Jason Albers & Marcy Giannunzio

Energy Survey Report

540 East Luray Ave. Alexandria, VA

Audit Performed on June 7, 2011

Prepared for: The City of Alexandria, T&ES Office of Environmental Quality

Prepared with: Funding from DOE's Energy Efficiency and Conservation Block Grant

Prepared by:
EarthCraft Virginia
1431 W. Main St.
Richmond, VA 23235

Table of Contents

1. Executive Summary 3
2. Customer Interview 3
3. Existing Building Conditions 3
Building Envelope 4
Heating Ventilation and Air Conditioning (HVAC) 4
Exhaust Fan 4
Lighting and Appliances 4
Water 4
4. Utility Data Analysis 5
5. Opportunities for Improvement 6

Appendices

Terms and Definitions ..... Appendix 1

1. Executive Summary

This report details recommendations and conclusions of an energy survey conducted on June 7th, 2011 at the above residence consisting of a visual inspection of the thermal envelope and system components. The intent is to help identify energy saving approaches and possible upgrade opportunities for the building envelope, HVAC, domestic hot water, lighting and other systems as applicable. A 12-month utility bill analysis has been utilized in an attempt to identify season energy use. This energy use analysis has been generated for electricity and natural gas energy use, and may be utilized as a tool to project or monitor future energy improvements. The building was thoroughly checked in the following areas: insulation, mechanical systems, probable air leakage sites, windows, doors and possible moisture problems. The energy and water conservation measures outlined in this report, if implemented, would directly affect the buildings operating cost and reduce its carbon footprint. The opportunities for improvement section are placed in order of priority levels. These are suggested improvements to be made to improve the quality of the building and increase energy efficiency. The key opportunities for improvement are to seal duct work which would have the added benefit of reducing the relative humidity in the building. Also, the addition of a programmable thermostat would have the potential of reducing energy usage if used properly.

2. Customer Interview

Mr. Albers, the homeowner, was present for the duration of the survey. Marcy Giannunzio was unable to attend. They have lived at the residence for four years and during that time have invested considerable efforts in updating the residence with many energy efficiency features. Mr. Albers thought they would possibly remain at this location for 3-5 years and depending on determining factors, look to sell and move on to another residence. They typically keep the home at 68°F-69°F during the heating season and around 72°F-74°F during the cooling season. They do not have a programmable thermostat. In order to eliminate stratification of air and enhance comfort levels they operate the air handler fan constantly. They leave their bedroom door open at night. The door to the second bedroom remains closed and they block the supply vent in that room. They also block off the supply vent to the basement. Mr. Albers noted that during some weather events he had observed water intrusion around the back door and in the basement window directly below.

3. Existing Building Conditions

The residence is an 816 sq ft two story townhouse with conditioned basement flanked on the east and west by other occupied residences. These two elevations are buffered by conditioned space. The front elevation faces south and the back faces north. Construction date was not known but is believed to have been constructed sometime in the mid nineteen forties. Occupancy is two individuals plus a cat. The building site was not notably well elevated but the front (south) demonstrated no evidence of standing water having occurred over any period of time. The back of the residence presented some evidence of standing water but was not obviously low or holding water at the time of this survey. The brick veneer displayed no evidence of capillary moisture movement at the time of this survey.

BUILDING ENVELOPE
FLOORS: Slab below grade construction. Time of construction would indicate no slab or floor insulation present.

WALLS: Masonry walls with brick veneer. Drywall hung on wood studs with no insulation present.

ROOF/CEILING: Roof is flat with undetermined membrane. Roof has gutters and down spouts on north elevation which appeared to be in good condition. There was no evidence of roof leaks. Ceiling cavity had no access panel or scuttle for inspection. Attic insulation if present could not be determined.

WINDOWS: Windows are double pane vinyl clad. Window u-value and solar heat gain coefficient were unknown and age of windows was indeterminable but were replacement units not original to the house, with the exception of the basement north window which appeared to be original to the home. No indication or discoloration of window sashes were noted which would indicate window condensation events. Mr. Albers has replaced one kitchen window on the north facing wall with a high efficiency, triple pane window.

DOORS: Exterior doors were insulated steel with storm doors. The front storm door was not operating or fitting correctly and the back entrance door had a bad hinge which required a special technique to close properly.

HEATING VENTILATION AND AIR CONDITIONING
HVAC: The building is heated with an American Standard 80 AFUE naturally aspirating gas furnace. A Carrier Air Conditioning unit with a SEER rating of 11.5 meets the cooling needs. Conditioned air is delivered by a forced air distribution system which displayed many leakage sites and is in need of air sealing. Combustion air is provided by the air volume within the thermal envelope and infiltration of exterior air during combustion appliance operation. The systems were believed to have been installed by a previous occupant around 2003. While not included in the scope of work of a survey, house pressure testing was done during combustion appliance operation and the residence experienced a two pascal depressurization limit which would be attributed to predominant supply side duct leakage.

EXHAUST FANS
The bath room exhaust fan could not be identified as Energy Star® rated. The perimeter of the fan grille is adequately sealed but often if the grille is sealed at this location, the rough opening at drywall penetration is not and as such represents an opportunity for air leakage into the attic.

LIGHTING AND APPLIANCES
Since acquiring the home the occupants have replaced all incandescent bulbs with CFL's or other high efficacy lighting. In 2009 during a kitchen remodel they installed all Energy Star® rated appliances to include refrigerator, clothes washer and dryer as well as new microwave and free standing gas range with electronic ignition. They replaced their old dishwasher with an Energy Star® rated unit in 2010.

WATER
Domestic hot water is provided by a 40 gallon A.O. Smith gas fired naturally aspirating hot water heater with an energy factor (EF) of .59. All fixtures including showerhead were pressure regulated 1.5 gpm

low-flow. The flow rate of the toilet appeared to be a 1.6 gpm appliance but could not be verified by the survey team.

4. Utility Data Analysis

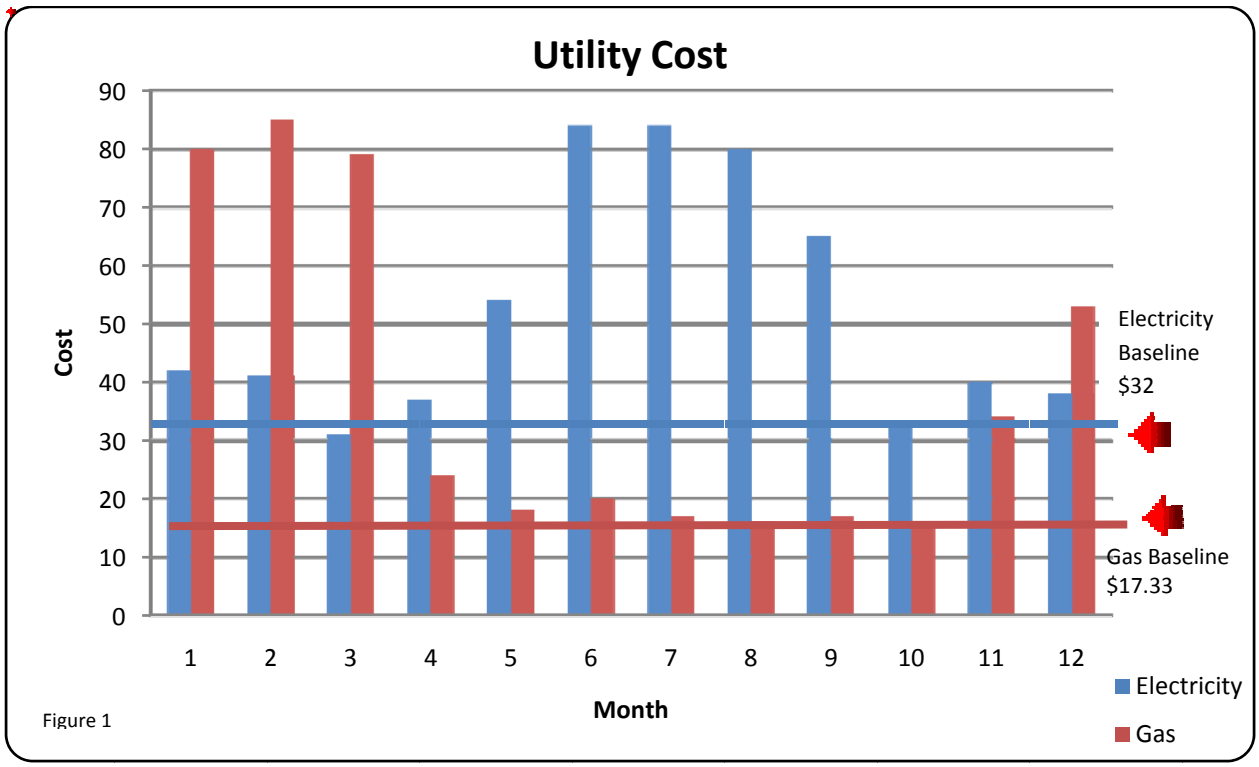

Figure 1

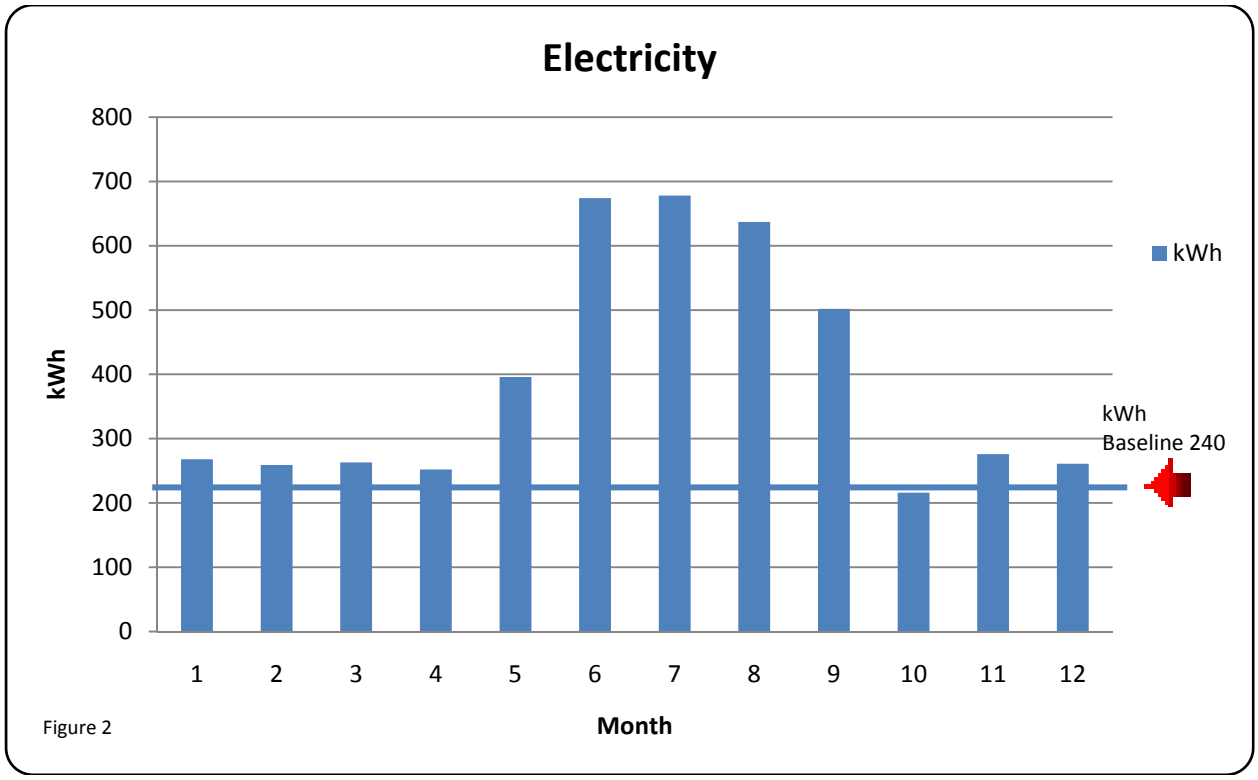

Figure 2

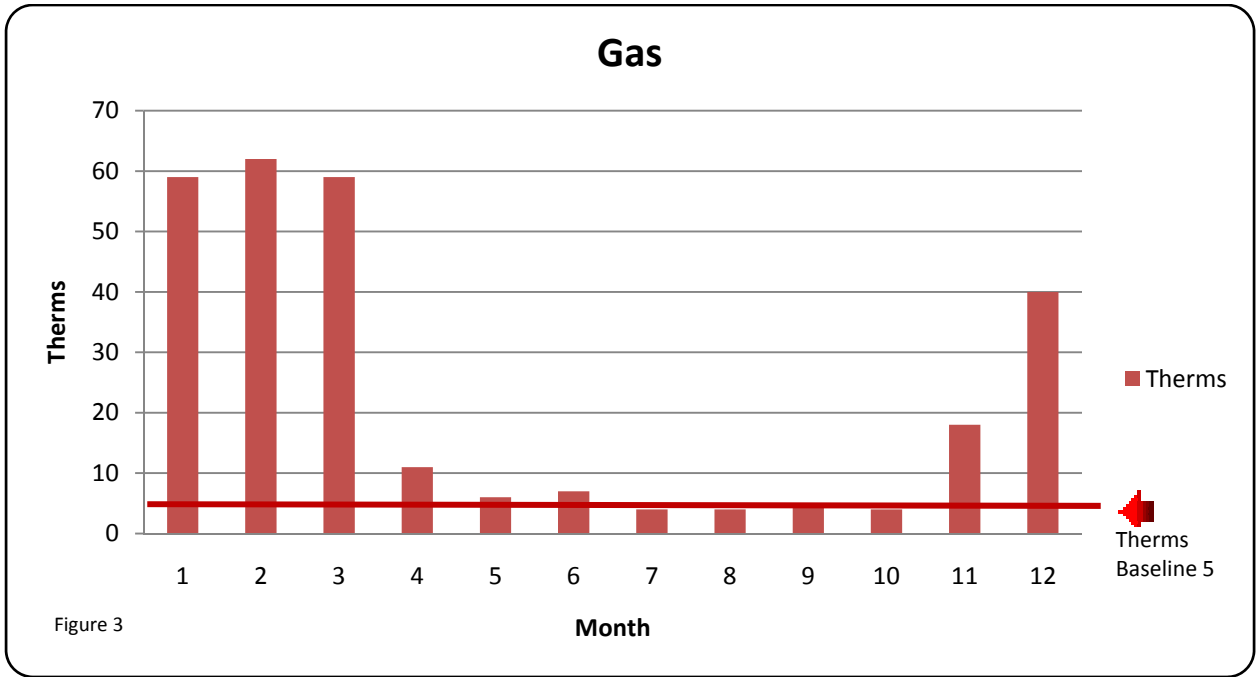

Figure 3

Energy usage can be divided into two categories: base load and seasonal energy use. Base load includes water heating, lighting, refrigerator, and other appliances. Seasonal energy use includes heating and cooling. If base load costs are high, potential savings for performing base load measures are high. If heating costs are high, savings for heating related measures are high. A home's total energy consumption determines its potential energy savings. Homes with inefficient thermal envelopes have

large seasonal energy use (heating/cooling costs) and smaller base loads (appliances, lighting, etc). More efficient homes are dominated by base load energy uses.

Utilizing the utility data provided, a base load was determined with which we can estimate heating/cooling costs from the energy bills. The baseline for electricity usage during the cooling season was calculated to be $32.00. This was the average of the two lowest months which it is assumed that no electricity is used for cooling. Any month that exceeded $32.00, that amount is assumed to be utilized for cooling energy consumption. This indicates that total electricity use for cooling between May and September was $207.00, for a total of 240 kWh, with an average of $41.40 per month. The baseline for gas usage was $17.33. Total gas usage for the heating season above the baseline, was $251.02, a total of 219 Therms, an average $41.84 per month.

This shows that baseline energy usage which does not include heat/cooling costs is very consistent. Likewise costs for heating and cooling were virtually the same. Total energy use including heating and cooling was $1,089.45 or an average $90.79 a month.

5. Opportunities for Improvement

GUIDE TO PRIORITY LEVELS
A: Essential items to address immediately
B: Important to address soon
C: Will provide some energy benefit
D: Least important to address
Ø: No Improvement is needed

Priority level B: How HVAC systems are operated by occupants can have a significant impact on energy usage. Usually it is not advantageous to close off rooms and supply air to those rooms as doing so has the potential to increase the static pressure on the forced air distribution system and contribute to house depressurization. If there are leakage sites in the duct system this increased pressure causes them to leak more, often in interstitial cavities outside the thermal envelope. If designed properly the system works best and more efficiently if it heats and cools the zones it was designed for. The survey team would not recommend compartmentalizing the home and closing off intentional openings in the forced air distribution system for the above mentioned reasons. It's likely that opening the bedroom door and the closed supply vents will allow the system to operate more efficiently and would have a positive effect on the depressurization issue. These steps could result in reducing heating and cooling cost as much as 5%-10% annually.

Priority level B: During the heating season 68°F is a desired temperature for occupant comfort and energy efficiency. 72°F-74°F, from an energy usage viewpoint, would be low during the cooling season. Often occupants can achieve comfort at 78°F if the humidity level is in the 40%RH-55%RH range as the drier the skin is the more comfortable people are at higher temperatures. As this house is depressurizing during system operation and is pulling in hot, humid summer air increasing interior relative humidity, it would be our recommendation to verify this by obtaining a digital humidistat to monitor interior humidity levels. If humidity is found to be consistently over 60%RH lowering relative humidity might allow occupants to achieve comfort levels around 78°F leading to reduced energy consumption. Digital humidistat are available from Radio Shack® and others

electronic suppliers in the $20-$30 range. You can save 5% of the energy used by your air conditioner for every degree you raise the thermostat (if it's set between 70°F and 82°F degrees).

Priority level B: In almost all cases when the house depressurizes during HVAC operation the cause is predominant supply side duct leakage. The negative pressure created by depressurization causes the home to draw in unconditioned air from outside or from areas of unconditioned space, such as attics, foundations, interstitial cavities, etc. Not only does this have a negative impact on energy usage, it can also create indoor air quality issues. Often this leakage is located in chases or other building cavities and never finds its way into the thermal enclosure. We would recommended either the homeowner initiate duct leakage repair or a qualified contractor be employed to address this concern. Duct repair is best performed by a professional but obvious leakage sites such as those depicted in the survey report can be performed by the homeowner. Only duct mastic should be used to seal ducts which is commonly available at home improvements centers such as *The Home De*pot *or Lowes*. Typically duct mastic is available for approximately $10-$15 per gallon. One gallon is normally sufficient for a residential duct system repair. Information on DIY duct repair can be found at http://www.energystar.gov/index.cfm?c=diy.diy_index

It would not be recommended to continuously operate the air handler fan to address stratification of air as this causes the house to be depressurized 24/7 and standard air handler fans are not very efficient unless they are utilizing electronically commuted motors (ECM's) which are rated for continuous operation. Duct repair has the potential of reducing heating and cooling costs 10%-20% annually. The average cost for duct repair per zone typically ranges from $750-$1,200 depending on the size of the system and the accessibility.

As noted duct leakage is the major deficiency identified and sealing the ducts has the highest priority. Not only does duct leakage cause the loss of conditioned air, it causes the building to either pressurize or depressurize depending on whether it has pre-domination supply or return side duct leakage. In the case of this project the house is depressurizing which would indicate predominant supply side duct leakage. This depressurization causes the house to draw in outside air which is cold in the winter and hot and humid in the summer, not only exacting an energy penalty but raising interior relative humidity levels. Mitigating this problem would not only save energy but would reduce relative humidity as HVAC system operation would no longer draw hot, humid ambient air into the building.

Duct leakage at supply take off.

Duct leakage at supply boot.

Priority level B: Water heaters have adjustable thermostats. If you have a dishwasher without its own water heating element (undetermined by the survey team), 140°F is needed, but be careful of scalding at this temperature. If your water heater only services bath and kitchen needs, 120°F will suffice. On water heaters over 10 years old for every 10 degrees you lower the temperature, you save approximately 6% of your water heating energy by avoiding less heat loss through the skin of the unit.

Priority level C: Mr. Albers is aware that some attention needs to be paid to both front and back doors to assure adequate weather sealing. We reinforce his concern on this issue.

Air leakage at back door jam

Priority level C: A programmable thermostat would be a desirable feature with its ability to maintain more efficient temperature set points when the house is not occupied. It would be programmed to ramp up or down to desired temperatures as desired. Since both occupants work during the day this would be an energy conservation feature worth consideration. By installing a programmable thermostat and using it properly a savings of up to 5%-10% annually could be realized. Programmable thermostats are available from various suppliers normally in a price range of $50 for a basic model to around $150-$200 for an advanced one.

Priority level D: The HVAC system is only eight years old and appears to be well maintained. It would be desirable if the furnace efficiency was over 90% AFUE and closed combustion but it would not be cost effective to change it out particularly as the occupants intentions are to move at some time in the near future. The same is true of the AC unit.

Priority level D: The only opportunity for increased insulation levels would be possibly in the roof/ceiling. It would require an “intrusive building investigation” (cut a hole in the ceiling) to determine if that was even a possibility. Most of buildings heat loss/heat gain is through floors and ceilings. While insulating the floor on this structure is impracticable, it might be possible to retrofit ceiling insulation which would certainly aid in reducing heating and cooling energy usage.

Thank you for the opportunity to allow our firm to conduct this energy survey on your residence.

TERMS AND DEFINITIONS

1. Absorption – The process whereby a fluid permeates or is dissolved by a liquid or solid. The formation of a gas or liquid film on a solid surface.
2. ACCA – Air Conditioning Contractors of America
3. Air barrier – Material(s) assembled and joined together to provide a barrier to air leakage through the building envelope. An air barrier may be a single material or a combination of materials. Any solid material installed to control air leakage either into or out of the building envelope. The material used shall have an air permeability not to exceed 0.004 cubic feet per minute per square foot under a pressure differential of 0.3 in. water (1.57 psf)(0.02 L/s.m2@75 Pa.) when tested in accordance with ASTM E2178-01.
4. Air changes per hour – A measure of how many times the volume of air within a defined space (normally a room or house) is replaced.
5. Air change rate – A measure of how quickly the air in an interior space is replaced by outside (or conditioned) air by ventilation and infiltration/exfiltration.
6. Air leakage – air leakage, or infiltration/exfiltration, occurs when outside air enters a house uncontrollably through cracks and openings in the thermal envelope.
7. Air Pressure Boundary – Any part of the building shell that offers resistance to air leakage. The most effective Air Pressure Boundary consists of a series of air barriers of interior and/or exterior sheeting material that resists airflow through it. An effective air pressure boundary is nearly airtight.
8. Air source heat pump – A compressor, condenser and refrigerant system that uses outside air as a heat source which is absorbed at one place and released at another.
9. Air system balancing – Adjusting air flow rates through air distribution devices, such as fans and diffusers, by manually adjusting the positions of dampers, splitter vanes, extractors, etc., or by using automatic control devices, such as constant air volume or variable-air-volume (VAV) boxes.
10. Annual Fuel Utilization Efficiency or AFUE – A standardized measure of heating system efficiency, based on the ration of annual output energy to annual input energy that includes any non-heating season pilot input loss.
11. As-measured Carbon Monoxide – A direct measurement of carbon monoxide CO in a sample of air or flue gas, usually measured in ppm (parts per million) units.
12. ASHRAE – American Society of Heating, Refrigerating and air-Conditioning Engineers
13. ASTM – ASTM International, originally known as the American society for Testing and Materials (ASTM).
14. Atmospherically-Vented – An appliance using a natural draft venting system.
15. Back Draft – Sustained downdraft during burner operation.
16. Boiler – A space heating appliance that heats water with hot combustion gases that pass through a heat exchanger.
17. British Thermal Unit (BTU) (see also "ton") – The measure used to determine heat energy. One BTU will raise the temperature of one pound of water by one degree Fahrenheit at sea level. For instance, it takes 2,000 Btu to make one pot of coffee. One Btu compares to 252 calories, 778 foot-pounds, 1055 joules, and 0.293 watt-hours.
18. Building analyst (BA), Certified – An individual who successfully passes the Building Performance Institutes written and field examination requirements for certification in order to evaluate the performance of a home, taking into account systems, physical conditions and other energy and non-energy characteristics of the home.

19. Building Envelope – The components of a building (walls, ceilings, windows, doors, floors, and foundations) that separate the conditioned space from the unconditioned spaces or conditioned space from outside.
20. Building thermal envelope – Depending on the code being applied to the structure, this can be defined as follows:
    a. *Under the 2009 IECC* – The basement walls, exterior walls, floor, roof or any other building element that enclose conditioned space. The boundary also includes the boundary between conditioned space and any exempt or unconditioned space.
    b. *Under ANSI/ASHRAE/IESNA Standard 90.1-2007* – The exterior plus the semi-exterior portions of a building. For the purpose of determining building envelope requirements, the classifications are defined as follows:
        i. *Building, envelope, exterior* – The elements of a building that separate conditioned spaces from the exterior;
        ii. *Building envelope, semi-exterior*– The elements of a building that separate conditioned space from unconditioned space or that enclose semi-heated spaces through which thermal energy may be transferred to or from the exterior , or to or from unconditioned spaces, or to or from conditioned spaces
21. Capacity modulation – A system that adjusts the ability of the compressor to circulate refrigerant *through* the refrigeration system and therefore adjust the ability of the refrigeration system to absorb and reject heat. It may also be used to adjust the capacity of the refrigeration system based upon a required heating and/or cooling demand
22. Cardinal directions – The most commonly used forms of direction, and include North, South, East and West. The four equal divisions – Northeast, Southeast, Southwest and Northwest – are called Primary Inter-Cardinal directions.
23. Climate zones – A region in which the climate can be defined by using a few key parameters such as temperature and rainfall.
24. Coefficient of performance (COP) – COP can be used to define either cooling efficiencies or heating efficiencies as for heat pumps.For cooling, it is the ratio of the rate of heat removal to the rate of energy input, in consistent units, for a complete refrigerating system of some specific portion of that system under designated operating conditions. For heating, it is the ratio of the rate of heat delivered to the rate of energy input, in consistent units, for a complete heat pump system, including the compressor and, if applicable, auxiliary heat, under designated operating conditions.
25. Combustion Appliance Zone – A contiguous air volume within a building that contains a combustion appliance; the zone may include, but is not limited to, a mechanical closet, mechanical room, or the main body of a house, as applicable.
26. Commercial Building – All buildings that are not included in the definition of "Residential Buildings."
27. Commissioning – The process of assuring that all systems and components of a building are designed, installed, tested and operating according to specific requirements.
28. Compact florescent bulb (CFL) – A type of fluorescent lamp designed to replace the standard incandescent lamp. CFLs use less power and have a longer rated life.
29. Conditioned floor area – The horizontal projection of the floors associated with the conditioned space.
30. Conditioned space – An area or room within a building being heated or cooled, containing un-insulated ducts, or within a fixed opening directly into an adjacent conditioned space.

31. Conduction – Heat transfer by means of molecular agitation within a material without any motion of the material as a whole.
32. Connected load – The sum of the continuous power ratings of all load-consuming apparatus connected to the electrical power distribution system or any part thereof.
33. Convection – The movement of molecules within fluids (i.e. liquids, gases). It is one of the major modes of heat transfer.
34. Cooling climate – A region with a 67 degree Fahrenheit or higher wet bulb temperature for 3,000 or more hours during the warmest six consecutive months of the year or a 73 degree Fahrenheit or higher wet bulb temperature for 1,500 or more hours during the warmest six consecutive months of the year.
35. COP – Coefficient of Performance is the ratio of the rate of heat delivered to the rate of energy input, in consistent units, for a complete heat pump system under designated operating conditions.
36. Curtain wall - Fenestration products used to create an external no-load bearing wall that is designed to separate the exterior and interior environments.
37. Degree day – The difference in temperature between the outdoor mean temperature over a 24-hour period and a given base temperature. For the purposes of determining building envelope requirements, the classifications are defined as follows:
    a. Cooling degree-day base 50°F (CDD50) – For any one day, When the mean temperature is more than 50°F., there are as many degree-days as degrees Fahrenheit temperature difference between the mean temperature for the day and 50°F. Annual cooling degree-days (CDDs) are the sum of the degree-days over a calendar year.
    b. Heating degree-day base 65°F (HDD65) – For any one day, when the mean temperature is less than 65°F, there are as many degree-days as degrees Fahrenheit temperature difference between the mean temperature for the day and 65°F. Annual heating degree-days (HDDs) are the sum of the degree-days over a calendar year.
38. De-superheater – An energy saving device in a heat pump that, during the cooling cycle, recycles some of the waste heat from the house to heat domestic water.
39. Dew point – The dew point is the temperature at which a given parcel of humid air must be cooled, at constant barometric pressure, for water vapor to condense into water.
40. Diagnostic Testing – The use of building performance-testing equipment (e.g. blower door, duct blaster, flow hood, infrared camera, CO monitor, etc.) to measure, assess and document specific performance characteristics of the building system.
41. Diffusion – The spread of particles through random motion from regions of higher concentration to regions of lower concentration.
42. Direct Vent Appliance – A combustion appliance for which all combustion gases are vented to the outdoors through an exhaust vent pipe and all combustion supply air is vented to the combustion chamber from the outdoors through a separate, dedicated supply-air vent.
43. Downdraft – Air flow from a chimney or venting system into an enclosed building space.
44. Draft – A pressure difference that causes combustion gases or air to move through a vent connector, flue, chimney, or combustion chamber.
45. Drainage Plane – A membrane material applied with laps or without seams, in order to direct water away from and off of vulnerable building shell materials.
46. Dry bulb temperature – The temperature of air measured by a thermometer freely exposed to the air but shielded from radiation and moisture. Dry bulb temperature is the temperature that is usually thought of as air temperature, and it is the true thermodynamic temperature. It is the temperature measured by a regular thermometer exposed to the airstream.

47. Economizer (air) – A duct and damper arrangement and automatic control system that allows a cooling system to supply outside air to reduce or eliminate the need for mechanical cooling during mild or cold weather.
48. Economizer (water) – A system where the supply air of a cooling system is cooled indirectly with water that is itself cooled by heat or mass transfer to the environment without the use of mechanical cooling.
49. Electronic commutated motor (ECM) – A synchronous electric motor, powered by direct current (DC) electricity that has an electronic commutation system, rather than a mechanical commutator and brushes.
50. Energy Analysis Tool – A computerized calculation procedure for determining a home's energy efficiency rating and estimating annual purchased energy consumption and cost.
51. Energy Efficiency Rati0 (EER) – The ratio of net cooling capacity in BTU/h to total rate of electric input in watts under designated operating conditions.
52. Energy Efficiency Rating-An unbiased indication of a home's relative energy efficiency based on consistent inspection procedures, operating assumptions, climate data and calculation methods.
53. Energy Factor or EF – A standardized measure of water heater energy efficiency as determined under Department of Energy Regulations, 10 CFR 430.23(2)(ii).
54. Energy recovery ventilation system – A system that employs air-to-air heat exchangers to recover energy from exhaust air for the purpose of preheating, precooling, humidifying or dehumidifying outdoor ventilation air prior to providing the air to a space, either directly or as a part of an HVAC system.
55. Energy Saving Measure or Feature – Any material, component, device, system, construction method, process or combination thereof that will result in a reduction of energy use.
56. Enthalpy – A measure of the total energy of a thermodynamic system. It includes the internal energy, which is the energy required to create a system, and the amount of energy required to make room for it by displacing its environment and establishing its volume and pressure.
57. Evaluation – An analysis of the data collected from any survey or audit, on-site data collection and performance testing, available energy usage records to determine energy use and potential savings from improvements.
58. Evaporation – The vaporization of a liquid that occurs only on the surface of a liquid. It is the process by which molecules in a liquid state (e.g. water) spontaneously become gaseous (e.g. water vapor).
59. Exfiltration – Air from conditioned space leaking outside of the thermal boundary of a structure.
60. Fenestration – Depending on the code being applied to the structure, this can be defined as follows:
    a. *Under the 2009 IECC* – Skylights, roof windows, vertical windows (fixed or moveable), opaque doors, glazed doors, glazed block and combination opaque/glazed doors. Fenestration includes products with glass and nonglass glazing materials, or
    b. *Under ANSI/ASHRAE/IESNA Standard 0.*1-2007 – All areas (including frames) in the building envelope that let in light, including windows, plastic panels, clerestories, skylights, doors that are more than one-half glass and glass block walls.
61. Floor, envelope – The lower portion of the building envelope, including opaque area and fenestration, that has conditioned or semi-heated space above and is horizontal or tilted at an angle less than 60 degrees from horizontal but excluding slab-on grade floors. For the purposes of determining building envelope requirement, the classifications are defined as follows:

a. Mass floor – a floor with a heat capacity that exceeds 7 BTU/ft2^{o}F provided that the floor has a material unit mass not greater than 120 lb/ft3.
b. Steel-joist floor – a floor that (1) is not mass floor and (2) that has steel joist members supported by structural members.
c. Wood-framed and other floors – all other floor types, including wood joist floors.

62. Furnace – A space heating appliance that heats indoor air with hot combustion gases that pass through a heat exchanger.
63. Gaps (insulation) – an insulation defect where installed insulation does not completely fill areas of the building enclosure, which allows for conductive and convective heat loss and a reduced R-value of the overall building enclosure.
64. Geo-thermal – Heat from the Earth's interior that is a potential source of energy.
65. Ground source heat pump – A central heating and/or cooling system that pumps heat to or from the ground. It uses the earth as a heat source in the winter and as a heat sink during the summer.
66. HCFC/Hydrochlorofluorocarbon-A fluorocarbon that is replacing chlorofluorocarbon as a refrigerant and propellant considered to be somewhat less destructive to the atmosphere.
67. Heating climate – A region with approximately 4,500 heating degree days or greater.
68. Heating degree day (HDD65) – see "degree-day"
69. Heating Seasonal Performance Factor (HSPF) –A standardized measure of heat pump efficiency, based on the total heating output of a heat pump, in Btu's, divided by the total electric energy input, in watt-hours, under test conditions specified by the Air conditioning and Refrigeration Institute Standard 210/240.
70. Heat trap – An arrangement of piping and fittings, such as elbows, or a commercially available heat trap that prevents thermosyphoning of hot water during stand-by periods.
71. HERS Index – a numerical integer value that represents the relative energy use of a Rated Home as compared with the energy use of the HERS Reference Home and where an Index value of 100 represents the energy use of the HERS Reference Home and an Index value of 0 (zero) represents a home that uses zero net purchased energy.
72. Home Energy Assessment – Defined by this standard as one of two levels of energy assessment of a home, including Home Energy Survey and Comprehensive Home Energy Audit.
73. Home Energy Rater or HERS Rater – An individual trained by an a Accredited Training Provider and certified by an Accredited Home Energy Rating Provider to inspect a home to evaluate the minimum rated features and prepare an energy efficiency rating.
74. Home Performance Assessment – A detailed evaluation of the condition of a home as a building system, including evaluation of all materials, components, features, systems and subsystems that affect the energy use of the home.
75. Humidity – The amount of water vapor in the air. Absolute humidity is the quantity of water vapor in a given volume of air, expressed by weight. Specific humidity is a ratio of weight quantities of water vapor to dry air, such as 1:200, for example. Relative humidity is the percentage of water vapor in how much of it the air, in its current condition of temperature and pressure, can possibly hold.
76. HVAC – Heating, Ventilation and Air Conditioning
77. Hydronic – the use of water as the heat-transfer medium in heating and cooling systems.
78. IECC – International Energy Conservation Code
79. Infiltration – Depending on the code being applied to the structure, this can be defined as follows:

a. *Under the 2009 IECC* – The uncontrolled inward air leakage into a building caused by the pressure effects of wind or the effect of differences in the indoor or outdoor air density or both.

80. *Under ANSI/ASHRAE/IESNA Standard 90.*1-2007 – The uncontrolled inward air leakage through cracks and crevices in any building element and around windows and doors of a building caused by pressure differences across these elements due to factors such as wind, inside and outside pressure differences (stack effect) and imbalance between supply and exhaust air system.
81. Infrared Imaging System – An instrument that converts radiation differences associated with surface temperature variations into a two dimensional image by assigning specific colors or tones to the differing temperatures.
82. Internal Gains – The heat gains within a home attributable to lights, people, and miscellaneous equipment.
83. International Energy Conservation Code (IECC) – The model code for building energy conservation as promulgated by the International Code Council.
84. Isolated Combustion Appliance Zone – A combustion appliance zone that is not a part of nor directly connected to, habitable space. It is either outdoors, or is a mechanical room or attached garage that is supplied with outdoor combustion air and separated from habitable space, and which complies with the criteria in Section B.3.2 of this standard.
85. Knob and Tube Wiring – An early method of electrical wiring in buildings, used from about 1880 to the 1930s. It consisted of single insulated copper conductors run within wall or ceiling cavities, passing through joist and stud drill-holes via protective porcelain insulating tubes and supported on nailed-down porcelain knob insulators.
86. Lighting zone – Areas based on type of use and activity which are used to determine the lighting allowances for compliance.
87. Luminaire – A complete lighting unit consisting of a lamp or lamps together with the housing designed to distribute the light, position and protect the lamps, and connect the lamps to the power supply.
88. Manual "J" calculations – Used to determine residential load calculations of HVAC equipment and for calculating heat loss and heat gain from the building.
89. Manual "S" calculations – Used for selecting and sizing the residential heating and cooling equipment.
90. Mass floor – see "Floor envelope"
91. Mass wall – see "Wall"
92. Mechanical Ventilation – The active process of supplying or removing air to or from an indoor space by powered equipment such as motor-driven fans and blowers but not by devices such as wind-driven turbine ventilators and mechanically operated windows.
93. Misalignment (insulation) – A defect which occurs when installed insulation is not in contact with the air barrier and air intrusion between the insulation and the air barrier seriously compromises the effectiveness of the insulation in framed buildings.
94. Mixed-humid climate zone – A region that receives more than 20 inches of annual precipitation, has approximately 4,500 heating degree days or less and where the monthly average outdoor temperature drops below 45 degrees Fahrenheit during the winter months. This definition applies to Climate Zone 4 which encompasses all of Virginia.

95. Pascal (Pa) – The metric unit of pressure equaling 1 Newton per square meter, or 0.004 inch water column pressure.
96. Path to performance – Process by which a specified proposed design undergoes approved simulated energy modeling and is shown to have an annual energy cost that is less or equal to a conventional code built project.
97. Photovoltaics – the direct conversion of light into electricity at the atomic level. Some materials exhibit a property known as the photoelectric effect that causes them to absorb photons of light and release electrons. When these free electrons are captured, an electric current results that can be used as electricity.
98. Power-Vented – An appliance that operated with positive static pressure in the vent, and is constructed and installed with a fan or blower to push all the products of combustion directly to the outdoors through independent sealed vents connected directly to the appliance.
99. Projection factor – The ratio of horizontal depth of the external shading projection divided by the sum of the height of the fenestration and the distance from the top of the fenestration to the bottom of the farthest point of the external shading projection, in consistent units.
100. Quality Assurance (QA) – The planned and systematic processes intended to ensure compliance with current applicable standards in a systematic, reliable fashion.
101. R-value (thermal resistance) –Resistance to heat flow representing the inverse of the time rate of heat flow through a body from one of its bounding surfaces to the other surface for a unit temperature difference between the two surfaces, under steady state conditions, per unit area (h x ft2 x ^{o}F/Btu) [(m2 x K)/W}.
102. Radiation – Heat transfer by the emission of electromagnetic waves which carry energy away from the emitting object. For ordinary temperatures (less than red hot”), the radiation is in the infrared region of the electromagnetic spectrum. The relationship governing radiation from hot objects is called the Stefan -Boltzmann law.
103. Refrigeration ton – A value approximately equal to the cooling power of one short ton (2000 pounds or 907 kilograms) of ice melting in a 24-hour period. The value is defined as 12,000 BTU per hour, or 3517 watts.
104. Residential building – Includes R-2, R-3, R-4 and R-5 buildings three stories or less in height above grade.
105. Room Pressure Differential – In many parts of the country, supply air is delivered to individual rooms, but return air is located only or primarily in the central body of the home. The absence of return air in closeable spaces causes positive pressure in the closed rooms and negative pressure in the central zone. These positive and negative pressure differentials create a number of unwanted impacts, which may include; contaminants in the soil (i.e. radon), sewer gases in poorly trapped drain lines, and air contaminants (i.e. pesticides, mold odors, chemicals, auto exhaust, dust) in unconditioned zones such as crawl spaces and garages being drawn into the conditioned living space. Negative pressure can also produce combustion venting problems such as high levels of Carbon Monoxide or pull the flame out of the combustion chamber in a process referred to as flame rollout. These combustion system impacts can create serious dangers for both home and occupants. In order to alleviate the differentials, “jumper ducts”, “transfer grills” or individual returns are installed to alleviate or balance the pressures differential between zones.
106. Seasonal Energy Efficiency Rating (SEER) –A standardized measure of air conditioner efficiency based on the total cooling output of an air conditioner in Btu/h, divided by the total electric energy input, in watt-hours, under test conditions specified by the Air Conditioning and Refrigeration Institute Standard 210/240.

107. Solar Heat Gain Coefficient (SHGC) – The ratio of the solar heat gain entering the space through the fenestration assembly to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation which is then reradiated, conducted or convected into the space.
108. Solar panel – A packaged interconnected assembly of solar cells, also known as photovoltaic cells. The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential application.
109. Solar radiation – A general term for the electromagnetic radiation emitted by the sun. Solar radiation can be captured and converted into useful forms of energy, such as heat and electricity, using a variety of technologies.
110. Solar water heating – Systems that consist of solar collectors and storage tanks to utilize the energy from the sun to produce hot water.
111. Thermal Boundary – The line or boundary where the air barrier and insulation are installed in a building
assembly. The air barrier and insulation should be adjacent to one another in a building assembly to prevent airflow from circumventing insulation.
112. Thermal Bridging – Heat conduction through building components, typically framing, that are more conductive than the insulated envelope.
113. Thermal Bypass – Air movement that circumvents the thermal barrier, is usually hidden and is the result of an incomplete or compromised air barrier.
114. Thermal isolation – Physical and space conditioning separation from conditioned space(s). The conditioned space(s) shall be controlled as separate zones for heating and cooling or conditioned by separate equipment.
115. Transfer Duct – Properly sized ducting and register grills installed in the wall or door between the central body of a home and an isolated area, in order to reduce room pressure differentials.
116. U-value (thermal transmittance) – The coefficient of heat transmission (air to air) through a building component or assembly, equal to the same time rate of heat flow per unit area and unit temperature difference between the warm and cold side of air films (Btu/h x ft2 x F)[W/(m2 x K)].
117. Unconditioned space – An enclosed space within a building that is not a conditioned space or semi-heated space; crawlspaces, attics, and parking garages with natural or mechanical ventilation are not considered enclosed spaces. Any enclosed space within a building that is neither directly nor indirectly conditioned.
118. Vapor – A substance in the gas phase at a temperature lower than its critical point. This means that the vapor can be condensed to a liquid or to a solid by increasing its pressure without reducing the temperature.
119. Vapor retarder – A material that reduces the rate at which water vapor can move through a material. It may also be referred to as a vapor diffusion retarder (VDR). Typically used in the construction process to either slow or stop the movement of moisture, whether in liquid or vapor form, into or out of the building envelope of the wall structure.
120. Variable air volume (VAV) system – An HVAC system that controls the dry-bulb temperature within a space by varying the volumetric flow of heated or cooled supply air to the space.
121. Ventilation– The process of providing or taking away available air by either mechanical or natural means to or from any area. The air may or may not have been previously treated.
122. Wall – That portion of the building envelope, including opaque area and fenestration, that is vertical or tilted at an angle of 60 degrees from horizontal or greater. This includes above- and below-grade walls, between floor spandrels, peripheral edges of floors and foundation

walls. For the purposes of determining building envelope requirements, the classifications are as follows:

a. Above-grade wall – A wall that is not a below-grade wall.
b. Below-grade wall – that portion of a wall in the building envelope that is entirely below the finish grade and in contact with the ground.
c. Mass wall – A wall with a heat capacity (HC) exceeding 7 BTU/ft2^{o}F provided that the wall has a material unit weight not greater than 120 lb/ft3.
d. Metal building wall – A wall whose structure consists of metal spanning members supported by steel structural members (i.e., does not include spandrel glass or metal panels in curtain wall systems).
e. Steel-framed wall – A wall with cavity (insulated or otherwise) whose exterior surfaces are separated by steel framing members (i.e., typical steel studs and curtain wall systems).
f. Wood-framed and other walls – All other wall types, including wood stud walls.

Wet bulb temperature – A type of temperature measurement that reflects the physical properties of a system with a mixture of a gas and a vapor, usually air and water vapor. Wet bulb temperature is the lowest temperature that can be reached by the evaporation of water only. It is the temperature you feel when your skin is wet and exposed to moving air. Unlike dry bulb temperature, wet bulb temperature is an indication of the amount of moisture in the air.