BEFORE THE
MARYLAND PUBLIC SERVICE COMMISSION

IN THE MATTER OF THE MERGER	**)**	
OF ALTAGAS LTD.	**)**	**Case No.: 9449**
AND WGL HOLDINGS, INC.	**)**	

POST-SETTLEMENT TESTIMONY OF PAUL J. HIBBARD

On Behalf of
The Applicants

January 5, 2018

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I. INTRODUCTION AND SUMMARY OF POSITIONS

A. INTRODUCTION AND OVERVIEW

Q. PLEASE STATE YOUR FULL NAME, BUSINESS ADDRESS AND OCCUPATION.

A. My name is Paul Hibbard. I am a Principal at Analysis Group, Inc. ("AGI"), an economic, finance and strategy consulting firm headquartered in Boston, Massachusetts, where I work on energy and environmental economic and policy consulting. My business address is 111 Huntington Avenue, 14th Floor, Boston, Massachusetts 02199.

Q. PLEASE DESCRIBE YOUR BACKGROUND AND EXPERIENCE.

A. I have been with AGI for approximately eleven years since 2003. First, from 2003 to April 2007, and most recently, from August 2010 to the present. In between, from April 2007 to June 2010, I served as Chairman of the Massachusetts Department of Public Utilities ("MA DPU"). While Chairman, I also served as a member of the Massachusetts Energy Facilities Siting Board, the New England Governors' Conference Power Planning Committee, and the NARUC Electricity Committee and Procurement Work Group. I also served as State Manager for the New England States Committee on Electricity and as Treasurer on the Executive Committee of the 41-state Eastern Interconnect States' Planning Council.

I worked in energy and environmental consulting with Lexecon, Inc. from 2000 to 2003. Prior to working with Lexecon, I worked in state energy and environmental agencies for almost ten years. From 1998 to 2000, I worked for the Massachusetts Department of Environmental Protection on the development and administration of air quality regulations, State Implementation Plans and emission control programs for the electric industry, with a focus on criteria pollutants and carbon dioxide ("CO_2"), as well as various policy issues related to controlling pollutants from electric power generators within the Commonwealth. From 1991 to 1998, I worked in the Electric Power Division of the DPU on cases related to the setting of company rates, the restructuring of the electric industry in Massachusetts, the quantification of environmental externalities, integrated resource planning, energy efficiency, utility compliance with state and federal emission control requirements, regional electricity market structure development, and coordination with other states on electricity and gas policy issues through the staff subcommittee of the New England Conference of Public Utility Commissioners.

I hold an M.S. in Energy and Resources from the University of California, Berkeley, and a B.S. in Physics from the University of Massachusetts at Amherst. My curriculum vitae is attached as Exhibit PJH-1.

Q. HAVE YOU PREVIOUSLY SUBMITTED TESTIMONY BEFORE THE MARYLAND PUBLIC SERVICE COMMISSION ("COMMISSION")?

A. No. However, I have previously submitted testimony related to the merger of AltaGas Ltd. ("AtlaGas") and WGL Holdings, Inc. ("WGL") before the Public Service Commission of the District of Columbia[1] and have submitted testimony on other matters before other state public utility commissions and the Federal Energy Regulatory Commission.

Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY?

A. I am testifying on behalf of AltaGas, WGL, and Washington Gas Light Company

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[1] *See* Rebuttal Testimony of Paul J. Hibbard, *In the Matter of the Merger of AltaGas Ltd. and WGL Holdings, Inc.*, Before the Public Service Commission of the District of Columbia, October 27, 2017.

(the "Applicants") in Case No. 9449, In the Matter of the Merger of AltaGas, Ltd. and WGL Holdings, Inc., ("WGL") in order to explain and evaluate the public health and environmental benefits of the commitments that were agreed to as part of the Applicants' final Settlement Agreement and Stipulation ("Settlement Agreement").

Q. ARE YOU SPONSORING ANY EXHIBITS?

A. Yes, I am sponsoring Exhibits PJH-1 through PJH-8, which were prepared by me or under my direction.

B. SUMMARY OF MY TESTIMONY AND CONCLUSIONS

Q. PLEASE SUMMARIZE YOUR CONCLUSIONS.

A. I have two principal conclusions regarding the public health and environmental benefits of the commitments set forth in the Applicants' Settlement Agreement:

- The Settlement Agreement includes at least three commitments that will generate benefits from public health, environmental, and climate change perspectives. These commitments are: 1) the Gas Expansion Fund (paragraph 5); 2) County Program Support (paragraph 7), a portion of which AltaGas intends to use towards weatherization and other energy efficiency programs in Montgomery and Prince George's counties; and 3) the commitment to build 5 MegaWatts ("MW") of low-carbon generation (paragraph 9). Implementation of these programs will reduce emissions of CO_2 (relative to no such commitments), and are likely to also reduce other air, water and solid waste impacts of electricity production and use.
- Certain of the emission reduction benefits associated with implementation of these programs may be quantified. In particular, I quantify the environmental benefits of the Gas Expansion Fund, County Program Support, and the commitment to install

5 MW of low-carbon generation. I find that the Gas Expansion Fund is likely to reduce average annual CO_2 emissions from an average Maryland household by just under 8,000 pounds ("lbs"), which corresponds to a nearly 50 percent reduction.[2] I further find that the County Program Support will likely reduce CO_2 emissions by between 0.4 billion and 1.2 billion pounds over the lifetime of programs and installations funded through the Program.[3] Finally, I find that the commitment for low-carbon generation will reduce annual CO_2 emissions by approximately 4.1 million pounds per MW.[4]

C. ORGANIZATION OF MY TESTIMONY

Q. HOW IS YOUR TESTIMONY ORGANIZED?

A. In Section II, I summarize each of the three commitments set forth in the Settlement Agreement that are highly likely to generate public health and environmental benefits, qualitatively describe the environmental impact of each commitment, and quantify various potential impacts in terms of CO_2 emissions. My conclusions are summarized in Section III.

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[2] As discussed further in Section II below, this estimate is based on average energy consumption of a residential household in Maryland.

[3] As discussed further in Section II below, this estimate is based on my review of energy efficiency programs and measures likely to result from Program implementation.

[4] As discussed further in Section II below, this estimate assumes funding of a mix of solar photovoltaic and wind generation.

II. QUALITATIVE AND QUANTITATIVE DESCRIPTION OF ENVIRONMENTAL BENEFITS ASSOCIATED WITH THE SETTLEMENT AGREEMENT COMMITMENTS

Q. WHICH OF THE SETTLEMENT AGREEMENT'S COMMITMENTS DO YOU ANTICIPATE IMPACTING THE ENVIRONMENT?

A. I anticipate that the Gas Expansion Fund, the County Program Support to Montgomery and Prince George's Counties, and the commitment to build 5 MW of low-carbon generation will all have net positive impacts in mitigating the public health, environmental and socioeconomic risks associated with climate change due to reductions in CO_2 emissions. I specifically quantify these reductions. In addition, I anticipate that the use of natural gas to displace other fuel sources, and the overall reduction in bulk power system ("BPS")-based generation of electricity due to all three Settlement Commitments, are likely to reduce the air, water, and solid waste public health and environmental impacts of electricity production and use above and beyond those related to CO_2 reductions.

Q. WOULD YOU PLEASE DESCRIBE THE LIKELY ENVIRONMENTAL IMPACT DUE TO THE GAS EXPANSION FUND?

A. Yes. The Gas Expansion Fund is a $33 million fund allocated to the Maryland Energy Administration ("MEA") in order to "promote … the expansion of natural gas infrastructure to underserved parts of Maryland."[5] Expanding natural gas infrastructure

[5] Settlement Agreement, ¶ 5.

will likely achieve significant reductions in emissions of CO_2. I explain this in more detail below.

Home heating technologies fueled by natural gas result in lower CO_2 emissions compared to technologies that rely on higher carbon fuel sources such as fuel oil or liquid petroleum gas ("LPG," or propane). In addition, the mix of fuel types used in the generation of electricity to support home space and water heating typically has a higher carbon content than the quantity of natural gas required to accomplish the same level of heating, making natural gas a less CO_2-intensive heating source than electricity generation. Expanding natural gas infrastructure to enable the use of natural gas in place of other fuel sources in households[6] who currently do not heat their homes with natural gas may facilitate a reduction in the number of customers who rely on more emission-intensive heating, thereby reducing overall emissions. In fact, I estimate that the average Maryland home[7] can reduce emissions of CO_2 by just under 8,000 lbs (which represents a nearly 50 percent reduction) by using natural gas heating instead of other heating sources that are typically used in Maryland (i.e., electricity, oil, and propane).

In addition, there are many Maryland residents who lack access to natural gas infrastructure but who would have a financial incentive to switch to natural gas if provided

[6] While the Settlement Agreement describes the Gas Expansion Fund as monies for "the purpose of promoting the expansion of natural gas infrastructure to serve businesses, residents, industrial enterprises, and utility generation facilities in Maryland," it is reasonable to expect that the majority of the expansion will be in regions that do not currently have access to natural gas distribution infrastructure, and that residential households will therefore be primarily impacted.

[7] As I discuss more below, an "average" home represents a 2,300 square foot detached home with 3 residents. *See* Michelfelder Exhibit RAM-9.

the opportunity. The EIA reports that in 2015, 53 percent of Maryland residential customers heated their homes with electricity, oil, or propane.[8] Furthermore, MEA witness Dr. Richard Michelfelder analyzes a range of space and water heating technologies, and concludes that Maryland households could save hundreds to over one thousand dollars in annual energy bills by using natural gas space and water heating.[9] This suggests that the financial incentive for using natural gas is large enough to ensure that expanding natural gas infrastructure will lead to significant usage.

Q. WOULD YOU PLEASE DESCRIBE IN MORE DETAIL THE METHODS, DATA, AND ANY UNDERLYING ASSUMPTIONS YOU RELIED ON TO QUANTIFY THE ENVIRONMENTAL IMPACTS OF THE GAS EXPANSION FUND?

A. I estimate the CO_2 emissions reductions that an average home achieves by using natural gas heating technologies instead of electric, oil, and propane heating technologies. I walk through each step in more detail below.

In order to characterize the market for potential use of natural gas for heating, I assume the definition of an "average home" and evaluate the specific heating technologies considered by Dr. Michelfelder in his testimony before this Commission. Dr. Michelfelder estimates the average Maryland residence as a 2,300 square foot detached home with 3 residents. The technologies he considers include seventeen representative technologies:

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8 Specifically, 40 percent use electricity, 10 percent use oil, and 3 percent use propane. A further 2 percent use some other fuel source, or no source at all. *See* Exhibit PJH-2.

9 *See* Michelfelder Exhibit RAM-9. It is my understanding that Dr. Michelfelder has relied on the technologies presented by the Applicants in their response to MEA DR 1-6.

high and low efficiency natural gas, electric, propane, and oil space and water heating technologies.[10]

I calculate annual CO_2 emissions for the average home and for each of the sixteen heating technologies described above using the Gas Technology Institute's Source Energy and Emissions Analysis Tool ("SEEAT").[11,12] The SEEAT model allows one to calculate CO_2 emissions for any building type, heating technology, and, for electric heating options, the energy generation portfolio and corresponding emissions profile. I understand that the

10 *See* Michelfelder Exhibit RAM-9.

11 SEEAT is a publicly available model developed by the Gas Technology Institute ("GTI") available at http://www.cmictools.com/Default.aspx. The model relies on government data and publicly available data sources to calculate point-of-use energy consumption and associated greenhouse gas emissions for various heating systems, cooling systems, and household appliances. Most inputs to the SEEAT model, including geographic area, electricity generation mix, composite emissions factors, and source energy factors, can be user-specified.

12 Of the seventeen technologies, I was unable to find exact matches between five technologies in the SEEAT tool and those listed by Dr. Michelfelder (Electric - Standard Efficiency Heat Pump, 8.7 HSPF 7,15; Electric - High Efficiency Heat Pump, 9.5 HSPC 7,15; Propane - Condensing Tankless Water Heater, 0.93 EF, Natural Gas - Standard Water Heater, 0.59 EF, Propane - Standard Water Heater, 0.59 EF). For these five technologies, I use the SEEAT technology that matches most closely on efficiency. For an additional two technologies, I could not find any match in the SEEAT model (Residential Heating Oil (#2) - Standard Water Heater, 0.59 EF; Residential Heating Oil (#2) - Condensing Tankless Water Heater, 0.93 EF 5).

Commission[13] has previously reviewed evidence using the SEEAT model to determine emissions reductions in a representative Maryland home.[14,15]

For electric heating options, the emission impact depends on the *effective* emission rate per unit of heat generated in the home. This in turn depends on (1) the fuels and conversion efficiencies - and thus the associated emission rates per MWh generated - of generating units operating on the margin at the time of use, and (2) the BPS and distribution system losses in transmitting generated electricity to the point of end use. The SEEAT model approximates transmission/distribution losses based on location, and allows the user to select the appropriate mix of generating resources to approximate emission rates at the

[13] Case No. 9433 – In the Matter of the Petition of Washington Gas Light Company for Approval of Revised Tariff Provisions to Facilitate Access to Natural Gas in the Company's Maryland Franchise Area Currently without Natural Gas Service.

[14] In addition, I understand that the Commission has recognized the environmental benefits associated with using natural gas for heating. For example, Washington Gas Light Company's witness Raab and Commission staff witness Bonikowski have both used SEEAT to estimate emissions reductions in a two-story home heated by natural gas versus electricity. Both witnesses demonstrated reductions in CO_2 equivalent emissions. *See* Brief by the Staff of the Public Service Commission, Case No. 9433 – In the Matter of the Petition of Washington Gas Light Company for Approval of Revised Tariff Provisions to Facilitate Access to Natural Gas in the Company's Maryland Franchise Area Currently without Natural Gas Service, pp 9-10 ("Using the typical consumption feature included in the SEEAT model, WGL witness Raab compared the usage of a two-story, all-electric residential detached home with that of the same home using natural gas for space heating, water heating, cooking, and clothes drying. Assuming all of the avoided electric use comes from non-baseload plants, the resulting estimated consumption figures from the SEEAT model showed that the home with natural gas will emit 10,480 fewer pounds of $C0_{2e}$ per year than the all-electric home […] Staff witness Bonikowski also calculated expected greenhouse gas emissions using the SEEAT model, but he assumed that the avoided electric use came from all plants, not just the non-baseload plants. The reduction in greenhouse gas emissions is less…").

[15] *See* Order No. 88324 – In the Matter of the Petition of Washington Gas Light Company for Approval of Revised Tariff Provisions to Facilitate Access to Natural Gas in the Company's Maryland Franchise Area Currently without Natural Gas Service, p. 27 ("Expanding natural gas access in Maryland has the potential to provide benefits to the State and its ratepayers, including environmental benefits when gas replaces electricity…[but] we cannot approve WGL's Petition at this time.") [bracketed text added for clarification]

point of generation. For this purpose, I use data from PJM to derive the winter[16] average marginal fuel generation portfolio within the PJM region in which Maryland resides. I summarize this electric generation portfolio in Exhibit PJH-3. I assume the average mix of resources operating on the margin since this represents the average emission rate that would be avoided at the time of use by avoiding or reducing electric heating use.[17]

Next, I approximate the net reductions in CO_2 due to using natural gas by comparing the amount of annual CO_2 emissions generated by the high and low efficiency electric, propane, and oil space and water heating technologies to that of the most comparable natural gas technologies. Exhibit PJH-4 summarizes the results of this calculation. Finally, I estimate the average annual CO_2 emissions reductions associated with an average home using natural gas instead of electric, propane, or oil space and water heating technologies.

Since the efficiency of Maryland household heating technology is distributed among low and high efficiency types, I estimate the annual household level CO_2 emissions reductions on a weighted average basis for a range of high and low heating technologies. This results in CO_2 emissions reductions for various technology efficiency combinations and for each fuel type. To estimate an average emissions reduction for each technology

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16 The PJM Manual 21 defines winter as the months of December, January, and February. I use a winter generation portfolio since most heating takes place during this season.

17 Over time the actual emission rate of generation at the time of use may be higher or lower depending on changes in the mix of resources operating in the region, and reduced demand associated with, among other things, increased use of natural gas for heating. However, for the purpose of estimating emission reduction benefits, I consider the recent average of marginal winter PJM emission rates to be a reasonable proxy given the limited scope and scale of use anticipated due to the Settlement Commitment.

efficiency combination, I sum CO_2 emissions reductions across fuel types, with each fuel type's associated emission reduction weighted by the share of households using that fuel type (i.e. electric, propane, and oil) relative to all non-natural gas heated Maryland households. Exhibit PJH-5 summarizes my results.

Notably, regardless of which technology/efficiency combination I assume, emissions reductions for an average home are just under 8,000 lbs of CO_2. This amounts to a percentage reduction of nearly 50 percent.

Q. WOULD YOU PLEASE DESCRIBE THE LIKELY ENVIRONMENTAL IMPACT DUE TO THE FUNDS ALLOCATED TO THE COUNTY PROGRAMS?

A. A wealth of information collected by energy utilities demonstrates the extent of energy and demand reductions associated with investments in energy efficiency programs and measures. Energy savings, in turn, allow for reduced energy generation from fossil fuel units and, therefore, reduced emissions of CO_2 (as well as reduced impacts from emissions of other air pollutants, and the generation of liquid and solid waste) to meet end-user demand. Thus the funds allocated to Montgomery County and Prince George's County will reduce CO_2 emissions since the Settlement Agreement ear-marks at least part of these funds for energy efficiency programs. I estimate that lifetime CO_2 emissions will fall by anywhere from 0.4 billion pounds to 1.2 billion pounds, depending upon the share of funds allocated to energy efficiency programs.

Q. WOULD YOU PLEASE DESCRIBE IN MORE DETAIL THE METHODS, DATA, AND ANY UNDERLYING ASSUMPTIONS YOU RELIED UPON TO QUANTIFY THE ENVIRONMENTAL IMPACTS DUE TO THE FUNDS ALLOCATED TO THE COUNTY PROGRAMS?

A. To estimate the CO_2 reductions due to the funds allocated to county programs, I proceed in three steps. First, I determine the amount of money that will be spent on energy efficiency programs. The Settlement Agreement commits $15 million to Montgomery County for "energy distribution-related customer or educational programs (such as: weatherization, energy efficiency, safety, renewable energy or workforce or educational development)" and $13.4 million to Prince George's County for the county's "Transforming Neighborhoods Initiative (TNI) Clean Energy Program, ENERGY STAR Certification & Green Leasing Program, and any other Prince George's County energy distribution-related customer or educational programs (such as: weatherization, energy efficiency, safety, and/or workforce or educational development)."[18] Since the language in the Settlement Agreement does not specify the amount of money to be allocated specifically to energy efficiency investments, I assume that anywhere from 25 percent to 75 percent of the funds go toward energy efficiency programs.

Second, I estimate the amount of energy saved due to the portion of the $28.4 million going towards funding energy efficiency programs. In order to develop this estimate, I rely on the compilation of data collected by the Northeast Energy Efficiency Partnership ("NEEP") using energy efficiency program measurement and verification data and analysis that is completed by Maryland's utilities and reviewed by the Commission. That is, NEEP's data summarizes and organizes specific measured results of energy efficiency investments made within the state. In particular, NEEP reports Maryland's

[18] Settlement Agreement, ¶ 7.

lifetime cost of energy saved in 2015 as $0.037 per kWh-saved.[19] Dividing the total monies spent on energy efficiency programs by this lifetime cost of energy yields lifetime energy savings.

Third, I estimate emissions reductions associated with the energy savings as the product of the energy savings and an emissions rate for the portfolio of electric generation plants in the PJM region. I estimate the emissions rate using the same methodology I relied on for my calculation of emissions reductions for the Gas Expansion commitment (described above), specifically using the SEEAT tool and the corresponding marginal emissions profile of the PJM region.[20] The product of the emissions rates and energy savings yields CO_2 reductions. Exhibit PJH-7 illustrates my results assuming that 25 percent, 50 percent and 75 percent of the monies are allocated towards energy efficiency programs.

Q. WOULD YOU PLEASE DESCRIBE THE LIKELY ENVIRONMENTAL IMPACT OF INSTALLING 5 MW OF LOW CARBON GENERATION?

A. The Settlement Commitments require the Applicants to invest in 5 MW of advanced energy technology, either combined heat and power ("CHP"), electricity storage

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19 See https://reed.neep.org. NEEP includes the following types of energy efficiency spending in its calculation for Maryland: lost opportunity programs; behavior programs; residential, and commercial and industrial retrofit programs; lighting and appliance programs (see http://reed.neep.org/Glossary.aspx for further definitions. As described in NEEP documents, Maryland utilities report energy efficiency data semiannually to the Maryland PSC. The PSC retains a third party contractor to review the energy efficiency data collection process and results (see https://reed.neep.org/StateDocs-MD.aspx for more information). This is the data that NEEP uses in its reports.

20 I base this analysis on the marginal mix of plants over the full year, rather than the marginal mix during the winter months, as the impact of energy efficiency would not be limited to the winter months in the same way that heating would. *See* Exhibit PJH-6.

or "Tier One" renewable resources.[21] While any or all of such advanced energy technologies can generate emission reduction and other environmental benefits, the ability to estimate such benefits is complicated by not knowing how the investments will be made, and by the fact it is very difficult to forecast with any specificity the benefits that may accrue due to storage or CHP technologies. Thus, my quantification of benefits necessarily relies upon a simplified approximation using renewable resource investment as a proxy, discussed below.

Installing low- or zero-carbon renewable generation - whether grid-connected or distributed - will reduce energy generated from higher-carbon sources on the system, and thereby reduce CO_2 emissions. But the ultimate impact of investments in CHP or storage technologies are more complex and uncertain. CHP benefits are highly site specific, and depend entirely on the current technology used (or future technology avoided) for the heating and/or process steam applications served by the CHP investment. With storage, there are also multiple modes of benefit - for example, immediate reductions in CO_2 emissions from storage could be realized if energy is stored at night when the marginal emission rate (of production) is low, and discharged during peak daytime hours when the marginal emission rate is higher. Longer-term emission reductions could flow if investments in storage capacity lead to the reliable integration of a greater quantity of variable renewable resources than otherwise would be installed. Conversely, while this

[21] Settlement Agreement, ¶ 9 (“A1taGas shall, within five years after Merger Close, develop or cause to be developed 5 megawatts (MW) of either electric grid energy storage, Tier 1 renewable resources, combined heat and power resources, or other distributed generation in Maryland”).

may be a less likely outcome, storage could be used at times in ways that could lead to a net increase in emissions (e.g., if energy is released when marginal emission rates are lower than at the time the energy is stored).[22]

Since the Settlement Agreement does not mandate the type or mix of storage/renewable technology investment, it is difficult to forecast the nature and quantity of potential emission reduction benefit of this commitment. However, I expect that it is more likely than not that this merger commitment will lead to investment in advanced energy technologies that will, over time, improve the emission profile of PJM operations, and produce emission reduction benefits. While the precise quantity of emission reductions is not possible to quantify at this time, I have made certain assumptions to conservatively approximate the potential magnitude of public health and environmental benefit associated with this Settlement Commitment.

Specifically, I calculate the per MW impact of the commitment assuming that the generation portfolio to be constructed will be an investment in renewable resources, and that those resources will be an equal mix of wind and solar. While wind and solar emit zero emissions, they also have lower capacity factors compared to conventional generation technologies. Consequently, I estimate the potential magnitude of emission reduction

[22] Storage is often viewed as an enabling resource - one that can directly support the reliability, capacity value, or cost reduction benefits of variable renewable resources. (U.S. Department of Energy, "Energy Storage," available at https://energy.gov/oe/activities/technology-development/energy-storage, accessed December 27, 2017.) However, to the extent storage is used exclusively to arbitrage energy prices in wholesale markets, the financial viability of this option rests with being able to use energy generated in low-price hours to support production in higher-priced hours, when the emission rates of marginal generation are often - if not mostly - higher than during lower-priced hours. (U.S. Environmental Protection Agency, "Electricity Storage," available at https://www.epa.gov/energy/electricity-storage, accessed December 27, 2017.)

benefits of every MW of wind and solar assuming an equal mix - that is, half wind and half solar - operating at capacity factors typical of such resources in this region. Based on these assumptions, I approximate the annual CO_2 emission reduction benefit of this merger commitment to be approximately 4.1 million pounds per MW. As shown in Exhibit PJH-8, if all 5 MW of the commitment were to be constructed as this mix of wind and solar, I estimate that it would reduce annual CO_2 emissions by 20.6 million pounds.

Q. WOULD YOU PLEASE DESCRIBE IN MORE DETAIL THE METHODS, DATA, AND ANY UNDERLYING ASSUMPTIONS YOU RELIED UPON TO QUANTIFY THE ENVIRONMENTAL IMPACT OF INSTALLING 5 MW OF ADVANCED ENERGY TECHNOLOGIES?

A. To develop a first order approximation of this potential benefit, I calculate the annual emissions avoided by the total quantity of generation (in MWh) associated with the operation of every MW of wind and solar assuming an equal mix - that is, half wind and half solar. This total generation is estimated by taking the product of the rated capacity and the capacity factor for each resource, and the number of hours in a year. I take the capacity factor for wind and solar to be 30 percent and 16 percent, respectively, and calculate the simple average of the two (23 percent).[23] Thus the total estimated MWhs represent the amount of energy displaced by renewables, and can therefore be used to estimate emissions reductions. To estimate CO_2 emissions reductions, I take the product of the displaced energy and the annual average emissions rate for marginal plants in the PJM region.

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[23] Data are from SNL Financial and based on the actual operations of wind and solar units in PJM.

III. CONCLUSIONS

Q. PLEASE SUMMARIZE YOUR CONCLUSIONS.

A. I find that the three Settlement Commitments (the Gas Expansion Fund, County Program Support, and the commitment to build 5 MW of low-carbon generation) will produce public health and environmental benefits through their reduction of emissions of CO_2 (relative to no such commitments), and are likely to also reduce other air, water and solid waste impacts of electricity production and use. Specifically, I find that the Gas Expansion Fund is likely to reduce average annual CO_2 emissions for an average Maryland household by just under 8,000 lbs, which corresponds to a nearly 50 percent reduction. I further find that the County Program Support will likely reduce CO_2 emissions by between 0.4 billion and 1.2 billion pounds over the lifetime of programs and installations funded through the Program. Finally, I find that the commitment for low-carbon generation will reduce annual CO_2 emissions by approximately 4.1 million pounds per MW.

Q. DOES THIS CONCLUDE YOUR TESTIMONY?

A. Yes, it does. Thank you.

Exhibit PJH-1
Curriculum Vitae & Testimony

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Principal

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EDUCATION

Ph.D. program (coursework), Nuclear Engineering, University of California, Berkeley

M.S. in Energy and Resources, University of California, Berkeley
Thesis: Safety and Environmental Hazards of Nuclear Reactor Designs

B.S. in Physics, University of Massachusetts, Amherst

PROFESSIONAL EXPERIENCE

2010 - Present Analysis Group, Inc., Boston, MA
Principal
Vice President

2007 - 2010 MA Department of Public Utilities, Boston, MA
Chairman
Member, Energy Facilities Siting Board
Manager, New England States Committee on Electricity
Treasurer, Executive Committee, Eastern Interconnect States' Planning Council
Representative, New England Governors' Conference Power Planning Committee
Member, NARUC Electricity Committee, Procurement Work Group

2003 - 2007 Analysis Group, Inc., Boston, MA
Vice President
Manager ('03 – '05)

2000 - 2003 Lexecon Inc., Cambridge, MA
Senior Consultant
Consultant ('00 – '02)

1998 - 2000 Massachusetts Department of Environmental Protection, Boston, MA
Environmental Analyst

1991 - 1998 Massachusetts Department of Public Utilities, Boston, MA
Senior Analyst, Electric Power Division

1988 - 1991 University of California, Berkeley, CA
Research Assistant, Safety/Environmental Factors in Nuclear Designs

TESTIMONY IN THE LAST FOUR YEARS

Rebuttal Testimony of Paul J. Hibbard before the Public Service Commission of the District of Columbia on behalf of AltaGas, Ltd and WGL Holdings, Inc., Formal Case No. 1142, October 27, 2017.

Rebuttal Testimony of Paul J. Hibbard before the State of Vermont Public Service Board on behalf of Vermont Gas Systems Inc., Docket No.s 8698 and 8710, September 26, 2016.

Affidavit of Paul J. Hibbard before the Federal Energy Regulatory Commission, Docket No. ER16-1751-000, May 20, 2016.

Testimony of Paul J. Hibbard before the Senate Committee on Global Warming and Climate Change, *Power System Reliability in New England: Meeting Electric Resource Needs in an Era of Growing Dependence on Natural Gas*, November 24, 2015.

Declaration of Paul J. Hibbard and Andrea M. Okie, in the United States Court of Appeals for the District of Columbia Circuit, Case No. 15-1363 (and consolidated cases), December 8, 2015.

Direct Testimony of Paul J. Hibbard, Florida Public Service Commission, on Behalf of Calpine Construction Finance Company, L.P., July 2014 before the Florida Public Service Commission, Docket No. 140110-E1, July 14, 2014.

Federal Energy Regulatory Commission, Docket Nos. ER14-1050-000 and ER14-1050-001, Testimony of Paul Hibbard and Todd Schatzki on Behalf of ISO New England Inc., February 12, 2014.

Rebuttal Testimony of Paul Hibbard, State of Minnesota, Minnesota Public Utilities Commission, on behalf of Calpine Construction Finance Compnay, L.P., MPUC Docket No. E-002/CN-12-1240, October 18, 2013.

Direct Testimony of Paul Hibbard, State of Minnesota, Minnesota Public Utilities Commission, on behalf of Calpine Construction Finance Compnay, L.P., MPUC Docket No. E-002/CN-12-1240, September 27, 2013.

Testimony of Paul J. Hibbard before the Massachusetts Department of Public Utilities on behalf of the Massachusetts Department of Energy Resources, DPU 13-07, May 31, 2013.

Testimony of Paul J. Hibbard before the House Committee on Energy and Commerce, Subcommittee on Energy and Power, *The Role of Regulators and Grid Operators in Meeting Natural Gas and Electric Coordination Challenges*, March 19, 2013.

Testimony of Paul J. Hibbard before the California Legislature, *The Economic Impacts of RGGI's First Three Years*, California Select Committee on the Environment, the Economy, and Climate Change, March 27, 2012.

Testimony of Paul J. Hibbard before the New Hampshire Legislature, *RGGI and the Economy – Following the Dollars*, NH House Committee on Science, Technology, and Energy, February 14, 2012.

Testimony of Paul J. Hibbard before the Massachusetts Legislature, *RGGI and the Economy – Following the Dollars*, Massachusetts Senate Committee on Global Warming and Climate Change, February 13, 2012.

PUBLICATIONS AUTHORED IN THE LAST TEN YEARS

Paul Hibbard, Susan Tierney and Katherine Franklin, *Electricity Markets, Reliability and the Evolving U.S. Power System*, June 2017.

Paul Hibbard, Craig Aubuchon and Mike Cliff, Ph.D., *Evaluation of Vermont Transco, LLC Capital Structure*, October 2016.

Susan F. Tierney, Paul J. Hibbard and Ellery Berk, *RGGI and CO2 Emissions Trading Under the Clean Power Plan: Options for Trading Among Generating Units in RGGI and Other States*, July 12, 2016.

Paul J. Hibbard and Craig P. Aubuchon, *Power System Reliability in New England: Meeting Electric Resource Needs in an Era of Growing Dependence on Natural Gas*, Report for the Massachusetts Office of the Attorney General, November 2015.

Susan Tierney, Paul Hibbard, and Craig Aubuchon, *Electric System Reliability and EPA's Clean Power Plan: The Case of MISO*, Report for the Energy Foundation, June 8, 2015.

Paul J. Hibbard, *Net Metering in the Commonwealth of Massachusetts: A Framework for Evaluation*, May 2015.

Paul Hibbard, Todd Schatzki, Craig Aubuchon, and Charles Wu, *NYISO Capacity Market: Evaluation of Options*, Report for the New York Independent System Operator, May 2015.

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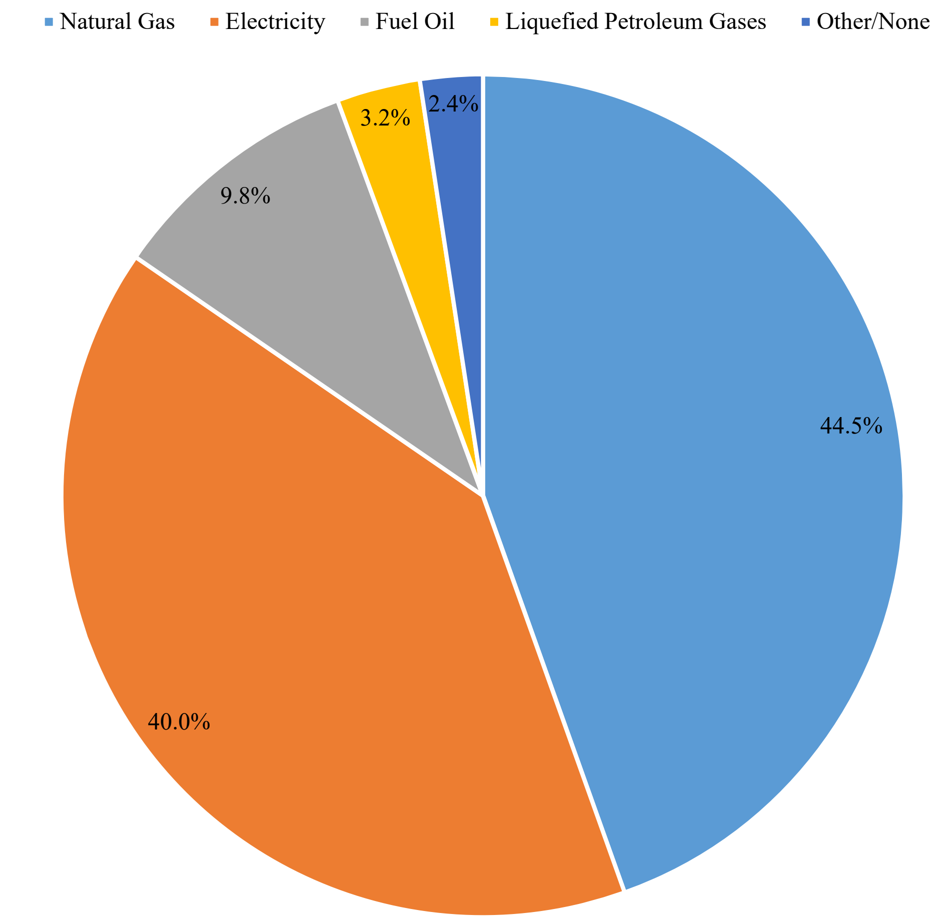
Exhibit PJH-2

Exhibit PJH-2
Energy Source Used for Home Heating (Share of Households)
Maryland, 2015



Source:
U.S. EIA, Maryland State Energy Profile, https://www.eia.gov/state/print.php?sid=MD.

Exhibit PJH-3
PJM Winter Average Marginal Fuel Type

Emission Category	PJM Winter Average Marginal Fuel Posting
Coal	43.4%
Natural Gas	41.6%
Oil	6.6%
Other Nonrenewable	0.2%
Solar	0.1%
Nuclear	1.5%
Wind	6.5%

Notes:

[1] Winter represents a three month average of December 2016, January 2017, and February 2017, as per PJM's definition of winter in Manual 21.

[2] In January 2017, 0.04% of the time the marginal unit was classified as "Missing Data," and 0.02% of the time as "Min Gen/Dispatch Reset." These categories are excluded from the calculated 3 month winter average marginal fuel posting.

Sources:

[1] Monitoring Analytics, 2017-02, 2017-01, and 2016-12 Marginal Fuel Postings, http://www.monitoringanalytics.com/data/marginal_fuel.shtml.

[2] PJM Manual 21.

Exhibit PJH-4
Annual Emissions for Household Space and Water Heating

Technology	Technology Efficiency	Annual Emissions (lbs CO_2)[1]	Annual Emissions Reduction Using Natural Gas (lbs CO_2)	Annual Emissions Reduction Using Natural Gas (%)
Natural Gas Space and Water Heating	Low Efficiency	9,910	0	0%
	High Efficiency	8,300	0	0%
Electric Space and Water Heating	Low Efficiency	17,780	7,870	44%
	High Efficiency	17,130	8,830	52%
Propane Space and Water Heating	Low Efficiency	12,420	2,510	20%
	High Efficiency	10,390	2,090	20%
Oil Space Heating and Electric Water Heating[2]	Low Efficiency	17,200	7,290	42%
	High Efficiency	15,370	7,070	46%

Notes:

[1] Modeling assumes 2,300 square feet; residential detached 2-story home; 3 people; Baltimore Maryland.

[2] Electric is used in place of oil for water heating as SEEAT provides no model option oil water heating.

[3] Technologies are based on Michelfelder Exhibit RAM 9. Low efficiency electric space heating reflects the “15 SEER /8.8 HSPF Heat Pump” technology.

Sources:

[1] Source Energy and Emissions Analysis Tools (SEEAT).

[2] Michelfelder Exhibit RAM-9.

[3] Monitoring Analytics, 2017-02, 2017-01, and 2016-12 Marginal Fuel Postings, available at http://www.monitoringanalytics.com/data/marginal_fuel.shtml.

Exhibit PJH-5
Average Annual Emissions Reduction When Using Natural Gas
CO_2 Emissions for Space and Water Heating [1]

Technology Efficiency	Electric to Natural Gas (lbs CO_2)	Propane to Natural Gas (lbs CO_2)	Oil to Natural Gas (lbs CO_2)[2]	MD Average to Natural Gas (lbs CO_2)	MD Average to Natural Gas (%)
70% Low/30% High	6,157	144	1,336	7,637	45%
60% Low/40% High	6,229	141	1,332	7,703	45%
50% Low/50% High	6,302	139	1,328	7,768	46%
40% Low/60% High	6,374	136	1,324	7,834	47%
30% Low/70% High	6,447	134	1,319	7,900	47%

Notes:

[1] Modeling assumes 2,300 square feet; residential detached 2-story home; 3 people; Baltimore Maryland.

[2] Electric is used in place of oil for water heating as SEEAT provides no model option oil water heating.

[3] Average emissions reductions by fuel type are calculated as the weighted average of emissions from the high and low efficiency heating technologies for that fuel type multiplied by the percentage of non-gas heated Maryland households which use that fuel for heating.

Sources:

[1] Source Energy and Emissions Analysis Tools (SEEAT).

[2] Michelfelder Exhibit RAM-9.

[3] Monitoring Analytics, 2017-02, 2017-01, and 2016-12 Marginal Fuel Postings, available at http://www.monitoringanalytics.com/data/marginal_fuel.shtml.

Exhibit PJH-6
PJM Full Year Average Marginal Fuel Type

Emission Category	PJM Full Year Average Marginal Fuel Posting
Coal	43.6%
Natural Gas	42.5%
Oil	7.1%
Other Nonrenewable	0.2%
Solar	0.0%
Nuclear	2.9%
Wind	3.6%

Note:
In 2016, 0.01% of the time the marginal unit was classified as "Missing Data," and 0.1% of the time as "Min Gen/Dispatch Reset." These categories are excluded from the calculated 2016 annual average marginal fuel posting.

Source:
Monitoring Analytics, 2016 Marginal Fuel Postings, available at http://www.monitoringanalytics.com/data/marginal_fuel.shtml.

Exhibit PJH-7
AltaGas/WGL Merger MD Commitment # 7
Lifetime CO_2 Emissions Reduction

Percent of Funding Spent on Energy Efficiency	Energy Efficiency Funding ($) [A]	Maryland Lifetime Cost of Energy ($/kWh) [B]	Energy Efficiency Savings (MWh) [A] / [B] / 1000 = [C]	Emission Rate Electricity (lbs CO_2/MWh) [D]	Lifetime Emission Reduction (lbs CO_2) [C] * [D] = [E]
25%	7,100,000	0.037	191,892	2,003	384,359,459
50%	14,200,000	0.037	383,784	2,003	768,718,919
75%	21,300,000	0.037	575,676	2,003	1,153,078,378

Sources:

[1] Energy efficiency commitment corresponds to item 7 of the Settlement Agreement and Stipulation submitted in the context of the AltaGas-WGL merger by the Applications, MEA, LiUNA and the Counties to the Maryland PSC December 1, 2017.

[2] Maryland Lifetime Cost of Energy is from the 2015 NEEP REED data.

[3] Emission rate data is from the Gas Technology Institute's SEEAT tool.

[4] Monitoring Analytics, 2016 Marginal Fuel Postings, available at http://www.monitoringanalytics.com/data/marginal_fuel.shtml.

Exhibit PJH-8
AltaGas/WGL Merger MD Commitment # 9

Percent of Commitment Allocation, by Fuel Type	Tier 1 Resource Commitment (MW) [A]	Capacity Factor [B]	Annual Tier 1 Replacement of Baseload (MWh) [A] * [B] * 8,760hrs = [C]	Emission Rate Electricity (lbs CO_2/MWh) [D]	Annual Emission Reduction (lbs CO_2) [C] * [D] = [E]	Annual Emission Reduction per MW (lbs CO_2) [E] / [A] = [F]
100% Wind	5	30%	13,353	2,003	26,745,909	5,349,182
50% Wind, 50% Solar	5	23%	10,276	2,003	20,582,948	4,116,590
100 % Solar	5	16%	7,199	2,003	14,419,986	2,883,997

Sources:

[1] The renewable and low carbon generation development in Maryland commitment corresponds to item 9 of the Settlement Agreement and Stipulation submitted in the context of the AltaGas-WGL merger by the Applications, MEA, LiUNA and the Counties to the Maryland PSC December 1, 2017.

[2] The capacity factors for PJM in 2016 from SNL Financial are: wind (30%) and solar (16%). For the mix of solar and wind, this table uses the average of the solar and wind capacity factors, 23%.

[3] Emission rate data is from the Gas Technology Institute's SEEAT tool.