A Blueprint for the House of the Future

EPRI Works with Builders and Utilities on Advanced Energy Communities

By Chris Warren

Brandon De Young's family tree makes him particularly well suited to conceive and build the California house of the future. On his maternal side, De Young is a third-generation housebuilder in California's San Joaquin Valley, where his grandfather began constructing dwellings during the state's post–World War II economic and population boom. His paternal grandfather worked his way up from elevator operator to vice president at San Francisco–based utility Pacific Gas and Electric Company (PG&E).

Given this family intersection of energy and housebuilding, it's no surprise that De Young—executive vice president of De Young Properties—is a leader in the multifaceted effort to advance zero net energy houses in California, and possibly all across the world.

In Clovis, California, a city just east of Fresno, De Young Properties has built the largest community of single-family zero net energy houses in California. Known as De Young EnVision at Loma Vista, the 3,300-acre development is the result of a collaboration with EPRI, PG&E, and BIRAenergy.

Watch **a video of EPRI's Ram Narayanamurthy discussing research on advanced energy communities.**

On the surface, De Young EnVision appears ordinary. The 36 houses are exactly what one would expect in a tidy California suburb, with floor plans boasting nearly 4,000 square feet and upwards of seven bedrooms.

The future is in the details. Tesla rooftop solar systems offer capacities ranging from 5 to 9 kilowatts. Houses are constructed using highly energy-efficient building envelopes, materials, and insulation, cooled and heated with electric heat pumps, and wired for electric vehicle charging. The sealed building envelopes combine with effective air filtration systems to keep indoor air clean.

“Most buyers notice the indoor comfort, solar systems, lower energy bills, and better indoor air quality,” said De Young.

A house in the De Young EnVision community in Clovis, California. Photo courtesy of De Young Properties.

A Collaborative Project

De Young’s interest in building zero net energy houses is as much a response to the market as it is a commitment to sustainability. “Zero net energy is a natural extension of an important housing trend in our area,” said De Young. “Here in the Central Valley, energy bills are high and it’s hot. Air quality is bad and everyone knows it. Consumers want efficiency for lower energy bills, more indoor comfort, and clean indoor air.”

With assistance from EPRI, PG&E, and BIRAenergy, De Young Properties determined the right mix of technologies for zero net energy, decarbonization, affordability, and attractiveness to local house buyers. One point of discussion was whether to replace natural gas cooking with electric alternatives. De Young determined that most consumers prefer natural gas and that electric induction cooking wouldn't make sense as a standard offering. It is offered as an option.

The initial response to De Young EnVision has been overwhelmingly positive: 30% of the houses offered in the first phase were purchased their first weekend on the market in late 2017.

PG&E is incorporating lessons from De Young EnVision into its customer programs, electrification efforts, and other opportunities to support customers. It's also using what it has learned to help evaluate grid integration needs.

EPRI's role will continue after all the houses are occupied. "Our research will quantify the benefits and impacts of near-all-electric, smart, and energy-efficient houses and communities, such as reduced CO_2 emissions, increased customer choice, and energy savings," said Ram Narayanamurthy, an EPRI principal program manager. "We want to understand the economic and technical feasibility of developing communities like this one."

Advanced Energy Communities: Integrating Numerous Technologies

The De Young EnVision project is part of a larger EPRI effort to help develop *advanced energy communities*. This term encompasses communities that integrate multiple customer resources, such as energy efficiency, demand response, connected devices, energy storage, solar or other on-site generation, electric vehicles, and other electrification technologies. They are intended to advance social and utility goals such as decarbonization, grid hardening, and grid support while enabling comfort, convenience, and affordability for customers. Zero net energy is one example.

EPRI is assisting in the technical aspects of numerous advanced energy communities in California and beyond. EPRI worked with Southern California Edison (SCE) to help develop zero net energy neighborhoods in Fontana and is assisting with a project in Irvine to construct all-electric, zero-carbon, multi-family houses. The Fontana community has already demonstrated the favorable economics of combining solar and energy efficiency. It also provides insights regarding how customers want advanced energy technologies to work in the background, improve comfort, and reduce costs.

Other benefits emerged as well. "Fontana is located in a very windy area, and customers like that the houses' good insulation reduced the noise from outside," said Narayanamurthy. "They like that the houses felt stable and didn't have things shaking around. Inside, the temperature is very even without any drafts or cold spots, creating a Zen environment."

In all these projects, EPRI provides technical assistance on the selection of technologies, monitors the communities' energy performance and impacts, and brings collaborators together. "We bring together builders and utilities to help develop new housing concepts that meet the needs of house buyers," said Narayanamurthy. "It's in the true spirit of EPRI as a public benefits research organization."

A Trend with Momentum

California utilities and builders face the common need to understand the impact, feasibility, and appeal of zero net energy communities. The state's ambitious greenhouse gas reduction goals aim to cut emissions to 1990 levels by 2020 (a reduction of about 30%), followed by an 80% reduction from 1990 levels by 2050. The state's Long-Term Efficiency Strategic Plan established a goal for all new houses to be zero net energy by 2020, and the state has committed that all new public buildings be zero net energy by 2025 and all new commercial buildings by 2030.

California isn't alone in pursuing zero net energy buildings. The European Union set a target that all new houses be "nearly zero" net energy by 2021.

The broader concept of advanced energy communities also is gaining ground. EPRI has been working with Southern Company in Alabama and Georgia to monitor advanced energy communities that incorporate numerous customer resources (such as high-efficiency HVAC systems, more efficient construction, heat pump water heaters, solar, and storage) and enhance utility infrastructure with microgrids. These efforts can enable new utility services that increase customer satisfaction.

The growing, mainstream interest in advanced energy communities could not be foreseen just a few years ago. "The first zero net energy house I was aware of was built in San Jose in 2011, and the builder spent an extra $100,000 to achieve it," said Peter Turnbull, who leads PG&E's Zero Net Energy Program.

De Young EnVision adds to a growing number of advanced energy communities demonstrating practicality and affordability for house owners and builders today. According to Turnbull, PG&E has worked with Habitat for Humanity to build zero net energy houses for low-income residents at no additional cost relative to the organization's base models.

Results and lessons from EPRI's work with its collaborators in Clovis, Irvine, and elsewhere are revealing ways to drive down costs. "EPRI, PG&E, and other utilities are working with builders and innovating least-cost methods of high performance in these houses," said Turnbull. "There are lots of ways to do it, and these projects help provide the quickest way to get there."

Understanding Grid Impacts

While housebuilders can use advanced energy communities to test new technologies and demonstrate the comfort and convenience of ultra-efficient houses, utilities can gain a better understanding of potential grid impacts.

"We participate in these demonstrations not only to test the technologies," said Jerine Ahmed, a senior engineer with SCE's Emerging Products Group. "We also look at the impacts of these buildings on the electric grid and how to mitigate them so that we can still provide reliable, safe, and affordable power."

A recent study by SCE on grid impacts of the Fontana community raised an important question: Would extensive zero net energy development across its California service territory impact the utility's traditional distribution planning? Traditionally, the utility used air conditioning loads as the primary driver for calculating expected system peaks. The study suggested that load profiles of zero net energy communities may require new approaches for determining peaks, along with infrastructure investment. For example, communities with substantial solar capacity produce more energy through the day as the sun shines and have a steep load ramp in the evening as solar generation decreases. The resulting net load profile, known as the duck curve, could require new ways of operating the distribution system and energy storage to manage the peak loads. Electric vehicle charging could also be an important factor in future load profiles.

Based on the Fontana experience, SCE gained a better understanding of potential impacts on switches, relays, and other feeder equipment. It found that customer-sited battery energy storage, when configured correctly, provided emergency power backup to customers. But the ability to reduce grid impacts was limited because the battery capacity (6.5 kilowatt-hours) was not sufficient to significantly reduce peak loads. Future research could evaluate how larger battery size could help optimize residential energy use with changing grid conditions (for example, use less energy during peak demand). Fontana can also provide insights on how distribution standards might need to be modified to accommodate more zero net energy communities.

“We are still collecting and analyzing the data on these facilities,” said Ahmed. “Fontana was the first zero net energy neighborhood we worked on. In the past it was one or two houses at a time. This experience helps us design incentive programs and work effectively with builders.”

In Irvine, SCE and EPRI will investigate zero net energy in townhouses and condos, in which many urban southern Californians live. “This project will be an all-electric community,” said EPRI’s Narayanamurthy. Besides highly efficient insulation and HVAC systems, the 44 residential units will have electric heat pumps, water heaters, appliances, and cooktops.

While new lessons about grid impacts and technical challenges will emerge in Irvine, the needs of housebuyers will likely remain constant. “Customers want these technologies to make a difference on comfort, cost, and convenience—and otherwise operate in the background,” said Narayanamurthy.

Key EPRI Technical Experts

Ram Narayanamurthy