Welcome

Managing HVAC in High Performance Buildings

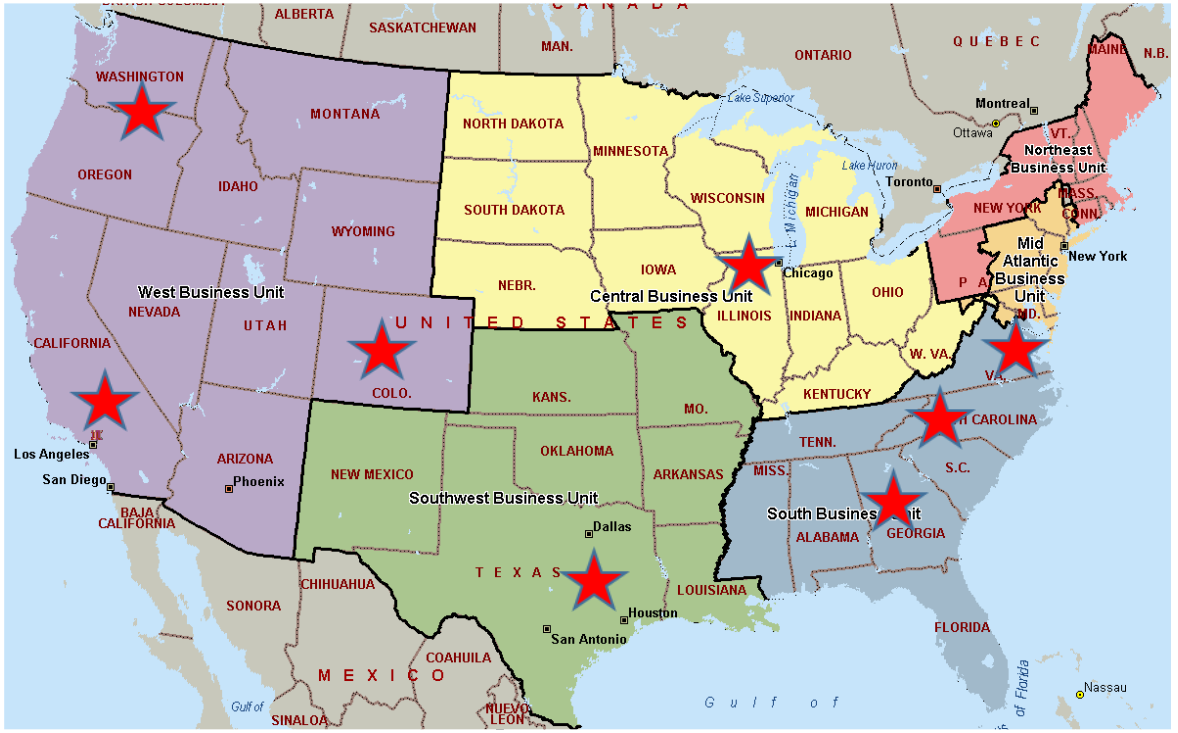
Hello my name is….

- Performance Construction Manager, Mitsubishi Electric Trane HVAC
- Former Director of Construction, Habitat for Humanity of Catawba Valley
- Former Sustainable Building Specialist, Habitat for Humanity International
- Licensed General Contractor
- HERS Rater
- EEBA Board Member

MITSUBISHI ELECTRIC COOLING & HEATING | PERFORMANCE BUILDER

Performance Construction Team

- Chad Gillespie, Senior Manager
- Rob Howard, Southeast Regional Mgr
  - Scott Simmons, Virginia
  - David Paschall, Georgia
- Mike Schaefer, Central
- Kimberly Llewellyn, Southwest
- Shawn LeMons, Colorado
- Ken Johnson, California
- Greg Davenport, Northwest



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Performance Construction Priorities

- Comfort
  - Individual room control
  - Quiet operation
- Health
  - Ductless (or less duct)
  - Filtration
  - Ventilation
  - Dehumidification
- Efficiency
  - Variable Refrigerant Flow
  - Inverter compressor

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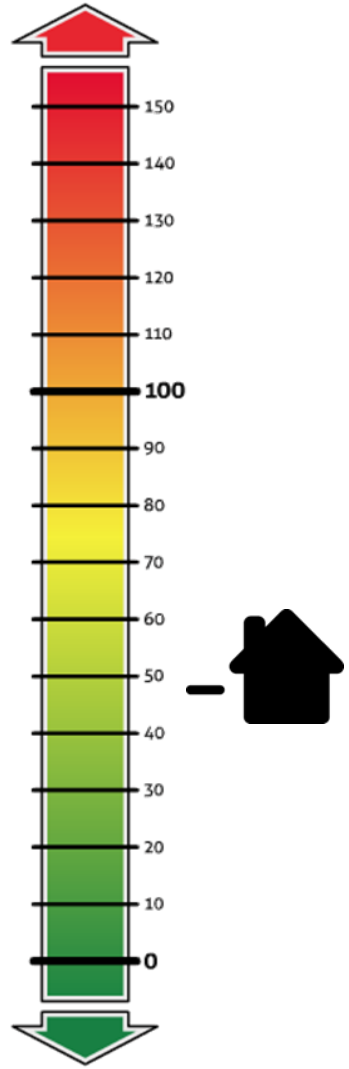
Performance Construction Goals

- Energy code compliance
- ERI performance path
- HERS score

Climates	2015 IECC HERS Index Scores
Zone 1 — 2	52
Zone 3	51
Zone 4	54
Zone 5	55
Zone 6	54
Zone 7 — 8	53



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Performance Construction Goals

- Certification Programs
  - ENERGY STAR
  - EPA Indoor airPLUS
  - DOE Zero Energy Ready
  - Passive House
  - Net-Zero

						Source Zero Renew-able Energy System
					Balanced Ventilation HRV/ERV	Balanced Ventilation HRV/ERV
				SOLAR READY Depends on climate	SOLAR READY ALWAYS	SOLAR READY ALWAYS
				Eff. Comps. & H2O Distrib	Eff. Comps. & H_2O Distrib	Eff. Comps. & H_2O Distrib
				EPA Indoor Air Pacakge	EPA Indoor Air Pacakge	EPA Indoor Air Pacakge
				Ducts in Condit. Space	Ducts in Condit. Space	Ducts in Condit. Space
		HVAC QI w/WHV	HVAC QI w/WHV	HVAC QI w/WHV	Micro-load HVAC QI	Micro-load HVAC QI
		Water Management	Water Management	Water Management	Water Management	Water Management
		Independent Verification	Independent Verification	Independent Verification	Independent Verification	Independent Verification
IECC 2009 Enclosure	IECC 2012 Enclosure	IECC 2009 Enclosure	IECC 2012 Enclosure	IECC 2012/15 Encl./ES Win.	Ultra-Efficient Enclosure	Ultra-Efficient Enclosure
HERS 85-90	HERS 70-80	HERS 65-75	HERS 55-65	HERS 48-55	HERS 35-45	HERS < 0
IECC 2009	IECC 2012	ENERGY STAR v3	ENERGY STAR v3.1	ZERH	PHIUS+	PHIUS+ SourceZero

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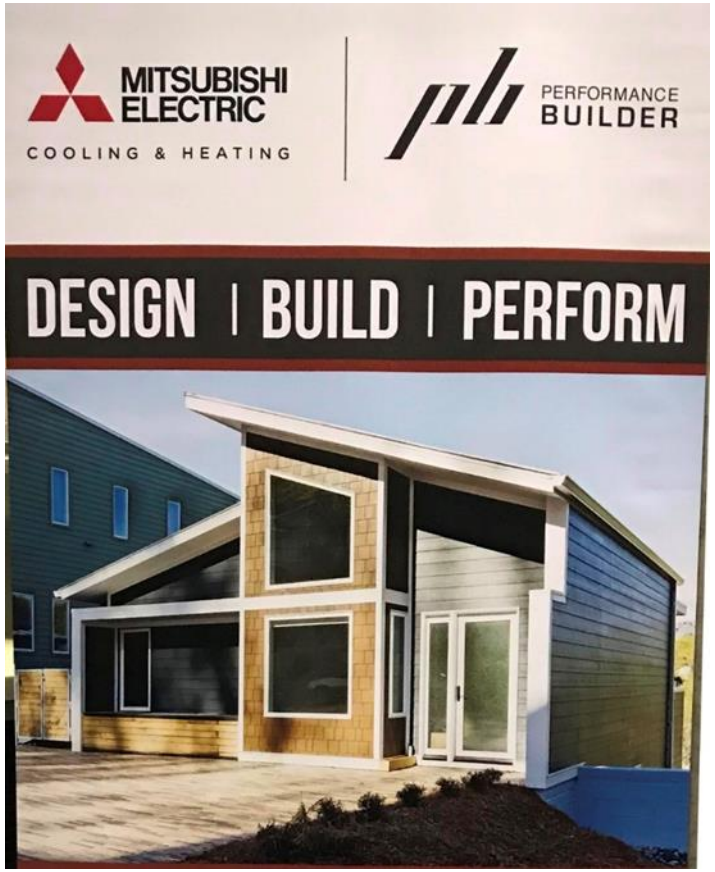
Performance Construction Process

- Design
  - Do the math!
- Build
  - Quality installation
- Perform
  - Commission
  - Monitor
  - Maintain



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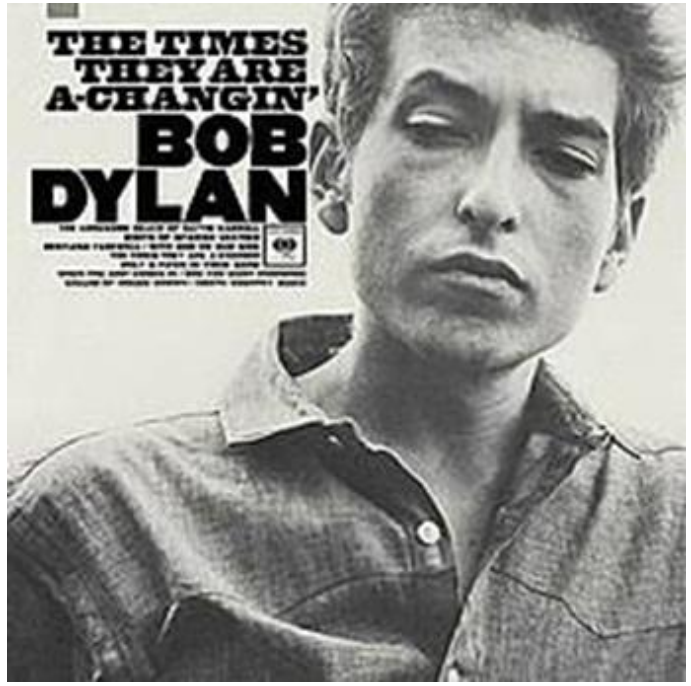
Changes impacting HVAC Design

- Energy Codes
  - All new homes are tighter and better insulated
  - Mechanical ventilation is now required
  - How do we deal with ventilation loads?
- Load Profiles
  - Peak Loads vs Partial Loads
  - Sensible Heat Ratios
  - Equipment Selection
- Climate
  - Is the weather data in our energy models accurate?



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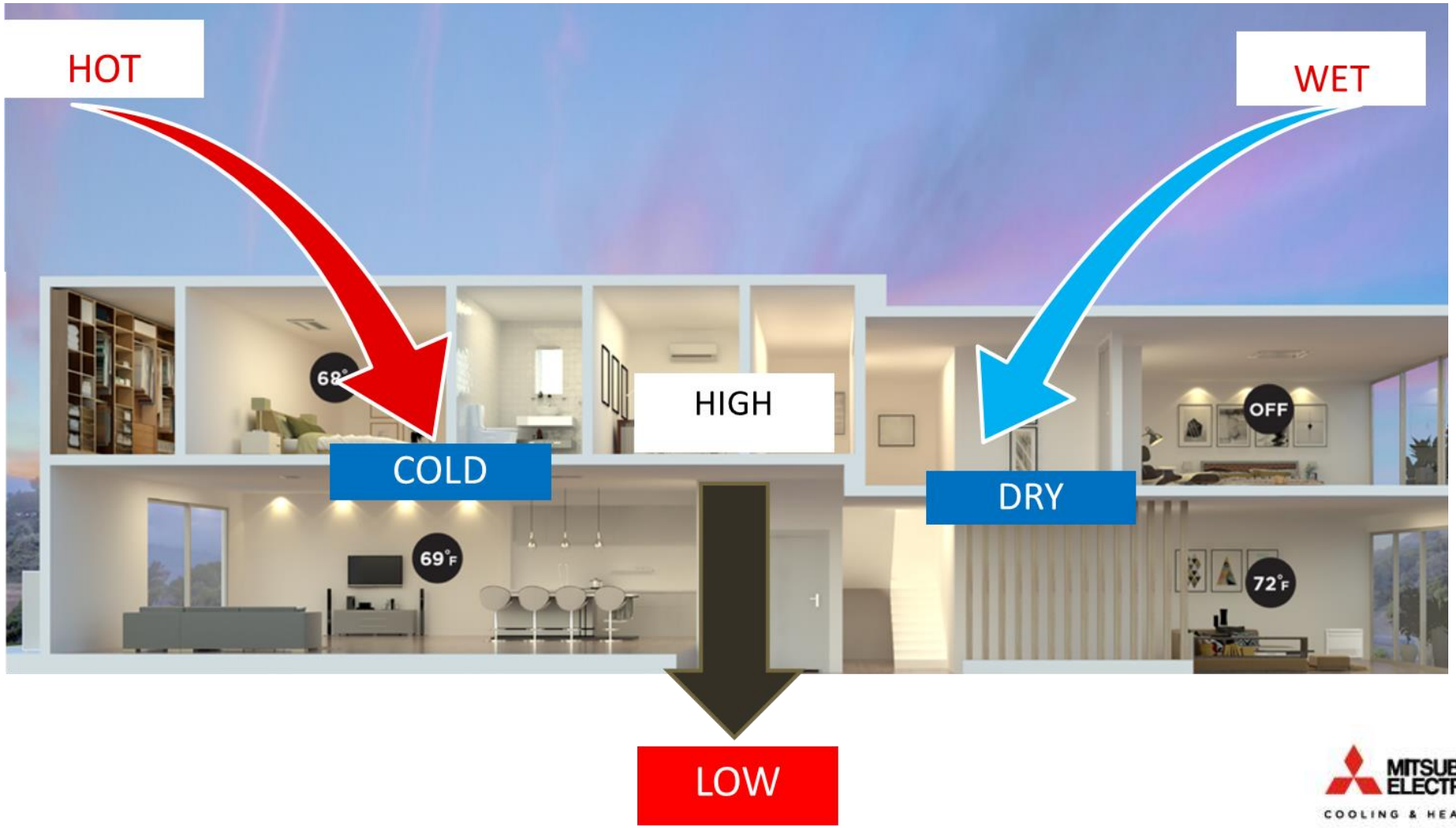
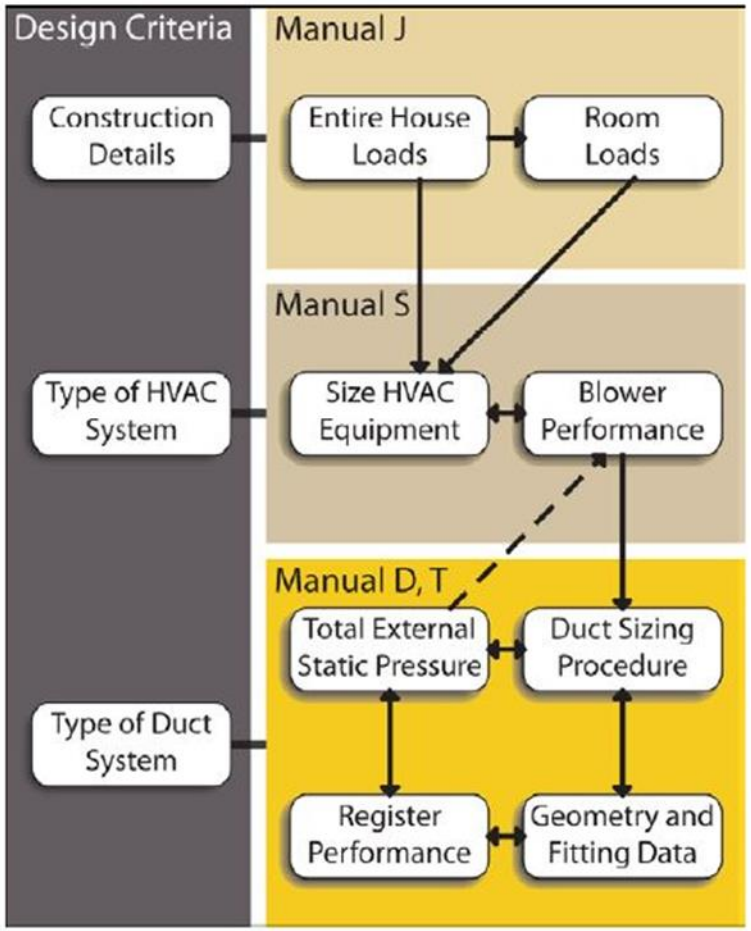
Good News: some things have not changed



Residential HVAC Design Process

- Manual J
- Manual S
- Manual D
- Manual T
- Manual DHP?
- Manual LLH



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Low Load Homes

- High Performance Homes have extremely low *sensible* loads (1000-1500 square feet/ton)
- Latent loads remain fairly constant
- Partial load runtime has increased
- HVAC equipment selection is more difficult
- Mechanical ventilation is now required
- How do we handle the ventilation load?
- Supplemental dehumidification may be required

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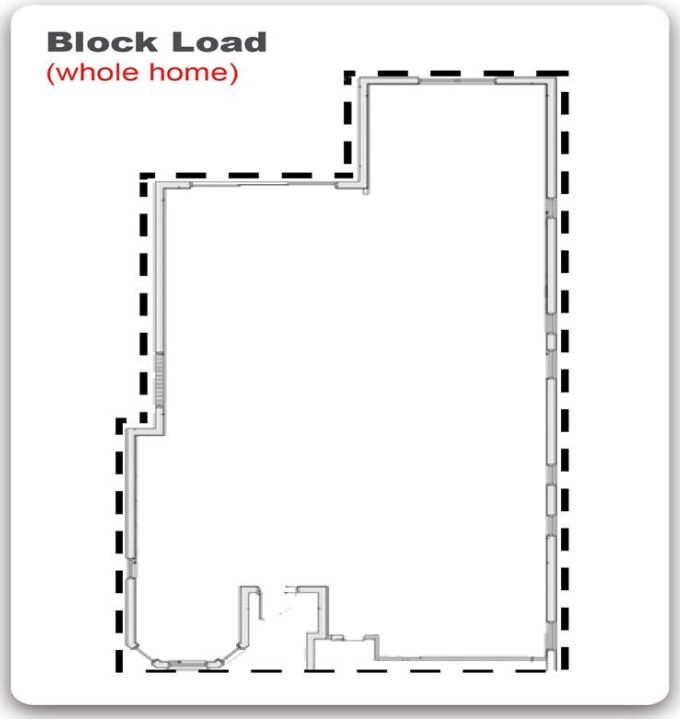
Issues With Oversizing

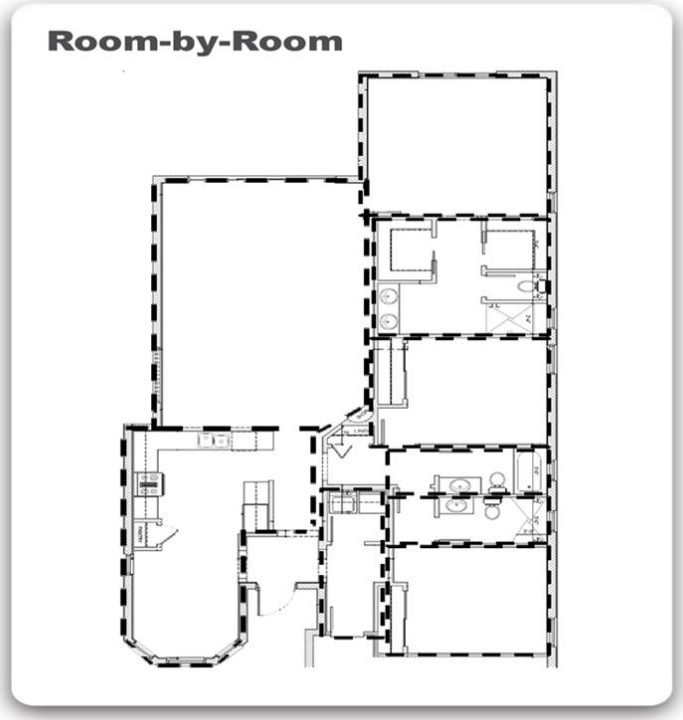
- What is the problem with oversized HVAC equipment?

Photo courtesy of Energy Vanguard

HVAC Design Without Borders

- Tear Down the Walls
- Interior walls divide us and make HVAC design really challenging





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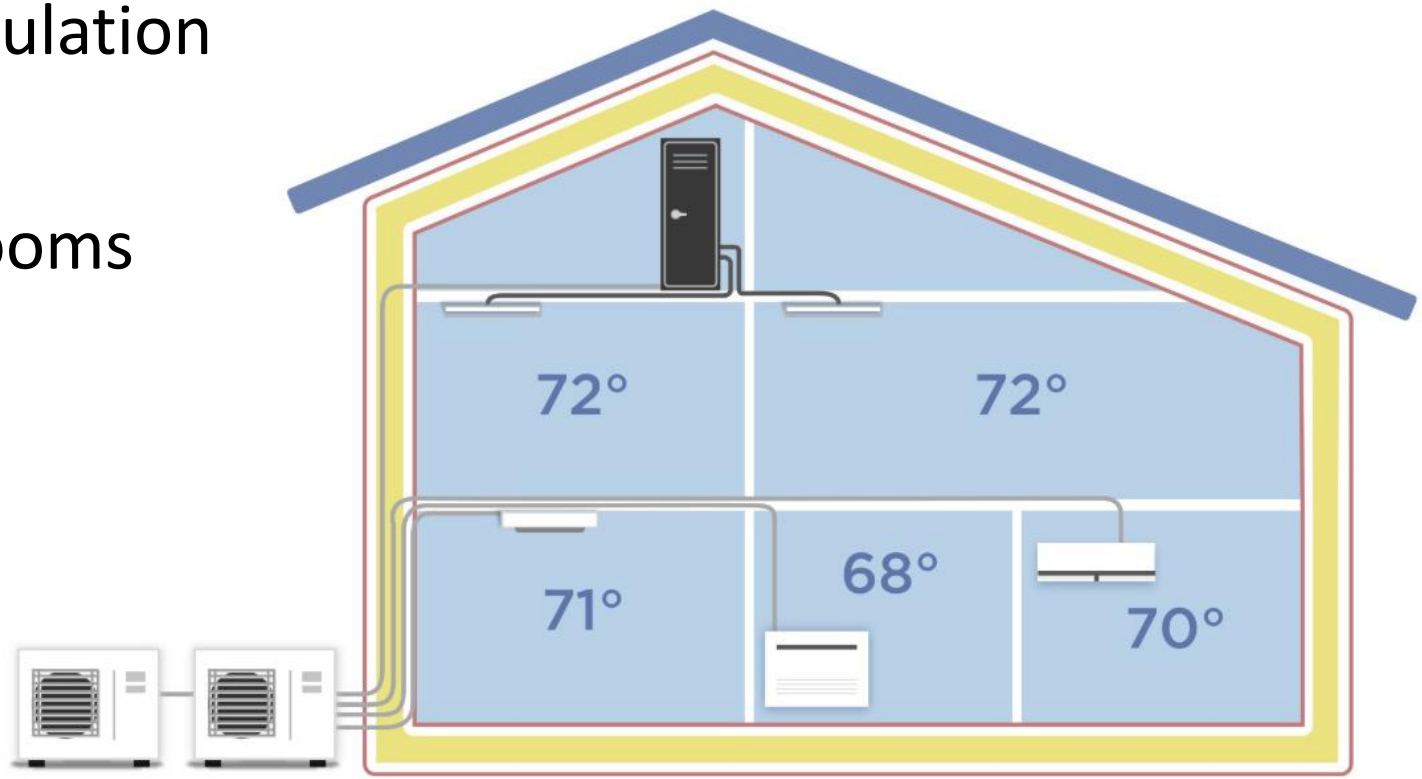
Designing with Ductless

- Room by room load calculation
- Creating comfort zones
- What about small bedrooms and bathrooms?



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Ductless Options

- Floor mount
- Wall mount
- Ceiling mount

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Air Distribution Strategies

- Exhaust fans (-)
- Transfer fans (+)
- Inline fans (+)

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Mechanical Ventilation

- Exhaust fans (-)
- Supply fans (+)
- ERV or HRV (+/-)

Whole House Filtration

- MERV 13 or HEPA
- 150-240 CFM Fan
- Supply and Return

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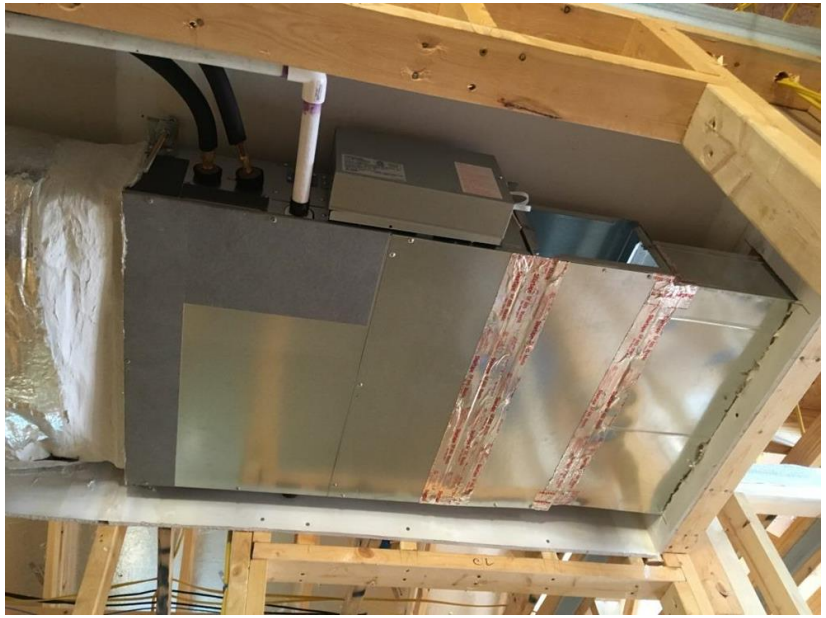
Horizontal Ducted

- Low static (SEZ)
- Mid static (PEAD)



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AIR HANDLER

SVZ 12-18

MVZ 12-36

PVA 12-42

CEILING MOUNT

SLZ 9-15

MLZ 9-42

PLA 12-42

PCA 12-42

FLOOR MOUNT

KJ 9-18

HORIZONTAL DUCTED

SEZ 9-18

PEAD 12-42

CONTROLS

Wireless Sensor

kumo station™

BACnet/Modbus

Thermostat Adapter

Wired and Wireless Controllers

WALL MOUNT

HM 9-24

GL 9-24

D 30-36

EF 9-18

FH 6-24

PKA 12-36

SINGLE-ZONE

COOLING ONLY
STANDARD HP
HYPER-HEATING

MULTI-ZONE

COOLING ONLY
STANDARD HP
HYPER-HEATING

BRANCH BOX

3 & 5 ZONE

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mylinkdrive.com

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Diamond System Builder

Indoor Units:	1 / 1 to 1		
Capacity:	12 / 6 to 12 (100.0%)		
* Connectable capacity is not actual capacity.			
Total Pipe Length:	32.9 / 65.0	feet	
Correction Factors			
Temperature:	0.97	1.00	
Piping Length:	0.98	0.99	
Defrosting:	-	1.00	
User Derate:	1.00	1.00	
Total Derate:	0.95	0.99	
Additional Refrigerant:	0.1	lb	
Total Refrigerant Amount:	2.7	lb	

Conditions (°F)

Cooling

Indoor DB	75.0	Humidity	59.0%	Indoor WB	64.9
Outdoor DB	97.0				

Heating

Indoor DB	70.0				
Outdoor DB	9.0	Humidity	50.0%	Outdoor WB	6.9

MUZ-FH12NA

System 1

1/4 / 3/8
30.0ft (3)

MSZ-FH12NA

N/A / 1

Pipe Dia. Liquid / Gas	Model Number	Clg.Total (Sens.)
Pipe Length (Elbows)	Group / Room / Tag Ref.	Htg.Total

11,350 BTU/h (8,501 BTU/h)
13,521 BTU/h

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Diamond System Builder

Indoor Units:	3 / 2 to 3		
Capacity:	30 / 15 to 30		
* Connectable capacity is not actual capacity.			
Total Pipe Length:	100.0 / 230.0	feet	
Furthest Actual:	40.0 / 82.0	feet	
Furthest Equiv.:	40.0 / 82.0	feet	
Correction Factors			
Outdoor Unit Capacity:	1.00	1.00	
Temperature:	0.97	0.99	
Piping Length:	0.99	1.00	
Defrosting:	-	0.95	
User Derate:	1.00	1.00	
Total Derate:	0.96	0.94	
Additional Refrigerant:	0.0	lb	
Total Refrigerant Amount:	8.8	lb	

Conditions (°F)

Cooling

Indoor DB 75.0 Humidity 59.0% Indoor WB 64.9

Outdoor DB 95.0

Heating

Indoor DB 70.0

Outdoor DB 21.0 Humidity 72.8% Outdoor WB 19.3

MXZ-3C30NAHZ2-U1

Pipe Dia. Liquid / Gas	Model Number	Clg.Total (Sens.)
Pipe Length (Elbows)	Group / Room / Tag Ref.	Htg.Total

1/4 / 3/8	SEZ-KD12NA4R1.TH	N/A / 2 / Master Bedroom	11,048 BTU/h (7,729 BTU/h) 10,700 BTU/h
30.0ft (4)			
1/4 / 3/8	MSZ-FH06NA	N/A / 3 / Living Room	5,529 BTU/h (4,858 BTU/h) 5,444 BTU/h
30.0ft (4)			
1/4 / 3/8	SEZ-KD12NA4R1.TH	N/A / 4 / Second Floor	10,947 BTU/h (7,687 BTU/h) 10,680 BTU/h
40.0ft (4)			

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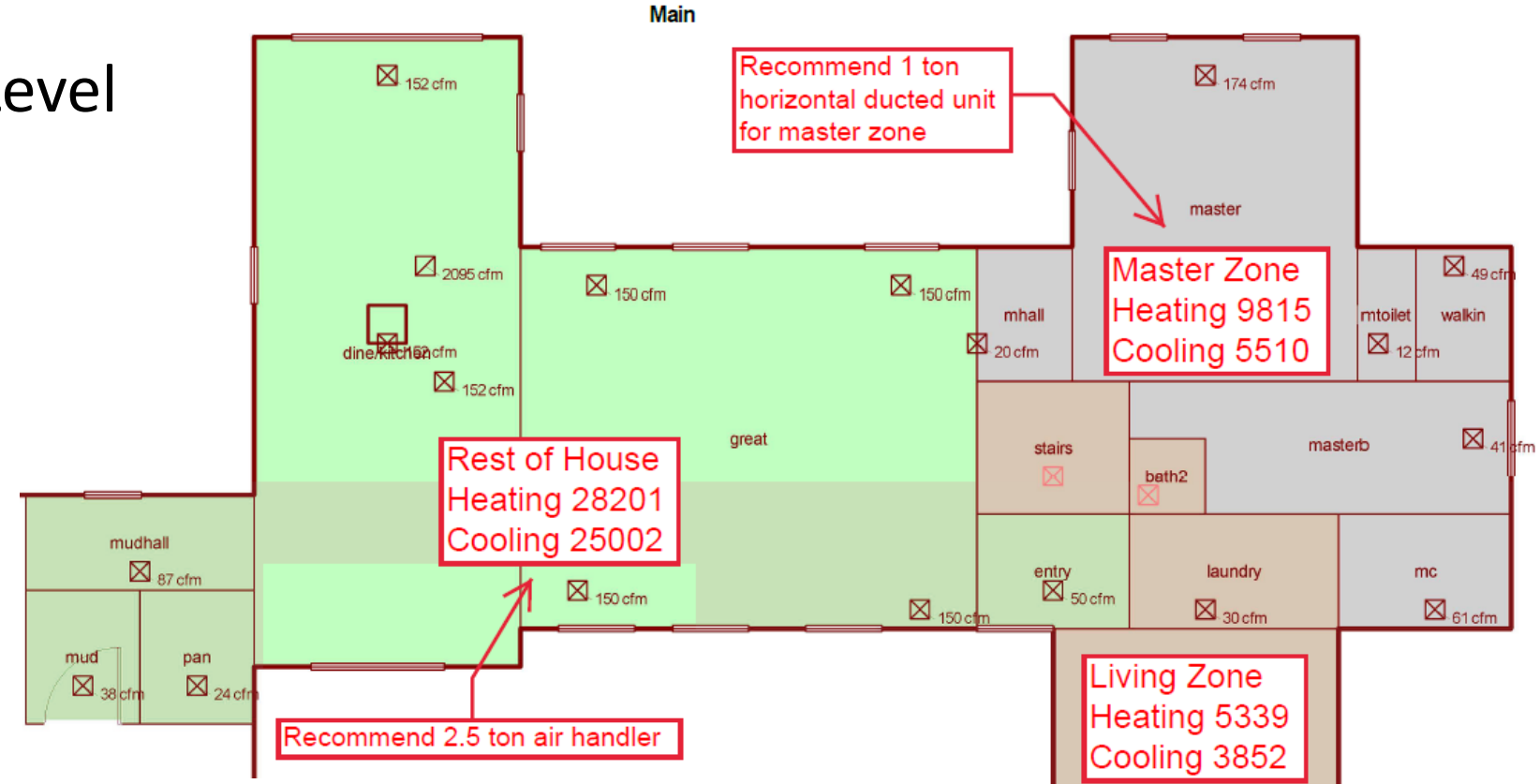
Comfort Zones

- Main Level



SEZ-KD12NA4R1.TH

N/A / 2 / Master Bedroom

11,048 BTU/h (7,729 BTU/h)
10,700 BTU/h

Recommend 1 ton horizontal ducted unit for master zone

Master Zone
Heating 9815
Cooling 5510

Rest of House
Heating 28201
Cooling 25002

Recommend 2.5 ton air handler

SVZ-KP30NA

N/A / 1 / Great Room

25,912 BTU/h (20,920 BTU/h)
30,913 BTU/h

Living Zone
Heating 5339
Cooling 3852

Recommend 1/2 ton ductless heat pump for living zone

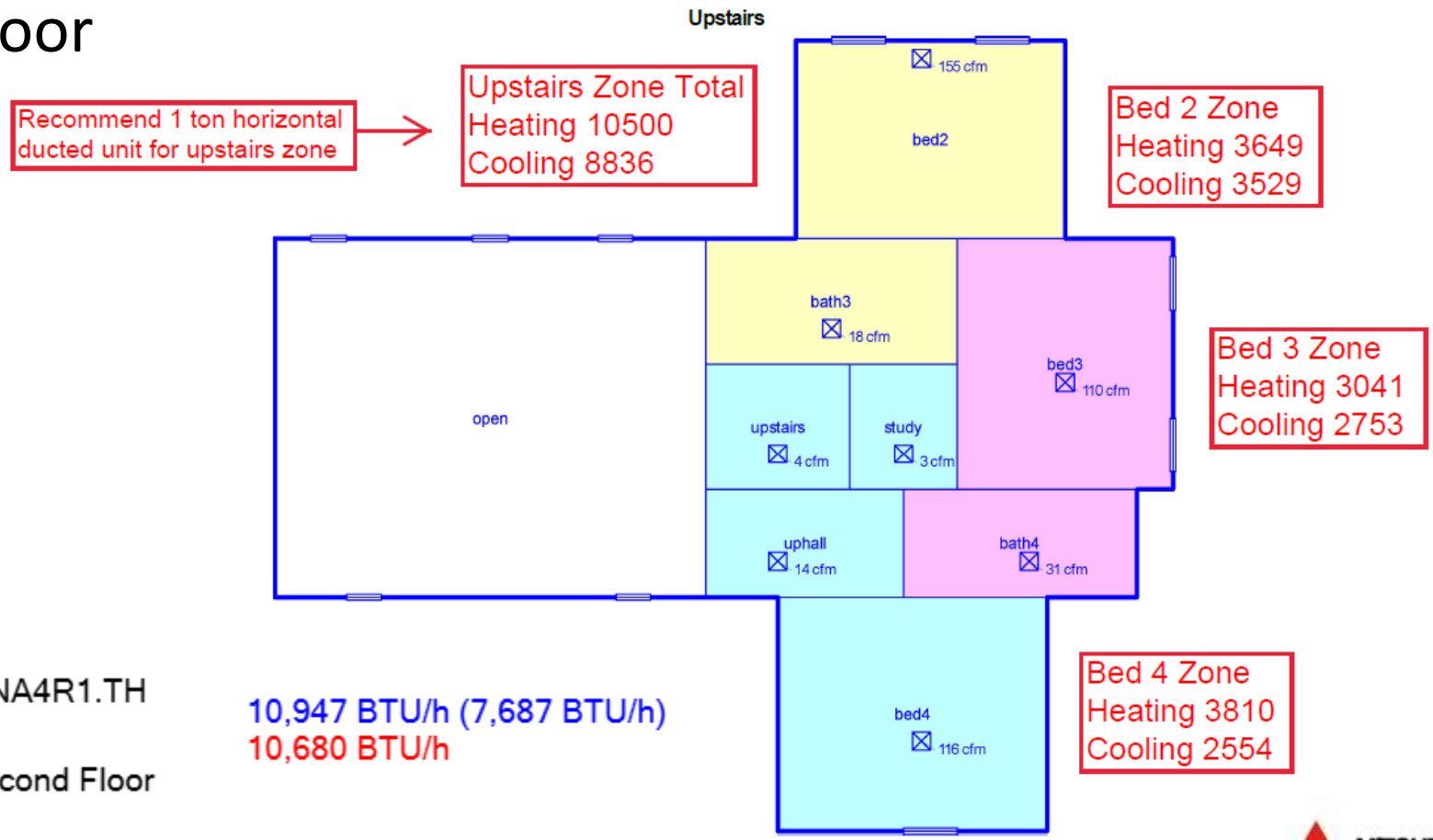
MSZ-FH06NA

N/A / 3 / Living Room

5,529 BTU/h (4,858 BTU/h)
5,444 BTU/h

Comfort Zones

- Second Floor



Zoned Comfort Solutions

- Customized comfort
- Healthy Indoor Air Quality
- Multiple points of filtration
- Mechanical ventilation
- Moisture management
- Controls integration
- Energy efficiency for lower utility bills

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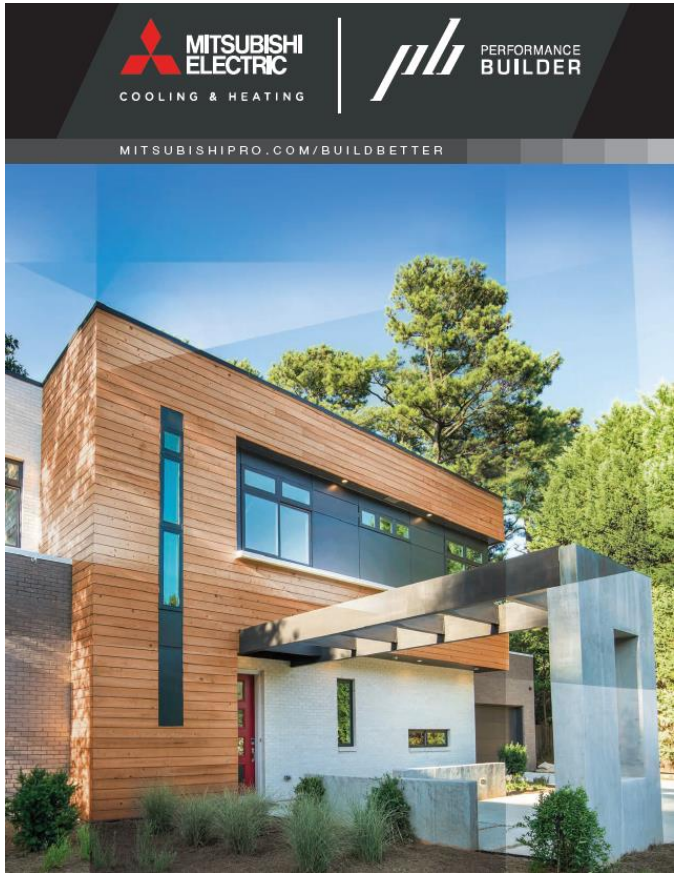
Performance Builder Program

- Loyalty program for builders including:
  - Training and technical assistance
  - Marketing support (case studies, spotlight videos)
  - Equipment discounts and rebates
  - Model home program
  - Extended warranty program



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Performance Contractors Wanted

- We are seeking Performance Contractors for design, installation, and commissioning of Zoned Comfort Solutions in high performance homes
- Our team will provide the training and technical support to help you succeed

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What's in it for builders?

- No ducts = no duct leakage + no duct testing
- Lower HERS scores
- Energy code compliance
- Certification goals
- Fewer call backs
- Happy customers

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2019 Housing Innovation Awards

Habitat for Humanity of Catawba Valley

The Rudy Project | Hickory, NC | HabitatCatawbaValley.org

"A home that is not only affordable to purchase, but also affordable to own and operate." *Habitat for Humanity Catawba Valley*

PROJECT DATA

- **Layout:** 3 bdrm, 2 bath, 1 fl, 1,160 ft²
- **Climate:** IECC 4A, mixed-humid
- **Completed:** January 2019
- **Category:** affordable

MODELED PERFORMANCE DATA

- **HERS Index:** without PV 40
- **Annual Energy Costs:** without PV $750
- **Annual Energy Cost Savings:** (vs typical new homes) without PV $300
- **Annual Energy Savings:** without PV 3,400 kWh
- **Savings in the First 30 Years:** $12,200

KEY FEATURES

- **Walls:** 2x6 24" o.c. advanced framing: ladder blocking, open and insulated headers, R-26 total: ½" drywall, R-19 unfaced batts, ½" OSB sheathing, 1" taped rigid foam, 1x4 furring strips, ¾" engineered wood lap siding.
- **Roof:** Gable roof; coated OSB sheathing, architectural asphalt shingles.
- **Attic:** Vented attic; 20" R-50 blown fiberglass; 24" raised heel trusses.
- **Foundation:** Unvented crawlspace, R-11 total: 2" rigid EPS on inside face of 8" CMU, rubberized waterproof coating, 12-mil reinforced polyethylene liner over dirt.
- **Windows:** Double-pane, argon-filled, low-e, vinyl single-hung frames, U=0.30, SHGC=0.22.
- **Air Sealing:** 2.5 ACH 50, drywall glued at top plate, sill seal.
- **Ventilation:** ERV, MERV 13 filters.
- **HVAC:** Ductless mini-split heat pump, 12.5 HSPF, 26.1 SEER, 1 indoor air handler, 1 outdoor compressor; dehumidifier in crawl.
- **Hot Water:** Heat pump water heater, 3.39 EF, 50-gal., compact plumbing design.
- **Lighting:** 100% LED, motion sensors on exterior lights.
- **Appliances:** ENERGY STAR refrigerator, dishwasher, clothes washer, and dehumidifier.
- **Solar:** Solar ready.
- **Water Conservation:** WaterSense-labeled fixtures and toilets.
- **Energy Management System:** Programmable thermostat.
- **Other:** 3-ft doors and hallways, low-VOC paint, Green Guard cabinets and flooring, passive radon vent, IBHS Fortified Home Bronze-level features.

CONTACT

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U.S. Department of Energy | Energy Efficiency & Renewable Energy

For more information on the **DOE Zero Energy Ready Home** program, go to http://energy.gov/eere/buildings/zero-energy-ready-home or scan the QR code.

Building America | U.S. Department of Energy

Imery Group

Monroe Farmhouse | Monroe, GA | ImeryGroup.com

"Despite extremely energy-efficient design, there was no compromise on aesthetics and only a reasonable cost premium." *Home owner*

PROJECT DATA

- **Layout:** 3 bdrm, 3 bath, 1.5 fls, 1,863 ft²
- **Climate:** IECC 3A, mixed-humid
- **Completed:** October 2018
- **Category:** custom buyer

MODELED PERFORMANCE DATA

- **HERS Index:** without PV 46; with PV -13
- **Annual Energy Costs:** without PV $1,250; with PV $100
- **Annual Energy Cost Savings:** (vs typical new homes) without PV $1,050; with PV $2,150
- **Annual Energy Savings:** without PV 8,200 kWh; with PV 19,500 kWh
- **Savings in the First 30 Years:** $91,600

KEY FEATURES

- **Walls:** 2x4 24 in. o.c., staggered on 2x6 plates; advanced framing; R-24 total: ½" drywall, R-21 cellulose; R-3 taped coated OSB sheathing, ¾" rigid rainscreen, fiber cement cladding.
- **Roof:** Gable roof; ½" drywall, taped coated OSB sheathing, flashing, 1x4 furring strips, standing seam metal roof, ENERGY STAR Cool Roof certified.
- **Attic:** Vented attic, 15.5" R-50 blown cellulose, 6" R-21 open-cell spray foam on rim bands and knee walls, 8" to 10" raised energy heels.
- **Foundation:** Raised slab 8" concrete-filled CMU stem wall, compacted dirt base, 4" #57 stone, 1" R-10 rigid foam under slab and on perimeter, poly taped at seams, 4" concrete slab.
- **Windows:** Triple-pane, argon-filled, low-e2, vinyl casement frames, U=0.19, SHGC=0.23.
- **Air Sealing:** 2.69 ACH 50.
- **Ventilation:** ERV with humidity sensor, MERV 8 filters, condensation sensors on bath fans.
- **HVAC:** 3 ductless mini-split heat pumps to 1 outside compressor, 1 ducted mini-split to 2nd compressor shared with a split-system water heater, 10 HSPF, 20 SEER; dehumidifier.
- **Hot Water:** Prototype split-system 80 gal. heat pump water heater shares HVAC outdoor condenser, est. EF=3.5; compact plumbing with PEX piping.
- **Lighting:** 90% LED, 10% CFL, motion sensors and timers.
- **Appliances:** ENERGY STAR refrigerator, dishwasher, ceiling fans, and bath fans.
- **Solar:** 8.2-kW PV system; inverter can disconnect from grid, battery storage.
- **Water Conservation:** WaterSense-labeled fixtures, drought-resistant landscaping.
- **Energy Management System:** Internet connected appliances, HVAC, PV tracking.
- **Other:** Wider doors, zero thresholds in bathroom, low-to-no-VOC products.

CONTACT

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U.S. Department of Energy | Energy Efficiency & Renewable Energy

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Building America | U.S. Department of Energy

Deltec Homes

Bluegate Horizon | Mills River, NC | DeltecHomes.com

"We have absolutely loved this home...just walking through the house every day is a joy." *A Deltec home owner*

PROJECT DATA

- **Layout:** 3 bdrm, 2 bath, 1 fl, 1,759 ft²
- **Climate:** IECC 4A, mixed-humid
- **Completed:** February 2019
- **Category:** custom for buyer

MODELED PERFORMANCE DATA

- **HERS Index:** without PV 45; with PV 0
- **Annual Energy Costs:** without PV $1,000; with PV $190
- **Annual Energy Cost Savings:** (vs typical new homes) without PV $900; with PV $1,750
- **Annual Energy Savings:** without PV 9,200 kWh; with PV 17,450 kWh
- **Savings in the First 30 Years:** $74,500

KEY FEATURES

- **Walls:** 2x6 24" o.c. advanced framing, R-24 total: ¾" drywall, 5.5" unfaced fiberglass batt, ½" plywood sheathing, 1" R-5 XPS, rigid foam, draining house wrap, fiber cement lap siding; wall panels built in factory powered by renewable energy.
- **Roof:** Vaulted asymmetrical roof with clerestory windows, ½" drywall, open web trusses at 24" o.c., ¾" plywood sheathing, polyolefin underlayment, ENERGY STAR Cool Roof.
- **Attic:** Unvented, vaulted ceilings; 8" R-30 open-cell spray foam under roof decking.
- **Foundation:** Slab on grade; 2" R-10 XPS at slab edge; termite inspection gap.
- **Windows:** Double-pane, argon-filled, low-e3, fiberglass double-hung, U=0.27, SHGC=0.21.
- **Air Sealing:** 1.44 ACH 50.
- **Ventilation:** Independently ducted HRV, also exhausts guest bath.
- **HVAC:** Combination ducted ductless mini-split heat pump, 10.7 HSPF, 17.45 SEER, 2 indoor air handlers; electric baseboard back-up. MERV 8 filters at return grills in bedrooms.
- **Hot Water:** Heat pump water heater, 3.69 EF, 50-gal.; push button recirculation pump.
- **Lighting:** 100% LED, daylighting.
- **Appliances:** ENERGY STAR refrigerator, dishwasher, clothes washer, and ceiling fans.
- **Solar:** 6.5-kW PV system.
- **Water Conservation:** EPA WaterSense fixtures and toilets; two 50-gal. rain barrels.
- **Energy Management System:** Wi-Fi-enabled thermostat remotely controls mini-splits, heat pump water heater, dishwasher, and range; PV monitoring system.
- **Other:** No-step entries, 3-ft doors. Zero-VOC interior paints and primers, Green Seal-labeled carpet, KCMA-certified cabinetry, Green Guard-labeled flooring.

CONTACT

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U.S. Department of Energy | Energy Efficiency & Renewable Energy

For more information on the **DOE Zero Energy Ready Home** program, go to http://energy.gov/eere/buildings/zero-energy-ready-home or scan the QR code.

Building America | U.S. Department of Energy

EEBA

Thank you!

Rob Howard, Regional Manager, Performance Construction
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Save the dates for next year:

EEBA