By Clayton DeKorne

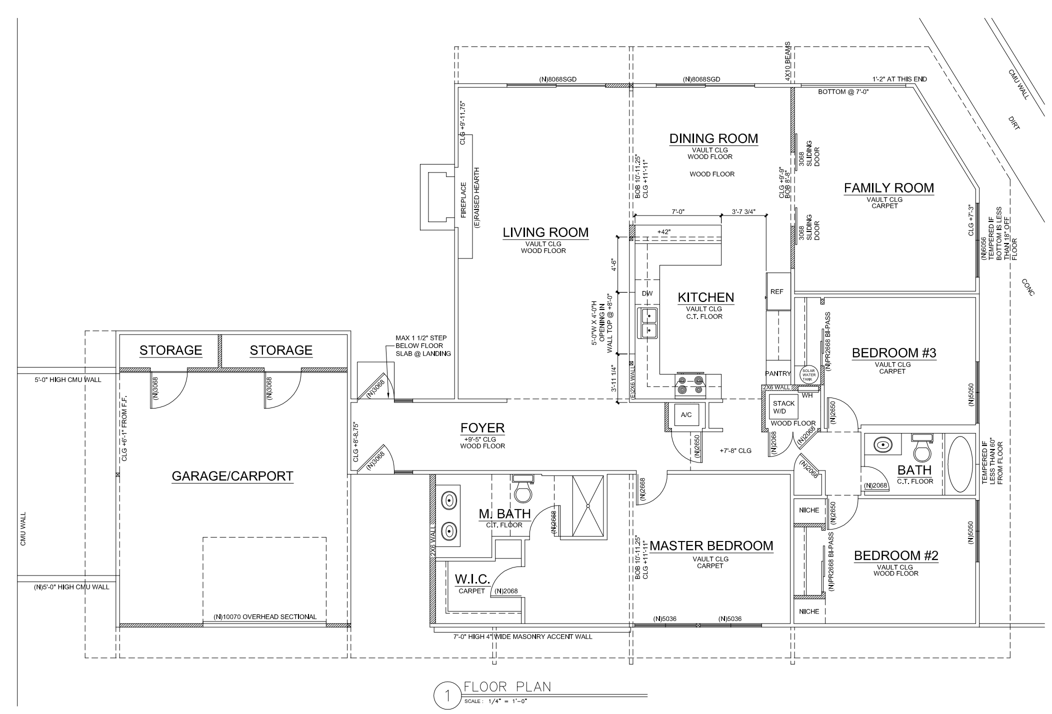
REVISIONING AMERICA

A GREEN DEMONSTRATION PROJECT IN LAS VEGAS SHOWS THE NUTS AND BOLTS OF A GREEN RETROFIT. THE TEAM PRESERVED THE INTEGRITY OF THE EXISTING STRUCTURE WHILE BRINGING IT TO NET-ZERO ENERGY.

As a research project, Green Builder Media's ReVISION House Vegas, in every way, pays homage to energy and sustainable retrofits. The emphasis here is on "retro," as this project is a purposeful revival of the modernist residential design made famous by Joseph Eichler in the late 1950s and early 1960s. Preserving this quintessential suburban home design has become an important focus for the project. Design features such as floor-to-ceiling glass and trapezoidal transoms, the low-sloping A-frame roof, areas of vertical pattern wood siding, and a spare façade with clean geometric lines are all signatures of the modern, airy style, which provided a lively contrast to the typical mass-produced "matchbox" homes built after World War II. Indeed, Eichler is credited with introducing many of the home features that today are so familiar to residential design they go unquestioned–things like glass patio doors, a standard second bathroom located in the master bedroom, and an atrium-type entrance foyer designed to advance (as so much of the Eichler style does) the now-very-green concept of integrating outdoor and indoor spaces.

The ReVISION House is first and foremost a demonstration of green retrofit, with emphasis on "fit." Every remodeling project is defined by dilemmas of what will fit, given a schedule and a budget. In this case, the new criterion of sustainability and energy efficiency are interjected with the mandate to match what already exists to preserve the home's vintage style.

Simply put, the fact that the project is a remodel is one of its greenest aspects. "A truly sustainable model must make use of what we've already got," says project manager Craig Savage of Building Media. That statement has become the mantra that drives this innovative project forward.



During the 2010 IBS show, the ReVISION House Vegas will be open for tours (Jan. 19 and Jan. 21, 3:00 p.m.–5:00 p.m.). The goal is to showcase the guts of a high-performance home, with peel-away exhibits throughout demonstrating the energy features and sustainability measures that are an essential part of achieving net-zero energy performance.

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AN ENTRY REVEALED

In a classic case of remuddling, the home's original open carport had been closed off, and the entryway to the front door turned into a hostile gated tunnel. This may have been an attempt to provide greater security, but it obliterated the more welcoming entryway that had originally existed.

The front door itself, like all the windows and doors in the home, are provided by Milgard Windows & Doors from its newest line, the Ultra Series. The full-glass, in-swing front door with matching sidelight mirrors a full-glass, out-swing door opening into the backyard pool area, providing a transparent entry that allows visitors to look through the house. Security, meanwhile, is handled by tempered glass and an electronic alarm system—modern solace to the armored fortress that once seemed so necessary to erect.

The Milgard series name no doubt refers to the windows' ultra-efficient triple-pane insulated glass units and ultra-durable pultruded fiberglass frames. With a U-factor around 0.3, and solar heat gain co-efficient (SHGC) below 0.2, these windows and doors go a long way to providing the kind of thermal enclosure that's essential to a net-zero home.

In Las Vegas' hot, dry climate, warding off solar heat gain proved by far the greatest energy performance challenge. And in the performance analysis conducted by Steven Winter Associates, great efforts were made to preserve the front façade's transom windows, which were signature features of the home's design.

The previous owners had white-washed these windows to reflect some of the heat away—clear testimony to the intensity of the south side's solar gains. But in the end, there was no rational way to retain these windows and achieve the net-zero energy goal. Such are the painful compromises that go along with a remodel of any sort, and in this case, to getting over the high energy performance bar that had been set.

A happy alternative, however, was found: Since the exterior cladding consists of Dryvit synthetic stucco over rigid polystyrene foam, the foam was sculpted to resemble the trapezoidal glass, and the Dryvit painted a metallic shade to define the missing glass.

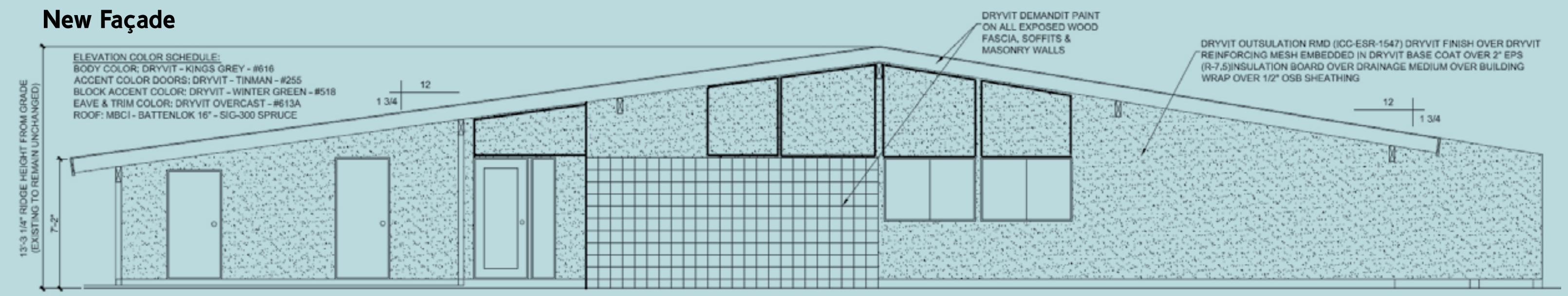
With its semi-circular driveway and xeriscape using pumice stone and palms, the home's site is typical of many suburban plots in the area. However, the concrete drive had been undermined by erosion and deeply cracked. Combined with the fact that the lot just isn't deep enough for a comfortable circle drive—and steep—there was no escaping the inevitable: The driveway had to go.

Landscape designer, Bill Bennett, opted for a straight drive into the carport and a wide set of concrete steps designed to invite visitors—who always parked on the street anyway—to the home (see landscape plan, above).

All the hardscaping is a pervious paving that allows runoff to soak into the ground, eliminating erosion and allowing Nevada's precious precipitation to return to the aquifer.

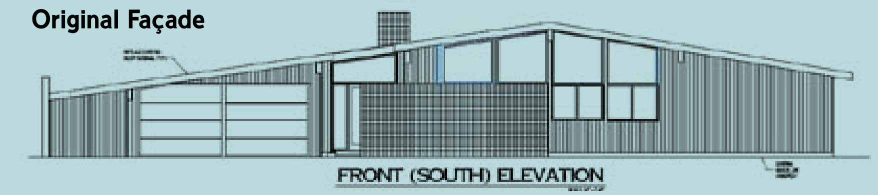
Two types of paving were selected—BASF's FilterPave, which uses crushed glass that has been tumbled to a smooth aggregate, and BASF's FlexiPave, which combines $^{3}/_{4}$" stone and resin—and arranged in the square motif that echoes the geometric design on the façade. Interspersed with FilterPave and around the pool, the backyard features ForeverLawn synthetic turf to preserve water, one of the state's scarcest resources.

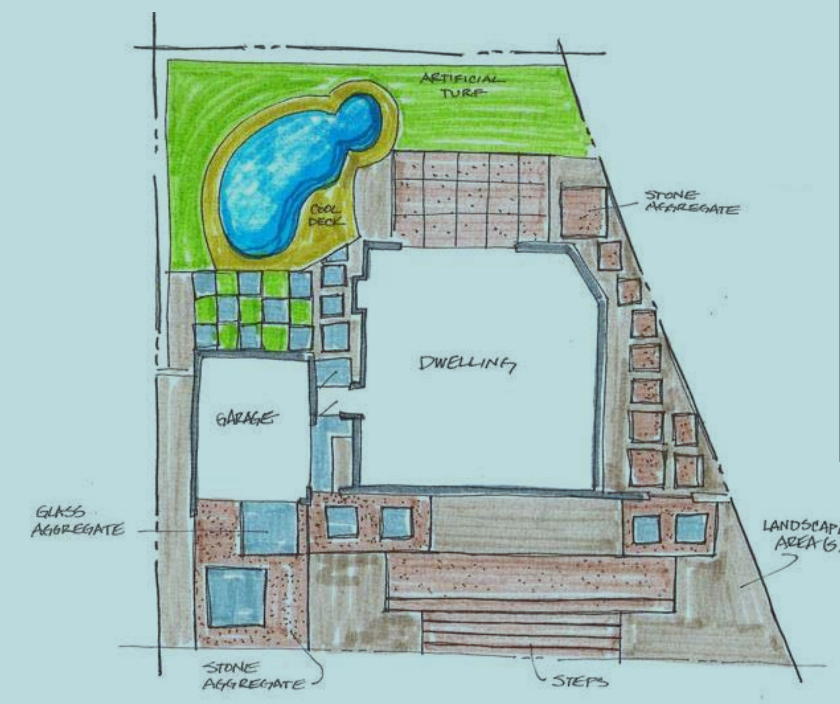
New Façade



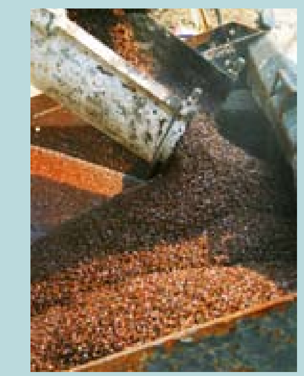
With the original façade's signature trapezoidal transom windows (right), so intense was the south sun through the glass the previous owners had painted them white. The new façade (above) with sculpted cladding, mimics the missing transom windows without the intense solar gains that wreaked havoc on the energy performance of the home.

Original Façade





Las Vegas landscaper Bill Bennett, owner of Native Design Landscaping, selected a mix of different pervious pavements arranged in a cubic pattern to provide a zero-water landscape matching the geometric detailing of the home.



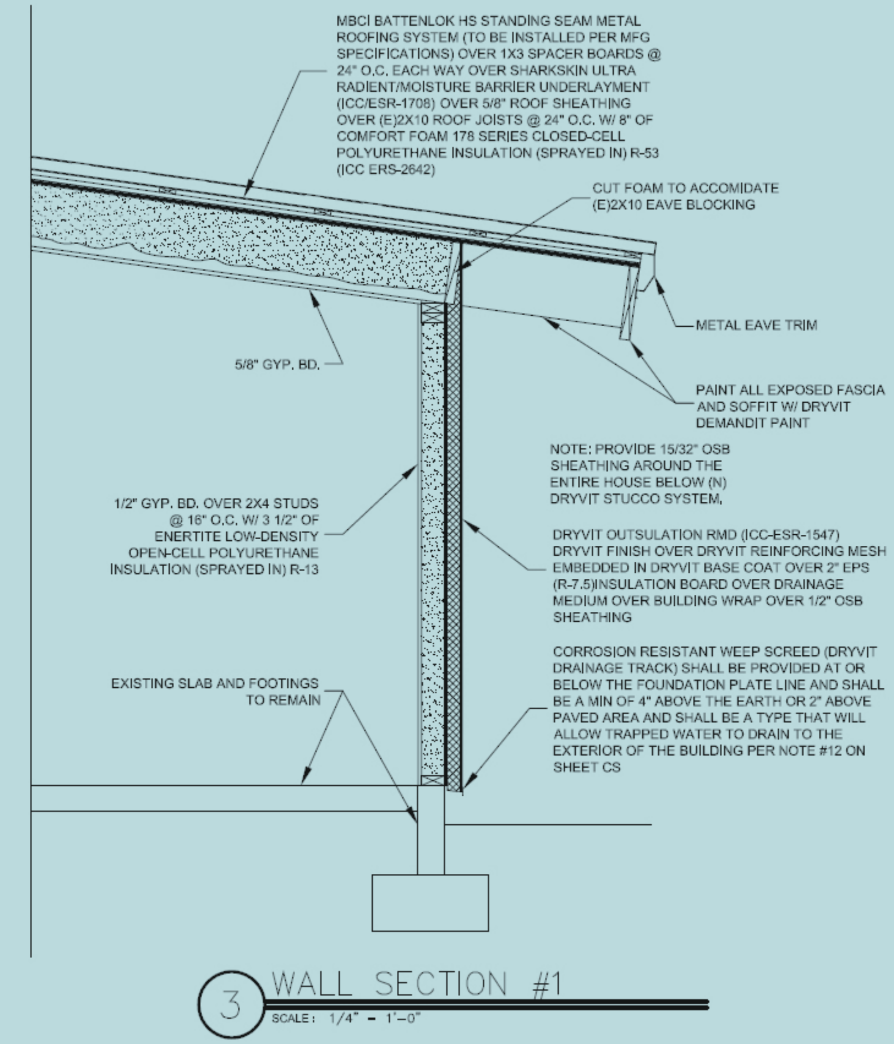
BASF's FilterPave uses recycled variant-colored glass bonded with a high-strength natural resin to create a 90% recycled porous hardscape intended to reduce storm runoff.

How to flay a house: A worker cuts through the stucco with a cut-off wheel on a grinder (above), exposing the underlying sheathing, which also gets ripped off to gain access to the wall cavities.

Clear redwood "batts" being carefully removed from redwood T-111 plywood (above). The Dryvit synthetic stucco system was applied with an additional layer of 1x6 foam to maintain the board and batt look, one of the design signatures of the exterior

Lois Arena, an engineer from DOE's Building America team, Steven Winter Associates (above), attaches heat sensors to one of two test rafter bays. One test patch will have DuPont RoofLiner; the second will have an additional foil radiant membrane. The result will determine if it is cost effective to add the radiant membrane to the roof, which is already super insulated and capped with a low-emitting metal cool roof.

Stripped from the outside, the rafter bays over a vaulted ceiling area are ready for BASF Comfort Foam closed-cell spray insulation (below). Working from the outside makes for an unobtrusive retrofit that could be of significant value in an occupied home.



The low-density spray foam in the walls yields R-3.5 per inch for an actual total in the cavities of R-12.25. The 2" of rigid EPS foam will provide an additional R-9, for a total wall R-value of 21.25. The roof assembly gets 8" of a denser, closed-cell spray for a total insulation value of at least R-53.

HOUSE AS THERMOS

The bulk of the net-zero solution for this project is borne by significant insulation and air sealing upgrades to the wall and roof assemblies. Access to the building cavities to add insulation proved to be the biggest challenge.

The interior had been entirely rerocked following a fire that swept through the interior. So the interior surfaces were in excellent condition, whereas the stucco on the exterior was cracked and poorly detailed, arguing for a complete reskinning of the exterior.

Deduction made: Work began immediately ripping off the stucco to expose the wall cavities. Done from the exterior, this insulation becomes an "unobtrusive retrofit." That is, the interior of the home is minimally disturbed, which would have real value for any occupied home.

The walls were insulated with low-density open-cell polyurethane foam, BASF Enertite. This water-sprayed material will fill the cavity and get shaved off flush to the studs before the house gets reskinned with ½" OSB and a layer of DuPont StuccoWrap. An additional 2" of EPS foam will be added, followed by a Dryvit synthetic stucco cladding.

A huge advantage of spray foam is that it flows into all the cracks and bonds to the studs, completely air-sealing the cavities. But there was still much work to be done to caulk the gaps at the plate lines to complete the air seal.

An old shingle roof got peeled away, and the existing OSB deck stripped off to reveal the 2x10 rafter cavities. These get a nominal 8" of BASF Comfort Foam high-density, closed-cell spray foam, which yields R-6.5 per inch. In the end, the insulation thickness will likely be more, though the entire 2x10 cavity will not get filled.

The decision to go with high-density foam in the roof was driven by the need for maximizing the roof's insulation. In Nevada's hot, dry climate, solar gain is the big beast that must be tamed. After the rafter bays were foamed, the roof was decked with 5/8-inch OSB, covered with DuPont RoofLiner, and the roof strapped out with 1x3s placed 24" on-center. The roofing is standing-seam metal coated with a high-radiant paint.

This Energy Star cool roof will absorb only about 20% of the heat it receives from the sun, but even that portion may be intense. Venting the roof helped cool the roof a little more, but wouldn't stop the hot metal from emitting radiant heat into the roof assembly.

This vent space, however, afforded the chance to apply an additional radiant barrier. (Radiant barriers will not work unless the reflective surfaces face at least a 3/4" air space.)

Still, the research team wanted to know just how practical this would be. Was the effort to stop these relatively small solar gains just a case of splitting hairs, or would a relatively cheap layer of foil placed over the RoofLiner yield significant value?

To find out, the research team embedded sensors into the foam of a couple test bays in the roof. The bays were foamed separately, in advance of the insulation crew that would do the bulk of the foam installation. One bay has a plain RoofLiner; the second has an additional layer of foil. The heat sensors will measure the temperature in the bays, and the readings will determine how helpful the addition of a radiant barrier is.

With the framing exposed, it became apparent that there was very little shear support in the north wall—nothing that would prevent racking from strong east-west winds or a total collapse from a seismic event.

To install the holddowns for the Simpson StrongWalls, the slab edge had to be cut away (right) and re-formed with an array of anchors..

SHORING THE STRUCTURE

Stripping the house from the exterior revealed some instances of shoddy framing that needed attention—and afforded the opportunity to make some much needed seismic upgrades, including new hold-downs throughout. The area in need of the most attention, however, was the entire north wall. With all its glass, this wall had very little lateral support, and while it may have been up to code in 1963 when the house was built, it wasn't even close to compliance with seismic codes in 2009.

The solution, however, was relatively painless with the insertion of two Simpson StrongWall shear panels flanking the glass doors (which were replaced with full-glass, triple-pane Milgard Ultra units, getting rid of divided light doors, which did not match the period of the home). These were tied together with a steel tube to create a moment frame around the entire door opening that would support the entire wall.

Once the StrongWall was put in, a tubular steel header got bolted in place to tie together the two shear panels on both sides of the wall's extensive door opening.

HVAC UPGRADES

The existing heating and air conditioning system in the home consisted of two enormous and grossly oversized package-unit heat pumps that had to be lifted off the home with a crane. With all the thermal upgrades provided to the building enclosure, the electric load was cut in half, and these monster package units were replaced with a high-efficiency (SEER 18) Trane heat pump with half the cooling capacity and about a third the size.

The vertical air handler for the new system tucks into a hall closet, while a small condensing unit now sits in the side yard. On the heating side, the heat pump has a heating season performance factor (HSPF) of 8.5. These days, anything with an HSPF over 5.7 is considered acceptable, something in the range of 6.5 would be considered good. At 8.5, the heating performance of this unit is exceptional.

Significant gains were also made by reducing duct losses. The existing ducts had been upgraded to R-6 flex duct after the fire, but they had been installed in a snake's nest in the attic area above the hall, and they leaked like a sieve. Duct leakage testing revealed that more than 11% of the conditioned air moving through the ducts leaked to the outside.

This ductwork was replaced by professionals from A-Bear Air Conditioning and Heating, who installed new R-8 ducting and paid close attention to sealing all connections. While the leakage rate is expected to be less than 2%, the ducts were run inside the conditioned space so virtually no conditioned air is lost to the outdoors.

Down the hall from the closet where the AC air handler lives is a second hallway closet with a stacked Whirlpool Duet washer/dryer, a Rinnai tankless water heater (backup to the solar water heating system), and the home's whole house ventilation fan.

In a very tight house, good ventilation is especially important to ensure a healthy indoor environment. In addition to low-sone Panasonic fans that provide spot ventilation in each bathroom, a continuously running Panasonic WhisperGreen fan exhausts a constant flow of air from the laundry closet. When the fan faces static pressure, its speed is automatically increased by electronic controls to ensure that the desired CFM is actually achieved.

All the fans use a super-efficient, permanently lubricated DC motor designed for extremely quiet, energy-efficient operation.

A 6-ton AC package unit used to sit on top of the roof and needed to be lifted off with a crane (far left). It was replaced by an 18-SEER, 3-ton Trane unit with a condensing unit that sits in the side yard and an air handler that fits into the hall closet (near left).

Ritchie Bedor, owner of A-Bear Air Conditioning and Heating, focuses his attention on sealing a Y-joint in the new ductwork before installing it in the conditioned attic space.

The right way to do a boot connection: Sealing flex duct to a boot requires UL-181 foil duct tape (not the usual cloth duct tape, which has a rubber-based adhesive that will dry out and eventually lose its bond). The foil tape gets applied twice—once to seal the insulation core to the boot and again to seal the outer foil sheath. Then, the entire assembly gets secured with a zip cord.

The fan in the laundry closet will be set to run constantly at a very low speed, assuring proper air changes in the urethane insulated "thermos bottle" of a house.

As a backup to the solar system, a gas-fired Rinnai tankless water heater has been installed in the laundry closet (left). This sealed combustion, direct vent unit with an efficiency factor (EF) of 8.0 replaces a 40-gallon storage water heater with an EF of 5.6 (below). Combined with the solar system, the water heating load has been reduced from 166 therms to just 28 therms.

Saving water is as important as saving energy in Nevada's desert climate, and this is helped along by a front-loading Whirlpool Duet washer/dryer combo (right). According to Whirlpool, the washer uses about 60% less water than a conventional top-loading machine, and up to 72% less electricity. The units typically sit side-by-side, but can be stacked using a conversion kit.

WATER HEATING AND PLUMBING

While the majority of the net-zero-energy solution is carried by the home's super tight, well-insulated enclosure and high-efficiency cooling and heating system, getting to that last 15% reduction in energy usage—close enough that an array of photovoltaic cells on the roof will generate enough electricity back to the grid to ensure zero net energy—requires a solar hot water heater to bear the brunt of the water heating.

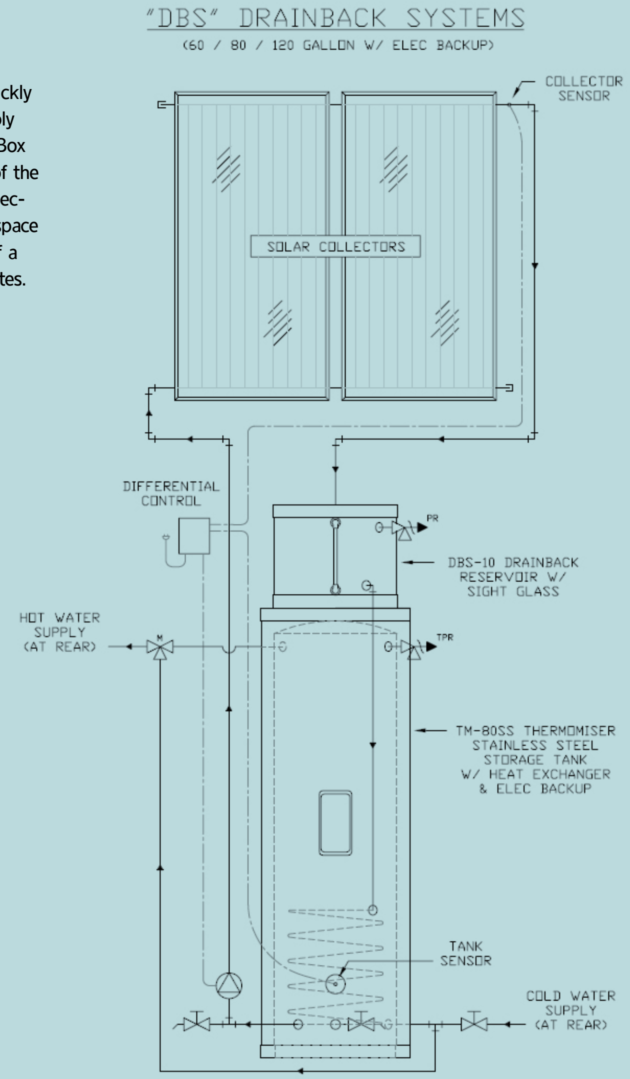
This is achieved with an EagleSun drainback system supplied by Ontility. This system relies on sensors in the collector and in the storage tank to turn the system on and off.

When the temperature at the collector is at least 10 degrees warmer than the temperature at the tank, a controller turns on the pumps; when the temperature difference drops to about 5 degrees, the pump turns off.

In this way, water always circulates through the collector when there is heat to be gained, and the pumps only operate when there is energy to be gained. When the pumps are circulating, the return water from the collectors passes through a heat exchanger that gives up the collected heat to the water in the storage tank, and the now cooler water is returned to the collectors to continue to collect heat.

All the lead-soldered copper hot and cold supply lines in the house were replaced with an Uponor AquaPEX plumbing system, which could be snaked through the walls quickly to provide lead-free water supply throughout the ReVISION House.

PEX piping goes into existing walls simply and quickly with little disruption. Here, Uponor AquaPEX supply lines feed the laundry closet. Note also the DryerBox installed high to accommodate the dryer on top of the washer. A DryerBox manages the dryer vent connection, allowing the unit to fit tightly in a confined space without restricting the vent, as the photograph of a similar unit (below), installed at floor level, illustrates.



A drainback solar water heating system provides a fail-safe method of ensuring that collectors and collector loop piping never freeze by draining all water from the collectors and loop piping when the system is not collecting heat. Freeze protection is provided when the pump shuts off and the water drains into the insulated drainback reservoir tank.

A plumber stretches the end of the PEX tubing before inserting an angle stop fitting. PEX tubing has "memory" and returns to original size, tightly fitting to the angle stop.

ILLUMINATION

The lighting throughout the ReVISION House consists entirely of energy-efficient compact fluorescent (CFL) and LED lamps.

The house already had a wide array of recessed cans, and since very little about the interior footprint changed, few of these light fixtures needed to be repositioned. In addition, the roof was insulated and air-sealed with high-density foam, so it didn't much matter that most of these recessed cans were not airtight. What did matter is that all of them had conventional sockets, raising the prospect of either wasting a lot of functional cans or confining the lighting choices to CFLs. These days, energy-efficient lighting is so much more than CFLs.

Help came from two fronts: Phillips recently introduced LED bulbs, which screw into conventional (Edison) sockets, and Cooper Lighting has introduced a series of retrofit inserts that accept a wide array of LED lamps. Both provide the advantages of LED lighting, which include better color rending, warmer white color temperatures, and longer-life lamps with no mercury or other special recycling requirements.

The LED bulbs used on the project are Phillips AmbientLED R20 medium base indoor flood lamps that are specifically designed for recessed and track fixtures. These bulbs consume just 7 watts of electricity, and have a rated average life of 40,000 hours (compare this to the life of a conventional incandescent bulb at 750 to 1,000 hours; 2,000 hours for so-called long-life incandescents; and 6,000 hours for most CFLs).

The Cooper Lighting Halo-series LED inserts were able to slip inside the existing recessed can, and an adapter plug fit into the screw-mount Edison base, which allowed use of the HALO LED lamps with a rated life of 50,000 hours (that's about 20 years if the lights are used for six hours each day), and a wide selection of trims to change the angle and quality of the light cone.

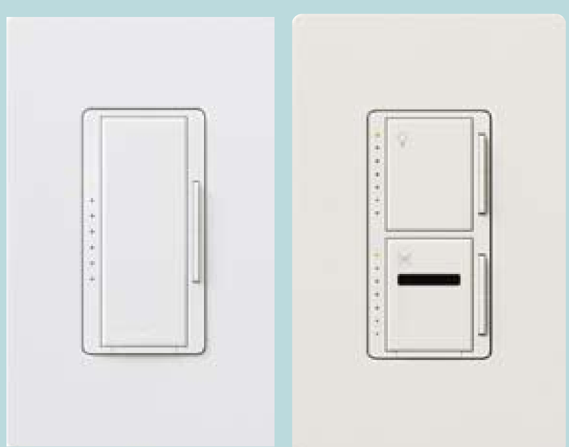
It's worth noting that while the insulating the roof made it possible to use the existing can lights, no one wanted to take responsibility for embedding the light fixtures in foam. Spray foam is a new enough technology, nobody really knows what the consequences might be (fire? chemical reaction?). To avoid a potential problem, steps were taken to isolate each can light with 8" aluminum flashing.

All the lighting in the house is controlled by Lutron Maestro line of electronic switches and dimmers. Most dimmers are resistance switches, so they are notoriously inefficient, turning much of the electricity into unwanted heat. They also afford a number of efficiency options not typically associated with conventional residential controls. This includes:

> zone-to-zone occupancy control (the lighting comes on and turns off as occupants move from room to room);
> delayed fade to off, which lets you leave the room before lights go out;
> multi-location dimming compatible with three-way wiring;
> built-in timer controls for bathroom fans to ensure they run long enough after a shower, separate from the lighting control;
> infrared remote control of lights and fans; and
> power failure memory that retains VCR , DVR, and other electronic settings in the event of a power outage.

Phillips latest line of screw-in LED bulbs will fit anywhere a CFL will, but will last about seven times longer and provide a warmer white light. They do not contain mercury or any other substance that requires special recycling.

Torsion spring clips on the LED module allowed these to fit inside the existing recessed lighting cans. The modules hold an LED lamp rated to last 50,000 hours—some 11 years if the light is left on 12 hours each day.



Lutron's eco-minder dimmers (DIR) are far more efficient than conventional dimmers, which turn most of the electricity that's not going to the bulb into heat. The same dimmer unit works for both single-pole and three-way switch configurations. Separate light and fan switches offer built-in timing for bath fans that can be operated separately from the light.

INTERIOR FINISHES

The selection of interior finishes and furnishings focused on two main criteria: efficient use of materials and improved indoor air quality. Interior materials tend to use a lot of energy in their manufacture, explains interior designer Patricia Gaylor. "All the gloss and shine that comes with deluxe interior finishing can be intensive to produce. And if it is made without regard to what is off-gassing in a tightly enclosed environment, it is a failure, regardless of how it looks."

Three types of flooring were chosen:

The wood floors are Mohawk engineered hardwood, which uses reclaimed wood from dismantled buildings. It is a durable, laminated material, which is manufactured without formaldehyde-based glues, and installs without adhesive, using a snap-together system the manufacturer refers to as UniClic.

Carpeted floors draw on Mohawk carpet lines: EverStrand carpeting, which is made with recycled plastic bottles, and SmartStrand Carpeting, which uses DuPont Sorona fibers, which are manufactured with corn oil rather than petroleum.

Daltile floor tile is used in the bathrooms and kitchen. More than 45% of this tile is a roof manufacturing by-product that used to be waste. The rest of the material is mostly talc and clay.

The ReVISION team used a no-VOC latex paint from Las Vegas-based GreenChoice Paint, which supplies paint on demand in lined reusable buckets. The raw materials for the paint are shipped in recyclable totes, and the product is manufactured on site from the paint's components. This provides greater control over each batch of paint. If you run out, the store runs the profile to produce the same paint. After the paint has been used, the plastic liners can be returned to the paint store for refilling.

Furnishings are provided by Pure Inspired Design, which designs and builds custom home furniture using only organic, natural, and recycled fabrics. The pieces are built with reclaimed and recycled materials finished with low- or no-VOC paints and stains.

In the kitchen, Energy-Star–rated Whirlpool Gold Resource dishwasher and refrigerator keep appliance energy use to a minimum. The dishwasher uses a third of the water and energy of most dishwashers, according to Whirlpool. It is rated by the Consortium for Energy Efficiency as Tier I qualified product, making it eligible for the rebate program announced by the DOE to encourage consumers to buy energy efficient appliances.

KraftMaid cabinetry in the kitchen uses low-VOC Environmentally Preferable Product (EPP) particle board. The EPP rating for particle board is established by the Composite Panel Association, which certifies that the particleboard contains 100% recycled or recovered wood fiber, and that formaldehyde emissions from the resins used to bind the fibers are equal to or lower than CARB (California Air Resources Board) Phase I levels—the most stringent air-quality standard in the country.

For bathroom fixtures, Gaylor chose WaterSense-labeled American Standard faucets. According to Gaylor, the WaterSense program, makes selecting highly efficient toilets or water-saving bathroom faucets much easier. "Any faucet with a flow of 1.5 gallons per minute is considered a low-flow faucet," she argues. "But the Water Sense program mandates criteria for pressure condensation, spray patterns, and effectiveness, so the 1.5-gallon flow from a WaterSense faucet feels effective to the user for cleaning. The WaterSense label is especially helpful for toilets. Before you install a toilet in a home, you need to know that it operates effectively, not just efficiently.

The American Standard H2Option dual-flush toilet chosen for the house has two modes of operation: one uses less a gallon per minute for flushing liquids, and the other uses 1.28 gallons per minute for flushing solids.

American Standard's WaterSense-labeled products are used throughout the house and can reduce water use by 30%.

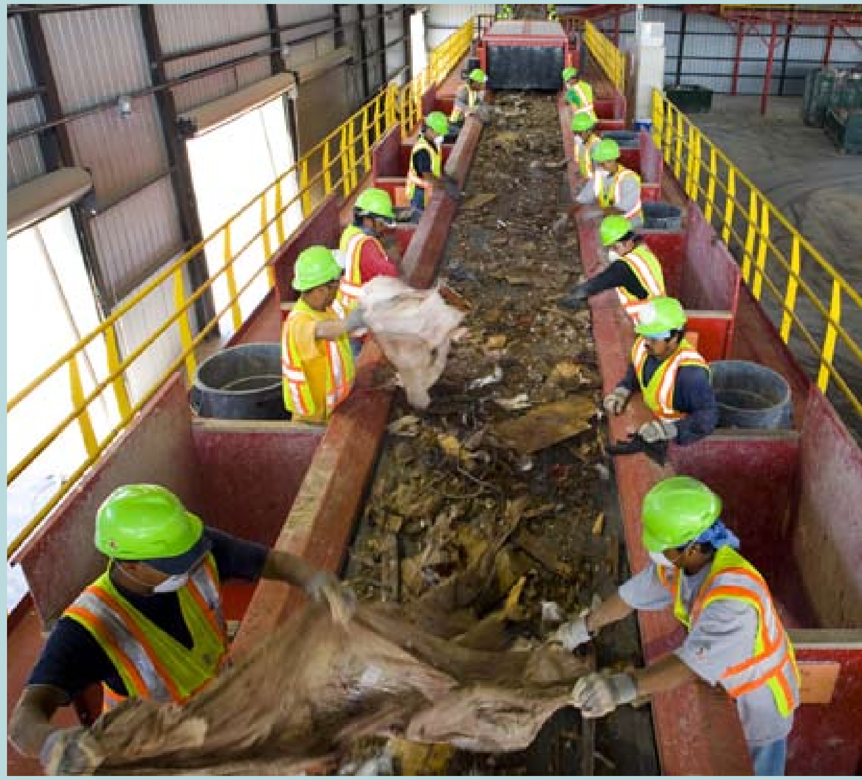
Interior designer Patricia Gaylor chose Zodiaq countertops throughout the house, selecting from the Terra Collection. This solid surfacing material contains more than 25% post-consumer recycled content bound in a glass resin.

Whirlpool's Gold Resource refrigerator is Energy Star rated. This replacement alone will reduce energy consumption from 1250 kWh/yr. to about 550 kWh/yr.

Kraftmaid cabinetry used in the kitchen is certified by the Composite Panel Association to contain 100% recycled or recovered wood.

Evergreen Recycling collected site debris in unsorted dumpsters (left). By eliminating the sorting on site, no time was lost by the demolition crew.

Nevada Concrete Services breaks up the existing driveway and patio at the ReVISION House (below). This concrete debris was hauled by Valley Recycling to a plant where it was ground and recycled for use in road beds.



Lois Arena of Steven Winters Associates (left) conducts a blower door test to measure the tightness of the building shell before demolition. This was just one step the Steven Winter team, assisted by workers from Home Energy Connection, did to establish baseline metrics for this net-zero energy retrofit.

At the Evergreen Recycling plant, the bulk of the demolition debris was first broken apart with a hydraulic shovel and hosed down to kill the dust. Then it was sorted by hand on this vibrating conveyor belt (above). Each worker on the line retrieves a different material and places it in bins for distribution to reuse markets.

A NEW STANDARD FOR GREEN PRACTICES

The work of remodeling consumes energy, and a number of augmented practices helped bring the ReVISION House project in line with sustainable best practices, defining a new standard for how the work of building should be conducted.

An important step in the planning phase of any green retrofit is the initial energy audit that assesses the existing energy use and informs the proposed measures.

This analysis was conducted by Steven Winter Associates, an energy consulting firm that has partnered extensively with the U.S. Department of Energy on the development of a number of other zero-energy demonstration homes.

The audit primarily consisted of:

- a thorough inspection of the building, focusing on the condition of the thermal enclosure (namely, the amount of insulation in the ceiling and walls) and the performance of the mechanicals, including the HVAC system, the water heating system, and the lighting;
- blower door pretesting to evaluate the rate of air infiltration and exfiltration through the enclosure;
- duct leakage testing to evaluate how much conditioned air is lost to duct leaks in the HVAC system; and
- an analysis of the building's historical energy usage, garnered from a review of past utility bills.

The information gathered from this work established the baseline energy performance for the building—information used to determine what needed to be done to get to zero-energy performance.

It was also used to conduct a detailed energy calculation for sizing the HVAC system. As a research home, this house will continue to be monitored, and this ongoing scrutiny will include a blower door "post test" to measure how tight the house actually gets after all the installation work is done.

On any construction project, waste is always an issue. On a remodeling project, at least you are eliminating an enormous amount of embodied energy by making use of existing materials.

The ultimate act of recycling is the reuse of an entire building. But there is actually a whole lot more construction debris generated by demolition work in a significant remodel than on most new construction projects. Fortunately, even this debris can be recycled.

Evergreen Recycling provided state-of-the-art construction recycling services, collecting the demolition debris in unsorted dumpsters at the site.

Once the dumpsters were filled, they were trucked to a plant located on the outskirts of Las Vegas, where the material was first broken up with a clamshell shovel, and then loaded onto a "single-stream separation line," which is a vibrating conveyor belt that is manned by workers who pick out assigned items—such as drywall, copper, wood, plastic, and cardboard—which have value in various resale markets. GB