

**DOE CHALLENGE HOME
CASE STUDY****Mandalay
Homes**

Phoenix, AZ

**BUILDER PROFILE****Mandalay Homes**

Builder: Dave Everson
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FEATURED HOME/DEVELOPMENT:**Project Data:**

- Name: Gordon Estates
- Location: Phoenix, AZ
- Layout: 4 bedrooms, 2.5 baths, 1 floor
- Conditioned Space: 1,700 ft²
- Completion: June 2013
- Climate Zone: 4
- Category: Affordable

Performance Data:

- HERS Index without solar PV: 58
- HERS Index with solar PV: 38
- Projected annual utility costs: without solar \$1,179; with solar \$905
- Projected annual energy cost savings (compared to a home built to the 2006 IECC): without solar \$583; with solar \$857
- PV production revenue: \$274
- Builder added first costs (compared to a home built to the 2006 IECC): \$7,650
- Annual energy savings: with solar 10,135 kWhs or 40.1 MMBtus; without solar 8,848 kWhs or 30.2 MMBtus

When builder Dave Everson, owner of Mandalay Homes, first heard about the U.S. Department of Energy's Challenge Home program, he was skeptical. The production home builder was focusing much of his time on affordable housing renovations for the City of Phoenix. The builder was already at better-than-code construction; he wondered how seeking even higher performance might impact the affordability of his homes.

But when the City of Phoenix awarded him the contract to build 14 new homes at Gordon Estates, a foreclosed subdivision of mostly empty lots, they stipulated that the homes should be a showcase for energy efficiency. When the previous builder foreclosed with only 6 of the 20 lots built, the property reverted to the city, which used federal Neighborhood Stabilization Program funds to sponsor the new construction there and in other Phoenix neighborhoods. The city recommended that Mandalay attain the National Green Building Standard (ICC 700) certification. Everson worked with green building consultant Philip Beere of G Street, who suggested the builder also pursue the EPA WaterSense and Indoor airPLUS certifications. Beere also introduced Everson to the DOE Challenge Home Program and suggested Everson use the HERS index as a design tool to pursue Challenge Home certification. Since the DOE program encompasses WaterSense and Indoor AirPLUS, Challenge Home certification was the next logical step.

Everson was taken with the idea of cutting his homes' HERS scores. "Everson really embraced the HERS index as a design tool. It became a challenge—how low can we go?" said Beere, who worked with Everson to bring his green homes to market. G Street provided third-party certification management, marketing tools, homeowner education, and design guidance. Everson had been following ENERGY STAR Version 2.0 for air sealing before Gordon Estates and analysis of some of his previous market-rate homes showed he had been achieving HERS



DOE Challenge Home builders are in the top 1% of builders in the country meeting the extraordinary levels of excellence and quality specified by the U.S. Department of Energy. Every DOE Challenge Home starts with ENERGY STAR for Homes Version 3 for an energy-efficient home built on a solid foundation of building science research. Then, even more advanced technologies are designed in for a home that goes above and beyond current code to give you the superior quality construction, HVAC, appliances, indoor air quality, safety, durability, comfort, and solar-ready components along with ultra-low or no utility bills. This provides homeowners with a quality home that will last for generations to come.

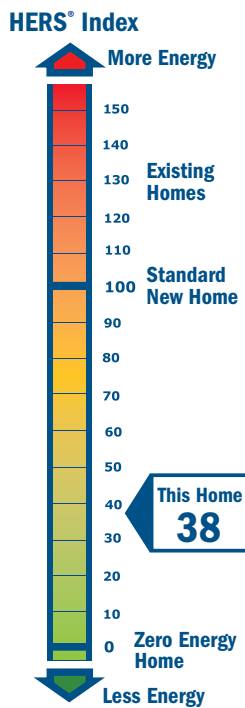
Jesse Garcia, City of Phoenix project manager; Danny McDevitt, Mandalay Homes project manager; and Daran Wastchak of Best Energy Rating, inspect a home at Gordon Estates.

The underside of the roof is covered with 5.5 inches (R-20) of closed-cell spray foam, which provides a protected attic space to shield the HVAC equipment from the extreme heat of a Phoenix summer. The walls are filled with 3.5 inches of closed-cell spray foam, which provides excellent insulating and air-sealing properties.



CHALLENGE HOME CERTIFIED:

- 1 BASELINE**
certified ENERGY STAR for Homes Version 3.0
- 2 ENVELOPE**
meets or exceeds 2012 IECC levels
- 3 DUCT SYSTEM**
located with the home's thermal boundary
- 4 WATER EFFICIENCY**
meets or exceeds the EPA WaterSense Section 3.3 specs
- 5 LIGHTING AND APPLIANCES**
ENERGY STAR qualified
- 6 INDOOR AIR QUALITY**
meets or exceeds the EPA Indoor airPLUS Verification Checklist
- 7 RENEWABLE READY**
meets EPA Renewable Energy-Ready Home.



scores in the high 60s, but with Challenge Home most of his homes are now in the low 50s, without solar. “He was always doing quality construction but now that he is using the HERS score, he can test the quality of his construction,” said Beere.

Mandalay achieved Challenge Home certification on all 14 homes at Gordon Estates. Every Mandalay home in the development also met the National Green Building Standard gold level. “Our energy efficiency and education scores were much higher than even the emerald level of the standard,” said Beere, but location limitations prevented the emerald rating.

To explore their options, G Street and Mandalay conducted a pre-design charrette. “This was a critical step in achieving a design strategy that resulted in superior health and energy performance while keeping the budget affordable,” said Beere. In addition to Everson and Beere, participants included the energy rater, mechanical engineer, architect, Mandalay Homes project managers, landscape architect, and National Green Building Standard verifier.

One of the most significant changes for the builder was transitioning from an uninsulated, vented attic to an attic that was insulated along the underside of the roof line with icynene closed-cell spray foam. In the fierce heat of a Phoenix summer, this insulated attic provides a much cooler environment for the home’s heat pump air handler and ducts. The builder ran the calculations on several options to determine the optimal set of measures for his climate zone. The wall cavities were filled with 3.5 inches of spray foam and an additional one inch of open-cell foam was installed on the outside of the framed walls, over the housewrap, to serve as a base for the one-part stucco wall cladding while also providing a thermal break. The 2x6 16-inch on-center walls incorporated some advanced framing techniques like two-stud corners and ladder blocking at intersecting interior walls to allow for more insulation but Everson is considering using 2x4 24-inch on-center framing for cost savings in future projects because analysis showed only a slight increase in insulation value when more than 3.5 inches of spray foam was added to the walls. The 3.5 inches of spray foam provides an R-13 insulation value while also sealing the walls against air leaks. Blower door tests confirmed the air-tight construction with impressive results of 2.73 air changes per hour at 50 Pascals pressure.

On the Gordon Estates homes, Mandalay installed a unique solar system that provides water and space heating and ventilation as well as electricity production from a roof-mounted photovoltaic system. The photovoltaics are integrated into a

“I love the fact that Challenge Home is performance-based instead of prescriptive. It allowed us to experiment, to see what works with our climate and building practices,” said Everson.



The windows are double pane and vinyl framed with low-emissivity coatings to reduce heat loss in winter and minimize heat gain in summer. The house has fewer windows on the west side to reduce solar heat gain. However, the open design ensures there is daylighting throughout the home, nearly eliminating the need for artificial light during the day. All of the home's light fixtures are fitted with LED or fluorescent bulbs.

patented triple-layer panel that mounts directly to the sub-roof. The panel has built-in ventilation channels that allow air to flow under the PV layer, which cools the PV and increases its electricity production. The ventilation air absorbs heat as it flows through the channels. This hot air is directed into the attic to flow across a heat exchanger that heats water for the home's domestic hot water needs. If the home's thermostat is calling for heat, the hot air can be further directed into the HVAC system's supply ducts to help heat some rooms of the house. If the heat is not needed, it is exhausted outside of the house.

The solar system can also function as a night ventilation cooling system. If the house's thermostat is calling for cooling, and the air outside is at least 5 degrees cooler than the ambient air inside the home (for example at night or early morning), the system can draw outside air through the ventilation channels and into the HVAC supply ducts to help cool down the house.

The system functions as part of the home's ASHRAE 62.2-compliant ventilation system, along with timer-controlled bath fans. Air is drawn in through an 8-MERV filter located in the attic. The system includes electronics that operate the homes' HVAC air handler fan, a compressor, and a thermostat to control how much air comes in based on interior and exterior temperatures. The controls can be accessed remotely via the internet.

In addition to the solar system, the Gordon Estates homes are also equipped with a high-efficiency (14 SEER, 8.2 HSPF) heat pump. The air handler and R-6 flex ducts are located in the insulated attic. The fan coil for the solar water heater is located in the attic and heated water is routed to a 150-gallon storage tank in the garage, which has an electric heating element if needed for back up.

To meet the requirements of the EPA WaterSense certification and the National Green Building Standard (ICC-700), Mandalay implemented several resource efficiency strategies at the site, including a natural resource inventory, preservation of existing foliage, creation of a non-invasive landscape design, and installation of drip irrigation, solar sync timers, rain sensors, composting bins, and permeable surfaces. All cabinetry and finishes in the home are low or no VOC. Construction debris was recycled.

The experience of building to Challenge Home performance levels made such an impression on Everson that he stopped production on a market-rate development he had started in Prescott, Arizona, for several weeks while

HOME CERTIFICATIONS:

DOE Challenge Home

ENERGY STAR Version 3

EPA WaterSense

EPA Indoor airPLUS

NAHB National Green Building Standard
- Gold



Every DOE Challenge Home combines building science specified by ENERGY STAR for Homes and advanced technologies and practices from DOE's Building America research program.

Mandalay redid their entire product line to incorporate what they learned on the Challenge Home. “We re-engineered the houses so it would be viable to get the costs down and still keep the integrity of the architectural design,” said Everson. “We wanted to get below [HERS] 50 without renewables.”

Everson has committed to achieving DOE Challenge Home certification on about 100 more new market-rate homes he will complete in Prescott, Prescott Valley, Chino Valley, Payson, and Phoenix, Arizona, in 2013 and 2014.

Although the planning time cost Everson some money, because he wasn’t selling houses while he was retooling his designs, the builder says that he has been able to keep actual construction costs down through production efficiencies and by identifying cost tradeoffs (for example, the spray foam costs more, but the HVAC system could be down sized). He made the foam more affordable by working with the foam vendor to get better prices in return for a commitment to install foam on whole developments this year.

In addition to the already low HERS score due to energy efficiency, Mandalay will be offering a 3-kW solar photovoltaic package on new market rate homes that will bring the HERS score down to a HERS 24 for a cost of \$9,000 to the builder with additional rebates to the home buyer. Or, home buyers can bring their home down to a HERS zero with a 6- or 7-kW system costing about \$18,000 before government incentives, which include \$1,500 from the state plus 30% of initial purchase and installation costs from the federal government. These costs are based on a standard photovoltaic-only system, which is less expensive than the PV/water/space heating system Mandalay installed at Gordon Estates.

Everson ran a small experiment to compare the performance of the two solar systems using model homes at his Prescott market rate development. In one home he installed the combination system with 1.4 kW of PV; in the other home he installed a standard 3-kW PV system with an on-demand water heater and an ERV. Overall energy savings were very similar, while installation costs were just slightly higher for the combination system.

Learning new ways to build has made the project fun for Everson, a third-generation home builder who has been working in construction for 28 years. The positive vibe has filtered through the whole company. “When you meet the HERS goal, it makes sense, it’s tangible, it’s something we’re all proud of. It shows in the attitude of everyone at the company, from the supervisors to the sales staff to the subs,” said Everson.

The City asked Mandalay to make Gordon Estates a showcase and they have. Mandalay hosted on-site education workshops developed by Beere and G Street. For the workshops, Mandalay kept one home at the pre-drywall stage so visitors could see the story behind the walls, including the insulation, air sealing, and HVAC equipment. Through these events, the company has hosted hundreds of visitors including realtors, state and local officials, other builders, university students, potential homeowners, and curious members of the public.

KEY FEATURES

- **Path:** performance
- **Walls:** 2x4 24-inch on-center, 3.5 inches closed-cell spray foam (R-13) in walls; housewrap on studs plus 1 inch of open-cell rigid foam and 1-coat stucco.
- **Roof:** 5.5 inches (R-20) closed-cell spray foam insulation along underside of roof deck for an unvented, insulated attic
- **Foundation:** post-tension slab, no insulation
- **Windows:** double-pane, vinyl-framed, low-e windows; U=0.34, SHGC=0.18
- **Air Sealing:** 2.56 ACH 50
- **Ventilation:** ASHRAE 62.2-compliant fresh air intake with solar system, kitchen exhaust fan, timed bath exhaust fans
- **HVAC:** 14 SEER, 8.2 HSPF air source heat pump with R-6 flex ducts in conditioned attic
- **Hot Water:** solar air over water coil in attic, with a 150-gallon tank with backup electric element in garage
- **Lighting:** 100% high efficacy LED and fluorescent
- **Appliances:** ENERGY STAR dishwasher, clothes washer, refrigerator
- **Solar:** 1.56 kW combo system for PV/water heating/space heating/ventilation
- **Water Conservation:** EPA WaterSense fixtures, drip irrigation, solar sync timers, rain sensors, preservation of existing plants, xeriscaping
- **eMonitor Management System:** for solar system and HVAC
- **Other:** all cabinets and finishes are low- or no-VOC; composting bins, and permeable surfaces

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For more information on the **DOE Challenge Home**,
go to www.buildingamerica.gov/challenge

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