CADMUS

# 2020 Residential New Construction Baseline Study

## BASELINE STUDY RESULTS

July 15, 2022

**Prepared for:**

Public Service Commission of Wisconsin
4822 Madison Yards Way
North Tower—6th Floor
Madison, WI 53705-9100

**Prepared by:**
Steve Cofer
Mitt Jones
Emily Vella

CADMUS

# Table of Contents

## Tables



## Figures

# Executive Summary

The Residential New Construction Offering provides Wisconsin builders with technical training and support, as well as incentives, to construct homes that meet Focus on Energy's prescriptive performance and modeled energy performance requirements. Focus on Energy delivers the Residential New Construction Offering throughout Wisconsin through the administrator (APTIM), the implementer (Willdan), an implementer subcontractor, participating trade allies (home builders), and Building Performance Consultants. Participating home builders hire Building Performance Consultants who are affiliated with the offering to guide them on better building techniques and to model and verify the new homes' energy performance using REM/Rate, a home energy software tool.

Residential New Construction is one of Focus on Energy's longest-running offerings and has been in place for over 20 years. To better understand how the offering has impacted residential building practices throughout Wisconsin, Cadmus (the program evaluation contractor) conducted a baseline study of newly constructed residential buildings in 2021. The study sample included homes built between 2018 and 2020 divided into two subsets based on their proximity to the operational regions of the Focus on Energy offering. Cadmus made comparisons between the two subsets, as well as to the results of a baseline and market characterization study performed by Seventhwave in 2017. Cadmus contracted with Resource Innovations to assist with recruiting study participants and to perform the field inspections; together the two companies are referred to as the Cadmus team in this study.

The 2020 Residential New Construction baseline study has four primary objectives:

- Inform the market baseline model used to quantify savings of the homes certified through the Focus on Energy offering.
- Compare the characteristics of the non-certified homes to Focus on Energy Residential New Construction offering homes to understand construction practices throughout Wisconsin.
- Compare the characteristics of non-certified homes located within proximity of the Focus on Energy offering to those of homes located outside the offering proximity to determine if the offering has had a spillover effect on new home construction practices throughout Wisconsin.[1]
- Observe how the implementation of energy efficiency measures has progressed in non-certified new home construction since the 2017 baseline study.

[1] A reason for conducting this study was to support the Cadmus team's theory that Focus on Energy's long-standing engagement with Wisconsin home builders has resulted in the adoption of energy-efficient home construction practices regardless of whether the homes are certified through the Focus on Energy offering. More information regarding the market effects theory can be found here: https://focusonenergy.com/sites/default/files/inline-files/Potential_Study-Market_Effects-Residental_New_Construction.pdf or in the 2019 and 2020 evaluation reports located here: https://focusonenergy.com/evaluation-reports.

The following text outlines the study conclusions and recommendations. The remaining chapters of this report provide further explanation of these findings and the context for our conclusions and recommendations.

CONCLUSION 1: While there are notable differences in findings between the 2017 and 2020 studies, the directionality of those differences varied by building or equipment characteristic, and not all were statistically significant. However, these differences warrant a review and a potential update to the baseline home characteristics used to model energy savings.

The Cadmus team identified several notable differences in the homes of the 2020 study, compared with those of the 2017 study:

- Average home size is smaller
- The homes are less airtight, as indicated by blower door test results
- Windows appear less efficient, though this was likely caused by differences in inferred data)
- Central air conditioner SEER ratings are higher
- LED lamps make up a greater percentage of lighting
- Homes used a wider variety of fuel types
- The modeled Home Energy Rating System (HERS) indexes were higher

**RECOMMENDATION**: Consider updating the baseline home characteristic model using data from this 2020 study. Given that some findings were not statistically different or may have varied from the 2017 study because of differences in data collection methods, consider working with the Cadmus team regarding the updates.

CONCLUSION 2: Study findings do not support the hypothesis that non-program homes built out of proximity from program homes are less efficient (use more energy) than non-program homes in closer proximity to program homes.

This 2020 study revealed few significant differences between in-proximity and out-of-proximity homes. The building characteristics that were statistically different between the two groups (such as fuel types) are not overwhelmingly meaningful from an energy efficiency perspective. This finding is also counterintuitive to the latest evaluation billing analysis, which shows that nonprogram homes constructed in zip codes with little to no program activity consume 8% more energy than nonprogram homes built in zip codes with lots of program activity. Because contractors tend to work in concentrated areas, this geographic difference in consumption suggests that nonprogram homes built away from program homes may not benefit from the offering’s market effects drivers, such as contractors learning new skills from program representatives.

There may be multiple reasons this hypothesis was not validated, such as how the Cadmus team defined the in-proximity and out-of-proximity homes or that the program market actors’ reach is wider than originally anticipated. Differences in occupant behavior may also affect relative energy consumption.

**RECOMMENDATION:** Due to the lack of evidence that in-proximity and out-of-proximity homes are constructed in a manner that impacts the buildings' energy performance, we recommend keeping one baseline model rather than moving to two baseline models.

CONCLUSION 3: Nonprogram home building and equipment characteristics—such as the homes' air tightness, heating equipment, ceiling insulation, and LED saturation—are less efficient than those found in program homes. However, the differences between nonprogram and program home characteristics are relatively small, and nonprogram homes are being built above code and to a high level of efficiency.

While this conclusion by itself does not support the theory that Focus on Energy's Residential New Construction Offering has increased the efficiency of construction features in nonprogram homes, it does indicate that the new home construction market is being influenced to build homes that are more efficient than code. There are likely several drivers causing builders to construct more efficient homes, such as customer demand, social demand for greener and more sustainable homes, the benefit of lower bills, and industry trainings. The last two impacts are likely driven in varying degrees by the longevity and success of the Focus on Energy's Residential New Construction Offering.

In 2020, the Cadmus team assembled a panel of market experts—including builders, contractors, code officials, and residential new construction efficiency experts—to assess possible program market effects. After reviewing multiple data points about the Wisconsin new home market, program activity, new home consumption, and builder and contractor feedback, panelists agreed that specific building features would be less efficient in nonprogram homes if the Focus on Energy offering did not exist. These experts concluded that without Focus on Energy's influence on the new home construction market, nonprogram homes being built today would have lower insulation levels, higher outside air infiltration, less efficient heating and cooling systems, and lower amounts of efficient lighting.

**RECOMMENDATION:** Continue with the plan to apply market effects to the Residential New Construction Offering at the end of the quadrennium. The original plan included applying market effects only to nonprogram homes in proximity to program homes. Based on this study's findings that there are no large differences in building practices between in-proximity and out-of-proximity homes, consider applying the market effects to all nonprogram homes.

# Study Methodology

Cadmus collected data on 68 non-program homes built in 2018 through 2020. These site visits involved a trained field engineer spending two to four hours in each home collecting information on the home's construction, appliances, and air leakage tests. We then modeled each home in REM/Rate software.

## *Sampling Plan*

The Cadmus team used results from the 2017 Seventhwave new homes baseline study to estimate expected variation across various new home metrics.[2] The team isolated five metrics that have a large impact on the overall home energy consumption and used the reported relative precision to calculate each metric's coefficient of variation (Table 1). Across all five metrics, air leakage (ACH50) had the highest coefficient of variation of 0.35.

**Table 1. Calculated Coefficient of Variance for Key Building Characteristics**

| Metric | 2017 Study Reported Estimate | 2017 Study Reported Absolute Precision | 2017 Study Reported Sample Size | Calculated Relative Precision | Calculated Coefficient of Variation |
|---|---|---|---|---|---|
| Wall R-Value | 20.1 | 0.7 | 50 | ±3.5% | 0.12 |
| Window U-Factor | 0.3 | 0.01 | 39 | ±3.3% | 0.10 |
| **Air Leakage (ACH50)** | **1.91** | **0.19** | **50** | **±9.9%** | **0.35** |
| Heating AFUE | 95.3 | 0.4 | 55 | ±0.4% | 0.01 |
| Water Heater Energy Factor | 0.68 | 0.02 | 36 | ±2.9% | 0.09 |

Using the coefficient of variance of 0.35, the Cadmus team developed several sampling plans and shared them with the administrator, implementer, and Public Service Commission of Wisconsin. For each plan, the team tried to achieve the best level of precision while keeping within the available budget. Ultimately, the Cadmus team and involved stakeholders chose a sampling plan that stratified the sample between in-proximity homes and out-of-proximity homes, with the goal of achieving 90% confidence within ±10% relative precision for most home characteristic metrics.

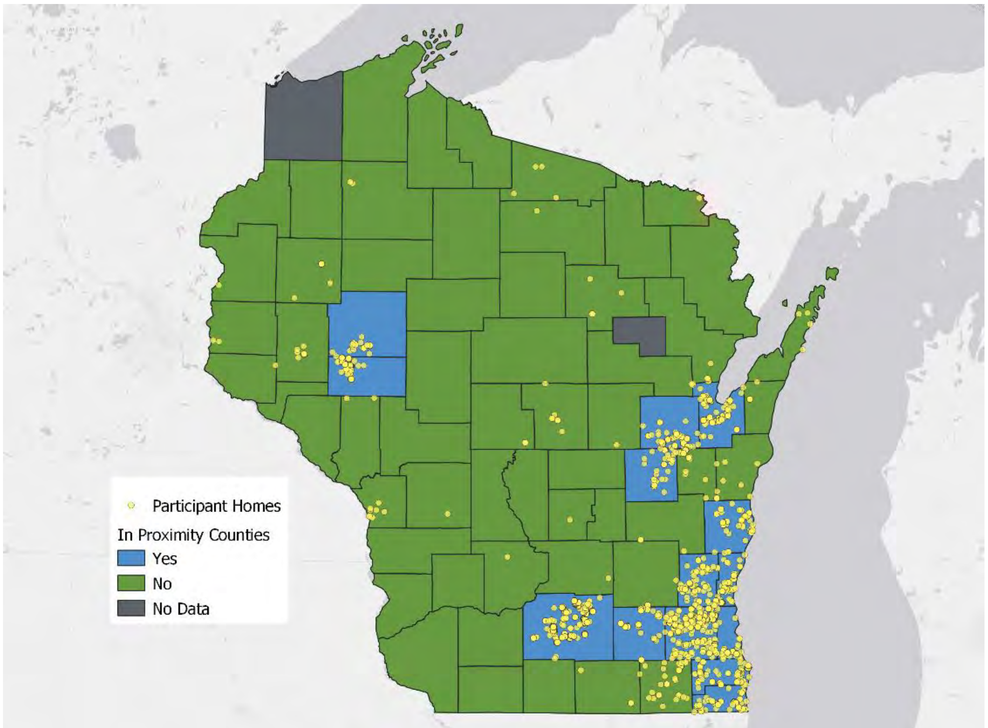
The Cadmus team stratified based on the estimated program participation by county, using a 5% participation proportion threshold to assign a county as "in proximity to program homes" or "out of proximity to program homes." The team determined these percentage estimates using U.S. Census new home construction permit data[3] and 2019 program participation data. Figure 1 shows how the team defined each county and where 2019 program participants were located.

---

2 https://focusonenergy.com/node/8966

3 Single-family Housing Permits in Wisconsin 2020

**Figure 1. Wisconsin Counties in and out of Proximity**




In addition, the in-and-out of proximity were further stratified by geographic location. Table 2 provides the final sample plan and quota.

**Table 2. Final Sample Distribution**

| Proximity to Program Homes | Region | Quota (n=68) |
|---|---|---|
| In Proximity of Program Homes (n=31) | Northeast | 7 |
| | South Central | 9 |
| | Southeast | 12 |
| | West Central | 3 |
| Out of Proximity of Program Homes (n=37) | North | 8 |
| | Northeast | 7 |
| | South Central | 6 |
| | Southeast | 2 |
| | West Central | 14 |
| **Totals** | | **68** |

## *Participant Recruitment*

The Cadmus team initially recruited study participants by mailing letters directly to homeowners listed in the sample frame. The sample frame was developed from requesting new home utility starts starting in 2018 from participating Focus on Energy utilities. These letters requested that homeowners complete an online survey intended to screen for single-family homes built in 2018 or later. Then the team contacted qualifying respondents to schedule a home inspection.

Unlike the 2017 baseline study, the 2020 study did not exclude electric-only homes or single-family attached homes with no common area, such as duplexes and townhouses. In the 2020 study the team also included three non-primary residences that would have been excluded in the 2017 study:

- A townhouse used only as a property management office during business hours (in-proximity)
- A single-family detached home reported to have a 40% occupancy rate (the reason for less than 100% occupancy is unknown; out-of-proximity)
- A single-family detached home that is currently under construction by the homeowner and not yet occupied (in-proximity)

## *Site Visit Training and Protocols*

The Cadmus team conducted site visits to 68 homes. Each member of the field team was Building Performance Institute certified and completed additional training provided by Cadmus specific to the baseline study. Cadmus conducted the two-day online training, which included a walkthrough of the data collection tool, information to collect in the field, and site visit best practices.

The team collected data on tablet PCs using a propriety data collection tool that Cadmus customized for this baseline study. Each site visit started with a homeowner interview that covered the usage and occupancy rate of the home, the number and age of occupants, the builder contact information, the thermostat type and usage, and details about a few home features such as fireplaces, ceiling fans, and solar PV systems. After the interview, the team conducted an on-site inspection to perform blower door testing and collect data on the building envelope, mechanical systems, lighting, and appliances. The team performed duct leakage testing only on homes with any portion of the HVAC system, including equipment and/or ducts, located outside the thermal envelope of the building.

## *Quality Control*

The team used several phases of quality control (QC) to ensure the integrity of the baseline study data. For the first phase the team used a web-based automated QC system Cadmus customized for the project. The QC system has several tests that the team programmed to flag incomplete data and anomalies. Cadmus team field engineers ran the data for each sampled home through the QC system after the site visit and follow-up data entry were completed. The field engineer resolved any items flagged for review.

In the second phase, the Cadmus team performed a manual QC check within the data collection tool for each sampled home, flagging questionable data and identifying and resolving any issues related to the field inspection process and/or data entry. The Cadmus team also ran each sampled home through the automated QC system and addressed any remaining data quality concerns. For certain data points, the QC tests were programmed so that only experienced Cadmus team members could approve resolution of flagged items. This ensured that adequate attention was given to addressing critical issues in the data.

Modeling homes in REM/Rate provided a third phase of QC. During the process of manually entering data into REM/Rate for each home, Cadmus identified and resolved any discrepancies with building dimensions and other data from sampled homes. The team used building plans, available for most homes, to verify the dimensions entered by field engineers.

## *Analysis*

The Cadmus team extracted baseline sample data from the data collection tool and compiled it into Excel for analysis. The team manually pulled 2017 baseline and market characterization data from the study published by Seventhwave. Cadmus developed a series of charts and tables to allow for a comparison of data from several samples: 2020 in-proximity homes, 2020 out-of-proximity homes, combined 2020 study homes, and 2017 study homes. These results are presented in the *Comparison of Home Characteristics* section.

The Cadmus team entered data for each sampled home into the REM/Rate energy modeling software (version 16.2) to determine the HERS index rating of each home. Cadmus also modeled the annual energy consumption required to heat and cool the home and provide hot water heating. These results, along with comparisons to the 2017 study, are presented in the *Comparison of Energy Modeling Results* section.

# Comparison of Home Characteristics

The figures and tables in this section provide a comparison between homes in the 2020 in-proximity sample, 2020 out-of-proximity sample, 2017 study, and combined 2020 sample. Most of the figures parallel the metrics included in the 2017 Seventhwave report to allow for comparison. Figures that do not include 2017 data represent results for metrics not reported in the 2017 study.

The Cadmus team calculated statistical differences between studies and participant groups, which are noted in the findings if they are statistically significant at the 90% confidence level.[4]

## *Completed Site Visits*

The Cadmus team completed 68 site visits and used 64 homes in the analysis: Table 3 provides the final distribution of site visits completed. The team completed four site visits that were ultimately removed from the analysis because Cadmus determined that those homes participated in the Focus on Energy Residential New Construction Offering.

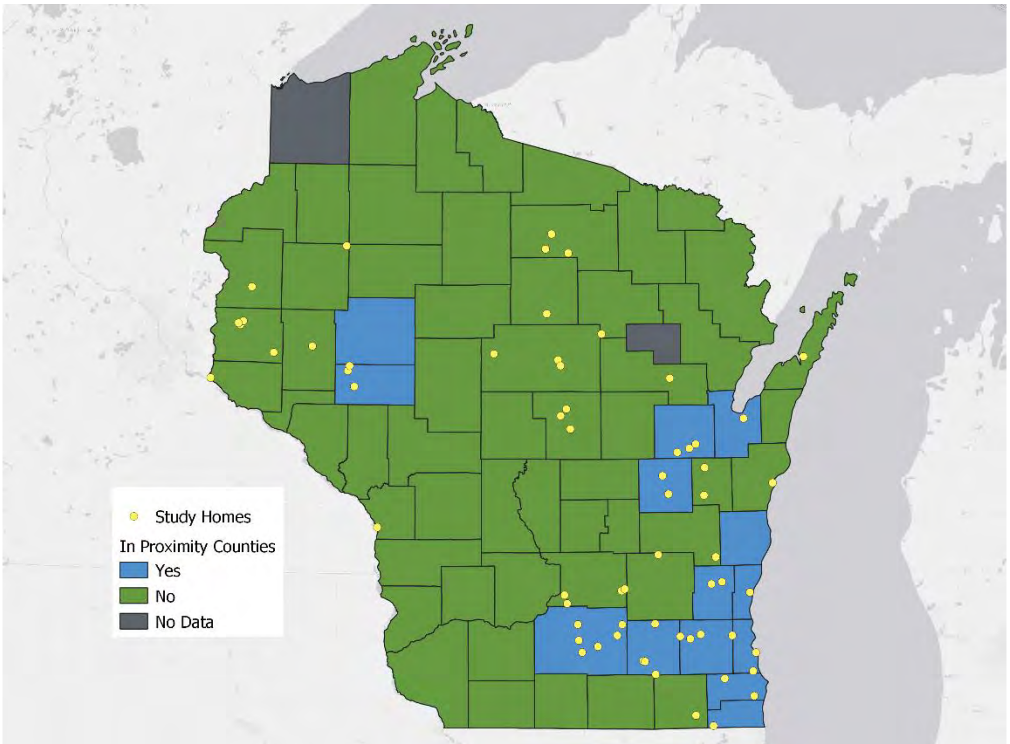
**Table 3. Final Sample Distribution**

| Proximity to Program Homes | Region | Quota (n=68) | Site Visits Completed | Removed Due to Program Participation | Final Site Visits |
|---|---|---|---|---|---|
| In Proximity of Program Homes (n=31) | Northeast | 7 | 7 | 1 | 6 |
| | South Central | 9 | 9 | - | 9 |
| | Southeast | 12 | 12 | - | 12 |
| | West Central | 3 | 3 | - | 3 |
| Out of Proximity of Program Homes (n=37) | North | 8 | 8 | 1 | 7 |
| | Northeast | 7 | 7 | 1 | 6 |
| | South Central | 6 | 6 | 1 | 5 |
| | Southeast | 2 | 2 | - | 2 |
| | West Central | 14 | 14 | - | 14 |
| **Totals** | | **68** | **68** | **4** | **64** |

Figure 2 shows the distribution of participants.

[4] Any differences that were significantly different at the 90% confidence level were considered to be "statistically significant. In effect, any differences of means t-test or chi-square independence test where the p-value was less than 0.10 was considered to be statistically significant

**Figure 2. 2020 Baseline Housing Study Participants**

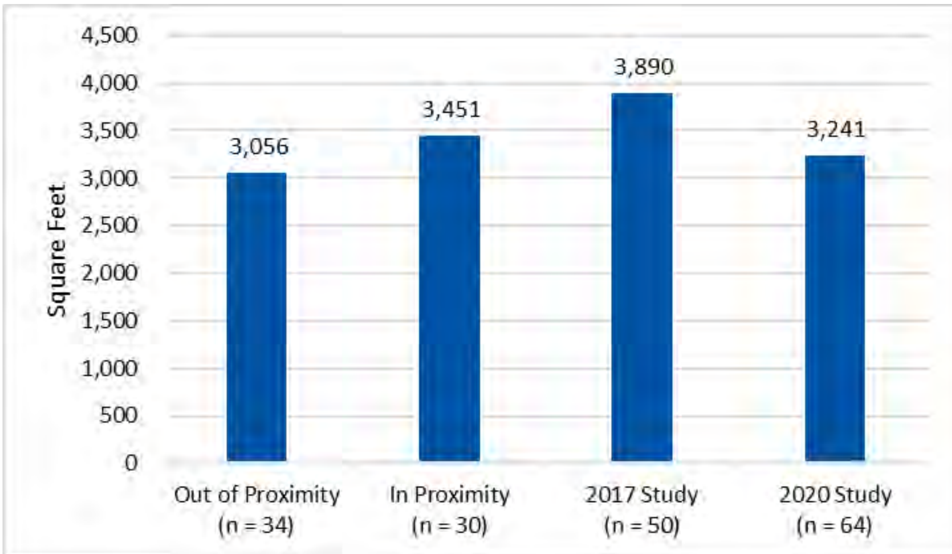



## *Home Size*

The homes sampled in the 2020 study are, on average, smaller than what Seventhwave reported in 2017. This is consistently true among all metrics related to home size, including conditioned area, conditioned volume, finished floor area, and building shell. Also, the out-of-proximity homes are, on average, smaller than the in-proximity homes. The home size trends may be partly attributed to fact that the out-of-proximity population includes four duplexes and the in-proximity population includes one duplex and two townhouses.

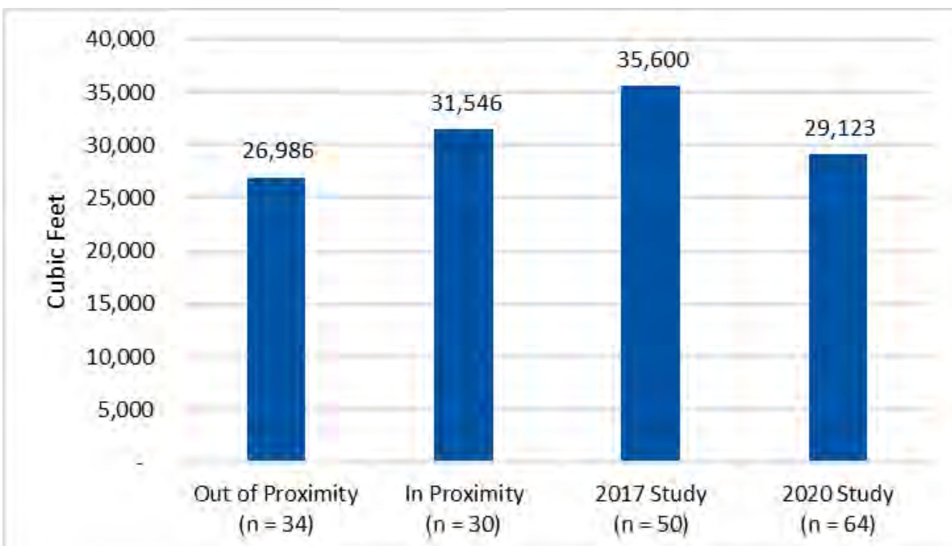
Conditioned floor area and volume, defined by RESNET as the space within the building that is serviced by the space heating and/or cooling system(s), are shown in Figure 3 and Figure 4. Conditioned floor area always excludes garages, thermally isolated sunrooms, attics, and both conditioned and unconditioned crawlspaces. A basement is included in the conditioned area only if it is within the thermal and pressure boundary of the home and the heating and cooling systems are designed to offset the thermal load of the entire space. Conditioned volume is similarly defined, except that it can include conditioned attics and crawlspaces that are within the thermal and pressure boundary of the home. All the basements in the 2020 sampled home were identified as conditioned basements.

**Figure 3. Conditioned Floor Area (square feet)**




The difference in conditioned floor area between the 2017 and 2020 studies is statistically significant.

**Figure 4. Conditioned Volume (cubic feet)**



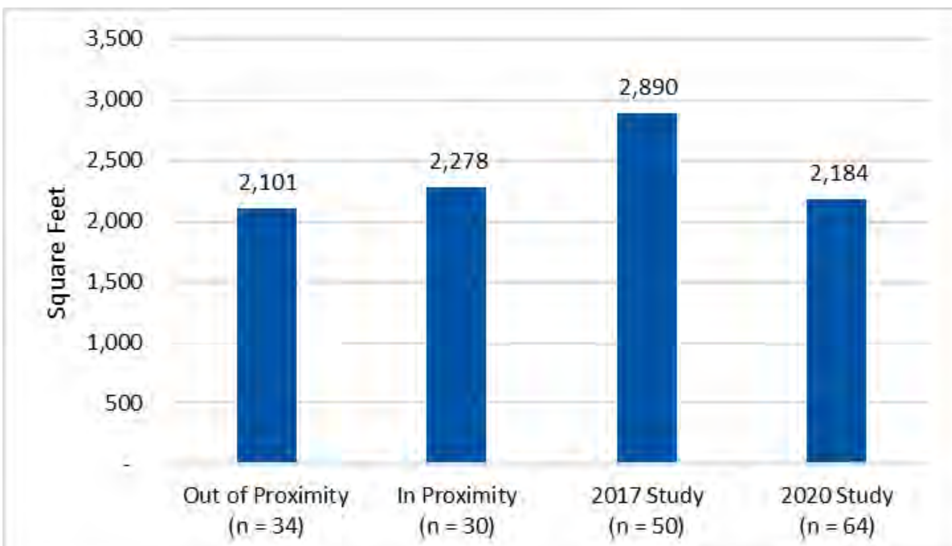

The difference in conditioned volume between the 2017 and 2020 studies is statistically significant.

The team calculated the finished floor area for the 2020 baseline study in accordance with a definition used in the real estate industry.[5] This includes all conditioned and finished spaces except three types of areas:

- Floor areas under ceilings or beyond walls that are less than five feet in height, such as those often found in homes with a half-story top floor
- Square footage of upper floor areas that are open to the downstairs and below vaulted ceilings
- Conditioned and finished spaces that do not meet the definition of being heated and having finished walls, finished ceilings (no exposed floor joists), and finished floors (painted concrete does not count)

It is possible that the criteria for determining finished floor area differed between the 2020 and 2017 studies. In the 2017 Seventhwave report, a finished floor area was noted as "includes finished areas of basement." The exact definition of finished basement areas was not provided. The report did not mention excluding other areas from the total finished floor area. Figure 5 provides the 2017 and 2020 study total finished floor area.

**Figure 5. Finished Floor Area (square feet)**

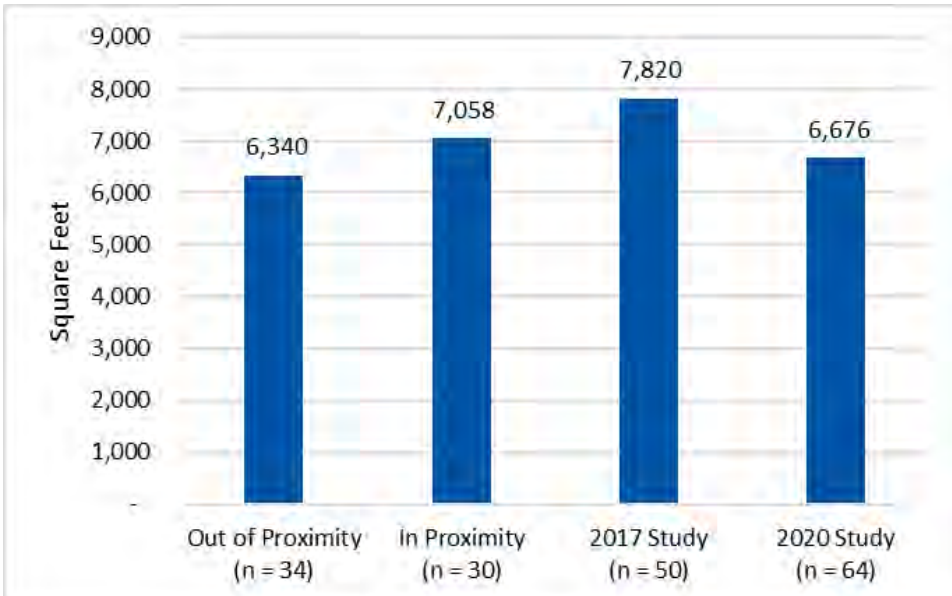



The difference in finished floor area between the 2017 and 2020 studies is statistically significant.

The building shell is defined by the thermal envelope of the building, where the thermal and air boundaries meet. The building shell area, shown in Figure 6, includes all ceilings, above-grade walls, foundation walls, slab floors, framed floors above unconditioned space, and knee walls between conditioned and unconditioned spaces.

5 REALTORS. January 2022. "Finished Square Footage." https://scwmls.com/wp-content/uploads/2021/06/sqftguide.pdf

**Figure 6. Building Shell Area (square feet)**

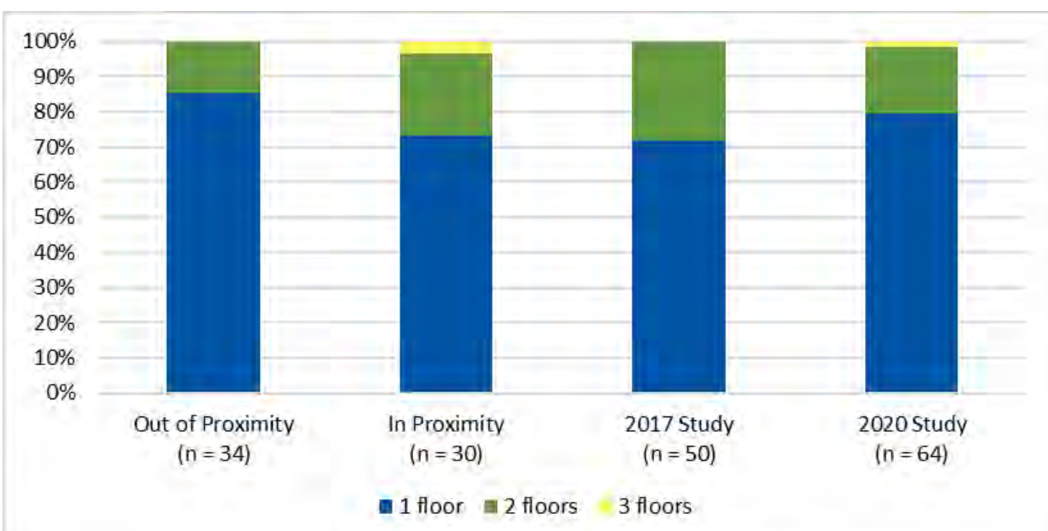



The difference in building shell area between the 2017 and 2020 studies is statistically significant.

## *General Building Characteristics*

The 2020 study has a larger percentage of single-story homes (80%) than what was reported in 2017 (72%), as shown in Figure 7. This may be partly due to the 2020 study including townhomes and duplexes, which were excluded from the 2017 study.

**Figure 7. Building Floors Above Grade**




The bedroom count distribution of the out-of-proximity homes closely resembles that of the 2017 study (Figure 8). The in-proximity homes have a more varied bedroom count distribution.

**Figure 8. Bedroom Count**

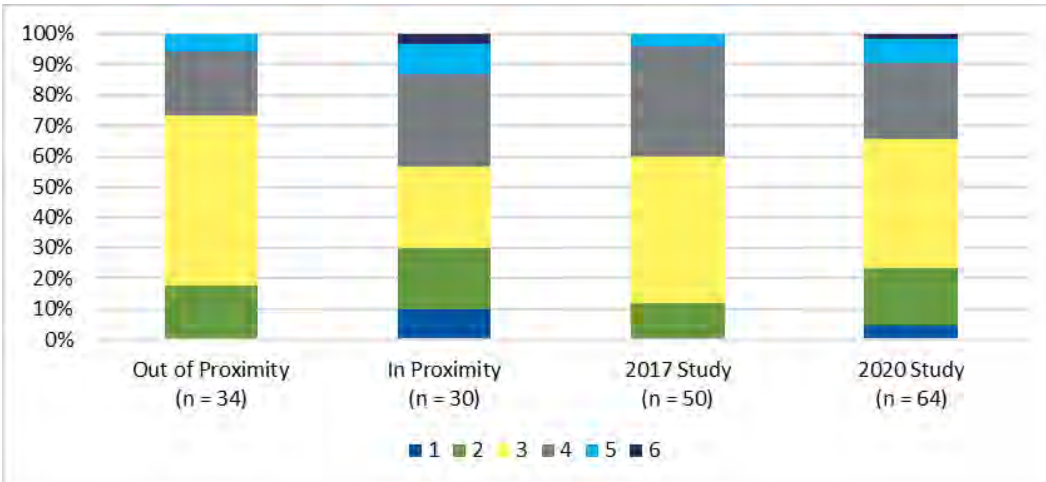
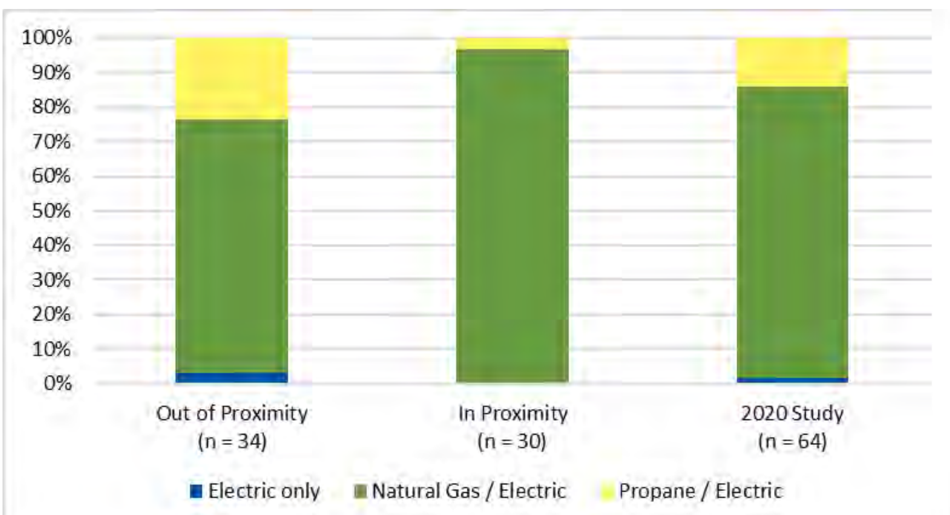



Figure 9 shows the distribution of fuel types for the 2020 sampled home. One out-of-proximity home is electric only. The 2017 study included only homes with natural gas and electricity, and so Figure 9 excludes 2017 study results. Propane was more common in the out-of-proximity homes (24%) than in the in-proximity homes (3%).

**Figure 9. Fuel Type by Home**




The difference in fuel type between the in-proximity and out-of-proximity homes is statistically significant.

Figure 10 shows the distribution of thermostat type by sample. The n-values represent the total number of thermostats. One 2020 out-of-proximity home has both a smart and standard programmable thermostat. The 2020 and 2017 studies show similar thermostat compositions, but the 2017 study had slightly more manual thermostats and fewer smart thermostats.

**Figure 10. Thermostat Type**

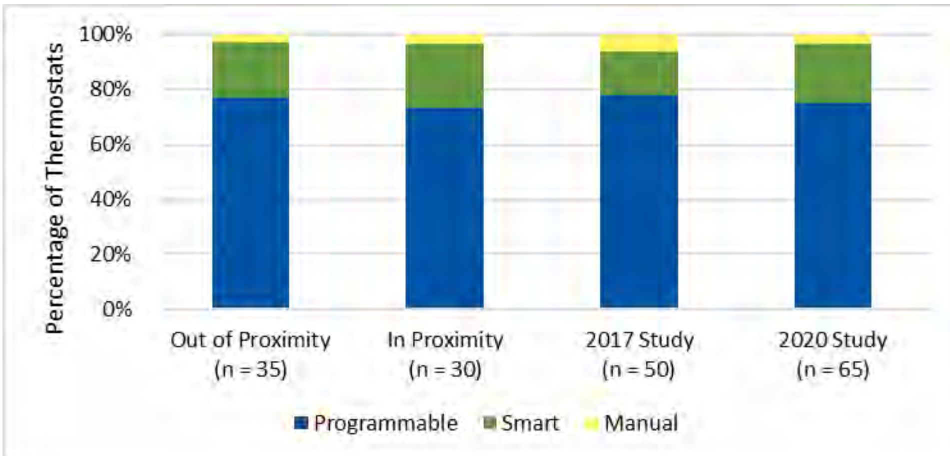
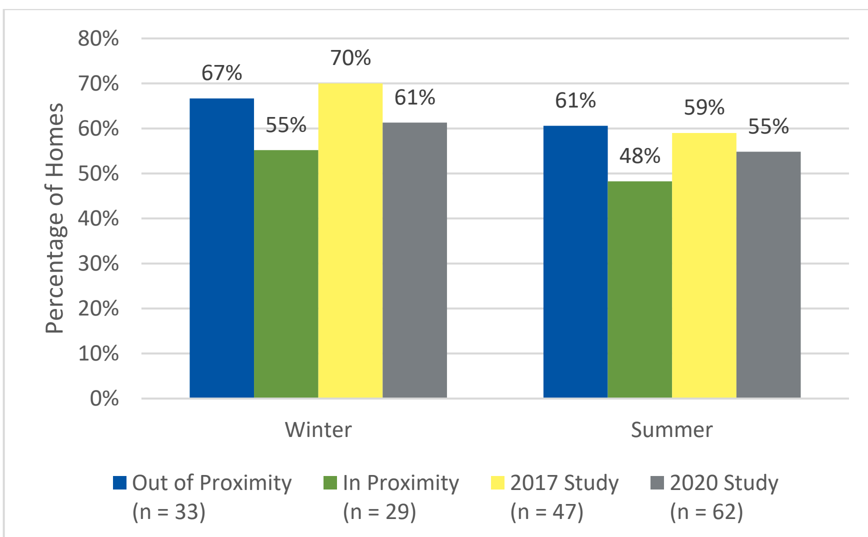



Figure 11 shows the percentage of homes in each sample that had their thermostat programmed for heating and/or cooling at the time of the site visit. The n-value is the total number of homes in the sample. These calculations exclude the two 2020 homes that have only a manual thermostat. Out-of-proximity homes were more likely to have a heating or cooling program scheduled compared to in-proximity homes, although these results are not statistically different.

**Figure 11. Thermostat Program Use by Season**

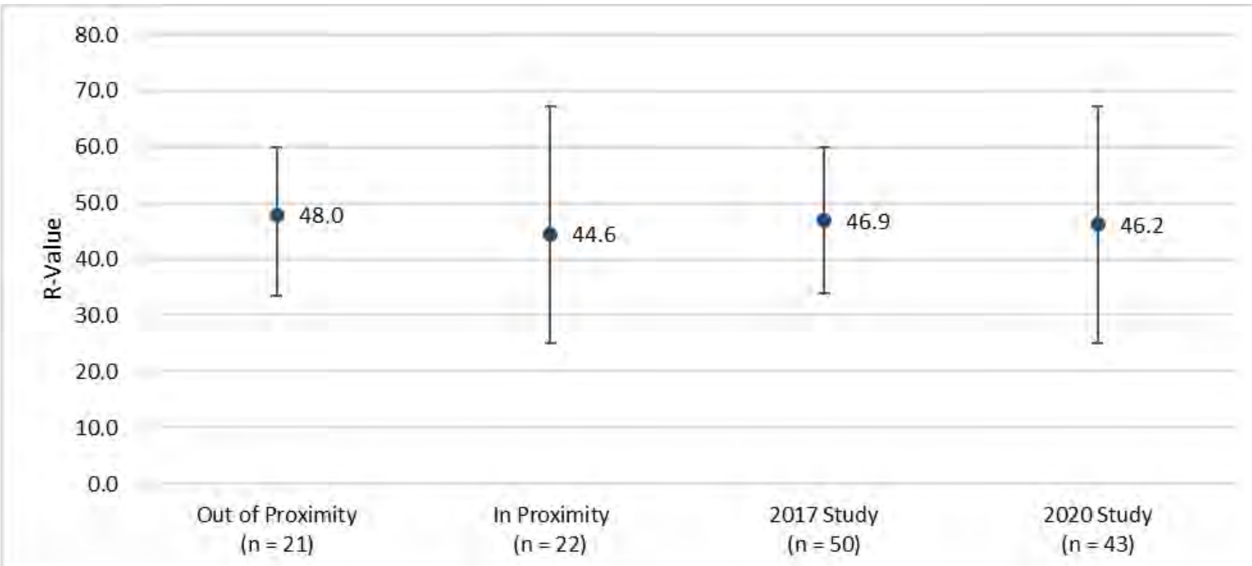


## *Building Insulation*

### Ceiling Insulation

Figure 12 shows the maximum, minimum, and mean ceiling insulation R-values for each sample.[6] The average ceiling R-values between the two studies did not differ much, at 46.9 in 2017 and 46.2 in 2020. Out-of-proximity homes have a higher average ceiling R-value, although the difference is not statistically different.

**Figure 12. Average Ceiling Insulation R-Value**




In all populations, 93% of the aggregate ceiling area is below attic space. The remaining 7% is ceiling area with no attic space above and mostly consists of vaulted ceilings. This ceiling type distribution is the same for the in-proximity, out-of-proximity, and 2017 study homes.

### Above-Grade Wall Insulation

Figure 13 shows the maximum, minimum, and mean above-grade wall cavity R-values for each sample. All the homes were constructed with 2x6 framing, with the exception of one 2020 out-of-proximity home and one 2017 study home that have 2x4 framing and continuous exterior insulation.

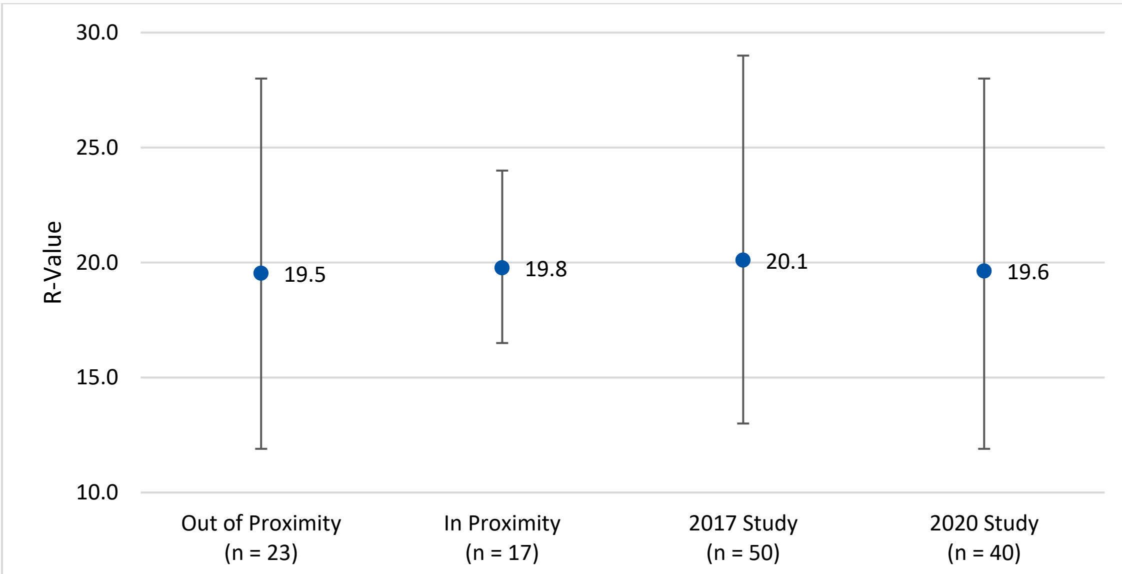
The 2020 sample includes three duplex units that have common walls with 2x4 framing and, as a result, have a lower R-value than the 2x6 exterior walls. To maintain consistency with the 2017 study, which excluded duplexes, the team did not include common wall insulation in the cavity insulation R-value

[6] The Cadmus team calculated the ceiling insulation R-value for each home by taking the inverse of the area-weighted average insulation U-value for the entire ceiling area. The team determined the ceiling insulation R-value for each ceiling segment via visual observation and/or building plans. In some homes, the team could not access the ceiling insulation, and building plans were not available. The n-values in Figure 12 reflect the number of homes where the ceiling insulation could be determined with confidence.

calculations. The report R-values represent the exposed above-grade wall cavity insulation found in each home.

As with ceiling insulation, the above-grade wall insulation of some homes could not be determined by visual inspection and/or building plans. The Cadmus team excluded these homes from the following figures and adjusted the n-values accordingly.

**Figure 13. Above-Grade Wall Cavity Insulation R-Value**




A large majority of sampled homes did not have exterior above-grade wall insulation (Figure 14). Two homes in both the 2020 out-of-proximity and 2017 samples had exterior insulation greater than R-6. The remaining homes with exterior above-grade wall insulation have between R-2 and R-6.

**Figure 14. Above-Grade Wall Exterior Insulation R-Value**

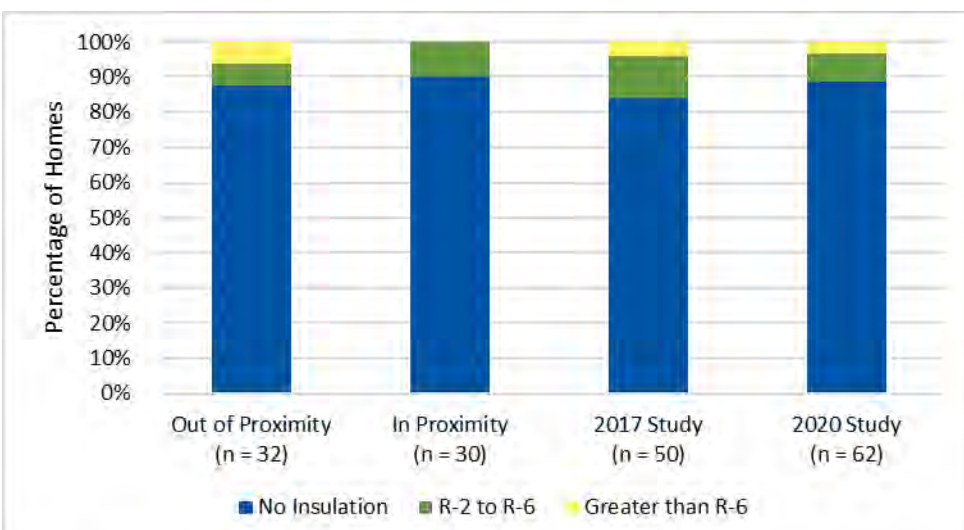
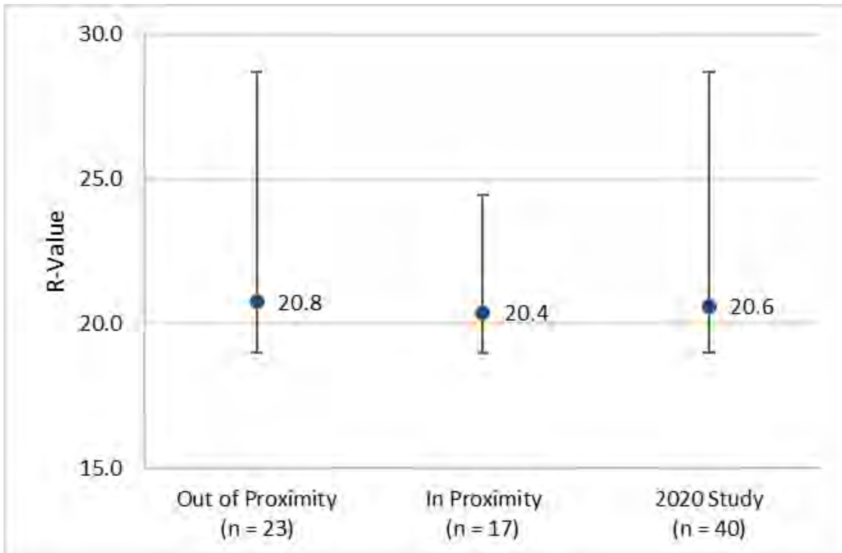


Figure 15 shows the minimum, maximum, and mean overall above-grade wall R-value for the 2020 in-proximity and out-of-proximity homes. This information was not provided in 2017, so a comparison to the previous study could not be made.

**Figure 15. Above-Grade Wall Overall R-Value**




## Foundation Insulation

The foundation types among the 2020 sample are more diverse than those in the 2017 study (Figure 16). The 2017 study included only one slab-on-grade home; the rest had conditioned basements. The 2020 sample has four slab-on-grade homes, two of which are either a townhouse or a duplex. One out-of-proximity home, which is a duplex, has a conditioned crawlspace. One in-proximity home, which is a townhouse, is constructed directly above the garage and was classified as a tuck under garage foundation.

**Figure 16. Foundation Type**

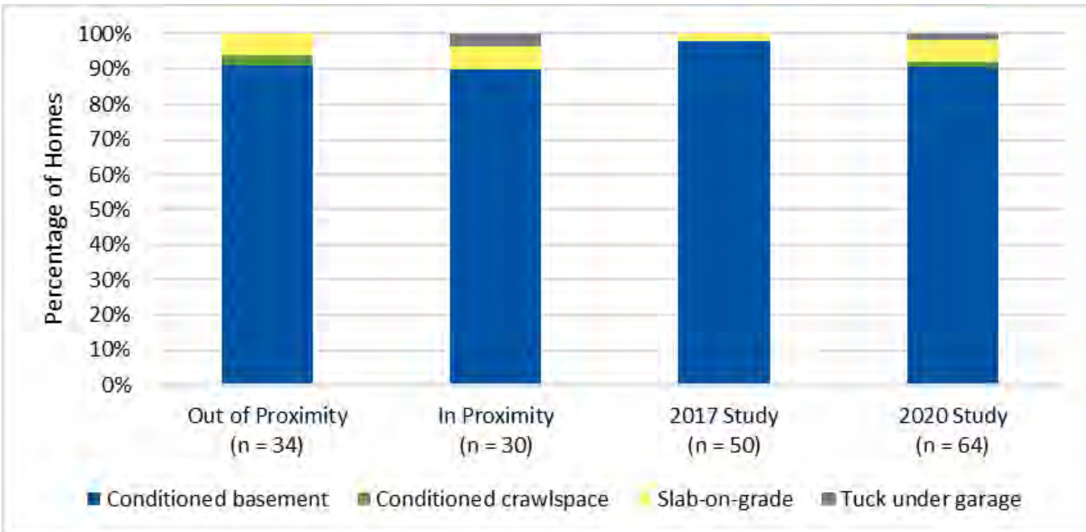



Figure 17 shows the location of conditioned basement wall insulation for each sample.

**Figure 17. Location of Conditioned Basement Wall Insulation**

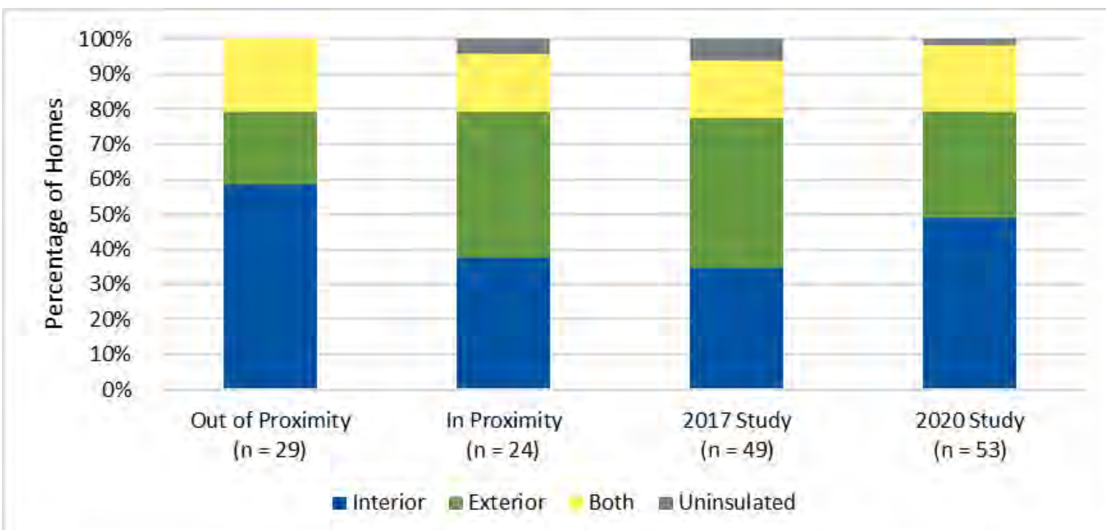



Figure 18 and Figure 19 show the level of interior and exterior insulation found in conditioned basements. These graphs exclude homes with slab-on-grade, tuck under garage, and conditioned crawlspace foundations. The team could not determine the conditioned basement wall insulation location and/or type for all homes in the 2020 sample. The n-values in the figures below reflect the number of homes where the team could determine basement wall insulation with confidence.

Of the homes with conditioned basements, three 2017 homes and one 2020 in-proximity home do not have foundation insulation. The conditioned basement walls of the 2017 and 2020 in-proximity homes were similarly insulated. The out-of-proximity population has a larger percentage of homes with insulation on the interior of conditioned basement walls.

**Figure 18. Conditioned Basement Wall Interior Insulation**

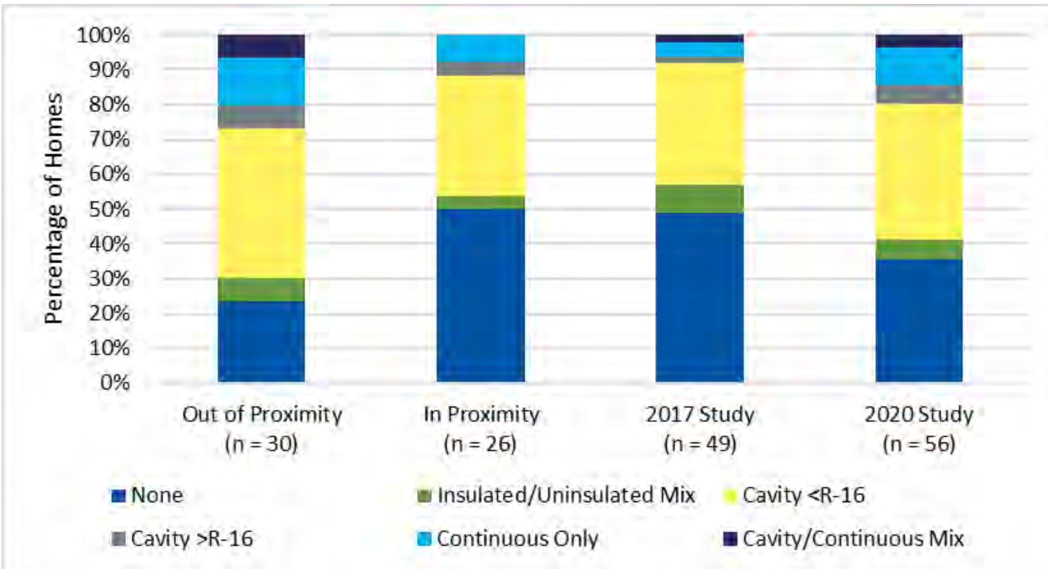



**Figure 19. Conditioned Basement Wall Exterior Insulation**

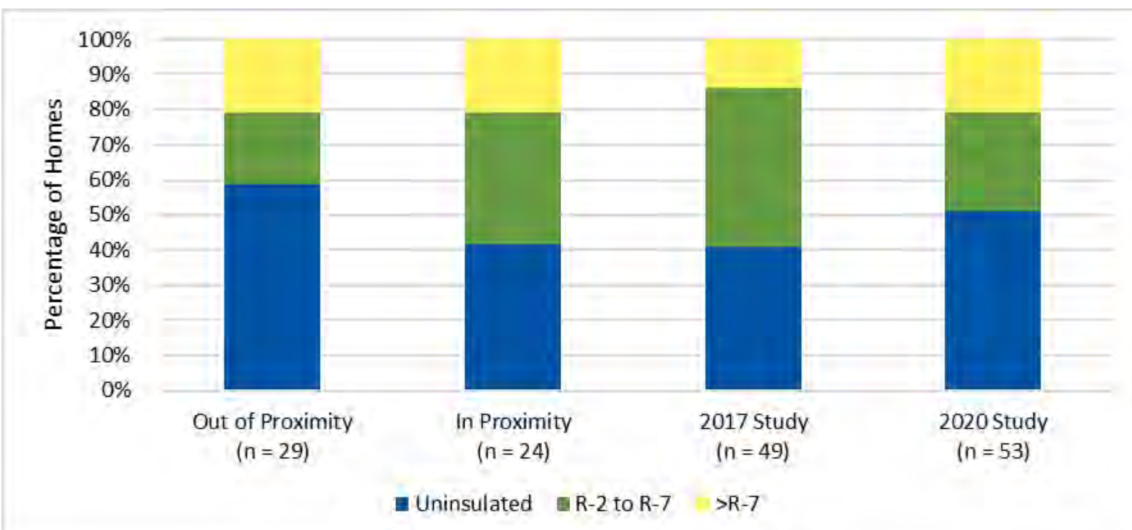
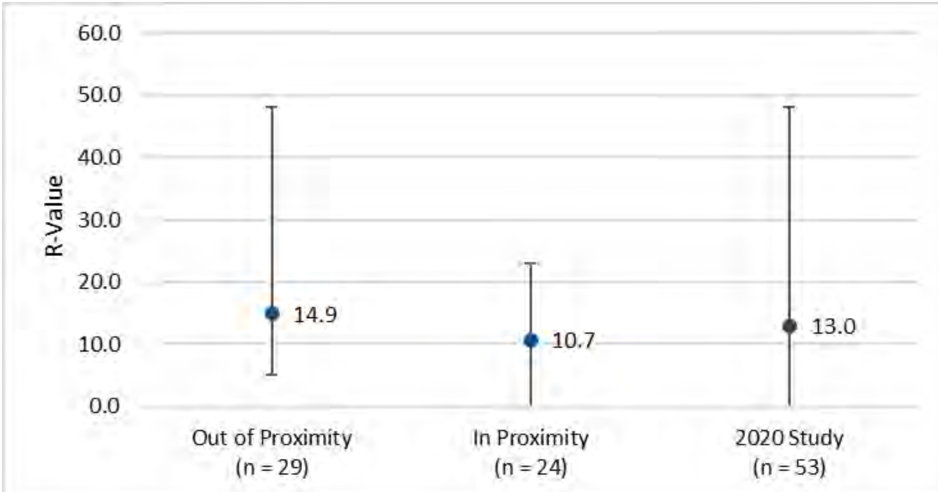



Figure 20 shows the minimum, maximum, and mean overall conditioned basement wall R-value for the 2020 in-proximity and out-of-proximity homes. This information was not provided in 2017, so a comparison to the previous study could not be made.

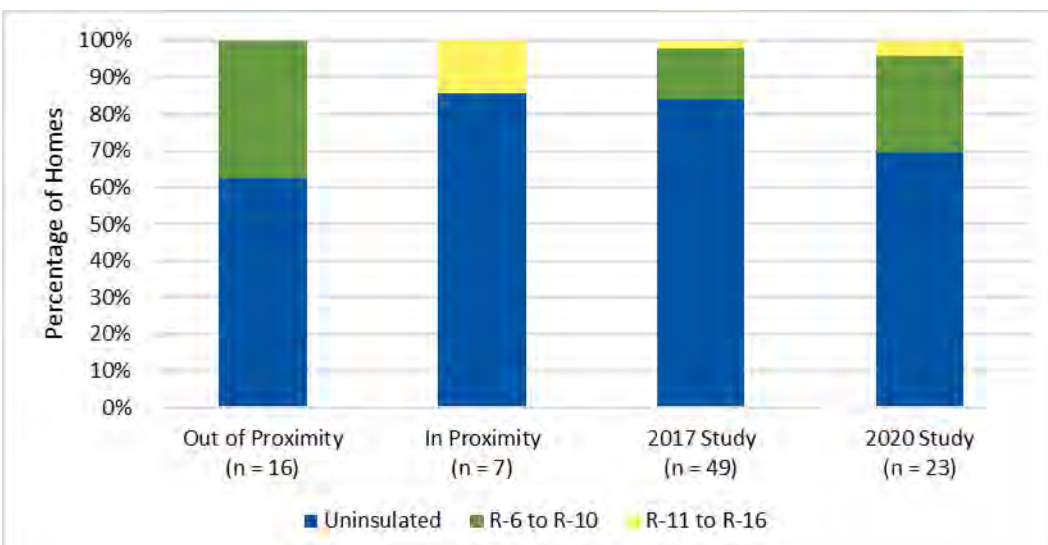
**Figure 20. Conditioned Basement Wall Overall R-Value**




The difference in overall basement wall R-value between the in-proximity and out-of-proximity homes is statistically significant.

Figure 21 shows the conditioned basement under-slab insulation R-value for each sample. The Cadmus team recorded slab insulation from the 2020 sample only if it was observable in person or in pictures, listed in building plans, or verbally confirmed by the building contractor or homeowner. The team was not able to determine under-slab insulation for most homes in the 2020 study. Note that the in-proximity n-value is seven, which is a small sample and may not be an accurate representation of the entire sample.

**Figure 21. Conditioned Basement Under-Slab Insulation**




The difference in basement under-slab insulation between in-proximity and out-of-proximity homes is statistically significant.

Figure 22 shows the percentage of homes where spray foam was used to insulate the foundation rim/band joist. Figure 23 shows the distribution of all insulation types observed at the foundation rim/band joists in the 2020 sample. This information was not included in the 2017 report. Both figures exclude the homes with slab-on-grade foundations as well as the home with a tuck under garage foundation (as the team could not determine the foundation rim/band joist insulation), resulting in an n-value of 59.

**Figure 22. Foundation Rim/Band Joist Insulation Type**

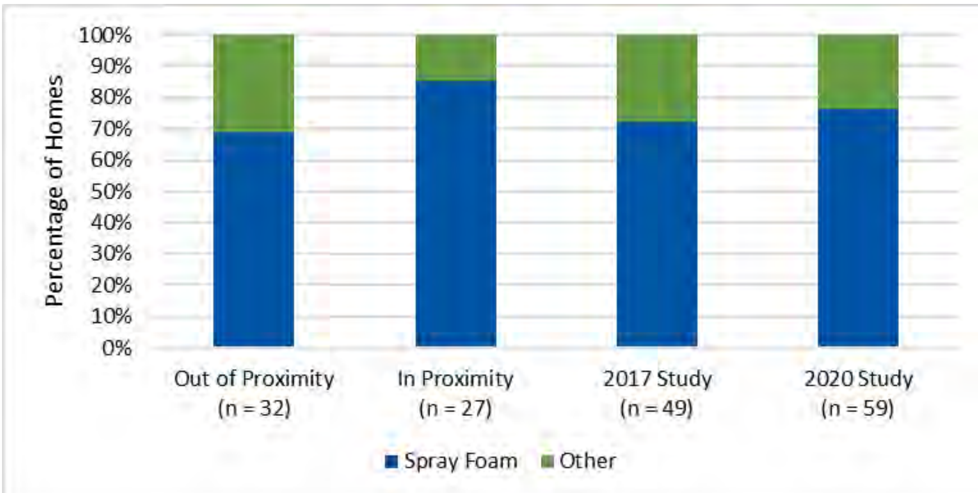
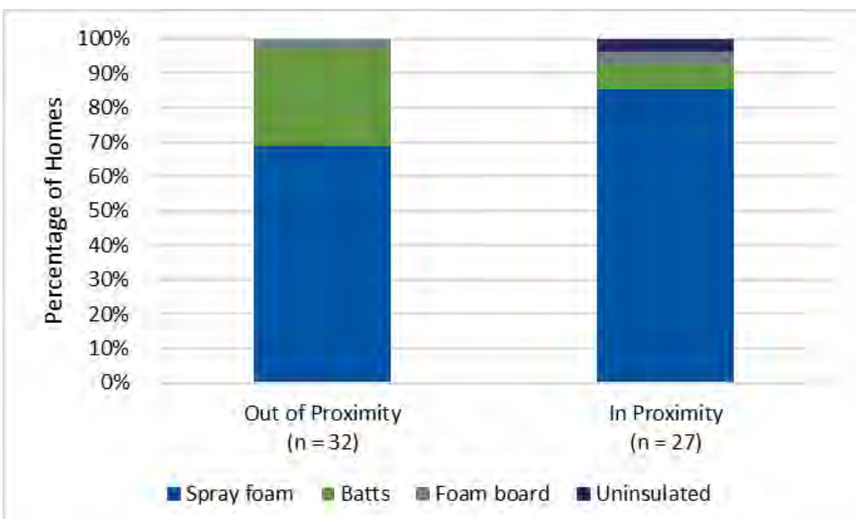


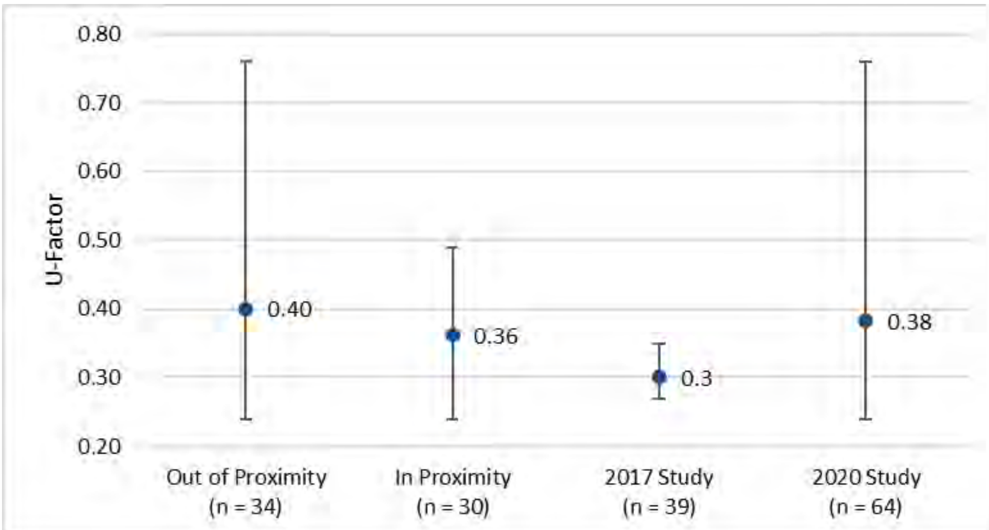

**Figure 23. Foundation Rim/Band Joist Insulation Type**




## *Windows*

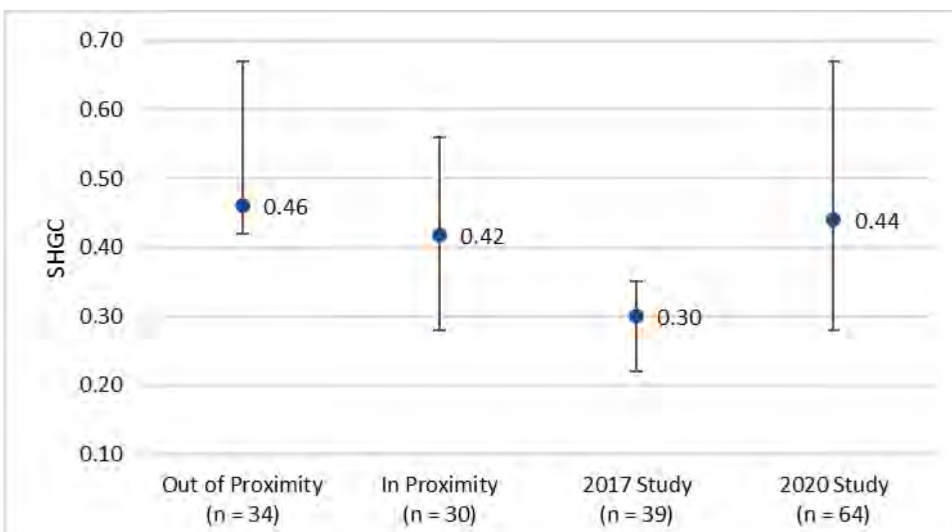
Figure 24 shows the minimum, maximum, and mean area-weighted window U-factors for each sample. Figure 25 shows the minimum, maximum, and mean area-weighted window solar heat gain coefficient (SHGC) for each sample. The Cadmus team could determine the actual window U-factor and SHGC for only seven homes in the 2020 sample. The mean U-factor of the seven 2020 homes with discernible window data is 0.27. The team inferred missing window data for the other 57 homes by mapping to the average U-factor and SHGC for each window type from the National Renewable Energy Laboratory *National Residential Efficiency Measures Database*.[7] This approach likely created different inferred values than the 2017 study, which may explain why 2020 results show less-efficient windows.

**Figure 24. Window Area-Weighted U-Factor**




The difference in window U-factor between the 2017 and 2020 studies is statistically significant but likely results from differences in inferred values; the difference in window U-factor between in-proximity and out-of-proximity homes is also statistically significant.

**Figure 25. Window Area-Weighted Solar Heat Gain Coefficient**




The difference in window SHGC between the 2017 and 2020 studies is statistically significant but likely results from differences in inferred values; the difference in window SHGC between in-proximity and out-of-proximity homes is also statistically significant.

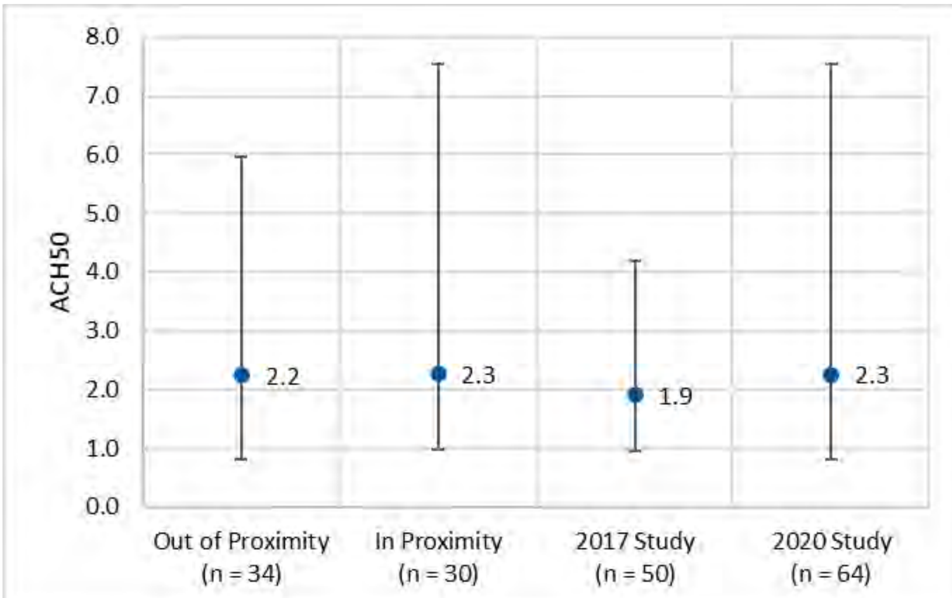
---

[7] National Renewable Energy Laboratory. n.d. *National Residential Efficiency Measures Database*. Version 3.1.0. https://remdb.nrel.gov/measures.php?gId=16&ctId=190

## *Air Leakage*

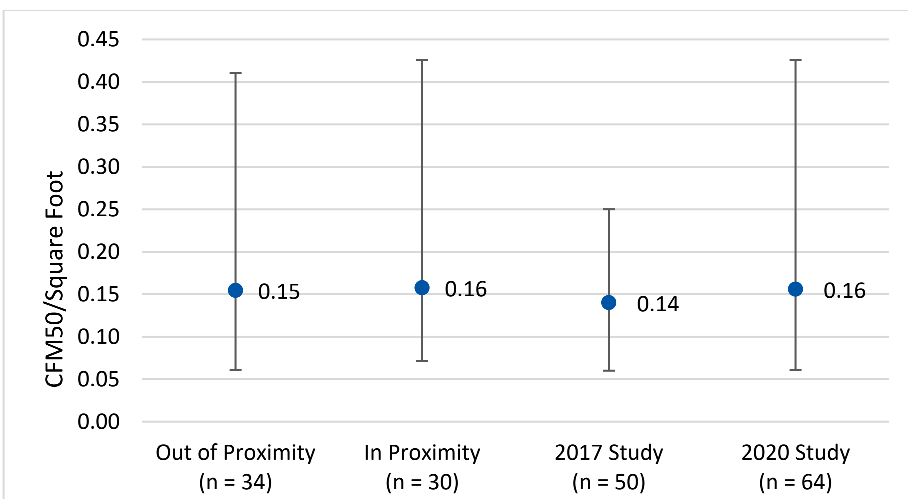
The Cadmus team measured air leakage using an automated multi-point blower door test. Figure 26 shows the minimum, maximum, and mean air leakage expressed as the number of air changes per hour at the normalized test pressure of 50 pascals (ACH50). Figure 27 shows the minimum, maximum, and mean air leakage in terms of cubic feet per minute at 50 pascals (CFM50) per square foot of building shell area.

**Figure 26. Air Leakage (ACH50)**




The difference in air leakage (ACH50) between the 2017 and 2020 studies is statistically significant.

**Figure 27. Air Leakage (CFM50 Per Square Foot of Building Shell)**

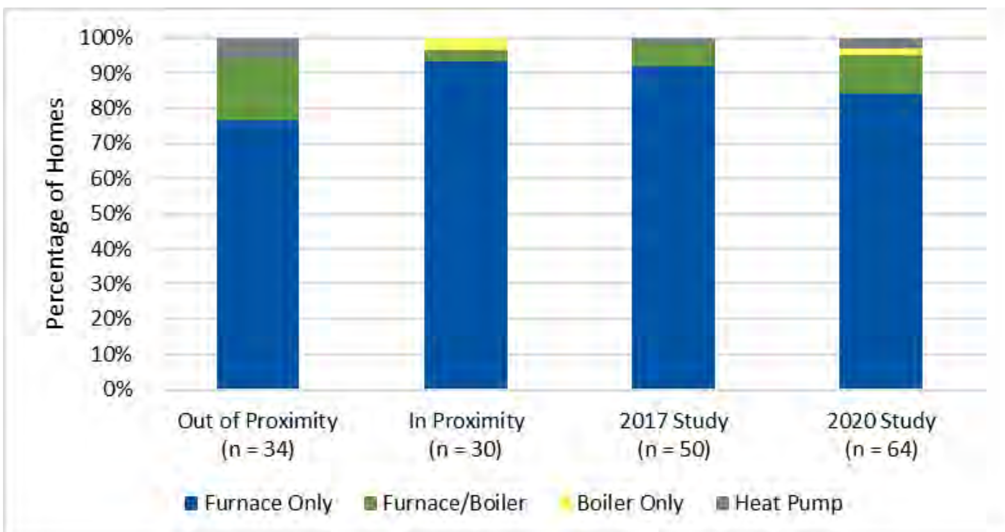



The test protocol specified duct leakage testing for any homes with HVAC equipment and/or ducts located outside the thermal envelope. Only one home in the 2020 sample required duct leakage testing: a duplex unit with a slab-on-grade foundation that has 30% of return ducting and 90% of supply ducting located in the attic under blown-in insulation. However, the team was unable to perform the duct leakage test. One of the return grilles was located behind a large piece of furniture that could not be safely moved during the inspection. It was not possible to properly seal the distribution system for the duct leakage test.

## *Primary Heating Systems*

Most of the homes use a natural gas furnace as the primary heating system (Figure 28). Seven of the 2020 homes also have a hydronic boiler that is used for secondary radiant floor heating (six out-of-proximity homes and one in-proximity home). The 2017 study included three homes with a natural gas furnace and hydronic boiler combination. Only one 2020 in-proximity home has a natural gas boiler as the primary heating source. Two out-of-proximity homes in the 2020 sample use a heat pump for primary heating: one of these homes has a ductless mini-split heat pump and the other has an air-source heat pump. The 2017 study included one home with a ground-source heat pump.

**Figure 28. Primary Heating System Type**




The variation in primary heating system types between in-proximity and out-of-proximity homes is statistically significant.

Figure 29 shows the minimum, maximum, and mean AFUE ratings for all gas-powered primary heating systems and boilers used for radiant floor heating. The n-values reflect the total number of gas–powered heating systems among all homes in the sample. The 2017 sample included 52 furnaces (two homes had double HVAC systems) and three boilers. The 2020 out-of-proximity sample includes 32 furnaces and six boilers. The 2020 in-proximity sample includes 31 furnaces (two homes have double HVAC systems) and two boilers. One in-proximity home has a furnace with an obscured nameplate, and the team could not determine the model number and AFUE rating.

**Figure 29. Gas–Powered Heating System Efficiency**

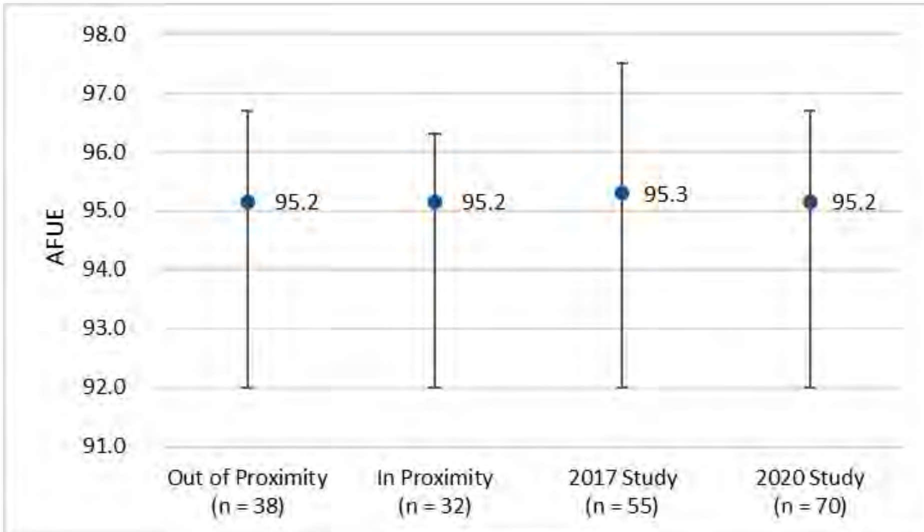
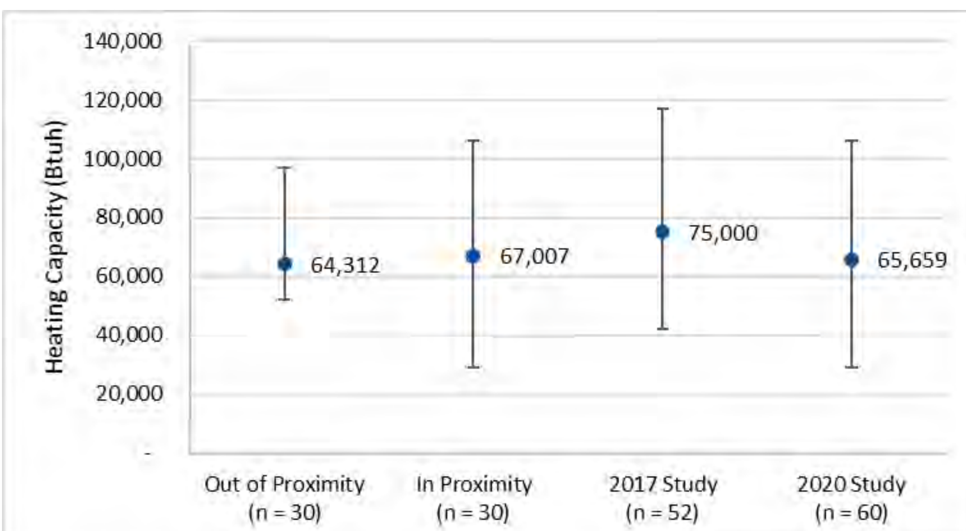



Figure 30 shows the minimum, maximum, and mean output heating capacity of the ducted furnaces from each sample. The n-values reflect the total number of ducted furnaces. The Cadmus team could not determine the heating capacity for one in-proximity and two out-of-proximity furnaces, which were excluded from the calculations. Note that the larger average heating capacity from the 2017 study aligns with the larger average home size of that study.

**Figure 30. Ducted Furnace Output Heating Capacity (Btuh)**




The difference in ducted furnace output heating capacity between the 2017 and 2020 studies is statistically significant.

## *Primary Cooling Systems*

Nearly all of the homes use a central air conditioner (A/C) as the primary cooling system (Figure 31). Two out-of-proximity homes in the 2020 sample use a heat pump for primary cooling: one has a ductless mini-split heat pump and the other has an air-source heat pump. The 2017 study included one home with a ground-source heat pump. Only one 2020 in-proximity home did not have a primary cooling system installed. At the time of the inspection, the home was being constructed by the owner and was unoccupied. The 2017 sample included four homes where indoor coils were in place but the outdoor condensing unit had not yet been installed.

**Figure 31. Primary Cooling System Type**

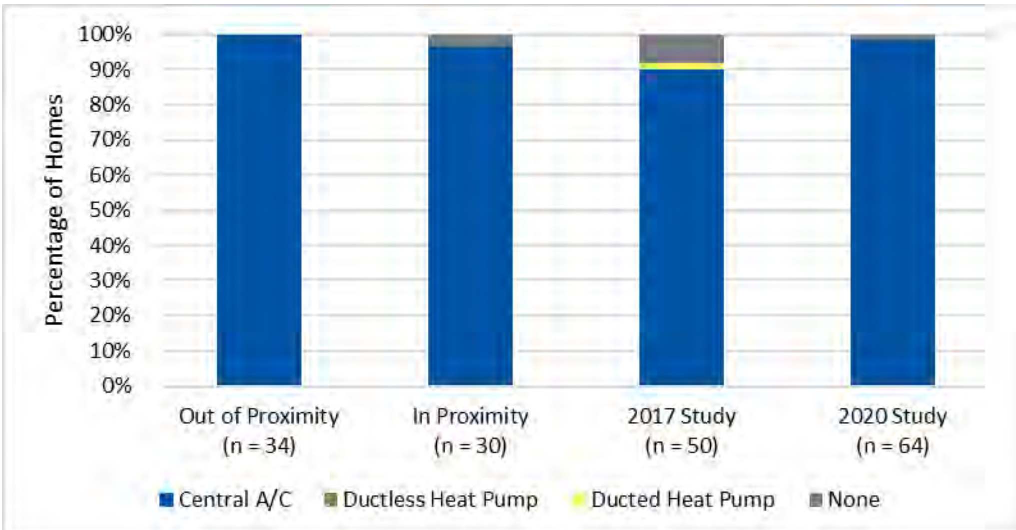
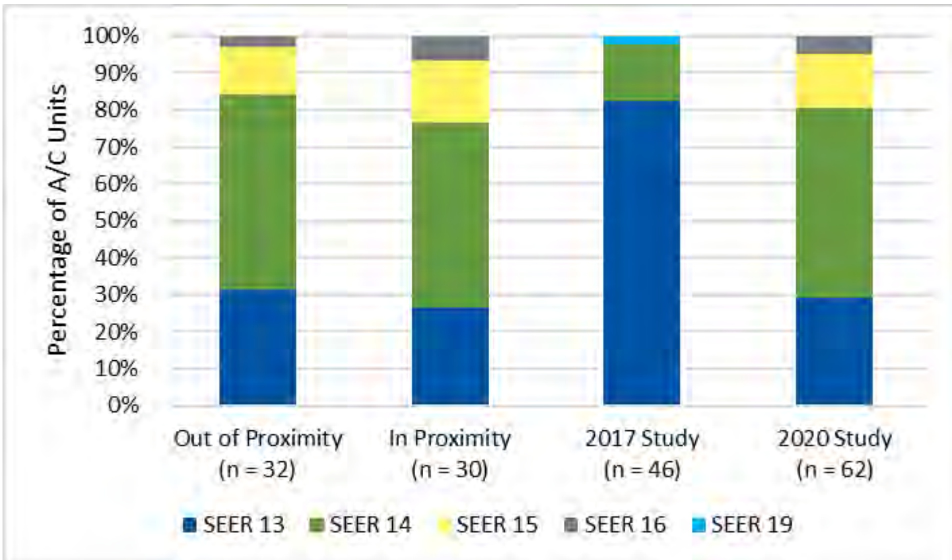



Figure 32 shows the efficiency distribution of all the central A/C systems. Figure 33 shows the average SEER rating for each population. The n-values reflect the total number of central A/C units among all homes in the sample. Both the 2017 sample and the 2020 in-proximity sample included two homes with double HVAC systems (two A/C units). One in-proximity home's A/C unit was missing a nameplate (and the team could not determine the model number and SEER rating).

The Cadmus team used the AHRI product directory[8] to determine the most accurate central A/C SEER rating by looking up the combination of model numbers for the outdoor condensing unit, indoor coil, and furnace. In some cases, the team could not determine one or more of these model numbers and based the SEER rating on the combination of model numbers that were available.

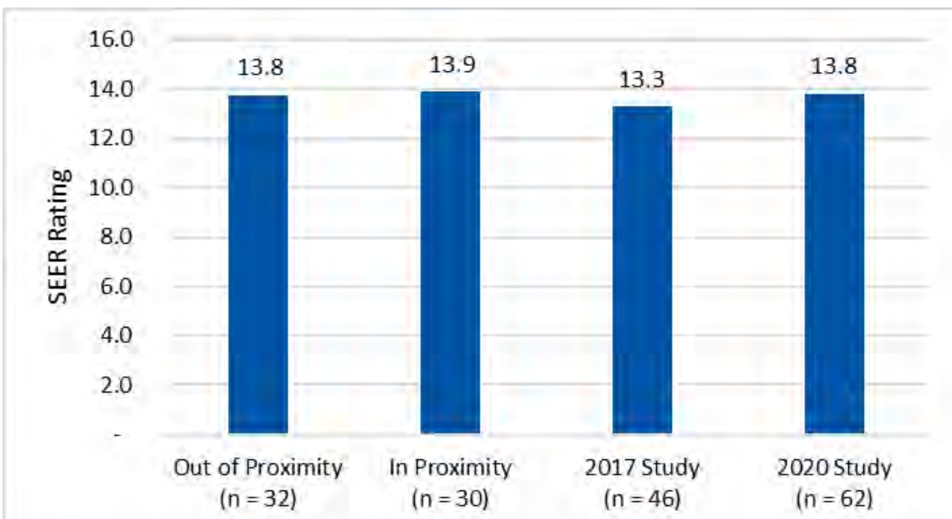
8 Air Conditioning, Heating, and Refrigeration Institute. 2022. "Directory of Certified Product Performance." https://www.ahridirectory.org/Search/SearchHome?ReturnUrl=%2f

**Figure 32. Central A/C Efficiency (SEER)**




The difference in central A/C SEER ratings between the 2017 and 2020 studies is statistically significant.

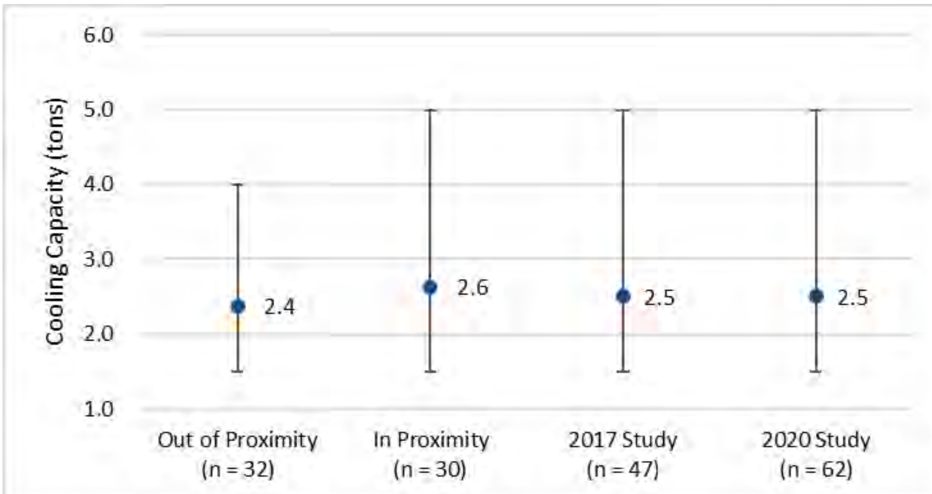
**Figure 33. Average Central A/C SEER Rating**




The difference in central A/C SEER ratings between the 2017 and 2020 studies is statistically significant.

Figure 34 shows the minimum, maximum, and mean cooling capacity of all the central A/C units from each sample. The n-values reflect the total number of central A/C units. The team could not determine the cooling capacity for one in-proximity home's central A/C unit and excluded it from the calculations.

**Figure 34. Central A/C Cooling Capacity (tons)**




## *Domestic Hot Water*

Over 80% of all the homes have conventional storage water heaters, the majority of which are gas powered. Figure 35 shows the distribution of domestic hot water (DHW) system types for each sample. The n-values reflect the total number of DHW systems. Two 2020 out-of-proximity homes and one 2020 in-proximity home have double DHW systems with two identical units.

**Figure 35. Domestic Hot Water System Type**

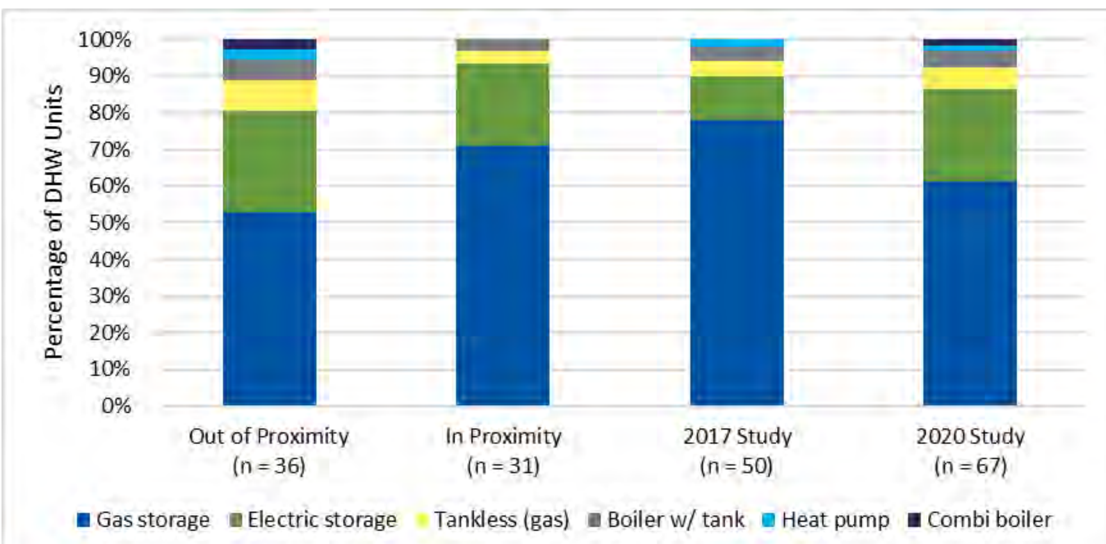



Table 4 lists the average energy factor of each DHW system type for each sample. The rating criteria for DHW systems has changed since 2017; only the uniform energy factor was listed for the DHW models found in the 2020 sampled homes. To make comparisons with the 2017 study, the team first verified the uniform energy factor ratings using the AHRI product directory,[9] then converted these to energy factors using a calculator published on the Residential Energy Services Network website.[10] The 2017 report excluded electric units and natural gas storage units with tanks larger than 75 gallons from the average energy factor calculations. Table 4 also excludes gas–powered boilers.

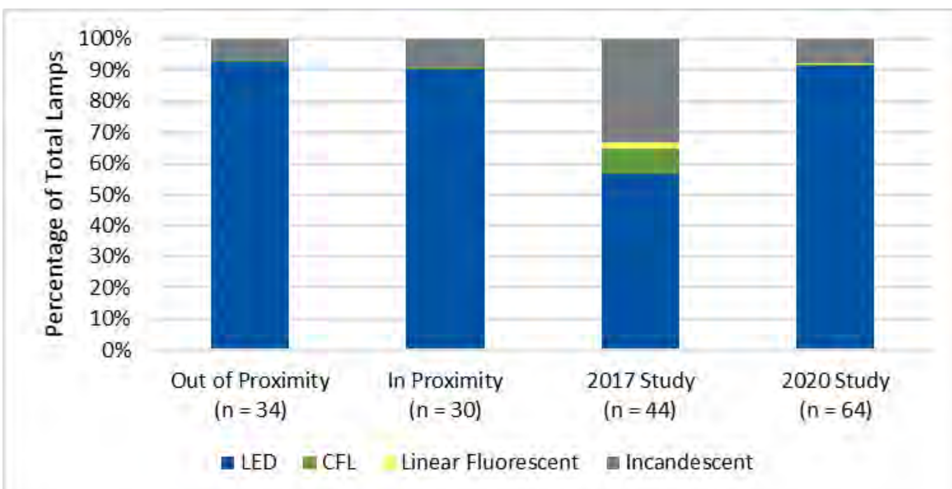
**Table 4. Domestic Hot Water Energy Factor**

| Unit Type | Out of Proximity (n=33) | In Proximity (n=30) | 2017 Study (n=36) | 2020 Study (n=63) |
|---|---|---|---|---|
| | Mean Energy Factor | | | |
| Gas Storage | 0.67 | 0.69 | 0.67 | 0.68 |
| Electric Storage | 0.94 | 0.94 | - | 0.94 |
| Tankless (Gas) | 0.94 | 0.95 | 0.95 | 0.94 |
| Heat Pump | 3.57 | - | - | - |

## *Lighting*

Figure 36 shows the distribution of lamp types found within each sample. The 2020 sampled home have a significantly larger percentage of LEDs than the 2017 sampled home. The percentages of CFLs, linear fluorescent, and incandescent bulbs have all decreased since 2017.

**Figure 36. Lamp Types Found in Sampled Homes**




The variation in lamp types between the 2017 and 2020 studies is statistically significant.

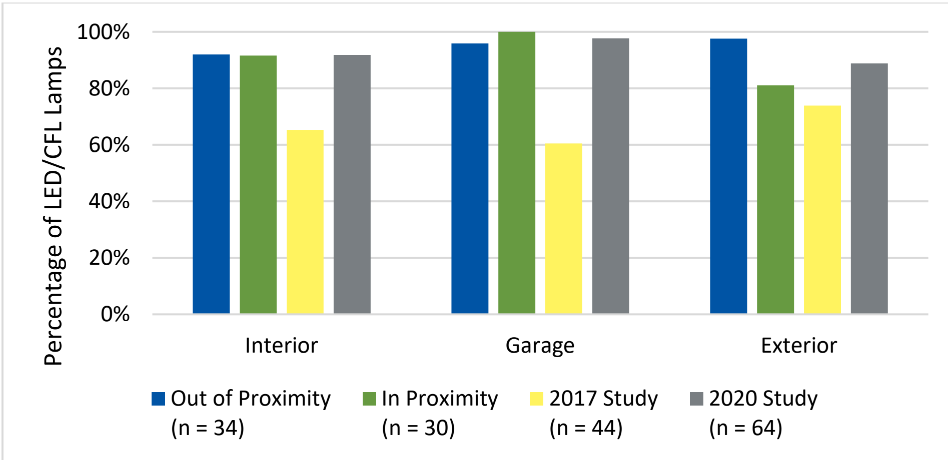
Figure 37 shows the percentage of energy-efficient lighting by location for each sample. Energy-efficient lighting was defined in the 2017 Seventhwave report as both LED and CFL bulbs. The Cadmus team used

[9] Air Conditioning, Heating, and Refrigeration Institute. 2022. "Directory of Certified Product Performance." https://www.ahridirectory.org/Search/SearchHome?ReturnUrl=%2f

[10] Residential Energy Services Network. 2021. "RESNET EF Calculator 2017." https://www.resnet.us/about/standards/resnet-ansi/resnet-ef-calculator-2017

this same definition in 2020 to allow for comparison to the 2017 data. This also aligns with how lighting is entered into the REM/Rate energy modeling software.

**Figure 37. Efficient Lighting (LED or CFL) Saturation by Location**




The difference in efficient lighting saturation between the 2017 and 2020 studies is statistically significant.

Table 5 shows the distribution of lamp types by location for all 2020 sampled homes. A large majority of lamps are LEDs. Incandescent lamps are the second most common lamp type. Less than 1% of the total lamps found were CFLs. All CFLs were used for interior lighting.

**Table 5. Combined 2020 Distribution of Lamp Type by Location**

| Lamp Type | Interior | Garage | Exterior |
|---|---|---|---|
| | Percentage of Total Lamps | | |
| LED | 91% | 98% | 89% |
| CFL | 1% | 0% | 0% |
| Fluorescent | 0% | 1% | 0% |
| Incandescent | 8% | 2% | 11% |

## *Appliances*

Figure 38 shows the minimum, maximum, and mean rated annual energy usage for the primary refrigerator in each home (defined as the refrigerator found in the kitchen). Figure 38 does not include secondary refrigerators found in garages, basements, and other non-kitchen locations. The team could not determine the annual energy usage of the primary refrigerator for all homes.[11]

[11] Appliances may not have been installed by the builder except for some appliances such as built-in oven, stoves, and dishwashers.

**Figure 38. Primary Refrigerator Rated Annual Energy Usage (kWh)**

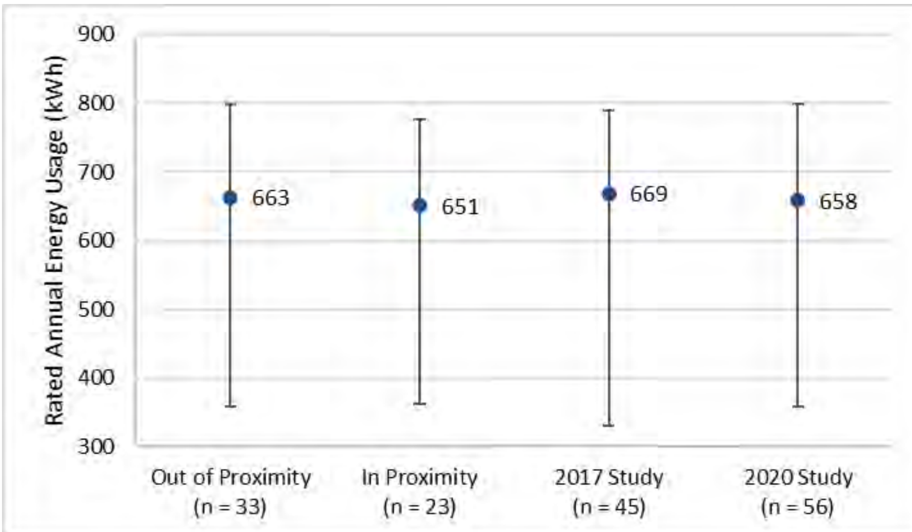
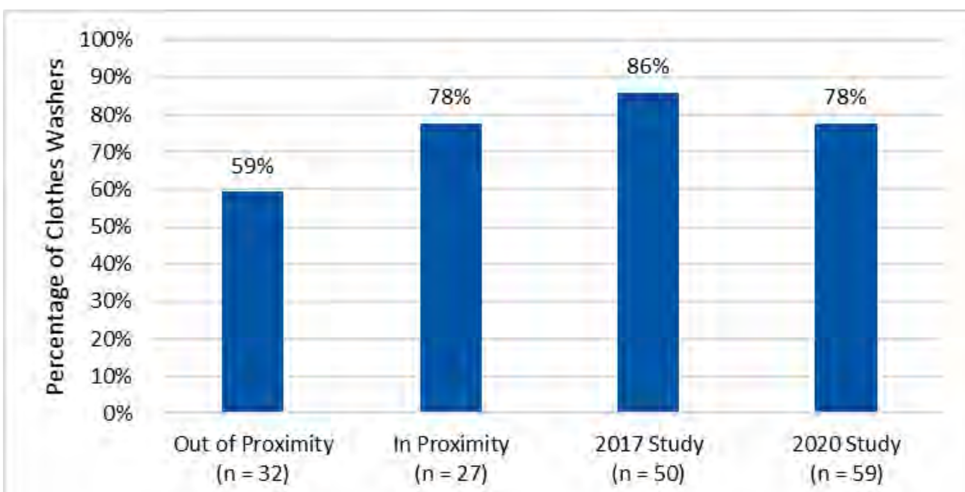



Figure 39 shows the percentage of all clothes washers that are ENERGY STAR certified. Seventhwave reported a larger percentage of ENERGY STAR clothes washers in 2017 than what was found in the 2020 sample. The team verified ENERGY STAR certification by looking up the model number in the ENERGY STAR *Qualified Products List*.[12] The n-values reflect the total number of clothes washers in each sample. The Cadmus team could not determine the clothes washer model number for five of the 2020 sampled homes. Another home was under construction by the owner at the time of the inspection and did not have a clothes washer. One 2020 in-proximity home has two clothes washers.

**Figure 39. ENERGY STAR Clothes Washers**



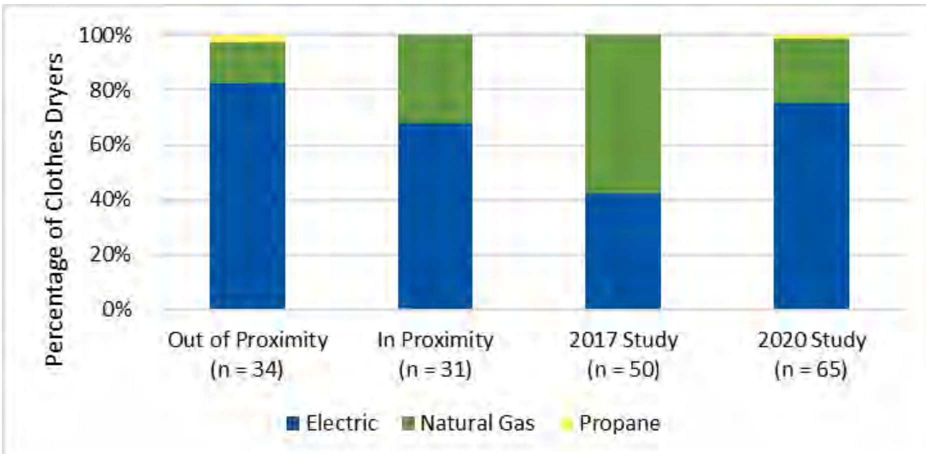

The difference in the percentage of ENERGY STAR clothes washers between the 2017 and 2020 studies is statistically significant.

---

12 ENERGY STAR. n.d. "ENERGY STAR Certified Residential Clothes Washers." https://www.energystar.gov/productfinder/product/certified-clothes-washers/

Figure 40 shows the distribution of clothes dryer fuel type by sample. The n-value represents the total number of clothes dryers in the sample. One 2020 in-proximity home has two clothes dryers. There was a larger percentage of electric clothes dryers in 2020 than what was reported by Seventhwave in 2017, especially among the out-of-proximity homes.

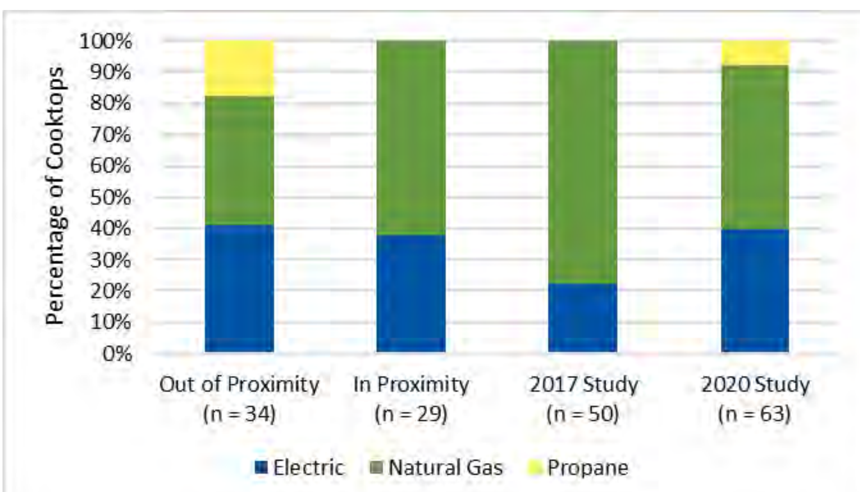
**Figure 40. Clothes Dryer Fuel Type**




The difference in clothes dryer fuel type between the 2017 and 2020 studies is statistically significant.

Figure 41 shows the distribution of cooktop fuel type for each sample. The n-values represent the total number of cooktop units in the sample. One home was under construction by owner at the time of the inspection and did not have a cooktop.

**Figure 41. Cooktop Fuel Type**




The difference in cooktop fuel type between the 2017 and 2020 studies is statistically significant.

## Comparison of Energy Modeling Results

The Cadmus team compared the REM/Rate energy modeling results for the 2020 in proximity, 2020 out of proximity, 2017 study, and combined 2020 study sampled homes. The team used REM/Rate version 16.2 to model the 2020 sampled homes. According to the Seventhwave report, REM/Rate version 15.3 was used to model the 2017 sampled homes. It is possible that some discrepancies in the energy models occurred as a result of using different software versions.

It was not possible for the Cadmus team to collect all data points during the site visits. This was especially true for window U-factors and SHGCs, as well as for inaccessible insulation. In cases of data gaps, the team made assumptions to complete the REM/Rate model. In most cases, the team based such assumptions on the Wisconsin Department of Safety and Professional Services *Energy Conservation Code*, chapter SPS 322.[13] A full list of the assumptions used for the REM/Rate modeling is available in *Appendix A*.

### *Home Energy Rating System Index*

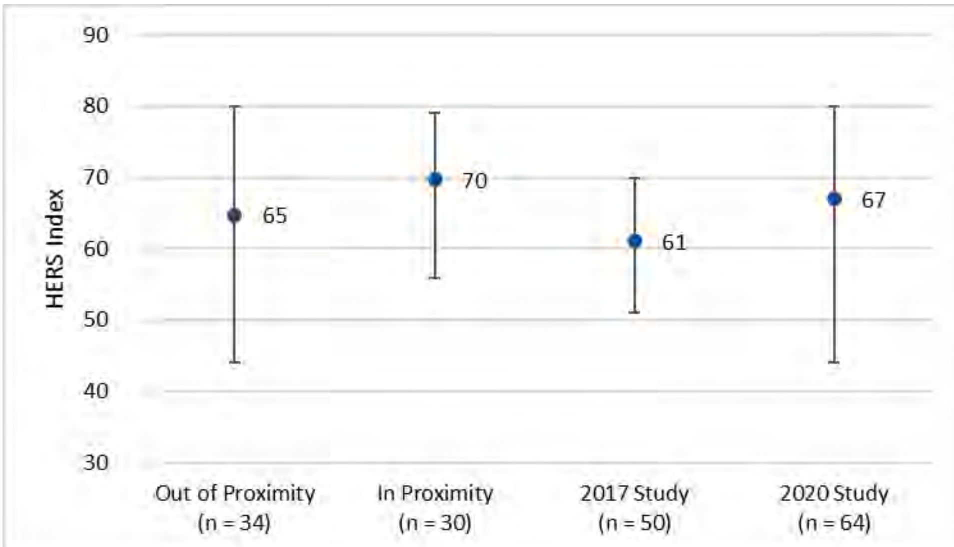
Figure 42 shows the minimum, maximum, and mean HERS index rating for each sample. The HERS index is an industry standard by which a home's energy efficiency is measured,[14] where lower ratings equate to more energy-efficient homes. The 2020 HERS index ratings were higher compared to 2017, indicating an overall decrease in estimated energy efficiency. The in-proximity homes had the highest HERS index ratings of all the samples. The Cadmus team found both comparisons to be statistically significant, though the difference between 2020 and 2017 may be partly due to the assumptions used during the modeling process.

---

13 Wisconsin State Legislature. May 2015. "Chapter SPS 322: Energy Conservation." https://docs.legis.wisconsin.gov/code/admin_code/sps/safety_and_buildings_and_environment/320_325/322

14 Residential Energy Services Network. Last updated 2021. "What is the HERS Index." https://www.hersindex.com/hers-index/what-is-the-hers-index/#:~:text=The%20Home%20Energy%20Rating%20System,calculating%20a%20home's%20energy%20performance

**Figure 42. Modeled HERS Rating**



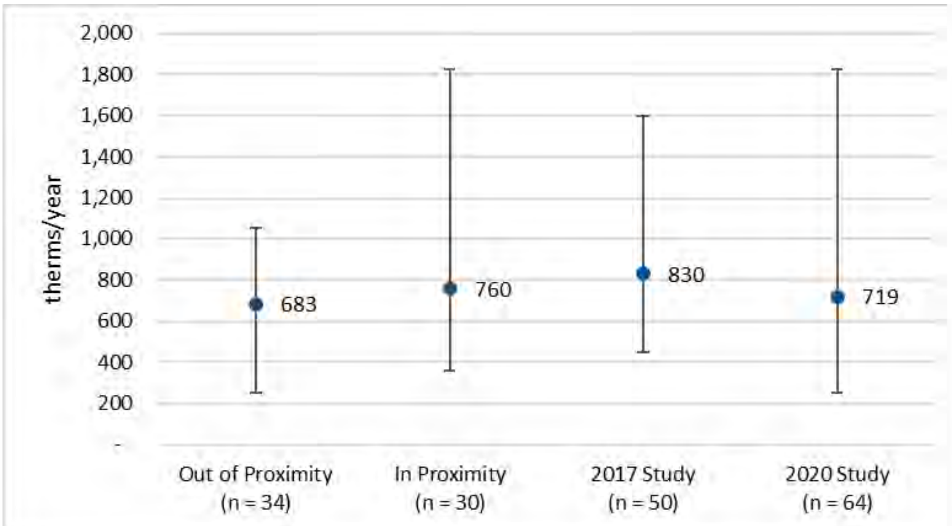

The difference in modeled HERS ratings between the 2017 and 2020 studies is statistically significant; the difference in modeled HERS ratings between in-proximity and out-of-proximity homes is also statistically significant.

## *Heating Energy Consumption*

Figure 43 shows the minimum, maximum, and mean modeled space heating energy consumption for each sample. REM/Rate reports annual energy consumption in MMBtu per year. The Cadmus team converted those results to therms per year to allow for comparison with the 2017 data.

The modeled heating energy consumption parallels the trend in home sizes for all three samples: 2017 homes were the largest and have the greatest mean heating energy consumption, whereas the out-of-proximity homes were the smallest and have the lowest mean heating energy consumption. Two of the 2020 in-proximity homes have double HVAC systems, resulting in modeled annual heating energy consumption over 1,600 therms per year. If those homes were excluded, the maximum heating energy consumption of the in-proximity population would be 1,425 therms per year and the mean would be 689 therms per year.

**Figure 43. Modeled Annual Heating Energy Consumption (therms/year)**



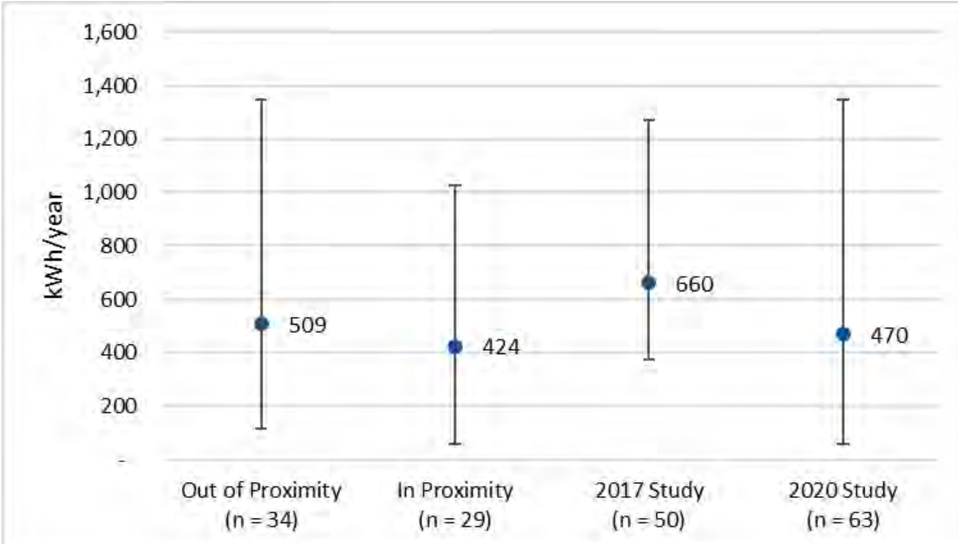

The difference in modeled annual heating energy consumption between the 2017 and 2020 studies is statistically significant.

## *Cooling Energy Consumption*

Figure 44 shows the minimum, maximum, and mean modeled space cooling energy consumption for each sample. REM/Rate reports annual energy consumption in MMBtu per year. The Cadmus team converted those results to kilowatt-hours per year to allow for comparison with the 2017 data. The 2020 in-proximity population excludes one home that did not have a cooling system installed at the time of the inspection. Per the 2017 Seventhwave report, only 46 homes had cooling systems installed, but a n-value of 50 was reported for the modeled annual cooling energy consumption data. It is not clear why those values do not match.

The 2020 homes were, on average, smaller than the 2017 homes and had a lower modeled cooling energy consumption as a result. The only 2020 home with an air source heat pump had a modeled cooling energy consumption of 1,348 kilowatt-hours per year, the maximum for out-of-proximity homes. If that home were excluded, the maximum cooling energy consumption of the out-of-proximity population would be 1,084 kilowatt-hours per year and the mean would be 484 kilowatt-hours per year. It is not clear why the air source heat pump seems to correlate to a higher modeled cooling energy consumption, but it may be due to assumptions programmed into the REM/Rate software.

**Figure 44. Modeled Annual Cooling Energy Consumption (kWh/year)**

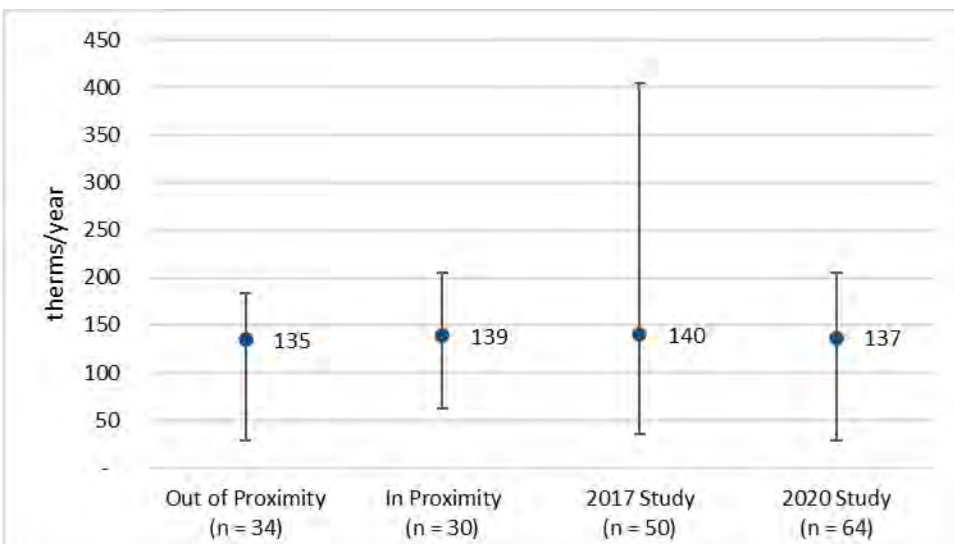



The difference in modeled annual cooling energy consumption between the 2017 and 2020 studies is statistically significant.

## *Domestic Hot Water Energy Consumption*

Figure 45 shows the minimum, maximum, and mean modeled hot water heating energy consumption for each sample. REM/Rate reports annual energy consumption in MMBtu per year. The team converted those results to therms per year to allow for comparison with the 2017 data. The mean modeled domestic hot water energy consumption is comparable between all samples; the difference is not statistically significant.

**Figure 45. Modeled Annual Domestic Hot Water Energy Consumption (therms/year)**



## Baseline Study Observations

Table 6 shows a comparison of the average building metrics of the 2017 baseline study, 2020 baseline study, and 2020 Focus on Energy program homes. Nonprogram home building and equipment characteristics—such as the homes' air tightness, heating equipment, ceiling insulation, and LED saturation—are less efficient than those found in program homes. However, the differences between nonprogram and program home characteristics are relatively small, and nonprogram homes are being built above code and to a high level of efficiency.

**Table 6. Comparison between Program Homes and Baseline Studies**

| Building Metric | 2017 Study | 2020 Study | 2020 Program Homes |
|---|---|---|---|
| | Metric Average | | |
| Air Leakage, ACH50 | 1.91 | 2.25 | 1.74 |
| Window U-Factor | 0.30 | 0.38 | 0.29 |
| Ceiling Insulation R-Value | 46.9 | 46.2 | 46.7 |
| Above-Grade Wall Cavity Insulation R-Value | 20.1 | 19.3 | 17.4 |
| Foundation Wall Insulation R-Value | - | 13.0 | 13.3 |
| Central A/C SEER Rating | 13.3 | 13.8 | 13.4 |
| Gas Furnace AFUE Rating | 95.3 | 95.2 | 96.0 |
| **Efficient Lighting (LED or CFL)** | | | |
| Interior | 65% | 92% | 99% |
| Exterior | 74% | 89% | 95% |
| Garage | 61% | 98% | 83% |

# Appendix A. REM/Rate Modeling Assumptions

The following is a list of assumptions the Cadmus team used to model the 2020 Focus on Energy Residential New Construction baseline study sampled homes in cases where the field data were incomplete. Any references to Wisconsin building code refer to the Wisconsin Department of Safety and Professional Services *Energy Conservation Code*, chapter SPS 322.[15]

1. Unheated slabs less than 12 inches below grade were assumed to have R-10 perimeter insulation with a depth of 4 feet, per Wisconsin building code. The sub-slab was assumed to be uninsulated.
2. Unheated slabs greater than 12 inches below grade were assumed to be uninsulated, both at the perimeter and sub-slab, per Wisconsin building code.
3. Heated slabs less than 12 inches below grade were assumed to have R-15 perimeter insulation with a depth of 4 feet and full coverage R-10 sub-slab insulation, per Wisconsin building code.
4. Heated slabs greater than 12 inches below grade were assumed to have full coverage R-10 sub-slab insulation, per Wisconsin building code. The perimeter was assumed to be uninsulated.
5. Above-grade walls in Zone 1[16] were assumed to have R-19 cavity insulation, per Wisconsin building code. Above-grade walls with unknown framing were assumed to be 2x6, 16 inches on center.
6. Basement walls were assumed to have R-15 continuous exterior insulation, which meets the requirements of Wisconsin building code. Furred basement walls with unknown framing were assumed to be 2x4, 16 inches on center.
7. Raised floors in Zone 1 were assumed to have R-30 cavity insulation, per Wisconsin building code.
8. Flat and inclined ceilings with vented attics were assumed to have R-49 blown-in insulation, per Wisconsin building code. This assumes 2x4, 24-inch on-center framing with a cavity of R-13 and continuous insulation of R-36, which is based on the R-49 ceiling option programmed into the REM/Rate software.
9. For flat and inclined ceilings where the framing could not be determined, 2x4, 24 inches on center was assumed.
10. For homes with both flat and inclined ceilings below attic spaces where the insulation for one ceiling type was observed but the other ceiling type was inaccessible, it was assumed that the insulation was the same for both ceiling types.
11. Cathedral ceilings were assumed to have R-49 insulation, per Wisconsin building code. This assumes 2x12, 24 inch on-center framing with R-49 cavity insulation.

---

[15] Wisconsin State Legislature. May 2015. "Chapter SPS 322: Energy Conservation." https://docs.legis.wisconsin.gov/code/admin_code/sps/safety_and_buildings_and_environment/320_325/322

[16] Wisconsin building code SPS 322.31(1)(b) lists 15 northern counties that are categorized as Zone 2; all other counties are classified as Zone 1. Some code requirements differ between the two zones. The 2020 sampled homes are all located in Zone 1.

12. For metal doors, the library option "Steel-polystyrene" with an opaque R-value of 2.60 was selected.
13. Wood doors were assumed to be solid core. The "Wd solid core" library option with the thickness closest to the actual door was selected.
14. Fiberglass doors were assumed to have an opaque R-value of 5.00.
15. Rim and band joists located between two conditioned floors were assumed to have the same R-value as the surrounding walls, per Wisconsin building code and REM/Rate modeling instructions.
16. Under DHW Efficiencies in REM/Rate, 50 feet was entered in the "Farthest fixture to DHW heater (ft)" question for all homes. This data was not collected in the field, but leaving this question blank resulted in REM/Rate errors.
17. If the adjusted total recovery efficiency of a heat recovery ventilator could not be determined, it was assumed to be 0% in accordance with REM/Rate modeling instructions.
18. Central fan integrated supply ventilation systems were assumed to operate 24 hours per day at a flow rate equal to 50% of the ASHRAE 62.2 2010 requirement for whole-house ventilation.
19. Supply and return ducts that are not located completely within conditioned space were assumed to have R-8 insulation, per Wisconsin building code.
20. If a home required a duct leakage test but one could not be performed, the duct system was modeled with a total duct leakage equal to 12 cfm per 100 square feet of conditioned floor area (at 25 Pascals). This is the maximum limit allowed by Wisconsin building code.
21. Only the primary refrigerator for each home was entered in REM/Rate. In most cases, the annual energy consumption could not be determined for secondary refrigerators found in the homes.
22. For primary refrigerators where the rated annual energy consumption could not be determined, the REM/Rate default value of 691 kWh per year was used.
23. Stand-alone freezers were excluded from the modeling due to a lack of information.
24. For dishwashers with annual energy consumption of 269 kWh to 270 kWh per year, the "ENERGY STAR, standard" preset was selected. If the annual energy consumption was known but outside of that range, it was entered directly. For dishwashers where the annual energy consumption could not be determined, the "Federal Minimum" preset was selected.
25. For clothes washers found in the ENERGY STAR *Qualified Product List*, the "ENERGY STAR 2018" preset was selected. For clothes washers that could not be identified as ENERGY STAR models, the "Standard 2018" preset was selected.
26. For homes with walk-out basements, the basement slab was divided into slab-on-grade and below-grade portions and entered separately into REM/Rate in accordance with REM/Rate modeling instructions. The dividing line between slab-on-grade (less than 12-inches) and below-grade was estimated based on exterior pictures of each home. Basement walls constructed with wood framing were entered as above-grade walls and assumed to have the same insulation as the other above-grade walls in the home. In cases where the field data did not seem to

accurately classify the basement wall construction type, the area of these walls were estimated based on photos and, if available, building plans.

# Appendix B. Participant Recruitment Survey

## Wisconsin Focus on Energy New Homes Characterization Study

Intro

Please enter the Unique ID included in the letter you received notifying you of the Wisconsin Focus On Energy new homes characterization study

________________________________

Thank you for expressing your interest in the Wisconsin Focus On Energy new homes characterization study.

By taking this short survey you will be assisting us in determining your eligibility for participation in the study and the $200 gift card.

First we need to collect your current contact information and confirm your address. Please provide the following information:

O First and Last Name (4) ________________________________________________

O Telephone Number (5) ________________________________________________

O E-mail Address (6) ________________________________________________

O Street Address (7) ________________________________________________

O City/Town (8) ________________________________________________

O Zip Code (9) ________________________________________________

Once the survey has been completed and it has been determined that your home qualifies for the study, you may be contacted to schedule an on-site visit. These on-site visits will be completed by engineers who have been fully vaccinated and who will strictly adhere to health and safety protocols that minimize any risks associated with COVID-19 exposure.

Participants that qualify will be offered a $200 gift card as a token of appreciation at the completion of the onsite inspection.

End of Block: Intro

---

Start of Block: Screening

X→

S1 To begin with, our records indicate that you live in a home that was built in 2018 or later, is this correct?

O Yes (1)

O No (2)

*Skip To: End of Survey If To begin with, our records indicate that you live in a home that was built in 2018 or later, is t... = No*

S2 Please enter the year that construction was completed on your home.

O 2020 (1)

O 2019 (2)

O 2018 (3)

O Before 2018 (4)

*Skip To: End of Survey If Please enter the year that construction was completed on your home. = Before 2018*

Page Break

S3 Is this home your primary residence?

O Yes, this is my primary residence (1)

O No this is not my primary residence (2)

O Other (please specify) (3) ________________________________________________

Page Break

S4 Is your residence a single family, multi-family or manufactured home?

O Single family home *(detached home, attached home with no common area in the building, or 1-3 unit multifamily building with a common area)* (1)

O Multi-family home *(4+ unit with common areas)* (2)

O Manufactured homes *(mobile homes, not modular)* (3)

*Skip To: End of Survey If Is your residence a single family or multi-family dwelling/home? = Multi-family home <em>(4+ unit with common areas)</em>*

*Skip To: End of Survey If Is your residence a single family or multi-family dwelling/home? = Manufactured homes <em>(mobile homes, modular)</em>*

Page Break

S5 Do you own or rent your home?

O I own the home (1)

O I rent the home (2)

Page Break

S6 Did you complete any home improvements since you occupied your home?

O Yes (1)

O No (2)

Display This Question:

*If Did you complete any home improvements since you occupied your home? = Yes*

S6A You selected "Yes" when asked if you had completed any home improvements since you occupied your home, can you please specify what improvements were completed?

________________________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

Page Break

S7 Have you completed any energy efficiency upgrades since you purchased your home (new/upgraded appliances, pipe insulation, etc.)?

O Yes (1)

O No (2)

*Display This Question:*

*If Have you completed any energy efficiency upgrades since you purchased your home (new/upgraded app... = Yes*

S7A You selected "Yes" when asked if you had completed any energy efficiency upgrades since purchasing your home, can you please specify what upgrades were completed?

________________________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

End of Block: Screening

Start of Block: Dwelling/Residence infoDR2 Which of the following statements best describes your involvement in the design and construction of your home?

O I worked with my builder to design the home specifically for my needs. (1)

O I selected my floor plan from among choices that my builder offered. This may have also included minor cosmetic and exterior choices (2)

O I purchased or occupied a home that was already built (3)

O Other (please specify) (4) ________________________________________________

DR3 What is the approximate square footage of your home (including a full basement that is finished or unfinished)?

________________________________________________________________

DR4 Who is your electricity service provider?

▼ Please select from the drop down menu (0) ... WPS (50)

DR5 Who is your gas service provider?

▼ Please select from the drop down menu (7) ... WPS (11)

DR6 What is the primary source of heating for your home?

- ▢ Furnace *(forced air distribution system)* (1)
- ▢ Boiler *(radiator distribution system)* (2)
- ▢ Heat pump (3)
- ▢ Hybrid heating *(combines the energy efficiency of a heat pump with the power of a gas furnace)* (4)
- ▢ Ductless Mini-Splits *(separate HVAC zones, each with a separate thermostat)* (5)
- ▢ Radiant heating (6)
- ▢ Baseboard heaters (7)
- ▢ Other (please specify) (8) ________________________________________________

DR7 What type of primary fuel is used to heat your home?

▼ Please select from the drop down menu (10) ... Propane (7)

DR8 Are there any additional sources of supplementary heat systems in use in the home ? *(wood burning stove, fireplace, portable electric heater, portable propane heater, etc.)*

- O Yes (please specify) (1) ________________________________________________
- O No (2)

DR9 Is your home air conditioned?

- O Yes (1)
- O No (2)

---

*Display This Question:*

*If Is your home air conditioned? = Yes*

DR10 What type of primary air conditioning unit do you use to cool your home?

- O Central AC (1)
- O Ductless mini split *(outdoor unit comprising of a compressor & a condenser that comes along with one or more indoor units)* (2)
- O Window AC (3)
- O Portable AC (4)
- O Floor mounted AC *(AC rests on the floor, and the outer unit can be installed without major site preparation or any ductwork)* (5)
- O Hybrid/Dual Fuel AC *(combines a gas furnace with an electric air-source heat pump to deliver a cost-effective & efficient performance in terms of heating & cooling.)* (6)
- O Smart AC *(a type of mini-split, window or portable air conditioner that are IoT "Internet of Things" enabled. These ACs are connected to the Wi-Fi and come with a native app providing global control through a smartphone.)* (7)
- O Geothermal AC *(this system has underground piping that consists of a loop that circulates water between your home, a heat pump & the ground)* (8)
- O Other (please specify) (9) ________________________________________________

End of Block: Dwelling/Residence info

Start of Block: Demographic

D1 Including yourself, how many individuals reside in the home?

- Children under 18 (1) ________________________________________________
- Between 18 to 64 (2) ________________________________________________
- 65 or older (3) ________________________________________________

End of Block: Demographic

Start of Block: Contact Info

C1 What day(s) and time(s) of the week would you be available for the onsite inspection?

| | AM (1) | PM (2) |
|---|---|---|
| Monday (1) | ☐ | ☐ |
| Tuesday (2) | ☐ | ☐ |
| Wednesday (3) | ☐ | ☐ |
| Thursday (4) | ☐ | ☐ |
| Friday (5) | ☐ | ☐ |
| Saturday (6) | ☐ | ☐ |
| Sunday (7) | ☐ | ☐ |

End of Survey/Thank you/Closing comments