U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

DOE ZERO ENERGY READY HOME™

U.S. DOE ZERO ENERGY READY HOME 2014 WINNER Housing Innovation Awards

M Street Homes

Smartlux on Greenpark
Houston, TX

BUILDER PROFILE

M Street Homes, LLC
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FEATURED HOME/DEVELOPMENT:

Project Data:

- Name: Smartlux on Greenpark
- Location: Houston, TX
- Layout: 4 bedrooms; 4.5 baths; 3 floors
- Conditioned Space: 4,507 ft^2
- Climate Zone: IECC 2A, hot-humid
- Completion: May 2014
- Category: Production

Modeled Performance Data:

- HERS Index: without PV 45; with PV 32
- Projected Annual Utility Costs: without PV $2,136; with PV $1,510
- Projected Annual Energy Cost Savings (compared to a home built to the 2009 IECC): without PV $1,193; with PV $1,819
- Annual PV Production Revenue: $194
- Builder's Added Cost Over 2009 IECC: with PV $40,000
- Annual Energy Savings: 7,859 kWhs, 622 therms

In May 2014, M Street Homes certified its first Zero Energy Ready Home. It is the first home in the world to use a tri-generation system to supply electricity, heating, and cooling on site. Not only does the M Street home meet all of the U.S. Department of Energy's Zero Energy Ready Home program requirements, it is constructed to ENERGY STAR Certified Homes Version 3.0, meets the U.S. Environmental Protection Agency's Indoor airPLUS and WaterSense requirements, and meets 2012 International Energy Conservation Code insulation levels.

Although M Street was founded in 2009, its past president Bob Solomon and vice president of sales and energy Randy Erwin have years of experience with a national production home builder. Erwin brought his experience starting that company's national energy-efficiency program to M Street, where the concept of energy-efficient construction has been embraced by the founder's son and current president Matt Solomon. M Street has a strategic plan to be the leader in energy efficiency in Houston. "But we don't just do things for the sake of doing them. We want to do things that make sense for our customers and ourselves, and this made sense," said Erwin.

Co-generation, the idea of using waste heat from one process for heat or energy production in another process, has been used in industrial settings for several years, and micro-generation systems for homes are now being used in Europe and Asia. But, the tri-generation system used in the M Street home, which incorporates cooling, heating, and power production, is the first of its kind. M Street collaborated with GE's Ecomagination division, BASF's Center for Building Excellence, and M-CoGen of Houston to install and test the system.

The micro tri-generation system starts with a natural gas-fired, 85% efficient generator that utilizes a 23-horse power engine. The generator is located outside

ZERO ENERGY READY HOME U.S. DEPARTMENT OF ENERGY

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 (formerly known as Challenge Home). Every DOE Zero Energy Ready Home starts with ENERGY STAR Certified Homes Version 3.0 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.

M Street Homes of Houston constructed this home with 2x6 framed walls filled with 1.5 inches of closed-cell spray foam to air seal and insulate the wall cavities, plus an additional 4 inches of blown cellulose to increase the insulation value. On the outside, an inch of rigid foam was installed over the plywood sheathing to provide a continuous insulating layer around the home's entire perimeter. In the attic, 7 inches of open-cell spray foam was sprayed along the underside of the roof to provide a sealed, insulated attic space for the HVAC ducts.

What makes a home a DOE ZERO ENERGY READY CERTIFIED?

1 **BASELINE**
ENERGY STAR Certified Homes Version 3.0

2 **ENVELOPE**
meets or exceeds 2012 IECC levels

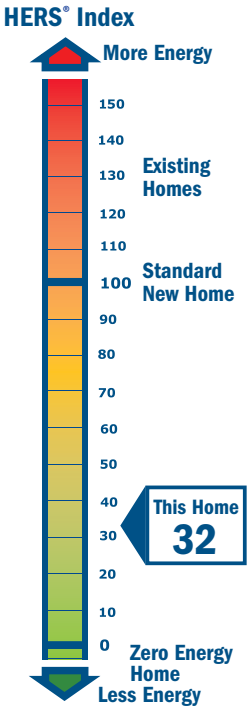
3 **DUCT SYSTEM**
located within the home's thermal boundary

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.



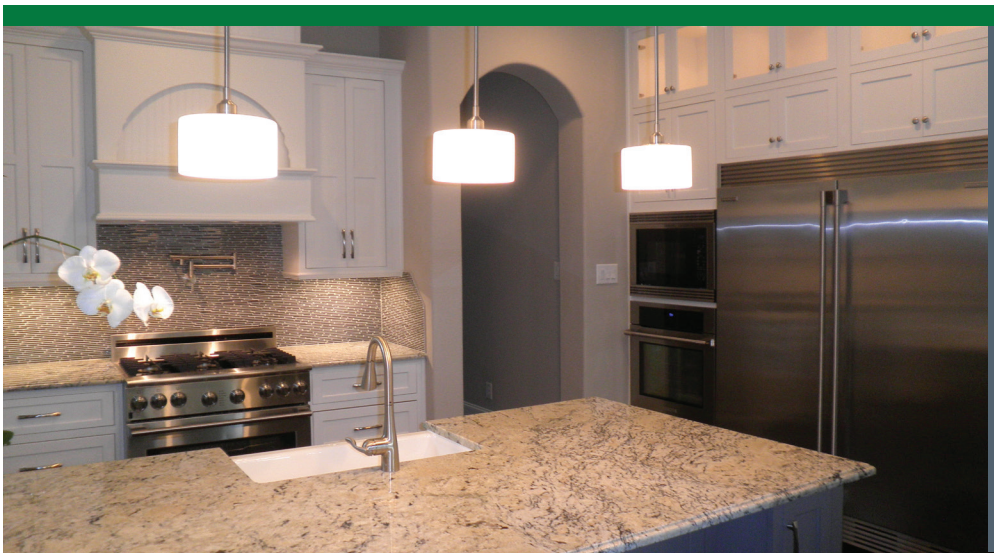
on the north side of the home and can generate up to 6 kW of power—enough power to meet the peak load demands for the highly efficient 4,500 ft^2 home. The unique "bundled" arrangement of the mechanical systems makes this possible. The generator will run between 40% and 60% of the time, using between 250 and 300 ccf of natural gas per month, and generating 3,000-5,000 kWh of electrical and thermal energy. However, without the electrical load from the AC compressor, water heater, and furnace, the home will typically consume about 2 to 3 kW of electricity per hour.

All of the home's space heating needs are provided by waste heat from the tri-generation system. The reason M-CoGen calls the system a tri-generator is because it provides electric power, heating, and cooling. The liquid coolant used to cool the generator absorbs heat from the engine and carries it to the radiator coils, located in the electric furnace plenum, where the furnace blower distributes it throughout the home with a heating efficiency of 100+%. Another hot water loop circulates from the generator to a heat exchanger outside the heat pump water heater. The water heater is essentially a storage tank and is only used for water heating if needed; however, the liquid line heats all of the water used by the family.

One line of the system goes to the attic where it dries a desiccant used to dehumidify the home. Hot, humid air from the home's return air system is circulated through the dehumidifying desiccant wheel then returned to the central furnace system before the condensing coil. The desiccant material is dried by air heated by the hot fluid coil.

The compressor for the air conditioner is located outside and is connected to the generator motor. M-CoGen has set up a unique system where the compressor motor is mechanically powered by a belt connected to the generator engine. The generator's ability to throttle allows the compressor to operate as a variable-speed unit that can adjust to the cooling demands of the home. Because the compressor is run by the generator, the air conditioner is removed from the home's electrical load, resulting in a sizable electricity savings and reduction in the cooling peak load.

The home also features 1.2 kW of photovoltaic panels on the south side of the home. The direct current (DC) power produced by the solar panels is sent to the tri-generation system where it is converted to alternating current (AC) through an inverter. The inverter is part of the energy control system, which manages



All of the home's appliances are ENERGY STAR rated including the dishwasher, refrigerator, freezer, ice maker, and wine cooler. Over 90% of the light fixtures use highly efficient CFL or LED bulbs. Most of the home's plumbing fixtures are EPA WaterSense certified. The coolant fluid used to cool the generator pulls heat from the generator. The heated fluid pipe loops through a water tank to heat water for household use. The home also has a back up heat pump water heater.

the home's four power sources (generator, solar, deep cycle batteries, and utility grid) to provide the best power source. On sunny days, the solar energy will be used first. If more solar power is being produced than is needed, the excess power will be used to charge the four batteries. The batteries, whose primary purpose is to manage peak loads, can be used to power the home for short periods of time. The main source of power is the internal combustion engine generator, which automatically engages when the house load exceeds the PV and battery capabilities, or when there is a demand for cooling. The grid serves as a backup to the generator in the unlikely event the generator becomes inoperable, and it is the mechanism by which excess power is delivered to the power provider. With the tri-generation system, the home is expected to operate as a net-zero, if not a plus energy, home. Any credit from surplus power generation can offset the cost of the natural gas needed to run the generator.

The mostly 2x6 wood-framed walls are filled with 1.5 inches of closed-cell spray foam that insulates, air seals, and glues the wall components together, providing up to 300% additional racking strength, which can help the home withstand high winds. The remainder of the wall cavity is filled with blown cellulose. The walls are sheathed with half-inch plywood that is covered with 1 inch of rigid foam insulation to provide a continuous layer around the home and stop thermal bridging. The rigid foam increases the walls' total R-value to R-23. The rigid foam is covered with house wrap under the stone brick areas. In portions of the home covered with three-coat stucco, a membrane covers the walls to ensure a proper drainage plane.

M Street chose a sealed, insulated attic without soffit vents to keep out rainwater during hurricanes. The attic is insulated by spraying 7 in. of open-cell spray foam (an R-26 insulation value) along the underside of the roof line. Above the roof deck is 15 lb. felt underlayment with a 30 lb. material in all of the valleys. A 30-year dimensional architectural shingle was used on a majority of the roof. In areas where metal roofing was used, an elastomeric underlayment was installed. The unvented, insulated attic served as a cool, dry place to locate the HVAC system ductwork. A code-required ignition barrier was sprayed onto the spray foam surface so the attic can be used for storage. The attic's temperature remains within 3 to 5 degrees of the living area throughout the year, decreasing the heat load on the ducts. All of the ducts are R-8 insulated, sealed, tested, and balanced in accordance with the requirements of the ENERGY STAR Certified Homes program and the Environments for Living program, diamond level.

HOME CERTIFICATIONS

- DOE Zero Energy Ready Home Program
- ENERGY STAR Certified Homes Version 3.0
- EPA Indoor airPLUS
- DOE Zero Energy Ready Home Quality Management Guidelines
- MAASCO Environments for Living, diamond level

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.

The home has the world's first tri-generation micro-generator to provide electricity, heating, and cooling in one.

High-performance dual-pane, low-emissivity, vinyl-framed windows were installed with proper sealing and flashing techniques to keep out rain and moisture. The kitchen, bathrooms, and laundry room all have exhaust fans that vent to the outside. The HVAC system has a metered and timed fresh air ventilation system that operates in the metered open position utilizing the fan mode when the system is running, and on a timer when there is a sustained period with no call for conditioned air. In addition, the supplemental desiccant wheel dehumidification system described above maintains an indoor relative humidity of 50% even when the air conditioner is not operating and substantially reduces the latent load on the HVAC system.

The refrigerator, dishwasher, freezer, ice maker, and wine cooler are all ENERGY STAR rated, and about 90% of the lighting is CFL or LED.

M Street knows an integral part of being a high-performance builder is helping consumers understand sustainable, high-performance construction. M Street conducts extensive training of all company personnel to help staff understand the building science behind features that appear in promotional literature by mandating structured seminars and assigning mandatory reading materials. Every model home sales office has a demonstration center where sales representatives show customers how M Street utilizes certain products to improve energy efficiency and the website provides extensive educational materials.

M Street's first DOE Zero Energy Ready Home has attracted a great deal of media attention. The builder was even honored by the Mayor when the City of Houston proclaimed May 8, 2014, as "Energy Independence Day" to celebrate the technological advancements made by M Street.

Erwin has high hopes for the technologies being demonstrated in the DOE Zero Energy Ready Home. He foresees the day when developers build communities equipped with tri-generation plants owned and maintained by a third party that harvests the power for resale to the utility grid, while homeowners enjoy the benefits of low or no utility bills. "The residual income the builder could experience from this type of arrangement would be astronomical. This is the beginning of the distributed grid," said Erwin.

Photos courtesy of M Street Homes, LLC.

KEY FEATURES

- **DOE Zero Energy Ready Home Path:** Performance
- **Walls:** 2x4 and 2x6 16-inch on center framing; 1.5 in. closed-cell spray-foam cavity insulation; balance of cavity filled with blown cellulose; 1-in. taped, grooved XPS rigid foam over OSB sheathing; total wall insulation value R-23
- **Roof:** Unvented attic; raised heel trusses 7 in., R-26, open-cell spray foam under roof deck (covering rafters); 30-yr architectural shingles over 15-lb or 30-lb felt and metal roof over elastomeric underlayment
- **Foundation:** Post tension; 6-mil polyethylene vapor barrier under slab
- **Windows:** Double-pane, low-e, vinyl-framed; U=0.33; SHGC=0.20
- **Air Sealing:** 1.82 ACH 50
- **Ventilation:** Fresh air intake to central HVAC with metered timered controls; bath, kitchen, and laundry exhaust fans
- **HVAC:** Gas-fired tri-generator for electricity, heating, and cooling with grid tie, PV tie, and battery storage; generator-driven air conditioning compressor; waste heat heats fluid for fan coil and domestic water heating
- **Hot Water:** Cogenerator heated; heat pump water heater backup.
- **Lighting:** 90% CFL and LED
- **Appliances:** ENERGY STAR-rated dishwasher; refrigerator; dishwasher; freezer; ice maker; wine cooler
- **Solar:** 1.2-kW PV
- **Water Conservation:** Two recirculation loops; EPA WaterSense faucets and toilets

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