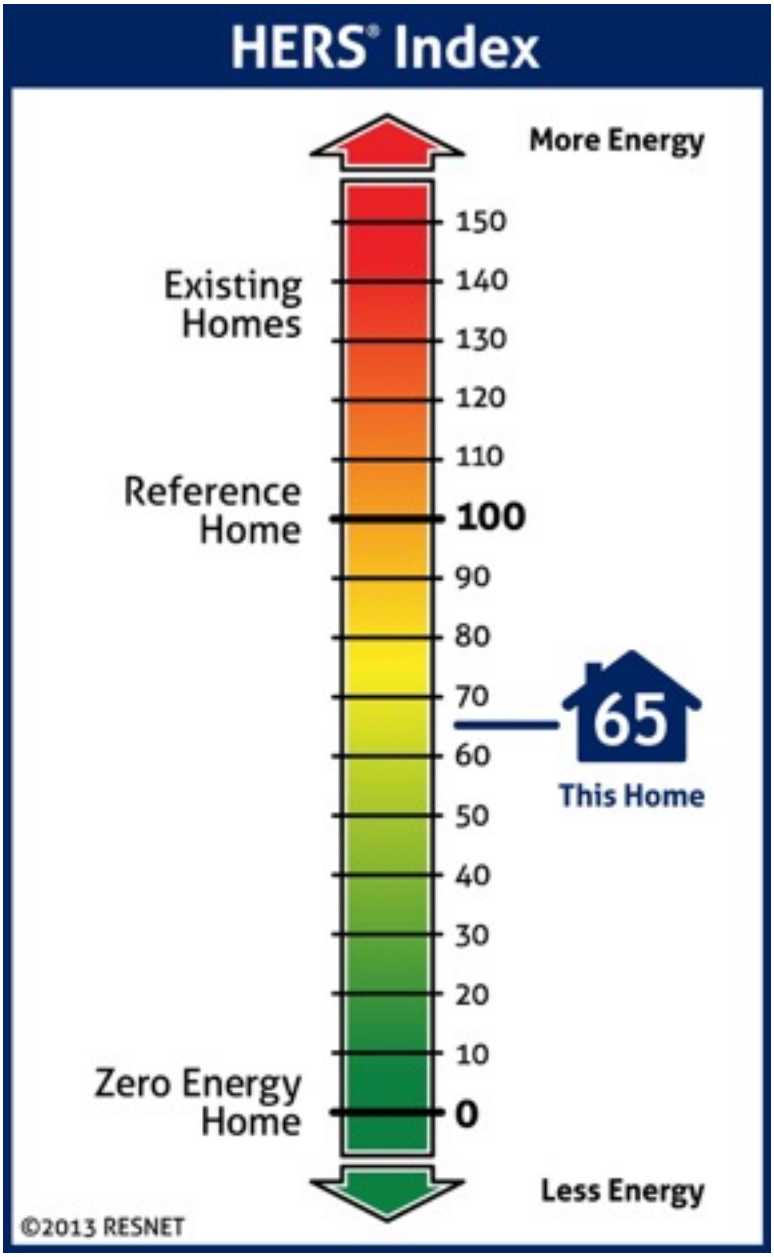

Upcoming Changes to the HERS Index and Potential Impact on HERS Index Scores

Executive Summary

In 2012, RESNET was accredited as an American National Standards Institute (ANSI) Standards Development Organization and embarked on a two year project to have the Home Energy Rating Systems (HERS) calculation methodology accredited as a consensus-based American National Standard.

This process resulted in two changes to the HERS Reference Home that will have an impact on the HERS Index values in all climate zones. These changes were necessary to shift the HERS Reference Home from a supplemental energy code released by the International Code Council (ICC) to an energy code published by the ICC. This shift was needed to lay the groundwork for the inclusion of the Energy Rating Index into the 2015 International Energy Conservation Code (IECC) as a viable option for builders to demonstrate energy code compliance in lieu of the more stringent prescriptive path and the unwieldy performance path.

The implementation of ANSI/RESNET Standard 301-2014 this year will cause HERS Index scores to increase by an estimated 2 to 3 points due to infiltration and ventilation changes, and decrease by an estimated 3 to 6 points due to changes related to efficient domestic water heating. This results in a net change of 1 to 3 points in HERS Index Scores over the current calculations.

In 2013 RESNET started to improve the quality assurance standards and procedures at the request of large national production builders who were legitimately concerned about the integrity and consistency of the HERS Index Scores nationally. These builders have heavily invested in the use of the HERS Index for marketing and in HERS Raters performing energy code compliance and tax credit verifications.

These efforts culminated in a set of RESNET policies that were adopted by the Board of Directors and the creation of a balanced ANSI Standard Development Committee to oversee the development of implementation standards to carry out those policies.

Some of these policies target specific practices through increased validation checks in RESNET-accredited HERS Software programs for reasonability.

These actions were taken to clearly define the boundaries on data that HERS Raters can input into the rating software programs.

There are also distinct differences between accredited HERS software tools, with the two dominant players taking distinct paths to producing residential energy simulations. Energy Gauge USA uses the DOE 2.1E hourly simulation as the core calculator, while REM/Rate uses a proprietary annual average load simulation to produce the calculations. The level of proportional precision in the outputs is likely to become more pronounced as the ANSI standard for calculating the energy performance of low-rise residential buildings becomes even more accurate and complex. These differences can account for an average 3 point change in the HERS Index, depending on the climate zone and rated home configuration.

The inconsistencies documented in this analysis represent a small percentage of homes rated in the United States.

Introduction

To determine the potential impacts on the HERS Index caused by changes to the calculation methodology resulting from the adoption of ANSI/RESENT Standard 301-2014 and bounds checks imposed by changes to the quality assurance protocols for RESNET-accredited software tools, RESNET contracted with IBS Advisors, LLC to perform an independent analysis. We were tasked with data analysis, not to make determinations of malfeasance. In this report we use terms such as “questionable” to indicate that the data entry is outside the expected range; the use of the term should not be construed to indicate anything else.

To conduct our research we used a statistically significant sample from the RESNET National Buildings Registry that was randomly pulled proportionally based on the number of ratings per state during the two-year analysis period. Since 2013, the RESNET National Buildings Registry has been the national archive of the energy rating simulation files. This allows us to have a 99% confidence interval in the quality of the analysis applied to the complete pool of homes rated between January 1, 2013 and December 31, 2014.

ANSI/RESNET Standard 301-2014

The Residential Energy Services Network (RESNET) became an American National Standards Institute (ANSI) Standards Development Organization in 2012 and embarked on an ambitious plan to develop a national standard for the calculation and labeling of the energy performance of low-rise residential buildings using the Home Energy Rating System (HERS) Index.

The HERS Index had been developed in 2006 and represented a major improvement in the energy rating industry, moving the industry away from a score based on performance in heating, cooling, and water heating against a reference home that used the 1993 Model Energy Code to a score on an index based on building loads benchmarked against a reference home that used the 2004 Supplemental IECC. The building loads now included lighting, appliances, and on-site power production and the calculation methodology used normalized, Modified End Use Loads (which cause

energy use, but do not use energy) to create a more neutral comparison between fuel types.

As part of the process of developing ANSI/RESNET Standard 301-2014, RESNET's Standard Development Committee included updates to the HERS Reference Home to bring it into closer alignment with the published 2006 International Energy Conservation Code (IECC). The two major points of friction that were addressed with this update dealt with the infiltration rate and window Solar Heat Gain Coefficients in the Reference Home. This was needed to gain acceptance of the concept of using an Energy Rating Index (ERI) to demonstrate energy code compliance.

The updated Reference Home infiltration rate went from a Specific Leakage Area of 0.00048 to a Specific Leakage Area of 0.00036. Specific Leakage Area is the ratio of the cross-sectional area of holes in the building enclosure divided by the conditioned floor area. The updated value reflects the improved tightness levels of newly constructed homes.

The updated Reference Home window solar heat gain coefficient went from a SHGC of 0.55 in climate zones 4 through 8 to a SHGC of 0.40 in those climate zones. This updated value reflects the market penetration of improvements in basic window technology and is in alignment with the 2006 IECC.

RESNET did not adopt the sliding scale window area used in the 2006 IECC Reference Home. If adopted, that particular provision would have created zero benefit for homes that used less than 18% window to floor area ratio; this had a huge impact on homes qualifying for the energy efficient home tax credit after the building code referenced in the federal statute went from the 2004 Supplemental IECC to the 2006 Supplemental IECC. In an analysis of 3,000 homes, built from New Mexico to North Carolina, the average window to floor area ratio was 12.41%.

Philip Fairey, Deputy Director of the Florida Solar Energy Center, performed research on the likely impact of this change in the Reference Home on the HERS Index values of Rated Homes in all 8 climate zones. His research indicates that HERS Index values will increase across all climate zones by a range of 1.7 to 4.5 points due to changes in the

HERS Reference Home envelope leakage area and revised mechanical ventilation requirements in ANSI/RESNET 301-2014 Standards (including recent interpretations).[1]

To put this into perspective, switching from 75% to 100% energy efficient lighting will typically produce up to a 2 point improvement in the HERS Index. This effect is more pronounced in the southern climate zones due to the impact of lighting on the internal cooling load of the home and tends to completely disappear in the northern climate zones due to the impact on the internal heating load. The RESNET Standards Development Committee has an interest in pursuing an amendment to Standard 301 to reflect the increased availability of LED and other energy efficient lighting technology which would result in reduced HERS Index Scores as builders switch to more efficient LED fixtures.

In addition, RESNET has adopted procedures to incorporate additional features of water heating energy use as an Addendum to ANSI/RESNET Standard 301-2014. This addendum gives credit for shorter pipe runs, drain water heat recovery systems, and higher performance appliances such as clothes and dish washers. If deployed, these technologies can provide builders up to a 3 point reduction in the HERS Index.

There are a number of strategies that can be employed to cost-effectively reduce the HERS Index. These measures are typically going to be climate zone dependent since the specifications for the Reference Home are based on the climate zone of the Rated Home.

Software Bounds Checks

In the past, RESNET's standards and procedures allowed too much flexibility in the software inputs of accredited rating software programs which resulted in inconsistencies between software tools and raters. In some cases, this led to HERS Index Scores that were lower than they should have been. A number of national production builders brought these inconsistencies to RESNET's attention.

[1] Private correspondence between the author and Mr. Fairey, January 17, 2015

RESNET created a HERS Index Consistency Task Force that consisted of builders, rating providers, and software vendors that produced recommendations to the RESNET Board of Directors at the 2013 Fall Board of Directors meeting. The Board of Directors acted on those recommendations and created a set of policies that were in line with the Task Force's recommendations. These policies included: Quality Assurance Designees would serve as agents of RESNET, have neither a financial interest nor an employee/ employer relationship with the entity performing the rating, keep the minimum field quality assurance requirement at 1% and the minimum software file review requirement at 10% of each rater's confirmed ratings, establish limits on the input variables for the RESNET-accredited software tools, and determine bounds checks on inputs to limit or warn users when input values are beyond reasonable limits.

The Board of Directors also established another Task Group and Working Groups that went to work further development of these general policies. At the same time, RESNET created another Standards Development Committee, SDC 900, to develop QA standards.

These groups, after extensive public comments, produced their recommendations to the RESNET Board of Directors at the 2014 Fall Board meeting. The RESNET Board adopted these recommendations and now SDC 900 will be tasked with developing the implementation standards.

The pivotal outcome was rating companies can no longer be vertically integrated with a quality assurance provider, but must either contract out quality assurance services to an outside contractor approved by RESNET or to an independent 3rd party quality assurance provider.

This independent review of practices will improve consistency in those cases where the inconsistency was caused by raters improperly rating the home.

RESNET addressed the issue of unrealistic data entry in the HERS software programs by creating a set of internal bounds checks that must be incorporated by all RESNET-accredited software tools by August 1, 2015. These checks will result in rejecting

unrealistic data entries and flagging questionable entries for review by the Quality Assurance Designee and RESNET staff.

How much inconsistency could be caused by improper inputs? The answer is software dependent, but the dominant software in the rating industry (REM/Rate) allows greater flexibility in data entries.

In 2013, 144,754 homes were rated and in 2014, 149,052 homes were rated. This provides a 2 year analysis pool of 293,806 homes. A sample set of 3,358 homes were pulled proportionally based on ratings per state by RESNETs contracted database manager who created an algorithm to randomly select homes within each state. Of this sample set, 478 homes were rated using Energy Gauge USA and 2,880 homes were rated with REM/Rate. The 2,880 REM/Rate files were uploaded to a database created within REM/Rate. The final sample size of 2,880 files provides a 99% confidence level with a margin of error of $\pm$ 2.18% using a standard deviation of 0.5.

Incorrect data entry to describe mechanical ventilation systems can have a large impact on the HERS Index depending on the type of mechanical ventilation system and the size of the data error.

Of the REM/Rate sample set:

- 20.5% had no mechanical ventilation ($\pm$ 1.8% margin of error)
- 2.5% had balanced ventilation systems such as an ERV or HRV ($\pm$ 0.7%)
- 38% had exhaust only ventilation systems ($\pm$ 2.1%)
- 10.2% had supply only ventilation systems ($\pm$ 1.3%)
- 28.8% had a motorized damper and timer control ($\pm$ 2%)

We analyzed the mechanical ventilation data to determine the likelihood of rating companies entering questionable fan wattage data on ventilation systems using a motorized damper and timer control (commonly known as an “Air Cycler”, although that is a brand name for these types of devices). These systems typically use the air handler fan as the ventilation fan when supplemental ventilation is called for. It is reasonable to assume that in a best case of an ECM fan, the ventilation only fan operation will be around 30% of the rated fan wattage. We analyzed the files in this group and looked at

files that had 100 watts or less entered for ventilation fan wattage (roughly 300 watt air handlers under best circumstances). Based on analysis of the files with fan wattages ≤ 100 watts, there is a strong likelihood (± 1% margin of error) that 33.5% of these ventilation systems are modeled incorrectly, which can cause the HERS Index to be artificially lowered by an average of 2 points for an ECM air handler fan (90%+ AFUE furnaces and heat pumps with 15+ SEER) and 12 points for a PSC air handler fan (80% AFUE furnaces).

Of the 40 Quality Assurance Providers and 107 Raters represented in the motorized damper and timer control ventilation file group, 10 Providers accounted for 94.5% of the files that likely have incorrect data entered for fan wattage. Within that Provider population, 17 Raters (15.88% of the total Raters represented) accounted for 86.718% of the files. This indicates a very strong relationship between questionable ratings and specific Raters and Quality Assurance Providers. Of these 10 Providers, 8 are vertically integrated with the rating company involved. There is one completely independent Quality Assurance Provider in this mix and all their questionable ratings came from one rating company (although the 28 ratings were spread evenly among 4 raters at that company). There is also a hybrid Quality Assurance Provider in this group: while they also perform ratings, 17 of the 20 questionable files they are responsible for came from one certified HERS Rater and had an average 2 point change in the HERS Index.

One of the 17 Raters involved was responsible for 21.4% of the total motorized damper and timer control ventilation files with fan wattages less than 100 watts. That HERS Rater's certification was revoked by the responsible Rating Quality Assurance Provider in the 1st quarter of 2015 before this analysis was conducted.

We also looked at this issue at the State level to try to detect if a regional pattern existed. There are 23 States represented in the files that had mechanical ventilation installed with a motorized damper and timer control. Within these States, 9 accounted for 98.2% of the questionable data entry related to ventilation fan wattage for systems with motorized dampers and timer controls.

- Texas, 55%

- Indiana, 9.6%
- Colorado, 8.5%
- Virginia, 7%
- Oklahoma, 6.3%
- Michigan, 4.8%
- Maryland, 4.1%
- Illinois, 1.5%
- North Carolina, 1.5%

Based on the data from the RESNET buildings registry, Air Cycler type ventilation systems are in 69% (± 3.9% margin of error) of the 58,000 homes rated in Texas during the analysis period, with a 43.5% probability (± 6%) that the incorrect fan wattage has been entered.[2]

In addition to analyzing the motorized damper and timer controlled ventilation systems, we looked at balanced (ERV or HRV), exhaust only, and supply only systems. Of the sample files with mechanical ventilation (2,259 files), 28.33% were modeled with ventilation fan wattages ≤ 20 watts. Since there are some extremely efficient ventilation fan systems that operate on as little as 6 watts of power, we used 5 watts or less as the benchmark for questioning the fan wattage entry. This gave us 56 files (2.47%) of the total with mechanical ventilation that became questionable with 11 homes modeled with 1 watt or less of ventilation fan wattage.

The supply only ventilation files had ventilation fan wattages ranging from 0.10 to 0.50 (delivering between 43 and 105 cubic feet per minute), produced by 4 raters working with 3 Quality Assurance Providers. This is statistically insignificant (1.8%, ±1.3%).

The exhaust only ventilation files had ventilation fan wattages ranging from 1 to 5.8 watts (delivering between 1 and 100 cubic feet per minute), produced by 19 raters working with 13 Quality Assurance Providers. This is also insignificant (4.9%, ±2%).

Based on the analysis of ventilation systems, 12.4% of the files with Air Cycler-type mechanical ventilation (±1.6%) are modeled with fan wattages that are not consistent with the updated bounds checks that go into effect August 1, 2015 and could cause HERS Index scores to be lower than they ought to be.

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[2] See Appendix for graphics related to this analysis

Software Sensitivities

REM/Rate is the dominant software tool used by HERS Raters across the country with the exception of Florida, where Energy Gauge USA reigns. There are stark contrasts between these two tools, both of which have successfully passed the suite of tests for software accreditation by RESNET. The accreditation tests include:

- ASHRAE Standard 140 Building Loads Test
- HERS Reference Home Rating Software Auto-Generation Test
- HERS Method Test
- HERS HVAC Test
- HERS Duct Distribution Efficiency Test
- HERS Hot Water Performance Test

Energy Gauge USA uses the DOE 2.1E energy simulation engine with additional functions added to simulate building features (such as dehumidification) that are not included in DOE 2.1E. The core simulation engine uses an hourly simulation of the energy flows based on Typical Meteorological Year 3 weather data, the latest available. Because Energy Gauge uses an hourly simulation methodology, the energy simulation models tend to reflect a proportional level of precision.

REM/Rate uses a proprietary energy simulation engine that uses average annual loads to determine the energy flows associated with the building. The use of average annual loads tends to increase the HERS Index scores generated when compared to an hourly simulation in two very specific areas: windows and mechanical ventilation.

While Energy Gauge calculates the solar exposure of the windows on an hourly basis, taking into account detailed roof overhang features that may be provided by homes, REM/Rate uses an annual average exposure that tends to over-predict the solar gains and uses a much simpler adjacent shading calculation (based on “None”, “Some”, or “Most” instead of the dimensions of the shading object and the distance from the shaded window) to take credit for shading provided by homes and trees that are next to the rated home. We have seen up to 4 points reduction in the HERS Index due to modeling the effects of “adjacent” shading in REM/Rate, which nearly caused one of our rater clients to fail her quality assurance review until I was able to ascertain the cause of the difference with help from REM/Rate’s software engineers.

REM/Rate uses a very simple method for estimating the fan energy used in mechanical ventilation. For a mechanical ventilation system that has a motorized damper controlled by a timer mechanism to control the amount of outside air distributed through the HVAC system (using the air handler fan as the ventilation fan), the number of heating and cooling load hours are subtracted from the number of hours in the year and then converted to days. This provides a number of days that are ventilation only. The input supplied by the rater for ventilation run time is then used to calculate the fan energy for the additional run time beyond that required for heating and cooling. This is also dependent upon the ventilation fan wattage that is entered into REM/Rate by the rater.

Ventilation is one feature that illustrates the contrast between the two software tools: REM/Rate uses a very simplified method that is heavily dependent upon the rater's inputs, often using weather data that is manufactured using a software program called MeteoNorm and minimal internal checks to ensure the inputs are reasonable (until the new requirements are put into place that were recently approved by the RESNET Board of Directors), while Energy Gauge uses a complex hourly analysis using TMY3 weather data from the National Oceanic & Atmospheric Administration and performs over 500 validation checks on the reasonability of the rater's inputs.

Based on our software analysis using identical inputs on 8 different floor plans, these differences alone can account for up to a 3 point difference on the HERS Index, depending on the home and climate zone, when these two software tools are compared —and Energy Gauge tends to produce lower HERS Index values because of the proportional level of precision in the calculation methodology.

Conclusion

The HERS Index values for builders are very likely to go up in all climate zones by an average of 2 to 3 points due to changes in the Reference Home that were essentially mandated by the ANSI process, and which provided the foundation for obtaining recognition in the International Code Council's residential codes for the energy rating index option for demonstrating energy code compliance in the 2015 IECC. On the other

hand, the HERS Index scores are likely to drop 3 to 6 points for builders who install efficient domestic water heating systems.

The HERS Index scores for builders whose raters made data entries that were questionable may go up an average of 7 points once the new RESNET quality assurance policies are implemented and the software bounds checks are in place. RESNET has no evidence of wrongdoing in the current boundaries set by HERS software providers, nor of HERS Raters applying interpretations of the reasonability of data entries.

One possible solution that has been floated is to have RESNET develop and own a central core HERS Index calculation engine that all software providers would use, thereby providing greater control and consistency between software tools and raters.

Accredited rating software programs that incorporate the software bounds checks will be released to HERS Raters in August 2015. HERS Raters will not be required to use that version for confirmed ratings until October 1, 2015, allowing a transition period for builders and program sponsors to adjust to the new requirements.

It is recommended that builders contact their certified HERS Raters to calculate the specific changes in the HERS Index Scores of their homes.

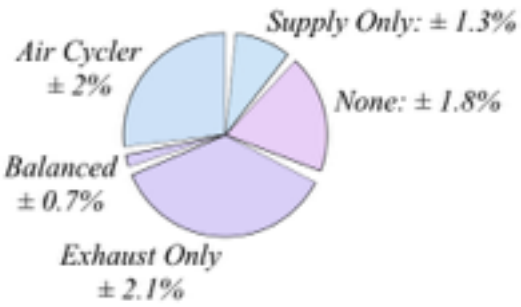
About the author:

Brett Dillon is the Managing Director of IBS Advisors, LLC, a quality assurance firm located near San Antonio, Texas, and CEO of The Dillon Group, Inc, a consulting firm. He was one of two subject matter experts hired by the US Green Building Council to develop their LEED for Homes Green Rater™ curriculum, and is a LEED Faculty™ member. He is also the Chair of the RESNET ANSI Standards Development Committee and serves on the RESNET Board of Directors. A former 4th generation builder, Brett combines his passion for sustainability and affordable housing into the work of his firm. A RESNET-credentialed HERS Rater Trainer and Quality Assurance Designee, he works with HERS Raters, builders, utility companies and local governments to instill sustainable practices into the built environment. IBS Advisors is a RESNET Quality Assurance Provider that works with independent raters who use both REM/Rate and Energy Gauge USA software.

Appendix

Distribution of Mechanical Ventilation Type

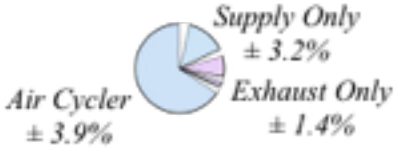
Observed Sample



Estimated Population

Distribution of Mechanical Ventilation Type [State = TX]

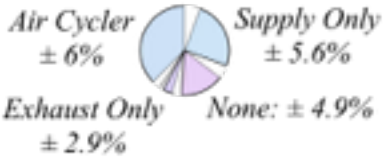
Observed Sample



Estimated Population

Distribution of Mechanical Ventilation Type [State = TX, Ventilation Fan Wattage < 101]

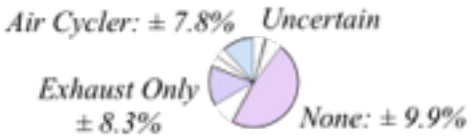
Observed Sample



Estimated Population

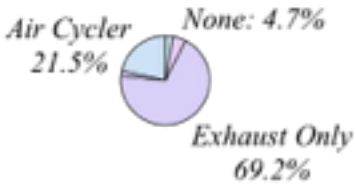
Distribution of Mechanical Ventilation Type [State = IN]

Observed Sample

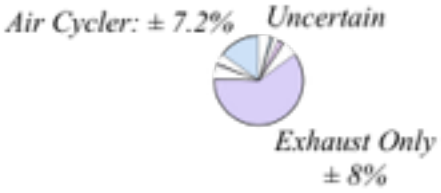


Estimated Population

Distribution of Mechanical Ventilation Type [State = CO]



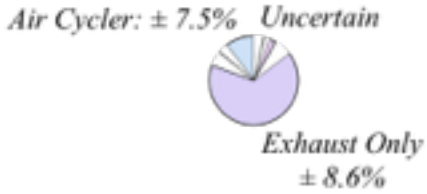
Observed Sample



Estimated Population

Distribution of Mechanical Ventilation Type [State = VA]

Observed Sample



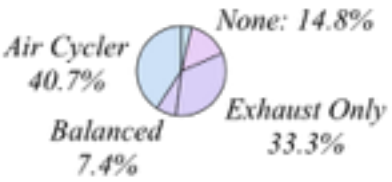
Estimated Population

Distribution of Mechanical Ventilation Type [State = OK]

Observed Sample

Estimated Population

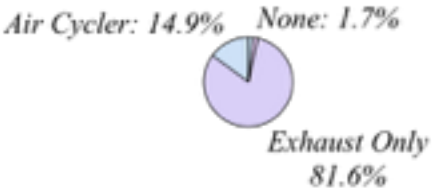
Distribution of Mechanical Ventilation Type [State = MI]



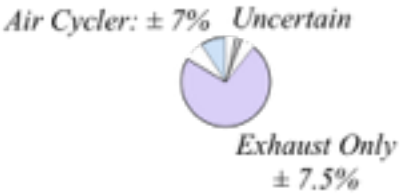
Observed Sample

Estimated Population

Distribution of Mechanical Ventilation Type [State = MD]



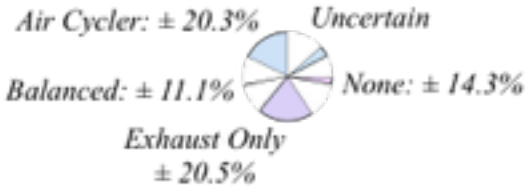
Observed Sample



Estimated Population

Distribution of Mechanical Ventilation Type [State = IL]

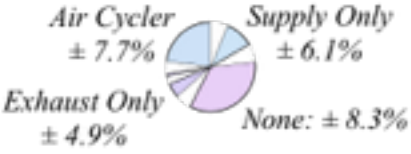
Observed Sample



Estimated Population

Distribution of Mechanical Ventilation Type [State = NC]

Observed Sample



Estimated Population