SMART-TECH HOUSING DEVELOPMENTS IN THE SOUTHWEST:
GRID-INTEGRATED AND ENERGY EFFICIENT
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ABOUT THE SOUTHWEST ENERGY EFFICIENCY PROJECT

The Southwest Energy Efficiency Project is a public interest organization dedicated to advancing energy efficiency in Arizona, Colorado, Nevada, New Mexico, Utah and Wyoming. For more information, visit www.swenergy.org

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PRODUCTION

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EXECUTIVE SUMMARY

Smart Home Systems Now Help the Utility Grid

The recent revolution in digital communication and smart home systems—allowing homes to connect and automate thermostats, lighting, music, security, refrigerators, and more—has spread to the energy sector as well. Not only can homes connect and automate their own appliances and devices to save energy, they can connect to the broader utility grid to manage electricity use during peak times (the "rush hour" of energy use), as well as manage and integrate renewable sources of energy. Home builders, recognizing consumers’ desires for more energy efficiency and renewables, are integrating smart energy solutions into their new developments. And utilities, taking note of this trend, are partnering with some of the builders and developments to test and deploy various solutions and arrangements.

The pieces are there and the opportunity is there, but how prevalent is this trend, really? We undertook this study in the Southwest to understand the penetration level of smart, connected, energy-saving, and grid-integrated technology in new housing developments. We found a few great examples that showcase the future of grid-integrated communities.

How do these all connect? Where are examples? Read on.
INTRODUCTION

Dumb Systems Become Smart

Ninety percent of U.S. consumers own at least one smart home device. (1) “Siri, turn on the lights in the living room.” “Alexa, close the blinds.” “Google, turn down the thermostat two degrees.” Phrases such as these, never uttered a decade ago, are now common lingo and show how consumers have embraced the “Internet of Things.” As consumers are increasingly intrigued by these connected devices in houses, home builders are jumping on opportunities to integrate them in new homes as a way to set themselves apart. Since home buyers are also demanding homes with ultra-efficient construction, solar power, battery storage, and energy monitoring, many of these same home builders are integrating these features as well.

The result: flexible, smart, efficient, connected, and interactive technologies integrated into new housing developments and seamlessly interacting with the power grid.

Take smart thermostats, for instance. Consumers love how they are attractive, user-friendly, and visible, whereas traditional energy efficiency products had operated behind the scenes with little fanfare. Utilities love them because they can get further granularity of energy use information, and that leads to opportunities to reduce energy demand during peak periods—when power is the most expensive. They’d historically used simple controls that could modulate customers’ air conditioning during peak times (with the customers’ permission), but this could only go so far.

With advancements in digital communications and renewables, the promise is there—and arguably, the technology is there as well. However, all of the pieces are not necessarily in a position yet to work together. The grid of today, made up mostly of legacy systems, does not easily move data between the end user and the electric grid. Nor does it allow a utility to support the dynamic use of energy and provide dispatchable resources where needed.

That’s why we’re excited to showcase housing developments in the Southwest that are making it happen. These examples that follow help us understand where we stand now—and point to where we will stand in a few years.
A BRIEF HISTORY OF COMMUNICATION AND MONITORING DEVICES, AND AN AMUSING ANECDOTE

Thomas Edison—yes, you knew this section would start with him—had a mathematician and physics colleague in his Menlo Park, NJ laboratory who helped on the early development of the incandescent lamp and watt-hour meter, and who became a partner and general manager of the Edison Lamp Works. This gentleman, Francis Robbins Upton, invented and patented the very first automatic fire alarm in 1890. An alarm would sound when the temperature of the room became too high. But—funny story—the accomplishment got overlooked initially because a typographical error labeled the device a “Portable Electric Tire-Alarm” rather than a “Portable Electric Fire-Alarm.”

The point is—for almost as long as we have had electricity we’ve had metering and automated safety features. Jump forward 129 years, and we now have homeowner-controlled smart appliances such as thermostats, lights, security, water irrigation, doorbells, cameras, stereos, and monitoring devices. Artificial Intelligence (AI) has been integrated into many of these, learning occupant behavior patterns and anticipating needs in order to increase convenience, save resources, and provide a safety feature. Tying in some of these to the electric grid is the next step—and is already in progress.

Francis Robbins Upton’s “Portable Electric Tire Alarm” shows that automated smart appliances go back a long way, as does the importance of proofreading. And he can’t even blame it on autocorrect.
Mandalay Homes was a 2019 ENERGY STAR Partner of the Year, receiving the Sustained Excellence Award, the highest honor of the ENERGY STAR Award winners, given to builders who have previously received the Partner of the Year award for at least two consecutive years. (2) That award is the latest in a long list of accomplishments including winning the U.S. Department of Energy (DOE) Zero Energy Ready Home (ZERH) program awards for Innovation in Affordable Housing, Production Housing, Most Homes Certified, Hive 50 Innovator Award, and Arizona Forward First Place Environmental Excellence Award of Merit. Mandalay Homes certifies 100 percent of their homes to DOE ZERH levels and has produced the most ZERH in the nation. (3)

Mandalay’s Arizona customers have embraced residential solar. The electricity production during the sunny middle of the day exceeds the households’ demand. Solar energy production decreases later in the day, though, just as people are coming home from work, turning on appliances, and cranking up air conditioners. In utility-speak, this is called the “Duck Curve,” which is a graph of solar power production over the course of a day that shows the timing imbalance between solar generation and peak demand, with the line shape resembling the shape of a duck.

Arizona Public Service has a Time-of-Use (TOU) rate structure, where energy costs are lower when the electricity supply is plentiful and higher when energy supply is strained. (4)

Mandalay Homes’ latest innovation in home building is the “Ion Series.” It combines an all-electric ZERH-certified home that has a Home Energy Rating Score (HERS) rating in the low 40s, with a small 2-kW solar PV system and a 10 kWh sonnenCommunity battery storage system. (5) Mandalay Homes is building its Ion Series in all of its four latest developments in Arizona’s Prescott Valley. Excess solar energy generated during the day is stored in each home’s smart battery and discharged later in the day for that home’s use.
With the objective of relieving pressure from the grid and reducing Arizona’s carbon footprint, Mandalay Homes “loosely” partnered with Arizona Public Service (APS) to garner a new rate plan incentive of $0.0475 per kWh by not drawing power from APS between 3-8 P.M., thus avoiding demand charges and higher rates. The battery storage systems on each house store low-cost, off-peak APS power and excess daytime solar generation, and release it again during peak times as needed.

The combination of solar PV and battery storage systems are eligible for the 30 percent Federal Innovation Tax Credit. (6)

Mandalay Homes buys everything in bulk and their Ion tech team installs the systems, driving the costs way down. The homeowner owns the system completely. Innovation per home is valued at $20,000. After rebates, the generation and storage system costs $5,000, adding to $20 per month to the mortgage and a relatively short payback period of six to seven years. Average monthly electric bills are under $40, compared to $140 for nearby average code homes. Natural gas doesn’t come standard but it’s available for $1,500 plus appliance(s) costs.

Water saving is also part of Mandalay’s recipe, with better landscaping and outdoor water monitoring, saving an estimated 800,000 gallons of water per house per year.

"A true renewable energy future is not possible for our society, or for any society, without the deployment of distributed energy storage resources that properly manage clean energy production, storage, grid usage, and home energy demand in an intelligent way, providing energy independence and true carbon neutral living."

-- Dave Everson, CEO and Founder of Mandalay Homes
The local school district in Basalt was struggling to attract and retain quality teaching staff because of low wages—30% less than comparable schools—and high housing costs—30% more than comparable schools. This difficult situation resulted in an incredible community collaborative effort to build Basalt Vista, a net zero affordable housing community targeting teachers and other county employees.

The Roaring Fork Valley Habitat for Humanity and Community Office for Resource Efficiency (CORE) teamed together with a goal of providing the lowest possible utility bills for each resident. That led to the goal of building an affordable net zero community and making it a template for other communities to follow. The idea is spreading by using community residents as promoters and advocates.

THE GAME PLAN

Electrification. All power and heating will be solely electric, with no natural gas service. Traditional gas-fired furnaces and water heaters are replaced with cold-climate heat pumps—safer and several times more efficient than old-style electric baseboard heaters—and able to provide summertime cooling from the same unit. Since electric grids are growing cleaner, all-electric homes help communities meet their climate goals.

High-Performance Building Envelope. Airtight, well-insulated homes are a fundamental step to achieve net zero.

On-site Energy Production. Meeting every house's total remaining energy demand with onsite solar energy was the final component to this net zero community. Each home has an 8-kW rooftop solar system connected to the local utility, Holy Cross Energy.
To further boost the impact of the development, Holy Cross Energy committed to pioneering an affordable net zero community template by making Basalt Vista a “Live Learning Lab.” It partnered with Habitat for Humanity and the National Renewable Energy Laboratory on a pilot equipping the first four homes with lithium iron phosphate (LiFePO4) batteries. The pilot project partners are hoping to:

- Prove how adjusting energy production from solar arrays and battery storage at a home can be more cost-effective than modifying energy production at a centralized power plant;
- Manage on-site storage and smart controls to send excess daytime electric generation back to the grid when a) it's not needed by the house and b) it is needed by the grid;
- Study operational items like “islanding” or disconnecting this microgrid community from the larger grid;
- Learn how Holy Cross Energy can save its members money by reducing the amount of energy needed during high-cost peak periods;
- Save the housing development $30,000 to $40,000 by avoiding new natural gas lines, and save homeowners money by making each home ultra-efficient and adding solar. Bills are expected to be 85 percent less than the typical energy bill;
- Integrate state-of-the-art efficient appliances (e.g. “smart” clothes dryers, induction cooktop stoves, air source heat pumps, smart thermostats) and test their compatibility with on-site renewables; and
- Prepare for natural disaster protection. On-site battery storage could be useful in case outside electrical transmission is disrupted. The Lake Christine fire in 2018 charred trees visible above the town and severed three of four transmission line delivering electricity to Basalt, Snowmass, and Aspen.

By carefully monitoring and optimizing five different systems (solar, batteries, thermostat controlling a heat pump HVAC, heat pump water heater, and electric vehicle charging) every five minutes for four months, Holy Cross Energy had enough net excess renewable energy to construct the subsequent homes.

In late June 2019, the first two homes of 27 homes were turned over to local school and Pitkin County employees. The homes are priced at $270,000-$395,000 for two, three, and four bedroom units, each between 1,150-1,675 square feet. The Roaring Fork Valley Habitat for Humanity is also a new DOE ZERH Builder Partner, and subsequent homes may also be DOE ZERH-certified (a HERS rating mid-50s or lower, indoor AirPLUS checklist, and parts of WaterSense and PV Ready checklists).

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<th>Organization</th>
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<th>Donation</th>
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<tr>
<td>Roaring Fork School District</td>
<td>$3.2 million</td>
<td>Land for the development</td>
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<td>Pitkin County</td>
<td>$3 million+</td>
<td>Road and utilities</td>
</tr>
<tr>
<td>Community Office for Resource Efficiency</td>
<td>$107,500+</td>
<td>High efficiency cold climate heat pump, appliances, PV, energy systems design</td>
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<td>Town of Basalt</td>
<td>$30,000+</td>
<td>Reduced fees + $30,000 in-kind towards net zero construction</td>
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<td>Holy Cross Energy</td>
<td>$50,000+</td>
<td>Smart inverters, PV inverters, EV charger hook ups, hot water heaters, controllers, and loaner batteries for the first four homes in the “Live Learning Lab”</td>
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<td>Expert Electric</td>
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<tr>
<td>Sunsense Solar</td>
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<td>Installed solar at discounted rates</td>
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<td>Private Donor</td>
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<td>Specialized cookware for induction cooktops</td>
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Mattamy Homes is the largest privately-owned home builder in North America. Standard features in all of the 286 Haven Community homes in Chandler, AZ include ENERGY STAR certified appliances, EcoBee4 Wi-Fi-enabled smart thermostats with Amazon Alexa voice command, low-flow water fixtures, radiant attic barriers, MERV 8 air filters, LED lights, dual-pane windows, and insulated garage doors. (7)

Mattamy Homes has continued to see homeowner desire for more control over energy consumption and supply across the country, but particularly in Arizona where utility demand charges can skyrocket electric bills. Energy storage company Electriq Power is collaborating with Mattamy Homes for an advanced energy program upgrade option, including solar panel roofing and Electriq PowerPod battery-storage units. Other packages add a variety of smart-home features like a wireless security system, touchscreen deadbolt, wireless appliance plug-in, and smart garage door.

Here we see an example of a builder and battery storage company partnership to reduce homeowner utility costs, without the utility being an active partner in the arrangement. The model home pilot estimates $1,800 in savings per year while providing the added benefit of backup power. Marketing for the homes also touts a healthier living environment and a reduced carbon footprint.

The Soleil Community in Herriman, Utah, is testing a battery demand-response project with Rocky Mountain Power. The development has 600 one-, two-, and three-bedroom units, and the project includes 5.2 MW of solar and ~5 MW of batteries on buildings and carports. Batteries in the first building were installed in August 2019, with the rest finishing by 2020.

Soleil will own and maintain the batteries, and Rocky Mountain Power will dispatch and control the batteries as well as the software. While it’s not a true microgrid, it will function as one during parts of the year. Individual apartments can function as a microgrid only when solar generation exceeds usage.

The buildings are all-electric. Residents should see lower overall energy costs, have backup power in case of an outage, and live in a community that is minimizing air pollution. The intent is to charge the batteries from the solar power only, and the batteries are designed for daily cycling. Rocky Mountain Power will be looking at daily load-shaping and peak impacts.
The Sterling Ranch Development, located in Douglas County in the south metro Denver area, wraps around the southern edge of Chatfield State Park. It has a planned buildout of 21,000 homes and 2 million square feet of commercial space over 20 years.

While water supply and conservation are key concerns across Colorado, it’s especially strong in the Sterling Ranch Development. Houses will have rainwater harvesting, tiered indoor and outdoor water budgets, irrigation controllers, and low-water landscaped front yards, resulting in just over half the water demand of a typical house (0.400 acre-feet/year/res allowance compared to the typical 0.750 acre-feet/year/res).

The other headliner about Sterling Ranch is its inclusion of large-capacity, internet-connected “smart” infrastructure from the start. In other words, it’s an Internet-of-Things community. Houses include Siemens’s Steward System, a non-monitored security system that tracks water, gas, and electric use (only seen by the homeowner) as well as a voice-activated “personal assistant” that can adjust the thermostat or lighting, monitor security and door alarms, and provide community information. Each house also has pre-wiring for EV charging, and connection to the Sensus FlexNet communication network, an advanced walk/drive-by radio system for data collection. The streets will have connected streetlights that can automatically dim as well as show a colored-coded message to indicate an emergency, such as blue for fire.

With all the systems in place to monitor water, the local utility Xcel Energy decided they should also monitor energy as well. Xcel has partnered with Copper Labs on a pilot with 700 homes to transmit meter data to Alexa and the Cloud using the home’s Wi-Fi. Alongside the monitoring, the utility is testing direct messaging to motivate customers to reduce energy use.

Sterling Ranch is evolving and experimenting, trying to find state-of-the-art solutions to housing that meets both the technological opportunities and resource constraints of the future.
Peña Station NEXT bills itself as a “real-world smart city.” It’s a public-private partnership on a light rail line near Denver International Airport, and it’s aiming to create a microgrid model. As a proving ground for microgrid integration and connection, this mixed-use development is demonstrating and fine-tuning resiliency and protection against outages, two-way power flow, responsive infrastructure, and seamless renewables and storage integration.

Stakeholders include Xcel Energy, Younicos (experts in megawatt battery storage, software and embedded energy management system), City and County of Denver, L.C. Fulenwider, Inc. (a sustainability-minded real estate developer) and Panasonic (Pena Station NEXT anchor corporate tenant, smart and sustainable technology lead, and invested equity partner).

The initial phase of this 382-acre transit-oriented development received two years of Innovative Clean Technology (ITC) funding from Xcel Energy. A single building—the Panasonic Headquarters—will test out serving as a “nano microgrid,” small microgrids typically serving a single building or a small load. The development has a PV system on the carport covering the buildings’ parking lot and another on the light rail station parking lot, a battery energy storage system, an islanding switch, and all related protection systems to make sure power only flows where and when it is meant to. The development is also envisioned to include EVs, autonomous vehicles, autonomous shuttles, and other mobility and connection options. Further construction is underway.

Panasonic’s Peña Station NEXT aims to be a “real-world smart city.” Located on a light rail line near Denver International Airport, it will eventually have commercial, residential, and mixed use full of smart connected infrastructure.
A large net zero energy community with modular housing is being built on 1,100 acres in Pueblo. These are not the modular homes of yore however, with the next-generation designs looking every bit like a stick built home, and built to very high efficiency standards from a factory located near the community. Every single one of the estimated 4,850 homes will be Department of Energy Zero Energy Ready Home (ZERH) certified, which includes not just low energy use but also water and indoor air quality thresholds. Sale and development of the first 162 homes began in the spring of 2019. The development will also include retail, office and commercial space.

The developer partnered with local ZERH modular factory home builder Sprouts Tiny Homes—although at 1,600 square feet the homes are not tiny.

Smart home automation—yes, that’s included. In addition to being DOE ZERH certified, these modern modular homes feature Structural Integrated Panels (SIPs) in the walls and truss, and radiant floor heat.

David Resnick, the developer of North Vista Highlands, described the philosophy behind “Sprouts” homes as “a drive toward smaller footprints and higher quality interiors that make you want to socialize and gather within a home. This can help cure a lot of social ills. This is the future of smart housing. We do not need expanding homes that create isolation, we need homes that create comfort, security, and connection.”

Fort Collins, Colorado is home to another large net zero energy development, with 4,000 next-generation modular homes planned over a 20-year build-out. Every home will be built in a factory onsite and will be DOE Zero Energy Ready-certified.

Montava bills itself as a “Complete Community,” designed to meet the basic needs of all residents with integrated land use planning, transportation planning, community design, and diversity. It’s based on New Urbanism-Mixed Income, where big homes may be next to small, residences may be above commercial spaces, and transportation, natural areas, and trails are planned from the beginning. Highlights of the development include:

- **Agri-Urban Community:** A farming community is woven together with housing and commercial;
- **Affordable Housing:** 10% of the homes will be affordable throughout the community;
- **Dark Sky Compliant:** Lighting plans and fixtures will reduce light pollution; and
- **Natural Areas:** 150 acres of storm water runoff will be restored to native areas, and a trail system will connect the farms and community.

How about smart appliances? These will be incorporated generally but not explicitly. The developer, Max Moss, said they will be building a community-wide platform of connectivity that will enable things like water monitoring and energy monitoring. “We’ll build a platform, then builders and homeowners will add layers to it,” said Moss.
WHAT WE OVERHEARD

The Future of Integrated Microgrids: Automatic & Managed

1. Some home buyers that are interested in technology have an interest in monitoring energy usage, but often only for a few weeks. Then, they're happy to let automation continue managing it for them.

2. Many home buyers don't care about the inner workings of the technology; they just want “it” to work. They're more interested in comfort, health, and savings. Too much energy data and monitoring can be overwhelming, and some also worry about the security of the data.

3. People currently report more trust in their local utility compared to a builder/developer or product manufacturer.

4. Incentive programs help encourage hesitant customers to participate in utility programs.

5. Utilities and cities want more publicly-available mapping resources so developers can know the solar capability of the feeders.

6. Through pilot programs and innovative developments, utilities are gaining experience and knowledge about the benefits of grid integration.
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