Climate Choice Homes
Research & Development Project

Final Report

Submitted by:

Vermont Energy Investment Corporation (VEIC)

New Jersey Institute of Technology's Center for Building Knowledge (NJIT)

MaGrann and Associates (MaGrann)

Rutgers Center for Green Building (Rutgers)

August 7, 2013

TABLE OF CONTENTS

TABLE OF TABLES

TABLE OF FIGURES

1 ACKNOWLEDGMENTS

This study was funded by the New Jersey Clean Energy Program (NJCEP) which is managed by the New Jersey Board of Public Utilities (BPU) Office of Clean Energy. The study was executed by a team of researchers with management and oversight from the New Jersey Clean Energy Residential Market Manager team and the BPU. The team members and roles are described below.

Table 1: NJCC R&D Project Team and Roles

Organization	Role	Staff
NJ Board Of Public Utilities	Project Direction	Mona Mosser
AEG	Project Oversight	Mike Ambrosio
Honeywell	Project Oversight	Joe Gennello, Dave Wolk
VEIC	Project Management	Rebecca Foster, Managing Consultant Alison Hollingsworth, Consultant Paul Scheckel, Consultant Nikki Clace, Project Support
New Jersey Institute of Technology's Center for Building Knowledge (NJIT)	Energy & Environmental Monitoring Builder Education and Field assistance	Christine Liaukus, R.A. CPHC
MaGrann and Associates (MaGrann)	NJCC Program Management Builder Recruitment Energy Rater Services Builder Education and Field Assistance	Mike Brown, Director of Business Development Brian Stanfill, Operations Manager – New Construction
Rutgers Center for Green Building (Rutgers)	Occupant Survey Life-Cycle Analysis	Jennifer Senick, PhD Candidate, MA, Executive Director Clinton Andrews, PhD, LEED AP, Faculty Director Deborah Plotnik, BArch, LEED AP, Program Coordinator Michael Manzella, MCRP 2014, BE Engineering Management Steven Malenchak, MPP 2014, MA Economics

2 EXECUTIVE SUMMARY

This report summarizes the work funded under the New Jersey Clean Energy Program Climate Choice Home (NJCC) R&D Project, which provided technical support to residential home builders as well as energy and environmental monitoring throughout design, construction, and post-occupancy to gain a better understanding of building construction techniques, occupant behavior influences on energy use, and the actual energy performance of the buildings. The NJCC R&D project was designed to support the efforts of the Residential New Construction program Climate Choice Homes Tier (Tier 3), which pushes the New Jersey market beyond the ENERGY STAR homes program and positions NJCEP in the lead on the path to zero net energy for residential buildings.

The specific tasks that were accomplished through this project are described in detail in subsequent sections of the report and high level findings are presented below. In summary the NJCC R&D project:

- Developed technical specifications to define Climate Choice Homes (Tier 3). The tier established a prescriptive path for new construction projects to be 50% more efficient than IECC 2009[1], which includes requirements that 50% of the projected electricity use be met with Photovoltaics (PV) and 50% of the domestic hot water load be met through solar thermal.[2]
- Recruited 5 builders and developers to participate.
- Enrolled 104 units to meet NJCC performance levels and incorporated additional technical support and builder education into NJCC services.
- Enrolled 11 units into the post occupancy evaluation (POE) of energy and environmental monitoring, comparison of modeled energy use to actual energy use, life cycle cost analysis, and occupant surveys.
- Used the results of the POE to develop recommendations for the NJCC program with respect to policy, technical specifications, and program design.

The results of the NJCC R&D Project are encouraging in that the units have achieved deep energy reductions and provided a test bed for installing new emerging technologies such as heat pump water heaters, PV, and solar thermal. Overall the NJCC Tier has the potential to:

- Prepare the new construction market for more stringent energy codes and pave the way to zero net energy homes
- Acquire more energy savings for the NJCEP by providing a vehicle for new construction projects to achieve deeper energy savings
- Build the demand for higher performance homes in the marketplace
- Increase the number of participants in NJCC across different builder types and resident demographics by moving beyond the early adopter low income housing developers
- Support New Jersey based business and technology experts including architects, engineers, and contractors

[1] IECC 2009 is the energy efficiency new construction code.
[2] Technical Specifications are located in Appendix B.

- Increase the awareness of the NJCEP by highlighting capabilities across new construction, building science, whole house monitoring, data analysis, and field consultation

2.1 Summary of Key Findings and Program Recommendations

EFFECTIVE TECHNICAL STANDARDS PROVIDE A PRESCRIPTIVE PATH BUT ALSO ALLOW FLEXIBILITY

Including a prescriptive and performance path is a sound approach to program design and helps builders achieve a home that is 50% better than code. The NJCC technical standard outlines a prescriptive path for builders to follow that gives concrete examples of systems that, when incorporated into a comprehensive design, achieve the desired level of energy savings. This is particularly useful for builders who are pursuing the NJCC tier for the first time. The standard also includes a provision for builders to propose an alternative path (without compromising energy savings), which provides flexibility for a variety of building configurations and issues that come up during design and construction.

During this project, the NJCC standards were revised based on feedback from the NJ developer and designer community that certain equipment and renewable configurations were difficult to implement in the field. The goal of this revision was to provide more flexibility for builders while maintaining the same level of performance and savings yields as the original specification. The specific changes made are listed below.

- Additional hot water technologies were added to the list of approved measures. The list was expanded from only two options (heat pump water heater and natural gas instantaneous water heater) to include electric storage, gas storage, and oil and gas indirect off of a boiler. Since all water heating energy use is required to be offset with 50% renewable energy, the tradeoff for the less efficient water heaters is a larger renewable system. The end result is flexibility for builders and comparable energy savings across technologies.

- The renewable requirement was made fuel and technology "blind" by allowing builders to choose either PV or solar hot water panels to provide 50% of the hot water energy load. In practice, the energy used by hot water is converted to either MMBTUs or kWh to determine renewable sizing.

- Drain water heat recovery (DWHR) systems were added as a cost effective way to capture energy from water as it goes down the drain and use it to preheat cold water entering the water heater. The revised specification requires DWHR and provides a list of approved units. In some slab on grade homes, building configuration will not allow for DWHR installation, so the revised technical requirements include a waiver request process for those building types.

- Language was changed in several places to clarify or update the requirements, including definition of low flow devices and efficient distribution, alignment with revised ENERGY STAR requirements, and updated web links to referenced standards.

TECHNICAL ASSISTANCE FROM NJCEP IS EFFECTIVE AND CRITICAL FOR MARKET TRANSFORMATION

In general, building materials and equipment are available to meet NJCC standards. That said, the value of NJCEP program support is greatest in terms of specifying those materials and providing technical assistance on newer building techniques needed to achieve the desired performance level.

One example of this is the NJCC air tightness requirement. Air sealing and tight construction are important components of high performance and energy efficient homes. However, these requirements were difficult for participating developers to achieve. In response to this, the project modified the services provided to builders in the following ways. First, MaGrann provided the builders and design team with a description of air sealing techniques at the initial design planning meeting. Second, the project instituted an additional air sealing inspection after framing is completed, but prior to insulation being installed, and a pre-drywall blower door test in addition to the final blower door test. These early testing opportunities facilitate the identification of leaky areas before the building is complete and help builders and contractors understand the level of effort needed to comply with the airtightness standard.

One developer struggled to meet the air sealing requirement on their first NJCC home. On the second NJCC home built by the developer, the NJCC team offered the additional services described above through design and construction. The second home met the air tightness standard, demonstrating the benefit of the technical assistance. In addition, the developer's crew now understands the techniques and can apply them on future projects, helping to transform the market.

REM/RATE MODELING IS IMPORTANT FOR MODELING BUT HAS LIMITATIONS

Within the NJCC Program, REM/Rate is used to model the energy use of homes. Its purpose is to help the building community (and energy efficiency program administrators) understand how the "as built" home should perform—under typical operating conditions—to a reference home (typically a code-compliant home).

This project demonstrated that while REM/Rate serves that function well, it is not a good predictor of actual energy use. The reason is that the "as built" home can be very different from the "as operated" home. Specifically, the research found that REM/Rate's limits on thermostat settings meant that the software could not accurately reflect the actual thermostat settings that the team observed in some units. In other words, some participants set their thermostats higher in the winter than REM/Rate would allow the team to model.

This finding underscores the point that homes designed and built to advanced technical requirements have the potential to save energy, but how they are operated determines whether the targeted savings are achieved.

RESIDENT EDUCATION IS IMPORTANT FOR THE OPTIMAL PERFORMANCE OF HOMES

The project team tracked the energy use of 11 homes in the NJCC program to compare actual performance with predicted performance based on energy modeling of the Climate Choice Homes requirement and of the same homes built to New Jersey's current energy code (IECC 2009).

As noted above, the purpose of energy modeling is to compare a structure to itself with different design options, not to reliably predict the future. Actual building operation will always vary from the modeled scenario due to the fact that occupants control their environment and use energy differently than any model can anticipate, weather conditions vary, and other unforeseen variables come into play. However, the research on the NJCC units suggests that resident education is an important component for the optimal performance of NJ Climate Choice Homes.

Anecdotal conversations with residents by the monitoring team (outside of the survey instrument) revealed that residents typically were not aware that they were living in housing designed to be very energy efficient. Further, survey responses indicate that most residents kept their thermostat at the same setting at all times. One resident was not able to say what temperature their thermostat was set to, as they did not know how to use their programmable thermostat.

IN HIGH PERFORMANCE HOMES, MISCELLANEOUS ELECTRIC LOADS (MELS) BECOME A BIGGER PORTION OF TOTAL ENERGY USE

Miscellaneous electric loads (MELs) are electric loads that do not fit into typical energy use categories of space conditioning, domestic hot water, ventilation, major appliances, and lighting. Based on the findings, the project team agrees with other recent research that shows MES are a bigger portion of total energy use in very efficient homes.

As noted by the National Renewable Energy Laboratory (NREL), "MELs present special challenges because their purchase and operation are largely under the control of the occupants. If no steps are taken to address MELs, they can constitute 40%-50% of the remaining source energy use in homes that achieve 60-70% whole house energy savings, and this percentage is likely to increase in the future as home electronics become even more sophisticated and their use becomes more widespread." (Hendron & Eastment, 2006). NREL notes that 14% of a home's typical energy use goes to MELs, while in a high performance home (with 54% whole house savings) MELs account for 32% of total energy use. This is on par with the findings for the NJCC homes.

ENVIRONMENTAL AND ENERGY MONITORING PROVIDE VALUABLE DATA BUT PRESENT UNIQUE CHALLENGES

One component of the project was to conduct environmental and energy monitoring. This provided the program with important information on the performance of the homes, and the data from the monitoring equipment has been used in developing the recommendations above. In addition, the monitoring equipment helped identify when equipment is not performing as expected. The monitoring equipment revealed potential issues with renewable systems and HVAC equipment, alerting building owners to follow up on the information.

However, conducting the environmental and energy monitoring was not without its challenges.

The first of these challenges is that the monitoring equipment used in this project requires a steady, reliable internet connection to transmit data. It is not possible to manually download the data or transfer it via another method. (The monitoring equipment manufacturer has now provided this functionality in the newest generation of its product.) Wireless internet coverage was specified by housing developer and incorporated into monitoring plan. After construction was complete, the team discovered wireless did not reach the enrolled units.

The second of the challenges encountered with the monitoring equipment is that it is not plug-and-play; significant on-site commissioning is needed to ensure reliable operation. For example, when monitoring electric loads at the panel, clear guidance is needed on electrical panel wiring. If possible, on-site observation during panel wiring can help ensure that the panel is wired as intended for load isolation.

2.2 Summary of Overall Performance of NJCC Homes

All of the NJCC homes used *less* energy than the average New Jersey home. However, as noted above in the discussion of REM/Rate, ten out of the eleven monitored NJCC homes used *more* energy than predicted by the energy model. Highlights of the home energy monitoring are provided below.

THREE HOMES USED MORE SIGNIFICANTLY MORE ENERGY THAN MODELED

All of the monitored NJCC homes used more energy than predicted by the energy model but less energy than the code compliant modeled homes. There were three homes with significant variation compared to the modeling.

NJCC1 had the third highest therm use among the monitored NJCC units. The residents of NJCC1 stated that they left the thermostat at 75F year round, and monitoring data shows that average indoor temperature for November through February was 77.34F and 75.8F during June July and August. The energy models for the NJCC units have the thermostats set at 70F for heating and 78F for cooling. Therefore, the resident kept the home an average of 7.34F warmer during the heating season and 2.2F cooler during the cooling season. Kilowatt-hour use is also very high in NJCC1. In addition to air conditioning use, the survey responses indicate that electronic appliance usage hours for this dwelling are the highest in hours per day among all the surveyed NJCC units.

NJCC2 had the highest annual therm use among the monitored NJCC units. The residents of NJCC2 did not know how to operate their thermostat and did not know what temperature it was set to. As such, there is limited information about the conditions to which they keep their indoor environment. Their therm use is comparable to that of NJCC1, suggesting that they may keep their indoor environment significantly warmer than the modeled baseline home. Kilowatt hour usage in NJCC2 benefitted from the unit’s PV generation and was the second lowest among all the monitored units.

NJCC4 had the second highest therm use among the monitored NJCC units and the highest kilowatt-hour use, despite having a 2.9 kW photovoltaic array. The residents of NJCC4 stated that they keep their home at 65F year round, but also noted that they are not sure how to regulate the temperature in their home with the radiant floor heating. NJCC4’s therm use exceeds that of NJCC1 at times, indicating that indoor temperatures during the heating season are likely higher than the reported thermostat setting of 65F. Further, the hot water load in NJCC4 includes relatively long showers (11-15 minutes) for some household members. With regard to electricity use, NJCC4’s 65F temperature during the cooling season deviates from the modeled setting of 78F by a full 13F. This greatly increases electricity use during the cooling season. Utility bill data for NJCC4 shows kWh use in July and August of over 1,000 kWh. NJCC4 uses a window air conditioner unit and a portable air conditioner unit for cooling; it does not have a central air conditioner system. Survey responses by the residents of NJCC4 suggest that their usage hours for electronic devices are below average among the surveyed NJCC units. The residents of NJCC4 stated that they thought there was a problem with their utility bills and had contacted PSE&G to attempt to resolve the issue.

ENERGY USE INTENSITY VARIED SIGNIFICANTLY

NJCC3, a 1741sf townhouse, had the lowest energy use intensity at 7.4 kBtu/sf/yr. This home benefitted from the load reduction of a 2.86 kW photovoltaic array. The second lowest energy use intensity among the monitored units was NJCC11, which performed at 19.89 kBtu/sf/yr. NJCC11 is one of the seven monitored multifamily units, which do not have the load reduction benefit of a PV array due to the fact that the array on their building feeds common area electric loads not individual unit loads. NJCC1, a 1567sf single family detached home, had the highest energy use intensity among the eleven monitored NJCC units at 51.9 kBtu/sf/yr.

In the multifamily units (NJCC5 – NJCC11) natural gas usage was much closer to the predicted consumption than the electricity use was. This is not surprising, given that in a multifamily building, envelope loads are less dominant than in single family attached and detached homes. Since the heat losses in NJCC5 – NJCC11 are minimal because each unit has either 1 exposure (1 wall) or two exposures (1 wall and the ceiling) to the outdoors, the heating load is greatly reduced. As such, even if residents keep their homes warmer than modeled, the impact on therm use is not as pronounced as in the single family (NJCC1) and townhouse (NJCC2 – NJCC4) units.

2.3 Summary of Life Cycle Calculator Results

Based on projected energy usage, the results of the life cycle calculator (LCC) analysis produced favorable results in terms of positive Net Present Value for two of the three buildings assessed in this study. The results below show NPV comparisons of costs, hence a positive ΔNPV (or NPV of as-built relative to baseline) implies that the as-built building is more cost-effective than the baseline. The following Net Present Values were calculated for each of the as-built buildings relative to their respective baseline configurations (on a square foot basis) using projected energy usage:[3]

Table 2: Net Present Values

	Building A.1 (Single-Family)	Building A.2 (Townhomes)	Building B.1 (Multi-Family)
Baseline NPV	($61.28/SF)	($66.81/SF)	($57.24/SF)
As-Built NPV	($63.08/SF)	($59.60/SF)	($54.51/SF)
ΔNPV	($1.80/SF)	$7.21/SF	$2.73/SF
Simple Payback	*13 years*	*3 years*	*9 years*

[3] Based on a discount rate of 5% and a building lifetime of 75 years

2.4 Summary of Occupant Survey Findings

The occupant surveys were intended to provide a view of how occupant behavior mapped to energy use. A baseline and follow up survey were given.

One characteristic examined was household size, with the expectation that more inhabitants would lead to greater electricity usage. This was not, however, the case. Each household had between two and four inhabitants at the time of the baseline survey, and the households with four inhabitants used more energy than those with two (330 kWh versus 290 kWh). The households with three inhabitants, however, used on average 475 kWh per month, over a hundred kWh more than those with four persons and almost 200 kWh more than those with two.

Of the other household characteristics and behaviors examined in detail, there were several that proved to be highly related to energy use. Households taking more than 20 showers per week consumed almost 80 kWh more per month on average than those taking less. When looking at meals cooked per week, those that cook less than once per day use about 35 kWh hours less per week than those that cook more than once per day. Those households that reported being empty more than seven hours per day consumed approximately half as much energy as those who did not, all else being equal.

3 OVERVIEW OF CLIMATE CHOICE HOMES R&D PROJECT

In 2009, the New Jersey ENERGY STAR Homes program adopted a progressive new standard called Climate Choice Homes (NJCC or "Tier 3"). NJCC established a prescriptive path for new construction projects to be 50% more efficient than IECC 2009[4] and included a requirement that 50% of the projected electricity use be met with Photovoltaics (PV). The NJCC technical requirements were based on the EPA draft protocol "ENERGY STAR Concept Home."[5] The goal was to align with a cutting edge national standard placing New Jersey in a clear leadership position in the zero energy homes movement.

Because NJCC was an advanced tier requirement that aimed to build market capabilities that were not widely available, the Market Manager team proposed this R&D project to research how best to understand the impact of "Tier 3" and how to move forward as the tier evolved and grew.

The core activities of the NJCC R&D project included builder education and field assistance, energy and environmental monitoring of homes, occupant surveys, and lifecycle cost analysis.[6] Several partners were recruited to participate on the team. A summary of the task descriptions and partners managing each task are shown below. More in depth discussion of each task and the results of each follow in individual sections of the report below.

Table 3: Project Tasks, Roles, and Responsibilities

Task	Organization	Description
Project Management	VEIC	
Builder Education and Field Assistance	The Center for Building Knowledge at NJIT (NJIT) MaGrann and Associates (MaGrann)	The goal of in-depth builder training was to introduce and reinforce advanced building science concepts, techniques, and best practices for ultra-efficient homes.
Developer and Resident Enrollment	MaGrann NJIT	
Energy and Environmental Monitoring	NJIT	Indoor conditions, building performance, and energy use was monitored in 11 housing units.
Occupant Surveys	Rutgers Center for Green Building (Rutgers)	Occupant surveys were designed to understand how each unit performed with respect to occupant comfort and the impact of occupant behavior on energy use.
Life-Cycle Analysis	Rutgers	This task evaluated the costs and performance of the units, and delivered a life cycle cost analysis to the program.

4 IECC 2009 is the energy efficiency new construction code.
5 The Concept Home specification was ultimately not adopted by EPA. EPA and DOE chose to collaborate
6 Builder recruitment and rater services for the NJCC tier are handled by MaGrann through the Market Manager contract. MaGrann was also part of the R&D team and enhanced its NJCC services to match the needs of builders participating in the program.

4 BUILDER EDUCATION AND FIELD ASSISTANCE

One of the first tasks of the NJCC R&D project was to implement builder education and field assistance to help builders learn about the advanced techniques required to meet the NJCC standards. These tasks complimented the work done by the Market Manager team to recruit and provide rater services for buildings under construction and striving for NJCC certification.

After initial testing of one NJCC home showed that it did not meet air leakage requirements, the project team conducted additional training and then videotaped interviews with the developer's contractors about new building practices used to meet the Climate Choice Homes standards. Footage from the building site and construction details were captured. Particular practices examined include those that current program participants have found to be especially novel and/or difficult, such as:

- Effective air sealing strategies
- Exterior rigid insulation
- Sub-slab insulation

The video is effective as a resource for other builders seeking to meet the Climate Choice Homes standards or other rigorous energy standards. Guidance from peers has been cited as one of the most effective ways for contractors to learn about new energy efficient practices. The video is currently available on the NJCEP website.

5 DEVELOPER AND RESIDENT ENROLLMENT

Two developers were recruited to participate in the NJCC R&D project and agreed to enroll residents for energy use tracking and participation in the occupant survey. In addition, the developers both agreed to provide building costs for life cycle cost analysis. One developer also agreed to provide wireless internet access in its large multifamily building, which was intended to be used to transfer data from the monitoring equipment to a remote server. The individual participants agreed to provide utility bill data, allow the NJCC R&D program to install energy monitoring equipment in their homes, and complete a survey about their schedules and home operating preferences. The data used for this report was gathered under confidentiality agreements with developers and residents, therefore the developers, buildings, and units are referenced using alpha numeric codes as listed below in Table 4.

Only low income developers agreed to participate in R&D project. These developers are more accustomed to working with multiple public agencies for funding and meeting specific health, safety, and efficiency standards. All of the monitored units are occupied by people that are income qualified. Four of the units are owner occupied. The other seven units are occupied by tenants.

Developer A is a nonprofit builder of affordable housing located in northern New Jersey. Two of their buildings were enrolled in the program: a single family home and a townhouse development with five units. Three of the five townhouse units participated in the R&D project.

Developer B is an affordable housing developer also located in northern New Jersey. This developer enrolled a 70 unit apartment building in the NJCC program, seven units of which participated in the R&D program.

Table 4: Participating Units

Developer	Building	Building Type	Unit Number
Developer A Nonprofit Builder	Building A.1	Single Family Home	NJCC1
	Building A.2	Townhouse development	NJCC2
			NJCC3
			NJCC4
Developer B Affordable Housing Developer	Building B.1	Multifamily Apartment Building	NJCC5
			NJCC6
			NJCC7
			NJCC8
			NJCC9
			NJCC10
			NJCC11

6 ENVIRONMENTAL AND ENERGY MONITORING

6.1 NJCC Homes Monitoring

The monitoring of energy use and production along with indoor and outdoor environmental conditions provided data to evaluate the performance of each NJCC home and to inform potential changes to the NJCC program over time. Eleven homes were monitored, allowing for 20% representation of the first year's projected enrollment in the NJCC program of 55 units. The original intent was to monitor eleven of the NJCC homes for 2 years after occupancy. Due to significant construction and occupancy delays, this was compressed to between three months and one year depending on the occupancy date of each unit.[7]

6.2 Monitoring Plan

The monitoring protocol for NJCC was designed to capture all measurable energy sources along with indoor and outdoor environmental conditions. The following were monitored:

- Indoor temperature and relative humidity (in the multifamily building, these data points were captured in one location, not in every unit)
- Net electrical energy used (from utility bill data)
- HVAC electricity
- Refrigerator electricity
- Electricity generated by the PV system
- Total natural gas consumption (from utility bill data)
- Solar thermal contribution to water heating

6.3 Monitoring Equipment

In addition to utility bill data, two in-home monitoring systems were used to gather data: the eMonitor, and the WEL (Web Energy Logger) unit. Both devices are designed to allow for data retrieval via the internet.

6.3.1 eMonitor

The eMonitor measures the electric loads and the photovoltaic power. In the multifamily units, the eMonitors did not measure PV production, as the PV offset a portion of the whole building's common area electric loads and not individual unit electricity use.

[7] Three of Developer A's units were not fully occupied and ready for monitoring until spring of 2013; they were originally supposed to be occupied by the summer of 2012.

Figure 1: eMonitor Schematic

Figure 2: eMonitor Schematic

The eMonitor is installed adjacent to the circuit breaker panel with sensors that clamp around each monitored circuit within the panel. For the NJCC units, sensors were clamped to circuits feeding the following loads:[8]

- Photovoltaic Production (where applicable)
- Air Conditioning
- Furnace
- Refrigerator
- Kitchen Outlets
- Other Outlets
- Washing Machine (where applicable)
- Lighting
- Solar thermal pump (where applicable)
- Energy Recovery Ventilator (where applicable)

In the field, panels were wired such that some loads (such as outlets and lighting) were often combined. The NJCC R&D team provided panel-wiring guidance to the developers, but the electricians on the job site typically deviated from the guidance.

The eMonitor is designed to communicate with the home's wireless internet connection, sending energy data to the eMonitor Analytics Engine on remote servers. This data is then available on the eMonitor website through a dashboard user interface.

The dashboard allows for tracking of overall electricity use and individual circuits as shown in Figure 3. This shows a snapshot of the top circuits in use at a given moment.

[8] Electrical panel layouts varied with each unit. This list is representative of monitored circuits. In some cases, items were combined (such as kitchen lighting and outlets) in one circuit and, as such, could not be monitored in isolation.

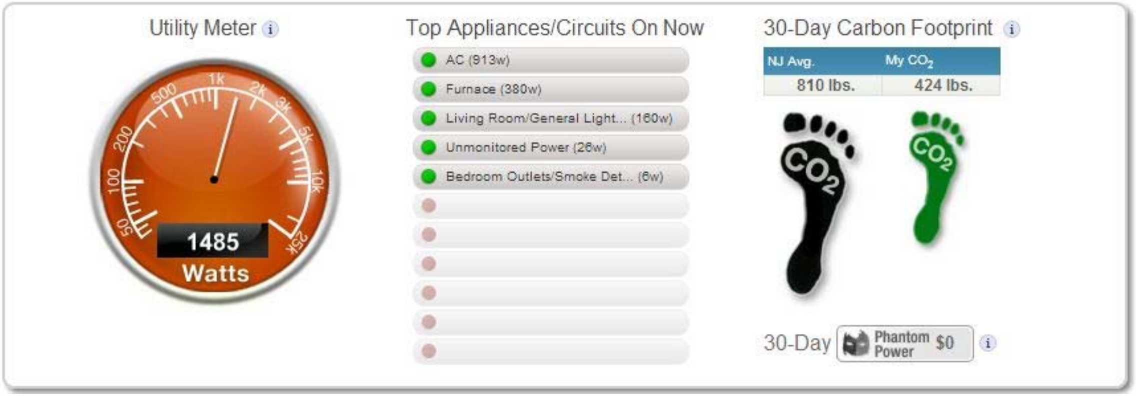


Figure 3: NJCC8 Partial eMonitor Dashboard

The eMonitor site also shows historical performance over the past 30 days and the past year. All the data is available for downloading once it has been uploaded to the eMonitor Analytics Engine server.[9]

6.3.2 Web Energy Logger (WEL)

The WEL units monitor indoor and outdoor temperature and relative humidity and the solar thermal contribution to hot water loads. As noted above, in the multifamily building, the indoor temperature and relative humidity were monitored in one location rather than in each unit. The WEL periodically posts its values to an external web site where it can be downloaded.

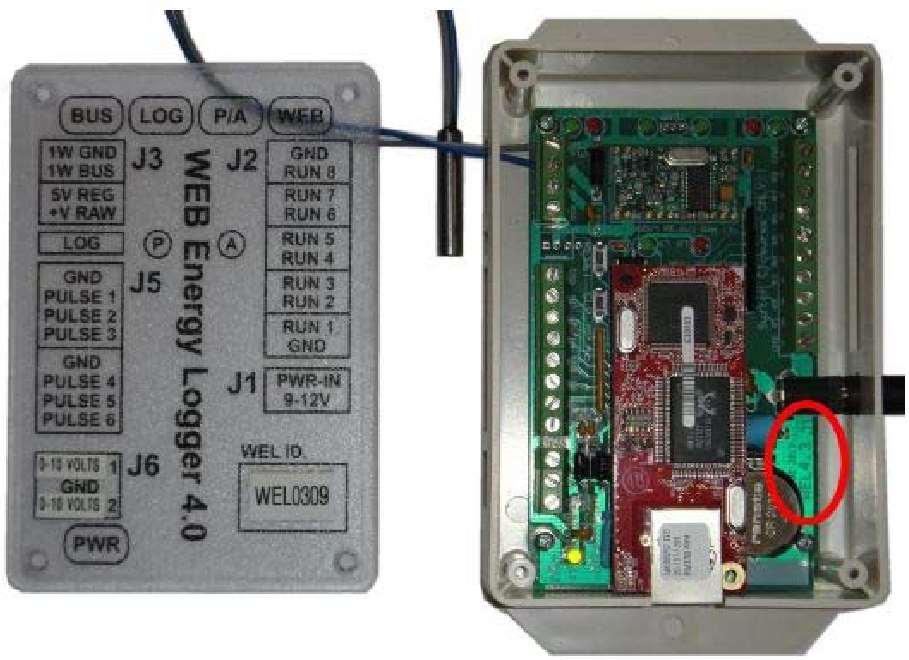


Figure 4: Detailed view of WEL

9 Later versions of the eMonitor allow for the monitoring of relative humidity, temperature and solar thermal systems, eliminating the need for a separate WEL system.

6.4 Monitoring Equipment Installation

Each monitored NJCC unit had an eMonitor installed. WELs were installed in the single family home NJCC1, and the attached townhomes NJCC2, NJCC3, and NJCC4, and in the mechanical room of the multifamily building with units NJCC5 – NJCC11. Individual WELs were not installed in each multifamily unit as the building has a central domestic hot water and solar thermal system.

6.4.1 eMonitor Installation

The eMonitors were mounted to the wall adjacent to the circuit panel. The eMonitor's current transformers (CT's) were clamped to the incoming power line and all other circuits being monitored. A channel setup worksheet was used to note which breakers were connected to the different eMonitor channels so that individual circuit loads could be accurately tracked.

Once all the physical connections were made, the eMonitor was connected to a wired Ethernet connection and plugged into a standard outlet. Finally, each eMonitor was registered and configured online. Once completed, the eMonitor online Dashboard was accessible and energy use data was available.

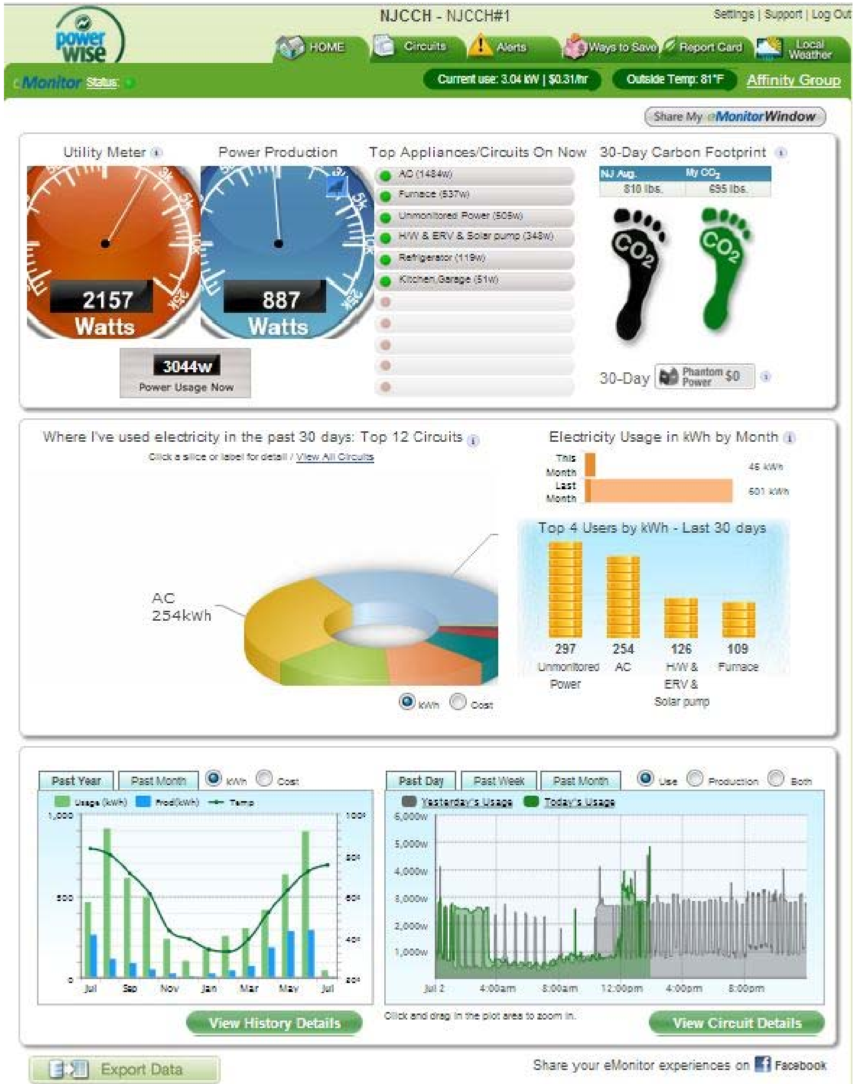


Figure 5: Example eMonitor Dashboard View

6.4.2 WEL (Web Energy Logger) Installation

The WEL requires wall mounting, an Ethernet connection and a power connection. For the NJCC project monitoring, temperature sensors, relative humidity sensors, and flow meters were connected to the WEL. The temperature and relative humidity readings come straight from their sensors. To monitor the solar thermal contribution to the domestic hot water, six separate temperature sensors and a flow meter were used to capture:

- Temperature of the cold water coming into the dwelling
- Temperature at the bottom of the solar thermal tank
- Temperature at the top of the solar thermal tank
- Temperature of the glycol going into the solar thermal panels
- Temperature of the glycol leaving the solar thermal panel
- Temperature of the DHW leaving the DHW tank
- Flow between the solar thermal tank and the DHW tank

An example wiring schematic for the WEL is shown in Figure 6.

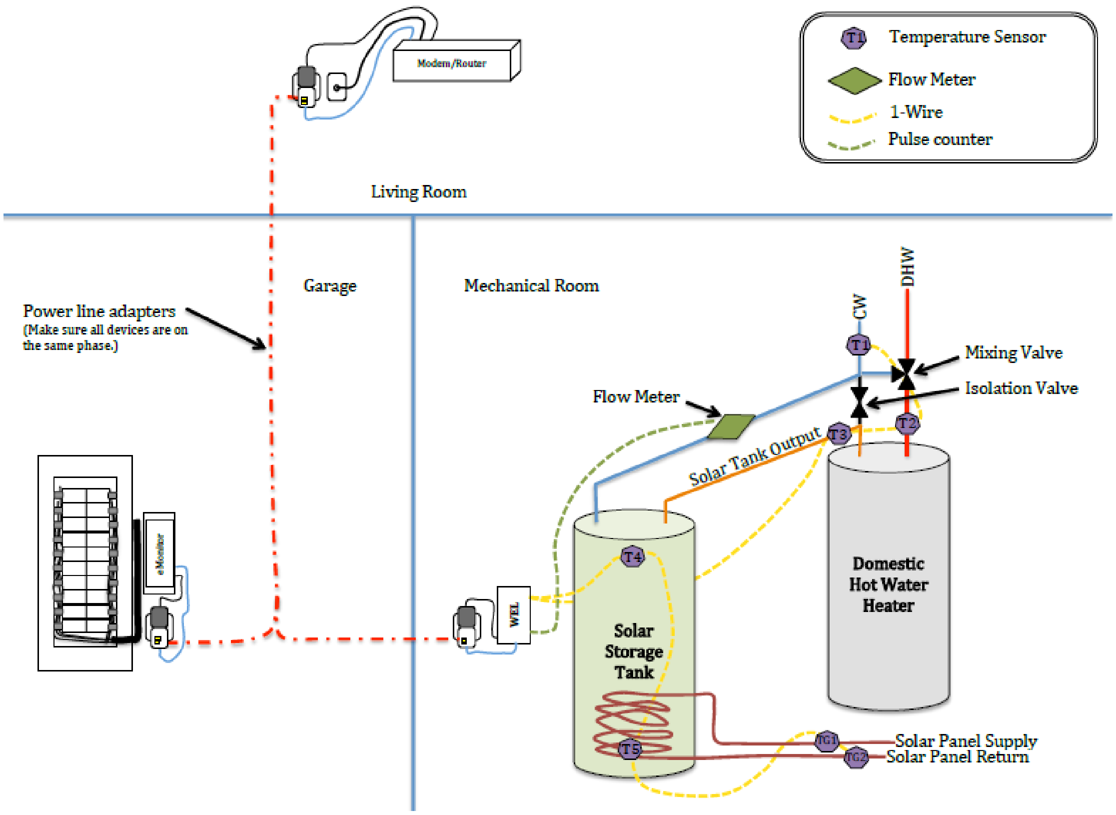


Figure 6: WEL Schematic, NJCC 2

Using these data points, the WEL dashboard provides the percentage of DHW coming from the solar system, see Figure 7.

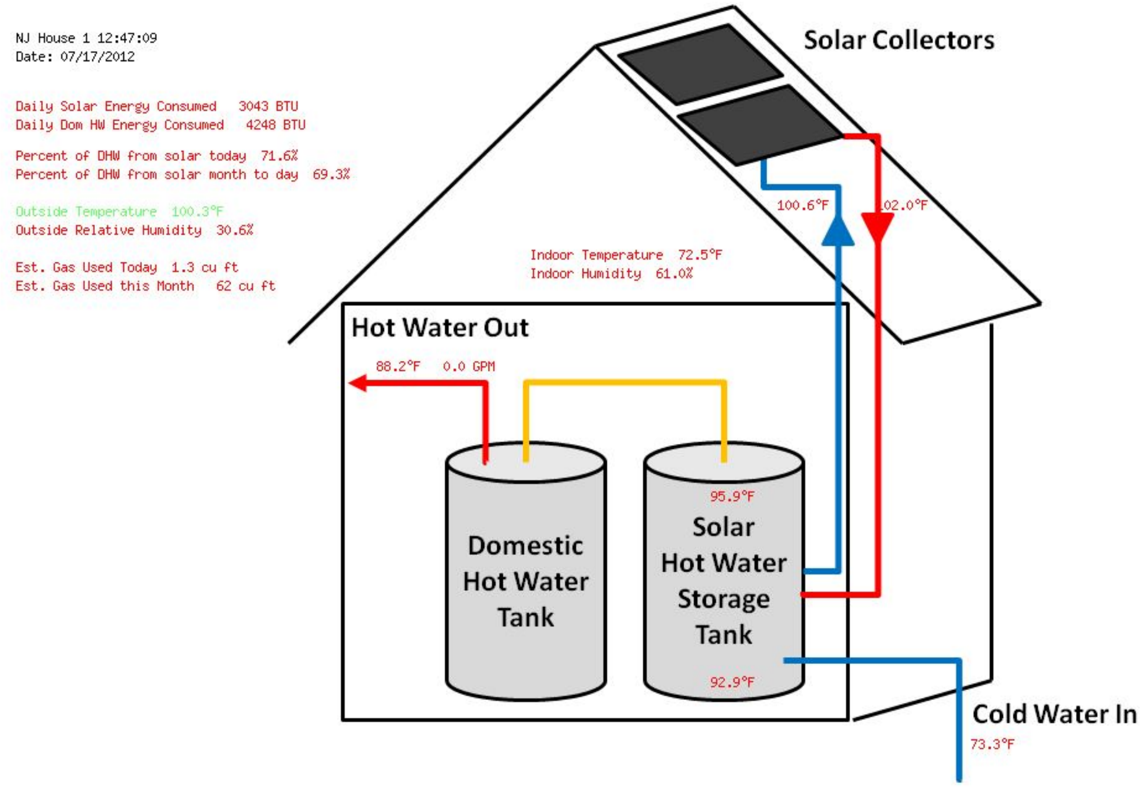


Figure 7: WEL Dashboard

6.5 Energy Use Data

There are three types of energy use data captured through the R&D project and included in this report: energy modeling projections, monitored data, and utility bill data. There is utility data and energy modeling data for all eleven units and monitored data for six of the units. The lack of monitored data for all units is discussed in more detail in section 6.5.3.

6.5.1 Utility Data

The project team was given utility data for each monitored unit through Developer A and Developer B. For all but the three attached townhouses at building site A.2, there is at least one year of utility data. The utility for all the monitored units is Public Service Electric and Gas (PSE&G).

6.5.2 Modeled Data

The energy modeling projections were generated using REM/Rate software. Two modeling scenarios were run. The first used 2009 IECC energy code models (models where each NJCC home was modified to comply with the 2009 International Energy Code, rather than the NJCC requirements. The second used the “as built” model, which included the NJCC requirements.

Energy modeling can help show whether a building is performing very differently than anticipated. Modeling accuracy can vary widely, particularly for high performance homes, where factors influencing performance can be difficult to model. (Holladay, 2012) Energy models are also limited by their assumptions about occupant behavior and how well the assumptions align with actual behavior. Modeling projections are most useful when comparing a model to itself, using different envelope and mechanical system characteristics.

6.5.3 Monitored Data

Monitored data was collected from six of the eleven participating units. Five of the instrumented units did not have data collected because either they had internet connectivity issues or they were not occupied early enough for the monitoring equipment to be fully commissioned and ready for data uploading.

CONNECTIVITY ISSUES – TWO UNITS

In the four-story multifamily building (building B.1), two of the seven instrumented units did not upload energy use data: NJCC5 and NJCC6. When this multifamily building was first enrolled in the NJCC program, the developer stated that the building had wireless internet service throughout. In addition, when recruiting participants for the study, the team specified that one condition was that participants needed to have regular internet access. All participants agreed to that condition.

After the NJCC R&D team found that data uploading was intermittent in some units and absent in others, the issue was investigated further with the developer. Upon further discussion, it was found that the developer provided one wireless router in the building's community room. This was not sufficient to serve the seven units with monitoring equipment. As such, Ethernet to Wi-Fi adapters were installed in all seven of the monitored units. These adapters worked in four of the units, but the signal was too weak in three. The project team investigated providing hard-wired internet service to each dwelling, but the estimate from the developer's electrician was prohibitively expensive. The electrician explained that he would have to penetrate fire rated assemblies at every unit and every floor for the new wiring and as such, the cost was very high. The NJCC team then experimented with providing cable internet service to one of the three problem units. This strategy worked. It was not implemented in the two remaining units because of the project timeline for completion and due to an outstanding balance on one participant's internet service provider bill, which prohibited him from receiving access to service.

EQUIPMENT COMMISSIONING – THREE UNITS

The three attached townhouse units in Building A.2 have not yet had their monitoring equipment properly commissioned and therefore, are not providing data. There were several contributing factors to this.

The first complication was a slower than expected building construction and occupancy timeline. As noted above, these three units were not fully occupied and ready for monitoring until spring of 2013. They were originally supposed to be occupied by the summer of 2012.

The team experienced several other site-specific challenges at building site A.2. In one townhouse, the power line adapters were stolen. In the second unit, the eMonitor malfunctioned and had to be replaced by the manufacturer. In the third, the eMonitor and the home's wireless router were not on the same wiring phase. These issues were in the process of being resolved in June of 2013 when the project ended.

The last complicating factor in the Building A.2 is that the developer's contractor installed noncompliant water heaters. Developer A was in the process of replacing the water heaters with different units at the time of project wrap up. As such, the flow meter for the WEL units could not be installed until the replacement water heaters were in place. As of June 2013, that had not yet occurred.

6.6 Data Collection Summary

Table 5 below summarizes the status of data collection at each of the eleven monitored NJCC dwellings.

Table 5: Data Collection Status Summary

<table>
<tr><th rowspan="2">Dwelling Number and Type</th><th colspan="2">Data Collection Status</th></tr>
<tr><th>Monitored Data</th><th>Utility Data</th></tr>
<tr><td>NJCC1 – single family detached</td><td>Ongoing data collection</td><td>Over one year</td></tr>
<tr><td>NJCC2 – townhouse</td><td rowspan="3">No data collection, monitoring equipment being commissioned</td><td>Feb – June</td></tr>
<tr><td>NJCC3 – townhouse</td><td>April – June</td></tr>
<tr><td>NJCC4 – townhouse</td><td>March – June</td></tr>
<tr><td>NJCC5 – flat</td><td rowspan="2">No data collection, connectivity issues</td><td rowspan="8">One year</td></tr>
<tr><td>NJCC6 – flat</td></tr>
<tr><td>NJCC7 – flat</td><td>Ongoing data collection</td></tr>
<tr><td>NJCC8 - flat</td><td>Data collection restored 2/24/13 through cable service</td></tr>
<tr><td>NJCC9 – flat</td><td>Intermittent data collection</td></tr>
<tr><td>NJCC10 - flat</td><td>Data collection restored 12/12/12</td></tr>
<tr><td>NJCC11 - flat</td><td>Ongoing data collection</td></tr>
</table>

6.7 Overall Data Analysis

This section includes annual data from each of the eleven NJCC monitored units.

Figure 8 shows a comparison between the modeled annual MMBtu's for each NJCC unit as built (the green bar), energy usage if the home were built to merely meet the current New Jersey energy code (the aqua bar), and the actual MMBtu's from utility bill data (the orange bar). The graph also includes the average MMBtu for a New Jersey home, shown as the orange NJ AVG bar.

The data to generate Figure 8 is also shown in Table 6 below.

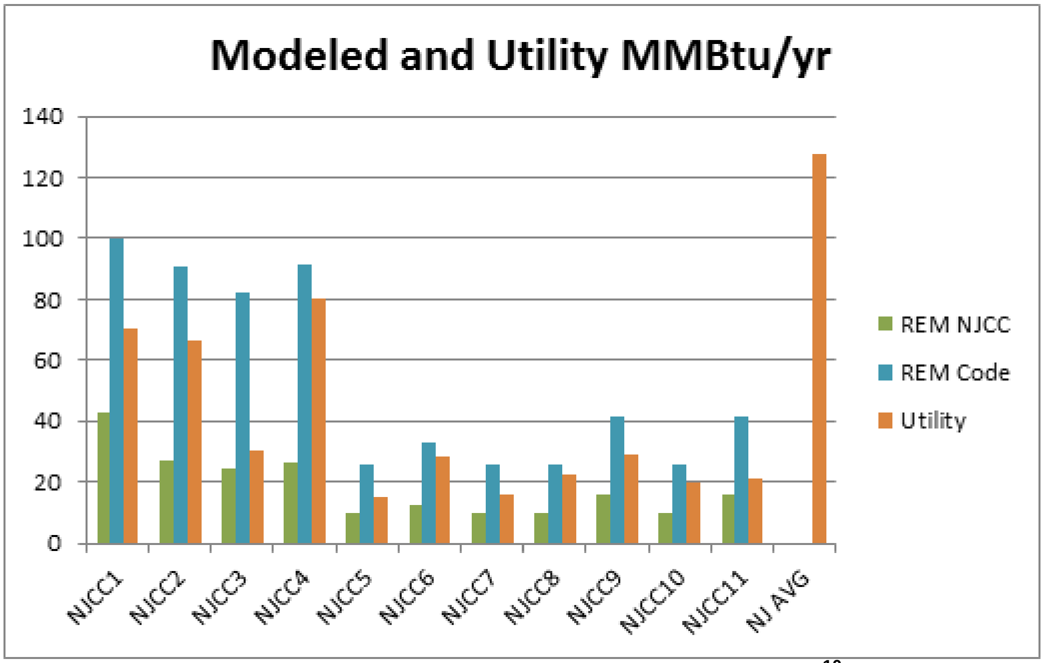


Figure 8: Modeled, Actual and Average MMBtu/yr[10]

Table 6: Modeled, Actual and Average MMBtu/yr

MMBtu per year				
Unit	**REM NJCC**	**REM Code**	**Utility**	**Ranking from lowest to highest MMBtu**
NJCC1	42.98	99.77	70.57	10
NJCC2	26.78	91.07	66.17	9
NJCC3	24.66	82.50	30.42	8
NJCC4	26.27	91.27	80.00	11
NJCC5	9.68	25.70	15.05	1
NJCC6	12.41	32.92	28.36	6
NJCC7	9.77	25.93	15.89	2
NJCC8	9.77	25.93	22.13	5
NJCC9	15.56	41.30	28.67	7
NJCC10	9.68	25.70	19.95	3
NJCC11	15.56	41.30	21.39	4
NJ AVG			127.40	

The lowest MMBtu/yr is in NJCC5 at 15.05 MMBtu/year. The highest is in NJCC4 at 80.00 MMbtu/yr. The figures for each unit are included with more detail under each unit's section of the report, 5.1 – 5.11.

[10] The value for the New Jersey average MMBtu/sf/yr is based on 2009 Residential Energy Consumption Survey data, table CE2.2 (US Energy Information Administration, 2009).

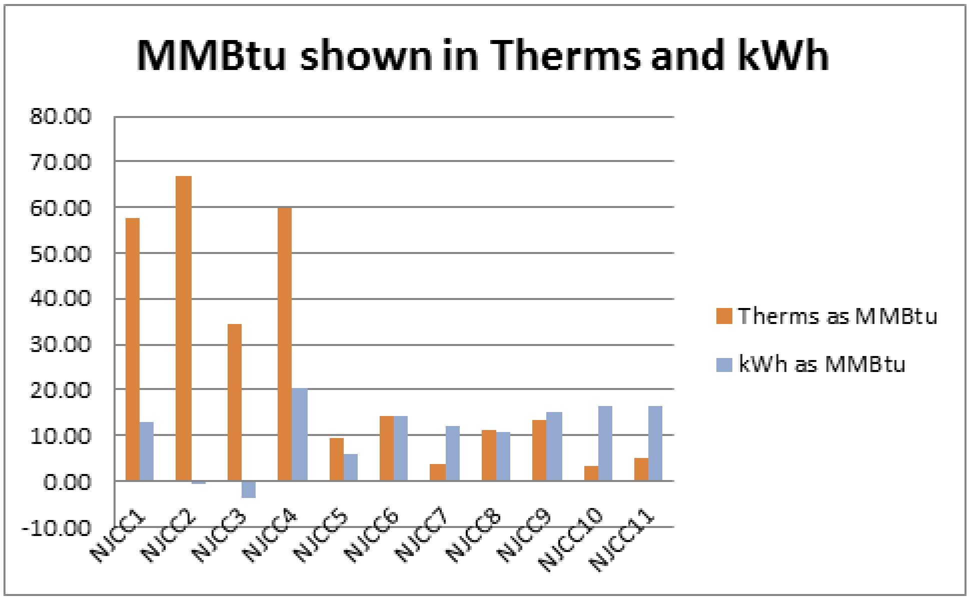


Figure 9: MMBtu shown in Therms and kWh

Figure 9 shows the breakdown between natural gas and electricity as the two components of total energy use in the monitored homes. NJCC1 through NJCC4 are dominated by therm use, whereas in NJCC5 – NJCC11 electricity use matches or well exceeds natural gas use. Two factors contribute to this: NJCC1 - NJCC4 are all single-family dwellings (NJCC1 is single family detached and NJCC 2 – NJCC4 are attached townhomes), while NJCC 5 – NJCC11 are flats in a multifamily building, with much lower heating loads.

As can be seen in Figure 10 and Table 7, Energy Use Intensity (EUI) among the monitored NJCC dwellings ranged from a low of 17.47 kBtu/sf/yr in NJCC3 and a high of high of 45.95 kBtu/sf/yr in NJCC4.[11] The average for NJ is 65.75 kBtu/sf/yr. (US Energy Information Administration, 2009) It might be expected that the lowest energy use intensity among the monitored units would be one of the flats in the multifamily building rather than one of the townhouses, however NJCC3 is a townhouse. Among the NJCC monitored units, the electric loads and offsetting of those loads with PV (or not) drove the rankings of energy use intensity, rather than the building type.

[11] Data for NJCC2, NJCC3 and NJCC4 based on available utility data and calculated energy use. This is explained further under sections 6.9.2, 6.9.3, and 6.9.4.

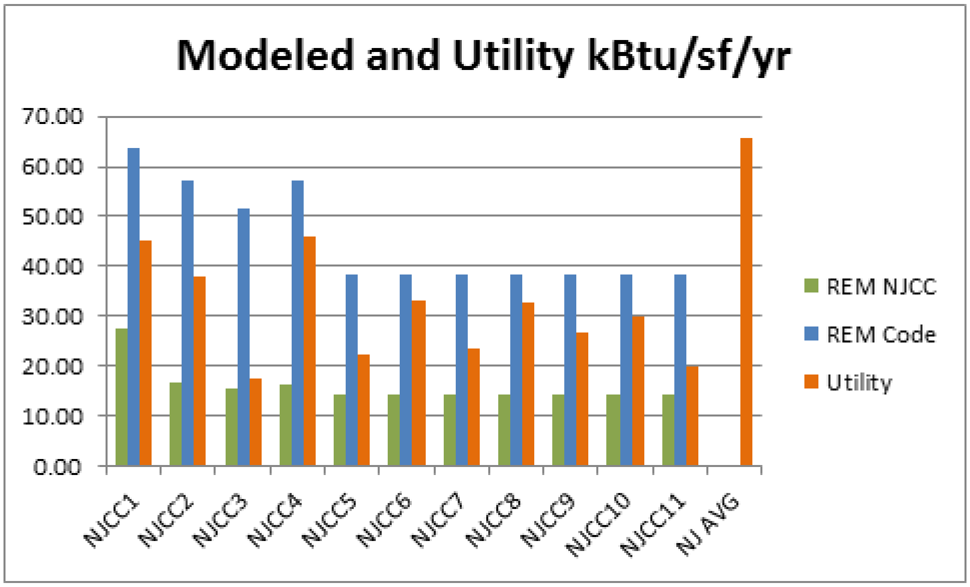


Figure 10: Modeled and Utility kBtu/sf/yr

Table 7: Modeled and Utility kBtu/sf/yr

Unit	kBtu/sf/yr			Ranking from Lowest to Highest Utility Energy Use Intensity
	REM NJCC	REM Code	Utility	
NJCC1	27.43	63.67	45.04	10
NJCC2	16.81	57.17	38.01	9
NJCC3	15.48	51.79	17.47	1
NJCC4	16.49	57.29	45.95	11
NJCC5	14.48	38.42	22.50	3
NJCC6	14.48	38.42	33.09	8
NJCC7	14.48	38.42	23.54	4
NJCC8	14.48	38.42	32.79	7
NJCC9	14.48	38.42	26.67	5
NJCC10	14.48	38.42	29.83	6
NJCC11	14.48	38.42	19.89	2
NJ AVG			65.75	

While air conditioning is among the top electric loads in the NJCC homes, much of the remaining electric load is not affected by the performance of the building envelope. Miscellaneous electric loads in particular are very high in some of the NJCC homes. This is a trend among all housing in the US, as can be seen in Figure 11 below. Here we can see that appliances, electronics and lighting have grown from 24% of energy consumption in homes in 1993 to 34.6% in 2009. In high performance homes, it becomes an even bigger portion of total energy consumption. (Hendron & Eastment, 2006)

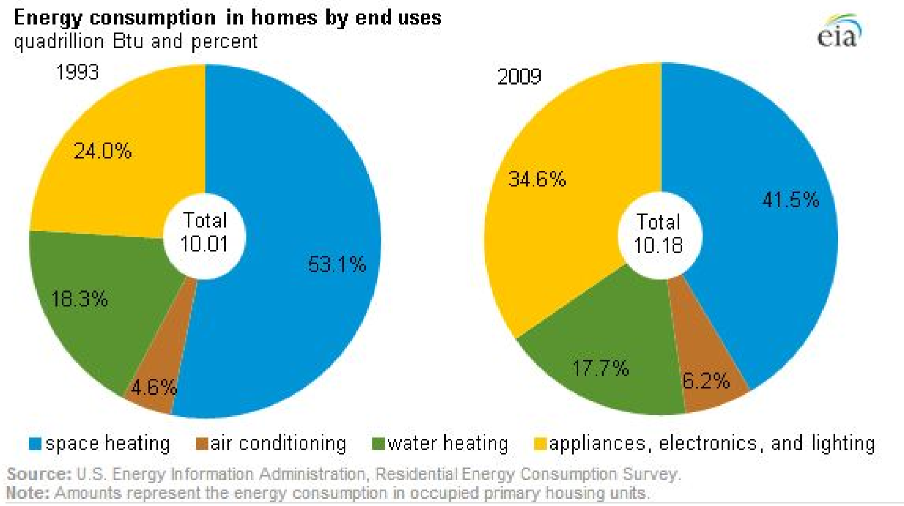


Figure 11: Energy consumption in homes by end uses. (EIA, 2013)

When modeled and actual energy use is broken down between electricity (kWh/yr) and natural gas (therms/yr), the prediction of therm use (which accounts for heating and hot water) is much closer to the utility data in the multifamily units (NJCC5 – NJCC11), as shown in Figure 12.

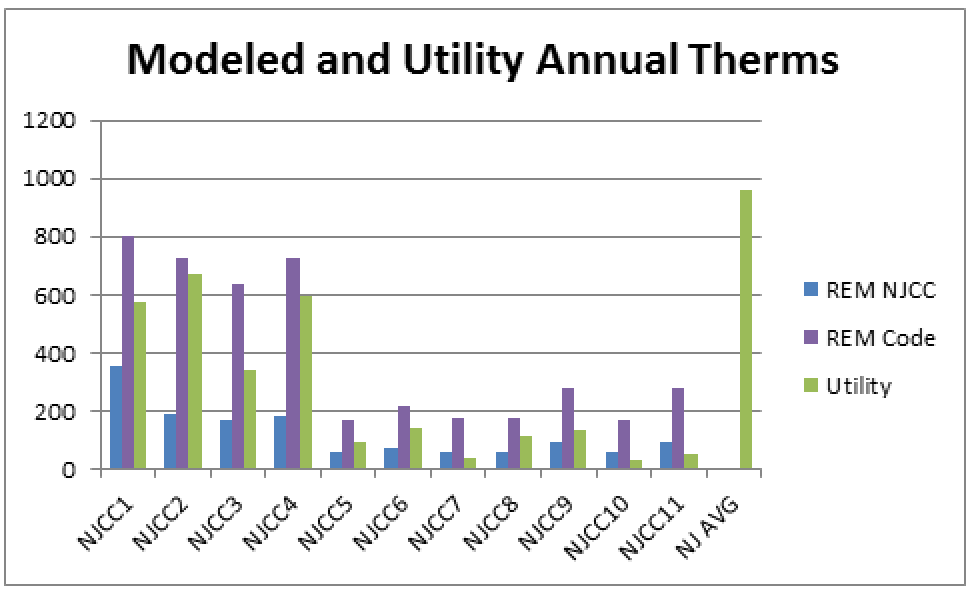


Figure 12: Modeled and Utility Annual Therms

As can be seen in Table 8, the highest therm use is among the townhouses (NJCC2 11/11, NJCC3 8/11, NJCC4 10/11) and the single family detached home (NJCC1, 9/11). These dwellings have a much greater heat load, not only because they are larger than the multifamily units, but because they each have at least three exposures (front and back façade and roof) versus a maximum of two (one façade and the roof).

Table 8: Ranking of Annual Utility Therms from Lowest to Highest

Unit	Annual Therms			Ranking from Lowest to Highest Utility Therms
	REM NJCC	REM Code	Utility	
NJCC1	355	801	577	9
NJCC2	189	724	668	11
NJCC3	168	639	343	8
NJCC4	184	726	597	10
NJCC5	59	172	93	4
NJCC6	76	220	143	7
NJCC7	60	173	37	2
NJCC8	60	173	112	5
NJCC9	96	276	134	6
NJCC10	59	172	35	1
NJCC11	96	276	51	3
NJ AVG			962	

Figure 13 shows that two of the monitored NJCC units are on track to be net electricity producers, NJCC2 and NJCC3. This is based on three months of American National Standards Institute (ANSI) meter data[12] for NJCC2 and four months for NJCC3, increased to a year of data using a PV Watts model to project monthly percentages of production. As noted earlier, NJCC5 – NJCC11 do not have an electric load reduction from the PV array on their building, as the array feeds common loads in the building, rather than individual unit loads.

[12] All solar energy systems eligible to earn SRECs must report system production based upon readings from a revenue-grade meter that meets the American National Standards Institute (ANSI) Standard C12.1-2008. (NJCEP, 2012).

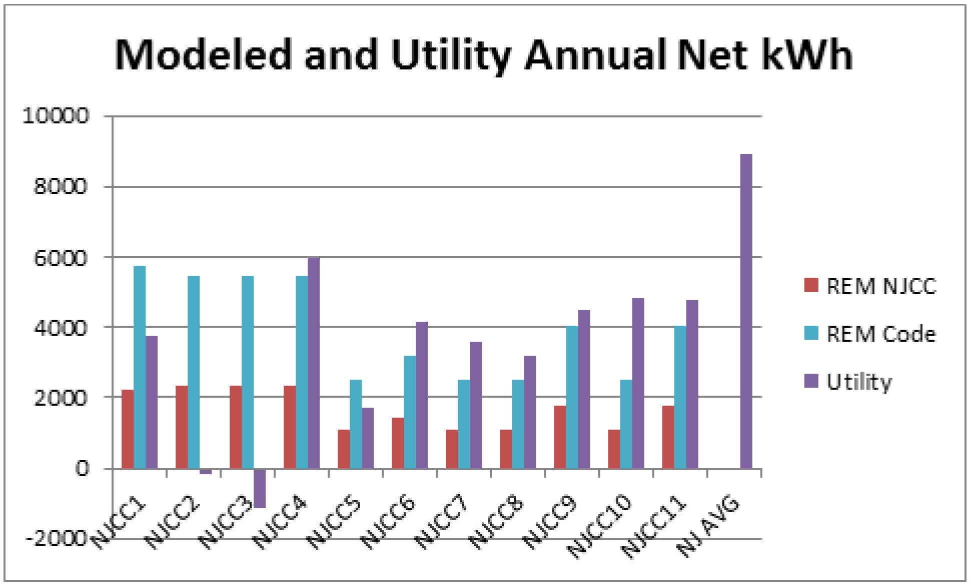


Figure 13: Modeled and Utility Annual kilowatt-hours

Table 9: Ranking of Utility kWh from Lowest to Highest

Unit	Annual Net kWh			Ranking from Lowest to Highest Utility kWh
	REM NJCC	REM Code	Utility	
NJCC1	2194	5767	3775	6
NJCC2	2310	5474	-184	2
NJCC3	2304	5456	-1137	1
NJCC4	2309	5475	5952	11
NJCC5	1096	2496	1686	3
NJCC6	1405	3198	4123	7
NJCC7	1106	2519	3575	5
NJCC8	1106	2519	3206	4
NJCC9	1762	4011	4479	8
NJCC10	1096	2496	4825	10
NJCC11	1762	4011	4776	9
NJ AVG			3775	

6.8 Compliance with Technical Requirements

Two compliance issues emerged among the monitored NJCC units: air infiltration rates and water heater efficiency. Eight of the units did not meet the 2.5 air changes per hour (ACH) infiltration requirement. Seven of the eight are in Building B.1, the multifamily building. The testing protocol for Building B.1 was to test the air tightness of the entire building envelope, rather than each individual dwelling unit. As such, all the units in the building have the same tested infiltration rate, 2.85 ACH. While this exceeds the program requirement, the building was modeled with a 2.86ACH and still met the NJCC HERS rating requirement of 50 before renewables. Because the NJCC Technical Standards allow for flexibility as long as the HERS 50 threshold is met, the building met the NJCC requirements.

Table 10: Target and Tested Air Changes per Hour

Unit	Unit ACH	NJCC ACH Requirement
NJCC1	2.79	2.5 ACH
NJCC2	2.5	
NJCC3	2.5	
NJCC4	2.5	
NJCC5	2.85*	
NJCC6		
NJCC7		
NJCC8		
NJCC9		
NJCC10		
NJCC11		

**These units are all in the same multifamily building that was not tested unit-by-unit, but overall.*

6.9 Individual Unit Analysis

The following sections examine data for each individual unit.

6.9.1 NJCC1

NJCC1 is a 1,567 square foot single family home with four occupants. NJCC1 has a structural insulated panel (SIP) entry level with two framed levels above and a truss roof. The home's entry level accommodates a single car garage, a laundry/mechanical room and an entry vestibule with a stair to the second level. Here the home has a living room, powder room and eat in kitchen. On the third level are three bedrooms and a full bathroom. NJCC1 has a 2.3 kW solar array and a liquid-indirect solar thermal system with a collector area of 44 square feet. Both systems are on the home's roof and are south facing.

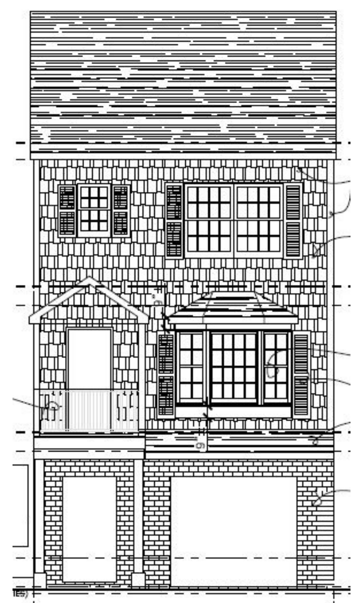


Figure 14: Front Elevation Cathy R. Benson, AIA Architect

Table 11 shows NJCC1's annual energy use based on utility bills and monitored data. NJCC1 has the highest energy use intensity among the NJCC monitored homes.

Table 11: NJCC1 Utility and Monitored Energy Use and Production

NJCC1	
Annual Utility kWh	6933
Annual Monitored PV kWh	-2565[13]
Annual Utility therms	577
Annual MMBTU	70.57
Energy Intensity kBtu/sf	45.04

Table 12 lists NJCC1's characteristics. The residents of NJCC1 keep the thermostat at 75F year round during the day and while sleeping.

Table 12: NJCC1 Characteristics

NJCC1 Characteristics		
Category	**Component**	**Value**
Size	Home Size	1567 sf
HERS Index	HERS Index maximum (before renewables)	50
Thermal Envelope	Air Leakage (ACH50)	4
Site Orientation	Orientation maximized for solar exposure	South
HVAC Proper Installation	Ductwork located in conditioned space	100%
	HRV or ERV	ERV
HVAC Equipment	Heating AFUE minimum	38kBtu, 95%
	Central AC SEER	14
	Motor	ECM
Water Heating System	Water heater AFUE	0.65
	Low-flow faucets and showerheads	low-flow
	Distribution	Manifold distribution
Lighting	Energy Star fixtures or bulbs	100%
Renewable Energy	PV or Solar Hot Water Heating	PV & Solar installed
Appliances	Refrigerator must be CEE Tier 3	Tier 3

For NJCC1, the modeled electric use is 41% of the actual use (2870 kWh versus 6933 kWh) and the natural gas use is 62% (355 therms versus 577 therms). However, the energy model's

[13] The utility bill figures for PV generation were 593 kWh for May 2012 – April 2013. This appeared to be very low when compared to eMonitor meter data (2656) and ANSI meter data (2937) based on five months of data scaled up for the year based on monthly percentages from PV Watts software for a 2.3 kW array in Newark, NJ. As such, the monitored data was used for PV generation. The developer is investigating utility generation numbers with the utility.

thermostat settings were 70F for heating and 78F for cooling. The survey of the NJCC1 resident noted that the thermostat was set to 75F summer and winter. When these temperature settings are modeled, the heating and cooling energy do increase, as shown in Table 13 and Figure 15, with total therms increasing to 411 (71% of actual) and kilowatt hours to 5143 (74% of actual). NJCC1 monitoring reflects an average indoor temperature of 76 degrees for August, and an average indoor temperature of 79F in December. Unfortunately, REM/Rate will not allow raising the thermostat setting above 75F, which would have shown the impact of the higher indoor temperature on the heating energy.

NJCC1's largest annual electric load is the combined circuit for the energy recovery ventilator (ERV), the solar thermal pump, and the gas water heater, while heating uses the most natural gas. NJCC1 did not meet the infiltration requirement of the NJCC program. (This was the home that prompted the need for additional training on this topic.) NJCC1's target infiltration rate was 529 CFM@50 Pa. The initial air leakage testing results were 797 CFM@50 Pa. With additional air sealing, the infiltration dropped to 739 CFM@50 Pa. This was determined to be the lowest achievable infiltration rate without making intrusive changes to the building envelope. While the target rate was not achieved, the home was modeled using 890 CFM50 for the infiltration rate and still met the HERS 50 requirement.

Table 13: Modeled Loads with Thermostat Setting Change

	As modeled Heating 70F, Cooling 78F	With T-stat at 75 during heating and cooling season	Utility Data
Heating (Therms)	226	285	
Heating (kWh)	344	417	
Cooling (kWh)	651	799	
Water Heating (Therms)	62	61	
Lights & Appliances (Therms)	65	65	
Lights & Appliances (kWh)	3927	3927	
Total Therms	355	411	577
Total kWh (with PV reduction)	2194	5143	6340

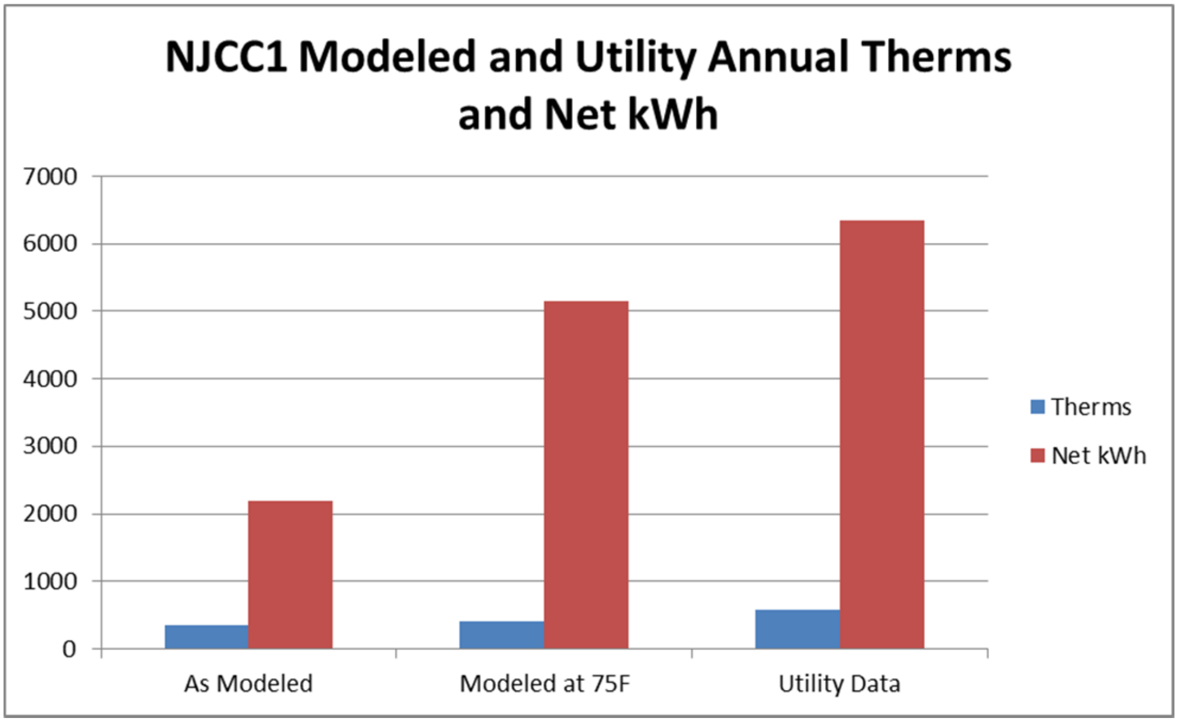


Figure 15: NJCC1 Modeled and Utility Annual Therms and kWh

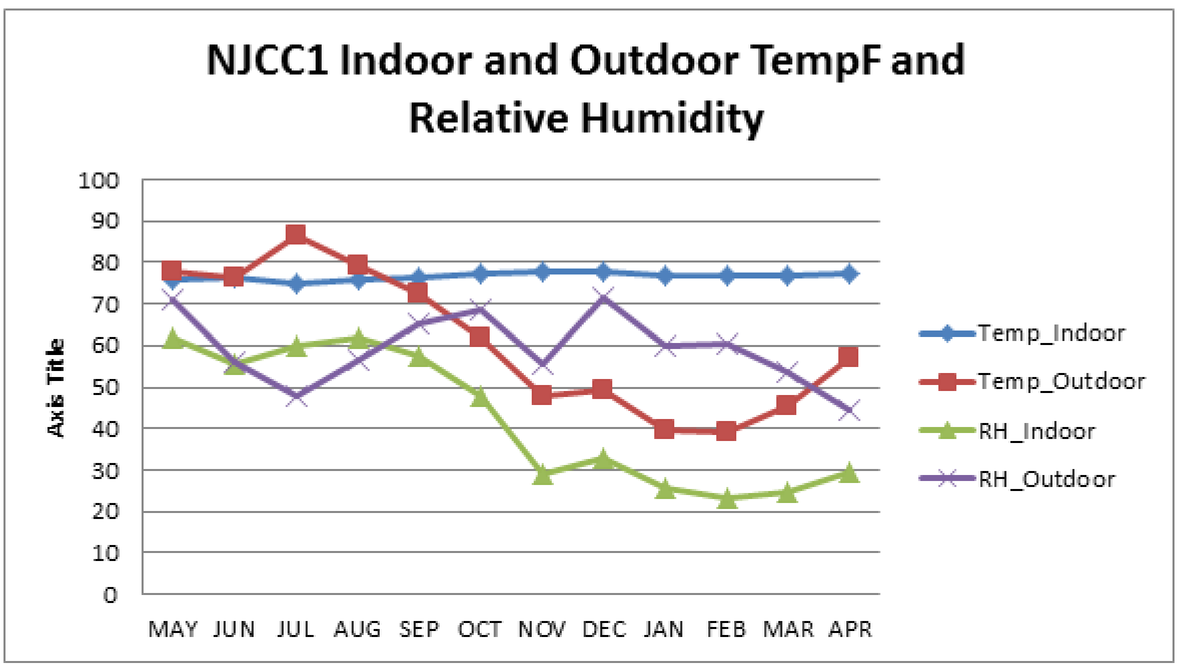


Figure 16: NJCC1 Indoor and Outdoor TempF and RH

Figure 16 shows the monthly average of indoor temperature and relative humidity as well as outdoor conditions.

ELECTRICITY

Figure 17 shows the monitored and utility kilowatt-hours for NJCC1. Monitored data for November and December were incomplete and not included.[14] The graph shows increased electricity use during the cooling months and a slight increase in December and January, which may be due to holiday lighting.

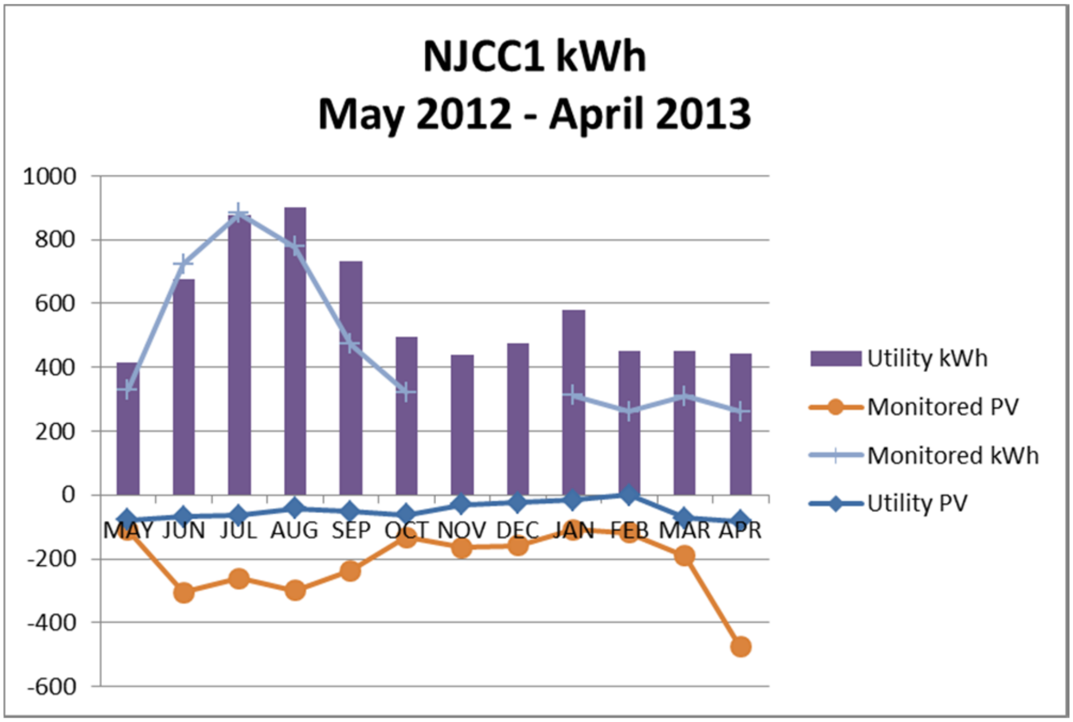


Figure 17: NJCC1 Utility and Monitored kWh and PV production

Table 14: NJCC1 Utility and Monitored kWh Use and Production (PV)

NJCC1	Utility kWh	Utility PV	Monitored PV	Monitored kWh
MAY	414	-78	-110.184	330.476
JUN	675	-68	-305.32	722.508
JUL	878	-64	-261.918	881.506
AUG	900	-42	-299.525	777.403
SEP	731	-53	-237.448	473.13
OCT	495	-62	-132.455	321.132
NOV	440	-31	-155.00	Incomplete data
DEC	474	-24	-148.00	
JAN	581	-16	-108.00	312.2727
FEB	451	0	-119.505	261.09
MAR	451	-72	-190.735	309.619
APR	443	-83	-476.083	262.186
TOTAL	**6933**	**-593**	**2544**	**4651**

[14] There were 22 days of readings in January, which was proportionally increased for the full month's kWh.

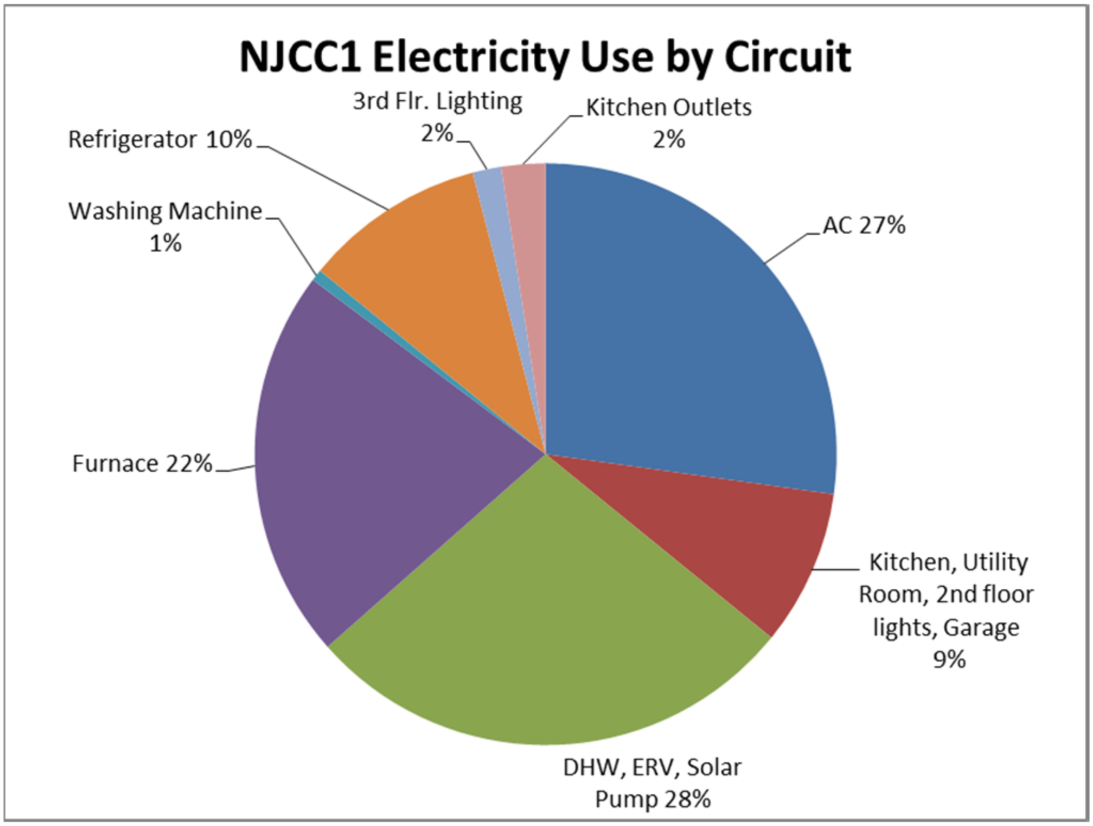


Figure 18: NJCC1 Electricity Use by Circuit

Figure 18 shows NJCC1's electricity use by circuit. Interestingly, the home has an electric resistance-heating strip at the grade level entry that caused some concern among the research team as a potentially big energy user. However, the monitoring data shows that it accounted for 0.0008% of annual electricity use. The three circuits using the most electricity are:

1. Energy Recovery Ventilator and Solar thermal pump and domestic hot water (gas water heater)
2. Air conditioning
3. Furnace

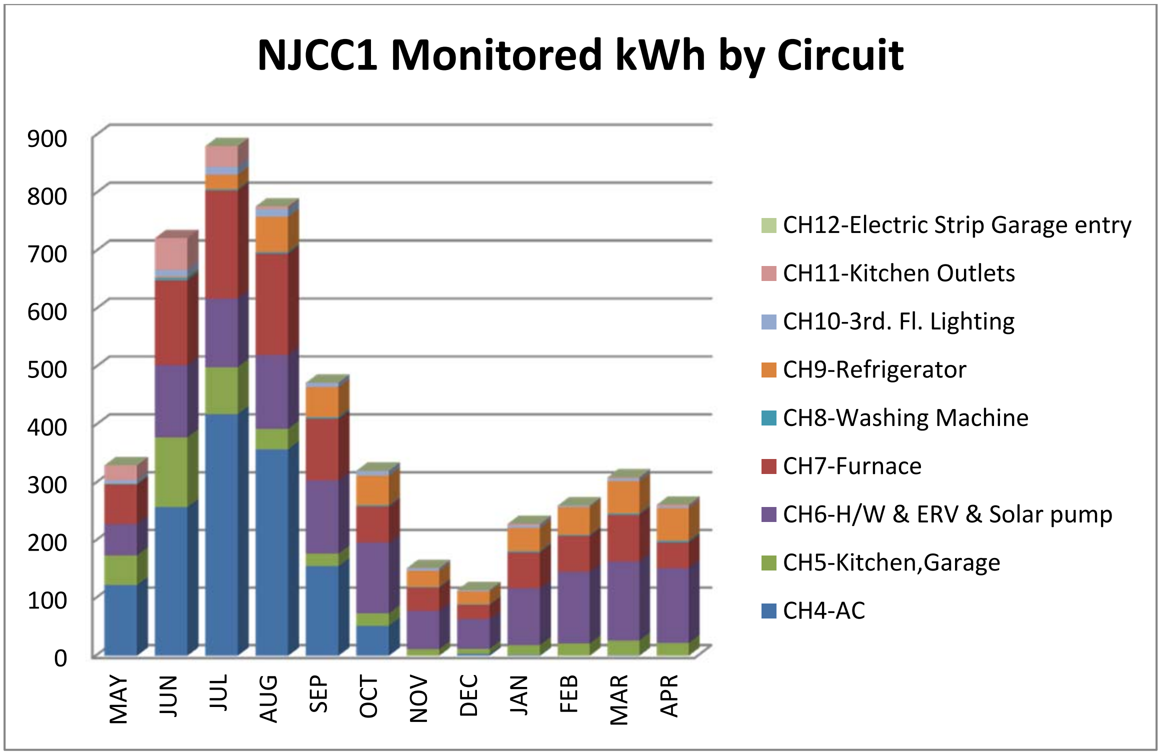


Figure 19: NJCC1 Monitored kWh by Circuit

Figure 19 clearly shows the increased electricity use during the cooling season in NJCC1. However, the furnace is among the top three electricity users at 22%. The high efficiency gas fired furnace in NJCC1 has an electronically commutated motor (ECM). This type of motor runs at variable speeds for reduced electricity use by the furnace fan. In NJCC1, the furnace fan works to distribute conditioned air during the heating and cooling season. Annual electricity use by the furnace for the monitored period was 1,059 kWh.[15] A 2010 Department of Energy report found that the average annual electricity use among 96% AFUE furnaces was 400 kWh during the heating season. (Department of Energy, 2010) Even if we assume that doubling this amount can account for the cooling season, the total use would be 800 kWh. As such, the furnace usage appears to be slightly high. This has been reported to the developer for further investigation.

PRODUCTION AND USAGE

NJCC1 has a 2.3 kW south facing solar array on its roof. Energy modeling predicted that the array would offset 67% of the home's annual electric load; however, NJCC1's original energy model did not include air conditioning. The homeowner installed central air conditioning after the home was built and as such, the electric load has increased. The monitored data shows a total PV production for May 2012 through April 2013 of 2544 kWh.[16] Using the 2544 kWh figure and the annual utility kWh for the same period of 6933, the PV offset is 37%. The utility consumption and monitored PV production can be seen in Figure 17.

---

[15] The amount of energy used by the furnace fan is not only dictated by the speed of the motor (here it is variable speed); it is also impacted by the pressure difference across the blower and the airflow.

[16] Using monthly production percentage from PV watts for a 2.3 kW array in Newark, the ten months of PV data for NJCC1 were proportionally increased for the year. This was used rather than the utility data, as the utility PV production numbers are much lower than modeled or monitored. This discrepancy has been raised with the developer who is in contact with the utility about the issue.

NATURAL GAS

NJCC1 uses natural gas for domestic hot water, heating, cooking, and the clothes dryer. Total natural gas data is from utility bills; the solar thermal contribution to domestic hot water is monitored data. Space heating drives the majority of therm use in NJCC1, as can be seen by the roughly inverse relationship between therms and outdoor temperature.

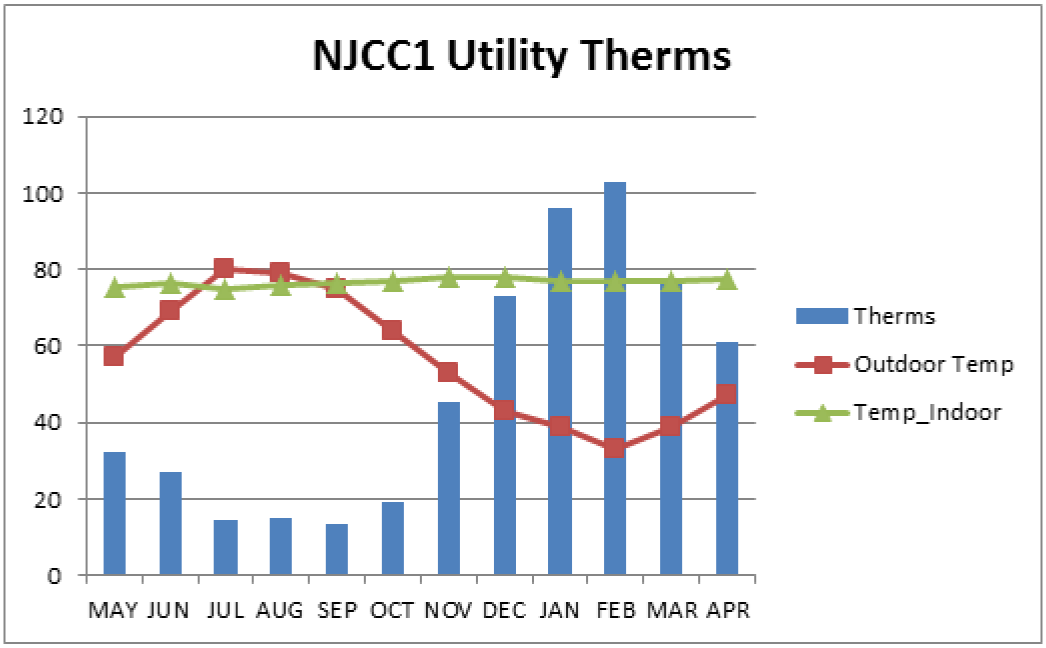


Figure 20: NJCC1 Utility Therms and Outdoor TempF

While the REM/Rate model predicted 355 therms of usage between May 2012 and April 2013, actual usage based on utility data was 577 therms.

SOLAR THERMAL

NJCC1 has a south-facing liquid-indirect solar thermal system with a collector area of 44 square feet. The home's energy model predicted that the solar thermal contribution to the hot water load would be 60% annually. The data to date shows an average contribution of 24% from June through April, with a high of 70% in July.

Table 15: Solar Thermal Contribution to Domestic Hot Water

Month	Domestic Hot Water Total BTU	Solar Thermal Total BTU	Percentage Solar Thermal Contribution
JUN	422,687	209,803	50%
JUL	204,557	143,385	70%
AUG	328,109	175,611	54%
SEP	307,596	119,211	39%
OCT	315,308	65,511	21%
NOV	451,532	43,677	10%
DEC	222,747	23,402	11%
JAN	736,900	57,849	8%
FEB	549,181	60,481	11%
MAR	627,993	86,303	14%
APR	462,121	126,010	27%
MAY	INCOMPLETE DATA		
AVERAGE	420,794	101,022	24.01%

HEATING

As noted in Table 12, NJCC1 has a 38 kBtu, 95.0% AFUE gas furnace with an ECM (electronically commutated motor). The modeled projection for NJCC1 was 226 therms/yr for heating. Utility bill data shows 577 therms annually. If we calculate that 78% of the natural gas is used for home heating (this proportion comes from NJCC1's energy model) the result is 450 therms. As noted earlier, the resident in NJCC1 keeps the indoor temperature well above the 70F set point used in the energy model, between 77F and 79F. As also noted earlier, these higher settings cannot be modeled to see what impact they would have on the predicted usage.

6.9.2 NJCC2

NJCC2 is an inner unit 1,741 square foot townhouse with three occupants. NJCC2 has an insulated panelized concrete entry level (Superior Wall) with two framed levels above and a truss roof. The framed levels are double stud walls with spray foam and dense pack cellulose insulation. The home's entry level accommodates a single car garage, a laundry/mechanical room and an entry vestibule with a stair to the second level. Here the home has a living room, powder room and eat in kitchen. On the third level are three bedrooms and a full bathroom. The residents in NJCC2 did not know how to use their programmable thermostat and did not know to which temperature(s) it was set.

Table 16 shows NJCC2's energy use based on five months of utility bill data scaled up to annual usage using proportional percentages based on annual usage from NJCC1.

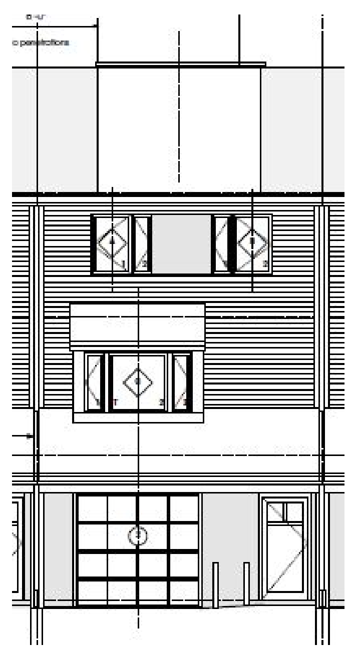


Figure 21: NJCC2 Front Elevation Steele Kellogg AIA

Table 16: NJCC2 Energy Use

NJCC2	
Annual Utility kWh	3589
Annual Utility PV kWh	-3772[17]
Annual Utility therms	668
Annual MMBTU	66.17
Energy Intensity kBtu/sf	38.01

NJCC 2 has a 2.9 kW photovoltaic array and 64 square feet of solar thermal collector area. Table 17 below lists NJCC2's characteristics.

Table 17: NJCC2 Characteristics

NJCC2 Characteristics		
Category	**Component**	**Value**
Size	Home Size	1741 sf
HERS Index	HERS Index maximum (before renewables)	Not yet determined[18]
Envelope	Air Leakage (ACH50)	2.5ACH50
Site Orientation	Orientation maximized for solar exposure	South
HVAC Proper Installation	Ductwork located in conditioned space	N/A[19]
	HRV or ERV	ERV
HVAC Equipment	Heating AFUE minimum	75%
	Central AC SEER	14
	Motor	ECM
Water Heating System	Water heater EF	Not yet determined
	Low-flow faucets and showerheads	low-flow
	Distribution	Manifold
Lighting	Energy Star fixtures or bulbs	90%
Renewables	PV or Solar Hot Water Heating	PV & Solar installed
Appliances	Refrigerator must be CEE Tier 3	Tier 3

[17] The utility bills for NJCC2 do not show bi-directional meter data with PV generation values. NJIT informed the developer, who in turn called the utility. PSE&G reported that going forward NJCC2 bills will have bi-directional meter data. The 3772 kWh is based on three months of ANSI meter scaled up using PV Watts software for a 2.9 kW array in Newark.

[18] NJCC2's final HERS rating will depend on its water heater. The water heater in place will be replaced with a different type, not yet finalized.

[19] NJCC2 does not have ductwork for heating and cooling. Heating is provided by radiant floors. Residents are using portable AC units and window units for cooling.

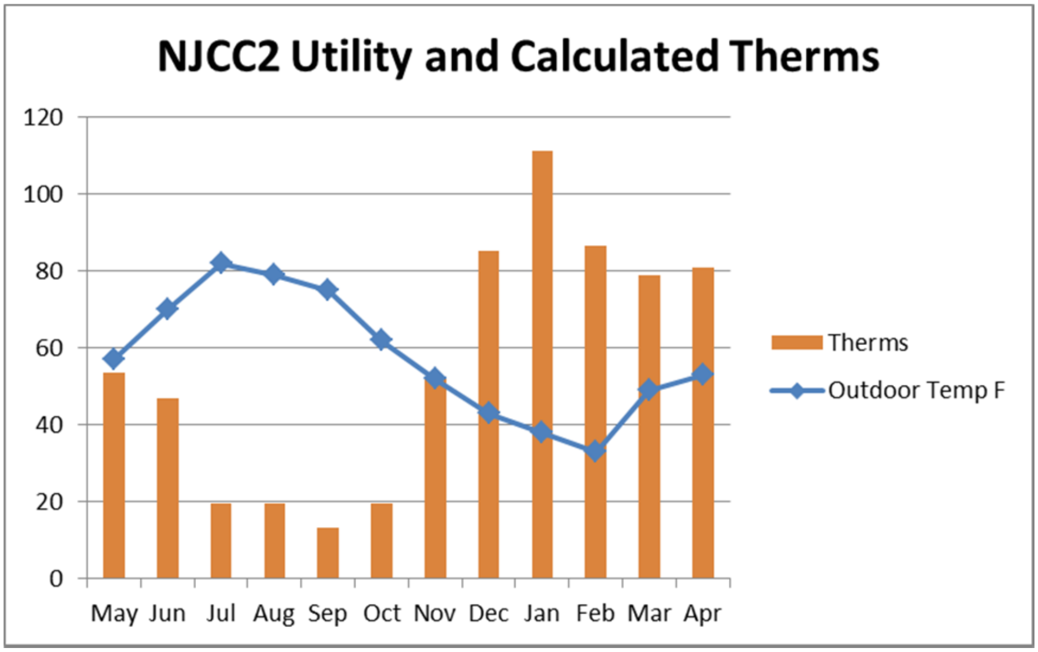


Figure 22: NJCC2 Utility Therms

Table 18: Utility and Calculated Therms

NJCC2	Therms	Data Source
MAY	54	Utility Bill
JUN	47	Utility Bill
JUL	19.65	Calculated
AUG	19.65	Calculated
SEP	13.10	Calculated
OCT	19.65	Calculated
NOV	52.40	Calculated
DEC	85.14	Calculated
JAN	111.34	Calculated
FEB	86.47	Calculated
MAR	79	Utility Bill
APR	81	Utility Bill
TOTAL	668	

Annual therms for NJCC2 are 668. The modeled annual therms are 168.

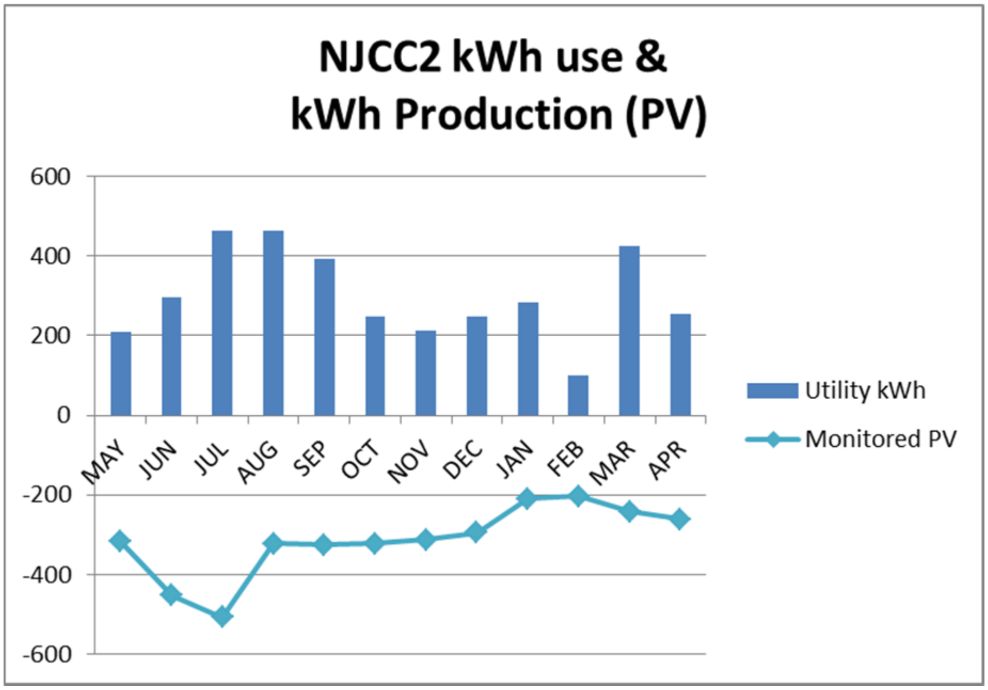


Figure 23: NJCC2 Utility kWh and Monitored PV production

Table 19: Utility kWh Use and Monitored PV Production

NJCC2	Utility kWh Use	Data Source	Monitored PV	Data Source
MAY	208	Utility Bill	-317	ANSI Meter
JUN	295	Utility Bill	-452	ANSI Meter
JUL	462	Calculated	-507	ANSI Meter
AUG	462	Calculated	-322	Calculated
SEP	391	Calculated	-326	Calculated
OCT	249	Calculated	-322	Calculated
NOV	213	Calculated	-313	Calculated
DEC	249	Calculated	-295	Calculated
JAN	284	Calculated	-210	Calculated
FEB	100	Utility Bill	-203	Calculated
MAR	423	Utility Bill	-242	Calculated
APR	253	Utility Bill	-262	Calculated
TOTAL	3589		3772	

Annual kilowatt-hours for NJCC2 are 3588. Calculated PV production based on three months of ANSI meter data show that the array should offset 105% of the electric load. The modeled annual kilowatt-hours for NJCC2 were 2304.

A breakdown of NJCC2's electricity use by circuit is not available, as the monitoring equipment for NJCC2 was not fully commissioned at the time of this reporting.

6.9.3 NJCC3

NJCC3 is adjacent to NJCC2 and is an inner unit 1741 square foot townhouse with four occupants. NJCC3 has an insulated panelized concrete entry level (Superior Wall) with two framed levels above and a truss roof. The framed levels are double stud walls with spray foam and dense pack cellulose insulation. The home's entry level accommodates a single car garage, a laundry/mechanical room and an entry vestibule with a stair to the second level. Here the home has a living room, powder room and eat in kitchen. On the third level are three bedrooms and a full bath.

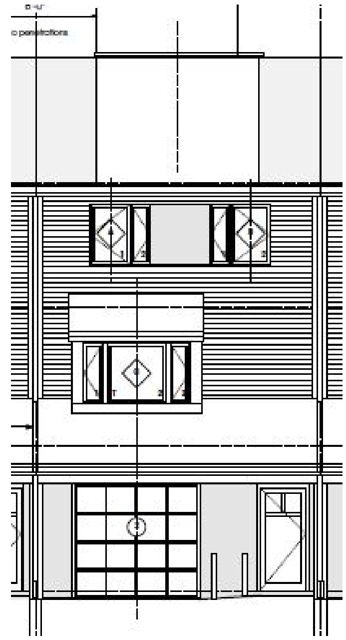


Figure 24: NJCC3 Front Elevation Steele Kellogg AIA

NJCC3 has a 2.9 kW photovoltaic array and 64 square feet of solar thermal collector area. NJCC3 is identical to NJCC2. Please refer to Table 17 for a list of NJCC3's characteristics.

The residents of NJCC3 keep the thermostat at 70F year round.

Table **20** shows NJCC3's energy use based on three months of utility bill data scaled up to annual usage using proportional percentages based on annual usage from NJCC1.

Table 20: NJCC3 Energy Use

NJCC3	
Annual Utility kWh	2006
Annual Utility PV kWh	-3143
Annual Utility therms	343
Annual MMBTU	30.42
Energy Intensity kBtu/sf	17.47

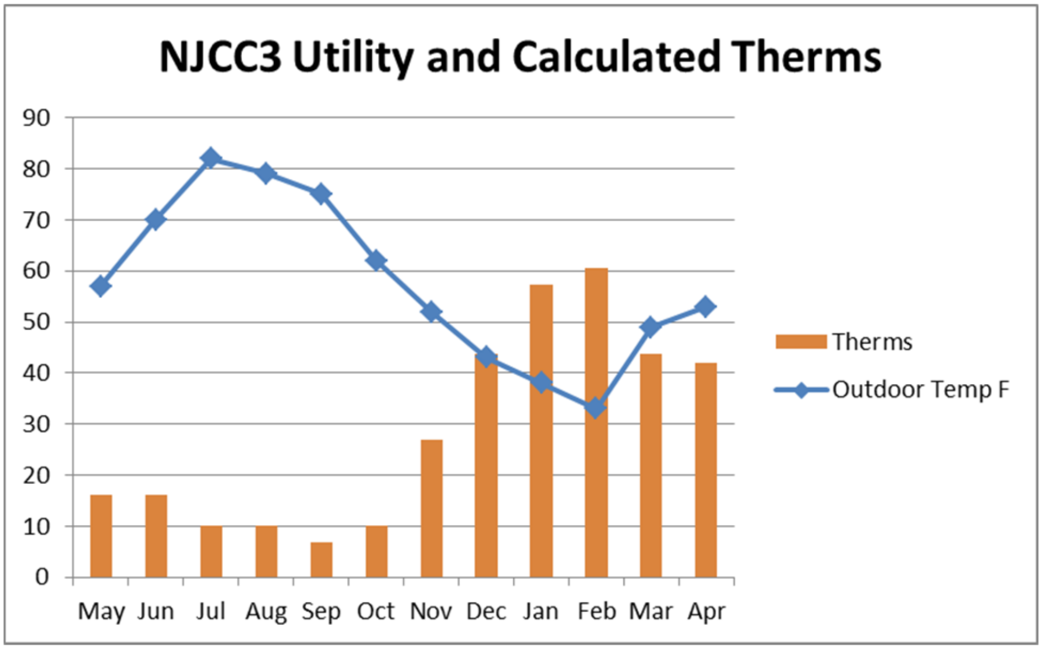


Figure 25: NJCC3 Utility Therms

Table 21: NJCC3 Utility and Calculated Therms

NJCC3	Therms	Data Source
MAY	16	Utility Bill
JUN	16	Utility Bill
JUL	10	Calculated
AUG	10	Calculated
SEP	7	Calculated
OCT	10	Calculated
NOV	27	Calculated
DEC	44	Calculated
JAN	57	Calculated
FEB	61	Calculated
MAR	44	Calculated
APR	42	Utility Bill
TOTAL	**343**	

Annual therms for NJCC3 are 343. The modeled annual therms are 168.

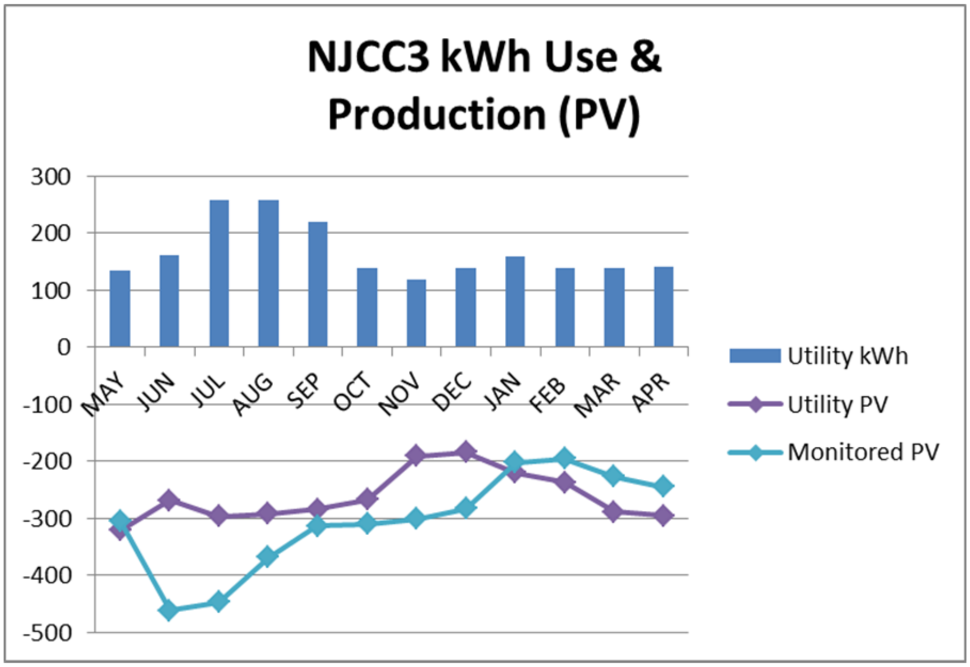


Figure 26: NJCC3 Utility kilowatt-hours

Table 22: Utility kWh Use and Monitored PV Production

NJCC3	Utility kWh	Utility PV	Data Source	ANSI Meter PV	Data Source
MAY	134	-321	Utility Bill	-304	ANSI Meter
JUN	162	-268	Utility Bill	-462	ANSI Meter
JUL	258	-296	Calculated	-447	Calculated
AUG	258	-292	Calculated	-368	Calculated
SEP	219	-284	Calculated	-313	Calculated
OCT	139	-267	Calculated	-309	Calculated
NOV	119	-191	Calculated	-301	Calculated
DEC	139	-184	Calculated	-283	Calculated
JAN	159	-220	Calculated	-202	Calculated
FEB	139	-237	Calculated	-195	Calculated
MAR	139	-288	Calculated	-226	ANSI Meter
APR	141	-295	Utility Bill	-244	ANSI Meter
TOTAL	2006	-3143		-3654	

Annual utility and calculated kilowatt-hours for NJCC3 are 2006. This is based on three months of utility bill data extrapolated for one year using the percentage of electricity use per month based on NJCC1. The modeled annual kilowatt-hours for NJCC3 are 2304. Based on the kWh use (2006 kWh) and production (-3143 kWh), NJCC3 should be a net electricity producer with the array meeting 156% of its needs.

A breakdown of electricity use by circuit is not available, as the monitoring equipment for NJCC3 was not fully commissioned at the time of this reporting.

6.9.4 NJCC4

NJCC4 is adjacent to NJCC3 and is an end unit, 1741 square foot townhouse with three occupants. NJCC4 has an insulated panelized concrete entry level (Superior Wall) with two framed levels above and a truss roof. The framed levels are double stud walls with spray foam and dense pack cellulose insulation. The home's entry level accommodates a single car garage, a laundry/mechanical room and an entry vestibule with a stair to the second level. Here the home has a living room, powder room and eat in kitchen. On the third level are three bedrooms and a full bath.

NJCC4 has a 2.9 kW photovoltaic array and 64 square feet of solar thermal collector area. NJCC4 is identical to NJCC2 and NJCC3; please refer to Table 17 for NJCC4's characteristics.

In their survey responses, the residents of NJCC4 stated that they keep the thermostat at 65F year round.

Table 23 shows NJCC4's energy use based on three months of utility bill data scaled up to annual usage using monthly energy use percentages based on NJCC1.

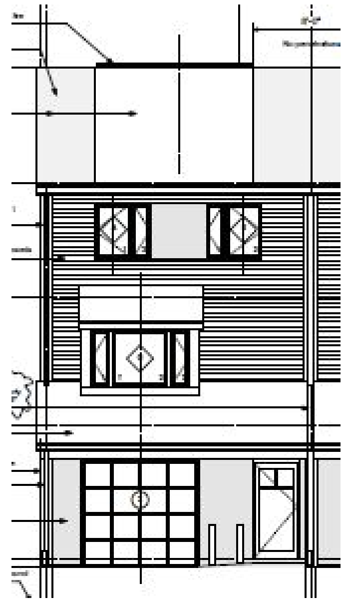


Figure 27: NJCC4 Front Elevation
Steele Kellogg AIA

Table 23: NJCC4 Energy Use

NJCC4	
Annual Utility kWh	8409
Annual Utility PV kWh	-2457
Annual Utility therms	598
Annual MMBTU	80.00
Energy Intensity kBtu/sf	45.94

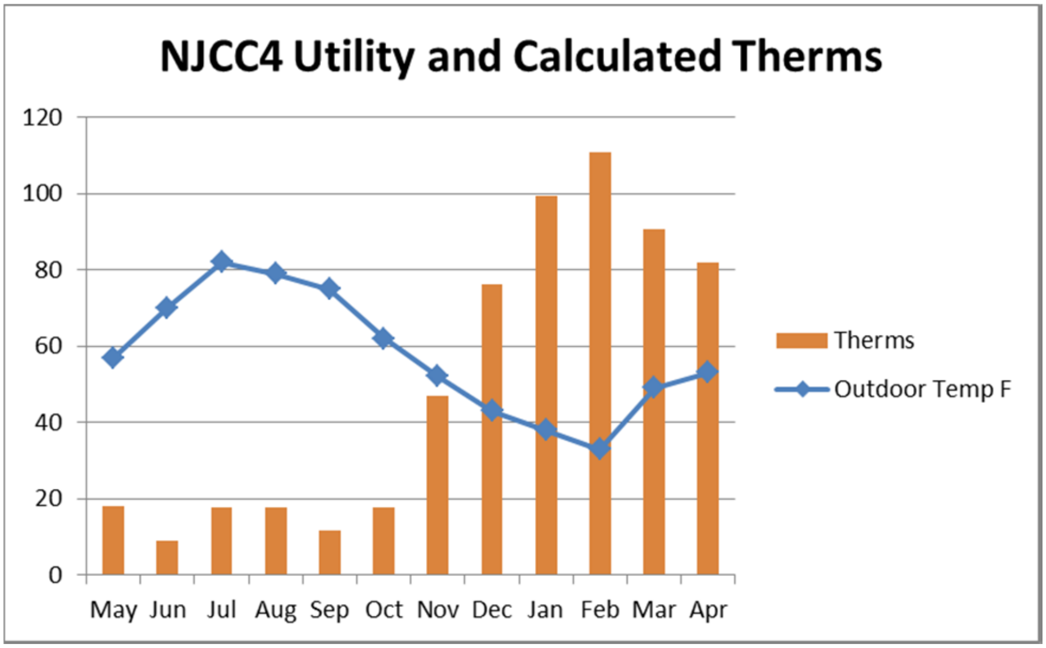


Figure 28: NJCC4 Utility Therms

Table 24: NJCC4 Utility and Calculated Therms

NJCC4	Therms	Data Source
MAY	18	Utility Bill
JUN	9	Utility Bill
JUL	17.56	Calculated
AUG	17.56	Calculated
SEP	11.71	Calculated
OCT	17.56	Calculated
NOV	46.83	Calculated
DEC	76.09	Calculated
JAN	99.51	Calculated
FEB	111	Utility Bill
MAR	91	Utility Bill
APR	82	Utility Bill
TOTAL	597	

Annual therms are for NJCC4 are 597. The modeled annual therms for NJCC4 are 184.

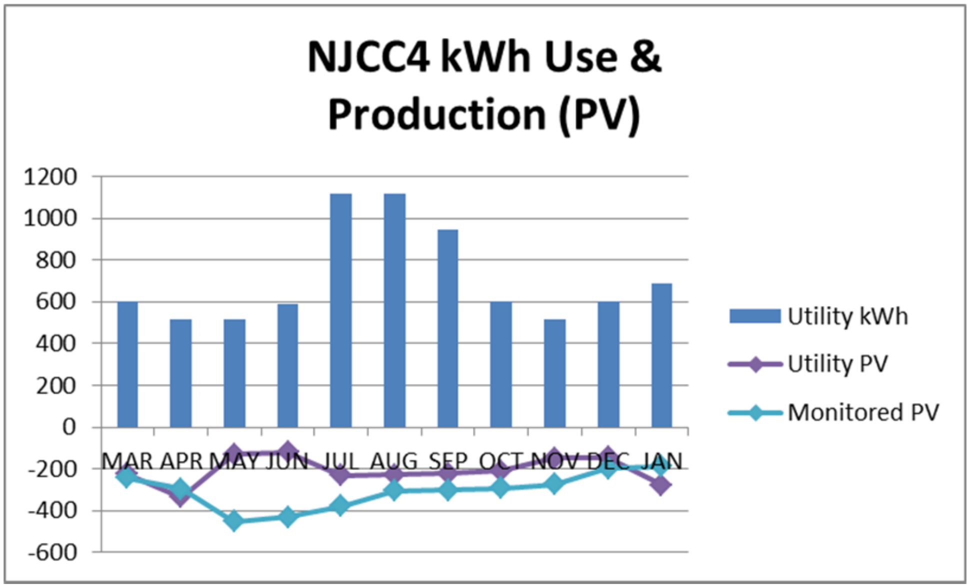


Figure 29: NJCC4 - Utility kilowatt-hours

Table 25: Utility kWh Use and Monitored PV Production

NJCC4	Utility kWh	Utility PV	Data Source	Monitored PV	Data Source
MAY	515.68	-130	Utility Bill	-452	ANSI Meter
JUN	588	-121	Utility Bill	-432	ANSI Meter
JUL	1117.32	-231	Calculated	-379	Calculated
AUG	1117.32	-228	Calculated	-305	Calculated
SEP	945.42	-222	Calculated	-301	Calculated
OCT	601.63	-209	Calculated	-292	Calculated
NOV	515.68	-149	Calculated	-275	Calculated
DEC	601.63	-144	Calculated	-196	Calculated
JAN	687.58	-276	Utility Bill	-190	Calculated
FEB	601.63	-185	Calculated	-226	Calculated
MAR	601.63	-225	Calculated	-244	ANSI Meter
APR	515.68	-336	Utility Bill	-296	ANSI Meter
TOTAL	8409	-2457		-3587	

Annual kilowatt-hours for NJCC4 are 5952 (total use of 8409 less the utility PV generation of -2457). The modeled annual kilowatt-hours for NJCC4 are 2309. The annual kWh and PV production calculated for NJCC4 suggest that the PV will offset approximately 43% of the electric load. NJCC4 has the highest electrical load of all eleven monitored NJCC units. While a breakdown of electricity uses is not available for NJCC4, the fact that the residents keep their townhouse at 65F year round implies that the air conditioning electricity use is significant.

A breakdown of electricity use by circuit is not available, as the monitoring equipment for NJCC4 was not fully commissioned at the time of this reporting.

6.9.5 Introduction to NJCC5-NJCC11

Figure 30: NJCC5 - NJCC11 Multifamily Building Photo, RPM Development

NJCC5-NJCC11 are all flats in building B.1, a 70-unit multifamily building shown in Figure 30. This is a wood frame building with closed cell foam and fiberglass insulation between the studs and rigid foam sheathing. The wall's full brick veneer is outboard of a 1" airspace from the sheathing. The window U value is .25 and the solar heat gain coefficient is .23.

PRODUCTION AND USAGE

Building B.1 has a centralized PV system serving the building. The PV does not offset loads within each unit. The building's PV production is shown below in Table 26.

Table 26: Building B.1 PV Production

Month	Date of KWH Reading	Total KWH Reading	Additional KWH Produced This Month
November	01-Dec-11	2530.60	0.00
December	31-Dec-11	5210.30	2679.70
January	31-Jan-12	7964.00	2753.70
February	29-Feb-12	14,954.00	6990.00
March	2-April-12	19,428.00	4474.00
April	4-May-12	28,044.00	8616.00
May	6-June-12	36,697.00	8653.00
June	1-July-12	44,791.00	8094.00
July	1-August-12	53,560.00	8769.00
August	5-Sept-12	62,672.00	9112.00
September	5-Oct-12	68,806.00	6134.00
October		72,612.00	3806.00

SOLAR THERMAL

The solar thermal system at Building B.1 is a south-facing liquid indirect system with a collector area of 1,025 square feet. The projected contribution to the domestic hot water load was modeled at 78%. The system monitoring conducted as part of this research project has uncovered some problems and led to some system troubleshooting. For example, the monitoring revealed that the solar controller had not been working consistently, and it appeared that the recirculation loop in the system was causing heated water to lose heat to the solar thermal storage tanks. The monitoring snapshot from September 27th shown in Figure 31 was sent to Developer B and solar thermal company, as were the associated data logs, to help determine how best to remedy the performance issues. The solar thermal company coordinated with the building superintendent to confirm that the solar controller was working. The solar thermal company thought that the system recirculation was bleeding already heated water into the solar storage tanks and gradually raising the temperature of the storage tanks. This was reducing the efficiency of the solar thermal equipment. The solar thermal company noted that when the system was adjusted in August of 2012, they had to compromise between efficiency and tenant comfort due to problems with cold water coming back through the building hot water return loop. The project team provided the solar thermal installer with login information to access the WEL data. Using that data and working with the building superintendent, the solar thermal company confirmed that the system was functioning as designed.

Temperature monitoring data is available for the solar thermal system at Building B.1, however the proportion of contribution to water heating provided by the solar thermal system is not available, as the flow meter was not installed in this monitoring system. The flow meter was to be installed at the time that the WEL logger was installed, but the plumber was not on site when the monitoring equipment consultant was available. The equipment and a diagram were left for the plumber, but once on site, the plumber was concerned that the location of the flow meter would provide the needed data. Another date was arranged for the plumber to meet a project team representative on site to coordinate the installation with phone support from the monitoring equipment company. On the arranged date, the project team representative was on site, but the plumber was not. The plumber was contacted but not able to come on site that day. Several additional attempts were made to coordinate the installation of the flow meter without success.

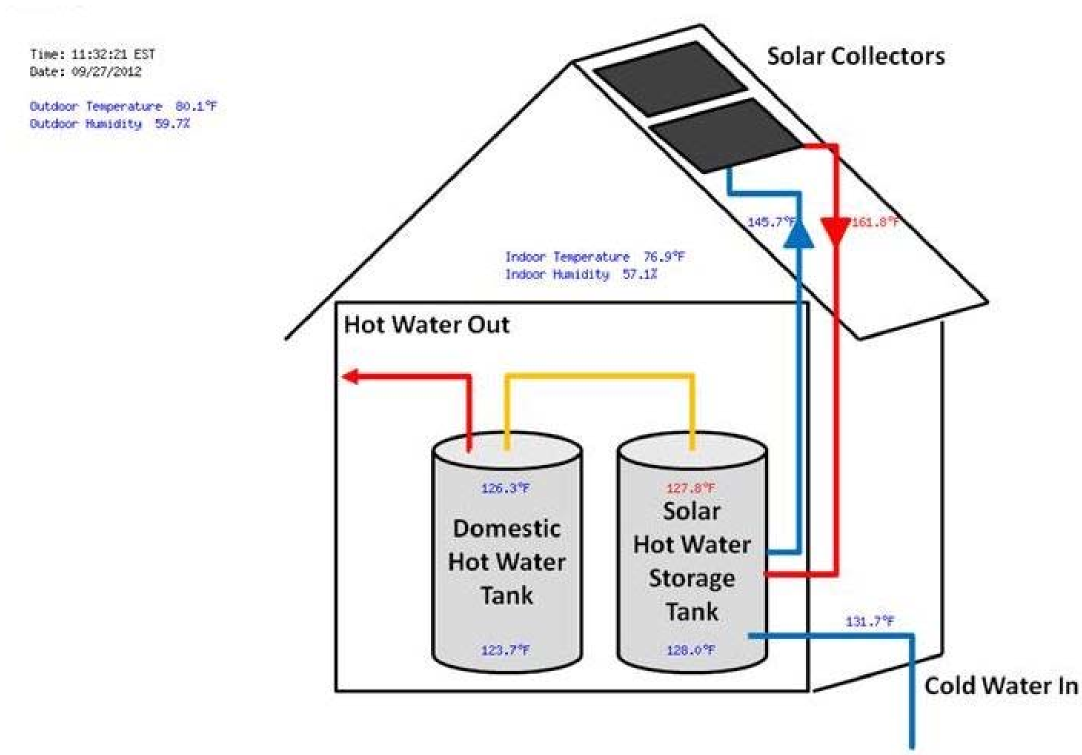


Figure 31: Building B.1 Solar Thermal Monitoring

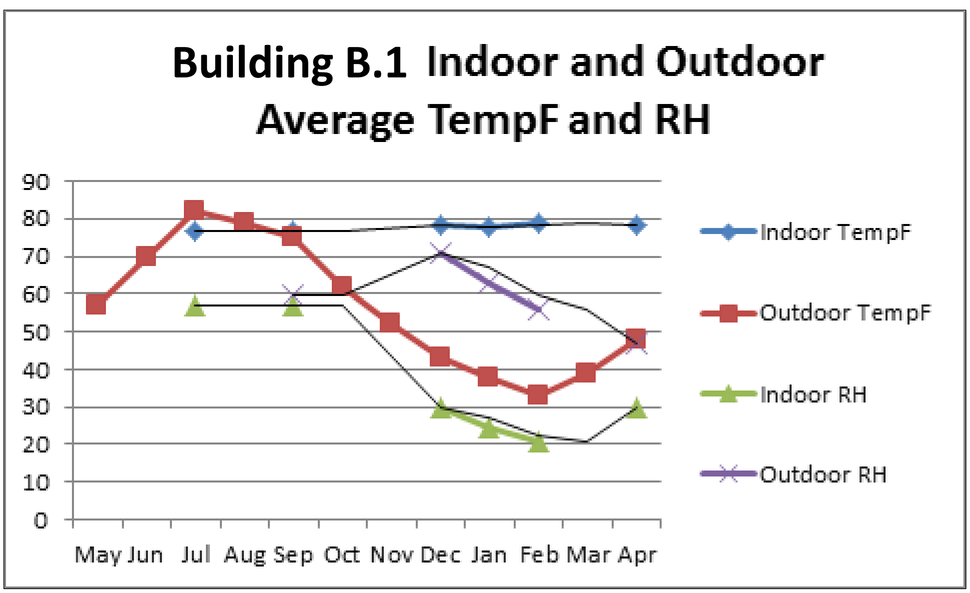


Figure 32: Building B.1 Indoor and Outdoor Average TempF and Relative Humidity

Figure 32 shows the indoor and outdoor temperature and relative humidity for the monitoring period. The indoor temperature and relative humidity shown here are those measured in the Building B.1 building's second floor mechanical room. The mechanical room does not have a dedicated heating and cooling system of its own. These data points are of limited use when considering indoor conditions in the monitored dwellings, but are included to give an overall recording of the building's temperature and relative humidity. Trend lines using a moving average are included for all but the outdoor temperature as data is missing for portions of the monitoring period.

6.9.6 NJCC5

NJCC5 is a ground floor, 675 square foot flat in the multifamily building shown in Figure 30. There are four inhabitants in NJCC5.

The residents of NJCC5 keep the thermostat at 73F during the heating season and 77F during the cooling season.

NJCC5 does not have its own photovoltaic system; rather one serves the common electric loads of the entire building. A central solar hot water system also serves the whole building. NJCC5's annual energy use is shown below.

Table 27: NJCC5 Energy Use

NJCC5	
Annual Utility kWh	1686
Annual Utility PV kWh	Not Applicable
Annual Utility therms	93
Annual MMBTU	15.05
Energy Intensity kBtu/sf	22.49

Table 28: NJCC5 Characteristics

NJCC5 Characteristics		
Category	**Component**	
Size	Home Size	669
HERS Index	HERS Index maximum (before renewables)	49
Envelope	Air Leakage (ACH50)	2.5
HVAC Proper Installation	Ductwork located in conditioned space	100%
	HRV or ERV	HRV
HVAC Equipment	Heating AFUE minimum	95.5%
	Central AC SEER	15
	Motor	ECM
Water Heating System	Water heater EF	.89
	Low-flow faucets and showerheads	low-flow
	Distribution	N/A
Lighting	Energy Star fixtures or bulbs	100%
Renewables	PV or Solar Hot Water Heating	PV & Solar installed
Appliances	Refrigerator must be CEE Tier 3	Tier 3

Annual therms for NJCC5 for June 2012 through May of 2013 are 93. The modeled annual therms for NJCC5 are 59.45.

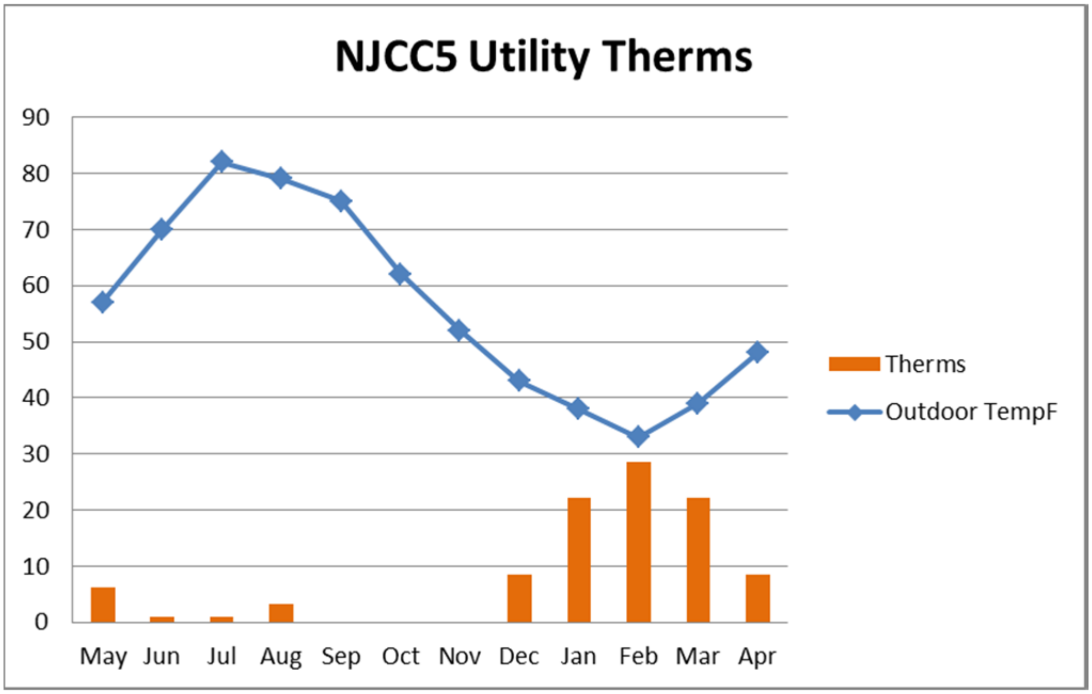


Figure 33: NJCC5 Utility Therms June 2012 - May 2013

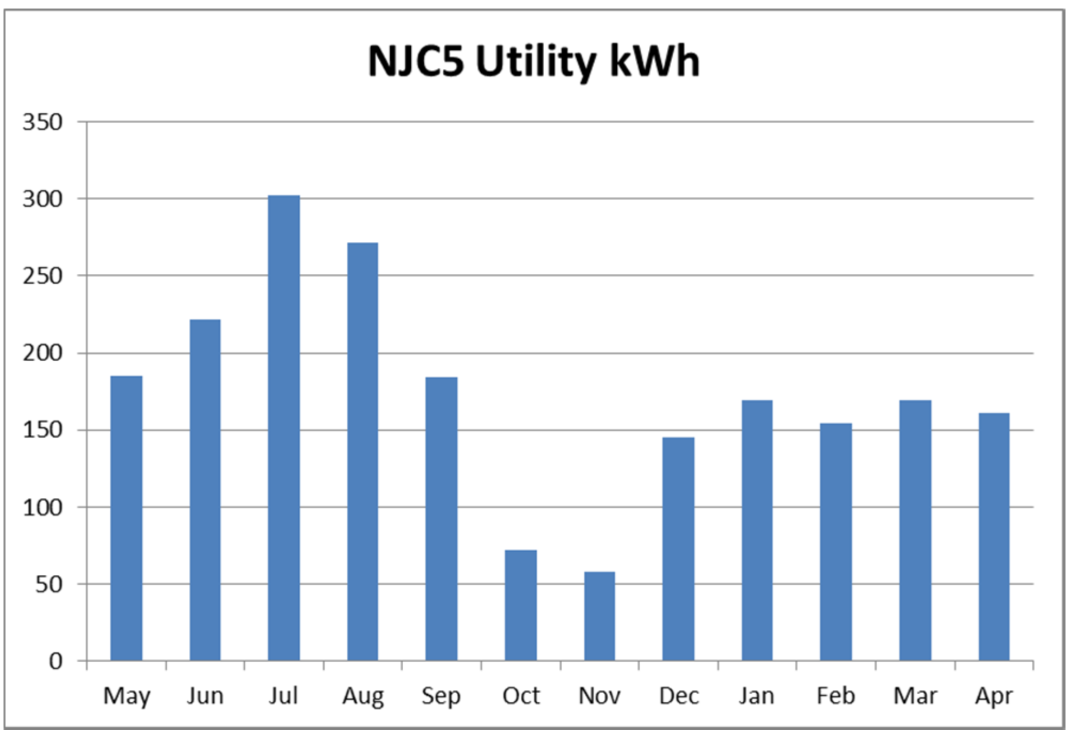


Figure 34: NJCC5 Utility kilowatt-hours June 2012 - May 2013

Annual kilowatt-hours for NJCC5 from May 2012 through June 2013 are 1686. The modeled annual kilowatt-hours for NJCC5 are 2039.

A breakdown of electricity use by circuit is not available, as the internet connectivity needed for data to be uploaded from NJCC5 has not been established. This is discussed further in section 6.5.3.

6.9.7 NJCC6

NJCC6 is a third floor, 857 square foot flat in the multifamily building shown in Figure 30. There are three inhabitants in NJCC6.

The residents of NJCC6 keep the thermostat at 75F year round.

NJCC6 does not have its own photovoltaic system; rather one serves the common electric loads of the entire building. A central solar hot water system also serves the whole building.

NJCC6's annual energy use is shown below in Table 29.

Table 29: NJCC6 Energy Use

NJCC6	
Annual Utility kWh	4123
Annual Utility PV kWh	Not Applicable
Annual Utility therms	143
Annual MMBTU	28.36
Energy Intensity kBtu/sf	33.09

Other than floor area, NJCC6's characteristics are the same as NJCC5. Please refer to Table 28.

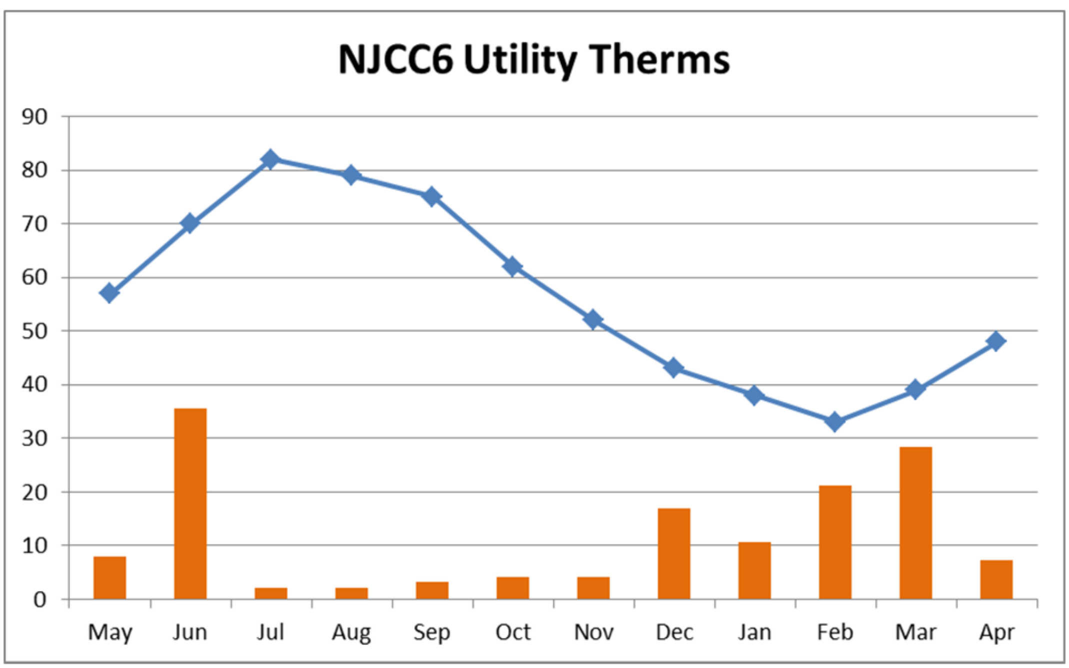


Figure 35: NJCC6 Utility Therms, June 2012 through May 2013

Annual therms for NJCC6 for June 2012 through May of 2013 are 140. The modeled annual therms for NJCC6 are 76.15. Therm use in NJCC6 peaked in June at 36 therms. This seems uncharacteristically high for a cooling season month, but the utility bill does not show this as an estimated amount. The June usage appears to be an anomaly when considering the other months, which show a fairly direct inverse relationship between outdoor temperature and therm use.

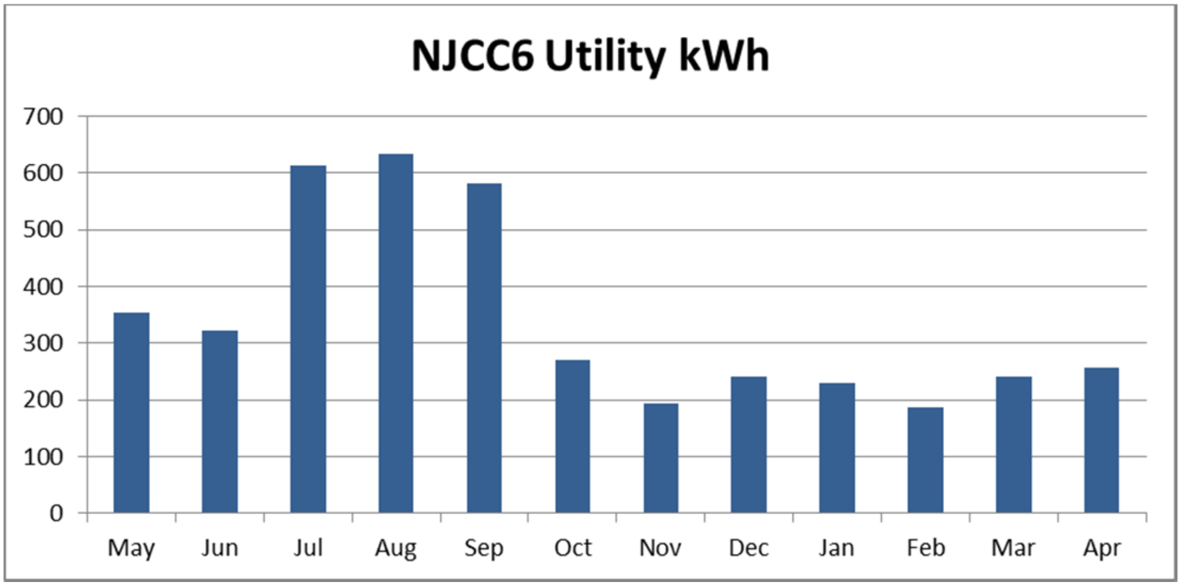


Figure 36: NJCC6 Utility kWh

Annual kilowatt-hours for NJCC6 from May 2012 through April 2013 are 4123. The modeled annual kilowatt-hours for NJCC6 are 1405.

A breakdown of electricity use by circuit is not available, as connectivity, allowing data to be uploaded for NJCC6 has not been established. This is discussed further in section 6.5.3.

6.9.8 NJCC7

NJCC7 is a third floor, 675 square foot flat in the multifamily building shown in Figure 30. There are two inhabitants in NJCC7.

During the heating season, the residents of NJCC7 keep the thermostat at 80F when home during the day and 78F at night. During the cooling season, they keep the home at 75F at all times.

NJCC7 does not have its own photovoltaic system; rather one serves the common electric loads of the entire building. A central solar hot water system also serves the whole building.

NJCC7's annual energy use is shown below.

Table 30: NJCC7 Annual Energy Use

NJCC7	
Annual Utility kWh	3575
Annual Utility PV kWh	Not Applicable
Annual Utility therms	37
Annual MMBTU	15.89
Energy Intensity kBtu/sf	23.54

Other than floor area, NJCC7's characteristics are the same as NJCC5. Please refer to Table 28.

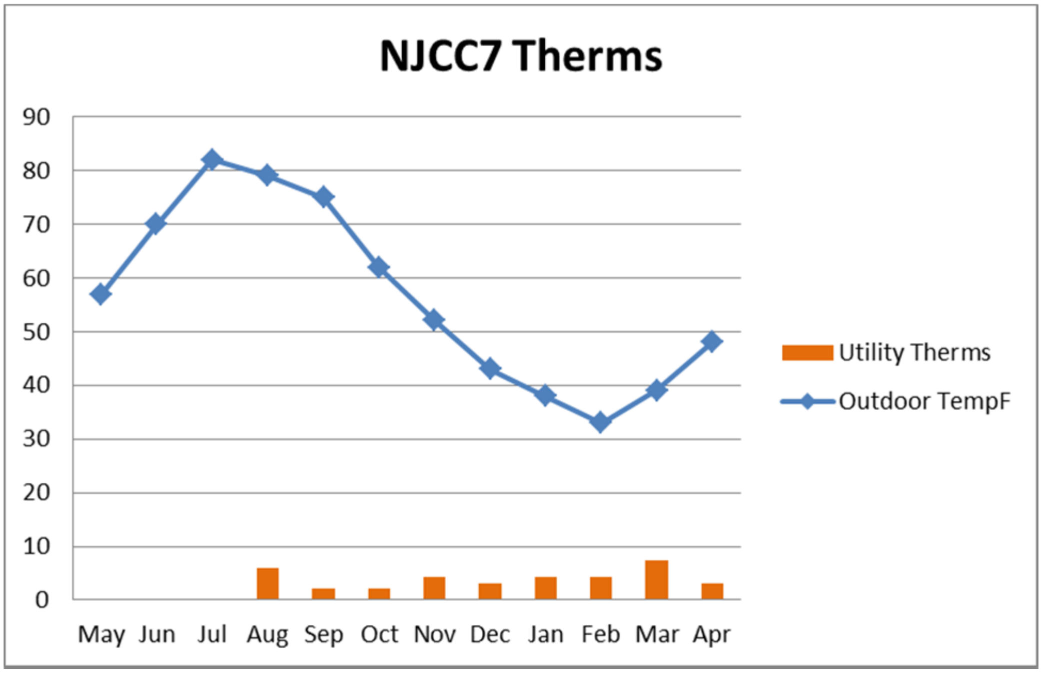


Figure 37: NJCC7 Utility Therms June 2012 through May 2013

Annual therms for NJCC7 for May 2012 through June of 2013 are 37. The modeled annual therms for NJCC7 are 59.98. NJCC7 is among three of the monitored units (NJCC7, NJCC10 and NJCC11) that had lower therm use than predicted by the energy model. In NJCC7, the highest circuit use is for living room outlets and lighting. In NJCC11 the living room outlets and lighting is exceeded only by the refrigerator for electricity use, and even then only by 1%. As such, it may be that the internal gains from lighting, televisions and other electronic devices is reducing the heating load in these units. This is all the more probable when the superior thermal envelope and low infiltration rate of these units is considered, maximizing internal thermal gains. This may also be the case for NJCC10, but the circuit monitoring there is not accurate (see section 6.9.11).

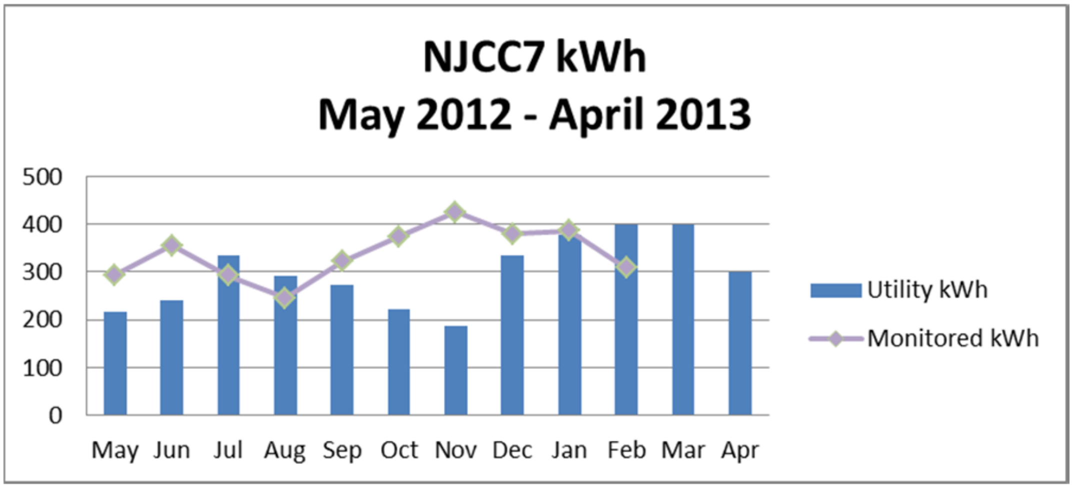


Figure 38: NJCC7 Monitored and Utility kWh

Annual kilowatt-hours for NJCC7 from May 2012 through June 2013 are 3575. The modeled annual kilowatt-hours for NJCC7 are 1106.

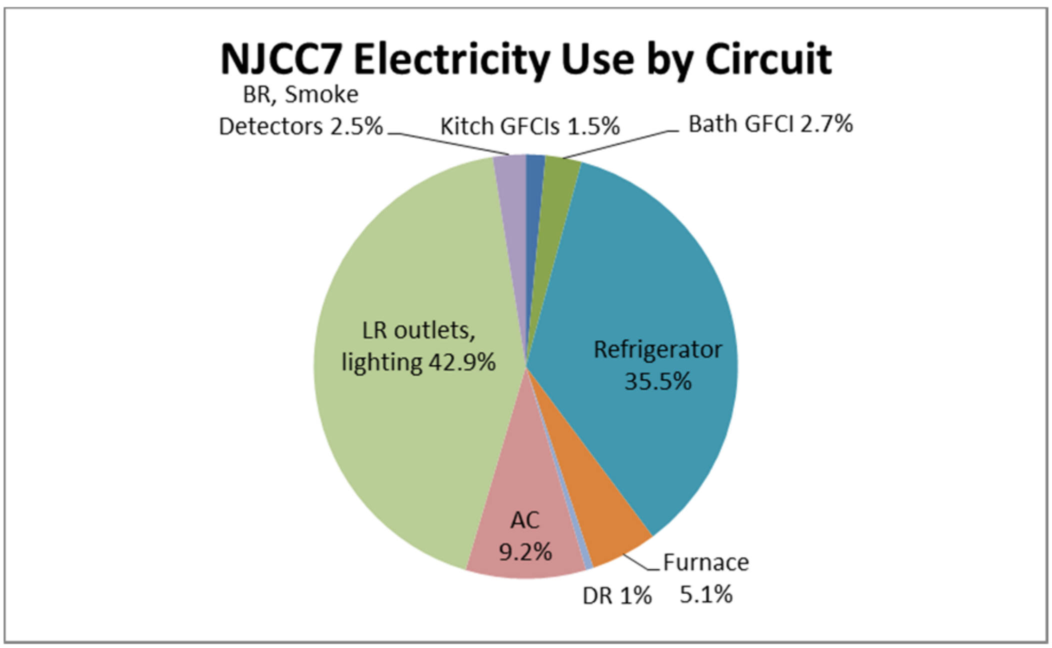


Figure 39: NJCC7 Electricity Use by Circuit

Figure 39 shows the electricity use by circuit for NJCC7. The top three circuits using the most electricity for NJCC7 are:

1. Living room outlets and lighting
2. Refrigerator
3. Air conditioning

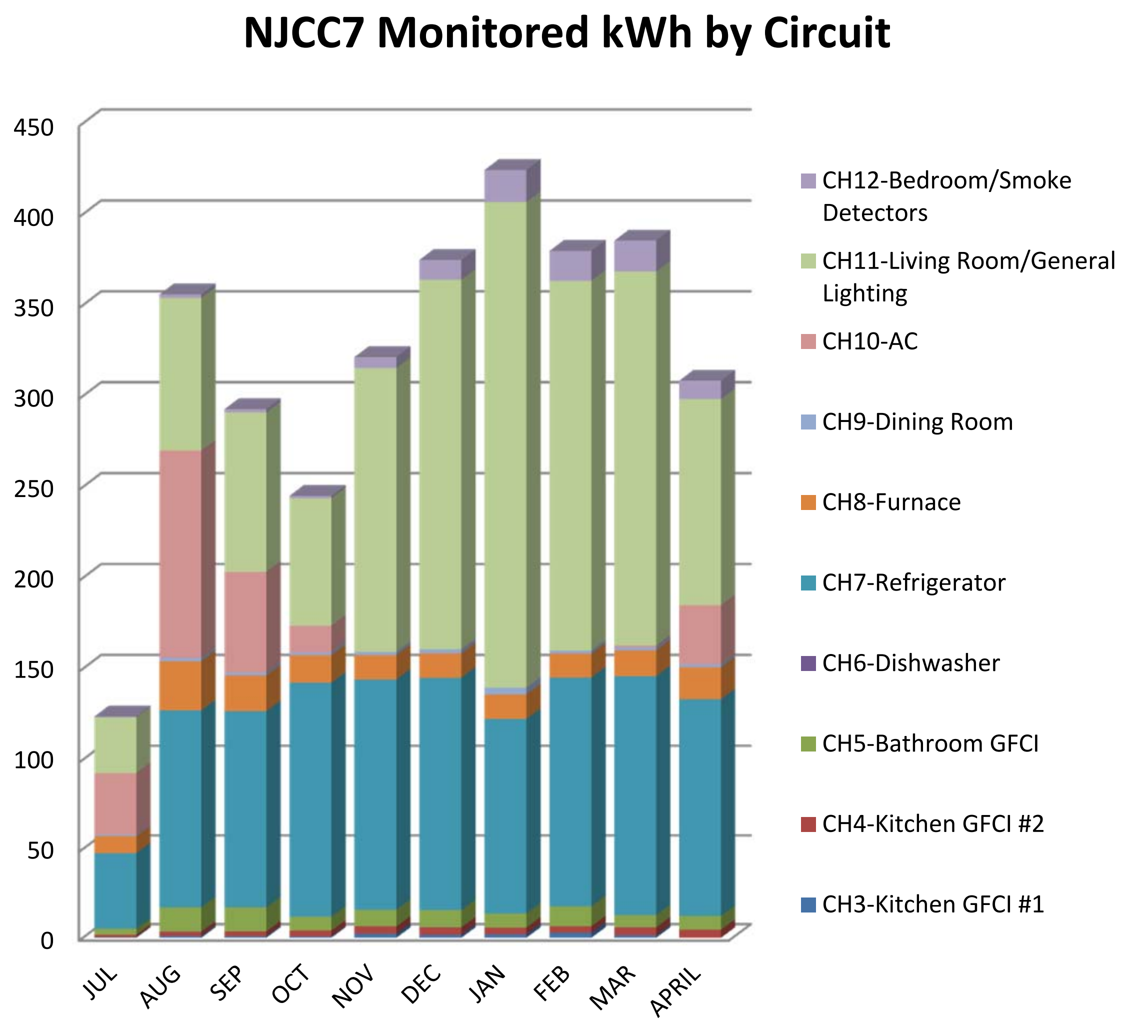


Figure 40: NJCC7 Monitored kWh by Circuit

Figure 40 is based on monitored electricity use and does not correspond well with utility bill data, as shown in Figure 38. However, both data sources do show that peak electricity use is not dominated by air conditioner use in this unit.

6.9.9 NJCC8

NJCC8 is a first floor 675 square foot flat in the multifamily building shown in Figure 30. There are two inhabitants in NJCC8.

The residents of NJCC8 keep the thermostat at 74F during the heating season, and 75 during the heating season while sleeping. They keep the thermostat at 72F during the cooling season

NJCC 8 does not have its own photovoltaic system; rather one serves the common electric loads of the entire building. A central solar hot water system also serves the whole building.

NJCC8's annual energy use is shown below.

Table 31: NJCC8 Annual Energy Use

NJCC8	
Annual Utility kWh	3206
Annual Utility PV kWh	Not Applicable
Annual Utility therms	112
Annual MMBTU	22.13
Energy Intensity kBtu/sf	32.79

Other than floor area, NJCC8's characteristics are the same as NJCC5. Please refer to Table 28.

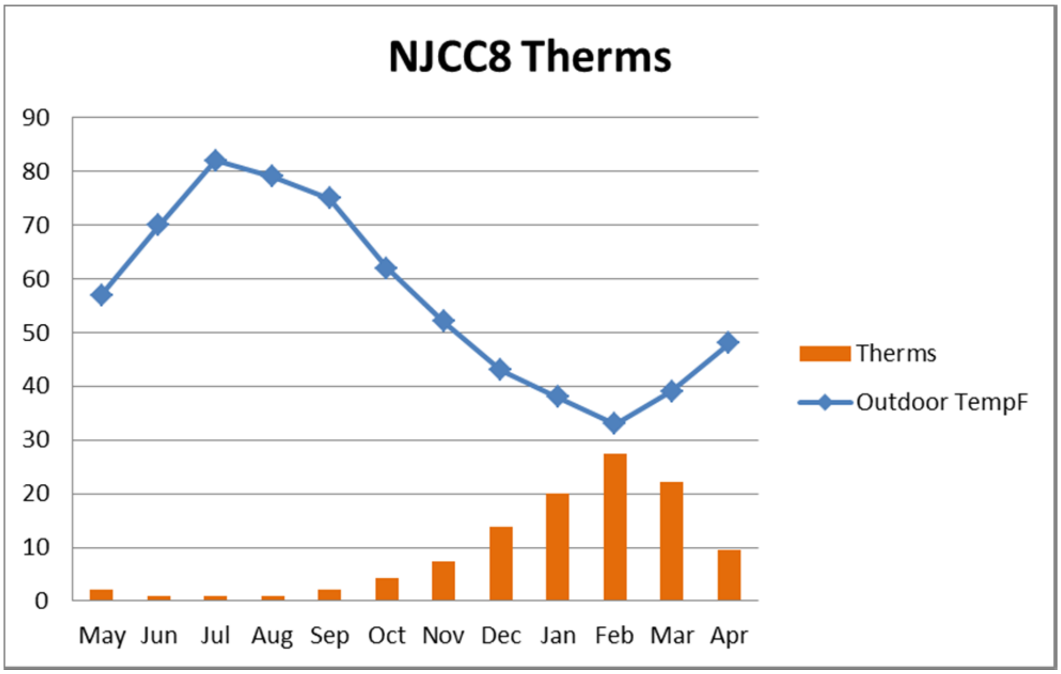


Figure 41: NJCC8 Therms

Annual therms for NJCC8 for May 2012 through April of 2013 are 112. The modeled annual therms for NJCC8 are 60.

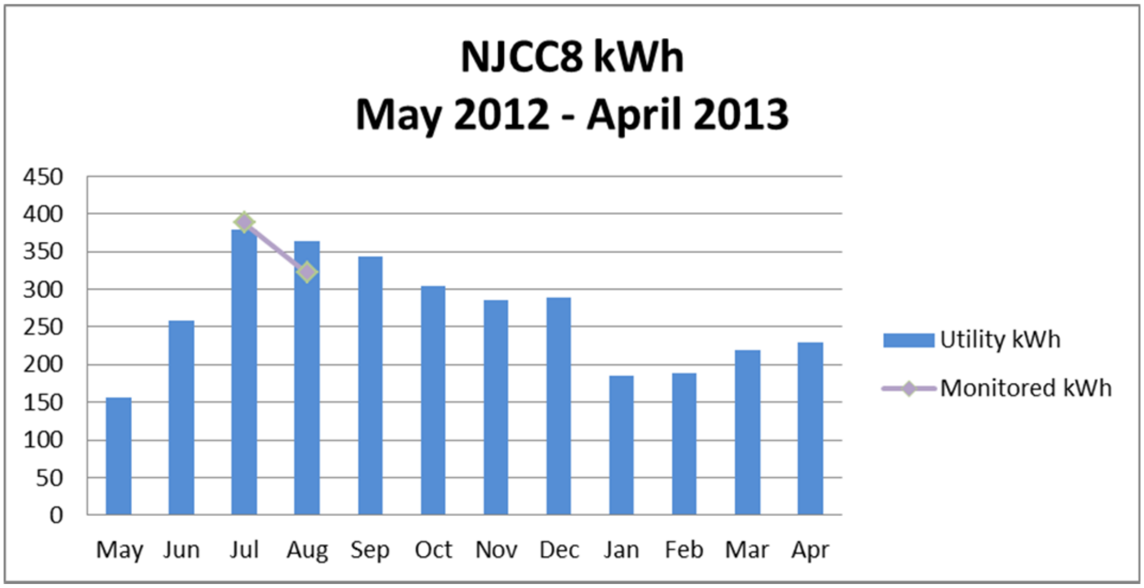


Figure 42: Annual kilowatt-hours for NJCC8 – May 2012 through April 2013

Annual kilowatt-hours for NJCC8 from May 2012 through April 2013 are 3206. The modeled annual kilowatt-hours for NJCC8 are 1106.

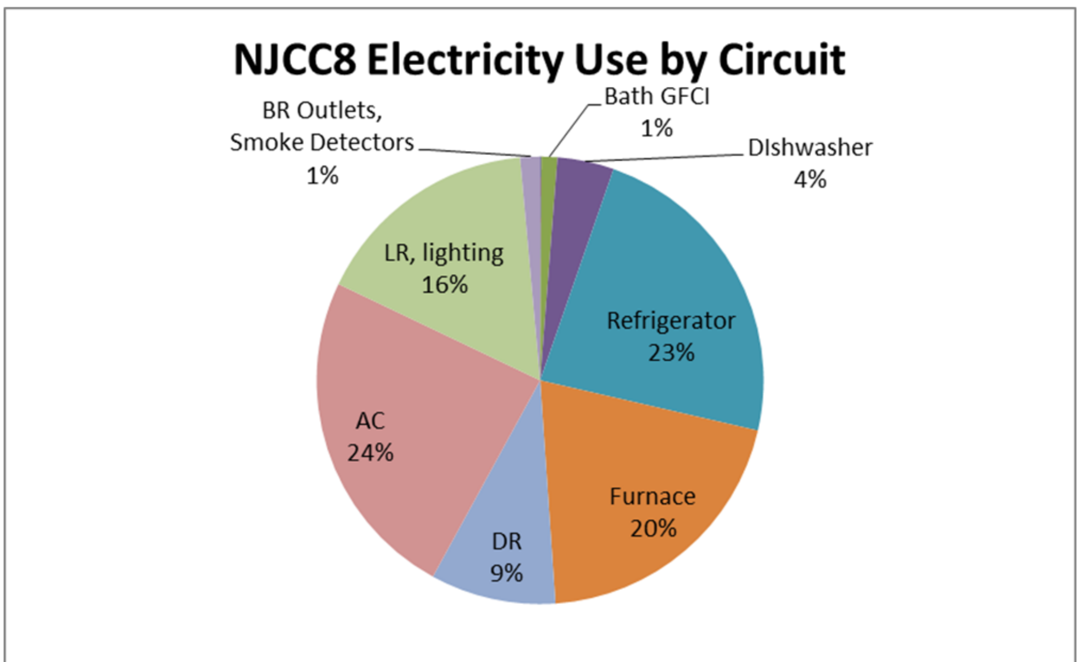


Figure 43: NJCC8 Electricity Use by Circuit[20]

Figure 43 shows the electricity use by circuit for NJCC8. The top three circuits using the most electricity for NJCC8 are:

[20] This chart is based on data from 6/22/12 – 8/27/12; 3/9/13 – 3/21/13; 4/18/2013 – 5-31/13. As such, there is a cooling season bias.

1. Air conditioning
2. Refrigerator
3. Furnace

Note that monitored data for NJCC8 is limited and has a cooling season bias, as shown in Figure 44 below.

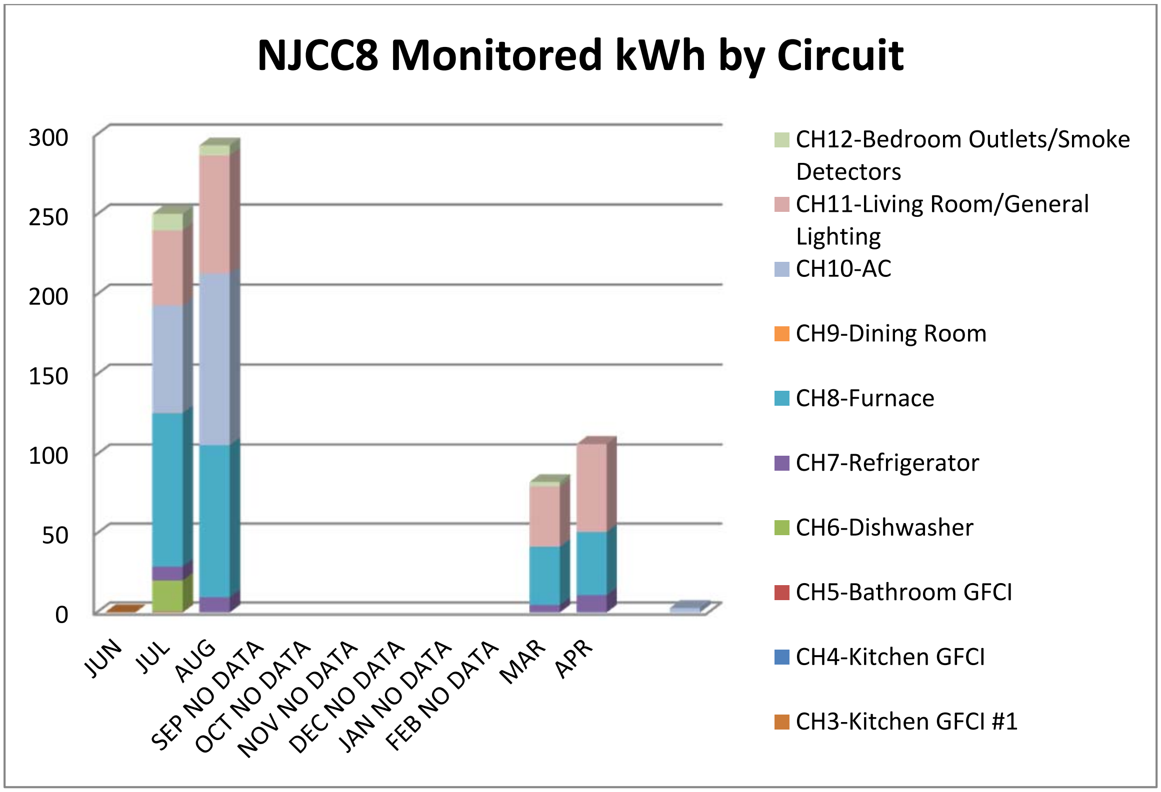


Figure 44: NJCC8 Monitored kWh by Circuit

6.9.10 NJCC9

NJCC9 is a second floor, 1075 square foot flat in the multifamily building shown in Figure 30. There are two inhabitants in NJCC9.

The residents of NJCC9 report keeping their thermostat at 70F at all times.

NJCC 9 does not have its own photovoltaic system; rather one serves the common electric loads of the entire building. A central solar hot water system also serves the whole building. .

NJCC9's annual energy use is shown below.

Table 32: NJCC9 Annual Energy Use

NJCC9	
Annual Utility kWh	4479
Annual Utility PV kWh	Not Applicable
Annual Utility therms	134
Annual MMBTU	28.67
Energy Intensity kBtu/sf	26.67

Other than floor area, NJCC9's characteristics are the same as NJCC5. Please refer to Table 28.

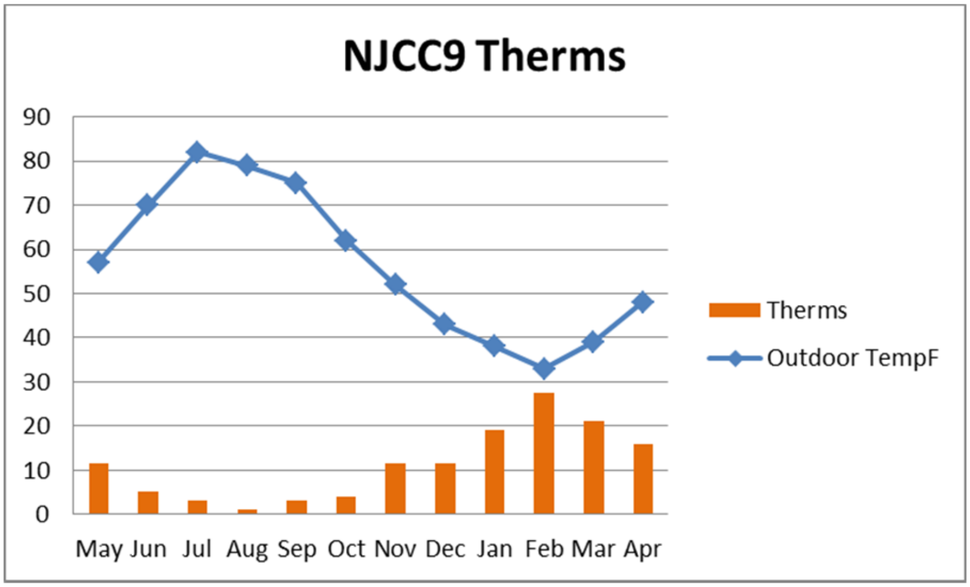


Figure 45: NJCC9 Therms and Outdoor TempF

Annual therms for NJCC9 for May 2012 through April of 2013 are 134. The modeled annual therms for NJCC9 are 96.

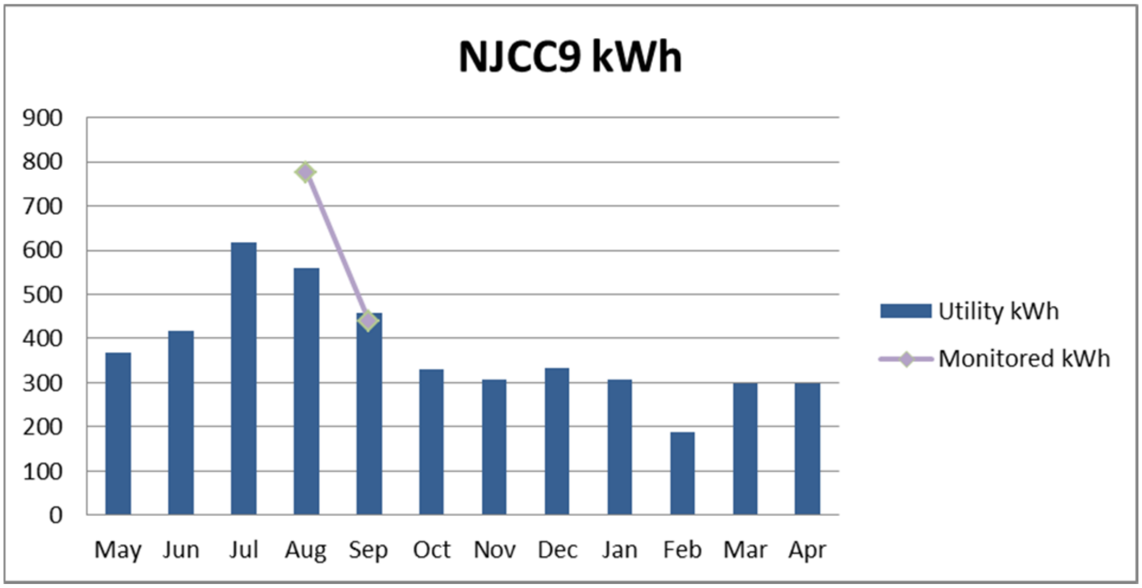


Figure 46: Annual kilowatt-hours for NJCC9 from May 2012 through April 2013

Annual kilowatt-hours for NJCC9 from May 2012 through April 2013 are 4479. The modeled annual kilowatt-hours for NJCC9 are 1762.

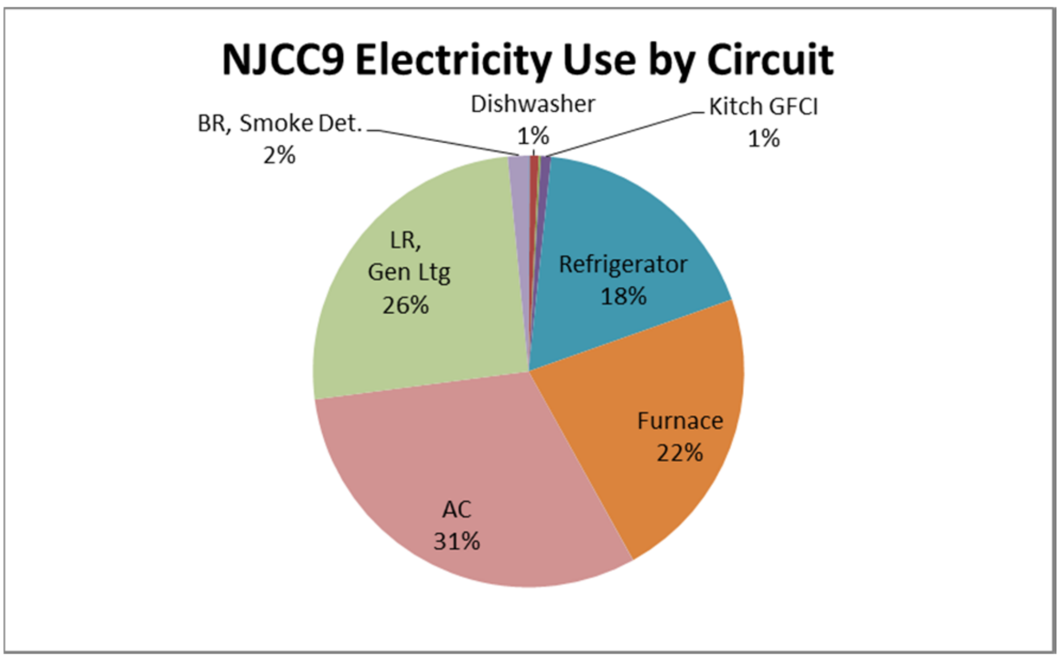


Figure 47: NJCC9 Electricity Use by Circuit[21]

Figure 47 shows the electricity use by circuit for NJCC9. The top three circuits using the most electricity for NJCC9 are:

1. Air conditioning
2. Living room and general lighting

[21] This is based on data from 7/24/12 – 9/26/12; 4/25/13 – 5/2/13, as such there is a cooling season bias.

3. Furnace

As with NJCC8, monitored data for NJCC9 is limited and shows a cooling season bias, as shown in Figure 48.

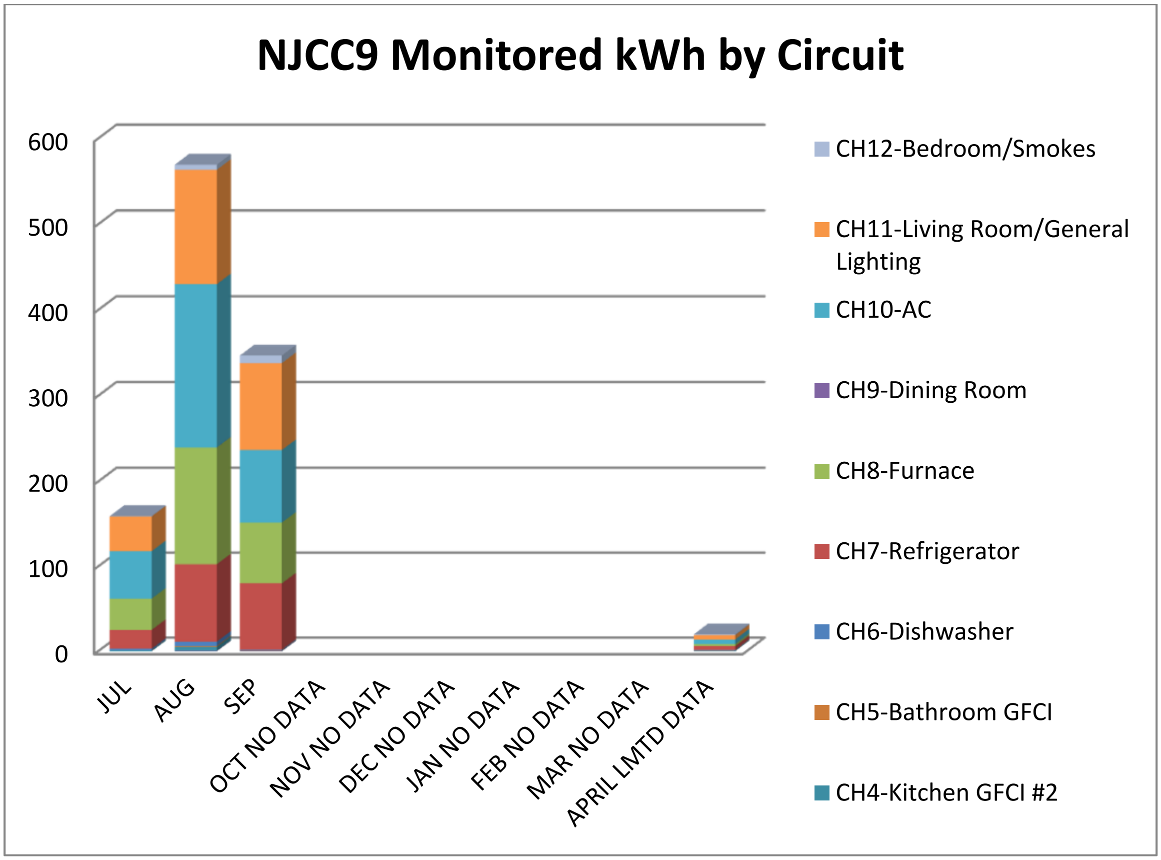


Figure 48: NJCC9 Monitored kWh by Circuit

6.9.11 NJCC10

NJCC10 is a second floor, 669 square foot flat in the multifamily building shown in Figure 30. There are three inhabitants in NJCC10.

The residents of NJCC10 report keeping their thermostat at 72 degrees at all times.

NJCC 10 does not have its own photovoltaic system; rather one serves the common electric loads of the entire building. A central solar hot water system also serves the whole building. .

NJCC10's annual energy use is shown below.

Table 33: NJCC10 Annual Energy Use

NJCC10	
Annual Utility kWh	4825
Annual Utility PV kWh	Not Applicable
Annual Utility therms	35
Annual MMBTU	19.95
Energy Intensity kBtu/sf	29.83

Other than floor area, NJCC10's characteristics are the same as NJCC5. Please refer to Table 28.

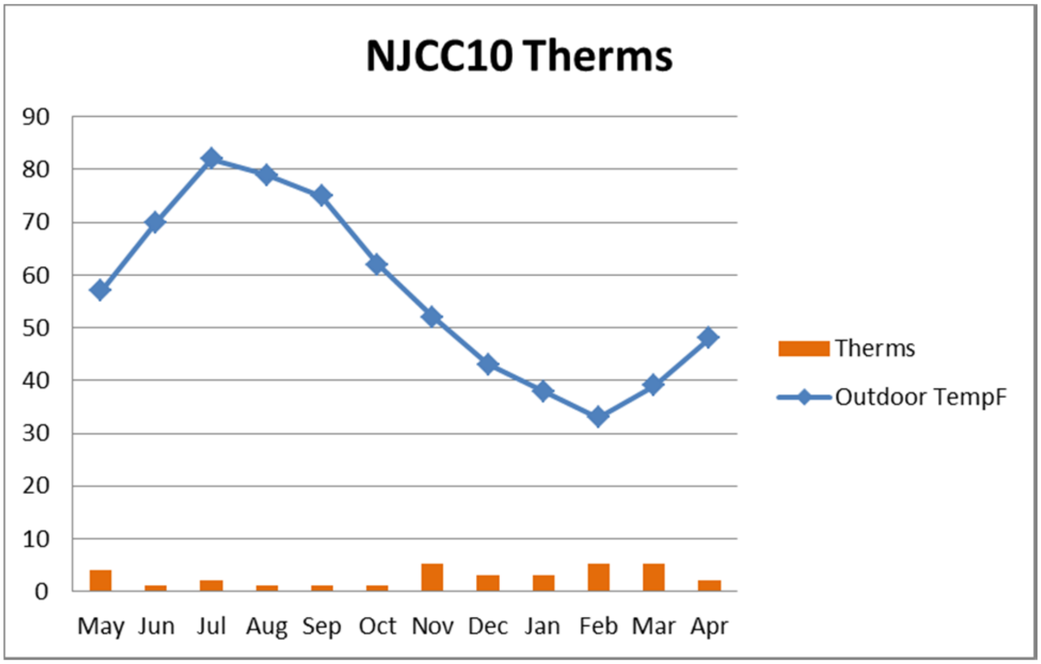


Figure 49: NJCC10 Therms and Outdoor TempF

Annual therms for NJCC10 for June 2012 through May of 2013 are 69. The modeled annual therms for NJCC10 are 59.49.

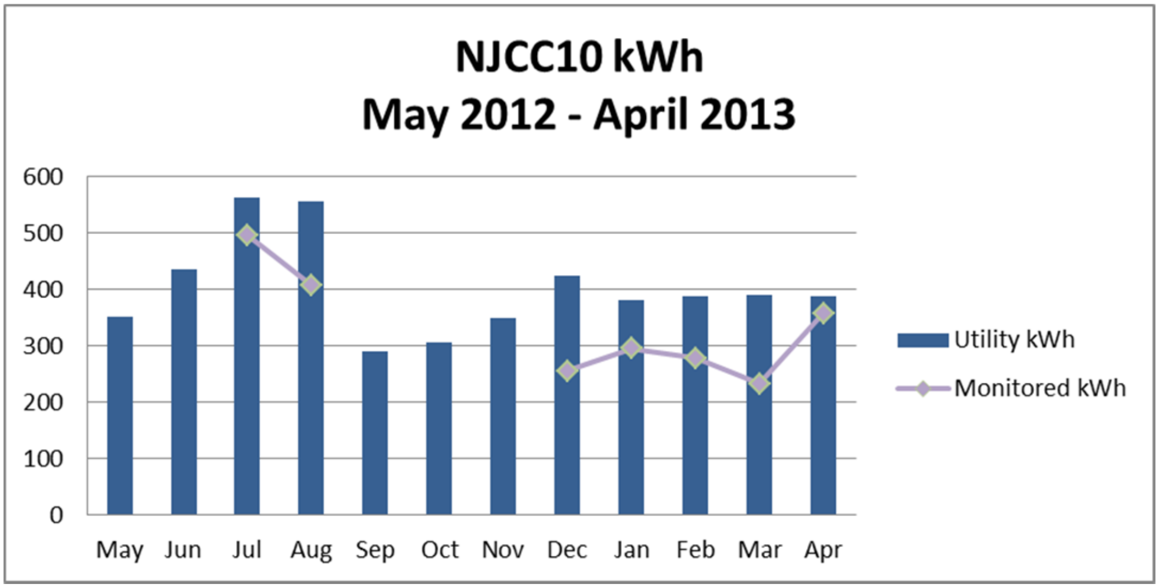


Figure 50: NJCC10 Monitored and Utility kilowatt-hours June 2012 - May 2013

Annual kilowatt-hours for NJCC10 from May 2012 through April 2013 are 4825. The modeled annual kilowatt-hours for NJCC10 are 1096.

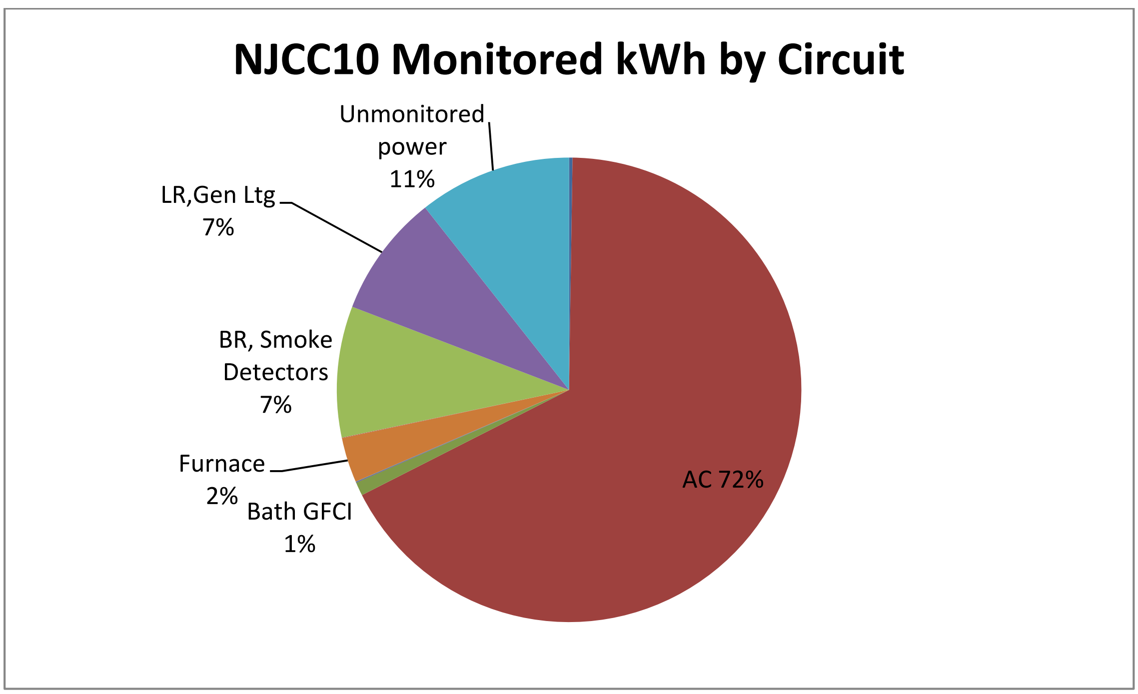


Figure 51: NJCC10 Monitored kWh by Circuit

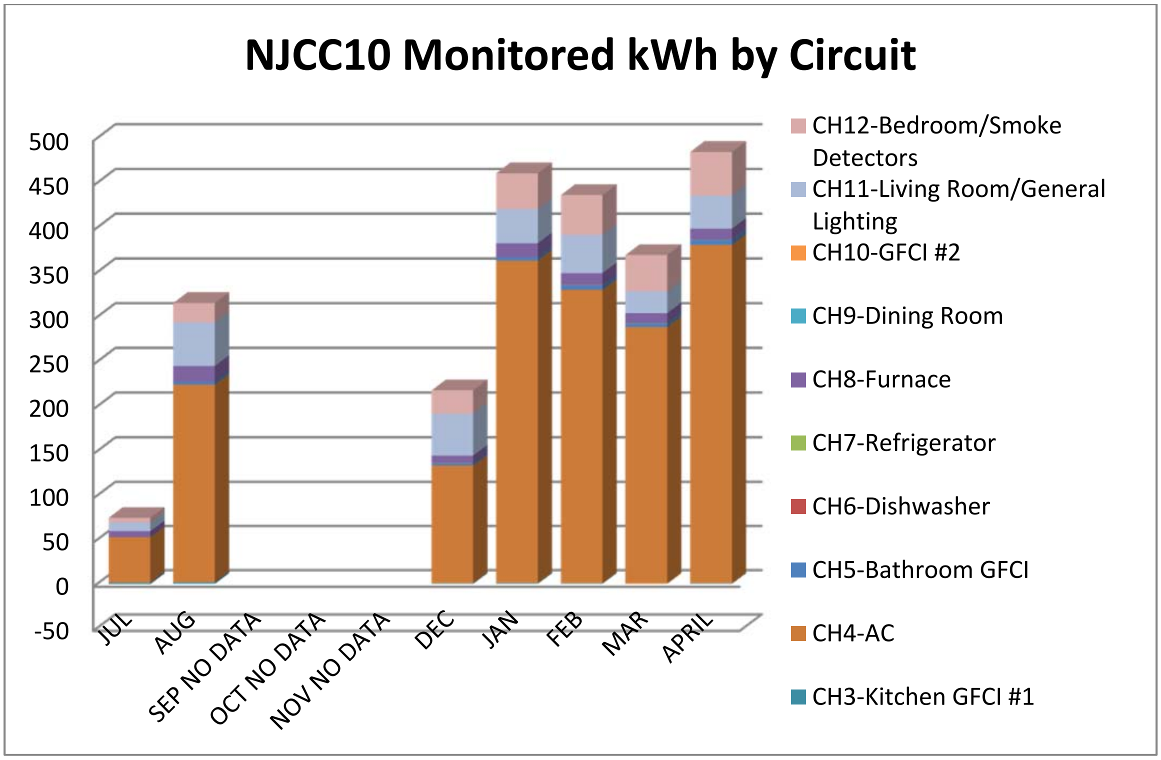


Figure 52: NJCC10 Monitored kWh by Circuit

NJCC10's overall electricity consumption looks comparable to that of the other multifamily units, yet the circuit data is suspect. The air conditioning is often the top electric load in the NJCC units, but the proportion should not be 74%, as shown in Figure 51, and the air conditioning load should not be so high during the heating months, as shown in Figure 52. The research team worked with the eMonitor engineer to troubleshoot the individual circuit readings and verify that the current transformers' (CTs) amperages were accurately entered on the server end (which affects how loads are reported to the eMonitor website). After looking at the data for NJCC10, it was concluded that this unit needs field troubleshooting with an electrician to review the CT installations. This work was not completed because of project timeline limitations.

6.9.12 NJCC11

NJCC11 is a fourth floor, 1075 square foot flat in the multifamily building shown in Figure 30. There are four inhabitants in NJCC11.

The residents of NJCC11 keep the thermostat at 74F during the heating season and 72F during the cooling season.

NJCC 11 does not have its own photovoltaic system; rather one serves the common electric loads of the entire building. A central solar hot water system also serves the whole building. .

NJCC11's annual energy use is shown below.

Table 34: NJC11 Annual Energy Use

NJCC11	
Annual Utility kWh	4776
Annual Utility PV kWh	Not Applicable
Annual Utility therms	51
Annual MMBTU	21.39
Energy Intensity kBtu/sf	19.89

NJCC11 had the lowest energy use intensity of all the multifamily units. This despite this unit being on the top floor of the building, causing it to have a greater heating and cooling load than other units in the building.

Other than floor area, NJCC11's characteristics are the same as NJCC5. Please refer to Table 28.

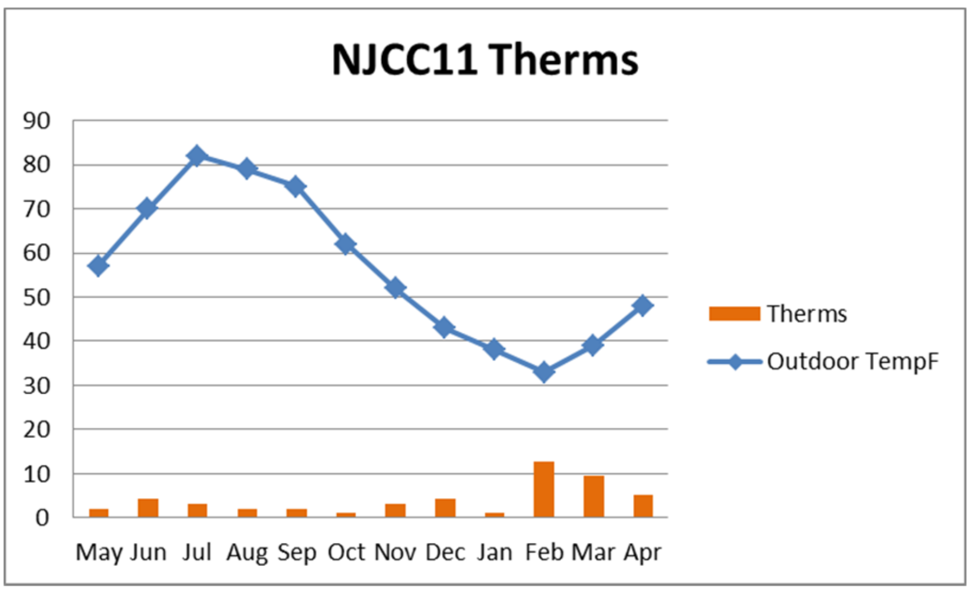


Figure 53: NJCC11 Utility Therms June 2012 - May 2013

Annual therms for NJCC11 for May 2012 through April of 2013 are 51. The modeled annual therms for NJCC11 are 96.

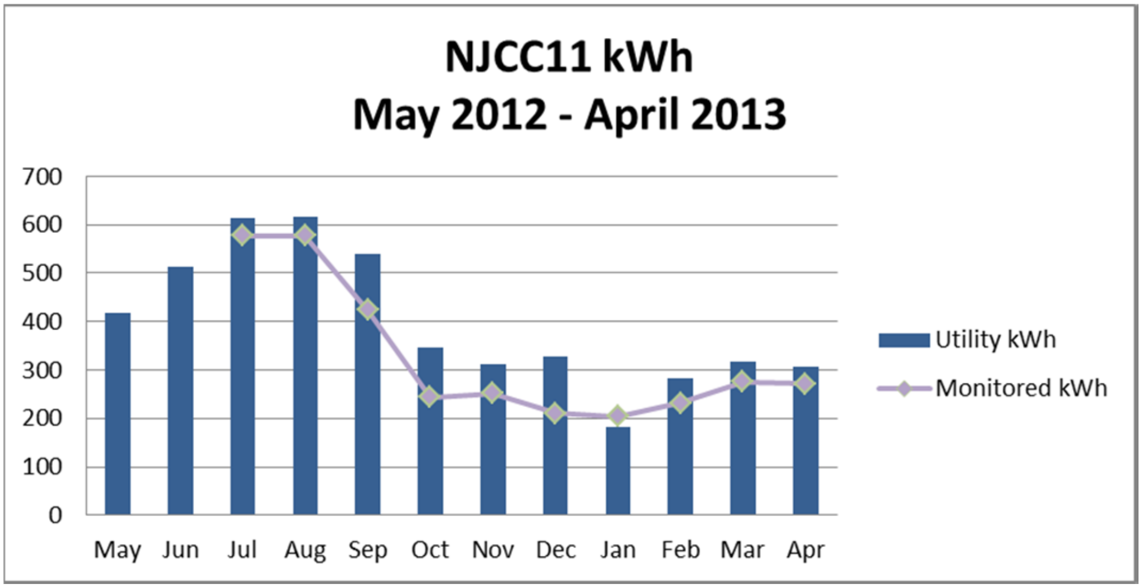


Figure 54: NJCC11 Monitored and Utility kWh June 2012 through May 2013

Annual kilowatt-hours for NJCC11 from June 2012 through May 2013 are 4776. The modeled annual kilowatt-hours for NJCC11 are 1762.

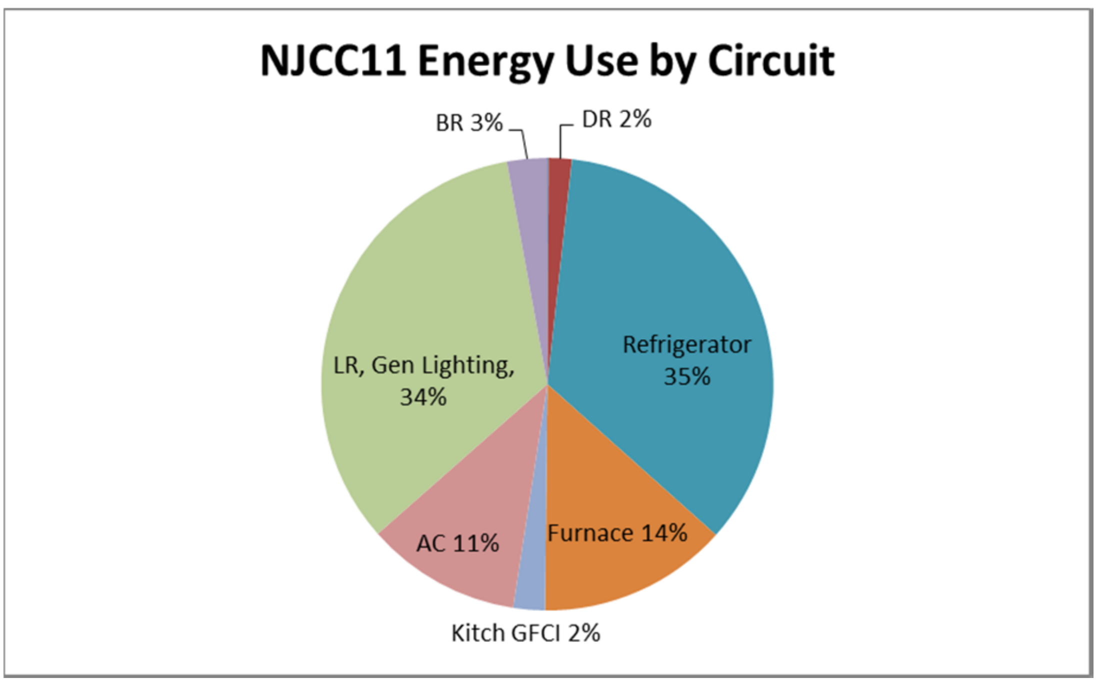


Figure 55: NJCC11 Energy Use by Circuit

Figure 55 shows the electricity use by circuit for NJCC11. The top three circuits using the most electricity for NJCC11 are:

1. Refrigerator
2. Living room and general lighting
3. Furnace

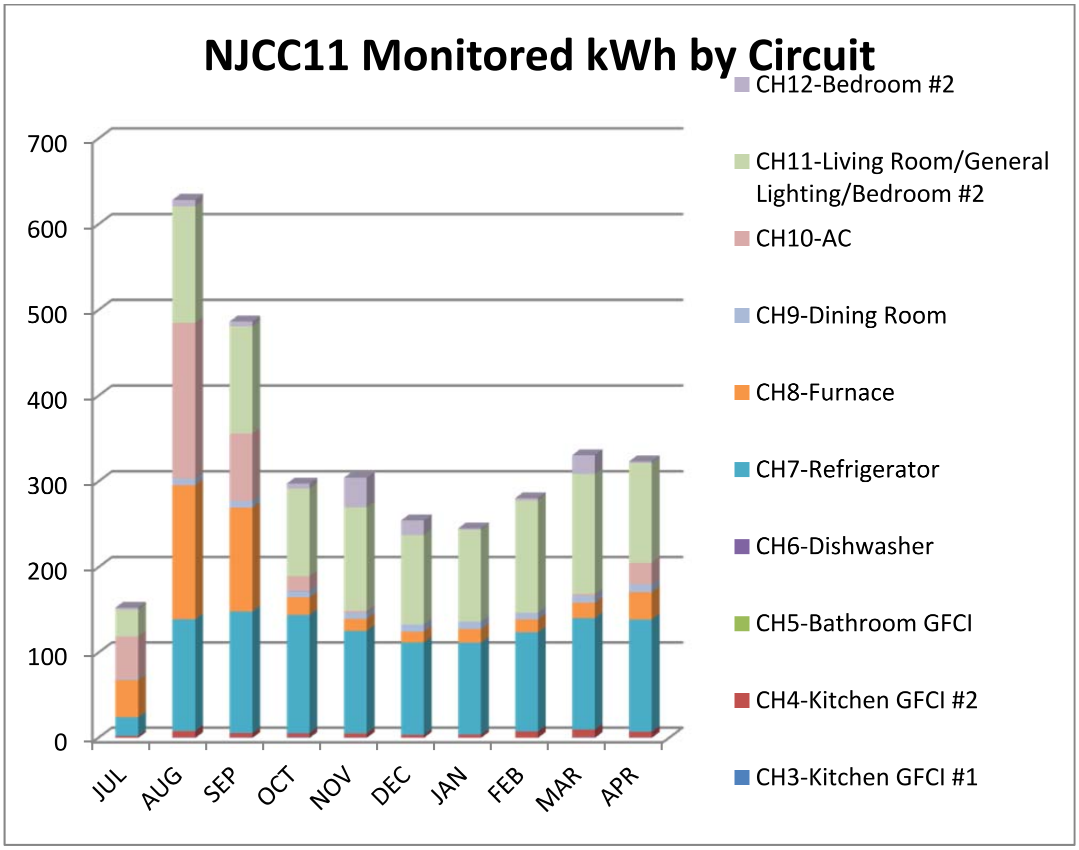


Figure 56: NJCC11 Monitored kWh by Circuit

6.10 Summary of Environmental and Energy Monitoring Results

Homes designed and built to NJCC technical requirements have the potential to save energy, but how they are operated determines whether targeted savings are achieved. The energy use of 11 homes in the NJCC program was tracked to see how they actually performed compared to a) energy models of the homes as built to the technical requirement and b) the same homes built to NJ's current energy code (IECC 2009). We did find differences between modeled and actual performance, although this finding is offered with the caveat that the purpose of energy modeling is to compare a structure to itself with different design options, not to reliably predict the future.

Further, this project found that in high performance homes, miscellaneous electric loads (MELs)—electric loads that do not fit into typical energy use categories (space conditioning, domestic hot water, ventilation, major appliances, and lighting)—become a bigger portion of total energy use. As noted by the National Renewable Energy Laboratory (NREL), "MELs present special challenges because their purchase and operation are largely under the control of the occupants. If no steps are taken to address MELs, they can constitute 40%-50% of the remaining source energy use in homes that achieve 60-70% whole house energy savings, and this percentage is likely to increase in the future as home electronics become even more sophisticated and their use becomes more widespread." (Hendron & Eastment, 2006). NREL notes that 14% of a home's typical energy use goes to MELs. In a high performance home (with 54% whole house savings) MELs account for 32% of total energy use, and the findings from this research are consistent with those results.

6.11 Overall Findings from Environmental and Energy Monitoring

DESIGN/CONSTRUCTION/MAINTENANCE ISSUES

- Energy models of the NJCC homes had thermostat-setting limitations that could not reflect actual thermostat settings in some units.
- Initially, the NJCC air tightness requirement was difficult for participating developers to achieve.[22]
- Renewable systems in NJCC homes (photovoltaics and solar hot water systems) require careful commissioning to ensure systems are operating as designed.
- When monitoring revealed potential issues with renewable systems and or HVAC equipment, it was sometimes difficult for developers and residents to follow up on the information. Finding the right professional to check that equipment is running optimally can be challenging.

MONITORING ISSUES

- When monitoring electric loads in multifamily buildings, monitoring equipment that requires internet connectivity will perform most reliably with hard-wired connections.
- When monitoring electric loads at the panel, clear guidance is needed on electrical panel wiring. If possible, on-site observation during panel wiring can help ensure that the panel is wired as intended for load isolation.

RESIDENT ISSUES

- Energy use data in the NJCC units suggests that resident education is an important component for the optimal performance of NJ Climate Choice Homes.
    - Anecdotal conversations with residents by the monitoring team revealed that residents typically were not aware that they were living in housing designed to be very energy efficient.
    - Survey responses show that most residents kept their thermostat at the same setting at all times. One resident was not able to say what temperature their thermostat was set to, as they did not know how to use their programmable thermostat.

6.12 Findings Related to Performance of Participating Units

- All of the NJCC homes used less energy than the average home in New Jersey.
- All of the NJCC homes used more energy than predicted by the energy model, but all used less energy than the code compliant modeled home.
- In the multifamily flats (NJCC5 – NJCC11) natural gas usage was much closer to the predicted consumption than the electricity use.

[22] After struggling with the air sealing requirement on their first NJCC home, Developer A was able to meet the air sealing requirement prior to installing gypsum on their second round of Climate Choice Homes.

- NJCC3, a 1741sf townhouse had the lowest energy use intensity at 7.4 kBtu/sf/yr. NJCC3 benefitted from the load reduction of a 2.86 kW photovoltaic array. The second lowest energy use intensity among the monitored units was NJCC11, at 19.89 kBtu/sf/yr. NJCC11 is one of the seven monitored multifamily flats. These flats do not have the load reduction benefit of a PV array, as the array on their building feeds common area electric loads, not individual unit loads. NJCC1, a 1567sf single family detached home, had the highest energy use intensity among the eleven monitored NJCC units at 51.9 kBtu/sf/yr.

6.13 Recommendations from Environmental and Energy Monitoring

DESIGN/CONSTRUCTION/MAINTENANCE ISSUES

Provide program participants with additional guidance on air sealing measures. Resources available through ENERGY STAR, Home Performance with ENERGY STAR, and the Weatherization Assistance Program (WAP) are a good starting point. However, both of the participating developers are ENERGY STAR developers and still had difficulty meeting the air tightness requirement on some of their units. This suggests that more guidance is needed.

RESIDENT ISSUES

Provide resident education on the different components of a high performance home and their optimal operation. Include leave behind reference material or develop mini tutorials accessed on the NJCEP website. Address the impact of increased electronics use in the home and the impact that has on energy use through complementary NJCEP programs. Include vacancy sensor lighting and smart power strips in the next version of technical requirements to bring down electric loads.

7 LIFECYCLE COSTING TOOL

7.1 Introduction

A comprehensive life cycle costing (LCC) tool was developed to analyze energy life cycle performance in a sample of the NJCC homes. LCC analysis is an engineering economics instrument used to examine the total operating costs associated with a building from its construction to its end of life. This comprehensive assessment not only incorporates the initial building costs, but the lifespan operating costs as well, so that a more complete picture of the total overall cost can be obtained.[23]

The LCC analysis used actual construction costs from participating developers as a foundation for incremental price forecasting. The building energy performance was evaluated under multiple scenarios where energy savings was calculated by subtracting NJCC Energy Use minus Baseline Energy Use. The scenarios use REM/Rate software modeled projections for energy consumption and generation (from PV and solar thermal) and compare baseline code compliant homes (IECC 2009) to NJCC homes. These results are compared to actual energy usage values for the buildings that have been occupied in order to validate the model.

A main component of the LCC is the analysis of the Net Present Value, or NPV. Net Present Value refers to the total present value of the lifetime costs associated with a particular project, accounting for the difference between the present value of cash inflows and present value of cash outflows. This measure is used to assess the attractiveness of an investment or project, taking into account rates of return and variability in utility rates. NPV analysis aids in understanding the relationship between monetary investment in the present and the expected returns that will be received in the future.

Another component of the LCC is simple payback, which is a complementary metric by which to assess investments in energy efficiency. It considers the initial investment costs and the resulting annual cash flow to determine the amount of time required to recover the initial costs. Simple payback does not account for the time value of money. Aside from the environmental benefits of energy consumption reduction, the expected results should indicate that a decrease in the operational costs over a building's lifetime will help mitigate any higher up-front costs associated with energy-efficient buildings. NPV and simple payback are both used by investors to determine the economic viability of a particular project and both metrics are used in this LCC analysis.

The LCC therefore helps to determine the feasibility of energy efficient features from an economic standpoint, given alternative market conditions and public policies. In the context of high performance homes, the LCC can be a powerful tool since it demonstrates the cost-effectiveness and worthiness of the initial investment in energy-efficient techniques and features for residential buildings.

Three buildings in Northern New Jersey were completed and analyzed through the LCC model. The first building was a single-family home – Building A.1- constructed by nonprofit developer (Developer A).

[23] End of life demolition costs are not included.

The second type of home examined – Building A.2 – was also built by nonprofit developer (Developer A). The building is divided into five single-family attached townhomes and was completed in 2012. These townhomes are working to obtain LEED certification.

The third and largest building assessed is Building B.1, built by Developer B and also located in Northern New Jersey. Building B.1 is a multi-family residential building consisting of 70 affordable rental units spanning 86,414 square feet. The building uses energy efficiency features like drought-tolerant landscaping and high-efficiency heating and cooling to achieve LEED and Climate Choice certification.

7.2 Development of the Life Cycle Cost (LCC) Model

In order to perform the LCC analysis, a modeling tool was developed in Microsoft Excel. The Excel workbook is separated into nine tabs, only some of which require input from the user. The images displayed in this section of the report are screenshots from one of the Building B.1 LCC runs.

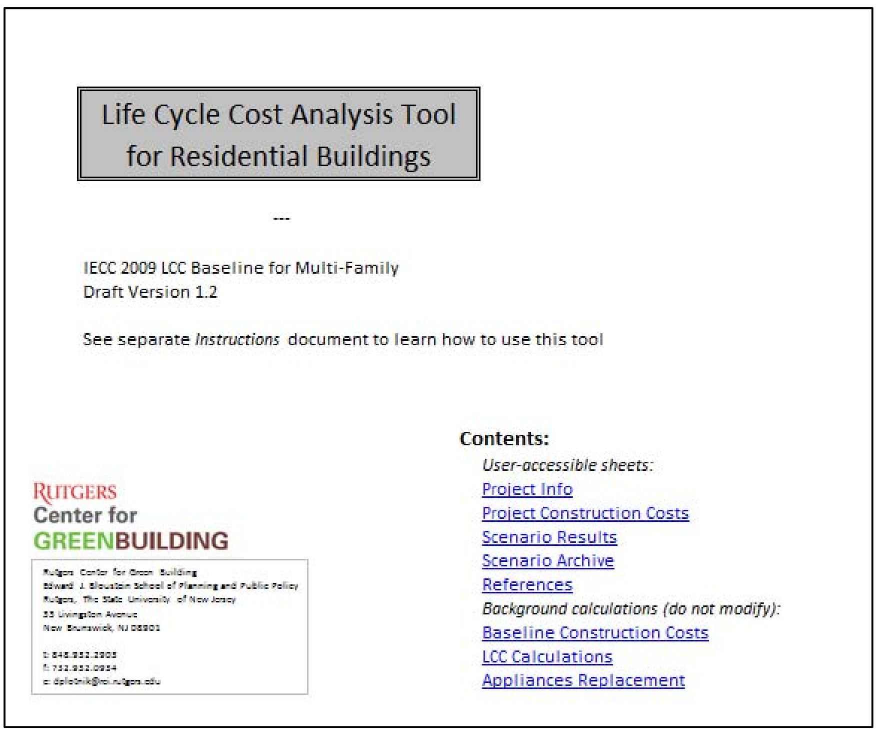
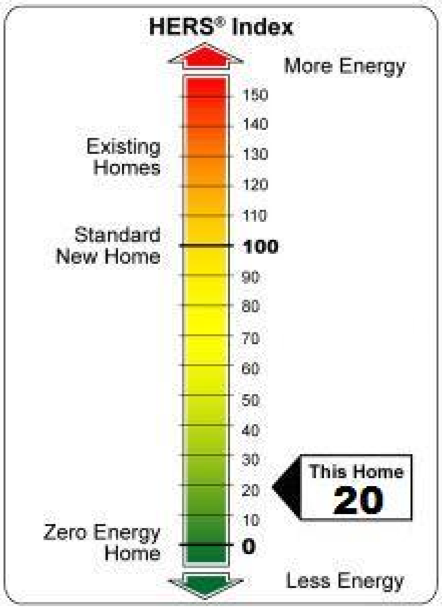


Figure 57: Cover

The first worksheet (Figure 57) is the 'Cover' sheet for the model type and contains a link to each of the other tabs. Second comes the worksheet titled, 'Project Info', which allows the user to enter general background information about the building. The square footage, for example, is entered here for use in the model.

BUILDING CONFIGURATIONS IN THE LCC



This study was conducted using four different configurations for each building modeled.

First, the "as-built" configuration refers to the cost for the building in the present, real-life configuration.

Second, the "baseline" configuration includes costs associated with a building without any of the energy efficient measures installed within the as-built building. These buildings are compliant with the 2009 IECC code and do not contain energy efficient features which would bring their HERS index down towards the required 50 for the New Jersey Climate Choice Homes program.

The third configuration studied was a 50 HERS index without renewables. This configuration was needed because the HERS Index operates upon the principle that a home or building built to code scores a 100. Any 1% reduction in energy usage results in a one (1) point lower score. As is required of a Climate Choice building, the minimum fifty (50) HERS index required reflects a 50% reduction of energy costs compared to a baseline building. Even after the research team removed the energy efficiency features from each building model, the building still performed below HERS 50 due to the renewable features. Therefore, this third configuration was created to remove the renewable energy features and come as close to the HERS 50 as possible.

However, the use of renewable energy is a requirement for the Climate Choice Home program. Thus, a fourth configuration was modeled for each building – the Climate Choice Home. This configuration included the renewable energy source that was removed from the HERS 50 configuration but continued to include some of the scaled back energy efficient features from the HERS 50 configuration. This building configuration represents a home that just meets the technical requirements of the program—including renewables—and goes no further. It also provides a data point between the as-built configuration and the HERS 50 configuration.

To summarize, the following four configurations were modeled for each of the homes assessed in this study:

- As-Built: Home as constructed with renewable energy and energy efficient features, often more efficient than the minimum required for NJCC program
- Baseline: 2009 IECC Code minimum building, same size and materials as as-built
- HERS 50: As-built without renewable energy along with scaled back energy efficiency measures, aiming for HERS rating of 50
- Climate Choice Home: As-built with renewable energy while scaling back on energy efficiency measures (such as lower performance insulation or windows) in order to come as close as possible the minimum accepted HERS rating of 50 for NJCC program

Table 35 below details the HERS ratings for each of the modeled buildings.

Table 35: HERS Index Rating of Modeled Energy Configurations

Configuration	Building A.1	Building A.2	Building B.1
As Built	31	41	36
Climate Choice Home	40	43	40
HERS 50	53	46	48
Baseline	77	80	79

CONSTRUCTION COSTS

Building Size (Sq. Ft.) 86414

		Building Capital Cost Inputs									
		(Option 1)				(Option 2)		(Option 3)			
Building Feature	Description (Material type, design, model #, etc.)	Qty.	Unit of Measure	Unit Cost Material	Unit Cost Labor	Total Cost Material	Total Cost Labor	Item Total	Baseline Cost	Incremental Cost	Scenario Cost
INSULATION											
Foundation walls, between conditioned space and:	(Thickness, Wall Construction, Interior or Exterior)										
ambient, material 1	R-0, 10" thick, 2' above grade, 9' below grade, 10.3'x11', solid poured concrete	113.30	SF					$0.00	$0.00		
ambient, material 2	R-0, 10" thick, 6' above grade, 5' below grade, 10.3'x11', solid poured concrete, didn't use block	113.30	SF					$0.00	$0.00		
other			SF					$0.00	$0.00		
garage	Foundation on grade concrete slab 18" Deep Outside Wall Thickness, cavity filled with cellulose & 1" UR spray foam, U=0.016, 16675 sq ft	16675.00	SF	$3.49				$58,195.75	$33,516.75		
crawl space			SF					$0.00	$0.00		
unconditioned basement			SF					$0.00	$0.00		
other conditioned unit (adiabatic)			SF					$0.00	$0.00		
Foundation walls, between unconditioned basement and:	(Thickness, Wall Construction, Interior or Exterior)										
ambient			SF					$0.00	$0.00		
garage			SF					$0.00	$0.00		
crawl space			SF					$0.00	$0.00		
Slab area	(Perimeter, Depth Below Grade)										
perimeter		504.00	SF	$6.40				$3,225.60	$917.28		
under slab			SF					$0.00	$0.00		
Frame floors, between conditioned space and:	(Thickness Conditioned or Unconditioned?)										
ambient			SF					$0.00	$0.00		
garage			SF					$0.00	$0.00		
crawl space			SF					$0.00	$0.00		
basement	R-19 batts, hallway - sound deadenign material, no spray		SF					$0.00	$0.00		
Joists, between conditioned space and:	(Joist Details, Spacing)										
ambient	R-12 cavity, R-10 continuous, thickness 5.5", grade I, 16" spacing, 690 sq ft	690.00	SF	$9.51				$6,561.90	$5,071.50		
garage			SF					$0.00	$0.00		
attic			SF					$0.00	$0.00		
crawl space			SF					$0.00	$0.00		
unconditioned basement			SF					$0.00	$0.00		
other conditioned unit (adiabatic)			SF					$0.00	$0.00		
Joists, between unconditioned basement and:	(Joist Details, Spacing)										
ambient			SF					$0.00	$0.00		

Figure 58: Project Construction Costs

The 'Project Construction Costs' worksheet (Figure 58) requires the acquisition of detailed cost information on energy features. The spreadsheet has a Description column for the builder to provide a short description of the materials used in the building, such as dimensions and material type. This is followed by associated construction costs. For the sake of this analysis, cost information can be provided three different ways:

1. The builder can provide a full Bill of Materials used in construction including quantity of material, material cost, and labor cost. This is the most accurate method of obtaining costs. However, builders often cannot provide all the information at once, so this method is the most difficult to complete.
2. If quantity of a particular item is unknown, but the total material and labor costs are known for that item, the builder can provide costs in this manner.
3. If the builder only has available lump sum costs for an entire aspect of the building, i.e. insulation or windows, that lump sum cost can be entered and individual item costs will not be broken down by material and labor.

The spreadsheet was designed to be flexible for the three methods of cost input so as not to duplicate effort or provide an inaccurate cost. Items which are not applicable to the energy efficiency state of a building are left blank. Labor rates are assumed to follow standard union structure. If non-union labor is used, Options 2 or 3 can be used to enter costs. The specific definitions of each of the cost categories and the items contained in each are described in detail in Appendix D. The user is also asked to provide any rebates or other incentives that can be applied to the building's end cost.

Table **36** below details the monetary incentives that have been distributed for each of the homes in the Climate Choice Home program.

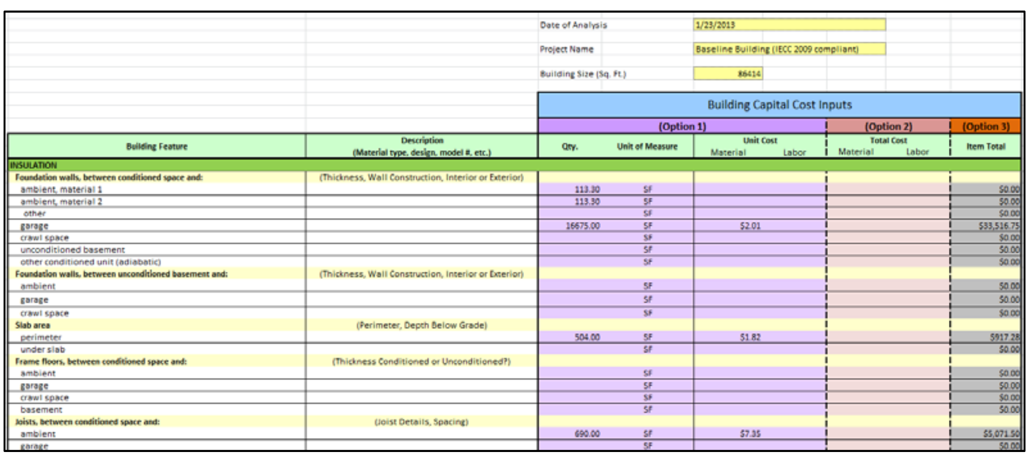
Table 36: Incentives Paid to Climate Choice Home buildings

BUILDING	INCENTIVE
Building A.1	$15,000
Building A.2	$20,000
Building B.1	$392,000

For each of the buildings analyzed in this study, the builder provided as-built construction costs. Given the lack of detail in some of the price break-downs, the costs provided were not adequate to extrapolate from them to a baseline "2009 IECC code" equivalent building. As a result, the project team developed a detailed itemization of project construction costs for the as-built and the baseline utilizing RSMeans[24] as a basis of cost estimation, along with engineering experience and judgment. At this point, an initial LCC run was produced using this RSMeans estimate for as-built costs versus RSMeans baseline costs.

The ratio of baseline costs to as-built costs as estimated by the project team in this first run was then applied to the as-built costs as provided by the builder. This formed the basis of the second LCC run, and its results are provided in the Results and Discussion section of this report as it presents the most realistic analysis for the Climate Choice program.

A third and fourth iteration of the LCC were conducted for each building in the HERS 50 and Climate Choice Home configurations described earlier, providing a calculation of the building while only incorporating certain features required to meet minimum energy performance of the program, in order to construct a cost curve for each of the buildings.



		Date of Analysis		1/23/2013				
		Project Name		Baseline Building (IECC 2009 compliant)				
		Building Size (Sq. Ft.)		86414				
		Building Capital Cost Inputs						
		(Option 1)				(Option 2)		(Option 3)
Building Feature	Description (Material type, design, model #, etc.)	Qty.	Unit of Measure	Unit Cost Material	Unit Cost Labor	Total Cost Material	Total Cost Labor	Item Total
INSULATION								
Foundation walls, between conditioned space and:	(Thickness, Wall Construction, Interior or Exterior)							
ambient, material 1		113.30	SF					$0.00
ambient, material 2		113.30	SF					$0.00
other			SF					$0.00
garage		16675.00	SF	$2.01				$33,516.75
crawl space			SF					$0.00
unconditioned basement			SF					$0.00
other conditioned unit (adiabatic)			SF					$0.00
Foundation walls, between unconditioned basement and:	(Thickness, Wall Construction, Interior or Exterior)							
ambient			SF					$0.00
garage			SF					$0.00
crawl space			SF					$0.00
Slab area	(Perimeter, Depth Below Grade)							
perimeter		504.00	SF	$1.82				$917.28
under slab			SF					$0.00
Frame floors, between conditioned space and:	(Thickness Conditioned or Unconditioned?)							
ambient			SF					$0.00
garage			SF					$0.00
crawl space			SF					$0.00
basement			SF					$0.00
Joists, between conditioned space and:	(Joist Details, Spacing)							
ambient		690.00	SF	$7.35				$5,071.50
garage			SF					$0.00

Figure 59: 'Baseline Construction Costs'

24 RSMeansOnline: http://www.rsmeansonline.com/

In addition to as-built construction costs, the baseline construction costs are also needed for the tool. These are found in the worksheet titled 'Baseline Construction Costs' (Figure 53). The worksheet is set up almost identically to the 'Project Construction Costs' worksheet. As previously mentioned, this baseline building is intended to represent the as-built building, save for the substitution of energy efficient upgrades with materials and methods consistent with the IECC 2009 code. These costs were determined by first creating an energy model with IECC standard materials and insulation R-values. These materials were then estimated for cost using the same quantities as the as-built building with RSMeans as a basis, using engineering judgment where necessary.

LCC Inputs

Step #	Assumptions	Unit	Value
1	**Annual Discount Rate**	%	0.05
2	**Investment Horizon**	yrs	15
3	**Current Utility Prices**		
	Electricity	$/kWh	0.18836
	Natural Gas	$/therm	1.5372
	Solar Renewable Energy Credit	$/kWh	0.075
4	**Energy Price Escalation Rates**		
	Electricity	%/yr	-0.02
	Natural Gas	%/yr	0.023
	Solar Renewable Energy Credit	%/yr	0.006198
5	**Building Size**	SF	86414
6	**Total Rebates Applied**	$	392000
		*(incl service charges)	

Step #	Energy Consumption and Generation	Baseline	As-Built
7	**Annual Electricity Consumed (kWh)**		
	Heating	14730	0
	Cooling	89489	0
	Lights & Appliances	124930	196254
	Total	229149	196254
	/SF	2.652	2.271
	Total, relative to baseline	N/A	-32895
	/SF, relative to baseline	N/A	-0.381
8	**Annual Natural Gas Consumed (therms)**		
	Heating	6553	6151
	Water Heating	5542	0
	Lights & Appliances	4281	0
	Total	16376	6151
	/SF	0.190	0.071
	Total, relative to baseline	N/A	-10225
	/SF, relative to baseline	N/A	-$0.12
	Annual Electricity Produced (kWh)		
9	Total	0.01	82981
	/SF	0.00000012	0.96
10	**Approximate Annual Plug Load (W / sq. ft.)**		

	Baseline	As-Built
Annual Natural Gas Consumed (KwH)	479953	180275
Annual Operating Costs	68335.69	24567.84
Annual Operating Costs (per sq. ft.)	0.791	0.284
Annual Net Energy Consumed (kWh)	709102	293548

You may enter or change data in the yellow cells. White cells are automatically calculated and may not be changed.

To save the results of a scenario calculation for future reference, select the boxes above, copy them, then paste only their values (via Paste Special) into the Scenario Archive worksheet.

Attention!
Cells with white backgrounds must be filled out by user.
Cells with grey backgrounds should be changed only by advanced users.

Proceed via step numbers in column B.

For current SREC values see: http://srectrade.com/srec_prices.php

Make sure square footage was entered on "Project Info" tab

Figure 60: Project Construction Costs - LCC Inputs

OPERATING COSTS

Operating costs are the other key element of the Life Cycle Cost analysis. They are modeled using the information that appears in the LCC Inputs table in the same worksheet (Tab 2: 'Project Construction Costs'). Using total construction costs over an investment horizon of the user's choice, the costs of the building are compared against a baseline building with similar physical characteristics. Energy price escalation rates are extrapolated from US Department of Energy Annual Energy data for electricity, natural gas, and solar renewable energy credits. The user can edit these escalation rates should one choose to try alternative scenarios. For the analysis of each of the buildings, an annual discount rate of 5% was used to reflect the approximate cost of capital in the current retail mortgage market for a typical homebuyer. The investment horizon for the building was initially determined to be 30 years, although this is easily modified within the LCC tool. The current utility prices for electricity and natural gas were entered, and the solar renewable energy credit price was determined by the current NJ SREC market price.[25] Building size is pulled from the 'Project Info' worksheet in the model and total rebates applied are pulled from the user input above.

[25] NJ Solar Renewable Energy Credits: http://srectrade.com/srec_prices.php. In New Jersey, Solar

ADDITIONAL LCC TOOL INPUTS

Two approaches can be used to compare energy consumption and generation. For this initial life cycle analysis of each of the buildings, projected consumption based on the energy model (REM/Design) software was utilized. With the acquisition of utility bills from the occupied units, an approach that utilized actual user consumption provided a second economic result for each of the buildings. The consumption of electricity and natural gas were modeled in REM/Rate and were then subsequently broken down by square foot and relative to the baseline building. Electricity produced by photovoltaic panels, if installed at the building, can also be extracted from the energy model. Approximate annual plug load for the building can be input, but this was not included in this initial cost analysis.

ANALYSIS AND RESULTS

The LCC tool calculates total annual operating costs and on a square foot basis as well as annual net energy consumed (in kilowatt-hours). This approach was expected to result in more favorable results than those using actual utility and monitoring data, since industry standard energy models do not usually accurately model the intricacies of energy system and user habits, especially for brand new homes.

Renewable Energy Credits (SRECs) are paid to photovoltaic users in addition to the savings from offset of utility power.

Net Present Value Calculations

Lifetime (yrs)	15	15		
Annual discount rate	0.05	0.05		
	Current Price	Units	Escalation (annual increase)	
Electricity	0.18836	$/kWh	-0.02	includes delivery surcharges
Natural Gas	1.5372	$/therm	0.023	includes delivery surcharges
Solar Renewable Energy Credit	0.075	$/kWh	0.006198	

Scenarios	1 Design Case	2 Baseline Case
Square Footage	86414	86414
Initial Cost ($)	2474458.57	1542418.56
Rebates and Incentives	392000.00	
Initial Cost after Rebates and Incentives	2082458.57	1542418.56
Initial Cost/Sq. Ft.	28.63	17.85
Intitial Cost/ Sq. Ft after Rebates	24.10	17.85
Initial Cost ($) relative to scaled baseline	932040.01	0.00
Initial Rel. Cost/Sq. Ft.	10.79	0.00
Initial Rel. Cost/Sq.Ft. after Rebates	6.25	0.00
Net Electricity Used (kWh/yr)	196254	229149
Net Elec. Used/Sq.Ft.	2.271090333	2.651757817
Natural Gas Used (therm/yr)	6151	16376
Nat. Gas Used/Sq.Ft.	0.071180596	0.18950633
Annual Energy Produced		
Solar kWh Produced (kWh/yr)	82981	0.01
Net Present Value (NPV)	-2856489.584	-2246731.453
NPV relative to baseline	-609758.1304	0
NPV/Sq.Ft.	-33.05586576	-25.99962336
NPV/Sq.Ft. relative to baseline	-7.056242396	0
Net Present Value (NPV) after Rebates	-2464489.584	-2246731.453
NPV relative to baseline after Rebates	217758.1304	0
NPV/Sq.Ft. after Rebates	-28.51956377	-25.99962336
NPV/Sq.Ft. relative to baseline after Rebates	2.519940408	0

Discrete NPV

Year	0	1	2	3	4	5	6	7	
Year within lifetime? (1=yes, 0=no)	1	1	1	1	1	1	1	1	
Scaled Baseline Case									
Expenses									
Initial cost	1542418.56								
Electricity	0	42299.25553	41453.27042	40624.21	39811.72	39015.49	38235.18	37470.47	36721.
Natural Gas	0	25752.17051	26344.47043	26950.39	27570.25	28204.37	28853.07	29516.69	30195.
Recurring Capital Expenses (HVAC)		749.7525	1353.52875	1090.374	879.135	709.7123	572.7965	511.9527	511.95
Total Undiscounted Expenses	1542418.558	68801.17853	69151.26959	68664.97	68261.11	67929.57	67661.04	67499.12	67428.
Revenues									

Figure 61: LCC Calculations

The next tab, 'LCC Calculations' (Figure 61), requires no user input and calculates the Net Present Values for various scenarios using values pulled from different sections of the LCC model. The National Association of Home Builders, in a February 2007 study, published expected appliance life expectancy values for HVAC and kitchen appliances.[26] This information was then applied using IRS depreciation schedules, in accordance with engineering economics best practice, to estimate the amount of money a builder would need to set aside each year to provide new appliances at the end of their useful lives.

[26] http://www.alltechhomeinspections.com/alltechequip.html, http://www.paccrestinspections.com/life.html

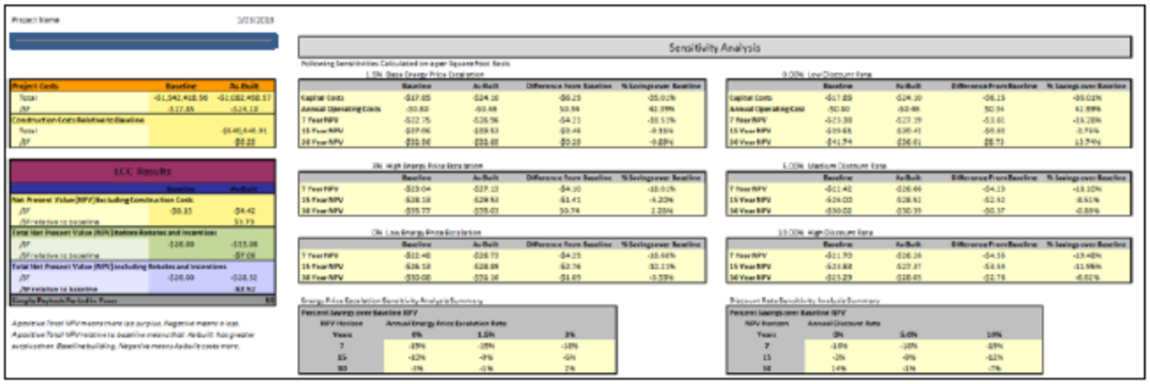


Figure 62: Scenario Results

Finally, the 'Scenario Results' worksheet (Tab 5) provides the results of the LCC calculations and a sensitivity analysis. The NPV Results table shows the difference between the Net Present Value of total costs of the input scenario and the baseline over a building lifetime of 75 years. Total Net Present Value for each project was largely dependent on initial costs. In order to accommodate all sizes of homes and give accurate comparisons, Net Present Value has been provided on a per square foot basis. **A negative ΔNPV (or NPV of as-built relative to baseline) means that the scenario costs more than the baseline case, whereas a positive number means that it costs less – a net savings for the as-built relative to the baseline.**

A sensitivity analysis shows the sensitivity of the results to differences in the assumptions, in terms of percentage difference for the input scenario relative to baseline. Assumptions examined include energy price escalation rates and discount rates. If all of the entries in the table display positive, then the scenario outperforms the baseline case robustly across a variety of assumptions about the future. If some table entries display positive and some are negative, then the relative performance of the baseline and scenario are more contingent and sensitive to particular assumptions. This sensitivity analysis compares the baseline building and the scenario in terms of construction cost, operating cost, and NPV of total costs for investment time horizons of 7, 15, and 30 years. The sensitivity analysis also considers alternative annual energy price escalation rates (0%, 1.5% and 3.0%) and discount rates (0%, 5% and 10%).

7.3 Results and Discussion

7.3.1 Building A.1

PROJECTED ENERGY USAGE ANALYSIS

As mentioned previously, by utilizing the ratio of estimated baseline building costs to the estimated construction cost, an equivalent baseline cost relative to the builder supplied actual construction cost was established. In this way, a comparison of builder actual costs vs. an equivalent baseline "code" building estimate was determined, and the results are shown below in Table 37. As expected, the life cycle cost model for Building A.1 provided results that showed the baseline IECC 2009 code building was much less expensive to build, yielding capital construction costs 63% of the builder's total as-built cost.

Table 37: As-Built Construction Costs - Building A.1

Project Costs	Baseline	As-Built
Total	-$59,016.68	-$93,021.49
/SF	-$37.66	-$59.36
Construction Costs Relative to Baseline		
Total		-$34,004.81
/SF		-$21.70

Table **38** below shows the cost difference between the Net Present Value of total costs in the as-built scenario and the baseline over 75 years for projected energy usage inputs.

Table 38: As-Built NPV Results Based on Projected Energy Usage - Building A.1

NPV Results (Projected Energy Usage)		
	Baseline	**As built**
Net Present Value - Appliance Replacement Only		
/SF	-$4.79	-$9.06
/SF relative to baseline		-$4.26
Net Present Value - Energy Usage Only		
/SF	-$18.82	-$4.23
/SF relative to baseline		$14.59
Net Present Value Excluding Construction Costs (Appliance Replacement + Energy Usage)		
/SF	-$23.62	-$13.29
/SF relative to baseline		$10.32
Net Present Value Including Construction Costs, before Rebates and Incentives		
/SF	-$61.28	-$72.65
/SF relative to baseline		-$11.38
Total Net Present Value (NPV), including Rebates and Incentives		
/SF	-$61.28	-$63.08
Total relative to baseline		**-$1.80**
Simple Payback Period in Years		**13**

When evaluating only the appliance replacement costs without construction costs, the as-built single family home with energy efficiency features had a negative Net Present Value compared to the baseline building built to IECC 2009 code, meaning the appliances for the as-built were estimated to be more costly. When only the energy usage was considered, the as-built single family home yielded a significantly higher NPV, indicating substantial energy savings over life. When the two were evaluated in combination, the net NPV remained positive relative to the baseline ($10.32/SF higher). This indicated that strictly looking at operating costs, the as-built home would provide significant cost savings over its lifetime. Factoring in construction costs, the NPV of the as-built building fell to a value less than that of the baseline ($11.38/SF lower), signifying that the cost of constructing the energy efficient as-built more than negate the lifetime savings to be realized from operating the building.

When the rebates and incentives were factored in, the as-built building NPV came much closer to the baseline building (less negative relative to the baseline), but still remained $1.80/SF lower comparatively. The simple payback period, or the amount of time required to recover the construction costs for the energy efficient as-built Building A.1 over what the baseline home would cost to build, using only energy cost savings, was found to be 13 years. The analysis shows that the energy investments made in Building A.1 would payback within the most popular 30-year mortgage timeline.

MINIMUM CLIMATE CHOICE REQUIREMENTS ANALYSIS

To compare two other cost points between the two build points - baseline and full as-built specifications - the building was also modeled at two different HERS index levels. The first was intended to be modeled at a HERS index of 50, which is the minimum required for a home to be considered to be qualified for the New Jersey Climate Choice Homes program. However, as discussed previously, in order to achieve this level of energy efficiency, renewable sources of energy were removed from the building. The second point modeled for comparison was a building that took some performance penalty from the as-built highly efficient building but still retained photovoltaic capability in order to remain a Climate Choice Home. This score was achieved by manipulating several key energy efficiency inputs in the building model. This configuration was determined to be a HERS 40, higher than the as-built but lower than the HERS 50 configuration. The as-built home scores approximately 31 on the HERS scale, which is significantly better than the minimum needed to qualify as a Climate Choice Home. For reference, the IECC 2009 code compliant building was modeled at HERS 77.

These two cost points provide an opportunity to see whether or not building to such specifications is financially feasible, while still meeting the program objectives, and they allow for the construction of a cost curve for the single family home. The graph below shows the increase in costs when building at these four building configurations.

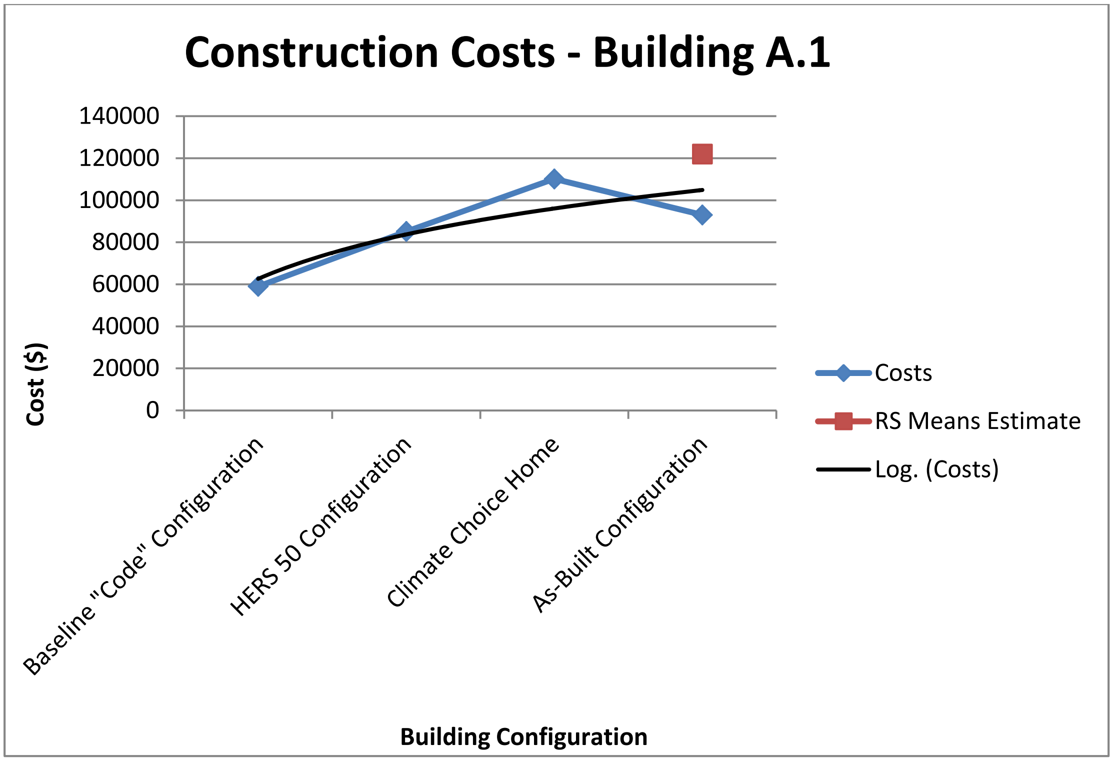


Figure 63: Project Construction Costs - Building A.1

As displayed in the figure above, the costs trend in a mostly linear pattern as costs increase. The construction costs are still significantly higher for the HERS 50 and Climate Choice buildings than the baseline building, but the HERS 50 is far less than the as-built Building A.1 home. The point breaking the trend is the as-built configuration. This is due to the fact that the labor for the construction of the actual building was largely donated, since it is a non for profit developer. For this building, the RSMeans estimated cost for the as-built was included in the graph to illustrate what cost was expected for constructing the single family home.

Both the HERS 50 building and Climate Choice Home had a longer payback period than the as-built building (18 years and 16 years vs. 13 years, respectively). The NPV results of the HERS 50 and Climate Choice Home configurations are shown in the tables below.

Table 39: HERS 50 Construction Costs - Building A.1

Project Costs		**Baseline**	**HERS 50**
Total		-$75,538.44	-$85,145.34
/SF		-$48.21	-$54.34
Construction Costs Relative to Baseline			
Total			-$9,606.90
/SF			-$6.13

Table 40: HERS 50 NPV Results - Building A.1

NPV Results (HERS 50)		
	Baseline	**HERS 50**
Net Present Value - Appliance Replacement Only		
/SF	-$6.55	-$10.68
/SF relative to baseline		-$4.13
Net Present Value - Energy Usage Only		
/SF	-$18.81	-$13.38
/SF relative to baseline		$4.13
Net Present Value Excluding Construction Costs (Appliance Replacement + Energy Usage)		
/SF	-$25.36	-$24.06
/SF relative to baseline		$1.30
Net Present Value Including Construction Costs, before Rebates and Incentives		
/SF	-$73.57	-$78.39
/SF relative to baseline		-$4.83
Total Net Present Value (NPV), including Rebates and Incentives		
/SF	-$73.57	-$78.39
Total relative to baseline		-$4.83
Simple Payback Period in Years		18

Table 41: Climate Choice Home Construction Costs - Building A.1

Project Costs	**Baseline**	**Climate Choice Home**
Total	-$75,538.44	-$110,145.34
/SF	-$48.21	-$70.29
Construction Costs Relative to Baseline		
Total		-$34,606.90
/SF		-$22.08

Table 42: Table Climate Choice Home NPV Results - Building A.1

NPV Results (Climate Choice Home)		
	Baseline	**Climate Choice Home**
Net Present Value Excluding Construction Costs and Energy Usage (Appliance Replacement Only)		
/SF	-$6.55	-$10.68
/SF relative to baseline		-$4.13
Net Present Value Excluding Construction Costs and Appliance Replacement (Energy Usage Only)		
/SF	-$18.82	-$6.29
/SF relative to baseline		$12.53
Net Present Value Excluding Construction Costs Only (Includes Appliance Replacement and Energy Usage)		
/SF	-$25.37	-$16.96
/SF relative to baseline		$8.40
Net Present Value Including Construction Costs, before Rebates and Incentives		
/SF	-$73.57	-$87.26
/SF relative to baseline		-$13.68
Total Net Present Value (NPV), including Rebates and Incentives		
/SF	-$73.58	-$77.68
Total relative to baseline		**-$4.10**
Simple Payback Period in Years		**16**

ACTUAL ENERGY USAGE ANALYSIS

The energy-efficient single family home at Building A.1 in Northern New Jersey was occupied beginning in early 2012. For more than a year, the utility bills for this home were collected as part of the program in order to understand the actual energy usage of the home and compare it to what was projected through the energy model. Utilizing the billed energy usage for both electricity and natural gas over a 12-month period (May 2012 through April 2013), new values for annual consumption were input into the LCC model and compared to the existing baseline usage. The assumed energy costs were changed from a projected value to an actual averaged value from the energy providers as detailed in the utility statements for both $/kWh (electricity) and $/therm (natural gas). A comparison of the assumed energy costs and projected energy usage to the measured energy cost and usage is displayed in Table 43 below.

Table 43: Energy Usage - Projected vs. Actual - Building A.1

	Baseline	Projected	Actual
Electricity Consumed (kWh)	5766	5063	6933
Electricity Consumed / S.F. (kWh)	3.68	3.23	4.42
Electricity Produced (kWh)	0	2870	593
Net Electricity (kWh)	5766	2193	6340
Gas Consumed (therms)	801	355	577

Gas Consumed / S.F. (therms)	0.511	0.227	0.368
Average Electricity Price ($/kWh)	0.153	0.153	0.16808
Average Gas Price ($/therm)	1.178	1.178	1.35013

The Net Present Value results are shown below in Table 44 for the as-built against the baseline using actual energy usage. Since the actual energy usage was recorded to be much higher than what was projected, and even higher than that of the baseline, the total NPV (-$13.44/SF relative to baseline) and simple payback (69 years) results were significantly poorer than what was projected.

Table 44: As-Built NPV Results Based on Actual Energy Usage - Building A.1

NPV Results (Actual Energy Usage)		
	Baseline	**As-Built**
Net Present Value - Appliance Replacement Only		
/SF	-$4.79	-$9.06
/SF relative to baseline		-$4.26
Net Present Value - Energy Usage Only		
/SF	-$21.15	-$18.20
/SF relative to baseline		$2.95
Net Present Value Excluding Construction Costs (Appliance Replacement and Energy Usage)		
/SF	-$25.94	-$27.25
/SF relative to baseline		-$1.31
Net Present Value Including Construction Costs, before Rebates and Incentives		
/SF	-$63.61	-$86.62
/SF relative to baseline		-$23.01
Total Net Present Value (NPV), including Rebates and Incentives		
/SF	-$63.61	-$77.05
Total relative to baseline		-$13.44
Simple Payback Period in Years		69

7.3.2 Building A.2

PROJECTED ENERGY USAGE ANALYSIS

The LCC for Building A.2 was conducted in the same manner as Building A.1, by developing an equivalent baseline cost relative to the builder supplied actual construction cost. Much the same as the single family home, the life cycle cost model for Building A.2 provided results (Table 45 below) that show the baseline IECC 2009 code building was less expensive to build, yielding capital construction costs 77% of the total for the actual as-built building.

Table 45: As-Built Construction Costs - Building A.2

Project Costs	Baseline	As-Built
Total	-$346,233.39	-$388,526.18
/SF	-$43.47	-$48.78
Construction Costs Relative to Baseline		
Total		-$42,292.78
/SF		-$5.31

Table 46 below shows the cost difference between the Net Present Value of total costs in the as-built scenario and the baseline over 75 years.

Table 46: As-Built NPV Results Based on Projected Energy Usage - Building A.2

NPV Results (Projected Energy Usage)		
	Baseline	**As built**
Net Present Value - Appliance Replacement Only		
/SF	-$7.58	-$11.47
/SF relative to baseline		-$3.90
Net Present Value - Energy Usage Only		
/SF	-$15.76	-$1.86
/SF relative to baseline		$13.91
Net Present Value Excluding Construction Costs (Appliance Replacement + Energy Usage)		
/SF	-$23.34	-$13.33
/SF relative to baseline		$10.01
Net Present Value Including Construction Costs, before Rebates and Incentives		
/SF	-$66.81	-$62.11
/SF relative to baseline		-$4.70
Total Net Present Value (NPV), including Rebates and Incentives		
/SF	-$66.81	-$59.60
Total relative to baseline		$7.21
Simple Payback Period in Years		3

When evaluating the NPV of the townhomes in Building A.2 (excluding construction costs) for appliance replacement costs only, it was calculated to be $3.90/SF less than the baseline, nearly equivalent to Building A.1. The NPV of solely energy usage was found to be positive relative to the baseline, yielding cash savings over the life of the building greater than the baseline by $13.91/SF. Much the same as the single family home, the difference between the appliance replacement NPV and the energy usage NPV was positive ($10.01/SF). This means that in a strictly operational sense, the energy efficient townhomes were projected to turn an annual profit. When construction costs were factored in, the NPV of the as-built building fell to a lower value than that of the baseline ($4.70/SF lower).

With the incentives included in the NPV calculation however, the building improvements more than paid for themselves, moving the total NPV far above zero when compared to the baseline ($7.21/SF). The fact that the NPV only became positive for the as-built energy efficient building after applying the rebate indicated why implementing the Climate Choice Home incentive program could be so attractive to prospective builders and homebuyers. The simple payback period, or the time required to recover the construction costs for the energy efficient as-built Building A.2 townhomes over what the baseline home would cost, was found to be much shorter than that of the single family home, estimated to break even after only 3 years.

MINIMUM CLIMATE CHOICE HOME REQUIREMENTS ANALYSIS

Much like the single family home, two other points were modeled at two different HERS index levels – a HERS 50 configuration and Climate Choice Home. The as-built townhomes score 41 on the HERS scale, which is again better than the minimum needed to qualify as a Climate Choice Home. For the IECC 2009 code compliant building, REM/Rate calculated it to score HERS 80. The Climate Choice Home configuration was determined to be a HERS 43, higher than the as-built but lower than the HERS 50 configuration. Figure 64 below graphs the increase in construction costs for the four Building A.2 configurations.

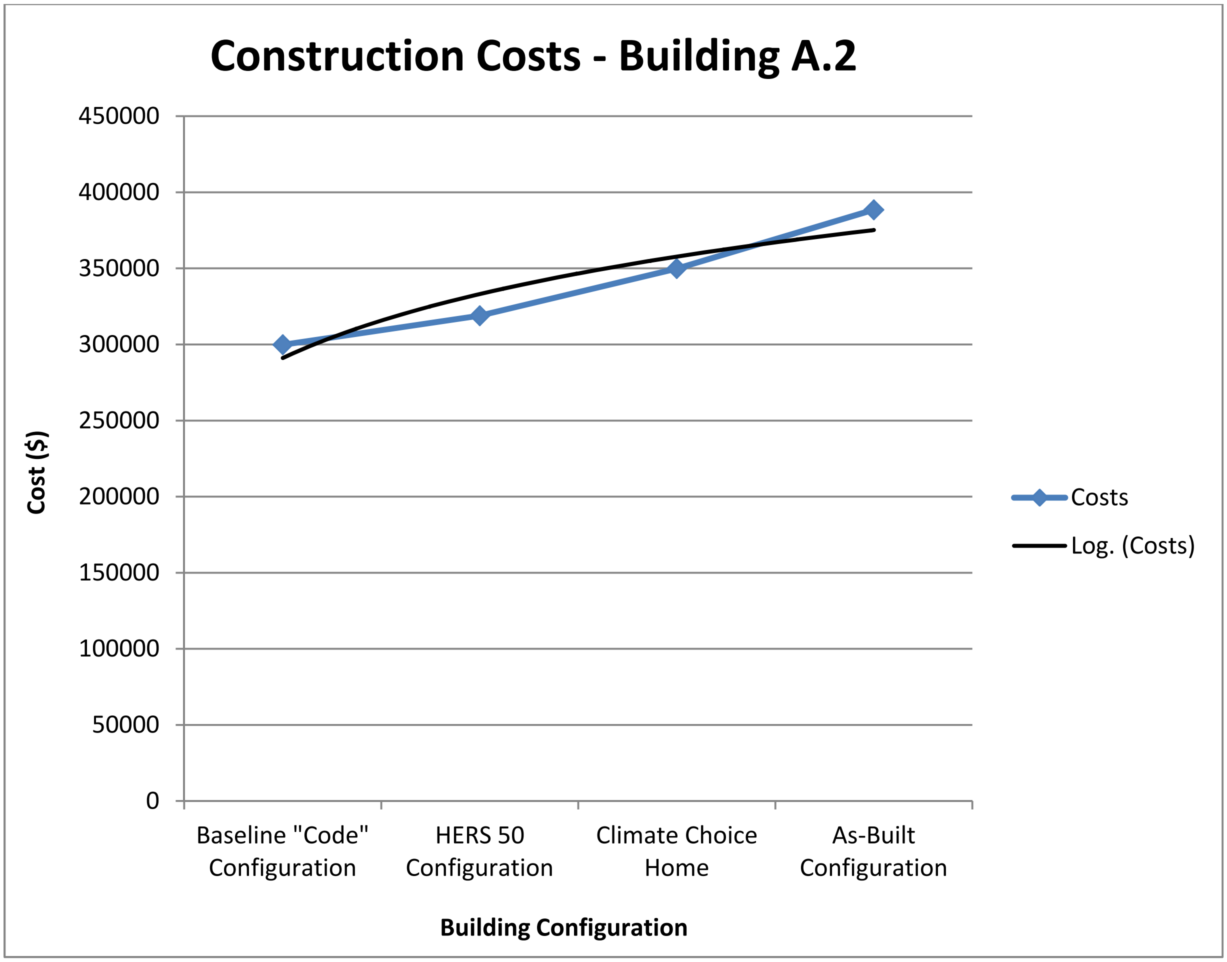


Figure 64: Project Construction Costs - Building A.2

The logarithmic trend line for the construction costs come much closer than the single family home to following the linear curve. The fact that the costs fall near the trend line suggests that the increases in cost are predictable. The HERS 50 building and Climate Choice Home for the Building A.2 homes were calculated to have much longer payback periods than the as-built building. The NPV results of the HERS 50 and Climate Choice Home configurations are shown in the tables below.

Table 47: HERS 50 Construction Costs - Building A.2

Project Costs	Baseline	HERS 50
Total	-$309,634.09	-$350,987.46
/SF	-$38.87	-$44.07
Construction Costs Relative to Baseline		
Total		-$41,353.36
/SF		-$5.19

Table 48: HERS 50 NPV Results - Building A.2

NPV Results (HERS 50)		
	Baseline	**HERS 50**
Net Present Value - Appliance Replacement Only		
/SF	-$6.07	-$11.47
/SF relative to baseline		-$5.40
Net Present Value - Energy Usage Only		
/SF	-$8.26	-$12.93
/SF relative to baseline		-$4.67
Net Present Value Excluding Construction Costs (Appliance Replacement + Energy Usage)		
/SF	-$21.83	-$24.81
/SF relative to baseline		-$2.98
Net Present Value Including Construction Costs, before Rebates and Incentives		
/SF	-$60.71	-$68.88
/SF relative to baseline		-$8.17
Total Net Present Value (NPV), including Rebates and Incentives		
/SF	-$60.71	-$68.88
Total relative to baseline		-$8.17
Simple Payback Period in Years		39

Table 49: Climate Choice Home Construction Costs - Building A.2

Project Costs	**Baseline**	**Climate Choice Home**
Total	-$309,634.09	-$349,873.58
/SF	-$38.87	-$43.93
Construction Costs Relative to Baseline		
Total		-$40,239.48
/SF		-$5.05

Table 50: Climate Choice Home NPV Results - Building A.2

NPV Results (Climate Choice Home)		
	Baseline	**Climate Choice Home**
Net Present Value - Appliance Replacement Only		
/SF	-$6.07	-$11.47
/SF relative to baseline		-$5.40
Net Present Value - Energy Usage Only		
/SF	-$8.26	-$10.42
/SF relative to baseline		-$2.16
Net Present Value Excluding Construction Costs (Appliance Replacement + Energy Usage)		
/SF	-$21.83	-$22.31
/SF relative to baseline		-$0.48
Net Present Value Including Construction Costs, before Rebates and Incentives		
/SF	-$60.71	-$66.23
/SF relative to baseline		-$5.53
Total Net Present Value (NPV), including Rebates and Incentives		
/SF	-$60.71	-$63.72
Total relative to baseline		-$3.02
Simple Payback Period in Years		**9**

ACTUAL ENERGY USAGE ANALYSIS

The townhomes at Building A.2 in Northern New Jersey were completed in late 2012, however each of the five units were occupied at different times following completion. The first townhome to be occupied was at the end of 2012, followed by a two others in early 2013 and another in April 2013. At the time of the submission of this report in June 2013, the last unit was about to be occupied for the first time. Since a full year of occupancy of the entire building could not be obtained, some projections for the building's energy usage needed to be made in order to assess actual performance.

In a process described fully in Appendix F, utility bill values for electricity and natural gas consumption and costs were scaled to other months in the period of one year to estimate the annual actual energy usage of the building. These estimated values for annual consumption and energy costs were input into the LCC model and compared to the existing baseline usage. A comparison of the projected energy costs and usage to the estimated actual energy cost and usage is displayed in Table 51 below. Another item to be noted is that the electricity produced by the building was not reported at the time of the publishing of this report, therefore the full projected energy production value (15,520 kWh annually) was assumed for the actual LCC run.

Table 51: Energy Usage - Projected vs. Actual - Building A.2

	Baseline	Projected	Actual*
Electricity Consumed (kWh)	27321	27056	22527
Electricity Consumed / S.F. (kWh)	3.430	3.397	2.828
Electricity Produced (kWh)	0	15520	Not measured (15520 assumed)
Net Electricity (kWh)	27321	11536	7007
Gas Consumed (therms)	3067	877	7160 (estimated)
Gas Consumed / S.F. (therms)	0.385	0.110	0.899 (estimated)
Average Electricity Price ($/kWh)	0.153	0.153	0.145
Average Gas Price ($/therm)	1.178	1.178	1.095

* estimated

The Net Present Value results are shown below in Table 52 for the as-built against the baseline using actual energy usage. Even though the electricity usage was recorded to be much lower than what was projected, the natural gas usage was much higher, even more than that of the baseline. The resulting total NPV (-$6.38/SF relative to baseline) results was significantly poorer than what was projected. The simple payback based on estimated actual energy usage could not be calculated, as there are no operational costs savings associated with increased capital cost of construction for the energy efficient improvements. Were the actual energy usage values over a full year to match what was estimated, the investment made in energy efficiency would not pay for itself during the assumed 75 year lifetime of the building.

Table 52: As-Built NPV Results Based on Actual Energy Usage - Building A.2

NPV Results (Actual Energy Usage)		
	Baseline	**As-Built**
Net Present Value - Appliance Replacement Only		
/SF	-$7.58	-$11.47
/SF relative to baseline		-$3.90
Net Present Value - Energy Usage Only		
/SF	-$14.83	-$14.52
/SF relative to baseline		$0.31
Net Present Value Excluding Construction Costs (Appliance Replacement and Energy Usage)		
/SF	-$22.41	-$25.99
/SF relative to baseline		-$3.58
Net Present Value Including Construction Costs, before Rebates and Incentives		
/SF	-$65.88	-$74.77
/SF relative to baseline		-$8.89
Total Net Present Value (NPV), including Rebates and Incentives		
/SF	-$65.88	-$72.26
Total relative to baseline		-$6.38
Simple Payback Period in Years		**80**

7.3.3 Building B.1

PROJECTED ENERGY USAGE ANALYSIS

The results for the LCC analysis of Building B.1 were found to be much more favorable than the previous two projects. As expected, much the same as the single family and townhomes, the life cycle cost model for Building B.1 provided results (Table 53) that shows the baseline IECC 2009 code building was less expensive to build, yielding capital construction cost 84% of the total for the actual as-built building.

Table 53: As-Built Construction Costs - Building B.1

Project Costs	Baseline	As-Built
Total	-$1,947,285.65	-$2,723,743.46
/SF	-$28.13	-$39.35
Construction Costs Relative to Baseline		
Total		-$776,457.81
/SF		-$11.22

Table 54 below shows the cost difference between the Net Present Value of total costs in the as-built scenario and the baseline over 75 years.

Table 54: As-Built NPV Results Based on Projected Energy Usage - Building B.1

NPV Results (Projected Energy Usage)		
	Baseline	**As-Built**
Net Present Value - Appliance Replacement Only		
/SF	-$15.12	-$16.31
/SF relative to baseline		-$1.19
Net Present Value - Energy Usage Only		
/SF	-$13.99	-$4.52
/SF relative to baseline		$9.48
Net Present Value Excluding Construction Costs (Appliance Replacement + Energy Usage)		
/SF	-$29.11	-$20.83
/SF relative to baseline		$8.28
Net Present Value Including Construction Costs, before Rebates and Incentives		
/SF	-$57.24	-$60.18
/SF relative to baseline		-$2.93
Total Net Present Value (NPV), including Rebates and Incentives		
/SF	-$57.24	-$54.51
/SF relative to baseline		$2.73
Simple Payback Period in Years		9

When excluding construction costs and energy usage (appliance replacement costs only), the as-built Building B.1 with energy efficiency features nearly matched the Net Present Value of the baseline building. Appliance costs were estimated to come in only slightly more expensive than the baseline. When considering only energy usage, the NPV was substantially higher than the baseline ($9.48/SF more). In combination, while still excluding construction costs, the as-built retained a higher NPV than the baseline building built to IECC 2009 code ($8.98/SF higher), meaning the operating costs of the energy efficient as-built over its lifetime would yield significant savings. However, once construction costs were factored in, the NPV of the as-built building fell to a value less than that of the baseline ($2.93/SF lower relative to the baseline). This indicated that the savings from decreased energy usage over life would not cover the higher cost of actually building the as-built.

Factoring in rebates and incentives, the as-built building relative NPV did cross the threshold into positive territory ($2.73/SF greater than baseline), again underscoring the value of the rebate program. The simple payback period, or the amount of time required to recover the construction costs for the energy efficient as-built Building B.1 over what the baseline building would cost to build, was found to be 9 years, lower than the single family home but higher than the townhouse style homes analyzed earlier, based on projected energy usage.

MINIMUM CLIMATE CHOICE REQUIREMENTS ANALYSIS

Building B.1 was also modeled in two different HERS index configurations. The Climate Choice Home model resulted in a HERS 40 rating, again higher than the as-built but lower than the HERS 50 configuration. The as-built home scores approximately 36 on the HERS scale, which is significantly better than the minimum needed to qualify as a Climate Choice Home. For the IECC 2009 code compliant building, REM/Rate calculated it to score HERS 79. Figure 3 below displays the cost curve for the four Building B.1 configurations.

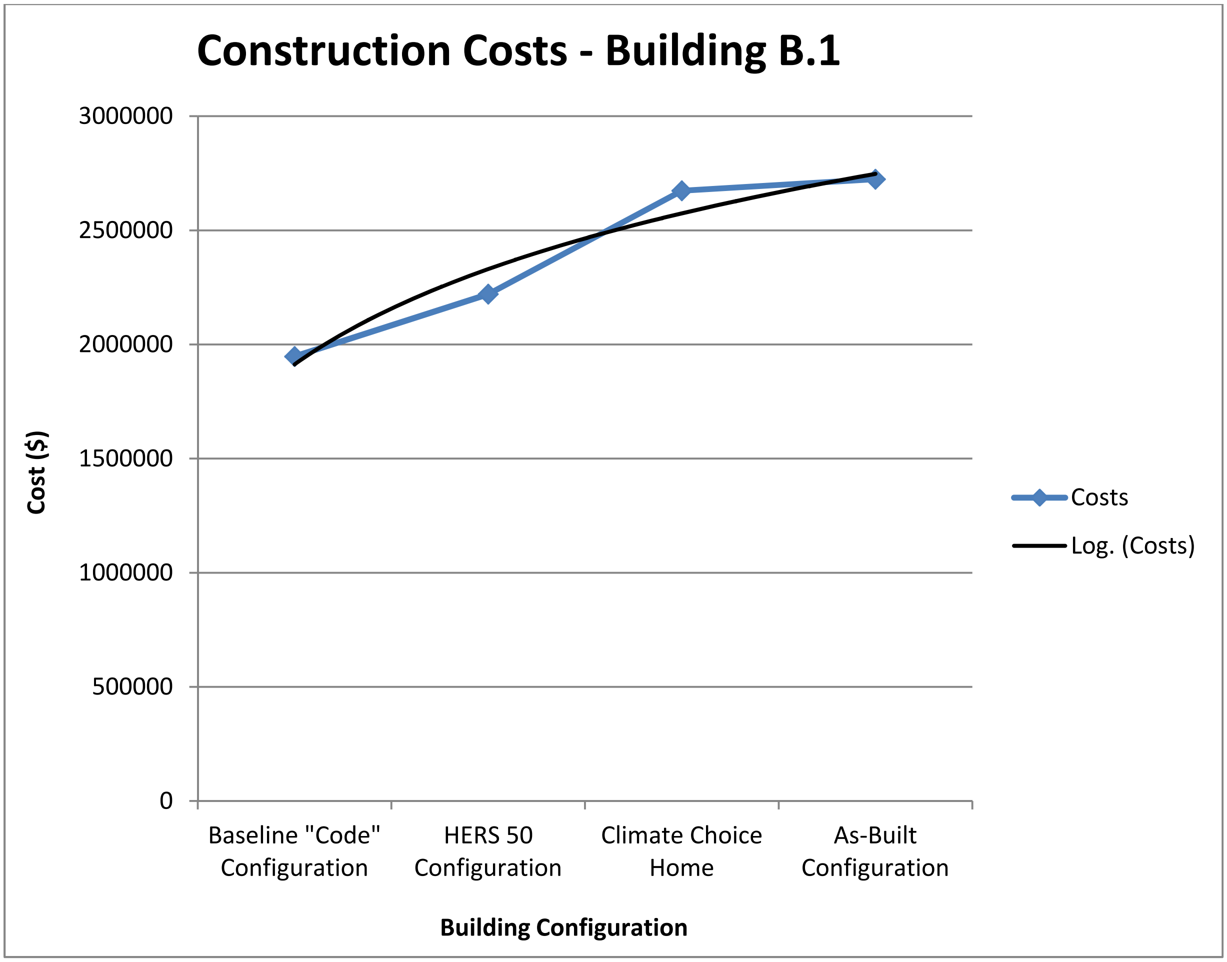


Figure 65: Project Construction Costs - Building B.1

The Building B.1 costs for the four configurations follow a logarithmic trend more closely than the single family home, but costs are just slightly less predictable than the townhomes previously analyzed. The construction costs are significantly higher for the HERS 50 and Climate Choice Home building than the baseline building, but are still less than the as-built Building B.1. This is due to the fact that the savings from the renewable energy incentives are less than what the difference in build cost is between the configurations. Thus, the HERS 50 building has a lower simple payback period than the as-built building (4 years vs. 9 years), as does the Climate Choice Home (3 years vs. 9 years). The NPV results of the HERS 50 and Climate Choice Home buildings are shown in the tables below.

Table 55: HERS 50 Construction Costs - Building B.1

Project Costs (HERS 50)	Baseline	HERS 50
Total	-$2,134,898.01	-$2,220,297.02
/SF	-$30.84	-$32.08
Construction Costs Relative to Baseline		
Total		-$85,399.01
/SF		-$1.23

Table 56: HERS 50 NPV Results - Building B.1

NPV Results (HERS 50)		
	Baseline	**HERS 50**
Net Present Value - Appliance Replacement Only		
/SF	-$16.22	-$12.66
/SF relative to baseline		$3.56
Net Present Value - Energy Usage Only		
/SF	-$13.99	-$9.29
/SF relative to baseline		$4.70
Net Present Value Excluding Construction Costs (Appliance Replacement + Energy Usage)		
/SF	-$30.21	-$21.95
/SF relative to baseline		$8.26
Net Present Value Including Construction Costs, before Rebates and Incentives		
/SF	-$61.06	-$54.03
/SF relative to baseline		$7.03
Total Net Present Value (NPV), including Rebates and Incentives		
/SF	-$61.06	-$54.03
/SF relative to baseline		$7.03
Simple Payback Period in Years		**4**

Table 57: Climate Choice Home Construction Costs - Building B.1

Project Costs (Climate Choice Home)	**Baseline**	**Climate Choice Home**
Total	-$2,134,898.01	-$2,673,580.78
/SF	-$30.84	-$38.62
Construction Costs Relative to Baseline		
Total		-$538,682.77
/SF		-$7.78

Table 58: Climate Choice Home NPV Results – Building B.1

NPV Results (Climate Choice Home)		
	Baseline	**Climate Choice Home**
Net Present Value - Appliance Replacement Only		
/SF	-$16.46	-$16.26
/SF relative to baseline		$0.20
Net Present Value - Energy Usage Only		
/SF	-$13.99	-$3.95
/SF relative to baseline		$10.05
Net Present Value Excluding Construction Costs (Appliance Replacement + Energy Usage)		
/SF	-$30.46	-$20.21
/SF relative to baseline		$10.25
Net Present Value Including Construction Costs, before Rebates and Incentives		
/SF	-$61.30	-$58.83
/SF relative to baseline		$2.47
Total Net Present Value (NPV), including Rebates and Incentives		
/SF	-$61.30	-$53.17
/SF relative to baseline		$8.13
Simple Payback Period in Years		**3**

ACTUAL ENERGY USAGE ANALYSIS

The multi-family building B.1, also in Northern New Jersey, was opened in 2011. Seven units were monitored and their utility bills collected, with residents occupying the units beginning at various points in early 2012. For more than a year and a half, the utility bills and other data for these units were collected as part of the program in order to understand the actual energy usage of the home and compare it to what was projected through the energy model. Utilizing the billed energy usage for both electricity and natural gas over a 12-month period (May 2012 through April 2013), new values for annual consumption were input into the LCC model and compared to the existing baseline usage.

Since only seven units were included in this study, the energy usage for the entire building needed to be estimated using a projection method unlike what was done for the townhomes. The process for estimating the building actual energy usage is detailed in Appendix E. The assumed energy costs were changed from a projected value to an actual averaged value from the energy providers as detailed in the utility statements for both $/kWh (electricity) and $/therm (natural gas). A comparison of the assumed energy costs and projected energy usage to the measured energy cost and usage is displayed in Table 59 below.

Table 59: Energy Usage - Projected vs. Actual - Building B.1

	Baseline	Projected	Actual
Electricity Consumed (kWh)	258297	200356	280191
Electricity Consumed / S.F. (kWh)	3.732	2.894	4.048
Electricity Produced (kWh)	0	82981	60340
Net Electricity (kWh)	258297	117375	219851
Gas Consumed (therms)	17783	9792	8293
Gas Consumed / S.F. (therms)	0.257	0.141	0.120
Average Electricity Price ($/kWh)	0.153	0.153	0.187482
Average Gas Price ($/therm)	1.178	1.178	2.058727

The Net Present Value results are shown below in Table 32 for the as-built against the baseline using actual energy usage. Despite the fact that measured electricity usage was higher, the total NPV remained positive, although barely (+$1.25/SF relative to baseline). The simple payback (11 years) is only slightly poorer than what was projected for Building B.1 and significantly better than the actual energy usage results for the other two buildings.

Table 60: As-Built NPV Results Based on Actual Energy Usage - Building B.1

NPV Results (Actual Energy Usage)		
	Baseline	**As-Built**
Net Present Value - Appliance Replacement Only		
/SF	-$15.12	-$16.31
/SF relative to baseline		-$1.19
Net Present Value - Energy Usage Only		
/SF	-$19.76	-$11.76
/SF relative to baseline		$8.00
Net Present Value Excluding Construction Costs (Appliance Replacement and Energy Usage)		
/SF	-$34.88	-$28.07
/SF relative to baseline		$6.80
Net Present Value Including Construction Costs, before Rebates and Incentives		
/SF	-$63.01	-$67.42
/SF relative to baseline		-$4.42
Total Net Present Value (NPV), including Rebates and Incentives		
/SF	-$63.01	-$61.76
Total relative to baseline		$1.25
Simple Payback Period in Years		11

7.4 Conclusions

A life cycle cost calculation tool was developed and results were analyzed for three buildings participating in the NJCEP Climate Choice Homes program. Through the analysis, four energy models were completed in REM/Rate to determine projected energy usage and the Home Energy Rating index – one for the as-built configuration, one for the baseline "code" configuration, one for a HERS 50 configuration, and one for a "minimum" Climate Choice Home configuration. Upon inputting the proper variables, LCC iterations for all three buildings were completed based on different configurations of the buildings based on projected energy consumption. Following various periods of occupation of each of the buildings, the actual or estimated utility bill energy usage was analyzed and also input in another LCC iteration for each project. All four iterations indicated different results, as displayed in a summary comparison (Table 61) below.

Table 61: Summary Comparison Table of Net Present Value for All Building Configurations

	Building A.1	Building A.2	Building B.1
Projected Energy Usage "As-Built"	($1.80)	$7.21	$2.73
HERS 50	($4.83)	($8.17)	$7.03
Climate Choice Home	($4.10)	($3.02)	$8.13
Actual Energy Usage	($13.44)	($6.38)	$1.25

Two of the three as-built buildings showed positive NPV results for the energy efficient investments that were made, and the single family home came close based on projected energy usage. The single family home at Building A.1 did not produce positive NPV for any of the configurations studied. It is worth noting that this was the Developer A's first experience building to the Climate Choice Homes technical requirements; higher costs to comply and come up the "learning curve" would not be unexpected. Once actual energy usage was factored in, which is typically higher due to the difficulty of predicting home system interactions and occupant behavior, only Building B.1 yielded positive Net Present Values.

Another evident observation was a general trend of higher performance results of the buildings with increasing scale, from single family to five-unit townhomes to a 70-unit complex. Two potential explanations for this trend could be the principle of economies of scale as it applies to energy efficient construction or the greater experience level of Developer B.

Table 62: Summary Comparison Table of Simple Payback for All Building Configurations

	Building A.1	Building A.2	Building B.1
Projected Energy Usage "As-Built"	13 years	3 years	9 years
HERS 50	18 years	39 years	4 years
Climate Choice Home	16 years	9 years	3 years
Actual Energy Usage	69 years	80 years	11 years

Regarding the simple payback calculation or timeframe to recover the additional costs of energy efficiency by savings in first-year energy costs and program incentives, as displayed in Table 62 above, all three buildings "broke even" relative to their baseline configurations in a relatively short period (3-13 years). These payback periods fell well within the timeframe of the most common real estate product, the 30-year mortgage. The payback period of the HERS 50 and Climate Choice configurations did not follow a trend across the three buildings relative to that of the as-built configurations, which is likely due to the nature of the individual decisions that were made to cost estimate the construction of these "imagined" buildings. The simple payback periods of the buildings using actual energy usage was in line with the NPV results for the buildings using actual values and showed the poorest results of any of the configurations.

The calculation of the LCC metrics using actual energy usage from utility bills proved to only convey a diminished cost-effectiveness of these efficient as-built homes. As with any new building, there are issues to be worked out in the first weeks, months or even years of operation. Energy systems often require monitoring and adjustment early on, and energy providers often lag in billing of energy consumption in the first few months, skewing actual usage. These factors are all likely to have contributed to the poorer LCC results using actual energy usage. If the same LCC process was repeated at a later point in time with the benefit of a longer record of utility bills for each of the occupied units in this study, the LCC results with actual energy usage would very likely improve, at least to the same level of projected energy use.

One item to make note of is that these calculations do not account for contributions to the value (as opposed to the costs) of the more tightly built homes due to increased occupant comfort and potential resale value. The research team has also conducted a post-occupancy survey of occupants of the same buildings assessed here and has provided a written summary of these results in the section that follows. A building that can provide its occupants with a healthy, energy-efficient environment, while still maintaining economic viability for its owners and operators, stands to be at the forefront of building practices for the future.

8 BEHAVIORAL SURVEY

This section of the project report presents baseline and follow-up results of a post occupancy evaluation (a behavioral survey) of eleven sample household units, participating in the NJCC R&D Project. The post occupancy evaluation (POE) is a study of the operation, status, and usability of a physical setting at some point after construction is completed and users move in (Wener, 2002)[27], and is intended to complete otherwise missing aspects of feedback loops that check how well the building's operation fits intentions, goals, program expectations, and design.

This report considers a baseline survey of the residential units supplemented by a limited second survey round. This work is integral to developing and implementing innovative green building and sustainable community strategies by NJCEP in the future.

8.1 Methodology

The surveys examined occupant schedules, habits, preferences, and other behavioral attributes associated with daily energy consumption. The data for this study were gathered through a paper survey sent to the head of household, with phone and in-person interview follow-up as needed. The occupant survey (Appendix G-Single Family, Appendix H-Multifamily) consists of questions aimed at collecting information about the physical aspects of the dwelling units, household demographics, daily schedule of occupants, household energy-using appliances and frequency of their use, heating/cooling experience, individual habits/behavior and personal experience in a green living space, and likes/dislikes about certain features of the building. Many, although not all, of the survey questions are drawn from the *NJ New Homes Survey Questionnaire.*[28] There are two versions of the survey – one for single family homes and one for multifamily units. The results of the survey analysis are descriptive in nature as the total sample population is too small (n= 11) to perform inferential statistics. Results are reported for the sample population as a whole, except in cases where the results for the single family homes diverge markedly from those for multi-family units. In those cases, the differences are noted.

8.2 Observation and Analysis

8.2.1 Round One - Baseline Results

The first round of surveys study included nine participating households[29] with varied characteristics. Out of the nine households, four occupied a 1-bedroom apartment, three occupied a 2-bedroom apartment, one occupied a 3-bedroom town house, and one occupied a 3-bedroom single family house. The apartments have one full bathroom while the single family house and townhome have an additional half bathroom.

The analysis is presented in four sections:

1. Household Characteristics
2. Energy Use Habits

---

[27] Wener, R. (2002). "Post Occupancy Evaluation," in The Encyclopedia of Psychological Assessment, Rocio Fernandez-Ballesteros (ed.)Thousand Oaks: Sage Publications.

[28] NJ New Homes Survey Questionnaire (June 17, 2009) developed and managed by APPRISE for NJ BPU NJ ENERGY STAR PROGRAM EVALUATION.

[29] When the first round of surveys was delivered, two units at Building A.2 were not yet occupied.

3. Water Use Habits
4. General Green Home Experience

HOUSEHOLD CHARACTERISTICS

The total number of occupants in each household varied from a minimum of two to a maximum of four. Most of the occupants are within the ages of 19 to 64 years old with only three between the ages of 7 and 18 (see Figure 66). In addition, there are a total of eight infants and toddlers (under 6 years old) in the sample group. All households reported an annual income of less than $40,000.

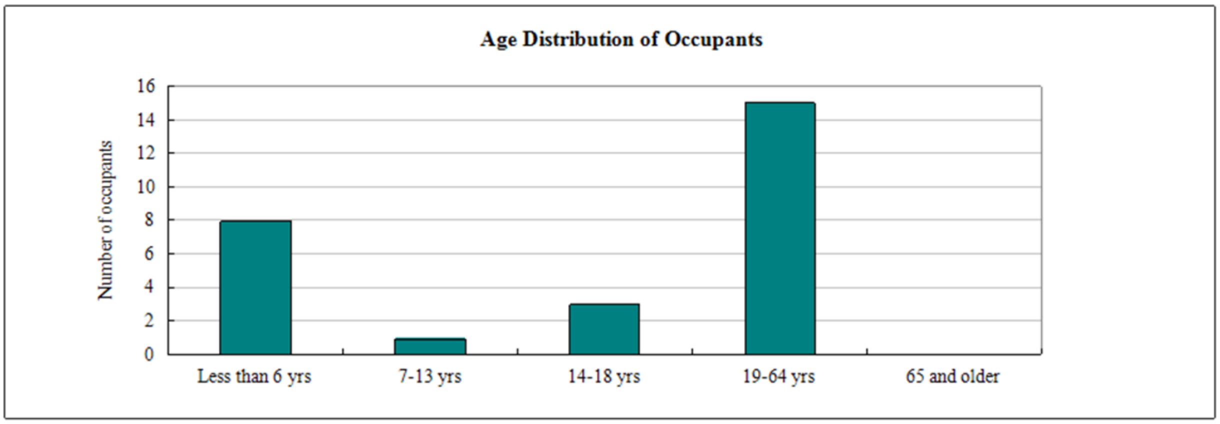


Figure 66: Age Distribution of the Sample Household Occupants

DAILY SCHEDULE

Reported Wake Up & Bed Time

The weekday and weekend schedules of the occupants were collected and analyzed to see if there were any trends that may affect energy usage. The reported wake up time on weekdays ranged from 5:00am to 7:30am, with 7:00am being the most frequent wake up time. The reported wake up time on weekends ranged from 4:00am to 12:30pm. In general, all occupants wake up about one to three hours later on weekends as compared to weekdays with the exception of one, who wakes up an hour earlier (4:00am) on weekends than on weekdays (5:00am). The bedtimes have a much higher range and distribution as compared to the wake up time. However, the most reported bedtimes on weekdays were 10:00pm and 11:00pm. The weekend bedtime remained the same for most occupants except three, who reported a delay of about 1 to 2 hours on weekends.

Occupancy time

The period of time that the units were unoccupied ranged from one hour to twelve hours on weekdays, with a majority of the occupants reporting that their unit was unoccupied for 7 to 12 hours. Regarding weekends, equal numbers of respondents said they were out of the house for 1-3 hours and for 7-12 hours. Other responses were between 4-6 hours (2) and 12 hours (1) (see Figure 67).

Later wake up times coupled with the total number of hours spent outside the house on weekends suggests that less energy is used on weekends as compared to weekdays.

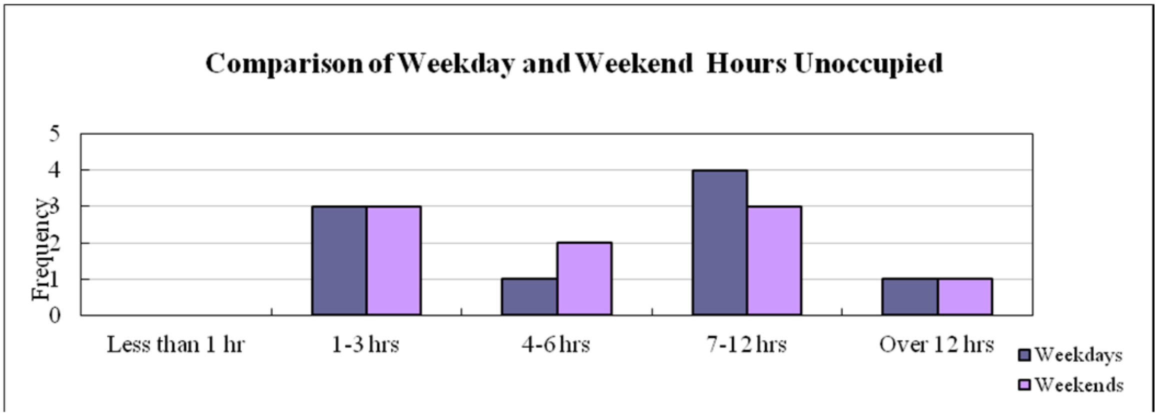


Figure 67: Comparison of Weekday and Weekend Hours - Units Are Unoccupied

ENERGY USE HABITS

This section evaluates how energy is used by sample households by taking into account factors such as the type of air conditioning, household temperature preferences, the number of appliances per household and the frequency of use of those appliances, the number of hot meals prepared and other similar variables.

Air Conditioning

Out of the nine units participating in round 1 of the survey, eight had central air conditioning with another one scheduled for installation at a future date. One also had an additional window box unit. The household that reported this additional window unit was among the households that reported dissatisfaction with the ability to adjust household temperature and also reported that some rooms are always too hot or too cold in summer. Thus the use of an additional cooling source is probably an adaptive response to these reported conditions.

Electronic Appliances

Each household in the study owns either a laptop or a computer, with almost all (8) owning a laptop and four owning both. Each household has at least one television set, with three owning multiple sets. Music systems are present in most residences (8 out of 9) while video games consoles and DVRs are less common (a total of only 3 and 4 of each, respectively). On an average, each household owns a total of about 4.5 electronic items (see Figure 68).

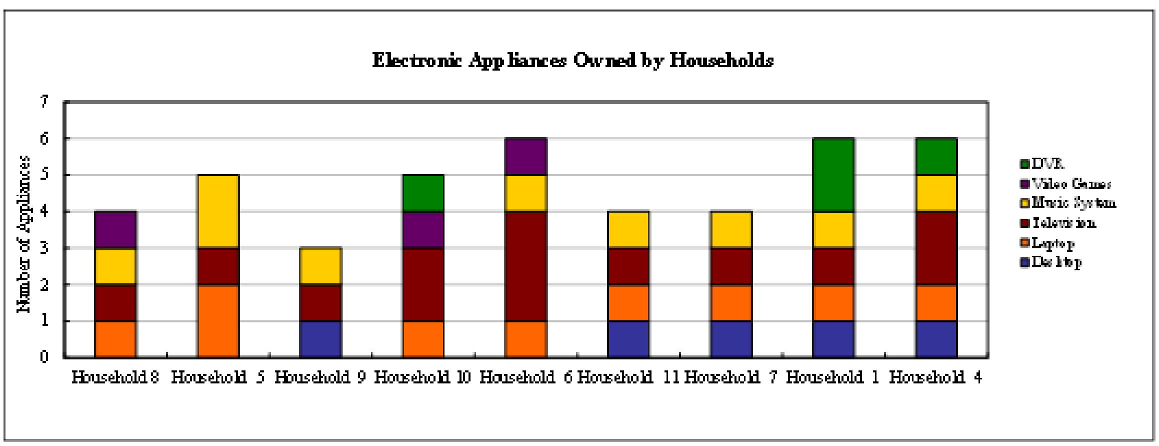


Figure 68: Type and Number of Electronic Appliances Owned by Study Households

When looking at the use of electronic appliances, television is the most used, with half of the households reporting 21 hours of TV time each week. The computer/laptop was the next most used appliance with a total of 5 to 10 hours of use each week per household (see Figure 69).

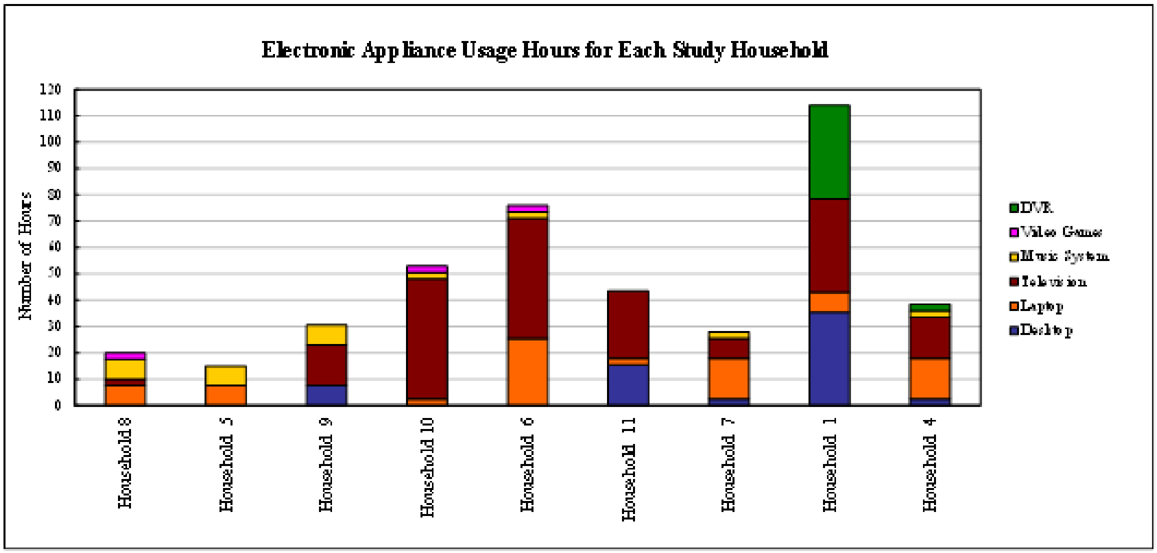


Figure 69: Electronic Appliance Usage Hours for Each Household

The survey also examined the presence and the use frequency of other common household appliances like clothes washer/dryer, dishwasher, refrigerator, kitchen stove/exhaust and microwave, along with additional appliances like portable heater, portable fan, humidifier/dehumidifier, air purifier, portable electric fireplace, wine cooler and hot bath/Jacuzzi. Most of the additional appliances were absent in the sample households and hence the data for these appliances was not further evaluated.

The analysis of microwave use shows a wide range of usage frequency - from 3 to 20 times per week, with the mode usage being 7 times per week.

Household Temperature

There is a wide range between the reported preferred temperature settings in the households. It is evident from the data that most of the energy use is in the heating season (fall/winter) and especially higher when occupants are at home during this season, as would be expected.

The widest range of temperature (15 degrees, purple bar in Figure 70) is seen in the fall/winter season when occupants are at home during the daytime (see Figure 70 and Figure 71). The highest preferred temperature (80 degrees F) also occurs during this timeframe. The next widest range (13 degrees) and highest temperature (78 degrees F) is seen at the night time during the fall/winter season (green bar).

The last column shows times when heating and cooling systems are reported not being used at all. The most frequent times (red and light blue bars) occur during times when occupants are not home, which is when we would expect the systems to be off. What is interesting is three reports (green and dark blue bars) where occupants report either not using heating during fall/winter nights or air conditioning during spring/summer nights.

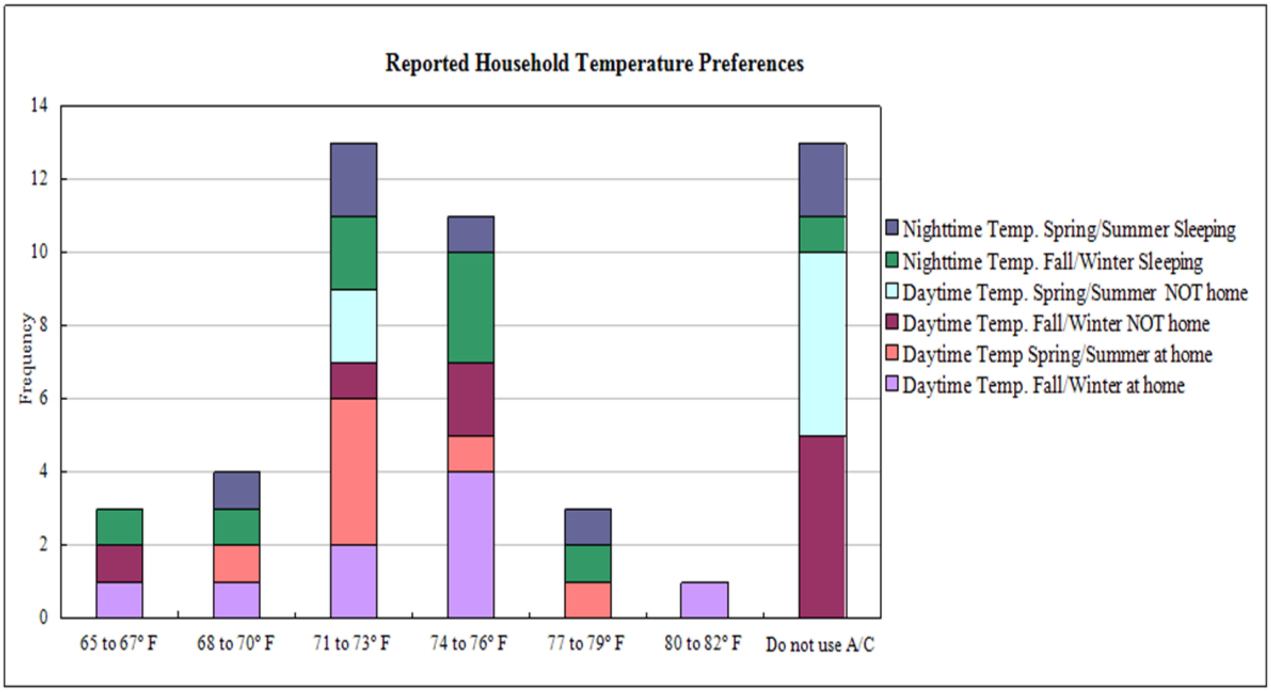


Figure 70: Reported Temperature Preferences and A/C Usage During Various Seasons and Time of Day

.

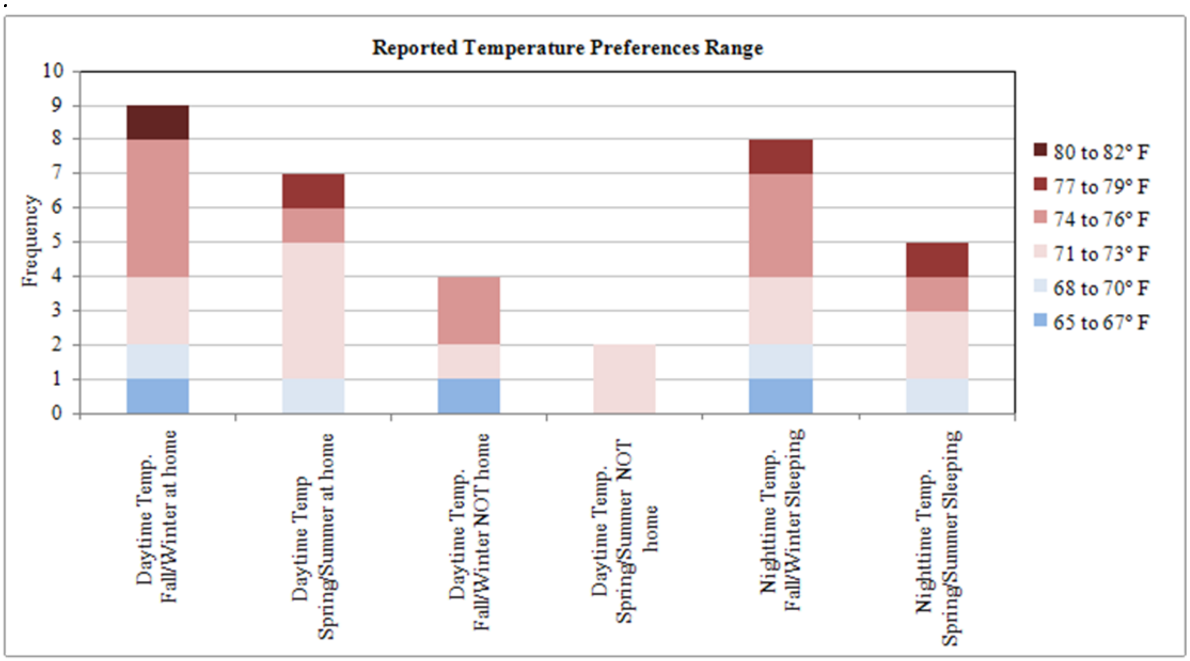


Figure 71: Reported Temperature Preference Range During Various Seasons and Time of Day

Six of the nine household occupants reported opening windows frequently to increase comfort levels. These same households reported using air conditioning more frequently as compared to the household occupants who did not open windows (see Figure 72).

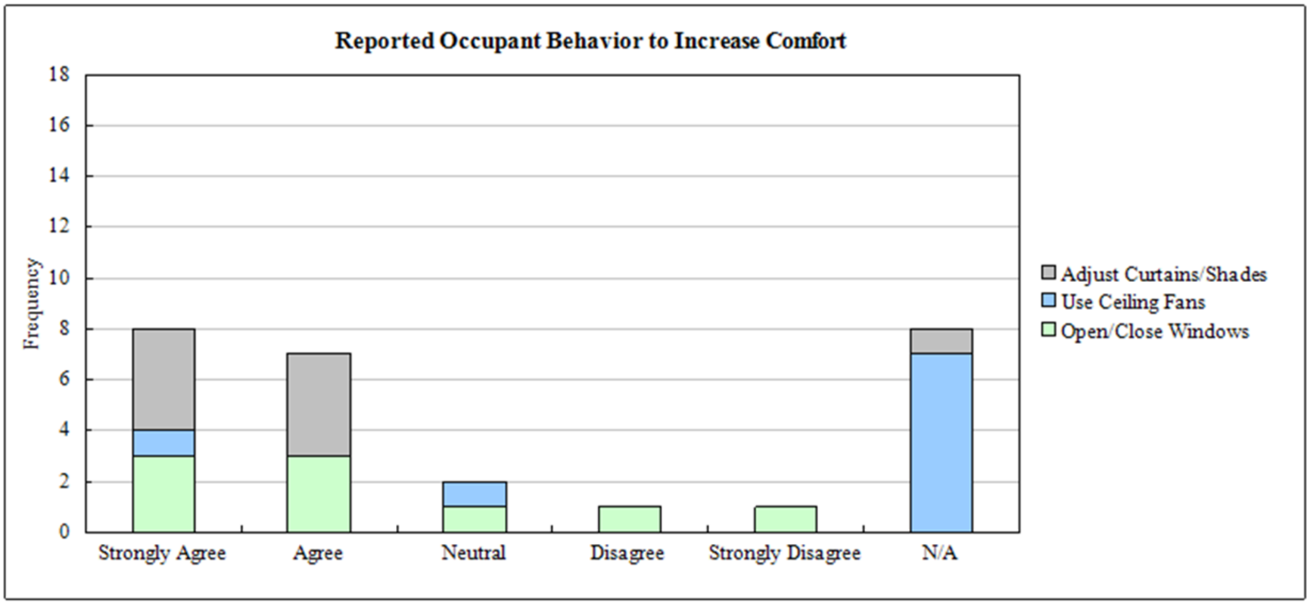


Figure 72*: *Reported Occupant Behavior to Increase Comfort Level

WATER USE HABITS

This section examines the water use habits of occupants in ways that may affect energy consumption, with a focus on the frequency of use of larger appliances like a clothes washer and/or dishwasher and the frequency and duration of baths/showers taken by the household occupants. Information was also acquired on the presence and number of conventional and /or low flow faucets in the units.

Showers & Baths

There was a wide range (14 to 50) of reported number of showers taken per week in each household with an average of 26 per household each week. The wide range is attributed to the number of members in a household - more members accounted for a greater number of showers per week.

Over half of the households (5) in the study reported taking no baths at all in a given week, with the others ranging from 2 to 14 baths per week averaging to 7.5 baths per week. Households with kids (under the age of 6 years) reported more baths than others.

Dishwasher Use

The use of the dishwasher ranged from 1 load to 5-9 loads per week. Three households reported doing one load; two each reported 2-4 loads and 5-9 loads. The higher number of loads does not correspond with higher number of occupants; the households that reported doing 5-9 loads had two to three occupants while two households with four people reported 2-4 loads per week. The households that reported higher loads also reported cooking meals two times a day as compared to other households who reported cooking meals only few times a week and hence reporting fewer dishwasher loads.

GREEN HOME EXPERIENCE

This section evaluates the home’s performance and personal experience/attitudes of occupants with regards to green living. The study also looks at the household's satisfaction with green building living experience through open ended questions and behavioral comparison of occupants who reported being "green" to those who did not.

Home Performance Satisfaction

The home performance satisfaction was evaluated using a five-point Likert scale of agreement (very satisfied, satisfied, neither satisfied or dissatisfied (neutral), dissatisfied and very dissatisfied) for twelve variables: indoor air quality, energy savings, water savings, ability to adjust temperature, ventilation, low flow fixtures, hot water supply from water heater, daylighting, energy efficient appliances and lighting fixtures, durability of green materials, and renewable energy equipment. Most of the responses ranged from very satisfied to neither satisfied or dissatisfied for all the variables except for the ability to adjust temperature (one dissatisfied and one very dissatisfied response) and low flow fixtures (one dissatisfied response, from the same household) (see Figure 73).

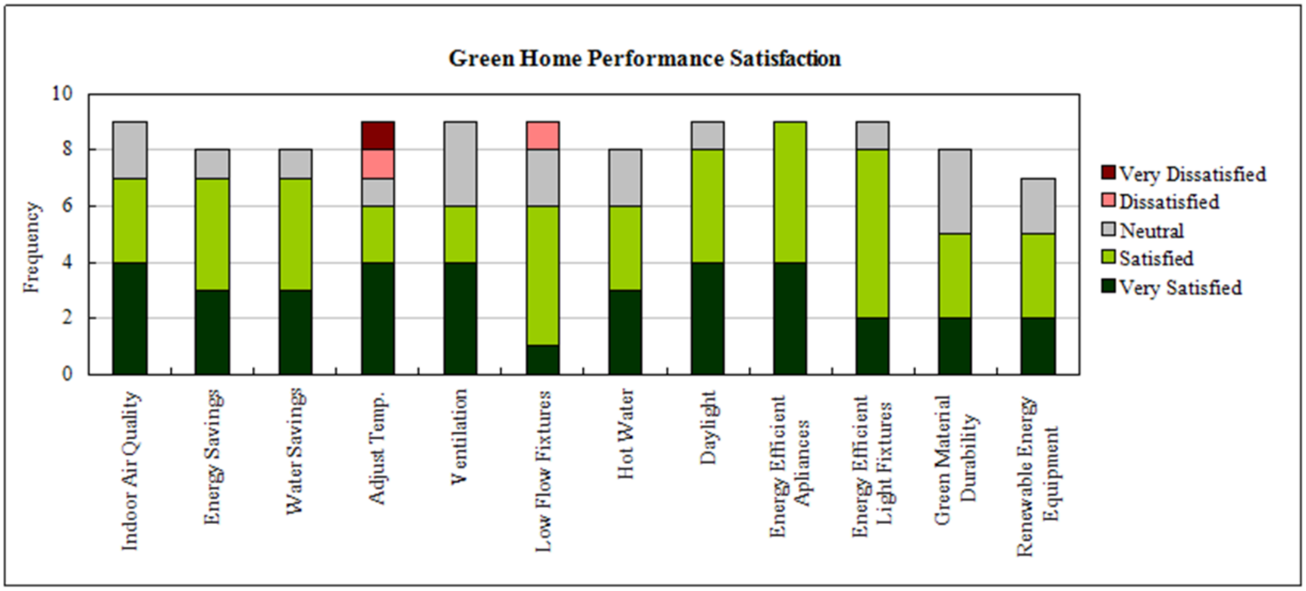


Figure 73*: *Reported Green Home Performance Satisfaction

Household Temperature

Problems or issues related to maintaining household temperature and comfort level were evaluated using a five-point Likert scale of frequency (always, frequently, sometimes, rarely and never). Two common problems experienced by most of the households were associated with maintaining comfortable household temperature during a particular season (summer/winter) and the floors being too cold in the winter. While there were no reports of condensation on windows, one household reported noticeable drafts sometimes.

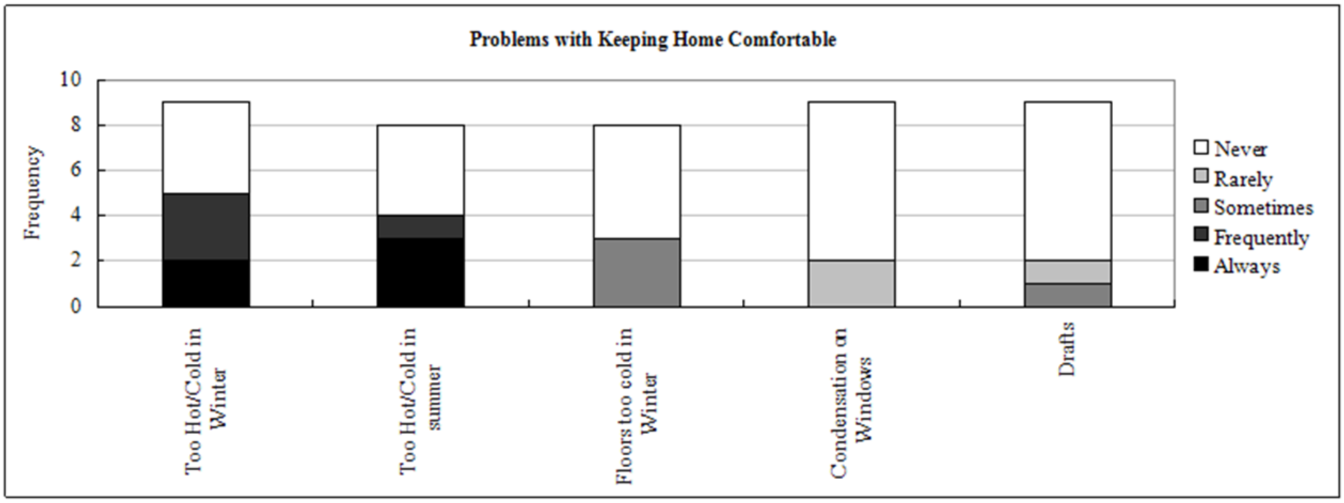


Figure 74: Reported Problems with Keeping Home Comfortable

GREEN BUILDING BENEFITS

When responding to the question regarding the benefits of living in a green building, six occupants from six households had positive comments:

- “Change towards the Earth's health is being made one property at a time.”
- “Building more comfortable.”
- “Solar Panels.”
- “High Energy Savings.”
- “Cleaner and efficient air system.”

BUILDING FEATURES

Most of the occupants liked the spacious layout of the multifamily building and the natural lighting, especially in the stairway. They also commented that it was very quiet and peaceful. In general, they were very satisfied with the household appliances. Some liked the newly renovated parts of the building, the interior of the apartment, laundry facility on the floor and broad stairs.

When commenting on the building features that the occupants did not like nor had most trouble with, their responses included:

- “The walls are easily marked by any soft scratch or touch.”
- “Insulation: The floors are too thin; you can hear everything from upstairs and the occupants upstairs and downstairs can hear me.”
- “Not enough closets. The water comes out really slow. Has to get used to the "green" materials. Does not like A/C unit, very hot in the rooms - A/C does not cool. People smoke inside the apartment - you can smell smoke and weed. Structure is bad and poorly built; there are cracks in the wall.”
- All but one household said they would recommend the purchase or renting of a green building to a close friend.

8.2.2 Round Two - Follow-up Results

This section considers the information gathered from the follow-up surveys with a focus mainly on changes in behavior that occurred over time in these residencies for the 5 complete sets of baseline-follow up data. Two additional baseline interviews were also conducted during this phase of the research along with follow up survey/interviews occurring approximately 2 months later. Their results are included here given the compressed timeframe and to avoid biasing the previous section's results wherein there is a 7-10 month lapse period between the initial and follow up survey.

The physical characteristics of these two additional single family (attached) homes are the same - each has 3 bedrooms, one and a half baths, and a room over the garage, both three story structures.

Overall, reports on daily household temperatures showed no real change between the two periods- one household reported cooler temperatures when at home, with the rest remaining mostly constant. Also, meals cooked at home remain mostly constant, with a few households reporting slightly more meals cooked per week, perhaps due to the presence in the home of school aged children, off from school for the summer.

One notable difference between the two period surveys was the amount of showers taken per week. One respondent reported taking seven times as many showers when compared to the baseline. Two other respondents, however, report taking two to seven times *fewer* showers per week.

The largest differences came from reported satisfaction and comfort. Figure 75 and Figure 76 look at reported baseline and follow-up green home performance satisfaction, as is reported in the previous section, for the 5 buildings who participated in the follow-up.

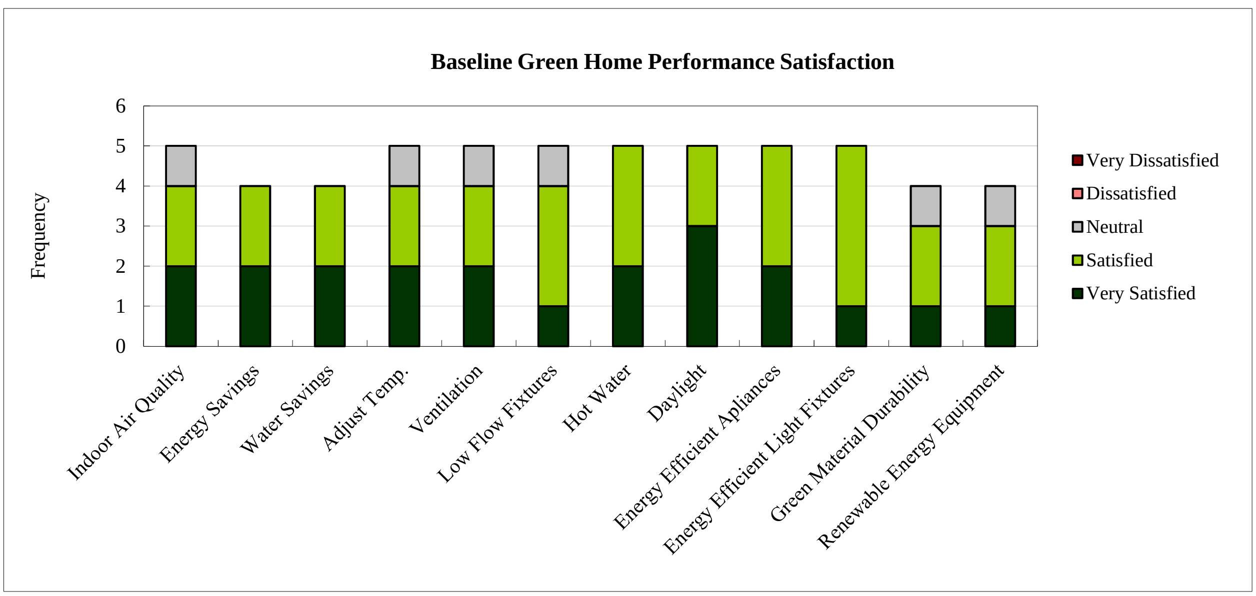


Figure 75: Baseline Performance Satisfaction

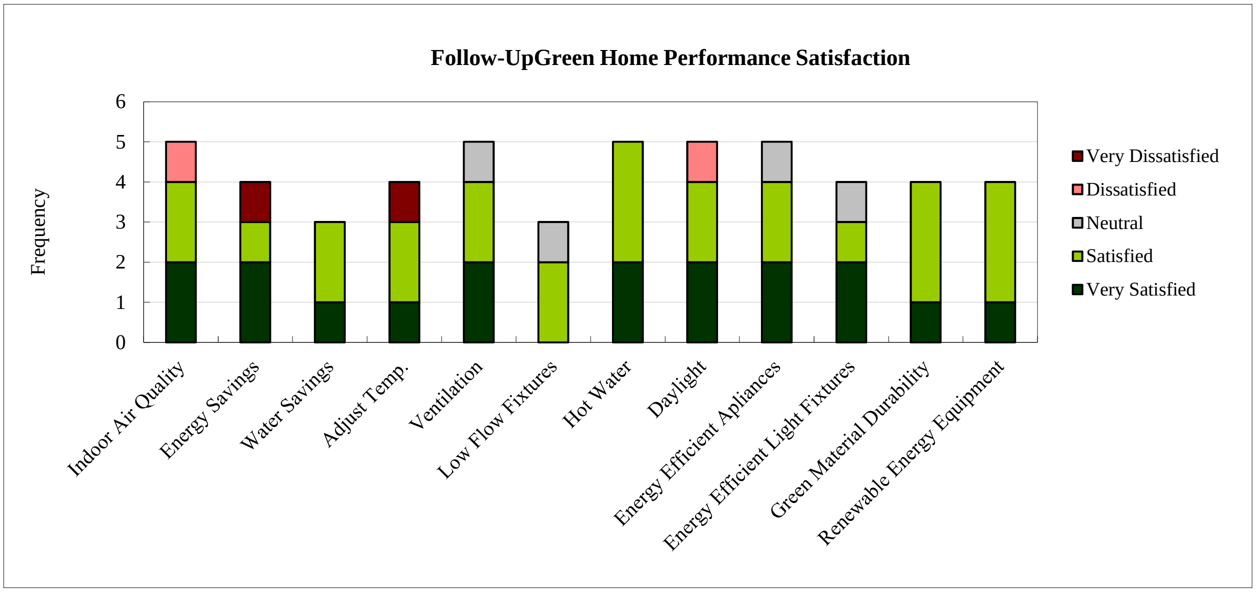


Figure 76: Follow-Up Performance Satisfaction

When looking at the baseline results (Figure 75) things seem fairly consistent with the previous baseline results, wherein the majority of the results are either satisfied or very satisfied. Looking at Figure 76 however, things seem less ideal. There are more reports of dissatisfaction (pink and red colors), and fewer of satisfaction. This could be due to the residents losing their initial fascination with the green features, it may be due to just overall worse performance, or it may be caused by something exogenous, like outdoor conditions.

Figure 77 and Figure 78 look at home comfort problems, wherein the lighter the responses are, the fewer the problems that are occurring. Once again, things appear worse during the follow-up survey.

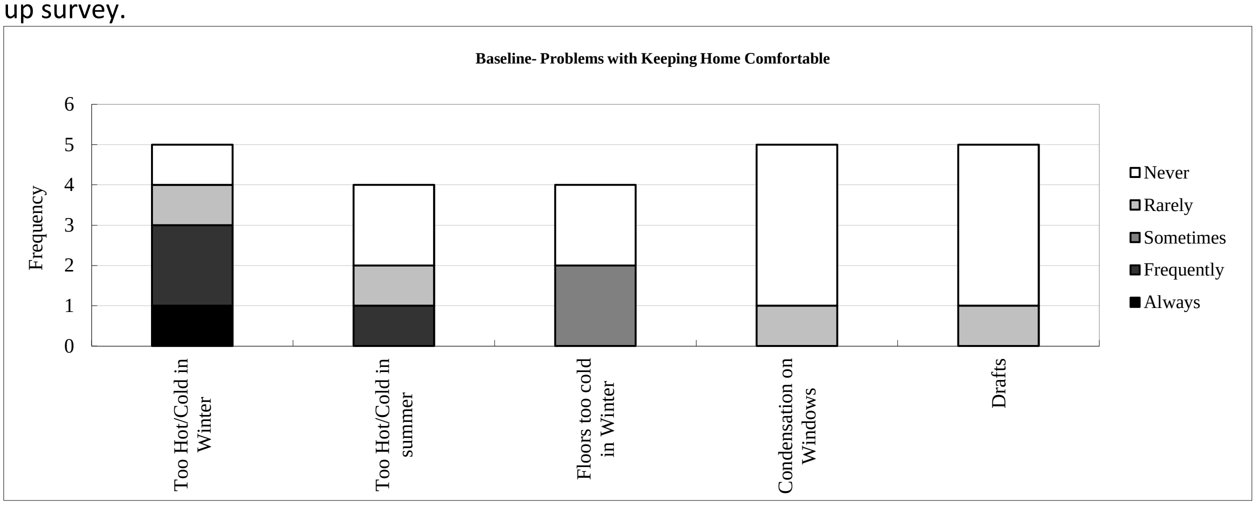


Figure 77: Baseline-Problems with Keeping Home Comfortable

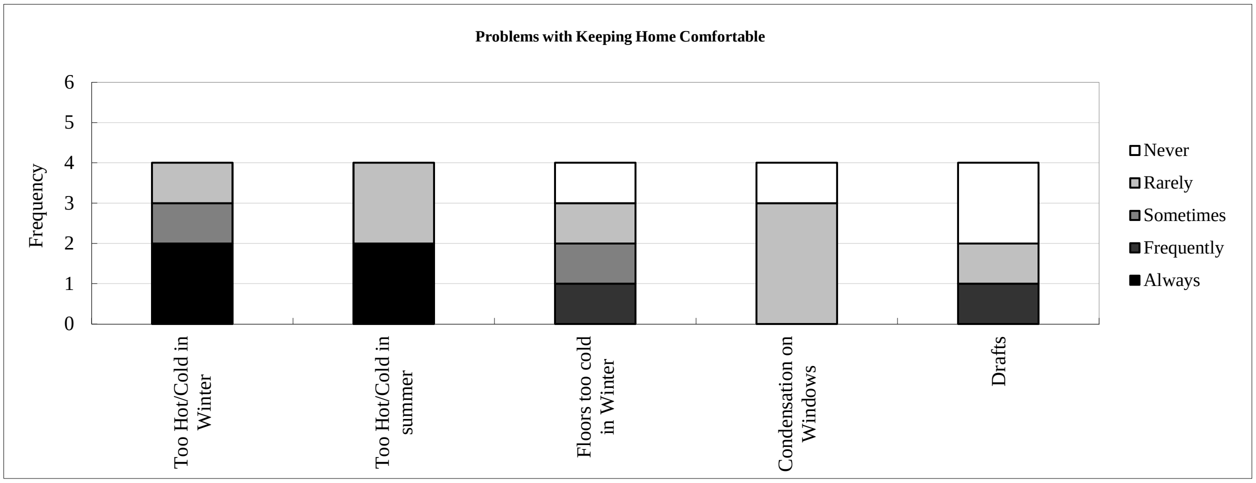


Figure 78: Problems with Keeping Home Comfortable

Figure 79 and Figure 80 look less at changes in satisfaction as changes in comfort behavior. Here, we see more adjustments taking place during the follow-up period, evidenced by more people agreeing strongly that they make changes, such as opening closing windows, or leaving less lights on. As with the previous two groups of figures, the reasons for this are unknown but could relate to seasonal factors, increased familiarity with the operable features of the house, or something else unknown to the project team.

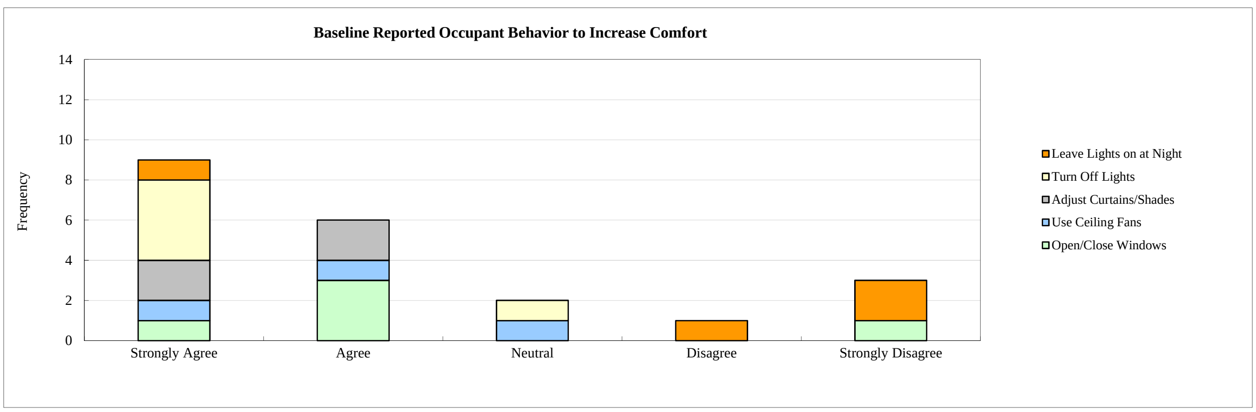


Figure 79: Baseline Reported Occupant Behaviors Increase Comfort

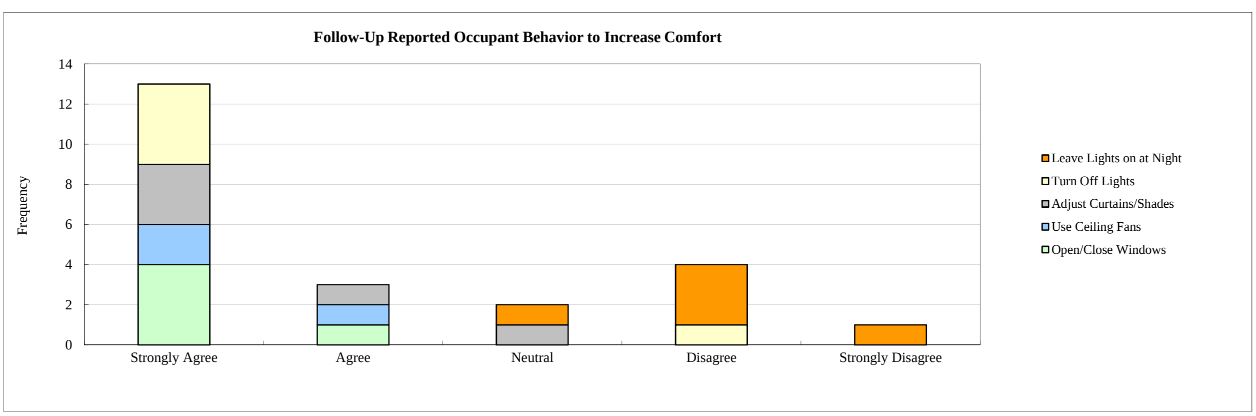


Figure 80: Follow-Up Reported Occupant Behaviors Increase Comfort

In comparing the results of the follow-up surveys to the baseline surveys for the townhomes occupied later during the research period only, there are no significant changes in terms of daily habits. The daily schedule and occupancy times between the surveys did not differ drastically, with the daily wakeup and bed times being about 20-30 minutes earlier overall, and only one household reporting any change in occupancy times, saying the house is occupied about 3 hours more per week since the baseline survey was conducted.

8.2.3 A Brief Look at Energy Usage and Behavior

This section looks at some summary statistics of the energy consumption of the participating households compared to behavior gathered from the baseline surveys. Due to the limited scope of our data, comparisons over time (utilizing both baseline and follow-up data) were not able to be considered.

The energy data used is average monthly kWh usage for each household, calculated by averaging consumption over a 12 month period. Considered are four indicators of energy usage to see how the participants' behavior might have affected energy consumption. The calculations for each indicator are taken *ceteris paribus*, meaning no factor other than the indicator and energy usage were considered for each.

The first characteristic examined was household size, with the expectation that more inhabitants would cause greater electricity usage. This was not, however, the case. Each household had between two and four inhabitants at the time of the baseline survey, and the households with four used more energy than those with two (330 kWh to 290 kWh). The households with three inhabitants, however, used on average 475 kWh per month, over a hundred more than those with four persons and almost 200 kWh more than those with two.

Figure 81 looks at the other three characteristics. Each trends in the direction we would expect. The first comparison is the number of showers taken per week. Households taking more than 20 showers per week consumed almost 80 kWh per month more electricity on average than homes that took less than 20 showers a week. When looking at meals cooked per week, those that cook less than once per day use about 35 kWh hours per week. Those household who reported being empty more than seven hours per day consumed approximately half as much electricity as those who did not, all else being equal.

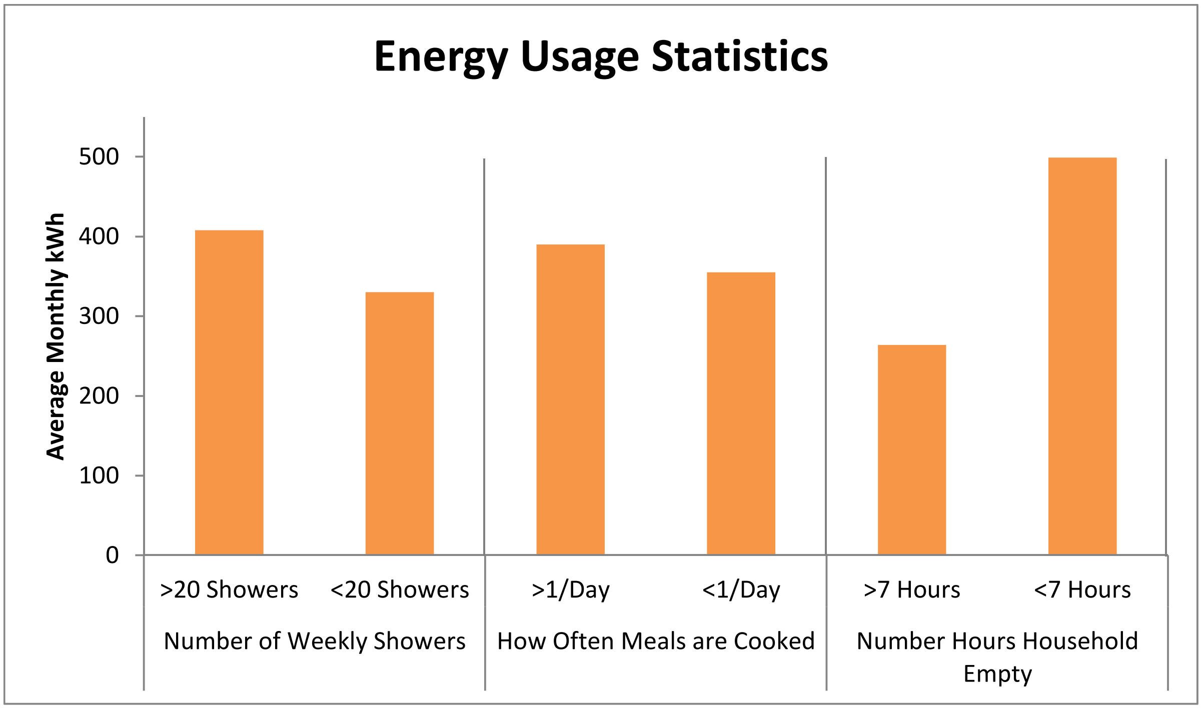


Figure 81: Energy Usage Statistics

9 SUMMARY OF RECOMMENDATIONS AND CONCLUSIONS

It is the hope of the R&D project team that the results of this research will inform NJCEP program managers as to the most useful and cost effective energy- and durability-related improvements that can be successfully implemented in today's residential new construction market. NJCEP programs and the building community at large will be well served by sharing the results of this effort. Below are the high-level recommendations generated by this R&D project.

EFFECTIVE TECHNICAL STANDARDS PROVIDE A PRESCRIPTIVE PATH BUT ALSO ALLOW FLEXIBILITY

Including a prescriptive and performance path is a sound approach to program design and helps builders achieve a home that is 50% better than code. The NJCC technical standard outlines a prescriptive path for builders to follow that gives concrete examples of systems that, when incorporated into a comprehensive design, achieve the desired level of energy savings. This is particularly useful for builders who are pursuing the NJCC tier for the first time. The standard also includes a provision for builders to propose an alternative path (without compromising energy savings), which provides flexibility for a variety of building configurations and issues that come up during design and construction.

During this project, the NJCC standards were revised based on feedback from the NJ developer and designer community that certain equipment and renewable configurations were difficult to implement in the field. The goal of this revision was to provide more flexibility for builders while maintaining the same level of performance and savings yields as the original specification. The specific changes made are listed below.

- Additional hot water technologies were added to the list of approved measures. The list was expanded from only two options (heat pump water heater and natural gas instantaneous water heater) to include electric storage, gas storage, and oil and gas indirect off of a boiler. Since all water heating energy use is required to be offset with 50% renewable energy, the tradeoff for the less efficient water heaters is a larger renewable system. The end result is flexibility for builders and comparable energy savings across technologies.

- The renewable requirement was made fuel and technology "blind" by allowing builders to choose either PV or solar hot water panels to provide 50% of the hot water energy load. In practice, the energy used by hot water is converted to either MMBTUs or kWh to determine renewable sizing.

- Drain water heat recovery (DWHR) systems were added as a cost effective way to capture energy from water as it goes down the drain and use it to preheat cold water entering the water heater. The revised specification requires DWHR and provides a list of approved units. In some slab on grade homes, building configuration will not allow for DWHR installation, so the revised technical requirements include a waiver request process for those building types.

- Language was changed in several places to clarify or update the requirements, including definition of low flow devices and efficient distribution, alignment with revised ENERGY STAR requirements, and updated web links to referenced standards.

TECHNICAL ASSISTANCE FROM NJCEP IS EFFECTIVE AND CRITICAL FOR MARKET TRANSFORMATION

In general, building materials and equipment are available to meet NJCC standards. That said, the value of NJCEP program support is greatest in terms of specifying those materials and providing technical assistance on newer building techniques needed to achieve the desired performance level.

One example of this is the NJCC air tightness requirement. Air sealing and tight construction are important components of high performance and energy efficient homes. However, these requirements were difficult for participating developers to achieve. In response to this, the project modified the services provided to builders in the following ways. First, MaGrann provided the builders and design team with a description of air sealing techniques at the initial design planning meeting. Second, the project instituted an additional air sealing inspection after framing is completed, but prior to insulation being installed, and a pre-drywall blower door test in addition to the final blower door test. These early testing opportunities facilitate the identification of leaky areas before the building is complete and help builders and contractors understand the level of effort needed to comply with the airtightness standard.

One developer struggled to meet the air sealing requirement on their first NJCC home. On the second NJCC home built by the developer, the NJCC team offered the additional services described above through design and construction. The second home met the air tightness standard, demonstrating the benefit of the technical assistance. In addition, the developer's crew now understands the techniques and can apply them on future projects, helping to transform the market.

REM/RATE MODELING IS IMPORTANT FOR MODELING BUT HAS LIMITATIONS

Within the NJCC Program, REM/Rate is used to model the energy use of homes. Its purpose is to help the building community (and energy efficiency program administrators) understand how the "as built" home should perform—under typical operating conditions—to a reference home (typically a code-compliant home).

This project demonstrated that while REM/Rate serves that function well, it is not a good predictor of actual energy use. The reason is that the "as built" home can be very different from the "as operated" home. Specifically, the research found that REM/Rate's limits on thermostat settings meant that the software could not accurately reflect the actual thermostat settings that the team observed in some units. In other words, some participants set their thermostats higher in the winter than REM/Rate would allow the team to model.

This finding underscores the point that homes designed and built to advanced technical requirements have the potential to save energy, but how they are operated determines whether the targeted savings are achieved.

RESIDENT EDUCATION IS IMPORTANT FOR THE OPTIMAL PERFORMANCE OF HOMES

The project team tracked the energy use of 11 homes in the NJCC program to compare actual performance with predicted performance based on energy modeling of the Climate Choice Homes requirement and of the same homes built to New Jersey's current energy code (IECC 2009).

As noted above, the purpose of energy modeling is to compare a structure to itself with different design options, not to reliably predict the future. Actual building operation will always vary from the modeled scenario due to the fact that occupants control their environment and use energy differently than any model can anticipate, weather conditions vary, and other unforeseen variables come into play. However, the research on the NJCC units suggests that resident education is an important component for the optimal performance of NJ Climate Choice Homes.

Anecdotal conversations with residents by the monitoring team (outside of the survey instrument) revealed that residents typically were not aware that they were living in housing designed to be very energy efficient. Further, survey responses indicate that most residents kept their thermostat at the same setting at all times. One resident was not able to say what temperature their thermostat was set to, as they did not know how to use their programmable thermostat.

IN HIGH PERFORMANCE HOMES, MISCELLANEOUS ELECTRIC LOADS (MELS) BECOME A BIGGER PORTION OF TOTAL ENERGY USE

Miscellaneous electric loads (MELs) are electric loads that do not fit into typical energy use categories of space conditioning, domestic hot water, ventilation, major appliances, and lighting. Based on the findings, the project team agrees with other recent research that shows MES are a bigger portion of total energy use in very efficient homes.

As noted by the National Renewable Energy Laboratory (NREL), "MELs present special challenges because their purchase and operation are largely under the control of the occupants. If no steps are taken to address MELs, they can constitute 40%-50% of the remaining source energy use in homes that achieve 60-70% whole house energy savings, and this percentage is likely to increase in the future as home electronics become even more sophisticated and their use becomes more widespread." (Hendron & Eastment, 2006). NREL notes that 14% of a home's typical energy use goes to MELs, while in a high performance home (with 54% whole house savings) MELs account for 32% of total energy use. This is on par with the findings for the NJCC homes.

ENVIRONMENTAL AND ENERGY MONITORING PROVIDE VALUABLE DATA BUT PRESENT UNIQUE CHALLENGES

One component of the project was to conduct environmental and energy monitoring. This provided the program with important information on the performance of the homes, and the data from the monitoring equipment has been used in developing the recommendations above. In addition, the monitoring equipment helped identify when equipment is not performing as expected. The monitoring equipment revealed potential issues with renewable systems and HVAC equipment, alerting building owners to follow up on the information.

However, conducting the environmental and energy monitoring was not without its challenges.

The first of these challenges is that the monitoring equipment used in this project requires a steady, reliable internet connection to transmit data. It is not possible to manually download the data or transfer it via another method. (The monitoring equipment manufacturer has now provided this functionality in the newest generation of its product.) Wireless internet coverage was specified by housing developer and incorporated into monitoring plan. After construction was complete, the team discovered wireless did not reach the enrolled units.

The second of the challenges encountered with the monitoring equipment is that it is not plug-and-play; significant on-site commissioning is needed to ensure reliable operation. For example, when monitoring electric loads at the panel, clear guidance is needed on electrical panel wiring. If possible, on-site observation during panel wiring can help ensure that the panel is wired as intended for load isolation.

10 APPENDIX A: ORIGINAL AND AMENDED SCOPES

New Jersey CEP Residential Energy Efficiency Programs
2009 and 2010 R&D Proposal
November, 2009

Program Area: New Jersey Energy Star Homes
Research Objective: Monitoring and Evaluation of Tier 3 Homes, and Development of Advanced Builder Training
Funding Period: This proposal requests funds from both 2009 and 2010 R&D budget periods. Phase 1 utilizes 2009 R&D funds, while Phase 2 anticipates R&D funding available in 2010. Details appear in budget tables.

Background

The Honeywell Market Manager Team has recently established and implemented a new level of advanced home building for New Jersey. The New Jersey Energy Star Labeled Homes Tier 3 ("Climate Choice") encourages the construction of homes that will make use of advanced, high efficiency building products, practices, lighting, and appliances. This new level is an "aspirational" tier in that it promotes innovation in building design, materials, techniques, and operation in order to achieve significant savings through a mix of conventional and unconventional approaches. Development of the Climate Choice Home Tier builds on the earlier work of the New Jersey DCA's Green Homes Office.

With this new highest tier approved and in place, there is an opportunity to research what it will take to build these homes, how they actually perform, why builders choose to construct to this level, why buyers purchase the homes, and what program managers should do to develop the program so that more homes move to this "home of the future" level going forward.

As Tier 3 is being launched at a pilot scale, there is much interest from builders and designers, and the program anticipates that 55 homes will be enrolled at this tier level with the expectation that they will be completed between 2009 and 2011. This level of interest provides a great opportunity to launch a research and development initiative for New Jersey's residential new construction program.

R&D Initiative

With the established Tier 3 level in place, we seek to use this R&D project as a platform for researching how best to effectively promote, market, and enhance its development. Our focus in this request is to understand building energy use, occupant behavior, measure costs and savings, and ensure builder success while placing New Jersey in a clear lead in the Zero Energy Homes movement. To achieve these goals, program developers and managers require a better understanding of the motivations behind builders and buyers in seeking out and building these high-performance homes, what sort of techniques they choose to incorporate to meet the technical standards, what works and doesn't work to deliver maximum energy savings, barriers to builders, and how to move forward as Tier 3 evolves and grows. A presentation of this initiative was delivered to BPU, Honeywell and CSG representatives by Mark MaGrann and VEIC on February 3rd, at which time the concept received positive feedback.

This is a comprehensive proposal developed in concert with program implementers, outlining work that will occur during 2009, 2010, and 2011. Upon approval of this plan, work will be implemented immediately and will continue during 2010. The Market Manager is requesting follow-on funding in the 2010 RNC R&D budget that will allow the work to be completed. Details are outlined in the timeline and budget section of this proposal. These expenditures will allow us to complete work and associated reporting that requires at least one full year of energy monitoring in order to gain useful information.

Approach

This R&D plan seeks to collaborate with multiple groups and institutions. Stakeholder input effectively began with a March 25th kick-off meeting among a group of 30 program developers, implementers, builders, architects, and advocates. The Climate Choice Home concept was introduced, feedback received, specifications modified and/or clarified, and builders recruited. The Honeywell Team now proposes the following initiatives as part of a comprehensive low energy home Research and Development effort:

1. Curriculum development and delivery for advanced builder training (supplemental to EPA resources);
2. Energy and Environmental Monitoring of homes
3. Occupant Surveys
4. Lifecycle Cost Analysis

1. **Curriculum Development for Builder Training:** Program developers have recognized a need for in-depth builder training in order to introduce and reinforce advanced building science concepts, techniques, and best practices for ultra efficient homes. The material covered will be above and beyond the basic building science and energy efficiency principles already covered in the NJ Energy Star Homes training. The request here is for curriculum development, production of training materials, and delivery of the advanced training session. This training will help to ensure successful, trouble-free homes garnering positive feedback towards the program, builders, and the benefits of low energy homes experienced by owners. Curriculum and materials for this training would be developed by The Center for Architecture and Building Science Research at NJIT, in conjunction with the US EPA. Training will be delivered to enrolled Tier 3 builders via existing NJESH process, with the addition of the advanced session delivered by NJIT.

   Advanced techniques not otherwise covered at the basic level include the following subject matter geared towards low energy homes:
   a. The House as a System and Advanced Building Science
   b. Thermal Envelope Requirements and Strategies
      i. Windows
      ii. Insulation
      iii. Thermal bridging
      iv. Air Barrier Assembly and Air Sealing
      v. Moisture Management

c. Site Orientation
    i. Solar gain
    ii. Glazing distribution
d. HVAC Systems requirements and strategies
    i. System options and efficiencies
    ii. Sizing
    iii. Design issues
    iv. Ventilation
e. Domestic Hot Water Systems requirements and strategies
    i. System options and efficiencies
    ii. Efficient distribution systems
f. Lighting and Appliances
g. Renewable Energy systems
h. Innovative design approaches – how to earn the "innovation award" specified as a program incentive for the best example of a Climate Choice Home.

2. **Energy and Environmental Monitoring:** The New Jersey Institute of Technology's Center for Architecture and Building Science Research proposes to assist the Honeywell Team by monitoring the energy and environmental performance of these homes over the course of two years, or until mid 2011, whichever comes first. NJIT will be responsible for data acquisition system specification, design, purchase, and installation, as well as all subsequent data analysis and reporting. NJIT will plan to monitor 11 homes in the program (20% of anticipated completions) to allow for representation in different areas of the state as well as the varying building performance that is inevitably encountered in residential construction. In the event the program participation does not meet the proposed goal of 55 units, the team would still monitor 11 homes. Data acquisition equipment has been identified that will allow remote monitoring of many measurable energy sources in the home, along with indoor and outdoor environmental conditions. Results will provide data to evaluate performance of the home, to provide the basis for developing energy and carbon footprints, and to inform improvements in the RNC program over time. There are two discrete components to this R&D item:

    a. **Monitoring** of all energy production and consumption along with selected end uses and environmental conditions will occur over two years once the home is occupied. Data not available from utility bills will be gathered using a web-based remote monitoring system (electric end use data monitoring will be provided via E-Monitors by Power House Dynamics). Isolation of gas use for heating and hot water will be done using disaggregation software in addition to the monitored data if applicable. Monitoring of the following end-uses and conditions are proposed:
        i. Indoor temperature and relative humidity
        ii. Outdoor temperature and relative humidity
        iii. Net electrical energy used (from utility bill data)
        iv. HVAC electricity
        v. Refrigerator electricity
        vi. Electricity generated from PV system
        vii. Total natural gas consumption (from utility bill data)
        viii. Natural gas used for water heating

b. **Data Analysis and Reporting:** The collected data will be monitored daily to confirm that systems are operating as intended, and used to evaluate the performance of each home and its renewable energy systems. This comparison will help bracket the cost effectiveness of building to Climate Choice homes levels and will help establish which strategies are more or less advantageous within the program. Building performance data will be tabulated and analyzed showing:
    i. Average daily electric consumption and generation
    ii. Average daily natural gas consumption
    iii. Natural gas used for water heating
    iv. Electric performance during peak demand period(s)
    v. HVAC system response to indoor conditions
    vi. Electric and natural gas use will be charted with indoor and outdoor conditions as appropriate to further reveal occupant behavior and home performance.

3. **Occupant Surveys:** There is much to be learned about energy related perceptions and occupant behavior, and much to be gained through occupant education in low-energy homes. Rutgers University's Bloustein Center for Green Building will design and deliver two occupant surveys. See attached proposal for details.

4. **Life-Cycle Analysis:** Rutgers University's Bloustein Center for Green Building has developed a budget and work scope to evaluate costs and performance of energy features, and to deliver a life cycle cost analysis to the program with a view toward long-term energy savings of installed efficiency measures. This work will coincide with the energy monitoring, which will provide supporting input to the life cycle cost analysis. See attached proposal for details.

Outcomes

Results of this research will inform OCE program managers as to the most useful and cost effective energy- and durability-related improvements that can be successfully implemented in today's construction market. OCE programs and the building community at large will be well served by sharing the results of this effort.

The primary outcomes of this R&D effort will be to:

1. Better understand builder motivations and understanding of low energy homes;
2. Develop a one-day curriculum for builders in advanced building science related to low energy homes. This piece is designed to help ensure builder and program success, and eliminate negative home owner feedback regarding this high profile tier;
3. Incorporate builder and homeowner feedback in developing an improved Tier 3 standard and offering;
4. Track, monitor and report on energy end-uses in low-energy homes to better understand where energy is used and how to further save it;
5. Better understand home buyer motivations and behavior changes as they purchase and then live in Tier 3 homes;
6. Provide cost-effectiveness and life-cycle-cost implications of Tier 3 homes;

7. Modify, change and enhance the Climate Choice Home standard to improve it's use and effectiveness in New Jersey, with a secondary consideration to informing and influencing EPA's national work on low energy use homes;
8. Develop criteria around the annual "Innovation Award" incentive that rewards the builder(s) of exemplary Tier 3 homes.
9. Raise the profile of NJ as a national leader in cutting edge standards development and service delivery by contributing to national industry forums such as RESNET and ACI conference presentations; articles in respected industry publications (such as Energy Design Update and Home Energy Magazine) on the technical and programmatic results and implications of this work; consider Program recognition through industry awards in conjunction with NJ Builders Association
10. Develop carbon and energy footprints of each of the 55 pilot homes;
11. Deliver annual and final reports to the OCE, in consultation with the project team, on the progress and results of this initiative with relevant data points.
12. Answer the following questions:
    a. How will builders and homeowners perceive this effort? (on-going R&D feedback activities and surveys)
    b. What specific trainings do builders need to achieve success? (Builder feedback and trainings)
    c. How much energy do Climate Choice Homes use? (Data monitoring)
    d. When do they use it? (Data monitoring)
    e. In what way do they use it? (Data monitoring)
    f. What is the effect of behavior on energy use? (Data monitoring and occupant interviews)
    g. Do occupants of Climate Choice homes behave differently or perceive living in these homes differently compared to their prior homes? (Occupant interviews)
    h. Which improvements are most cost-effective? (Building cost data, lifecycle cost analysis)
    i. Which technologies and approaches work and don't work to save energy, and which would builders be willing to incorporate in future projects? (Monitoring, LCC)

Timeline and Budget

Success of the Tier 3 home R&D strategy relies on contributions from both 2009 and 2010 R&D budgets as outlined in Table One. Tasks associated with each year's funding are outlined in Table Two. Note that funds required to wrap up the project in 2011 will make use of encumbered 2010 funds. Final work products and reports will be delivered in 2011, allowing for collection and analysis of enough data to be of value.

Table One: R&D Budget Request by Category and Year

Category	2009	2010
Market Manager Project Management	$57,170	$55,460
NJIT and Rutgers	$40,654	$109,134
Annual sub-totals	$97,824	$164,594
Grand Total **$262,418**		

Table Two: Deliverables by Year			
	2009	2010	2011
Develop supporting materials for builders	X		
Advanced training curriculum development and delivery	X	X	
Develop life cycle cost analysis tools and procedures	X	X	
Purchase and install monitoring equipment	X	X	
Deliver occupant survey(s)	X	X	X
Monthly data collection, analysis, and reporting	X	X	X
Manage and support R&D efforts as needed	X	X	X
Develop builder innovation award		X	
Develop presentations, reports, and papers			X
Occupant survey analysis and report			X
Life cycle cost analysis report			X
Year end status report to OCE	X	X	
Final project report to OCE			X

Payment Schedule

The table below shows the end dates for each proposed task in each funding cycle. Invoices will be sent at the time of actual milestone completion, which may occur before or after the listed end date.

Phase 1: 2009 Development Tasks	Bill Date	Honeywell Total
Proposal Development	11/2/2009	$15,921
Develop supporting materials for builders	12/31/2009	$12,016
Develop builder training materials, Deliver training, 1	1/30/2010	$10,067
Develop LCC tools and procedures, Phase 1	1/30/2010	$20,847
Purchase and Install monitoring equipment	2/15/2010	$16,781
Data collection and monitoring compilation, 1	6/30/2010	$11,097
Data collection and monitoring compilation, 2	12/30/2010	$11,097
Phase 1 Total (2009 funding cycle)		**$97,824**

Phase 2: 2010 Development/Implementation Tasks		
Survey Development	2/1/2010	$8,822
Deliver Builder Training, 2	5/1/2010	$5,522
Data Collection and Survey delivery, 1	6/30/2010	$8,822
Data collection/analysis/reporting	6/30/2010	$9,072
Purchase and Install remaining monitoring equipment	9/1/2010	$14,756
Draft LCC tool and report	10/30/2010	$23,822
Data Collection and Survey delivery, 2	12/1/2010	$8,822
Data collection/analysis/reporting	12/31/2010	$9,072
Phase 2 Total (2010 funding cycle)		**$88,709**

Phase 3: 2010/11 Completion and Reporting

Monthly data collection/analysis/reporting	8/1/2011	$27,221
Final monitoring analysis and report	10/1/2011	$11,221
Final LCC tool, report, and customer surveys	10/1/2011	$31,221
Final Report to OCE	11/1/2011	$6,221
Phase 3 Total (2010 funding cycle)		**$76,365**

Grand Total		**$262,418**

Memo

Date: December 13, 2011
To: Mona Mosser
From: Rebecca Foster and Alison Hollingsworth
cc: Mike Ambrosio; Dave Wolk; Joe Genello; Tom Timberg; Mike Flannery; Mike Brown; Christine Liakus; Jennifer Senick; Nikki Kuhn; Paul Scheckel
Re: Request to Extend Climate Choice Homes R&D Project Through 2012

This memo provides an update on the status of the NJ Climate Choice Homes (NJCC) R&D Project and a request to continue the project through the end of 2012 under a revised timeline and budget at no additional cost to the Office of Clean Energy (OCE).

2011 Accomplishments

The NJ Climate Choice Homes Pilot Program helps build demand for high performing, low energy load homes. The construction techniques and technologies incorporated into these buildings are commercially available but some are not yet widely adopted, so long term monitoring and data on these systems are not readily available. The NJCC R&D project monitors the performance of these advanced buildings and provides valuable data which will be incorporated into future program planning. Specific accomplishments from 2011 are listed below with supporting material in appendices.

- Enrollments and completions have created a pool of units for monitoring.
  The NJCC R&D project plan called for the monitoring of 11 NJCC units. In 2010 three projects enrolled (a single family, a 5-unit multi-single, and a 70-unit multifamily). In 2011 five projects enrolled (a duplex, a 9-unit multi-single, a 6-unit multifamily, a 7-unit multifamily, and a 22-unit multifamily). This provides the NJCC R&D project with a pool of 122 units from which to select the 11 homes that are monitored.
- Home monitoring equipment was purchased and installed (Phase 1, Task 5).
  With the BPU's approval, the R&D team purchased home energy monitoring equipment for the 11 homes that will be evaluated through the NJCC R&D project. (This equipment was included in the original project budget.) The monitoring equipment was installed in the Patterson Habitat for Humanity single-family home. Once tenants move in and specific units are selected for monitoring, the same equipment will be installed in the RPM Grand Central building. As discussed later in the memo, the remaining installations are dependent on an extension being granted by the OCE.
- Completion of Occupant Survey Draft and Life Cycle Cost Calculator (Phase 1, Task 4 and Phase 2, Task 1)
  The Rutgers University Bloustein Center for Green Building completed two deliverables associated with the NJCC R&D project: the final draft of a life cycle cost calculator and a survey for use with NJCC occupants. These deliverables were reviewed and approved by the OCE in July 2011.
- Completion of Builder Training Power Point (Phase 1, Task 3)
  The New Jersey Institute of Technology (NJIT) developed a curriculum to be used in training builders to comply with the NJCC standards and delivered a targeted technical training to Habitat for Humanity Paterson staff. This deliverable was circulated to the OCE with a request for permission to bill via email on December 5, 2011.

Request to Continue Project through 2012

Rationale, Scope and Budget for 2012

The sustained housing downturn in New Jersey and throughout the nation has slowed new home construction significantly, yet the NJCC program has helped foster and build demand for high performing, low energy load homes, many of which completed and will be occupied in 2011. Because of slower than expected completions, the project is behind schedule, but the significant progress has framed up a strong foundation for results in 2012.

To determine which buildings should be monitored, the project team evaluated the buildings enrolled in the program to date based on their completion timelines with the thinking that the earlier the completion timeline, the more data could be collected through the R&D project. The units that will be enrolled in the project include three housing types: single family home, townhouse, and multifamily building. The buildings that we propose to monitor in 2012 are:

- Paterson Habitat for Humanity Governor Street – Single Family
- RPM Grand Central Orange – Multifamily
- Paterson Habitat for Humanity Harrison Street – Townhouse

We are proposing to continue with the original research plan with minor modifications that have been informed by the 2010-2011 program activities and building enrollments. We are requesting no new budget for 2012. Rather, we are proposing to carry forward remaining funds from the original R&D project plan and use them to complete the project, with the modifications discussed below. Assuming that we receive permission to bill for the above items, the carryover from the original project plan is $169,934.98 and the modified project can be completed at $169,934.98.

New tasks proposed are noted here:

- Rutgers will update the life cycle costing calculator to reflect new building code at no additional cost.
- Rutgers will create a new life cycle cost calculator for multifamily buildings. The original program assumed primarily single family housing enrollment so only a single family tool was developed. The multifamily version of the calculator will cost $10,724.50.
- Rutgers will develop a version of the occupant survey geared toward multifamily buildings. The occupant survey will cost $2,000.00.
- NJIT will videotape interviews with contractors about new building practices used to meet the Climate Choice Homes standards. Footage from building sites and construction details will be captured as appropriate and available. Particular practices to be examined will include those that current program participants have found to be especially novel and or difficult, such as:
    - effective air sealing strategies;
    - exterior rigid insulation; and
    - sub-slab insulation.

  The video generated from this task is anticipated to be particularly effective as a resource for other builders building to the Climate Choice Homes standards or other rigorous energy standards. Guidance from peers has been cited as one of the most effective ways for contractors to learn about new energy efficient practices. The final video will be edited and included with the final report narrative documenting lessons learned. This task will cost $18,144.00.

Together, the new tasks will cost $30,868.50. In order to free up budget for the new tasks, the team identified two tasks included in the original proposal that were no longer necessary given the number of builders enrolled in the project and their technical knowledge and familiarity with NJCC requirements.

- Supporting materials for builders (Phase 1, Task 2) - $12,015.80
- Builder Training #2 (Phase 2, Task 2) - $5,522.00

The tasks that were removed from the project plan total $17,537.80. To make up the difference between the cost of the new tasks and the savings from removing the older tasks, the team modified the budget for the other remaining tasks, reducing budget amounts wherever possible. This enabled the project team to deliver the new tasks to the OCE at no change in overall project cost.

The appendices include a full timeline *(Appendix A)* and comparison of original project budget and new project budget *(Appendix B).* You will note in the timeline that we plan to complete all deliverables and billing by December 2012, and throughout 2012 we plan to monitor progress and adjust the tasks if needed to keep to that schedule. We look forward to OCE's response to the request to continue the NJCC R&D project and would be happy to discuss the project with you at any point.

Revised Proposed Budget for 2012
Climate Choice Homes Research & Development Project

Deliverable			Expected Completion Date	Total Budget	
Phase	Task	Description			
4	1.0	Update LCC Single Family Tool with Current Code and Develop New LCC Tool for Multifamily	1/30/2012	$	10,724.50
4	2.0	New Survey for MF Buiding Type	1/30/2012	$	2,000.00
4	3.0	Deliver Survey #1 to Builidng Occupants		$	8,822.00
4	3.1	Habitat Paterson Governor Street (1 Unit)	1/15/2012	$	802.00
4	3.2	RPM Orange (9 units)	2/28/2011	$	7,218.00
4	3.3	Habitat Paterson Harrison Street (1 unit)	4/15/2012	$	802.00
4	4.0	Input Cost Data and Estimated Energy Savings into LCC Tool & Summarize Results		$	23,822.00
4	4.1	Habitat Paterson Governor Street (1 Unit)	2/15/2012	$	2,165.64
4	4.2	RPM Orange (9 units)	2/15/2012	$	19,490.73
4	4.3	Habitat Paterson Harrison Street (1 unit)	4/1/2012	$	2,165.64
4	5.0	Install Remaining Monitoring Devices		$	6,795.00
4	5.1	RPM Orange (9 units)	1/15/2012	$	5,935.00
4	5.2	Habitat Paterson Harrision Street (1 unit)	4/15/2012	$	860.00
4	6.0	Deliver Survey #2 to Builidng Occupants		$	8,822.00
4	6.1	Habitat Paterson Governor Street (1 Unit)	8/1/2012	$	802.00
4	6.2	RPM Orange (9 units)	8/1/2012	$	7,218.00
4	6.3	Habitat Paterson Harrison Street (1 unit)	8/1/2012	$	802.00
4	7.0	Monitoring, Data Collection, and Analysis		$	31,432.27
4	7.1	Monitoring, Data Collection, and Analysis: Update 1	2/1/2012	$	10,477.42
4	7.2	Monitoring, Data Collection, and Analysis: Update 2	5/1/2012	$	10,477.42
4	7.3	Monitoring, Data Collection, and Analysis: Update 3	8/1/2012	$	10,477.42
4	8.0	Field Observations and Documentation - Habitat Paterson Harrison Street	5/1/2012	$	18,144.00
4	9.0	Final Report	12/1/2012	$	59,373.20
4	9.1	Final analysis of metered data, conclusions and recommendations for Final Report	12/2/2012	$	28,979.19
4	9.2	Completed LCC tool conclusions and recommendations for Final Report	12/3/2012	$	30,394.01
Total				**$**	**169,934.98**

Climate Choice Homes (NJCC) R&D Project
Comparison of Original and 2012 Proposed Deliverables/Budget

Original Budget/Deliverables

Deliverable	Description	Expected Completion Date	Budget	Invoice Status	Notes
Phase 1: 2009 Development Tasks					
1	Proposal development	11/2/2009	$15,921.00	Paid	
2	Develop supporting materials for builders	12/31/2009	$12,015.80		Proposed to be cancelled in 2012
3	Develop builder training materials, Deliver training #1	1/30/2010	$10,066.64	Received approval to bill on 12/13/11	
4	Develop LCC tools and procedures, Phase 1	1/30/2010	$20,846.64	Paid	
5	Purchase and install monitoring equipment	2/15/2010	$16,780.64	Paid	
6	Data collection and monitoring compilation, #1	6/30/2010	$11,096.64		
7	Data collection and monitoring compilation, #2	12/30/2010	$11,096.64		
Phase 2: 2010 Development and Implementation Tasks					
1	Survey development	2/1/2010	$8,822.00	Paid	
2	Deliver builder training #2	5/1/2010	$5,522.00		Proposed to be cancelled in 2012
3	Data collection and survey delivery #1	6/30/2010	$8,822.00		
4	Data collection/ analysis/ reporting	6/30/2010	$9,072.00		
5	Purchase and install remaining monitoring equipment	9/1/2010	$14,756.00	Paid	
6	Draft LCC tool and report	10/30/2010	$23,822.00		
7	Data collection and survey delivery #2	12/31/2010	$8,822.00		
8	Data collection/ analysis/ reporting	12/31/2010	$9,072.00		
Phase 3: 2010 Completion and Reporting					
1	Monthly data collection/ analysis/ reporting	8/1/2011	$27,341.45		
2	Final monitoring analysis and report	10/1/2011	$11,341.45		

3	Final LCC report and customer surveys, final report to OCE	11/1/2011	$37,442.00		
TOTAL FOR PROJECT			**$262,658.87**		

New Proposed Budget/Deliverables

Deliverable	Description	Expected Completion Date	Budget	Invoice Status	Notes
Phase 1: 2009 Development Tasks					
1	Proposal development	Completed	$15,921.00	Paid	
3	Develop builder training materials, Deliver training #1	Completed	$10,066.64	Received approval to bill on 12/13/11	
4	Develop LCC tools and procedures, Phase 1	Completed	$20,846.64	Paid	
5	Purchase and install monitoring equipment	Completed	$16,780.64	Paid	
Phase 2: 2010 Development and Implementation Tasks					
1	Survey development	Completed	$8,822.00	Paid	
5	Purchase and install remaining monitoring equipment	Completed	$14,756.00	Paid	
Phase 4: 2012 Implementation, Completion, and Reporting Tasks					
1.0	Update LCC Single Family Tool with current code and develop new LCC Tool for MF	1/30/2012	$10,724.50		
2.0	New Survey for MF Building type	1/30/2012	$2,000.00		
3.0	Deliver survey #1 to building occupants		$8,822.00		
3.1	Habitat Paterson Governor Street (1 Unit)	1/15/2012	$802.00		
3.2	RPM Orange (9 units)	2/28/2011	$7,218.00		
3.3	Habitat Paterson Harrison Street (1 unit)	4/15/2012	$802.00		
4.0	Input costs data and estimated energy savings into LCC tool & summarize results		$23,822.00		
4.1	Habitat Paterson Governor Street (1 Unit)	2/15/2012	$2,165.64		
4.2	RPM Orange (9 units)	2/15/2012	$19,490.73		
4.3	Habitat Paterson Harrison Street (1 unit)	4/1/2012	$2,165.64		
5.0	Install remaining monitoring devices		$6,795.00		

5.1	RPM Orange (9 units)	1/12/2012	$5,935.00		
5.2	Habitat Paterson Harrison Street (1 unit)	4/12/2012	$860.00		
6.0	Deliver survey #2 to building occupants		$8,822.00		
6.1	Habitat Paterson Governor Street (1 Unit)	8/1/2012	$802.00		
6.2	RPM Orange (9 units)	8/1/2012	$7,218.00		
6.3	Habitat Paterson Harrison Street (1 unit)	8/1/2012	$802.00		
7.0	Monitoring data collection and analysis		$31,432.27		
7.1	Monitoring data collection, analysis and update 1	2/1/2012	$10,477.42		
7.2	Monitoring data collection, analysis and update 2	5/1/2012	$10,477.42		
7.3	Monitoring data collection, analysis and update 3	8/1/2012	$10,477.42		
8.0	Field observations and documentation - Habitat Paterson Harrison Street	5/1/2012	$18,144.00		
9.0	Final report	12/1/2012	$59,373.20		
9.1	Final analysis of metered data, conclusions and recommendations for Final report	12/2/2012	$28,979.19		
9.2	Completed LCC tool conclusions and recommendations for Final report	12/3/2012	$30,394.01		
TOTAL FOR PHASE 4			**$169,934.98**		
TOTAL FOR PROJECT			**$257,127.89***		

** Note that the total in the new proposed project budget is $5,530.98 less than the total in the original budget. This is due to the timing of finalizing the carryover numbers for the full EE program budget. When the R&D project team moved to finalize its 2012 plans, it calculated that project carryover was $175,465.96. However, an earlier estimate of carryover of $169,934.98 had already been included in the final proposed budgets being presented to the Board. Rather than attempt to modify the full EE program budget, the R&D project team chose to propose a lesser amount for its work in 2012, which lowers the overall project cost of the project by $5,530.98.*

11 APPENDIX B: NJCC TECHNICAL STANDARDS

New Jersey Climate Choice Home

Minimum Technical Specifications V.1

To earn the New Jersey Climate Choice Home (CCH) and EPA Climate Choice labels, a project must meet or exceed the technical specifications below as well as meet or exceed all requirements for NJ ENERGY STAR Homes and EPA Indoor AirPLUS; be verified and field-tested in accordance with NJCCH, EPA and national Home Energy Rating System standards (including all applicable checklists), and meet all applicable codes. In the event of conflicting standards, the standard with the highest efficiency or performance requirement will prevail.

Size	**Maximum home size is 3,000 square feet**
HERS Index	**Maximum 50 points**

Thermal Envelope

Insulation:

- Prescriptive R-value requirements ≥ 150% IECC 2009, OR
- Performance (Energy Rating) must show total thermal building envelope UA ≤ 50% IECC 2009

Minimum Envelope Insulation levels

Zone	Window U-factor	Window SHGC (see “site orientation” below)	Ceiling R-value	Wall R-value	Mass wall R-value	Exposed Floor R-value	Basement/ Crawl Wall continuous R-value	Slab edge/under **Add R7.5 for heated slabs** R/depth (ft)
4	<=.27	<=.27	57	19.5	7.5	28.5	15	15/2
5	<=.23	<=.27	57	30	19.5	45	15	15/2

- Minimal thermal bridging in framed assemblies (i.e. continuous insulation over framing, double stud wall, or SIPS)
- RESNET Level 1 Insulation (gaps, voids, compression ≤ 2%)
- Complete air barrier assembly (ENERGY STAR TBC)
- Air leakage ≤2.5ACH50

Site Orientation

- House needs to be oriented for maximum solar exposure
- If passive solar design is planned, windows must be orientation-tuned. Not required, but strongly recommended. (whole unit values shown)
    - West and east facing glazing
        - U≤.20
        - SHGC ≤.27
    - South facing glazing
        - Overhangs must be designed for passive winter gain and summer shading
        - U-factor of ≤.25
        - SHGC ≥.40
    - North facing glazing
        - U-factor ≤.20
        - SHGC no spec

<table>
<tr><td rowspan="1">HVAC Proper Installation</td><td colspan="3">
Ductless HVAC system preferred. If a ducted system is used:
• All ducts must be inside conditioned space
• Provide documentation of ACCA Manual D and T duct and terminal sizing or equivalent
• Compact duct layout recommended
• Total duct leakage ≤ 5% of furnace fan flow
• Verified room-by-room air flow
• Verified air flow across coil/heat exchanger per manufacturer spec
• Pressure balancing (transfer grills, cross-over ducts, or dedicated returns)

Ventilation:
• Whole-house, heat recovery ventilation with air flow verified to meet ASHRAE 62.2

Equipment:
• Provide documentation of ACCA Manual J and S heating/cooling equipment sizing or equivalent
• Ensure proper refrigerant charge
• Comply with NJ Quality Installation Verification requirements
• Comply with ACCA QI Specs http://www.cee1.org/resid/rs-ac/HVACQIspec.pdf
</td></tr>
<tr><td rowspan="8">HVAC Equipment</td><td>Element</td><td>Technical Standard</td><td>Notes</td></tr>
<tr><td>Heating AFUE</td><td>≥ 94% gas, ≥86 oil</td><td rowspan="5">See minimum renewable energy requirements below for supply power</td></tr>
<tr><td>Central AC SEER</td><td>≥ 15</td></tr>
<tr><td>Air-source heat pump HSPF</td><td>≥ 9</td></tr>
<tr><td>COP (GHP)</td><td>ENERGY STAR labeled</td></tr>
<tr><td>Ventilation</td><td>HRV or ERV</td></tr>
<tr><td colspan="3">Multiple or variable speed equipment required</td></tr>
<tr><td colspan="3">Central cooling dehumidification SHR ≤.7, or central cooling with supplemental dehumidification to SHR ≤.7</td></tr>
<tr><td rowspan="2">Water Heating System</td><td colspan="3">
Efficient Equipment;
• heat pump electric ≥ 2.0 COP, or
• direct-vent gas water heater ≥ .8 EF, AND
• Solar hot water system
</td></tr>
<tr><td colspan="3">
Efficient Distribution:
• Low-flow faucets and showerheads
• Efficient distribution (demand pumping, manifold, or core layout)
</td></tr>
<tr><td>Lighting</td><td colspan="3">90% ENERGY STAR Qualified Fixtures and/or Bulbs</td></tr>
<tr><td>Renewable Energy</td><td colspan="2">Solar Electric must provide at least 50% of modeled electricity consumption. Small wind or hydro may be used with engineering estimate of available resource.</td><td>Solar Thermal must provide at least 50% of modeled hot water energy requirement.</td></tr>
<tr><td>Appliances</td><td colspan="2">Refrigerator: CEE Tier 3 (≥ 30% of federal standard)
Dishwasher, standard: CEE Tier 2 (EF ≥.68)
Dishwasher, compact: CEE Tier 1 (EF ≥.88)</td><td>Appliance specs and lists are available at:
www.cee1.org
www.energystar.gov</td></tr>
<tr><td>Moisture Management</td><td colspan="3">Water-managed roof, walls, foundation (see EPA Indoor AirPLUS specs)</td></tr>
</table>

New Jersey Climate Choice Home

Minimum Technical Specifications V.2

Updated June 7, 2012

To earn the New Jersey Climate Choice Home (NJCCH) label, a project must meet or exceed the technical specifications below as well as meet or exceed all requirements for NJ ENERGY STAR Homes, ENERGY STAR v.3.0, and EPA Indoor AirPLUS; be verified and field-tested in accordance with NJCCH and Residential Energy Services Network (RESNET) standards (including all applicable checklists), and meet all applicable codes. In the event of conflicting standards, the standard with the highest efficiency or performance requirement will prevail.

The prescriptive path outlined below is one way to achieve the requirements for incorporation of renewables, 50% energy savings over IECC 2009, and HERS maximum of 50 points (before the inclusion of renewables in the rating software). Builders may propose alternative compliance paths to achieving these metrics which the program will consider for approval.

Size	**Maximum home size is 3,000 square feet**
HERS Index	**Maximum 50 points**

Thermal Envelope

Insulation:

- Prescriptive R-value requirements ≥ 150% IECC 2009, OR
- Performance (Energy Rating) must show total thermal building envelope UA ≤ 50% IECC 2009

Minimum Envelope Insulation levels								
Zone	Window U-factor	Window SHGC (see "site orientation" below)	Ceiling R-value	Wall R-value	Mass wall R-value	Exposed Floor R-value	Basement/ Crawl Wall continuous R-value	Slab edge/under **Add R7.5 for heated slabs** R/depth (ft)
4	<=.27	<=.27	57	19.5	7.5	28.5	15	15/2
5	<=.23	<=.27	57	30	19.5	45	15	15/2

- Minimal thermal bridging in framed assemblies (i.e. continuous insulation over framing, double stud wall, or SIPS)
- RESNET Grade 1 Insulation
- Complete air barrier assembly (ENERGY STAR TERC)
- Air leakage ≤2.5ACH50

<table>
<tr><td>Site Orientation Recommendations</td><td>

- Best practices in passive solar design call for buildings to be oriented for maximum solar exposure during heating season, along with orientation-tuned glazing. (Suggested whole unit window values shown)
  - West and east facing glazing
    - U≤.20
    - SHGC ≤.27
  - South facing glazing
    - Overhangs designed for passive winter gain and summer shading
    - U-factor of ≤.25
    - SHGC ≥.40
  - North facing glazing
    - U-factor ≤.20
    - SHGC no spec

</td></tr>
<tr><td>HVAC Proper Installation</td><td>

Ductless HVAC system preferred. If a ducted system is used, the following requirements apply:

- All ducts must be inside conditioned space
- Provide documentation of ACCA Manual D and T duct and terminal sizing or equivalent
- Compact duct layout recommended
- Total duct leakage shall meet ENERGY STAR v 3.0 specifications
- Verified room-by-room air flow
- Verified air flow across AC coil/heat exchanger per manufacturer spec
- Pressure balancing (transfer grills, cross-over ducts, or dedicated returns)

Ventilation:

- Whole-house, heat recovery ventilation with air flow verified to meet ASHRAE 62.2

Equipment:

- Provide documentation of ACCA Manual J and S heating/cooling equipment sizing or equivalent
- Ensure proper refrigerant charge
- Comply with NJ Quality Installation Verification requirement defined by the Air Conditioning Contractors of America Quality Installation Specification (ACCA QI Spec)[30]

</td></tr>
<tr><td>HVAC Equipment</td><td>
<table>
<tr><th>Element</th><th>Technical Standard</th></tr>
<tr><td>Heating AFUE</td><td>≥ 94% gas, ≥86 oil</td></tr>
<tr><td>Central AC SEER</td><td>≥ 15</td></tr>
<tr><td>Air-source heat pump HSPF</td><td>≥ 9</td></tr>
<tr><td>Ground source heat pump COP</td><td>ENERGY STAR labeled</td></tr>
<tr><td>Ventilation</td><td>HRV or ERV</td></tr>
<tr><td colspan="2">Multiple or variable speed equipment required</td></tr>
<tr><td colspan="2">Central cooling dehumidification SHR ≤.7, or central cooling with supplemental dehumidification to SHR ≤.7</td></tr>
</table>
</td></tr>
</table>

[30] http://www.cee1.org/resid/rs-ac/HVACQIspec.pdf

<table>
<tr><td rowspan="8">Water Heating System</td><td colspan="3">All installations require a drain water heat recovery (DWHR) unit approved by NRCAN[31,32]</td></tr>
<tr><td>Water Heating Technology</td><td>Minimum EF</td><td>Additional Requirements</td></tr>
<tr><td>Gas, on demand</td><td>0.92</td><td>Sealed combustion</td></tr>
<tr><td>Gas, stand-alone storage</td><td><76kbtu: ≥.70 EF
≥76kbtu: ≥95%TE</td><td>Sealed combustion</td></tr>
<tr><td>Gas or oil, indirect off boiler</td><td>N/A
(EF=AFUE*.92)</td><td>Boiler meets CCH technical specs</td></tr>
<tr><td>Electric, standard, storage</td><td>0.95</td><td></td></tr>
<tr><td>Electric, HPWH, storage</td><td>COP 2.0</td><td></td></tr>
<tr><td colspan="3">Efficient Distribution:
• Low-flow faucets and showerheads meeting EPA WaterSense standards[33]
• Efficient distribution (demand pumping, manifold, or core layout) as defined by USGBC's LEED for Homes[34]</td></tr>
<tr><td>Renewable Energy</td><td colspan="2">Solar Electric must provide at least 50% of modeled electricity consumption. Small wind or hydro may be used with engineering estimate of available resource.</td><td>Solar Thermal or Solar Electric must provide at least 50% of modeled hot water energy requirement.</td></tr>
<tr><td>Lighting</td><td colspan="3">90% ENERGY STAR Qualified Fixtures and/or Bulbs</td></tr>
<tr><td>Appliances</td><td colspan="2">Refrigerator: CEE Tier 3 (≥ 30% of federal standard)
Dishwasher, standard: CEE Tier 2 (EF ≥.68)
Dishwasher, compact: CEE Tier 1 (EF ≥.88)</td><td>Appliance specs and lists are available at:
www.cee1.org
www.energystar.gov</td></tr>
<tr><td>Moisture Management</td><td colspan="3">Water-managed roof, walls and foundation (see EPA Indoor AirPLUS specs)</td></tr>
</table>

[31] NRCAN equipment list: http://oee.nrcan.gc.ca/residential/personal/retrofit/13302
[32] Homes built slab on grade generally do not have drain configuration to accept DWHR unit. Those homes can request waiver from DWHR requirement.
[33] http://epa.gov/watersense/new_homes/index.html
[34] http://www.usgbc.org/ShowFile.aspx?DocumentID=3638

12 APPENDIX C: NJCC PROGRAM IMPLEMENTATION OVERVIEW

The Climate Choice Home program implementation procedures were developed with two goals in mind: to incorporate sufficient verification to validate the projected savings of the participating homes and to provide the technical support required by the participating project teams to successfully complete their homes within the framework of the program. As the performance of the homes and the amount of the incentives earned in the program were significantly superior to homes participating in the standard operational tiers of the NJCEP-Energy Star Homes program, so the validations required and the technical support offered had to be deeper and broader as well.

With those two goals as a guide, an implementation procedure was designed to maximize the chances of projects completing successfully while ensuring that program requirements were being met. Each step listed is described in greater detail following the high-level list below.

Implementation Procedure Details

1. **Potential participant submits an application package**
   Homeowners, developers or builders interested in participating in the Climate Choice Home program complete an application package consisting of the following items:
   a. Detailed plans and specifications
   b. A proposed construction schedule
   c. A design narrative
   d. A signed participation agreement

   The design narrative was eliminated from the application package after the first few projects, as it was determined that it did not add any substantive value.

   MaGrann Associates reviews the application package for completeness and soundness. After initial review, the potential participant is notified that the project has been accepted into the Climate Choice Home program.

2. **Preliminary energy model is created**
   MaGrann Associates creates a preliminary energy model using REM/Rate software. The detailed architectural plans and equipment specifications form the inputs for the model, and any unclear elements are clarified with the participant so that a complete model can be developed. Any design elements that do not comply with the program prescriptive requirements are identified and documented for problem resolution. The model is then validated against program energy saving requirements, and potential design upgrades that will lower the project's HERS index to below 50 (excluding proposed renewable energy elements) are documented.

3. **Design team review meeting**
   A meeting consisting of the participant's design team and MaGrann Associates is held to review the planned project. The design team includes the homeowner or developer, the architect, the general contractor, and any other relevant persons. The preliminary

energy model is reviewed along with the proposed design upgrades envisioned in step 2. All non-compliance issues must be resolved and the design upgrades agreed upon by all parties.

4. **Preliminary energy model is finalized**
   The outcomes from the design team review meeting are used to update the REM/Rate model. A final list of agreed upon upgrades is formalized in a letter to the participant. When the upgrade letter is signed by the participant and returned to the program, the first incentive tranche is processed for payment.

5. **Foundation Inspection**
   Prescriptive and upgraded foundation items are visually inspected. Some items on the Water Management checklist are inspected at this time. If the building is slab-on-grade construction, the slab edge insulation is inspected. Any non-compliant items identified during the inspection must be corrected and verified prior to construction continuing. This inspection must take place after the foundation is set and prior to framing commencing.

6. **Site Orientation meeting**
   After framing has commenced a Site Orientation meeting is scheduled. MaGrann Associates meets at the construction site with the general contractor and all relevant sub-contractors from the various building trades. Of particular importance are the HVAC and insulation sub-contractors. If possible, the specific crews that will be working on the project should be present. Program requirements and project specific upgrades will be reviewed, along with best practices. All elements that will be inspected at the Air Sealing and Insulation inspections are described and discussed in detail. Final building performance testing procedures are explained, along with air infiltration and duct leakage targets and requirements.

7. **Air Sealing Inspection**
   After framing is completed but prior to insulation being installed, the building is inspected for air sealing details. Some items from the Water Management, Thermal Enclosure, Framing Quality and Indoor Air Quality checklists are inspected at this time. Any non-compliant items identified during the inspection must be corrected and verified prior to insulation installation.

8. **Insulation and HVAC Inspection**
   After insulation has been installed but prior to sheet rock being installed, the building is inspected for insulation details. Some items from the Thermal Enclosure, HVAC Quality Installation and Indoor Air Quality checklists are inspected at this time. The ductwork is inspected for adequate sealing, as is any HVAC equipment that has been set (this often only occurs after sheet rock installation), and the overall quality of the insulation installation is graded. Any non-compliant items identified during the inspection must be corrected and verified prior to sheet rock installation. Upon passing the Insulation Inspection, the second incentive tranche is processed for payment.

9. **Mid-Construction meeting (at program discretion)**
   If the technical team feels it is warranted, a Mid-Construction meeting is held at the construction site, including the general contractor and the relevant subcontractors. The complexity of the building design, specific challenges related to construction practices and upgrades, the experience of the work crews, and the degree of success of the earlier inspections all factor into the decision to hold a Mid-Construction meeting. If construction is progressing well, and there have been no significant issues uncovered at the pre-drywall inspections, then no Mid-Construction meeting is required. If there have been significant issues that required redress, if subcontractor crews have changed personnel or if other concerns are raised, then a Mid-Construction meeting may be requested.

10. **Final Inspection**
   After construction is completed, a final inspection is performed. During the Final Inspection, any remaining items from the Thermal Enclosure, Indoor Air Quality, HVAC Quality Installation and Water Management checklists are verified. HVAC systems are checked to ensure that the specified efficiency level equipment has been installed. The building is tested for air infiltration through the envelope and for duct leakage. Any non-compliant items identified during the inspection or testing must be corrected and verified prior to Project Certification.

11. **Project Certification**
   All data collected during the various inspections is entered into REM/Rate to generate a Final Rating for the building. Two HERS indexes are generated. One considers efficiency measures only, which must be below 50, while the other includes installed onsite renewable measures. All checklists are reviewed for completeness and compliance. When all program requirements are determined to have been met, certificates are generated and delivered to the participant. The total incentive amount is calculated (based on the final HERS index), and the final tranche is processed for payment.

Completed Projects

1. **Homes for Our Troops – Gonzalez Project**

Builder: Godsil Construction
Location: Hillsdale, NJ
Construction Type: New Construction
3,000 Square foot single family house
HERS Index = 21
Estimated savings: 9042 kW, 3.7 kW
Energy Saving Features: R-22 SIP walls, R-12.5 Superior Foundation Walls, R-60 Spray Foam insulation in ceilings, Geothermal Heat Pump

2. **Grand Central Senior**

Builder: RPM Development
Location: Orange, NJ
Construction Type: New Construction
70 unit, 4 story multifamily building
HERS Index = 30
Estimated savings: 47,773 kWh, 13982 therms, 78 kW
Features: Flash and batt walls with R-10 continuous exterior insulation, R-60 plus cellulose insulation in ceiling, 97% Furnaces with ECM motors, 16 SEER AC units, 96% efficient central water heating system

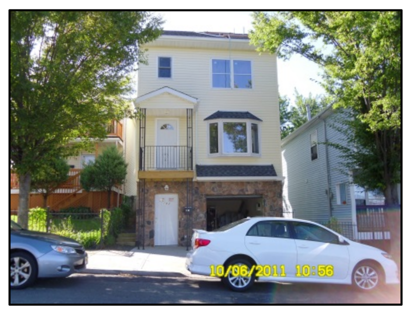
3. **Central Orange Village**

Builder: RPM Development
Location: Orange, NJ
Construction Type: New Construction
Three buildings consisting of 3-unit triplexes (total 9 units)
HERS Index = 23
Estimated Savings: 15,642 kWh, 6886 therms, 25 kW
Features: Flash and batt walls with R-6 continuous exterior insulation, R-60 cellulose insulation in ceiling, 95% AFUE Furnaces with ECM motors, 15 SEER AC, 98% efficient tankless water heaters

4. **152 Pierson Street, 166 Pierson Street, & 310 Mechanic Street**
Builder: RPM Development
Location: Orange, NJ
Construction Type: Gut-Rehab
Description: 2 unit duplex, 6-unit multifamily building, & 7 unit multifamily building
HERS Index = 20, 36, & 36
Estimated Savings: 5500 kWh, 2640 therms, 9.7 kW
Features: Closed cell spray foam filled walls, R-60 cellulose insulation in ceiling, 17 SEER minisplit AC system, 97% efficient hybrid tankless water heater providing both space heating & domestic hot water heating

5. **102 Governor Street**

Builder: Paterson Habitat for Humanity
Location: Paterson, NJ
Construction Type: New Construction
Description: 1500 sq ft single family home
HERS Index= 27
Estimated Savings: 874 kWh, 756 therms, 0.3 kW
Features: R-12.5 Superior foundation walls, R-30 SIP walls, closed cell spray foam and blown-in insulation in ceilings, 95% AFUE furnace with ECM motor



Projects in Process

1. **208-216 Harrison Street**

Builder: Paterson Habitat for Humanity
Location: Paterson, NJ
Construction Type: New Construction
Description: 5 townhomes roughly 1700 sq ft each
Features: R-12.5 Superior foundation walls, double stud wall construction filled with cellulose insulation, closed cell spray foam and blown-in insulation in ceilings, hybrid hot water system providing both space heating & domestic hot water heating
Status: Expected to be completed certification during summer of 2013

2. **Levin Residence**
Builder: Kirsten Levin (homeowner)
Location: Margate, NJ
Construction Type: New Construction
Description: 2600 sq ft single family house
Features: Dense packed cellulose walls & ceilings with 4" of continuous insulation on exterior, 16.5 SEER / 9.1 hspf air source heat pump, 2.2 EF heat pump water heater
Status: Expected to be completed inspections & certification during fall of 2013

3. **Price Duplex**
Builder: Pinneo Construction
Location: Princeton, NJ
Construction Type: New Construction
Description: 2200 sq ft duplex
Features: Cellulose filled walls & ceilings with exterior insulation, geothermal heat pump, 2.4 EF heat pump water heater
Status: Design of project completed. Construction has not begun. Not expected to be completed until 2014.

13 APPENDIX D: LCC RUN ESTIMATED COSTS

Building A.1

Project Costs	Baseline	As-Built
Total	-$75,538.44	-$121,987.15
/SF	-$48.21	-$77.85
Construction Costs Relative to Baseline		
Total		-$46,448.71
/SF		-$29.64

NPV Results (Projected Energy Usage)		
	Baseline	**As built**
Net Present Value - Appliance Replacement Only		
/SF	-$6.55	-$7.98
/SF relative to baseline		-$1.43
Net Present Value - Energy Usage Only		
/SF	-$18.82	-$4.23
/SF relative to baseline		$14.59
Net Present Value Excluding Construction Costs (Appliance Replacement + Energy Usage)		
/SF	-$25.37	-$12.22
/SF relative to baseline		$13.16
Net Present Value Including Construction Costs, before Rebates and Incentives		
/SF	-$73.58	-$90.06
/SF relative to baseline		-$16.49
Total Net Present Value (NPV), including Rebates and Incentives		
/SF	-$73.58	-$80.49
Total relative to baseline		**-$6.91**
Simple Payback Period in Years		**22**

	Rutgers Estimated Construction and Baseline Costs	Builder Provided Costs (with Rutgers estimated cost ratio to determine baseline)	Difference (Method A – B)
Construction Costs	$121,987.15	$93,021.49	$28,965.66
Baseline Costs	$75,538.44	$59,016.68	$16,521.76
Difference (Construction – Baseline)	$46,448.71	$34,004.81	

Building A.2

Project Costs	Baseline	As-Built
Total	-$309,634.09	-$390,367.47
/SF	-$38.87	-$49.01
Construction Costs Relative to Baseline		
Total		-$80,733.37
/SF		-$10.14

NPV Results (Projected Energy Usage)		
	Baseline	**As built**
Net Present Value - Appliance Replacement Only		
/SF	-$6.07	-$10.85
/SF relative to baseline		-$4.78
Net Present Value - Energy Usage Only		
/SF	-$8.26	-$0.29
/SF relative to baseline		$8.55
Net Present Value Excluding Construction Costs (Appliance Replacement + Energy Usage)		
/SF	-$21.83	-$12.70
/SF relative to baseline		$9.13
Net Present Value Including Construction Costs, before Rebates and Incentives		
/SF	-$60.71	-$61.71
/SF relative to baseline		-$1.01
Total Net Present Value (NPV), including Rebates and Incentives		
/SF	-$60.71	-$59.20
Total relative to baseline		**$1.51**
Simple Payback Period in Years		9

	Rutgers Estimated Construction and Baseline Costs	Builder Provided Costs (with Rutgers estimated cost ratio to determine baseline)	Difference (Method A – B)
Construction Costs	$390,367.47	$388,526.18	$1,841.29
Baseline Costs	$309,634.09	$346,233.39	($36,599.30)
Difference (Construction – Baseline)	$80,733.38	$42,292.79	

Building B.1

Project Costs	Baseline	As-Built
Total	-$2,134,898.01	-2,711,651.98
/SF	-$30.84	-$39.17
Construction Costs Relative to Baseline		
Total		-$576,753.97
/SF		-$8.33

NPV Results (Projected Energy Usage)		
	Baseline	**As-Built**
Net Present Value - Appliance Replacement Only		
/SF	-$15.29	-$12.66
/SF relative to baseline		$2.64
Net Present Value - Energy Usage Only		
/SF	-$13.99	-$4.52
/SF relative to baseline		$9.48
Net Present Value Excluding Construction Costs (Appliance Replacement + Energy Usage)		
/SF	-$29.29	-$17.17
/SF relative to baseline		$12.11
Net Present Value Including Construction Costs, before Rebates and Incentives		
/SF	-$60.13	-$56.35
/SF relative to baseline		$3.78
Total Net Present Value (NPV), including Rebates and Incentives		
/SF	-$60.13	-$50.68
/SF relative to baseline		**$9.44**
Simple Payback Period in Years		**5**

	Rutgers Estimated Construction and Baseline Costs	Builder Provided Costs (with Rutgers estimated cost ratio to determine baseline)	Difference (Method A – B)
Construction Costs	$2,711,651.98	$2,723,743.46	($12,091.48)
Baseline Costs	$2,134,898.01	$1,947,285.65	$187,612.36
Difference (Construction – Baseline)	$576,753.97	$776,457.81	

14 APPENDIX E: LCC REM/RATE™ FUEL SUMMARY REPORTS

Building A.1 – Baseline

Fuel Summary

Code Single Family.blg

Annual Energy Cost	$/yr
Natural gas	1066
Electric	1042

Annual End-Use Cost	$/yr
Heating	889
Cooling	149
Water Heating	253
Lights & Appliances	817
Photovoltaics	-0
Service Charge	93
Total	2201

Annual End-Use Consumption	
Heating (Therms)	541
Heating (kWh)	896
Cooling (kWh)	824
Water Heating (Therms)	194
Lights & Appliances (Therms)	66
Lights & Appliances (kWh)	4046
Total (Therms)	801
Total (kWh)	5767

Annual Energy Demands	kW
Heating	0.4
Cooling	1.0
Water Heating (Winter Peak)	0.0
Water Heating (Summer Peak)	0.0
Lights & Appliances (Winter Peak)	0.3
Lights & Appliances (Summer Peak)	0.7
Total Winter Peak	0.7
Total Summer Peak	1.7

Utility Rates	
Electricity	PSE&G Elec 5/20/11***
Natural Gas	PSE&G Gas 5/20/11***

REM/Design - Residential Energy Analysis Software v14.0
This information does not constitute any warranty of energy cost or savings.
© 1985-2012 Architectural Energy Corporation, Boulder, Colorado.

Building A.1 – As-Built
Fuel Summary

2010.0426_ESTR.1_U0001 Vbs
(With Renewables).blg

Annual Energy Cost	$/yr
Natural gas	472
Electric	396

Annual End-Use Cost	$/yr
Heating	366
Cooling	143
Water Heating	83
Lights & Appliances	796
Photovoltaics	-519
Service Charge	93
Total	961

Annual End-Use Consumption	
Heating (Therms)	226
Heating (kWh)	344
Cooling (kWh)	792
Water Heating (Therms)	63
Lights & Appliances (Therms)	66
Lights & Appliances (kWh)	3927
Photovoltaics (kWh)	-2870
Total (Therms)	355
Total (kWh)	2194

Annual Energy Demands	kW
Heating	0.2
Cooling	0.7
Water Heating (Winter Peak)	0.0
Water Heating (Summer Peak)	0.0
Lights & Appliances (Winter Peak)	0.3
Lights & Appliances (Summer Peak)	0.7
Total Winter Peak	0.5
Total Summer Peak	1.4

Utility Rates	
Electricity	PSE&G Elec 5/20/11***
Natural Gas	PSE&G Gas 5/20/11***

REM/Design - Residential Energy Analysis Software v14.0
This information does not constitute any warranty of energy cost or savings.
© 1985-2012 Architectural Energy Corporation, Boulder, Colorado.

Building A.1 – HERS 50
Fuel Summary

Single Family - HERS 50 remove
pv.blg

Annual Energy Cost	$/yr
Natural gas	619
Electric	889

Annual End-Use Cost	$/yr
Heating	366
Cooling	117
Water Heating	229
Lights & Appliances	796
Photovoltaics	-0
Service Charge	93
Total	1601

Annual End-Use Consumption	
Heating (Therms)	226
Heating (kWh)	344
Cooling (kWh)	647
Water Heating (Therms)	176
Lights & Appliances (Therms)	66
Lights & Appliances (kWh)	3927
Total (Therms)	468
Total (kWh)	4919

Annual Energy Demands	kW
Heating	0.2
Cooling	0.7
Water Heating (Winter Peak)	0.0
Water Heating (Summer Peak)	0.0
Lights & Appliances (Winter Peak)	0.3
Lights & Appliances (Summer Peak)	0.7
Total Winter Peak	0.5
Total Summer Peak	1.4

Utility Rates	
Electricity	PSE&G Elec 5/20/110***
Natural Gas	PSE&G Gas 5/20/110***

REM/Design - Residential Energy Analysis Software v14.0
This information does not constitute any warranty of energy cost or savings.
© 1985-2012 Architectural Energy Corporation, Boulder, Colorado.

Building A.1 – Climate Choice Home
Fuel Summary

As Built Single Family 40-50.blg

Annual Energy Cost	$/yr
Natural gas	658
Electric	436

Annual End-Use Cost	$/yr
Heating	587
Cooling	147
Water Heating	83
Lights & Appliances	796
Photovoltaics	-519
Service Charge	93
Total	1187

Annual End-Use Consumption	
Heating (Therms)	364
Heating (kWh)	540
Cooling (kWh)	816
Water Heating (Therms)	63
Lights & Appliances (Therms)	66
Lights & Appliances (kWh)	3927
Photovoltaics (kWh)	-2870
Total (Therms)	493
Total (kWh)	2414

Annual Energy Demands	kW
Heating	0.3
Cooling	0.9
Water Heating (Winter Peak)	0.0
Water Heating (Summer Peak)	0.0
Lights & Appliances (Winter Peak)	0.3
Lights & Appliances (Summer Peak)	0.7
Total Winter Peak	0.6
Total Summer Peak	1.5

Utility Rates	
Electricity	PSE&G Elec 5/20/11***
Natural Gas	PSE&G Gas 5/20/11***

REM/Design - Residential Energy Analysis Software v14.0
This information does not constitute any warranty of energy cost or savings.
© 1985-2012 Architectural Energy Corporation, Boulder, Colorado.

Building A.2 – Baseline

Fuel Summary

Proposed
Inner Unit CODE.blg

Annual Energy Cost	$/yr
Electric	2597

Annual End-Use Cost	$/yr
Heating	1015
Cooling	177
Water Heating	0
Lights & Appliances	1405
Photovoltaics	-0
Service Charge	27
Total	2624

Annual End-Use Consumption	
Heating (kWh)	3360
Cooling (kWh)	541
Lights & Appliances (kWh)	4498
Total (kWh)	8399

Annual Energy Demands	kW
Heating	4.5
Cooling	0.8
Water Heating (Winter Peak)	0.0
Water Heating (Summer Peak)	0.0
Lights & Appliances (Winter Peak)	0.4
Lights & Appliances (Summer Peak)	0.8
Total Winter Peak	4.9
Total Summer Peak	1.6

Utility Rates	
Electricity	PSE&G Elec 8/21/09********

REM/Design - Residential Energy Analysis Software v14.0
This information does not constitute any warranty of energy cost or savings.
© 1985-2012 Architectural Energy Corporation, Boulder, Colorado.

Proposed
Left End Unit CODE.blg

Annual Energy Cost	$/yr
Electric	2761

Annual End-Use Cost	$/yr
Heating	1173
Cooling	183
Water Heating	0
Lights & Appliances	1405
Photovoltaics	-0
Service Charge	27
Total	2788

Annual End-Use Consumption	
Heating (kWh)	3883
Cooling (kWh)	559
Lights & Appliances (kWh)	4498
Total (kWh)	8940

Annual Energy Demands	kW
Heating	5.0
Cooling	0.8
Water Heating (Winter Peak)	0.0
Water Heating (Summer Peak)	0.0
Lights & Appliances (Winter Peak)	0.4
Lights & Appliances (Summer Peak)	0.8
Total Winter Peak	5.4
Total Summer Peak	1.6

Utility Rates	
Electricity	PSE&G Elec 8/21/09******

REM/Design - Residential Energy Analysis Software v14.0
This information does not constitute any warranty of energy cost or savings.
© 1985-2012 Architectural Energy Corporation, Boulder, Colorado.

Proposed
Right End Unit CODE.blg

Annual Energy Cost	$/yr
Electric	2880

Annual End-Use Cost	$/yr
Heating	1295
Cooling	180
Water Heating	0
Lights & Appliances	1405
Photovoltaics	-0
Service Charge	27
Total	2907

Annual End-Use Consumption	
Heating (kWh)	4287
Cooling (kWh)	549
Lights & Appliances (kWh)	4498
Total (kWh)	9335

Annual Energy Demands	kW
Heating	5.4
Cooling	0.9
Water Heating (Winter Peak)	0.0
Water Heating (Summer Peak)	0.0
Lights & Appliances (Winter Peak)	0.4
Lights & Appliances (Summer Peak)	0.8
Total Winter Peak	5.8
Total Summer Peak	1.7

Utility Rates	
Electricity	PSE&G Elec 8/21/09****

REM/Design - Residential Energy Analysis Software v14.0
This information does not constitute any warranty of energy cost or savings.
© 1985-2012 Architectural Energy Corporation, Boulder, Colorado.

Building A.2 – As-Built

Proposed
Inner Unit Pbs (PV).blg

Annual Energy Cost	$/yr
Electric	2223

Annual End-Use Cost	$/yr
Heating	400
Cooling	183
Water Heating	531
Lights & Appliances	1444
Photovoltaics	-335
Service Charge	27
Total	2250

Annual End-Use Consumption	
Heating (kWh)	1325
Cooling (kWh)	555
Water Heating (kWh)	1696
Lights & Appliances (kWh)	4615
Photovoltaics (kWh)	-1070
Total (kWh)	7121

Annual Energy Demands	kW
Heating	2.7
Cooling	0.6
Water Heating (Winter Peak)	0.3
Water Heating (Summer Peak)	0.2
Lights & Appliances (Winter Peak)	0.4
Lights & Appliances (Summer Peak)	0.8
Total Winter Peak	3.4
Total Summer Peak	1.7

Utility Rates	
Electricity	PSE&G Elec 8/21/09**

REM/Design - Residential Energy Analysis Software v14.0
This information does not constitute any warranty of energy cost or savings.
© 1985-2012 Architectural Energy Corporation, Boulder, Colorado.

Proposed
Left End Unit Pbs (PV).blg

Annual Energy Cost	$/yr
Electric	2303

Annual End-Use Cost	$/yr
Heating	479
Cooling	184
Water Heating	531
Lights & Appliances	1444
Photovoltaics	-335
Service Charge	27
Total	2331

Annual End-Use Consumption	
Heating (kWh)	1586
Cooling (kWh)	560
Water Heating (kWh)	1696
Lights & Appliances (kWh)	4615
Photovoltaics (kWh)	-1070
Total (kWh)	7388

Annual Energy Demands	kW
Heating	2.9
Cooling	0.6
Water Heating (Winter Peak)	0.3
Water Heating (Summer Peak)	0.2
Lights & Appliances (Winter Peak)	0.4
Lights & Appliances (Summer Peak)	0.8
Total Winter Peak	3.6
Total Summer Peak	1.7

Utility Rates	
Electricity	PSE&G Elec 8/21/09**

REM/Design - Residential Energy Analysis Software v14.0
This information does not constitute any warranty of energy cost or savings.
© 1985-2012 Architectural Energy Corporation, Boulder, Colorado.

Proposed
Right End Unit Pbs (PV).blg

Annual Energy Cost	$/yr
Electric	2331

Annual End-Use Cost	$/yr
Heating	508
Cooling	183
Water Heating	531
Lights & Appliances	1444
Photovoltaics	-335
Service Charge	27
Total	2358

Annual End-Use Consumption	
Heating (kWh)	1681
Cooling (kWh)	557
Water Heating (kWh)	1696
Lights & Appliances (kWh)	4615
Photovoltaics (kWh)	-1070
Total (kWh)	7479

Annual Energy Demands	kW
Heating	3.0
Cooling	0.6
Water Heating (Winter Peak)	0.3
Water Heating (Summer Peak)	0.2
Lights & Appliances (Winter Peak)	0.4
Lights & Appliances (Summer Peak)	0.8
Total Winter Peak	3.7
Total Summer Peak	1.7

Utility Rates	
Electricity	PSE&G Elec 8/21/09**

REM/Design - Residential Energy Analysis Software v14.0
This information does not constitute any warranty of energy cost or savings.
© 1985-2012 Architectural Energy Corporation, Boulder, Colorado.

Building A.2 – HERS 50
Fuel Summary

Proposed
Right End Unit Pbs HERS 50.blg

Annual Energy Cost	$/yr
Electric	2666

Annual End-Use Cost	$/yr
Heating	508
Cooling	183
Water Heating	531
Lights & Appliances	1444
Photovoltaics	-0
Service Charge	27
Total	2693

Annual End-Use Consumption	
Heating (kWh)	1681
Cooling (kWh)	557
Water Heating (kWh)	1696
Lights & Appliances (kWh)	4615
Total (kWh)	8550

Annual Energy Demands	kW
Heating	3.0
Cooling	0.6
Water Heating (Winter Peak)	0.3
Water Heating (Summer Peak)	0.2
Lights & Appliances (Winter Peak)	0.4
Lights & Appliances (Summer Peak)	0.8
Total Winter Peak	3.7
Total Summer Peak	1.7

Utility Rates	
Electricity	PSE&G Elec 8/21/09***

REM/Design - Residential Energy Analysis Software v14.0
This information does not constitute any warranty of energy cost or savings.
© 1985-2012 Architectural Energy Corporation, Boulder, Colorado.

Building A.2 – Climate Choice Home
Fuel Summary

Proposed
Right End Unit Pbs (PV) 40-50.blg

Annual Energy Cost	$/yr
Electric	2414

Annual End-Use Cost	$/yr
Heating	590
Cooling	185
Water Heating	531
Lights & Appliances	1444
Photovoltaics	-335
Service Charge	27
Total	2441

Annual End-Use Consumption	
Heating (kWh)	1951
Cooling (kWh)	562
Water Heating (kWh)	1696
Lights & Appliances (kWh)	4615
Photovoltaics (kWh)	-1070
Total (kWh)	7755

Annual Energy Demands	kW
Heating	3.3
Cooling	0.6
Water Heating (Winter Peak)	0.3
Water Heating (Summer Peak)	0.2
Lights & Appliances (Winter Peak)	0.4
Lights & Appliances (Summer Peak)	0.8
Total Winter Peak	4.0
Total Summer Peak	1.7

Utility Rates	
Electricity	PSE&G Elec 8/21/09****

REM/Design - Residential Energy Analysis Software v14.0
This information does not constitute any warranty of energy cost or savings.
© 1985-2012 Architectural Energy Corporation, Boulder, Colorado.

Building B.1 – Baseline-
Fuel Summary
2009 Code with decrease in appliances.blg

Annual Energy Cost	$/yr
Natural gas	20258
Electric	48456

Annual End-Use Cost	$/yr
Heating	9473
Cooling	17983
Water Heating	7534
Lights & Appliances	33724
Photovoltaics	-0
Service Charge	6493
Total	75207

Annual End-Use Consumption	
Heating (Therms)	6050
Heating (kWh)	14349
Cooling (kWh)	93525
Water Heating (Therms)	6609
Lights & Appliances (Therms)	5124
Lights & Appliances (kWh)	150423
Total (Therms)	17783
Total (kWh)	258296

Annual Energy Demands	kW
Heating	11.9
Cooling	61.5
Water Heating (Winter Peak)	0.0
Water Heating (Summer Peak)	0.0
Lights & Appliances (Winter Peak)	14.2
Lights & Appliances (Summer Peak)	26.8
Total Winter Peak	26.2
Total Summer Peak	88.3

Utility Rates	
Electricity	PSE&G Elec 9/7/11******
Natural Gas	PSE&G Gas 9/7/11******

REM/Design - Residential Energy Analysis Software v14.0
This information does not constitute any warranty of energy cost or savings.
© 1985-2012 Architectural Energy Corporation, Boulder, Colorado.

Building B.1 – As-Built –
Fuel Summary

Annual Energy Cost	$/yr
Natural gas	7012
Electric	21519

Annual End-Use Cost	$/yr
Heating	0
Cooling	13744
Water Heating	2131
Lights & Appliances	28035
Photovoltaics	-15379
Service Charge	6493
Total	35024

Annual End-Use Consumption	
Cooling (kWh)	71502
Water Heating (Therms)	1870
Lights & Appliances (Therms)	4281
Lights & Appliances (kWh)	124930
Photovoltaics (kWh)	-82981
Total (Therms)	6151
Total (kWh)	113451

Annual Energy Demands	kW
Heating	0.0
Cooling	39.6
Water Heating (Winter Peak)	0.0
Water Heating (Summer Peak)	0.0
Lights & Appliances (Winter Peak)	11.8
Lights & Appliances (Summer Peak)	22.3
Total Winter Peak	11.8
Total Summer Peak	61.9

Utility Rates	
Electricity	PSE&G Elec 9/7/11****
Natural Gas	PSE&G Gas 9/7/11****

REM/Design - Residential Energy Analysis Software v14.0
This information does not constitute any warranty of energy cost or savings.
© 1985-2012 Architectural Energy Corporation, Boulder, Colorado.

Building B.1 – HERS 50
Fuel Summary

Annual Energy Cost	$/yr
Natural gas	9727
Electric	37199

Annual End-Use Cost	$/yr
Heating	0
Cooling	14045
Water Heating	4846
Lights & Appliances	28035
Photovoltaics	-0
Service Charge	6493
Total	53419

Annual End-Use Consumption	
Cooling (kWh)	73063
Water Heating (Therms)	4251
Lights & Appliances (Therms)	4281
Lights & Appliances (kWh)	124930
Total (Therms)	8532
Total (kWh)	197993

Annual Energy Demands	kW
Heating	0.0
Cooling	40.2
Water Heating (Winter Peak)	0.0
Water Heating (Summer Peak)	0.0
Lights & Appliances (Winter Peak)	11.8
Lights & Appliances (Summer Peak)	22.3
Total Winter Peak	11.8
Total Summer Peak	62.5

Utility Rates	
Electricity	PSE&G Elec 9/7/11****
Natural Gas	PSE&G Gas 9/7/11****

REM/Design - Residential Energy Analysis Software v14.0
This information does not constitute any warranty of energy cost or savings.
© 1985-2012 Architectural Energy Corporation, Boulder, Colorado.

Building B.1 – Climate Choice Home

Fuel Summary

As Built 40-50.blg

Annual Energy Cost	$/yr
Natural gas	7798
Electric	23696

Annual End-Use Cost	$/yr
Heating	1202
Cooling	15505
Water Heating	2131
Lights & Appliances	28035
Photovoltaics	-15380
Service Charge	6493
Total	37988

Annual End-Use Consumption	
Heating (Therms)	692
Heating (kWh)	2303
Cooling (kWh)	80655
Water Heating (Therms)	1870
Lights & Appliances (Therms)	4281
Lights & Appliances (kWh)	124930
Photovoltaics (kWh)	-82981
Total (Therms)	6842
Total (kWh)	124907

Annual Energy Demands	kW
Heating	5.6
Cooling	44.3
Water Heating (Winter Peak)	0.0
Water Heating (Summer Peak)	0.0
Lights & Appliances (Winter Peak)	11.8
Lights & Appliances (Summer Peak)	22.3
Total Winter Peak	17.4
Total Summer Peak	66.6

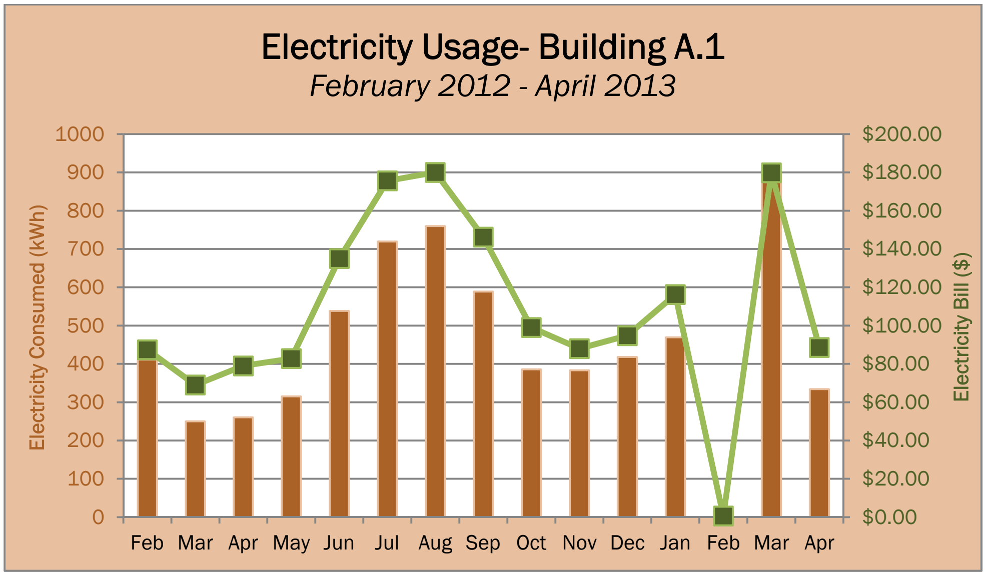
Utility Rates	
Electricity	PSE&G Elec 9/7/11*****
Natural Gas	PSE&G Gas 9/7/11*****

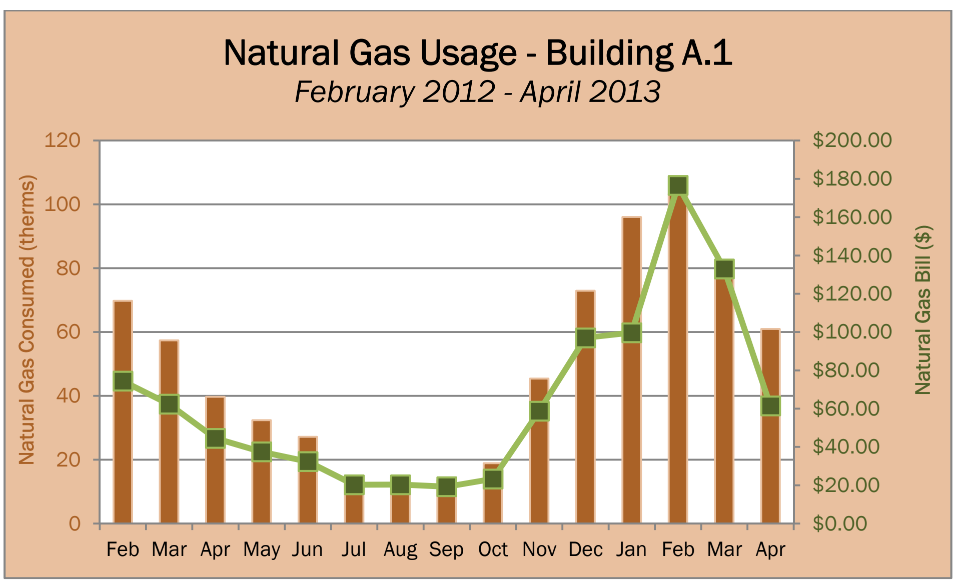
REM/Design - Residential Energy Analysis Software v14.0
This information does not constitute any warranty of energy cost or savings.
© 1985-2012 Architectural Energy Corporation, Boulder, Colorado.

15 APPENDIX F: LCC ACTUAL UTILITY BILLS FROM HOMES

Building A.1

The utility bills for the single family home, Building A.1, were obtained on May 13, 2013. The bills for February 2012 through April 2013 were provided by the builder. The service provider for the home is PSE&G for both natural gas and electricity. The amount of energy produced by the photovoltaic panels on the home was also discerned from the provided utility bills. The graphs below chart the electricity and natural gas usage, both in energy consumed and money value paid for this building.



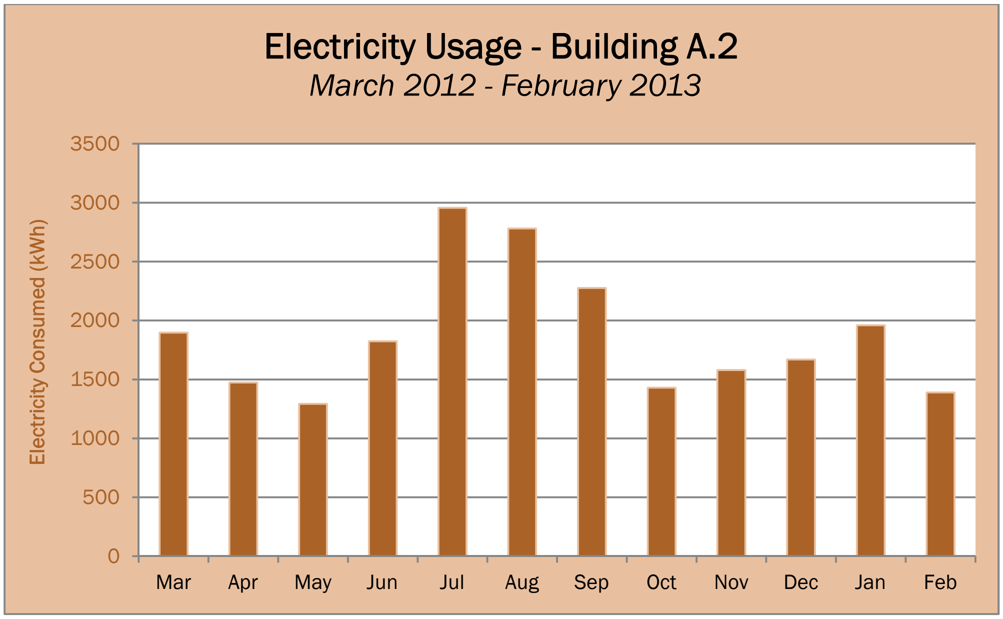


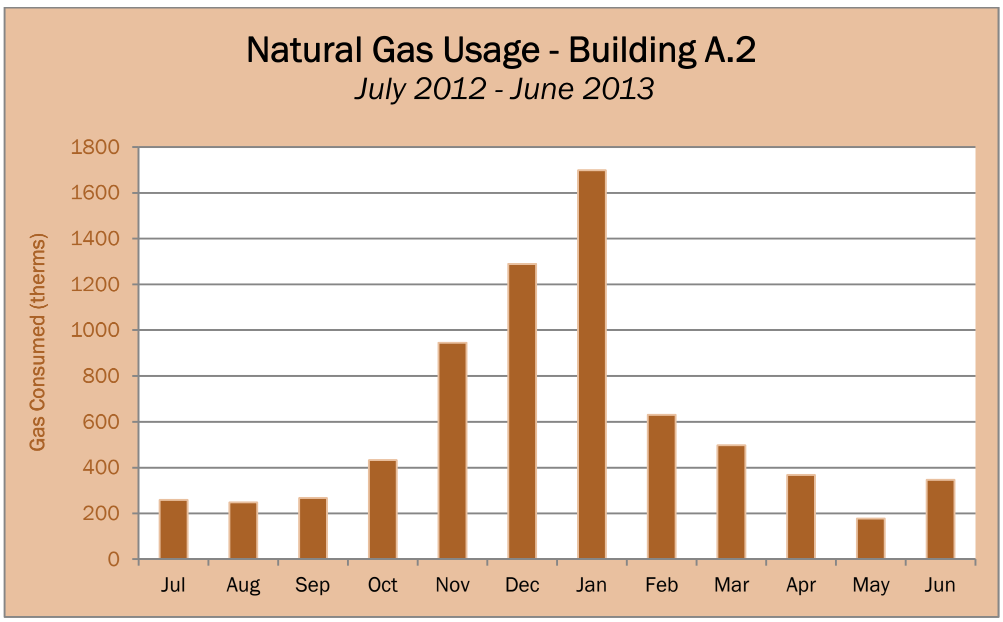
In order to determine the actual annual energy usage for the home, the latter 12 months (May 2012 through April 2013) were totaled and input into the LCC model. To find the actual average electricity and natural gas rates, the total amount paid in energy bills (by each commodity, respectively) was divided by the total amount of energy consumed. This value was also input in the LCC model, replacing the assumed energy rates for New Jersey.

	May 2012 - April 2013
Electricity Consumed (kWh)	6933
Electricity Consumed / S.F. (kWh)	4.42
Electricity Produced (kWh)	593
Net Electricity (kWh)	6340
Gas Consumed (therms)	577
Gas Consumed / S.F. (therms)	0.368
Electricity Bill ($)	$1165.30
Gas Bill ($)	$779.28
Average Electricity Price ($/kWh)	0.16808
Average Gas Price ($/therm)	1.35013

Building A.2

The utility bills for four of the five units of the attached townhomes at the Building A.2 complex were obtained on May 13, 2013. The bills for May through June 2013 were provided for unit #20, February through May 2013 for unit #2, April through May 2013 for unit #3, and December 2012 through June 2013 for unit #4. The service provider for the home is PSE&G for both natural gas and electricity. The amount of energy produced by the photovoltaic panels on the home was not yet obtained for this building at the time of the completion of this report. Since less than one year of utility bills for the entire building was provided, some assumptions needed to be made in order to project the annual energy usage for the building. The first assumption was that unit #21 for which no utility bills were provided for, had the same actual energy profile as unit #2, another inner unit in the building. Using the total electricity and natural gas usage in the NJ residential market by month over a 12-month period from the US Energy Information Administration, the available utility bill values were scaled to a period of one year. The total building energy consumption using this method was entered into the LCC model. The actual average electricity and natural gas rates were also input into the model by dividing the available total amount paid in energy bills by the available amount of data for energy consumed. The graphs below chart the electricity and natural gas usage in energy consumed for this building.





	March 2012 - February 2013
Electricity Consumed (kWh)	22527*
Electricity Consumed / S.F. (kWh)	2.828*
Electricity Produced (kWh)	15520 (assumed)*
Net Electricity (kWh)	7007*
Gas Consumed (therms)	7160*
Gas Consumed / S.F. (therms)	0.899*

Electricity Bill ($)	$1112.50
Gas Bill ($)	$1411.61
Average Electricity Price ($/kWh)	0.145
Average Gas Price ($/therm)	1.095

* estimated

Building B.1

The utility bills for seven units from the multi-family building, Building B.1, were obtained on May 13, 2013. The bills for January 2012 through April 2013 were provided for units #8, #5, #9, #10, #6, #11 and #7 by the builder. The service provider for the home is PSE&G for both natural gas and electricity. The amount of energy produced by the photovoltaic panels on the home was provided by monitored data from the partners of this study. In order to determine the annual energy consumption for the entire building, a method needed to be developed in order to scale the available energy data to the rest of the units. This was done by assigning a unit of similar size with available utility data to each of the units in the building, and then to scale the energy usage by square footage. These values were then summed and entered into the LCC model, along with the actual average energy costs from the utility data.

	May 2012 - April 2013
Electricity Consumed (kWh)	280191*
Electricity Consumed / S.F. (kWh)	4.048*
Electricity Produced (kWh)	60340
Net Electricity (kWh)	219851*
Gas Consumed (therms)	8293*
Gas Consumed / S.F. (therms)	0.120*
Electricity Bill ($)	$52,530.82
Gas Bill ($)	$17,072.68
Average Electricity Price ($/kWh)	0.187
Average Gas Price ($/therm)	2.059

* estimated

The following table lists the full range of units located at Building B.1 with the energy basis assumed for each unit.

Unit No.	Size	BRs	Basis	Total Electricity Consumed (kWh)	Total Gas Consumed (therms)
22	726	1	8	3445.004444	120.1987111
23	726	1	8	3445.004444	120.1987111

8	**675**	**1**	8	3203	111.755
24	675	1	8	3203	111.755
25	669	1	5/10	4627.5	92.5765
26	669	1	5/10	4627.5	92.5765
27	663	1	5/10	4627.5	92.5765
28	666	1	5/10	4627.5	92.5765
29	284		8	1347.632593	47.01988148
30	935	2	6	4498.255543	233.0190198
31	857	2	6	4123	213.58
32	666	1	5/10	4627.5	92.5765
5	**669**	**1**	5/10	4627.5	92.5765
33	675	1	8	3203	111.755
34	675	1	8	3203	111.755
35	721	1	8	3421.278519	119.3708963
36	687	1	8	3259.942222	113.7417556
37	726	1	8	3445.004444	120.1987111
38	726	1	8	3445.004444	120.1987111
39	675	1	8	3203	111.755
40	675	1	8	3203	111.755
10	**669**	**1**	5/10	4627.5	92.5765
41	669	1	5/10	4627.5	92.5765
9	**1075**	**2**	11	4627.5	92.5765
42	666	1	5/10	4627.5	92.5765
43	935	2	310	4498.255543	233.0190198
44	857	2	310	4123	213.58
45	663	1	5/10	4627.5	92.5765
46	666	1	5/10	4627.5	92.5765
47	669	1	5/10	4627.5	92.5765
48	669	1	5/10	4627.5	92.5765
49	675	1	103	3203	111.755
50	675	1	103	3203	111.755
51	721	1	103	3421.278519	119.3708963
52	687	1	103	3259.942222	113.7417556
53	726	1	103	3445.004444	120.1987111
54	726	1	103	3445.004444	120.1987111
55	675	1	103	3203	111.755
56	675	1	103	3203	111.755
57	669	1	5/10	4627.5	92.5765
58	669	1	5/10	4627.5	92.5765
59	1075	2	11	4627.5	92.5765
60	666	1	5/10	4627.5	92.5765

61	935	2	6	4498.255543	233.0190198
6	**857**	**2**	**6**	4123	213.58
62	663	1	5/10	4627.5	92.5765
63	666	1	5/10	4627.5	92.5765
64	669	1	5/10	4627.5	92.5765
65	669	1	5/10	4627.5	92.5765
66	675	1	8	3203	111.755
67	675	1	8	3203	111.755
68	721	1	8	3421.278519	119.3708963
69	687	1	8	3259.942222	113.7417556
70	726	1	8	3445.004444	120.1987111
71	726	1	8	3445.004444	120.1987111
72	675	1	8	3203	111.755
73	675	1	8	3203	111.755
74	669	1	5/10	4627.5	92.5765
75	669	1	5/10	4627.5	92.5765
11	**1075**	**2**	11	4627.5	92.5765
76	666	1	5/10	4627.5	92.5765
77	935	2	6	4498.255543	233.0190198
78	857	2	6	4123	213.58
79	663	1	5/10	4627.5	92.5765
80	666	1	5/10	4627.5	92.5765
81	669	1	5/10	4627.5	92.5765
82	669	1	5/10	4627.5	92.5765
7	**675**	**1**	8	3203	111.755
83	675	1	8	3203	111.755
84	721	1	8	3421.278519	119.3708963
85	687	1	8	3259.942222	113.7417556
			TOTAL	**280191**	**8293**

16 APPENDIX G: POE SINGLE FAMILY SURVEY

CHARACTERISTICS OF YOUR HOME

Please confirm the following characteristics of your home, condominium or apartment by checking an answer to each of the queries below.

# bedrooms	___1	___2	___3	___4	___5+
# full bathrooms	___1	___2	___3	___4+	
# of half bathrooms	___1	___2	___3+		
# of stories (excluding basement)	___1	___2	___3	___4+	

Which of the following features does your home have? (Check all that apply)
___Multistory entryway
___Cathedral ceiling(s)
___Heated garage
___Room over garage
___Finished basement
___Wall that is one-third glass or more
___Sun room
___Fireplace
___Ceiling fans
___Sun shades/ Awnings
___Insulating blinds

What month and year did you move in? (MM/YYYY)
_ _ / _ _ _ _

Which of the following renewable energy features does your home have? (Check all that apply)
___Solar photovoltaic panels
___Solar hot water heating
___Ground source heat pump system (Geothermal)
___Small wind turbines
___Other (please specify): _____________________________________

HOUSEHOLD CHARACTERISTICS

How many people are in your household? Do not include people who are just visiting or children away at college.

	Under 6	7-13	14-18	19-64	65 or Older
Number of people					

Last week how many hours per day, on average, was your household **empty** (that is, no one was at home)?

Weekdays	Weekends
___Less than 1 hour	___Less than 1 hour

___1-3 hours ___4-6 hours ___7-12 hours ___More than 12 hours	___1-3 hours ___4-6 hours ___7-12 hours ___More than 12 hours

What is this household's typical daily schedule, that is, what is the predominant wake up time and bedtime of household members during the Monday-to-Friday time period? Weekends?

	Monday – Friday	Weekends
Wake-up time		
Bed time		

Which category best describes the total combined income in the last 12 months of all household members?
___Less than $40,000
___$41,000-$50,000
___$51,000-$99,999
___$100,000 - $149,999
___$150,000-$199,999
___$200,000 or more

ENERGY USE IN THE HOME

PLEASE CONFIRM THE TYPE OF HEAT YOUR HOME USES
___Gas
___Oil
___Electric Heat Pump (Split System Allowed)
___Geothermal (Electric Backup)
___Other, please specify:_____________________________

And, what does your hot water heater run on?
___ Gas
___ Electric
___ Solar
___ Other, please specify:______________________________

How is your home cooled?
___ Central Air
___ Window boxes
___ Other, please specify:_________________________

When you use your heating or cooling system, how warm or cool do you keep your home (in degrees)…? Please answer the questions in the table below.

→→→→→→→→	Daytime At Home		Daytime No One Home		At Night When Sleeping	
	Temp	Don't Use	Temp	Don't Use	Temp	Don't Use
Fall/Winter						
Spring/Summer						

If you have a fireplace, how many of each kind of fireplace do you have in your home? And how often do you use it/them?

	Number	Frequency of use in cold weather
Wood/ Pellet	___0 ___1 ___2 ___3 ___4	___All of the time ___Frequently (once per week or more) ___Infrequently (once per month or less) ___Never
Gas	___0 ___1 ___2 ___3 ___4	___All of the time ___Frequently (once per week or more) ___Infrequently (once per month or less) ___Never
Electric	___0 ___1 ___2 ___3 ___4	___All of the time ___Frequently (once per week or more) ___Infrequently (once per month or less) ___Never

How much do you agree or disagree with the following statements about how you operate your home. Please use the following scale:

	Strongly Agree	Agree	Neither Agree Nor Disagree	Disagree	Strongly Disagree	N/A
I open and close the window frequently to increase comfort						
I use ceiling fans frequently to increase comfort						
I often adjust curtains/window shades for comfort/light						
I always turn off indoor lights when no one is in the room						
I always leave some indoor lights on at night						

Appliances

What types of appliances are installed in your home?

Appliance	Installed	Fuel Source	Type	Energy Star
Clothes Washer	___Yes ___No	___Gas ___Electric	___ Front loading ___ Top loading	___Yes ___No
Clothes Dryer	___Yes ___No	___Gas ___Electric	___ Front loading ___ Top loading	___Yes ___No
Dishwasher	___Yes ___No	___Gas ___Electric	___Standard ___Compact	___Yes ___No
Refrigerator	___Yes ___No	___Gas ___Electric	___Top or Bottom Freezer ___Side-by-Side	___Yes ___No
Kitchen Exhaust Hood	___Yes ___No	___Gas ___Electric	___N/A	___Yes ___No
Stove	___Yes ___No	___Gas ___Electric	___N/A	___N/A

Which of the categories shown best describes, on average, how often hot meals are usually cooked in your home?

___Three or more times a day
___Two times a day
___Once a day
___A few times each week
___About once a week
___Less than once a week
___ Doesn't cook/Never cooks

In an average week, how many loads of laundry are washed in your clothes washer?

___1 load or less each week
___2 to 4 loads per week
___5 to 9 loads per week
___10 to 15 loads per week
___More than 15 loads per week

In an average week, how often do you use your clothes dryer?

___Every time I wash clothes
___For some but not all loads of wash
___Infrequently

In an average week, how many loads of dishes are washed in your dishwasher?

___1 load or less each week
___2 to 4 loads per week
___5 to 9 loads per week
___10 to 15 loads per week

___More than 15 loads per week
___Dishes are washed by hand
Office Equipment and Electronics

How many of the following electronics are in your home?

	Number
Desktop	
Laptop	
Television	__# LCD TV's <35 inches __# LCD TV's 36 to 60 inches __# LCD TV's > 60 inches __# Plasma TV's <35 inches __# Plasma TV's 36 to 60 inches __ # Plasma TV's > 60 inches
Music System (stereo, boom box)	
Video Game Console (Xbox, Playstation, Wii)	
Digital Video Recorder (DVR)	

On average, how many hours does the household use each of the following per week?

	Hours per week
Desktop	___Less than 5 hours ___5 to 10 hours ___11 to 20 hours ___21 to 30 hours ___31 to 40 hours ___41 to 50 hours
Laptop	___Less than 5 hours ___5 to 10 hours ___11 to 20 hours ___21 to 30 hours ___31 to 40 hours ___41 to 50 hours
Television	___Less than 5 hours ___5 to 10 hours ___11 to 20 hours ___21 to 30 hours ___31 to 40 hours ___41 to 50 hours
Music System (stereo, boom box)	___Less than 5 hours ___5 to 10 hours ___11 to 20 hours ___21 to 30 hours ___31 to 40 hours ___41 to 50 hours
Video Game Console (Xbox, Playstation, Wii)	___Less than 5 hours ___5 to 10 hours

	___11 to 20 hours ___21 to 30 hours ___31 to 40 hours ___41 to 50 hours
Digital Video Recorder (DVR)	___Less than 5 hours ___5 to 10 hours ___11 to 20 hours ___21 to 30 hours ___31 to 40 hours ___41 to 50 hours

Do you operate a home-based business or service?
___Yes
___No
___ [If yes] What kind of energy or water using equipment is part of this business?
____

Is there any other kind of activity occurring in your home that uses more than a normal amount of energy?
___Yes
___No
___ [If yes] Would you please tell me what kind of activity this is?
____

What other large items does your home have? And how are these items fueled?

	None	Electric	Gas	Solar
Unheated Pool				
Heated Pool				
Hot Tub or Jacuzzi bathtub				
Wine Cooler				
2nd Refrigerator or Freezer				
Humidifier or Dehumidifier				
Air purifier				

Do you have an outdoor gas grill that is connected to your home's central gas line?
___Yes
___No
___DON'T KNOW

Lighting

How many lamps or lighting fixtures in your home use tube fluorescent or compact fluorescent bulbs?
___None
___0-3

___3-6
___6-10
___More than 10

Does your home have outdoor security lighting?
___Yes, and it is used:
___All night
___With a timer
___With a motion detector
___With an LED bulb
___With a CFL bulb
___No
Does your home have outdoor accent lighting?
___Yes, and it is used:
___All night
___With a timer
___With an LED bulb
___With a CFL bulb
___No

WATER USE IN THE HOME
Plumbing

Please confirm what kind of fixtures and how many of each are installed in your home?

Bathroom Faucets	__# of low-flow faucets (e.g., WaterSense Labeled, 1.5 gpm) __# of conventional faucets (2.2 gpm)
Kitchen Faucets	__# of conventional faucets (2.2 gpm) __# of low-flow aerators or other water saving devices
Showerheads	__# of low-flow showerheads (WaterSense Labeled, 2.0 gpm or less) __# of conventional showerheads (2.5 gpm or more)
Toilets	__ # of dual-flush toilets (WaterSense Labeled, full flush 1.6 gpf and reduced flush of 1.1 gpf) __# of low-flow toilets (WaterSense Labeled, 1.28 gpf or less) __ # of conventional toilets (1.6 gpf)

Have you changed any faucets or toilets since moving in?
___No
___Yes, from low flow to conventional.
___Yes, from conventional to low flow or (for toilets) dual flush.

Last week, about how many showers and baths in total were taken in the home?
___ Showers
___ Baths

On average, what is the duration of a typical shower in your home? (check one)
___Less than 5 minutes

___5 to 10 minutes
___11 to 15 minutes
___More than 15 minutes

Landscaping

What percentage of your landscaping is lawn?
___Less than 25%
___25 to about 50%
___51 to about 75%
___76% or more
___DON'T KNOW

Does your landscaping include water efficient plants?
___Yes
___No
___DON'T KNOW

How is your lawn and garden watered?
___Automatic sprinkler
___Water by hand from garden hose
___Water by hand from buckets
___Use a soaker hose or trickling hose for trees and shrubs
___None of the above -- no need to water

What is the source of the water for your lawn and garden?
___Private well
___Municipal water supply
___Rain barrels

If you have a sprinkler system, does the system have a timer that controls the watering schedule?
___Yes
___No
___DON'T KNOW

HOME PERFORMANCE

How satisfied are you with your home's performance in the following areas:

	Very Satisfied	Satisfied	Neither Satisfied or Dissatisfied	Dissatisfied	Very dissatisfied	N/A
Indoor air quality						
Energy savings						
Water savings						
Ability to adjust						

temperature						
Ventilation						
Low flow fixtures						
Hot water supply from water heater						
Amount of natural light/daylighting						
Energy-efficient appliances						
Energy-efficient lighting fixtures						
Durability of green materials						
Renewable energy equipment						

Renewable Energy System

Have you experienced any difficulty in the operation of your home's renewable energy system?
___Yes
___No

If yes, please describe: ____
____

How satisfied are you with the <u>level of maintenance and/or repair</u> required for your home's renewable energy system?
___Very satisfied
___Satisfied
___Unsatisfied
___Very unsatisfied
___N/A

How likely are you to recommend installing a renewable energy system to a friend or family member considering a new home or home remodel?:
___Very likely
___Likely
___Neither likely or unlikely
___Unlikely
___Very unlikely

General Performance

How often do you experience the following problems with keeping your home comfortable?

	Always	Frequently	Sometimes	Rarely	Never
Some rooms too hot/cold in winter					
Some rooms too hot/cold in summer					
Floors too cold in the winter					
Condensation on inside of windows					
Noticeable drafts					

How quiet do you feel your home is?
___Very quiet
___Somewhat quiet
___Not at all quiet

How well-built do you feel your home is?
___Very well-built
___Somewhat well-built
___Not at all well-built

Was the fact that this is a green (or high-performance) home a factor in your purchase/building of this home?
___Yes
___No

Do you think that there are any benefits to living in a green (high-performance) home?
___Yes
___No
___ [If yes] Can you provide any examples from your own experiences?
____

Describe the features of the home that you like most/find most useful about this home?
____
____
____

Describe the features of the building that you like least/have most trouble with in this home?
____
____
____

Is there anything that you would change about the home? Please describe.
____

____
____

Would you recommend a close friend to purchase a green (high performance) home?
___Yes
___No

Please explain any additional comments or recommendations about your personal experience living in a green (high performance) home?
____
____
____

Thank you for your participation!

17 APPENDIX H: POE MULTI FAMILY SURVEY

CHARACTERISTICS OF YOUR HOME

Please confirm the following characteristics of your condominium or apartment by checking an answer to each of the queries below.

bedrooms ___1 ___2
bathrooms ___1 ___2

Which of the following features does your condo or apartment have? (Check all that apply)
___Fireplace
___Ceiling fans
___Sun shades/ Awnings
___Insulating blinds

What month and year did you move in? (MM/YYYY)
_ _ / _ _ _ _

HOUSEHOLD CHARACTERISTICS

How many people are in your household and how old are they? Do not include people who are just visiting or children away at college.

	Under 6	7-13	14-18	19-64	65 or Older
Number of people					

Last week how many hours per day, on average, was your household <u>empty</u> (that is, no one was at home)?

Weekdays	Weekends
___Less than 1 hour ___1-3 hours ___4-6 hours ___7-12 hours ___More than 12 hours	___Less than 1 hour ___1-3 hours ___4-6 hours ___7-12 hours ___More than 12 hours

What is this household's typical daily schedule, that is, what is the predominant wake up time and bedtime of household members during the Monday-to-Friday time period? Weekends?

	Monday – Friday	Weekends
Wake-up time		
Bed time		

Which category best describes the total combined income in the last 12 months <u>of all household members?</u>
___Less than $25,000

___ $26,000- $30,000
___ $31,000- $40,000
___$41,000- $50,000
___$51,000- $99,999
___$100,000 - $149,999
___$150,000 or more

ENERGY USE IN YOUR HOME (CONDO, APT)

How is your apartment cooled?
___ Central Air
___ Window boxes, How many ______?
___ Other, please specify:_________________________

When you use your heating or cooling system, how warm or cool do you keep your home (in degrees)…? Please answer the questions in the table below.

	Daytime At Home		Daytime No One Home		At Night When Sleeping	
	Temp	Don't Use	Temp	Don't Use	Temp	Don't Use
Fall/Winter						
Spring/Summer						

How much do you agree or disagree with the following statements about how you operate your home. Please use the following scale:

	Strongly Agree	Agree	Neither Agree Nor Disagree	Disagree	Strongly Disagree	N/A
I open and close the windows frequently to increase comfort						
I use ceiling fans frequently to increase comfort						
I often adjust curtains/window shades for comfort/light						
I always turn off indoor lights when no one is in the room						
I always leave some indoor lights on at night						

Appliances
How many and what types of these appliances are installed in <u>your</u> apartment?
(we are not asking about the common area laundry facility)

Appliance	Installed	Fuel Source	Type	Energy Star Certified
Clothes Washer	___Yes ___No	___Gas ___Electric	___ Front loading ___ Top loading	___Yes ___No
Clothes Dryer	___Yes ___No	___Gas ___Electric	___ Front loading ___ Top loading	___Yes ___No
Have you made any changes to any of the standard equipment that came with your apartment? If yes, please complete the information below				
Dishwasher	___No ___Yes	___Gas ___Electric	___Standard ___Compact	___Yes ___No
Refrigerator	___No ___Yes	___Gas ___Electric	___Top or Bottom Freezer ___Side-by-Side	___Yes ___No
Kitchen Exhaust Hood	___No ___Yes	___Gas ___Electric	___N/A	___Yes ___No
Stove	___No ___Yes	___Gas ___Electric	___N/A	___N/A

Which of the categories shown best describes, in an average week, how often hot meals are usually cooked in your home?
___Three or more times a day
___Two times a day
___Once a day
___A few times each week
___About once a week
___Less than once a week
___Doesn't cook/Never cooks

In an average week, how many loads of dishes are washed in dishwasher?
___1 load or less each week
___2 to 4 loads per week
___5 to 9 loads per week
___10 to 15 loads per week
___More than 15 loads per week
___Dishes are washed by hand

If you have a washer or dryer IN YOUR APARTMENT, please answer the next 2 questions, otherwise, please skip to question #16

In an average week, how many loads of laundry are washed in YOUR clothes washer?
___1 load or less each week
___2 to 4 loads per week
___5 to 9 loads per week

___10 to 15 loads per week
___More than 15 loads per week
___None, I don't have a clothes washer in my apartment

In an average week, how often do you use YOUR clothes dryer?
___Every time I wash clothes
___For some but not all loads of wash
___Infrequently
___None, I don't have a clothes dryer in my apartment

Office Equipment and Electronics

How many of the following electronics are in your home?

	Number
Desktop	
Laptop	
Television	__# LCD TV's <35 inches __# LCD TV's 36 to 60 inches __# LCD TV's > 60 inches __# Plasma TV's <35 inches __# Plasma TV's 36 to 60 inches __ # Plasma TV's > 60 inches
Music System (stereo, boom box)	
Video Game Console (Xbox, Playstation, Wii)	
Digital Video Recorder (DVR)	
Other: ____________________________ __________________________________	

On average, how many hours per week does the household use each of the following?

	Hours per week
Desktop	___Less than 5 hours ___5 to 10 hours ___11 to 20 hours ___21 to 30 hours ___31 to 40 hours ___41 to 50 hours

	Hours per week
	___N/A
Laptop	___Less than 5 hours ___5 to 10 hours ___11 to 20 hours ___21 to 30 hours ___31 to 40 hours ___41 to 50 hours ___N/A
Television	___Less than 5 hours ___5 to 10 hours ___11 to 20 hours ___21 to 30 hours ___31 to 40 hours ___41 to 50 hours ___N/A
Music System (stereo, boom box)	___Less than 5 hours ___5 to 10 hours ___11 to 20 hours ___21 to 30 hours ___31 to 40 hours ___41 to 50 hours ___N/A
Video Game Console (Xbox, Playstation, Wii)	___Less than 5 hours ___5 to 10 hours ___11 to 20 hours ___21 to 30 hours ___31 to 40 hours ___41 to 50 hours ___N/A
Digital Video Recorder (DVR)	___Less than 5 hours ___5 to 10 hours ___11 to 20 hours ___21 to 30 hours ___31 to 40 hours ___41 to 50 hours ___N/A
Other: ________________	___Less than 5 hours ___5 to 10 hours ___11 to 20 hours ___21 to 30 hours ___31 to 40 hours ___41 to 50 hours

Do you operate a home-based business or service?

___Yes
___No
___ [If yes] What kind of energy or water using equipment is part of this business?
____

Is there any other kind of activity occurring in your home that uses more than a normal amount of energy?
___Yes
___No
___ [If yes] Would you please tell me what kind of activity this is?
____

What other appliances does your home have and how many times per week are they used?

	Number	Times per week?
Microwave		___ times ___N/A
Portable Heater		__ times ___seasonally use ___N/A
Floor Fan		__ times ___all the time ___seasonally use ___N/A
Humidifier or Dehumidifier		___ times ___all the time ___seasonally use ___N/A
Air purifier		___ times ___all the time ___seasonally use ___N/A
Portable Electrical Fireplace		___ times ___seasonally use ___N/A
2nd Refrigerator or Freezer		___all the time ___seasonally use ___N/A
Wine Cooler		___all the time ___seasonally use ___N/A
Hot Tub or Jacuzzi bathtub		___ times ___seasonally use ___N/A

Other		___ times ___all the time ___seasonally use

Lighting

How many lamps or lighting fixtures in your apartment use tube fluorescent or compact fluorescent bulbs?
___None
___0-3
___3-6
___6-10
___More than 10

How many lamps or lighting fixtures in your apartment use LED bulbs?
___None
___0-3
___3-6
___6-10
___More than 10

Does your apartment have outdoor security lighting that you control/pay for?
___Yes, and it is used:
___All night
___With a timer
___With a motion detector
___With an LED bulb
___With a CFL bulb
___No

Does your apartment have outdoor accent lighting that you control/pay for?
___Yes, and it is used:
___All night
___With a timer
___With an LED bulb
___With a CFL bulb
___No

WATER USE IN THE HOME

Plumbing

Please confirm what kind of fixtures and how many of each are installed in your apartment?

Bathroom Faucets	__# of low-flow faucets (e.g., WaterSense Labeled, 1.5 gpm) __# of conventional faucets (2.2 gpm)

Kitchen Faucets	__# of conventional faucets (2.2 gpm) __# of low-flow aerators or other water saving devices
Showerheads	__# of low-flow showerheads (WaterSense Labeled, 2.0 gpm or less) __# of conventional showerheads (2.5 gpm or more)
Toilets	__ # of dual-flush toilets (WaterSense Labeled, full flush 1.6 gpf and reduced flush of 1.1 gpf) __# of low-flow toilets (WaterSense Labeled, 1.28 gpf or less) __ # of conventional toilets (1.6 gpf)

Have you changed any faucets or toilets since moving in?
___No
___Yes, from low flow to conventional.
___Yes, from conventional to low flow or (for toilets) dual flush.
___Yes, from low flow to low flow or (for toilets) dual flush.

Last week, about how many showers and baths in total were taken in the home?
___ Showers
___ Baths

On average, what is the duration of a typical shower in your home? (check one)
___Less than 5 minutes
___5 to 10 minutes
___11 to 15 minutes
___More than 15 minutes

HOME PERFORMANCE
How satisfied are you with your home's performance in the following areas:

	Very Satisfied	Satisfied	Neither Satisfied or Dissatisfied	Dissatisfied	Very dissatisfied	N/A
Indoor air quality						
Energy savings						
Water savings						
Ability to adjust temperature						
Ventilation						
Low flow fixtures						
Hot water supply from water heater						
Amount of natural light/daylighting						

Energy-efficient appliances						
Energy-efficient lighting fixtures						
Durability of green materials						
Renewable energy equipment						

Renewable Energy System

Have you experienced any difficulty in the operation of your apartment due to the building's renewable energy system(s)?
___Yes
___No
___Not Applicable
If yes, please describe: ____

General Performance

How often do you experience the following problems with keeping your home comfortable?

	Always	Frequently	Sometimes	Rarely	Never
Some rooms too hot/cold in winter					
Some rooms too hot/cold in summer					
Floors too cold in the winter					
Condensation on inside of windows					
Noticeable drafts					

How quiet do you feel your apartment is?
___Very quiet
___Somewhat quiet
___Not at all quiet

How well-built do you feel your apartment is?
___Very well-built
___Somewhat well-built

___Not at all well-built

Was the fact that this is a green (or high-performance) building a factor in your purchase/renting of this apartment?
___Yes
___No

Do you think that there are any benefits to living in a green (high-performance) building?
___Yes
___No
___ [If yes] Can you provide any examples from your own experiences?
____

Describe the features of the apartment/building that you like most/find most useful?
____
____

Describe the features of the apartment/building that you like least/have most trouble with?
____
____

Is there anything that you would change about the apartment/building? Please describe.
____
____

Would you recommend a close friend to purchase or rent a green (high performance) apartment?
___Yes
___No

Please explain any additional comments or recommendations about your personal experience living in a green (high performance) apartment building?
____
____
____

Thank you for your participation!

18 APPENDIX I: POE PROCESS TO CONTACT PARTICIPANTS

The following is a summary of the survey process that the Rutgers Center for Green Building conducted as related to the New Jersey Climate Choice Home Project of the NJ Board of Public Utilities. Pursuant to an earlier-agreed research design, a total of 11 residential building occupants were surveyed: one unit from Building A.1, seven units from Building B.1, and units from Building A.2.

The purpose of the homeowner interview/survey is to gather information on occupancy patterns, behaviors or other factors affecting energy consumption. Six occupants were surveyed twice – once after the occupant settled in, and another one approximately 6 months to a year later, from the 5 remaining, 2 have moved out, 2 have withdrawn, and one was not possible to reach. The homeowner survey developed for this project was approved by the Rutgers University Institutional Review Board for Human Subjects Research, protocol #11-362M.

Process

Building A.1, Paterson, NJ

Rutgers conducted the initial interview in January 2012 and the follow up in December 2012. Both interviews were conducted in person.

Building A.2, Paterson, NJ

Rutgers conducted the baseline interview for the first unit occupied in December 2012, in person. The other 2 units were surveyed in April 2013, after the units were occupied (one in person and one by mail, after not being able to reach the occupant in person).

For the follow up interviews, they were mailed in June 2013 - to allow more time for the occupants to settle in - with a letter and a self-stamped return envelope. This was followed by several phone calls, 2 were returned by mail and the last one after more phone calls was completed over the phone.

Building B.1, Orange, NJ

From August 2012 to June 2013, Rutgers administered the survey in the manner described below. Note that contact information for the 7 occupant sample was provided by a research team member at NJIT.

Initial Survey:

In August 2012, a package was mailed to each resident containing the Survey, Informed Consent, and a letter explaining the project, along with a self-addressed, stamped envelope for return of the completed, signed materials.

This was followed by a phone call explaining that a package had been mailed, along with a request to please review, complete, and send it back to Rutgers.

After a few weeks, Rutgers received 2 surveys back. In one of the multiple reminder calls that were made, Rutgers was able to conduct one of the surveys by phone.

Rutgers continued calling the remaining 4 apartments and in September received one more by mail and conducted another one by phone.

For the 2 remaining households, Rutgers continued with the calls, and Christine Liaukus from NJIT posted a note on their doors reminding them of the survey. Then at the beginning of October 2012, Rutgers made multiple trips to the building to attempt to conduct the surveys in person (based on permission of the building manager and request and agreement by the resident(s)), Rutgers was able to complete one.

In October 2012 the last initial survey arrived by mail.

Follow up Surveys:
The package containing the follow-up survey, letter, and self-addressed, stamped envelope was mailed to all 7 households in May 2013, followed by a phone call.

After several additional phone calls, 2 surveys were received.

During the following calls, we found out that 2 families had moved out from the building, and two expressed that they were not interested in continuing with the survey.

For the last household, additional calls were made, but with no results.