Before the
New York Public Service Commission

Proceeding on Motion of the Commission as to the Rates, Charges, Rules and Regulations of New York State Electric & Gas Corporation for Electric Service.	))))	Case 19-E-0378
Proceeding on Motion of the Commission as to the Rates, Charges, Rules and Regulations of Rochester Gas and Electric Corporation for Electric Service.	))))	Case 19-E-0380
Proceeding on Motion of the Commission as to the Rates, Charges, Rules and Regulations of New York State Electric & Gas Corporation for Gas Service.	))))	Case 19-G-0379
Proceeding on Motion of the Commission as to the Rates, Charges, Rules and Regulations of Rochester Gas and Electric Corporation for Gas Service.	))))	Case 19-G-0381

DIRECT TESTIMONY OF

Robert W. Howarth

ON BEHALF OF

Fossil Free Tompkins

September 20, 2019

TABLE OF CONTENTS

1. INTRODUCTION AND QUALIFICATIONS 2
2. OVERVIEW 8
3. EXHIBITS 11
4. CLIMATE LEADERSHIP AND COMMUNITY PROTECTION ACT 12

1. INTRODUCTION AND QUALIFICATIONS

Q. Please state your name, title and employer.

A. My name is Robert W. Howarth. I am the *David R. Atkinson Professor* at Cornell University, Ithaca, NY 14853.

Q. Please summarize your relevant educational background and experience.

A. I hold a BA (*magna cum laude*) from Amherst College and a Ph.D. awarded jointly by the Massachusetts Institute of Technology (MIT) and the Woods Hole Oceanographic Institution. I am an Earth system scientist who has researched and taught about climate change and other human-caused alterations of the environment since earning by Ph.D. in 1979. In 1979, I was a postdoctoral fellow at the Ecosystems Center, Marine Biological Lab, in Woods Hole, MA. From 1980 to

1985, I was a staff scientist in the Ecosystems Center. I joined the faculty at Cornell University as a tenured Associate Professor in 1985, and I was promoted to full professor in 1990. I was further promoted to my current endowed Professorship (the *David R. Atkinson Professor*) in 1993.

I have held a series of leadership positions at Cornell, with most of these related to global change. I was a Senior Fellow and coordinator for the Initiative in Earth, Atmospheric, and Aquatic Sciences in the Center for the Environment from 1992 to 1995. I was the Director of the Program in Biogeochemistry & Environmental Change from 1995 to 2000. I was the Director of the Program in Agriculture, Energy, & Environment from 2005 to 2012. I served on the Senior Leaders Climate Action Group from 2016 to 2019. I was the Chair of the Campus Infrastructure Committee from 2018 to 2019. I currently serve on the newly formed Carbon Neutral Campus Steering Committee, a group that advised the Provost on how Cornell can reach our goal of carbon neutrality by 2035.

I also have held adjunct appointments at many other institutions. Currently, I am an MBL Fellow at the Marine Biological Lab and a Distinguished Visiting Scientist at the Woods Hole Research Center, both in Woods Hole, MA. Before that, I was an Adjunct Senior Scientist at the Marine Biological Lab, from 2000 to 2017. From 2000 to 2001, I was Director of the Oceans Program and a Senior Scientist with the Environmental Defense Fund, New York, NY. In 2009, I was a Visiting Professor at the University of Paris VI, Paris, France. In 1999 I was a Visiting Professor at the University of California in Santa Barbara. Previously I had held adjunct appointments at the University of Georgia, the University of Rhode Island, and Aarhus University in Denmark.

Q. Can you please summarize your peer-reviewed research papers, and particularly those relevant to climate change and greenhouse gas emissions?

A. I am the author or co-author of over 200 peer-reviewed articles, and the author or editor of 9 books, including one environmental sciences textbook. My articles have been cited in other peer-reviewed papers over 58,000 times, making me one of the 100 most cited

environmental scientists globally. A majority of my papers have involved global change research to at least some extent. The following are particularly relevant to greenhouse gas emissions:

- Howarth, R.W. 2019. Ideas and perspectives: is shale gas a major driver of recent increase in global atmospheric methane? *Biogeosciences* 16: 3033–3046
- Hong, B., and R.W. Howarth. 2016. Greenhouse gas emissions from domestic hot water: heat pumps compared to most commonly used systems. *Energy Science & Engineering* 4: 123-133
- Howarth, R.W. 2015. Perspectives on air emissions of methane and climatic warming risk from hydraulic fracturing and shale-gas development: Implications for policy. *Energy & Emission Control Technologies* 3: 45-54.
- Costello, C., X. Xue, and R.W. Howarth. 2015. Comparison of production-phase environmental impact metrics derived at the farm- and national-scale for United States agricultural commodities. *Environmental Research Letters* 10: 114004
- Howarth, R.W. 2014. A bridge to nowhere: Methane emissions and the greenhouse gas footprint of natural gas. *Energy Science & Engineering* 2: 47-60,
- Caulton, D.R., P. B. Shepson, R.L. Santor0, J.P. Sparks, R.W. Howarth, A. Ingraffea, M.O. Camaliza, C. Sweeney, A. Karion, K.J. Davis, B.H. Stirm, S.A. Montzka, and B. Miller. 2014. Toward a better understanding and quantification of methane emissions from shale gas development. *Proceedings of the National Academy of Sciences* 111: 6237-6242.
- Jacobson, M.Z., M.A. Delucchi, A.R. Ingraffea, R.W. Howarth, G. Bazouin, B. Bridgeland, K. Burkart, M. Change, N. Chowdhury, R. Cook, G. Escher, M. Galka, L. Han, C. Heavey, A. Hernandez, D.F. Jacobson, D.S. Jacobson, B. Miranda, G. Novotny, M. Pellat, P. Quach, A. Romano, D. Steward, L. Vogel, S. Wang, H. Wang, L. Willman, and T. Yeskoo. 2014. A roadmap for repowering California for all purposes with wind, water, and sunlight. *Energy,* doi.org/10.1016/j.energy.2014.06.099
- Jacobson, M.Z., R.W. Howarth, M.A. Delucchi, S.R. Scobies, J.M. Barth, M.J. Dvorak, M. Klevze, H. Katkhuda, B. Miranda, N.A. Chowdhury, R. Jones, L. Plano, and A.R. Ingraffea. 2013. Examining the feasibility of

converting New York State's all-purpose energy infrastructure to one using wind, water, and sunlight. *Energy Policy* 57: 585-601

- Howarth, R. W., R. Santoro, and A. Ingraffea. 2012. Venting and leakage of methane from shale gas development: Reply to Cathles et al. *Climatic Change* 113: 537-549
- Howarth, R. W., D. Shindell, R. Santoro, A. Ingraffea, N. Phillips, and A. Townsend-Small. 2012. Methane emissions from natural gas systems. Background paper prepared for the National Climate Assessment, Reference # 2011-003, Office of Science & Technology Policy Assessment, Washington, DC.
- Howarth, R., W., and A. Ingraffea. 2011. Should fracking stop? Yes, it is too high risk. *Nature* 477: 271-273.
- Howarth, R. W., R. Santoro, and A. Ingraffea. 2011. Methane and the greenhouse gas footprint of natural gas from shale formations. *Climatic Change Letters* 106: 679–690

Q. Please briefly summarize your activities with national and international agencies.

A. I have served on 9 committees or panels of the US National Academy of Sciences, and have chaired 3 of these. The Panel on Fluxes of Trace Gases and Nutrients to and from Terrestrial Ecosystems, Committee on Global Change (1989-1990) is most directly relevant to methane: I was the methane expert on that panel. Most of the other NAS committees and panels also considered questions relevant to global change. I have also served on numerous committees and projects of the United Nations Environmental Programme and the International Council of Science, and was chair of two of these. I was

a delegate observer to the United Nations COP21 negotiations on climate change in Paris, France, in 2015 and to the COP23 negotiations in Bonn, Germany in 2017. I have also served on over 30 other advisory panels and groups over my career, and currently sit on a panel of the Clean Air Science Advisory Committee of the US Environmental Protection Agency.

Q. Have you previously provided testimony in regulatory, legislative, or legal proceedings?

A. Yes. I have twice testified in person in courts in New York State as an expert witness, addressing the urgency of climate change and the role of methane emissions from natural gas as a driver of climate change. I have many times testified in person before the US Congress and Senate, usually on issues related to water quality pollution, including the role of climate change in aggravating this. I have testified in person before the European Parliament on methane, natural gas, and climate change. And I have given two briefings in person to senior staff in the Executive Office of the White, one in 2016 on methane, natural gas, and climate change, and one in 2006 on water quality and

climate change. In addition, I have submitted numerous briefs to state and federal agencies. And I have submitted *amicus* briefs to federal courts on several occasions, including to the US Supreme Court.

Q. On whose behalf are you testifying in this proceeding?

A. I am testifying on behalf of Fossil Free Tompkins.

2. OVERVIEW

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to provide guidance on how NYSEG, RG&E, DPS, and others should calculate the CO_2 equivalent of methane emissions as mandated by the Climate Leadership and Community Protection Act (CLCPA) of 2019.

The goal of making these calculations would be to assess the impact of NYSEG and RG&E's proposals relative to the State's greenhouse gas (GHG) reduction goals. Using the CLCPA CO_2e definitions, I provide a comparison of the lifecycle CO_2e of propane, heating oil and natural gas per unit of energy produced and demonstrate that conversion from

heating oil or propane to natural gas does not provide a reduction in GHG emissions. Rather, GHG emissions are increased

Q. What conclusions and recommendations do you provide in your testimony?

A. I conclude that methane emissions have risen globally at a rapid rate over the past decade. Shale gas (natural gas taken from shale through high-volume hydraulic fracturing) development in North America (mostly the United States) has contributed one third of this global increase.

I conclude that methane is a very powerful greenhouse gas, and recent increased emissions from shale gas have contributed significantly to the rate of global warming.

I conclude that methane emissions from the use of natural gas in New York State are a major portion of total GHG emissions in the State, when calculated following the guidance of the CLCPA.

I conclude that estimates for GHG emissions previously reported by NYSERDA and the DEC for New York State are not compliant with the guidelines of the CLCPA. These estimates from NYSERDA and

DEC greatly underestimate methane emissions, particularly from natural gas.

I conclude that to meet the CLCPA-mandated reduction of 40% in GHG emissions (relative to 1990) by 2030 requires a rapid decrease in the use of natural gas in New York State, and no further expansion of natural gas.

I recommend that New York State immediately adopt the new GHG accounting principles mandated by CLCPA.

I recommend that electrification for space and water heating be pursued in New York as rapidly as possible, and that the use of natural gas and other fossil fuels for heating be prohibited in any new construction.

I recommend that the State and companies operating in the State stop providing any incentives or rebates that encourage the use of natural gas. Rather, all incentives and rebates for residential and commercial space and water heating should be used to promote high-efficiency heat pumps.

3. EXHIBITS

Q. Are you relying on any exhibits to support your testimony?

A. Yes, I am providing the following exhibits:

- Howarth, CV
- Howarth, R.W. 2014. A bridge to nowhere: Methane emissions and the greenhouse gas footprint of natural gas. *Energy Science & Engineering* 2: 47-60,
- Howarth, R.W. 2019. Ideas and perspectives: is shale gas a major driver of recent increase in global atmospheric methane? *Biogeosciences* 16: 3033–3046
- Hong, B., and R.W. Howarth. 2016. Greenhouse gas emissions from domestic hot water: heat pumps compared to most commonly used systems. *Energy Science & Engineering* 4: 123-133
- Jacobson, M.Z., R.W. Howarth, M.A. Delucchi, S.R. Scobies, J.M. Barth, M.J. Dvorak, M. Klevze, H. Katkhuda, B. Miranda, N.A. Chowdhury, R. Jones, L. Plano, and A.R. Ingraffea. 2013. Examining the feasibility of converting New York State's all-purpose energy infrastructure to one using wind, water, and sunlight. *Energy Policy* 57: 585-601
- Howarth, R.W., Methane Emissions and Greenhouse Gas Accounting: A Case Study of a New Approach Pioneered by the State of New York, manuscript submitted to the *Journal of Integrative Environmental Sciences* for consideration as part of a peer-reviewed special issue for papers from the 8th International Symposium on Non-CO2 Greenhouse Gases held in Amsterdam, the Netherlands, June 2019.
- A spreadsheet for calculating greenhouse gas emissions following the CLCPA guidance.

4. CLIMATE LEADERSHIP AND COMMUNITY PROTECTION ACT

Q. What was your role in assisting in the development of the CLCPA?

A. I worked with Assemblyman Englebright and Assembly staff in drafting the language provisions relating the the greenhouse gas accounting for methane. This was informed by my research, particularly my 2014 peer-reviewed paper in *Energy Science & Engineering.*

Q. How does the CLCPA define Statewide greenhouse gas emissions, greenhouse gas, and carbon dioxide equivalent?

A. CLCPA section 75-0101 provides definitions for all these terms. It says that "Statewide greenhouse gas emissions" means “the total annual emissions of greenhouse gases produced within the state from anthropogenic sources and greenhouse gases produced outside of the state that are associated with the generation of electricity imported into the state and the extraction and transmission of fossil fuels imported

into the state. Statewide emissions shall be expressed in tons of carbon dioxide equivalents."

"Greenhouse gas" is defined as "carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and any other substance emitted into the air that may be reasonably anticipated to cause or contribute to anthropogenic climate change."

And "carbon dioxide equivalent" is defined as "the amount of carbon dioxide by mass that would produce the same global warming impact as a given mass of another greenhouse gas over an integrated twenty-year time frame after emission."

Q. What is new in the way CLCPA treats GHG emissions versus how they have previously been accounted for?

A. The most important consequences affect the accounting for methane as a greenhouse gas. There are three key differences between the approach traditionally used by NYSERDA and the DEC to estimate greenhouse gas emissions and the new approach mandated by the CLCPA:

1) the CLCPA-mandated approach requires comparing methane to carbon dioxide over a 20-year time period, while the previous reporting from NYSERDA used a 100-year time frame;

2) the previous accounting from NYSERDA only considered methane emissions that occur within the boundaries of the State of New York, while the CLCPA mandates that methane emissions that occur outside of the State be included if they are associated with the development of fuels used within the State; and

3) the previous accounting from NYSERDA underestimated the extent of methane emissions even within New York State, and was not based on the most current information available. The CLCPA mandates that the best available science be used.

Q. Please explain the importance of the time frame, 20 years vs 100 years.

A. Methane is a far more potent greenhouse gas than carbon dioxide, more than 100-fold so for the time that methane remains in the

atmosphere, according to the most recent synthesis report from the Intergovermental Panel on Climate Change (IPCC) from 2013; see discussion in my 2014 paper in *Energy Science and Engineering*. However, methane has a half life in the atmosphere of only 12 years. NYSERDA in the past has compared methane to carbon dioxide over an integrated 100-year time period, which greatly underestimates the importance of methane as a greenhouse gas at shorter time periods. Specifically, NYSERDA used the Global Warming Approach (GWP), where the mass of methane emissions was multiplied by 25 to convert to an equivalent heating from carbon dioxide (CO2e, or CO2-equivalents). That value of 25 is specific for the 100-year time period, and further is based on old, out of date science.

The CLCPA mandates comparing methane with carbon dioxide at a 20-year time frame. The best available science (from the IPCC 2013 report, as discussed in my 2014 *Energy Science and Engineering* paper) leads to a use of GWP of 86, not 25. For this reason alone, the CLCPA accounting increases methane emissions when expressed as CO2-equivalents by 3.44 fold (86 divided by 25).

Q. Please explain the importance of the boundary issue, from your point #2 above.

A. Almost all of the fossil fuels used in New York are produced outside of the State. While some methane emissions occur from transportation, storage, and distribution of fuels within the State, the majority occur outside, largely in the regions where the fuels are developed and processed. For example, in a new paper I have just submitted for publication in a peer-reviewed journal (Howarth, "Methane Emissions and Greenhouse Gas Accounting: A Case Study of a New Approach Pioneered by the State of New York," submitted to the *Journal of Integrative Environmental Sciences*), I estimate that for the natural gas used in New York, less than 25% of methane emissions occur with New York State and more than 75% occur outside of the State.

The CLCPA mandates that all emissions associated with the use of the fuel be included in the greenhouse gas accounting, while the approach used to date by NYSERDA and DEC would not include the majority of emissions that occur outside of the State. For this reason alone, the

CLCPA accounting increases methane emissions from natural gas by somewhat more than 4-fold.

Q. Please explain your statement in point #3 above that NYSERDA has underestimated the extent of methane emissions.

A. The accounting software used by NYSERDA relies on methane emission estimates generated by the US EPA. Many peer-reviewed studies have now documented that these EPA-based values underestimate methane emissions from the natural gas industry, as I review in my 2014 paper in *Energy Science and Engineering*.

The CLCPA mandates the use of best available science, including recent peer-reviewed science, for greenhouse gas accounting. This leads to estimates for methane emissions that are far greater than those used in the NYSERDA accounting.

Q. Can you state the overall consequences of using the CLCPA-mandated approach to greenhouse gas accounting compared to that traditionally used by NYSERDA and DEC?

A. Yes. The most recent accounting from the State is from the "New York State Greenhouse Gas Inventory: 1990-2015," final report from NYSERDA as revised September 2018. There for 2015, emissions from the use of fossil fuel are reported as 180.39 MMtCO2e for carbon dioxide and 2.61 MMtCO2e for methane (see Table S-1 of that report). That is, methane emissions are only 1.4% of the carbon dioxide emissions.

In my newly submitted paper "Methane Emissions and Greenhouse Gas Accounting: A Case Study of a New Approach Pioneered by the State of New York," I estimate 2015 emissions from the use of fossil fuel in New York State as 194 MMtCO2e for carbon dioxide and 115 MMtCO2e for methane. That is, methane emissions are 44-times larger than reported by NYSERDA.

Q. How much of this difference is due to reporting for emissions for natural gas?

A. Most of the difference is due to natural gas. This is discussed in some detail in my newly submitted paper. For natural gas using the CLCPA-mandated approach, I estimate that methane emissions expressed as CO2-equivalents actually exceed carbon dioxide emissions.

Q. How large are these methane emissions, and how do you estimate that?

A. In my most recent submitted paper, "Methane Emissions and Greenhouse Gas Accounting: A Case Study of a New Approach Pioneered by the State of New York," I estimate that based on a full lifec-cycle assessment (from production to delivery to final consumer, as mandated by the CLCPA), at least 3.6% of the methane in natural gas consumed in New York State is emitted to the atmosphere. This is based on 0.85% emissions that occur within the State from natural gas delivery systems and 2.75% emissions that occur largely outside of the State at the well production site, at storage and processing facilities,

and from high-pressure pipelines and associated compressor stations. The detailed methodology is provided in my paper, but briefly, emissions from delivery systems are calculated from the best available and most-recent peer-reviewed science. For the delivery systems, this is an integrated assessment published by Plant et al. in 2019. The estimate for other emissions is based on the synthesis paper of Alvarez et al. (2018), corrected from the percentage of natural gas produced to that consumer, using data from the Energy Information Agency of the US Department of Energy.

Q. Are methane emissions from the use of natural gas an important driver of global warming?

A. Yes. According to the IPCC (2013) synthesis report, methane has contributed 1 watt per square meter to global warming since the start of the industrial revolution (when indirect effects are included), compared to 1.66 watts per square meter for carbon dioxide. Methane emissions have been rising rapidly in the atmosphere over the past decade, and this is one of the causes in the unprecedented global warming experienced in the past 5 to 6 years.

Q. What is the cause of the recent increase in methane emissions globally?

A. In my paper in *Biogeosciences* published in August 2019, I conclude that emissions from the oil and gas industry are responsible for almost two thirds of the total increased emissions. Emissions from shale gas development using high-volume hydraulic fracturing is the single largest increased source. Approximately one-third of all new methane emissions globally over the past decade are from the development and use of shale gas, due almost entirely to shale gas development in North America and largely in the United States.

Q. Is shale gas used in New York State?

A. Yes. The vast majority of natural gas used in New York State is shale gas produced from the Marcellus and Utica shales in Pennsylvania, Ohio, and West Virginia.

Q. What are the consequences of switching from using fuel oil or propane to natural gas for heating of homes and businesses in New York?

A. Switching from fuel oil or propane to natural gas for heating results in a large increase in greenhouse gas emissions, when estimated using the approach mandated in the CLCPA.

Q. Please elaborate on how these emissions can be estimated.

A. The carbon dioxide released from burning natural gas is less than for fuel oil or propane, 55 g CO_2 per MJ of energy for natural gas vs 73 g CO_2 per MJ of energy for fuel oil and propane (see Table 1 in my newly submitted paper, and the supporting references listed there). However, the methane emissions associated with using natural gas (again calculated using the CLCPA approach as outlined in my paper, see Table 1 and supporting references) are much larger): 8 g CO_2-e as methane per MJ for fuel oil and propane, and 64 g CO2-e as methane per MJ for natural gas. Therefore, the total emissions for natural gas are 119 g CO2-e per MJ compared to total emissions of 81 g CO2-e for fuel oil and propane. The emissions for natural gas are almost 50% greater.

Q. Should switching to natural gas for residential and commercial heating be encouraged?

A. No. As I state above, this actually increases total greenhouse gas emissions, when emissions are estimated using the approach of the CLCPA. To address global warming, the world in general needs to move away from all fossil fuels as quickly as possible. Importantly, switching from petroleum products such as heating oil to natural gas greatly aggravates global warming, rather than helping solve the problem.

Q. Please explain this in the context of New York State and the CLCPA.

A. The CLCPA mandates that New York's greenhouse gas emissions be reduced by 40% relative to the 1990 baseline by 2030, only 10.5 years away. In my recently submitted paper, I estimate 1990 emissions as 373 Tg CO_2-eq yr^{-1} using the CLCPA guidelines. Thus, emissions must be reduced to 224 Tg CO_2-eq yr^{-1} or less by 2030, a reduction of at least 149 Tg CO_2-eq yr^{-1}. Further reductions are required by 2050.

As I conclude in my recently submitted paper, "To meet the CLCPA 2030 target of a 40% emissions decrease will require a focus on greatly

reducing the use of natural gas in the residential and commercial sector and petroleum products in transportation." Any further expansion of natural gas use in New York is not consistent with the mandates of the CLCPA.

Q Do you have a recommendation as to how best reduce emissions in New York from residential and commercial heating?

A Yes. The best path forward is to move as quickly as possible to use modern, high-efficiency heat pumps for both space and water heating, replacing the use of natural gas as well as fuel oil and propane. This is one of the central recommendations that I and others made in a peer-reviewed energy plan for New York State, published in 2013 in *Energy Policy* (Prof. Mark Jacobson of Stanford University is the first author; I am the second author).

In a follow-up paper published in *Energy Science and Engineering* in 2016, Dr. Bonghi Hong and I demonstrated that for domestic hot water, emissions from a modern heat pump are less than from using natural gas in the home, even if the electricity used to power the heat pump comes from natural gas. This is due to the high degree of energy extraction from the environment by the heat pump. This point is even

more true for using ground-source heat pumps for space heating, due to even greater levels of energy extraction.

Q. Does that conclude your testimony for now?

A. Yes.