ADVANCED THERMAL ENERGY STORAGE FOR DIRECT LOAD CONTROL - - - - - IN A LOW LOAD GROWTH -- HIGH DG FUTURE

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EXECUTIVE SUMMARY

After decades of high growth in electricity demand, during the past several years, growth has slowed sharply. This recent graph from the U.S. Energy Information Administration (EIA) illustrates that long term slowdown.

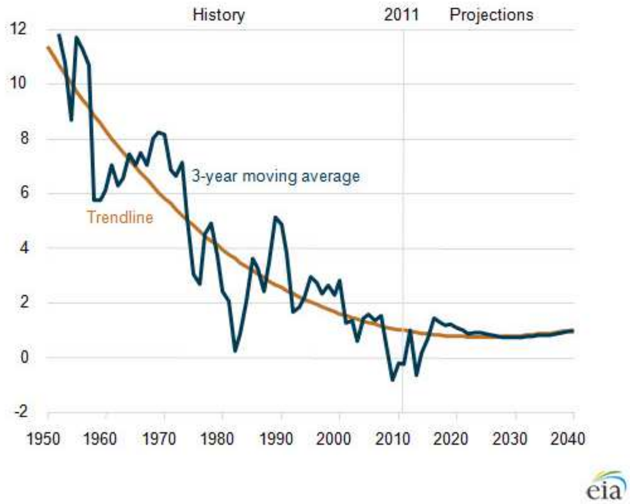

Figure 1 US Electricity Demand Growth, 1950-2040 (percent, 3-year moving average)[1]

Added to this persistent low growth environment, distributed electrical generation (usually in the form of solar or wind) may further retard future electrical demand.

Electric utilities have long used direct load control of water heaters, space heaters, and air conditioners to modify load or demand curves (to shave peak needs and fill in lower daily valleys in electrical demand).

A new technology called grid-interactive electric thermal storage (GETS) adds new benefits to those long standing utility control programs and can provide the leverage to deal with a slow / low / no / or negative electrical demand environment.

BACKGROUND - OUR ELECTRICAL GRID

Currently, electricity is produced to satisfy constantly changing levels of demand and produced - as needed - rather than stored. Utilities are constantly faced with a "balancing act" due to second-to-second fluctuation between generation supply and electrical demand.

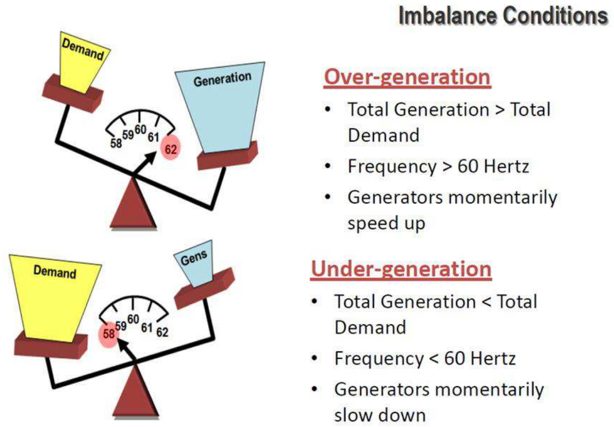

Figure 2 Grid Balancing – PJM Training Presentation[2]

The electric "grid" system is composed of four primary components: 1) large centralized power plants, 2) a backbone high voltage transmission network, 3) a "stepped down" sub-transmission leg, and 4) distribution – the final leg that delivers electricity to end users.

The 50+ year old U.S. electrical grid is governed by The Federal Energy Regulatory Commission, or FERC, an independent agency that regulates the interstate transmission of electricity, natural gas, and oil. When first appointed as a Commissioner in 2006, Outgoing FERC Chairman Jon Wellinghoff's priorities included opening wholesale electric markets to renewable resources and providing a platform for participation of demand response and other distributed resources in wholesale electric markets, including energy efficiency and local storage systems such as those in plug-in hybrid and all electric vehicles. In addition, he is focused on promoting greater efficiency in our nation's energy infrastructure through the institution of advanced technologies and system integration.[3]

Wellinghoff testified December 10, 2009, at a Senate Committee on Energy and Natural Resources hearing regarding integrating energy storage into the electricity grid. He spoke about "warehousing" electricity. Many now believe that "warehousing" or energy storage is the key to dispersing our highly concentrated electrical grid into a system of more distributed generation (DG).

DEFINING ENERGY STORAGE

In April of 2012, the California Public Utility Commission provided language to help define energy storage. CPUC Staff proposal references the statute creating the Storage OIR, Assembly Bill (AB) 2514 (Stats. 2010, ch. 469), which provides guidance on defining energy storage systems. The applicable language is quoted below (reformatted for clarity):

(1) "Energy storage system" means commercially available technology that is capable of absorbing energy, storing it for a period of time, and thereafter dispatching the energy.

(2) An "energy storage system" may have any of the following characteristics:
- (A) Be either centralized or distributed.
- (B) Be either owned by
  - a load-serving entity or local publicly owned electric utility,
  - a customer of a load-serving entity or local publicly owned electric utility, or
  - a third party,
  - or
  - is jointly owned by two or more of the above.

(3) An "energy storage system" shall be cost effective and either
- reduce emissions of greenhouse gases,
- reduce demand for peak electrical generation,
- defer or substitute for an investment in generation, transmission, or distribution assets, or
- improve the reliable operation of the electrical transmission or distribution grid.

(4) An "energy storage system" shall do one or more of the following:
- (A) Use mechanical, chemical, or thermal processes to store energy that was generated at one time for use at a later time.
- (B) Store thermal energy for direct use for heating or cooling at a later time in a manner that avoids the need to use electricity at that later time.
- (C) Use mechanical, chemical, or thermal processes to store energy generated from renewable resources for use at a later time.
- (D) Use mechanical, chemical, or thermal processes to store energy generated from mechanical processes that would otherwise be wasted for delivery at a later time.[4]

The U.S. Energy Storage Market has large potential. However, the market is still developing with technology and policy still evolving. The market needs to continue with initiatives to reduce costs and increase experience in order for growth to meet expectations. DNV KEMA consultants estimate that by 2017, the U.S. grid storage market could grow to between two to four gigawatts (GW), depending on the existence of financial incentives.[5]

FACTORS IMPACTING ELECTRICAL DEMAND

During the past several years, utilities faced four main and disruptive challenges:

- Slow / low / no / or actual negative growth in electricity demand
- Demand Response (DR)
  - o Highly successful, particularly in the PJM wholesale electricity market
  - o Although designed to alleviate peak, by doing so, it also reduces the electric utility's most valuable kilowatt hour (kWh) sales and strands those assets that ordinarily provide peaking power and energy
  - o The utility industry both supports and is forced to support DR which ironically results in less kWh revenues
- Renewable Energy (Re E) and the growth of decentralized – distributive generation (DG)
  - o Variable and unpredictable supply of wind and solar Re E generation is already disruptive despite <u>very minor</u> penetration and a small percentage share of the total generation mix
  - o Examples of double digit Re E penetration elsewhere (in the U.S. Texas market - ERCOT, Portugal, Spain, and Denmark) have resulted in sharply higher, unique, acute, and sometimes severe challenges for both utilities and grid operators
- Energy Efficiency (EE)
  - o EE is the #1 focus for the White House
    - ▪ EE is easily understood and will be aggressively implemented
    - ▪ EE has no or very low political barriers and carries strong and very wide support and policy consensus

Combined, these conditions present the potential for significant challenges to existing electrical energy demand.

EMERGENCE OF DISTRIBUTED GENERATION (DG)

DG or Distributed Generation can refer to all types of smaller decentralized power generation – but is now commonly used to describe distributed generation photovoltaic (DGPV) or (generally) rooftop solar.

In April of this year, in a presentation by Lawrence Berkeley National Lab, they posed a question "Is there an "existential threat" to the business model of regulated utilities?" They noted the fact that annual growth rate of PV in the U.S. exceeds 30%/yr since 2001. They cited a quote from Jim Rogers CEO of Duke Energy who told Bloomberg that utilities are aware that generating power at customer sites will disrupt their business.
"There's been a huge effort to build solar on the rooftop, both residential and commercial," Duke's Rogers said, as well as systems that generate power at industrial sites. "All of this is leading to a disintermediation of us from our customers." "If the cost of solar panels keeps coming down, installation costs come down and if they combine solar with battery technology and a power management system, then we have someone just using us for backup," he said. [6]

The electric industry is changing in accelerating and disruptive ways. Utilities are struggling in a low / no / or (most commonly) a negative demand environment. Sharply lower costs of distributed generation (DG), particularly photovoltaic (PV) and increasing customer, regulatory, and political interest in decentralized power production are combining to destabilize electric utilities who are aggressively looking for solutions – particularly solutions that bolster declining kilowatt hour (kWh) power sales.

THERMAL ENERGY STORAGE

Thermal energy storage or, Electric Thermal Storage (ETS) is sometimes referred to as Community Energy Storage (CES), Distributed Energy Resources (DER), and Grid-edge and / or behind the meter aggregated assets.

THERMAL SPACE AND WATER STORAGE

Depending upon both geography and power costs, space & water heating can combined account for up to 75% of the typical home's energy bill, with water heating alone averages approximately 18% (in a range of 15 – 30%). In all cases, utilities have long been faced with the challenge of cost effectively balancing electric generation with consumer demand. In order to address this, for decades many electric utilities have opted to manipulate load to flatten out their costs via direct load control (DLC) of electrical space heating, water heating, and air conditioning. A typical system sends a simple signal to turn devices on / off, but it has limited flexibility and no verification. Due to the opaqueness of that system, consumer comfort often suffers and for that reason utilities often "dial back" and reduce program hours to avoid losing customers.

In the case of water heaters, and regardless of geography, each North American home has one and nearly half of those are electric. A version of thermal space and water storage called the Grid-interactive Electric Thermal Storage (GETS) allows the water heater to go beyond common DLC peak load shift / valley fill and become a more flexible and valuable energy storage device for providing grid balancing services and renewable integration. The GETS smart control on each water heater continually reports its storage capacity, water tank temperature, the unit's energy consumption, and responds within seconds to control commands provided from the utility or power provider. The GETS online portal enables the utility to view the entire fleet of water heaters as a single aggregate in order to gauge total available capacity allowing operators to then execute broad fleet control or pinpoint changes by individual groupings thereby precisely regulating operations according to the needs of the consumer *and* the electric grid. That ability to dispatch GETS by the hour, minute, or second in the precise amount needed to follow the immediate needs of the grid makes it ideal for enhancing grid reliability, stability and optimization. Pilots across North America are showing outstanding "Double Green" benefits - both economic and environmental. The key is that by quickly fine tuning ***load*** to stabilize and balance the grid - versus the tradition of using slow moving and inflexible fuel-consuming fossil ***generation*** – yields significant carbon reduction savings.

There are many emerging forms of large scale electrical energy storage but all these carry very high associated CapEx costs. Most of the technology is variations of large batteries for upstream application located near large centralized electrical generation. Besides size, cost, and location, there are two other key distinctions between these sources of energy storage and the GETS system. The first factor - and very significant differentiator - is that these devices are all "electricity in / out", versus GETS technology "electricity in and thermal energy out". The second aspect is the fact that these technologies are still largely unproven and still emerging in their development.

As evidenced by a White House sponsored Dialogue on Demand Response on February 26th, along with speeches and policy pronouncements by Secretary Moniz, Demand Response (DR) is at the very top of the administration's energy agenda and is an issue with clear and strong bipartisan support. Combined, DR and EE cut into the kWh sales of utilities – often during their weakest daily demand periods. Yet, importantly and unlike standard DR and EE, GETS provides the ability to increase load ("find a home" for energy) and act as a buffer in addition to the attrition / reduction of standard DR and EE.

These combined challenges not only threaten utilities, but, ironically, due to the resulting reduction in the demand base, put significant *upward* pressure on residential electricity rates. The utilities end up having to spread out their costs over a diminishing level of sales.

In addition, certain types of EE when combined with the growth of DR and Re E will aggravate up / down "energy ramp" (the swing in immediate need or lack of demand for energy).

For instance, on the west coast, because of accelerated deployment and much greater share of Re E, California has already recognized the acute, critical, and immediate need for "flexible" resources and "fast-ramp" assets – both of which are unique aspects of the GETS system.

The sharp growth in distributive solar photo voltaic (DGPV) is captured in the following diagram and illustrates California's incredible – and very immediate – challenge to the "net load" on the electrical system as greater amounts of this renewable energy enter the system:

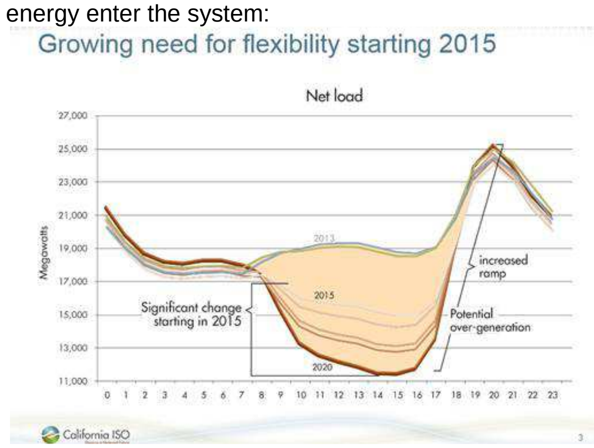

Figure 3 CAISO Presentation on Impact of DG into 2020[7]

- Note the dramatic slump in net utility electrical load demand – during the middle of the day
- That drastic reduction in ramp doubles the required “up ramp” into the typical evening
- All this has significant impact on resource adequacy as well

Due to its flexibility coupled with its dual capability to provide or reduce demand (known as load), GETS can easily be part of the solution to address this growing reduction in daily load as well as mitigate those severe up ramps that begin in late afternoon.

WHY IS RENEWABLE ENERGY “VARIABLE”?

For one reason, although wind blows more at night and more in winter, it is still variable monthly, day-to-day, intra-day, and even minute to minute.

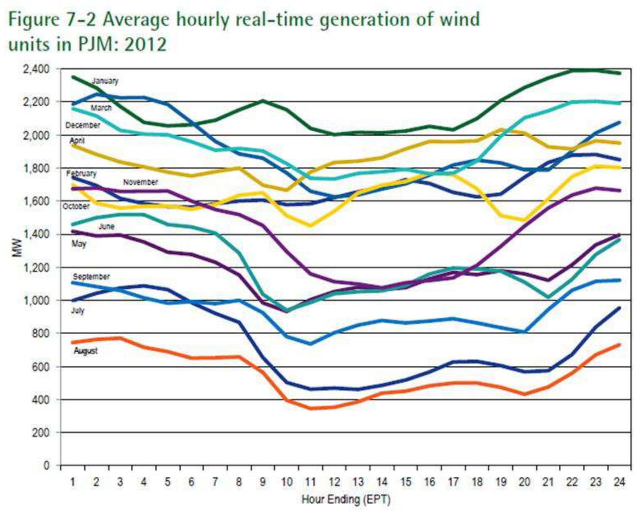

Figure 4 PJM Monthly Real-Time Wind Generation[8]

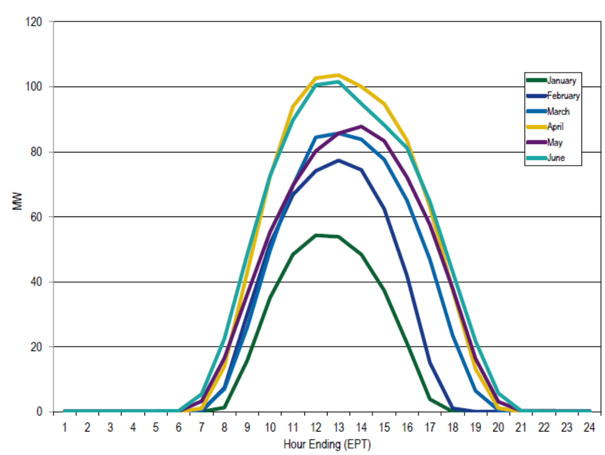

Figure 5 Seasonal Variations within a Day for Wind Generation[9]

THERMAL ENERGY STORAGE METRICS

GETS value, like that of all energy storage, varies by region and rules.

Bristol Tennessee Essential Service (BTES) is a municipally-owned electric utility within Tennessee Valley Authority (TVA) system who reported that studies show the approximate average load shed from a water heater is 0.8 kilowatt (kW) in the summer (June- September), 1.2 kW in the winter (December –March) and 1 kW in the transition months (April, May, October, November) for an average of 1 kW throughout the year.[10]

That 1kW is an often cited metric for water heater load shift.

They also addressed the question: how much more “thermal storage capacity” does an 80 gallon water heater have over a 40 gallon? BTES says about 60% but it depends on the water heater strategy (smaller water heaters do not have the capability of maintaining water temperature over longer periods of time, hence shorter control applicability and other constraints).[11]

It is intuitive that more energy can be stored in larger water heaters, but exactly how more much more energy can be stored by simply raising the temperature in a typical 55 gallon water heater?

In July of 2012, in a submittal to the Department of Energy, PJM Interconnection, APPA, NRECA, EEI, and Steffes Corporation defined that answer as 6.75 kilowatt hours (kWh).[12]

So, as can be seen from each of these pieces, the complete answer to how much energy can be stored in an electric water tank is a combination of water heater storage strategy, size of the tank, and the temperatures.

PRESENT VALUE OF THERMAL STORAGE

In February 2010, an in depth study by Sandia National Laboratories created a very useful grid comparison of benefits of energy storage. In it they defined a high / low range of net present value dollar benefits to which the author of this white paper has added the net single yearly dollar revenue for each aspect. All these are represented as dollars / kilowatt ($/kW).

Energy Storage - Benefit Type	Benefit Net Present Value ($/kW) Low	Benefit Net Present Value ($/kW) High	Single Year Benefit Value ($/kW/yr) Low	Single Year Benefit Value ($/kW/yr) High
Electric Energy Time-shift	400	700	59.26	103.70
Electric Supply Capacity	359	710	53.19	105.19
Load Following	600	1000	88.89	148.15
Area Regulation 15 min. 30 min.	785	2010	116.30	297.78
Electric Supply Reserve Capacity	57	225	8.44	33.33
Voltage Support 15 min.	400	400	59.26	59.26
Transmission Support 2 sec. 5 sec.	192	192	28.59	28.44
Transmission Congestion Relief	31	141	4.59	20.89
T&D Upgrade Deferral 50th percentile††	481	687		
T&D Upgrade Deferral 90th percentile††	759	1079		
Substation On-site Power	1800	3000	266.67	444.44
Time-of-use Energy Cost Management	1226	1226	181.63	181.63
Demand Charge Management	582	582	86.22	86.22
Electric Service Reliability 5 min.	359	978	53.19	144.89
Electric Service Power Quality 10 sec. 1 min.	359	978	51.70	144.89
Renewables Energy Time-shift	233	389	34.52	57.63
Renewables Capacity Firming	709	915	105.04	135.56
Wind Gen Integration, Short 10 sec. 15 min.	500	1000	74.07	148.15
Wind Gen Integration, Long Duration	100	782	14.81	115.85
*Hours unless indicated otherwise. min. = minutes. sec. = seconds.				
**Lifecycle, 10 years, 2.5% escalation, 10.0% discount rate				
†Based on potential (MW, 10 years) times average of low and high benefit ($/kW)				
†† 1 yr Benefit - could be used at more than one location at different times for similar benefits				

Table 1 Sandia - Energy Storage Valuation Table [13]

Here are some of the range of present value benefits that apply to GETS:

- Electrical Time-shift – 400-700 $/kW
- Electrical Time Capacity – 359-710 $/kW
- Load Following - 600-1000 $/kW
- Area Regulation – 785-2010 $/kW
- Time-of-use Energy Cost Management - 1226 $/kW
- Demand Charge Management - 582 $/kW
- Renewables Energy Time-Shift - 233-389 $/kW
- Renewables Capacity Firming - 709-915 $/kW

It is important to note that care must be taken when you tally up these benefits of shifting the typical 1kW of load due to the fact that the mix of values are unique for each utility and also some of these benefits may overlap (and be double counted). When you add together some of the values for a single year, it can easily be seen that even without including a yearly revenue stream for Regulation, benefits can conservatively total from $300 to $600 in a single year. In certain wholesale markets, the ability to respond to a fast-ramp Regulation signal can add approximately $200 to those net benefits.

HOW ABOUT THE FOCUS ON THE VALUE OF "FLEXIBILITY" IN CALIFORNIA?

In California, the E3 Renewable Energy Flexibility Model (REFLEX) is used to evaluate alternative strategies for meeting power system flexibility needs:

- Including new and existing flexible resources: Including natural gas combustion turbines (CTs) and energy storage
- Operating strategies: scheduled renewable curtailment and optimal reserve scheduling
- Structural improvements: within-hour scheduling, Energy Imbalance Market and forecasting improvements

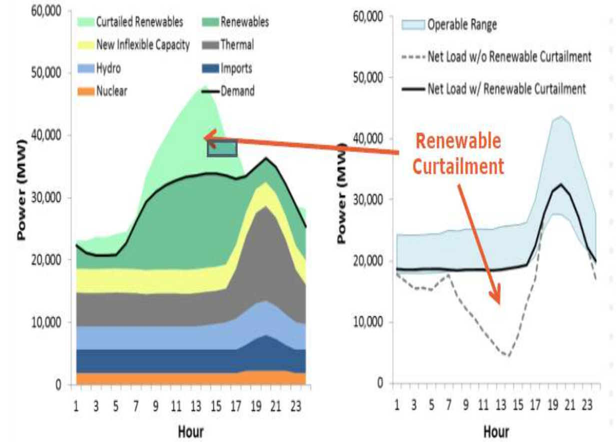

Figure 6 Example of the E3 Reflex Model Results

Cost of Flexibility Mitigation Strategies	
Scheduled Renewable Curtailment	*$0-50/MWh*
Overgeneration	$50-250/MWh
Subhourly Downward Flexibility Violation	$250-500/MWh
Subhourly Upward Flexibility Violation	$2,000-10,000/MWh
Unserved Energy	$10,000-30,000/MWh

Figure 7 E3 Reflex "Flexible" Modeling Results[14]

WHAT IS THE COST OF THERMAL STORAGE AND HOW DOES IT MEASURE UP TO ALTERNATIVES?

Sandia's ES-Select software Energy Storage Software Tool provides an excellent software tool for comparisons[15]

In order to make it easier to compare capabilities and costs of various energy storage options, the Department of Energy in collaboration with Sandia National Laboratories developed a software tool to rank existing and emerging storage solutions. The graph below illustrates the significant advantage that thermal storage enjoys compared to those other alternatives.

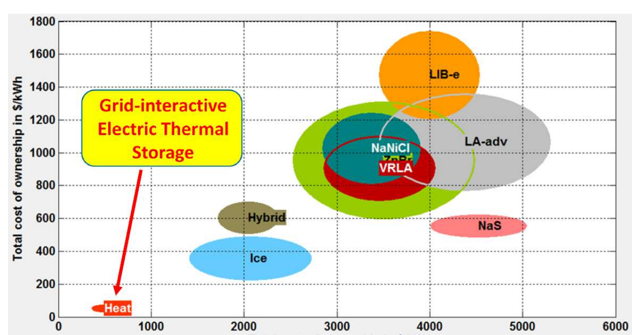

Figure 8 ES-Select Energy Storage Ownership Cost

As made clear by this slide and supported by the Sandia study, GETS thermal technology has an order of magnitude advantage compared to other energy storage applications.

Another important aspect and differentiator of GETS technology is that when energy storage is characterized as "being at the grid edge" or "behind the meter" this usually means small devices incapable of doing larger grid-scale duties like other energy storage devices. For that reason this segment is often ignored by energy storage experts for in depth study and funding. Yes, the GETS system is correctly defined as "grid edge" and "behind the meter", yet the modular and accretive capability that can be added at-will can be aggregated and flexibly scaled to function as though the system is one single upstream massive grid-scale installation. This is a very subtle but extremely importation characteristic of the GETS system.

That unique capability to scale differentiates the GETS grid-edge assets and allows them to be aggregated and controlled as a much larger asset – even to terawatt scale. This also makes them eligible to participate in wholesale markets for regulation payment where other grid-edge assets cannot.

Low CapEx and operating costs combined with flexible scalability makes these GETS assets not only cost effective but opens the door to additional revenue usually reserved to large centralized fossil fuel alternatives. As DOE's Sandia software model has already noted and as nearly 2 dozen trials confirm, GETS costs are an order of magnitude lower than any other existing or emerging storage technologies, GETS reacts or "ramps" faster than nearly any other storage or fossil-based alternatives, and GETS, does so, much more efficiently and with much greater accuracy than any other substitute.
Those trials indicate that GETS can adjust its charge rate and change as fast as wind and other renewable generation change and so 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 uninterrupted hot water or space heating to the customer. That means that utilities can integrate one tool that can peak shave, load shift, take advantage of low (or in some parts of the country, negative) wholesale electricity prices or "locational marginal prices" (LMP's), stabilize the grid with regulation, neutralize fast ramp challenges of unexpected shifts in variable energy resources (especially when baseload is at minimum run rate), and help accommodate greater penetration of renewable energy.

Utilities are looking for answers in a sluggish low-load environment and they are feeling increasingly challenged with the additional outlook of high penetration DG. Adding 2-way communication, high speed telemetry, monitoring, measurement, and verification creates an "Intelligent Efficiency" system that adds a string of new values to that well known utility DLC tool.

DOES IT PENCIL OUT?

The ES-Select values for energy time shift (arbitrage), load following, and area regulation are shown below:

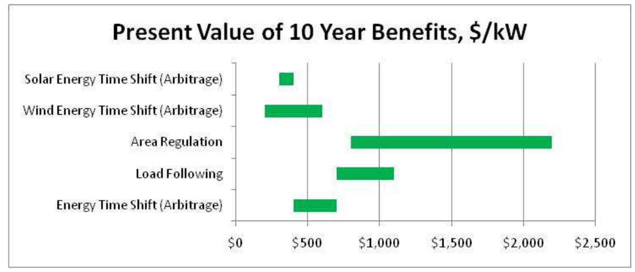

Figure 9 ES-Select Present Value Example

The Following 6 slides are all generated by ES-Select

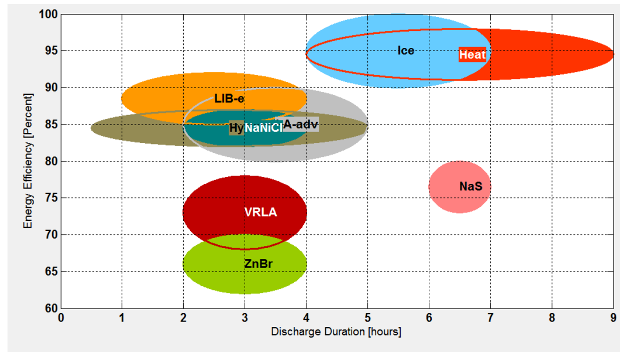

Figure 10 ES-Select Thermal Energy Efficiency

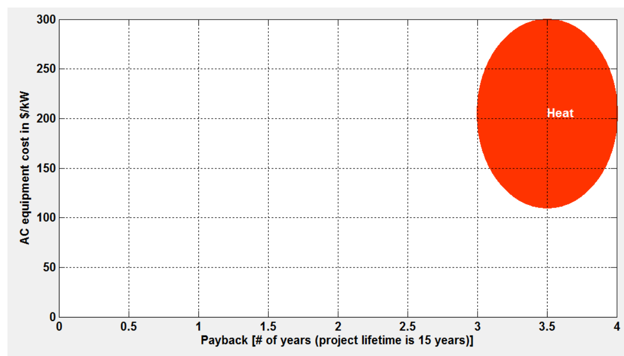

Figure 11 ES-Select Thermal Payback

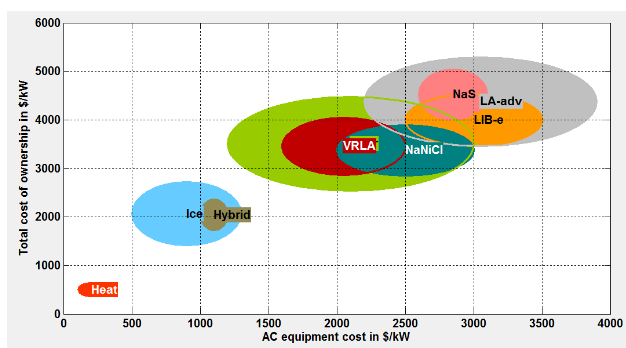

Figure 12 ES-Select Equipment Cost Comparisons

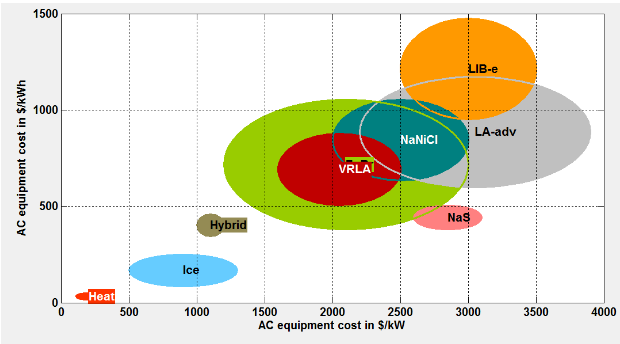

Figure 13 ES-Select Total Cost Comparisons

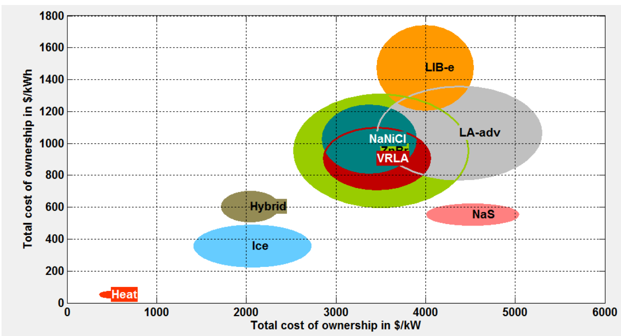

Figure 14 ES-Select Ownership

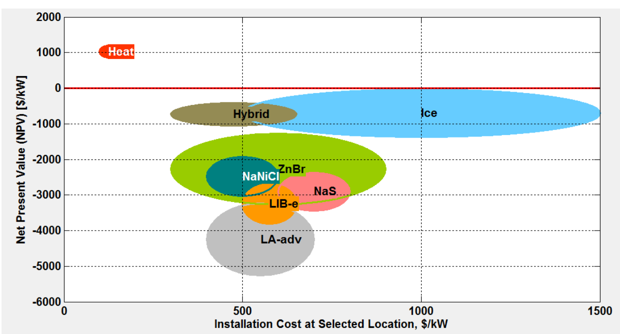

Figure 15 ES-Select Present Value [16]

HOW BIG IS THE MARKET?

Last June, the American Council for an Energy-Efficient Economy (ACEEE) coined the term “intelligent efficiency” and went on to say “the potential for new energy efficiency remains enormous”.

“Intelligent efficiency is a systems-based holistic approach to energy savings, enabled by information and communication technology (ICT) and user access to real-time information. Intelligent efficiency differs from component energy efficiency in that it is adaptive, anticipatory, and networked.”

“While discrete, device-level technology improvements will continue to play an important role, looking ahead we must take a systems-based approach to dramatically scale up energy efficiency to meet our future energy challenges.
If homeowners and businesses were to take advantage of currently available information and communications technologies that enable system efficiencies, the United States could reduce energy use by about 12–22% and realize tens or hundreds of billions of dollars in energy savings and productivity gains. In addition, there are technologies that are just beginning to be implemented that promise even greater savings.” [17]

HOW DOES GETS WORK?

The Grid-interactive Electric Thermal Storage (GETS) system aggregates individual space and water heaters (end points) as a single resource (group) to provide autonomous control based on real-time control signals. The system utilizes an eDirector application to provide both energy balancing services to the end points and resource control and forecasting to utility or power provider customers.

For the purposes of control, each end point periodically logs a minimum, actual, and maximum state of charge (SOC) to the end point aggregation server.

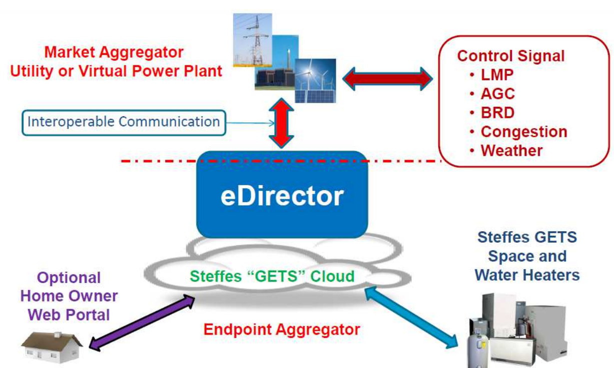

Figure 16 The GETS System[18]

The average water heater consumption is approximately 12 kilowatt hours (12 kWh) , but on a daily basis, individual electric water and electric space heating usage patterns can be all over the board. For instance, just below is data from a single water heater during each day for an entire year.

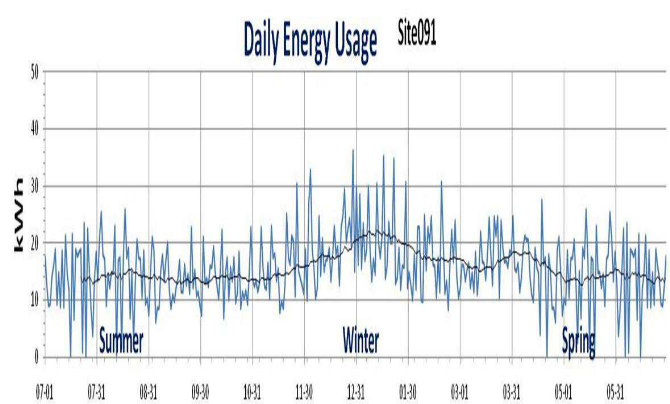

Figure 17 Daily Electric Water Heater kWh over a year[19]

A good sized fleet will diminish the random nature of that individual home usage, but GETS also utilizes a strategy called "Dynamic Dispatch". Dynamic Dispatch is a proprietary selection process for preferentially charge end point load levels combined with safeguards for optional local control, lost communications, and customer comfort assurance. Also included in Dynamic Dispatch is a flexible grouping system which, for instance, could be organized in some logical or territorial grouping, or by substation, or even at feeder level. Adjustments can also be made for operational constraints, operational histories, a desired load schedule, day-ahead energy costs and/or regulation prices, weather forecasts, and time-of-day, day-of-week, or seasonal factors. Those unique strategies allow the power provider to have the flexibility to address a variety of system bottlenecks or constraints.

Cost-effective energy storage and flexible load such as GETS represents an opportunity to respond to various signals and to harness the value of renewable energy - an emissions-free, zero fuel cost resource. The importance of flexible load and energy storage, particularly at night – is an ideal use of grid-interactive - GETS - water (or space) heaters.

HOW EASILY CAN THESE GETS ASSETS IMPACT THE MARKET?

We know that incorporating the GETS system has low or very low barriers since it:

- Is inexpensive and saves upfront money for those that must replace their existing water heater
- Impacts from 16 – 20% of the home energy budget – but at no cost to the consumer
- Is neither difficult nor inconvenient to the end user because it operates in the background – by merely switching the water heater charge cycle to non-demand periods
- Has very little – if any - impact on lifestyle, in fact, because it is essentially invisible to the user, there is no alteration, no disruption, and is seamlessly compatible with their existing behavior
- Because it can soak up off-peak wind generated electricity, its operation could have very high impact on things that matter to users – namely, helping them utilize more Re E and replace carbon based electricity with non-carbon sustainable energy – a great no-cost, smart decision – and for that reason, why wouldn't they do it?

WHAT ABOUT THAT "GREEN" VALUE?

Dollar for dollar there is no greater way for an individual or a community to have a greater impact on the adoption and the utilization of renewable energy – all without any change in behavior and without a cost.

WILL UTILITIES ADOPT THIS SOLUTION?

Yes and they will do so because utilities understand and are strong proponents of one such technology, direct load control (DLC), and they strongly desire to upgrade the now primitive and simple on / off controls that dominate the technology. However, many utilities want - and may adopt - a cheap "bridge" solution which merely adds verification. The Steffes Corporation has a long history of implementing a variety of DLC solutions and we have designed our GETS controller to provide much greater capabilities.

Not every market area currently rewards all of those much higher capabilities, but PJM, the largest US wholesale electricity market, is one of the only locations that has monetized and incented that Steffes "fast ramp" capability. As an immediately available and attractive market, it stands alone as an outstanding, singular, and large scale opportunity. Other large wholesale markets are moving in the direction and GETS will have great application there too.

GETS – THE RIGHT CHOICE – A GREAT SOLUTION

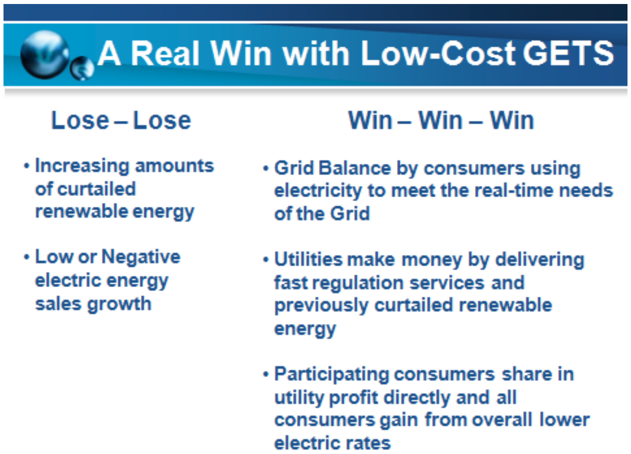

Figure 18 Across the System Benefits of GETS[20]

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ABOUT THE AUTHOR

Paul Steffes P.E. is the CEO of Steffes Corporation based in Dickinson North Dakota. Steffes Corporation is a North American manufacturer of Electric Thermal Storage products for residential and commercial applications. Paul has worked closely with power companies from across North America for the past 26 years, successfully applying ETS products and solutions within Utility load management and demand response programs.

For the past 40 years, Steffes has been manufacturing Electric Thermal Storage (ETS) heating equipment and electrical load management controls. In doing so, Steffes has worked very closely developing solutions for utilities across North America. As result, Steffes has also cultivated a close working relationship with 200 utilities as well as industry groups such as NRECA, EPRI, EEI, APPA and others.

Paul's current work is focused on applying Grid-interactive Electric Thermal Storage (GETS) systems as a "Thermal Battery", in particular to provide "up" and "down" fast regulation services and assisting in integrating large amounts of renewable energy. This is in addition to traditional load management and consulting services.

Paul is a Professional Engineer and is nationally recognized by many Investor Owned, Municipal, and Rural Electric Cooperative power companies as an expert in ETS and GETS technology.