DIRECT TESTIMONY OF

HERBERT H. WOODSON

ON BEHALF OF

HOUSTON LIGHTING & POWER COMPANY

RE TEX PIRG CONTENTION 5/ SOLID WASTE COMBUSTION

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Q. Please state your name and position.

A. My name is Herbert H. Woodson. I am Professor and Chairman of Electrical Engineering and Director of the Center for Energy Studies at the University of Texas at Austin.

Q. Please describe your education.

A. I have S.B., S.M. and Sc.D degrees in electrical engineering from the Massachusetts Institute of Technology.

Q. What are your professional accomplishments?

A. My professional activities are primarily in electric power systems engineering and electromechanics. I am a registered professional engineer in Texas and Massachusetts and I hold four patents. I have been a teacher for more than 20 years at M.I.T. and U.T. and have authored many papers and coauthored two textbooks, Electromechanical Dynamics (with J. R. Melcher) and Electromechanical Energy Conversion (with D. C. White).

I have been a consultant for 14 firms, including a large number of electric utilities and electric power equipment manufacturers, and have served on several advisory panels for industry and government, including service on the Comanche Peak Design Review Team for Texas Utilities Company.

I am a Past President of the Power Engineering Society of the Institute of Electrical and Electronics Engineers and a Fellow of IEEE. I am also a member of the National Academy of Engineering and of a number of other professional and honorary organizations.

I established and was the first Director of the Electric Power Systems Engineering Laboratory at M.I.T. in 1968. In 1974 I was appointed the Director of the newly founded Center for Energy Studies at UT. The center is an inter-disciplinary research organization that carries on a diverse array of energy related projects. As Director of the Center, I keep abreast of technological developments which hold the promise of utilizing new resources for central station power generation. I am familiar with research and technical literature in such areas as synthetic fuels, solar energy, biomass and combustion of refuse.

Q. What is the purpose of your testimony.

A. My testimony responds to TexPirg Contention 5 which alleges that

> "Neither the Applicant nor the Staff have given adequate consideration to the combustion of solid waste as an alternative energy source, because:
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> a. The Staff concludes on § 9-9 of the DS-FES that "the lack of demonstrated technology on a commercial basis eliminates the potential future energy sources from consideration as

alternatives for central station power by the late 1980's, apparently including refuse combustion among the "future alternatives". However, the evidence will indicate that the Staff has been inaccurate with regard to solid waste combustion. Twenty-one operational plants exist in the United States, with more than one dozen under construction, over forty in the advance planning stage, and over sixty in the feasibility study stage. Further, such facilities have operated successfully in Europe for over 40 years.

b. The Staff states on § 9-6 of DS-FES that solid waste generation plants should be used to "regain lost energy", but expresses doubt that such plants will be contributing electricity in the near future. The heat content of solid mixed municipal waste is approximately 5,000 BTU/lb. or 40 percent the value of coal. In waste processing systems, the removal of light combustibles and separation of non-combustibles like glass and metals yield a paper-rich fraction in excess of 10,000 BTU/lb. or 90 percent the heat value of coal. Among the 80 operating "waste-to-electricity" plants in Europe are plants in Amsterdam and Frankfurt which supply six and seven percent of their city's electricity needs, respectively. The assumptions of the Staff regarding the use of this option are therefore incorrect.

c. The six thousand tons per day of solid waste in Houston are more than adequate to support a three-thousand ton per day conversion plant that would obviate the need for the proposed ACNGS; and this alternative is technologically, environmentally, and economically desirable relative to nuclear generation stations. (This option should be an issue at this hearing. Petitioner believes the solid waste of Houston can sustain 800-1,000 MWe of production; though this level of supply could not have substituted for the two-unit ACNGS proposal in 1975, it does

become viable in comparison to only one unit. In addition, since July, 1975, 28 communities have begun feasibility studies for solid waste power generation, 14 new plants went into the planning stage, and two more plants became operational - thus suggesting an increased viability of this option during that time)."

Q. Have you examined the testimony and materials produced in the discovery period pertaining to this contention?

A. Yes, I have reviewed the deposition of TexPirg's expert witness, Mr. Gregory Skie, and all the interrogatory answers and documents produced by TexPirg concerning this contention.

Q. Can you summarize your understanding of this contention?

A. TexPirg asserts that the municipal waste of Houston can be used to generate up to 469 megawatts of electric power in the same time frame and at a cost comparable to Allens Creek. (The original contention stated that such a station could generate 800-1000 MWe). The contention is based on an energy conversion calculation, using estimates of municipal waste heat content and net cycle efficiency. Various existing and planned solid waste conversion plants are cited as evidence of the present feasibility of solid waste fueled electric generation.

Q. Are you aware of the solid waste combustion plants planned under construction and operating, in the United States?

A. Yes, they number about forty. None have a capacity in excess of 3000 tons per day and, of those which produce electricity, none have an output in excess of approximately 80 MWe.

Q. What is your general assessment of the technology and its present limitations?

A. I believe that under certain circumstances the technology may be attractive. On the plus side, waste segregation would allow recovery of valuable materials for recycling; there would be some reduction in the volume of landfill; and, finally, the electricity or steam produced would be of value. Of course, the economics of the process depend on the particular circumstances and would have to be demonstrated.

There are a number of variations on the basic solid waste combustion technology which are derived either from the degree of preparation of the waste as a fuel or improvements in the combustor efficiency. For example, fuel preparation ranges from simple shredding and separation (air or magnetic) to complicated pretreatments producing mechanically and chemically uniform fuel products such as

Hydraposal (wet pulping) and Eco-Fuel II (fine particulate). The sophistication in combustion then corresponds with the preparation of the fuel, ranging from simple mass burning to special waterwall and fluidized bed furnaces. In all cases, however, no matter what the degree of fuel preparation or the complexity of the combustor design, the total amount of potential energy that can be extracted from municipal solid waste is restricted to the latent energy contained in the untreated solid waste. Therefore, a reasonable calculation of energy conversion potential for solid waste combustion will tell you the maximum power available from this source regardless of the available technology and techniques used.

Q. Would present engineering and any reasonably anticipated improvements permit the generation of as much as 469 megawatts electric fueled by the solid waste gathered from the Houston area?

A. No. A calculated energy conversion potential based on the most up-to-date designs of solid-waste combustion plants for the production of electricity shows that a maximum of approximately 100 megawatts of electric power can be generated by the municipal solid wastes available in Houston at the present time.

Q Would you describe your calculation of energy conversion potential for solid waste combustion.

A. First, I developed a reasonable calculation of the amount of municipal solid waste generated in the City of Houston. I relied, in part, on a paper entitled "Evaluation of Energy Recovery from Municipal Solid Waste in Oil-Fired Power Plants," by V. G. Forzley of Stone and Webster Management Consultants, Inc., and presented in a Seminar on Municipal Solid Waste as a Utility Fuel sponsored by the Electric Power Research Institute in Fort Lauderdale, Florida, January 9-11, 1980. The paper shows that municipal solid waste (excluding sewage sludge) produced in the United States in 1977 was 130 million tons. For a population of 220 million people this calculates on the average to 3.24 pounds per capita per day.

Assuming that a population of 1.7 million people (the approximate population of the Houston metropolitan area) produces this per capita amount of municipal solid waste, which is then collected and made available for energy production, an amount of 2750 tons per day would be available as fuel.

As a check on that calculation, I reviewed a proposal to the City of Houston by the Gulf Coast Waste Disposal Authority, Brown & Root, Inc., Browning-Ferris

Industries, Inc. and Grumman Energy Systems, Inc., for a refuse disposal and energy recovery program (the "GCWDA proposal"). That proposal states that 2550 tons of solid waste is available, reflecting the "total solid waste stream collected by the City of Houston." The figure derived from the GCWDA proposal corresponds approximately with my calculation derived from national figures (about 2750 tons per day).

Next I approximated the heat content of this solid waste. In the study by Forzley cited earlier, the heat content of the municipal solid waste (from a New York City location) is 4375 BTU per pound. This is somewhat lower than the 5000 BTU per pound used in the GCWDA proposal to the City of Houston. (Higher heat contents are possible through segregation of garbage, isolating its most heat-rich content; this, of course, reduces the total volume available for burning.)

As a basis for evaluating the electric energy production potential of municipal solid waste in Houston, I postulated a system of the type described and evaluated in the Forzley paper. That system used 100 percent firing of untreated municipal solid waste in a dedicated waterwall incinerator and utilization of the steam produced in a dedicated turbine generator unit to generate electricity.

The system evaluated by Forzley consumed 3620 tons per day of municipal solid waste having a heat content of 4375 BTU per pound and produced electricity at a heat rate of 14,286 BTU per KWH.

To be more Houston-specific in my evaluation, I used the GCWDA proposal figures of 2550 tons per day with a heat content of 5000 BTU per pound. The higher heat content should allow a better heat rate and I assumed 12,500 BTU per KWH which roughly scales heat rate with heat content.

Using these figures of 2550 tons per day of municipal solid waste having a heat content of 5000 BTU per pound and producing electric energy at a heat rate of 12,500 BTU per pound, an amount of 2,040,000 KWH would be produced daily with an average power of 85 megawatts.

The GCWDA proposal cited a 3 percent growth rate in the municipal solid waste available which would reach a level of 3500 tons in about 10 years. This amount of waste having 5000 BTU per pound and producing electric energy at a heat rate of 12,500 BTU per KWH would produce 2,800,000 KWH per day or an average power of 117 megawatts.

Q. Do the present state-of-the art designs for solid waste combustion plants corroborate this calculated estimates of net energy produced from municipal waste consuming plants?

A. Yes. One primary example is a system which is

proposed for operation on Staten Island using municipal solid waste from New York City. That system, which is one of the possible systems evaluated in the Forzley paper I have mentioned, was designed to consume 3620 tons per day of municipal solid waste having a heat content of 4375 BTU per pound and producing 2,210,000 KWH per day or an average power of 92 megawatts.

A second example is a plant under construction in Dade County, Florida, which is designed to consume 3000 tons per day of segregated garbage having a heat content of 7000 to 8000 BTU per pound and to produce steam to drive two 38 megawatt-electric, turbine-generator units for a total of 76 megawatts. Both of these plants incorporate the best technology and techniques available and closely corroborate the simple calculation of potential electric generation I described.

Q. What do these facts suggest about the feasibility of a solid waste combustion plant of about 469 MWe in the Houston area?

A. Obviously, the solid waste available in the Houston area, assuming use of all solid refuse generated in the area and allowing for reasonable growth, is not sufficient to generate even one fourth of the amount (469 MWe) postulated by Tex Pirg.

Q. Please elaborate on the GCWDA proposal you cited earlier, and, if it goes forward, the effect on the availability of solid waste fuel in the Houston area.

A. That proposal is to build a plant containing four waterwall incinerators of German design each capable of consuming 875 tons of untreated municipal solid waste per day for a total capacity of 3500 tons per day. The primary purpose of the plant is to produce steam for use by industries along the ship channel in Houston, but a steam-turbine generating unit nominally rated for about 6.5 megawatts and operating on the main steam out of the plant will provide the electrical needs of the plant.

It appears that if the GCWDA proposed project goes forward, there will be virtually no municipal solid waste available in Houston for primarily generating electricity.

Q. What is your opinion about the overall feasibility of using solid waste combustion as an alternative to Allens Creek?

A. Based on my examination of the current status and future prospects of using municipal solid waste combustion as an alternative source of energy, it is my opinion that municipal solid waste can produce only a small fraction of the energy needs of an urban area, so it should be considered a supplemental rather than an alternative source of energy.

It is not a potential replacement for a large, modern base-load electric generating plant such as Allens Creek.

Q. Does that conclude your testimony?

A. Yes.