STATE OF NEW JERSEY
BOARD OF PUBLIC UTILITIES

In the Matter of the Merger of South	**)**	
Jersey Industries, Inc. and Boardwalk	**)**	**Docket No. GM22040270**
Merger Sub, Inc.	**)**	

PRE-FILED DIRECT TESTIMONY
OF
TIANYI SUN
ON BEHALF OF
ENVIRONMENTAL DEFENSE FUND

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I. Introduction and Qualifications

Q: Please state your name, title, and business address.

A: My name is Tianyi Sun. My title is Climate Scientist at Environmental Defense Fund. My business address is 301 Congress Ave, Austin TX 78701.

Q: On whose behalf are you submitting this testimony in this proceeding?

A: I am submitting this testimony on behalf of Environmental Defense Fund ("EDF").

Q: Please provide a summary of your education and experience.

A: I earned my Bachelor of Science in Atmospheric Sciences at Nanjing University in China and my Ph.D. in Climate Dynamics at University of Texas at Austin in 2019. For the past three years, I have conducted peer-reviewed research at EDF on climate impacts of short-lived climate pollutants and their potential mitigation strategies;[1] net-zero greenhouse gas ("GHG") pathways and their climate impacts;[2] and the climate impacts of hydrogen pathways. I currently lead the design and coordination of field campaigns for data collection of fugitive hydrogen emissions from commercial facilities and coordination of research on hydrogen emission quantification methods. I have attached a copy of my curriculum vitae in Attachment __ (TS-1).

Q: Have you previously filed testimony or otherwise presented on your work before regulatory or academic bodies?

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[1] Tianyi Sun et al., *The Value of Early Methane Mitigation in Preserving Arctic Summer Sea Ice*, 17 ENV'T RSCH. LETTERS 044001 (2022), https://iopscience.iop.org/article/10.1088/1748-9326/ac4f10.

[2] Tianyi Sun et al., *Path to Net Zero is Critical to Climate Outcome*, 11 SCI. REPORTS 22173 (2021), https://doi.org/10.1038/s41598-021-01639-y.

A: Yes. I have presented my scientific research at several international academic conferences such as the American (and European) Geophysical Union annual meetings that are the largest academic conferences in Geoscience. I have been invited to speak about climate change science and mitigation at Cal Poly University, and internationally at the Korean Young Women Global Peace Leadership Program. I have provided several hydrogen science briefings to government agencies in the United States (e.g., Department of Energy) and Europe (e.g., UK Department for Business, Energy and Industrial Strategy). I have also spoken at multi-stakeholder (e.g., academic, government, industry) hydrogen events such as the Hydrogen Americas Summit in Washington, D.C., and virtually at the World Hydrogen Energy Summit in New Delhi, India.

II. Purpose of Testimony and Recommendations

Q: What is the purpose of your testimony?

A: My testimony is submitted in this proceeding before the New Jersey Board of Public Utilities ("NJ BPU" or "Board") regarding the merger transaction proposed by South Jersey Industries Inc., Boardwalk Merger Sub, Inc., and other entities ("Joint Petitioners"[3]). The purpose of my testimony is (1) to describe the scientific imperative to address the climate crisis and the role of natural gas use in contributing to climate change; (2) to explain concerns, from a climate science and safety perspective, with blending low-carbon fuels such as biomethane and hydrogen into the gas distribution system; and (3) to address environmental justice concerns related to gas leaks. My

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[3] The complete list of Joint Petitioners seeking BPU approval for the merger transaction are: IIF US Holding 2 LP ("IIF US 2"), NJ Boardwalk Holdings LLC ("Boardwalk"), Boardwalk Merger Sub, Inc. ("Merger Sub"), South Jersey Industries, Inc. ("SJI"), SJI Utilities, Inc. ("SJIU"), Elizabethtown Gas Company ("ETG"), and South Jersey Gas Company ("SJG").

testimony provides recommendations for conditions that should be incorporated into any transaction approved by the NJ BPU so that an approved acquisition is consistent with statutory requirements for the provision of safe and adequate service. I am advised by counsel that the statute includes requirements "to conserve and preserve the quality of the environment and prevent the pollution of the waters, land and air of this State." N.J.S.A. 48:2-23. Another witness for EDF, David Hill, presents additional recommended conditions that should be included if the Board approves the requested merger.

Q: Please provide a summary of your testimony and recommendations.

A: Methane, the main component of natural gas, and carbon dioxide, which is emitted when natural gas is combusted, each significantly contribute to climate change and its impacts. Given the severity of climate impacts occurring today and the urgency to limit further warming, it is critical to reduce GHG emissions as fast as possible from all economic sectors, including the natural gas sector. My testimony speaks to whether the proposed merger transaction's representations regarding incorporating hydrogen and biomethane into the gas distribution system would yield meaningful climate benefits.

I review the current scientific knowledge on hydrogen's role as an indirect GHG; assess hydrogen's environmental impacts, leakage risks, and safety concerns of hydrogen blending; evaluate the potential of biomethane (also known as renewable natural gas) to deliver net GHG reduction; and consider the potential air quality impacts from both fuels. SJI's business plans represented in the merger petition raise significant climate, environmental, safety, and equity concerns, and are unlikely to deliver meaningful climate benefits.

Based on this analysis, I recommend conditions that the NJ BPU should impose on any approved merger transaction to prevent inappropriate investments in hydrogen and biomethane (RNG) and to equitably reduce GHG emissions from the existing system.

Q: Are you providing any attachments to your testimony?

A: Yes. I am attaching the following exhibits to my testimony:

- **Attachment __ (TS-1): Curriculum Vitae**
- **Attachment __ (TS-2): Joint Petitioners' Response to EDF Information Request EDF-5**

III. Scientific Evidence of Climate Change and the Need to Reduce GHG Emissions Associated with Natural Gas Use

Q. What is the scientific consensus regarding climate change?

A. Scientific evidence overwhelmingly demonstrates that climate change is causing immediate, devasting impacts, and that these harms will worsen dramatically as GHG pollution continues to rise. Human activities have unequivocally caused significant increases in GHG concentrations, which is warming the atmosphere, land, and ocean, and increasing the frequency of extreme weather events.[4] The Intergovernmental Panel on Climate Change ("IPCC") stated in its most recent report: "Human influence has warmed the climate at a rate that is unprecedented in at least the last 2000 years."[5] The U.S.

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[4] *See generally* N.J. DEP'T ENV'T PROT., *2020 New Jersey Scientific Report on Climate Change* (June 30, 2020), https://www.nj.gov/dep/climatechange/docs/nj-scientific-report-2020.pdf#page=6 [hereinafter N.J. 2020 Scientific Report on Climate Change].

[5] INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, *Climate Change 2021: The Physical Science Basis: Summary for Policymakers* (2021), at 6, https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf [hereinafter IPCC Summary for Policymakers (2021)].

Global Change Research Program ("USGRCP") has concluded that "evidence of human-caused climate change is overwhelming and continues to strengthen," "the impacts of climate change are intensifying across the country," and "climate-related threats to Americans' physical, social, and economic well-being are rising."[6] In its Fourth National Assessment, the USGCRP found that "there is no convincing alternative explanation" for the observed warming of the climate over the last century other than human activities.[7]

Q. How are GHG emissions affecting the Earth's climate with regard to temperature?

A. Climate change caused by GHG emissions is resulting in a hotter climate with more severe extreme weather events such as heat waves, flooding, droughts, and wildfires. According to the 2021 Annual National Climate Report from the National Oceanic and Atmospheric Administration ("NOAA"), 2021 was the sixth-warmest year on record, with an average annual temperature 2.5 degrees Fahrenheit hotter than the 20th century average.[8] The 2021 data confirms a warming trend that has accelerated in recent years and decades. Over the last 127 years, the six warmest years in the contiguous U.S. have all occurred since 2012. In the Northeast region, 2021 was the third warmest year since recordkeeping began in 1895. Newark, New Jersey, for example, recorded its all-time

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[6] Alexa Jay et al., *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment*, U.S. GLOB. CHANGE RSCH. PROGRAM, Vol. II, Ch. 1, at 36 (David Reidmiller et al. eds.) (2018), https://nca2018.globalchange.gov/ [hereinafter USGCRP 2018].

[7] *Climate Science Special Report: Fourth National Climate Assessment*, U.S. GLOB. CHANGE RSCH. PROGRAM, Vol. I, Executive Summary (Donald J. Wuebbles et al. eds.) (2017), https://science2017.globalchange.gov/ [hereinafter USGCRP 2017].

[8] *State of the Climate: Annual 2021 National Climate Report*, NOAA NAT'L CTRS. ENV'T INFO. (Jan. 2022),https://www.ncei.noaa.gov/access/monitoring/monthly-report/national/202113 [hereinafter NOAA Annual 2021 National Climate Report].

hottest June temperature on record with a high of 103°F on June 30, 2021.[9] The IPCC reported with high confidence that "[g]lobal surface temperature has increased faster since 1970 than in any other 50-year period over at least the last 2000 years."[10] The State of New Jersey, in particular, has experienced a 3.5°F increase in average temperature since 1895, which is faster than the rest of the Northeast region and the world.[11]

The U.S. is expected with high confidence to warm by an additional 2.5°F, on average, over the next few decades.[12] Daily highs are likewise projected with high confidence to increase.[13] Under business as usual, the hottest days of the year could be at least 5°F warmer in most areas by mid-century and 10°F warmer by the end of this century.[14] The urban heat island effect—which is expected with high confidence to strengthen as urban areas expand and become denser—will amplify climate-related warming even beyond those dangerous increases.[15] The State of New Jersey average temperature is expected to increase by 4.1-5.7°F by 2050.[16] Heatwaves are projected to

[9] *Id.*

[10] IPCC, Summary for Policymakers (2021), at 8, A.2.2.

[11] N.J. 2020 Scientific Report on Climate Change, at vii.

[12] USGCRP 2017, at 11.

[13] *Id.* at 185.

[14] *Id.* at 197.

[15] *Id.* at 17; IPCC, Summary for Policymakers (2021), at 25, C2.6. In addition, expanding urban areas and populations will also increase precipitation in and near cities (medium confidence).

[16] N.J. 2020 Scientific Report on Climate Change, at 29; *see also* Radley Horton et al., *New York City Panel on Climate Change 2015 Report*, 1336 ANNALS N.Y. ACAD. SCI. 18, 30 (2015), https://doi.org/10.1111/nyas.12586;

occur more often, impact larger areas, and last longer, which could increase summer heat-related mortalities by 55%.[17]

Q. How are GHG emissions affecting the Earth's climate with regard to extreme weather?

A. Not only is the overall climate warming, extreme weather events are becoming more intense, dangerous, and frequent. The 2021 U.S. Climate Extremes Index was the third highest on record in 112 years, with an index 115% percent above average.[18] As the most recent IPCC report explained:

> Many changes in the climate system become larger in direct relation to increasing global warming. They include increases in the frequency and intensity of hot extremes, marine heatwaves, heavy precipitation, and, in some regions, agricultural and ecological droughts; an increase in the proportion of intense tropical cyclones; and reductions in Arctic sea ice, snow cover and permafrost.[19]

With additional warming, continued sea level rise will make coastal floods more frequent and severe during storms; heavy precipitation will continue to become more frequent and intense in most U.S. regions; very dry and very wet precipitation events will get more extreme; droughts and western U.S. wildfires will increase in likelihood and severity; and the probability and frequency of compound events will increase.[20]

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[17] N.J. 2020 Scientific Report on Climate Change, at 29.

[18] NOAA Annual 2021 National Climate Report.

[19] IPCC, Summary for Policymakers (2021), at 15, B.2.

[20] *See generally* NOAA Annual 2021 National Climate Report; *see also* USGCRP 2017, at 218, 231, 243-44; Daniel B. Wright et al., *Regional Climate Model Projections of Rainfall from U.S. Landfalling Tropical Cyclones*, 45 CLIMATE DYNAMICS 3365 (2015), https://link.springer.com/article/10.1007%2Fs00382-015-2544-y.

Human-caused GHG emissions have contributed to higher intensity North Atlantic hurricanes since the 1970s, a trend that is expected to continue (medium confidence).[21] In a 2020 study, researchers from NOAA and the University of Wisconsin Madison estimated that hurricanes and tropical cyclones have become about 5% more likely to reach "major" hurricane status in each successive decade since 1979.[22] The most damaging U.S. hurricanes are now three times more frequent than 100 years ago, and that the proportion of hurricanes that are Category 3 or above in the Atlantic Ocean has doubled since 1980.[23]

An increase in more intense rain events—spurred by climate change—has increased the magnitude and frequency of floods in the Northeast in recent years,[24] including many major floods in New Jersey that have occurred since 2000.[25]

Q. Does the climate crisis generate disproportionately negative impacts for disadvantaged communities?

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[21] USGCRP 2017, at 257; Kieran Bhatia et al., *Projected Response of Tropical Cyclone Intensity and Intensification in a Global Climate Model*, 31 J. CLIMATE 8281, 8282 (2018), https://doi.org/10.1175/JCLI-D-17-0898.1.

[22] James P. Kossin et al., *Global Increase in Major Tropical Cyclone Exceedance Probability Over the Past Four Decades*, 117 PROCEEDINGS NAT'L ACAD. SCI. 11975, 11976 (2020), https://www.pnas.org/content/117/22/11975.

[23] *Id*. at 11977; *see also* Aslak Grinsted, *Normalized US Hurricane Damage Estimates Using Area of Total Destruction, 1900-2018*, 116 PROCEEDINGS NAT'L ACAD. SCI. 23942 (2019), https://dx.doi.org/10.1073/pnas.1912277116.

[24] Mathias J. Collins, *River Flood Seasonality in the Northeast United States: Characterization and Trends*, 33 HYDROLOGICAL PROCESSES 687 (2018), https://doi.org/10.1002/hyp.13355.

[25] New Jersey Water Science Center, *New Jersey Flood Reports*, U.S. GEOLOGICAL SURVEY (Sept. 19, 2017), https://www.usgs.gov/centers/new-jersey-water-science-center/science/new-jersey-flood-reports.

A. Yes. The U.S. Environmental Protection Agency 2021 report, *Climate Change and Social Vulnerability in The United States: A Focus on Six Impacts*, finds that communities of color and low-income communities in the U.S. are at increased risk of climate-driven harms compared to other communities.[26] "Black and African American individuals are 40[-59%] more likely than non-Black and non-African American individuals to currently live in . . . areas with the highest projected increases in temperature mortality from climate-driven changes in extreme temperatures."[27] The report also found that, with 2°C of warming, "Hispanic and Latino individuals are 43% more likely than non-Hispanic and non-Latino individuals to live" in areas that have "the highest projected labor hours losses due to climate-driven increases in high-temperature days."[28]

In addition, "[c]oastal road networks and the communities they support are increasingly at risk of impacts from sea level rise and intensifying coastal flood events," a risk which again disproportionately impacts communities of color and low-income communities.[29] Communities of color are 41% more likely to live in areas projected to have the highest increase in traffic delays due to climate-driven changes in high-tide flooding with 50 cm of global sea level rise.[30]

Q. **Is climate change continuing to worsen?**

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[26] *See generally* U.S. EPA, *Climate Change and Social Vulnerability in The United States: A Focus on Six Impacts* (Sept. 2021), https://www.epa.gov/system/files/documents/2021-09/climate-vulnerability_september-2021_508.pdf.

[27] *Id.* at 35.

[28] *Id.* at 40.

[29] *Id.* at 46.

[30] *Id.* at 48.

A. Yes. Recent scientific studies confirm that climate change harms are escalating, and that the U.S. must take immediate action to rapidly reduce GHG pollution to avoid catastrophic damages. The Fourth National Climate Assessment indicates that choices made now to reduce GHG pollution will affect the severity of climate change damages in the coming decades and centuries, stating: "[t]he impacts of global climate change are already being felt in the United States and are projected to intensify in the future—but the severity of future impacts will depend largely on actions taken to reduce greenhouse gas emissions and to adapt to the changes that will occur."[31]

The IPCC found in 2021 that "[h]uman-induced climate change is already affecting many weather and climate extremes in every region across the globe," and evidence demonstrating the link between human GHG emissions and "changes in extremes such as heatwaves, heavy precipitation, droughts, and tropical cyclones . . . has strengthened since" the prior IPCC report.[32] In addition to exacerbating extreme weather, "[h]eating of the climate system has caused global mean sea level rise through ice loss on land and thermal expansion from ocean warming." Increasing sea level rise is caused in part by the rate of ice-sheet loss globally, which quadrupled between the 1990s and 2010s.[33]

Q. Can we still mitigate climate change by reducing GHG emissions from human activities?

[31] USGCRP 2018, at 34.

[32] IPCC, Summary for Policymakers (2021), at 8, A.3.

[33] *Id.* at 11, A.4.3.

A. Yes. While the Fourth National Climate Assessment states that "[i]t is very likely that some physical and ecological impacts will be irreversible for thousands of years, while others will be permanent," the report also explains that "[m]any climate change impacts and associated economic damages in the United States can be substantially reduced over the course of the 21st century through global-scale reductions in greenhouse gas emissions."[34]

According to the IPCC, "[g]lobal warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in CO2 and other greenhouse gas emissions occur in the coming decades."[35] Cutting GHG emissions now is critical because "there is a near-linear relationship" between human-caused GHG emissions and related global warming, meaning that each additional increment of global warming exacerbates changes in extreme weather events. But the Production Gap Report 2021 facilitated by the U.N. Environment Programme has found that "the world's governments still plan to produce more than double the amount of fossil fuels in 2030 than would be consistent with limiting global warming to 1.5°C."[36] Preventing the worst impacts of climate change "requires steep and sustained reductions in fossil fuel production and use," in addition to measures that reduce production-cycle emissions.[37]

Q. How does natural gas use contribute to climate change?

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[34] USGCRP 2018, Ch. 29, at 1347.

[35] IPCC, Summary for Policymakers (2021), at 14, B.1.

[36] THE PRODUCTION GAP REPORT, *Summary of Findings*, at 1, https://productiongap.org/2021report/.

[37] *Id.*

A. The production, transportation, and combustion of natural gas releases GHGs that contribute to the climate crisis. Natural gas is composed primarily of methane, a potent GHG with an especially strong warming impact over shorter time periods. Compared with carbon dioxide of equal mass, fossil fuel methane's warming potential is 83 times higher over a 20-year period and 30 times higher over a 100-year period.[38] Human-caused methane emissions are responsible for nearly 30% of today's warming.[39] The natural gas supply chain—upstream production, to transportation, to local distribution—releases methane through leakage and operational releases.[40] A measurement-based study estimates that the U.S. EPA national inventory may underestimate actual methane emissions from the oil and gas sector by as much as 60%.[41]

Once produced and delivered, natural gas is combusted to heat homes and buildings, facilitate heavy industrial processes, and generate power in appliances and power plants.[42] Combustion of natural gas releases carbon dioxide ("CO2"), the primary long-lived GHG emitted from human activities.[43] Natural gas combustion also emits particulate matter ("PM"), nitrogen oxides ("NOx"), and volatile organic compounds

[38] IPCC, WG 1, The Physical Science Basis, at 7-125.

[39] IPCC, Summary for Policymakers (2021), at 13.

[40] Ramón Alvarez et al., *Assessment of Methane Emissions from the U.S. Oil and Gas Supply Chain*, 361 SCIENCE 186, 186 (2018), https://doi.org/10.1126/science.aar7204.

[41] *Id.*

[42] U.S. EPA, *Compilation of Air Pollutant Emissions Factors (AP-42)*, Vol. 1 Ch. 1.4, Natural Gas Combustion (1998), https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-fifth-edition-volume-i-chapter-1-external-0.

[43] U.S. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks* (last updated Apr. 14, 2022), https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks.

("VOCs") that contribute to the formation of ground-level ozone. The presence of these gases can lead to harmful respiratory effects, including decreases in lung function, increased asthma emergency room visits, and premature death.[44]

In New Jersey, 26% of state GHG emissions (24.6 MMT CO2e) are from residential and commercial buildings, which primarily rely on natural gas for space and water heating.[45] According to the Residential Energy Consumption Survey, New Jersey households, on a per-household basis, are the highest consumers of natural gas used in residential heating in the country (in Btu per year).[46]

Q. Can GHG emissions associated with natural gas use be reduced?

A. Yes. Natural gas consumption must decrease significantly to mitigate catastrophic climate change impacts. Reducing natural gas use will reduce carbon dioxide and methane emissions associated with leakage and operational releases in the natural gas production, distribution, transmission, and delivery. The New Jersey 80x50 Report states that "emissions from the residential and commercial building sectors must be reduced by

[44] U.S. EPA, *Integrated Science Assessment (ISA) for Ozone and Related Photochemical Oxidants*, EPA/600/R-20/012 (Final Report: Apr. 2020), at ES1-ES8, https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=348522; Ananya Roy, *The Science is Clear: We Need a Stronger Smog Standard*, ENV'T DEF. FUND (Sept. 4, 2018), https://blogs.edf.org/climate411/2018/09/04/the-science-is-clear-we-need-a-stronger-smog-standard/ (citing Stephanie Holm et al., *Human Health Effects of Ozone: The State of Evidence Since EPA's Last Integrated Science Assessment*, ENV'T DEF. FUND (2018)).

[45] N.J. DEP'T OF ENV'T PROT., *New Jersey's Global Warming Response Act 80x50 Report* (Oct. 2020), at xi, https://www.nj.gov/dep/climatechange/docs/nj-gwra-80x50-report-2020.pdf [hereinafter N.J. 80x50 Report].

[46] N.J. 80x50 Report, at 41 (*citing* USEIA, *2015 Residential Energy Consumption Survey*, https://www.eia.gov/consumption/residential/data/2015/).

89% to 2.7 MMT CO2e by 2050," primarily through building electrification to reduce end-use gas combustion.[47]

Q. How can methane emissions associated with natural gas use be reduced?

A. Cost-effective, near-term emission reduction opportunities in the natural gas sector could significantly limit methane emissions.[48] Recent peer-reviewed research demonstrates that rapid implementation of all methane mitigation measures could slow the rate of near-term warming by 30% and avoid a quarter of a degree centigrade of additional warming by midcentury.[49] According to the International Energy Agency (IEA), the U.S. could abate nearly 20% of methane emissions from the oil and gas sector at no net cost, and currently available technologies could abate up to 70% of oil and gas methane emissions.[50] Specific to gas distribution systems, peer-reviewed research has demonstrated that observed methane emissions from cities are about twice that reported in the U.S. EPA inventory, and that nationwide fugitive methane emissions from the gas distribution sector are approximately five times greater than reported in the U.S. EPA inventory.[51]

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[47] NJ 80x50 Report, at xi.

[48] UN ENVIRONMENT PROGRAMME, *Annual Report 2021* (Jan. 28, 2022), https://www.unep.org/resources/annual-report-2021.

[49] Ilissa Ocko et al., *Acting Rapidly to Deploy Readily Available Methane Mitigation Measures by Sector can Immediately Slow Global Warming*, 16 ENV'T RSCH. LETTERS 054042, 054042 (2021), https://iopscience.iop.org/article/10.1088/1748-9326/abf9c8.

[50] IEA, *Methane Tracker Data Explorer* (last updated Oct. 3, 2022), https://www.iea.org/articles/methane-tracker-data-explorer.

[51] Genevieve Plant et al., *Large Fugitive Methane Emissions from Urban Centers Along the U.S. East Coast*, 46 GEOPHYSICAL RSCH. LETTERS 8500 (2019), https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2019GL082635; Zachary D. Weller et al., *A National Estimate of Methane Leakage from Pipeline Mains in Natural Gas Local Distribution Systems*, 54 ENV'T SCI. TECH. 8958 (2020), https://doi.org/10.1021/acs.est.0c00437.

IV. The Merger Petition Proposes Reliance on Hydrogen and Renewable Natural Gas to "Decarbonize" the Utilities' Gas Distribution Systems

Q. Please explain the hydrogen and RNG proposals in the merger petition.

A. The supporting documentation to the merger petition states that one of SJI's objectives is to "[d]eliver carbon neutral energy by 2050,"[52] and states that "[d]ecarbonization, via RNG and Hydrogen, are vital to achieving emissions-reduction targets."[53] SJI CEO Michael Renna testifies that IIF's acquisition of SJI will "provide SJI with efficient access to capital and a long-term strategic focus to continue SJI's efforts to modernize and enhance its utility distribution system," and that in the "[l]onger-term, a modern delivery system will allow SJG and ETG to safely deliver to customers the low carbon energy of the future."[54] SJI Vice President and South Jersey Utilities President Melissa Orsen testifies that SJI is planning on "investing in projects that facilitate the environmental goals of the State, including infrastructure enhancements and clean energy projects that will help decarbonize our natural gas supply."[55] The supporting documentation also states that SJI's "Strong Track Record" and "Demonstrated Record

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[52] *In the Matter of the Merger of South Jersey Industries, Inc. and Boardwalk Merger Sub, Inc.*, NJ BPU Docket No. GM22040270, Petition Exh. G p22 (PDF p150).

[53] *In the Matter of the Merger of South Jersey Industries, Inc. and Boardwalk Merger Sub, Inc.*, NJ BPU Docket No. GM22040270, Exh. EL-3, Fourth Quarter and Full Year 2021 Earnings Presentation (Feb. 24, 2022), at 27 (PDF p456).

[54] *In the Matter of the Merger of South Jersey Industries, Inc. and Boardwalk Merger Sub, Inc.*, NJ BPU Docket No. GM22040270, Direct Testimony of Michael Renna, at Page 6, Lines 3-5; Page 7, Lines 6-8.

[55] *In the Matter of the Merger of South Jersey Industries, Inc. and Boardwalk Merger Sub, Inc.*, NJ BPU Docket No. GM22040270, Direct Testimony of Melissa Orsen at Page 5, Lines 13-15.

of Commitment to Key Priorities" include "RNG/Hydrogen initiatives to lower carbon content of gas and reduce emissions."[56]

In the merger petition, SJI and Joint Petitioners do not present feasibility analyses or other analytical support for these statements. The Joint Petitioners state that "an analysis of the impact to greenhouse gas emissions of blending hydrogen and/or RNG into the gas distribution system has not yet been performed, and an "analysis is in progress to review the impact of hydrogen blending on its gas system."[57]

These statements by the Joint Petitioners indicate an intention to facilitate continued reliance on the gas distribution system and to incorporate biomethane (referred to as "renewable natural gas" or "RNG" by the companies) and hydrogen into the gas distribution system, with an expectation that so doing will reduce overall GHG emissions.

V. Climate Implications of Hydrogen as a Clean Fuel

Q. What is hydrogen? How is it different from methane?

A. Hydrogen (H_2) is an energy carrier that can be combusted for heat or converted to electricity. Unlike methane, the combustion and conversion of hydrogen does not emit carbon dioxide, so it has the potential to be a low-carbon fuel and play a role in

[56] *In the Matter of the Merger of South Jersey Industries, Inc. and Boardwalk Merger Sub, Inc.*, NJ BPU Docket No. GM22040270, Petition Exh. G p21 (PDF p149).

[57] Attachment __ (TS-2), Joint Petitioners' Response to EDF Information Request EDF-5(a), (c), from witnesses Michael J. Renna and Melissa J. Orsen (Sept. 30, 2022).

decarbonizing hard-to-electrify sectors.[58] However, hydrogen itself is an indirect GHG and will cause warming when emitted into the atmosphere.[59]

When it escapes into the atmosphere, hydrogen has two main fates: around 70%–80% is estimated to be removed by soils via diffusion and bacterial uptake, and the remaining 20%–30% is oxidized by reacting with the naturally occurring hydroxyl radical (OH), yielding an atmospheric lifetime of around a few years.[60]

[58] *Net Zero by 2050: A Roadmap for the Global Energy Sector*, INT'L ENERGY AGENCY (revised Oct. 2021), https://www.iea.org/reports/net-zero-by-2050.

[59] Ilissa B. Ocko & Steven P. Hamburg, *Climate Consequences of Hydrogen Emissions*, 22 ATMOS. CHEM. PHY. 9349 (2022), https://acp.copernicus.org/articles/22/9349/2022/; Fabien Paulot et al., *Global Modeling of Hydrogen Using GFDL-AM4.1: Sensitivity of Soil Removal and Radiative Forcing*, 46 INT'L J. HYDROGEN ENERGY 13446 (2021), https://www.sciencedirect.com/science/article/abs/pii/S0360319921001804; Dick Derwent, *Hydrogen for Heating: Atmospheric Impacts – A Literature Review*, U.K. DEP'T BUS., ENERGY & INDUS. STRATEGY (Oct. 7, 2018), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/760538/Hydrogen_atmospheric_impact_report.pdf; Nicola Warwick, *Atmospheric Implications of Increased Hydrogen Use*, U.K. DEP'T BUS., ENERGY & INDUS. STRATEGY (Apr. 8, 2022), https://www.gov.uk/government/publications/atmospheric-implications-of-increased-hydrogen-use.

[60] Thom Rahn et al., *Extreme Deuterium Enrichment in Stratospheric Hydrogen and the Global Atmosphere Budget of H_2*, 424 NATURE 918, 920 (2003), https://doi.org/10.1038/nature01917; Fabien Paulot et al., *Global Modeling of Hydrogen Using GFDL-AM4.1: Sensitivity of Soil Removal and Radiative Forcing*, 46 INT'L J. HYDROGEN ENERGY 13446 (2021), https://www.sciencedirect.com/science/article/abs/pii/S0360319921001804; Dick Derwent, *Hydrogen for Heating: Atmospheric Impacts – A Literature Review*, U.K. DEP'T BUS., ENERGY & INDUS. STRATEGY (Oct. 7, 2018), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/760538/Hydrogen_atmospheric_impact_report.pdf; Nicola Warwick, *Atmospheric Implications of Increased Hydrogen Use*, U.K. DEP'T BUS., ENERGY & INDUS. STRATEGY (Apr. 8, 2022), https://www.gov.uk/government/publications/atmospheric-implications-of-increased-hydrogen-use.

The oxidation of hydrogen molecules in the atmosphere leads to increasing concentrations of GHGs in both the troposphere and stratosphere, as shown in the figure below.

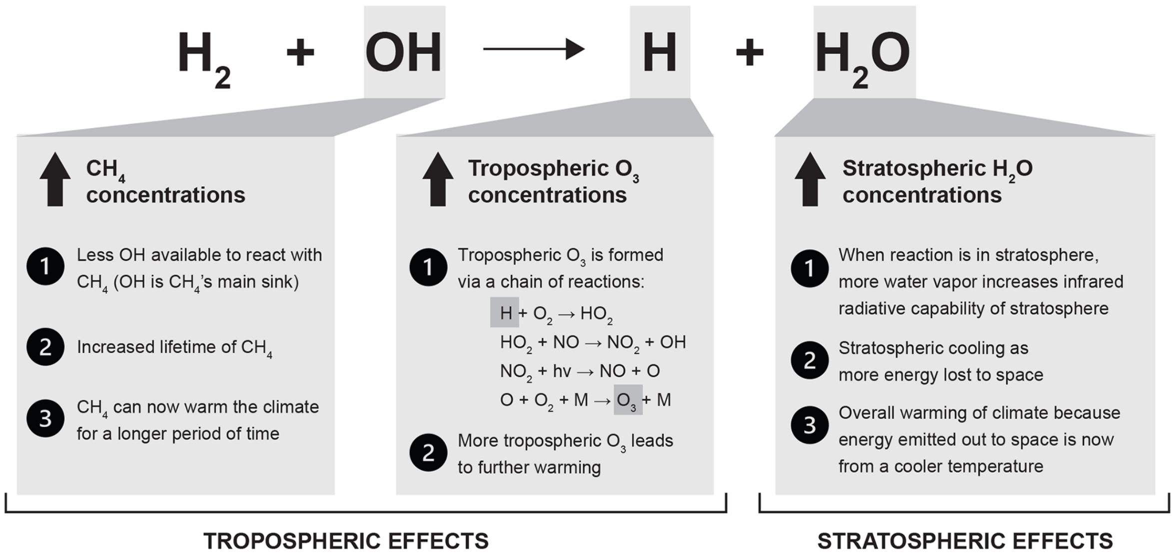

Figure 1: Effects of hydrogen oxidation on atmospheric greenhouse gas concentrations and warming.[61]

In the troposphere, less OH is available to react with methane; given that methane's reaction with OH is its primary sink, this leads to a longer atmospheric lifetime for methane which accounts for around half of hydrogen's total indirect warming effect.[62] Moreover, the production of H radical from hydrogen oxidation in the troposphere leads to a series of reactions that ultimately form tropospheric ozone, a GHG that accounts for about 20% of hydrogen's indirect warming effect.[63] In the stratosphere, the oxidation of

[61] Ilissa B. Ocko & Steven P. Hamburg, *Climate Consequences of Hydrogen Emissions*, 22 ATMOS. CHEM. PHY. 9349 (2022), https://acp.copernicus.org/articles/22/9349/2022/.

[62] Fabien Paulot et al., *Global Modeling of Hydrogen Using GFDL-AM4.1: Sensitivity of Soil Removal and Radiative Forcing*, 46 INT'L J. HYDROGEN ENERGY 13446 (2021), https://www.sciencedirect.com/science/article/abs/pii/S0360319921001804.

[63] *Id.*

hydrogen increases water vapor, which leads to stratospheric cooling. When the stratosphere gets cooler, the Earth emits less outgoing radiation (heat) into the space, which leads to more heat trapped inside of the climate system and an overall warming effect on the Earth surface. This stratospheric effect accounts for about 30% of hydrogen's climate impacts.[64]

Q. What climate concerns do you have regarding use of hydrogen as a fuel?

A. Hydrogen's indirect warming impact is concerning because hydrogen is a small molecule known to easily leak into the atmosphere,[65] and the total amount of emissions from existing hydrogen systems is unknown (i.e., leakage, venting, and purging). The effectiveness of hydrogen as a decarbonization strategy, especially over timescales of several decades, remains unclear.

Recent peer-reviewed research found that the near-term warming power of hydrogen is two to six times greater than previously recognized.[66] The research assessed the climate impact of hydrogen made either by using renewable electricity ("green" hydrogen) or from natural gas with the residual carbon dioxide emissions captured and

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[64] *Id.*

[65] *Fugitive Hydrogen Emissions in a Future Hydrogen Economy*, FRAZER-NASH CONSULTANCY (Mar. 2022), https://www.gov.uk/government/publications/fugitive-hydrogen-emissions-in-a-future-hydrogen-economy, Zhiyuan Fan et al., Hydrogen Leakage: A Potential Risk for the Hydrogen Economy, CTR. GLOB. ENERGY POL. (July 2022), https://www.energypolicy.columbia.edu/sites/default/files/file-uploads/HydrogenLeakageRegulations_CGEP_Commentary_070622.pdf; Jasmin Cooper et al., *Hydrogen Emissions from the Hydrogen Value Chain-Emissions Profile and Impact to Global Warming*, 830 SCI. TOTAL ENV'T 154624 (2022), https://doi.org/10.1016/j.scitotenv.2022.154624.

[66] Ilissa B. Ocko & Steven P. Hamburg, *Climate Consequences of Hydrogen Emissions*, 22 ATMOS. CHEM. PHYS. 9349, 9363 (2022), https://acp.copernicus.org/articles/22/9349/2022/.

stored ("blue" hydrogen) – the two most widely anticipated methods for producing climate-friendly (or low-carbon) hydrogen.[67] The study found that with a hydrogen leak rate of 10% across the value chain—which many scientists agree is plausible—switching to blue hydrogen (with carbon capture and 3% methane emissions) could cause more warming than the traditional fossil fuel over the first 20 years. Green hydrogen with a high hydrogen leak rate may still achieve a climate benefit—reducing the 20-year warming effects by two-thirds relative to fossil fuels—but far less than the climate-neutral promise that many hydrogen proponents claim.

As the smallest molecule on earth, hydrogen is difficult to contain. Extensive measurements of methane emissions from the natural gas value chain show that there is often significant leakage.[68] If methane is hard to manage, hydrogen can be even harder based on its physical properties.

Q. Is blending hydrogen into existing natural gas distribution pipeline networks beneficial from a climate perspective?

A. From a climate perspective, research indicates that blending hydrogen into existing natural gas distribution systems raises significant concerns.

First, hydrogen (and methane) leakage will be at least as bad, and likely worse, than the already-significant leakage from gas distribution systems, which contributes to

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[67] *Id.*

[68] Ramón Alvarez et al., *Assessment of Methane Emissions from the U.S. Oil and Gas Supply Chain*, 361 SCIENCE 186 (2018), https://doi.org/10.1126/science.aar7204; Zachary D. Weller et al., *A National Estimate of Methane Leakage from Pipeline Mains in Natural Gas Local Distribution Systems*, 54 ENV'T. SCI. TECH. 8958 (2020), https://doi.org/10.1021/acs.est.0c00437.

climate pollution.[69] Research shows that hydrogen/natural gas blends can leak either at the same rate or faster from pipelines compared to traditional natural gas, depending on the type of leakage. Because the lower viscosity and smaller molecular size, hydrogen is expected to leak more easily (1.3-3 times faster) than natural gas based on fundamental fluid dynamic theories.[70] However, recent experimental studies reveal different leak behaviors through different leakage pathways. One study conducted by researchers at UC Irvine suggests that hydrogen and methane would leak at a similar rate if the gas mixtures are leaked through the joints and fittings of a low pressure distribution pipeline.[71] Another study conducted by researchers at UC Riverside suggests that hydrogen/natural gas blends would leak faster than natural gas itself and the leak rate increases as the proportion of hydrogen increases, if the gas mixtures are leaked through cracks or pinholes.[72] Overall, leakage of hydrogen blends will occur at least at the same rate of traditional natural gas and likely faster, which would lead to an unintended warming effect that would be especially strong in the near-term. Thus, leakage of hydrogen and hydrogen/natural gas blends warrants further investigation before any large-scale blending occurs.

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[69] *Id.*

[70] M.R. Swain, *A Comparison of H_2, CH_4 and C_3H_8 Fuel Leakage in Residential Settings*,17 INT'L J. HYDROGEN ENERGY 807 (1992), https://doi.org/10.1016/0360-3199(92)90025-R.

[71] Alejandra Hormaza Mejia, *Hydrogen Leaks at the Same Rate as Natural Gas in Typical Low-Pressure Gas Infrastructure*, 45 INT'L J. HYDROGEN ENERGY 8810 (2020), https://www.sciencedirect.com/science/article/abs/pii/S0360319919347275.

[72] Arun SK Reju, *Hydrogen Blending Impacts Study*, CAL. PUB. UTIL. COMM. (July 18, 2022), https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M493/K760/493760600.PDF.

Second, the process of producing hydrogen consumes energy that could severely undermine or even outweigh any climate benefits of blending hydrogen with natural gas. In the case of blending blue hydrogen produced with natural gas as a feedstock, more natural gas will be needed to deliver the same amount of energy to end users due to the energy loss in the hydrogen production process.[73] This approach would result in a larger amount of fugitive methane emissions compared to the status quo of no hydrogen blending. Given the scale of upstream methane emissions today, it is possible that the increase in methane emissions could outweigh any near-term climate benefit of carbon dioxide reduction from blending blue hydrogen.

Third, producing green hydrogen requires even more energy than blue hydrogen.[74] Research shows that using green hydrogen for home heating, for example, requires six to fourteen times more energy compared to direct electrification, such as using that electricity directly for space or water heating or cooking.[75] In a region where renewable energy capacity is limited, it is highly questionable whether green hydrogen is the best use of renewable energy from a decarbonization perspective, especially for an end use that can be electrified.

Fourth, hydrogen blending in gas distribution systems could prolong fossil fuel reliance by facilitating continued investment and expansion of a pipeline network that

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[73] Christian Bauer et al., *On the Climate Impacts of Hydrogen Production*, 6 SUSTAINABLE ENERGY FUELS 66 (2021), https://pubs.rsc.org/en/content/articlelanding/2022/SE/D1SE01508G.

[74] Falko Ueckerdt, *Potential and Risks of Hydrogen-based E-fuels in Climate Change Mitigation*, 11 NATURE CLIMATE CHANGE 384 (2021), https://www.nature.com/articles/s41558-021-01032-7.

[75] *Id.*

still primarily delivers and facilitates combustion of natural gas. To facilitate decarbonization and achieve climate goals in New Jersey and beyond, it is essential to avoid unnecessary expansion of fossil fuel infrastructure.[76]

Q. Is blending hydrogen into existing natural gas distribution pipeline networks safe?

A. Blending hydrogen into existing natural gas distribution systems raises several concerns from a safety perspective.

First, there is not a clear consensus regarding to what extent hydrogen can be safely blended into existing gas distribution systems, and there is likely significant variability depending on pipeline material, age, and other factors. There are several studies that address the safety of hydrogen blending with natural gas, examining pipeline and infrastructure integrity as well as compatibility with end-use technology. For instance, an NREL 2013 study claimed that less than 5%-15% hydrogen blended by volume has minor issues and should not increase risks associated with end use devices and public safety.[77] NREL later published a 2022 report which argues that "[b]lending limit generalization is problematic because hydrogen compatibility depends on existing infrastructure component factors including specific equipment model, equipment condition, and material of construction".[78] A 2022 UC Riverside study says only 5% by

[76] *See generally Net Zero by 2050: A Roadmap for the Global Energy Sector*, INT'L ENERGY AGENCY (revised Oct. 2021), https://www.iea.org/reports/net-zero-by-2050.

[77] M.W. Melainaet al., *Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues*, NREL (Mar. 2013), https://www.nrel.gov/docs/fy13osti/51995.pdf.

[78] Kevin Topolski et al., *Hydrogen Blending into Natural Gas Pipeline Infrastructure: Review of the State of Technology*, NREL (Oct. 2022), https://www.nrel.gov/docs/fy23osti/81704.pdf.

volume is safe for system-wide blending,[79] and a 2022 report by Fraunhofer Institute says there is no established limit value for hydrogen when blending, and that it depends on a case-by-case basis.[80] The main engineering concerns with hydrogen blending includes embrittlement in steel pipelines, compromising the integrity of polymeric materials (such as those used in pipelines in the gas distribution systems), capacity of in-line compressors, and compatibility with end-use appliances like cooktop burners and heating furnaces. Without a scientific consensus on safe hydrogen blending limit, large-scale hydrogen blending into gas distribution systems should not be pursued.

Second, hydrogen leakage from natural gas pipelines and end use appliances also poses a safety concern in addition to a climate concern. Hydrogen has a wide flammable range (flammable at 4-74% volume concentration in air; methane is flammable at 5-15% volume concentration in air in comparison) and it burns 500°F hotter than natural gas.[81] Thus, hydrogen distribution and use in enclosed spaces (e.g., underground pipelines, homes, and other buildings) potentially poses higher explosion risk than methane alone.

Third, hydrogen combustion likely generates higher nitrogen oxides ("NOx") emissions than natural gas, and it is unclear whether current NOx removal technologies

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[79] Arun SK Reju, *Hydrogen Blending Impacts Study*, CAL. PUB. UTIL. COMM. (July 18, 2022), https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M493/K760/493760600.PDF.

[80] Jochen Bard et al., *The Limitations of Hydrogen Blending in the European Gas Gird,* FRAUNHOFER IEE (Jan. 2022), https://www.iee.fraunhofer.de/content/dam/iee/energiesystemtechnik/en/documents/Studies-Reports/FINAL_FraunhoferIEE_ShortStudy_H2_Blending_EU_ECF_Jan22.pdf.

[81] *Hydrogen Safety Fact Sheet*, HYDROGEN ASS'N, https://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/h2_safety_fsheet.pdf.

are effective against NOx generated from blended methane/hydrogen used in buildings.[82] NOx is a harmful pollutant that reduces air quality and can have adverse effects on lung health.[83] Thus, combustion of hydrogen or methane/hydrogen blends in buildings could increase health risk for consumers. Further research and technology demonstrations are needed to ensure low NOx emissions with hydrogen combustion.

Q. Is use of hydrogen in buildings an ideal decarbonization scenario?

A. No. Because hydrogen production is energy intensive, it should not be a ubiquitous decarbonization solution and it should not be widely deployed in buildings. Instead, it should be reserved for hard-to-electrify sectors, such as steel and cement making, shipping, and aviation.[84] Furthermore, because hydrogen is a small molecule with low viscosity that can leak at least at the same rate and likely faster than methane, transportation of hydrogen through pipeline networks and other pathways should be minimized. Hydrogen use in a highly distributed manner such as buildings would likely increase leakage risks and be more difficult to manage.

Leading economy-wide decarbonization analyses identify building electrification as the primary, most cost-effective pathway to reduce GHG emissions from the building sector, and identify the best application of hydrogen for hard-to-electrify sectors such as

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[82] Madeleine Wright & Alastair C. Lewis, *Emissions of NO_x from Blending of Hydrogen and Natural Gas in Space Heating Boilers*, 10 SCI. ANTHROPOCENE 00114 (2022), https://online.ucpress.edu/elementa/article/10/1/00114/183173/Emissions-of-NOx-from-blending-of-hydrogen-and.

[83] *Nitrogen Dioxide*, AM. LUNG. ASS'N, https://www.lung.org/clean-air/outdoors/what-makes-air-unhealthy/nitrogen-dioxide (last visited Nov. 10, 2022).

[84] U.S. DEP'T ENERGY, *DOE National Clean Hydrogen Strategy and Roadmap* (Sept. 2022), at 39, https://www.hydrogen.energy.gov/pdfs/clean-hydrogen-strategy-roadmap.pdf.

heavy industrial.[85] New Jersey analyses have similarly stated that building electrification is the most cost-effective pathway to achieving GHG reductions, and that at least 90% of residential and commercial sectors must be electrified by 2050 to meet the state's clean energy and climate goals.[86]

Q. What climate concerns do you have regarding the Companies' assumed reliance on hydrogen as a pathway to decarbonize the gas distribution system?

A. Given the scientific research on the climate impacts of hydrogen and hydrogen blending mentioned above, I am concerned that reliance on hydrogen blending into gas distribution systems will not yield a meaningful climate benefit.

The Joint Petitioners have not specified in their plans what type of hydrogen is being considered for blending. There is no plan for where natural gas feedstock will be sourced from in the case of blue hydrogen, which can determine the scale of upstream methane emissions and their warming effects. There is also no plan for what renewable electricity source will be employed in the case of green hydrogen. If the renewable electricity is not responsibly sourced, it could distract from grid decarbonization and retirement of fossil fuel power generation, which could detract from achievement of New Jersey climate goals. Regardless of what type of hydrogen is used, hydrogen emissions pose a climate concern as an indirect warming pollutant, which could severely undermine

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[85] *Net Zero by 2050: A Roadmap for the Global Energy Sector*, INT'L ENERGY AGENCY, Part 2.5.5, Part 3.7 (revised Oct. 2021), https://www.iea.org/reports/net-zero-by-2050; Jan Rosenow, *Is Heating Homes with Hydrogen All But a Pipe Dream? An Evidence Review*, 6 JOULE 2225 (2022), https://doi.org/10.1016/j.joule.2022.08.015.

[86] N.J. BD. PUB. UTILS., *2019 New Jersey Energy Master Plan: Pathway to 2050* (Jan. 2020), at 160, https://www.nj.gov/emp/docs/pdf/2020_NJBPU_EMP.pdf; N.J. 80x50 Report, at xi.

any intended climate benefits of using hydrogen. For these reasons, it is questionable in my opinion that the Joint Petitioners' plan for hydrogen blending will contribute to decarbonization in a meaningful way.

Q. What safety concerns do you have regarding the Companies' assumed reliance on hydrogen as a pathway to decarbonize the gas distribution system?

A. Given the current scientific knowledge on the safety risks of hydrogen and hydrogen blending, I am concerned that reliance on hydrogen in gas distribution systems and buildings may increase the safety and health risks of consumers. There is currently no established safe blending limit or protocols for gas distribution infrastructure; nor are there clear plans to demonstrate safe blending that does not affect the integrity of pipelines and equipment, and to facilitate zero or low hydrogen leakage and low NOx emissions at end use.

VI. Climate Implications of Biomethane

Q. What is biomethane? How is it different from methane?

A. Biomethane, short for biogenic methane, is methane emitted from biogenic materials decomposing in an anerobic environment.[87] It is the same compound as fossil methane and has the same warming effect on the climate as fossil methane. The difference between biomethane and fossil methane lies in the resultant carbon dioxide after it is combusted or oxidized in the atmosphere. The carbon dioxide resultant from biomethane was initially absorbed from the atmosphere via photosynthesis by plants, thus it is not

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[87] *See generally* Emily Grubert, *At Scale, Renewable Natural Gas Systems Could be Climate Intensive: The Influence of Methane Feedstock and Leakage Rates*, 15 ENV'T RSCH. LETTERS 084041 (Aug. 2020), https://iopscience.iop.org/article/10.1088/1748-9326/ab9335.

adding net carbon dioxide emissions into the atmosphere. Fossil methane, on the other hand, moved carbon that was stored deep underground to the surface. When fossil methane is oxidized or combusted into carbon dioxide, it results in net addition of carbon dioxide into the atmosphere. This difference is reflected in the Global Warming Potential (GWP) values of biomethane and fossil methane.[88] For example, the GWP of biomethane is 80 on a 20-year time horizon, whereas the GWP of fossil methane is 83 on a 20-year time horizon.[89]

Q. What climate and environmental concerns do you have regarding use of biomethane as a fuel?

A. Using biomethane as a fuel raises concerns related to climate change and air quality.

First, biomethane may or may not result in climate benefits depending on the source. Biogenic methane is typically emitted from sources such as landfills, lagoons, and animal-feeding operations. Capturing and using this biomethane can be beneficial because it can yield a net reduction in methane emissions, even if there is some leakage. But if new biomethane is generated—for example, from wood product wastes or purpose-grown crops—subsequent leakage of that new biogenic methane would increase overall atmospheric methane concentrations and be counterproductive to addressing climate

[88] GWP measures a pulse emission of a non-carbon dioxide gas's warming power over a certain period of time compared to an equal mass of carbon dioxide emissions. It is a metric that allows for the comparison of the warming impact of different gases.

[89] IPCC, Chapter 7 (2021).

change.[90] For a biomethane source to provide genuine climate benefit, the fuel must result in a net reduction in methane emissions. To demonstrate that benefit, biomethane production and use must not result in new or excess methane emissions relative to current waste management practices.[91] But this is unlikely, and gasifying organic sources of biomethane would likely result in more net climate pollution due to methane leakage during production, processing, transportation, and end-use applications—due in part to leakage throughout the existing gas supply chain, discussed further below.[92] A study from Lawrence Livermore Laboratory found that organic sources such as forest biomass and agricultural residue are not viable source materials for biomethane because they would not yield a net reduction in climate pollution.[93]

Supplies of climate-beneficial biomethane are limited and are best allocated for hard-to-electrify sectors rather than blending into gas distribution systems for delivery to

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[90] Joe Rudek & Stefan Schwietzke, *Not All Biogas is Created Equal*, EDF ENERGY EXCHANGE (Apr. 15, 2019), https://blogs.edf.org/energyexchange/2019/04/15/not-all-biogas-is-created-equal/.

[91] Mark Omara & Joe Rudek, *Careful Accounting is Critical to Assessing the Climate Benefits of Biomethane*, EDF ENERGY EXCHANGE (Mar. 24, 2021), https://blogs.edf.org/energyexchange/2021/03/24/careful-accounting-is-critical-to-assessing-the-climate-benefits-of-biomethane/.

[92] *See, e.g.*, Ramón Alvarez et al., *Assessment of Methane Emissions from the U.S. Oil and Gas Supply Chain*, 361 SCIENCE 186 (2018), https://doi.org/10.1126/science.aar7204; Weller et al., *Vehicle-Based Methane Surveys for Finding Natural Gas Leaks and Estimating Their Size: Validation and Uncertainty*, 52 ENV'T SCI. & TECH. 11922 (2018), https://doi.org/10.1021/acs.est.8b03135.

[93] Sarah E. Baker et al., *Getting to Neutral: Options for Negative Carbon Emissions in California*, LAWRENCE LIVERMORE NAT'L LAB., LLNL-TR-796100 (Jan. 2020), at Fig. 15, https://www.osti.gov/biblio/1597217.

buildings.[94] An ICF study for the American Gas Foundation found that biomethane and synthetic gas could provide 5-12% of U.S. natural gas demand, and a Natural Resources Defense Council analysis concluded that "ecologically sound biogas and synthetic gas" could replace just 3-7% of demand.[95] A National Renewable Energy Laboratory analysis found that methane potential from landfill material, animal manure, wastewater, and industrial, institutional, and commercial organic waste in the U.S. is ~420 billion cubic feet, which would displace 1.4% of U.S. gas demand (30.28 trillion cubic feet in 2021).[96]

Second, biomethane combustion releases CO2 and local pollution at the same rates as natural gas combustion since both are comprised primarily of methane. CO2 from currently emitted biomethane does not increase the atmospheric CO2 levels as it is derived from pre-existing CO2 via photosynthesis, unlike new biomethane and fossil natural gas sources. However, local emissions of air pollution (such as NOx) from biomethane combustion are equivalent to natural gas combustion and contribute to

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[94] *See* Sherri Billimoria & Mike Henchen, *Regulatory Solutions for Building Decarbonization*, ROCKY MOUNTAIN INST. (2020), at 21, https://rmi.org/wp-content/uploads/2020/07/Regulatory-Solutions-Framework-Report-070820.pdf; NAT. RES. DEF. COUNCIL, *Issue Brief: A Pipe Dream or Climate Solution? The Opportunities and Limits of Biogas and Synthetic Gas to Replace Fossil Gas* (June 2020), https://www.nrdc.org/sites/default/files/pipe-dream-climate-solution-bio-synthetic-gas-ib.pdf [hereinafter NRDC Biogas].

[95] *See* ICF, *Renewable Sources of Natural Gas: Supply and Emissions Reduction Assessment*, AM. GAS. FOUND. (Dec. 2019), https://www.gasfoundation.org/wp-content/uploads/2019/12/AGF-2019-RNG-Study-Full-Report-FINAL-12-18-19.pdf; NRDC Biogas, at 5.

[96] NREL, *Biogas Potential in the United States* (Oct. 2013), https://www.nrel.gov/docs/fy14osti/60178.pdf; *Frequently Asked Questions: How much natural gas is consumed in the United States?*, EIA (last updated May 11, 2022), https://www.eia.gov/tools/faqs/faq.php?id=50&t=8.

negative health effects—which could be eliminated by converting homes from gas combustion to electrification.

Q. Do you have any additional climate concerns regarding use of biomethane as a fuel?

A. Biomethane leakage is of particular concern from the climate perspective because methane is a potent GHG that has over 80 times the warming power of CO2 pound for pound over the first 20 years, regardless of whether it is biogenic or fossil. Existing research estimates that methane leakage from biomethane production and biogas-to-biomethane upgrading facilities is in the 2-4% range, up to as much as 15%.[97] In addition, distributing biomethane through current natural gas infrastructure also poses leakage risk.

Peer-reviewed research has demonstrated that nationwide fugitive methane emissions from gas distribution pipelines are approximately five times greater than reported in the U.S. EPA inventory.[98] Researchers in one study observed methane emissions from six U.S. cities to be about twice that reported in the U.S. EPA inventory; and another study observed urban methane levels in the Boston area to be consistently three times higher than Massachusetts inventories had previously indicated, over an eight-year period.[99] Methane leakage is innate in a complex methane distribution system,

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[97] Emily Grubert, *At Scale, Renewable Natural Gas Systems Could be Climate Intensive: The Influence of Methane Feedstock and Leakage Rates*, 15 ENV'T RES. LETTERS 084041 (2020), https://iopscience.iop.org/article/10.1088/1748-9326/ab9335.

[98] Zachary D. Weller et al., A National Estimate of Methane Leakage from Pipeline Mains in Natural Gas Local Distribution Systems, 54 ENV'T SCI. TECH. 8958 (2020), https://doi.org/10.1021/acs.est.0c00437.

[99] Genevieve Plant et al., *Large Fugitive Methane Emissions from Urban Centers Along the U.S. East Coast*, 46 GEOPHYSICAL RSCH. LETTERS 8500 (2019), https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2019GL082635; Maryann Sargent et al., *Majority of US Urban Natural Gas Emissions Unaccounted for in Inventories*, 118

including from pipelines, appliances, and buildings, and use of biomethane would perpetuate these existing leakage challenges.

Furthermore, SJI is already investing in biomethane production at dairy farms outside of New Jersey,[100] with plans to truck the biomethane back to its gas distribution systems in New Jersey.[101] Depending on the mode of transportation, this can generate additional GHG emissions from leakage and trucking, as well as local air pollution.

The most likely climate-beneficial biomethane projects are those that capture preexisting sources of biomethane (landfills, lagoons, and animal-feeding operations) and are used to generate heat and electricity on site. Any other projects, particularly those projects using diesel trucks to transport RNG or projects proposing the buildout of new transportation pipelines, may not be beneficial and must be held to a high standard that addresses methane leakage as well as local air pollution.

Q. What climate concerns do you have regarding the Joint Petitioners' assumed reliance on biomethane as a pathway to decarbonize the gas distribution system?

A. Given the scientific understanding of biomethane and its potential climate benefit or lack thereof, I am concerned that reliance on biomethane for blending into gas distribution systems may result in increased methane emissions rather than delivering a climate benefit. Because the Joint Petitioners present only high-level statements about SJI's

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PROCEEDINGS NAT'L ACAD. SCI. e2105804118 (2021), https://www.pnas.org/doi/10.1073/pnas.2105804118.

[100] Exh. EL-3, Fourth Quarter and Full Year 2021 Earnings Presentation at 18 (Feb. 24, 2022) (Petition PDF p447).

[101] SJI, *Investor Fact Sheet: REV LNG, LLC* (Feb. 25, 2021), https://www.sjindustries.com/sji/media/ir/SJI-Investor-Fact-Sheet-REV-LNG-02-25-21.pdf.

future use of biomethane in utility gas distribution systems, without detailed plans, it is impossible to precisely evaluate the climate impact of their long-term vision. In general, the most climate-beneficial use of biomethane is for projects that capture preexisting sources of biomethane (landfills, lagoons, and animal-feeding operations) that can be used for onsite energy generation, and that minimize transportation distances to minimize both associated methane leakage and local air pollution.

VII. Equity Concerns Associated with Leakage

Q. How are environmental justice issues considered in the context of this proceeding?

A. I have been advised by counsel that the BPU incorporates environmental justice into its work and approval processes. I have been advised that a definition of Environmental Justice for use by New Jersey executive agencies issued by the NJ Department of Environmental Protection is as follows:

> The U.S. Environmental Protection Agency (EPA) defines environmental justice as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies." EPA has further explained that:
>
> "Fair treatment" means that no group of people should bear a disproportionate share of the negative environmental consequences resulting from industrial, governmental and commercial operations or policies. EPA also recommends that "fair treatment" include consideration of how environmental and public health benefits, as well as stressors, are distributed across all populations.
>
> "Meaningful involvement" means that people have an opportunity to participate in decisions about activities that may affect their environment and/or health; the public's contribution can influence the regulatory agency's decision; community concerns will be considered in the decision-making process; and decision makers will seek out and facilitate the involvement of those potentially affected.
>
> In New Jersey, we support the EPA's definition of environmental justice. We identify environmental justice communities using three sets of data: demographics, such as low-income households, minority status, and limited English proficient populations. We also consider the presence of

disproportionate environmental and public health stressors. And finally, we consider the lack or absence of environmental and public health benefits. [102]

Q. What equity concerns do you have regarding the Companies' assumed reliance on biomethane and/or hydrogen blending as a pathway to decarbonize the gas distribution system?

A. Peer-reviewed research analyzing gas leak data from at least nine U.S. cities found that neighborhoods with higher proportions of people of color and lower-income households tended to have more methane leaks.[103] The study found that average leak density increased by 37% for these populations compared to predominantly white neighborhoods.[104] Leak density — the number of leaks per mile of pipeline — also increased slightly in neighborhoods with older housing infrastructure.

The research did not assess cities in New Jersey. The findings, however, demonstrate a concerning trend that should be considered by the Utilities to ensure equitable leak management.

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[102] N.J. DEP'T ENV'T PROT., *Furthering the Promise: A Guidance Document for Advancing Environmental Justice Across State Government* (2020), at 8, https://nj.gov/dep/ej/docs/furthering-the-promise.pdf.

[103] Zachary D. Weller et al., A National Estimate of Methane Leakage from Pipeline Mains in Natural Gas Local Distribution Systems, 54 ENV'T SCI. TECH. 8958 (2020), https://doi.org/10.1021/acs.est.0c00437; *see also* Marcos Luna & Dominic Nicholas, *An Environmental Justice Analysis of Distribution-Level Natural Gas Leaks in Massachusetts, USA*, 162 ENERGY POL. 112778 (2022), https://www.sciencedirect.com/science/article/pii/S0301421522000039.

[104] Zachary D. Weller et al., *A National Estimate of Methane Leakage from Pipeline Mains in Natural Gas Local Distribution Systems*, 54 ENV'T SCI. TECH. 8958 (2020), https://doi.org/10.1021/acs.est.0c00437.

Gas leaks pose multiple risks to communities. Methane is a potent GHG that contributes rapidly to climate change. Gas leaks can also result in explosions that are dangerous to people and property—and though such explosions are rare, they can be disastrous. Furthermore, the ongoing presence of leaked gas can create a nuisance odorand can harm vegetation such as the urban tree canopy, which adversely affects neighborhood aesthetics, shade, cooling, and property values.[105] Biomethane leakage has the same impacts as traditional natural gas methane, and hydrogen leakage could present additional safety concerns, discussed *supra* Part V.

Given the scientific understanding of current natural gas leakage and its disproportionate impact on low-income communities and people of color, a continued reliance on the gas distribution system, including blending hydrogen and/or biomethane, could perpetuate those impacts.

Overburdened communities, which already face increased cumulative burdens, face additional risks due to the possibility of increased density of gas leaks. Without a clear plan to address gas leaks from an environmental justice perspective, the Companies' plans to extend the use of the gas distribution system, including through blending biomethane and/or hydrogen, could perpetuate existing inequities associated with leak densities.

Q. What steps could be taken to address this issue?

[105] Claire Schollaert, *Natural Gas Leaks and Tree Death: A First-Look Case-Control Study of Urban Trees in Chelsea, MA USA*, 263 ENV'T POLLUTION 114464 (2020), https://www.sciencedirect.com/science/article/pii/S0269749119376717?via%3Dihub.

A. Because an environmental justice analysis of gas leak data has not been conducted for New Jersey, it is unknown if specific inequities exist, and a first step would be to analyze gas leak data accordingly. To improve the Utilities' consideration of overburdened communities, the Utilities should assess gas leak density by census blocks. The Utilities should analyze whether there is a correlation between overburdened communities and higher natural gas leak density. If such areas exist, the Utilities should prioritize addressing those leaks through leak repairs, replacing leak-prone pipes, or through non-gas alternatives such as an electrification or geothermal programs. The Utilities should also include plans for engaging and partnering with community members in any such initiative. One important step to enhancing transparency and accountability around gas leaks would be for the Utilities to publish interactive leak maps on their websites so that the public can understand where leaks are and how long they have been on the system.[106] This step would be a logical and appropriate extension of the recent New Jersey Department of Environmental Protection rule requiring gas utilities to annually report on the location of gas leaks.[107]

VIII. Proposed Solutions to Improve the Merger

Q. What recommendations do you have to improve the proposed merger and ensure that the transaction will bring benefits to the State of New Jersey and ratepayers?

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[106] *See, e.g.*, CON EDISON, *Reported Gas Leaks*, https://apps.coned.com/gasleakmapweb/GasLeakMapWeb.aspx (last accessed Nov. 10, 2022); NATIONAL GRID, *Gas Leak Map*, https://www.nationalgridus.com/ny-Home/natural-gas-safety/gas-leak-map (last accessed Nov. 10, 2022).

[107] N.J. Department of Environmental Protection, Final Rule: Greenhouse Gas Monitoring and Reporting, at 7:27E-3.1(b)(3) (adopted Apr. 22, 2022, effective June 6, 2022), https://www.nj.gov/dep/rules/adoptions/adopt-20220606a.pdf.

A. Based on the urgent need to reduce reliance on natural gas and the many uncertainties around the climate, air pollution, and safety impacts of blending hydrogen and biomethane into the gas distribution system, the Joint Petitioners should include the following commitments in any merger proposal, and the Board should require the following conditions if it approves the proposed merger transaction:[108]

- **Avoiding Inappropriate Investments in Hydrogen and Biomethane**:
  1. The Utilities shall not pursue any utility or ratepayer-supported investments in hydrogen blending until the NJ BPU has determined that such hydrogen deployment is consistent with safe and adequate service.
  2. SJI and the Utilities shall not pursue any utility or ratepayer-supported biomethane blending until the NJ BPU has determined that such biomethane deployment is consistent with safe and adequate service.
- **Reporting and Reducing GHG Emissions from the Existing System**:
  3. To identify and address environmental injustices, the Utilities should analyze whether there is a correlation between overburdened communities and natural gas leak densities, and if such correlations exist, the Utilities should prioritize addressing those leaks through leak repairs, replacing leak-prone pipes, or through non-gas alternatives such as an electrification or geothermal programs. The Utilities should also engage and partner with community members in any such initiative.

[108] EDF presents additional recommended merger conditions in the Direct Testimony of David Hill for EDF.

4. The Utilities should publish interactive leak maps on their websites so that the public can understand where leaks are and how long they have been on the system.

Q. Does this conclude your testimony?

A. Yes.

TIANYI SUN, Ph.D.

CLIMATE SCIENTIST

E-mail: sun.tianyi@yahoo.com | Phone: 512-695-9543 | Website: tsun-climate.org

AREAS OF EXPERTISE

Quantitative research on topics of climate change and impact, climate modeling, ocean-atmosphere dynamics, greenhouse gas emissions and mitigations, and climate metrics; Scientific communications; Project management

EDUCATION

Ph.D.	Climate Dynamics, University of Texas at Austin, 2019
B.S.	Atmospheric Sciences, Nanjing University, 2013

PROFESSIONAL EXPERIENCE

Climate Scientist 2021-present

Environmental Defense Fund Austin, TX

- Lead peer-reviewed research on climate impacts of short-lived climate pollutants and their potential mitigation strategies, net-zero greenhouse gas pathways and their climate impacts; Promote this research at international conferences
- Conduct data analysis, visualization and climate modeling for various EDF initiatives, such as the *Climate Microsite* and *Stabilizing the climate and averting catastrophe*
- Support EDF's climate communication efforts to improve public understanding of climate change by publishing blog posts, preparing factsheets and memorandums, and ensuring scientific accuracy of EDF's reports and media outreach materials

Postdoctoral Climate Science Fellow 2019-2021

Environmental Defense Fund Austin, TX

- Lead peer-reviewed research on greenhouse gas mitigation
- Support climate analytics for EDF initiatives and ensure scientific accuracy of EDF communications
- Advise EDF-Oceans on climate resilient fisheries management project in Cuba
- Facilitate collaborations between EDF-Beijing office and Office of the Chief Scientist on air quality research in Chinese cities

Graduate Research Assistant 2014-2019

Institute for Geophysics, University of Texas at Austin Austin, TX

- Lead peer-reviewed research on topics of ocean-atmosphere interactions using state-of-the-art global climate models. Design and conduct novel climate model experiments in a parallel computing environment. Conduct rigorous process-based diagnostic analysis of large model outputs of atmosphere and ocean variables

Teaching Assistant 2018

University of Texas at Austin Austin, TX

- Teaching assistant and lab instructor for Geoscience course: *Earth Wind and Fire*

PUBLICATIONS

PEER-REVIEWED

Sun, T., I.B. Ocko and S.P. Hamburg 2022: Early Methane Mitigation Critical to Preserving Arctic Summer Sea Ice, *Environmental Research Letters* **17** 044001. https://iopscience.iop.org/article/10.1088/1748-9326/ac4f10

Sun, T., I.B. Ocko, E. Sturcken and S.P. Hamburg 2021: Net-zero greenhouse gas targets: pathway and when reached equally important, *Scientific Reports* **11,** 22173. https://doi.org/10.1038/s41598-021-01639-y

Ocko, I.B., **T. Sun**, D. Shindell, M. Oppenheimer, A. Hristov, S.W. Pacala, D.L. Mauzerall, Y. Xu and S.P. Hamburg 2021: Acting rapidly to deploy readily available methane mitigation measures by sector can immediately slow global warming, *Environmental Research Letters,* https://doi.org/10.1088/1748-9326/abf9c8

Morée, A., **T. Sun**, A. Bretones, E. O. Straume, K. H. Nisancioglu and G. Gebbie 2021: Cancellation of the precessional cycle in δ18O records during the Early Pleistocene. *Geophysical Research Letters*, doi:10.1029/2020gl090035.

Sun, T. and Y. M. Okumura 2020: Impact of ENSO-like tropical Pacific decadal variability on the relative frequency of El Niño and La Niña events. *Geophysical Research Letters,* doi: 10.1029/2019GL085832

Sun, T. and Y. M. Okumura 2019: Role of Stochastic Atmospheric Forcing from the South and North Pacific in Tropical Pacific Decadal Variability. *Journal of Climate,* doi:10.1175/JCLI-D-18-0536.1.

Okumura, Y.M., **T. Sun**, and X. Wu, 2017: Asymmetric Modulation of El Niño and La Niña and the Linkage to Tropical Pacific Decadal Variability. *Journal of Climate*, doi:10.1175/JCLI-D-16-0680.1

BLOG POSTS

Tianyi Sun and Ilissa Ocko 11/12/2021: How Does Methane Fit into Net Zero Targets? *EDF+Business,* https://business.edf.org/insights/how-does-methane-fit-into-net-zero-targets/

Ilissa Ocko and **Tianyi Sun** 8/27/2020: What you need to know about hurricanes and climate change. *Climate 411*, http://blogs.edf.org/climate411/2020/08/27/what-you-need-to-know-about-hurricanes-and-climate-change/

Tianyi Sun 10/3/2019: Four takeaways on climate change and sea level rise in the latest IPCC report. *Climate 411*, http://blogs.edf.org/climate411/2019/10/03/four-takeaways-on-climate-change-and-sea-level-rise-in-the-latest-ipcc-report/

SELECTED PRESENTATIONS

YWCA

"5 Advancements of the IPCC Report Lead Us to a Safer Climate Future", Climate Solutions Now, Cal Poly, October 2021, virtual (*keynote*)

"Early Methane Mitigation Critical to Preserving Arctic Summer Sea Ice", EGU meeting, April 2021, virtual *(short talk)*

"Impact of ENSO-like tropical Pacific decadal variability on the relative frequency of El Niño and La Niña events", AGU fall meeting, December 2019, San Francisco, California *(poster)*

"Impact of Stochastically Forced Tropical Pacific Decadal Variability on the El Niño-Southern Oscillation", AMS annual meeting, January 2019, Phoenix, Arizona *(talk)*

"Tropical Hydroclimate Change during Heinrich Stadial 1 – A Proxy-Model Synthesis", PMIP4 conference, September 2017, Stockholm, Sweden *(talk and poster)*

"Role of Stochastic Atmospheric Forcing in Tropical Pacific Decadal Variability and ENSO Modulation", CESM workshop, June 2017, NCAR, Boulder, Colorado *(invited talk)*

SCIENTIFIC SERVICES

MEDIA

CaiXin Weekly 07/04/2022 What's the pain point of reducing methane emissions? https://weekly.caixin.com/2022-07-02/101907189.html

Minnesota Public Radio 03/21/2022 https://www.mprnews.org/episode/2022/03/31/reducing-methane-emissions-could-play-a-significant-role-in-saving-arctic-sea-ice

National Observer 03/15/2022 https://www.nationalobserver.com/2022/03/15/news/we-still-have-chance-stop-arctic-summer-sea-ice-melting

WIRED 08/11/2021 https://www.wired.com/story/the-ipcc-reports-silver-lining-we-can-tackle-methane-now/

Bloomberg Green 10/05/2021 https://www.bloomberg.com/graphics/2021-methane-impact-on-climate/?sref=jjXJRDFv

PEER-REVIEWER

Communications Earth & Environment, Climate Dynamics, Journal of Marine Science and Engineering, Earth's Future, Atmosphere

OUTREACH

2021	Interview with Damiana De La Paz at University of Texas at Austin
2021	Interview with Ryder Hill at Liberal Arts and Science Academy
2021	Career panel discussion for class of *Science of Climate Change* at Rice University, Houston TX (panelist)
2021	Phone interview with Ryan Pischinger at Lake Travis High School
2020	Interview with Nicholas Hong at Whitney Young, Chicago

DIVERSITY & INCLUSION

2020-2022	Steering committee member of EDGE (EDF Gender Equity)
2020-	Member of ASPIRE (Asian/Pacific Islanders) IDEA group at EDF

TECHINICAL SKILLS

NCAR Command Language, Python programming, geospatial data analysis, time series analysis, Microsoft Office, Google applications, Chinese (Mandarin)

AWARDS

2021	Significant Figure of the Quarter, Office of the Chief Scientist, EDF
2019	Bjerknes visiting fellowship, Bjerknes Center for Climate Research, University of Bergen, Norway
2019	Outstanding oral presentation award, AMS annual meeting, Phoenix, Arizona
2018	Ewing-Worzel Fellowship, Institute for Geophysics, University of Texas at Austin
2018	Outstanding oral presentation award, AMS annual meeting, Austin, Texas
2017	Early career scientist travel grant, PMIP4 conference, Stockholm, Sweden
2017	Early career scientist travel grant, CESM workshop, NCAR, Boulder, Colorado
2013	Outstanding undergraduate thesis in Atmospheric Sciences, Nanjing, China

In the Matter of the Merger of
South Jersey Industries, Inc. and Boardwalk Merger Sub, Inc.
BPU Docket No. GM22040270

Environmental Defense Fund Information Requests-Set One

EDF-5. Please refer to Exhibit G at p. 21, which lists items under the heading "Demonstrated Record of Commitment to Key Priorities" for SJI, including "RNG/Hydrogen initiatives to lower carbon content of gas and reduce emissions."

a) Has SJI, SJG, or ETG conducted or commissioned any feasibility and/or cost analyses related to blending hydrogen into the gas distribution system, or conveying 100% hydrogen to customers? If so, please provide those analyses.

b) Has SJI, SJG, or ETG conducted or commissioned any feasibility and/or cost analyses related to blending RNG (renewable natural gas, also known as biomethane) into the gas distribution system, or conveying 100% RNG to customers? If so, please provide those analyses.

c) Has SJI, SJG, or ETG conducted or commissioned any analyses of the greenhouse gas emissions impact of blending hydrogen and/or RNG (renewable natural gas, also known as biomethane) into the gas distribution system, or conveying 100% hydrogen or 100% RNG to customers? If so, please provide those analyses.

Responsible Witness: **Michael J. Renna and Melissa J. Orsen**

Response: The Joint Petitioners object to this request to the extent that it seeks information that is not relevant or likely to lead to the discovery of relevant information. Notwithstanding the foregoing objection, the Joint Petitioners respond as follows.

a. An analysis is in progress to review the impact of hydrogen blending on its gas system. The Companies have relied on the following references for data:

- Effect of hydrogen gas impurities on the hydrogen dissociation on iron surface, A. Staykov et al. Quantum Chemistry 2014, 114, 626 – 635.
- Hydrogen embrittlement of structural steels, B. Somerday, reactH2, May 15, 2013.
- Cialone, H,j. et al., "Sensitivity of Steels to Degradation in Gaseous Hydrogen", in Hydrogen Embrittlement: Prevention and Control, ASMT STP 962, 1988.

b. The gas specifications for RNG of GTI Energy and other utilities were reviewed and potential producers were consulted to ensure the end product of RNG production, when blended into the Companies' systems, is indiscernible from conventional natural gas which is currently flowing through the distribution system. The Companies have not evaluated conveying 100% RNG through their systems.

c. An analysis of the impact to greenhouse gas emissions of blending hydrogen and/or RNG into the gas distribution system has not yet been performed.