Green Hydrogen. Exec. Summary. Page 1.

Figure 3. Carbon dioxide emission reduction for hydrogen-gas fuel blends by volume



Source: Reproduced from Electric Power Research Institute. November 19, 2019. Technology Insights Brief: Hydrogen-Capable Gas Turbines for Deep Decarbonization. Figure 1. Available at: https://www.epri.com/research/products/000000003002017544.

A 2021 study conducted by General Electric on its gas combustion turbines confirms Astoria's technical issues with using a high share of hydrogen in its proposed Project. General Electric suggests that reaching a 50-50 blend of hydrogen and gas fuel would require even more extensive modifications to the proposed Project than those necessary to reach the "technically feasible" 10 percent blend, including different ventilation systems, enclosures, and controls to address hydrogen's flammability:[19]

> "Today, based on laboratory testing and analysis, GE's fielded and proven DLN 2.6e combustion system available for 7HA gas turbines has the capability to operate up to 50% hydrogen by volume in natural gas with minimal modifications to the turbine itself. Supporting systems, however, will need to be either installed or upgraded for the turbine to operate on hydrogen. One such example of an additional system that would need to be installed is a hydrogen blending system upstream of the gas turbines. Other examples of upgrades needed would be the fuel handling equipment, piping sizing and materials, and enclosure ventilation. Additionally, changes to the gas turbine control software, flame detectors, fire protection and area classification will be required at higher levels of H2."[20]

[19] GE. 2021. "Hydrogen as a Fuel for Gas Turbines: A Pathway to Lower CO2." Available at: https://www.ge.com/content/dam/gepower-new/global/en_US/downloads/gas-new-site/future-of-energy/hydrogen-fuel-for-gas-turbines-gea34979.pdf. Pages 3-4.
[20] DSEIS Appendix L: Information from General Electric Regarding Use of Green Hydrogen. Technology Stages. Page 2.

According to the Company, the proposed Project is not equipped to blend any hydrogen and, even with modifications, could not currently blend more than 10 percent hydrogen into its gas fuel,[21] and, therefore, could only provide a 3 percent emission reduction.[22] That means the proposed Project cannot, at present, achieve meaningful emission reductions and would need extensive modifications to be able blend enough hydrogen to achieve even just 20 to 25 percent carbon dioxide emission reductions. (Figure 2 shows that a 50 percent hydrogen blend achieves less than 25 percent emission reductions.[23]) Beyond that, the use of 100 percent hydrogen in utility gas systems is purely hypothetical (currently, only one commercially available gas turbine can accommodate 100 percent hydrogen fuel[24]) and, even if Astoria were able to achieve it, would not be zero greenhouse gas emissions (for reasons given below).

2. *Conversion of the proposed Project to hydrogen is infeasible and, even if accomplished, may be unsafe*

Second, the Company admits that there is insufficient hydrogen fuel supply of any type to fuel even 10 percent of the proposed Project's needs and research indicates that—even if the proposed Project can be modified at great cost to accommodate 10 percent or more hydrogen into its fuel mix—the existing gas pipeline system cannot ensure its safe transport.

Current use of hydrogen fuel (from any source material) is infeasible for the proposed Project due to insufficient supply of hydrogen and lack of safe hydrogen transportation options. Astoria admits as much, stating that "[h]ydrogen…is not commercially available to serve the Project at this time," and is presently "a technically infeasible fuel choice for the Project's CTG."[25] To produce enough green hydrogen to power the proposed Project, using today's technology, over 1,700 MW of wind power would be required.[26] (As of 2020, New York State had approximately 1,990 MW of wind capacity installed.[27]) Demand for renewable

[21] DSEIS Appendix L: Information from General Electric Regarding Use of Green Hydrogen. Exec. Summary. Page 1.
[22] GE Power. February 2019. "Power to Gas: Hydrogen for Power Generation." Available at: https://www.ge.com/content/dam/gepower/global/en_US/documents/fuel-flexibility/GEA33861%20Power%20to%20Gas%20-%20Hydrogen%20for%20Power%20Generation.pdf.
[23] Electric Power Research Institute. November 19, 2019. Technology Insights Brief: Hydrogen-Capable Gas Turbines for Deep Decarbonization. Available at: https://www.epri.com/research/products/000000003002017544. Figure 1.
[24] GE. 2021. "Hydrogen as a Fuel for Gas Turbines." Available at: https://www.ge.com/content/dam/gepower-new/global/en_US/downloads/gas-new-site/future-of-energy/hydrogen-fuel-for-gas-turbines-gea34979.pdf. Page 7.
[25] AECOM on behalf of Astoria Gas Turbine Power LLC. May 2021. Title V Air Permit Major Modification Turbine Replacement Project. Available at https://www.nrg.com/assets/documents/legal/astoria/00_2021/astoria-gas-turbine-llc-air-permit-application-revision-5-28-2021.pdf. Page 4-5.
[26] Calculated using GE's Hydrogen Cost Calculator tool. Available at: https://www.ge.com/gas-power/future-of-energy/hydrogen-fueled-gas-turbines. (select "Try our hydrogen calculator"; choose "7HA.03" from the "What kind of gas turbine do you have?" dropdown; choose "simple" under the "How is your plant configured?" dropdown; type "2710" in the "HRS" box under "What are the expected annual operating hours of your gas turbine?"; type "99" in the "%" box under "What's the volume percent of hydrogen you want to run through?"; type "4.60" in the "$" box under "What CO_2 tax rate do you pay today, if any?"; then click "See your hydrogen potential") (last visited Sept. 7, 2021). This result is based on estimate of 2,710 annual operating hours at 99% hydrogen on a 7HA.03 turbine configured as a simple cycle plant and a current CO_2 tax of $4.60 per ton (RGGI) and assumes a 50 percent capacity factor for wind.
[27] US EIA. June 3, 2021. Form EIA-860 detailed data with previous form data (EIA-860A/860B). 20202ER. Available at: https://www.eia.gov/electricity/data/eia860/.

energy supplies in New York will grow as the state moves towards meeting the requirements of the CLCPA and as electrification becomes more widespread. Producing green hydrogen would have the effect of further increasing demand for renewable energy sources. It is also important to note that according to the U.S. Department of Energy less than 1 percent of hydrogen fuel today is green.[28]

According to research published in *Oil, Gas & Energy Law* in 2021, significant infrastructure upgrades and/or new infrastructure would be needed to safely transport and store hydrogen for electricity production to overcome hydrogen's key safety risks: degrading pipeline integrity, the need for higher pipeline pressure, and the risk of leakage.[29] In its DSEIS for the proposed Project, Astoria confirms that, given the location of the proposed Project, green hydrogen fuel could not be produced on-site and would need to be compressed and transported via existing or not-yet-constructed gas pipelines or some other unspecified form of transport.[30] New York State's aging gas pipelines and other gas infrastructure result in tens of thousands of gas leaks each year. In 2020, there were 18,330 gas leaks reported, or about 370 gas leaks per 1,000 miles of pipeline, leaving a volume of gas equal to almost 20 percent of total gas demand lost or unaccounted for.[31] The cost of replacing leak-prone pipeline ultimately works its way into the fuel costs paid by electric generators, wholesale electric prices, and, ultimately, customer electric rates.

3. All hydrogen fuel—even green hydrogen—results in greenhouse gas and conventional air pollutant emissions

Third, so-called "green" hydrogen is not actually a zero-emission fuel source. Hydrogen fuel combustion entails greenhouse gas and conventional air emissions, no matter the share of hydrogen in question and regardless of how the hydrogen is produced.

Regardless of the share or type of hydrogen in question, hydrogen combustion emits nitrogen oxide (NO_x)—an indirect greenhouse gas and an air pollutant—and any leaked hydrogen is itself an indirect greenhouse gas. Furthermore, gas turbines burning hydrogen-gas blends (the only possibility for the proposed plant at present) produce higher NO_x emissions than hydrogen fuel alone.[32]

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[28] U.S. Office of Energy Efficiency & Renewable Energy. August 30, 2021. "How Wind Energy Can Help Clean Hydrogen Contribute to a Zero-Carbon Future." Available at: https://www.energy.gov/eere/articles/how-wind-energy-can-help-clean-hydrogen-contribute-zero-carbon-future.

[29] Verdonck, P.K.A. and Kammoun, M. 2021. "Is Hydrogen a Viable Alternative to Lithium Under the Current Energy Storage Regulatory Framework?" *Oil, Gas & Energy Law Intelligence, 18(6)*. Available at: https://www.lexology.com/library/detail.aspx?g=e908442d-8b33-462c-ae23-9c1dcb917127.

[30] DSEIS. Page 3-50.

[31] US DOT PHMSA. 2020. "Gas Distribution, Gas Gathering, Gas Transmission, Hazardous Liquids, Liquefied Natural Gas (LNG), and Underground Natural Gas Storage (UNGS) Annual Report Data." Gas Distribution Annual Data [Workbook]. Available at: https://www.phmsa.dot.gov/data-and-statistics/pipeline/gas-distribution-gas-gathering-gas-transmission-hazardous-liquids.

[32] European Turbine Network. January 2020. *Hydrogen Gas Turbines: The Path Towards A Zero-Carbon Gas Turbine.* Available at: https://etn.global/wp-content/uploads/2020/02/ETN-Hydrogen-Gas-Turbines-report.pdf. Page 9.

Two European studies from the City of Leeds and the *International Journal of Hydrogen Energy*[33] found that combusting green hydrogen produces NO_x emissions—an indirect greenhouse gas and a conventional air pollutant.[34] (NO_x acts as an "indirect greenhouse gas" when it reacts photochemically in the atmosphere to produce the greenhouse gas tropospheric ozone.)[35] A 2020 report from the European Turbine Network found that gas turbines burning hydrogen-gas blends result in higher NO_x emissions "if no additional measures are undertaken."[36] The 2021 General Electric study found that a 50/50 mixture of hydrogen and gas fuel increased concentrations of NO_x in gas exhaust by 35 percent.[37] Despite the significant concerns that green hydrogen combustion raises with regard to local air quality and greenhouse gas emissions, the Company does not present any plans for NO_x emissions controls at the proposed Project in its SDEIS or Title V permit application.

According to 2006 research from the Massachusetts Institute of Technology, hydrogen—regardless of whether it is green or not—is also itself an indirect greenhouse gas when leaked:

> "Because hydrogen reacts with tropospheric hydroxyl radicals, emissions of hydrogen to the atmosphere perturb the distributions of methane and ozone, the second and third most important greenhouse gases after carbon dioxide. Hydrogen is therefore an indirect greenhouse gas with a global warming potential GWP of 5.8 over a 100-year time horizon. A future hydrogen economy would therefore have greenhouse consequences and would not be free from climate perturbations."[38]

[33] 1) Cellek, M.S. and Pınarbaşı, A. 2018. "Investigations on Performance and Emission Characteristics of an Industrial Low Swirl Burner While Burning Natural Gas, Methane, Hydrogen-Enriched Natural Gas and Hydrogen as Fuels." *International Journal of Hydrogen Energy, 43(2) 1194–1207.* Available at: https://doi.org/10.1016/j.ijhydene.2017.05.107;
2) Sadler, D., et. Al. 2017. *H21 Leeds CityGate Project Report*. City of Leeds. Available at: https://www.h21.green/wp-content/uploads/2019/01/H21-Leeds-City-Gate-Report.pdf.

[34] 1) Milford, L., Mullendore, S. and Ramanan, A. December 14, 2020. "Hydrogen Hype in the Air." *Clean Energy Group*. Available at: https://www.cleanegroup.org/hydrogen-hype-in-the-air/. 2) Lewis, A.C. June 2021. "Optimising air quality co-benefits in a hydrogen economy: a case for hydrogen-specific standards for NOx emissions." *Environmental Science: Atmospheres*, 1, 201. Available at: https://pubs.rsc.org/en/content/articlepdf/2021/ea/d1ea00037c.

[35] Derwent, R., Simmonds, P., O'Doherty, S., Manning, A., Collins, W. and Stevenson, D. 2006. Global environmental impacts of the hydrogen economy. *Int. J. of Nuclear Hydrogen Production and Applications*. 1(1): 57-67. Available at: http://agage.mit.edu/publications/global-environmental-impacts-hydrogen-economy.

[36] European Turbine Network. January 2020. *"Hydrogen Gas Turbines: The Path Towards A Zero-Carbon Gas Turbine."* Available at: https://etn.global/wp-content/uploads/2020/02/ETN-Hydrogen-Gas-Turbines-report.pdf. Page 9.

[37] GE. 2021. "Hydrogen as a Fuel for Gas Turbines." Available at: https://www.ge.com/content/dam/gepower-new/global/en_US/downloads/gas-new-site/future-of-energy/hydrogen-fuel-for-gas-turbines-gea34979.pdf. Page 5.

[38] Derwent, R., Simmonds, P., O'Doherty, S., Manning, A., Collins, W. and Stevenson, D. 2006. "Global Environmental Impacts of the Hydrogen Economy." *Int. J. of Nuclear Hydrogen Production and Applications*. 1(1): 57-67. Available at: http://agage.mit.edu/publications/global-environmental-impacts-hydrogen-economy.

In addition, a report released by the Columbia Climate School in 2021 found that hydrogen is difficult to transport due to its small molecular size (smallest of all molecules), making it prone to leakage.[39]

The prospect of running Astoria's proposed Project on a zero-emission fuel is wholly speculative. It is impossible for the plant to secure enough hydrogen of any type to blend the current technically feasible potential of 10 percent hydrogen fuel[40] or to use hydrogen as a dominant fuel (and no other possible fuels have been identified), and it is clear that gas turbines that can burn 100 percent hydrogen are a ways off: a January 2020 report by European Turbine Network Global—a non-profit membership organization—indicated that the "gas turbine industry strongly committed to develop gas turbines operating with 100% hydrogen till (sic) 2030."[41] Assuming that gas turbines are someday developed that can burn 100 percent hydrogen, the proposed Project would still emit NO_x—an indirect greenhouse gas and a conventional air pollutant—and associated infrastructure could leak hydrogen—an indirect greenhouse gas in its own right. As discussed above, even if the proposed Project were able to burn hydrogen fuel of any color, significant infrastructure upgrades would be needed to safely transport hydrogen fuel.[42] In the future, even if the proposed Project were able to be modified to run on 100 percent hydrogen and were able to safely supply 100 percent green hydrogen, green hydrogen is not a zero-emitting fuel. The use of hydrogen fuel—if it were practicable and available—interferes with statewide attainment of CLCPA greenhouse gas emission limits.

Hydrogen has negative environmental justice and public health implications

Hydrogen entails significant public health and safety risks that are different than those of gas, and—if the proposed Project is approved—the brunt of these risks will be borne by low-income communities and communities of color in the vicinity of the proposed Project. Astoria claims that, despite not relying on a transition to hydrogen for consistency with CLCPA targets for 2030 or 2040, the proposed Project is "well positioned to transition to renewable hydrogen fuel,"[43] but nevertheless neglects to assess environmental, public health, and safety risks related to hydrogen or its impacts on Environmental Justice communities.[44]

[39] Cho, R. January 7, 2021. "Why We Need Green Hydrogen." *Columbia Climate School*. Available at: https://news.climate.columbia.edu/2021/01/07/need-green-hydrogen/. ("Because hydrogen is so much less dense than gasoline, it is difficult to transport. It either needs to be cooled to -253˚C to liquefy it, or it needs to be compressed to 700 times atmospheric pressure so it can be delivered as a compressed gas").
[40] AECOM on behalf of Astoria Gas Turbine Power LLC. May 2021. Title V Air Permit Major Modification Turbine Replacement Project. Page 4-5.
[41] ETN Global. January 2020. "Hydrogen Gas Turbines." Available at: https://etn.global/wp-content/uploads/2020/01/ETN-Hydrogen-Gas-Turbines-report.pdf. Page 2.
[42] Verdonck, P.K.A. and Kammoun, M. 2021. "Is Hydrogen a Viable Alternative to Lithium Under the Current Energy Storage Regulatory Framework?" *Oil, Gas & Energy Law Intelligence,* 18(6). Available at: https://www.lexology.com/library/detail.aspx?g=e908442d-8b33-462c-ae23-9c1dcb917127.
[43] DSEIS Appendix D.5: Final Scoping Document. Page 2-1.
[44] DSEIS. Page ES-10.

1. Safety and public health risks of hydrogen

Hydrogen creates risks to safety because of its flammability and propensity for leakage. A 2021 study by General Electric found that hydrogen is even more flammable than methane gas, and—when it catches fire—hydrogen's flame speed is an order of magnitude faster than methane (meaning that hydrogen-caused fires would spread much faster than gas-caused fires).[45] Analysis released in 2021 by the U.S. Congressional Research Service found that because hydrogen molecules are the smallest of any gas, it is more likely than other gases to leak through existing pipelines, especially those with imperfections, [46] like the aging, leaky gas pipelines in New York. In addition, a May 2021 report by the consulting firm Arup found that hydrogen fuel used in United Kingdom homes would increase the risk of explosions and the risk of injury more than three-fold, as compared to gas.[47] The 2021 Congressional Research Service report established that when hydrogen leaks, it rises and disperses in the air more quickly than methane gas, meaning that a hydrogen gas cloud is larger than a comparable gas cloud and a hydrogen fire requires much less air to burn. [48] In addition, hydrogen can degrade materials commonly used for pipelines, like pipes, pipe welds, valves, and fittings.[49]

Second, hydrogen fuel results in emissions that are harmful to public health. In April 2021, researchers from Cornell University and Stanford University found that the greenhouse gas footprint of "blue" hydrogen (that is, hydrogen produced from fossil fuels and emissions are captured and either stored or repurposed) is "more than 20% greater than burning natural gas or coal for heat and some 60% greater than burning diesel oil for heat."[50] A 2020 study by the Clean Energy Group based on research with public health experts, found that combusting hydrogen of any kind (whether green hydrogen or not) produces NO_x emissions that—in addition to creating greenhouse gases in the atmosphere—are harmful to human health and produces up to six times the level of NO_x emissions produced by gas combustion.[51] According to 2011 research published in the *Annals of the New York Academy of Sciences*, NO_X emissions combine "with volatile organic compounds [to] form not only particulates but also ground-level ozone (photochemical smog), [which is]

[45] GE. 2021. "Hydrogen as a Fuel for Gas Turbines." Available at: https://www.ge.com/content/dam/gepower-new/global/en_US/downloads/gas-new-site/future-of-energy/hydrogen-fuel-for-gas-turbines-gea34979.pdf. Page 4.
[46] U.S. Congressional Research Service. March 2, 2021. "Pipeline Transportation of Hydrogen: Regulation, Research, and Policy." Available at: https://crsreports.congress.gov/product/pdf/R/R46700. "Summary."
[47] Arup. May 1, 2021. "Work Package 7—Safety Assessment: Conclusions Report" (Incorporating Quantitative Risk Assessment). Available at: https://static1.squarespace.com/static/5b8eae345cfd799896a803f4/t/60e399b094b0d322fb0dadc4/1625528759977/conclusions+inc+QRA.pdf.
[48] U.S. Congressional Research Service. March 2, 2021. "Pipeline Transportation of Hydrogen: Regulation, Research, and Policy." Available at: https://crsreports.congress.gov/product/pdf/R/R46700. Page 2.
[49] Ibid. "Summary."
[50] Howarth, R.W. and Jacobsen, M.Z. April 2021. "How Green is Blue Hydrogen?" *Energy Science & Engineering*, 00, p.1-12. Available at: https://onlinelibrary.wiley.com/doi/10.1002/ese3.956.
[51] 1) Milford, L., Mullendore, S. and Ramanan, A. December 14, 2020. "Hydrogen Hype in the Air." *Clean Energy Group*. Available at: https://www.cleanegroup.org/hydrogen-hype-in-the-air/; 2) E4tech (UK) Ltd for the Department for Business Energy and Industrial Strategy (BEIS). October 2018. "H2 Emission Potential Literature Review: Final report." Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/798243/H2_Emission_Potential_Report_BEIS_E4tech.pdf.

corrosive to the lining of the lungs."[52] A 2010 report from the Clean Air Task Force demonstrated that particle-forming pollutants like NO_x take a substantial toll on the health of millions of Americans.[53] Comments submitted to the Department of Energy by Clean Energy Group in 2021 describe how particulate pollutants harm human health by passing through the lungs and causing significant damage to the respiratory system over time and by entering the bloodstream and leading to other serious, chronic health problems like cardiovascular and pulmonary disease[54]:

> "NOx does significant damage to the respiratory system over time. In areas affected by smog resulting from NOx emissions, symptoms including coughing, increased rates of asthma, and comorbidities with other respiratory illness develop. This impact is readily apparent in many frontline communities dealing with heavy NOx emissions emitted by nearby high-polluting peaker power plants and other sources. These communities have developed stark health disparities as a result of elevated NOx exposure."[55]

Hydrogen—green or not—entails significant public health and safety risks.

2. Environmental justice impacts of hydrogen

The public health risks presented by localized air emissions from hydrogen fuel combustion are an environmental justice issue. Low-income communities and communities of color near the proposed Project are more vulnerable to negative health impacts from localized air emissions, including particulate emissions like NO_x, because they have higher rates of asthma and other respiratory conditions (according to 2020 research from the American Lung Association);[56] higher rates of COVID-19 infections and hospitalizations;[57]

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[52] Epstein et al. 2011. "Full Cost Accounting for the Life Cycle of Coal." *Ecological Economics Review, Annals of the New York Academy of Sciences*, issue 1219. Available at: http://www.coaltrainfacts.org/docs/epstein_full-cost-of-coal.pdf, Page 85.

[53] Clean Air Task Force. September 2010. "The Toll From Coal." Available at: https://www.catf.us/resource/the-toll-from-coal/. Page 4.

[54] Price, D., Birnbaum, R., Batiuk, R., McCullough, M., Smith, R. 1997. "Nitrogen Oxides Impacts On Public Health And The Environment." *U.S. Environmental Protection Agency*. Available at: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=2000DM8Q.txt.

[55] Clean Energy Group. July 7, 2021. "Response of Clean Energy Group to DOE Hydrogen Program Request for Information #DE-FOA-0002529". Available at: https://www.cleanegroup.org/wp-content/uploads/CEG-Response-to-DOE-Hydrogen-RFI.pdf. Page 3.

[56] American Lung Association. July 6, 2020. "Current Asthma Demographics." *American Lung Association*. Available at: https://www.lung.org/research/trends-in-lung-disease/asthma-trends-brief/current-demographics#:~:text=Current%20Asthma%20Rates%20by%20Race,%25)%20to%20still%20have%20asthma. The cited source finds that "Blacks and American Indian/Alaska Natives have the highest current asthma rates compared to other races and ethnicities. In 2018, Blacks (10.9%) were 42 percent more likely than Whites (7.7%) to still have asthma."

[57] Carroll, N. October 23, 2020. The Backstory: Pollution. "Poor Health Care. Crowded Housing. High-Risk Jobs. Prejudice. Why People of Color Are Dying of COVID-19." *USA Today*. Available at: https://www.usatoday.com/story/opinion/2020/10/23/covid-racism-communities-color-have-higher-rates-covid-here-why/3727325001/. The cited report finds that "[p]eople of color make up the majority in 62% of counties with the highest COVID-19 death rates."

are more likely to have serious chronic medical conditions;[58] and are more likely to live nearby sites responsible for emitting localized air pollution like generators, refineries, and highways.[59]

Hydrogen fuel combustion at the proposed Project—regardless of its share or type—will increase greenhouse gas emissions and conventional air pollutants like NO_x, the harms of which will fall disproportionately on nearby low-income communities and communities of color. The proposed Project—regardless of whether it burns gas, hydrogen, or a blend of the two—will negatively impact public health and environmental equity.

With or without switching to hydrogen, the proposed Project is not consistent with the CLCPA

In April 2020, the New York State Energy Planning Board amended the 2015 State Energy Plan to incorporate the CLCPA § 7(2) requirement that all state agencies "consider whether [their] decisions are inconsistent with or will interfere with the attainment of the statewide greenhouse gas emissions limits established in [the CLCPA]."[60] Gas-fired resources—like Astoria's proposed Project—interfere with CLCPA renewable energy and emission reduction requirements.

NYSDEC's approval of the proposed Project would lock in polluting generation for decades to come and lower the share of total generation from renewable resources, meaning that renewable capacity will be needed to meet CLCPA-mandated renewable generation shares. The more fossil fuel capacity added in New York, the more challenging it will be for the State to wean itself off of its fossil fuel dependence and establish a reliable fossil-free electric grid by 2040.

In its consideration of Astoria's proposed Project, the New York Department of Environmental Conservation should be aware that—even in the unlikely event that Astoria were to commit to run the proposed Project entirely on green hydrogen by 2040—the proposed Project would still not be consistent with 70 percent renewable electric supply by 2030 or 100 percent zero-emission electric supply by 2040 as required by the CLCPA. New greenhouse gas emitting generation does not aid in the attainment of the statewide CLCPA greenhouse gas emissions limits; indeed, it interferes with the attainment of these limits. Actions, like the proposed Project threaten New York State's ability to achieve the ambitious goals of the CLCPA.

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[58] Thorpe, K.E., Chin, K.K., Cruz, Y., Innocent, M.A., Singh, L. August 17, 2017. "The United States Can Reduce Socioeconomic Disparities By Focusing On Chronic Diseases." *Health Affairs*. Available at: https://www.healthaffairs.org/do/10.1377/hblog20170817.061561/full/.

[59] 1) Kravchenko, J. and Lyerly, H.K. 2018. "The Impact of Coal-Powered Electrical Plants and Coal Ash Impoundments on the Health of Residential Communities." *N C Med Journal*; 79(5): 289-300. Available at: https://pubmed.ncbi.nlm.nih.gov/30228133/; 2) Mikati, I., Benson, A.F., Luben, T.J., Sacks, J.D. and Richmond-Bryant, J. April 1, 2018. "Disparities in Distribution of Particulate Matter Emission Sources by Race and Poverty Status." *American Journal of Public Health*; 108(4): 480-485. Available at: https://ajph.aphapublications.org/doi/10.2105/AJPH.2017.304297.

[60] New York. April 8, 2020. "Amendment to the 2015 State Energy Plan." Available at: https://energyplan.ny.gov/-/media/nysenergyplan/meeting/2015-SEP-Amendment.pdf.