July 13, 2012

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U.S. Department of Energy
Building Technologies Program, Mailstop EE–2J
1000 Independence Avenue, SW
Washington, DC 20585– 0121

Subject: Docket No. EERE-2012-BT-STD-022

Re: Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Energy Conservation Standards for Residential Water Heaters

Joint Comments of PJM Interconnection L.L.C., National Rural Electric Cooperative Association, American Public Power Association, Edison Electric Institute, and Steffes Corporation to Request for Information RIN 1904-AC78

PJM Interconnection, L.L.C. ("PJM"), the National Rural Electric Cooperative Association ("NRECA"), the American Public Power Association ("APPA"), the Edison Electric Institute ("EEI"), and the Steffes Corporation ("Steffes") (together, "Joint Commenters") are pleased to provide these comments in response to the Department's Request for Information ("RFI") on the impact of its amended energy conservation standards for residential electric water heaters on utility demand response and energy storage programs.[1]

The Joint Commenters are grateful for the Department's consideration of their request that the Department consider the impacts of its amended water heater efficiency standards on existing and future demand response programs, as well as energy storage services that promote peak load shifting and renewable energy integration. Joint Commenters believe that, with narrow and targeted action as proposed herein, the Department's goal of driving appliance-specific efficiency can be fully harmonized with Congress' embrace of smart grid development and promotion of demand response through the Energy Independence and Security Act of 2007. Absent action by the Department, the

[1] Federal Register, April 16, 2010, Vol. 75, No. 73, pp. 20112-20236

water heater energy efficiency standards established by the Department on April 16, 2010 will have serious adverse (albeit unintended) consequences. In short, existing demand response programs providing millions of dollars of value to American consumers each year (as detailed herein) will begin to decline and eventually disappear should the large-capacity electric resistance water heaters on which they rely not be recognized in a new classification that would harness the benefits of "grid-interactive" water heaters. Moreover, the industry is on the cusp of dramatically expanding the value of grid-interactive water heaters by using them as energy storage devices that can facilitate the integration of renewable resources such as wind and solar generation.[2] The level of renewables interconnecting with the grid has increased exponentially since the development of the original standard. Yet, the standard itself will adversely impact the development of residential energy storage devices---devices which are critical to ensuring that renewables (and particularly wind generation) can realize their full potential for the ultimate consumer. Finally, the grid-interactive water heater provides a valuable resource which has been proven to be a true asset to system operators in controlling system frequency and responding quickly to sudden renewable energy ramping events. Joint Commenters have proposed a variety of ways that the Department can ensure that its new standard recognizes these grid-interactive features rather than stifle their development. Given the imminent elimination of certain manufacturing product lines associated with electric resistance water heaters above 55 gallons, now is the time to adopt these reforms.[3]

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[2] Wind generation is often at its maximum output in the late evening and early morning hours, which is generally inversely proportional to system peak demand, which usually occurs during the daytime on hot summer days. The development of effective energy storage through electric water heaters can provide the technology which can help to harness this off-peak renewable resource.

[3] Joint Commenters are respectful of the need to meet the "no backsliding" provisions in Section 6295 (o)(1) of the Energy Policy Act of 1992 (Pub L. No. 102-486 (Oct. 24, 1992) 106 Stat. 2776)("the Act"). Accordingly, Joint Commenters propose the development of a new classification consistent with Section 6295 (o)(2)(A) of the Act. This proposal is discussed further in Section 4 of these comments. Moreover, Joint Commenters have been in touch with the original commenters in this docket to explore additional ways to ensure harmony with Section 6295(o) of the Act.

<u>Description of Parties</u>

PJM Interconnection: *PJM Interconnection, founded in 1927, ensures the reliability of the high-voltage electric power system serving 60 million people in all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia. PJM coordinates and directs the operation of the region's transmission grid, which includes 62,000 miles of transmission lines; administers a competitive wholesale electricity market; and plans regional transmission expansion improvements to maintain grid reliability and relieve congestion.*

NRECA: *The National Rural Electric Cooperative Association is the national service organization that represents the nation's more than 900 private, not-for-profit, consumer-owned electric cooperatives, which provide service to 42 million people in 47 states.*

APPA: *Based in Washington, D.C., the American Public Power Association is the national service organization for the nation's more than 2,000 community- and state-owned not-for-profit electric utilities serving 46 million customers.*

Edison Electric Institute: *The Edison Electric Institute (EEI) is the association of U.S. shareholder-owned electric companies. EEI's members serve 95 percent of the ultimate customers in the shareholder-owned segment of the industry, and represent approximately 70 percent of the U.S. electric power industry. EEI also has more than 65 international electric companies as affiliate members, and more than 170 industry suppliers and related organizations as associate members.*

Steffes Corporation: *Based in Dickinson, North Dakota, the Steffes Corporation is a 40 year old manufacturer of specialty products and a leader in Electric Thermal Storage (ETS) systems.*

Overview of Proposal

The Joint Commenters submit for the record their prior submittals to the Department outlining the legal and technical basis for development of a "grid-interactive" electric water heater standard (Attachments A-C). In addition, the Joint Commenters provide the responses below to the specific inquiries set forth in the Request for Information.

In a nutshell, the Joint Commenters urge the Secretary to use his authority pursuant to 42 U.S.C. § 6295 (o)(2)(A) to develop a new standard that reflects the unique value provided by large-volume electric resistance water heaters which interact with the grid pursuant to: a. utility demand response programs; b. ISO/RTO frequency response programs; or c. energy storage devices which, due to their grid interaction, operate in response to grid conditions to facilitate the integration of renewable-sourced electricity. Grid interactivity makes this specific group of water heaters different from the general class of electric water heaters and thus deserving of a new classification pursuant to Section 6295 (o)(2)(A).[4][5]

Responses to RFI Section III.B, "Issues on Which DOE Seeks Comment"

Section 1 – Response to Issue #1

The Department seeks information on the effects of utility programs designed to reduce peak energy demand by heating water only during off-peak times and storing the water for use during peak demand periods. In particular, DOE is interested in information on the penetration of residential water heater load shifting programs throughout the U.S. (i.e., what percentage of total water heaters installed are used in these programs), the economic benefits of such programs to consumers, and the energy impacts (if any) or other National benefits that are achieved through the use of such programs.

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[4] As per an original whitepaper submitted to the Department and attached hereto as Attachment A, the Department may also consider setting a standard for large-volume electric water heaters with new grid-interactive functionality pursuant to 42 U.S.C. Section 6295 (o)(5).

[5] Joint Commenters have been in touch with representatives of the environmental community who have suggested development of a targeted waiver from the existing standard as another means to accomplish the stated goal of recognizing the "grid interactive" feature of certain water heaters not considered under the present standard.

1.1 Penetration of Utility Water Heater Programs

According to the 2011 Federal Energy Regulatory Commission's (FERC) "Assessment of Demand Response and Advanced Metering", direct load control programs are the most commonly used type of incentive-based demand response program and are widely available nationally.[6] Approximately 5.6 million customers were enrolled in direct load control programs across the nation, including every North American Electric Reliability Corporation (NERC) region. The report also finds that demand response resources are present in every ISO and RTO in the nation, and that the capacity of those resources represent between 2 and 11% of peak load in those ISO/RTO territories, and 7% of total peak load across all ISOs and RTOs.[7] A data set of demand response survey results accompanying the FERC report further indicates that electric resistance water heater programs are an integral part of the national demand response strategy. Water heater programs were identified in 35 of 50 U.S. states and were conducted by investor owned utilities (IOU), cooperatively owned utilities (Co-op), and municipally owned utilities (Muni).[8] As the FERC report did not specifically quantify the concentration of water heater programs within the category of "direct load control" programs, Joint Commenters have undertaken their own surveys to supplement the FERC report findings on the overwhelming penetration of direct load control programs throughout the country.

In order to provide more detailed information while still ensuring a national sample, the National Rural Electric Cooperative Association (NRECA) issued a demand response survey in early 2012 to its members – rural, cooperatively owned electric utilities across the country. NRECA members are located in 47 of the 50 U.S. states. Collectively, rural cooperatives serve over 42 million Americans in areas ranging from suburbs of major cities, to "exurbs", to remote rural communities.

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[6] "Assessment of Demand Response and Advanced Metering". Federal Energy Regulatory Commission, Staff Report. November 2011.

[7] Ibid, Table 2, page 10.

[8] Data set available from http://www.ferc.gov/industries/electric/indus-act/demand-response/2010/dr-data.xlsx

The NRECA survey revealed that 30% of respondents currently offer their customers a water heater direct load control program as part of their overall direct load control program. Another 10% are actively considering implementing a water heater program. Furthermore, those utilities with direct load control programs are experiencing, on average, a 4% annual participation growth rate in large-volume electric water heaters used in their programs, indicating that such water heaters are expected to continue to be a significant part of their ongoing direct load control programs. The survey also provided water heater load control capacity amounts from 109 cooperative utility survey respondents. The estimated peak load reduction capability for those utility systems is more than 500 MW during both summer and winter months. For many systems, large-volume water heaters comprise a significant portion of the controlled units. Under DOE's final rule, the inability to replace large-volume units at the end of their service life with another large volume unit with direct load control will certainly result in a significant loss of load control and energy storage capability, and increased costs for all customers of those utility systems. Moreover, as noted in Section 3 of these comments, the heat pump water heater, although potentially beneficial for some homeowner applications, is a poor fit for providing the grid interactive services that are available from 55+ gallon grid-enabled electric resistance water heaters.

An American Public Power Association (APPA) survey of its membership across 49 states discovered that 44.5% of respondents currently offer their customers a water heater direct load control program as part of their overall direct load control program. Based on this survey it was also found that the average water heater load control program had a summer reduction of 4.9 percent of load while in winter the average reduction was 4.4 percent of load. APPA will provide its aggregate survey information in a separate submission.

The Edison Electric Institute (EEI) reviewed member company web sites and found that at least 14 investor-owned utility operating companies in at least 12 states operate demand response programs for residential electric resistance water heaters. It is likely that with the increase in households with "smart meters" over the next several years as a result of the "smart grid", the number of utilities that offer such programs for "smart" water heaters will increase.[9] EEI will provide information on member company programs in separate comments filed in response to this RFI.

1.2 Economic benefit to consumer

The direct and indirect economic benefits to consumers from the use of grid-interactive large volume electric storage water heaters can be segmented into three distinct areas:

a. ***Peak Shaving*** *– curtailing the heating element on a water heater for an hour or more in order to reduce load in response to peak grid conditions and resulting peak hour prices. Under the demand response programs detailed above, this element of grid controllability provides a revenue stream for the appliance owner, allows the utility to maintain reliability of the overall supply of electricity to their customers and forestalls the need to build new power plants to meet growing peak demand.*

b. ***Renewable Energy Integration through Use of the Water Heater as an Energy Storage Device*** *– controlling a water heater's heating element to turn on only at night and to store enough hot water to serve the daily demand of the customer without having to heat water during the day. This controllability is of particular benefit to "marry" the grid storage functions of the water heater with the integration and utilization of increased renewable energy (often available, in the case of wind, mostly during off-peak hours) to both meet individual consumer demands to use more "green" energy as well as promote national energy independence. Additionally, without energy storage there will be situations where renewable generation may have to be curtailed.*

c. ***Use of Electric Water Heaters to Provide Critical Ancillary Services*** *– controlling a water heater's load in response to grid operation signals including excess generation events related to wind energy production or system balancing signals such as frequency regulation. This use of*

[9] Congress embraced development of the Smart Grid as part of national policy in the Energy Independence and Security Act of 2007.

the water heater provides a significant revenue stream for the individual customer as well as helps to promote reliability of that individual's and his or her community's electricity supplies.

Each of these benefits is discussed below. Large-volume heat pump water heaters are not effective for use in these three types of utility control strategies due to various technical operating and design, as well as economic limitations. We detail these limitations in Section 3 of these comments.

a. *Peak Shaving*

Electric water heater direct load control programs aimed at peak shaving can provide significant benefits to individual consumers as well as the greater community dependent on reliable, low-cost supply of electricity. The homeowner is paid by the utility for their participation in the program through bill credits, rebates, discounted rates and/or free water heater installation or maintenance. The level of compensation is set based on the regulator's, or municipality's, review of the cost savings achieved by the utility that operates a peak shaving direct load control program. These cost savings are in the form of new capacity that can be deferred as a result of peak shaving, and the reduced peak energy costs that also result from peak shaving.

Based on a recent survey of its cooperatively owned utility members conducted by the NRECA, the average bill credit for participating customers per water heater is $58 per year. In addition to the bill credit, customers are often eligible to receive an upfront rebate to off-set a portion of the purchase cost of an electric water heater when the customer agrees to participate in the direct load control program. The average rebate among the survey respondents that also offered the bill credits is $230. Over a ten-year period, the combination of the upfront rebate and annual bill credits can amount to $800 for the participating customer.

Non-participating customers also receive in-direct benefits in the form of lower overall electric rates made possible by the utility's reduced capacity and energy costs. Where wholesale markets exist, these cost savings are readily apparent.

For example, in PJM's capacity market, the value of a Megawatt (MW) of demand response is a found in the capacity auction and resulting clearing price. In the most recent auction held in May 2012 for the delivery year 2015/2016, that value was $136/MW-day for the RTO. In that same auction, PJM cleared a record 14,833 MWs of demand response having an approximate value in that year of $736M.[10] The amount of demand response being offered into RTO/ISO markets continues to grow at a rapid pace, indicating the competitive value proposition between building new generation and lowering a utility's capacity costs through demand response programs.

In addition to capacity value, demand response resources in direct load control programs help utilities avoid costly on-peak energy purchases and, in organized wholesale markets, are offered the opportunity to be paid the same energy price for reducing load as a generator is paid for creating it.[11]

b. *Renewable Energy Integration through Use of the Water Heater as an Energy Storage Device*

Grid-interactive electric water heaters are also available to serve as energy storage devices providing a market for consumption of wind generation in off-peak hours which can then be made available to customers upon demand in the form of stored hot water, during on peak hours. In these programs, utilities incentivize customers to install water heaters with a grid-interactive device that provides the communication and control to heat water only during off-peak periods. Since low-cost, base load and wind energy generation is typically available at night (sometimes in excess and at negative prices) this strategy is ideal for lowering the overall energy costs of a utility, thereby applying downward pressure on electric rates for the consumer. Moreover, this strategy can assure customers who "buy green" electricity that they are taking affirmative steps to shift their consumption to enable the use and development of such renewable resources.

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[10] In PJM's capacity market, clearing prices are both location and product specific. To be conservative, this calculation multiplies the number of Demand Response MWs cleared (regardless of DR product type) by the RTO-wide clearing price of $136/MW-day. These values apply to the 2015/2016 delivery year. For more information, visit http://www.pjm.com/markets-and-operations/rpm/~/media/markets-ops/rpm/rpm-auction-info/20120518-2015-16-base-residual-auction-report.ashx

[11] "Demand Response Compensation in Organized Wholesale Energy Markets". FERC Docket No. RM10-17-000, Order No. 745, (March 15, 2011)

With the advent of hourly energy markets and the accessibility to real time market price information in nearly every region of the U.S., advanced storage strategies based on wholesale Locational Marginal Price (LMP) have been implemented. When utilities control the water heater so that it is allowed to charge only when the LMP is low, the water heater will operate at a lower cost than if the unit is operated without regard to the time of day or price signals. Through grid-interaction, a decision can be made by the utility to charge the unit if the price falls below certain levels and prohibit the charging of the unit if the price exceeds certain levels. A large-volume electric resistance water heater with integrated controls can be used to implement this strategy. With sufficient storage capacity and fast enough heating capability, the charge level can be determined such that it avoids the problem of running out of hot water as a result of the control strategy and does not inconvenience the consumer.

For example, EPRI recently compared wholesale energy cost savings and ancillary services revenue of a large-volume electric resistance water heater controlled based on wholesale price information (Locational Marginal Price, or LMP), controlled for the ancillary service 'Regulation', and uncontrolled. Lab results in the table below indicate significant cost savings from advanced water heater control strategies over non-controlled devices.[12] EPRI found that operating a large-volume water heater based on wholesale price information yielded a 21.5% energy cost savings when compared to the same uncontrolled water heater. When a water heater was controlled based on price information and to provide frequency regulation services, the water heater was 55% less cost to operate than the uncontrolled water heater.

[12] "Peak Load Shifting by Thermal Energy Storage: Assessment of Smart Electric Water Heater." EPRI, Palo Alto, CA: 2011, Report No. 1021965.

Smart Electric Water Heater Operating Cost Summary (based on wholesale prices)

Type of Water Heater	**Energy Cost ($/Year)**		
	Uncontrolled	**Optimizing LMP**	**Regulation**
Regular Water Heater (Uncontrolled)*	$111.40	$100	$175
Smart Electric Water Heater		$78.50 (21.50% reduction)	$145.9 - $67.50 payout (55% reduction)

*The cost of operation of regular water heater varies with the different strategies due to which days were used in calculations and which sources of wholesale pricing data were used (MISO/PJM). Please refer to EPRI report No. 1021965, referenced above, for specific calculations.

c. Use of Electric Water Heaters to Provide Critical Ancillary Services

A third control strategy being piloted in select areas around the country involves the utilization of large-volume electric resistance storage water heaters as a tool for regulating frequency and otherwise ensuring the reliability of the grid through cycling of the water heater in response to short-term grid signals. This use of water heaters is being demonstrated in PJM and in other markets.

The quick response features of being able to cycle certain appliances such as electric water heaters without adversely impacting the customer's hot water needs is being seen as increasingly critical to cost-effectively maintaining grid reliability while at the same time accommodating renewable integration and reducing dependence on fossil fuels. It is widely accepted that the need for short-term balancing resources (second-by-second or minute-by-minute) increases with wind energy penetration levels.[13] New technologies (flywheels and advanced batteries) and new control strategies for common technologies (water heaters, pumps, motors) have proven capable, and in some cases superior, in providing this fast-response

[13] Eto, J.H. et al. Use of frequency response metrics to assess the planning and operating requirements for reliable integration of variable renewable generation. Lawrence Berkeley National Laboratory. LBNL-4142E, December 2010; "Eastern Wind Integration and Transmission Study". Enernex Corporation prepared for the National Renewable Energy Laboratory. February 2011; "Growing Wind: Final Report of the NYISO Wind Generation Study". New York Independent Systems Operator. September 2010.

balancing service when compared to most traditional generation. The FERC recently recognized the value of these fast-response devices in its Order 755, which mandates ISOs and RTOs to implement a 'pay-for-performance' mechanism in their frequency regulation markets. In Order 755, FERC stated: "the use of faster-ramping resources for frequency regulation has the potential to improve operational and economic efficiency and, in turn, lower costs to consumers in the organized markets."[14] This FERC mandate creates a new market opportunity for fast-response, highly controllable loads such as electric resistance water heaters.

Two of the nation's largest electric grid operators, PJM and Bonneville Power Administration (BPA), are actively involved in testing the ability of grid-interactive water heaters to provide frequency regulation and controllable ramping ability during periods of excess renewable energy generation, respectively.[15] In the case of PJM, nearly 2 years of operational experience using a water heater located in their office building to 'charge' during periods of low-cost wholesale power while simultaneously providing frequency regulation in response to a 4-second control signal has yielded extremely positive results. The water heater has been able to choose and heat water during the hours of lowest wholesale prices based on the day-ahead schedule. As a result it is able to respond as fast and as accurately, if not more so, than many other advanced storage technologies coming to market today, all while providing continuous hot water to the customer with no interruption.[16]

In the case of BPA, as part of a series of smart grid demonstration pilots, BPA and five partner utilities across the Pacific Northwest have deployed hundreds of grid-interactive water heaters in residences (some new, some retrofitted with controls) to test the aggregated bulk energy storage and balancing capabilities of large-volume devices. Today, BPA faces difficult wind integration scenarios in which they need resources to store energy quickly in response to wind energy ramping events, or face having to curtail wind generators or take other emergency

[14] "Frequency Regulation Compensation in the Organized Wholesale Power Markets". FERC Docket Nos. RM11-7-000 and AD10-11-000, Order No. 755, (October 20, 2011).

[15] Wald, M.L. "Taming Unruly Wind Power". New York Times. November 4, 2011.

[16] Information available at: http://www.pjm.com/~/media/about-pjm/exploring-tomorrows-grid/advance_tech-4pg_2.ashx

operating procedures. Wind generation in BPA has been installed at a rapid pace and the balancing authority can now foresee a future where the current installed wind capacity of 4,750 MW increases to a level close to their peak load, making flexible operating conditions and resources that much more important. These pilots are running for two years and were started in September 2010.[17] The data, results, benefits, and next steps that result from these pilots will continue to inform the industry of the value proposition of these advanced grid-interactive features of large-volume water heaters. Joint Commenters encourage the Department's review of these programs.

Section 2 – Response to Issue #2

Information on the effects of the amended energy conservation standards for electric storage water heaters with rated storage volumes above 55 gallons on utility programs designed to reduce peak energy demand by heating water only during off-peak times and storing the water for use during peak demand periods.

The amended energy conservation standard will adversely impact current load shifting programs and inadvertently suppress many of the developing energy storage features of grid controlled water heaters outlined above. In a nutshell, there are technological limitations on heat pump water heaters under the standard being able to meet any of the key grid-interactive features outlined above. These limitations include:

- Large volume electric resistance water heaters are able to store and maintain the temperature of water by heating water to above 130 degrees Fahrenheit during off-peak hours thus providing enough energy and volume to be able to carry the typical customer through the daytime hours without having to further operate during on-peak hours. Due to size and design limitations, the heat pump water heater defined under the Department's standard is not able to "super-heat" the

[17] Personal communication, Bonneville Power Administration, July 9, 2012.

water and avoid having to run during on-peak daytime hours in order to meet typical customer needs;

- Due to the relative lack of moving parts and the features of the electric coil, the electric resistance water heater is able to be cycled in response to grid conditions (such as peak shaving or for frequency control). By contrast, active cycling of the heat pump water heater in response to a grid signal would rapidly deteriorate the life of the unit; and

- Large volume electric water heaters, when coupled with the savings to the consumer through rebates or reduced rates from their local utility, are a viable economic choice. The monetization of the grid-interactive features through utility rebates or reduced rates becomes the key to making what otherwise would be an uneconomic choice under the proposed standard into an economic choice both for the individual user as well as all users of the grid.

In short, each of these programs (peak shaving, renewable integration or frequency response services) is reliant on tanks that are both grid-interactive and have enough volume along with electric resistive elements in order to continue to meet customer needs with minimal and controllable operation during on-peak hours. Unfortunately, absent a separate standard that recognizes these separate uses and benefits of grid-interactive electric water heaters, manufacturers will, after April 15, 2015, no longer produce the large-volume electric resistance storage water heater around which smart grid and energy storage control strategies have been developed or are now emerging. As innovation around demand response and smart grid connectivity continues to develop, the loss of customers and utilities to choose a large, highly controllable energy storage device for cost savings and efficiencies would be an extremely negative and counterproductive result. [18]

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[18] At a bare minimum, 109 rural electric cooperatives in 22 states across the country will be immediately impacted by these standards. In addition, approximately 40 public power utilities and an additional number of investor owned utilities will be directly impacted.

<u>Section 3 – Response to Issue #3</u>

Information on capacity or other performance-related feature(s) for residential water heaters which other water heaters do not have that are used in demand-response programs and whether such feature(s) justifies a separate standard from that which will apply to other electric water heaters with rated storage volumes above 55 gallons.

It is well known that heat pump water heaters provide great end point efficiency and recognizable energy savings benefits to consumers in the form of lower kilowatt hour usage, and thus lower energy bills. However, several characteristics of the heat pump water heater make them ineffective and impractical for meeting critical needs of utilities and incompatible with the notion of a "Smart Grid" – interconnected devices providing value to customers and to the electric system at large through controllability.

Here, we detail the characteristics of a heat pump water heater that preclude these devices from being used in various utility demand response programs, but specifically off-peak energy storage, renewable integration, and ancillary services.

Limitations to Achieving Grid-Interactive Benefits Using the Heat Pump Water Heater

a. Compressor Cycling

Heat pump water heater systems, like HVAC systems, are more efficient when run for extended 'on' cycles. Practically speaking, compressors and other moving parts of a heat pump water heater are designed with duty cycles consistent with longer run cycles. Attempting to "short cycle" the heat pump water heater circuit to take advantage of variable renewable energy production that often comes in shorter-term duration "events" would result in, at a minimum, dramatic reduction of life for these components and practically would result in loss of reliability due to short cycling of compressors. This precludes the heat pump water heater from being an option for utility peak-shaving, renewable integration and energy storage, and grid balancing programs, in which the water heater is controlled to stop or start operating at different times of the day and sometimes for multiple on/off cycles per day or per hour.

b. Heating Capacity

By design, heat pump water heaters recover slowly to ensure optimum efficiency through the heat pump circuit. When independent of grid-interactive control, this solution is appropriate as an option to improve water heater efficiency; however, it is not applicable for renewable integration and off-peak energy storage for two reasons: (1) the typical energy storage window of opportunity is during just a few hours at night. The recovery capability during this time would be insufficient to ensure that the service of providing hot water not be compromised during daytime use by the customer, unless the heat pump water heater was allowed to run during peak demand periods, defeating the purpose of peak load reduction; and (2) the ability to raise the temperature of the water beyond normal use is impractical since the compressor / refrigerant system has a practical limit of 130 degrees Fahrenheit.

c. Using the Electric Resistance Element in a hybrid heat pump water heater

Hybrid heat pump water heaters as designed (and in distribution in the US) leverage both heat pump and resistive heating elements concurrently. Hybrid heat pump water heaters gain their high Energy Factor (EF) ratings by operating nearly entirely as heat pump water heaters, with minimal or no supplemental electric resistance heating at the rating conditions. This high efficiency operation mode limits the maximum heat pump generated storage temperature to approximately 130°F. If the accompanying electric resistance elements were used to store at higher temperatures for the sake of energy storage and renewable integration, the effect is to decrease the use of the heat pump, thereby lowering aggregate efficiency. Though technology may develop to allow heat pumps to operate as grid interactive resources, they presently cannot effectively support the needs of utility energy storage programs.

Section 4 – Response to Issue #4

Information on potential solutions that would resolve the concerns of utilities that administer load shifting programs for residential water heaters that require the use of large-volume electric storage water heaters, including potential solutions identified in this RFI.

The Joint Commenters propose the following solution that will allow utility demand response programs using large-volume electric resistance water heaters to continue their success and expand within new smart grid control strategies for the benefit of the consumer and the electric system as a whole.

Creation of a new product class – "Grid-Interactive Storage Water Heaters"

Pursuant to 42 U.S.C. § 6295 (o)(2)(A) and the applicable regulations, the Secretary has the discretion and the authority to assign a new standard to cover the technological developments that have allowed for the development of a grid-interactive water heater. Specifically, Joint Commenters believe the record in this matter supports the Secretary determining that the grid connectivity feature of "Grid-Interactive Water Heaters" constitutes a new product class warranting a separate standard for the new product class as the product is clearly distinguishable from water heaters not directly interconnected and responsive to grid signals.[19] In this instance, "Grid-Interactive Water Heaters" provide uninterrupted hot water to consumers, large amounts of energy storage during times when there is an excess of unused, available renewable energy, the ability to reduce load on the grid to enhance reliability or reduce congestion on the transmission grid, and reliability services in the form of frequency regulation or other grid ancillary services.

The Joint Commenters propose that a "Grid-Interactive Water Heater" be defined as a product containing the following characteristics:

1) a storage tank greater than 55 gallons;

[19] The current standard for electric storage water heaters is an Energy Factor (EF) of 0.97 – (0.0132* Rated Storage Volume in Gallons). For an 80 gallon electric storage water heater, the current EF is 0.86. For a 120 gallon electric storage water heater, the current minimum EF is 0.81. Based on a review of electric storage water heaters in the AHRI directory, there are 80 gallon electric storage products that range in efficiency from 0.86 to 0.95 EF, and there are 120 gallon products that range in efficiency from 0.81 to 0.86 EF. To meet the Department's goals of cost-effective energy efficiency, the Joint Commenters would suggest a new energy efficiency standard for the new class of products of 0.99 – (0.0132 * Rated Storage Volume). This would correspond to a level of 0.88 EF for 80 gallon units and 0.83 for 120 gallon units.

2) a control device capable of receiving communication from a grid operator, electric utility, or other energy services company that provides real-time control of the heating element;

3) evidence that the appliance owner is enrolled in a grid operator, electric utility, or other energy services company program to provide demand response or related interactive electric grid services;

4) a thermostatic mixing valve if the water heater is capable of heating water greater than 120 degrees Fahrenheit

Joint Commenters Response to Department's List of Potential Alternative Solutions in RFI

The RFI seeks comment on a number of alternative solutions. The proffered alternatives are listed below along with Joint Commenters' response to each of these alternatives.

RFI Alternative: A waiver system that would allow manufacturers to produce small quantities of electric resistance models at storage volumes above 55 gallons and sell them directly to utilities that operate such programs

In the RFI, the Department proposes that a waiver be allowed under the condition that water heater manufacturers sell grid-interactive electric resistance storage water heaters above 55 gallons only to utilities. While the Joint Commenters agree that this appears to address the concerns herein, legal restrictions would prevent the utility from directly purchasing these water heaters and selling them to customers. In the 1950s and 1960s utilities were active in the sale of appliances to customers. A host of regulatory proceedings at the state level, concerned with issues such as cross-subsidization of competitive activities with monies from captive ratepayers, led to utilities being required under state regulation to terminate such programs. As a result, in most states, utilities generally perform service or install products only on the utility side of the meter, leaving to licensed electricians and plumbers to install electric devices and even circuitry that meets code standards. In short, were the Department to appear to be reinstating utility appliance programs, it would be running afoul of years of state regulations and even legislation. Merely the litigation that would ensue and the balkanization of the market that would occur as these issues are fought in each state would render any reforms largely illusory. The Department should not countenance a solution that drives up consumer costs and increases complexity and space problems for the consumer.

RFI Alternative: using multiple smaller water heaters in place of a single large water heater to satisfy the needs of consumers who participate in these programs

This option may well be utilized by customers NOT enrolled in a utility load control program opting for more hot water capacity at a lower cost when compared to a heat pump water heater. For utility load control programs, a dual-tank system would be a sub-optimal option. This option exists, but at a higher cost (two tanks, increased labor), increased complexity (communications to two devices, increased space needed, increased maintenance), and less efficiency (greater losses with two devices as opposed to one, super-insulated device). Moreover, this alternative ignores the practical space limitations associated with fitting in two water heaters in a residential space designed for one such appliance. Moreover, this option does not take into account the practical economics to the consumer who would be forced to buy two appliances to meet his or her needs. In addition, two units would potentially cause higher energy consumption on the grid as the efficiencies of scale associated with larger volume single tanks would be lost, thus leading to an overall more inefficient means to heat water in the customer's home.

RFI Alternative: using large-storage-volume heat pump water heaters to satisfy the needs of consumers who participate in these programs.

As the Joint Commenters note in response to Issue #3 above, the heat pump water heater as defined by the current DOE efficiency standard in unable to provide energy storage, renewable integration, and ancillary services benefits because of the technical limitations associated with heat pump compressor operations. Only a hybrid heat pump water heater with a large enough resistive element would be capable of providing these same services, as the electric resistance element would be capable of heating water faster and to a higher temperature as well as endure frequent on/off cycling under control by the utility without affecting its life span. If the electric resistance element is engaged for utility load control purposes, the heat pump water heater would no longer meet the TSL 5 efficiency rating. At that point, the heat pump water heater effectively becomes an extremely expensive TSL 4 product, not cost-effective enough to warrant utility investment in these programs and customers savings on their energy bills.

Conclusion

The Joint Commenters greatly appreciate the Department's review of our comments and the Department's consideration of the impact the existing efficiency standards will have on utility peak shaving and peak reduction (off-peak energy storage) programs, renewable energy integration, and the enabling of highly flexible and controllable residential loads that communicate with the electric system (the 'smart grid'). Accordingly, Joint Commenters urge the Department to create a new product class and energy efficiency standard as soon as possible to facilitate the continued use of grid-interactive large-volume electric resistance water heaters to provide important, cost-effective demand response functions.

The Joint Commenters are prepared to meet with the Department and other stakeholders to ensure that this issue can be addressed in a timely and effective manner.

Respectfully submitted,

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ATTACHMENT A

Incorporating Advanced Uses of Technology in the DOE Electric Water Heater Standard: A Proposal to Recognize Grid Services.

This paper addresses the need to reflect in Department of Energy (DOE) efficiency standards the distinctive values and services that large grid-interactive residential water heaters can provide the electric grid. These distinctions in design and capability distinguish such grid-interactive water heaters from the electric storage water heaters for which DOE recently adopted new efficiency standards. Specifically, grid-interaction enables these technologies to serve as energy storage resources that can offer utilities and other grid operators new tools for enhancing reliability, relieving congestion, and storing intermittent renewable resources. This paper sets forth a specific proposal to adopt standards to be applied to a new classification of "Grid-Interactive Storage Water Heaters", standards that would complement, rather than supplant, the existing standard for electric storage water heaters. The paper will: a. describe the technological distinctions between Grid-Interactive Storage Water Heaters and the electric storage water heaters for which DOE developed the original standard, b. outline the specific proposal for a new standard, and c. detail how this proposal is consistent with Congressional directives including those embodied in the Energy Policy Act of 1992 ("The Act")[1].

Technology Explanation:

Smart Grid technology provides the potential for electric water heaters to interact directly with the grid as an energy storage resource. For example, Rural Electric Cooperatives have a long history of using large grid-interactive electric resistance type water heaters to store energy and cut system demand. In a recent survey, 109 cooperatives in 22 states offer such programs using more than 150,000 large water heaters. This program is growing as 22 additional cooperatives in 7 other states are considering adopting this demand response tool. In total, the cooperatives were able to cut peak demand by 1663 MW. The survey also showed that 49 cooperatives store energy from wind and 52 store hydroelectric energy. A number of cooperatives are now working closely with the regional transmission organizations to use water heaters to help stabilize the grid as fast–acting, non- CO_2 emitting devices.

Newer technologies will provide a higher level of visibility, dependability, control, and accountability for grid services provided by electric storage water heaters. Because of new controller technology, electric storage water heaters may now be optimized to provide more value and benefit to the electric system.

For example, new controller devices are able to receive an Automatic Generation Control (AGC) signal from grid operators and provide frequency regulation services, i.e. the second by second balancing of load and generation that is essential for keeping the electric system operating at 60 Hertz. The water heater's performance is able to be communicated back to grid operators in real-time and verified by certified electric meters in the control device. This new visibility and accountability at the device level was not widely deployed at the time DOE promulgated its efficiency standards. In practice, PJM Interconnection and electric utilities (including rural

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[1] Pub L. No. 102-486 (Oct. 24, 1992) 106 Stat. 2776

cooperatives as noted above) have demonstrated the ability of Grid-Interactive Storage Water Heaters to respond to real-time electric system conditions in order to provide reliability services in the form of frequency regulation. The result is a more reliable electric system and demonstrable value for the customer.

In addition to providing frequency regulation, some Grid-Interactive Storage Water Heaters are able to take advantage of dynamic pricing signals by receiving electricity price information and making decisions on when to heat water at the lowest possible cost based on these real time pricing signals. The control device is critical for this functionality because it is able to monitor the temperature in the tank and make the most economical decisions about how to keep the water hot at the lowest possible price. In turn, this real time functionality benefits not only the owner of the water heater, but all rate payers as dynamic price signals incent the most cost-effective usage of electricity.

Finally, the deployment of Grid-Interactive Storage Water Heaters can play a vital role in the integration of increasing amounts of renewable energy into the nation's electric grid. In many places of the country, wind energy is wasted when, as a result of its being generated in off-peak hours, it cannot be effectively utilized by the grid operator. Unlike conventional generators which can store fuel and choose when to run, wind generators always operate when the wind blows because their fuel cannot be stored. To have to "spill" wind energy is to effectively throw away a low-cost, low-emission, renewable source of energy. Because wind energy can be forecasted and control devices can communicate with the electric system, grid-interactive storage water heaters can provide a load (heating water) during off-peak times of high wind generation output, thus absorbing the renewable energy produced. This functionality not only helps meet the policy objectives of many state Renewable Portfolio Standards, but also works to lower the wholesale cost of electricity and electric system emissions. Furthermore, studies by grid operators, academia, national labs, and independent industry consultants show that the need for Ancillary Services, particularly frequency regulation, will increase as renewable energy penetration increases[2] [3] [4]. Not only does the gross requirement amount increase, in terms of megawatts, but the speed at which resources can respond also becomes a critical aspect of controlling frequency when large amounts of renewable energy are on the system. PJM and others have verified that grid-interactive storage water heater can potentially respond to dispatch signals in less than a second (Figure 1), thereby providing superior performance over traditional sources of frequency control (that typically respond in seconds to minutes). In addition, frequency control with water heaters is provided free of emissions, further aiding the environmental improvements to the electric system which they stand to support.

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[2] Eto, J.H. et al. Use of frequency response metrics to assess the planning and operating requirements for reliable integration of variable renewable generation. Lawrence Berkeley National Laboratory. LBNL-4142E, December 2010; "Eastern Wind Integration and Transmission Study". Enernex Corporation prepared for the National Renewable Energy Laboratory. February 2011.

[3] "Growing Wind: Final Report of the NYISO Wind Generation Study". New York Independent Systems Operator. September 2010.

[4] "Eastern Wind Integration and Transmission Study". Enernex Corporation prepared for the National Renewable Energy Laboratory. February 2011.

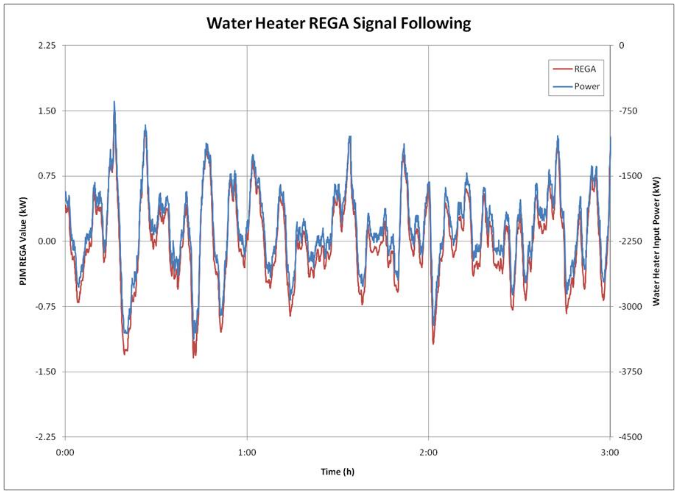

Figure 1.

Load-frequency control with a water heater. Here, the water heater adjusts the rate at which it heats water based on PJM's signal used to balance generation and load, responding in milliseconds. The red line is PJM's signal and the blue line is the response of the water heater. In most cases, the red line is not visible because the water heater is accurately following the signal. This level of performance is not typically seen with many of today's sources of frequency

The benefits of grid-interactive storage water heaters are recognized when the available energy storage capacity of the water heater is "right sized" to always ensure that adequate hot water storage is available to meet demand while also allowing utilities or grid operators control and flexibility over when a water heater turns on. This enables the grid operator or utility to optimize the load, something that cannot be done with an electric storage water heater as defined in the DOE efficiency standard because it lacks the additional storage capacity needed to make it useful to the electric system for storing renewables and providing Ancillary Services. For example, an uncontrolled water heater tends to have a peak load during the morning hours, when demand for hot water is greatest and wholesale electricity prices are increasing. If a grid-interactive water heater had greater storage capacity, it could store more energy at night (when prices are lower and wind blows strongly), still deliver adequate hot water during the high-demand morning period, and delay heating water or heat water at a controlled, slower rate, during hours when grid conditions are less favorable. Because average daily hot water usage is around 13 kWh worth, storage water heaters with smaller capacities do not have this much flexibility.

There are two ways to increase the storage capacity of a water heater: increase the temperature to which the water is heated, increase the size of the tank, or both. For example, a 55-gallon water heater under the existing standard that typically heats 55°F water to 120°F is able to 'super heat' water to 170°F, and increase its storage potential from 8.75 kWh to 15.5 kWh, or 77%[5]. However, this additional capacity still does not provide much flexibility in meeting the average demand for hot water (13 kWh). This is the reason a new standard is needed for grid-interactive storage water heaters that allows for a larger tank and more water to be 'super heated'.

[5] **Calculation, 55 Gallon tank heating water from 55° F to 120° / 170° F**
$BTU_{55/120}$ = 55 gal x 8.35 lb/gal x 65 degrees = 29,851 BTU / 3,412 BTU/kWh = 8.75 kWh
$BTU_{55/170}$ = 55 gal x 8.35 lb/gal x 115 degrees = 52,814 BTU/3,412 BTU/kWh = 15.5 kWh

Tank Size (gal.)	Storage Capacity (kWh)	
	120°F	170°F
55	8.7	15.5
80	12.7	22.5
105	16.7	29.6
120	19.1	33.8

Table 1.

Storage capacity of different tank sizes and maximum water temperature.

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Existing Standard Impediments:

In its Final Rule on April 16, 2010[6], the Department of Energy (DOE) issued an efficiency standard for electric storage water heaters that effectively precludes the manufacturing and installation of electric resistance water heaters greater than 55 gallons by instituting an efficiency factor (EF) of greater than 200%, which can only be achieved by heat pump water heaters[7]. This type of water heater does not possess the capability to act as a cost-effective storage mechanism for integrating large amounts of renewable generation into the electric system because it cannot provide the 'super heating' capabilities of electric resistance heating elements to increase the storage capacity of electric water heaters. Moreover, the refrigeration cycle of commercially available heat pump water heaters limits the maximum water temperature because efficiency and reliability of the compressor are significantly affected as water temperature is raised.

The Proposal:

The solution to this problem is not to change the existing standards used for electric storage water heaters per se but instead to adopt a new classification of electric storage water heaters, to take into account a new energy efficiency policy relevant specifically to this new product class. This "Grid-Interactive Storage Water Heater" would be defined as any electric storage water heater that possesses the following qualities:

1) a storage tank greater than 55 gallons;

2) a control device capable of receiving communication from a grid operator, electric utility, or other energy services company that provides real-time control of the heating element;

3) an agreement to be enrolled in a grid operator, electric utility, or other energy services company program to provide demand response or other electric grid services;

4) a thermostatic mixing valve if the water heater is capable of heating water greater than 120 degrees Fahrenheit

[6] Federal Register, April 16, 2010, Vol. 75, No. 73, pp. 20112-20236
[7] Ibid., pp. 20113, Table I.1

Legal Analysis:

As noted above, the creation of a new classification of “Grid Interactive Storage Water Heaters” will recognize the very goals that the efficiency standards are designed to meet. Moreover, the enabling legislation not only contemplates such new classifications but in fact sets forth clear direction from the Congress to the Secretary to create such new classifications in response to changing technology. Moreover, as explained below, existing DOE precedent also supports such action by the Secretary.

Under the Energy Policy Act of 1992 and the applicable regulations, the Secretary has the discretion and the authority to assign a new standard to a grid interactive water heater by determining either that:

1) The grid interactive features of the water heater warrant consideration of the water heater as a “multi-function” covered product and thus eligible for specific standards governing each such function. Specifically, section 6295(o)(5) of the Energy Conservation Standards provides that “[t]he Secretary may set more than 1 energy conservation standard for products that serve more than 1 major function by setting 1 energy conservation standard for each major function.”[8] In short, because a grid interactive water heater serves more than one function and the regulations allow the Secretary to set one energy conservation standard for each function, a new standard is warranted for this multi-function product.

-or-

2) The Secretary could recognize that the grid interactive feature of “Grid Interactive Water heaters” constitutes a new product class warranting a separate standard for a new product class as the product is clearly distinguishable from water heaters not directly interconnected and responsive to grid signals.[9] As noted in the Final Rule amending the existing energy conservation standards for water heaters, the DOE established a separate product class for lowboy and tabletop water heaters due to strict size limitations for such products.[10] In this instance, “the grid interactive water heater not only provides uninterrupted hot water to consumers, it also provides storage for large quantities of energy during times when there is an excess of unused, available renewable energy, the ability to reduce load on the grid to enhance reliability or reduce congestion on the transmission grid, and in some instances reliability services in the form of frequency regulation. The grid interactive water heater can utilize and integrate renewable energy and support grid optimization strategies by utilities and consumers.

Because of the existence of two clear paths pursuant to sections 6295 (o)(2)(A) and (o)(5) of the Energy Policy Act of 1992 for recognizing those additional services that transform the nature and use of the product, the “no backsliding” provision set forth in Section 42 USC 6295(o), which prohibits the Secretary from prescribing an “amended” standard which increases the maximum

[8] 42 USC § 6295 (o)(5)

[9] 42 USC § 6295 (o)(2)(A).

[10] *See* 66 F.R. 4477 – 4478 (Jan. 17, 2001.

allowable energy use is not a bar to the Secretary using his discretion to assign a “new” standard to a grid interactive water heater. In fact, as shown above, the Act provides for the Secretary to exercise his discretion, (either because a product may provide for more than one conservation standard (42 USC § 6295 (o)(5) or is distinguishable from other products in a class (42 USC § 6295(o)(2)(A)), in order to consider new technologies that provide greater or different efficiencies.

There is ample precedent for the Secretary exercising his authority under the Act. For example, during the hearing and in the comments stemming from the notice of rulemaking issued by the DOE, the DOE (at the request of the Gas Suppliers Manufacturing Association) established a separate product class for tabletop water heaters, with no change to existing standards. The Secretary took this action to recognize that “tabletop water heaters” represented an entirely different product than those products otherwise covered in the standard. See Final Rule, 66 FR 4474 at 4477- 78 (Jan. 17, 2001). Just as new classifications should be created to reflect design characteristics (as in the case of table top devices) so too should new classifications of products be considered to address the significant technological advances and benefits to be realized from Grid-Interactive Storage Water Heaters.

Conclusion and Request for Action:

The DOE should promptly commence a rulemaking to create a new product class of “Grid-Interactive Storage Water Heaters” and thus a new energy efficiency standard and testing procedure for electric storage water heaters that fit within this new class, as defined above. Development of this new standard ensure that the Secretary’s Energy Efficiency Standards should and embrace, rather than retard, the development of such innovative uses of technology. Either recognition of the multi-functional nature of Grid-Interactive Storage Water Heaters pursuant to 42 USC Sec 6295(o)(5) or the development of a new classification within the covered product class pursuant to 42 USC Sec. 6295(o)(1) would serve to effectuate this important goal. As such, the initiation of a rulemaking will allow the true potential of grid-interactive electric water heaters as energy storage devices to be realized.

For more information or to discuss this proposal further, please contact:

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ATTACHMENT B

MEMORANDUM

Date: April 16, 2012

To: Kathleen Hogan, DOE Office of General Council

Subject: *Natural Resources Defense Council v. Abraham*

Question Presented

This memo will address the relationship between the 2d Circuit's decision in *National Resources Defense Council v. Abraham*[1] and the question whether the Secretary ("Secretary") of the Department of Energy ("DOE") can create a new product class of "Grid-Interactive Storage Water Heaters," pursuant to sections 325(o)(2)(A) and 6295 (o)(5) of the Energy Policy Act of 1992.

Brief Answer

Based on the following legal analysis, under the proposal to create a separate class of electric storage water heaters presented by the consortium of electric grid system operators, cooperatives, municipals, and suppliers, DOE would not be amending downward efficiency standards for home water heaters as prohibited by section 325 of the Energy Policy Conservation Act ("EPCA") but, rather, would be prescribing an energy conservation standard for a new covered product as permitted under section 325 (o)(2)(A). As *NRDC v. Abraham* only addressed whether the Secretary can amend promulgated standards before they are effective, it did not limit the Secretary's authority to prescribe efficiency standards for a new covered product such as "Grid-Interactive Storage Water Heaters." This right of the Secretary was expressly authorized by Congress in Sections 325 (o)(2)(A) and 6295 (o)(5)of EPACT 1992.

Discussion

The DOE has questioned whether this proposal contravenes the "no backsliding" provision as addresses in the 2d Circuit decision of *NRDC v. Abraham*.

Section 325(o)(1) of the EPCA, codified at 42 U.S.C. § 6295(o)(1), provides that:

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[1] *NRDC v. Abramson*, 355 F.3d 179 (2d Cir. 2003).

The Secretary may not prescribe any amended standard which increases the maximum allowable energy use, or, in the case of showerheads, faucets, water closets, or urinals, water use, or decreases the minimum required energy efficiency, of a covered product.

The EPCA established strict timelines under which the Secretary of the DOE was to develop test procedures for covered appliances. *See* EPCA §§ 323l-35, 1975 U.S.C.C.A.N. (89 Stat.) at 919-26. The covered products were specifically enumerated in the Act and included water heaters. Three years later, Congress completely overhauled the national energy policy, including amending the EPCA's appliance energy efficiency program, requiring the DOE to establish mandatory efficiency standards for covered home appliances that would achieve the maximum improvement in energy efficiency that was technologically feasible and economically justified. *See* NECPA, Pub. L. 95-619, sec. 422, §325(a) & (c), 1978 U.S.C.C.A.N. (92 Stat.) at 3259. The NECPA directed the DOE to give priority to nine of the thirteen covered products specifically enumerated in the original EPCA.

Ten years after passage of the EPCA, Congress passed legislation known as the National Appliance Energy Conservation Act ("NAECA"). The NAECA set specific efficiency standards and testing methods for the covered products and required the DOE to undertake a rulemaking to decide whether to amend the standards and mandated that any amended standards must be designed to achieve the maximum improvement in energy efficiency which the Secretary determined is technologically feasible and economically justified. *See* NAECA, sec. 5, § 325(1)(2)(A), 1987 U.S.C.C.A.N. (101 Stat.) at 114. The NAECA also added a new provision to section 325, which provided that the DOE could not amend the standards so as to weaken efficiency requirements. *See* NAECA sec. 5, § 325(1)(1), 1987 U.S.C.C.A.N. (101 Stat.) at 114. This is the EPCA "anti-backsliding" mechanism, which allows for efficiency standards for consumer appliances to be amended in one direction, only, *i.e.*, to make them more stringent.

In *NRDC v. Abraham*, the 2d Circuit court was presented with, among other things, the question of whether the DOE acted contrary to the standards for central air conditioners and heat pumps as dictated under the EPCA by withdrawing the original standards and replacing them with less stringent standards in violation of the no backsliding provisions. The 2d Circuit found that based on a reading of section 325, "once DOE [ ] complied with section 325's requirement that it prescribe final rules amending home appliance efficiency standards by publishing them in the Federal Register, section (o)(1) operates to restrict DOE's discretionary ability to amend standards downward thereafter." *See NRDC v. Abraham* at 15. According to the Opinion's recitation of facts, DOE did not deny that it had proposed to amend the minimum required energy efficiency for central air conditioners and heat pumps but rather defended its interpretation of section 325(o)(1) on the basis that it had proposed amendments prior to the rules being final. The 2d Circuit disagreed with DOE's interpretation and held that section 325(o)(1) was operative upon publication of the efficiency standards in the Federal Register. *See NRDC v. Abraham* at 16. DOE also claimed that it had "inherent power" to reconsider final rules. The 2d Circuit found that the DOE's interpretation was not supported by the EPCA or any other statutory provision.

If the DOE were to conclude that Grid-Interactive Storage Water Heaters were not a new covered product, then the anti-backsliding provision would apply and the DOE would be prohibited from amending downward efficiency standards for home water heaters. However, we are not proposing to amend a covered product. Instead, we are proposing to include a new product class warranting a separate standard for a new product class not contemplated under the Act. Grid-Interactive Storage Water Heaters were not considered at the time the DOE amended the standards reviewed by the court under *NRDC v. Abraham*.

Section 325(o)(2)(A) of the EPCA, codified at 42 U.S.C. § 6295(o)(2)(A), contemplates a process for the Secretary to propose a new standard for a new product class. As noted in the Final Rule amending the existing energy conservation standards for water heaters, the DOE established a separate product class for lowboy and tabletop water heaters due to strict size limitations for such products. *See* 66 F.R. 4477-4478 (Jan. 17, 2001). Proposing a separate product class for Grid-Interactive Storage Water Heaters would be appropriate as it not only provides uninterrupted hot water to consumers, it also has the ability to provide storage for large quantities of energy during times when there is an excess of unused, available renewable energy on the grid.

Since the Secretary would be prescribing an energy conservation standard for a new covered product as permitted under section 325 (o)(2)(A) and *NRDC v. Abraham* did not address the Secretary's authority to prescribe efficiency standards for a new covered product such as "Grid-Interactive Storage Water Heaters," the decision is inapplicable to this proposal. Rather, Sections 325 (o)(2)(A) and 6295 (o)(5) provide express Congressional authorization for the request presented by PJM, NRECA, APPA and others.

ATTACHMENT C

Respondents

This response to the U.S. Department of Energy's (DOE) request for information was prepared on behalf the following parties:

- National Rural Electric Cooperative Association (NRECA)
- PJM Interconnection
- American Public Power Association (APPA)
- Steffes Corporation

Preface

The final rule issued by the DOE adopting amended energy conservation standards for residential water heaters, direct heating equipment, and pool heaters (collectively, the "three heating products") was published in the Federal Register on April 16, 2010. The final rule separated residential water heaters by "product class" into the following categories: gas-fired storage, electric storage, oil-fired storage, and gas-fired instantaneous. DOE typically categorizes products by the type of energy used or by capacity or performance-related feature that justifies a different standard for products having such feature, considering such factors as the utility of the feature to users (42 U.S.C. 6295(q)). The key features affecting the energy efficiency of water heaters on which DOE focused were the type of energy used and the volume of the storage tank. With respect to the latter of those two features, DOE's final rule added a new Trial Standard Level (TSL) 5 energy efficiency requirement that effectively mandates all large-volume (above 55 gallons) electric storage water heaters use heat pump technology, while allowing small-volume electric storage water heaters to use electric resistance technology to achieve a required efficiency level of TSL 4. Although TSL 5 has been added to promote the penetration of advanced technologies and additional energy savings in the electric and gas-fired storage water heater markets, *the elimination of all future large-volume electric storage resistance water heaters will adversely impact the expansion of many utilities' demand response and energy storage programs*. As detailed below, throughout the Nation demand response and energy storage programs involving control of electric water heaters provide meaningful benefits to consumers, utilities, and society. In those programs, large-volume electric resistance water heaters often play a significant role which, for reasons later described, cannot always be filled as well by heat pump water heaters. Moreover, TSL 4 large-volume electric storage resistance water heaters are effective and economical when they are used in conjunction with the evolving "advanced technologies" of the smart grid for applications such as renewable energy integration, ancillary services and regulation services. When large-volume electric storage resistance water heaters can be controlled to provide value to the consumer and the electric grid (hereinafter referred to as "grid-interactive water heaters"), they possess a "performance-related feature" that establishes a new product class and justifies a different energy conservation standard, specifically TSL 4 in lieu of TSL 5.

Executive Summary

The Energy Policy Act of 1992 and applicable regulations grant the Secretary of the DOE the authority to assign a different energy efficiency standard to grid-interactive water heaters by determining that such water heaters possess features that distinguish them from other products in a class[1]. In making that determination, the Secretary shall consider factors, such as the utility to the consumer of such features, and such other factors as the Secretary deems appropriate. As explained herein, the multi-function, performance-related features of grid-interactive water

1 Refer to "Legal Analysis" section of the "Incorporating Advanced Uses of Technology in the DOE Electric Water Heater Standard: A Proposal to Recognize Grid Services" paper previously submitted to DOE.

heaters set them apart from other products (i.e., large-volume heat pump water heaters) and provide utility to the consumer, the electric grid, and the Nation in a number of beneficial, cost effective ways, and thus justify the establishment of a separate product class with a TSL 4 energy conservation standard.

Grid-interactive water heaters meeting the TSL 4 standard provide many meaningful benefits to consumers, including rebates to offset the initial cost of the water heater, discounted bills, off-peak pricing, free water heater maintenance, and lower overall rates due to the utility's reduced costs. The value of such benefits to participating consumers may total approximately $58 per year, as further explained in the section below titled "Responses to DOE's Request for Information."

Grid-interactive water heaters meeting the TSL 4 standard provide substantial benefits to utilities, including reduced wholesale demand charges, reduced costs of operating less efficient peaking generators, less exposure to wholesale spot market prices, reduced capacity obligations (regulatory and/or market), emergency load control system regulation, storage of energy generated by renewable resources during off-peak periods, lower transmission system congestion, and improved distribution system operations (e.g., soft system restoration). Some of these values are readily estimated, and are shown in the attached Tables, while other system benefits have dollar values that are less apparent.

Grid-interactive water heaters meeting the TSL 4 standard provide societal benefits as well. They enable greater penetration and utilization of renewable energy assets, facilitate more efficient operation of existing base load generating plants, and delay construction of new generating plants, all of which mitigate environmental impacts by lowering carbon emissions from fossil-fuel resources.

Most of the above-listed benefits for grid-interactive water heaters meeting the TSL 4 standard are the result of an important performance-related feature, which is their ability to provide cost effective energy storage in the form of hot water. The need for grid-scale energy storage has become an increasingly critical part of realizing the smart grid's full potential. In order to make the best use of grid-interactive water heaters to help meet that need, such water heaters should have a large-volume capacity and utilize resistance heat.

The grid-interactive water heater's performance-related features enable both peak load reduction and energy storage programs, as well as additional benefits of smart grid optimization, and integration of renewable resources, thus promoting the energy policies set forth in the Energy Policy Act of 2005 and the Energy Independence and Security Act of 2007, thereby furthering the goals of both the U.S. Congress and the DOE. The grid-interactive water heater capabilities and features should be included in the "other factors" that the Secretary deems appropriate in justifying the creation of a separate product class for those water heaters.

Therefore, to sustain the proven widespread and energy efficient utilization of grid-interactive water heaters for utility demand response and energy storage programs, and to provide utilities with the opportunity also to utilize those water heaters to effectuate additional benefits via interaction with the smart grid, it is respectively requested that the DOE consider opening a rulemaking to determine the appropriateness of establishing separate product class with a TSL 4 energy efficiency requirement for large-volume electric resistance storage water heaters that are specifically used in conjunction with utility demand response, energy storage, or smart grid programs.

<u>Responses to DOE's Request for Information</u>

The responses below are provided to the initial questions posed by DOE regarding the establishment of a separate product class consisting of large-volume electric resistance water heaters used for utility demand response, energy storage, or smart grid applications. In practice, the initial costs of the water heater and controls as well as the operating costs and benefits of control vary by region and the individual utility. It should be noted that the cost estimates discussed below are based upon DOE analysis developed in support of the final rule as well as other available information related to operations costs, as well as the installation and maintenance costs of water heating control devices. The benefits described in the responses, including customer incentives, are representative of the available data related to the actual benefits of the water heating applications.

The attached Table 1 and Table 2 have been developed to demonstrate and compare the costs of the proposed product, represented by an 80 gallon grid-interactive electric resistance water heater, to three other alternatives: (1) a 50 gallon non-controllable electric resistance water heater meeting the TSL 4 requirement (Table 1); (2) an 80 gallon non-controllable electric resistance water heater meeting the TSL 4 requirement (Table 2); and (3) an 80 gallon non-controllable heat pump water heater meeting the TSL 5 efficiency requirement. Tables 1 and 2 are constructed in the same manner; the difference being the volume of the uncontrolled electric resistance water heater, shown in columns "b" and "c". Due to the similarities and for ease of review, the below discussion responding to the initial questions raised by DOE does not always refer to both tables. Both tables contain a range of values for the proposed product. The "Low" end of the range represents the costs associated with an electric resistance water heater that has load control and energy storage capabilities, while the "High" end of the range represents the costs to provide these capabilities as well as those necessary to achieve additional benefits such as renewable energy integration, ancillary services and regulation services.

(1) What is the incremental cost (delta) of the proposed product relative to the same without the control technology?

The proposed product could vary in size and control technology. Typically, the customer is responsible for the purchase and installation cost of the water heater, but such cost may be off-set in part by a utility rebate. The cost of the control technology is typically borne by the utility, with no direct charge to the participant. The costs described below reflect the total cost of the product, regardless of whether it is borne by the customer or the utility.

As shown in the attached Table 1, Row 3, the total installed cost of the proposed product (80 gallon grid-interactive electric resistance water heater) is $1,663, compared to $925 for a 50 gallon TSL 4 water heater without the control technology, yielding an incremental cost of $738.

However, another relevant comparison in Table 1 is the cost of the proposed product versus a non-controllable 80 gallon electric heat pump water heater, which costs an estimated $1,975. That electric heat pump water heater has an incremental cost of $312 over the cost of the proposed grid-interactive water heater product.

The above incremental cost analysis includes recognition of several performance-related features of grid-interactive water heaters compared to water heaters without such control technology, which is appropriate because both the capacity and type of electric water heater specifically used for demand response, energy storage and smart grid programs are important. In that role, large-volume water heaters are preferential relative to small-volume water heaters and electric resistance water heaters hold significant advantages over heat pump water heaters for demand response and energy storage purposes.

First, with respect to capacity, there are a several reasons why large-volume water heaters are preferred over small-volume water heaters. The most apparent reason is that consumers will be much less likely to run out of hot water. That is true in terms of both the consumer's initial perception and the consumer's on-going satisfaction, each one being critical to achieving and maintaining higher consumer participation in demand response, energy storage, and smart grid programs. In addition, a larger capacity water heater enhances the flexibility and effectiveness of demand response programs, and increases the amount of energy storage available for a number of applications, including more renewable energy integration, which has related energy independence and environmental benefits.

Secondly, with respect to the type of water heater, though electric resistance water heaters and heat pump water heaters both provide hot water, they do so using very different technologies. As such, there are several attributes that distinguish one type of water heater from the other. For example, the heat pump water heater's method of heating water is certainly different than the electric resistance water heater and is in fact what drives the heat pump water heaters' lower energy consumption relative to electric resistance water heaters. Also, the heating capacity of the heat pump water heater is variable depending on the temperature of the air provided to the heat pump. Those differing characteristics mean the performance of the heat pump water heater, unlike the electric resistance water heater, varies depending on the season of the year, the customer's geographic location, and the location of the water heater. A recent analysis by the Steffes Corporation of the economic and environmental value of using grid-interactive electric water heaters to integrate renewable generation resources examined performance data for the eight DOE climate zones. The major finding regarding those climate zones is that, except for Zone 1 (representing a small fraction of the geographical area of North America), the grid-interactive electric resistance water heater performed better than the heat pump water heater in terms of providing lower overall wholesale power cost, utilizing a greater percentage of renewable power, and offering a greater amount of carbon reduction.

Another distinguishing heat pump water heater characteristic is that the unit cannot heat water above approximately 135 degrees Fahrenheit. This temperature limitation means that electric resistance water heaters have the ability to heat water to a much higher temperature. Thus, when used with a temperature mixing device, electric resistance water heaters have the ability to store greater amounts of energy.

A heat pump water heater must be installed in a space large enough to provide the necessary volume of air for the unit to adequately heat water. This distinguishing space requirement characteristic may impair the heat pump water heater's ability to replace electric resistance water heaters, particularly in apartments and condominiums, thus reducing the benefits from existing and future demand response, energy storage and smart grid programs that would have been realized if grid-interactive electric resistance water heaters were permitted. The larger size of the heat pump water heater also reduces the maximum capacity of the water tank that can be fit in many spaces, again reducing the storage capacity that can be used for demand response and wind integration purposes.

For these and other reasons presented throughout these comments, grid-interactive water heaters, characterized as large-volume electric resistance water heaters specifically used in conjunction with demand response, energy storage, or smart grid programs provide additional (and thus different) utility compared to large-volume heat pump water heaters, and have significantly different performance-related features that make them better suited for that purpose. They should thus be placed in a separate product class from heat pump water heaters.

(2) Is there any additional installation or maintenance cost as a result of the introduction of this type of control strategy?

Installation costs are included in the descriptions in item (1) above, and such costs as shown in Row 2 of both Tables are the same (approx. $531) for the water heater portion of the resistance water heater alternatives. Costs are increased to install the control unit by an estimated $80, for a total of $611, for either the radio-controlled or grid-interactive control units. The estimated installation cost for the electric heat pump water heater is $932, which is $321 higher than the 80 gallon electric resistance water heater with a control switch.

Maintenance costs have been included in the lifecycle operating cost portion of the analysis by using DOE estimates of Total Repair Cost as developed in support of the final rule. Such costs for the life of the units are $246 for an uncontrolled resistance unit and $554 for the heat pump water heater. The maintenance cost of the grid-interactive water heater is $780 which includes an estimated $3 monthly charge for the telemetry required to aggregate the combined load of the water heaters necessary for the utility to operate the grid-interactive water heaters collectively.

(3) What is the energy factor (EF) of the proposed product?

The energy factors for the proposed product will meet the requirements of TSL 4.

We are not aware of any evidence to demonstrate that there is any significant difference in the EF of the storage water heating units in the field as compared to the ratings as determined at the factory.

Also, it should be noted, that the distinguishing features of the grid-interactive water heater product increase the efficiency of the grid in many ways, from dispatching and ramping of fossil generators, to relieving transmission congestion, to distribution system operations.

(4) What is the energy price to the customer based on participation?

The reduction in the generation resources necessary to meet the peak demand requirements of those utilities with water heater direct load control (DLC) programs is considerable. One value stream to the participating customer originates from the significant portion of the cost savings achieved by the utility from a "traditional" DLC program that is focused on peak demand reduction. Utility cost savings under traditional programs primarily can include avoided generation and transmission capacity costs as well as lower energy costs. Utility cost savings such as avoided generation and transmission capacity costs, lower energy costs, and enhanced efficiency in generation dispatching and system operations are typically flowed through to participating customers via various forms and levels of incentives such as lower off-peak rates, bill credits, rebates, discounted rates, and/or free lifetime water heater maintenance. While the load reductions vary depending on the region of the country and local operational philosophies, a typical average peak demand reduction per unit is 1.1 kW during winter months and 0.7 kW during summer months. Based on a recent survey of its members conducted by the NRECA, the average annual cost savings for the customer per unit is $58, as shown in Row 8 of the attached Tables. Electric distribution cooperatives predominantly provide these annual savings to customers through monthly bill credits. In addition, customers are often eligible to receive an upfront rebate to off-set a portion of the purchase cost of an electric water heater when the customer agrees to participate in the DLC program. The average rebate among the survey respondents that also offered the bill credits is approximately $230. Over a ten-year period, the combination of the upfront rebate and annual bill credits can amount to $800 for the participating customer. Non-participating customers also receive benefits in the form of lower overall rates made possible by the utility's reduced costs.

The electric distribution cooperatives' DLC programs are often coordinated by their generation and transmission (G&T) cooperative power supplier. For example, East River Electric Power Cooperative (East River), with an annual peak demand of about 575 MW, serves 24 member distribution cooperatives and their customers in the states of South Dakota, North Dakota, Minnesota, Iowa and Nebraska. Approximately 75% of the residential customers on the East River system have electric water heating. Due to the successes of their long-standing program, East River operates an extensive DLC system that includes roughly 46,000 controlled residential water heater units, of which 70% are large-volume electric resistance water heaters. The program is currently focused on peak load reduction, but with the substantial penetration of controlled large capacity units, they also have important energy storage capabilities. East River has approximately 50 MW of peak water heater load control in the winter and 32 MW in the summer, which are significant amounts relative to the system annual peak. The water heater DLC program currently saves the G&T approximately $5.2 million annually in reduced demand charges from their supplier. Retail incentives are determined by each of the member distribution cooperatives, and participating customers can save up to $75 annually. It should be noted that in East River's service territory, the customers' water heaters are commonly located within the home's conditioned space. Thus, if the large-volume electric resistance water heaters were replaced with heat pump water heaters, the heat pump water heater's operation would increase the customer's space heating energy use during seven months of the year, including the months when the annual peak demands are established.

In a very different geographic region, Central Electric Power Cooperative, Inc. (Central) in South Carolina also coordinates a water heater DLC program for its member distribution cooperatives, with approximately 112,000 units controlled, and the vast majority of those having an 80 gallon capacity. The incentives to participating customers are typically a $350 rebate for units at a new residence or a $250 rebate for a conversion on an existing water heater, plus a five-year warranty on the water heater.

As they have done for these traditional demand response programs, we expect that utilities will continue to pass through to the customer a significant portion of the additional savings resulting from future smart-grid capabilities. Through the use of smart grid technology, water heating storage programs can provide the additional benefits to the utility of (1) responding dynamically to Locational Marginal Pricing (LMP), (2) providing fast-response regulation services, and (3) providing balancing services for valuable renewable energy resources. As required by FERC Order 745, a demand response resource participating in a Regional Transmission Organization (RTO) or

Independent System Operator (ISO) must be compensated for the service it provides to the market at 100% of the LMP.

The amount of demand response being offered into RTO/ISO markets continues to grow a rapid pace. PJM Interconnection, considered the largest wholesale demand response market, had 15,545 MW of DR offered into its most recent auction.

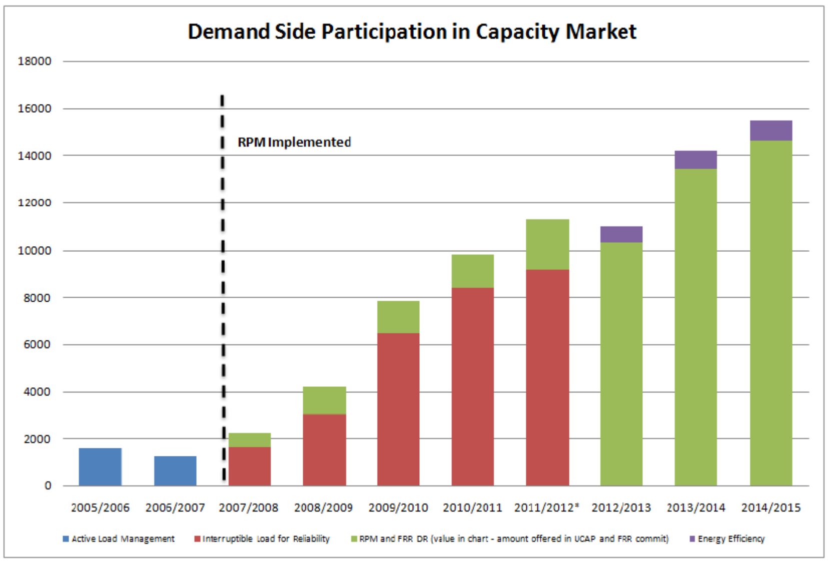

Figure 1. Values are in Megawatts (MW) per delivery year.

The value of a large capacity storage water heater is established in PJM's capacity market through the Reliability Pricing Model, which is a 3-year forward capacity market. As an example, if a large capacity water heater, with 0.7 kW load reduction capability, were to be enrolled in a demand response program that was bid into PJM's capacity market, its gross value would be directly tied to the market clearing price. In the most recent auction, the annual value of demand response per water heater ranged from $32 to $35 for the period June 2014 through May 2015.

In a demand response program that participates in the wholesale capacity market, this revenue is paid on the condition that water heaters are able to curtail during emergency events as dictated by the grid operator. This means it is possible for a water heater to be used both as a peak shaving device for the local utility, as described above, and as a capacity resource for the grid operator.

Future Utilization and Benefits

Utility demand response and energy storage programs have included both standard size and large-volume water heaters. For certain systems such as East River, as noted above, large-volume units have already become the focus of their program. To take advantage of the numerous opportunities described below, the utilization of large-volume units will be increasingly important in the future.

In the future, the just described benefits derived from utilizing large-volume electric resistance water heaters in conjunction with utility demand response and energy storage programs will not only continue, but increase as advanced technologies expand through smart grid investments, resulting in lower functional costs. For example, Automated Metering Infrastructure (AMI) will include the capability for communicating with and controlling of water heaters, precluding the need for an independent, dedicated DLC system investment. Furthermore, recent advances in technology offer important opportunities for large-volume electric resistance water heaters to become smart grid-interactive and will provide additional opportunities for benefits to customers, utilities and society. The “traditional” primary benefit of peak demand reduction provided by a DLC program can be significantly expanded into other areas. Through the use of smart grid technology, water heating storage programs can provide the additional benefits of responding dynamically to Locational Marginal Pricing (LMP), providing high-quality, fast-response frequency regulation services, and providing off-peak load during times of high wind energy generation, making it easier for grid operators to efficiently operate the system. A smart electric water heater has two-way communications between the utility and controls implemented at the water heater.

Besides the benefits provided by reducing electric loads during peak periods, charging water heaters during lower cost off-peak hours has also been a long-standing strategy of utilities. With the advent of hourly energy markets and the accessibility to the real time market price information, a more advanced storage strategy based on LMP's can be implemented. If the utility can control the water heater so that it is allowed to charge only when the LMP's are low, the water heater will operate at a lower cost than if the unit is operated simply in response to the homeowner's demands for hot water. With access to real-time LMP values, a decision can be made by the utility to charge the unit if the price falls below a certain level and prohibit the charging of the unit if the price exceeds a certain level. A large-volume electric resistance water heater with a smart-grid control unit can be used to implement this strategy. With sufficient storage capacity and high enough charging speed, the charge level can be determined to avoid the problem of running out of hot water due to the control strategies of optimizing LMP.

Water heating with smart-grid technology can also offer fast acting regulation service to provide effective frequency control. To provide the regulation service, the grid-interactive electric water heater can be set to draw power at a fraction of the rated power draw when the water heater elements are "on". This capability provides the system operator the ability to modulate up or down regulation. For example if one thousand smart electric water heaters with 4.5 kW elements are aggregated to a total of 4.5 MW, the charge rate can be modified to anywhere between 0 MW and 4.5 MW.

PJM Interconnection is pursuing such smart-grid technology aimed at enhancing PJM's ability to ensure the reliability of the grid and help the industry prepare for future technologies and opportunities. A 105-gallon electric water heater has been installed in PJM's Technology Center to provide hot water to the building. Simultaneously, the water heater responds instantly to changes in grid needs when its controller receives a pricing and regulation signal from PJM dispatch. The device began communicating with the grid and responding to the PJM frequency signal in December 2010.

Additional Smart Grid Benefits Example

As shown in the attached Table 1, the $1,663 "High" total installed cost of the proposed product with smart grid capabilities is greater than the $1,313 "Low" cost of a controlled unit by $350. Yet, the additional operational benefits of the grid-interactive water heater outweigh the higher incremental costs. While the incentive structures vary widely among utilities that offer DLC programs, the incentives are well established. Since it is standard practice for utilities to spread the costs of the DLC program across all customers (not just participants), the program benefits are also shared among all customers. Therefore, to estimate the total customer benefits associated with the grid-interactive water heater, we have projected the incremental benefits to the utility of the additional smart-grid capabilities. While the percentage of savings passed to the customer varies between utilities, for the purpose of this analysis, we have assumed that 50% of those benefits are directly passed through to the participating customer, while remaining benefits are passed through to participating and non-participating customers through lower rates. For not-for-profit utilities, all such cost savings must be passed through to the customers.

As shown in the attached Table 1, Row 8, the annual operating cost of a large volume energy storage water heater for the customer that participates in a DLC program is $471 compared to $529 for a 50 gallon unit - for the same operating conditions. The operating costs for the customer that participates in a DLC program are reduced by annual program incentives, an average reduction of $58, based on results of the recent NRECA survey. Many systems offer even greater savings to customers. Brown County REA, a distribution cooperative member of Great River Energy, offers its customers an bill credit of $90 each year and a $300 rebate when a large capacity water heater is purchased and when the customer agrees to participate in the cooperative's interruptible water heater program.

With the smart-grid control unit, additional cost reductions from LMP optimization and regulation services are shown to accrue on Rows 12 and 13. Using results of an analysis developed of the PJM system, additional savings estimated to be $74 and $94, for LMP optimization and regulation services, respectively, are provided to the participant for a total operational cost of $303 (Table 1, Row 15) and a savings per year of $226 to the participating customer. The operating cost for a large capacity heat pump electric water heater is $379, $76 higher than the smart-grid unit.

Row 16 in the Tables illustrates the 10-year net present value (NPV) of the operating costs for each of the alternatives. Both the "Low" and the "High" values of the proposed product have a lower NPV as compared to the 50 gallon uncontrollable unit in Table 1 and the 80 gallon uncontrollable unit in Table 2. The NPV of the "High" end of the range for the proposed product also shows savings as compared to the heat pump water, while the NPV of the "Low" end of the range has a slightly higher NPV.

(5) What is the percentage of households Nationally that participate in this scheme?

According to the 2011 Federal Energy Regulatory Commission's (FERC) "Assessment of Demand Response and Advanced Metering", DLC programs are the most commonly used type of incentive-based demand response program and are widely available nationally. Approximately 5.6 million customers were enrolled in DLC programs across the nation. For many years electric resistance water heaters, and in particular large-volume electric resistance water heaters, have been an integral part of utility demand response programs.

DLC programs are a critical resource for the electric utility industry in this country. The aforementioned FERC report states that the total potential peak reduction for all regions and customer classes is 53,062 MW. The report also notes that residential customers, including the control of water heating account for about 14 percent of total demand response resource potential nationally.

The FERC assessment shows that more than 4.2 million customers of investor-owned utilities are enrolled in DLC programs. Residential customers of those utilities, participating in various demand response programs, have an estimated peak load reduction capability in excess of 5,400 MW.

A recent survey of its members conducted by the National Rural Electric Cooperative Association (NRECA) revealed that 30% of the respondents currently offer a water heater DLC program. Another 10% are actively considering implementing a water heater DLC program. *Furthermore, those utilities with DLC programs are experiencing on average a 4% annual growth in large-volume electric water heaters, indicating that such water heaters are expected to continue to be a significant part of their ongoing DLC programs.*

Based on the recent NRECA survey, and limited to the 109 systems that provided load control amounts in response to the survey, the estimated peak load reduction capability for those systems is more than 500 MW during both summer and winter months. For many systems, large-volume water heaters comprise a significant portion of the controlled units, with East River being the best example, where 70% of all water heaters are large volume. Under DOE's final rule, the inability to replace these large-volume units at the end of their service life with another large volume unit with DLC will certainly result in a significant loss of load control and energy storage capability and increased costs for all customers of those systems.

The APPA also recently conducted a similar survey of its members regarding the importance of water heater programs for municipal power systems across the country. Approximately 45% of respondents indicated that they offer a water heater program, and 35% of the respondents that do not currently have a program are actively considering one.

(6) What is the impact of the proposed product on carbon emissions?

Grid-interactive water heaters bring conservation and efficiency to the electric grid. Many states have adopted Renewable Portfolio Standards (RPS) in an attempt to shift power generation away from fossil fuel generation sources. Most of this new generation will come from wind farms. While wind resources offer tremendous opportunities for production of renewable energy, their diurnal generation patterns create difficulties in predicting the amount of generation available at any given time, and the moment to moment fluctuations in output create unique operational issues for the utility. Wind generation is often most productive during low load periods; ramping up in the evening as load drops and then dropping off in the morning as load – including water-heater load – ramps up. These patterns often force system operators to curtail wind generation, to operate fossil generation at inefficient levels, and to ramp fossil generation in a manner that burns extra fuel and emits additional pollutants. The addition of energy storage to the system, through large capacity resistance water heaters can mitigate all of these adverse results, thereby allowing the integration of more wind, saving fuel, extending the life of fossil generation, reducing emissions, and reducing costs to consumers. Moreover, even during normal operations, when load or other generation resources cannot respond as quickly as the changes in the wind generation, significant amounts of this carbon free resource may be wasted. This variability must be carefully integrated with other generation sources to maintain grid stability. Grid-interactive water heater loads can adjust and change as fast as wind and other renewable generation change, allowing more renewable energy to be fully integrated into the grid, thereby reducing stress on fossil generation, reducing fuel use, emissions, and customer costs. This ability to track and use real time renewable generation and meet other critical needs of the grid can significantly reduce the water heating carbon footprint and lower the cost of operation.

Based on studies of the PJM system conducted by KEMA Inc. (KEMA Project BPCC.0003.001), it is estimated that energy storage devices that provide fast regulation service, such as grid-interactive water heaters, reduce carbon emissions by as much as 67% as compared to traditional methods of providing fast regulation with fossil fuel generation. Further reductions in carbon emissions are attained if the grid-interactive water heater is used for the storage of surplus wind and other renewable energy sources.

Using an assumed carbon cost of $20/ton, first effective in the year 2016, the ten-year

Net Present Value ("NPV") for the cost of carbon emissions for the uncontrolled electric resistance water heater is $171. The NPV of the carbon costs for the grid-interactive water heater is only $56, a reduction of $115, or 67%. The estimated ten-year Net Present Value ("NPV") for the carbon cost for the heat pump water heater is $123, which is $67 higher than the grid-interactive water heater.

(7) Is there any other pertinent information?

Wind Energy Integration Challenges

The potential value provided nationally by grid-interactive storage water heaters in integrating wind energy, the predominant renewable energy resource, cannot be overstated. PJM Interconnection projects that 14% of its energy will come from wind by 2026, representing close to 42,000 MW. Even with today's installed capacity of just 5,200 MW, market impacts are already apparent. Negative wholesale prices persist at night when PJM's load is lightest and its wind generation is producing at its greatest. Negative prices mean that PJM will pay loads to consume energy and that generators must pay to produce – an unsustainable situation that can only compound if solutions are not put in place to better match generation to load. Large energy storage grid-interactive water heaters appear to be a perfect, if partial, solution to this problem because water can be heated during nighttime hours, thereby aligning load, wind generation, and market price forecasts. The grid operator would benefit by potentially avoiding having to decide whether to dump significant quantities of wind or alternatively significantly ramp thermal generating units outside of their normal operating ranges. Dumping has already taken place in several regions even at low wind penetration levels. And significant, repeated ramping dramatically increases O&M costs and decreases long-term unit availability of major fossil-fueled base load generation. Studies have shown that for a typical 440 MW thermal plant, increased cycling increases annual O&M costs by $4-5 million per year. Utilities buying from the wholesale market would experience cost savings. Retail customers would certainly see cost savings on their bill. Wind integration is a challenge facing the industry nationwide, from PJM (Mid-Atlantic), to MISO (Mid-West), to ERCOT (Texas), to CA-ISO (California), to BPA (Pacific Northwest) – all looking for cost-effective energy storage solutions flexible enough to ease the accommodation of variable renewable energy resources.

Manufacturer Concerns

Water heater manufacturers are well aware of the DOE's amended energy conservation standards for residential water heaters and are now making plans to discontinue manufacturing of large volume electric resistance water heaters and beginning the process of either retooling, or in some cases shutting down assembly lines. If these manufacturers do not receive some indication or decision from the DOE within the next 12 months that establishes a new product class it may be too late and many utilities will lose one of their most critical residential demand response and energy storage programs.

Table 1

Water Heating Alternatives
Installed and Operating Cost Comparison

#	Description	Standard Volume WH		Large Volume Controllable Electric Resistance WH				Large Volume Heat Pump WH	
	Alternative	**TSL #4**		**TSL #4 - Proposed Product**				**TSL #5**	
		50 gallon WH, No load control		80 gallon WH				80 gallon Heat Pump WH, no load control	
			Incremental	Range of Costs		Range of Incremental Costs			Incremental
		Cost	Cost	Low (1)	High (2)	Low (1)	High (2)	Cost	Cost
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
1	Purchase Price	$394		$702	$1,052	$308	$658	$1,043	$649
2	Installation Cost	$531		$611	$611	$80	$80	$932	$401
3	Total Installed Cost	$925		$1,313	$1,663	$388	$738	$1,975	$1,050
4	Annual kWh	4,805		4,805	4,805			3,448	
5	Typical Rate ($/kWh)	$0.110		$0.098 (3)	$0.098 (3)	($0.012)	($0.012)	$0.110	$0.000
6	Installed Cost	$925		$1,313	$1,663	$388	$738	$1,975	$1,050
7	Less Rebate	$0		$230	$275	$230	$275	$100	$100
8	Yr. 1 Op. Cost	$529		$471	$471	($58)	($58)	$379	($149)
9	Net Yr. 1 Op. Cost	$1,454		$1,554	$1,859	$100	$405	$2,254	$801
10	10 Yr. Op. Cost and repair cost	$6,933		$6,531	$7,301	($401)	$369	$6,252	($681)
11	NPV Op. Cost	$5,213		$4,942	$5,489	($271)	$277	$4,873	($339)
	Savings From Add. Benefits (#12-#14)								
12	LMP Mgt				($74)				
13	Regulation Svc				($94)				
14	Yr. 1 Op. Cost	$0		$0	($168)			$0	
15	Net Yr. 1 Op. Cost	$529		$471	$303	($58)	($226)	$379	($149)
16	NPV Op. Cost	$5,213		$4,942	$4,154	($271)	($1,059)	$4,873	($339)

Notes:
1. Load control and energy storage capabilities
2. Load control and energy storage capabilities plus additional benefits
3. Typical reduced rate is shown, some discounts are more than $0.06/kWh

Table 2

Water Heating Alternatives
Installed and Operating Cost Comparison

#	Alternative	Large Volume WH w/no load control		Large Volume Controllable Electric Resistance WH				Large Volume Heat Pump WH	
		TSL #4		**TSL #4 - Proposed Product**				**TSL #5**	
#	Description	80 gallon WH, No load control		80 gallon WH				80 gallon Heat Pump WH, no load control	
			Incremental	Range of Costs		Range of Incremental Costs			Incremental
		Cost	Cost	Low (1)	High (2)	Low (1)	High (2)	Cost	Cost
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
1	Purchase Price	$552		$702	$1,052	$150	$500	$1,043	$491
2	Installation Cost	$531		$611	$611	$80	$80	$932	$401
3	Total Installed Cost	$1,083		$1,313	$1,663	$230	$580	$1,975	$892
4	Annual kWh	4,805		4,805	4,805			3,448	
5	Typical Rate ($/kWh)	$0.110		$0.098 (3)	$0.098 (3)	($0.012)	($0.012)	$0.110	$0.000
6	Installed Cost	$1,083		$1,313	$1,663	$230	$580	$1,975	$892
7	Less Rebate	$0		$230	$275	$230	$275	$100	$100
8	Yr. 1 Op. Cost	$529		$471	$471	($58)	($58)	$379	($149)
9	Net Yr. 1 Op. Cost	$1,612		$1,554	$1,859	($58)	$247	$2,254	$643
10	10 Yr. Op. Cost and repair cost	$7,091		$6,531	$7,301	($559)	$211	$6,252	($839)
11	NPV Op. Cost	$5,362		$4,942	$5,489	($420)	$128	$4,873	($488)
	Savings From Add. Benefits (#12-#14)								
12	LMP Mgt				($74)				
13	Regulation Svc				($94)				
14	Yr. 1 Op. Cost	$0		$0	($168)			$0	
15	Net Yr. 1 Op. Cost	$529		$471	$303	($58)	($226)	$379	($149)
16	NPV Op. Cost	$5,362		$4,942	$4,154	($420)	($1,208)	$4,873	($488)

Notes:
1. Load control and energy storage capabilities
2. Load control and energy storage capabilities plus additional benefits
3. Typical reduced rate is shown, some discounts are more than $0.06/kWh