Zero Peak Communities Electric Utility Benefits

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ABSTRACT

"Zero peak communities" (ZPC) have the potential to help electric utilities reduce peak loads, provide affordable and reliable electric power, enhance environmental stewardship, and encourage sustainable economic growth. A "zero peak community" is a subdivision that does not contribute to the utility system peak. This report analyzes energy performance data gathered on the first four of five near zero energy test houses (ZEH) in Lenoir City, Tennessee that are the result of a collaboration among TVA, DOE's Building America program, Habitat for Humanity Loudon County Affiliate and ORNL between 2002 and 2006. This data shows that these small, all electric, near zero energy houses reduce both summer and winter peak by more than 1 kW or 30-40% per house, yet have the potential to preserve utility off-peak revenue by encouraging more all electric homes, ultimately with a zero peak load on the grid.

This paper proposes utility incentives that could provide the stepping stone to zero peak demand housing with positive cash flow between mortgage and utility bills. The key incentive that could enable zero cost in climates similar to those in Lenoir City are to offer homeowners a premium price for all the renewable power produced at their home site. The utility sells this green power to the customer base willing to pay a premium to have electricity generated by renewable sources. This second tier for the buying of renewable power would only be available to those homeowners willing to invest in 50% energy saving houses and install at least 2 kW of peak solar power generation.

For example, if the local electricity provider to the near zero energy houses in Lenoir City were to offer $0.20 to 0.31/kWh for the solar power, rather than the flat current rate of $0.15, this would provide a strong incentive for Zero Peak Communities because these houses could be sold along with the cost for energy to run them in the mortgage. The electric utility benefits are; reduce peak electric loads, gains in off peak revenue by encouraging all electric houses, help in meeting higher required renewable generation percentages, reduce distribution & grid infrastructure expansion needs, and enhance air quality in EPA noncompliant air sheds that threaten growing customer base in their territories.

INTRODUCTION

ZPC have the potential to help electric utilities reduce peak loads. This paper analyzes peak energy performance data gathered on four of the five near zero energy test houses (ZEH) in Lenoir City, Tennessee that were designed, monitored, and analyzed as collaboration among the Tennessee Valley Authority (TVA), the U.S. Department of Energy's Building America program, and the Oak Ridge National Laboratory (ORNL) between 2002 and 2005. The data obtained from these near zero energy houses shows they reduce both summer and winter peak by more than 1 kW or 30-40% per house. Other Zero Energy Home experience across the Nation has reduced summer peak loads by up to 75%[11-13].

Electric-only utilities in the mixed humid climates frequently offer demand side management incentives that encourage the use of electric energy in the winter. For example, TVA has the energyright® program (energyright.com), which encourages the use of high efficiency heat pumps to

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capture a larger fraction of the winter heating energy market. Currently the energyright® homes program provides \$300 to the builder if the house is all electric, has a SEER rating of >13 heat pump, a HERS rating of > 86, and passes a TVA whole house inspection.

The solar photovoltaic (PV) system, on the demand side of the meter, in ZEHs reduces peak power demand. In addition to the four near zero energy houses in Lenoir City, the Lakeland house in Central Florida[11], the Hathaway house in Virginia[12], and the SMUD (Sacramento Municipal Utility District) zero energy community in Sacramento California[13] all show that these houses can come very close to zero peak demand during the utility system summer peak. It is recognized that orientation of available roof area from south to west has little annual energy generation impacts but can shift the solar energy generation to later in the day, better overlapping grid peaks.

The peak load reduction is based on a conservative estimate of 1 kW/house as shown by Figures 1 and 8. With the right-sized electric utility incentives, many home builders and homebuyers would construct near zero energy houses, resulting in at least 2 kW of peak solar power generation and a whole house savings of 50% compared to the DOE Building America Benchmark house[1].

Specifically, the opportunity is to develop an electric utility incentive program to encourage whole house 50% energy saver houses and purchase on-site energy at a rate to potentially off set the cost of grid energy. The 1100 ft^2 all-electric near zero energy test houses in Lenoir City required 7000 to 8000 kWh/year and produced about 2300 kWh of solar AC. If the residential rate was \$0.075/kWh the annual cost to the homeowner for the grid power comes to \$735. To offset that expense the utility AC solar buy back incentive would have to be $\$735_{\text{annual grid cost}}/2300_{\text{solar kWh AC}}$ or \$0.31/kWh.

With winter natural gas prices rising an average of 13%/year from 2002-2006[4], more residential homeowners are installing heat pumps particularly in the mixed humid climates. The migration from predominately gas heated homes to all electric ZEH homes would be a better outcome for electric-only utilities. This will allow them to continue to deliver affordable (\$0.07/kWh residential power) and reliable (over the last 7 years an average total outage per customer per year of less than 3.1 minutes) power, while these homes, in aggregate, increase off-peak electricity sales yet don't significantly increase summer and winter peak.

Electric utilities fundamental missions are to supply affordable and reliable electric power, provide environmental stewardship, and lead sustainable economic development in their service territories. This paper shows how ZPC will aid in the first objective by better management of peak load growth.

OBJECTIVE

The objective of this paper is to summarize a project, which was to review the major strategic goals of a large electric utility and identify the benefits to the electric utility industry of zero peak communities and the role ZPC might play toward attainment of utility overarching goals. A second objective is to identify how the electric utility could encourage the market transformation toward zero energy communities in the future.

GOOD BUSINESS

Supply Affordable and Reliable Electric Power

Some large electric utilities are net buyers of electric power during their system peak summer and winter periods. The available power during those times is almost entirely from natural gas turbines. For example TVA, the electric utility providing grid power to the five near zero energy houses in Lenoir City, has a much smaller fraction of natural gas powered generation (15%) compared to surrounding North American Electric Reliability regions excluding TVA (36%)[17]. When TVA has to buy power, the differential cost is substantial compared to their base load costs from coal, nuclear, and hydroelectric. One of the greatest rising costs of doing business for electric utilities is paying for additional peak power[17]. Therefore the cost effectiveness of demand side peak power reductions is more attractive than ever to help continue to supply affordable and reliable power.

Peak Load Reductions

Winter peak. On January 18, 2005 TVA hit a winter peak of 29,279 MW. That was the fifth highest on record. Figure 1 shows the average electric load on this day, for the 1200 ft^2 two story ZEH4[18] (This was the fourth in the ZEH series designed and monitored for DOE and TVA by ORNL) and the 1056 ft^2 ZEH3 (This is the third house, and has a geothermal heat pump for space heating and cooling). For more detail on these houses please see Christian, 2006[16]. Figure 2 shows the temperature inside ZEH4 on both floors and the ambient from the site weather station, which reflects that the house was kept very steady and warm throughout the day. Figure 1 shows that by midday the net average power from these two houses resulted in solar energy being supplied to the grid on this peak winter day.

January peak day data for a conventional house is also shown in Figure 1. This curve is based on normalized data from a larger house (4000 ft^2). This house is all electric with a SEER 13 heat pump and a Heat Pump Water Heater (HPWH) similar to the one in ZEH1, 2, and 4. The raw data is normalized down to the same size house as ZEH4, using equation 1. The measured 15-minute raw average wattage is normalized by the fraction of floor area (or 30% of a weighted 76% of the total load (W_{4000})) and by ratio of bedrooms (or 3 bedrooms for the smaller near ZEH compared to 4 bedrooms for the larger or 75% of 9% of total load). Plus, 15% of the load is independent of house floor area or number of bedrooms. These weighting ratios of 0.76, 0.09 and 0.15 are obtained from the Building America benchmark house "other" load schedule[1].

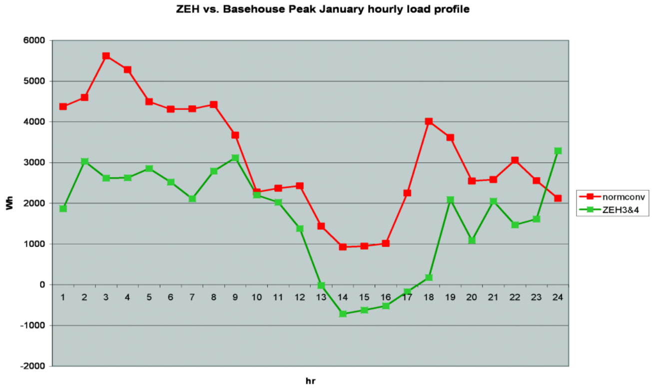


Figure 1 *Average hourly energy use (Wh) for ZEH3 and ZEH4 vs normconv house (normalized for delta T).*

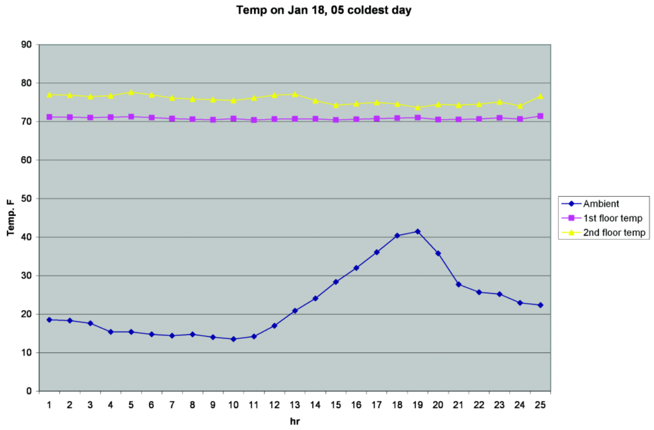


Figure 2 *2 ZEH4 interior temperatures and ambient shown for each hour from midnight until midnight for TVA peak heating season day (January 15, 2005).*

$$W_{1200} = W_{4000}(((1200ft^2/4000ft^2)\times 0.76) + ((3bd/4bd)\times 0.09) + 0.15) \quad (1)$$

where

W_{4000} = measured data for larger 4000 ft^2 conventional house) (W)

W_{1200} = normalized for 1200 ft^2 conventional house of similar occupancy as ZEH4 (W)

The data for the conventional house is also normalized using the measured delta temperatures (interior to ambient), since the data for the conventional house does vary from that measured for ZEH4. The normalized electric load for the conventional house is labeled *normconv* in Figure 1. The average hourly demand from 7:00 AM to 9:00 AM, which corresponds to the utility system peak, for the average of ZEH3 and ZEH4 was 2.7 kWh compared to 4.1 kWh for the normalized conventional house. This represents a 1.4 kWh winter peak reduction or 34%.

In Figure 10, the average daily energy load profiles are shown for each month for the near zero energy Hathaway house in Virginia. This 3000 ft^2 house has an average winter peak load in January of 4 kW and has many of the same technologies as the Lenoir City near ZEHs, including geothermal and a PV system three times larger. During summer the house was a net producer early in the PM, with an energy management system the house could be pre-cooled in early PM and the air conditioner shut off during utility peaks. This would not be necessary every summer afternoon only those few very hot days that cause a utility system critical peak period.

The actual 15-minute peak in the 4000 ft^2 conventional house was 28 kWh occurring at 4:45PM on Jan. 18, 2003. Using Equation 1 yields a peak of 12.4 kWh for the *normconv* house. The 15-minute peak in ZEH4 of 9.2 kWh occurred on December 6, 2004 at 10:15 PM, which results in a peak reduction of 26%. These absolute peak differences of the two houses is not the peak loads that matter the most to electric utilities, which care mostly about the house coincidence load at the time of the electric grid peak.

Figure 3 shows actual 15-minute data in watts for the same time period shown in Figure 1 as Wh. The average watts for each 15-minute interval from 7:00 AM until 9:00AM for the normconv house is 4400 compared to the average of 2800 for ZEH3 and ZEH4. This is a 36% peak load reduction. In comparison the average hourly energy use reduction (Figure 1) was 34%. On a shorter time frame this is a 1600-watt reduction during 15- minute winter peak.

Planned future DOE and TVA work on ZPC should be able to generate true zero peak load reductions for 2-3 hours with a modest amount of smart energy management control. This control could automatically shut off HVAC and water heating equipment for short periods of time during the utility system peak with less impact in a ZEH than conventional house because of the superior energy efficiency features. Preheating and precooling could also be done more easily in these houses because of the strategic use of thermal mass, envelope airtightness and controllable mechanical ventilation.

Summer Peak Reductions. The TVA power system reached a new summer time peak demand of 31,935 MW at 4 p.m. CDT on July 26, 2005 amid a week of hot weather throughout the Southeastern United States.

Figure 4 shows the electric load demanded from the grid by ZEH4 on the day TVA hit this all time peak. At this peak it is estimated that about 25% of the capacity was generated from natural gas. The spike in the ZEH4 demand on that day was caused in part by the homeowner turning down the thermostat when arriving home. Figure 4 shows the energy needed for the heat pump was 2.3 kWh at this peak. The remaining load was due to other loads, most likely the oven or clothes dryer. This illustrates the need to have some onboard electric load controller in the ZEH to maximize the peak load savings potential and to have critical peak pricing programs. Although the peak was 4.2 kW and only about 55% cooling equipment related, the high fraction of energy demanded by the HVAC

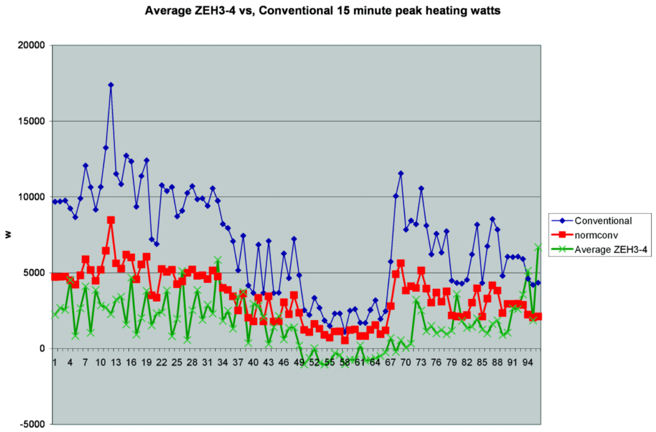


Figure 3 *Fifteen minute data in watts for the same time period as shown in Figure 1.*

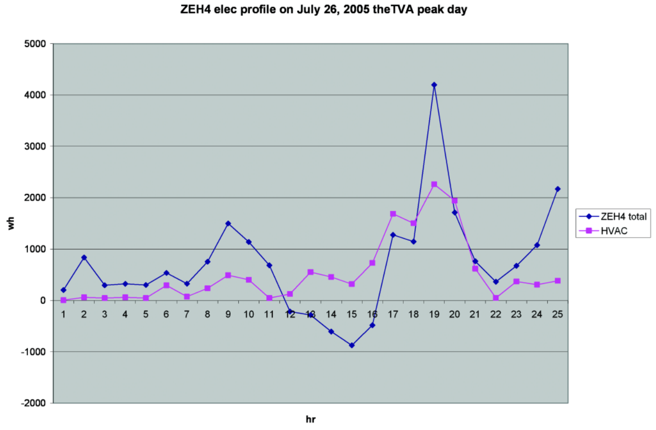


Figure 4 *ZEH4 actual Wh load profile on July 26, 2005, the day TVA hit an all time peak electric demand.*

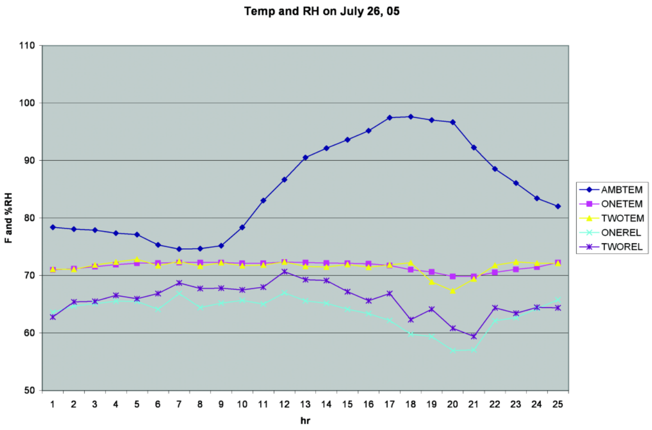


Figure 5 *Air temperatures and relative humidity in ZEH4 on July 26, 2005, the day TVA hit an all time high peak electric demand.*

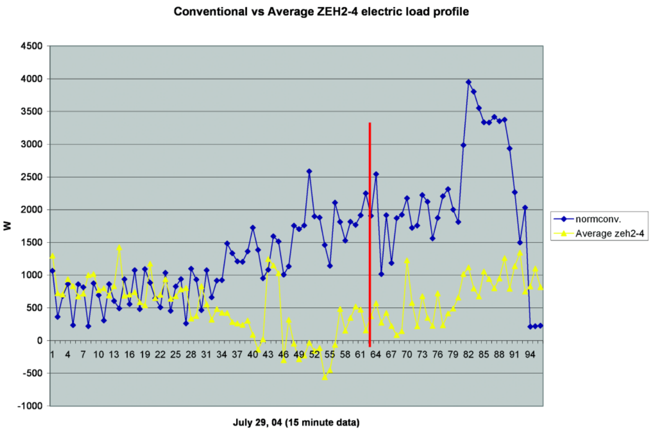


Figure 6 *Average 15 minute electric load profile of ZEH2-4 compared to conventional house on July 29, 2004.*

equipment was partially caused by the high relative humidity (RH), not the house temperature, as shown in Figure 5. The RH was approaching 70% and this caused the homeowner to occasionally lower the temperature setting on the thermostat. On-going research uncovered that much of the first year of high RH was due to the heavy hydration moisture release during the first year of concrete curing in the floor and walls of the walk out basement on ZEH4. The second summer found the average RH was less than 50% for the summer months.

Figure 6 shows the average 15-minute electric load profile in watts on July 29, 2004, for the average of ZEH2, ZEH3 and ZEH4 compared to that of the normconv house. This was a day in which data was being collected on all four of these houses exposed to the same weather conditions. This was a hot day but not a peak for the TVA grid. The vertical line identifies 4:00 PM when the TVA peak typically occurs. The average 15-minute wattage for the conventional house from 4:00 PM until 6:00 PM is 1696 W, and the average of the near zero energy houses is 396 W. This is a peak load reduction of 1300 W or 78%. It would be most desirable to have a whole development of conventional houses to compare with a development of houses like ZEH2-4.

The peak load reduction for the Sacramento Utility District (SMUD) zero energy community in Sacramento California has been a very consistent 1500 W and data indicates this would be less than 1 kW by not installing PV on eastern roof slopes[13]. A 4 kW peak load reduction was demonstrated with the Lakeland house in Central Florida[11]. A community of 6000 houses in Tennessee using a 1300 W per house peak load reduction represents a potential 7.8 MW grid peak load reduction. Figure 7 is the same data as displayed for Figure 6 only in watt-hours, which tends to smooth the data compared to 15-minute data.

To make sure that the day available for direct comparison was representative of the summertime performance of these four all electric houses, we generated an average daily electric

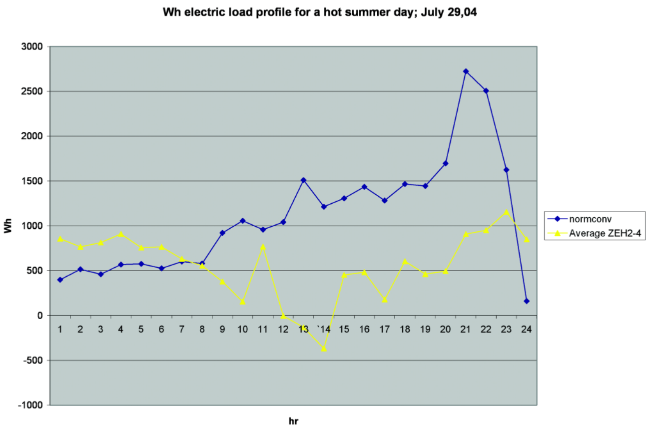


Figure 7 *ZEH 2-4 compared to conventional house Wh profile on July 29, 2004.*

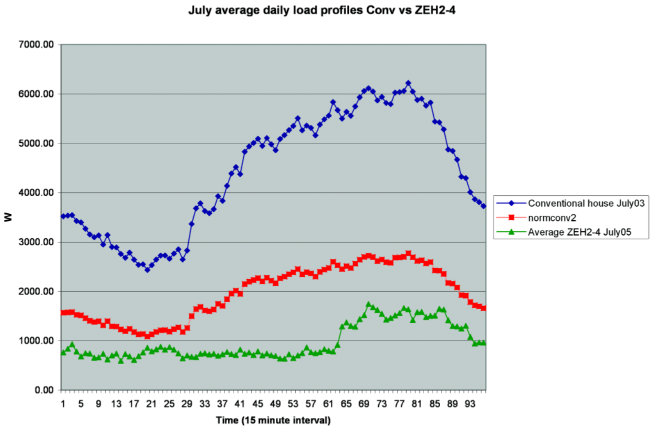


Figure 8 *Average electric load profile in watts for ZEH2, -3, and -4 compared to the actual labeled "Conventional house July 03" and normalized conventional house labeled "normconv2".*

load profile for the entire month of July, as shown in Figure 8. We used July 2003 with 376 cooling degree days at 65°F for the *normconv* house and July 2005 with 423 cooling degree days at 65°F for the ZEHs. This would tend to make the conventional house performance appear better, since it was not as hot July, 2003 as in 2005. This is offset by the fact that the conventional house was actually kept at an average of 3.8°F lower average interior temperature than ZEH2, ZEH3 and ZEH4. This tilts the comparison the other way by making the ZEHs appear to perform better, since it did not cool the house to a lower set point. The two lower curves in Figure 8 show this comparison. The average hourly peak load for the *normconv* house from 4:00 PM until 6:00PM is 2600 W. The comparable average for the three near zero energy houses is 1500 W. The average peak load reduction for July is 1100 W. This represents an average 43% reduction in average daily peaks for July. The top curve shows the actual data for the larger all electric-conventional house, during what is generally the hottest months of the year in the Knoxville climate. The actual larger (4000 ft^2) conventional house has a peak load more than 4 kW higher than the average of ZEH2, ZEH3 and ZEH4.

Summer time peak load savings of ZEH from around the United States. Data from the Lakeland House monitored by Florida Solar Energy Center found that compared to an identical conventional house one block away, the peak load was almost completely eliminated on a peak summer day. The reduction in peak watts was around 4000, as shown in Figure 9. This house had 4 kW of peak PV capacity almost twice that of the near zero energy houses in Lenoir City.[11]

The Hathaway house is a 3000 ft^2 ZEH with 6 kW of PV, has 2 X 6 framing with 24 inch on center studs and R5 exterior insulated sheathing. It is heated and cooled by a geothermal heat pump. The house is located near Washington D.C. in Purcellville, VA, 22132. There is no base house for comparison but on average in summer it is clear, in Figure 10, that the house is producing net power during the early afternoon time period.[12] With automated energy management system shifting loads later in the day and precooling the house on critical peak pricing days this house could clearly be a net energy producer of a couple of kW in the late afternoon time period.

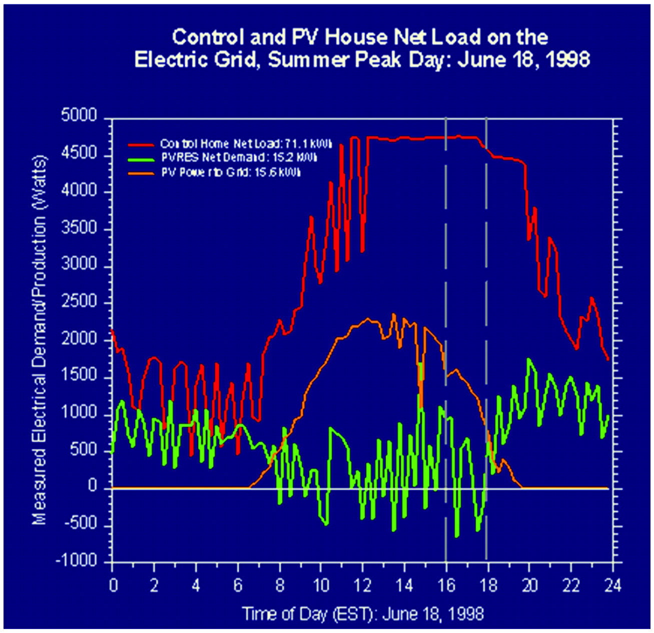


Figure 9 *Peak summer day data from the Lakeland House in Central Florida.*

The SMUD community called Premier Gardens has peak load data from 18 near ZEH houses and 18 conventional houses. Figure 11 shows the average daily loads in July peak load savings of about 1.8 kW per house. These houses all have about the same size PV system as those in Lenoir City; 2kW. The AC units in the ZEH are SEER 14 and the base units have SEERs of 10. The base units have peak July loads around 2.75

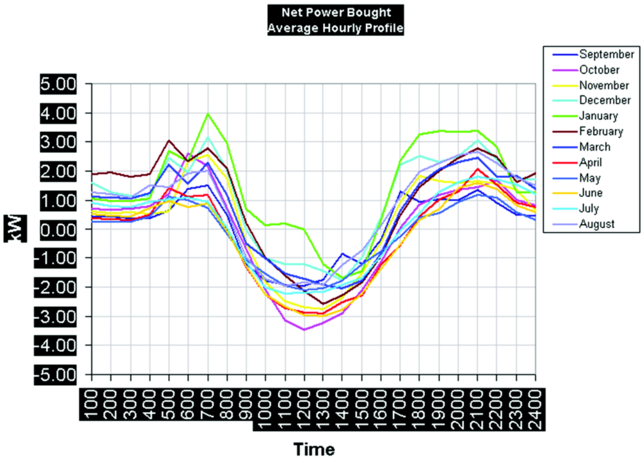
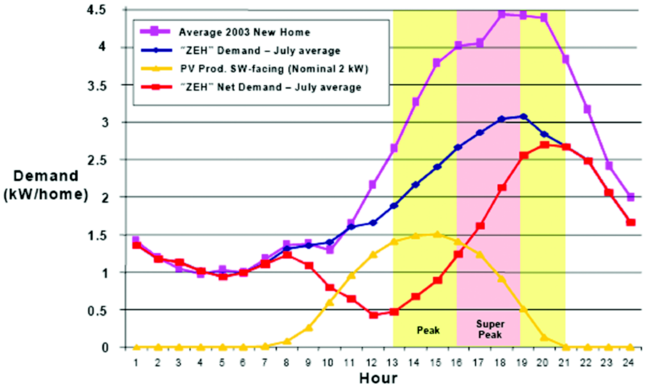


Figure 10 *Hourly average data from the Hathaway ZEH located in Purcellville, VA.*



Source: SMUD/Consol 15-minute interval data

Figure 11 *Premier Gardens near Sacramento, CA average daily loads in July peak load savings of about 1.8 kW per house.*

kW and the near ZEH houses measured an average peak around 1.25 kW at about 5 PM. This data is also 15 minute intervals.[13] The top curve in Figure 11 shows that the average new home built in this area in 2003 has a 4.5 kW peak. About 50% of the super peak savings was from energy efficiency and 50% from the PV.

OTHER UTILITY BENEFITS

Reduce Down-Side Risk

The encouragement of ZPC has very little down side risk to utilities and considerable potential benefits to assuring reliable and affordable electric power supply without taking on additional liability. Because of the well-insulated, air tight construction and proper use of envelope thermal mass, ZEHs are much easier to preheat and precool prior to utility peak.

The solar electric — photovoltaic (PV) system on the demand side of the meter in ZEHs reduces peak power demand. In addition to the four near zero energy houses in Lenoir City, the Lakeland house in central Florida, the Hathaway house in Virginia, and the SMUD zero energy community in Sacramento California all show that these houses can come very close to zero peak demand during the utility system summer peak. It is recognized that orientation of available roof area slightly west of true south has little annual energy generation impacts but can shift the solar energy generation to later in the day, better overlapping grid peaks[11]. In TVA's case, this would have significant benefits with the typical 4:00-6:00 PM peak load demand.

The marginal cost of electric power during summer peak power demand periods can be as high as ten times the cost for generation at off-peak periods [3]. During the 2002 summer, TVA provided marginal cost power which topped out at $0.12/kWh (personal conversation with high level TVA official suggested summer 2006 marginal cost was around $0.22/kWh). For $0.31/kWh or about $700 per house per year, TVA would reap the peak load reductions due to efficiency at summer time peak ~$0.24/kWh and winter of ~$0.36/kWh, plus be able to sell the green power for ~$0.102/kWh. The customer would invest a lot in energy efficiency in order to capture the higher solar buyback rate of $0.31 compared to $0.15 broadly offered, even to residences with very high summer and winter peak demand. For the electric utility to recoup this investment completely the argument would have to include the benefits of capturing added revenue from off peak periods as a result of all electric homes plus reduced distribution and grid infrastructure costs. This may be highly significant where a potential major development adds a substantial load in a small rural service area.

TVA's Green Power Switch program provides a choice for consumers seeking cleaner technology that does not create air pollution and helps to sustain resources for future generations. TVA and locally owned distributors of TVA power, in cooperation with the environmental community, worked together to develop this program. Unlike many other green pricing programs, all of TVA's green power comes from within its service territory, ensuring that Valley residents benefit directly from this environmental program.

The most impressive element of TVA's Green Power Switch program is that the people in the Valley can actually be a part of the solution. It is a very low cost first step toward converting to the ultimate goal of net zero. For each additional $4 consumers add to their electric bill, a "block" of 150 kWh of renewable energy is generated and placed on the TVA electric grid. Consumers can buy as many blocks as they like. People can set a goal for themselves; "I would like to live in a house powered entirely with renewables." With a phone call they can sign up for Green Power Switch and be on their way. When their house is ready for renovation they can take additional steps. When the cost of solar technology comes down or the opportunity to get in on a mass purchase of key zero energy components they can continue toward their goal of taking more aggressive action toward creating a better environment in which to live their life. When it is time for a new house they will look for housing opportunities in a ZPC.

Small Investments Today Can Pay Big Dividends in the Future

An electric utility zero peak community incentive program would provide a very low cost lever for turning on larger fractions of renewable power to increase the renewable portfolio, as frequently being mandated by states, countries and public utility commissions. Locally, this utility incentive provides the 8.5 million customers in the TVA service area the opportunity to reduce their carbon footprint and minimize climate change.

Capture Larger Share of Residential Space and Water Heating Energy Market

In some mixed humid climate areas electric powered heating amounts to just above 50% of the total heating energy market. Right-sized high efficiency electric heat pumps work exceptionally well in this mixed humid climate. Geothermal heat pumps are especially good for electric utility business because they have much less impact on peak loads than air source systems. The large peak loads in conventional houses resulting from low SEER air source heat pumps are avoided by geothermal systems. On January 18, 2005 when TVA reached an up-to-that-time, record high electric power demand the surrounding soil of ZEH3 was 60^{o}F compared to 18^{o}F ambient temperature. The five test ZEHs have shown that geothermal can play a key role in meeting the 50% energy saving house that will be capable of reaping the homebuilder Federal $2000 business tax credit in 2007.

Be Better Environmental Stewards by Reducing Carbon Emissions

To calculate the amount of carbon-dioxide (CO_2) emissions saved from the all electric ZEH in Lenoir City, TN, we need the type and amount of fossil-fuel consumed for servicing a similar but all electric conventional reference house. In fiscal year 2005 TVA generated or purchased 25.7% of its power from nuclear and 8.8% from hydro with zero carbon emissions, 55.9% from coal (266 grams of carbon/kWh), and 9.6% from natural gas (148 grams of carbon/kWh). These percentages are based on the assumption that all the TVA-purchased power comes from gas turbines.

The main products of fossil-fuel combustion are carbon dioxide and water vapor. For natural gas, which has a large hydrogen/carbon ratio, about 0.01447 grams of carbon dioxide are generated per British thermal unit (Btu) of thermal energy realized. For coal the corresponding number is 0.0026.[5] Since 1/3 of thermal energy generated is converted to electrical energy[6], the amount of CO_2 per kWh of electricity is about three times the amount of carbon emitted per unit of thermal energy. Energy units are given here in terms of kWh. One kWh = 3412 Btu. It is conventional to express carbon dioxide emissions in terms of only the carbon fraction. To obtain equivalent amounts of carbon dioxide, multiply by 44/12. About 266 grams of carbon are emitted per kWh of electrical energy realized from coal combustion; less risk of danger from combustion of natural gas, the number is 148. The CO_2 emission from a house in the TVA service territory can be calculated by equation 2:

$$\begin{array}{ccccc} \text{Hydro} & + \text{ Coal} & + \text{ Nuclear} & + \text{ Natural Gas} & = \text{Total} \\ 0X0.088 & + \ 0.559X266 & + \ 0.257X0 & + \ 0.096X148 & = 162.9 \text{ g carbon /kWh} \end{array} \quad (2)$$

Compared to the *normconv* house, the ZEH saves 5935 kWh of total energy per year. The actual measured energy from the 4000 ft^2 house from March 2003 until February 2004 was 31,752 kWh. Using equation 1 for scaling, the *normconv* house would have used 14,145kWh. Another base house used for annual comparison, which is an actual Habitat for Humanity house built by the same contractor as ZEH4 and with almost identical floor plans, totaled 15,168 kWh.[7] Compared to the Building America benchmark house, ZEH4 saves 9090 kWh/yr.[17] Thus the estimate of carbon reductions is believed to be very conservative. The amount of carbon emissions this house would save can be calculated as:

$$9090 \text{ X } 162.9 = 1{,}480{,}76 \text{ g-C} = 1481 \text{ kg-C per year} \quad (3)$$

The 2627 kWh generated by the solar PV system is included in this calculation. Assuming four people live in both of these houses, then:

$$1481/4 = 370 \text{ KG-C per person per year are saved} \quad (4)$$

The per-capita emissions for 2003 in the United States were:

> 1,562 e^6 million grams[5] / 291 million people [8] = 5.368 x 10^6 grams/person = 5,368 Kg-C/person. The methodology used to obtain these carbon emissions is given by Blasing et al.[9, 10]

The average savings is 370 Kg-C/person-year and the national average is 5,368 Kg-C/year. Thus, to a first approximation, if everyone lived in a near zero energy house like ZEH 1-5 we could estimate the carbon-emissions savings at 6.9% of the national total. Comparing the actual conventional house this savings would increase to 23%. This last comparison reflects that bigger savings could come from people choosing to live in houses that are not only NZEH but 1200 ft^2 rather than 4000 ft^2.

Utility growth models are usually based on population growth to estimate residential electric power growth, number of jobs to measure commercial and industrial growth and the regional GNP. If a utility can bring population into their service territory and house them in ZPC, this would increase the number of people available to take jobs without the costly expansion of peak electric capacity infrastructure.

SUMMARY

Accelerating the development of ZPC is mutually beneficial to the homeowner, utility, and Nation. Key areas for success are:

- Ensure ZEH supports electric utility operational excellence,
- Enhance financial flexibility,
- Build strong partnerships with distributors and large power users, and extend integrated resource management to span the use of natural resources right into the way homes are built and operated.

The results from the analysis of the four near zero energy test houses indicate that with a second higher solar buyback tier the homeowner could cut their energy bills by at least 50% and possibly even attain zero energy *cost*, a huge marketing feature which would capture serious attention from the home building and buying market. This concept offers virtually no capital investment on the part of the electric utility, and a potentially large reduction in peak load growth. This can be attained as suggested by the analysis of the zero energy test houses discussed in this paper.

RECOMMENDATIONS

The major recommendations are very specific suggestions to help utilities stimulate economic growth by supporting community development of a viable market for ZPC. This is consistent with the realization that electric utilities must prepare for greater long-term competition.

Zero peak community incentives should be taken to the whole house level and optimized for the utility service territory. The incentives should leverage available Federal and State programs. Set the house performance level to attain a HERS index[2] <60 which documents a 50% heating, cooling, and hot water savings compared to IECC 2006. Once qualified for this higher level, which will take an investment on the part of the builder and homeowner, the homeowner will be eligible for a larger solar buyback rate from the utility Green Power buyback to cover the cost for the small remaining electricity need at the going residential rate. (Using the four near zero energy test houses in Lenoir City, TN leads to a $0.31/kWh instead of the already established tier of $0.15/kWh). Additional data would be very useful to determine rates that are mutually advantageous to the homeowner and the utility.

Further research on the operations and maintenance costs for the technology to deliver zero energy communities is needed. This includes examining the effect on property taxes and added hazard insurance riders, as well as more detailed business and environmental cases for the electric utility to offer solar and energy efficiency buyback rates of $0.15, $0.20, $0.25 and $0.30 /kWh. Additional site specific data are needed on optimized solar angles of the PV annual benefits vs. utility system peak reduction benefits. Finally, more research is needed to determine the cost and occupant comfort impacts of adding demand side management automatic controls to these houses. We also need to determine how much peak load can be obtained by simply restricting operations of some energy consuming devices like space heating, AC and domestic water heaters and from pre-heating and cooling scenarios.

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