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Cleveland EcoVillage Energy Analysis

Building Characteristics

The following building envelope and mechanical system characteristics were used in our energy models and calculations.

Building envelope

Ceiling	R-38 (insulation type unknown)
Walls	R-19 24 oc + R-5 XPS exterior @ brick
	R-19 24 oc + R-4 EPS exterior @ stucco
Band joists	R-19 24 oc + R-5 XPS/R-4 EPS exterior
Foundation	R-10: 2" XPS on basement walls w. GWB
	2x3 framing, assume no cavity insulation
	R-4 3/4" XPS on basement to slab wall
Slab	R-8 2" EPS under entire slab
Depressed patios	R-10 2" XPS 4' wide frost protection
Windows	Double-glazed low-emissivity wood frame
	(vinyl clad) U=0.36, SHGC=0.45
Infiltration	2.5 sq in leakage area per 100 sf envelope

Mechanical systems

Heat	90%+ AFUE Sealed-Combustion Furnace
	in conditioned space (basement)
Cooling	12 SEER Air Conditioner Split System
DHW	0.59 EF Power-Direct Vent Water Heater
	(40 gallon) in conditioned space (basement)[1]
Ducts	In conditioned space
Duct Leakage	none to outside (5% or less)
Ventilation	AirCycler™ Supply-only system
	integrated with AHU (return side)
	30-40 CFM continuous average flow
	33% duty cycle (e.g., 10 on; 20 off)
Pressure relief	Tranfer grilles/jump ducts at bedrooms

Details and explanations on the ventilation system, and pressure relief/transfer grilles are enclosed.

1: This assumes the installation of an A.O. Smith Sealed Shot unit; State manufactures a unit that will meet our specification, but has a lower efficiency. Details can be found in Appendix B.

Energy Star Calculations

Energy Star scores were computed with the software REM/Design; all units passed (scores over 86.0).

Plan	Nominal floor area	Stories	Window area (sf)	Floor Glazing	Wall Glazing	Energy Star
End Slab	1604	2	266	16.6%	11.7%	91.0
Middle Next to Slab	2396	2	285	11.9%	9.5%	90.4
Middle Next to Bsmt	2415	2	268	11.1%	8.8%	89.8
End Bsmt Upper	1666	2	359	21.6%	15.0%	90.2
End Bsmt Lower	833	1	77	9.2%	10.3%	89.4

Design Loads

The heating and cooling design loads were calculated with RHVAC, a computerized version of Manual J, the ACCA industry standard load calculation method. The party walls (between units) were not computed as "adiabatic" for heat loss (i.e., no heat loss or gain). Instead, they were computed as partition walls with a 10° F temperature difference (e.g., in winter 70° F indoors, 60° F in the interstitial cavity). Resulting loads were as follows:

Plan	Nominal floor area	Stories	Design Heating	Sensible Cooling	Latent Cooling	Total Cooling
End Slab	1604	2	20.2	16.2	2.3	18.5
Middle Next to Slab	2396	2	23.0	20.5	3.8	24.2
Middle Next to Bsmt	2415	2	22.0	19.7	3.8	23.5
End Bsmt Upper	1666	2	22.4	21.4	3.1	24.5
End Bsmt Lower	833	1	12.6	7.3	2.0	9.4

Calculations were done with the following design conditions for Cleveland, OH:

Winter design temperatures: indoor 72° F, outdoor 5° F, ΔT = 67° F
Summer design temperatures: indoor 75° F, outdoor 90° F, ΔT = 15° F

Equipment Sizing: Cooling

The drawings are set up with cooling equipment as follows:

Plan	Nominal floor area	Stories	Specified Tons A/C
End Slab	1604	2	2.0
Middle Next to Slab	2396	2	2.5
Middle Next to Bsmt	2415	2	2.5
End Bsmt Upper	1666	2	2.5
End Bsmt Lower	833	1	1.5

Although the End Slab and End Basement Upper units are close to the same size (square footage, 2 stories), the latter has a ½ ton larger system. This is due to the greater window area of the End Basement Upper unit; a large portion of cooling load (typically 40-50%) comes from the windows.

The End Bsmt Lower unit could be cooled by a 1-ton unit; however, the smallest typically available size condenser is a 1-½ ton unit.

Equipment Sizing: Heating

Given the relatively low loads of these units, the smallest capacity furnaces available will suffice (typically 40,000 Btu input units). For combustion safety and efficiency reasons, we require a sealed combustion/direct vent condensing gas furnace (e.g. Carrier 58MXA series; specification sheet enclosed). Sample sizings are shown below:

Plan	Nominal floor area	Carrier Unit	Input Btu/hr	Nom. Cool. Airflow
End Slab	1604	58MXA-040-130-08	40,000	895 CFM
Middle Next to Slab	2396	58MXA-040-130-12	40,000	1215 CFM
Middle Next to Bsmt	2415	58MXA-040-130-12	40,000	1215 CFM
End Bsmt Upper	1666	58MXA-040-130-12	40,000	1215 CFM
End Bsmt Lower	833	58MXA-040-130-08	40,000	895 CFM

The airflows shown are at 0.5 external static pressure (W.I.C.), at high speed.

Note that these units are shown as an example; favored brands of the builder or HVAC contractor can be substituted, assuming they meet the heating and cooling loads, airflow requirements (400 CFM per ton nominal), and combustion safety requirements (sealed combustion/direct vent).

Limitations of Sizing Strategy

The equipment sizing assumed certain attributes of the house. If the house is not built within these parameters, heating and cooling performance problems may result.

- Airtightness: the air infiltration requirements for the units are stated below (see Appendix A, Test Requirements). The Manual J calculations assume an air change rate of 0.1 natural ACH; this has been measured in various Building America level houses across the country.

- Duct leakage: the duct blaster test requirements are shown below (see Appendix A). The leakage that will be measured and compared to the goal is duct leakage to outside. However, we also have a program-wide recommendation that total duct leakage should not exceed 10% of nominal system flow, if possible.

- Windows: the high-performance, low-E, wood frame (vinyl clad) windows must be used (U=0.36, SHGC=0.45). This item is one of the keys to occupant comfort. Furthermore, a common failure is that the IGU (insulated glass unit) is installed backwards at the factory. The low-emissivity coating should be on the inner surface of the inner pane of glass (surface 2, counting from inside to outside). An example of a glass testing unit can be seen at http://www.edtm.com/ae1600.htm

- Setback performance: on the cooling side, this equipment is sized to maintain the house at temperature setpoint, not to bring it from 95° F indoors down to 75° F during peak afternoon loads. Therefore, large temperature set-ups (with a setback programmable thermostats) should be avoided; 3-5° F should be used, maximum.

  With the efficient envelope and ducts within the conditioned space, maintaining the house at setpoint during the day is a more economical way to run the house than to let it heat during the day then cool it down. This is called our “set it and forget it” philosophy.

Appendix A: Test Requirements

Infiltration/air flow retarder (a.k.a. air barrier): The envelope is tightened to a target based on the surface area of the house (including floor slab). The Building America target is 2.5 square inches of equivalent leakage area per 100 square feet of envelope area.

The airtightness of these test houses will be measured with a blower door test. The targets are shown in the table below, in CFM 50 (cubic feet per minute at a test pressure of 50 Pascals) and in ACH 50 (air changes per hour at 50 Pascals). Note that ACH 50 is not the same as natural air changes per hour (nACH).

Plan	Nominal floor area	Stories	Surface area (ft^2)	Volume (cu ft)	Goal CFM 50	Goal ACH 50
End Slab	1604	2	4,015	13,634	1000	4.4
Middle Next to Slab	2396	2	4,961	19,977	1240	3.7
Middle Next to Bsmt	2415	2	4,982	20,125	1250	3.7
End Bsmt Upper	1666	2	4,197	14,161	1050	4.4
End Bsmt Lower	833	1	2,891	6,664	720	6.5

Duct system: The ductwork system will be tested for tightness in the completed house with a duct blaster test. The goal is a CFM 25 (cubic feet per minute at 25 Pascals test pressure) equal to 5% of the high-speed air handler nominal flow, at 400 CFM per ton. For instance, a 3-ton unit has a nominal 1200 CFM flow, with a 60 CFM 25 goal. This requirement is for duct leakage to the outside, not total duct leakage.

This table also shows square feet per ton; a common sizing metric used by HVAC contractors. These numbers are higher than typically seen numbers; this is due to the tighter sizing strategies that we used, as well as the improved building envelope. The low square footage per ton for the End Basement Lower unit is due to the fact that a 1-ton capacity unit is not available; 1.5 is the smallest available.

Plan	Nominal floor area	Specified Tons A/C	Duct leak (CFM 25)	sf/ton
End Slab	1604	2.0	40	802
Middle Next to Slab	2396	2.5	50	958
Middle Next to Bsmt	2415	2.5	50	966
End Bsmt Upper	1666	2.5	50	666
End Bsmt Lower	833	1.5	30	555

Appendix B: Water Heater Options

The following water heaters meet the combustion safety requirements for the Building America program. Note that the A.O. Smith units are the more energy-efficient option, according to GAMA ratings.

Item	Model #	Input kBtu/hr	Gallons	Energy Factor (EF)	Recovery Efficiency
State Select Power Direct-Vent	PR6 40 NBDVT	40.0	40.0	0.54	0.76
	PR6 50 NBDVT	40.0	50.0	0.54	0.76
	PR6 75 NRDVT	70.0	75.0	0.48	0.76
add heat traps	PR6 40 NBDVTW	40.0	40.0	0.56	0.76
	PR6 50 NBDVTW	40.0	50.0	0.56	0.76
	PR6 75 NRDVTLW	70.0	75.0	0.50	0.76
A.O. Smith Sealed Shot	FPD-40-***	42.0	40.0	0.59	0.76
	FPD-50-***	42.0	50.0	0.60	0.76