STATE OF NEW YORK
PUBLIC SERVICE COMMISSION

Case 02-E-0781 - Consolidated Edison Company of New York, Inc. – Proceeding on Motion of the Commission as to an Electric Tariff Filing to Establish a New Standby Service in Accordance With Commission Order.

Case 02-E-0780 - Orange & Rockland Utilities, Inc. – Proceeding on Motion of the Commission as to an Electric Tariff Filing to Establish Standby Service in Accordance With Commission Order.

PREFILED DIRECT TESTIMONY OF

R. NEAL ELLIOTT

MARCH 20, 2003

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I. INTRODUCTION AND WITNESS QUALIFICATION

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

A. My name is R. Neal Elliott. I am the Industrial Program Director and a Senior Associate at the American Council for an Energy Efficient Economy (ACEEE). My business address is 1001 Connecticut Avenue, N. W., Suite 801, Washington, DC 20036.

Q. WOULD YOU PLEASE DESCRIBE YOUR QUALIFICATIONS?

A. Yes. I received my Bachelor's and Master's Science degrees in Mechanical Engineering from North Carolina State University in Raleigh, North Carolina. I received my Doctorate from the Graduate School at Duke University in Durham, North Carolina for research into solid fuels combustion.

I have held my current position at ACEEE since February 1993. Prior to joining ACEEE, I was employed as an engineer at the North Carolina Alternate Energy Corporate (NCAEC) in Research Triangle Park, North Carolina from August 1986 to January 1993. My responsibilities related to the development and implementation of industrial and agricultural energy efficiency programs in cooperation with member electric utilities. While at NCAEC, I also served as adjunct professor of environmental engineering at Duke University from September 1986 to August 1988, and adjunct professor of textile engineering at North Carolina State University from October 1991 to December 1992. From 1978 until 1986 I served as principal engineer for the North Carolina Wood Energy Assistance Project located variously in the Extension Wood Products and Industrial Extension Service Departments at North Carolina State University. I am a Registered Professional Engineer in the state of North Carolina license number 14483.

In 1996 I began working on analysis of combined heat and power (CHP) and the development of programs and policies to encourage its broader adoption. Working with various colleagues, I performed some of the initial baseline analysis of the technical potential for CHP, and undertook analyses of the market hurdles that exist to the expanded deployment of CHP. As part of this work I have chaired the CHP Analysis Working Group, a group of CHP analysts assembled to support federal CHP policy programs, founded in 1997. I have written and presented extensively on this topic, including the preparation of six major reports and more than 25 conference papers.

As part of my CHP analysis and policy work, my colleagues at ACEEE and I have been involved with the development of CHP friendly utility and air quality management regulatory practices. We have commented on proceeding before the Federal Energy Regulatory Commission, Texas

Public Utilities Commission and Natural Resources Conservation Commission (now Commission on Environmental Quality), California Air Resources Board and Public Utilities Commission, and State of New York Public Service Commission.

In addition, I am a founding board member of the U.S. Combined Heat and Power Association, an independent trade association representing the interests of the CHP developers, owners and equipment suppliers. I continue to serve on the Executive Committee of the association and chair the Legislative Affairs Committee. A copy of my CV is provided in Exhibit ___ (RNE-1).

Q. ARE YOU EMPLOYED BY A PRIVATE GROUP IN NEW YORK TO PRESENT THIS TESTIMONY?

A. Yes. The Joint Supporters employ me as a consultant.

Q. WHAT IS THE PRIMARY PURPOSE OF YOUR TESTIMONY IN THIS CASE?

A. I will present testimony concerning the environmentally preferred nature of combined heat and power systems (CHP) (also know as cogeneration).

Q. WOULD YOU PLEASE DESCRIBE HOW YOUR DIRECT TESTIMONY IS ORGANIZED IN THIS CASE?

A. My testimony is organized into the following sections:

(1) Relevancy to this proceeding.

(2) CHP in an efficiency and air emissions context

(3) Characterizing the efficiency and emissions of CHP in various applications

(4) The case for CHP as an environmentally advantaged resource

(5) Specifying criteria for an environmentally advantaged resource

Q. WAS THIS TESTIMONY PREPARED BY YOU OR PREPARED UNDER YOUR DIRECTION?

A. Yes. I prepared it, with assistance from my colleague at ACEEE Anna Monis Shipley.

II. RELEVANCY TO THIS PROCEEDING

Q. Why is the question of CHP efficiency relevant to this proceeding?

A. Under the terms of the Joint Proposal, CHP systems are not eligible for the phase-in of the standby rate, while a phase-in is available to other environmentally preferred systems such as fuel cells, and renewable energy sources such as solar and wind. Given the proven environmental benefits offered by CHP systems, it is my contention that this is a significant omission. In fact, given the precedents outlined below, there is considerable justification for exempting highly efficient CHP systems from such rates altogether. While some parties may contend that CHP should not be given such consideration and that such an action is not appropriate in this forum, that is a mistaken belief. While I agree this is an issue that is under discussion in other arenas and involving other parties such as the New York State Department of Environmental Conservation (DEC), there is more than ample precedent for taking action here.

For example, California Public Utilities Commission in its Decision 01-07-27 has provided exemptions from standby rate charges for CHP projects that meet specific efficiency levels.[1]

III. CHP IN AN EFFICIENCY AND AIR EMISSIONS CONTEXT

Q. HOW ARE THE MAJORITY OF CHP SYSTEMS SIZED?

A. Most industrial CHP systems are sized to meet an existing thermal load. The power sub-system is then sized based on the size and duration of the thermal load. Most building CHP systems are designed to capture 50-70% of peak building electric load, then the systems are adjusted, if necessary, to meet the Qualify Facilities (QF) requirements established in the Public Utilities Regulatory Policy Act (PURPA) of 1978. This design approach optimizes the size of the system to obtain the best economics for the system as well as provide the maximum amount of peak demand reduction. Building CHP

[1] California Public Utilities Commission. 2001. Order Instituting Rulemaking into Distributed Generation: Decision 01-07-27. URL: www.cpuc.ca.gov/published/proceedings/R9910025.htm. San Francisco, California.

system thermal uses include steam or hot water for space heating or thermally activated cooling for space conditioning.

Q. WHAT IS DONE WITH THE ELECTRICITY GENERATED BY A CHP SYSTEM?

A. The electric power generated by a CHP system is used, in net, to displace electricity that would otherwise be purchased from the grid. In most industrial applications, the CHP system provides the electricity base load for the facility with supplemental power purchased from the utility. In building CHP systems, the predominant practice is to use all of the power in the building and not export to the grid. This is very important since it means that the CHP system only positively impacts the grid, and any grid problems that might be caused by power export are avoided. The current average efficiency of the electric generation in the United States is approximately 33% according to the U.S. Department of Energy's Energy Information Administration. This efficiency has remained essentially constant for the past half-century. In addition, the power that is generated on-site does not experience the line losses that are incurred with power purchased from the electric grid, and avoids any transmission and distribution congestion during peak demand periods in the summer within the greater New York City area. In most circumstances, the on-site power increases the reliability of the grid, as well as the customer's site. Most distributed generation technologies have proven very reliable, and, when operated in parallel, in addition to offloading the grid during peak periods provide the customer with two reliable sources of power.

IV. CHARACTERIZING THE EFFICIENCY AND EMISSIONS OF CHP IN VARIOUS APPLICATIONS

Q. IS THE EFFICIENCY OF A CHP SYSTEM DEFINED IN THE SAME MANNER AS ARE ELECTRIC OR THERMAL ONLY SYSTEMS?

A. No. Because a CHP system produces two or more usable outputs from a single fuel source, defining overall system efficiency is more complex than with simple systems. The CHP system can be viewed as two subsystems: the power system, which is usually an engine or turbine, and the heat recovery system, which is usually some type of boiler. The efficiency of the overall system results from an interaction between the individual efficiencies of the power and heat recovery systems. In almost all circumstance the efficiency of the combined system will be higher than that for two separate systems.

Since we assume that the thermal load would exist independent of the CHP facility, the net power heat rate represents the additional fuel input required to generate a unit of power produced by a CHP system, over and above that required to generate the thermal energy alone. The net power heat rate is analogous to the electric heat rate for separate power generation. The net power heat rate for CHP systems is typically in the range of 4,000 to 4,600 British thermal units per kilowatt of electricity produced (Btu/kWh_e), which reflects a net power efficiency of between 70 to 85 percent in some instances. The low magnitude of these heat rate numbers is appreciated by comparison to stand-alone electric power generation, where heat rates frequently range from 7,000 for the newest systems to well over 10,000 Btu/kWh_e for older systems.

Q. WHAT ARE SOME OF THE GENERAL TYPES OF APPLICATIONS OF CHP TECHNOLOGIES AND DO DIFFERENT APPLICATIONS HAVE DIFFERENT POTENTIAL MAXIMUM EFFICIENCY LEVELS?

A. Combined heat and power systems may be installed in almost any facility that has a demand for both thermal and electric energy. Many of the CHP systems that were installed in the past were put into facilities that have high thermal demands such as manufacturing facilities and hospitals, which use thermal energy not only for space heating but also for critical facility processes. These systems were easier to design since most CHP technologies produce more thermal energy than electrical energy. Recently, as technologies have improved in cost and performance CHP systems have begun to be used in other types of applications including the commercial and residential applications. One of the major challenges in designing CHP systems for commercial and residential applications is accounting for seasonal variations in the thermal demand, variations that are not significant in most industrial applications.

Different technologies generally have different capabilities in terms of their maximum design efficiencies. Reciprocating engines, which will likely be the most common technology used for CHP systems in the next 5-10 years, can generally achieve electric-only efficiencies of 33 to 38%, while in CHP mode, the system efficiencies can exceed 65%. Today's fuel cells can usually achieve electricity efficiencies of 30 to 40%, but normally exceed 65% in CHP applications. In fact some fuel cell technologies, such as phosphoric acid and solid oxide, operate at high temperature and require cooling, so unless this high quality is used in a CHP application, a significant efficiency opportunity is lost. Micro-turbines can achieve efficiencies in the range of 23% - 30% in electricity only operation but can usually exceed 55% in CHP applications.

The challenge to designing high efficiency systems is finding a use for all the thermal energy. Many commercial and residential CHP systems can be designed to capture the maximum available thermal energy in the summer and winter wherein they operate at efficiencies at or above 80% yet due to minimum thermal demand over the shoulder months may have difficulty achieving 60% on an annual basis.

Q. ARE CHP SYSTEMS CLEANER THAN OTHER ENERGY RESOURCES?

A. Yes. Since pollution stems from the combustion of a fuel, and, all other things being equal, the less fuel burned to satisfy a demand, the less pollution that is created. The environmental benefit of CHP results primarily from its more efficient use of fuel. As discussed above, CHP systems are more efficient than the separate heat and power systems that have been traditionally been employed to meet end-users' power and thermal needs. For building CHP systems, the use of the waste heat from the prime mover to power absorption cooling is particularly efficient because it is displacing electricity that would otherwise be required for chilled water production. For example, a building with a 1,000 ton electric chiller that installs a 1 MW CHP system can provide approximately 280 ton hours of cooling. Assuming the electric chiller used 1 kWh of electricity to produce 1 ton-hour of cooling, the building's air conditioning system efficiency is increased in effect by 28%.

CHP systems are not technology specific, so the emissions will vary by the technology and fuel chosen for a specific application, as has been indicated by work of Dr. Bruce Hedman with Energy and Environmental Analysis, Inc. Nitrogen oxides (NO_x), Sulfur Oxides (SO_2), Particulate matter (PM-10), and Carbon dioxide (CO_2) are four of the primary pollutants regulated in the permitting of distributed generation. Generally speaking, as the efficiency of a system increases, the pollutant emissions decrease. It is difficult to give definitive estimates of CHP emissions rates because of the high variability of these systems. The emissions rates of the systems vary according to the power-to-heat ratios and the prime mover technologies. A typical example can be determined by estimating CHP emissions by subtracting the displaced boiler emissions from the emissions of the prime mover technology.

When calculating compliance of an individual CHP unit with electric output-based emissions standards, the emissions from the unit should be discounted by the avoided emissions that a conventional system would have otherwise emitted had it provided the same thermal output. This approach to

CHP has been adopted by several states including Texas and California[2]. For example, a 35-megawatt electric (MW_e) CHP system with a power-to-heat ratio of 0.7 produces 50-megawatt thermal (MW_t). For this system, we assume that the CHP unit displaces a typical small industrial, commercial, or residential boiler with an efficiency of 80%. Using this assumption and a sample emissions standard for boilers, we assume that the displaced boiler would emit 0.036 lbs/MMBtu (California's standard for new industrial boilers) on an input basis, equivalent to 0.154 lbs NO_x/MWh_e on an output basis. Based on a power-to-heat ratio of 0.7, the emission credit on an electric basis would be 0.220 lbs NO_x/MWh_e. In other words, a CHP unit could emit 0.72 lbs NO_x/MWh_e and still comply with a 0.5 lbs/MWh standard (since 0.72 lbs NO_x/MWh_e - 0.220 lbs/MWh_e = 0.5 lbs/MWh_e). A 0.5 lbs/MWh standard would represent the typical emissions rate of a 3-way catalyst rich

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[2] California Air Resources Board. 2001. *Regulation to Establish a Distributed Generation Certification Program.* Title 17, Chapter 1, Subchapter 8, Article 3, Sections 94200-94214. Sacramento, Calif.: California Air Resources Board.

Texas Commission on Environmental Quality. 2001. *Air Quality Standard Permit for Electric Generating Units*. Austin, Texas: Texas Commission on Environmental Quality.

burn natural gas engine producing electricity only. Texas and California have adopted 0.5 lbs/MWh NO_x emissions for CHP[3]. Compare this to the NO_x emissions rates of other fossil fuel-fired distributed generation technologies including uncontrolled natural gas lean burn engines (2.2 lbs/MWh), uncontrolled diesel engines (21.8 lbs/MWh), SCR controlled diesel engines (4.7 lbs/MWh), small gas turbines (1.15 lbs/MWh), and microturbines (0.44 lbs/MWh).

A CHP system that achieves 0.5 lbs/MWh NO_x represents a major improvement over the current, average U.S. utility system average. While a new state-of-the-art utility sized combined cycle gas turbine can achieve 0.06 lbs/MWh NO_x under ideal operating conditions, the average emissions rate of the fossil-based utility electricity generation remains at over 5.0 lbs/MWh NO_x. When renewable-based generation (largely CHP systems in the wood products industry) is included in the mix, the average emissions rate is still over 3.4 lbs/MWh NO_x.

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[3] Ibid.

Q. HOW SHOULD THE EMISSIONS FROM A CHP SYSTEM BE VIEWED TO FAIRLY REFLECT THEIR EFFICIENCY ADVANTAGE?

A. An output-based approach most fairly reflects the true emission from a CHP system, and allows them to be compared on an equal basis to other power systems such as boilers and stand-alone power generators. For CHP systems, the usable outputs from the system need to be combined.

Current air regulations do not take into account the increased efficiency benefits that occur when heat is recovered in a generation system. Creating output-based standards for pollutants (in pounds per megawatt-hour [lbs/MWh] output or equivalent unit) for emissions would allow CHP to take credit for this increased fuel utilization. The creation of output-based standards is absolutely key in encouraging the adoption of the cleanest and most efficient electricity generation technologies. Several states have prepared rules for the adoption of output-based standards. For example, in California CHP system efficiency, as well as the reduction in transmission and distribution system line losses are used to calculate CHP emissions. The same is true in New Jersey. The Massachusetts restructuring legislation directs its Department of Environmental Protection (DEP) to develop an output-based standard for any pollutant determined to be of concern to public health and also to implement at least one standard by May 2003.[4] In a related effort, the Northeast States for Coordinated Air Use Management (NESCAUM) has devised a model Emission Performance Standard rule, on an output basis, for its member states. [5]

When devising output-based standards, it is important to understand the importance and value of thermal energy and the impact of avoided transmission and distribution line losses. There have been many debates over the value of recovered heat in a CHP system. For most people, it is difficult to imagine process steam or heated water output as being of the same value as electricity. However, in typical industrial and institutional settings, boilers fueled by natural gas, fuel oil, or coal are required to provide steam and hot water needs. The combustion of a fuel to produce this heat has

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[4] Massachusetts Department of Environmental Protection. 1999. *Background Information on DEP's Proposed Output-Based Allocation.* http://www.state.ma.us/dep/bwp/daqc/files/output.htm. Boston, Mass.: Massachusetts Department of Environmental Protection.

[5] Northeast States for Coordinated Air Use Management. 1999. *NESCAUM Emission Performance Standard (EPS) Model Rule.* Boston, Mass.: Northeast States for Coordinated Air Use Management.

its own set of thermal losses and emissions. These losses are in addition to the losses and emissions inherent to grid-supplied electricity. The value of the thermal output must be considered in comparison to how it is obtained in conventional applications.

While many regulators and energy experts consider CHP to be primarily an electricity-generating technology, it is important to understand that industrial and commercial operators frequently think of CHP as a heat-generating technology with the added benefit of on-site power production. Therefore, while thermal energy may be considered to be lower quality (based on its difficulty in being converted to other forms of energy) than electricity, it is nonetheless very highly valued in both industrial and commercial settings.

V. THE CASE FOR CHP AS AN ENVIRONMENTALLY ADVANTAGED RESOURCE

Q. WHAT IS AN ENVIRONMENTALLY ADVANTAGED RESOURCE?

A. An environmentally advantaged resource is an energy resource that offers significant fuel efficiency and lowers air emissions compared to conventional technologies. While having zero emissions would be desirable, it is not practical today to meet thermal requirements without combusting some fuel resulting in the production of air emissions.

Q. WHY SHOULD CHP BE CONSIDERED AN ENVIRONMENTALLY ADVANTAGED RESOURCE?

A. CHP can represent a clean and efficient means of meeting the power and thermal requirements of an end-user. CHP systems need to be compared to the separate systems that are required as the alternative means of meeting these requirements. In this context, most CHP systems clearly meet this requirement, achieving a very high net power heat rate.

As was described before, the emissions for CHP systems will be significantly lower than from the separate systems. For a fair comparison, the emissions from the displaced grid-purchased electricity need to be combined with the emissions from the displaced on-site boiler or other thermal device. Measuring the emissions from the on-site boiler is fairly straightforward. However, estimating the displaced utility generation emissions is more complicated because of the time and location nature of the displaced utility generation and accounting for the line losses. CHP system that are base loaded can be viewed as reducing the utility generation at all times, so a plausible estimate is to use the average utility generation and take into account the average line losses. However, many building CHP systems are only operated during the daily peak and mid-peak periods. In these cases, grid power has a much higher component of peaking plants that frequently have a higher average emissions rate. In this case, the environmental benefit of CHP may be greater compared to the grid-average emissions rate.

Q. HOW DOES CHP RELATE TO RENEWABLE TECHNOLOGIES?

A. CHP is not a technology, but rather a way to maximize the efficiency of an energy system. CHP systems can be fueled by both fossil and renewable energy sources, with approximately 40% of the electricity generated from CHP in this country coming from renewable energy sources. Irrespective of the fuel, CHP systems contrast with conventional, inefficient centralized power system and distributed technologies, by offering greater efficiency and reduced emissions to satisfy the same end-user demands.

VI. SPECIFYING CRITERIA FOR AN ENVIRONMENTALLY ADVANTAGED RESOURCE

Q. HOW CAN AN ENVIRONMENTALLY ADVANTAGED RESOURCE BE IDENTIFIED?

A. Using a single criterion such as efficiency or emissions rate for defining an environmentally advantaged resource is neither practical nor fair. A very efficient, but dirty resource should not meet the criteria, nor should a very inefficient but clean system. In my opinion, it is better to look at a combination of criteria that include efficiency, emissions rate, source of energy, and system size.

I would suggest three criteria that build upon the definitions of efficient CHP developed by the U.S. Combined Heat and Power Association and emissions criteria that emerged by the Regulatory Assistance Project's (RAP) model emission rule discussions. To qualify for environmentally advantaged status a CHP system should:

1. Have a total system design efficiency, adjusted for seasonal thermal demand factors, of at least 55% for systems with a power output of less than 500kW and 60 % for systems of 500 kW or greater.
2. Produce at least 15% of the total usable energy output in the form of electrical power and at least 20% of the total usable energy output in the form of thermal power.
3. Achieve an emissions rate for NO_X equal to or less than 0.35 pounds per kWh based on the total usable system output converted into kWh.

Any system that is added to an existing thermal facility that recovers waste heat to produce usable power should be excluded from the above criteria. This exclusion is added for such instances as the application of a heat engine such as a Stirling engine or the replacement of a steam pressure-reducing valve when a backpressure turbine is added to an existing system. In these cases power is produced directly from reducing wasted energy, and no addition fuel consumption or emissions result from the modification.

VII. CONCLUSIONS AND RECOMMENDATIONS

Q. WHAT ARE YOUR PRINCIPAL CONCLUSIONS AND RECOMMENDATIONS CONCERNING THE TREATMENT OF CHP FACILITIES FROM AN ENVIRONMENTAL AND RESOURCE EFFICIENCY STANDPOINT?

A. Based on my research and analysis, CHP represents an environmentally advantaged technology. While fossil fueled CHP may not offer all the benefits of some renewable energy resources, it does offer significant reductions in emissions of both greenhouse gasses and improvements in the efficiency of utilization of non-renewable energy resources relative to conventional separate heat and power systems. As the New York State Energy Planning Board has indicated in its state energy plan, these factors together benefit the state by providing improvements in environmentally emission and resource utilization efficiency while addressing the expanding need for energy to fuel economic growth in the state. As a result, I conclude that clean and efficient CHP systems should be eligible for the phase-in of the standby rate, as are other environmentally preferred systems. In fact, there is considerable justification for exempting highly efficient CHP systems from such rates altogether.

Q. Does this conclude your testimony?

A. Yes.