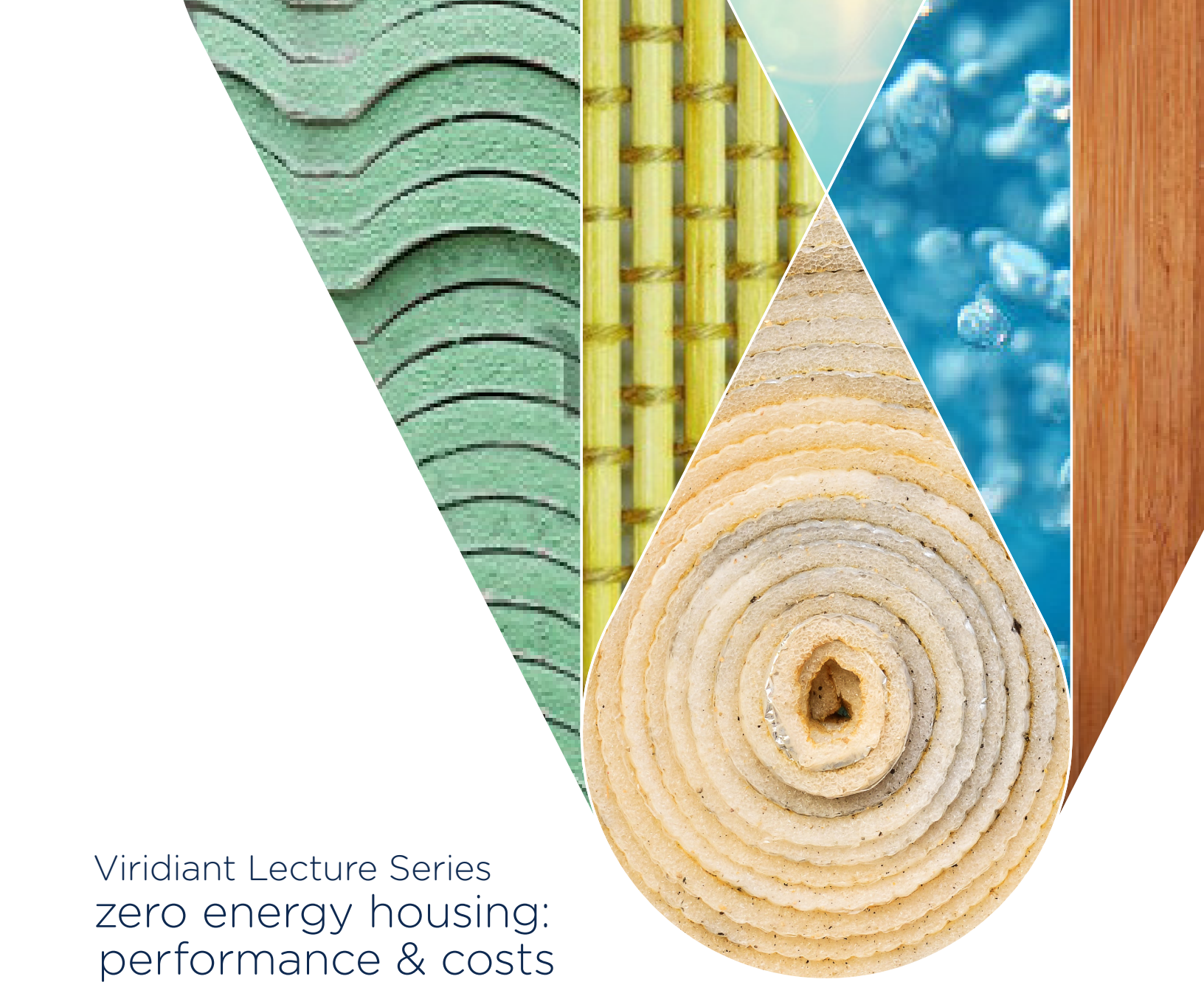


An abstract collage of natural textures arranged in geometric shapes. A green wavy pattern is on the left. A yellow woven texture is in the top center. A large circular cross-section of a tree trunk is on the right. A blue water bubble pattern is in the top right. A wooden texture is on the far right.

Viridiant Lecture Series zero energy housing: performance & costs

Findings from a multi-year study of Community Housing Partners' Grissom Lane Apartments. The study, undertaken by Philip Agee of the Virginia Center for Housing Research (VCHR) at Virginia Tech, aims to report findings on Zero Energy Housing (ZEH) energy performance and development costs.



viridiant



development, building systems, & enclosure: sample apartments

development context

- Location: Blacksburg, VA, USA
- Climate zone: 4A, mixed-humid
- Population: Senior, affordable
- Heating Degree Days (HDD): 5446
- Number of units: 8
- Number of unit types: 2
- Number of buildings: 4
- Fuel source(s): Electric, net-metered solar photovoltaic (PV)

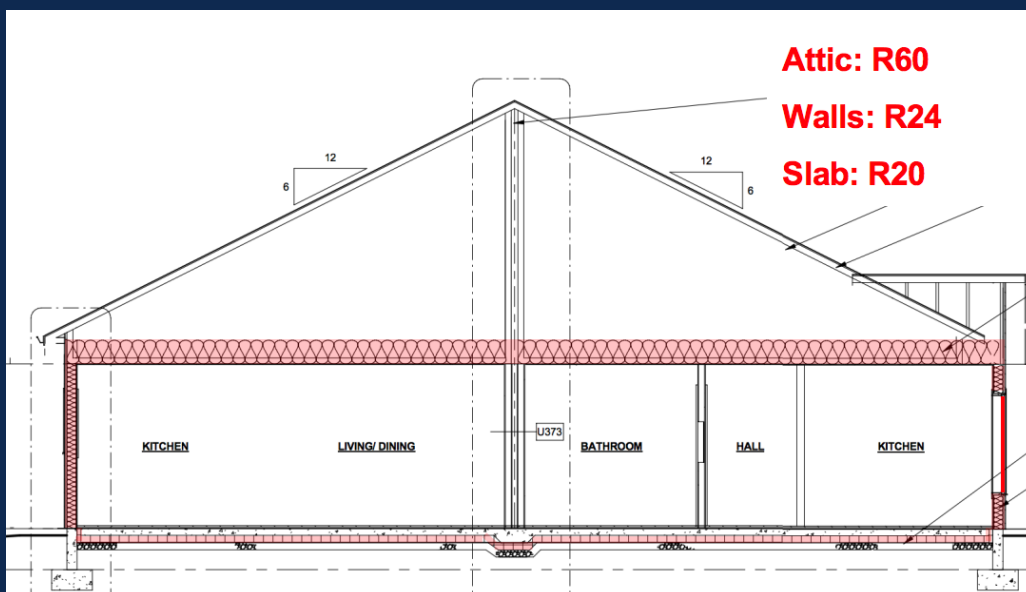
enclosure

- Condition area/apt: 966 ft² (90 m²)
- Volume/apt: 7728 cf (218.8 m³)
- Window to wall ratio: 0.141
- Window U-value: 0.25 BTU_h/ft²/°F
- Window SHGC: 0.27
- Slab U-value: 0.05 BTU_h/hr/ft²/°F
- Wall U-value: 0.04 BTU_h/ft²/°F
- Ceiling U-value: 0.02 BTU_h/ft²/°F
- Avg. enclosure tightness: 2.0 ACH₅₀

systems & electric loads

- *Space heating: 9K Btu/h, 18 SEER
- *Space cooling: 9K Btu/h, 10 HSPF
- Ducted air system tightness: 1%
- *Water heating: 2.75 EF, 50 gal. electric hybrid
- Ventilation: balanced, 1 cfm/Watt exhaust fan with passive inlets
- PV system: south-facing, 3.8 kWp
- Lighting: 100% LED
- ENERGY STAR Dishwasher, clothes washer, & clothes dryer

*per residential unit



Simple yet robust thermal enclosure was designed, constructed, and tested. The impact of thermal bridging was minimized through the use of exterior continuous insulation on the above grade walls, slab, and vented attic assemblies.

zero energy
housing:
performance &
costs

Findings from a multi-year study of Community Housing Partners’ Grissom Lane Apartments. The study, undertaken by Philip Agee of the Virginia Center for Housing Research (VCHR) at Virginia Tech, aims to report findings on Zero Energy Housing (ZEH) energy performance and development costs.

The study reports findings from an affordable, rental housing development that provides housing for seniors (55+ years old). The project was developed and is currently managed by Community Housing Partners. The case study is a measured zero energy development located in Blacksburg, VA (Climate Zone 4A) consisting of four single-story, all electric, sub-metered duplexes, where the residents are not responsible for their utility bills (owner paid). Further, the project pursued third party certification programs (EarthCraft House and ENERGY STAR) that assisted the project team with setting performance goals, energy modeling during design, and verification and diagnostic testing (enclosure tightness and duct tightness) during construction. Occupancy and data collection began in fall 2014. CHP, Viridiant, and Think Little monitored the

performance over 12 months to document net zero operation for Viridiant’s Net Zero certification. A summary of the development, building system, and enclosure characteristics can be found on the previous page. The apartments’ enclosures were tested and the mechanical systems were commissioned. An overview of the development and unit-level energy use, solar PV generation and net-measured performance is provided in Table A.



East elevation of Grissom Lane Apartments.
Photo Credit: Community Housing Partners

Table A. Energy use overview			
Unit	Actual Use kWh/yr	Generated kWh/yr (solar pv)	Net-Measured kWh/yr
A	6,775	5,617	1,158
B	2,299	5,480	-3,181
C	5,467	4,887	580
D	4,936	4,763	143
E	6,152	5,052	1,100
F	5,734	4,943	791
G	4,840	5,216	-376
H	4,711	5,282	-571
Total	40,914	41,270	-356
Sample Mean	5,114	5,158	-45
Note: Measurement period for analysis was 1/14/2015-1/13/2016, addresses were removed and randomized for resident privacy			

August 2017

zero energy housing: performance & costs

Zero Energy Performance

Grissom Lane Apartments achieved zero energy performance with a combination of using a systems approach to housing development and having the right team in place throughout design, construction, development, management, and maintenance. The team focused on optimizing the enclosure, followed by the systems and finally offsetting the small energy use load with an appropriately sized solar photovoltaic system.

Think Little provided energy modeling, building envelope specifications, HVAC design, PV system sizing, hot water distribution specifications, and building commissioning to set the project on the right path towards zero energy performance.

Table B. GLA performance compared to VA & US MF average			
	GLA Avg.	VA MF Avg. ¹	US MF Avg. ¹
kWh/unit/yr	-44.5	11,748	15,936
\$/unit/yr	-\$4.83	\$1,275.83	\$1,730.65
Virginia Tech Electric Service rate: \$0.1086/kWh. ¹ Source: U.S. EIA			

Table B provides an overview of the project's average energy use and energy cost compared to the average VA Multifamily (MF) and US MF annual energy use and costs for rental, affordable housing.

Cost Analysis

A detailed cost analysis was performed (Table C) to evaluate the cost impact of building zero energy housing. RSMeans, a national construction cost data base was used to perform cost/unit and cost/FT². Results suggest that zero energy housing is cost neutral in terms of cost/unit and cost/FT².

Table C. Project cost analysis			
\$/Per FT ²	Hard Costs	Soft Costs	Total
GLA	\$121.11	\$30.71	\$151.82
RSMeans ¹	\$122.61	\$39.44	\$162.05
Diff. (± %)	-1.22%	-22.13%	-6.31%
¹ RSMean 2013, normalized for Blacksburg, VA.			

Community Housing Partners and Think Little deserve recognition for demonstrating that Zero Energy affordable housing is within reach.



Photo Credit: Community Housing Partners

Lessons Learned

A number of lessons and practices can be taken away from this study. The case study demonstrated that Zero Energy Housing is achievable in Climate Zone 4 with the right team and goals. It is important to design for the residents' needs.

Teams can optimize the building system in the following order:

- 1) Enclosure (including glazing)
- 2) Mechanical
- 3) Plumbing
- 4) Electric loads (lighting and appliances)
- 5) Renewable energy

Energy modeling and commissioning should be used to reduce risk along with measuring the performance in real-time with circuit-level energy monitoring systems.

