The U.S. Department of Energy invites home builders across the country to meet the extraordinary levels of excellence and quality specified in DOE’s Zero Energy Ready Home program. Every DOE Zero Energy Ready Home starts with ENERGY STAR Certified Homes Version 3.0/3.1/3.2 for an energy-efficient home built on a solid foundation of building science research. Advanced technologies are designed in to give you superior construction, durability, and comfort; healthy indoor air; high-performance HVAC, lighting, and appliances; and solar-ready components for low or no utility bills in a quality home that will last for generations to come.
The lot provided some challenges for solar potential. The wooded 11-acre parcel already had a 3.5-acre pond, a barn, a shed, an existing occupied home that was staying, and limited locations suitable for a drain field. Kuntz originally hoped to convert the shed into a home, but after site visits he and Imery decided the shed would not work due to its orientation, existing trees, and structural limitations. They thought however, that the barn could be repurposed as a detached two-car garage with solar panels installed on the roof and the new zero energy home could be built next to it.

To achieve the goal of a home that performed at net zero or better, Imery sought to first design a highly insulated building envelope that would be resilient to the location’s ever present precipitation and humidity. The next step was to add high performance HVAC, then to determine how much solar would still be needed to get to zero. “We relied heavily on our experience with Zero Energy Ready Homes, Passive House design, and energy modeling software, as well as the HVAC expertise of Mitsubishi’s construction team,” said Imery. Imery designed a modern farm house-style home that was 1,863 ft², with one and a half floors, 3 bedrooms, 3 baths, and no basement. The home design achieved a projected Home Energy Rating System (HERS) index score of 46 without PV, or minus 13 when the PV was added, far below the HERS 80 to 100 of typical homes built just to code and even well below the HERS 0 of a home that makes just as much power as it uses over the course of a year.

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“The moment we had established a good schematic design of the home and a baseline energy model, we then proceeded to estimate the construction cost of the home,” said Imery. “Our process goes through a reality check at this point to minimize the risk of designing something that the owner can’t afford. We completed the estimate and came in within the target budget, which then allowed us to complete the architectural design and value engineer the home.”

One result of this value engineering process was that Imery decided to change his wall design from a 2x6 24-inch on-center wall with R-6 exterior rigid foam sheathing to R-3 exterior sheathing installed over 2x4 studs staggered on 2x6 plates, where the studs are spaced 12 inches apart, with studs staggered to touch the interior edge and the exterior edge every 24 inches. This wall gave them the same performance as the 2x6 stud wall according to the energy models, and allowed the R-21 of blown cellulose to wrap around the inside edges of each stud, preventing thermal bridging across the wall. Thermal bridging was further stopped by the R-3 layer of rigid foam adhered to the coated OSB exterior sheathing product. The sheathing was taped at the seams to seal out air and water, then was topped with a stiff corrugated plastic rain screen product before installing the fiber cement siding.
The builder incorporated several advanced framing features into the framed walls, including insulated three-stud California corners, insulated headers over windows, and no solid headers on non-load-bearing walls, ladder blocking at interior/exterior wall intersections, and reduced lumber around windows and doors. Air sealing techniques included using canned spray foam and caulk to seal top and bottom plates, rough openings around windows and doors, and interior wall penetrations around mechanical, electrical, and plumbing, etc. Open-cell spray foam was installed in hard-to-reach places and critical areas such as band and rim joists. On the exterior, any penetrations through the envelope were sealed with either stretch tape or traditional tape. Third-party blower door testing is a required part of the DOE Zero Energy Ready Home certification. Testing of this house showed air leakage of 2.69 air changes per hour at 50 Pascals.

Energy modeling and past experience with Passive House strategies also influenced attic design, helping Imery to determine that a vented attic with blown cellulose was a better option than an unvented attic with spray foam on the underside of the roof decking. Imery designed vaulted ceilings with scissor trusses chosen to accommodate R-50 of blown cellulose. The roof decking consisted of a coated OSB sheathing product that was taped at the seams and flashed, then topped with 1x4-inch furring strips and 26-gauge standing-seam metal roofing.

Because the home site was less than 100 feet from the lake, Imery chose a raised slab foundation to minimize flooding risks. A footing was poured then a 3-foot stem wall was constructed out of 8-inch concrete masonry unit (CMU) blocks that were filled solid with concrete. The interior of this CMU perimeter was filled with dirt that was compacted, then topped with 4 inches of #57 stone, which was leveled. This was topped with 1 inch of R-10 rigid foam. Then 6-mil polyethylene vapor barrier sheeting was laid and the seams were taped, then the 4-inch concrete floor slab was poured.

“Controlling water in all of its forms is paramount for the durability of the home and the quality of the air inside the home,” said Imery. “The end result was fantastic—a home that kept water intrusion out, with a good sweater (exterior continuous insulation), and properly ventilated walls and attic.”

For windows, the owner requested triple-pane windows. Energy modeling actually showed more benefit from insulating the edges of the foundation slab then from upgrading from double-pane to triple-pane windows. The owner found a bargain on triple-pane windows and they ended up installing both the triple-panes and the slab-edge insulation. The triple-pane, argon-filled, vinyl-framed, mostly casement

HOME CERTIFICATIONS

- **DOE Zero Energy Ready Home Program**
- **ENERGY STAR Certified Homes Version 3.1**
- **EPA Indoor airPLUS**
- **DOE Zero Energy Ready Home Quality Management Guidelines**
- **EarthCraft House**

“Despite extremely energy-efficient design, there was no compromise on aesthetics and only a reasonable cost premium.” Homeowner

Every DOE Zero Energy Ready Home combines a building science baseline specified by ENERGY STAR Certified Homes with advanced technologies and practices from DOE’s Building America research program.
A prototype split-system heat pump water heater was tested in the home that pulls heat from outside rather than inside in winter. ENERGY STAR appliances and LED lighting add to energy savings, while low- and no-VOC paints and finishes contribute to cleaner indoor air.

The builder used energy modeling and worked with an HVAC consultant and Mitsubishi’s construction team to help design the HVAC system, which consisted of three ductless mini-split heat pumps (one in each bedroom) and one ducted mini-split (to supply the common areas), with a heating efficiency of 10 HSPF and a cooling efficiency of 20 SEER. The ducts for the ducted heat pump were all short, rigid metal ducts located in conditioned space. The three ductless units are hooked to one outdoor condenser, while the ducted mini-split is connected to a second outdoor condenser. That second compressor is shared with a prototype split heat pump water heater being tested by Mitsubishi. This split system uses the HVAC’s outdoor condenser to capture heat from the outdoors during the winter so it isn’t robbing the home of space heat to heat the water as other heat pump water heaters typically would. In the summer, it will use the heat pulled from inside the home by the HVAC system, rather than that heat being discharged outside, so in that sense it’s contributing to cooling the home as well.

For ventilation the builder installed an energy recovery ventilator (ERV) with a relative humidity sensor on the intake port to limit outside air intake on very humid days. Imery also installed a separate in-wall dehumidifier to better manage latent loads given the expected low cooling load in the home. Bathroom exhaust fans were equipped with condensation sensors. All of the components are monitored by wireless devices and settings can be adjusted remotely.

Regarding the solar panels, Imery’s team originally determined that a 5.1-kW system would meet the net zero goal, but the client had access to discounted solar panels and upgraded to an 8.1-kW system. Thirty panels were installed and wired to a bi-directional inverter to then feed the house on true net metering. The bi-direction inverter will allow the homeowner to store solar-generated power in an electric vehicle and pump it back to the house when needed, or to a solar battery bank.

“We were ultimately able to determine the most cost-effective combination of assemblies,” said Imery. With the PV panels and the high-performance building envelope and mechanicals, Kuntz should pay less than $10 a month in power bills. The home is estimated to save $2,150 per year in energy costs compared to a home built to code.

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Photos courtesy of Imery Group