FINAL REPORT

Validating the COOLNOMIX AC and Refrigeration Compressor Control Retrofit

ESTCP Project EW-201513

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Bryan Urban
Fraunhofer USA Inc.

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Fraunhofer USA Center for Sustainable Energy Systems
5 Channel Center St.
Boston, MA 02210

CoolGreenPower, LLC.
60 Thoreau St., Suite 222
Concord, MA 01742

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COOLNOMIX, a patented compressor control retrofit designed to reduce air conditioning and refrigeration energy consumption, was evaluated at twelve DoD test sites. On/off testing in dry and humid climates was performed over two cooling seasons on six single-zone packaged and split air conditioning systems and six walk-in coolers. Cooling equipment, which tends to be oversized for typical part-load operation, can waste energy when compressors run longer than necessary. Using a sensor-based relay to intelligently cycle the compressor and modulate capacity, COOLNOMIX aims to supply just enough liquid refrigerant to cool the space, thereby reducing compressor runtime and saving energy. Targeting a 15% savings across up to 70% of cooling end-uses at DoD facilities could yield over $60 million in annual savings opportunity, or 1.5% of total facility energy utilization.

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ACRONYMS AND ABBREVIATIONS

AC	Air Conditioning
AHU	Air Handling Unit
Btu	British thermal unit
CDD	Cooling Degree Days
CNMX	COOLNOMIX[1]
CT	Current Transformer
DoD	Department of Defense
DOE	Department of Energy
DX	Direct Expansion
EO	Executive Order
EPA	U.S. Environmental Protection Agency
ESCO	Energy Service Company
ESPC	Energy Service Performance Contract
ESTCP	Environmental Security Technology Certification Program
EW	Energy and Water
HDD	Heating Degree Days
HP	Horsepower
HVAC&R	Heating Ventilation Air Conditioning and Refrigeration
kW	kilowatt
kWh	kilowatt hour
NDAA 2007	National Defense Authorization Act of 2007
NIST	National Institute of Standards & Technology
O&M	Operation and Maintenance
OAT	Outdoor Air Temperature
OEM	Original Equipment Manufacturer
RCRA	Resource Conservation and Recovery Act
RH	Relative Humidity
RTU	Rooftop Unit
SD	Standard Deviation
SHR	Sensible Heat Ratio
SIR	Savings to Investment Ratio
UESC	Utility Energy Service Contract

[1] COOLNOMIX is a registered trademark of Agile8 Consulting, LLC

VRV	Variable Refrigerant Volume
VRF	Variable Refrigerant Flow

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The following current and former team members contributed to this project:

Fraunhofer CSE:	Bryan Urban, Kurt Roth, Bob Andrews, Duncan Howes, Aldis Elfarsdottir, Anne-Marie Baker, Diane DeAngelis
CoolGreenPower:	Joseph Mueller, Joe Milando, Jill Appel, Colleen Morris
Agile8 Consulting:	Kevin Moore

Finally, we thank the occupants and operators of the test buildings who graciously welcomed our experiments in climate control.

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ABSTRACT

Introduction and Objectives

Cooling and refrigeration equipment can waste energy when fixed-capacity compressors run longer than necessary during part-load conditions. This demonstration evaluated a relay-based compressor control retrofit designed to modulate part-load capacity in six single-zone ducted (packaged RTU and split-system, 5-7.5 ton) air conditioning systems and six single-room walk-in cooler refrigeration applications. On/off testing was performed in hot and dry climates. The goal was to demonstrate predictable, cost-effective, and replicable cooling energy savings of at least 15% with a <2 year payback; ability to maintain or improve space temperature control; ease of installation; reliable operation; and end-user satisfaction. Space cooling and refrigeration accounts for about 15% of commercial building site energy use. This represents an addressable savings opportunity of about $60M per year or a 1.5% reduction in total DoD facility energy utilization.

Technology Description

COOLNOMIX is a standalone control retrofit for vapor-compression air conditioners and refrigerators that modulates compressor runtime using a relay to save energy while maintaining temperature setpoints. A patented algorithm uses signals from wired supply and return air temperature sensors to intelligently cycle the compressor, aiming to supply just enough liquid refrigerant to meet space cooling loads. Evaporator fans continue running between cycles to provide residual cooling while the compressors remain off. The controller is installed in-line with the existing thermostat or control system and requires no special hardware or software integration.

Performance and Cost Assessment

Energy savings results were mixed. Air conditioning systems performed as designed for five of six cases, but meaningful savings were found in only two special cases whose ventilation fans were programmed to run all the time: (1) 17% net savings (4,030 kWh/yr) and (2) 8% net savings (1,960 kWh/yr). In other cases, savings were either not significant or caused total energy use to increase. The single-zone ducted cooling systems, common in the U.S., had high-powered ventilation fans that were caused to run about twice as much, incurring steep fan energy penalties and higher ventilation loads. All six refrigeration systems performed as designed, though none met the 15% savings target (best-case was about 5% savings, or 100 kWh/yr). Installation cost per system ranged from about $560-880, including hardware ($500) plus labor and materials ($60-380). Further technical development is underway to address the excess fan runtime issue.

Implementation Issues

COOLNOMIX was compatible with most existing single-zone equipment, functioned as designed, and caused no significant equipment problems. Aside from causing excess fan runtime in most air conditioning applications, implementation issues were relatively minor. In some cases, zone temperature and humidity were affected slightly, but not enough to seriously impact thermal comfort. In this study, several recommended improvements to the installation procedures were identified related to sensor placement, temperature setpoint selection, and commissioning.

Publications

Urban, B. (2017). Validating the COOLNOMIX AC and Refrigeration Compressor Control Retrofit. *Poster: ESTCP Symposium.* Washington, D.C.

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EXECUTIVE SUMMARY

COOLNOMIX, a patented compressor control retrofit designed to reduce air conditioning and refrigeration energy consumption on systems with excess part-load capacity, was evaluated at twelve DoD test sites. On/off testing in dry and humid U.S. climates was performed for over one year on six single-zone air conditioning systems for office cooling (5-7.5 ton ducted packaged and split systems and six single-compressor (≤2.0 HP) walk-in coolers used for food service.

Cooling equipment, which tends to be oversized for typical part-load operation, can waste energy when compressors run longer than necessary. Using a sensor-based relay to intelligently cycle the compressor and modulate cooling capacity, COOLNOMIX aims to supply just enough liquid refrigerant to satisfy space cooling loads, thereby reducing overall compressor runtime and saving energy. Realizing savings of 15% across up to 70% of cooling energy end-uses at DoD facilities could yield over $60 million in annual savings, or 1.5% of total facility energy utilization.

TECHNOLOGY DESCRIPTION

COOLNOMIX is a standalone compressor control retrofit for air-based vapor-compression cooling systems (Figure ES-1). It is installed in-line with the existing thermostat controls by an HVAC technician, requires no special integration with building automation or control systems, and does not include any networking capabilities. Compared to more involved retrofits, like variable speed motor/drive replacements, COOLNOMIX is designed to be a simpler, lower cost alternative that is practical for a wide range of existing cooling equipment.

COOLNOMIX uses two wired sensors that measure supply and return air temperature to operate a relay. The relay temporarily stops the compressor during the cooling cycle, resulting in shorter, more frequent cycles, thereby modulating cooling capacity. Ideally, this reduces the total compressor runtime and therefore reduces cooling system energy consumption.

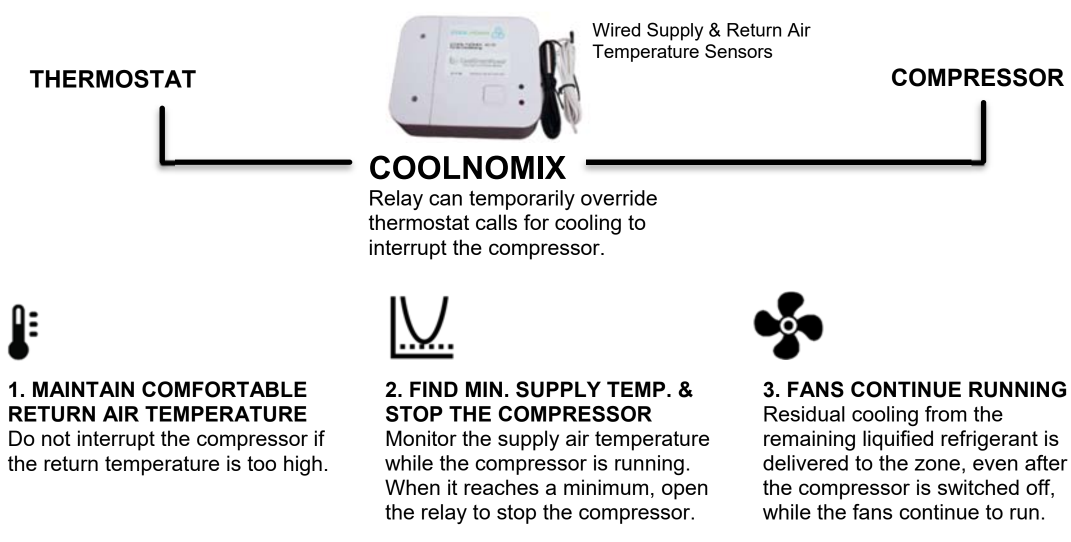

Figure ES-1. COOLNOMIX Diagram.

The operating theory is based on optimizing the supply of liquid refrigerant. Ordinarily, when a compressor runs too long, it can flood the evaporator with excess liquid refrigerant. COOLNOMIX stops the compressor before this happens when it detects that enough liquid refrigerant has been supplied (determined by finding a minimum supply air temperature) and when the return air temperature is not too high (determined by a user-selectable setpoint). The evaporator fans continue to run as long as the thermostat calls for cooling, delivering residual cooling into the space. To prevent short-cycling, the relay remains open for a minimum lockout period (3 min.). After this period, the relay closes when the return air temperature approaches the COOLNOMIX setpoint or when the supply air temperature becomes too hot. Finally, normal operation resumes until the next cycle, when the control sequence repeats.

RESULTS AND RECOMMENDATIONS

Performance objectives were evaluated on the following metrics:

1. Cooling Electricity Savings (normalized savings ≥15%)
2. System Economics (simple payback period <5 years)
3. Climate Control (setpoints maintained as frequently as baseline)
4. Ease of Installation (<1 hour by a technician)
5. Reliability (% uptime, no impact on existing equipment reliability)
6. Short-cycle and Frost Prevention (features work as designed)
7. Facility Satisfaction (no facility issues)
8. Warranty Compatibility (no impact on original equipment manufacturer)

Non-cost savings metrics (3-8) were all generally satisfied. The retrofit, compatible with most of the tested equipment,[2] resulted in shorter but more frequent compressor cycles, with mild impacts on zone temperature, humidity, and thermal comfort. No obvious problems to the existing equipment were observed. Several practical implementation and installation challenges were noted, though most were not severe and could be overcome with minor technical development and/or training as described in this report.

Energy and cost metrics (1-2) showed mixed results. For walk-in refrigeration, we found no evidence of meaningful savings. For air conditioning, results varied, largely because COOLNOMIX caused fans to run much longer (often twice as long), influencing ventilation loads and incurring a steep fan energy penalty.[3] Meaningful net cooling energy savings of up to 17% were found in only two special air conditioning cases whose fans already ran most of the time. In other cases, cooling energy use increased because of increased fan runtime.

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[2] One of six air conditioning sites did not apparently control the compressor due to an unknown fault.

[3] Single-zone ducted cooling systems, common in the U.S., tend to also control high-powered ventilation fans. In contrast, many overseas applications involve VRV/VRF and mini-/multi-split systems, with smaller evaporator fans and no ventilation fans. Fan penalties in those cases were much less significant.

Air Conditioning Results

Cost-effective energy savings were identified in only one special air conditioning case – the only case whose baseline ventilation fans were programmed to run all the time. Energy savings were about 4,030 kWh/yr (25% of condenser and 17% of total cooling system energy use).[4] Based on a 10-year measure life, a $0.06/kWh electricity rate, and a 3% discount rate, we estimate a simple payback period (SPP) of 4.1 years, a savings-to-investment ratio (SIR) of 1.8, and a lifecycle cost savings (LCCS) of $1,270. Doubling the electricity rate yields SPP 2.1, SIR 4.9, and LCCS $3,505.

Table ES-1. Air Conditioning System Energy Performance Results.

Site	Climate	Regression Terms	R^2	CV-RMSE	Energy Change (kWh/yr)	%	Notes
AC1	DRY	CDD, Occupancy	0.80	0.13	+1,691	+15	Significant increase due to extra fan runtime.
AC2	DRY	CDD, Occupancy	0.89	0.08	-1,522	-6.5	Significant savings, but below target. System slightly undersized.
AC3	DRY	CDD, Occupancy	0.84	0.14	-4,030	-17	Significant savings, met target. Dual stage condenser. Ventilation fans always on.
AC4	HUMID	CDD, Occupancy	0.89	0.14	-	-	COOLNOMIX effect not significant.
AC5	HUMID	CDD, Occupancy	0.88	0.17	+2,544	+26	Significant increase due to extra fan runtime. Condenser energy not significantly changed.
AC6	HUMID	CDD, Occupancy	0.68	0.30	-	-	No compressor control observed.

Notes: Cooling System Energy Change = (Baseline – COOLNOMIX). Includes ventilation fans and condenser.
Statistically significant savings highlighted.

Results for this successful case come with two caveats. First, they were based on a shorter testing period with limited shoulder season data. Second, cycling both condensers together led to slightly elevated afternoon zone temperature (about 2°F higher). The energy regressions control for this difference, though occupant comfort could be adversely affected. Nevertheless, savings were statistically significant, and these results suggest promise for niche applications where the evaporator and ventilation fans need to run continuously.

Statistically significant savings (9.9% condenser, 6.5% system, 1,522 kWh/yr net) were also identified in a second air conditioning case; however, these were below the success target and are unlikely to be cost effective. This case was unique for being slightly undersized, with fans that ran frequently in the baseline, such that the fan penalty was lower than in other cases. These two cases suggest net-positive savings are possible when fans must run frequently in the baseline.

In all other cases, COOLNOMIX caused the fans to run a far greater portion of the time, incurring a significant electricity penalty. This increased the average ventilation rates, having mixed effects on cooling loads. The net effect in most cases was no discernable change in condenser energy use and a substantial increase in fan electricity consumption.

[4] During the initial testing period, when COOLNOMIX was incorrectly configured to control the first stage compressor only, energy savings were positive, but much lower (5.7% condenser and 3.8% system).

Several factors contributed to the mixed results for air conditioning.

1. Large ventilation fans, common to split-system air handlers and packaged RTUs in the U.S., ran significantly longer with COOLNOMIX, leading to higher and more variable ventilation loads and steep fan energy penalties.

2. Some cooling systems had limited excess part-load capacity. None were grossly oversized, one was marginally undersized, and many were older and/or poorly maintained (low refrigerant charge, clogged fan filters, loose fan belt). Older systems, common at many DoD facilities, are more likely to experience issues that reduce their capacity. Without significant excess part-load capacity, savings opportunity is limited.

3. The existing thermostats were well positioned, loads were not extremely variable, and spaces were not grossly overcooled in the baseline, further limiting savings opportunity. Using the COOLNOMIX return air sensor to control space temperature, therefore, did not significantly change or improve the zone temperature control.

Refrigeration Results

In most refrigeration cases, energy consumption did not change significantly or meaningfully. The best-case scenario demonstrated a 5% reduction in compressor energy use (3% of total refrigeration system energy). This savings totaled about 100 kWh/yr, well below the economically viable threshold.

Table ES-2. Refrigeration System Energy Performance Results.

Site	Climate	Regression Terms	R^2	CV-RMSE	Energy Change (kWh/yr)	Energy Change %	Notes
REF1	DRY	T_{out}, Occupancy	0.67	0.18	-96	-2.0	Significant savings, well below target.
REF2	DRY	T_{out}, Occupancy	0.60	0.16	-63	-1.1	Savings not statistically significant.
REF3	DRY	T_{out}, Occupancy	0.74	0.16	-95	-1.1	Savings not statistically significant.
REF4	HUMID	T_{out}, Occupancy	0.45	0.17	+110	+3	Increase not statistically significant.
REF5	HUMID	T_{out}, Occupancy	0.40	0.21	+142	+4	Increase statistically significant.
REF6	HUMID	T_{out}, Occupancy	0.57	0.09	-101	-3	Significant savings, well below target.

Notes: Cooling System Energy Change = (Baseline – COOLNOMIX). Includes evaporator fans and compressor.
T_{out} = outside air temperature. Statistically significant savings highlighted.
Excludes evaporator fan penalty on REF4-5, up to +300 kWh/yr.

Several factors contributed to the absence of meaningful refrigeration savings:

1. Baseline compressor cycles were already fairly short (typ. <10 min.), limiting the amount they could be reduced.

2. Two coolers had an evaporator fan control strategy that reduced fan speed during off-cycles to save energy. COOLNOMIX caused these fans to run mostly at full speed, leading to significantly higher fan energy use (about 300 kWh more per year).

3. Off-cycle defrost was implemented on all coolers, so no energy benefit was observed related to frost prevention. Frosting issues were not observed in the baseline, so there was also no apparent frost prevention benefit.

4. Compressor energy consumption in the walk-in coolers was relatively low (all <8,000 kWh/yr), making cost effectiveness unlikely even if 15% savings were achieved.

As a result, the single-compressor walk-in coolers we tested do not represent cost-effective target applications.

Conclusions and Recommendations

For the walk-in cooler refrigeration cases, the baseline compressor energy consumption was generally too small to justify cost effective savings even if the savings targets were achieved. Furthermore, although COOLNOMIX caused the compressors to run with shorter cycles, the net effect on refrigeration consumption was negligible in most cases, with savings far below the target. Consequently, we do not recommend further pursuit of this refrigeration application.

For air conditioning, significant savings were achieved only in special cases where ventilation fans already ran most of the time. Additional hardware development is needed to greatly reduce the fan energy penalty on ducted packaged rooftop unit and split-system configurations before further testing or deployment is performed. Promising results from the two successful cases suggests potentially significant energy savings if this fan issue can be resolved. At the time of publication, the COOLNOMIX manufacturer and U.S. vendor were pursuing new installation strategies to overcome these technical challenges; however, results from their preliminary tests were not yet available.

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1.0 INTRODUCTION

1.1 BACKGROUND

Air-conditioning and refrigeration systems, which account for about 15% of commercial building site energy use ($580 million per year for the DoD) ,[5] are normally sized to meet harsh design load conditions; yet much of their runtime occurs during mild part-load conditions. Systems with excess part-load capacity can run compressors longer than necessary, overcooling the conditioned zone and wasting energy. By implementing better compressor controls that reduce effective capacity during part-load conditions, it is theoretically possible to improve cooling energy performance by 15% or more. This represents an addressable savings opportunity of about $60 million per year or a 1.5% reduction in total DoD facility energy utilization.[6]

Limitations with existing cooling system controls can cause compressors to run excessively. While there is ample opportunity to retrofit the large stock of existing vapor-compression cooling equipment with more energy efficient and advanced controls, most existing retrofit solutions are complex, expensive, and/or lack the sensor-driven feedback needed to achieve reliable savings.

COOLNOMIX is a patented relay-based compressor control retrofit technology designed to improve cooling and refrigeration performance by adjusting compressor runtime in response to precision temperature feedback. This technology could save energy primarily in four ways:

1. **Optimized Compressor Control** Precision supply and return air temperature sensors and patented algorithms shut off the compressor during its cycle while still satisfying the desired setpoint. Evaporator fans run while the compressor is off, delivering residual cooling between compressor cycles. As a result, the compressor runs in shorter, more-frequent cycles to deliver just enough cooling. This is intended to reduce both the zone temperature deadband and the total compressor runtime.
2. **Improved Temperature Sensing** A wired return air temperature sensor is used to more accurately control the zone temperature. Poorly-positioned thermostats (e.g., high on a wall, near a door, or near a window) can trigger excessive calls for cooling. By placing the wired return sensor in a more representative area, COOLNOMIX can shut off the compressor when the setpoint is satisfied in that location.
3. **Minimum Return Air Temperature Lockout** This prevents occupants from setting the thermostat setpoint too low, a common source of wasted energy. Although many thermostats already have a lockout feature, occupants or maintenance personnel often override these settings. Adding a hardware-based lockout could increase the likelihood of retaining energy savings over time.
4. **Frost Prevention (Refrigeration Only)** When COOLNOMIX shuts off the compressor, the evaporator fans continue running, melting any accumulated frost on the cooling coil before the next cycle begins. This reduces the need for defrost cycles, which can consume gas or electricity, or maintenance for manual de-icing.

[5] Air conditioning and refrigeration comprise about 10% and 4.5% of commercial building site energy consumption, respectively (DOE 2011). Applied to DoD's $4B annual energy expenditure yields about $580M/yr for cooling.

[6] Assumes a sensor-based controls retrofit produces a 15% energy savings applicable to 70% of cooling equipment end-uses at DoD facilities.

Proven retrofit options for improving cooling efficiency involve costly hardware and/or controls, often with complex integration challenges. Typical examples include variable fan speed control, demand-control ventilation, and economizer integration. These upgrades can require costly hardware (e.g., motor or drive replacements) or complex control system integration, which may be cost prohibitive or have a long or uncertain payback period. Consequently, these upgrades are rarely pursued by the DoD and significant energy efficiency opportunities remain unaddressed.

Few retrofit approaches address the compressor, which is normally a large component of cooling energy use. Cooling equipment, both old and new, typically lacks the sensing and precise control needed to optimize compressor runtime. Prior attempts at using relay-based compressor controls to reduce cooling energy use have met with limited success, often due to the lack of integrated temperature feedback. Without this feedback, adjusting compressor cycling may not optimize performance and could risk overheating the conditioned zones. COOLNOMIX differentiates by using built-in sensing of both the return and supply air temperature, along with patented algorithms (Moore 2017), to provide better control capabilities.

1.2 DEMONSTRATION OBJECTIVES

Our primary objective was to quantify the real-world energy and cost savings potential of the COOLNOMIX compressor control retrofit in both humid and dry climates. A demonstration was needed to evaluate energy savings claims, to understand the impact (if any) on thermal comfort, and to verify compatibility with typical U.S. cooling equipment. COOLNOMIX has been successfully deployed in other regions with notably different climates and equipment types, so it was necessary to perform a rigorous U.S. evaluation to obtain relevant savings estimates. Secondary objectives aim to verify that the technology can be readily installed, maintained, and adopted across common DoD facilities.

Energy performance was validated by submetering cooling system electricity consumption and by monitoring the indoor and outdoor conditions and relevant activity in targeted applications at each test site. Pre- and post-retrofit energy performance was assessed using and on/off testing design, alternately enabling and disabling COOLNOMIX at each site.

Cost savings estimates, evaluated based on actual energy costs, were also calculated for several DoD scenarios (based on climate and energy costs). Lifecycle cost analyses were conducted based on the hardware cost, labor and installation cost, expected maintenance, and hardware lifetime.

We do not anticipate this demonstration or technology to impact DoD regulations or standards.

To facilitate technology transfer, the U.S. distributor (CoolGreenPower, LLC.) has taken a proactive role:

1. **On-site Training** During the retrofit installations, they provided on-site training of DoD maintenance personnel on how the system works, how it is installed, and how it can be removed or disabled if necessary.
2. **Best Practices and Adapt Training Materials** During the demonstration, we identified improvements to installation and operation procedures. Key lessons, summarized in this report, are being incorporated into the user and training manuals.

3. **DoD Outreach** Through active participation in trade shows and DoD meetings, the team has identified key DoD stakeholders to pursue with further outreach, pending project completion, to scale technology adoption.

To increase technology acceptance within the DoD, our team has worked closely with the host site Energy Managers, facilities personnel, and HVAC technicians and electricians to identify adoption pathways and potential roadblocks or areas of concern. Maintenance personnel and/or facilities managers were consulted to ensure that the technology did not cause noteworthy adverse effects on the system equipment operation.

1.3 REGULATORY DRIVERS

COOLNOMIX could contribute directly to several relevant DoD, Federal, and industry energy drivers, primarily by providing cost-effective reductions in site energy consumption for air conditioning and refrigeration. If realized, this would lead to significant reductions in energy costs and greenhouse gas emissions by improving building energy efficiency. Specific goals for relevant drivers are noted (Table 1-1).

Table 1-1. Key Regulatory Drivers

Driver	Relevant Goals
EO 13693	**Agency Greenhouse Gas Emission Reductions**. …reduce agency direct greenhouse gas emissions by at least 40 percent over the next decade while at the same time fostering innovation, reducing spending, and strengthening the communities in which our Federal facilities operate. In implementing the policy set forth in section 1 of this order, the head of each agency shall, within 90 days of the date of this order, propose to the Chair of the Council on Environmental Quality (CEQ) and the Director of the Office of Management and Budget (OMB) percentage reduction targets for agency-wide reductions of scope 1 and 2 and scope 3 greenhouse gas emissions in absolute terms by the end of fiscal year 2025 relative to a fiscal year 2008 baseline. **Sustainability Goals for Agencies**. …the head of each agency shall, where life-cycle cost-effective, beginning in fiscal year 2016, unless otherwise specified: (a) promote building energy conservation, efficiency, and management by: (i) reducing agency building energy intensity measured in British thermal units per gross square foot by 2.5 percent annually through the end of fiscal year 2025, relative to the baseline of the agency's building energy use in fiscal year 2015 … implementing efficiency measures based on and using practices such as: (F) identifying opportunities to transition test-bed technologies to achieve the goals of this section; and (h) improve building efficiency, performance, and management
Energy Independence and Security Act of 2007	**High-Performance Commercial Buildings:** New initiatives for promoting conservation in buildings and industry. Aims to create a nationwide zero-net-energy initiative for commercial buildings built after 2025. Buildings built before 2025 should also meet the initiative by 2050. The Department of Energy is responsible for educating the public about high performance green buildings.
FDA & USDA	**Food Safety Requirements for Refrigeration:** Refrigerator temperature must be maintained at or below 40°F to ensure food safety (FDA, USDA).
ASHRAE Standard 55	**Thermal Comfort:** Standard 55 specifies conditions for acceptable thermal environments and is intended for use in design, operation, and commissioning of buildings and other occupied spaces.

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2.0 TECHNOLOGY DESCRIPTION

2.1 TECHNOLOGY OVERVIEW

2.1.1 Hardware Description

COOLNOMIX is a standalone hardware control retrofit for vapor-compression air conditioners and refrigerators that controls the compressor to save energy while maintaining the desired temperature setpoints. It works with the existing thermostats or control systems to temporarily stop the compressor(s) earlier during the cooling cycle to improve energy performance.

The hardware consists of a small, self-contained electronics package that is installed in-line with the existing thermostat or control system and requires no special hardware or software integration (Figure 2-1). It includes a built-in relay that, when open, shuts off the compressor by overriding the thermostat's cooling signal to the compressor. It includes two wired sensors that monitor the supply and return air temperatures. A patented algorithm uses this temperature data to determine when to shut off the compressor.

The retrofit is designed to be installed on existing cooling equipment by 1-2 maintenance technicians in under two hours. A DIP switch selector allows the user to specify the maximum desired return air temperature. An optional audible alarm can be enabled to alert users of cooling system issues. The device does not include or require any networking or wireless communications. Two colored LEDs on the front of the device provide status and diagnostic codes.

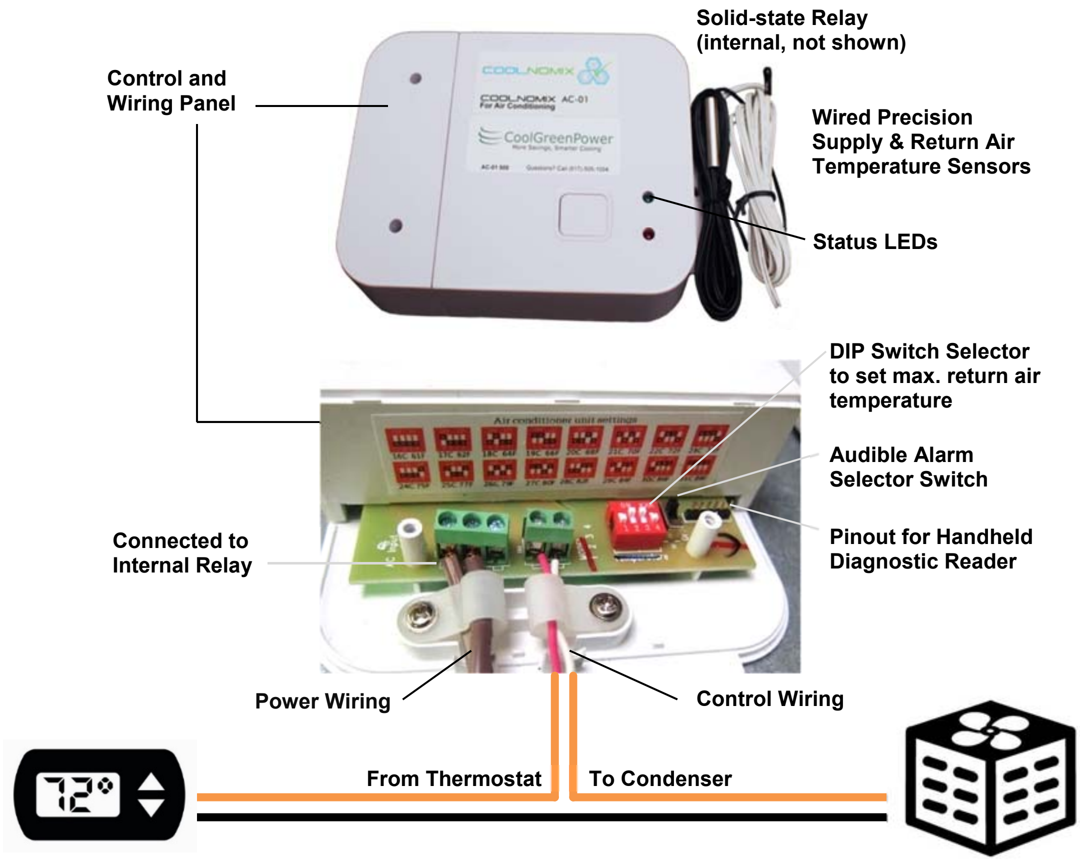

Figure 2-1. COOLNOMIX Unit Schematic.

2.1.2 Operating Theory

During part-load conditions, compressors with excess capacity can run too long, leading to overcooled spaces and inefficient operation. The primary savings mechanisms of COOLNOMIX stems from relay-based compressor cycling to reduce part-load capacity.

Compressors convert low pressure refrigerant vapor into high pressure liquid refrigerant. Expansion of the liquid refrigerant in the evaporator provides cooling, and fans deliver that cooling into the conditioned zone. When the compressor runs long enough, it can flood the evaporator with too much liquid refrigerant. Running the compressor beyond this point could provide excessive cooling and waste energy.

Normally, when a thermostat calls for cooling, the compressor runs until the setpoint is reached (within the deadband). When the thermostat is satisfied, the compressor and evaporator fans stop. Between cycles, there is usually some residual cooling capacity in the liquid refrigerant that is lost to off-cycle migration.[7] Fan overrun strategies, like those available in some thermostats, seek to reduce that loss by running the evaporator fan for several minutes after the compressor shuts off to draw the residual cooling into the conditioned zone.

[7] Off-cycle migration loss could exceed 22% during months of low cooling (Bahel et al. 1988). See also, Illic (2001).

COOLNOMIX takes this fan overrun strategy several steps further, using a patented algorithm called optimal refrigerant supply (ORS) that continuously monitors the supply air temperature to detect when the evaporator has reached a minimum cold temperature. At this point, there is likely an ample supply of liquid refrigerant in the evaporator and the compressor can be shut off temporarily to save energy. Meanwhile, the evaporator fans continue running to draw residual cooling into the conditioned zone. Frequently, this minimum supply temperature is reached before the thermostat is satisfied, so COOLNOMIX can stop the compressor and reduce its runtime.[8]

To ensure this control strategy does not adversely impact the realized zone temperature, COOLNOMIX uses a wired return air sensor and a user-adjustable return air temperature setpoint. To prevent zone overheating, COOLNOMIX does not shut off the compressor while the return air temperature is above this setpoint. COOLNOMIX also includes a built-in delay between compressor starts/stops to prevent short cycling and to ensure soft starts. These time-delay safeguards are common in both thermostats and cooling equipment.

As a result of this revised compressor control strategy, COOLNOMIX causes the compressor to run with shorter, more frequent cycles. The evaporator fan continues to run between cycles, as long as the thermostat is not satisfied, providing residual cooling similar to the fan overrun approach. Running shorter compressor cycles also tends to reduce the zone temperature deadband.

Several secondary energy savings mechanisms, described in the following paragraphs, are possible with COOLNOMIX. We did not evaluate these mechanisms, however, since they can be addressed in other ways, and since the issues were not prevalent among the test sites considered.

Poorly situated thermostats (e.g., high on a wall, near a door, or by a window) may cause compressors to run longer than necessary and overcool the space. For walk-in coolers, thermostats positioned near the door could trigger cooling calls unnecessarily. COOLNOMIX can correct these problems by controlling the compressor based on a wired return air sensor that is placed in a more appropriate location.

Thermostats that are set too cold can waste significant energy. Many thermostats or building management systems offer lockout features that prevent occupants from adjusting these settings or limit the allowable temperature range. Often, however, occupants find ways to adjust thermostat settings or place service calls to have them adjusted. COOLNOMIX could be used to increase the minimum allowable zone temperature by adjusting its return air setpoint, adding another hardware layer redundancy to the indoor setpoint lockout.

Finally, in refrigeration applications, many systems periodically use defrost cycles to eliminate frost from the evaporator coil. Some approaches consume energy (e.g., electric resistance, gas heaters).

[8] The air conditioning systems in this test were typically factory-charged with about 8 pounds of refrigerant (R-22 or R-410A). When all the refrigerant is liquified, its total latent capacity is about 800 Btu (8lb × ~100 Btu/lb, ASHRAE 2009). For a five-ton system (60,000 Btu/hour), this amounts to about 1 minute of full residual capacity per cycle. When COOLNOMIX holds off the compressor, the supply temperature will start to increase, reducing the effective system capacity, and providing several minutes of partial capacity cooling.

Others, like off-cycle defrost, do not. Off-cycle defrost holds the compressor off for a period of time (e.g., for one hour 2-4 times per day). Eventually the return air temperature becomes warm enough to melt any accumulated frost or ice. By running shorter cycles and holding the compressor off until the return air setpoint is met, COOLNOMIX acts like an off-cycle defrost between cycles, which could help prevent frost buildup and reduce energy use and/or service calls.

2.1.3 Installation

COOLNOMIX is installed in-line with the existing thermostat's control wire and requires no significant hardware modifications to the condenser.[9] It is compatible with existing thermostat control systems and does not interfere with energy savings from scheduled temperature setpoint changes. COOLNOMIX could be installed either in the conditioned zone near the thermostat or inside the evaporator or condensing unit (Figure 2-2).

Installation involves the following steps:

1. Perform any required maintenance on the cooling system.
2. Verify that the unit has sufficient excess capacity during part-load conditions.
3. Shut off power to the cooling equipment.
4. Connect the COOLNOMIX power wiring terminal to an AC voltage source.
5. Install a manual override bypass switch (optional, recommended).
6. Connect the control wiring in-line with the thermostat and condenser unit.
7. Position the supply air sensor near the cooling coil or in a supply air vent.
8. Position the return air sensor in a return air vent in the conditioned zone.
9. Set the maximum desired return air temperature using DIP switches.
10. Restore power to the cooling equipment.

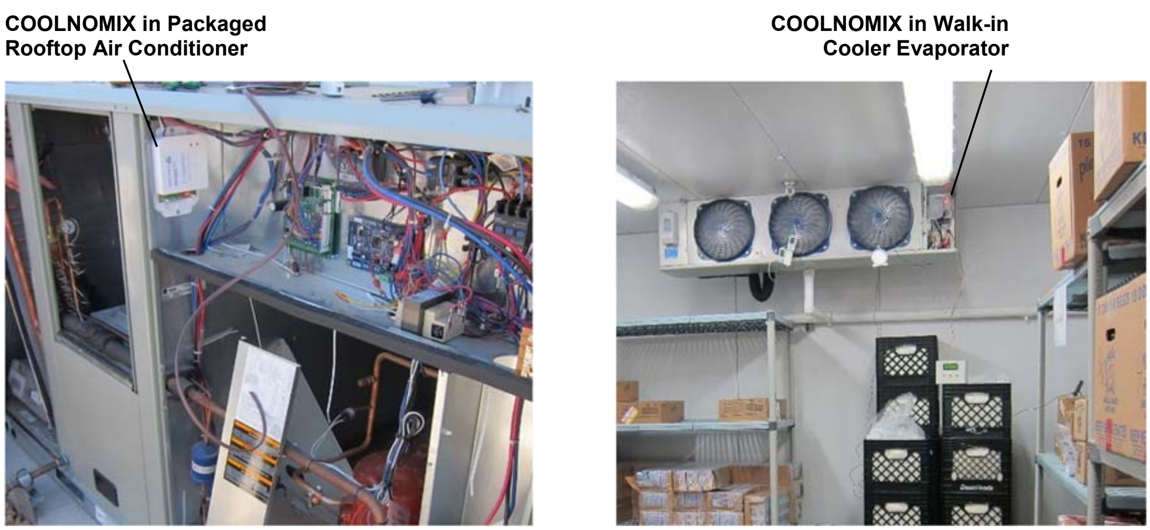

Figure 2-2. COOLNOMIX Installed in Existing Cooling Equipment.

[9] In some units, it is necessary to install a relay coil to provide a continuous signal to the control board. In multi-stage units, some additional control wiring is needed to control both compressor stages. These modifications are minor.

Once installed, the system must be commissioned according to the following steps:

1. Verify the cooling system is working normally (no error codes).
2. Verify that COOLNOMIX is in control of the compressor (functional testing).
3. Verify the cooling system is able to satisfy the desired setpoints (functional testing).
4. Adjust or reposition the COOLNOMIX setpoints and/or return air sensors as necessary.

The installer should allow the system to cycle before and after COOLNOMIX is installed, while monitoring the diagnostic LEDs, to verify that the sensors are correctly positioned and that the controller is not causing any faults or error codes. Step (2) can be accomplished by manually toggling the COOLNOMIX temperature setpoint DIP switches to verify that COOLNOMIX is in control of the compressor. Steps (3-4) must be done during a hot period to ensure adequate occupant comfort.

Maintenance for COOLNOMIX is fairly minimal. During routine preventative maintenance, technicians should check to ensure the COOLNOMIX units are still connected and enabled, that there are no fault codes, and that the temperature setpoints have not been altered, which could compromise savings.

2.1.4 Compatibility

COOLNOMIX is compatible with virtually all vapor compression cycle air conditioning and refrigeration units, where air is cooled by the evaporation of refrigerant.[10] The range of applications includes:

> **Air Conditioning:** Packaged rooftop units (RTUs), ducted systems with air handling units (AHUs), split system air conditioners, ductless mini-split systems; ceiling cassettes; variable refrigerant volume (VRV) or variable refrigerant flow (VRF) systems; Compatible with both inverter and non-inverter drives.
>
> **Refrigeration:** Walk-in refrigeration (not freezers), food manufacturing, and retail refrigerated display cases.

These systems are widespread and apply to DoD-specific end-use applications, such as walk-in refrigeration (dining facilities, commissaries), space air conditioning (in virtually all settings), and targeted cooling applications (server rooms, equipment rooms). Prior COOLNOMIX installations overseas have addressed systems in these applications ranging in capacity from 2 to 105 kW.

To save energy, the cooling equipment must be sized to have significant excess capacity during ordinary part-load conditions. The COOLNOMIX manual suggests verifying this by confirming that (1) the minimum achievable cold supply air temperature is at least 18°F colder than room temperature for AC applications and 9°F below the chilled zone temperature for walk-in refrigeration applications, and (2) starting from the desired set point, the installed equipment should be able to reduce room temperature by 1.8°F within 15 minutes.

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[10] Chillers are not covered by this version of COOLNOMIX; however, a chiller-based product is in development.

2.2 TECHNOLOGY DEVELOPMENT

Launched in European and Asian markets in 2012, COOLNOMIX is a patented, third-generation energy control technology, the result of more than 10 years of research and development by Agile 8 Consulting. A U.S. patent application was filed in 2012 (as an international submission under the terms of the Patent Corporation Treaty) and granted in May 2017 (Moore 2017). No further technical development was required prior to this demonstration.

To date, thousands of systems have been successfully deployed in Australia, Indonesia, Malaysia, Korea, Philippines, China, Hong Kong, Thailand, Israel, South Africa, Dominican Republic, Taiwan, Mexico, Fiji, and Vietnam. Recognizable brands who have installed COOLNOMIX include Hutchison Global Communications, Ocean Park, IBIS Hotels, Novotel, ASM Pacific Technology, 7-Eleven, and Mannings Retail Stores (part of Dairy Farm group). Sectors include telecommunications, entertainment, hotels, financial services, manufacturing – food and high technology, education, retail, and pharmaceuticals. The largest scale deployment at a single location is 200 units in telecommunications and broadcast equipment rooms.

The COOLNOMIX product line is certified under CE, C-Tick, FCC, and RoHS. In 2015 it passed ETL/UL certification for compatibility with U.S. safety codes. No further product development was necessary prior to this demonstration project; however, Agile 8 Consulting has continued to develop new and improved firmware based on field experience from installed units.

In 2015 CoolGreenPower became a U.S. distributor of the COOLNOMIX technology and is currently pursuing sales in targeted locations across the U.S.

Agile 8 Consulting is currently developing additional products that may help optimize chillers and commercial freezers, which could provide future opportunities for energy savings. Once energy performance has been established, there may be possibilities to license the technology to the original equipment manufacturers (OEMs) so that its capabilities could be integrated directly into the cooling equipment or thermostats.

Based on the technical challenges encountered in this demonstration related to excess ventilation fan runtime, CoolGreenPower began working with Agile 8 Consulting in 2018 to develop new installation strategies and/or hardware modifications to overcome them. Details surrounding these efforts were not yet available at the time of this publication.

2.3 ADVANTAGES AND LIMITATIONS OF THE TECHNOLOGY

Relatively few aftermarket control options exist for improving the energy performance of compressors and these are not widely adopted. Direct competitors offer controls that cycle the compressor in a similar fashion, using different logic and/or temperature measurements. COOLNOMIX differs from most competing systems by using a second zone temperature sensor to help prevent thermal runaway, a condition that can occur when repeatedly holding the compressor off leads to increasing and eventually unacceptable zone temperatures. The installation, maintenance, and cost characteristics of COOLNOMIX are likely similar to competing technologies.

Limited technical details are available regarding most competing controllers, making them difficult to compare. In addition, many vendors of aftermarket compressor controls cite "case-studies" that indicate very high cooling energy savings, often 30% or more; however, detailed technical reports and data are rarely available, and those that are generally lack sufficient depth and rigor to support definitive conclusions. Some common shortcomings of these evaluations, many noted by Webster and Beneson (1998) and WSU (2008), include: inadequate test duration, no/incorrect weather normalization, failure to maintain equivalent zone temperature and humidity, failure to account for total system or fan energy, failure to describe the equipment and surroundings, and general lack of detail about factors that could influence performance (such as occupancy variability, changes to HVAC equipment, maintenance, etc.). This study, therefore, was intended to provide a more comprehensive analysis for specific end-uses.

Other options for reducing part-load compressor capacity involve costly hardware-based modulation, which can save over 15-40% on cooling energy (Illic 2001, Emmerson 2014). Common options include two-stage modulation, multiple compressors stages, variable speed compressor motor, and continuously variable modulation. COOLNOMIX modulates existing compressors by cycling between 100% and 0% capacity and does not require special compressors or additional hardware.

Numerous other strategies exist for improving cooling system performance, though these tend to focus on variable speed fans, motors, demand control ventilation, and economizers (see, for instance, PNNL 2012, 2013) and tend to be more costly. Replacing a compressor with a more efficient model, for instance, can take four to eight hours of skilled labor, and requires refrigerant evacuation, charging, leak-testing, and commissioning. Consequently, these strategies are rarely pursued by the DoD. See Appendix C for additional discussion of competing technologies.

2.3.1 Performance Advantages

In the test set of buildings, we did not observe the expected performance advantages as frequently or completely as anticipated. The following list describes the expected advantages and our observations in this demonstration.

1. EXPECTED: Reduced cooling and refrigeration energy consumption of 15% or more by optimizing compressor runtime. Achieved by monitoring the evaporator/supply air temperature and the zone temperature and switching the compressor off during the cycle when the refrigerant has reached an optimal state of compression. In baseline, compressors will normally run longer than necessary.

   - OBSERVED: Significant savings occurred only in two of the six air conditioning test sites, primarily due to increased ventilation fan runtime with COOLNOMIX. Savings for all six refrigeration sites were either not significant or not meaningful.

2. EXPECTED: Thermal stability is maintained or improved in the conditioned space by reducing the occurrence of unnecessary compressor starts (e.g., when the door opens briefly, a thermostat can be fooled into thinking the temperature has dropped below acceptable levels, running the compressor unnecessarily). Wired temperature sensors provide localized temperature monitoring and control to prevent this from happening.

- OBSERVED: In most test buildings, thermal stability was adequate in the baseline, so there was not much room for improvement. For refrigeration cases, the thermostats were located away from the door and were not frequently triggered unnecessarily. For air conditioning cases, thermostats tended to be positioned in appropriate locations (not too high on the wall, away from doors or other sources of heating or cooling). In several cases, thermal stability was improved slightly (tighter temperature deadband), but in others, COOLNOMIX caused zone temperature or humidity to increase.

3. EXPECTED: Compatibility with most existing thermostats or HVAC control systems. No need for a special controller, integration, or communication. Equipment is installed in-line with the existing thermostat.

   - OBSERVED: Most existing cooling systems were compatible with COOLNOMIX. One AC system was not (unusual configuration). Some systems, however, were more complex and required additional commissioning steps, including rewiring, testing, changing settings, and moving sensors.

4. EXPECTED: For refrigeration applications, defrost heaters are not necessary during post-retrofit operation, and icing can be eliminated, since the evaporator fans must run continuously. This could reduce energy consumption and service calls.

   - OBSERVED: Defrost heaters were not used in the baseline refrigeration systems. Instead, off-cycle defrost was used. No frost/icing issues were reported or observed in the baseline condition, so it was not possible to identify savings for this metric.

2.3.2 Cost Advantages

1. EXPECTED: Significant energy and cost savings of 15% or more (e.g., ~4,000 kWh/yr, $400/yr per device, depending on system size, type, and operating conditions).

   - OBSERVED: Insignificant savings for refrigeration cases (<5%), energy increases for most cooling systems due to increased fan runtime and ventilation loads, and cost-effective savings for one case with fans running most of the time.

2. EXPECTED: Low first cost (~$500 hardware) relative to more involved HVAC retrofits (e.g., variable-speed drive motor replacement, ~$1,000s).

   - OBSERVED: First cost of hardware was $500. Installed cost including labor and materials can range from about $560-$880, depending on the existing system complexity. This is still significantly less expensive than a major hardware retrofit.

3. EXPECTED: Simple installation relative to typical HVAC retrofits (can be completed in 1-2 hours by a technician).

   - OBSERVED: Generally correct. Some installations required additional time or materials, but typical installations can be completed in under 2 hours.

4. EXPECTED: Short payback period (expected <5 years, and <2 years in targeted applications).

    - OBSERVED: Payback period of <5 years was observed only for the single AC case where ventilation fans ran all the time in baseline. This depends strongly on actual electricity rates and cooling energy consumption.

5. EXPECTED: Long expected lifetime >10 years (no moving parts, simple relay-based control).

    - OBSERVED: No equipment failures were observed during the tests (>1 year). Not possible to evaluate long-term lifetime within this validation effort.

2.3.3 Performance Limitations

1. This demonstration found that continuous evaporator or ventilation fan operation caused by COOLNOMIX can offset potential energy savings and may *increase* cooling system energy consumption. Savings were observed only in systems where these fans were already running frequently or all the time.

2. HVAC systems that are undersized or that do not cycle (those that run all the time) may not save energy because there must be residual capacity during ordinary part-load operation to achieve savings. (Most systems are sized [or oversized] for worst-case design day conditions and have significant residual capacity during ordinary load days).

3. COOLNOMIX is not compatible with freezers or chiller/chilled-water-based HVAC systems (vapor-compression systems only). Plans to address chillers in future product lines are currently underway.

4. There is potential for reduced dehumidification performance in some applications due to continuous fan operation requirement.

2.3.4 Cost Limitations

1. Savings and Simple Payback Period may be below the threshold to interest ESCOs except for large scale deployments.

2. Hardware pricing may change and is expected to vary by cooling system capacity.

3. Increased compressor cycling frequency accelerates wear of the contactor that controls the compressor, potentially leading to premature replacement (typically <$200 installed).

2.3.5 Potential Barriers to Acceptance

1. COOLNOMIX adds one extra controller to the existing system. This adds a small amount of complexity in equipment management and maintenance. To address this, future versions of the hardware may be integrated with a thermostat or the HVAC controller.

2. Prior compressor control energy retrofits have an inconclusive track record (Webster and Beneson 1998 and WSU 2008). Those with poor past experiences with similar technologies could provide resistance to adoption.

3. Wired temperature sensors may not be acceptable in all building locations, aesthetically or functionally.

4. Educational barriers of communicating the benefits of the technology to DoD stakeholders, and the training requirements needed to ensure the devices remain connected and properly configured could complicate adoption.

5. Potential for voiding the cooling system warranty could limit adoption. This technology is similar to a thermostat and is ETL listed. Depending on how it is installed, and specifically, whether it constitutes a “modification” of the cooling system hardware, the OEM warranty could be voided. Specific warranty details and requirements vary by manufacturer. Much of the addressable equipment is likely already out of warranty and would not be affected.

3.0 PERFORMANCE OBJECTIVES

Performance objectives were evaluated at two host sites, representing dry and humid climates (Table 3-1). Three air conditioners (AC) and three walk-in coolers for refrigeration (REF) were tested at each host site.

Table 3-1. Summary of Performance Objectives

Objective		Metric	Data Required	Success Criteria	Results
QUANTITATIVE OBJECTIVES					
1	Cooling Electricity Savings	Savings (%, kWh/yr)	Power (kW) Temperature (zone & outdoor, °F) Occupancy (%)	≥15% reduction in normalized system energy consumption	4,030 kWh (17%) savings in one AC case with fans set to always ON Increased energy for four AC cases with fans set to AUTO (high fan penalty) Not working in one AC case. No significant savings for any refrigeration cases.
2	System Economics	SPP (years) LCCS ($) SIR	Hardware cost Labor time/cost Energy savings Maintenance	Simple payback: <5 year (<2 stretch goal) SIR>1	For single success case: SPP: 4.1 Annual savings: $241/yr Lifecycle savings: $1,270 SIR: 1.8
3	Climate Control	Time at target temperature & RH (%)	Zone temperature & RH Target setpoint conditions	Refrigeration: 32-40°F, no freezing, no spoilage AC: zone temp. similar to baseline (typ. 72°F)	Setpoints maintained, zone temperatures slightly elevated (<2°F) in some cases; humidity not well controlled in baseline
4	Ease of Installation	Time to install (hrs)	Observe installations	Install in 3 hrs untrained, 1 hr trained Compatibility with target systems Staff satisfied	Compatibility verified. Typically takes 1-2 installers, 1-2 hrs to install and commission.
5	Reliability	Uptime (%)	Time working Maintenance feedback	Time working (%) Does not reduce reliability of existing equipment	No equipment failures No maintenance complaints related to COOLNOMIX
6	Short-Cycle & Frost Prevention	Features work as designed	Compressor runtime Coil inspection	≥3 min cycle duration No frost accumulation	Minimum cycle times confirmed No frosting observed
QUALITATIVE OBJECTIVES					
7	Facility Satisfaction	Staff satisfaction	Likert scale survey	Acceptable to staff, maintenance	Acceptable, no major complaints
8	Warranty Compatibility	Voids warranty (yes/no)	Manufacturer terms	System does not void manufacturer's warranty	Likely depends on how COOLNOMIX is installed

3.2 COOLING ELECTRICITY SAVINGS

3.2.1 Purpose

Our goal was to rigorously evaluate the normalized net effects of COOLNOMIX on cooling system electricity consumption, following industry-standard measurement and verification guidelines (ASHRAE Guideline 14). The cooling system includes all components influenced by COOLNOMIX, primarily the condenser (compressor + condenser fan) and any associated evaporator or ventilation fans.

3.2.2 Metrics

Absolute and relative changes (kWh, %) in annual cooling system energy consumption, normalized by weather and occupancy.

3.2.3 Data

Using data loggers and public weather data,[11] we measured or calculated the following:

1. Daily Cooling System (Component) Electricity Consumption (kWh) Submetered electricity for each compressor or packaged rooftop unit, recorded at one-minute intervals based on sub-second sampling, used to assessing energy savings.
2. Fan and Compressor Runtime (hours/day, cycles/day) Calculated from submetered electricity data, motor state loggers, and/or typical schedules; used to calculate energy penalty of running the fan continuously.
3. Daily Cooling Degree Days (*CDD*) and Avg. Daily Temperature (°F) Calculated based on hourly local weather station data, used for weather normalization. To account for variations in zone temperature across periods (due to thermostat adjustments or COOLNOMIX control) we also calculated Adjusted Cooling Degree Days (CDD_{adj}) by subtracting deviations in average daily zone temperature from the *CDD*.[12]
4. Occupancy (*OCC*, %) Occupied hours of each site, measured with passive infrared occupancy sensors and/or door state loggers, used to ensure consistency across test periods and in some cases, as regression terms.

3.2.4 Analytical Methods

During the test, COOLNOMIX was alternately enabled and disabled, approximately monthly, providing energy consumption data for pre- and post- retrofit conditions.

The approach to calculating energy consumption and savings for air conditioning systems included the following steps:

[11] Weather stations were located within three miles and less than 50ft of elevation change relative to the test sites (Iowa State University 2017).

[12] Adjusted cooling degree days account for differences in actual daily average zone temperatures: $CDD_{adj} = CDD_{65} - (T_{avg} - 72°F)$.

1. Calculate daily cooling energy consumption (by component)
2. Calculate cooling degree hours and cooling degree days (CDD_{65}, base 65°F)
3. Calculate adjusted cooling degree days (CDD_{adj})
4. Calculate average outdoor dry bulb temperature (T_{avg}, for refrigeration)
5. Filter out days with heating and/or with minimal cooling energy
6. Filter out days with data quality problems or equipment issues based on visual inspection
7. Develop candidate regression models for the relationship between daily (component) energy use, CDD_{65}, CDD_{adj}, occupancy, and/or COOLNOMIX status
8. Select statistically preferred models by evaluating fit metrics and significant regression terms ($p<0.05$)
9. Using regressions, model annual energy use based on actual weather data
10. Verify that occupancy conditions and zone temperatures were similar among test periods
11. Compare estimated annual energy consumption for both cases

The approach for refrigeration was similar, except that we did not exclude heating days, and we used T_{avg} instead of *CDD*.

Normalized pre- and post- retrofit energy consumption were compared to calculate absolute and percent savings by end-use application and by season. Fan energy penalty (if any) was calculated and subtracted from the observed energy savings to determine the net energy savings.

Results were used to calculate system economics under various scenarios.

3.2.5 Success Criteria

Target of 15% or higher reduction in cooling system energy use, selected to provide a reasonably fast simple payback period of less than five years.

3.2.6 Results

In most air conditioning cases, COOLNOMIX increased cooling system energy consumption (negative savings) because its control strategy significantly increased ventilation fan runtime and electricity consumption. Statistically significant compressor energy savings were observed in only two of the six air conditioning sites (AC2 and AC3, Table 3-2).

Site AC3 had the greatest savings (17% reduction) and was the only case to exceed the 15% success criteria. This site was unique in that its ventilation fans were programmed to run all the time in the baseline. In all other cases, ventilation fans were normally programmed to run on AUTO (running only when the thermostat calls for cooling) during much of the cooling season.

Site AC2 had lower savings (6.5%) and did not meet the 15% success criteria. This site was also unique in that it was the only unit that was slightly undersized. As a result, the fan energy penalty was lower than average, since the fans ran frequently in the baseline.

Although some refrigeration sites showed statistically significant differences in energy consumption (some positive, some negative), none met the energy savings success criteria. In the two cases that had an energy-saving fan speed controller, energy consumption is likely to have increased.

Table 3-2. Cooling System Energy Performance Results.

AIR CONDITIONING

Site	Climate	Regression Terms	R^2	CV-RMSE	Energy Change (kWh/yr)	Energy Change %	Notes
AC1	DRY	CDD, Occupancy	0.80	0.13	+1,691	+15	Significant increase due to extra fan runtime.
AC2	DRY	CDD, Occupancy	0.89	0.08	-1,522	-6.5	Significant savings, but below target. System slightly undersized.
AC3	DRY	CDD, Occupancy	0.84	0.14	-4,030	-17	Significant savings, met target. Dual stage condenser. Ventilation fans always on.
AC4	HUMID	CDD, Occupancy	0.89	0.14	-	-	Insignificant COOLNOMIX effect.
AC5	HUMID	CDD, Occupancy	0.88	0.17	+2,544	+26	Significant increase due to extra fan runtime. Condenser energy not significantly changed.
AC6	HUMID	CDD, Occupancy	0.68	0.30	-	-	No compressor control observed.
AC7	HUMID	-	-	-	-	-	Incompatible. Unusual dual condenser, single air-handler configuration.

Notes: Cooling System Energy Change = (Baseline – COOLNOMIX). Includes ventilation fans and condenser. Statistically significant savings highlighted.

REFRIGERATION

Site	Climate	Regression Terms	R^2	CV-RMSE	ENERGY CHANGE (kWh/yr)	ENERGY CHANGE %	Notes
REF1	DRY	T_{out}, Occupancy	0.67	0.18	-96	-2.0	Significant savings, well below target.
REF2	DRY	T_{out}, Occupancy	0.60	0.16	-63	-1.1	Savings not statistically significant.
REF3	DRY	T_{out}, Occupancy	0.74	0.16	-95	-1.1	Savings not statistically significant.
REF4	HUMID	T_{out}, Occupancy	0.45	0.17	+110	+3	Increase not statistically significant.
REF5	HUMID	T_{out}, Occupancy	0.40	0.21	+142	+4	Increase statistically significant.
REF6	HUMID	T_{out}, Occupancy	0.57	0.09	-101	-3	Significant savings, well below target.

Notes: Cooling System Energy Change = (Baseline – COOLNOMIX). Includes evaporator fans and compressor. T_{out} = outside air temperature. Statistically significant savings highlighted. Excludes evaporator fan penalty on REF4-5, up to +300 kWh/yr.

3.3 SYSTEM ECONOMICS

3.3.1 Purpose

Quantify cost savings and economic benefits of COOLNOMIX under different scenarios to enable DoD to identify financially viable candidate retrofit sites.

3.3.2 Metrics

Several economic metrics were evaluated including: annual savings ($/yr), lifecycle cost savings (LCCS, $), simple payback period (SPP, years), and savings to investment ratio (SIR).

3.3.3 Data

Metrics were calculated based on the following:

1. Normalized Energy Savings (kWh/yr) From Section 3.1.
2. Electricity Price ($/kWh) A typical range of prices were considered in the cost analysis
3. Cost of Installation ($) Including all required hardware and labor, estimated based on the demonstration installs and DoD input.
4. Cost of Maintenance ($) Lifetime maintenance cost to DoD per application, to be estimated with input from the vendor and the DoD facilities personnel, including any added wear-and-tear on HVAC equipment.

3.3.4 Analytical Methods

System economics calculations were performed following DoD guidelines and using the NIST Building Life Cycle Cost program (BLCC 5.3-2018).[13] These calculations involved scenario-based analysis to quantify savings and return on investment for selected combinations of climate regions, energy cost, system type, and usage scenarios for the application(s) where savings were identified.

3.3.5 Success Criteria

Target simple payback period of less than five years (threshold for success), with a stretch target of less than two years.

3.3.6 Results

For the single air conditioning case that met the energy performance success criteria (AC3), we estimated a SPP of 4.1 years, SIR 1.8, and LCCS of $1,270, thus satisfying the success criteria.[14] Doubling the electricity price (or the baseline system energy consumption) leads to a SPP of 2.1 years, SIR 4.9, and LCCS of $3,505.

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[13] http://www1.eere.energy.gov/femp/information/download_blcc.html#blcc.

[14] Based on annual energy savings of $241/yr (at $0.06/kWh), $722 first cost (installation + materials + labor), and annual maintenance + training costs of $16/yr 3% discount rate, and a 10-year product life. Additional cost model assumptions and scenarios are provided in the Cost Assessment section.

For the remaining air conditioning sites (those with fans set to AUTO) and all refrigeration sites, COOLNOMIX did not yield sufficient savings to merit a cost analysis.

3.4 CLIMATE CONTROL

3.4.1 Purpose

Ensure that energy savings do not adversely impact thermal comfort, refrigeration target temperature, or food spoilage in DoD facilities.

3.4.2 Metrics

Percent of occupied hours at or below target temperatures and/or humidity.

3.4.3 Data

1. Conditioned Space Temperature (°F) Measured near the thermostat (for AC) and near the door (for refrigeration). For larger zones, multiple measuring points were compared and/or averaged. Sampling frequency was five minutes or less, and typically one minute.
2. Relative Humidity (% RH) Measure RH in the same locations as above (20-60%, typ.)
3. Thermostat Setpoints (°F) Recorded all thermostat setpoints during each site visit to understand occupant-driven sources of variability.

3.4.4 Analytical Methods

We compared the fraction of occupied hours that the desired temperature or humidity was unsatisfied (>75°F and >60% RH for air conditioning, >40°F for refrigeration) with and without COOLNOMIX. As appropriate, we plot zone temperature against other variables, such as *CDD*, to illustrate their influence.

3.4.5 Success Criteria

Insignificant zone temperature and relative humidity change, relative to baseline, while occupied.

Food spoilage does not occur due to modified compressor control.

Humidity levels do not increase beyond acceptable target levels (e.g., 60% RH) more frequently than in the pre-retrofit condition.

3.4.6 Results

Results varied by test site according to many factors (see individual sections for more details), though overall, COOLNOMIX did not severely influence indoor climate once properly configured and commissioned.

For air conditioning, COOLNOMIX generally increased average zone temperature slightly (<2°F) for air conditioning. Often, the temperature deadband decreased slightly with COOLNOMIX enabled.

In one case, occupants apparently noticed this difference (AC1). In some cases, however (e.g. AC3), temperature increased throughout the afternoon due to more frequent compressor cycling. In one undersized unit (AC2), the cooling system ran continuously for most afternoons, unable to meet the load.

Humidity increased in some air conditioning cases, though this may have been caused in part by weather variables, especially as the ventilation hours increased with COOLNOMIX. Baseline zone humidity levels often exceeded 60% at the humid site.

Temperatures in walk-in coolers were not significantly affected by COOLNOMIX and remained within acceptable limits. No food spoilage was reported.

Overall, the changes to the zone conditions caused by COOLNOMIX were acceptable to the occupants and facility operators.

3.5 EASE OF INSTALLATION

3.5.1 Purpose

Confirm that the system can be efficiently installed by DoD technicians with limited training.

3.5.2 Metrics

Time to train and time to install COOLNOMIX (hours).

3.5.3 Data

1. Time to Train and Install (hours) We trained and supervised DoD facilities personnel and HVAC technicians during the installations, noting time spent. We also interviewed the installers to obtain estimates for typical installation scenarios.
2. Qualitative Installation Notes During and after installations, installers provided feedback about the installation process to highlight potential challenges, identify best practices, and indicate areas for improving installation efficiency.

3.5.4 Analytical Methods

Summarize the range and average installation times for refrigeration and HVAC retrofits.

Summarize findings from the field installations, noting best practices, highlighting any difficulties during installation that must be addressed before large-scale rollout, and noting factors that affect installation time.

3.5.5 Success Criteria

Less than 3 hours required to train DoD facilities technicians, and 1 hour for trained DoD personnel to complete a retrofit.

Identify any major challenges encountered during installations.

3.5.6 Results

Installers (both DoD technicians and HVAC contractors) were successfully trained during a one-hour meeting followed by supervised installations.

Typical installation and commissioning takes about 1-2 hours and requires up to two people. While this was somewhat higher than the target criteria, the added labor is unlikely to have a strong affect the system economics. Furthermore, actual deployments could be faster and more time-efficient if many similar buildings are addressed at the same time. A basic model for estimating time and materials is included in the Cost Assessment section.

Several challenges occurred during installations, primarily related to identifying systems with sufficient excess capacity, selecting appropriate fan settings, tuning up the cooling systems, and commissioning COOLNOMIX. These challenges are discussed in further detail in the Implementation Issues section, along with potential remedial pathways.

3.6 RELIABILITY

3.6.1 Purpose

Demonstrate that COOLNOMIX does not adversely affect cooling or refrigeration system uptime and reliability.

3.6.2 Metrics

Change in system uptime or number of failure rates (% of time, hours, events)

3.6.3 Data

1. System Uptime (%, hours/day) System uptime can be inferred from electricity data.
2. Equipment Issue Reporting DoD facilities personnel reported selected equipment issues during the testing period, indicating the type of fault, corrective actions taken, and the probable cause of the issue.

3.6.4 Analytical Methods

Summarize any equipment issues that arise during the testing period and identify any that could be related to the COOLNOMIX technology.

Compare the frequency of issues (if enough occur) during each pre- and post- retrofit period. Results are qualitative, recognizing this is a small sample.

3.6.5 Success Criteria

System failure rate or downtime (attributable to the COOLNOMIX retrofit) is not significantly higher in the post-retrofit condition.

3.6.6 Results

No significant impact on cooling system reliability was reported or observed. Maintenance records were not provided, so we could not directly evaluate system failures.

Twice during the study COOLNOMIX was found to be disabled, likely by a maintenance technician. Once, the bypass switch was activated and once the control wires were disconnected. Further investigation showed that the maintenance issues occurred that were unrelated to COOLNOMIX and that the technician likely disabled the device during diagnostics.

Electricity data and site inspections led us to identify several neglected maintenance issues unrelated to COOLNOMIX (clogged fan filters, low refrigerant charge) that were addressed during the test.

More frequent compressor cycling could cause the contactor to wear out prematurely. This replacement is a relatively low -cost item and has been included in the cost model.

While more frequent compressor cycling could impact compressor lifetime, this could not be evaluated in the span of a one-year demonstration. No compressor issues were observed during the test. Minimum cycle on/off times were sufficient to avoid short-cycling (less than three minutes) for both refrigeration and air conditioning applications.

3.7 SHORT-CYCLE AND FROST PREVENTION

3.7.1 Purpose

Confirm that the retrofit does not induce compressor short-cycling, which could damage the equipment, and ensure that no frost accumulation occurs while the defrost heaters are disabled during the post-retrofit periods.

3.7.2 Metrics

Minimum Cooling Cycle Duration (minutes), Frost Accumulation Event Reports (count)

3.7.3 Data

1. <u>Cooling Equipment Electricity Data</u> Submetered electricity consumption with a resolution of 1 minute, used to estimate compressor runtime.
2. <u>Frost accumulation events (count)</u> DoD facilities personnel provided qualitative reports about issues pertaining to frost accumulation on the evaporator coil.

3.7.4 Analytical Methods

Compressor runtime was identified based on submetered electricity data. For each unit, we identified a typical power threshold that indicates when the compressor was running. We then identified the portion of cycles (if any) lasting less than 3 minutes.

Frost accumulation events (if any) will be compared between testing periods.

3.7.5 Success Criteria

Cycles of less than 3 minutes occur no more frequently than the baseline.

Frost accumulation is not significantly different than the baseline.

3.7.6 Results

Short-cycle prevention apparently worked as designed. No issues with short cycling were observed during the test in any of the COOLNOMIX cases.

Frost accumulation was not observed in any refrigeration systems while COOLNOMIX was enabled. The same was true of the baseline, with the exception of one system (REF6) whose thermostat was improperly adjusted to below freezing. In that case, frost built up while COOLNOMIX was disabled and required a de-icing maintenance call. After the thermostat was corrected, no further frosting issues were observed.

The cooling systems we tested apparently used off-cycle defrost and did not use heaters. The built-in defrost mechanisms were not disabled during the test, as they were necessary during the COOLNOMIX bypass periods. Even with COOLNOMIX installed, it is unlikely that technicians would be comfortable disabling defrost timers/heaters due to the potentially significant risk of spoiled product and/or expensive maintenance.

3.8 FACILITY SATISFACTION

3.8.1 Purpose

Identify occupant and facility satisfaction with the technology.

3.8.2 Metrics

Qualitative survey of DoD facilities personnel satisfaction

3.8.3 Data

1. Occupant Satisfaction Survey A basic survey was offered periodically to identify any potential issues (e.g., likes, dislikes, overall satisfaction).
2. Facilities Issue Reports Reported issues or complaints about space conditioning or refrigeration temperature were noted including time/date/nature of the complaint.

3.8.4 Analytical Methods

Survey results were summarized and compared across test periods.

3.8.5 Success Criteria

No significant differences in occupant satisfaction between pre- and post- retrofit conditions.

No significant issue reports that could prevent technology adoption.

3.8.6 Results

Comfort surveys for the dry climate sites indicated no significant or negative changes to comfort. Surveys for the humid sites were limited to periods before COOLNOMIX was working properly and were therefore not included. Informal staff questioning during site visits at those sites revealed occasional complaints of high humidity and temperatures; however, such complaints were not limited to COOLNOMIX periods.

Occasionally, during site visits, occupants reported specific comfort complaints. In those cases, we adjusted the COOLNOMIX setpoints and/or sensor wiring positions or checked and tuned-up the cooling equipment, which apparently resolved the issues. Specifics for each site, along with user comments, are documented in the site-specific Performance Assessment subsections.

Facilities personnel provided no negative feedback about the installed systems, and there were no major technical issues with COOLNOMIX related to space conditioning.

3.9 WARRANTY COMPATIBILITY

3.9.1 Purpose

Confirm that the COOLNOMIX system does not void manufacturer's warranty.

3.9.2 Metrics

Does or does not void warranty.

3.9.3 Data

Review manufacturer system owner manuals.

3.9.4 Success Criteria

Does not void warranty for majority of candidate equipment

3.9.5 Results

Based on the language in popular equipment manufacturer warranties, equipment failures caused by "modifications" can void the warranty.

Whether COOLNOMIX constitutes a modification is open to interpretation and may depend on how it is installed. Specifically, if COOLNOMIX is wired and installed inside the existing cooling equipment (as it was in most of the test sites in this demonstration), this is more likely to constitute a modification. This is especially likely if the compressor stages are re-wired to be controlled differently, or if a relay coil is installed to override current detection circuits.

On some simpler installations, COOLNOMIX can be installed by modifying the thermostat. In this case, it is likely to void the warranty of the thermostat, but not the cooling equipment. If concerned, users could focus on equipment whose warranty has expired (typically after five years).

4.0 FACILITY/SITE DESCRIPTION

4.1 FACILITY SITE LOCATION AND OPERATIONS

Testing was performed at twelve sites, including six refrigeration and six air conditioning, in two distinct climates:

1. Hot/Dry: Ft. Bliss, El Paso, TX (ARMY)
2. Mild/Humid: Joint Base Anacostia-Bolling, Washington, D.C. (NAVY/AIRFORCE)

Figure 4-1. Demonstration Host Sites.

Air conditioning test sites were all cooled by direct expansion (DX) vapor-compression systems with single or dual sage compressors. These included a mix of ducted single-zone packaged rooftop units (RTUs) with integrated ventilation fans and split system condensers with a separate air handler. In each test building, one thermostat directly controlled each condenser.

Refrigeration test sites included walk-in coolers used for food service applications. Five of the walk-in coolers relied on packaged rooftop condensing equipment that served multiple coolers, each with its own dedicated compressor, and shared condenser fans. The sixth was a standalone cooler with a dedicated condensing unit.

The facilities and cooling equipment are summarized in Table 4-1 and Table 4-2. Additional details are provided in the individual Performance Assessment subsections.

Table 4-1. Test Facility Summary.

Climate	Site	Building	Description	Typ. Hours
AIR CONDITIONING				
DRY	AC1	Basement Office	Newly renovated open plan office, part of a 3-story building, with many computers, monitors, televisions, a small server closet and a second office area. Cooled by a single packaged RTU.	M-F (0730-1630) Sa-Su (closed)
DRY	AC2	Motor Pool	Single-zone one story building includes waiting area, open plan office, restrooms, and several small offices. Cooled by a single packaged RTU.	All Days (0500-2400)
DRY	AC3	Second Floor Office	Single-zone open plan office on second floor of two-story building. Cooled by a single packaged RTU with ducted plenum, VAV boxes.	M-F (0600-1700)
HUMID	AC4	Post Office	Single-story brick building with moderate traffic, with two main doors: lobby and loading. Cooled by a single split-system heat pump.	M-F (0800-1700) Sa (0900-0400) Su (closed)
HUMID	AC5	Single Floor Office	Single-story brick building with moderate traffic, consisting of one large room and several smaller offices. Cooled by a single split-system heat pump.	M-F (0600-1600)
HUMID	AC6	Break Room	Newly renovated, part of 3-story building, with two doors, open break area, small adjoining office rooms; and restrooms. Occupancy varies through the day. Cooled by a single packaged RTU, w/ ducted plenum.	All Days (0600-1800)
HUMID	AC7	Convenience Store	A large store cooled by two condensing units and one air handler. (Decommissioned after challenges with multiple condenser configuration, see Section 8: Implementation Issues)	M-F (0600-2300) Sa-Su (0800-2300) Hol. (1000-1700)
REFRIGERATION				
DRY DRY DRY	REF1 REF2 REF3	Dining Facility	Three adjacent walk-in coolers for food storage and prep (and a fourth, not tested, for defrosting). Cooled by a shared rooftop condensing unit, with dedicated compressor for each cooler.	M-W (0730-1830) R (0600-1830) F (0730-1830) Sa-Su (0930-1830)
HUMID HUMID	REF4 REF5	Banquet Hall	Two adjacent walk-in coolers, one for food storage and prep and the other for defrosting. Cooled by a shared rooftop condensing unit, with dedicated compressor for each cooler.	M (closed) T-F (1100-1330) Sa (closed) Su (1030-1400)
HUMID	REF6	Fast Food Service	Walk-in cooler at a bowling alley. Cooled by a dedicated condensing unit.	M-F (1000-2200) Sa (1200-1930)

Table 4-2. Cooling Equipment Summary.

AIR CONDITIONING										
Climate	**Site**	**Building**	**Est. Zone Area (ft^2)**	**Equip**	**Make**	**Model**	**CAP (ton)**	**STA-GES**	**FAN(S) (HP)**	**Year**
DRY	AC1	Basement Office	2,000	RTU	TRANE	THC072F4RKA07	6.0	1	1.0	2015
DRY	AC2	Motor Pool	2,800	RTU	RHEEM	RLKA-A060JK	5.0	1	0.75	2005
DRY	AC3	2nd Floor Office	4,000	RTU	TRANE	YHC092A4RMA2ND0010020000 D	7.5	2	2.75	2007
HUMID	AC4	Post Office	2,100	Heat Pump	TRANE	TWA090A300FB	7.5	1	-	2005
				AHU	-	-	-	-	NA	-
HUMID	AC5	Single Floor Office	2,700	Heat Pump	York	E3FB090A25A	7.5	1	-	1997
				AHU	-	-	-	-	1.5	1997
HUMID	AC6	Break Room	2,500	RTU	TRANE	TWE090A100BA	7.5	1	0.75	1992
HUMID	ACX	Convenience Store	11,000	Condenser	YORK	H5CE180A25A	15	2	-	2008
				Condenser	YORK	H5CE180A25A	15	2	-	2008
				AHU	-	-	-	-	NA	-
REFRIGERATION										
Climate	**Site**	**Equipment**			**Make**	**Model**	**CAP (HP)**		**FAN(S) (HP)**	**Year**
DRY	**Dining Facility**									
	REF1, 2, 3	Condenser (x1)			KAIRAK	ZB13KCE	-		-	2008
		Compressor (x3, 1 per walk-in)			-	-	1.75		-	2008
		Evaporator (x3, 1 per walk-in)			-	-	-		3x (1/15)	2008
HUMID	**Banquet Hall**									
	REF4 and 5	Condenser (x1)			KEEPRITE	KFZD110C9-HT3B-X1028	-		-	2011
		Compressor (x2, 1 per walk-in)			Copeland	ZB15KCETF5	2.0		-	2011
		Evaporator (x2, 1 per walk-in)			KEEPRITE	KPL317ME-S2B-TD2NN	-		3x (1/15)	2011
HUMID	**Fast Food Service**									
	REF6	Condenser (standalone)			BOHN	HEATCRAFT BHT015H2BF	-		-	2008
		Compressor			-	-	1.5		-	-
		Evaporator			BOHN	HEATCRAFT ADT104AK	-		2x (1/15)	2006

4.2 FACILITY/SITE CONDITIONS

Pre-deployment site visits at Joint Base Anacostia Bolling (JBAB) and Ft. Bliss were performed on May 12 and 18, 2015 to identify suitable HVAC&R equipment to retrofit with COOLNOMIX.

The goal was to identify up to three (3) air conditioning and three (3) refrigeration sites at each base that are compatible and whose building or facility managers would allow us to monitor the energy and thermal performance for a one-year period. A secondary goal was to introduce the technology to the bases' technicians and electricians in preparation for the installation phase. With assistance from the base Energy Managers and facilities personnel, our team identified several candidate demonstration sites.

Dining facility staff confirmed that the temperature in walk-in refrigeration units must be kept above freezing (32°F) and below 40°F for food safety and to minimize food spoilage. Due to its thermal mass, food temperature may differ slightly from refrigerator air temperature, and is likely to respond more slowly to changes in temperature than the surrounding air. Analog thermometers were located in each of the refrigerators, normally near the door, along with a hand-written log of refrigerator temperatures; however, these readings did not appear to be precise. The evaporators all had a temperature controller on the right side of the unit, and a wired temperature sensor on the rear of the unit.

In air conditioning applications, we noted the temperature setpoints as shown on the thermostat displays. Some buildings and units include centralized control logic (e.g., based on Lonworks protocol) that handle temperature setbacks during periods of reduced occupancy. HVAC&R technicians were not immediately aware of all the specific settings. Since COOLNOMIX is compatible with temperature setbacks, this was not a problem, as long as the setpoint programs remain fixed during each experiment.

4.2.1 Weather

Cooling loads and cooling energy consumption depend strongly on weather. We obtained weather data from airport weather stations within ten miles of the test sites (El Paso International Airport in El Paso, TX and National Airport in Washington, D.C.; archived by Iowa State University, 2017). Relevant data fields include hourly temperature, dew point, relative humidity, wind speed, and precipitation.

Actual daily temperature range (max/min in orange) is shown along with the 30-year historical max/min daily range (light grey). El Paso, TX was hot (more orange above the 65°F reference line) and dry and had large diurnal temperature swings. Washington, D.C. was hot and humid, with smaller diurnal swings. Cumulative monthly precipitation (Figure 4-3) confirms that Washington, D.C. was also much wetter than El Paso, TX and that monthly trends were similar to historic trends.

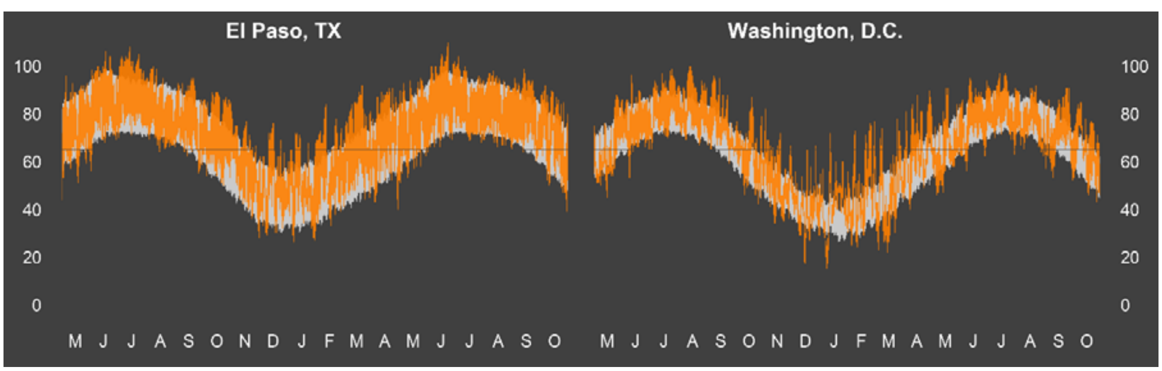

Figure 4-2. Daily Outdoor Temperature Range (ºF).

Actuals for 2016-2017 test period (orange) and 30-year avg. range (grey). Reference line at 65°F.

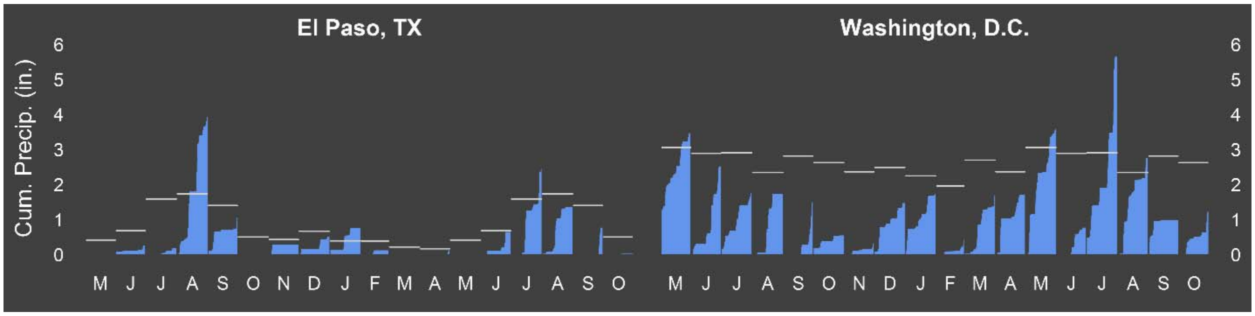

Figure 4-3. Cumulative Monthly Precipitation (in.), Actuals for 2016-2017.

Reference lines indicate 30-year average monthly totals.

4.2.2 Cooling Degree Days

To weather-normalize the submetered energy data, we calculated cooling degree days based on the outdoor dry bulb temperature. Cooling degree days (*CDD*) are a modified average daily temperature designed to represent weather related effects. *CDD* can be calculated in several ways. While basic methods rely on the average (or range) of daily temperatures, we used the more precise hourly method, first calculating cooling degree hours and then averaging those to calculate the daily cooling degree days:

$$CD_{hour} = \max(0, T_{hour} - T_{base})$$

$$CDD = \frac{1}{24} \sum_{hour=1}^{24} CD_{hour}$$

Calculating degree hours also have the advantage of allowing partial day analysis, potentially for excluding periods of the day where the systems may have been undersized. Cooling degree days are defined relative to a baseline temperature (normally 65ºF, CDD_{65}), that indicates the threshold below which cooling is not typically needed.

Compared to the previous 30 years, annual degree days were higher than average at both test sites (+24% for El Paso, TX and +17% for Washington, D.C, Table 4-3). Since the bulk of the valid data collection period pertained to the 2017 cooling season, we calculated the CDD_{65} for Oct. 2016 to Oct. 2017.

Table 4-3. Annual CDD65 during Test Compared with Historic Range.

SITE	Oct. 2016 – Oct. 2017	May 2016 – May 2017	30-YEAR (1985-2014) … MEAN	MAX	MIN	SD
El Paso, TX	3,403	3,205	2,749	3,447	2,117	312
Washington, D.C.	1,905	2,009	1,635	2,204	1,214	204

Monthly degree days were generally in line with 30-year historic monthly averages (Figure 4-4), though several months were the hottest experienced in the last 30 years. As expected, the cooling season in El Paso, TX was longer and more intense than in Washington, D.C.

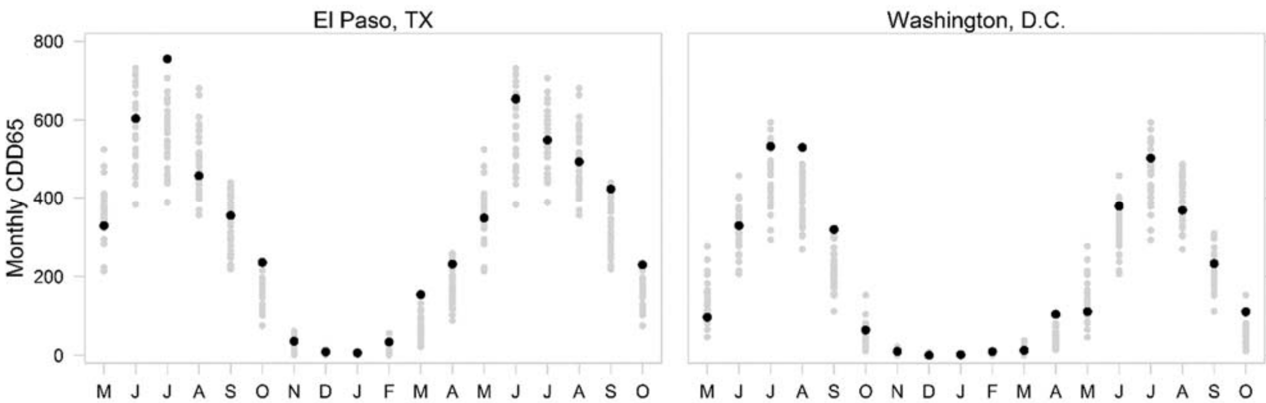

Figure 4-4. Monthly CDD65 (black, May 2016 to Oct. 2017) and 30-year Range (grey, 1985-2014).

For reference, in Hong Kong, where this technology was developed, typical annual degree days are higher still, often exceeding 4,000 CDD_{65}. Differences in annual cooling loads, cooling season duration, and diurnal temperature variation can all affect cooling system performance and the cost effectiveness of cooling efficiency technologies.

4.2.3 Occupancy and Activity

Occupancy can influence cooling loads, both directly (heat and moisture emitted by occupants) and indirectly (e.g., interactions with lights, equipment, ventilation). For refrigeration, activity (opening and closing of doors, loading and unloading food) can impact energy consumption.

While average occupancy profiles varied among test sites, they were consistent between on- and off-testing periods (Figure 4-5).[15] It is therefore unlikely that variation in occupancy had significant influence on the test results. Occupancy terms were used selectively in condenser energy use regressions models when they helped improve the fit.

[15] Using passive infrared sensors that measured occupancy at every minute, we identified periods of activity by first down-sampling to 15 minutes (assuming the space was occupied if the sensor gave a positive reading any time during each fifteen-minute window). Next, we calculated average occupancy profiles (probability of occupancy vs. time of day) separately for weekends and weekdays during experimental and bypass periods. Due to unreliable sensors readings in two walk-in coolers (REF4 and REF5), data from door state sensors are shown instead.

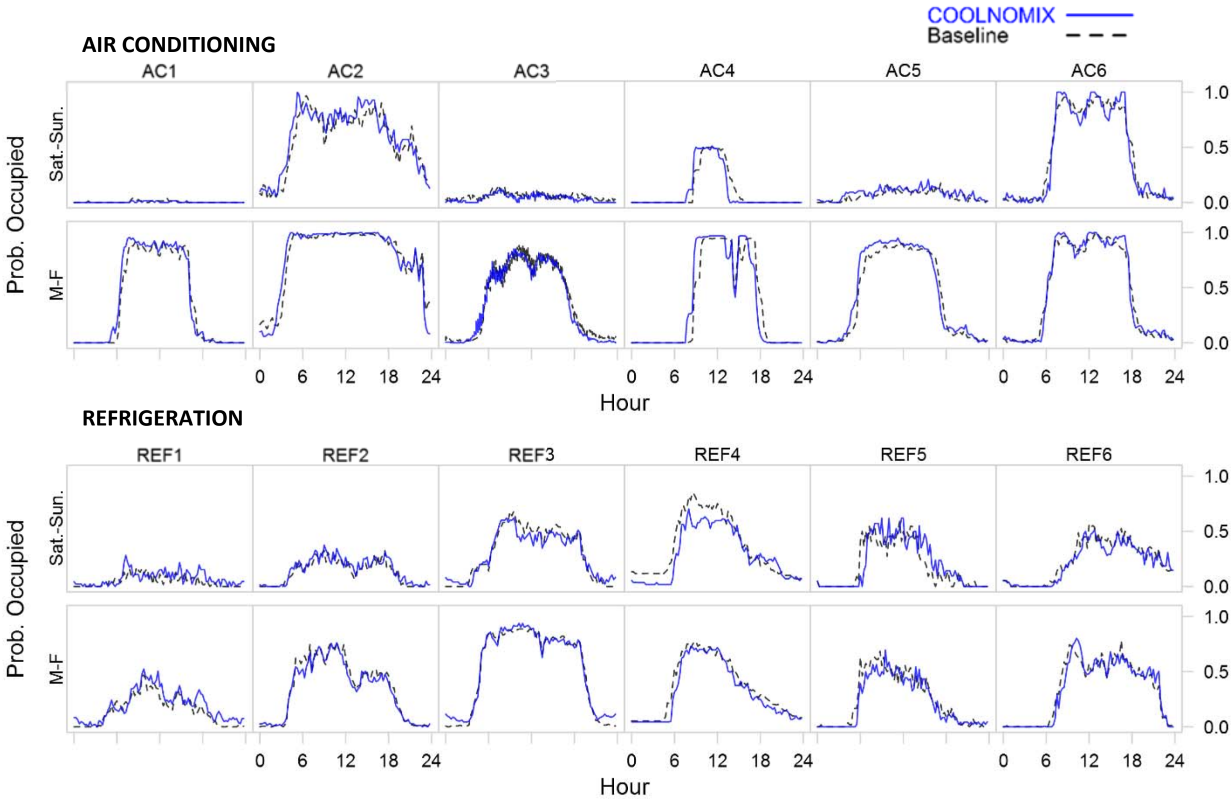

Figure 4-5. Occupancy Profiles by Hour of Day, Day of Week, Site, and COOLNOMIX Status.

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5.0 TEST DESIGN

5.1 CONCEPTUAL TEST DESIGN

The main goal was to evaluate the ability of COOLNOMIX to practically and reliably reduce cooling system energy consumption while maintaining acceptable zone temperature. To this end, we conducted a multi-year field monitoring program in two U.S. climates, representing dry and humid conditions, testing six air conditioning and six refrigeration systems.

An on/off experimental design was implemented, with the COOLNOMIX controller acting as the independent variable. Periodically (approximately monthly), COOLNOMIX was alternately bypassed or enabled using a manual switch to provide a site-specific seasonal baseline. The on/off approach was chosen to reduce the influence of confounding factors, such as changes to equipment performance over time.

The dependent variable, total cooling system energy consumption, was measured using electrical submetering. The cooling system includes all energy-consuming components, such as compressors and compressor fans (collectively the "condenser"), ventilation fans, and evaporator fans. Cooling system and/or component energy use was submetered using split-core current transformers (typ. <1% error at rated current) with data loggers (DENT ElitePro XC) programmed to measure true RMS power based on 12 kHz samples integrated to one-minute resolution.

Additional variables were measured to normalize energy consumption using multiple linear regression models and to ensure zone temperature was kept within acceptable bounds. These additional variables included outdoor, zone, supply, and/or return air temperature and relative humidity; occupancy; activity (door opening); and motor runtime.

Test sites were selected to represent a narrow range of common DoD end-use applications. These included six office sites for air conditioning and six walk-in coolers used for food service. We selected sites with typical and regular usage patterns, so results could be reasonably extrapolated to other similar use cases. To reduce experimental confounds and to limit potential maintenance issues, we focused on cooling systems that served a single zone with a single thermostat. In practice, COOLNOMIX is compatible with multi-zone systems.

To evaluate performance, we calculated site-specific normalized energy consumption to estimate typical full-year cooling energy consumption, comparing results for the baseline and test conditions. Since small changes to thermostat setpoints and zone temperatures can have a large effect on cooling energy consumption, we compared pre- and post- retrofit conditions to ensure consistency and used adjusted cooling degree days in regression models when this helped improve the statistical fit.

5.2 BASELINE CHARACTERIZATION

Due to the on/off testing approach, baseline performance data was collected throughout the experiment during the "off" periods. During the installation visit, COOLNOMIX was installed with an external manual bypass switch that allows enable facilities personnel to readily disable the device at will. When the switch is toggled "off" the cooling system performs nominally. When it is toggled "on" the COOLNOMIX logic is activated.

Electrical submeters were installed to measure cooling system electricity consumption and indoor environmental sensors were installed to monitor zone and equipment conditions. Occupant comfort surveys and interviews were conducted periodically throughout the test during site visits to assess user acceptance.

The baseline initially reflected the as-found condition of the cooling systems. During the demonstration, minor maintenance issues (low refrigerant charge, loose fan belts, clogged air filters, etc.) were identified and subsequently corrected on several systems. In other cases, COOLNOMIX was initially misconfigured or improperly commissioned and required some adjustments. As a result, the testing period was extended, and new baselines were obtained as the experiment progressed for selected units. At sites where multiple baselines were identified, we designated data as "Pre-" and "Post-" tune up periods. Detailed descriptions of the energy and performance baselines are provided in separate sections for each test site.

Manual bypass switching was performed by electricians or Energy Managers, who provided email confirmation with before and after photos of the switch position each time a switch was made. Manual inspection of the power and temperature data was also used to verify COOLNOMIX operational status. In some cases, it was discovered that the system had been inadvertently bypassed, perhaps during routine or diagnostic maintenance.

The baseline was intended to represent the following site-specific characteristics:

1. Reference Conditions: Conditioned zone room or space temperatures, relative humidity, fan runtime, daily occupancy hours, door opening and closing events.

2. Baseline Collection Period: Target at least one month each of on/off data per season.

3. Baseline Estimation: Most energy components were measure directly and were not estimated. When it was not practical to measure ventilation or evaporator fan energy, we estimated the fan energy consumption based on known or typical duty cycles and power draw values. Detailed methods for all estimates are described in the relevant sections.

4. Data Collection Equipment: Standalone data loggers (Table 5-1).

Table 5-1. Data Collection Equipment Summary.

Measurement	Make	Model	Notes
Power	DENT	ElitePro XC	Resolution 1 min. Typ. error <1% of rated CT current.
Temperature & Relative Humidity	Onset	UX100-003M UX100-014M UX100-023	Resolution 1 min. (some 2-5 min.)
Occupancy & Light	Onset	UX90-006M	Resolution 1 min.
Fan Motor Status	Onset	UX90-004M	Resolution 1 min. Used to estimate fan duty cycle in select applications
Door Status	Onset	UX90-001M	Resolution 1 min. Unreliable, used only as a backup for occupancy sensors.
Local Weather	-	-	Hourly temperature and humidity. Archive of METAR weather data from nearby airports (Iowa State 2017).

For each test site, multiple linear regression models were developed to normalize cooling system energy consumption by daily cooling degree days (average daily outdoor temperature for refrigeration) and occupancy. Various combinations of variables, including COOLNOMIX terms, were tried and tested for statistical significance to select appropriate models. We sought models with terms significant at the 0.05 level that best described the data. Models were then applied to actual 2018 weather data to estimate annual pre- and post-retrofit energy consumption. When COOLNOMIX terms were statistically significant, we compared values to estimate energy and cost savings.

5.3 DESIGN AND LAYOUT OF TECHNOLOGY COMPONENTS

The COOLNOMIX technology is described in Section 2: Technology Overview. Full details of its design, workings, and photographs are available in the product manual and patent (Moore 2017). This section provides some additional context about the technology layout and relation to other cooling system components.

5.3.1 COOLNOMIX Hardware Components

COOLNOMIX is an ETL listed hardware compressor controller that works together with the existing thermostat to optimize compressor cycling. Its main components (Figure 5-1) include:

1. A solid-state relay used interrupt the thermostat's compressor control signal
2. Two precision wired sensors that measure return and supply air temperature
3. Terminals for power and control wiring
4. A heat pump selector switch
5. A pinout for a handheld diagnostic reader
6. An audible alarm selector switch
7. Status LEDs

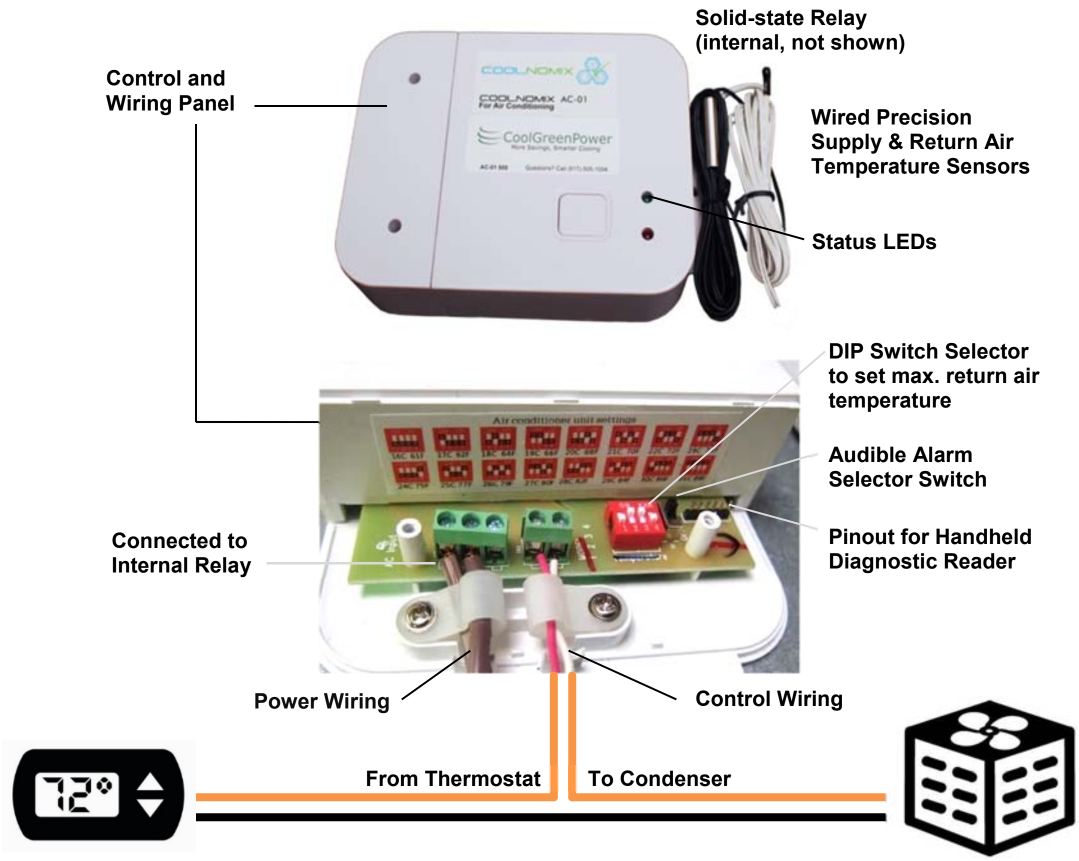

Figure 5-1. COOLNOMIX Unit Schematic.

The first sensor measures room or space temperature more precisely than a conventional thermostat using precision thermistors and is used to maintain zone temperatures within ±0.5°C (±0.9ºF) of the designated set point. This is designed to improve space temperature stability and prevent systems from running when the thermostat erroneously calls for cooling.

The second sensor is connected to the evaporator coil or supply air vent and is used, along with a controls algorithm, to detect the optimal time during the cycle to stop running the compressor.

5.3.2 Technical Design and Layout

Direct expansion (DX) cooling systems include an outdoor condensing unit and an evaporator. The condensing unit uses one or more compressors (1) to generate a supply of liquid refrigerant and an outdoor condenser fan (2) to reject heat to the outdoors. Refrigerant cools as it expands (3) and flows into the indoor evaporator unit's heat exchanger (4). A blower fan (5) moves return air across the evaporator and into the zone to provide cooling.

COOLNOMIX controls the compressor circuit on DX air conditioning and refrigeration systems by temporarily interrupting the thermostat's control signal[16] (Figure 5-2). For most single-zone cooling systems, the compressor circuit includes both the compressor(s) and the condenser fan(s), collectively the "condenser." COOLNOMIX uses two temperature sensors, one that measures the return air temperature from the zone to maintain appropriate temperature setpoints and a second that measures the evaporator temperature (or the supply air temperature as a proxy) to identify when to shut off the compressor.

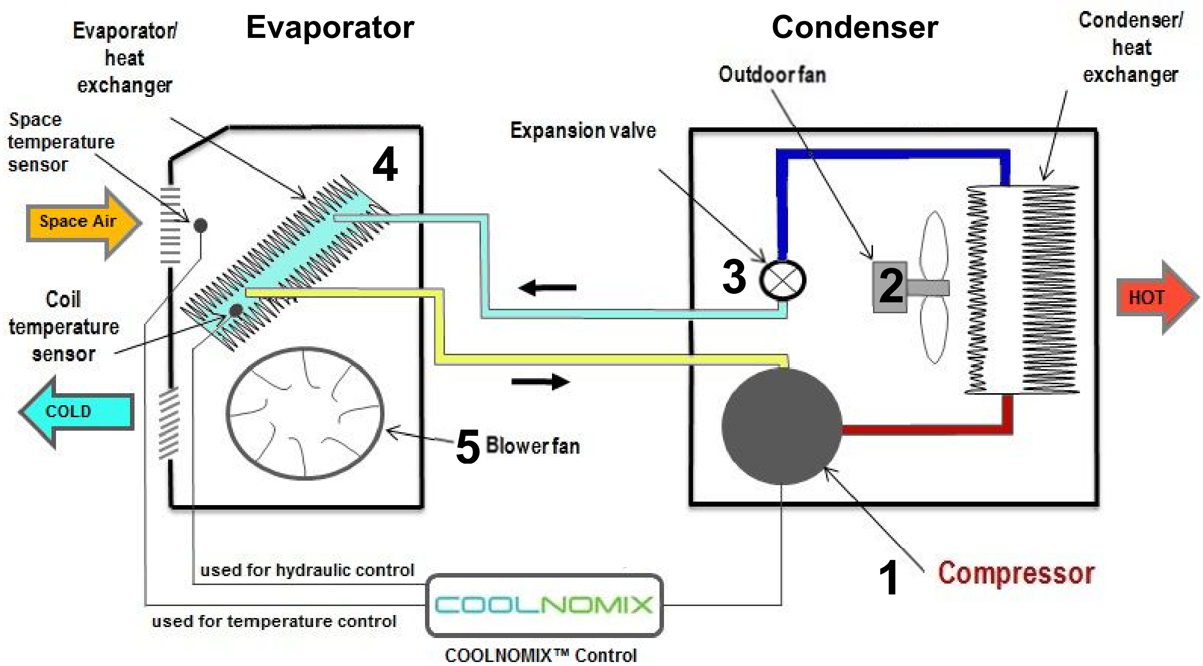

Figure 5-2. Schematic Diagram for a Split-system Air Conditioner or Refrigerator.

The COOLNOMIX relay can be installed at any of three places between the thermostat and the contactor: (1) between the thermostat and air handler, (2) between the air handler and control board, or (3) between the control board and the contactor.[17] With any of these wiring configurations, the thermostat will continue calling for cooling while the compressor is held off, and the evaporator or ventilation fans will continue to run until the thermostat is satisfied. This delivers residual cooling into the conditioned space.

An example wiring diagram is shown for a split-system air conditioner with a separate condensing unit and air handler (Figure 5-3). In that diagram, the Y terminal of the thermostat, which controls the compressor, would normally connect directly to the Y terminal of the air handler; however, in this case, the wire has been cut and the new ends connected to the COOLNOMIX relay control terminals.

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[16] Thermostats rarely control compressors directly; instead, the compressor control wire may first connect to an air handler and then to a condensing unit control board. The control board then operates a contactor, an electrical switch capable of handling high currents, to switch the compressor and/or condenser fan circuit on or off.

[17] Note that installing COOLNOMIX between the control board and the contactor may constitute a hardware modification that could void the condenser manufacturer's warranty.

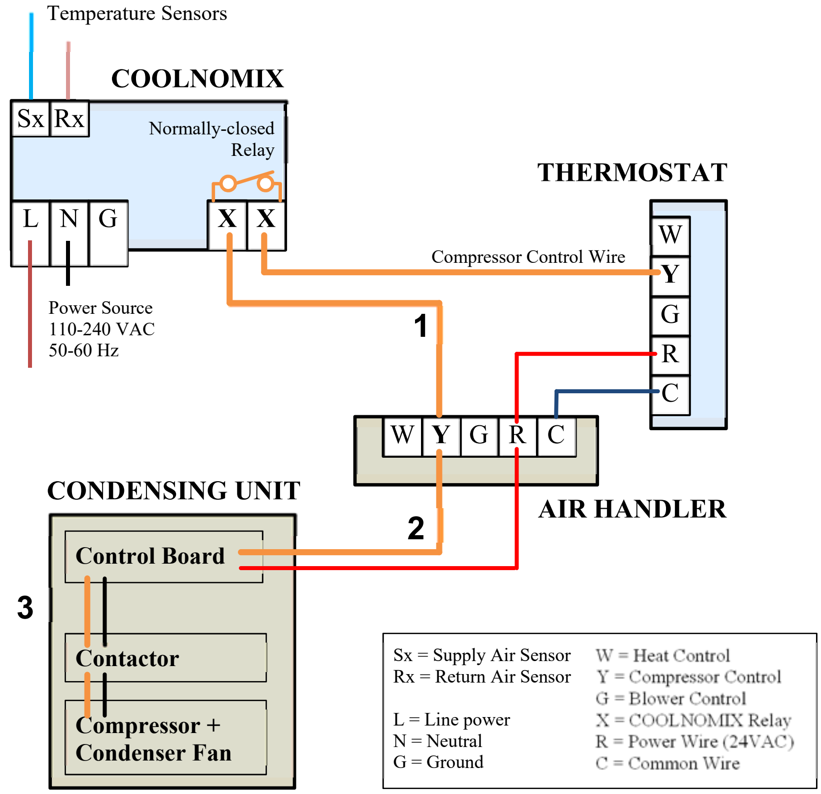

Figure 5-3. Schematic Wiring Diagram for a Split-system Air Conditioner Application.

Other wiring scenarios are somewhat more complex. Systems with multi-stage compressors, for instance, may require an additional relay to allow COOLNOMIX to control both compressors together. Furthermore, certain manufacturers include current detection circuits that produce error codes that shut down the system when the COOLNOMIX relay interrupts the control signal between the controller board and the contactor. For these systems, installing a 24 VAC relay coil can prevent these errors. A wiring diagram addressing both situations is shown for a two-stage compressor (Figure 5-4). In that case, COOLNOMIX is wired to shut off both compressors simultaneously by installing a double pole, single throw, normally open (SPDT-NO) relay. Additional wiring scenarios, along with optional bypass switch circuit diagrams, are provided in the manufacturer's installation manuals.

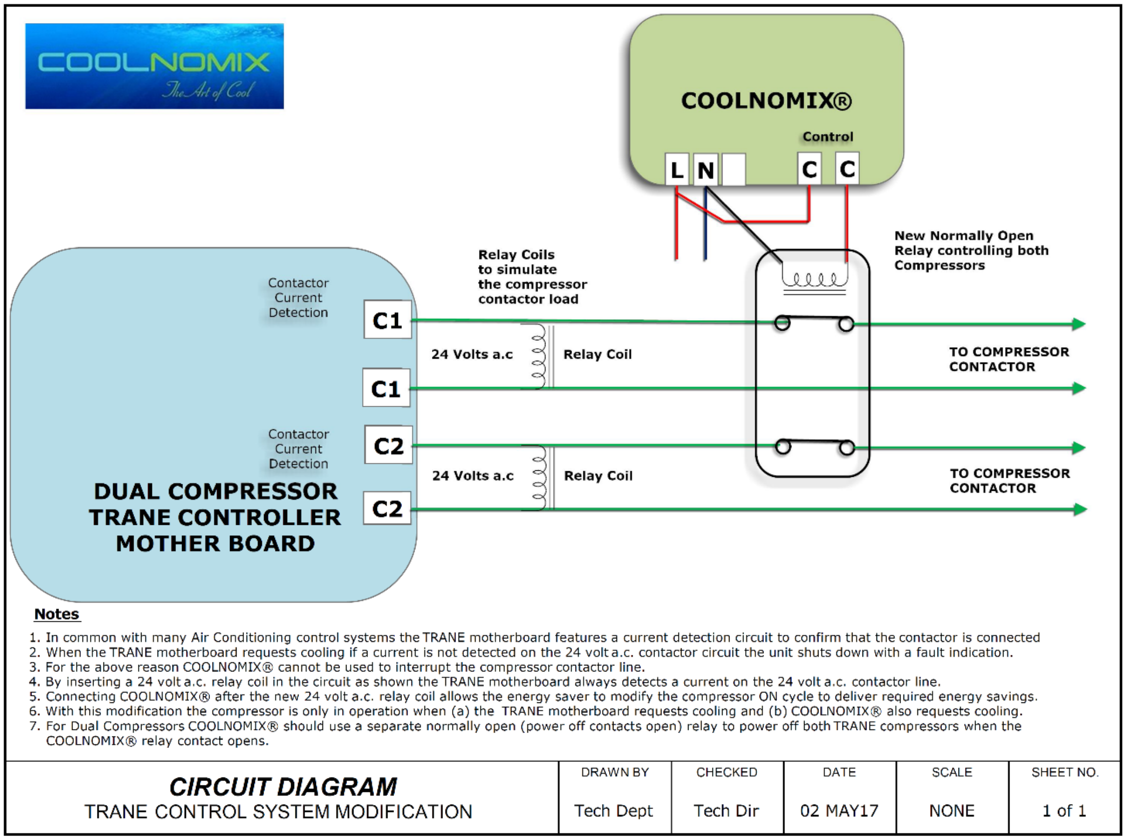

Figure 5-4. Wiring Diagram for Dual Compressor Unit with Current Detection Circuit.

An alternate control wiring method, intended for inverter-driven variable-refrigerant volume or variable refrigerant flow (VRF/VRV) systems and not evaluated in this demonstration, modifies the temperature sensing circuit. In this scenario, instead of overriding the compressor control signal directly, the COOLNOMIX relay switches a resistor into the sensing circuit that causes the thermostat to read a false (low) temperature and stop cooling. In contrast with the direct control method, if the fan controls are set to AUTO, the fans will not continue to run when COOLNOMIX engages.

COOLNOMIX is powered by hard-wiring a 110-240 VAC source (live and neutral connections required, ground optional), such as power terminals commonly available on the condenser or air handler control panel. Systems that operate at higher voltages (e.g., 408/277 V) require a step-down transformer (not included) or a separate power source. When installing COOLNOMIX indoors near the thermostat, power can be supplied by tapping into a standard 110 VAC circuit.

5.3.3 Control Strategy

COOLNOMIX uses a built-in normally-closed relay to control the compressor. The only direct control action COOLNOMIX can perform is to open the relay to override the thermostat's compressor control signal. When the COOLNOMIX relay is energized, the condenser shuts off (or holds off) the compressor. When the relay is closed (including when COOLNOMIX loses power), the system operates normally.

To configure COOLNOMIX, the user must set the desired minimum return air temperature setpoint using a DIP switch selector. Real-time control logic then compares the measured return air temperature with this setpoint to ensure that the zone temperature remains within acceptable limits. When the temperature approaches or exceeds this limit, the relay closes, and the compressor is allowed to operate normally without interference.

While the return air temperature is below the COOLNOMIX setpoint, COOLNOMIX measures and tracks the supply air temperature during compressor cycles. When the supply air temperature approaches a minimum value, the relay engages (opens) to stop the compressor. The evaporator or ventilation fans continue to run, delivering residual cooling into the conditioned zone, as long as the thermostat calls for cooling. The relay disengages (closes) when the return or supply air temperatures become too high, and the system resumes ordinary operation.

For refrigeration systems, evaporator frosting can reduce system efficiency by restricting air flow over the heat exchanger surface. Typically, cooling equipment will periodically activate a heating cycle or off cycle to melt any frost accumulation, potentially using additional energy. COOLNOMIX is designed to prevent icing of the evaporator coil by reducing excess compressor run-time, and by implementing a compressor restart delay timer and an evaporator coil temperature restart threshold (>1ºC, 1.8ºF).

To prevent short cycling, many thermostats and condenser controls include on/off-cycle delays of several minutes to prevent damage or excessive wear on the compressor. If COOLNOMIX is installed anywhere between the thermostat and the control board, the control board's built-in short-cycle prevention features are likely to remain intact. However, if COOLNOMIX is installed between the control board and the contactor, these safeguards may be circumvented. To prevent short-cycling in this scenario, COOLNOMIX will wait for at least three minutes after a cooling cycle begins before engaging the relay.

Additional details about the control logic are provided in the patent (Moore 2017). Further refinements to the control logic are under development and have been released through updated firmware releases.

5.4 OPERATIONAL TESTING

Operational testing included several phases: installation, initial testing (pre tune-up), maintenance and recommissioning, final testing (post tune-up), and decommissioning (Figure 5-5).

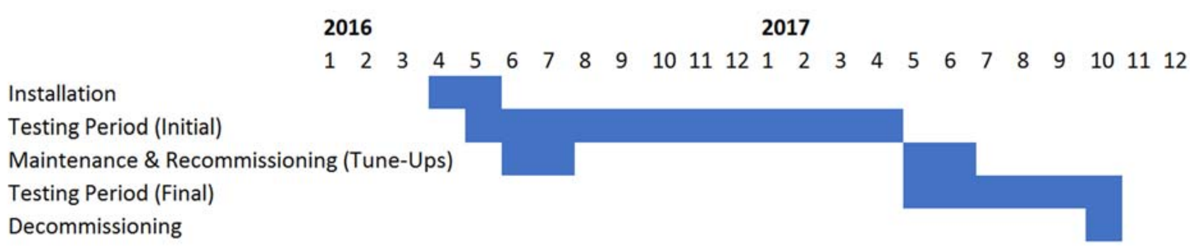

Figure 5-5. Testing Program Gantt Chart.

Installation was performed in Spring 2016. At each host site, we completed six installations (three refrigeration and three air conditioning) over three days. This began with a one-hour overview training session with the HVAC&R maintenance technicians, electricians, installers, and energy managers. After the basic training, we supervised the on-site installations.

Initial testing followed, with COOLNOMIX initially enabled at all test sites. Electricians or energy managers were instructed to switch the units into bypass periodically (ideally monthly, but at least one switch per season) and to administer paper occupant comfort surveys. Details about the actual switching timelines are provided in the site-specific performance assessment sections. At subsequent site visits approximately every 3-6 months, we downloaded data, re-deployed the data loggers, and addressed any technical issues.

Maintenance and recommissioning efforts were undertaken when it was discovered that COOLNOMIX was not engaging as frequently as expected at certain test sites. These issues were resolved, and testing was extended to span an additional cooling season to reflect the post tune-up condition. Site-specific details are provided in the appropriate performance evaluation sections.

Final post tune-up testing was completed in Fall 2018. At the conclusion of the experiment, the team decommissioned and removed all sensor equipment and transferred ownership of COOLNOMIX hardware to the host installations.

5.5 SAMPLING PROTOCOL

Data loggers were deployed to measure the parameters described in Table 5-1. Generally, all energy data were based on 1-minute averages of 12 kHz power measurements. All other environmental parameters were measured or integrated to the nearest minute. Some supplemental (duplicate) loggers with lower memory capacity were programmed to measure at two to five-minute intervals; however, these were used for qualitative comparisons and were not used in the regression analyses. Weather data from the nearest airport weather stations were hourly.

Sensors used for this study came factory-calibrated, and no additional calibration was required.

Environmental data loggers (temperature, relative humidity, door, and occupancy) were placed in consistent locations at each test site.

Temperature and relative humidity loggers measured zone, supply, and return air temperature at all sites. For air conditioning tests, zone temperature was measured on the wall just above the wall-mounted thermostat. Occasionally, for larger zones, a supplemental zone temperature logger was added in a second interior location to indicate spatial variation. The supply and return air temperature sensors were typically positioned either in the air handler, or in a supply/return duct. For refrigeration systems, the zone temperature was measured near the door, where temperature tends to be highest. Supply air sensors were mounted to the evaporator fan outlet and return air sensors were mounted to the evaporator intake. When possible, supply and return air temperatures were measured as close as possible to the COOLNOMIX sensors.

Occupancy sensors were placed above the thermostat (for air conditioning) and above the door facing the evaporator (refrigeration). Door state loggers were installed on refrigerator doors and on some exterior doors, but these proved unreliable due to frequently being knocked out of alignment.

Motor loggers were used to monitor ventilation and/or evaporator fan motor runtime when possible.

Quality assurance checks on the data were completed using a combination of automated and manual techniques and used to filter out bad or questionable data. Examples include identifying outliers, unrealistic measurements, and identifying data gaps (and especially power outages). Unreliable data were flagged and engineering judgment was used to determine which days had insufficient data quality to be included in the regressions. Generally, we required that at least 1420 min (out of 1440 min.) of daily power data be available to be included.

Manual analytical techniques were used to identify extraneous maintenance issues or abnormal activity that could influence energy patterns. One example is fan power, which decreases as the air filter becomes clogged and air flow is reduced. By calculating the minimum daily fan power and showing its trends over time, it was possible to identify confounding periods where the filter was clogged. A second example is a cooler that exhibited increasingly erratic power draw, potentially linked to a maintenance issue. A third example is an extended period where a number of coolers were not in use. Such abnormal periods were manually excluded from the analysis.

A basic occupant survey (See Appendix B) was developed to assess comfort perceptions. These surveys were administered periodically, typically when switching COOLNOMIX on or off. Due to the limited number of occupants at the test sites, the high occupant turnover, and irregularity of the survey periods, their results are especially qualitative, and were primarily valuable for identifying technical issues before the data analyses could be completed. As we measured zone conditions directly, comfort issues are best captured through the measured zone data.

5.6 SAMPLING RESULTS

Summary performance data are included in the site-specific performance assessment sections and filtered daily data summaries are given in Appendix D.

6.0 PERFORMANCE ASSESSMENT

6.1 AIR CONDITIONING SITE 1: DRY CLIMATE

6.1.1 Site, Equipment, and Controls

COOLNOMIX was installed inside the packaged RTU serving a single-zone basement office (approximately 2,000 ft^2, Figure 6-1). This windowless zone had an open-plan layout with a moderate density of computers and monitors, a small sever closet, and several small isolated offices. A back room had an exterior door; however, this was infrequently used and did not directly influence the conditioned zone.

Figure 6-1. COOLNOMIX Air Conditioning Installation.

The 6-ton packaged RTU (TRANE model THC072F4RKA07) included a single-speed 1.0 HP ventilation fan, a 0.7 HP condenser fan, and a compressor. The unit was relatively new (manufactured in 2015) and in good condition. Fan filters were routinely replaced and refrigerant charge was checked and found correct during the second-year test. We submetered the RTU power draw on a circuit that included the ventilation fan, compressor, and condenser fan.

A single non-programmable digital thermostat, centrally located in the zone, controlled the space temperature. The ventilation fan was set to AUTO (runs only when the thermostat calls for cooling). An economizer was set to run when the thermostat calls for cooling and the outdoor dry bulb temperature is below 55°F.

Initially, the COOLNOMIX return air temperature sensors were installed inside the RTU, where solar heat gains inflated the sensor readings during the day. This prevented COOLNOMIX from operating during most daytime periods. After discovering this issue, we extended the sensor wires through the ductwork into the conditioned zone, which allowed COOLNOMIX to operate throughout the day. As a result, we divide the analysis into pre- and post tune-up periods.

FINDING: The COOLNOMIX return air sensor MUST be positioned close to the conditioned zone and away from other sources of heat.

6.1.2 Occupancy

Occupancy followed a typical M-F schedule from about 7AM to 6PM and was consistent across all test periods (Figure 6-2 and Figure 6-3). Average occupancy, as measured, was 3.0 h/d (SD 1.4) on weekdays and 0.0 h/d (SD 0.05) on weekends. These values, however, are artificially low and more closely represent activity than occupancy. This is because occupants often remained stationary or out of view and failed to trigger the sensor. Assuming the space is actually occupied when motion is detected at least once during each fifteen-minute window yields more realistic estimates of 8.8 h/d (SD 1.9) for weekdays and 0.1 h/d (SD 0.4) for weekends.

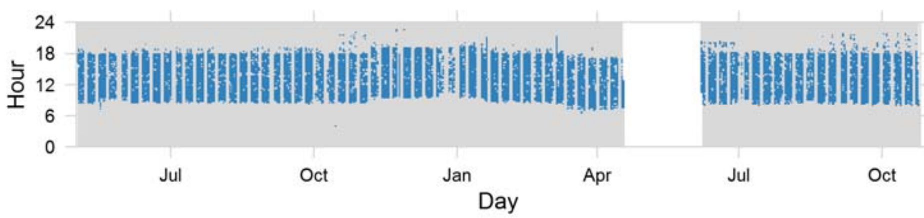

Figure 6-2. Occupancy by Day and Hour.

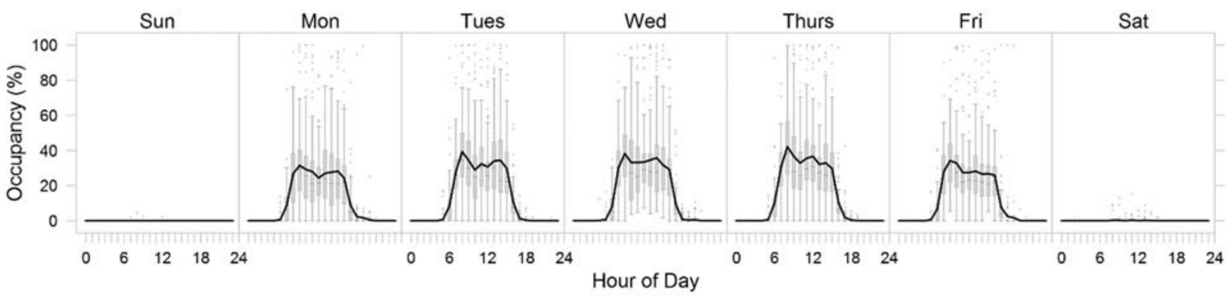

Figure 6-3. Occupancy Profiles by Day of Week.

6.1.3 Thermal Comfort

With COOLNOMIX enabled, shorter and more frequent compressor cycles reduced the zone temperature deadband while only slightly increasing the average zone temperature (Figure 6-4, Figure 6-5, and Figure 6-6). Relative humidity, however, did increase when COOLNOMIX was enabled. Specifically, the portion of occupied hours (on days with CDD_{65}>10) with RH above 60% increased from less than 2% in the baseline to 11% with COOLNOMIX. The increase could be due to two factors. First, frequent cycling could reduce dehumidification performance, a finding consistent with prior work that found dehumidification performance degrades under part-load conditions.[18] Second, longer ventilation fan runtime with COOLNOMIX brought in more outdoor air, especially at night. Unchecked, these higher humidity levels could lead to thermal discomfort.

[18] Prior work has shown the greatest dehumidification degradation occurs when the ventilation fan continues running after the compressor shuts off, re-evaporating coil moisture into the supply air stream (Shirey and Henderson 2004, Shirey et al. 2006), similar to the behavior induced by COOLNOMIX.

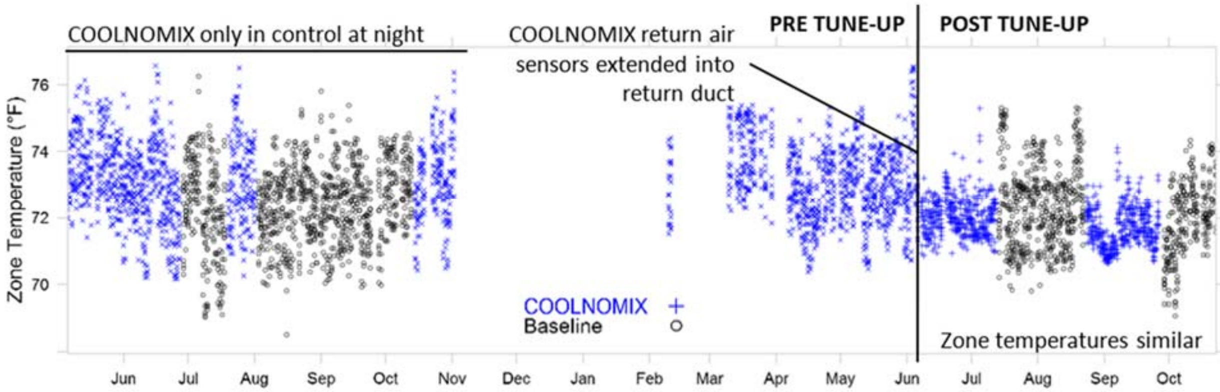

Figure 6-4. Average Hourly Zone Temperature during Occupied Hours.

Based on days with CDD_{65}>0.

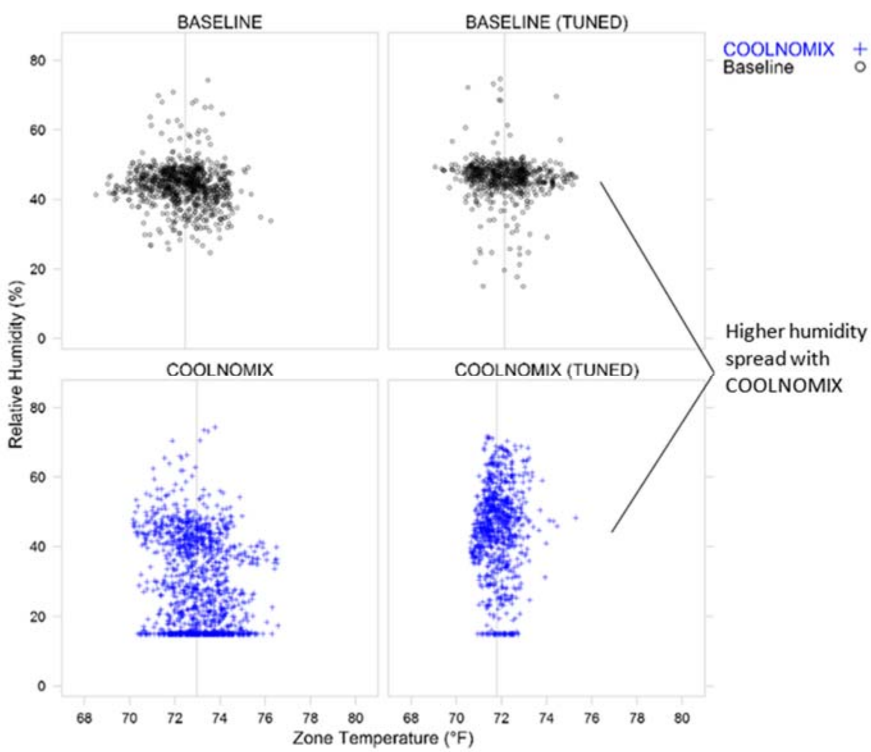

Figure 6-5. Relative Humidity vs. Zone Temperature, Hourly Averages During Occupied Hours.

Based on days with CDD_{65}>10. Vertical lines represent medians.

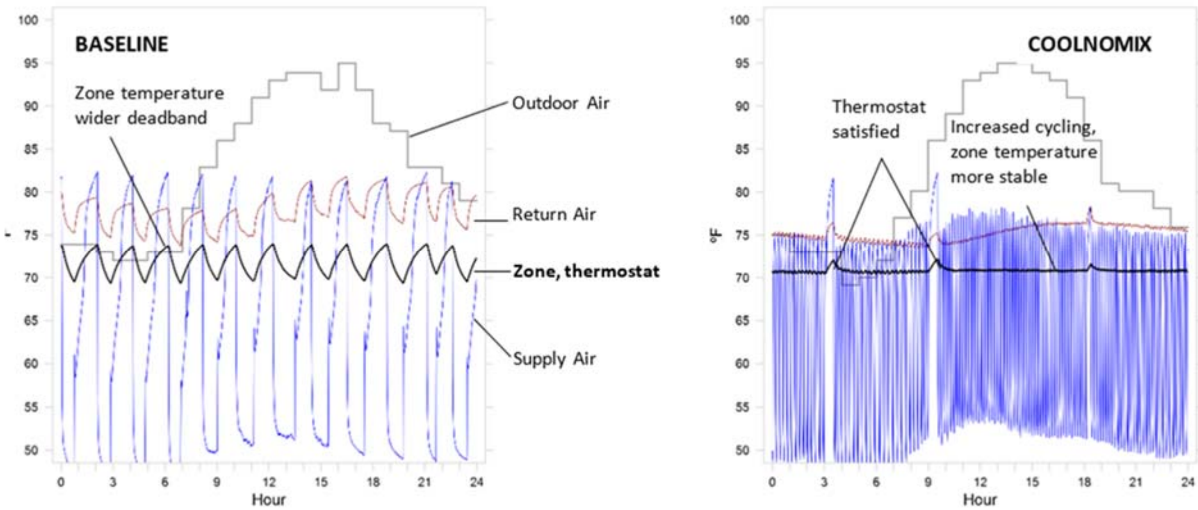

Figure 6-6. Temperature for Two Sample Hot Days, by COOLNOMIX Status.

Despite observing somewhat higher humidity levels, the surveys showed no significant comfort issues with COOLNOMIX. Throughout the test, occupants indicated the air was too humid in the mornings, especially after rain, consistent with the explanation that extra night ventilation with COOLNOMIX can lead to more AM humidity. Occupants did apparently notice the long cycle times and large deadband of the baseline system (Table 6-1). The number of responses varied depending on how many occupants were present during the site survey visits, so these results are highly qualitative.

Table 6-1. Comfort Survey Results (Number of Responses).

Question	Never	Rarely	Sometimes	Often	Always	Status
Too Hot?	6	9	8	-	-	Baseline
	2	**5**	**6**	**-**	**-**	**COOLNOMIX**
Comfortable?	-	-	4	15	5	Baseline
	-	**-**	**4**	**8**	**2**	**COOLNOMIX**
Too Cold?	13	5	6	-	-	Baseline
	7	**4**	**2**	**-**	**-**	**COOLNOMIX**
Too Humid?	3	3	4	-	-	Baseline
	1	**2**	**2**	**-**	**-**	**COOLNOMIX**
Too Hot in AM?	8	7	9	-	-	Baseline
	4	**5**	**4**	**-**	**1**	**COOLNOMIX**
Too Hot in PM?	7	7	8	-	-	Baseline
	3	**5**	**6**	**1**	**-**	**COOLNOMIX**

Occupant Notes:

[Baseline]	7/13/2016	Unit takes too long to turn on
[Baseline]	8/31/2016	AC system takes too long to start, 2-4°F
[Baseline]	11/10/2016	Too humid after it rains, usually in AM AC doesn't turn on until later in day
[Baseline]	8/23/2017	AC unit over cools or under cools
[COOLNOMIX]	4/17/2017	Unit was reset
[COOLNOMIX]	6/7/2017	Humidity up in AM
[COOLNOMIX]	6/7/2017	AC takes too long to cycle off or on

Occupants verbally indicated that some employees prefer the temperature a few degrees warmer than the others, but were unwilling to indicate this on the anonymous surveys.

Author's Notes:
COOLNOMIX return sensors were extended into the zone after 6/7/2017. Comfort survey results reflect COOLNOMIX for both pre- and post- sensor extension. No notes were provided after the sensors were extended.

Most survey data corresponds to times when COOLNOMIX was enabled but before the sensors were extended (overnight and AM operation only).

The number of responses varied significantly by period depending on who was available in the building during each site visit.

6.1.4 Ventilation Fan Runtime

Ventilation fans were set to AUTO, running only when the thermostat calls for cooling. By design, COOLNOMIX causes the evaporator fan to run longer. In most packaged RTUs we tested, including this one, a single fan was used for the evaporator and supply air. Increasing fan runtime, therefore, could unintentionally increase ventilation and cooling loads in the space, leading to higher cooling system energy consumption. This finding was consistent across most test sites.

Ventilation fan runtime approximately doubled,[19] with the duty cycle increasing from about 20-40% in the baseline to about 60-100% with COOLNOMIX (Figure 6-7, Figure 6-8, and Figure 6-9). Pre tune-up, fan runtime increased mainly at night, when COOLNOMIX was active.

[19] Post tune-up median fan duty cycle approximately doubled with COOLNOMIX (87% vs. 41%, based on CDD_{65}>10 to exclude heating days and days with economizer activity).

Post tune-up, after extending its return air sensors into the conditioned zone, COOLNOMIX engaged far more frequently and the fans would often run continuously much of the day and night.

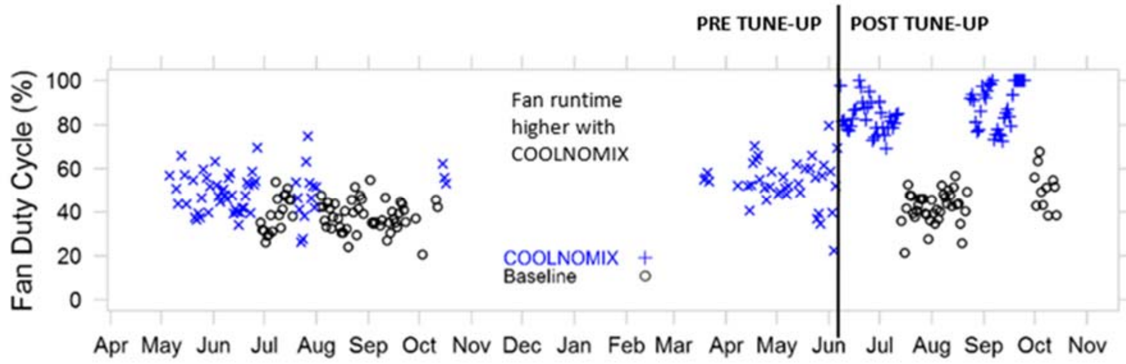

Figure 6-7. Ventilation Fan Duty Cycle by Day.

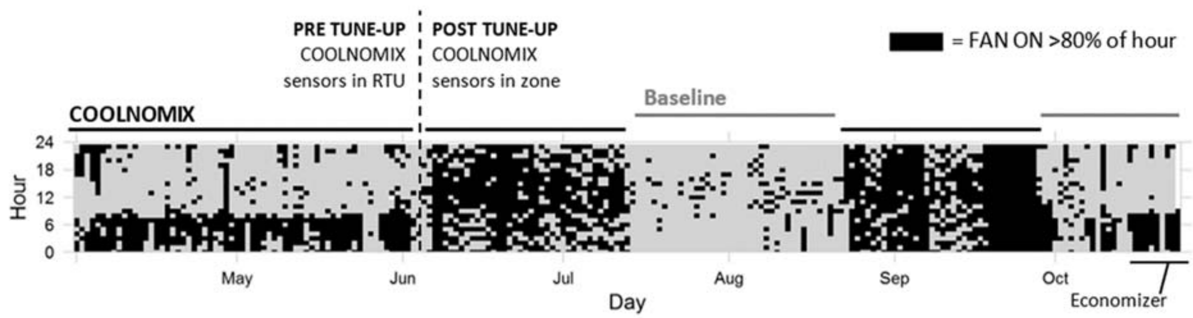

Figure 6-8. Fan Status by Hour and Day.

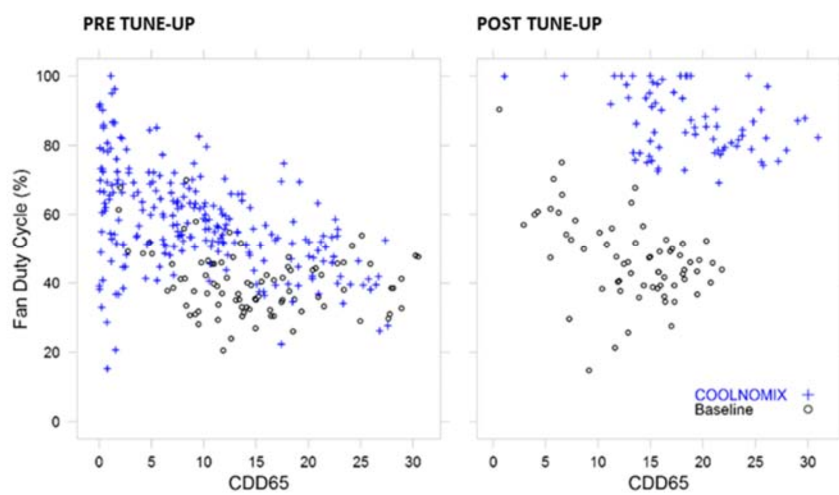

Figure 6-9. Daily Fan Duty Cycle vs. Cooling Degree Days and COOLNOMIX Status.

Increased ventilation adds to the daytime cooling load in proportion to the difference in enthalpy between the outdoor air and zone conditions during occupied hours. Assuming an outdoor air supply rate of 400 CFM (0.2 CFM/ft^2 and 2,000 ft^2 conditioned floor area) when the fans are on[20] and a doubling in daytime fan duty cycle from 40% to 80%, the average extra supply intake is at least 160 CFM. Taking the average enthalpy difference between indoor and outdoor air during the day on cooling days yields an increased ventilation load of at least 2,700 Btu/h (and potentially more depending on the actual ventilation damper position[21]) for about 12 hours per day. At SEER 15, this amounts to at least 350 kWh per year in additional energy needed to compensate for the extra ventilation. Nighttime effects are less clear, since on some nights the added ventilation could pre-cool the space (potentially reducing loads), while on others it could increase humidity or add heat (potentially increasing loads).

FINDING: Installing COOLNOMIX on systems with fan controls set to AUTO (where the fan runs only during calls for cooling) can increase the outdoor air supply, leading to higher cooling loads.

FINDING: Installing COOLNOMIX can significantly increase fan runtime and fan energy use. Increased fan energy could also increase cooling loads somewhat.

6.1.5 Compressor Runtime

Before the tune-up, COOLNOMIX engaged mainly at night, and showed a noticeable increase in the number of daily cycles and a reduction in cycle duration (Table 6-2 and Figure 6-10). Post tune-up, COOLNOMIX engaged day and night, and the median number of daily compressor cycles increased about 10-fold (from about 12 to 120 cycles per day). This could result in faster wear on the contactor that controls the compressor. Contactor replacement is a low-cost repair, typically less than $50 for the part, plus labor.

Table 6-2. Compressor Cycle Duration.

Minutes Median (Mean)	PRE TUNE-UP	POST TUNE-UP
Baseline	40 (42.9)	44 (44.3)
COOLNOMIX	17 (24.0)	6 (6.1)

Note: Cycle times in this table are qualitative, differences in weather could bias summaries. Based on days with CDD_{65}>10.

[20] This RTU had a minimum design flow rate of 320 (max. 480) CFM per ton, or 1,920-2,880 CFM. The actual ventilation fraction depends on the damper position. Our assumption of 400 CFM represents a 20% outdoor air fraction.

[21] Economizers are notorious for being poorly maintained and misconfigured. Dampers, for instance, can become stuck in the open position. If that happens, any extra supply fan runtime could increase the ventilation-driven cooling loads by a factor of 5 (or more) than our estimate.

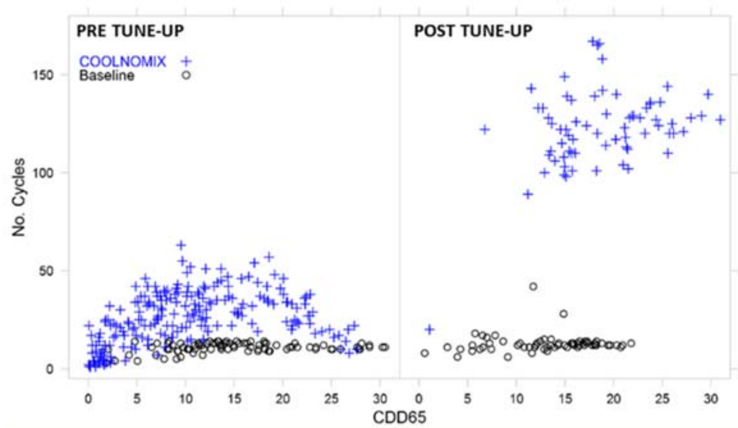

Figure 6-10. Compressor Cycles per Day vs. Cooling Degree Days.

6.1.6 Energy Performance

RTU power draw for three typical hot days shows how COOLNOMIX sensor position influences operation (Figure 6-11). With the return air sensor in the RTU, solar heat gains prevented COOLNOMIX from engaging during the daytime. Extending the wires into the zone resolved the issue.

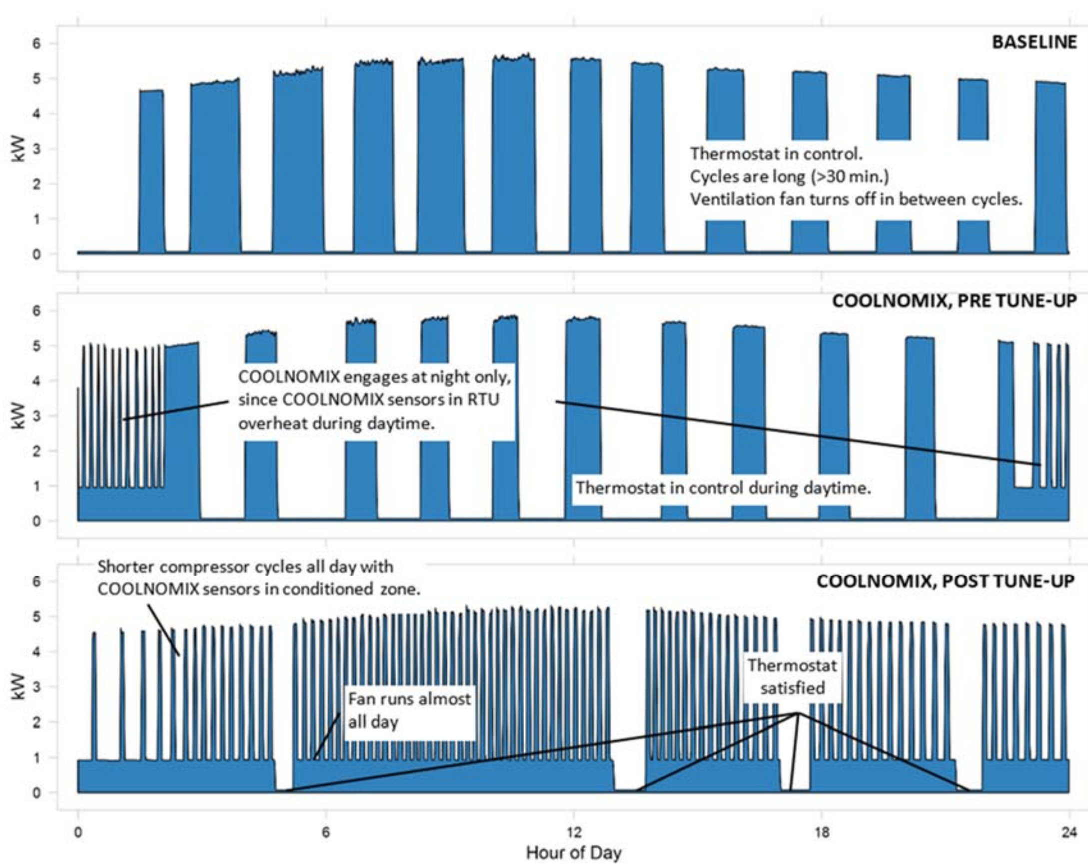

Figure 6-11. RTU Power Draw vs. Time of Day, by COOLNOMIX Status for Three Sample Days.

Condenser and ventilation fan energy were analyzed separately for the pre- and post-tune-up periods. With COOLNOMIX, the compressor used about the same amount of energy, while the fans used more energy than baseline (Figure 6-12 and Figure 6-13).

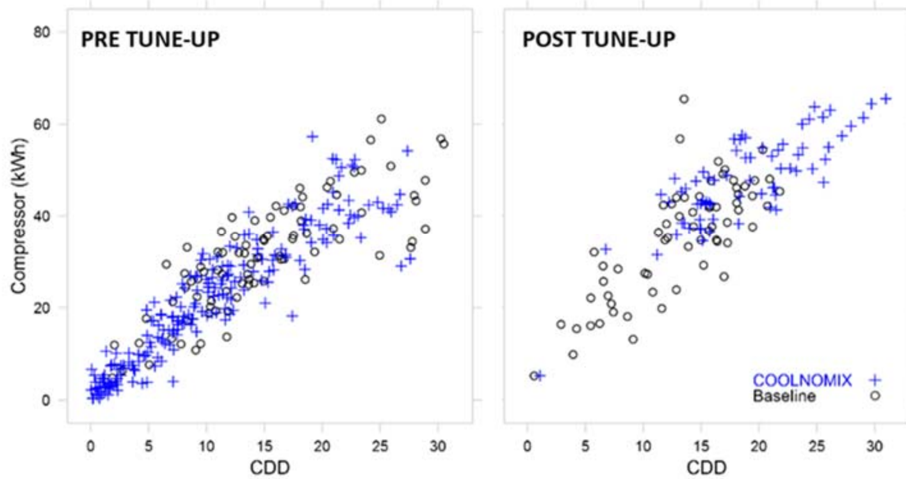

Figure 6-12. Condenser Energy Use vs. Cooling Degree Days by COOLNOMIX Status.

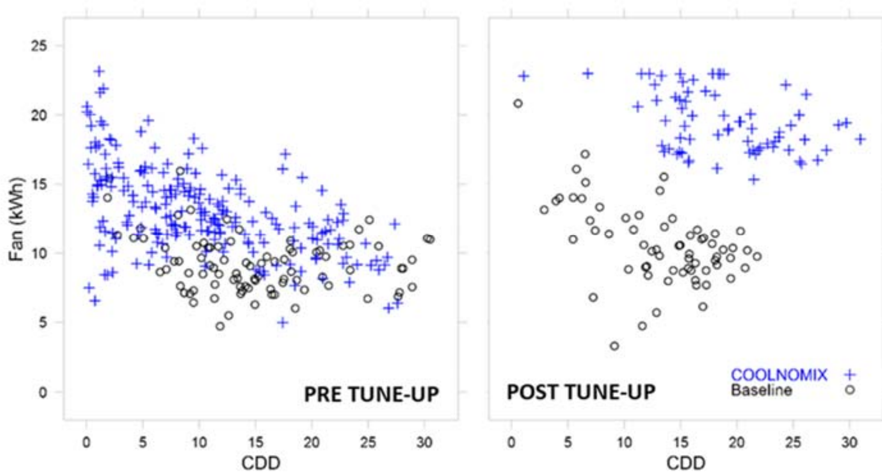

Figure 6-13. Ventilation Fan Energy Use vs. Cooling Degree Days by COOLNOMIX Status.

Multiple linear regressions were calculated to predict condenser energy use ($E_{condenser}$, kWh) based on cooling degree days (CDD_{65}), adjusted[22] cooling degree days (CDD_{adj}), occupancy (*OCC*, hours), and COOLNOMIX status. Separate combinations of these variables and interaction terms with COOLNOMIX status were tried to identify model parameters significant at the 0.05 level.

[22] Adjusted cooling degree days account for differences in actual daily average zone temperatures: $CDD_{adj} = CDD_{65} - (T_{avg} - 72°F)$.

Cooling degree days explained 70-81% of the total variance in the data (Table 6-3). Adjusted cooling degree days, which adjust for the differences in average daily zone temperature, improved the fit for both periods, so we used these for subsequent regressions. Occupancy terms were significant ($p<0.001$) but small relative to degree day effects. Pre tune-up, COOLNOMIX interaction terms were significant for both occupancy (-1.65 kWh/d per occupied hour, $p<0.001$) and adjusted degree days (+0.20 kWh/CDD_{adj}, $p=0.002$); however, their effects were in opposing directions and somewhat cancelled out. Post tune-up, COOLNOMIX interaction terms were not significant.

Table 6-3. Condenser Energy Regression Models: Parameter Estimates and (Standard Errors).

PRE TUNE-UP: COOLNOMIX Working at Night Only

(kWh/d) Term \ MODEL	M1		M2		M3		M4		M5		M6		M7	
Intercept	**4.54**	**(0.66)**	**6.66**	**(0.57)**	**3.82**	**(0.76)**	**6.58**	**(0.57)**	**3.38**	**(0.77)**	**4.19**	**(0.76)**	**4.31**	**(0.74)**
CDD_{65}	**1.70**	**(0.05)**												
CDD_{65}:CNMXon														
CDD_{adj}			**1.67**	**(0.04)**	**1.70**	**(0.04)**	**1.65**	**(0.05)**	**1.69**	**(0.05)**	**1.65**	**(0.04)**	**1.53**	**(0.06)**
CDD_{adj}:CNMXon							0.05	(0.05)	0.01	(0.05)			**0.20**	**(0.06)**
OCC					**0.94**	**(0.19)**			**0.94**	**(0.19)**	**1.66**	**(0.28)**	**2.20**	**(0.33)**
OCC:CNMXon											**-0.93**	**(0.28)**	**-1.65**	**(0.36)**
Adj. R^2	0.81		0.84		0.87		0.84		0.87		0.87		0.88	
AIC	1918		1881		1555		1882		1557		1545		1538	
RMSE	6.05		5.69		5.33		5.68		5.33		5.22		5.12	
CV(RMSE)	0.25		0.23		0.22		0.23		0.22		0.21		0.21	
No. Obs.	297		297		250		297		250		250		250	
kWh Mean (SD)	24.6	(14.1)	24.6	(14.1)	24.4	(14.7)	24.6	14.1	24.4	(14.7)	24.4	(14.7)	24.4	(14.7)

POST TUNE-UP: COOLNOMIX Working Correctly

(kWh/d) Term \ MODEL	M1		M2		M3		M4		M5		M6		M7	
Intercept	**12.96**	**(1.75)**	**12.55**	**(1.56)**	**8.67**	**(1.53)**	**13.03**	**(1.71)**	**8.92**	**(1.67)**	**8.94**	**(1.62)**	**8.96**	**(1.68)**
CDD_{65}														
CDD_{65}:CNMXon	**1.78**	**(0.10)**												
CDD_{adj}			**1.81**	**(0.09)**	**1.83**	**(0.08)**	**1.75**	**(0.13)**	**1.80**	**(0.11)**	**1.81**	**(0.09)**	**1.81**	**(0.12)**
CDD_{adj}:CNMXon							0.05	(0.08)	0.02	(0.07)			0.09	(0.05)
OCC					**1.66**	**(0.28)**			**1.65**	**(0.27)**	**1.55**	**(0.36)**	**1.62**	**(0.45)**
OCC:CNMXon											0.19	(0.38)	0.18	(0.51)
Adj. R^2	0.70		0.75		0.80		0.75		0.80		0.80		0.80	
AIC	908		881		851		883		853		853		855	
RMSE	7.00		6.34		5.62		6.33		5.61		5.61		5.61	
CV(RMSE)	0.17		0.15		0.13		0.15		0.13		0.13		0.13	
No. Obs.	134		134		134		134		134		134		134	
kWh Mean (SD)	41.6	(12.8)	41.6	(12.8)	41.6	(12.8)	41.6	(12.8)	41.6	(12.8)	41.6	(12.8)	41.6	(12.8)

Notes: Preferred model highlighted, based on Akaike Information Criteria (AIC). Significant terms in bold ($p<0.05$).

Based on days with $CDD_{65}>0$.

To estimate condenser energy use, we applied the models to 2017 cooling season weather data (days with CDD_{65}>0), observed 2017 occupancy data, and COOLNOMIX status (Table 6-4). Pre tune-up, the best fit model predicted a 312 kWh annual condenser energy savings (4.6%). Savings in that case could have resulted from running the fans longer overnight, which may have reduced cooling loads. Post tune-up, when COOLNOMIX engaged both day and night, there was no significant change in condenser energy use due to increased daytime ventilation loads. Modeled post tune-up energy use was higher than pre-tune up, likely because those models were fit using a shortened test period that lacked shoulder season data.

Table 6-4. Modeled Annual Condenser Energy Use.

(kWh)	PRE TUNE-UP			POST TUNE-UP		
Model	Baseline	CNMX	Δ	Baseline	CNMX	Δ
M1	6,489	-	**-**	8,952	-	**-**
M2	6,944	-	**-**	8,920	-	**-**
M3	6,814	-	**-**	8,902	-	**-**
M4	6,847	7,014	**+167**	8,854	9,018	**+164**
M5	6,799	6,828	**+29**	8,871	8,949	**+78**
M6	6,640	7,164	**-524**	8,860	8,970	**+110**
M7	7,116	6,804	**-312**	8,858	8,973	**+115**

Notes: Cooling season includes 267 days (CDD_{65}>0) with a total of 3,123 CDD_{65}.
Statistically-preferred models highlighted.
Occupancy averaged 2.1 h/d (SD 1.8) [as measured by sensor].

Ventilation fans were set to AUTO. With COOLNOMIX, these fans ran significantly longer, especially on days when the economizer was inactive. To estimate fan energy, we evaluated bounding cases where the baseline fans are always ON and set to AUTO. Always ON assumes typical fan power (0.95 kW) for 6,408 hours on days with CDD_{65}>0, or about 6,065 kWh. For the AUTO case, we estimated baseline ventilation fan energy based on compressor runtime and economizer runtime. Compressor runtime (1,780 hours) was found by dividing the modeled condenser energy consumption (8,902 kWh) by the typical average compressor power draw (5.0 kW). With COOLNOMIX, the fan runtime approximately doubled (3,560 hours). Economizer runtime was assumed to be up to 461 hours (based on hours below 55°F on days with CDD_{65}>0). Multiplying fan hours by typical fan power (0.95 kW) gives the fan energy.

Table 6-5. Modeled Annual Cooling Energy Use Impact.

	Ventilation Fans AUTO				Ventilation Fans ON			
(kWh)	COND	FAN	TOTAL	kWh/ft²	COND	FAN	TOTAL	kWh/ft²
Baseline	8,902	2,129	**11,031**	5.5	8,902	6,065	**14,967**	7.5
COOLNOMIX	8,902	3,820	**12,722**	6.4	8,902	6,065	**14,967**	7.5
Δ kWh	-	+1,691	**+1,691**	-	-	-	**-**	-
% change	-	+79%	**+15%**	-	-	-	**-**	-

Notes: Based on model M3 (post tune-up), applied to 2017 cooling season data.
Cooling season includes 267 days (CDD_{65}>0) with a total of 3,123 CDD_{65}.
Occupancy averaged 2.1 h/d (SD 1.8) [as measured by sensor].

The primary conclusion for this site is that COOLNOMIX had no net effect on condenser energy use, but increased cooling system energy use by about 15% due to increased fan runtime. This increase, which led to substantially higher fan energy consumption and higher fresh air supply rates, exceeded any potential compressor performance benefits. When COOLNOMIX was functioning only at night, there was apparently a slight condenser energy reduction of up to 312 kWh; however, this effect was insufficient to overcome the fan energy penalty.

6.2 AIR CONDITIONING SITE 2: DRY CLIMATE

6.2.1 Site, Equipment, and Controls

COOLNOMIX was installed inside a packaged RTU serving a single-zone one-story building (approximately 2,800 ft^2, Figure 6-14). The building had a reception desk, an open-plan waiting area with adjoining conference area, restrooms, and several small closed offices. The space had few non-operable windows and three exterior doors that were frequently used.

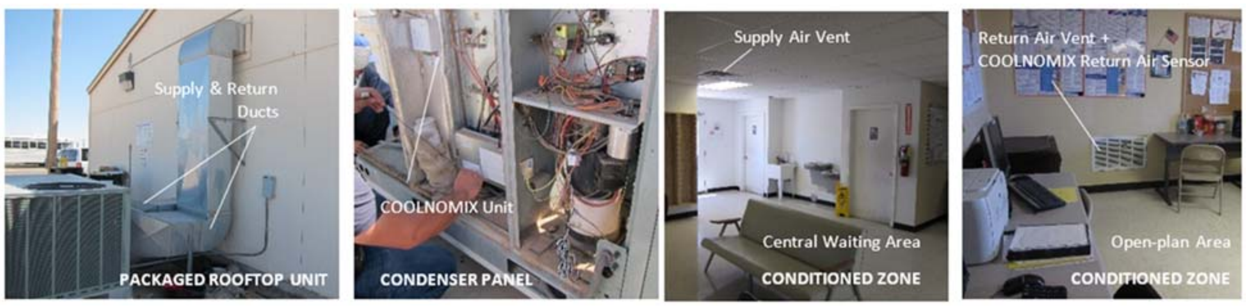

Figure 6-14. COOLNOMIX Air Conditioning Installation.

The 5-ton RTU (RHEEM model RLKA-A060JK) included a single compressor, a 1/3 HP condenser fan and a 3/4 HP three-speed blower (only the high speed was connected). A 14.4 kW electrical unit heater was also installed and used only during the heating season. The unit had a working economizer that was enabled. We submetered the RTU power draw on a circuit that included the fans, compressor, and heater.

The RTU, manufactured in 2005, was in worn but functional condition. Fan filters were routinely replaced, though at least once a service call was issued when the unit stopped cooling (June 6, 2016), likely due to obstructed airflow. The unit was slightly undersized, as it ran continuously for hours during most days, often unable to meet the target setpoint. During these undersized periods, COOLNOMIX could not engage, limiting its annual energy savings opportunity. After identifying undercapacity, we checked and corrected refrigerant charge, which was found to be about 1-2 lbs. low (8 lbs. nominal). This improved performance but did not fully resolve the undercapacity issue.

A single non-programmable digital thermostat, centrally located in the zone, controlled the space temperature. The thermostat was locked inside a plastic case, preventing the occupants from adjusting the settings. The setpoint was kept at 70°F, with the fan set to AUTO (runs only when the thermostat calls for cooling).

Initially, the COOLNOMIX return air temperature sensors were installed inside the RTU, where solar heat gains could have inflated the sensor readings during the day, preventing COOLNOMIX from operating during most mid-day periods. After discovering this potential issue, we extended the sensor wires through the ductwork into the conditioned zone (June 7, 2017). Extending the wires did not make much difference, as daytime cycling was already constrained by undercapacity. Because changes to refrigerant charge and COOLNOMIX wiring were made during the test, we analyzed pre- and post tune-up periods separately.

FINDING: Undersized units and units operating at less than full capacity (e.g., due to low refrigerant charge) can limit the portion of the day that COOLNOMIX can cycle the compressor. Screening tools should be used to identify systems that are likely undersized.

6.2.2 Occupancy

Occupancy hours were primarily between 6AM to 1AM (Figure 6-15 and Figure 6-16). Weekday occupancy was about twice as high on weekdays vs. weekends (11.4 vs 5.2 h/d).

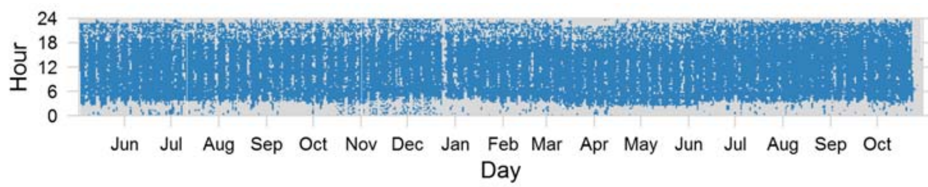

Figure 6-15. Occupancy by Day and Hour.

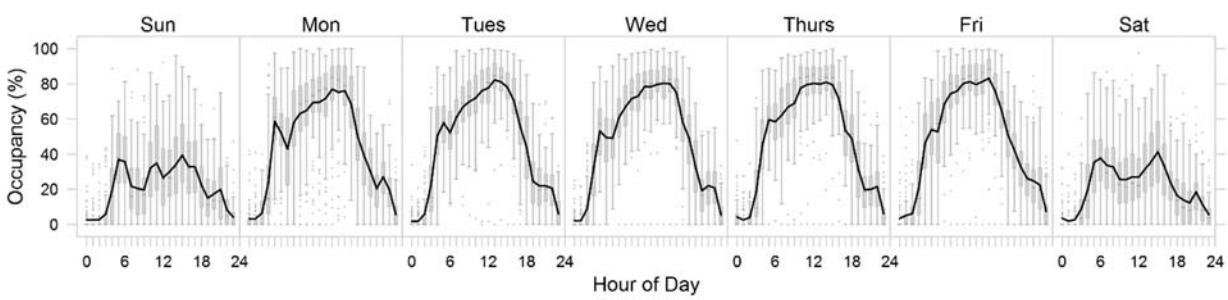

Figure 6-16. Occupancy Profiles by Day of Week.

6.2.3 Thermal Comfort

Pre tune-up, COOLNOMIX increased the minimum zone temperature by +1-2°F. Post tune-up (after correcting refrigerant charge and extending the COOLNOMIX sensor into the return air duct), this difference was reduced to +0.5°F (Figure 6-17). Due to undercapacity, the baseline system could not satisfy the cooling setpoint during hot conditions, typically after noon. At times, the indoor temperature exceeded 80°F (Figure 6-18 and Figure 6-19). Consequently, COOLNOMIX could only engage during mild temperature periods, normally at night or in the morning. Relative humidity (hourly average values) consistently remained below 60% (less than 3% of occupied hours) throughout all periods.

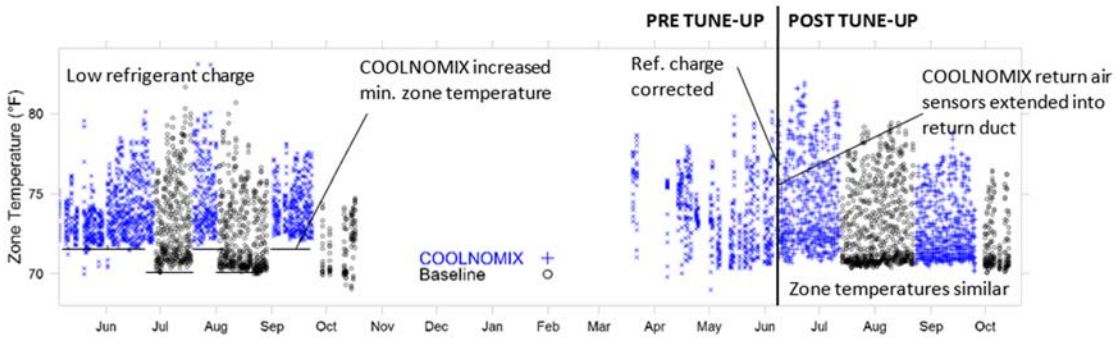

Figure 6-17. Average Hourly Zone Temperature During Occupied Hours.

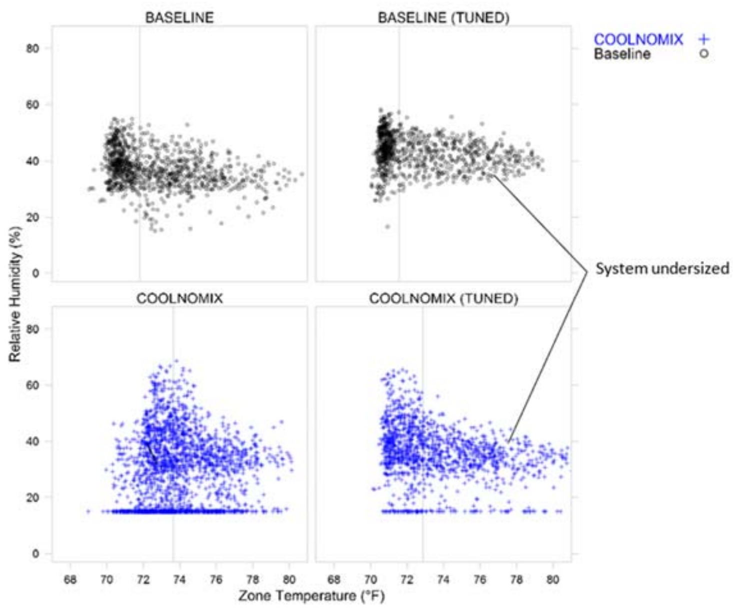

Figure 6-18. Relative Humidity vs. Zone Temperature, Hourly Averages During Occupied Hours.

Based on days with CDD_{65}>10. Vertical lines represent medians.

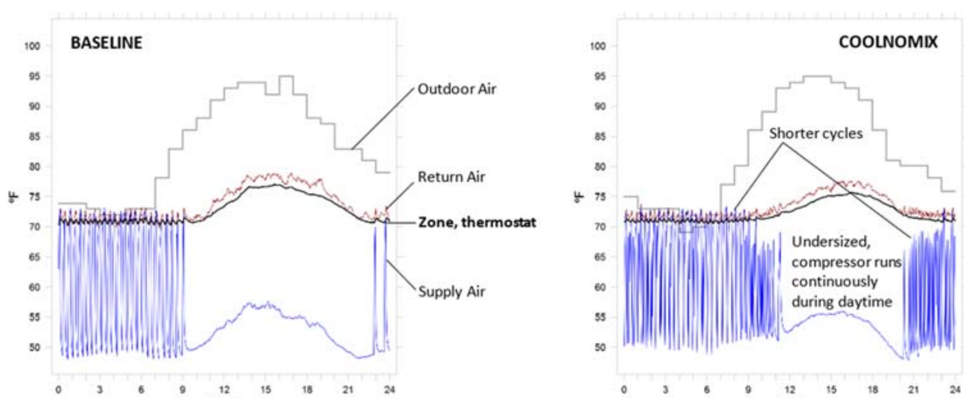

Figure 6-19. Temperature for Two Sample Hot Days, by COOLNOMIX Status.

Table 6-6. Comfort Survey Results (number of responses).

Question	Never	Rarely	Sometimes	Often	Always	Status
Too Hot?	7	2	3	1	-	Baseline
	6	**6**	**9**	**2**	**-**	**COOLNOMIX**
Comfortable?	-	-	3	6	4	Baseline
	-	**-**	**6**	**8**	**8**	**COOLNOMIX**
Too Cold?	1	3	2	3	4	Baseline
	1	**11**	**3**	**1**	**5**	**COOLNOMIX**
Too Humid?	3	1	2	1	-	Baseline
	11	**2**	**5**	**1**	**-**	**COOLNOMIX**
Too Hot in AM?	10	4	2	-	-	Baseline
	11	**4**	**6**	**2**	**-**	**COOLNOMIX**
Too Hot in PM?	10	2	2	1	2	Baseline
	8	**4**	**4**	**9**	**-**	**COOLNOMIX**

Occupant Notes:

[Baseline] 8/23/2017 During the hottest part of day the system doesn't cool the building properly.

[COOLNOMIX] 4/17/2017 Evening or after 12:30/13:00 is too hot
AC good around 7-8AM. After 11-12 it gets warm and we have to prop the door open sometimes.
[COOLNOMIX] 6/6/2017AC went offline, contractor came to fix.
[COOLNOMIX] 7/13/2017 AC has improved by a large amount.

Author's Note:
The number of responses varied by period depending on who was available in the building during each site visit. Results are qualitative.

6.2.4 Ventilation Fan Runtime

The RTU had an outdoor air fan and indoor blower that ran only when the thermostat called for cooling. By design, COOLNOMIX increases fan runtime. Due to the thermostat's AUTO fan control strategy, running the fans longer also increased the outdoor air supply. Since this RTU was undersized, the fans (and compressors) tended to run continuously for hours on most hot days, especially during the pre tune-up period when the COOLNOMIX setpoint was two degrees higher than the thermostat setpoint (Figure 6-20). After reducing the COOLNOMIX setpoint slightly post tune-up, the fan penalty was reduced. Additional fan runtime occurred mostly at night and in the morning hours (Figure 6-21 and Figure 6-22).

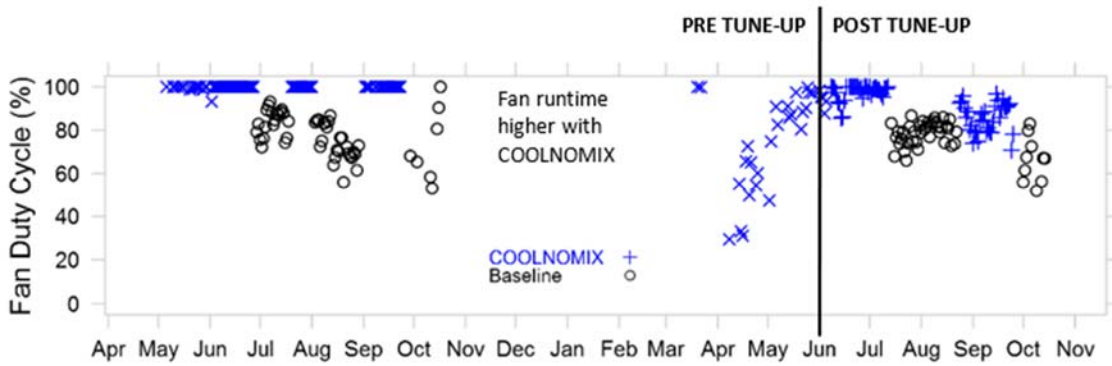

Figure 6-20. Ventilation Fan Duty Cycle by Day.

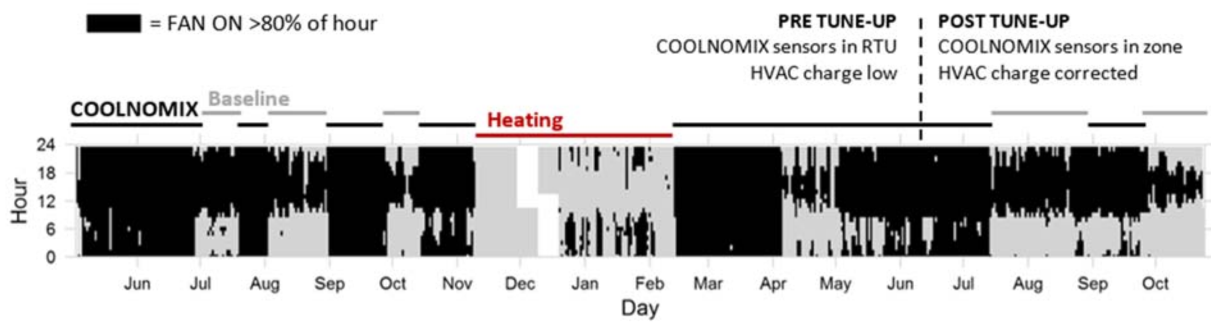

Figure 6-21. Ventilation Fan Status by Hour and Day.

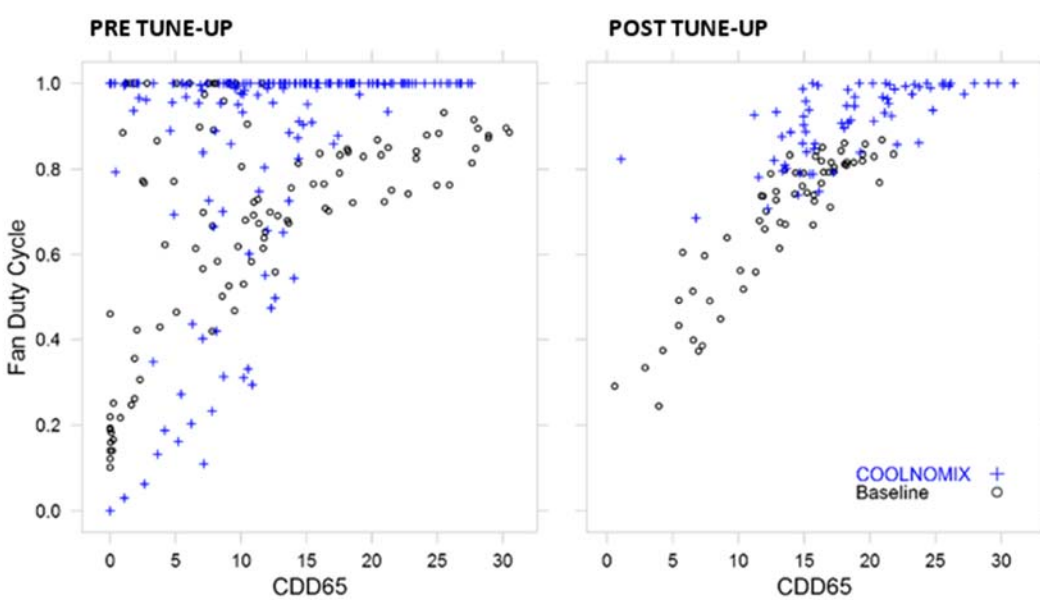

Figure 6-22. Daily Fan Duty Cycle vs. COOLNOMIX Status.

The COOLNOMIX fan penalty depends on more than just cooling degree days. Notably, in the pre tune-up period, there were some low cooling degree days (CDD_{65}<10) in the baseline that had fan duty cycle above 80% due to economizer action in October and November (Figure 6-21). There were also some low cooling degree days with COOLNOMIX that showed fan duty cycle below 40% in February and April. In the latter case, the thermostat becomes satisfied and COOLNOMIX does not keep the fan running longer. For the remaining days, however, COOLNOMIX keeps the fans running most of the time, which could have mixed effects on cooling loads: increasing loads during the hot portions of the day and decreasing them when it is cooler out (but not cold enough for the economizer to run).

6.2.5 Compressor Runtime

The effect on typical compressor cycle duration was difficult to measure due to the unit being undersized. To exclude periods where the unit could not meet the load, we compared summaries of cycles with duration of less than 30 minutes. By this metric, there was no significant difference in cycle duration pre tune-up and a slight decrease post tune-up (Table 6-7). COOLNOMIX increased the number of daily cycles significantly in both periods (Figure 6-23), though the effect was apparently reversed on some cooler days in the pre tune-up period, again potentially due to economizer activity.

Table 6-7. Compressor Cycle Duration.

Minutes Median (Mean)	PRE TUNE-UP	POST TUNE-UP
Baseline	13 (13.5)	13 (13.4)
COOLNOMIX	9 (10.6)	8 (9.6)

Note: Cycle times in this table are qualitative, differences in weather could bias summaries. Based on days with CDD_{65}>5 and cycle durations < 30 min.

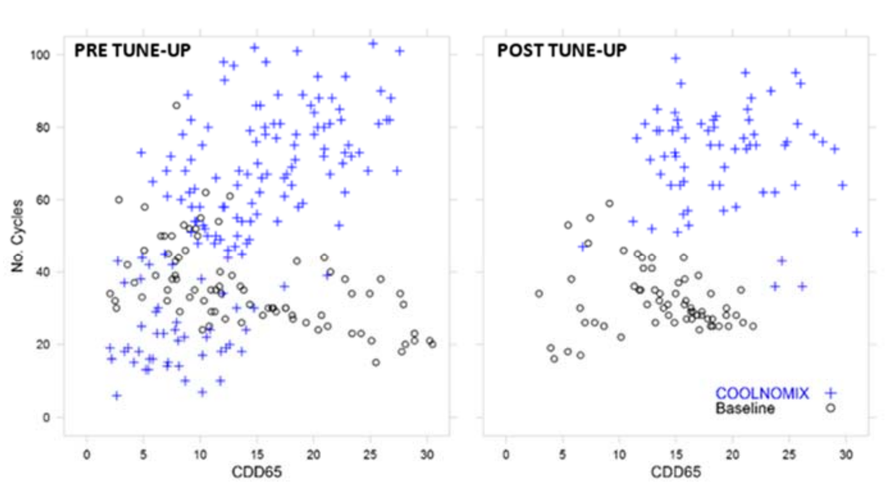

Figure 6-23. Compressor Cycles per Day vs. Cooling Degree Days.

6.2.6 Energy Performance

RTU power draw for two hot days shows typical behavior (Figure 6-24). In both cases, the compressor ran for many hours continuously during the hottest daytime periods. During cooler periods, COOLNOMIX caused shorter, more frequent compressor cycles. In the baseline, the fan stops running between cycles, whereas with COOLNOMIX the fan runs nearly all the time.

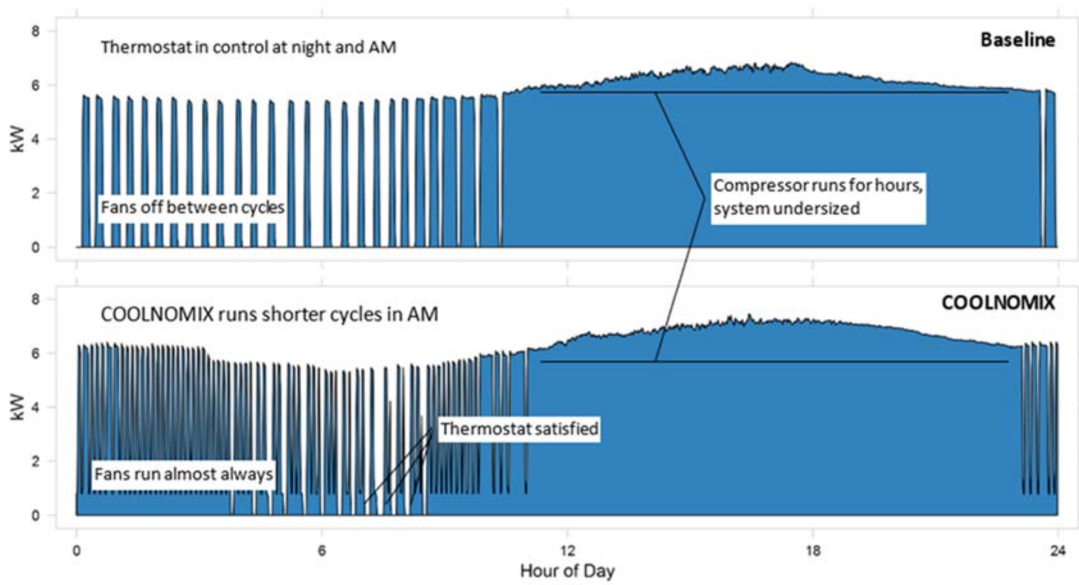

Figure 6-24. RTU Power Draw vs. Time of Day, by COOLNOMIX Status for Two Sample Days (post tune-up).

Condenser and ventilation fan energy were considered separately for the pre- and post-tune-up periods. With COOLNOMIX, the compressor used less energy and the fans used more energy (Figure 6-25 and Figure 6-26). During the pre tune-up period, differences in compressor energy consumption were due at least partially to higher average zone temperatures with COOLNOMIX enabled. In the post tune-up periods, zone temperatures were closer.

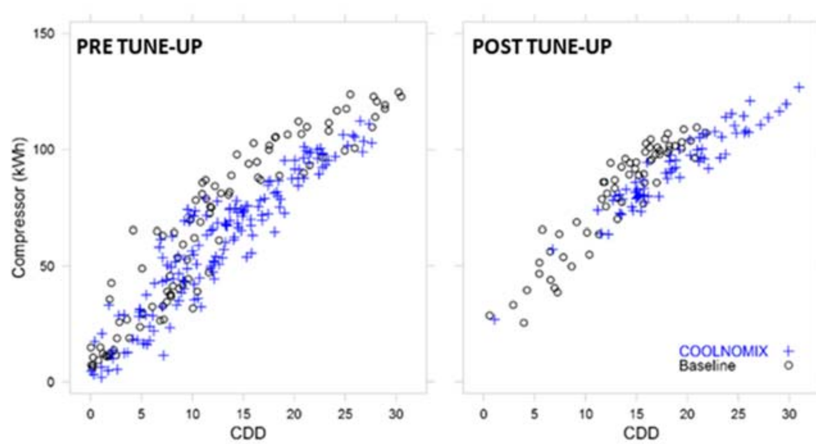

Figure 6-25. Condenser Energy Use vs. Cooling Degree Days by COOLNOMIX Status.

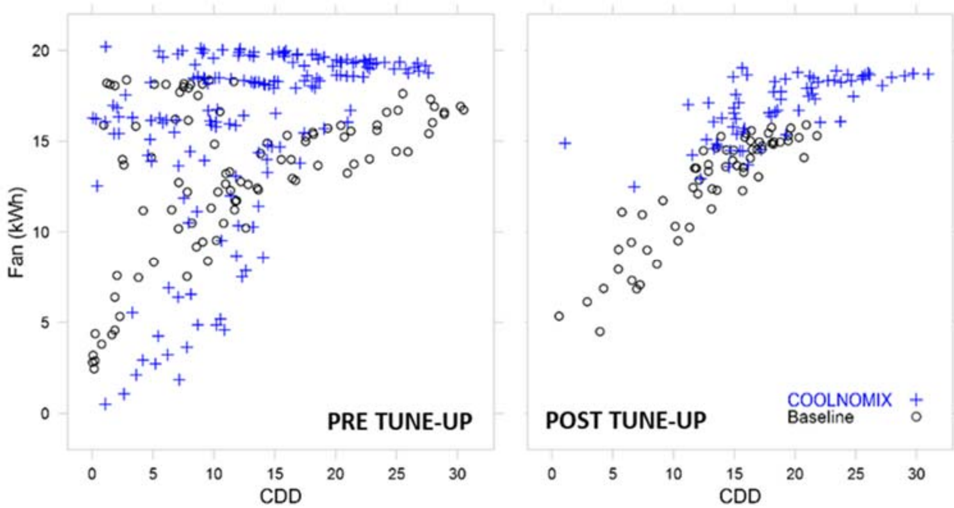

Figure 6-26. Ventilation Fan Energy Use vs. Cooling Degree Days by COOLNOMIX Status.

Multiple linear regressions were calculated to predict condenser energy use ($E_{condenser}$, kWh) based on cooling degree days (CDD_{65}), adjusted[23] cooling degree days (CDD_{adj}), occupancy (*OCC*, hours), and COOLNOMIX status. Separate combinations of these variables and interaction terms with COOLNOMIX status were tried to identify model parameters significant at the 0.05 level.

Cooling degree days explained 83-86% of the total variance in the data. Adjusted cooling degree days, which adjust for the differences in average daily zone temperature, improved the fit for the pre tune-up period, but not for the post tune-up period (likely because the zone temperatures were similar post tune-up). Consequently, we used adjusted CDD only for the pre tune-up period COOLNOMIX regressions. Occupancy terms were significant ($p<0.001$). COOLNOMIX interaction terms were significant mainly with *CDD* ($p=0.048$ pre tune-up and $p<0.001$ post tune-up). Adding COOLNOMIX occupancy terms did not improve the fits.

[23] $CDD_{adj} = CDD_{65} - (T_{avg} - 72°F)$

Table 6-8. Condenser Energy Regression Models: Parameter Estimates and (standard errors).

(kWh/d) Term \ MODEL	M1	M2	M3	M4	M5	M6	M7
	PRE TUNE-UP: Low Refrigerant Charge, COOLNOMIX Sensor in RTU						
Intercept	**13.05 (1.46)**	**12.65 (1.42)**	**-0.50 (2.21)**	**12.92 (1.42)**	-0.27 (2.20)	-0.41 (2.20)	-0.31 (2.21)
CDD_{65}	**3.89 (0.10)**						
CDD_{65}:CNMXon							
CDD_{adj}		**4.19 (0.10)**	**4.15 (0.09)**	**4.27 (0.12)**	**4.24 (0.10)**	**4.14 (0.09)**	**4.20 (0.13)**
CDD_{adj}:CNMXon				-0.18 (0.11)	**-0.19 (0.10)**		-0.12 (0.17)
OCC			**1.45 (0.20)**		**1.46 (0.20)**	**1.63 (0.22)**	**1.54 (0.25)**
OCC:CNMXon						-0.27 (0.14)	-0.13 (0.24)
Adj. R^2	0.86	0.86	0.89	0.86	0.89	0.89	0.89
AIC	2040	2025	1978	2024	1976	1976	1978
RMSE	11.92	11.58	10.54	11.52	10.46	10.46	10.45
CV(RMSE)	0.19	0.19	0.17	0.19	0.17	0.17	0.17
No. Obs.	261	261	261	261	261	261	261
kWh Mean (SD)	62.2 (31.4)	62.2 (31.4)	62.2 (31.4)	62.2 (31.4)	62.2 (31.4)	62.2 (31.4)	62.2 (31.4)
	POST TUNE-UP: Correct Refrigerant Charge, COOLNOMIX Sensor in Zone						
Intercept	**34.94 (2.16)**	**28.14 (2.78)**	**25.72 (3.41)**	**28.90 (1.93)**	**21.53 (2.86)**	**21.77 (3.11)**	**22.09 (2.86)**
CDD_{65}	**3.18 (0.13)**		**3.19 (0.12)**	**3.95 (0.14)**	**3.93 (0.14)**	**3.49 (0.12)**	**4.07 (0.16)**
CDD_{65}:CNMXon				**-0.65 (0.08)**	**-0.63 (0.08)**		**-0.91 (0.18)**
CDD_{adj}		**3.73 (0.17)**					
CDD_{adj}:CNMXon							
OCC			**0.86 (0.25)**		**0.71 (0.21)**	**1.16 (0.23)**	0.45 (0.25)
OCC:CNMXon						**-0.76 (0.13)**	0.46 (0.27)
Adj. R^2	0.83	0.79	0.84	0.89	0.89	0.88	0.90
AIC	944	976	935	893	884	905	883
RMSE	8.45	9.52	8.10	6.93	6.64	7.19	6.56
CV(RMSE)	0.10	(0.11)	(0.09)	(0.08)	0.08	0.08	0.08
No. Obs.	132	132	132	132	132	132	132
kWh Mean (SD)	86.4 (20.7)	86.4 (20.7)	86.4 (20.7)	86.4 (20.7)	86.4 (20.7)	86.4 (20.7)	86.4 (20.7)

Notes: Preferred model highlighted, based on Akaike Information Criteria (AIC). Significant terms in bold ($p<0.05$). Based on days with $CDD_{65}>2$.

To estimate actual condenser energy use, we applied the models to 2017 cooling season weather data (days with $CDD_{65}>0$), observed 2017 occupancy data, and COOLNOMIX status (Table 6-4). Condenser energy savings was about 3.5% in the pre tune-up and 9.9% in the post-tune up cases.

Table 6-9. Modeled Annual Condenser Energy Use.

(kWh)	PRE TUNE-UP			POST TUNE-UP		
Model	Baseline	CNMX	Δ	Baseline	CNMX	Δ
M1	15,640	-	**-**	19,253	-	**-**
M2	16,445	-	**-**	19,160	-	**-**
M3	16,437	-	**-**	18,953	-	**-**
M4	16,792	16,229	**-563**	20,040	18,004	**-2,036**
M5	16,809	16,206	**-603**	19,763	17,804	**-1,959**
M6	16,856	16,196	**-660**	19,588	17,704	**-1,884**
M7	16,869	16,178	**-691**	19,734	18,059	**-1,675**

Notes: Cooling season includes 267 days (CDD_{65}>0) with a total of 3,123 CDD_{65}.
Occupancy averaged 9.4 h/d (SD 3.3).
Statistically-preferred models highlighted.

Modeling fan energy is more challenging, owing to economizer activity and COOLNOMIX setpoints, as discussed earlier. When fans are set to AUTO (as they were throughout this test), they run only when the thermostat calls for cooling. In such cases, COOLNOMIX tends to increase fan runtime to near 100% during hot periods by keeping the thermostat from being satisfied. During shoulder months or heating[24] season, when the thermostat is satisfied without the need for cooling or when the economizer runs, these COOLNOMIX-driven increases can be less pronounced.

Based on modeled compressor energy and typical compressor power draw of 6.6 kW, we estimate a baseline minimum cooling season fan duty cycle of at least 45-50% in the AUTO mode. Based on visual inspection of the data, we estimate that about 40 days of the year involved economizer action, during which the fans ran at about 80% duty cycle. This results in an overall baseline fan duty cycle of about 55%. With COOLNOMIX, we estimate fan duty cycle on economizer days and on days with CDD_{65}>10 (40 and 161 days, respectively) about 90%, and that half the remaining days (33 days) duty cycle is 20% and the other half (33 days) duty cycle is 80%. This leads to an overall ventilation fan duty cycle of about 81% with COOLNOMIX. Typical fan power was about 760 W.

Table 6-10. Modeled Annual Cooling Energy Use Impact.

	Ventilation Fans AUTO				Ventilation Fans ON			
(kWh)	COND	FAN	TOTAL	kWh/ft^2	COND	FAN	TOTAL	kWh/ft^2
Baseline	19,763	3,524	**23,287**	8.3	19,763	4,870	**24,633**	8.8
COOLNOMIX	17,804	3,961	**21,765**	7.8	17,804	4,870	**22,674**	8.1
Δ kWh	-1,959	+437	**-1,522**	0.5	-1,959	-	**-1,959**	0.7
% change	-9.9%	+12.4%	**-6.5%**	-	-9.9%	-	**-8.0%**	-

Notes: Based on M5 models, post tune-up, applied to 2017 cooling season data.
Cooling season includes 267 days (CDD_{65}>0) with a total of 3,123 CDD_{65}.
Occupancy averaged 4.0 h/d (SD 2.2).

[24] Some days required both heating and cooling at different times of day.

In conclusion, we estimate that COOLNOMIX reduced condenser energy use by 10% and overall cooling system energy use by 6.5-8.0% at this site (post tune-up), depending on the fan strategy employed. Savings estimates for the pre tune-up case were about three times lower, mainly due to low refrigerant charge leading to reduced system capacity. The energy penalty associated with extra fan runtime consumed about 22% of the condenser energy savings. Smarter fan control could reduce this fan energy penalty. The source of savings for this case could stem (at least partially) from extra cooling associated with extra night ventilation. Increasing fan runtime at night would tend to mimic economizer action, providing some additional space cooling. Although the system had an economizer, it typically engaged only during the shoulder and winter months.

6.3 AIR CONDITIONING SITE 3: DRY CLIMATE

6.3.1 Site, Equipment, and Controls

COOLNOMIX was installed inside a packaged RTU serving a single zone (about 4,000 ft^2) on the second floor of a two-story building (Figure 6-27). The zone included a reception window with a large open plan office. The zone had no exterior doors and few inoperable windows. Conditioned air was provided through supply ducts in a plenum beneath the roof.

Figure 6-27. COOLNOMIX Air Conditioning Installation.

The 7.5-ton dual-stage RTU (EER 11.5, TRANE model YHC092A4RMA2ND0010020000 D) included a 0.7 HP outdoor fan, a 2 HP belt-driven indoor fan, gas heating, and two scroll compressors. A dry-bulb economizer was installed. We submetered the RTU power draw on a circuit that included the ventilation fans and compressors.

The RTU, manufactured in 2007, was in good condition. Fan filters were routinely replaced, though not always before airflow became obstructed.[25] A single non-programmable analog dial thermostat, centrally located in the zone, controlled the space temperature. Occupants were able to adjust the setpoint. We set it to 73°F and added a sticker reminding staff to keep it there. The ventilation fans on this unit were programmed to run continuously day and night.

Initially, COOLNOMIX was wired to control the first stage of cooling only. After the first portion of the test, we determined that the first stage ran nearly continuously and the second stage intermittently. As a result, this strategy did not have a large effect on compressor runtime.

[25] The minimum daily power draw (MDPD), a proxy for fan power, revealed a decay in fan power as the filters became clogged, reducing airflow. Fortunately, the only two significant degradation periods (Sept.-Oct. 2016 and Jan. to Mar. 2017) did not coincide with our testing periods.

Furthermore, the return air sensor was initially positioned inside the RTU, where it was susceptible to solar heating. To correct these potential issues, we rewired the compressor during a recommissioning visit (2017-06-07) to apply a different strategy that controls both compressors simultaneously. During this visit, we extended the COOLNOMIX return air sensor from the RTU into the ductwork, corrected the refrigerant (R-22) charge, which was found to be about 1-2 lbs. low (12.2 lbs. nominal), and replaced a loose fan belt. Consequently, we analyze these two test periods independently, designated pre- and post tune-up.

FINDING: Dual stage compressor wiring can be challenging to implement. Installers struggled to correctly interpret the wiring diagrams. More detailed and specific wiring instructions (with photographs), along with explicit commissioning test protocols, are needed to ensure correct installation.

It was also necessary to perform a minor modification for COOLNOMIX to function properly, since the RTU had a current detection failsafe feature used to ensure the contactor is connected. When the COOLNOMIX relay opens, the current is interrupted and the RTU shuts down with an error code. To overcome this issue, we installed a 24 V relay coil in line with COOLNOMIX to simulate the contactor load.

6.3.2 Occupancy

Occupancy hours were primarily M-F, 7AM to 6PM (Figure 6-28 and Figure 6-29). Average occupancy was 4.7 h/d (SD 2.7) on weekdays and 0.5 h/d (SD 1.4) on weekends. These values, however, are artificially low and more closely represent activity than occupancy. This is because occupants often remained stationary or out of view and failed to trigger the sensors. Assuming the space was actually occupied if motion is detected at least once during each fifteen-minute window yields more realistic estimates of 9.6 h/d (SD 4.1) for weekdays and 1.2 h/d (SD 3.1) for weekends.

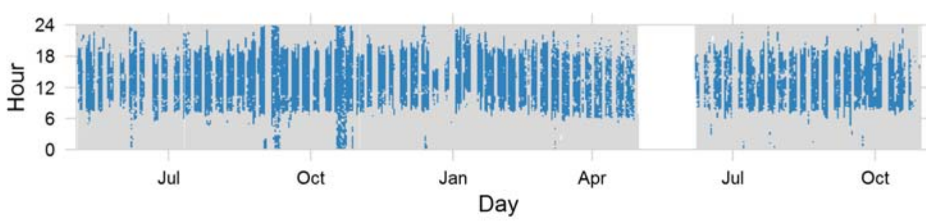

Figure 6-28. Occupancy by Day and Hour.

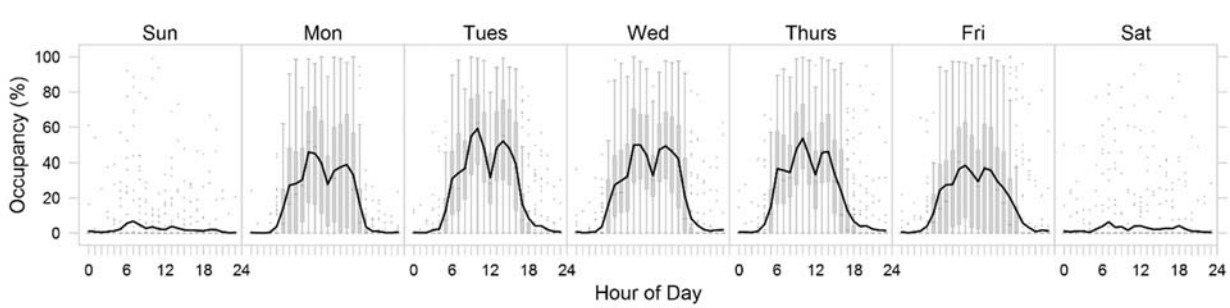

Figure 6-29. Occupancy Profiles by Day of Week.

6.3.3 Thermal Comfort

COOLNOMIX increased the zone temperatures on most hot days (Figure 6-30 and Figure 6-31). Average hourly zone temperatures increased by about 2°F and maximum hourly zone temperature increased by up to 4°F during occupied hours. Nonetheless, fewer than 3% of occupied hours were above 75°F across all periods. Relative humidity levels were not significantly affected. Qualitatively, occupants did seem to perceive these increased zone temperatures when COOLNOMIX was enabled (Table 6-11). While the effects on comfort were not severe, they have significant bearing on the energy savings calculations.

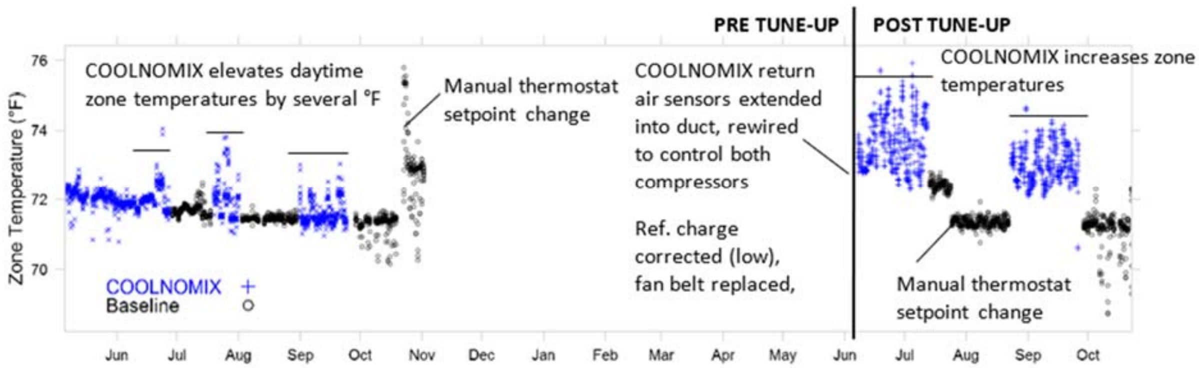

Figure 6-30. Average Hourly Zone Temperature During Occupied Hours.

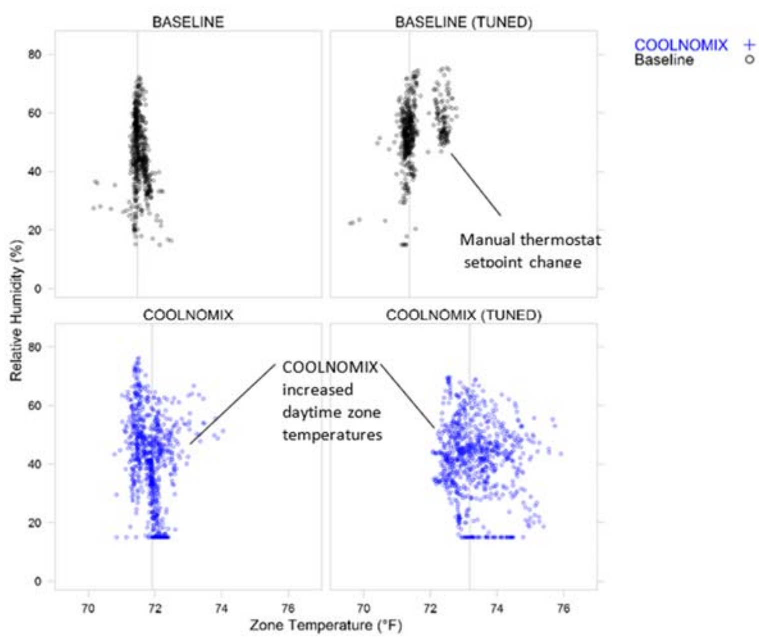

Figure 6-31. Relative Humidity vs. Zone Temperature, Hourly Averages During Occupied Hours.

Based on days with CDD_{65}>10. Vertical lines represent medians.

During a typical hot day (Figure 6-32), the average supply air temperature was elevated with COOLNOMIX. In baseline, the stage 1 compressor ran most of the time day and night and the stage 2 compressor cycled as necessary to meet the varying load. With COOLNOMIX, both compressors normally cycled on and off together. The return air temperature, measured in the return vent, was somewhat cooler than the air near the thermostat or near the rear door, likely due to short circuiting of cold supply air. COOLNOMIX return air sensors were located higher in the return duct (in the plenum) and were likely hotter than shown. Average zone temperature was several degrees higher with COOLNOMIX, and elevated during the afternoons, when the dual compressor cycling strategy was unable to completely satisfy the loads.

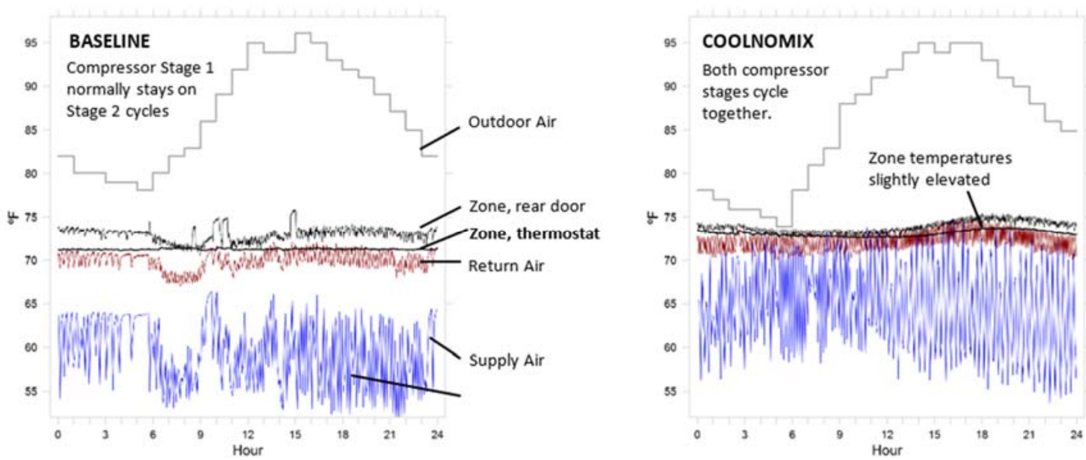

Figure 6-32. Temperature for Sample Hot Days with and Without COOLNOMIX, Post Tune-up.

Table 6-11. Comfort Survey Results (number of responses).

Question	Never	Rarely	Sometimes	Often	Always	Status
Too Hot?	2	4	-	-	-	Baseline
	3	**4**	**3**	**1**	**-**	**COOLNOMIX**
Comfortable?	-	-	-	5	1	Baseline
	-	**1**	**1**	**8**	**2**	**COOLNOMIX**
Too Cold?	1	3	2	-	-	Baseline
	6	**3**	**3**	**-**	**-**	**COOLNOMIX**
Too Humid?	3	2	-	-	-	Baseline
	5	**3**	**-**	**-**	**1**	**COOLNOMIX**
Too Hot in AM?	4	2	1	-	-	Baseline
	3	**6**	**2**	**1**	**-**	**COOLNOMIX**
Too Hot in PM?	3	2	1	-	-	Baseline
	3	**4**	**4**	**1**	**-**	**COOLNOMIX**

Occupant Notes: None.
Author's Notes: Survey data from heating season was excluded. Data for COOLNOMIX was limited due to a shortened testing period.
The number of responses varied by period depending on who was available in the building during each site visit. Results are qualitative.

6.3.4 Ventilation Fan Runtime

The single-speed ventilation fans on this unit were programmed to run continuously and were not controlled by the thermostat. As a result, COOLNOMIX did not influence fan runtime. When running, the fans typically drew about 1.2 kW.

6.3.5 Compressor Runtime

The RTU had two compressor stages. In baseline, thermostat calls for cooling caused the primary stage to come online first, and as needed, the second stage cycled to satisfy the load. Frequently, on hot days, the first stage would run continuously for much of the day (Figure 6-33, A and C).

Initially, COOLNOMIX was wired to directly control the first stage only. This resulted in more daily cycles for stage one and fewer cycles for stage two (Figure 6-33, A and B). After rewiring COOLNOMIX to control both stages together (post tune-up), both stages tended to be either on or off simultaneously, and the number of daily cycles increased for both stages (Figure 6-33, C and D). Cycle duration decreased significantly for stage one during both phases of this test, while the second stage was less affected (Table 6-12).

Table 6-12. Compressor Cycle Duration by Stage (S).

Minutes	PRE TUNE-UP				POST TUNE-UP			
Median (Mean)	S1		S2		S1		S2	
Baseline	1067	(859)	7	(15)	249	(587)	6	(9.8)
COOLNOMIX	23	(215)	8	(15)	6	(8.5)	4	(4.8)

Note: Cycle times in this table are qualitative, differences in weather could bias summaries. Based on days with CDD_{65}>10.

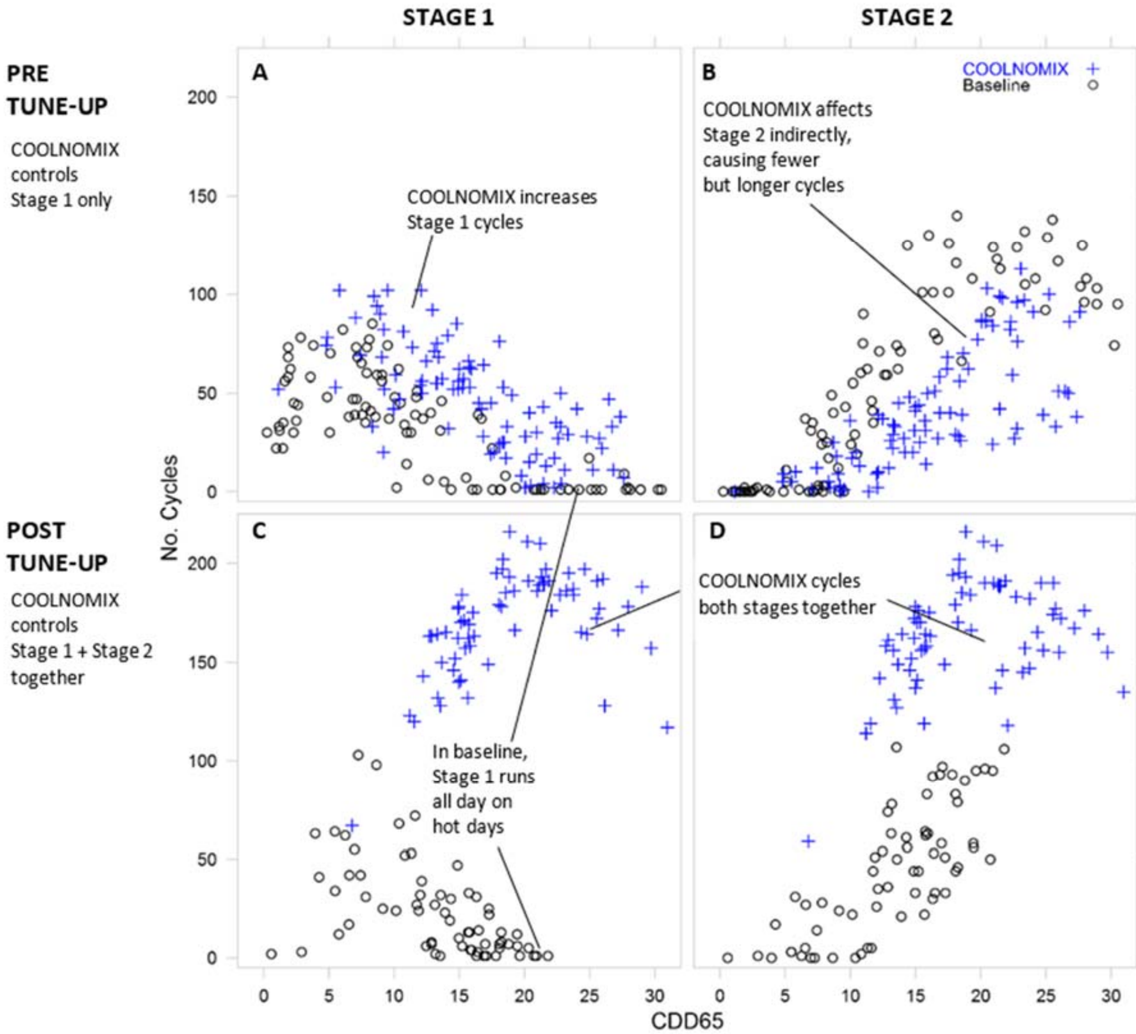

Figure 6-33. Compressor Cycles Per Day vs. Cooling Degree Days, by Stage and Period.

6.3.6 Energy Performance

RTU power draw for two sample days shows typical hot day behavior (Figure 6-33). In both cases, the fans run continuously. In the baseline, the first stage compressor does most of the cooling, running continuously for much of the day, while the second stage cycles more frequently and runs only when needed to supplement stage one. In contrast, COOLNOMIX turns off both compressors together. This causes the system to run both stages together most of the time, leading to a more balanced workload across compressors.

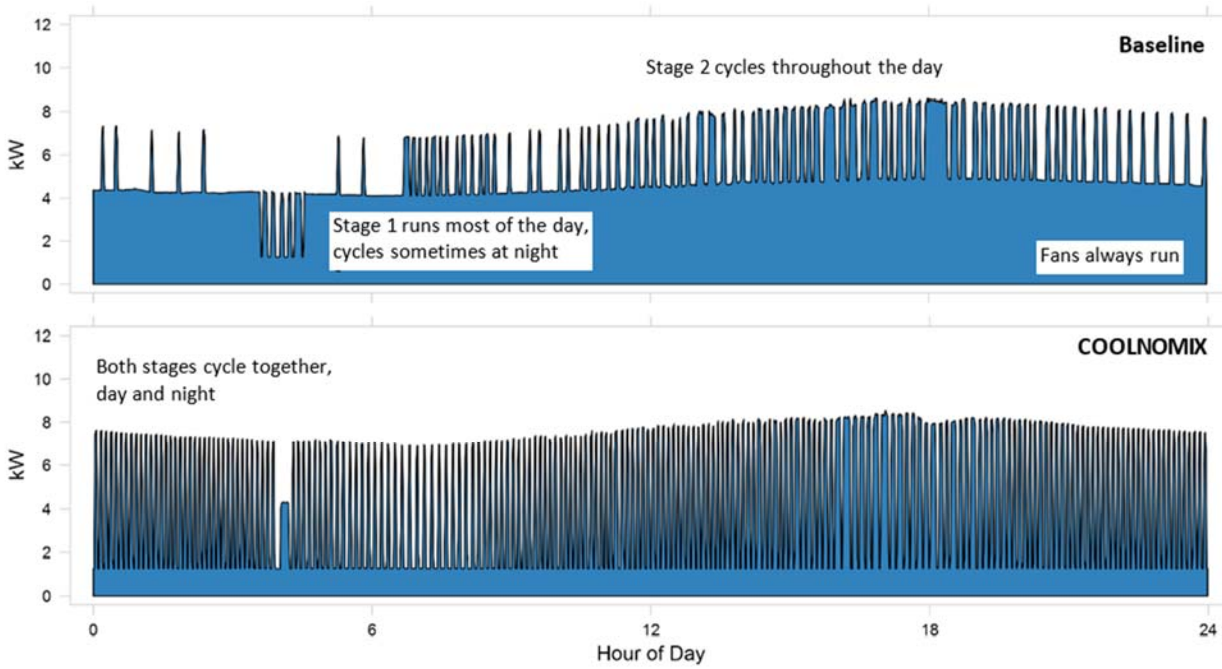

Figure 6-34. RTU Power Draw vs. Time of Day, by COOLNOMIX Status for Two Sample Hot Days, Post Tune-up.

To estimate energy savings, we focused on the compressors, as the ventilation fans ran continuously and were not controlled by COOLNOMIX. Since our power measurements included both ventilation fans and compressors, we deducted fan power, which varied with time as the air filters became clogged and were periodically replaced. To estimate fan power as a function of time, we found the minimum circuit power draw on days where both compressors were off at least once and interpolating on other days (Figure 6-35). Fan power was about 1.2 kW on average, consuming about 29 kWh per day. Deducting the daily fan power from the circuit power gives the total condenser power draw, from which we calculated the daily condenser energy use (Figure 6-36). We excluded periods when the filters apparently became clogged.

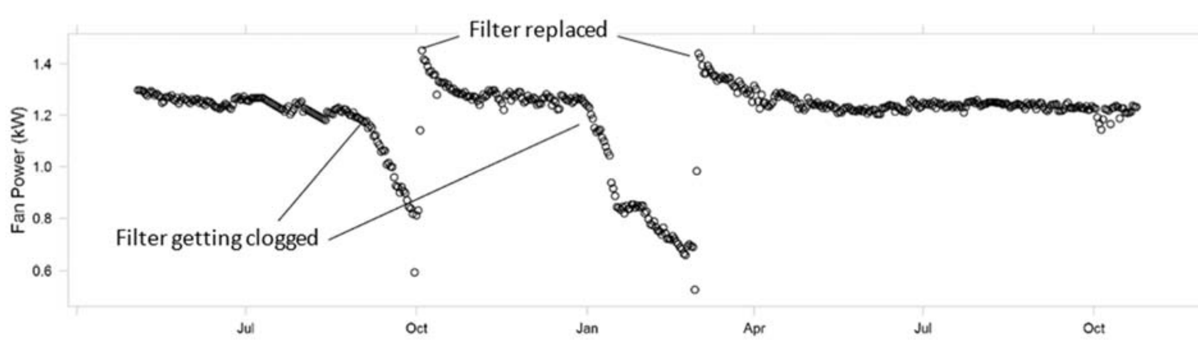

Figure 6-35. Fan Power Draw Estimates.

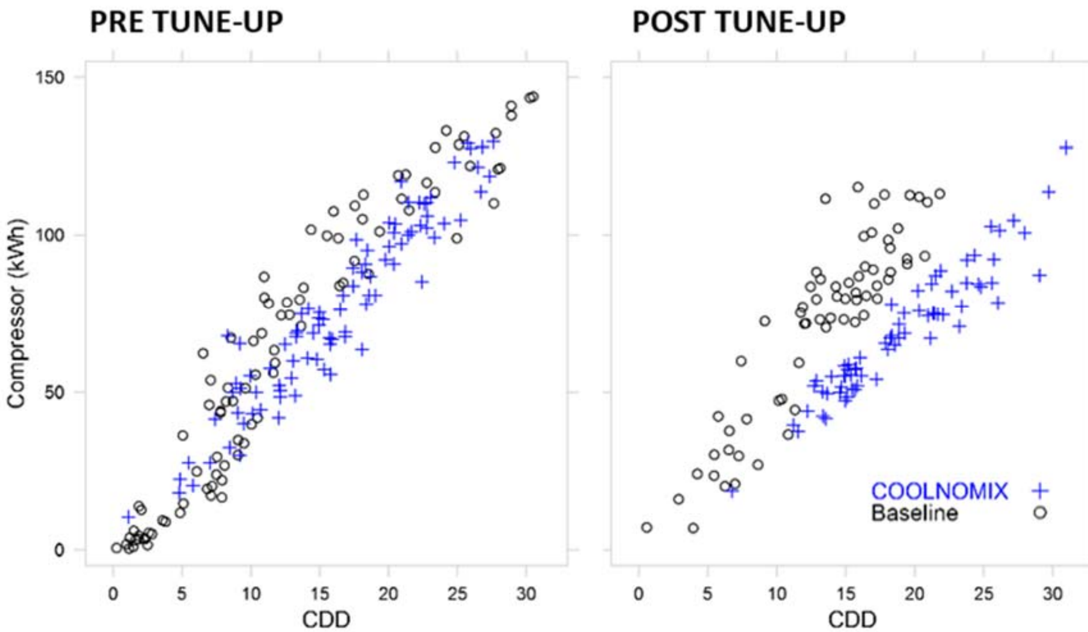

Figure 6-36. Condenser Energy Use vs. Cooling Degree Days by COOLNOMIX Status.

Multiple linear regressions were calculated to predict condenser energy use ($E_{condenser}$, kWh) based on cooling degree days (CDD_{65}), adjusted[26] cooling degree days (CDD_{adj}), occupancy (*OCC*, hours), and COOLNOMIX status. Separate combinations of these variables and interaction terms with COOLNOMIX status were tried to identify model parameters significant at the 0.05 level.

Cooling degree days explained 62-90% of the total variance in the data. Adjusted cooling degree days, which adjust for the differences in average daily zone temperature, improved the fit for both periods, so we used these for subsequent regressions. Occupancy terms were significant ($p<0.001$), but their effect was smaller relative to cooling degree days. COOLNOMIX interaction terms with CDD_{adj} were significant ($p=0.025$ pre tune-up and $p<0.001$ post tune-up). COOLNOMIX occupancy terms did not improve the fits.

[26] $CDD_{adj} = CDD_{65} – (T_{avg} – 72°F)$

Table 6-13. Condenser Energy Regression Models: Parameter Estimates and (Standard Errors).

(kWh/d) Term \ MODEL	M1	M2	M3	M4	M5	M6	M7
PRE TUNE-UP: COOLNOMIX Controls Compressor Stage 1 Only							
Intercept	**1.35 (1.85)**	-0.75 (1.81)	**-9.40 (2.07)**	**-1.18 (1.87)**	**-10.56 (2.11)**	**-9.66 (2.19)**	**-10.06 (2.17)**
CDD_{65}	**4.64 (0.12)**						
CDD_{65}:CNMXon							
CDD_{adj}		**4.72 (0.12)**	**4.91 (0.11)**	**4.98 (0.18)**	**5.19 (0.16)**	**4.93 (0.12)**	**5.21 (0.17)**
CDD_{adj}:CNMXon				-0.26 (0.14)	**-0.28 (0.12)**		**-0.36 (0.15)**
OCC			**1.46 (0.22)**		**1.47 (0.22)**	**1.52 (0.27)**	**1.28 (0.29)**
OCC:CNMXon						-0.11 (0.30)	0.37 (0.35)
Adj. R^2	0.90	0.91	0.93	0.91	0.93	0.93	0.93
AIC	1230	1215	1178	1213	1175	1180	1176
RMSE	11.08	10.58	9.37	10.46	9.22	9.36	9.19
CV(RMSE)	0.18	0.17	0.15	0.17	0.15	0.15	0.15
No. Obs.	160	160	160	160	160	160	160
kWh Mean (SD)	61.9 (34.8)	61.9 (34.8)	61.9 (34.8)	61.9 (34.8)	61.9 (34.8)	61.9 (34.8)	61.9 (34.8)
POST TUNE-UP: COOLNOMIX Controls Both Compressor Stages							
Intercept	**16.87 (3.72)**	9.61 (3.81)	3.69 (4.34)	-2.53 (3.05)	**-8.29 (3.33)**	-1.48 (4.05)	**-8.27 (3.33)**
CDD_{65}	**3.14 (0.22)**						
CDD_{65}:CNMXon							
CDD_{adj}		**3.68 (0.23)**	**3.81 (0.23)**	**5.26 (0.23)**	**5.39 (0.22)**	**4.13 (0.22)**	**5.44 (0.23)**
CDD_{adj}:CNMXon				**-1.29 (0.13)**	**-1.29 (0.12)**		**-1.37 (0.16)**
OCC			**1.25 (0.47)**		**1.22 (0.34)**	**2.82 (0.52)**	**0.99 (0.47)**
OCC:CNMXon						**-2.93 (0.55)**	0.60 (0.72)
Adj. R^2	0.62	0.67	0.69	0.82	0.84	0.75	0.84
AIC	1019	1003	997	928	917	974	919
RMSE	14.36	13.45	13.08	9.88	9.39	11.78	9.37
CV(RMSE)	0.21	0.20	0.19	0.15	0.14	0.18	0.14
No. Obs.	124	124	124	124	124	124	124
kWh Mean (SD)	67.3 (23.7)	67.3 (23.7)	67.3 (23.7)	67.3 (23.7)	67.3 (23.7)	67.3 (23.7)	67.3 (23.7)

Notes: Preferred model highlighted, based on Akaike Information Criteria (AIC). Significant terms in bold ($p<0.05$). Based on days with $CDD_{65}>0$.

To estimate actual condenser energy use, we applied the models to 2017 cooling season weather data (days with $CDD_{65}>0$), observed 2017 occupancy data, and COOLNOMIX status (Table 6-4). Pre tune-up, when COOLNOMIX only controlled the stage one compressor, the best fit model predicted annual condenser energy savings of 864 kWh (4.6%). Post tune-up, when COOLNOMIX controlled both compressors together, the best fit model predicted annual savings of 4,030 kWh (25.2%).

Table 6-14. Modeled Annual Condenser Energy Use.

(kWh) Model	PRE TUNE-UP Baseline	PRE TUNE-UP CNMX	PRE TUNE-UP Δ	POST TUNE-UP Baseline	POST TUNE-UP CNMX	POST TUNE-UP Δ
M1	14,847	-	**-**	14,312	-	**-**
M2	14,541	-	**-**	14,056	-	**-**
M3	14,438	-	**-**	14,267	-	**-**
M4	15,083	14,264	**-819**	15,762	11,722	**-4,040**
M5	15,010	14,146	**-864**	15,965	11,935	**-4,030**
M6	14,495	14,368	**-127**	15,633	12,375	**-3,258**
M7	15,000	14,284	**-716**	15,869	12,069	**-3,800**

Notes: Cooling season includes 267 days (CDD_{65}>0) with a total of 3,123 CDD_{65}.
Statistically-preferred models highlighted.
Occupancy averaged 4.0 h/d (SD 3.3) [as measured by sensor].
Post tune-up models lacked significant shoulder season data and could be biased towards hot-day performance.

Ventilation fans in this test were set to ALWAYS ON in the baseline. As a result, COOLNOMIX did not affect fan runtime or energy consumption. To estimate cooling-day fan energy, we apply typical fan power (1.2 kW) for 6,408 hours on days with CDD_{65}>0, or about 7,640 kWh. As with other test cases, if a different fan strategy were in place (e.g., fans set to AUTO), the energy impacts could differ substantially, since COOLNOMIX tends to keep the fans running most of the time.

Table 6-15. Modeled Annual Cooling Energy Use Impact.

(kWh)	PRE TUNE-UP COND	PRE TUNE-UP FAN	PRE TUNE-UP TOTAL	PRE TUNE-UP kWh/ft^2	POST TUNE-UP COND	POST TUNE-UP FAN	POST TUNE-UP TOTAL	POST TUNE-UP kWh/ft^2
Baseline	15,010	7,640	**22,650**	5.7	15,965	7,640	**23,605**	5.9
COOLNOMIX	14,146	7,640	**21,786**	5.4	11,935	7,640	**19,575**	4.9
Δ kWh	-864	-	**-864**	-	-4,030	-	**-4,030**	-
% change	-5.7	-	**-3.8%**	-	-25.2%	-	**-17.1%**	-

Notes: Based on model M5 (post tune-up), applied to 2017 cooling season data.
Cooling season includes 267 days (CDD_{65}>0) with a total of 3,123 CDD_{65}.
Occupancy averaged 4.0 h/d (SD 3.3) [as measured by sensor].

The primary conclusion for this site is that COOLNOMIX resulted in significantly lower condenser energy use. The effect was small when COOLNOMIX controlled only the first stage compressor, since that compressor ran most of the day; however, the effect was significantly larger when it controlled both stages together. Savings could reach 25% of condenser energy, or 17% of total cooling system energy, however these estimates come with two caveats. First, the post tune-up period lacked significant shoulder season data and included mostly days with CDD_{65}>10. As a result, applying this regression to lower degree days may be less accurate. Second, although COOLNOMIX produced significant savings, daytime indoor zone temperatures were increased by up to 2°F on average as a result. The regressions with adjusted degree days attempted to account for this increase; however, the elevated temperatures could cause some occupant discomfort. Adjusting the COOLNOMIX settings to keep temperatures more consistent may result in lower savings.

6.4 AIR CONDITIONING SITE 4: HUMID CLIMATE

6.4.1 Site, Equipment, and Controls

We installed COOLNOMIX near the air handler of a single-zone single-story brick post office (about 2,100 ft^2), cooled by a split system heat pump (Figure 6-37). The building included an open plan service counter, a break area with large inoperable windows, an office, a restroom, and a loading area. Two exterior doors – a front door with a vestibule and a rear door by the loading area – were used frequently. The hallway near the thermostat had a large north-facing windowed area. Conditioned air was provided through ducts.

Figure 6-37. COOLNOMIX Air Conditioning Installation.

The 7.5-ton split system heat pump, (EER 10.1, TRANE model TWA090A300FB), included a compressor motor and condenser fan. The air handler had a 1.5-HP belt-driven motor (3,000 CFM). Outdoor air dampers were fixed and no economizer was installed. The heat pump, manufactured in 2005, was in fair condition. Fan filters were routinely replaced. The fan belt was found to be loose and was replaced once during the test near the start of the second-year test. Refrigerant charge was initially low, leading to high supply-air temperatures. Charge was corrected in May of the first-year test and checked again prior to the second-year test. We submetered the heat pump power draw on a circuit that included the compressor and condenser fan. The indoor fan was not monitored directly.[27]

A single non-programmable digital thermostat, centrally located in the zone, controlled the space temperature. Despite setting the setpoint to 72°F and requesting it be kept there, occupants were able to adjust the setpoint and did so to manage their comfort. In 2017, we added a sticker reminding the staff to keep the temperature fixed during the experiment. This reduced, but did not eliminate, the occupant-driven adjustments. The thermostat controlled the ventilation fan. Throughout the test, we determined that occupants changed the thermostat ventilation fan settings between ALWAYS ON and AUTO at least six times, based on photographs of the thermostat during site visits.

> **FINDING: Thermostats that allow occupants to control the fan settings could result in poor or unexpected performance.**

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[27] Attempts use motor state sensors to track fan runtime were unsuccessful since the motor was too far from the housing to be detected.

Although COOLNOMIX was connected properly, it apparently did not control the compressor during most of the first-year test due to a return air setpoint that was too low (70°F). We installed COOLNOMIX in the morning on a mild spring day, when the return air was cooler than usual for the cooling season. Thus, while COOLNOMIX was working correctly when installed, it did not engage during most of the first year. To correct this, we increased the COOLNOMIX setpoint to 73°F for the second-year test (on May 25, 2017). As a result, we focus on COOLNOMIX effects primarily during periods after this change.

FINDING: Selecting the correct return air temperature limit on COOLNOMIX is critical and should be configured and tested on a hot day.

6.4.2 Occupancy

Occupancy followed a regular M-F 9AM-5PM schedule, with reduced Saturday hours, and closed Sundays and holidays (Figure 6-38 and Figure 6-39).

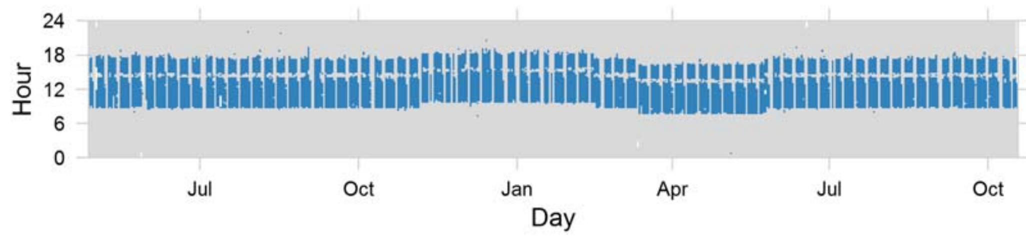

Figure 6-38. Occupancy by Day and Hour.

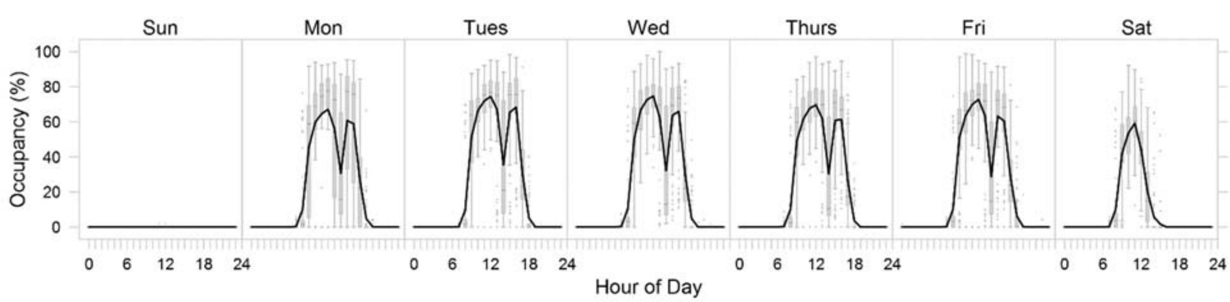

Figure 6-39. Occupancy Profiles by Day of Week.

6.4.3 Thermal Comfort

Pre tune-up, when COOLNOMIX was installed but not actually in control, the zone temperature varied significantly due to manual thermostat adjustments (between 70-75°F, Figure 6-40). Post tune-up, after COOLNOMIX was working correctly, setpoints were still adjusted but less-so (between 71-74°F). Zone temperatures during occupied hours remained below 75°F during virtually all of the post tune-up period.

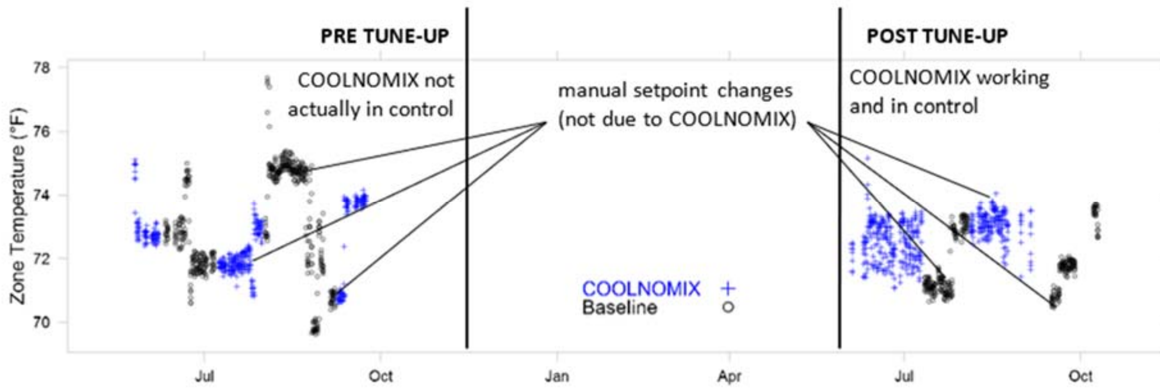

Figure 6-40. Average Hourly Zone Temperature During Occupied Hours

Zone relative humidity frequently exceeded 60% during occupied hours in both the baseline and COOLNOMIX cases (Figure 6-41). Differences in relative humidity could not be attributed to COOLNOMIX and were mostly dependent on the variable weather conditions.

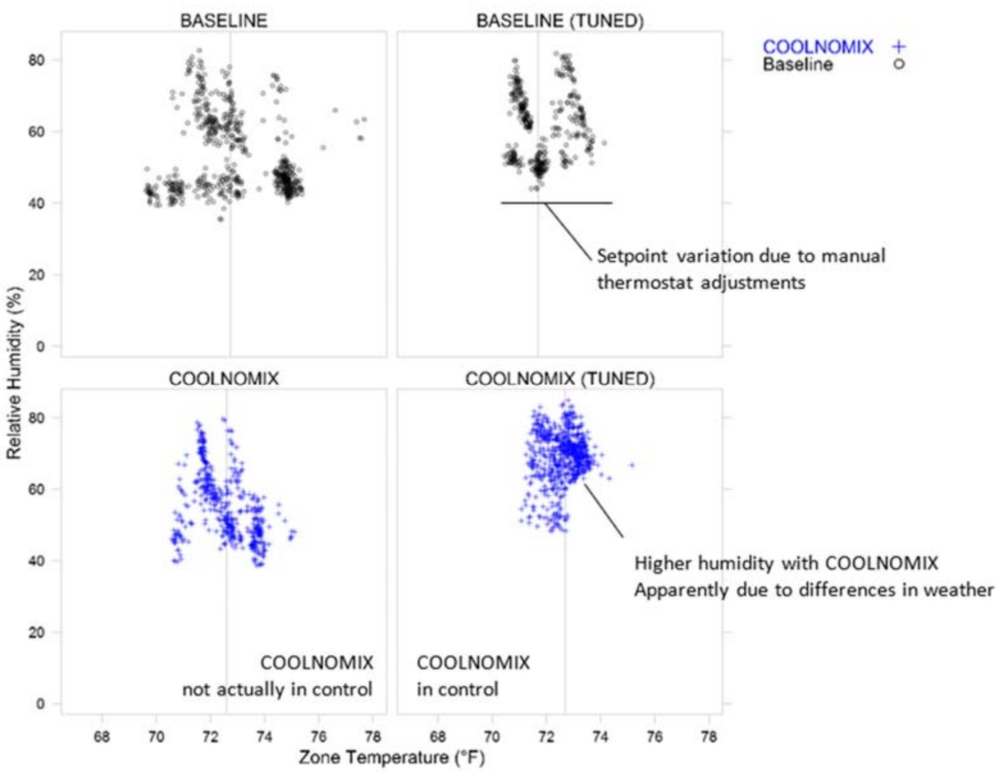

Figure 6-41. Relative Humidity vs. Zone Temperature (Near Thermostat), Hourly Averages During Occupied Hours.

Vertical lines represent medians.

We measured zone temperature in two places – near the thermostat and in the middle of the main open plan zone where the occupants spent the most time (Figure 6-42). Temperatures in these two locations differed during the day, with the thermostat area up to several degrees warmer during the afternoons.

This difference was likely caused by solar gains from a large bank of windows near the thermostat. Sunlight did not strike the thermostat directly, but it may have warmed the wall differently than the rest of the building. When COOLNOMIX was cycling, the temperature deadband was reduced slightly, though in the baseline case, the deadband was already fairly small.

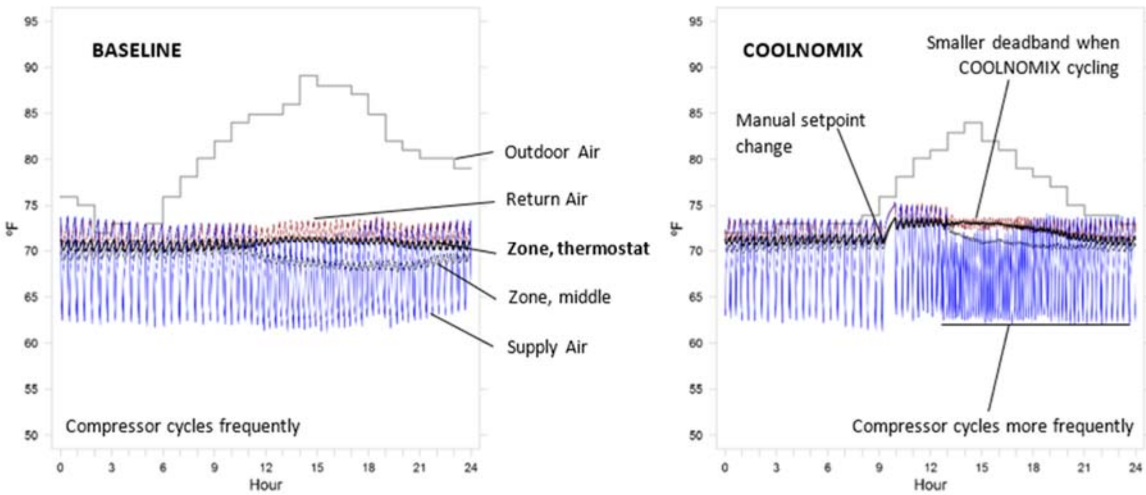

Figure 6-42. Temperature for Two Sample Days by COOLNOMIX Status.

6.4.4 Ventilation Fan Runtime

During site visits, we photographed the thermostats and found that occupants had changed the ventilation fan settings on between AUTO and ON at least six times (Table 6-16). Unfortunately, changes in ventilation strategy can strongly influence total cooling energy consumption. As we were unable to measure the ventilation fan status directly in this case, we rely on the known thermostat settings and insights from other cases to estimate ventilation effects.

Based on other cases, when COOLNOMIX is enabled, the ventilation fans tend to run most of the time, regardless of the thermostat fan control settings. This increases fan energy, while running fans overnight could increase or decrease the following day's thermal loads, depending on the outdoor temperature. Generally, on hot days, running the ventilation fans all the time increases cooling loads.

Table 6-16. Thermostat Settings Observed During the Test.

Date	Fan Status	Mode	Setpoint (°F)
2015-05-12	AUTO	COOL	70
2016-04-24	ON	COOL	69
2016-06-18	AUTO	COOL	72
2016-07-07	ON	COOL	71
2016-09-02	AUTO	COOL	70
2016-10-17	AUTO	HEAT	69
2017-02-15	AUTO	HEAT	75
2017-07-11	ON	COOL	68
2017-08-04	ON	COOL	72
2017-09-15	AUTO	COOL	70
2017-10-17	AUTO	COOL	72

6.4.5 Compressor Runtime

The cooling system was adequately sized and able to satisfy the loads throughout the cooling season, cycling normally throughout the day. During the initial phase, before COOLNOMIX was properly configured, the baseline and COOLNOMIX periods showed identical cycling behavior, indicating that COOLNOMIX was rarely engaging. After tuning up the unit and correcting the COOLNOMIX settings, the number of daily cycles increased with COOLNOMIX. The increase in cycles, however, was smaller than that seen in other tests (Figure 6-43), due to the relatively short cycles in the baseline (Table 6-12). Average cycle times were about 9-10 minutes in baseline and 6 minutes with COOLNOMIX.

Table 6-17. Compressor Cycle Duration.

Minutes Mean (Median)	PRE TUNE-UP		POST TUNE-UP	
Baseline	9	(10.3)	9	(9.8)
COOLNOMIX	9	(9.9)	6	(6.4)

Note: Cycle times in this table are qualitative, differences in weather could bias summaries. Based on days with CDD_{65}>5.

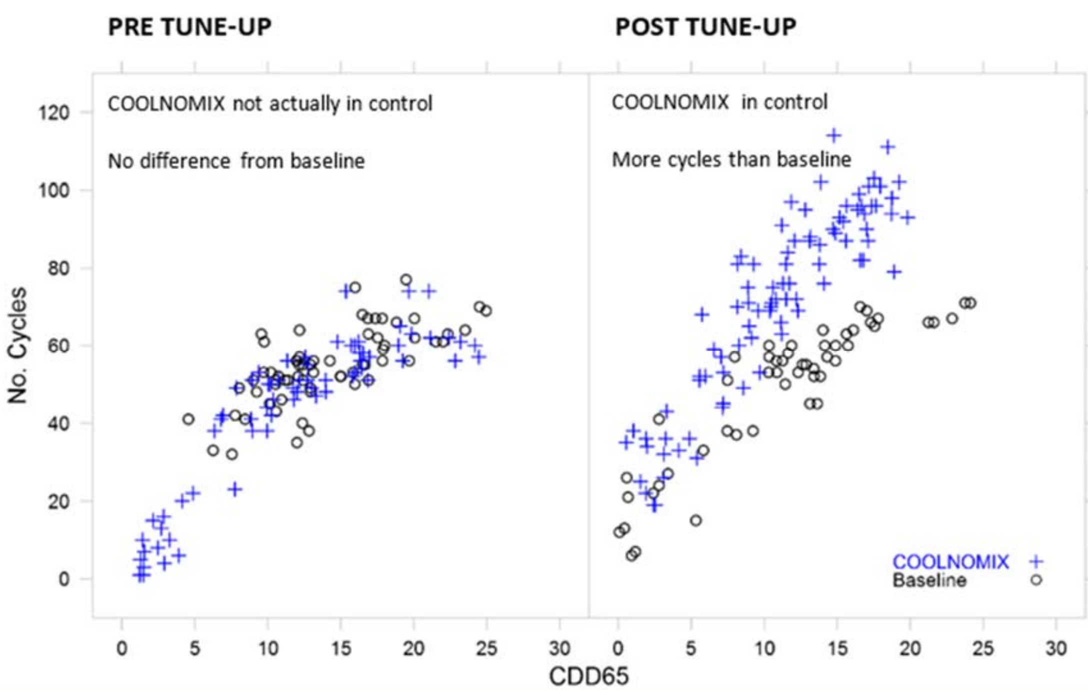

Figure 6-43. Compressor Cycles per Day vs. Cooling Degree Days, by Stage and Period.

6.4.6 Energy Performance

Condenser power draw for two sample days (Figure 6-44) shows typical hot day behavior. In both cases, the compressors cycled throughout the day and night. In the baseline, the cycles are slightly longer during the daytime. With COOLNOMIX working, compressor cycles are shortened during the day and at night.

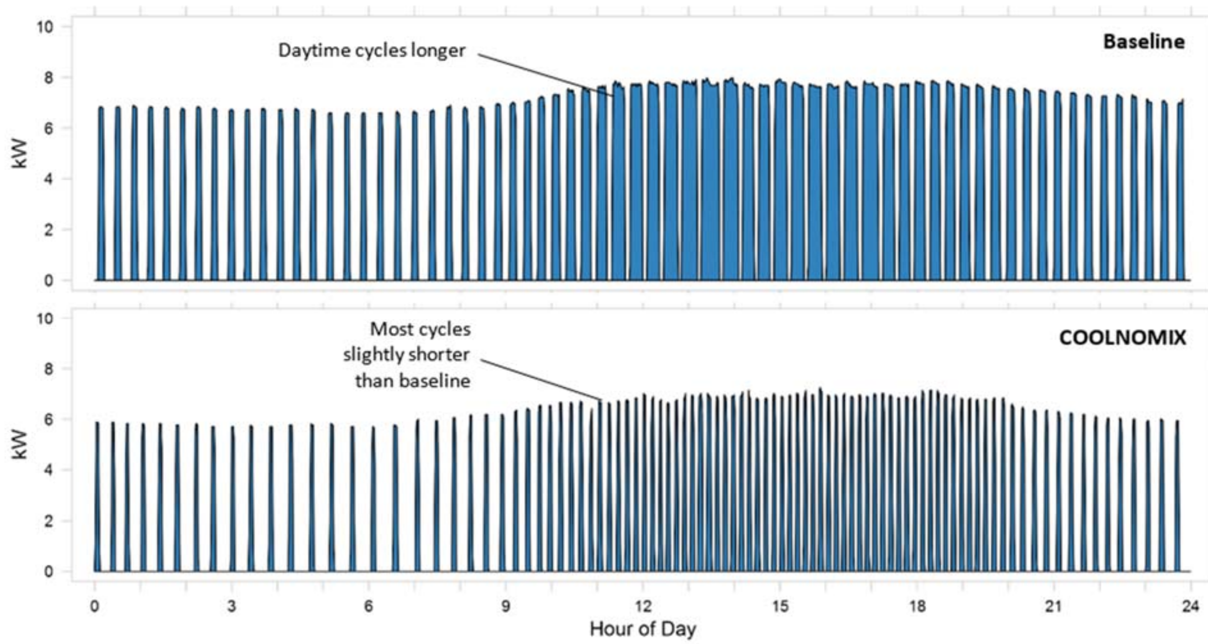

Figure 6-44. Compressor Power Draw vs. Time of Day, by COOLNOMIX Status for Two Sample Days.

Since COOLNOMIX was not working initially due to an incorrect setpoint, we focused on regression results on the post tune-up data set (Set 2, Figure 6-45) when trying to identify a COOLNOMIX effect. When developing regressions, we restricted data Set 2 to the range of CDD where both the baseline and COOLNOMIX periods had valid data ($2<CDD_{65}<20$). We also performed regressions on Set 1 and used these separately to predict energy use for the baseline.

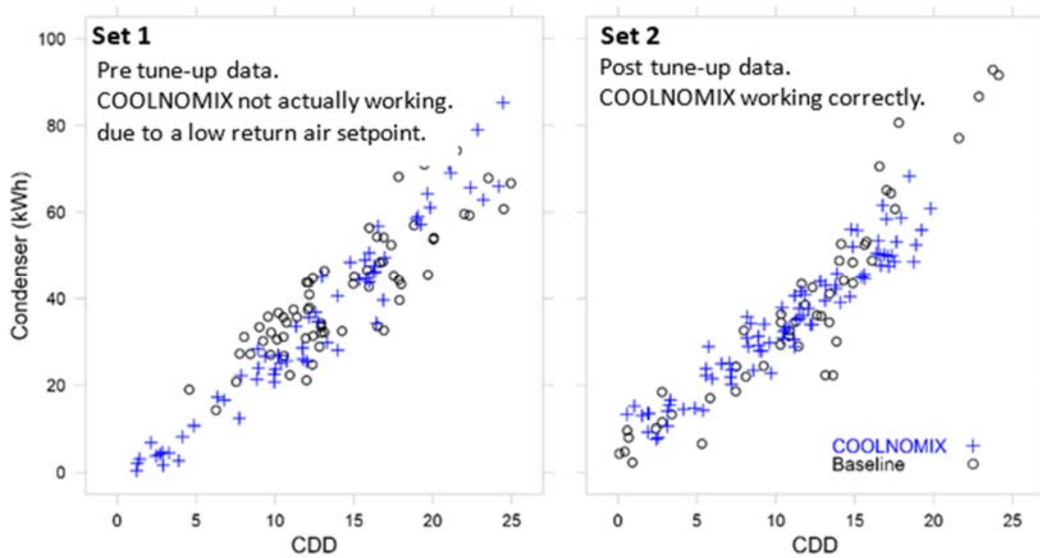

Figure 6-45. Condenser Energy Use vs. Cooling Degree Days by COOLNOMIX Status.

Multiple linear regressions were calculated to predict condenser energy use ($E_{condenser}$, kWh) based on cooling degree days (CDD_{65}), adjusted[28] cooling degree days (CDD_{adj}), occupancy (*OCC*, hours), and COOLNOMIX status. Separate combinations of these variables and interaction terms with COOLNOMIX status were tried to identify model parameters significant at the 0.05 level.

Cooling degree days explained about 83% of the total variance in the data. Adjusted cooling degree days, which adjust for the differences in average daily zone temperature, performed slightly better, and explained 85% of the total variance. Occupancy terms were also significant ($p<0.001$); however, COOLNOMIX interaction terms with CDD_{adj} and *OCC* were not ($p=0.08$, $p=0.21$, respectively).

Table 6-18. Condenser Energy Regression Models: Parameter Estimates and (Standard Errors).

(kWh) Term \ MODEL	M1		M2		M3		M4		M5		M6	
SET 1: PRE TUNE-UP, COOLNOMIX NOT YET WORKING												
Intercept	-2.63	(1.82)	0.33	(1.16)	**-6.03**	**(2.10)**	**-3.88**	**(1.30)**	**-**		**-**	
CDD_{65}	**3.03**	**(1.39)**			**3.04**	**(0.13)**						
CDD_{65}:CNMXon												
CDD_{adj}			**2.93**	**(0.09)**			**2.96**	**(0.82)**	**-**		**-**	
CDD_{adj}:CNMXon									-			
OCC					**0.80**	**(0.27)**	**0.97**	**(0.18)**			**-**	
OCC:CNMXon											-	
Adj. R^2	0.81		0.90		0.82		0.92		-		-	
AIC	725		652		718		628		-			
RMSE	6.35		4.57		6.10		4.05		-			
CV(RMSE)	0.18		0.13		0.18		0.12		-			
No. Obs.	110		110		110		110		-		-	
kWh Mean (SD)	34.6	(14.8)	34.6	(14.8)	34.6	(14.8)	34.6	(14.8)	-	-	-	-
SET 2: POST TUNE-UP, COOLNOMIX WORKING												
Intercept	1.95	(1.55)	1.39	(1.43)	**-2.89**	**(1.67)**	**-3.50**	**(1.51)**	**-3.50**	**(1.51)**	**-3.50**	**(1.51)**
CDD_{65}	**3.01**	**(0.13)**			**3.02**	**(0.11)**						
CDD_{65}:CNMXon												
CDD_{adj}			**3.06**	**(0.12)**			**3.06**	**(0.10)**	**3.06**	**(0.11)**	**3.06**	**(0.10)**
CDD_{adj}:CNMXon									0.00	(0.08)		
OCC					**1.20**	**(0.23)**	**1.21**	**(0.20)**	**1.21**	**(0.21)**	**1.18**	**(0.25)**
OCC:CNMXon											0.04	(0.21)
Adj. R^2	0.83		0.85		0.86		0.89		0.89		0.89	
AIC	782		763		758		734		736		736	
RMSE	6.14		5.67		5.51		4.98		4.98		4.98	
CV(RMSE)	0.17		0.15		0.15		0.14		0.14		0.14	
No. Obs.	120		120		120		120		120		120	
kWh Mean (SD)	36.6	(15.0)	36.6	(15.0)	36.6	(15.0)	36.6	(15.0)	36.6	(15.0)	36.6	(15.0)

Notes: Preferred model highlighted, based on Akaike Information Criteria (AIC). Significant terms in bold ($p<0.05$). Models with COOLNOMIX terms (Set 1, M5 and M6) not included, since COOLNOMIX was not engaging. Based on days with $2<CDD_{65}<20$.

[28] $CDD_{adj} = CDD_{65} - (T_{avg} - 72°F)$

To estimate actual condenser energy use, we applied models from Set 2 to 2017 cooling season weather data (days with CDD>2), observed 2017 occupancy data, and COOLNOMIX status. Based on these results, there was not statistically significant evidence for compressor energy savings with COOLNOMIX.

Table 6-19. Modeled Annual Condenser Energy Use (kWh).

	Set 1			Set 2		
Model	**Baseline**	**CNMX**	**Δ**	**Baseline**	**CNMX**	**Δ**
M1	4,947	-	**-**	5,650	-	**-**
M2	5,243	-	**-**	5,631	-	**-**
M3	4,924	-	**-**	5,627	-	**-**
M4	5,215	-	**-**	5,608	-	**-**
M5	-	-	**-**	5,613	5,607	**-6**
M6	-	-	**-**	5,592	5,617	**+24**

Notes: Cooling season includes 159 days (CDD_{65}>2) with a total of 1,770 CDD_{65}.
Occupancy averaged 4.0 h/d (SD 2.2).
Statistically-preferred models highlighted.

As noted earlier, we were unable to monitor ventilation fan runtime directly. To estimate fan energy consumption, we considered ALWAYS ON or AUTO control settings. ALWAYS ON assumes constant typical fan power during the cooling season. AUTO assumes the fan runs only when the compressor runs. Based on other cases with COOLNOMIX operating correctly, ventilation fan duty cycle is near 100% and mimics the ALWAYS ON state, even when the thermostat fan control is set to AUTO. Based on modeled compressor energy and typical compressor power draw of 6.5 kW, we estimate an average cooling season fan duty cycle of 21-22% in the AUTO mode (Set 1, Set 2 respectively). Assuming a fan motor power draw of approximately 1.5 kW (roughly corresponding to the 1.5 HP motor), seasonal fan energy is about 5,724 kWh in all cases except the AUTO mode in baseline (1,259 kWh).

Total modeled air conditioner energy use (Table 6-20) shows that the ventilation fans could consume about as much energy as the heat pump during the cooling season if kept on all the time. The actual fan energy penalty for COOLNOMIX depends on the actual modes used in the baseline and could be as high as 4,465 kWh. Since the ventilation fan likely ran significantly longer when COOLNOMIX was enabled (for at least part of the test), additional ventilation loads and fan energy would also have increased cooling loads. Even if COOLNOMIX had achieved the target 15% savings on condenser power draw, the annual savings would have been about 841 kWh, which is significantly less than the fan energy penalty.

Considering that ventilation rates were higher with COOLNOMIX, it is plausible to expect that condenser energy use would have increased significantly. That we did not observe such an increase suggests that COOLNOMIX may have demonstrated savings if ventilation rates were in fact kept similar across periods. Thus, in situations where the ventilation fans are always on, or controlled separately from the thermostat, savings may be possible or more likely. This is consistent with findings across the other test sites in this study.

Table 6-20. Modeled Annual Air Conditioner Energy Use (kWh).

Set	Condenser	Ventilation Fan	Total	kWh/ft²
Set 1 (Pre tune-up, Fan ON)	5,215	5,724	**10,939**	5.2
Set 1 (Pre tune-up, Fan AUTO)	5,215	1,203	**6,418**	3.1
Set 2 (Post tune-up, Fan ON)	5,608	5,724	**11,332**	5.4
Set 2 (Post tune-up, Fan AUTO)	5,608	1,259	**6,867**	3.3

Notes: Based on model M4 applied to 2017 cooling season (CDD_{65}>2) of 159 days, 1,770 CDD_{65}. Occupancy averaged 4.0 h/d (SD 2.2).

In sum, although COOLNOMIX was ultimately working correctly (after adjusting its setpoints) and did increase compressor cycling, it did not have a measurable impact on condenser energy use. This was due at least in part to extra ventilation associated with the fan running all the time.

6.5 AIR CONDITIONING SITE 5: HUMID CLIMATE

6.5.1 Site, Equipment, and Controls

We installed COOLNOMIX near the air handler of a single-zone single-story brick building (about 2,700 ft², Figure 6-46), cooled by a split system heat pump. The building included an open plan area, a restroom, and several small offices. There were few windows and three doors, one that was frequently propped open slightly. Conditioned air was provided through ducts in the attic space.

Figure 6-46. COOLNOMIX Air Conditioning Installation.

The 7.5-ton split system heat pump (York model E3FB090A25A) included a compressor motor and 3/4 HP condenser fan. The air handler had a belt-driven motor. Outdoor air dampers were fixed and no economizer was installed. We submetered the heat pump power draw on a circuit that included the compressor and condenser fan. The ventilation fan was monitored using a fan motor state sensor. The RTU was older (15+ years), and initially struggled to meet the load on hot days. This issue was resolved after refrigerant charge was corrected following a service call.

A single non-programmable digital thermostat, centrally located in the zone, controlled the space temperature. A large paper sign posted on the thermostat instructed occupants not to touch the thermostat under any circumstances and seemed rather effective. The thermostat also controlled the blower fan. During the cooling season, the fan was normally set to ALWAYS ON.[29]

[29] Keeping the fans always on consumes unnecessary electricity and introduces additional outdoor air that must be

Although COOLNOMIX was connected properly, it apparently did not control the compressor during most of the first-year test due to a poorly located return air sensor. In addition, during the first year, an unrelated cooling problem led a technician to disconnect the COOLNOMIX control wires during diagnosis without notifying anyone and without reconnecting them. This was discovered during the summer of the second year, and COOLNOMIX was then reconnected. At that time, we also identified and corrected a low refrigerant charge and extended the COOLNOMIX return air sensor wires through the ductwork. On a subsequent visit, occupants indicated the zone temperatures were uncomfortably warm, so we again re-wired the return air sensor, this time closer to the thermostat.

FINDING: Return air sensor placement is critical and can strongly influence occupant comfort and energy savings potential. Indoor zone temperatures can vary significantly by location. It could take several tries to find a spot that is adequately representative and stable.

FINDING: Technicians unfamiliar with COOLNOMIX may disconnect or disable it while diagnosing unrelated HVAC problems. In addition to proper training, it may be necessary to periodically check the connections as part of routine maintenance.

6.5.2 Occupancy

Occupancy followed a typical office schedule with hours of operation from 6AM to 4PM, Monday through Friday (Figure 6-47 and Figure 6-48).

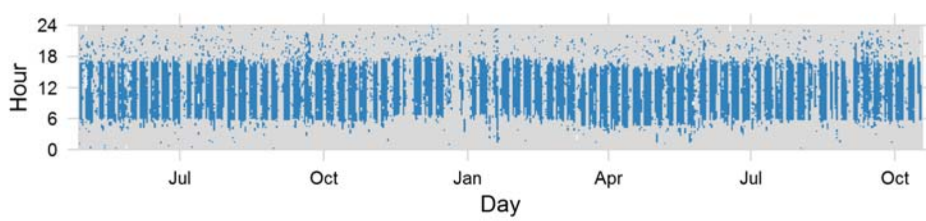

Figure 6-47. Occupancy by Day and Hour.

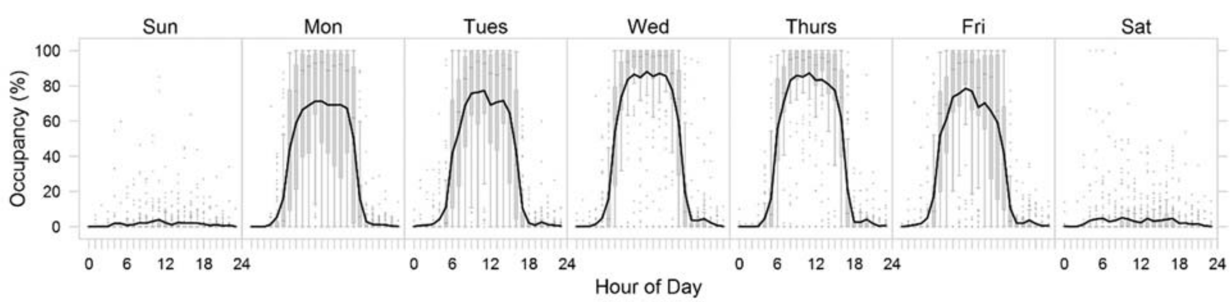

Figure 6-48. Occupancy Profiles by Day of Week.

conditioned.

6.5.3 Thermal Comfort

At the start of the test, the air conditioning system was unable to satisfy the cooling loads on hot days due to low refrigerant charge (Figure 6-49). After correcting the charge, temperatures returned to normal. During the remainder of the first year, temperatures were relatively consistent across periods with COOLNOMIX enabled or disabled. However, there COOLNOMIX may not have been cycling during much of this time. A second-year recommissioning visit, revealed that the COOLNOMIX control wires had been manually disconnected by a maintenance technician sometime prior, likely during the initial service call.

During the recommissioning visit and prior to the second-year test, we increased the COOLNOMIX setpoint and extended the return air sensor into a return air duct to promote cycling. We also checked and made minor adjustments to the refrigerant charge and ventilation fan belt. During a follow-up visit, occupants indicated that zone temperatures were higher than usual, so we repositioned the COOLNOMIX return air sensors a final time, this time near the thermostat, resolving the comfort issues.

Second year zone temperatures fluctuated more than in the first year, especially during periods with COOLNOMIX disabled, indicative of manual thermostat adjustments. When COOLNOMIX ran shorter cycles, the temperature deadband decreased, though it was already relatively tight in the baseline (Figure 6-51). Relative humidity frequently exceeded 60% in all periods (Figure 6-50), and tended to be higher with COOLNOMIX enabled.

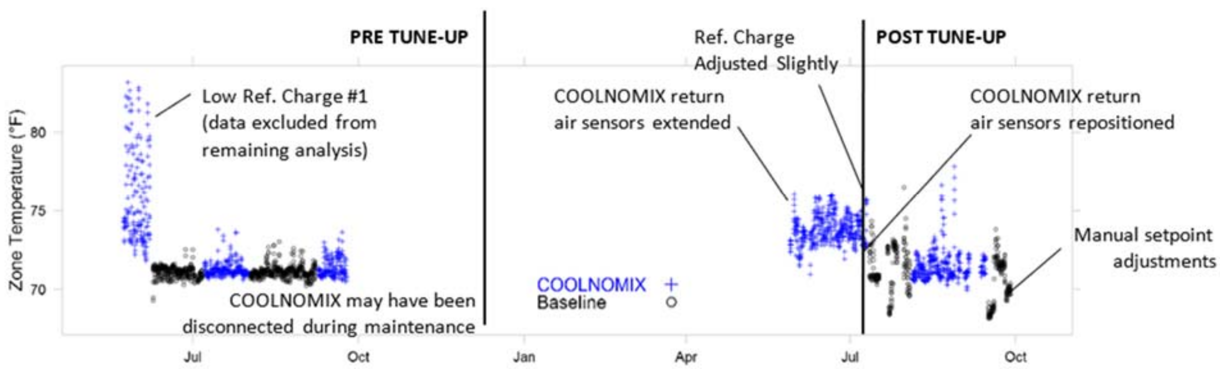

Figure 6-49. Average Hourly Zone Temperature During Occupied Hours.

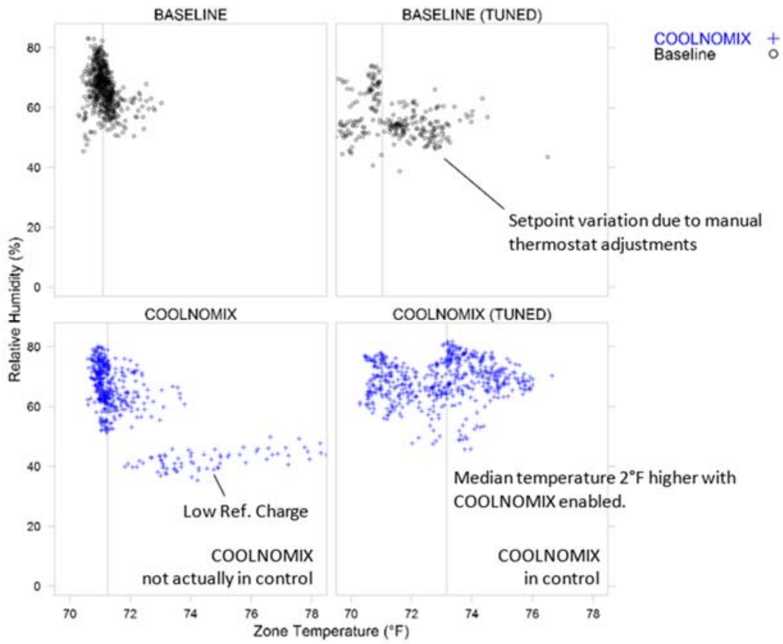

Figure 6-50. Relative Humidity vs. Zone Temperature (near thermostat), Hourly Averages During Occupied Hours.

Vertical lines represent medians.

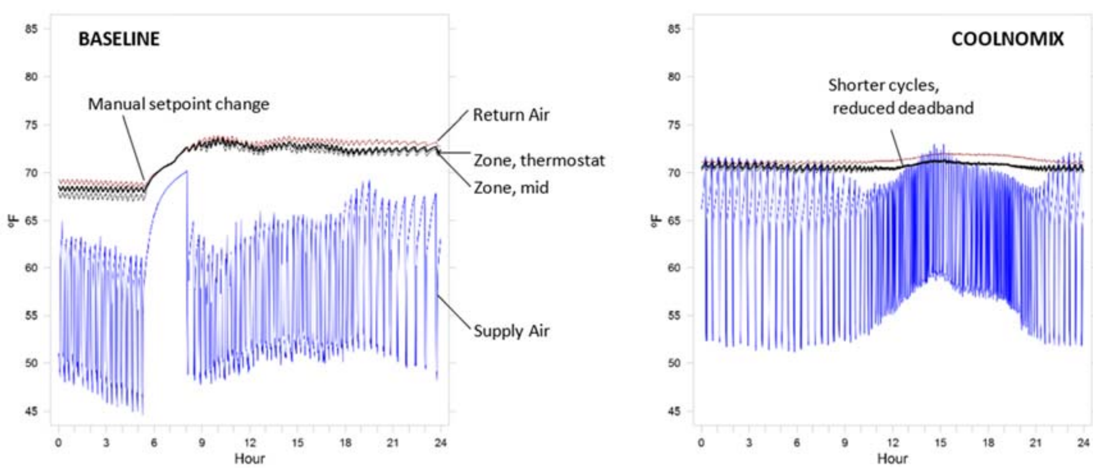

Figure 6-51. Temperature for Two Sample Days by COOLNOMIX Status.

6.5.4 Ventilation Fan Runtime

Thermostat control settings of ventilation fan runtime apparently changed periodically during the test from always on to intermittent mode, likely due to occupant intervention (Figure 6-52). During the post-tune up period (second year test), the fan ran continuously on most days that COOLNOMIX enabled and cycled on most days that COOLNOMIX was enabled. When set to intermittent mode, COOLNOMIX tends to cause the fans to run longer than they otherwise would.

Since ventilation comprises much of the cooling and heating loads, these differences in ventilation control can significantly impact both cooling and fan energy consumption.

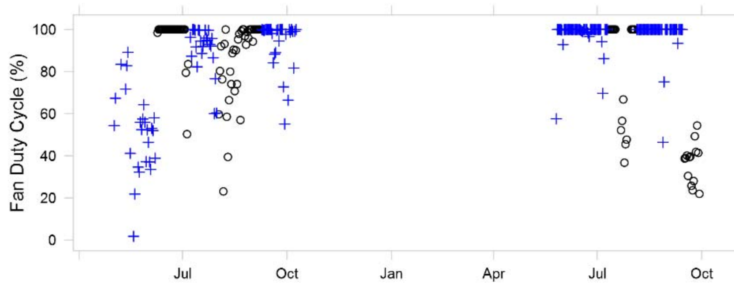

Figure 6-52. Fan Duty Cycle by COOLNOMIX Status.

6.5.5 Compressor Runtime

After correcting the refrigerant charge, the unit was adequately sized to satisfy the cooling loads, cycling normally throughout the day on most days. During the initial phase (pre tune-up, before COOLNOMIX was working right), cycling behavior was essentially the same. After COOLNOMIX was configured properly (post tune-up), cycle durations were about half that of the baseline (Table 6-7) and the number of daily cycles increased from about 50 to 120 cycles per day (Figure 6-53). These results confirm that COOLNOMIX was not in control or had minimal effect during the pre tune-up period.

Table 6-21. Compressor Cycle Duration.

Minutes Median (Mean)	PRE TUNE-UP		POST TUNE-UP	
Baseline	12	(19.2)	12	(28.2)
COOLNOMIX	12	(20.1)	6	(14.1)

Note: Cycle times in this table are qualitative, differences in weather could bias summaries.

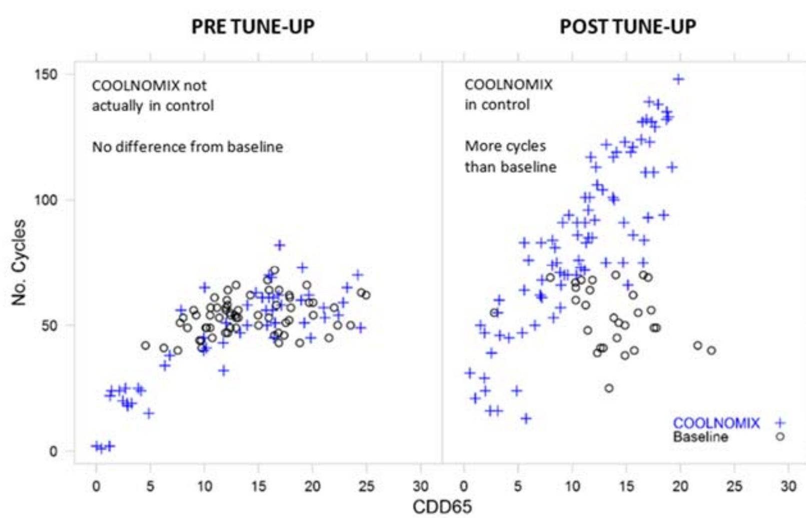

Figure 6-53. Compressor Cycles Per Day vs. Cooling Degree Days, by Stage and Period.

6.5.6 Energy Performance

Condenser power draw on typical hot days shows cycling throughout the day and night (Figure 6-54). Cycle duration was about twice as long in the baseline.

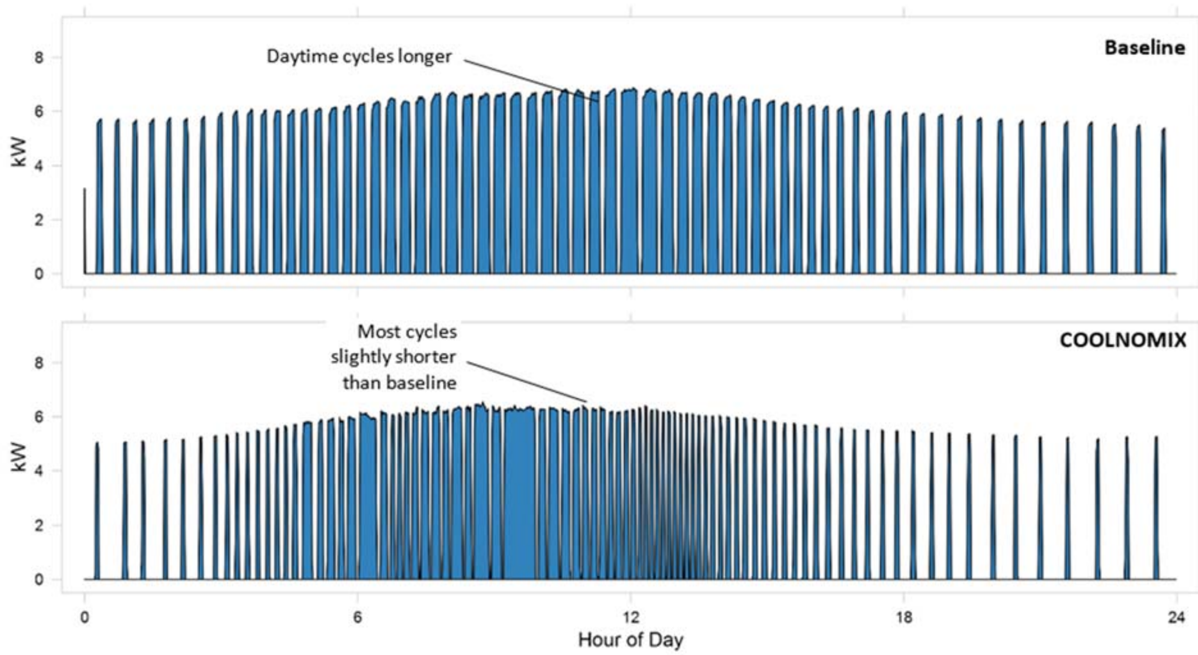

Figure 6-54. Condenser Power Draw vs. Time of Day, by COOLNOMIX Status for Two Sample Days.

Due to the limited post tune-up data and inconsistencies in fan settings and temperature setpoints across periods, we performed regressions on two separate filtered data sets (Figure 6-55). Set 1 includes only the post tune-up data and has notable differences in fan behavior and setpoint temperature discussed earlier. Set 2 is larger and includes baseline data from any period (pre- or post-tune-up), COOLNOMIX data from post-tune-up only. All days in Set 2 are filtered to require fan duty cycle above 90%.

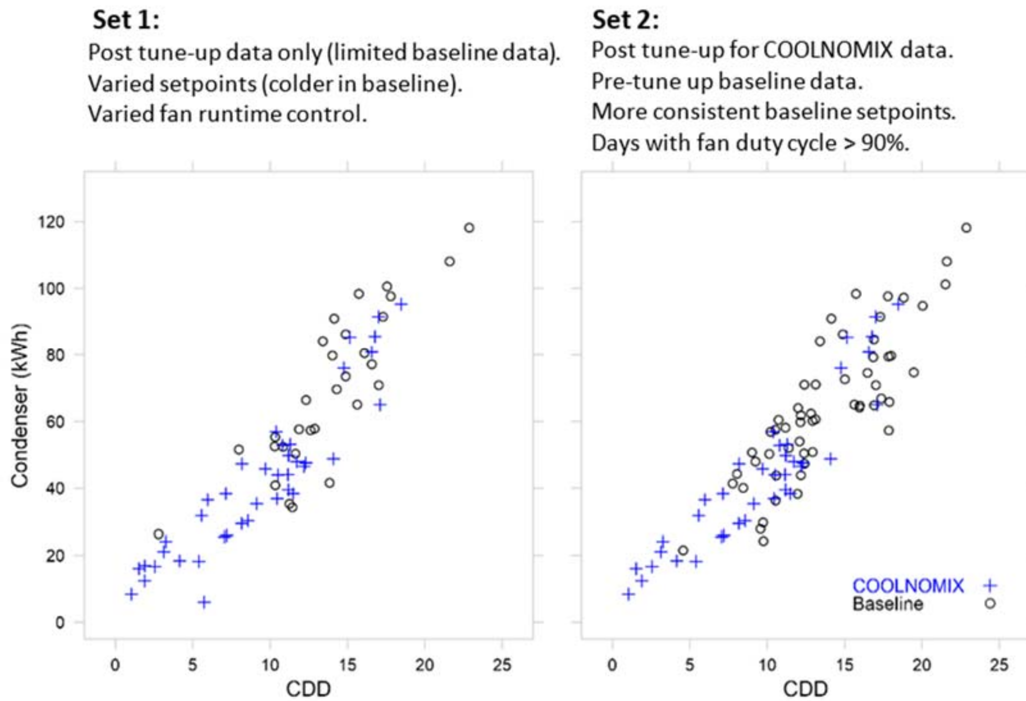

Figure 6-55. Condenser Energy Use vs. Cooling Degree Days by COOLNOMIX Status.

Multiple linear regressions were calculated to predict condenser energy use $E_{condenser}$ (kWh) based on cooling degree days (CDD_{65}), occupancy (*OCC*, hours), and COOLNOMIX status. Separate combinations of these variables and interaction terms with COOLNOMIX status were tried to identify model parameters significant at the 0.05 level.

Cooling degree days explained over 80% of the total variance in the data. Based on Set 1, COOLNOMIX appeared to save about 0.5 kWh per CDD_{65} ($p<0.05$, Set 1 M2, Table 6-22); however, this effect was no longer statistically significant after controlling for occupancy (M3-M6). Model M5 suggests a savings of up to 0.64 kWh per occupied hour ($p<0.05$); however, differences in fan cycling patterns and setpoint temperatures in Set 1, noted earlier, further confound these results. For instance, realized zone temperatures were about 2°F higher in the COOLNOMIX case for Set 1, which could explain the apparent savings.

Results for Set 2, which better control for fan runtime and realized zone temperature, suggest no statistically significant COOLNOMIX terms for the preferred model (Set 2 M3, Table 6-22). Model M6, if valid, suggests a significant COOLNOMIX occupancy term (-0.77 kWh/occupied hour) that is counteracted by an increase in energy with degree days (0.34 kWh/CDD_{65}).

Table 6-22. Condenser Energy Regression Models: Parameter Estimates and (Standard Errors).

(kWh) Term \ MODEL	M1		M2		M3		M4		M5		M6	
SET 1: POST TUNE-UP ONLY (differences in zone temperature and fan settings)												
Intercept	-1.60	(3.27)	0.41	(3.30)	**-8.90**	**(3.09)**	**-7.19**	**(3.23)**	**-6.51**	**(3.24)**	**-1.97**	**(0.05)**
CDD_{65}	**4.93**	**(0.27)**	**4.98**	**(0.26)**	**4.86**	**(0.22)**	**4.90**	**(0.22)**	**4.66**	**(0.24)**	**4.68**	**(0.28)**
CDD_{65}:CNMXon			**-0.49**	**(0.03)**			-0.31	(0.19)			-0.06	(0.28)
OCC					**1.31**	**(0.25)**	**1.23**	**(0.25)**	**1.62**	**(0.29)**	**1.57**	**(0.37)**
OCC:CNMXon									**-0.64**	**(0.31)**	-0.57	(0.47)
Adj. R^2	0.83		0.84		0.88		0.88		0.88		0.88	
AIC	538		535		516		515		513		515	
RMSE	10.8		10.4		9.09		8.92		8.82		8.81	
CV(RMSE)	0.2		0.19		0.17		0.17		0.16		0.16	
No. Obs.	70		70		70		70		70		70	
kWh Mean (SD)	53.7	(26.8)	53.7	(26.8)	53.7	(26.8)	53.7	(26.8)	53.7	(26.8)	53.7	(26.8)
SET 2: POST TUNE-UP COOLNOMIX, ANY BASELINE (days with fan duty>90%)												
Intercept	0.47	(2.93)	1.01	(3.05)	**-6.67**	**(2.38)**	**-6.80**	**(2.50)**	**-5.48**	**(2.51)**	**-5.81**	**(2.49)**
CDD_{65}	**4.59**	**(0.23)**	**4.59**	**(0.23)**	**4.42**	**(0.17)**	**4.42**	**(0.17)**	**4.32**	**(0.19)**	**4.21**	**(0.20)**
CDD_{65}:CNMXon			-0.13	(0.19)			0.15	(0.17)			0.34	(0.20)
OCC					**1.55**	**(0.18)**	**1.55**	**(0.19)**	**1.68**	**(0.20)**	**1.89**	**(0.24)**
OCC:CNMXon									-0.35	(0.25)	**-0.77**	**(0.35)**
Adj. R^2	0.81		0.81		0.89		0.89		0.89		0.89	
AIC	734		735		681		683		681		680	
RMSE	10.3		10.3		7.8		7.8		7.7		7.6	
CV(RMSE)	0.18		0.18		0.14		0.14		0.14		0.13	
No. Obs.	97		97		97		97		97		97	
kWh Mean (SD)	56.2	(24.0)	56.2	(24.0)	56.2	(24.0)	56.2	(24.0)	56.2	(24.0)	56.2	(24.0)

Notes: Preferred model highlighted, based on Akaike Information Criteria (AIC). Significant terms in bold ($p<0.05$).

To estimate actual compressor energy use, we applied models from Set 1 and Set 2 to 2017 cooling season weather data (days with CDD>2), observed 2017 occupancy data, and COOLNOMIX status. As noted earlier, Set 2 is a more consistent comparison, owing to more similar thermostat and fan control settings.

Table 6-23. Modeled Annual Compressor Energy Use (kWh).

	Set 1			Set 2		
Model	**Baseline**	**CNMX**	**Δ**	**Baseline**	**CNMX**	**Δ**
M1	8,470	-	**-**	8,207	-	**-**
M2	8,886	8,013	**-874**	8,283	8,060	**-223**
M3	8,453	-	**-**	8,261	-	**-**
M4	8,716	8,165	**-551**	8,247	8,291	**-45**
M5	8,768	8,152	**-616**	8,395	8,053	**-342**
M6	8,783	8,132	**-651**	8,345	8,214	**-130**

Notes: Cooling season includes 159 days ($CDD_{65}>2$) with a total of 1770 CDD_{65}.
Occupancy averaged 6.1 h/d (SD 4.3).
Statistically-preferred models highlighted.

To estimate ventilation fan energy consumption, we considered two scenarios: always ON and AUTO. Always ON assumes constant fan power during the cooling season (about 3,816 hours). AUTO assumes the fan runs only when the compressor runs. Based on modeled compressor energy and typical compressor power draw of 6.4 kW, we estimate an average fan duty cycle of 33% over the season in baseline and near 100% duty cycle for COOLNOMIX (97% observed during days in the study). Assuming a fan motor power draw of approximately 1 kW (roughly corresponding to a 1 HP motor, specs not available), seasonal fan energy is 3,816 kWh in all cases except the intermittent baseline (1,272 kWh).

Table 6-24. Estimated Annual Energy Use Impact.

	Ventilation Fans Intermittent (Set 1)			Ventilation Fans Always On (Set 2)			
	COMP	FAN	TOTAL	COMP	FAN	TOTAL	kWh/ft^2
Baseline	8,453	1,272	**9,725**	8,261	3,816	**12,077**	4.5
COOLNOMIX	8,453	3,816	**12,269**	8,261	3,816	**12,077**	4.5
Δ kWh	-	+2,544	**+2,544**	-	-	**-**	
% change	-	+200%	**+26%**	-	-	**-**	

Notes: Based on M3 models.
COOLNOMIX compressor energy savings estimates not statistically significant.

In conclusion, although COOLNOMIX functioned correctly and increased compressor cycling, energy savings were minimal at best. The best-case model from Set 2 (M5) predicted an annual compressor savings of about 4% (342 kWh/yr), assuming the ventilation fans are always programmed to stay on. In contrast, if the fans are set to intermittent, fan runtime could double with COOLNOMIX, increasing overall cooling energy consumption by at least 26% (+2,544 kWh/yr). By keeping the fans on all the time, COOLNOMIX could inconsistently affect zone loads from ventilation (increasing them during hot days, and potentially mitigating some through night ventilation), leading to unpredictable savings.

6.6 AIR CONDITIONING SITE 6: HUMID CLIMATE

6.6.1 Site, Equipment, and Controls

We installed COOLNOMIX in a packaged rooftop unit serving a single-zone first-floor break room (about 2,500 ft^2, Figure 6-56) adjacent to a three-story building. The zone included an open-plan area, several small offices, and a restroom, with east-facing windows and two main exterior doors. Conditioned air was provided through a ducted plenum via vents and curtain diffusers.

Figure 6-56. COOLNOMIX Air Conditioning Installation.

The 7.5-ton RTU (TRANE model TWE090A100BA) included a compressor motor, condenser fan, and ventilation fan. Outdoor air dampers were fixed and no economizer was installed. We submetered the heat pump power draw on a circuit that included all components. The RTU, manufactured in 1992, was in good operating condition. Fan filters were routinely replaced. Refrigerant charge was initially found to be low and was corrected early in the first-year test. In the second year, charge was checked again, and minor adjustments were made (post tune-up).

A single non-programmable digital thermostat, centrally located in the zone, controlled the space temperature. Despite setting thermostat the setpoint to 72°F and requesting it be kept there, occupants could adjust the setpoint and did so frequently to manage their comfort. Since this break room was used by a large number of staff, it is likely there were many different competing temperature preferences, leading to high variability in zone temperature. The thermostat controlled the ventilation fan, and occupants occasionally switched these settings between AUTO and ON.

At this test site, COOLNOMIX did not appear to influence the compressor. In the second year, we identified several potential causes including low refrigerant charge (leading to insufficient capacity), poor COOLNOMIX return air sensor placement (inside the RTU), and a COOLNOMIX setpoint that was too low. To address these issues, we adjusted the refrigerant charge and reconfigured COOLNOMIX for the second-year test, increasing its setpoint and extending the return-air sensor through a return-air duct into the conditioned zone. Despite these actions, COOLNOMIX still did not apparently influence the compressor, potentially due to a hardware fault or incorrect control wiring.

FINDING: Low refrigerant charge, a common fault, could limit COOLNOMIX performance because it reduces system capacity. Units should be well maintained prior to installation.

FINDING: A field commissioning protocol is needed to verify that COOLNOMIX is correctly measuring supply and return air temperatures and that its relay is actually controlling the compressor.

6.6.2 Occupancy

Occupancy was consistent seven days a week, from about 6 AM to 6PM, and averaged 6.7 hours per day (Figure 6-57 and Figure 6-58).

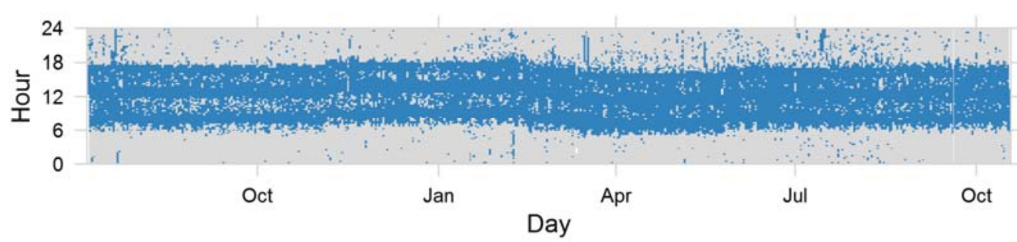

Figure 6-57. Occupancy by Day and Hour.

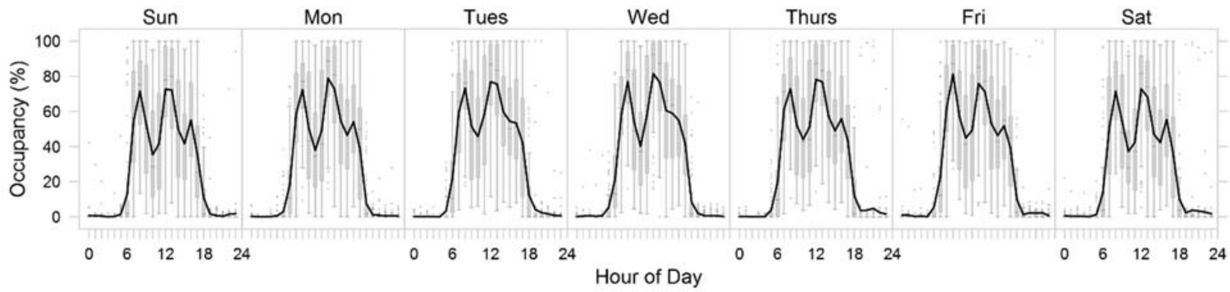

Figure 6-58. Occupancy Profiles by Day of Week.

6.6.3 Thermal Comfort

Frequent manual thermostat adjustments led to highly variable zone temperatures from about 68-76°F (Figure 6-59, Figure 6-60, and Figure 6-61). The RTU was able to maintain the desired setpoints during all test periods. Relative humidity was frequently above 60% before the tune-up, and dehumidification apparently improved after adding refrigerant (post tune-up). COOLNOMIX did not have a significant effect on temperature or humidity. Temperature deadband did not apparently decrease with COOLNOMIX enabled (Figure 6-61). In addition, while COOLNOMIX was enabled, the zone temperatures occasionally remained well below the COOLNOMIX setpoint (73°F), suggesting a problem with the COOLNOMIX installation.

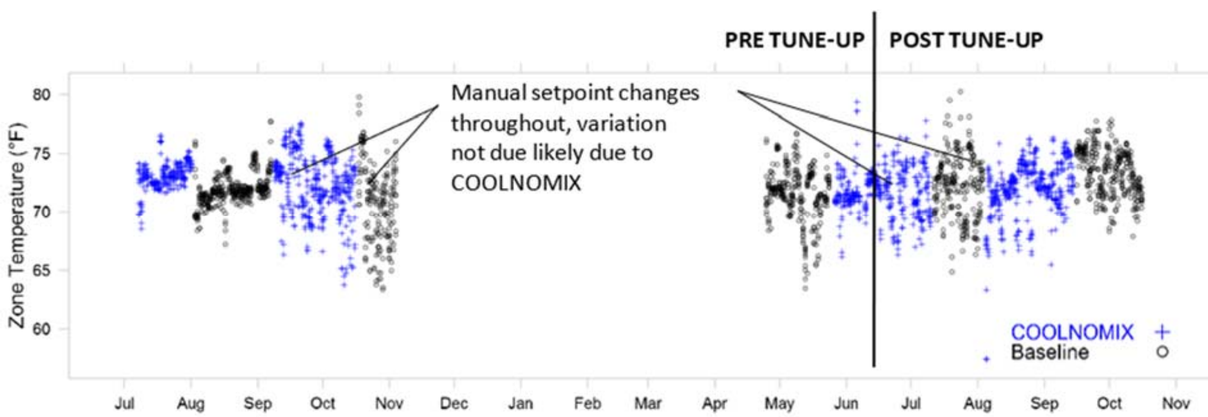

Figure 6-59. Average Hourly Zone Temperature During Occupied Hours.

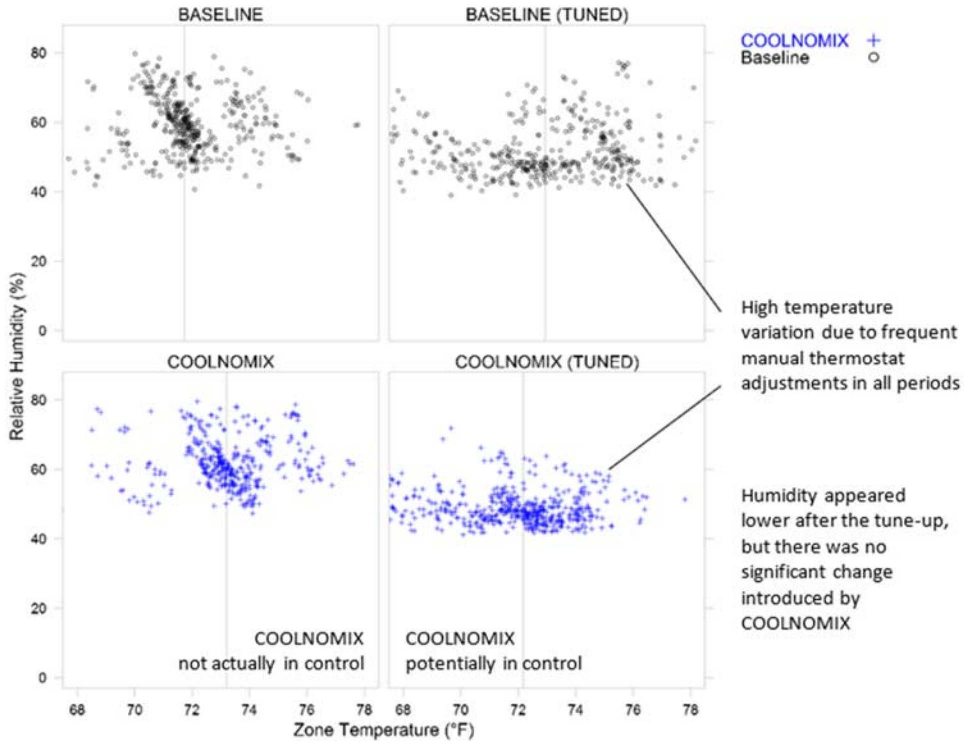

Figure 6-60. Relative Humidity vs. Zone Temperature (Near Thermostat).

Hourly averages during occupied hours, days with CDD65>10.
Vertical lines represent medians.

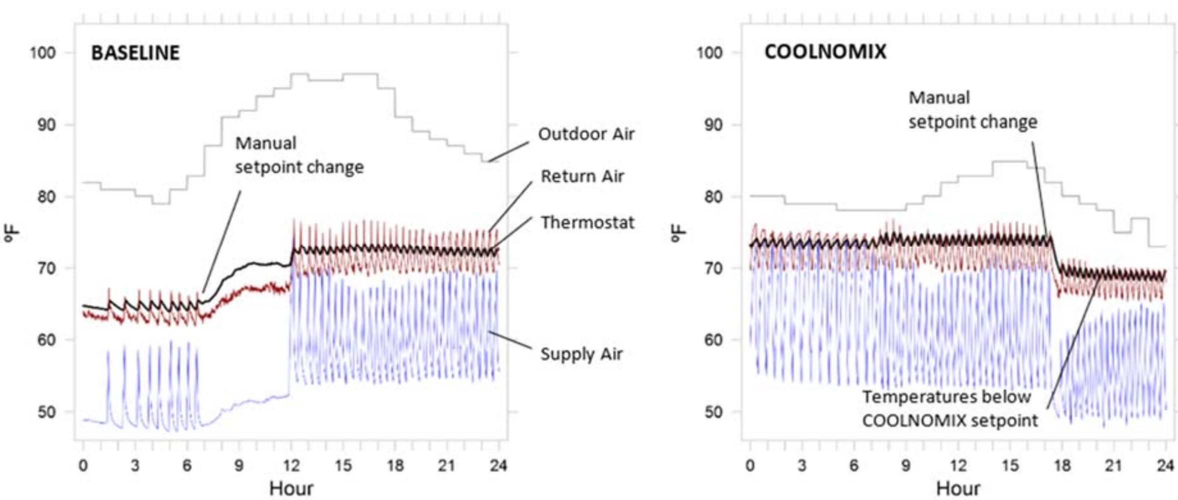

Figure 6-61. Temperature for Two Sample Days with Manual Setpoint Changes, by COOLNOMIX Status.

6.6.4 Ventilation Fan Runtime

The fans on this unit were initially programmed to run continuously; however, the occupants apparently changed these settings occasionally during the test (Figure 6-62). Most of the first year (pre tune-up), the fans were ALWAYS ON. In contrast, most of the second year, after COOLNOMIX was reconfigured, the fans were usually set to AUTO.

Typically, when fans are set to AUTO, COOLNOMIX causes fan duty cycle to increase significantly and stay on most of the time. This behavior was not seen here, providing further evidence that COOLNOMIX was not working properly at this site.

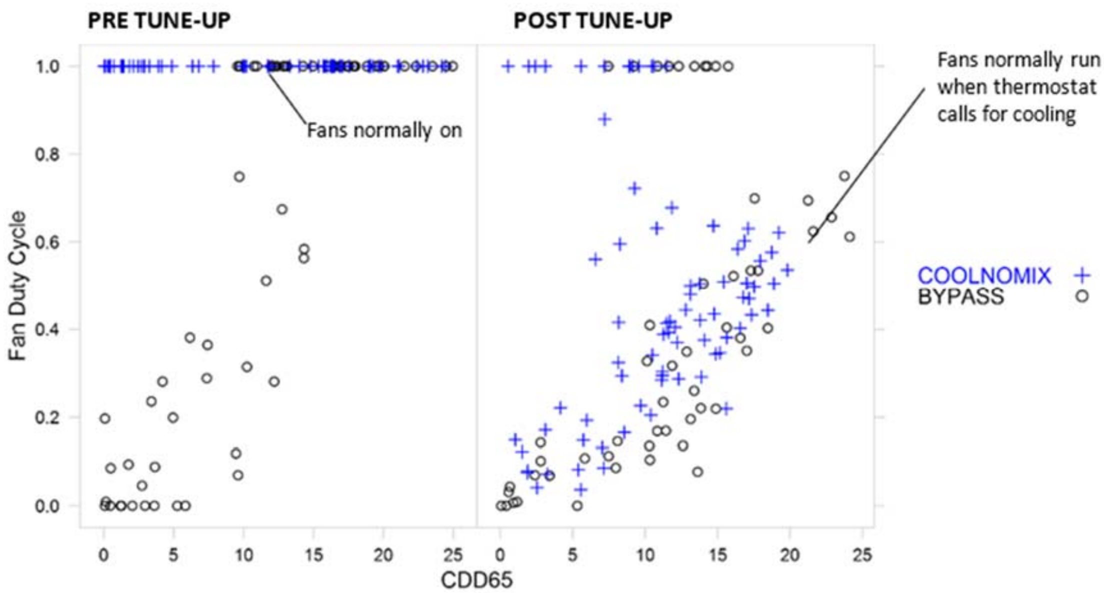

Figure 6-62. Ventilation Fan Duty Cycle by Period.

6.6.5 Compressor Runtime

The RTU was adequately sized and able to satisfy the loads throughout the cooling season, cycling normally throughout the day. During the initial phase (pre tune-up), the baseline and COOLNOMIX periods showed similar cycling behavior, showing no clear difference from baseline. After tuning up the unit and reconfiguring COOLNOMIX, the number of daily cycles appears to have increased, but only slightly and much less than for all other tests (Figure 6-63). The average cycle duration was also not significantly affected Table 6-12), suggesting that COOLNOMIX had little effect, despite the reconfiguration efforts.

Table 6-25. Compressor Cycle Duration.

Minutes Mean (Median)	PRE TUNE-UP	POST TUNE-UP
Baseline	15 (17.8)	13 (15.5)
COOLNOMIX	15 (17.0)	13 (15.1)

Note: Cycle times are qualitative, differences in weather could bias summaries. Based on days with CDD65>10.

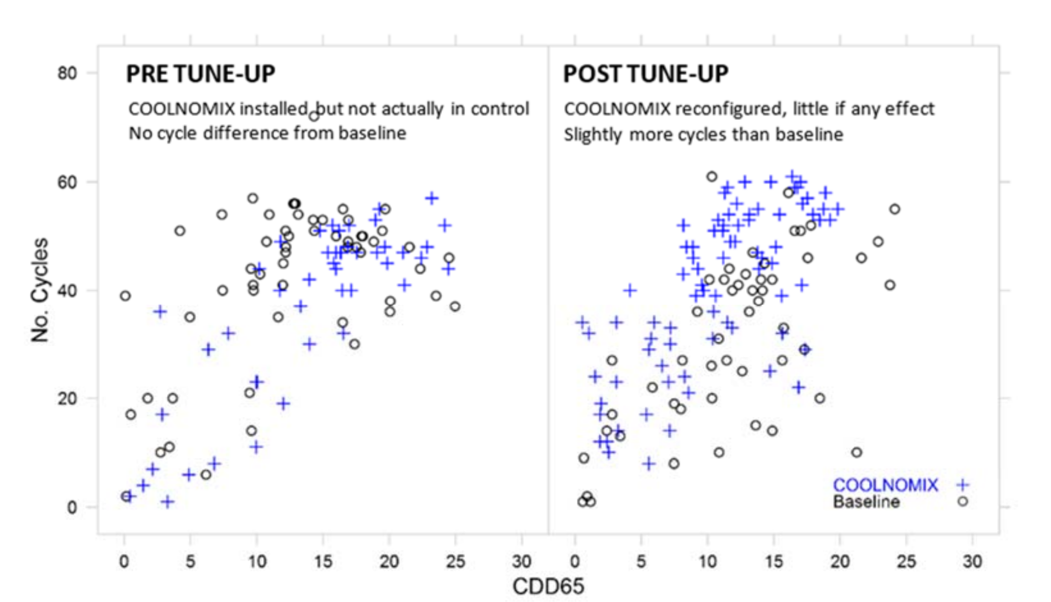

Figure 6-63. Compressor Cycles Per Day vs. Cooling Degree Days, by Stage and Period.

6.6.6 Energy Performance

Condenser power draw for a typical hot day shows compressors cycling throughout the day and night (Figure 6-64). Cycle duration was not significantly different with COOLNOMIX enabled. When set to AUTO, the ventilation fan did not run between cycles even with COOLNOMIX enabled, a clear indication that COOLNOMIX was not active.

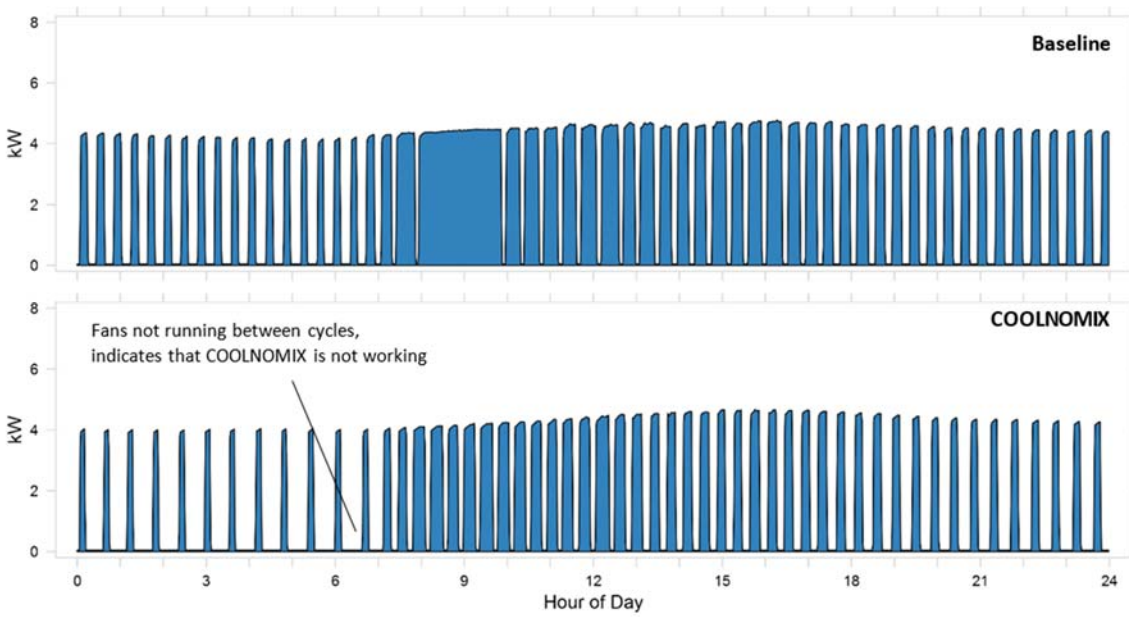

Figure 6-64. Condenser Power Draw vs. Time of Day, by COOLNOMIX Status for Two Sample Days.

Since COOLNOMIX was not active, we could not calculate energy savings for this case. For completeness, we estimate the annual energy consumption. Multiple linear regressions were calculated to predict condenser energy use $E_{condenser}$ (kWh/d) based on cooling degree days (CDD_{65}) and occupancy (*OCC*, hours). Separate combinations of these variables were tried to identify model parameters significant at the 0.05 level.

We tried regressions on four data sets, splitting the data two ways. First, we examined the pre- and post- tuned periods (Sets 1 and 2), and second, we filtered data by periods with the fan set to ALWAYS ON or AUTO (Sets 3 and 4). Cooling degree days explained 62-71% of the total variance in the data, while occupancy improved the regressions marginally.

Table 6-26. Condenser Energy Regression Models: Parameter Estimates and (Standard Errors).

	SET 1 (PRE-TUNE)				SET 2(POST-TUNE)				SET 3 (FAN ON)				SET 4 (FAN AUTO)			
(kWh/d) Term \ MODEL	M1		M2		M1		M2		M1		M2		M1		M2	
Intercept	-0.97	(3.17)	**-14.7**	**(5.79)**	-3.12	(2.39)	**-12.1**	**(4.25)**	-2.48	(2.95)	**-11.41**	**(5.16)**	-2.32	(2.59)	**-16.68**	**(4.67)**
CDD_{65}	**2.94**	**(0.21)**	**2.91**	**(0.20)**	**2.81**	**(0.19)**	**2.69**	**(0.19)**	**3.01**	**(0.19)**	**2.96**	**(0.19)**	**2.76**	**(0.20)**	**2.60**	**(0.20)**
OCC			**2.17**	**(0.78)**			**1.63**	**(0.64)**			**1.52**	**(0.73)**			**2.50**	**(0.69)**
Adj. R^2	0.67		0.70		0.66		0.68		0.71		0.72		0.62		0.66	
AIC	752		747		867		863		762		760		863		852	
RMSE	11.3		10.9		9.6		9.3		10.2		10.0		10.7		10.1	
CV(RMSE)	0.28		0.27		0.30		0.30		0.25		0.25		0.36		0.34	
No. Obs.	97		97		117		117		101		101		113		113	
kWh Mean (SD)	40.8	(20.1)	40.8	(20.1)	30.2	(16.6)	30.2	(16.6)	40.5	(19.1)	40.5	(19.1)	30.1	(17.5)	30.1	(17.5)

Notes: Preferred model highlighted, based on Akaike Information Criteria (AIC). Significant terms in bold ($p<0.05$). COOLNOMIX was apparently not functioning in this case.

To estimate actual compressor energy use, we applied models to 2017 cooling season weather data (days with $CDD_{65}>2$), observed occupancy data, and COOLNOMIX status (Table 6-20). To estimate fan energy consumption, we considered ALWAYS ON or AUTO control settings. Always on assumes constant typical fan power during the cooling season (0.65 kW for about 3,816 hours). AUTO assumes the fan runs only when the compressor runs. Based on modeled compressor energy and typical compressor power draw of 4.5 kW, we estimate an average cooling season fan duty cycle of 27% in the AUTO mode. These modeled energy results reflect the improved energy performance of correct refrigerant charge (Set 1 > Set 2) and AUTO fan control (Set 3 > Set 4).

Table 6-27. Modeled annual air conditioner energy use (kWh).

Set	Compressor	Fan	Total	kWh/ft^2
Set 1 (Pre-Tune)	5,048	varied	**varied**	-
Set 2 (Post-Tune)	4,636	varied	**varied**	-
Set 3 (Fan ON)	5,110	2,478	**7,588**	3.0
Set 4 (Fan AUTO)	4,714	674	**5,388**	2.1

Notes: Based on model M2 applied to 2017 cooling season ($CDD_{65}>2$) of 159 days, 1770 CDD_{65}. Occupancy averaged 6.9 h/d (SD 1.3).

6.7 AIR CONDITIONING SITE 7: HUMID CLIMATE

COOLNOMIX was installed and later disconnected at this site due to an unusual mechanical configuration. This section provides a basic description of the system, basic data, and why it was unsuitable for COOLNOMIX.

6.7.1 Site, Equipment, and Controls

We installed COOLNOMIX at the air handler of a single-story convenience store (about 11,000 ft^2, Figure 6-65).

Figure 6-65. COOLNOMIX Air Conditioning Installation.

Two 15-ton split-system condensing units (YORK model H5CE180A25A) each had dual stage compressor motors and condenser fans. A single air handler served both condensing units. Economizer damper motors were disconnected and ventilation dampers were fixed in place.

Two non-programmable digital thermostats in different parts of the large single zone controlled the condensing units. Both evaporator coils fed the same air distribution system. This configuration is somewhat unusual. Normally, two thermostats would correspond to a zoned system. In practice this system behaved like a staged system, such that the second condenser would run only when the first compressor could not keep up with the load. This implies that the thermostats were wired such that the condensers would run when either thermostat calls for cooling. It is likely that a separate logic circuit determined when to cycle the compressors.

Typically, one COOLNOMIX device is installed per thermostat. However, when multiple thermostats control a single condenser or multiple staged condensers, this approach requires modification. In these rare situations, the complexity increases along with risks of incorrect wiring or inappropriate control schemes.

Setpoints were kept at about 70-72°F. The thermostats controlled the ventilation fan and were set to AUTO, though occupants could adjust the setpoints and fan settings freely.

During installation, only one of the two condensing units was working due to a faulty thermal expansion valve. We attempted to reconfigure the system to operate both condensers together (both on or both off) so that one COOLNOMIX device could control both compressors when the system was eventually repaired. Although we verified that the single compressor continued working correctly, we could not verify that the second compressor would work until it was repaired.

When the valve was repaired, a different technician rewired COOLNOMIX to control a single condenser only, which was counter to the intended design. During a subsequent maintenance visit, a technician found that the second condenser was not operating as expected and disabled COOLNOMIX while diagnosing the issue.

FINDING: Unconventional cooling system configurations could lead technicians to rewire systems incorrectly or disable COOLNOMIX during maintenance.

Because this configuration was uncommon, and potentially incompatible, we ultimately removed COOLNOMIX and installed it at an alternate site (Air Conditioning Site 6).

6.7.2 Occupancy

Occupancy was moderately high and consistent, typically from about 6AM to 11PM most days.

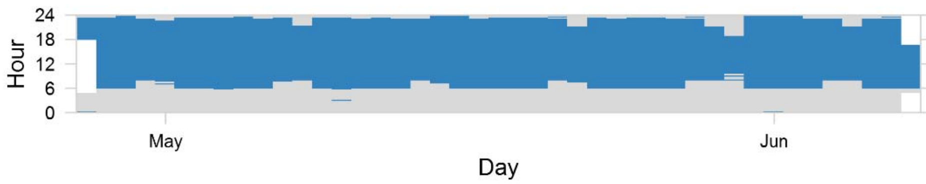

Figure 6-66. Occupancy by Day and Hour.

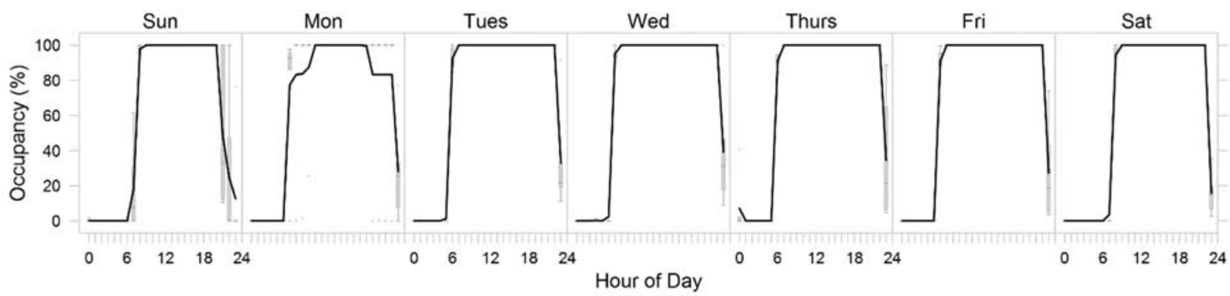

Figure 6-67. Occupancy Profiles by Day of Week.

6.7.3 Energy Performance

Since COOLNOMIX was not compatible with this site, we could not evaluate its energy performance. For completeness, we provide a brief summary of the limited condenser power baseline data.

The dual-thermostat control strategy treated the second condenser like a supplemental stage (Figure 6-68). By the late afternoon when the cooling load reaches a peak, both stages of Condenser 1 and the first stage of Compressor 2 ran continuously, while the remaining stage cycled. With this configuration, Condenser 1 is likely to experience a much higher duty cycle.

This site experienced the highest total daily energy consumption of all sites considered. Coefficients for a simple regression model are shown in (Table 6-28).

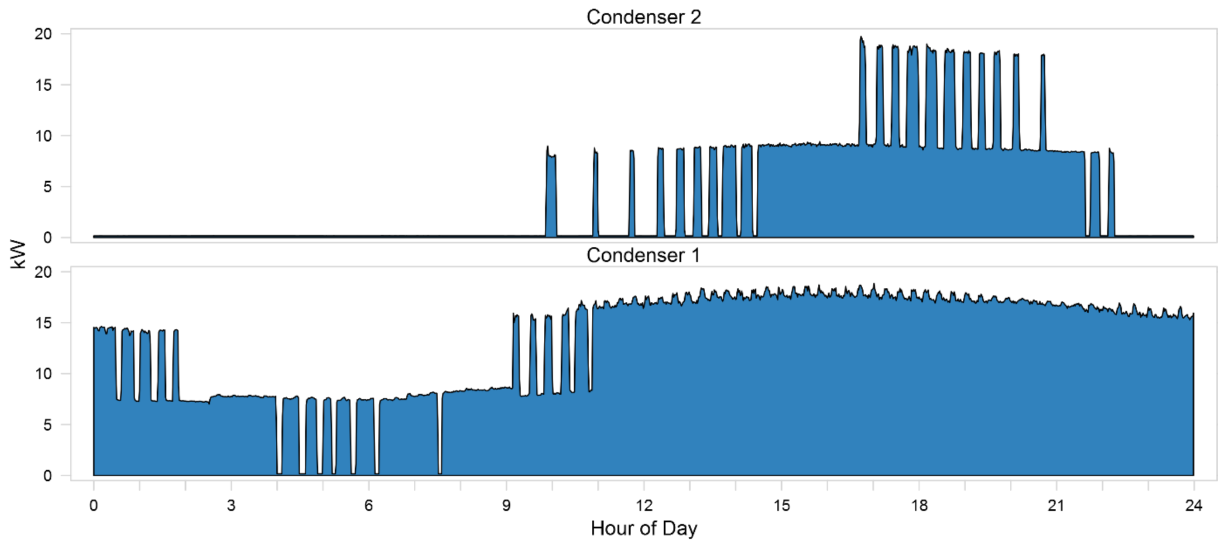

Figure 6-68. Sample Hot Day Condenser Electricity Profile.

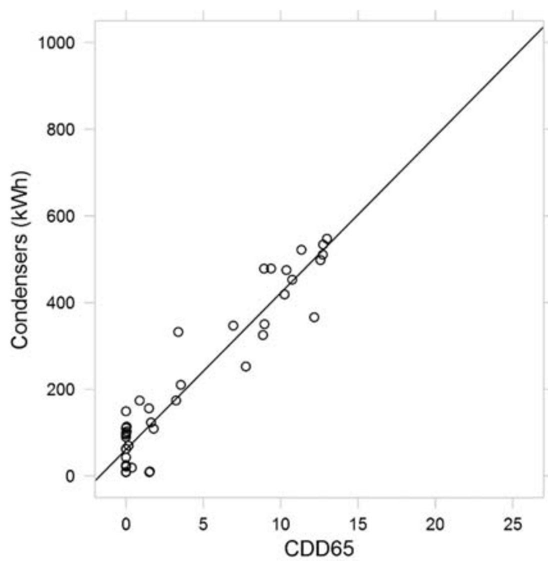

Figure 6-69. Daily Condenser Energy vs. CDD65.

Table 6-28. Condenser Energy Regression Model: Parameter Estimates and (Standard Errors).

(kWh/d) Term \ MODEL	M1	
Intercept	**63.19**	**(11.93)**
CDD_{65}	**35.91**	**(1.85)**
Adj. R^2	0.90	
AIC	465.2	
RMSE	57.2	
CV(RMSE)	0.3	
No. Obs.	42	
kWh Mean (SD)	213.6	(186.6)

6.8 REFRIGERATION SITES 1-3: DRY CLIMATE

6.8.1 Site, Equipment, and Controls

At a dining facility COOLNOMIX was installed in three adjacent walk-in coolers (about 200 ft^2 each), designated “C: Produce,” “D: Dairy”, and “E: Cook’s Box” served by a common rooftop condensing unit[30] with dedicated compressors for each cooler, each on a separate circuit. The COOLNOMIX units were installed inside each evaporator’s control panel (Figure 6-70) and worked reliably throughout the test.

Figure 6-70. COOLNOMIX Refrigeration Installation.

The rooftop condensing unit (KAIRAK compressor model ZB13KCE) had five compressors, one for each cooler or freezer (1.75 HP each, for the three coolers tested). We submetered power draw of the three relevant compressors individually. We did not monitor the condenser fans, since they served the entire unit, including two compressors that were not controlled by COOLNOMIX.

Evaporators in the walk-in coolers each had three fans that ran continuously. Off-cycle defrost timers were installed in each evaporator, set to run for 45 minutes each, 3-4 times per day. The refrigeration equipment was relatively new and in good condition. Refrigerant charge was checked during the second year of the test and found to be acceptable. A digital thermostat mounted on the evaporator, in close proximity to the COOLNOMIX return air sensor, was used to maintain cooler temperature setpoints.

COOLNOMIX had a negligible effect on cooler “E,” which apparently suffered from an unrelated equipment issue. Mid-way through the demo, cooler “E” began running with longer cycles, eventually running most of the day and night. Its compressor power draw patterns also became increasingly erratic. This issue started in January 2017 and progressively worsened during the final months of the test when the unit started losing the ability to maintain temperature setpoints. Eventually that unit was taken offline, apparently for repairs. Energy savings, therefore, could not be evaluated for cooler “E.”

[30] The rooftop unit also served two other evaporators, “B: Defrost Cooler” and “A: Freezer,” that were not part of this demo.

6.8.2 Occupancy

Occupancy[31] in the walk-in coolers followed regular hours between 6 AM to 10 PM on weekdays and reduced weekend activity (Figure 6-71 and Figure 6-72). Cooler "E" was the most used, followed by "D," and "C."

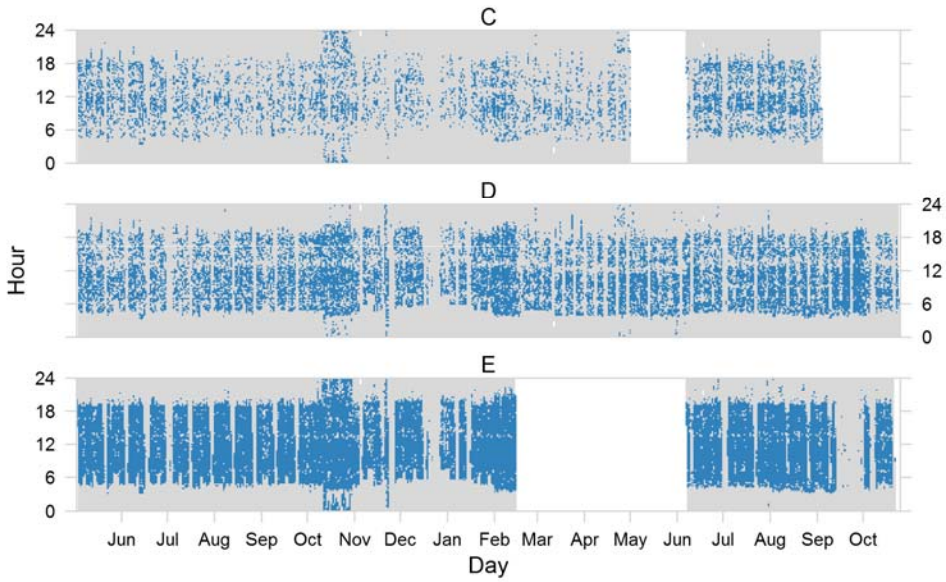

Figure 6-71. Occupancy by Day and Hour for Three Walk-in Coolers.

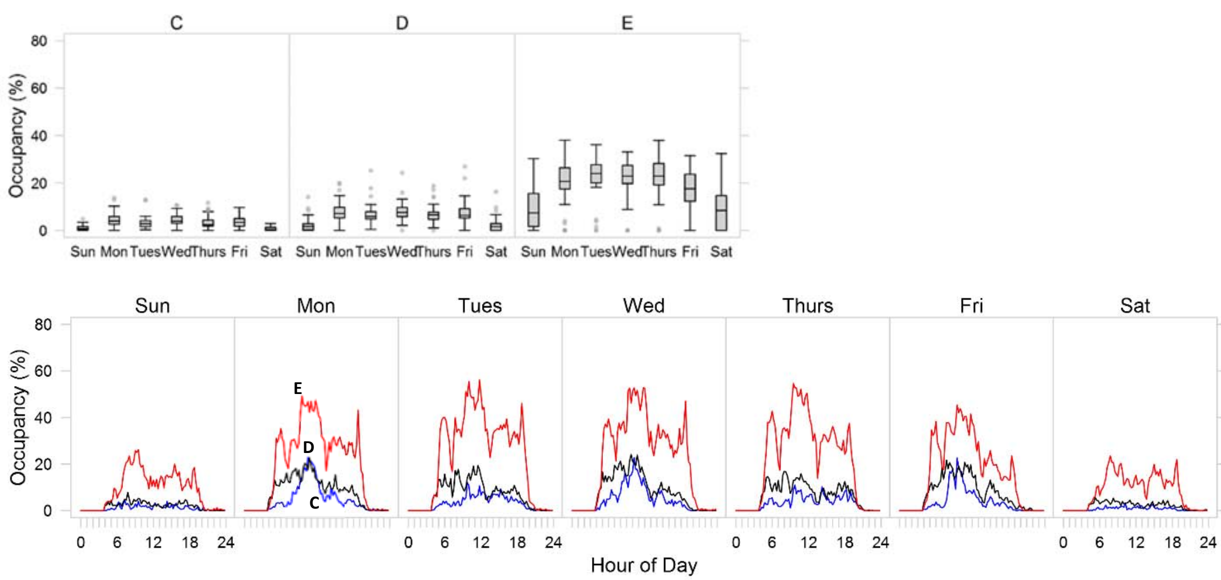

Figure 6-72. Occupancy Profiles by Day of Week.

[31] Data gaps in occupancy were caused by data logger battery failure. When normalizing for occupancy, we considered only days with valid data. Data from door state sensors were unreliable and not used.

6.8.3 Temperature

FDA food safety guidelines recommend that perishable products be kept at 41°F or lower. We monitored cooler temperature in three locations: near the door (middle height), by the evaporator return (near the ceiling), and supply air (at the evaporator fan outlet). As the coolers were small, spatial temperature variation was fairly low: return air was generally up to several degrees (°F) warmer than by the door. For each cooler, the hourly average return air temperatures remained within acceptable ranges most of the time and were not significantly affected by COOLNOMIX (Figure 6-73 and Figure 6-74).

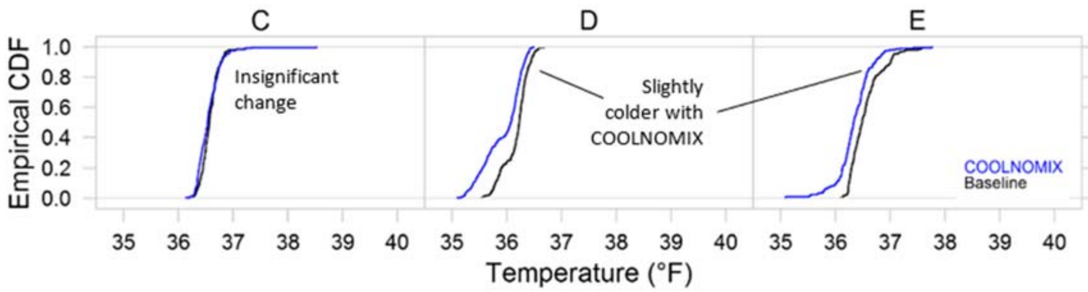

Figure 6-73. Empirical CDF of Average Daily Return Air Temperature by COOLNOMIX Status.

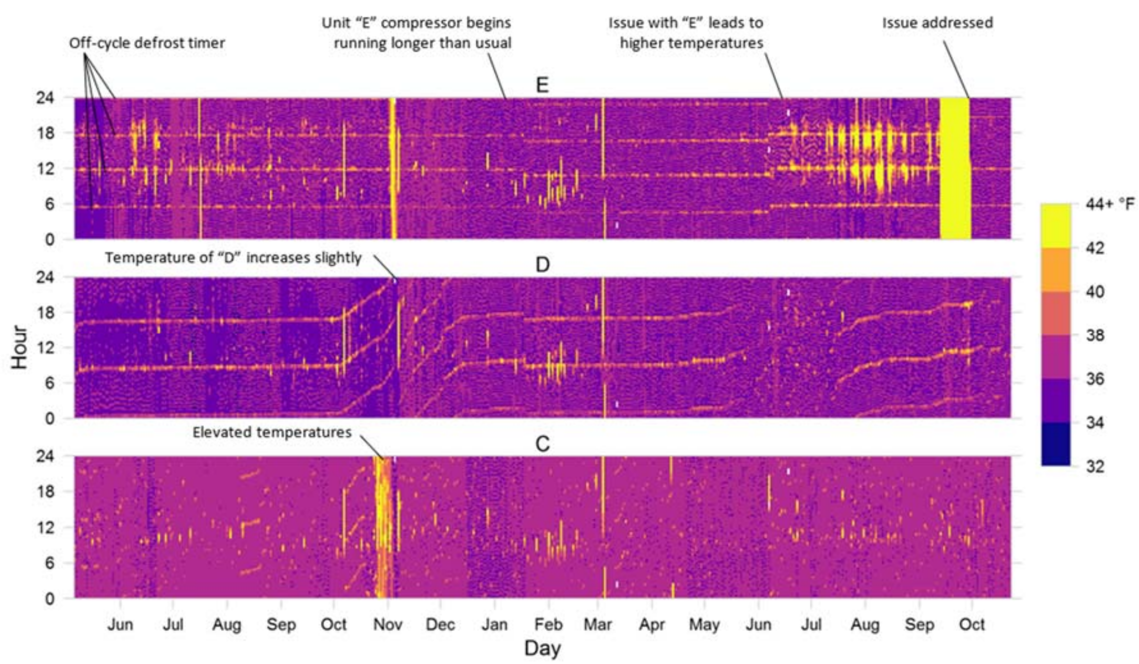

Figure 6-74. Return Air Temperature of Walk-in Coolers, 15-min. Averages.

At times, temperatures temporarily exceeded acceptable limits due to factors unrelated to COOLNOMIX, such as product deliveries, power outages, defrost cycles, or maintenance.[32]

[32] The average temperature of cooler "D" increased slightly after November 2016. This could be due to a faulty strip curtain that initially prevented the door from closing all the way until it was fixed.

Several anomalous periods of elevated temperatures were identified.[33] To reduce the effect of these confounds, days with more than four hours above 41°F were excluded from the energy analysis.

With COOLNOMIX enabled, the compressors often cycled more frequently, leading to a reduced deadband temperature (Figure 6-75). This cycling behavior was inconsistent among the three coolers. Coolers "C" and "D" showed consistent patterns of COOLNOMIX activity, with cycling evident throughout the day on most days. Cooler "E" was affected much less, with COOLNOMIX activity occurring typically only up to several hours of the day, normally in the morning, and sometimes not at all. The reason for this difference was not immediately obvious, as all coolers had similar temperature patterns (especially overnight when there was no occupancy), but may have been related to an issue with compressor "E."

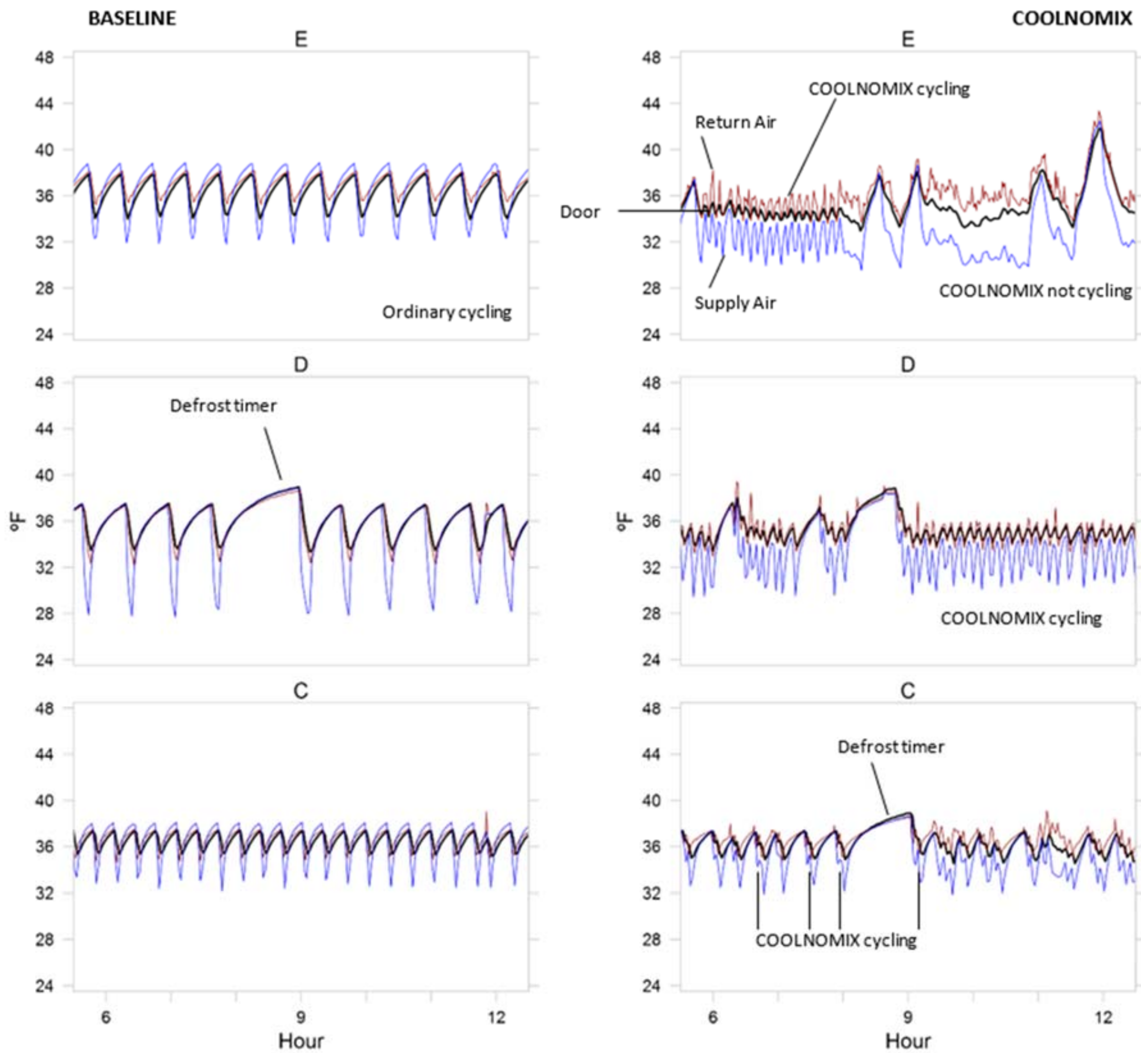

Figure 6-75. Temperature for Two Sample Days by Cooler and COOLNOMIX Status.

[33] Cooler "C," for instance, showed elevated temperatures for about one week in October 2016, likely due to a door left opened.

6.8.4 Ventilation Fan Runtime

Each evaporator had three fans that were programmed to run continuously. As a result, COOLNOMIX did not directly influence fan runtime, so we did not evaluate its impact.

6.8.5 Compressor Runtime

With COOLNOMIX enabled, mean compressor cycle duration was reduced by 13-44% (Table 6-29) and the number of daily cycles increased (Figure 6-76). As noted earlier, the effect was more pronounced on coolers “C” and “D” and not significantly different for cooler “E.” The relatively short cycles in the baseline, especially for coolers “C” and “D,” limit the ability to shorten cycle duration much further.

Table 6-29. Compressor Cycle Duration by Cooler.

Minutes Median (Mean)	C	D	E
Baseline	5 (7.1)	8 (9.5)	16 (29.6)
COOLNOMIX	3 (5.6)	4 (5.3)	16 (34.0)

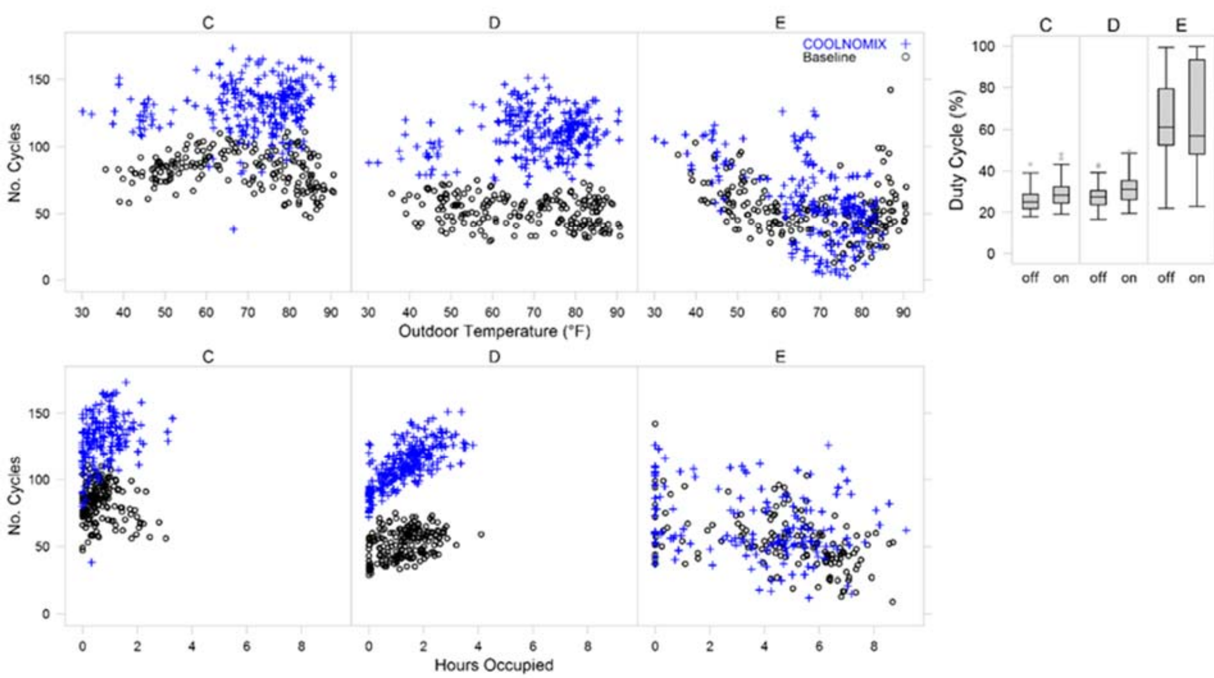

Figure 6-76. Compressor Cycles per Day vs. Mean Outdoor Temperature and Occupied Hours.

6.8.6 Energy Performance

Although coolers "C" and "D" both showed clear evidence of shorter cycles with COOLNOMIX (Figure 6-77), this was offset by an increased number of cycles and there was limited statistical evidence for a net energy savings. As noted earlier, COOLNOMIX had minimal effect on Cooler "E," likely due to an unrelated compressor issue. Consequently, energy savings results for cooler "E" are less reliable. Compressor energy consumption varied significantly with both occupied hours and outdoor temperature, but showed no clear dependence on COOLNOMIX status (Figure 6-77 and Figure 6-78).

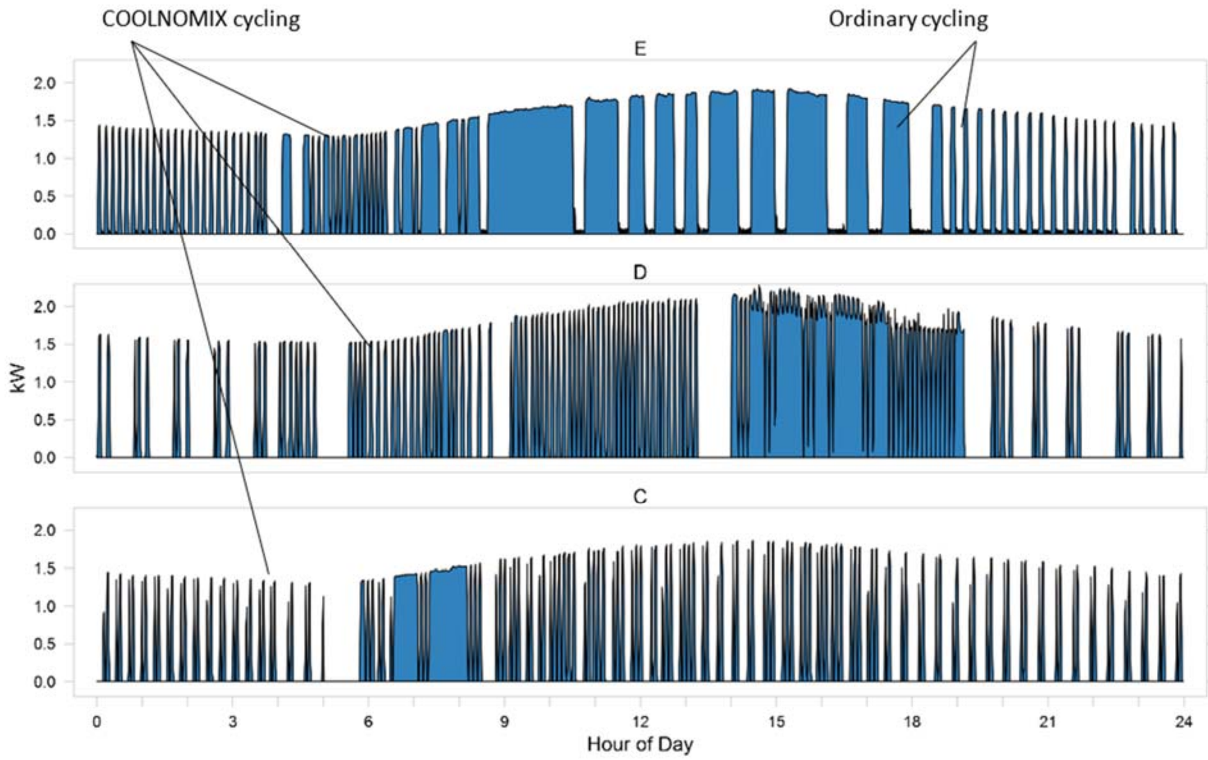

Figure 6-77. Compressor Power Draw on a Sample COOLNOMIX Day.

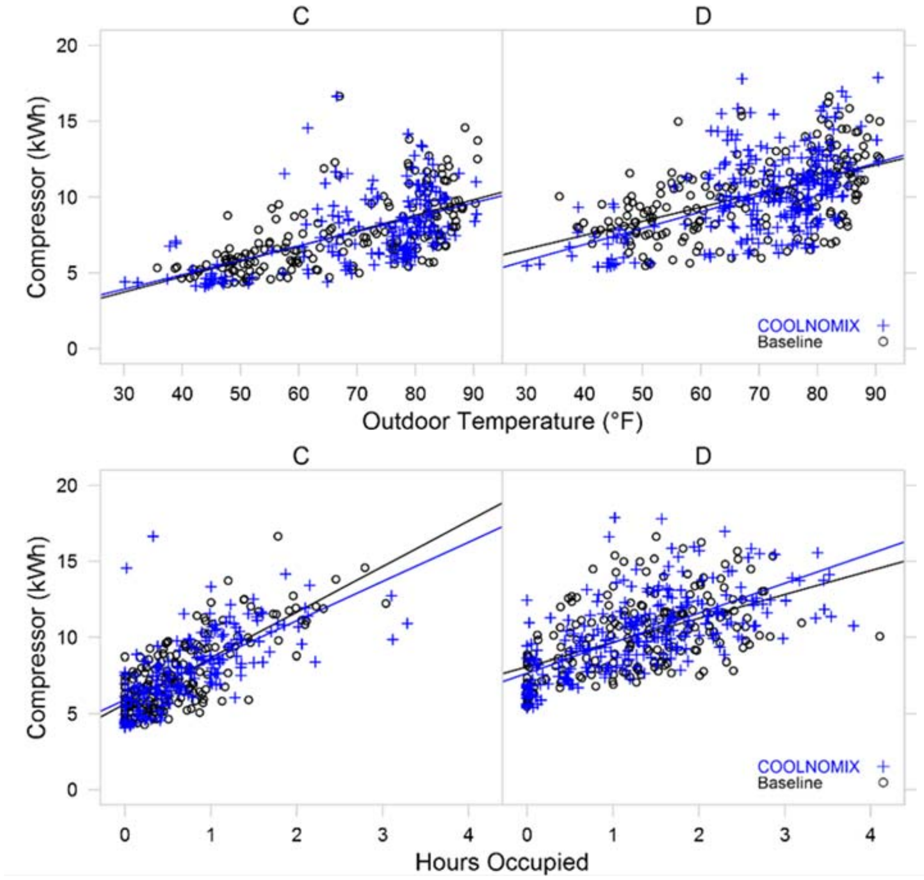

Figure 6-78. Compressor Energy Use vs. Mean Daily Outdoor Temp. and Occupancy by COOLNOMIX Status.

To eliminate outliers, we filtered the data prior to fitting regressions by excluding days with:

1. More than 20 minutes of missing electricity data.
2. More than 40 minutes of missing occupancy data.
3. More than four hours of return air temperature above 41°F.
4. Known or suspected problems with the equipment.

Multiple linear regressions were calculated to predict compressor energy use ($E_{compressor}$, kWh) based on average outdoor temperature (T_{out}, °F), occupancy (*OCC*, hours), and COOLNOMIX status (*CNMX*, 0 = not enabled, 1 = enabled). Separate combinations of these variables and interaction terms with COOLNOMIX status were tried to identify model parameters significant at the 0.05 level. Two independent variables (occupied hours and outdoor temperature) explained about 60-74% of the variance in the data. COOLNOMIX status was significant at the 0.05 level only as an interactive term with occupancy for cooler "C" (-0.38 kWh/occupied-hour, M5 in Table 6-30). The COOLNOMIX terms (M5) were not significant for coolers "D" and "E," however they did have the same sign.

Table 6-30. Compressor Energy Regression Models: Parameter Estimates and (Standard Errors).

(kWh/d) Term \ MODEL	M1		M2		M3		M4		M5	
Cooler "C"										
Intercept	**0.87**	**(0.49)**	**5.77**	**(0.13)**	**1.39**	**(0.35)**	**5.76**	**(0.13)**	**1.31**	**(0.35)**
T_{out}	**0.098**	**(0.007)**			**0.07**	**(0.01)**			**0.07**	**(0.01)**
OCC			**2.79**	**(0.14)**	**2.29**	**(0.12)**	**2.90**	**(0.18)**	**2.50**	**(0.15)**
OCC:CNMXon							-0.20	(0.19)	**-0.38**	**(0.16)**
Adj. R^2	0.35		0.52		0.67		0.52		0.67	
AIC	1540		1432		1294		1433		1290	
RMSE	1.93		1.67		1.38		1.67		1.37	
CV(RMSE)	0.25		0.22		0.18		0.22		0.18	
No. Obs.	369		369		369		369		369	
kWh Mean (SD)	7.7	(2.4)	7.7	(2.4)	7.7	(2.4)	7.7	(2.4)	7.7	(2.4)
Cooler "D"										
Intercept	**3.27**	**(0.10)**	**7.84**	**(0.17)**	**1.46**	**(0.42)**	**7.85**	**(0.17)**	**1.36**	**(0.43)**
T_{out}	**0.10**	**(0.01)**			**0.09**	**(0.01)**			**0.09**	**(0.01)**
OCC			**1.80**	**(0.11)**	**1.73**	**(0.09)**	**1.71**	**(0.14)**	**1.82**	**(0.11)**
OCC:CNMXon							**0.16**	**(0.13)**	-0.14	(0.10)
Adj. R^2	0.26		0.37		0.60		0.37		0.60	
AIC	2006		1935		1732		1936		1733	
RMSE	2.22		2.05		1.64		2.05		1.63	
CV(RMSE)	0.22		0.20		0.16		0.20		0.16	
No. Obs.	451		451		451		451		451	
kWh Mean (SD)	10.1	(2.6)	10.1	(2.6)	10.1	(2.6)	10.1	(2.6)	10.1	(2.6)
Cooler "E"										
Intercept	**4.86**	**(1.27)**	**10.35**	**(0.49)**	1.21	(0.81)	**10.35**	**(0.49)**	1.19	(0.81)
T_{out}	**0.19**	**(0.02)**			**0.15**	**(0.01)**			**0.15**	**(0.01)**
OCC			**1.67**	**(0.10)**	**1.49**	**(0.08)**	**1.67**	**(0.11)**	**1.52**	**(0.08)**
OCC:CNMXon							-0.01	(0.10)	-0.06	(0.08)
Adj. R^2	0.32		0.55		0.74		0.55		0.74	
AIC	1298		1205		1084		1207		1085	
RMSE	4.38		3.56		2.70		3.56		2.70	
CV(RMSE)	0.25		0.20		0.16		0.20		0.16	
No. Obs.	223		223		223		223		223	
kWh Mean (SD)	17.4	(5.3)	17.4	(5.3)	17.4	(5.3)	17.4	(5.3)	17.4	(5.3)

Notes: Preferred model highlighted, based on Akaike Information Criteria (AIC).
Significant terms in bold ($p<0.05$).
Cooler "E" models based on periods before its maintenance issue became severe.

Since occupancy contributes unknown sources of variability, such as product deliveries or door openings, we isolated its influence by developing separate candidate regressions based on the subset of days without occupancy, when compressor cycling was far more consistent. These regressions did not yield statistically significant COOLNOMIX terms.

Each evaporator had three 1/15 HP fan motors that ran continuously, consuming about 1,710-2,365 kWh annually.[34] In addition, one set of condenser fans served five evaporators and ran only when one or more compressors were running. We did not measure or estimate condenser fan power draw.

If valid, the best-case model (Cooler C, M5) predicts that for every hour of occupancy, COOLNOMIX could save up to 0.38 kWh.[35] Applied to one year of outdoor temperature and occupancy data for cooler C, model M5 predicts a 3.4% reduction in compressor energy use, or a 2% reduction in refrigeration system energy use. Similar estimates for coolers "D" and "E," using their respective model M5, yielded lower savings of about 1.1%, though these were not statistically significant.

Table 6-31. Estimated Annual Refrigeration Energy Consumption Change by Cooler.

	COOLER "C" (M5)				COOLER "D" (M5)				COOLER "E" (M5)			
(kWh)	Baseline	CNMX	Δ	%	Baseline	CNMX	Δ	%	Baseline	CNMX	Δ	%
Compressor	2,747	2,651	-96	-3.5	3,552	3,489	-63	-1.7	6,701	6,606	-95	-1.4
Evap. Fans	2,040	2,040	-	-	2,040	2,040	-	-	2,040	2,040	-	-
Total	**4,787**	**4,691**	**-96**	**-2.0**	**5,592**	**5,529**	**-63**	**-1.1**	**8,741**	**8,646**	**-95**	**-1.1**

Several factors may have limited the ability for COOLNOMIX to save energy. One energy savings mechanism stems from unnecessary calls for cooling triggered by doors opening and closing near the thermostat. In all of our tests, the existing thermostat was located in close proximity to the COOLNOMIX return air sensor, at height on the evaporator. As a result, it was unlikely that brief thermal disturbances would trigger unnecessary calls for cooling. A second potential savings mechanism is to stop the compressor earlier in its cycle to avoid flooding the evaporator. During normal operation, the compressors already had relatively short cycles much of the time, thus limiting the potential to eliminate unnecessary compressor work.

In conclusion, while there was clear evidence that COOLNOMIX was working as intended for all three coolers, and appreciably affected cycle duration for two of the three coolers, there was limited evidence for meaningful energy savings.

6.9 REFRIGERATION SITES 4-6: HUMID CLIMATE

6.9.1 Site, Equipment, and Controls

We installed COOLNOMIX in three walk-in coolers. In this application, the COOLNOMIX controller unit was installed outside the walk-in coolers by the door. Its control and sensor wires were run along the length of the cooler box wall to the evaporator (Figure 6-79). Two coolers at a banquet facility ("A: Defrost Cooler" and "B: Cook's Box") and a third for quick-service food and beverage ("C") were tested. Evaporators "A" and "B" were served by a single rooftop condensing unit that also served two additional freezers that were not part of this demo, with dedicated compressors for each cooler. Its condenser fans were shared across the coolers and freezers. Cooler "C" was served by a dedicated outdoor condensing unit.

[34] Typical power draw for a 1/15 HP fan ranges from about 65-90 W depending on motor type (Navigant 2009).

[35] Since cooler "C" did not experience days with occupancy higher than about 3 hours, we cannot say if the linear relationship holds for occupancy values greater than this.

Figure 6-79. COOLNOMIX Refrigeration Installation.

The rooftop condensing unit for coolers "A" and "B" (KEEPRITE model KFZD110C9-HT3B-X1028) had four compressors, one for each cooler or freezer, each with a 50 W crankcase heater. The compressors for the two coolers (Copeland model ZB15KCETF5) were each 2.0 HP. We submetered power draw of the two relevant compressors individually. We did not monitor the two condenser fans, since they served the entire unit, including the compressors not controlled by COOLNOMIX. The standalone condensing unit for cooler C (BOHN HEATCRAFT model BHT015H2BF) had a single 1.5 HP compressor with a 40 W crankcase heater, and we submetered two circuits that included the condenser fan and compressor loads. All equipment was in good condition. The condenser fins were notably dirty and somewhat obstructed throughout most of the test, though this was fixed during the final month of the test. The refrigerant charge for all three units was tested and found to be acceptable.

The evaporators "A" and "B" (KEEPRITE model KPL317ME-S2B-TD2NN) each had three 1/15 HP fan motors, and three defrost heaters (rated 490-720 W). Evaporator "C" had two 1/15 HP fan motors set to run continuously and did not have a defrost heater (it used a timer-based off-cycle defrost). All fan motors were set to run continuously. During the test, however, it was discovered that evaporators "A" and "B" had a two-speed fan controller that reduces to low speed when the compressor cycles off.[36] By overriding the thermostat, COOLNOMIX could cause the dual-speed fans to run at the high speed more often.

The refrigeration equipment was relatively new and in good condition. Refrigerant charge was checked during the second year of the test and found to be acceptable at all sites. A manual dial thermostat mounted on the evaporator, located in close proximity to the COOLNOMIX return air sensor, maintained cooler temperature setpoints. COOLNOMIX units were installed outside the cooler near the door and worked reliably throughout the test.

6.9.2 Occupancy

Occupancy patterns were fairly consistent among the test sites throughout the test (Figure 6-80 and Figure 6-81). Coolers "A" and "B" were normally occupied from 6AM to 3PM, with evening hours on Thursdays to Saturdays, and closed most Mondays. Cooler "C" occupancy was typically from 7AM to 10PM. Due to unreliable passive infrared measurements in coolers "A" and "B", we used door open/close status measurements instead to derive daily occupancy profiles by day of week.

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[36] The manufacturer claims this feature can save up to 10% on system energy consumption (KEEPRITE http://k-rp.com/products/technology/smartspeed/). During a site visit, a technician was repairing a walk-in freezer adjacent to our demo due to a failed smart fan speed controller relay.

Average daily occupancy values were then assigned by day of week for these two coolers to address data gaps caused by the failed sensors.

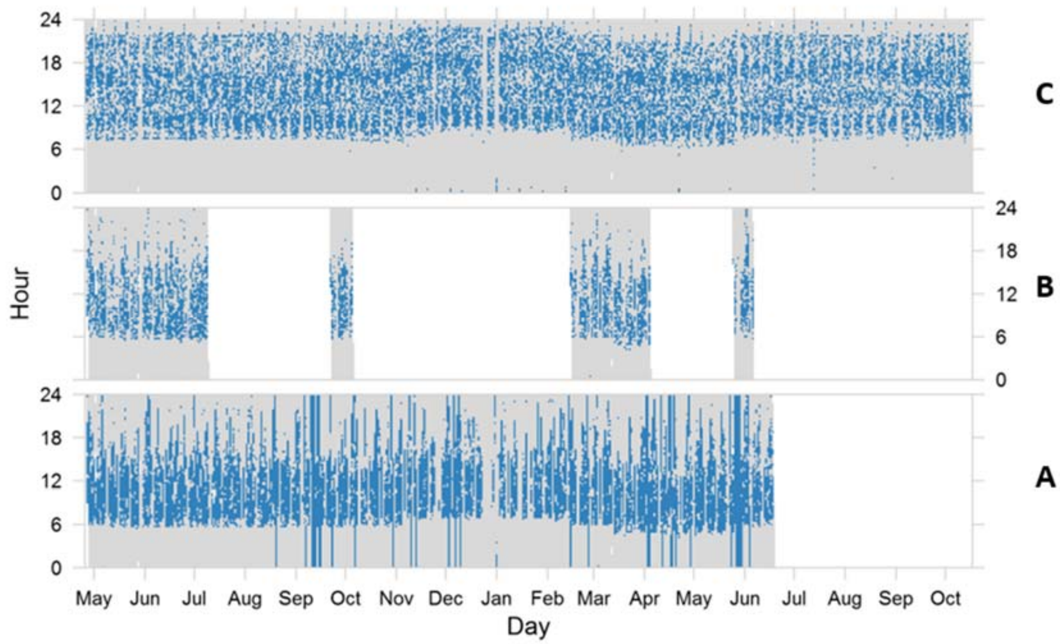

Figure 6-80. Occupancy by Day and Hour for Three Walk-in Coolers.

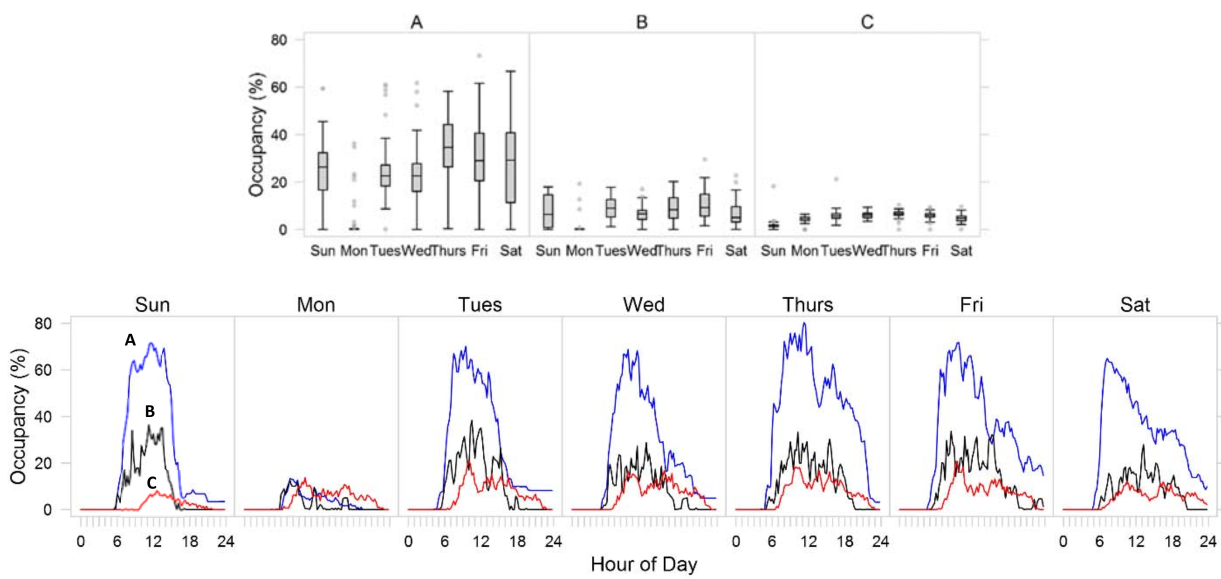

Figure 6-81. Average Occupancy Profiles by Day of Week for Three Walk-in Coolers.

6.9.3 Temperature

FDA food safety guidelines recommend that perishable products be kept at 41°F or lower. We monitored cooler temperature in three locations: near the door (middle height), by the evaporator return (near the ceiling), and supply air (at the evaporator fan outlet). As the coolers were small, spatial temperature variability was fairly low: the return air was generally up to several degrees (°F) warmer than by the door.

After the first year, we found that the thermostats in all three coolers were set just above food safety limits (Figure 6-82 and Figure 6-83). As a result, and as designed, COOLNOMIX did not engage much during this time, especially for coolers "A" and "C." After the issue was identified, we notified the facility managers, who took corrective action.[37] The subsequent testing period for these sites were consequently truncated, spanning from about June to October of the second year.

During the remainder of the test, the average return air temperatures remained within acceptable limits most of the time. With COOLNOMIX, the temperature of coolers "A" and "C" did not change significantly, while "B" was about 3-4°F warmer on average but still within acceptable limits (Figure 6-82). This change was likely due to COOLNOMIX and an unplanned manual setpoint lowering temperature inexplicably dropped by several degrees while COOLNOMIX remained enabled (Figure 6-83).

With COOLNOMIX, the compressors cycled more frequently, leading to a slight reduction in temperature deadband. The temperature response differed slightly among the three coolers. Cooler "C" was smaller, and cycled frequently in the baseline condition, leading to an already small deadband (Figure 6-84). As a result, in this cooler, COOLNOMIX tended to engage mainly during the occupied hours when people were opening and closing the door, increasing refrigeration loads. Coolers "A" and "B" were very well insulated and cycled infrequently, especially cooler "B." COOLNOMIX tended to engage about once per thermostat cycle with cooler "A," and several times for cooler "B."

[37] Outside contractors came to adjust the settings, but they overcompensated and set the cooler temperature below freezing on all three coolers. This led to a frozen coil issue on cooler C. During a follow-up site visit, we manually adjusted the settings and the systems resumed working as intended.

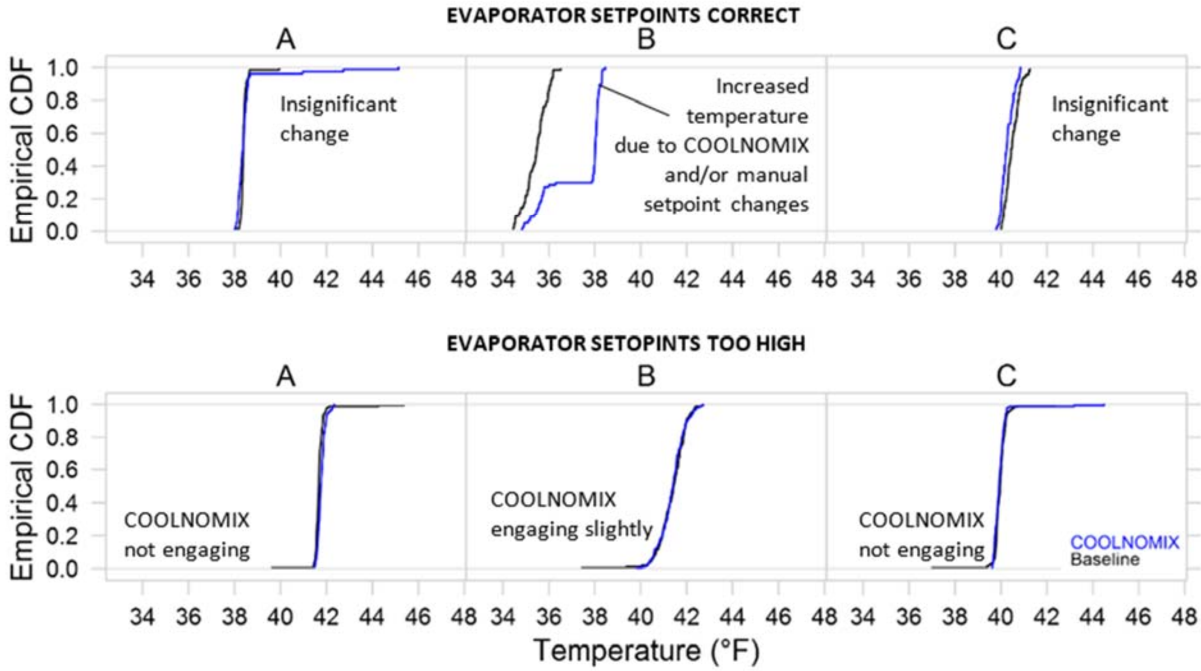

Figure 6-82. Empirical CDF of Average Daily Return Air Temperature by COOLNOMIX Status.

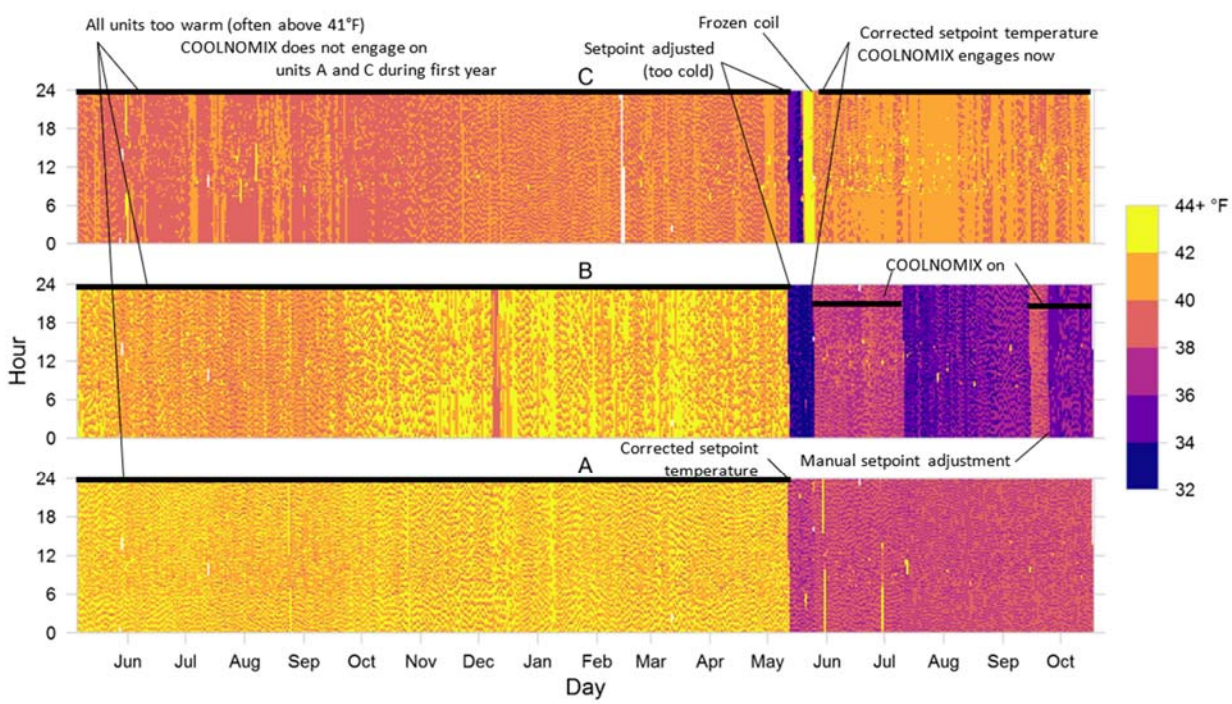

Figure 6-83. Return Air Temperature of Walk-in Coolers, 15-min. Averages.

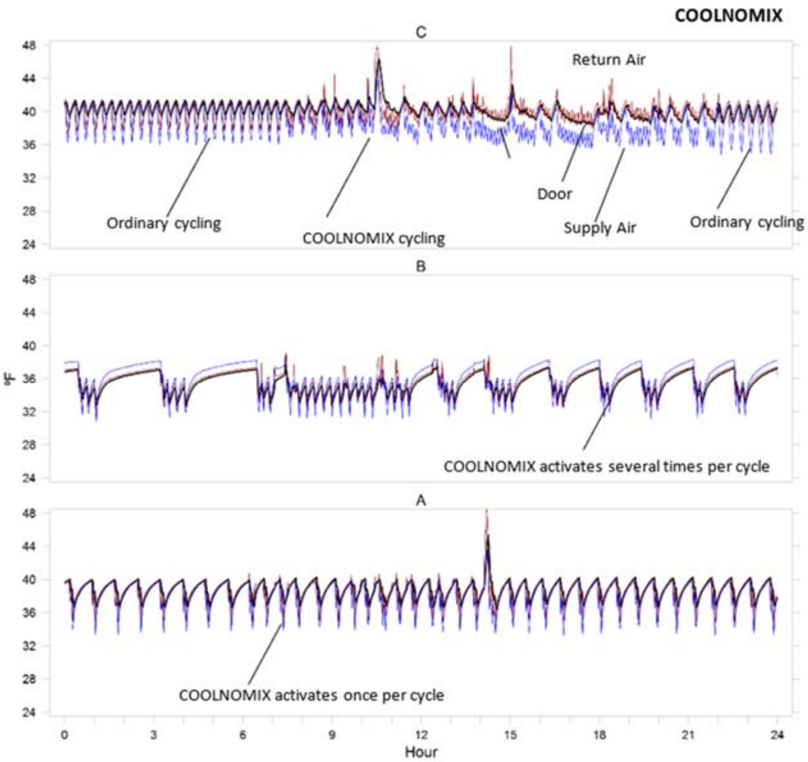

Figure 6-84. Temperature for a Sample Day by Cooler with COOLNOMIX Enabled.

6.9.4 Evaporator Fan Runtime

The fans on cooler "C" were programmed to run at full speed all the time, so COOLNOMIX did not influence its runtime. Coolers "A" and "B," however, had an energy-saving fan controller that lowers the speed when the thermostat is satisfied. As a result, the duty cycle measurements (Figure 6-85) for coolers "A" and "B" represent the full speed stage only. Cooler "B" showed no a significant change in fan duty cycle with COOLNOMIX status; however, once properly configured, cooler "A" spent about twice as much time at the high fan speed with COOLNOMIX enabled. Thus, on systems with variable speed fan controls, COOLNOMIX could increase fan energy use.

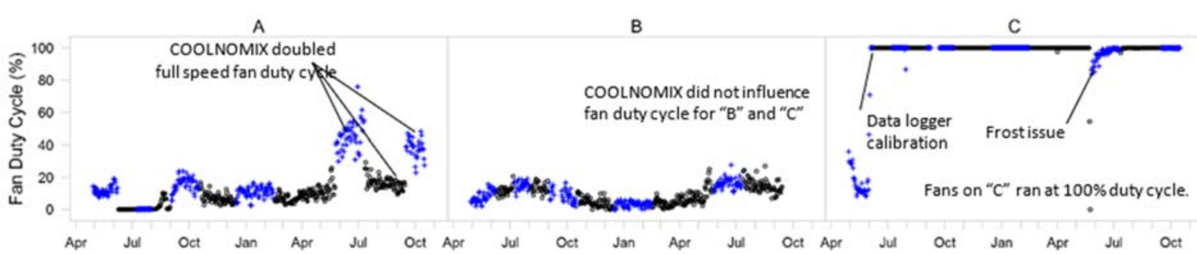

Figure 6-85. Daily Fan Duty Cycle of Full Speed Stage by Cooler and COOLNOMIX Status.

6.9.5 Compressor Runtime

After the thermostats were set correctly, COOLNOMIX reduced the mean compressor cycle duration by about 17-44% (Table 6-32) and approximately doubled the number of daily cycles (Figure 6-86, top). Pre tune-up, when the cooler setpoints were set too high, COOLNOMIX was mostly inactive: coolers "A" and "C" showed virtually no difference in their number of daily cycles, and cooler "B" cycled slightly more during that period (Figure 6-86, bottom).

Table 6-32. Compressor Cycle Duration by Walk-in Cooler.

Minutes Mean (Median)	A	B	C
Baseline	6 (6.5)	8 (9.1)	9 (11.9)
COOLNOMIX	4 (5.4)	4 (5.0)	7 (7.6)

Note: Based on correct evaporator setpoints.

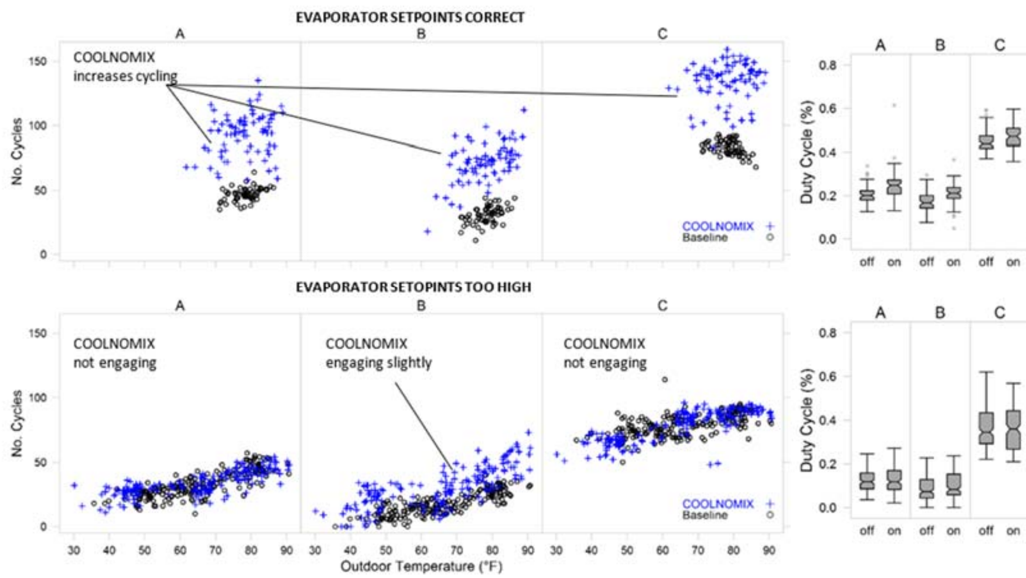

Figure 6-86. Compressor Cycles per Day vs. Mean Outdoor Temperature (LEFT) and Duty Cycle by COOLNOMIX Status (RIGHT).

6.9.6 Energy Performance

After adjusting the evaporator setpoints, all coolers showed clear evidence of shorter cycles with COOLNOMIX enabled (Figure 6-87). COOLNOMIX cycled cooler "A" several times per thermostat cycle, while it mostly ran cooler "B" with shorter cycles throughout the day. Cooler "C" cycled shorter mainly during occupied hours and operated similar to the baseline overnight. Compressor "C" drew about half as much power[38] and cycled about twice as frequently as the other two compressors, due to its lower capacity. Despite clear evidence of COOLNOMIX operation, there was not a clear difference in total compressor energy use (Figure 6-88).

[38] Power draw for compressor "C" also includes the condenser fans (about 130 W), since it was a dedicated unit serving only one evaporator.

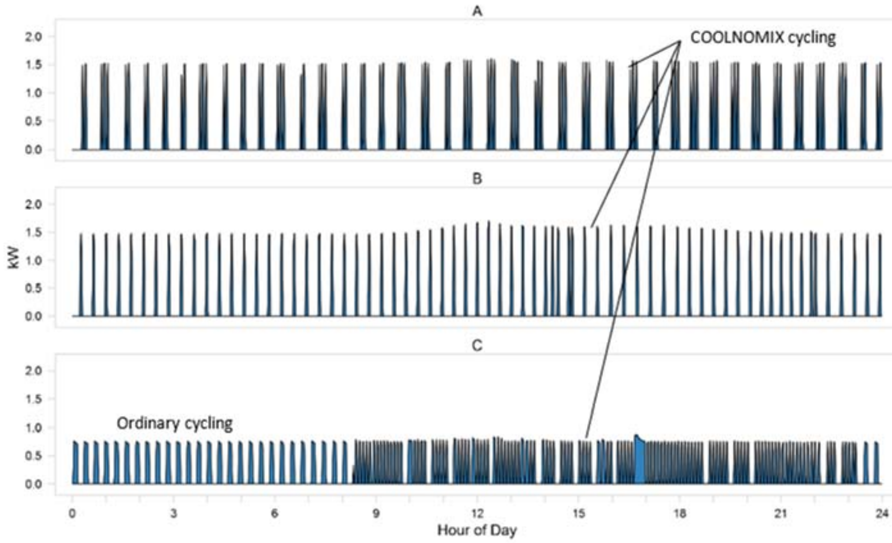

Figure 6-87. Compressor Power Draw on a Sample COOLNOMIX day.

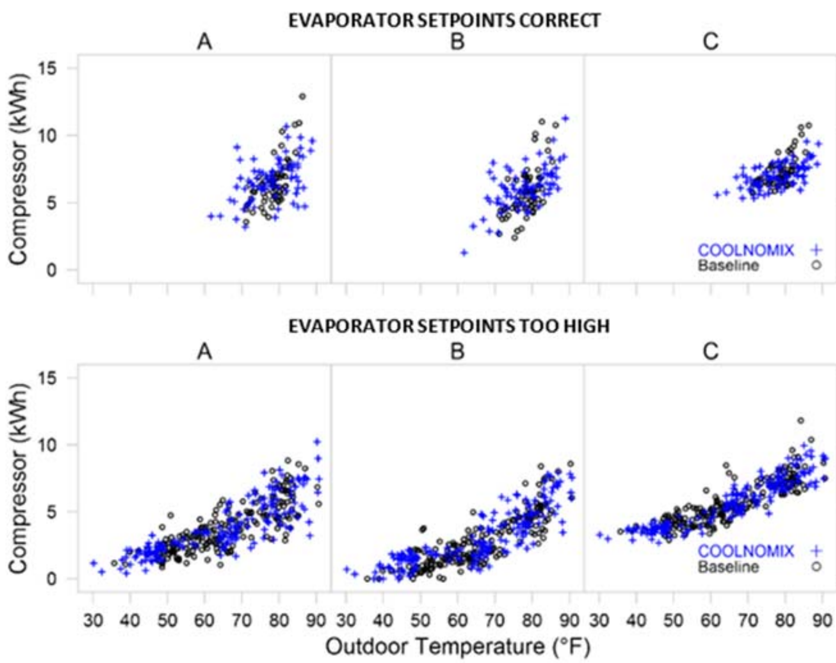

Figure 6-88. Compressor Energy Use vs. Mean Daily Outdoor Temperature by COOLNOMIX Status.

To eliminate outliers, we filtered the data prior to fitting regressions by excluding days with:

1. More than 20 minutes of missing electricity data.
2. More than 40 minutes of missing occupancy data (cooler "C" only).
3. Outliers with abnormally high or low average daily return air temperature (manual inspection), indicative of improper temperature setpoints (see earlier discussion).
4. Known or suspected problems with the equipment.

Multiple linear regressions were calculated to predict daily compressor energy use ($E_{compressor}$, kWh), including the condenser fan for compressor "C" only) based on average outdoor temperature (T_{out}, °F), cooling degree days (CDD_{65}), occupancy[39] (*OCC*, hours, for cooler "C" only), and COOLNOMIX status (*CNMX*, 0 = not enabled, 1 = enabled). Separate combinations of these variables and interaction terms with COOLNOMIX status were tried to identify model parameters significant at the 0.05 level. Regressions were applied in the post-adjustment period, after the evaporator temperatures were reduced and COOLNOMIX was working properly. Since COOLNOMIX was working to a limited extent before this adjustment in cooler "B", we added an additional regression for that case.

Two independent variables (outdoor temperature and occupancy) explained about 39-73% of the variance in the data. COOLNOMIX status was significant at the 0.05 level as an interactive term with occupancy for coolers "B" and "C."

COOLNOMIX terms showed a small, but not significant, energy increase for cooler "A." Cooler "B" had a significant COONLMIX occupancy term that showed an increase in energy consumption (0.51 kWh per occupied day), despite having generally a higher average return air temperature while COOLNOMIX was enabled.

Cooler "C" showed a small but statistically significant COOLNOMIX energy reduction of -0.062 kWh per hour occupied (model M5). In this cooler, COOLNOMIX engaged primarily during occupied hours and rarely overnight. Occupancy averaged about 5.4 hours per day (IQR 4.3-6.6 h/d), implying daily savings of about 0.34 kWh or approximate annual savings of 122 kWh. Compared to typical average energy consumption of about 6.5 kWh, this represents about a 5% reduction in compressor energy.

[39] Coolers "A" and "B" did not have reliable occupancy data during much of the post-adjustment test period; however, occupancy was primarily linked to the day of week, with the facility closed on Mondays and most holidays. Occupied days were identified graphically and flagged with a binary variable "OCC" for these two coolers during the testing period with correct evaporator temperatures.

Table 6-33. Compressor Energy Regression Models: Parameter Estimates and (Standard Errors).

(kWh/d) Term \ MODEL	M1		M2		M3		M4		M5	
Cooler “A”										
Intercept	**-5.13**	**(1.92)**	**5.50**	**(0.24)**	**-7.62**	**(1.67)**	**5.50**	**(0.24)**	**-7.80**	**(1.65)**
T_{out}	**0.15**	**(0.02)**			**0.17**	**(0.02)**			**0.17**	**(0.02)**
OCC			**1.49**	**(0.28)**	**1.68**	**(0.23)**	**1.33**	**(0.32)**	**1.46**	**(0.26)**
OCC:CNMXon							0.29	(0.28)	0.40	(0.23)
Adj. R^2	0.21		0.18		0.45		0.19		0.46	
AIC	465		472		421		472		420	
RMSE	1.34		1.37		1.13		1.37		1.12	
CV(RMSE)	0.20		0.21		0.17		0.21		0.17	
No. Obs.	134		134		134		134		134	
kWh Mean (SD)	6.6	(1.5)	6.6	(1.5)	6.6	(1.5)	6.6	(1.5)	6.6	(1.5)
Cooler “B”										
Intercept	**-8.37**	**(1.94)**	**5.19**	**(0.29)**	-3.85	(-10.2)	**5.19**	**(0.28)**	**-10.46**	**(1.82)**
T_{out}	**0.18**	**(0.02)**			**0.19**	**(0.02)**			**0.20**	**(0.02)**
OCC			**1.06**	**(0.32)**	**1.28**	**(0.26)**	**0.86**	**(0.36)**	**1.01**	**(0.29)**
OCC:CNMXon							0.38	(0.31)	**0.51**	**(0.25)**
Adj. R^2	0.28		0.07		0.39		0.07		0.40	
AIC	483		520		463		520		461	
RMSE	1.38		1.58		1.27		1.57		1.25	
CV(RMSE)	0.23		0.26		0.21		0.26		0.21	
No. Obs.	137		137		137		137		137	
kWh Mean (SD)	6.0	(1.6)	6.0	(1.6)	6.0	(1.6)	6.0	(1.6)	6.0	(1.6)
Cooler “C”										
Intercept	**-2.20**	**(1.14)**	**6.02**	**(0.17)**	**-2.34**	**(0.91)**	**5.97**	**(0.17)**	**-2.26**	**(0.89)**
T_{out}	**0.12**	**0.01**			**0.23**	**(0.03)**			**0.11**	**(0.01)**
OCC			**0.25**	**(0.03)**	**0.11**	**(0.01)**	**0.30**	**(0.04)**	**0.28**	**(0.03)**
OCC:CNMXon							**-0.07**	**(0.03)**	**-0.06**	**(0.02)**
Adj. R^2	0.33		0.26		0.56		0.29		0.57	
AIC	349		343		277		339		271	
RMSE	0.82		0.83		0.64		0.81		0.63	
CV(RMSE)	0.11		0.12		0.09		0.11		0.09	
No. Obs.	140		137		137		137		137	
kWh Mean (SD)	7.2	(1.0)	7.1	(1.0)	7.1	(1.0)	7.1	(1.0)	7.1	(1.0)

Notes: Based on limited testing period after evaporator temperature setpoints were adjusted.
Preferred model highlighted, based on lowest Akaike Information Criteria (AIC).
Significant terms in bold ($p<0.05$).

Finally, we examined regressions during the period when the setpoints were too high (but consistent). For cooler “B,” COOLNOMIX was still engaging regularly, but less frequently than with correct (lower) evaporator setpoints. In this case, COOLNOMIX used slightly more energy, about 0.02 kWh per occupied hour. With 7.7 occupied hours per day on average, this is an additional 0.2 kWh per day. Compared with average compressor “B” consumption of about 3 kWh per day, this reflects about a 7% increase in compressor energy.

Table 6-34. Compressor Energy Regression Models: Parameter Estimates and (Standard Errors).

(kWh/d) Term \ MODEL	Cooler "B" with High Setpoints M1		M2		M3		M4		M5		M6	
Intercept	**4.74**	**(0.28)**	**2.54**	**(0.24)**	**-6.02**	**(0.49)**	**2.49**	**(0.24)**	**-5.95**	**(0.48)**	**-4.96**	**(0.27)**
CNMXon											**0.39**	**(0.11)**
T_{out}	**0.12**	**(0.00)**			**0.13**	**(0.01)**			**0.12**	**(0.01)**	**0.12**	**(0.00)**
OCC			**0.05**	**(0.02)**	**0.05**	**(0.01)**	0.03	(0.03)	**0.04**	**(0.01)**		
OCC:CNMXon							**0.07**	**(0.03)**	**0.04**	**(0.02)**		
Adj. R^2	0.69		0.03		0.73		0.06		0.75		0.70	
AIC	1064		498		337		496		333		1054	
RMSE	1.08		1.68		0.88		1.65		0.86		1.06	
CV(RMSE)	0.37		0.57		0.30		0.56		0.29		0.37	
No. Obs.	354		127		127		127		127		127	
kWh Mean (SD)	2.9	(1.9)	2.9	(1.7)	2.9	(1.7)	2.9	(1.7)	2.9	(1.7)	2.9	(1.7)

Notes: Based on testing period when evaporator temperature setpoints were too high.
Preferred model highlighted, based on lowest Akaike Information Criteria (AIC).
Significant terms in bold (p<0.05).

To estimate annual energy savings, we used the fitted models to predict consumption based on a full year of observed weather data and occupancy profiles experienced by each site. For each we applied model M5 to illustrate the expected change, however, we note the COOLNOMIX terms were not significant for cooler "A." Estimated annual savings were below 5%, well below the target of 15%.

Table 6-35. Predicted Annual Refrigeration Energy Consumption Change.

	COOLER A (M5)				COOLER B (M5)				COOLER C (M5)			
(kWh)	Baseline	CNMX	Δ	%	Baseline	CNMX	Δ	%	Baseline	CNMX	Δ	%
Compressor	1,523	1,633	+110	+7	1,136	1,278	+142	+12	2,136	2,035	-101	-4.7
Evap. Fans	2,040	2,040	-	-	2,040	2,040	-	-	1,360	1,360	-	-
Total	**3,563**	**3,673**	**+110**	**+3**	**3,176**	**3,318**	**+142**	**+4**	**3,496**	**3,395**	**-101**	**-2.9**

Notes: Evaporator fan energy estimates are based on always on, high speed.

Each evaporator had 1/15 HP fan motors (three for coolers "A" and "B" and two for cooler "C") that ran continuously, consuming up to 2,040 kWh annually.[40] Although, this site had a fan speed controller, we assumed full duty cycle in this calculation to be more representative across typical sites that lack this feature.

For coolers with multi-speed fan controllers, COOLNOMIX could increase fan runtime and energy use. For instance, COOLNOMIX increased high-speed stage fan duty cycle on cooler "A" from about 15-20% to 40-60%. If the low speed uses half the power of the high speed, this could increase average fan power by about +25%, increasing fan energy by about +300 kWh (from 1,200 to 1,500 kWh). To be cost effective, COOLNOMIX would need to more than overcome this penalty with compressor savings on such units.

[40] Typical power draw for a 1/15 HP fan ranges from about 65-90 W depending on motor type (Navigant 2009).

For cooler “C” the compressor energy includes the condenser fan. For coolers “A” and “B” one set of condenser fans served four evaporators and ran only when the compressors were running. We did not measure or estimate condenser fan power for those cases.

Several factors may have limited the ability for COOLNOMIX to save energy. One mechanism for COOLNOMIX to save energy is to avoid unnecessary calls for cooling triggered by doors opening and closing near the thermostat. In all tests, the existing thermostat was located in close proximity to the COOLNOMIX return air sensor, at height on the evaporator. As a result, we did not experience a situation where a brief thermal disturbance would trigger unnecessary calls for cooling. A second mechanism for saving energy is to stop the compressor earlier in its cycle before it floods the evaporator. During normal operation, the compressors were already running relatively short cycles much of the time, thus limiting the potential to eliminate unnecessary compressor work.

In conclusion, while there was clear evidence that COOLNOMIX modified compressor operation as expected for all three walk-in coolers, there was limited evidence for a significant impact on energy consumption.

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7.0 COST ASSESSMENT

7.1 COST MODEL

The cost model for COOLNOMIX is based on the elements highlighted in (Table 7-1). Typical estimated values for the test sites in this demonstration are given in the table. The following subsections define the underlying assumptions in greater detail.

Table 7-1. Cost Model for COOLNOMIX.

Cost Element	Data Tracked During the Demlonstration	Estimated Costs (Rounded)
Hardware Capital Costs	Cost of COOLNOMIX unit hardware incurred in this demonstration.	$500 per COOLNOMIX unit; typically one per thermostat or condenser
Installation	Labor and material required to install and commission COOLNOMIX	1.25-7.0 labor-hours (@ $50/h nominal) + $0-70 materials = $60-380
Consumables	None.	-
Maintenance	Worn contactor replacement (1x per compressor stage during lifetime [@ year 5])	Recurring cost, $200 every five years
Hardware Lifetime	Could not evaluate in two years. No failures observed in working units.	10 years, estimated.
Operator Training	Assume four hours training per year per technician.	$20 per year per COOLNOMIX unit
Facility Operational Costs	Annual energy savings from COOLNOMIX (depends on many factors, best-case observed 17% on total cooling system energy use for the only system with fans always on)	% of annual cooling system energy, $/kWh (e.g., 24,000 kWh/year x 17% x = 4,000 kWh; x $0.10/kWh = $400/yr in savings)

7.1.1 Hardware Capital Costs

One COOLNOMIX unit is needed per thermostat. In all the test cases we evaluated, there was only one thermostat per condenser. At the time of this demonstration, hardware costs were $500 per unit for cooling systems with less than 10 tons of capacity.

7.1.2 Installation Costs

Installation costs are broken into labor and materials and are typically about $300 ($60-380) per site.

We estimate typical labor costs range from about $60-310 (Table 7-2), based on a nominal $50 hourly technician or electrician rate and a $30 hourly assistant rate. Actual labor rates vary by location and should be updated accordingly. Depending on the structure of HVAC maintenance contracts, some bases have technicians on staff who can perform the installations, while others will require third party contractors. We observed both scenarios.

Table 7-2. Installation Labor Cost Model for COOLNOMIX.

Labor Element\ (hours)	Technician	Electrician	Assistant	Total
Basic Installation	0.75	-	-	
Need to extend sensor wire?	0.50	-	-	
Need a ladder?	-	-	0.50	
Need to run power?	-	1.00	-	
Multi-stage condenser?	0.50	-	-	
Need to install relay coil?	0.25	-	-	
Basic Commissioning	0.50	-	-	
Extended Commissioning	1.50	-	1.50	
Min Labor:	**1.25**	**-**	**-**	**1.25**
Max Labor:	**4.00**	**1.00**	**2.00**	**7.00**
Labor Cost ($/h)	$50	$50	$30	
LABOR COST RANGE:	**$63-200**	**$0-50**	**$0-60**	**$63-310**
MATERIAL ELEMENT		**$/UNIT**	**QTY**	**COST**
Sensor Wire (50 ft)		$20	1	$20
Relay Coil		$20	1-2	$20-40
Misc. (wire, switch, duct tape, splice caps)		$10	1	$10
MATERIAL COST RANGE:				**$0-70**
TOTAL INST. COST RANGE:				**$63-380**

Prior to installing COOLNOMIX, cooling systems should undergo a maintenance checkup/tune-up. The cost of these checkups is not included in the COOLNOMIX cost estimates, since they should be done periodically anyway and could yield significant savings in the form of energy savings and equipment life extension that lie outside the scope. Cooling systems should be properly maintained and configured prior to COOLNOMIX installation.

Labor time and tasks for installation and commissioning depend on several site-specific factors.

All sites require basic installation that includes wiring COOLNOMIX, positioning sensor wire, and connecting power. In many installations additional steps are needed. Often, it is necessary to extend sensor wiring more than a few feet into the conditioned zone. Sometimes this process is involved and requires a ladder and fishing wire through ducts. For safety reasons, when a ladder is needed, an assistant or second technician should be present.

Normally, COOLNOMIX can be powered from mains voltage up to 240V A/C, or from the HVAC unit itself. In most cases, this connection can be made by a technician. Some HVAC units operate at higher voltages, and an electrician may be required to run power a short distance. This occurred at only one of our test sites.

All sites also require basic commissioning that includes selecting the return air setpoint, and confirming the system is wired correctly and operational. Commissioning could be more involved depending on the test site. For instance, when the condenser is far away from the conditioned zone, it is often necessary to have one person inside and one person near the condenser while testing the system. For larger zones, it may take several attempts to find a good combination of return air temperature sensor placement and setpoint.

Additional materials for installation also depend on the situation. Often, it was necessary to extend the temperature sensor wiring through ductwork into the conditioned zone. Shielded speaker wire can be used for this purpose and is relatively inexpensive (<$20 for 50 ft). In some cases, it was necessary to install one or more relay coils to prevent HVAC error codes. Relay coils also typically cost less than $40. Other optional components include a bypass switch, control wiring, electrical caps, and duct tape (<$10).

Applying the model to the 12 test sites, yields average estimated installation costs of $222 for air conditioning and $153 for refrigeration (Table 7-3).

Table 7-3. Modeled Installation Costs Modeled for Units in Demonstration.

LABOR ELEMENT	AC1	AC2	AC3	AC4	AC5	AC6	REF1	REF2	REF3	REF4	REF5	REF6
Basic Installation	1	1	1	1	1	1	1	1	1	1	1	1
Need to extend sensor wire?	1	1	1	-	1	1	-	-	-	1	1	1
Need a ladder?	-	-	-	-	1	1	-	-	-	1	1	1
Need to run power?	1	-	-	-	-	-	1	1	1	1	1	1
Multi-stage condenser?	-	-	1	-	-	-	-	-	-	-	-	-
Need to install relay coil?	1	-	1	-	-	-	-	-	-	-	-	-
Basic Commissioning	1	1	1	1	1	1	1	1	1	1	1	1
Extended Commissioning	-	-	1	1	1	1	-	-	-	-	-	-
Condenser Stages	1	1	2	1	1	1	1	1	1	1	1	1
LABOR (hours)												
Technician	2.0	1.8	4.0	2.8	3.3	3.3	1.3	1.3	1.3	1.8	1.8	1.8
Electrician	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0
Assistant	0.0	0.0	1.5	1.5	2.0	2.0	0.0	0.0	0.0	0.5	0.5	0.5
LABOR COST	**$150**	**$88**	**$245**	**$183**	**$223**	**$223**	**$113**	**$113**	**$113**	**$153**	**$153**	**$153**
MATERIAL												
Sensor Wire	$20	$20	$20	-	$20	$20	-	-	-	$20	$20	$20
Relay Coil	$20	-	$40	-	-	-	-	-	-	-	-	-
Misc.	$10	$10	$10	$10	$10	$10	$10	$10	$10	$10	$10	$10
MATERIAL COST	**$50**	**$30**	**$70**	**$10**	**$30**	**$30**	**$10**	**$10**	**$10**	**$30**	**$30**	**$30**
INSTALLATION COST	**$200**	**$118**	**$315**	**$193**	**$253**	**$253**	**$123**	**$123**	**$123**	**$183**	**$183**	**$183**

7.1.3 Maintenance Costs

By increasing compressor cycles, COOLNOMIX could increase wear on the compressor contactor, leading to premature part failure. Including labor, contactor replacement can range from $150-350.[41] We assume that in half of COOLNOMIX units, one additional contactor replacement would be required (for each compressor stage during) the remaining system lifetime, at an installed cost of approximately $200 (+$80 for each additional stage beyond one). Thus, for the cost model, we would assign a one-time cost of $140 = 0.5 x ($200 + $80) for a two-stage condenser.

Since COOLNOMIX could be disconnected or disabled during maintenance, it is important to initiate periodic checkups to ensure the systems remain functional. This COOLNOMIX checkup could be integrated into the existing preventative maintenance program (e.g., filter replacement). For instance, annually, technicians could complete a checklist confirming/adjusting COOLNOMIX settings. This would add approximately 15 minutes of labor per year per site (about $12 per year at a $50 hourly rate).

[41] See: https://www.strandbrothers.com/blog/how-much-does-air-conditioning-service-cost.

7.1.4 Hardware Lifetime

We assume a 10-year COOLNOMIX lifetime. We could not evaluate lifetime during a two-year demonstration. Once all units were working, none failed within two years of continuous use. Since COOLNOMIX is a solid-state relay-based control device, it has only one moving part, two sensors, and one circuit board that could fail. The relay operates on control voltage, and therefore does not experience the same high inrush current that contactors do. Wear is more likely to come from environmental exposure to moisture and dust, which is site-dependent.

Potentially more important, however, is the remaining lifespan of the HVAC system in which COOLNOMIX is installed. Cost effectiveness calculations should be adjusted based on the expected remaining equipment life. ASHRAE[42] estimates typical useful service life of 15 years for packaged and split HVAC systems, beyond which failure rates increase. Much of the equipment we observed at DoD facilities was still functioning well beyond 15 years, suggesting longer than average equipment service periods. As a result, our cost calculations assume that COOLNOMIX is installed only on units that will remain operational for at least 10 more years.

7.1.5 Operator Training Costs

Once properly configured, there are no operator actions required. Technicians should be trained to make COOLNOMIX setpoint and sensor adjustments and to prevent accidental disabling of COOLNOMIX units during routine or diagnostic maintenance.

Maintenance training should be hands-on and could be combined with on-site installer training. During this demonstration, we spent about one hour reviewing the technology with the installing technicians and supervised all installations. After about three installations, technicians became familiar and more comfortable with the installation process.

During a full day of training, a technician (or a group) could complete two to three installations. Afterwards, this technician could train others on how the system works and how to install and maintain the units during routine maintenance. If a base had 100 air conditioners suitable for COOLNOMIX, this training could be amortized across all the units. Suppose one installer and three maintenance technicians required four hours of training each (on average) to support the 100 cooling systems. At a $50 hourly rate, this is $800 in training labor. Due to staff turnover, suppose this training must be repeated every two years. This amounts to about $400 per year in annual training costs, or about $4 per COOLNOMIX unit per year.

7.2 COST DRIVERS

We found significant savings with COOLNOMIX only in two of the four air conditioning test sites and none of the six refrigeration sites. Recommendations, therefore, focus on the common aspects of the successful air conditioning cases. Several key drivers influence cost effectiveness:

1. Baseline ventilation fan control strategy (always on, or independent from thermostat)
2. Cooling degree days (higher is better)
3. Cooling loads (higher is better)
4. Cooling system capacity (higher is better)

[42] See: https://emcorgroup.com/downloads/eblasts/Equipment-Life-Estimates.pdf.

5. Electricity rates (higher is better)
6. Labor rates (lower is better)

7.2.1 Fan Control Strategy

Energy savings were found in two of the six air conditioning cases. In both cases, the fans ran most of the time in the baseline. All other cases that did not show savings had ventilation fans set to AUTO during most of the cooling season. When the fans were set to AUTO, COOLNOMIX increased fan runtime and total cooling system energy consumption.

With future development, COOLNOMIX could control the fans differently to avoid substantial extra ventilation fan runtime, which could result in savings in a broader range of applications; however, as the technology stands, we can only recommend considering COOLNOMIX as-is for the limited cases where the ventilation fans run most of the time or are otherwise not influenced by the thermostat or calls for cooling.

7.2.2 Cooling Degree Days

Cooling degree days drive air conditioning loads. In hotter climates, total cooling system energy consumption is higher and the condenser consumes a greater portion of the total cooling system energy consumption, leading to higher savings potential.

7.2.3 Cooling Loads

Buildings with higher internal gains, such as from computers, servers, or other sources of heat, could increase the portion of the year that cooling is required, and therefore, the energy saving potential. Annual cooling loads differed significantly among the two test sites.

7.2.4 Cooling System Capacity

Larger cooling systems, and especially those that are well oversized, offer the highest opportunity for savings. Unfortunately, in this demonstration, many of the units we tested were not significantly oversized or had reduced capacity due to maintenance issues. In at least one case, the system was slightly undersized. Despite this, savings were still observed in the undersized case, though to a smaller degree.

7.2.5 Electricity Rates

Electricity costs vary significantly across regions and DoD installations. Higher unit costs per kWh lead to faster payback times. The range of electricity rates across all states was \$0.076-0.246/kWh commercial (mean 0.10) and \$0.043-0.21 industrial (mean 0.068). At Ft. Bliss, the blended electricity rate[43] was about \$0.06/kWh in 2010, close to the El Paso, TX industrial rate. Industrial rates in Washington, D.C., where JBAB is located, were about \$0.08/kWh.

7.2.6 Labor Rates

Labor rates influence the installed and maintenance costs associated with COOLNOMIX. Doubling the assumed rates could increase first costs by about 26% (from \$722 to \$907).

[43] See: https://www.army.mil/e2/c/downloads/216568.pdf.

7.3 COST ANALYSIS AND COMPARISON

Since positive energy savings were found only in a limited air conditioning case (when fans are always on in the baseline), we performed a cost analysis for this situation only for illustration and note that savings percentages could differ at other sites.

Lifecycle costs, calculated by applying the NIST Building Life Cycle Cost program (BLCC 5.3-2018),[44] are summarized for different scenarios in (Table 7-4). All scenarios assume a 10-year product lifetime and a 3% real discount rate.

Table 7-4. Cost Analysis Scenarios for COOLNOMIX.

ASSUMPTIONS \ SCENARIO	S0	S1	S2	S3
FINANCIAL				
Lifecycle (years)	10	10	10	10
Real Discount Rate	3%	3%	3%	3%
Electricity Price ($/kWh)	$0.06	$0.12	$0.06	$0.06
Labor Rate Tech./Electrician ($/hr)	$50	$50	$50	$50
Labor Rate Assistant ($/hr)	$30	$30	$30	$30
COSTS				
Hardware ($)	$500	$500	$500	$500
Installation ($)	$222	$222	$222	$222
First Cost ($)	**$722**	**$722**	**$722**	**$722**
Contactor Replacement ($)	$125	$125	$125	$125
Maintenance + Training ($/yr)	$16	$16	$16	$16
10-year life costs (non-discounted $)	**$1,007**	**$1,007**	**$1,007**	**$1,007**
COOLING SYSTEM				
Compressor Stages	2	2	2	1
Cooling System Capacity (tons)	7.5	7.5	15	3.25
Cooling System Capacity (Btu/h)	9,000	9,000	18,000	4,500
ENERGY COST SAVINGS				
Cooling System Savings (%)	17%	17%	17%	17%
Energy, Baseline (kWh/yr)	23,605	23,605	47,210	11,803
Energy, COOLNOMIX (kWh/yr)	19,575	19,575	39,150	9,787
Energy Savings (kWh/yr)	4,030	4,030	8,060	2,015
Energy Cost Savings ($/yr)	$241	$481	$481	$120
COST MODEL RESULTS				
Lifecycle Energy, Baseline (kWh)	$13,091	$26,182	$26,182	$6,546
Lifecycle Energy, COOLNOMIX (kWh)	$11,821	$22,677	$22,677	$6,393
Lifecycle Cost Savings (LCCS, $)	$1,270	$3,505	$3,505	$153
Simple Payback Period (SPP, years)	4.1	2.1	2.1	8.4
Savings to Investment Ratio (SIR)	1.8	4.9	4.9	0.2
LIFECYCLE GHG EMISSIONS				
Baseline (thousand kg CO_2)	154	154	308	77
COOLNOMIX (thousand kg CO_2)	128	128	256	64
GHG Reduction (thousand kg CO_2)	26	26	52	13

[44] http://www1.eere.energy.gov/femp/information/download_blcc.html#blcc.

Scenario S0 represents the best-case result as-is (17% total cooling systems energy savings), with the actual electricity price ($0.06/kWh). In this case, we estimate $241 in annual energy cost savings, a simple payback period (SPP) of 3.0 years, $1,270 in lifecycle cost savings (LCCS), and a savings to investment ratio (SIR) of 1.8.

Scenario S1 shows how doubling the electricity rate to $0.12/kWh increases LCCS (to $3505) and increases SIR (to 4.9). Scenario S2, which doubles the baseline cooling system electricity consumption and capacity (for instance, by increasing the loads or conditioned floor area), gives the same result. Scenario S3, which halves the baseline cooling system electricity consumption, increases SPP to 6 years while reducing SIR to 0.2.

These results suggest that there is likely a minimum viable baseline annual cooling system energy consumption for a project to be financially attractive. This minimum depends on electricity prices and the actual savings percentage. For instance, at a $0.06/kWh rate and a 17% savings, annual consumption (per thermostat/condenser) would need to be about 18,000 kWh/yr to deliver an SIR of 1.0. As a result, most cooling systems smaller than 5 tons are unlikely to be cost effective.

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8.0 IMPLEMENTATION ISSUES AND TECHNOLOGY TRANSFER

This demonstration revealed several implementation issues related to pre-installation, installation, COOLNOMIX hardware, and reliability that could affect energy savings, thermal comfort, installed cost, or practical success. As we did not identify savings with the refrigeration equipment, we restrict this discussion to air conditioning systems. We identify the main considerations and discuss potential pathways for addressing them (Table 8-1). By far, the most important issues were related to control and commissioning, and above all, fan control.

Table 8-1. Implementation Considerations.

Issue	Details	Remedy
INSTALLATION		
HVAC Capacity and Condition	Undersized and poorly maintained systems may have reduced savings opportunity.	Develop more detailed screening procedure to identify cooling systems with enough excess capacity. Develop detailed procedure for pre-install checkup and tune-up. Combine pre-installation/screening with routine preventative maintenance.
Integration	The installation process depends on the thermostat and cooling system type, and may require additional components.	Develop wiring diagrams, parts lists, and install kits for common system/thermostat combinations.
CONTROL and COMMISSIONING		
Fan Control	For cooling systems with ventilation fans set to AUTO (run only during calls for cooling), COOLNOMIX can significantly increase fan runtime, ventilation rates, fan energy use, and cooling system energy.	Do not install COOLNOMIX on thermostats where fans are set to AUTO. Ensure that ventilation runs on a fixed timer/schedule. Modify COOLNOMIX to keep fans on for only several minutes after each cooling cycle. Integrate COOLNOMIX with thermostats and/or cooling systems.
Setpoint Selection	If COOLNOMIX setpoint is too high, the zone could get too hot. If too low, COOLNOMIX may not engage.	System must be commissioned and tested on a hot day. Installer must allow system to cycle several times to verify ability to maintain setpoints.
Sensor Placement	Misplaced sensors can lead to discomfort or no savings.	Develop more detailed guidelines for return sensor placement for common zone layout scenarios.
Commissioning	COOLNOMIX could be installed but may not actually engage if wired or set up incorrectly.	Develop more detailed prescriptive step-by-step methods for confirming and diagnosing COOLNOMIX operation.
COOLNOMIX HARDWARE		
Setpoint Interface	DIP switch temperature settings were difficult to read/program, sometimes changed by accident.	Change the user interface to a numeric selector and/or digital read-out.
Error Code Interface	Meaning of flashing color codes is not intuitive or easy to understand.	Develop more detailed description of system codes or an easier to understand system.
Power Source	COOLNOMIX requires a power source that may require an electrician.	Wiring was typically simple, but requires a competent worker. In some situations, a 120V A/C power cord would be desirable.
Bypass Switch	No bypass switch makes diagnostics more difficult.	Integrate a manual bypass switch.
Onboard Measurement and Verification	There is no easy way to tell if COOLNOMIX is actually saving energy.	Add ability to log and report the number of daily compressor cycles and average cycle duration for diagnostic / evaluation purposes.
Humidity Sensor	Dehumidification could be reduced when running COOLNOMIX.	Add a return air humidity sensor to bypass COOLNOMIX if the zone gets too humid.

Table 8-1. Implementation Considerations. (continued)

Issue	Details	Remedy
RELIABILITY		
Persistence	COOLNOMIX could be uninstalled, disabled, or adjusted over time during ordinary maintenance.	Train maintenance staff. Include COOLNOMIX checkups in routine preventative maintenance.
Contactor Wear	Contactors may wear out faster with COOLNOMIX installed.	Keep extra contactor on hand for replacement when it wears out.
Compressor Wear	Compressor may wear out faster, but this is unlikely.	Track compressor maintenance issues over time.
COOLNOMIX Wear	COOLNOMIX lifetime is not known, especially for units installed outdoors.	Track COOLNOMIX reliability over time.
OEM Warranty	Installing COOLNOMIX could void equipment warranty, depending on how it is installed.	Install on systems that are out of warranty (typically after 5 years) or install only on the thermostat.

CoolGreenPower is developing a network of distributors. Technology transfer strategies include direct sales to DoD and other relevant customers.

8.1 ENERGY PERFORMANCE AND EXCESSIVE FAN RUNTIME

Energy performance results in this demonstration were substantially different, and generally much less favorable, than those reported by studies conducted in overseas regions. This was the most significant implementation issue. At least five factors likely contributed to this outcome.

First and foremost, differences in air conditioning system architecture related to fan power and control strategy led to overwhelming fan energy penalties. By design, COOLNOMIX runs connected evaporator and ventilation fans longer to extract residual cooling from the refrigerant lines during the compressor off-cycle. This additional runtime incurs a fan energy penalty. To achieve net positive savings, the compressor energy savings must exceed this fan energy penalty.

In Asia, where COOLNOMIX was developed, and in many other regions, ductless air conditioning systems like VRV/VRF and mini-/multi-split systems are common. These systems supply refrigerant to indoor evaporator units, each equipped with a low power blower fan (typically around 150 W), and the fan penalty is less severe. Ventilation air is typically handled separately, so larger ventilation fans and loads are not affected.

In contrast, the ducted single-zone packaged RTUs and split-system condensers we tested, common to the U.S., all relied on much larger fans (often 1,000 W or more) to supply both ventilation and cooling. These fans were controlled directly by the thermostat and were normally programmed to run only when the thermostats in the zone called for cooling. With COOLNOMIX enabled, the fan runtime more than doubled in many cases, leading to a steep fan energy penalty. In addition, extra ventilation fan runtime resulted in higher ventilation rates, which had variable effects on cooling loads, often increasing them during the day and occasionally reducing them at night. These penalties and factors are discussed at length in the Performance Assessment.

Second, longer and hotter cooling seasons in other regions yield higher savings opportunity. Hong Kong, where COOLNOMIX was developed, typically has over 4,400 CDD_{65} per year – substantially more than most U.S. locations, about 30% more than El Paso, TX, and more than twice that of Washington, D.C. In such a climate, there is more cooling energy consumption, longer cooling season, and higher nighttime temperatures. Hotter climates would also tend to reduce fan penalties, as the fans would likely to run longer during the baseline.

Third, there is a tendency to oversize cooling equipment in the U.S., as builders wish to avoid and to provide resiliency against space reconfigurations that may lead to increased cooling loads. At the DoD facilities we tested, however, the cooling systems were not extremely oversized, and in at least one case, the unit was slightly undersized. If oversizing is not as prevalent at DoD facilities, the savings opportunity could be lower.

Fourth, at the DoD test sites we encountered, thermostats in both cooling and refrigeration systems were positioned appropriately, and generally controlled the zone temperature adequately. In most baseline cases, we did not find evidence of significant overcooling. Moving the control temperature sensing position, therefore, did not apparently improve space temperature, so the opportunity for this type of savings was not significant.

Fifth, and finally, we reviewed some third-party case studies provided by CoolGreenPower and Agile8 Consulting. Often, important contextual details were lacking that made it impossible to evaluate the quality or validity of the results. Many tests, for instance, took place over a short duration (one week on / one week off) and did not measure or report all relevant system characteristics, and environmental parameters. Similar criticisms have been made about other compressor control technologies' case studies (LBNL 1998, WSU 2008).

Additional development is required to address the excessive fan runtime issue before any further rigorous testing takes place. CoolGreenPower and Agile8 Consulting have begun developing new installation methods, hardware configurations, and firmware to address this issue, and are currently testing preliminary solutions in U.S. pilots. Future demonstrations must carefully consider how compressor controls affect all HVAC fans.

8.2 INSTALLATION

8.2.1 HVAC Capacity and Condition

Before installation, energy managers must identify the relevant air-based vapor-compression cooling systems that have excess capacity on most ordinary days. Installing COOLNOMIX on undersized units or those operating at partial capacity (due to wear, low charge, poor maintenance, etc.) could limit energy savings potential.

This could be addressed by developing a more detailed pre-installation screening procedure to identify cooling systems with sufficient excess capacity. For specific cooling applications or building types, exclusionary rules of thumb could be applied (e.g., minimum cooling capacity per conditioned floor area) to reduce the time and effort spent at irrelevant sites. Once appropriate candidate sites have been identified, additional on-site screening and tune-ups could be performed during routine preventative maintenance. Before installing COOLNOMIX, cooling systems should have their refrigerant checked and corrected, as this was a common fault. A formal check-up and screening process should be developed and validated as part of technology deployment.

Additionally, fan control settings (schedule, always on, auto) should be noted, as this plays a critical role that we discuss later on.

8.2.2 Integration

The COOLNOMIX installation process varies depending on the thermostat and cooling system type and may require additional components beyond those provided in the COOLNOMIX installation kit. When wiring COOLNOMIX to certain kinds of thermostats, a resistor (not supplied) must be wired into the circuit. When the HVAC equipment voltage is too high (e.g., 408/277 V), it may be necessary to install a step-down transformer to power COOLNOMIX. Additionally, some condensers use current detection circuits to tell if the contactor is connected and produce error codes if the circuit is interrupted. In these cases, it is necessary to wire in a separate relay to avoid this error code. For systems with multi-stage compressors, COOLNOMIX can be wired in several ways, controlling one stage or both stages together. In practice, technicians found it difficult to interpret these wiring diagrams, which led to incorrect installations that had to be corrected.

To address potential issues with integration, we recommend developing detailed wiring diagrams, parts lists, and install kits for common system/thermostat combinations. In addition, for the most common cases, these wiring diagrams should be supplemented with step-by-step picture instructions to avoid misinterpretation. A multi-stage model with multiple built-in relays could be developed to avoid the need for on-site wiring.

8.3 CONTROL AND COMMISSIONING

8.3.1 Fan Control

Perhaps the most important and critical finding of this study, some thermostat-controlled ventilation fan settings can cause COOLNOMIX to use significantly more energy. Specifically, in cases where the ventilation fans are set to AUTO (common in this test), such that they run only when the thermostat calls for cooling, COOLNOMIX can increase fan energy and ventilation rates, often by a factor of two or more. This happens because when COOLNOMIX works, it often keeps the zone temperature just slightly above the thermostat setpoint. In doing so, the thermostat calls for cooling (and runs the fans) almost all the time, while COOLNOMIX cycles the compressor to modulate the zone temperature. Energy increases associated with additional fan runtime can completely offset the potential condenser energy performance gains. Increased fan runtime could be reduced in several ways, each with different advantages.

Before installing COOLNOMIX, facilities should evaluate their current ventilation strategy. Excessive ventilation and cooling while zones are unoccupied (e.g., overnight), was common across test sites. Significant savings could immediately be realized in these cases simply by correcting the faulty strategies. Steps should be taken to prevent occupants from altering these settings. Once this is done, there are at multiple paths for addressing the COOLNOMIX fan issues.

First, COOLNOMIX could be installed as-is, but only in buildings or spaces where the fans do (and should) always run continuously, such as buildings that are always occupied or those with consistently high around-the-clock cooling loads; or applications where the thermostat does not control the ventilation fans. In practice, this would greatly diminish the number of relevant candidate sites and applications.

Second, the COOLNOMIX hardware could be modified to minimize extra fan runtime. For instance, instead of overriding the control signal to the compressor, COOLNOMIX could be configured to provide a false temperature signal to the thermostat. The thermostat, in turn, would control the compressor and fans together. In this case, COOLNOMIX would also need a way to keep the ventilation fans on and running for several minutes after each cycle to realize the fan-overrun capabilities. Some thermostats offer fan overrun capabilities. In those that don't, the thermostat could be replaced, or the control wiring modified. If COOLNOMIX controls ventilation fans, care must be taken such that adjusting the fan control strategy does not interfere with normal economizer function, provided one is installed. Installations in these cases could require more steps for installation and commissioning, potentially increasing the marginal labor and hardware costs.

Third, COOLNOMIX capabilities could be directly integrated into OEM thermostat products. This, too, would limit applications to sites that are willing to replace their existing thermostats, and would require additional hardware development or integration. Ensuring compatibility across a wide range of equipment types would make this option challenging.

Fourth, COOLNOMIX capabilities could be directly integrated into OEM cooling system equipment. This could be a long and slow path to commercialization and would depend on getting the interest and commitment of manufacturers.

Other options for addressing increased fan runtime may exist, though we cannot recommend installing COOLNOMIX until this issue is addressed.

8.3.2 Setpoint Selection

During configuration, users must select the COOLNOMIX return air temperature setpoint. If this setpoint is set too high, the zone temperature could become too hot when COOLNOMIX holds the compressor off. If it is set too low, COOLNOMIX may not engage. Getting this COOLNOMIX setpoint just right depends on the thermostat's setpoints and the placement of the return air sensor.

To address setpoint selection, COOLNOMIX must be commissioned and tested during a hot portion of a hot day. This ensures that the system will be able to condition the zone during the heat of the summer. During commissioning, the system should be allowed to cycle at least several times while monitoring the return air temperature and the zone temperature. The appropriate setpoint is closely related to the return air temperature sensor placement, discussed in the next section. More specific guidance should be developed to help users balance comfort tradeoffs while ensure that savings are being realized.

8.3.3 Sensor Placement

Placement of the COOLNOMIX return air temperature can strongly affect the cooling system's ability to maintain the desired zone temperature setpoint. In the demonstration, return air sensors were initially placed in the condenser, where they were subject to solar heat gains. When the return sensors became heated, their readings inflated, preventing COOLNOMIX from engaging.

Extending the return air sensors into the conditioned zone resolved the issue in most cases. This involves running sensor wiring through ductwork. Often, this is simple and straightforward. In some cases, it took substantial effort and time to run the wiring into the zone.

Return sensors in the ductwork, however, are still not immune from external heating. Sensors in ducts located beneath a roof or in an uninsulated plenum, for instance, could also be influenced by variable heat gains. In other cases, short-circuiting of supply air into return ducts could lead to lower or variable return temperatures. Finally, there may be several available return air vents – selecting one that leads to stable temperature control could take several attempts. In one case, we extended the return air temperature sensor to the thermostat to resolve the issue.

To address the return air sensor placement issue, we recommend developing more detailed instructions and guidelines for common zone layout scenarios.

8.3.4 Commissioning

In several cases, COOLNOMIX was installed and apparently working (no error codes, status lights nominal), but later it was discovered that it was not actually controlling the compressor. Reasons for this varied (return air setpoint too low, sensor placement, incorrect control wiring, low refrigerant charge, undersized unit), but all point to the need for a more detailed, prescriptive step-by-step commissioning process for validating correct configuration and diagnosing issues.

For instance, a sequence of steps should be developed that will allow the installer to verify that COOLNOMIX is indeed controlling the compressor. This could be done by following a sequence like this:

1. Before connecting COOLNOMIX, observe typical on/off compressor cycle duration (min.)
2. Set the COOLNOMIX return air setpoint to the lowest setting
3. Turn the zone thermostat to the coldest temperature (verify that the compressor turns on)
4. Wait three minutes
5. Set the COOLNOMIX return air setpoint to the highest setting (verify that the compressor shuts off immediately)
6. Wait five minutes
7. Set the COOLNOMIX return air setpoint back to the lowest setting (verify that the compressor turns back on immediately).

After confirming correct operation, the return air setpoint can be set to its appropriate setting. Once the system is up and running and has been cycling normally for at least an hour, the installer should monitor a typical cycle duration (on/off time in minutes) and compare this with baseline values. Cycles should be notably shorter and more frequent (typically less than 10 min. on and 3 min. off).

Further steps for diagnosing issues should be developed, especially related to diagnosing and correcting improper wiring, return air setpoint settings, and sensor placement.

8.4 COOLNOMIX HARDWARE

8.4.1 Setpoint Interface

To program the return air setpoint, users must toggle four DIP switches housed inside a screw-mount panel on the COOLNOMIX unit. Several usability issues were encountered during the installations that could lead users to implement incorrect setpoints, which could compromise thermal comfort or energy savings.

First, the switches were small, difficult to read, and difficult to adjust. Adjustments were especially challenging when the COOLNOMIX unit was mounted inside an RTU or control panel. In those cases, there is often limited clearance and other wires that obstruct access. In at least one case, the technician unintentionally changed the setpoints while putting the cover back on.

Second, the DIP switches and the temperature code sticker were easily misinterpreted. Black and white squares on the temperature stickers representing DIP switch position were often confused by the installers, such that switches that should have been toggled up were toggled down instead.

These issues could be overcome with proper training and careful works, or preferably, by upgrading the interface to a more usable numeric selector, ideally with a digital read-out. A digital read-out would also be useful for diagnostic purposes, such as indicating the measured return and supply air temperatures, and COOLNOMIX relay status.

8.4.2 Error Code Interface

COOLNOMIX includes two blinking LEDs to communicate device status and error codes. These codes were not intuitive and did not provide complete ability to diagnose and resolve issues.

For instance, in one case, the COOLNOMIX control wires were disconnected by a technician during diagnostic HVAC maintenance. The COOLNOMIX status lights continued blinking normally, giving no clue that the system was no longer connected.

Similarly, there is currently no direct way to verify that the temperature sensors are properly connected and reading expected values. In one case, while the electrician was extending a sensor wire, he failed to connect the sensor leads. Without catching this mistake in the field, there would be no indication that COOLNOMIX was not properly configured, and the unit would not function as intended.

The COOLNOMIX control board does include a pinout for a hand-held diagnostic reader; however, this reader was not yet available for purchase. To provide more complete and clear diagnostic capabilities, we would recommend a simple digital readout capable of displaying measured supply and return air temperature, COOLNOMIX relay status, and/or other relevant error codes. Numeric codes could be used to communicate status, along with a sticker on the device to translate their meaning.

8.4.3 Power Supply

COOLNOMIX requires a hard-wired A/C voltage source for power. This could be obtained from the control panel of most RTUs or air handlers, or from a standard 120V A/C source indoors. Depending on the situation, this could require an electrician; however, in most cases, HVAC technicians were comfortable performing the minimal wiring required. When installing COOLNOMIX indoors near a thermostat, there may not be a readily-accessible voltage source. In such cases, it could be desirable to have a plug-style power adapter. On the other hand, this carries a risk that the unit could eventually become unplugged without being noticed, which would eliminate any future savings.

8.4.4 Bypass Switch

During diagnostics, it is sometimes desirable to temporarily bypass COOLNOMIX by forcing the relay closed. Currently, this feature does not exist onboard. During the test, we installed a third-party switch in-line with the COOLNOMIX relay, effectively shorting out the relay when the bypass switch is closed. This worked, but added unnecessary complexity, installation labor, and another potential failure point. If a temporary bypass switch was available, this could simplify diagnostic procedures. Integrating the bypass into the COOLNOMIX unit would also make it possible to alert users if the switch was left off by accident.

8.4.5 Onboard Measurement and Verification

It can be difficult to tell if COOLNOMIX is actually working or saving energy. One way to verify that COOLNOMIX is engaging, is to include the ability to log and report the number of daily compressor cycles and average cycle duration. Typically, compressor cycles are much shorter and more frequent with COOLNOMIX. Adding the ability to run in a "baseline" mode for a period of time with COOLNOMIX temporarily in bypass could allow simple before and after comparisons of compressor runtime. These estimates, however, would provide only crude approximations for savings, since a robust analysis would require weather normalization. It is unclear if reliable, onboard savings estimates could be achieved in a low-cost form factor.

8.4.6 Humidity Sensor

Prior research indicates that running shorter, more frequent compressor cycles while keeping the supply fans running could lower dehumidification performance. Moisture on the coil has less time to fully condense, and between cycles residual moisture on the cooling coil can re-evaporate and enter the conditioned space. In our tests, there was some evidence to support this result, but it varied by site.

Currently, COOLNOMIX lacks the ability to measure and control based on relative humidity levels. In humid climates especially, adding a relative humidity sensor to the return air stream could trigger bypass when humidity levels exceed a specified threshold.

8.5 RELIABILITY

8.5.1 Persistence

At any time during ordinary maintenance, COOLNOMIX could be uninstalled, disabled, or adjusted in a way that compromises energy savings. In a two-year demonstration, we could not fully quantify these effects, but we did observe them on several occasions. In one case, the technician completely disconnected the control wires. In another case, a technician apparently flipped the bypass switch to the OFF position. Such changes can defeat energy savings.

Addressing persistence issues, common among thermostat controls, requires proper training (and re-training) of maintenance staff and regular COOLNOMIX checkups during routine preventative maintenance. A checklist could be developed where staff can annually record COOLNOMIX setpoints, temperature setpoints, fan settings, wiring status, error codes, and other factors that could affect operation, adjusting as necessary.

8.5.2 Contactor Wear

Contactors are the electrical switches that control the compressor circuit. With COOLNOMIX, the compressors can cycle far more frequently (up to 10 times more frequently at one site). This additional cycling could lead to premature contactor wear. The contactor is a relatively low-cost part. To address this issue, spares should be kept on hand for quick replacement.

8.5.3 Compressor Wear

Increased compressor cycling could increase compressor wear; however, we could not evaluate this effect in a two-year demonstration. No compressor failures were observed. In a large rollout, compressor failure rates should be tracked over time to ensure premature wear does not occur.

Short-cycling is well known to cause premature wear on compressors (Tomczyk 2010, Marchese 2012). Each time a compressor stops, refrigerant and lubricant mixture migrates to the suction line or crankcase during the off cycle. When the compressor starts, there is a reduction in pressure drop of this mixture, resulting in the mixture flashing into foam/vapor. As a result, a large percentage of crankcase oil is pumped out of the compressor. To return, the oil must travel with the refrigerant through the system and back to the compressor's suction port. This only happens when the compressor is running. Cycling too frequently, therefore, creates an imbalance, leading to inadequate compressor lubrication and resulting in mechanical parts becoming scored. Eventually, components like bearings, valves, and motors, can fail.

Although COOLNOMIX cycles the compressor more frequently, it also includes safeguards to prevent short cycling through 3-minute start and stop lockout delays. Additionally, depending on how COOLNOMIX is installed, short-cycling safeguards that are built in to the cooling equipment will continue to function.

8.5.4 COOLNOMIX Wear

The field lifetime of COOLNOMIX is not yet established and could not be evaluated in the span of a two-year demonstration. Of the twelve test sites, one unit was defective and was immediately replaced. Another unit appeared to function (diagnostic lights worked) but did not apparently engage during the demonstration. This could have been due to faulty control wiring, misconfiguration, sensor wiring, or a problem with the hardware. The remaining units functioned as intended for the duration of the demonstration without incident.

COOLNOMIX uses a solid-state relay to modulate the compressor.[45] Solid state relays can last for tens of millions of cycles when operated within specifications and provided heat can be adequately rejected (Crydom 2011). The relay, therefore, would not be expected to fail over the life of the HVAC equipment.[46]

[45] In most installations, this relay does not actually bear the compressor load. Instead, it switches the low-voltage control line, which uses a separate contactor to power and switch the compressor.

[46] Even if a compressor cycled every 3 min. for 50 years, this would still be less than 10 million cycles.

Depending on where COOLNOMIX is installed, there could be issues with moisture or dust ingress that could eventually damage the components,[47] however we did not observe any such issues. With any rollout program at scale, it would be prudent to track COOLNOMIX reliability over time.

8.5.5 OEM Warranty

Installing COOLNOMIX could void the original equipment manufacturer warranty. Typically, warranties include disclaimers that limit responsibility in the case of equipment modification. Whether the warranty is voided is open to interpretation. If COOLNOMIX is installed inside the condenser, it is likely that this would be considered a modification. This is especially likely if additional components are installed, such as relay coils to fool the current detection system, or rewiring the control circuit for multiple compressor stages. However, COOLNOMIX could also be installed by modifying the thermostat. This approach was not evaluated in this demonstration. In that case, it would likely void the thermostat warranty, but may not void the warranty on the condenser. To avoid this issue altogether, COOLNOMIX could be installed only on equipment that is already out of warranty.

8.6 INTEGRATION WITH HVAC OEMS

Ultimately, the COOLNOMIX control technology could be licensed and integrated directly into thermostat and/or condenser control units, eliminating the need for an aftermarket retrofit. This could provide a long-term path to wider scale adoption. Given the mixed results from this study, more development is likely needed to address the fan energy penalty issues before such conversations can take place.

[47] Coincidentally, during the demonstration, a similar (but unrelated) relay-based fan controller failed in a freezer unit adjacent to one of our tests. This relay was located inside the walk-in unit and failed in the open position, causing the evaporator fans to stop. As a result, an emergency service call was made to prevent loss of perishable product.

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Appendix A POINTS OF CONTACT

POINT OF CONTACT	ORGANIZATION Name / Address	CONTACT Phone / E-mail	ROLE IN PROJECT
Mr. Bryan Urban	Fraunhofer USA Center for Sustainable Energy Systems 5 Channel Center St. Boston, MA 02210	(617) 714-6514 burban@cse.fraunhofer.org	Principal Investigator
Mr. Kurt Roth, PhD		(617) 575-7256 kroth@cse.fraunhofer.org	Technical Advisor
Mr. Josef Mueller	CoolGreenPower, LLC. 60 Thoreau St., Suite 222 Concord, MA 01742	(617) 505-1004 jmueller@coolgreenpower.com	Technology Vendor
Mr. Kevin Moore	Agile8 Consulting Suite 7B, 7/F., 235 Wing Lok Street, Sheung Wan Hong Kong SAR, China	(852) 2185-7679 kevin.moore@agile8consulting.com	Technology Inventor
Mr. B.J. Tomlinson	Fort Bliss Directorate of Public Works Bldg. 777 Room 301 1733 Pleasanton USAG Fort Bliss, TX 79916	(915) 568-6514 benny.j.tomlinson.civ@ mail.mil	Energy Manager
Mr. Don Vincent Jr.	Fort Bliss Directorate of Public Works Bldg. 777, Room 300 1733 Pleasanton Road USAG Fort Bliss, TX 79916	(915) 568-5172 donald.e.vincent.civ@mail.mil	Energy Manager
Mr. Tim Min	Joint Base Anacostia-Bolling NAVFAC Washington Public Works Department Joint Base Anacostia-Bolling 370 Brookley Ave. SW Washington, DC 20032	(202) 767-8615 tim.h.min1@navy.mil	Energy Manager

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Appendix B OCCUPANT COMFORT QUESTIONNAIRE

The DoD is testing a new air conditioner/refrigeration controller that could save energy in your building. This anonymous questionnaire is meant to obtain comfort feedback from people who routinely work in the space. Your feedback is important. Please take a moment to fill out this form.

Today's Date: ___________________________

Building Number:

PLEASE CIRCLE ONE RESPONSE PER LINE:

1. I worked in this building at least 3 of the past 7 business days: YES NO

2. During the past WEEK, the room temperature has been:

Too hot…?	never	rarely	sometimes	often	always
Comfortable…?	never	rarely	sometimes	often	always
Too cold…?	never	rarely	sometimes	often	always
Too humid…?	never	rarely	sometimes	often	always

3. During the past WEEK, please indicate how often the room was TOO HOT:

Before noon?	never	rarely	sometimes	often	always
After noon…?	never	rarely	sometimes	often	always

4. During the past TWO WEEKS, were there any problems with the cooling system that required a service call?

YES NO Don't Know

If YES, briefly describe the issue:

If YES, was it resolved? YES NO Don't Know

5. If you have any comments on the air conditioning system, its operation, or your thermal comfort during the previous week, please describe:

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Appendix C COMPETING TECHNOLOGY

Various competing retrofit technologies exist for improving air conditioning and/or refrigeration energy performance, yet relatively few address compressors. This section compares several alternative hardware and control retrofits with COOLNOMIX in terms of energy savings strategy, cost, and performance metrics, with a focus on packaged rooftop units (RTUs). According to Honeywell, over 12 million RTUs currently serve about 60% of the commercial floor area in North America, and typical candidates for upgrades include well-maintained RTUs in good condition that are five tons or larger and less than 15 years old (Honeywell 2017).

COMPRESSOR RETROFIT

Upgrading existing compressors from fixed- to variable-capacity can save energy by more closely matching the cooling capacity with changing loads. Ideal applications include situations with inadequate temperature or humidity control and highly variable loads, such as restaurants, schools, hospitals, and museums. Multiple technologies are available, including mechanically-modulated (constant speed) and inverter-driven (variable speed) compressors. For an overview, see Emerson (2014).

Compressor retrofits are capital and labor intensive. Installation requires a refrigerant technician to evacuate the system, remove the existing compressor, install the new compressor, braze tubing, perform leak tests, and re-charge the system. A special thermostat and controller may also be required, typically replacing the existing thermostat, which can involve running wires into the conditioned zone. According to Copeland, an RTU compressor replacement would typically require at least four hours if everything is prepared, and potentially longer depending on system complexity and location. Replacing a single compressor on a 5 ton RTU, for instance, could cost $2,000 or more. Generally, upgrading a compressor is worth considering when a compressor fails and must be replaced anyway; but the high upfront cost for typical functional equipment makes for a slower payback.

ADVANCED ROOFTOP CONTROL

Replacing older, less efficient hardware components (like drives, motors, or compressors) or adding more advanced controls can improve cooling system efficiency; however, these upgrades also tend to be capital and labor-intensive.

Advanced Rooftop Control (ARC) kits for packaged RTUs provide aftermarket controls featuring integrated air-side economizers, supply fan-speed controls, and demand control ventilation (DCV) to provide more granular and optimized control of existing cooling equipment. Typically, the supply air fan is retrofit with a variable-frequency drive (VFD), that can modulate airflow depending on the operating mode and conditions. Much of the savings comes from reducing fan runtime and related ventilation-driven loads, based on integrated sensors and updated control logic. Occupancy and ventilation demand can be sensed using CO_2 sensors placed in the return air stream. Many ARCs offer more even more advanced controls, including wireless monitoring and fault detection that could further enhance RTU performance. Unlike COOLNOMIX, most ARCs do not directly control or optimize the compressor.[48]

[48] At least one ARC is able to modulate the compressor speed to control cooling capacity (PNNL 2013).

In recent years, ARCs for packaged RTUs have achieved significant, cost-effective cooling energy savings between 22-90% (57% avg.), with relatively short payback of 2-6 years depending on electricity price (PNNL 2012, 2013; NREL 2014). Installed costs vary with RTU capacity, with estimates for controller hardware ranging from $2,200 (for a 5 ton RTU with 1 HP supply fan) to $4,100 (20 ton RTU with 7.5 HP fan) and a fixed labor cost of about $750 per RTU, leading to significant upfront costs of about $3,000 to $5,000 per RTU.

Due to the relatively high implementation cost, hardware-based retrofit solutions are not frequently pursued by the DoD as a cost-effective efficiency measure. Instead, older equipment tends to operate for the duration of its useful life until it is eventually replaced with newer, and often more efficient systems.

COMPRESSOR CONTROL

Other aftermarket compressor control technologies function similarly to COOLNOMIX by changing compressor cycling behavior to improve cooling system efficiency at reasonably lower installed costs. These retrofits could lead to faster payback periods, greater savings to investment ratios, and overall more attractive economics, provided they can overcome the technical barriers identified in this report.

Several competing controls vendors offer relay-based compressor controls that operate on principles similar to COOLNOMIX (selected products shown in Table C-1). By cycling the compressor more intelligently, these products aim to reduce overall compressor runtime while still meeting the target zone temperature setpoints. Most such devices are likely to have broadly similar installation and operational costs. COOLNOMIX is different from most competing approaches in that it measures both supply and return air temperature to reduce/prevent thermal runaway (steadily increasing zone temperatures over time caused by shorter compressor cycling). Many vendors do not provide complete details about how their product works or saves energy, making it difficult to evaluate or compare technologies.

Table C-1. Compressor Control Products.

Product	Sensor		Notes	References
	Supply	Zone		
AIRCOSAVER	X	-	Up to 10-ton systems.	AIRCOSAVER (2017)
ACES	X	-	Self-learning microprocessor controls duty cycle.	ACES (2017)
COOLNOMIX	X	X	Compatible with most vapor-compression air conditioning and refrigeration equipment.	CoolGreenPower (2018)
EniSaver	?	?	Up to 20-ton systems. Window, split, tower, cassette, ducted, and packaged ACs. Number of sensors not indicated. (Claimed: 16-30% savings)	QuasarEnviro (2018)
Pace Controls	?	?	Operates the compressor for programmed intervals. Includes optional peripherals for extending compressor runtime if outdoor temperature is above 85 or 95°F.	WSU (2008)
Ref-Saver	?	X	Senses and mimics the food temperature rather than the air temperature, thereby decreasing the number of refrigeration cycles without compromising the quality of food products.	QuasarEnviro (2018)
SmartCool	?	?	AC, refrigeration, heat pumps. Refrigeration packs and racks, single/multi-compressor ACs, chillers, chilled lines, and process cooling.	SmartCool (2013)

Vendors commonly claim cooling system energy savings of 15-30% or more; however compelling evidence from rigorous measurement and verification tests is generally lacking (LBNL 1998, WSU 2008). These claims typically reference case studies with varying levels of sophistication, many with weaknesses like short testing duration (weeks), incomplete system and method descriptions, missing or incomplete weather normalization, failure to extend results to full-year performance, and omission of important variables like zone temperature, relative humidity, occupancy, or fan energy. Furthermore, confounding factors, such as schedules, economizer status, fan filters, refrigerant charge, extent-of-oversizing, thermostat location, and other site-specific variables can strongly influence cooling system performance and energy consumption. Without carefully monitoring and controlling these factors, there can be substantial uncertainty.

These challenges emphasize the need for additional testing on a range of representative buildings, equipment, and climates to reach generalizable conclusions. Some other tests are ongoing. Several RTU controller retrofits were recently tested by San Diego Gas and Electric (SDGE). A single-building test on a controller that adjusted compressor runtime based on outdoor temperature yielded 18% energy savings (2013). An air conditioning trial of COOLNOMIX was reportedly completed as of 2018, with results pending.

Additional COOLNOMIX development is underway to address the fan energy challenges identified in this study. Initial approaches are currently being tested, and results are anticipated in the coming months. Contact CoolGreenPower for more details about these efforts.

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Appendix D DATA TABLES

The following data tables summarize cooling system operating characteristics for each test case. Additional data processing, including filtering of outliers and bad data, was performed and described in the corresponding analysis sections.

Most tests were split between pre and post tune-up periods. During the pre tune-up periods, the as-found HVAC equipment may have had issues or the COOLNOMIX equipment was connected and enabled, but not functioning. The post tune-up periods generally corrected these issues and are the most valid.

For additional context, please refer to the site-specific sections of this report.

Data include:

1. Ambient Conditions
    a. Cooling Degree Days (*CDD65,* CDD_{65}, °F), air conditioning only
    b. Adjusted Cooling Degree Days (CDD_{adj}, °F), air conditioning only
    c. Average Outdoor Temperature (T_{out}, °F), refrigeration only
2. COOLNOMIX Status (*CNMX)*, on or off
3. Flags:
    a. Tune-up Status (*TUNE*, pre- or post), indicates periods before or after any significant adjustments to experimental setup or mechanical equipment; generally post tune-up periods provide better quality data
    b. Setpoint Flag (*FLAG*), refrigeration only, indicates when setpoint was too hot (H), too cold (C), or good (G)
4. Daily Cooling System Energy Consumption (kWh) by component:
    a. Fan (*F*)
    b. Compressor by stage (*C1*, *C2*)
    c. Condenser = sum of Fan and Compressors (*TOTAL*)

    Note: Energy for refrigeration includes compressor only
5. Runtime (min.) by component, same notation as (4)
6. Number of Cycles, same notation as (4)
7. Typical Compressor Cycle Duration (Dur_{typ}), runtime (5) divided by number of cycles (6)
8. Zone Conditions, as measured by the thermostat for air conditioners and by the door for refrigeration systems. Temperature and humidity are based on hourly average measurements derived from 1-2 min. samples. Occupancy is based on 15 min. occupancy windows.
    a. Temperature (T_{min}, T_{avg}, and/or T_{max}, °F),
    b. Relative Humidity (*RH*, %)
    c. Occupancy (*OCC,* %)
    d. Average Return Air Temperature for walk-in coolers (T_{return}, °F)

D1.1 AIR CONDITIONING DRY CLIMATE SITE 1

Air Conditioning: Dry Climate Site 1 (El Paso, TX)																				
DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C1	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2016-05-06	15.9	14.5	on	pre	13.0	31.4	44.4	818	466		33		14		72	73	75	16	12
2016-05-07	8.5	6.9	on	pre	13.1	18.5	31.5	827	313		36		9		72	74	75	15	0
2016-05-08	5.8	3.9	on	pre	16.2	13.6	29.8	1026	244		37		7		72	74	75	15	0
2016-05-09	7.0	5.1	on	pre	13.6	17.9	31.5	859	319		39		8		73	74	75	18	23
2016-05-10	10.7	8.5	on	pre	11.6	24.3	35.9	730	381		28		14		72	74	76	17	23
2016-05-11	12.1	9.9	on	pre	10.1	24.2	34.3	630	375		26		14		73	74	76	15	14
2016-05-12	10.0	7.6	on	pre	13.6	26.1	39.8	846	417		32		13		72	74	76	25	10
2016-05-13	13.3	11.8	on	pre	15.3	35.8	51.1	948	555		44		13		72	74	75	43	13
2016-05-14	8.9	7.0	on	pre	16.1	20.2	36.3	1009	341		38		9		72	74	76	42	0
2016-05-15	12.1	10.1	on	pre	13.1	21.8	34.9	821	340		30		11		71	74	76	37	0
2016-05-16	14.8	13.2	on	pre	10.1	30.5	40.5	628	468		36		13		72	74	75	25	21
2016-05-17	7.4	5.4	on	pre	14.6	22.3	36.9	911	375		37		10		72	74	75	29	18
2016-05-18	1.1	-0.4	on	pre	23.1	4.6	27.7	1440	87		14		6		72	73	74	38	14
2016-05-19	4.9	4.2	on	pre	16.0	14.0	30.0	991	262		42		6		71	73	74	37	23
2016-05-20	13.2	11.5	on	pre	12.6	23.8	36.4	787	357		22		16		72	74	75	29	16
2016-05-21	15.3	13.1	on	pre	8.7	25.5	34.2	540	383		28		14		73	74	76	16	0
2016-05-22	15.8	13.7	on	pre	8.4	28.2	36.6	525	424		27		16		73	74	75	15	0
2016-05-23	16.9	14.9	on	pre	9.1	31.0	40.0	567	460		32		14		73	74	75	15	7
2016-05-24	15.7	13.7	on	pre	8.7	30.3	39.0	540	457		31		15		73	74	76	15	6
2016-05-25	15.8	14.2	on	pre	10.7	36.4	47.2	669	555		46		12		72	74	75	16	7
2016-05-26	12.1	10.8	on	pre	13.8	29.0	42.7	858	482		51		9		72	73	75	17	6
2016-05-27	9.2	7.5	on	pre	14.6	23.7	38.3	909	389		43		9		72	74	76	15	5
2016-05-28	12.0	10.3	on	pre	12.9	18.7	31.6	802	286		22		13		72	74	75	15	0
2016-05-29	18.1	16.7	on	pre	9.2	30.2	39.4	572	453		36		13		72	73	75	15	0
2016-05-30	12.9	11.8	on	pre	11.9	26.5	38.5	745	420		42		10		72	73	75	30	0
2016-05-31	9.1	7.4	on	pre	17.2	26.8	44.0	1077	429		41		10		72	74	76	46	11
2016-06-01	5.5	4.2	on	pre	19.6	21.2	40.8	1226	341		25		14		71	73	76	41	6
2016-06-02	10.1	9.2	on	pre	14.6	23.4	38.0	911	379		37		10		71	73	74	42	12
2016-06-03	16.8	15.3	on	pre	12.1	31.5	43.6	755	455		23		20		72	74	75	35	15
2016-06-04	18.4	17.2	on	pre	10.9	37.9	48.8	677	564		42		13		72	73	74	36	0
2016-06-05	19.0	18.2	on	pre	10.4	39.0	49.4	644	575		33		17		72	73	74	41	0
2016-06-06	20.9	20.0	on	pre	11.5	45.2	56.6	712	642		33		19		72	73	74	39	14
2016-06-07	21.7	21.2	on	pre	11.7	50.6	62.3	727	696		23		30		71	72	74	38	9
2016-06-08	20.1	19.3	on	pre	11.1	41.6	52.7	688	604		46		13		71	73	74	40	12
2016-06-09	22.3	21.1	on	pre	10.6	43.4	54.0	661	596		33		18		72	73	74	38	9
2016-06-10	22.8	22.4	on	pre	12.9	52.3	65.2	801	722		38		19		71	72	74	39	10
2016-06-11	18.6	18.8	on	pre	13.4	39.3	52.7	833	598		57		10		70	72	73	47	0
2016-06-12	22.4	22.6	on	pre	11.0	40.2	51.2	686	561		37		15		70	72	73	45	0
2016-06-13	25.2	24.5	on	pre	9.1	41.7	50.8	567	545		16		34		70	73	74	32	13
2016-06-14	20.4	18.7	on	pre	9.6	37.2	46.7	594	523		34		15		72	74	76	25	14
2016-06-15	22.8	20.7	on	pre	9.2	39.6	48.8	575	525		23		23		73	74	75	24	12
2016-06-16	23.3	20.9	on	pre	7.9	35.2	43.1	491	466		18		26		73	74	77	18	12
2016-06-17	24.0	21.8	on	pre	9.2	42.4	51.5	570	543		19		29		71	74	76	16	11
2016-06-18	26.7	25.6	on	pre	9.7	44.7	54.4	603	569		20		28		71	73	75	15	0
2016-06-19	23.1	22.0	on	pre	9.7	40.0	49.7	603	544		29		19		71	73	75	26	0
2016-06-20	20.5	19.5	on	pre	11.0	42.5	53.5	682	603		34		18		72	73	74	40	12
2016-06-21	21.5	21.0	on	pre	12.4	48.8	61.2	773	674		31		22		71	72	74	45	9
2016-06-22	27.4	27.4	on	pre	12.1	54.2	66.3	755	684		22		31		70	72	73	42	11
2016-06-23	26.5	25.8	on	pre	9.1	42.4	51.6	569	547		14		39		70	73	75	40	14
2016-06-24	22.6	21.8	on	pre	13.5	51.1	64.6	843	679		27		25		71	73	75	46	16
2016-06-25	19.8	19.9	on	pre	12.2	38.0	50.1	758	551		41		13		70	72	73	49	0
2016-06-26	16.5	16.7	on	pre	12.5	32.7	45.3	780	502		47		11		70	72	73	49	0
2016-06-27	17.4	17.6	on	pre	16.1	42.1	58.2	1002	628		44		14		71	72	73	55	24
2016-06-29	17.5	17.6	off	pre	8.1	35.7	43.8	506	500		10		50		70	72	73	47	13
2016-06-30	19.3	18.7	off	pre	7.3	32.1	39.4	458	450		12		38		71	73	75	44	12
2016-07-01	13.8	12.8	off	pre	7.3	29.4	36.7	453	447		12		37		72	73	74	45	9
2016-07-02	18.5	17.4	off	pre	6.0	26.1	32.1	375	370		9		41		71	73	74	45	0
2016-07-03	25.0	23.8	off	pre	6.7	31.3	38.0	418	411		10		41		72	73	74	41	0
2016-07-04	27.7	26.4	off	pre	6.9	33.1	39.9	428	420		11		38		72	73	74	37	0
2016-07-05	28.1	26.9	off	pre	8.9	43.3	52.2	555	545		13		42		72	73	74	34	10
2016-07-06	27.8	25.8	off	pre	7.2	34.4	41.5	447	440		10		44		72	74	77	38	10
2016-07-08	25.1	25.1	off	pre	12.4	61.2	73.6	775	771		10		77		69	72	75	43	14
2016-07-09	23.4	24.6	off	pre	10.6	49.9	60.5	662	654		10		65		69	71	72	43	0
2016-07-10	27.9	29.1	off	pre	8.9	44.5	53.4	555	552		10		55		69	71	72	39	0
2016-07-11	28.9	28.2	off	pre	7.5	37.1	44.7	471	465		11		42		69	73	75	37	6
2016-07-12	28.9	27.9	off	pre	9.5	47.8	57.3	594	588		12		49		71	73	75	34	11

Air Conditioning: Dry Climate Site 1 (El Paso, TX)

DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C1	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2016-07-13	30.5	30.6	off	pre	11.0	55.7	66.7	686	682		11		62		70	72	73	31	11
2016-07-14	30.3	30.0	off	pre	11.1	56.9	67.9	691	684		11		62		70	72	74	29	16
2016-07-15	24.2	24.7	off	pre	11.7	56.6	68.3	732	728		12		61		69	72	74	37	10
2016-07-16	22.8	24.0	off	pre	10.5	49.5	60.1	658	653		11		59		69	71	72	41	0
2016-07-17	25.9	27.1	off	pre	10.5	50.9	61.4	656	651		10		65		69	71	72	41	0
2016-07-18	23.4	23.4	off	pre	8.8	40.7	49.5	548	543		11		49		70	72	74	43	21
2016-07-20	22.8	22.4	on	pre	12.4	50.6	63.0	773	684		27		25		71	72	74	48	12
2016-07-21	24.8	24.3	on	pre	10.7	43.0	53.7	668	574		20		29		71	73	74	47	9
2016-07-22	25.7	24.4	on	pre	9.5	41.5	51.0	592	536		17		32		71	73	76	42	20
2016-07-23	26.8	24.6	on	pre	6.0	29.0	35.0	377	371		8		46		72	74	76	37	0
2016-07-24	27.6	25.5	on	pre	6.4	30.6	37.0	399	389		10		39		72	74	76	37	0
2016-07-25	26.0	23.8	on	pre	8.8	40.9	49.7	549	531		10		53		71	74	77	41	14
2016-07-26	20.9	19.7	on	pre	14.5	52.5	67.0	910	718		20		36		70	73	77	47	10
2016-07-27	17.7	17.4	on	pre	17.2	42.7	59.8	1077	633		37		17		70	72	74	59	12
2016-07-28	22.3	21.7	on	pre	12.3	38.4	50.6	768	553		36		15		71	73	75	54	9
2016-07-29	21.5	20.3	on	pre	10.7	41.3	51.9	667	574		24		24		72	73	74	47	9
2016-07-30	20.1	19.0	on	pre	11.9	34.8	46.7	747	510		38		13		71	73	74	52	0
2016-07-31	20.4	19.2	on	pre	9.7	34.1	43.8	605	487		24		20		71	73	75	47	0
2016-08-01	18.5	17.4	on	pre	11.9	37.1	49.0	742	536		35		15		71	73	75	50	8
2016-08-03	16.0	16.0	off	pre	9.7	42.2	51.9	609	605		13		47		70	72	74	47	10
2016-08-04	18.1	18.2	off	pre	10.9	42.0	52.9	684	596		13		46		71	72	73	48	11
2016-08-05	21.2	21.1	off	pre	9.7	44.6	54.4	610	602		13		46		70	72	73	46	10
2016-08-06	21.0	21.0	off	pre	8.3	37.2	45.5	518	511		11		46		70	72	73	45	0
2016-08-07	21.5	21.5	off	pre	7.6	34.9	42.5	479	471		11		43		70	72	73	43	0
2016-08-08	20.7	20.8	off	pre	10.2	47.6	57.7	638	633		11		58		70	72	73	44	14
2016-08-09	17.6	17.8	off	pre	9.5	42.2	51.7	598	594		12		50		70	72	73	46	18
2016-08-10	14.4	13.8	off	pre	7.5	30.8	38.2	467	458		10		46		70	73	74	47	18
2016-08-11	18.2	17.5	off	pre	8.7	38.9	47.6	542	539		10		54		70	73	74	47	13
2016-08-12	20.4	20.6	off	pre	10.1	46.3	56.3	630	621		10		62		70	72	73	47	8
2016-08-13	9.8	9.7	off	pre	10.5	27.8	38.3	661	432		11		39		70	72	73	50	0
2016-08-14	11.8	11.3	off	pre	8.5	13.7	22.1	533	207		7		30		71	72	74	52	0
2016-08-15	13.6	13.2	off	pre	7.6	25.0	32.6	476	370		11		34		71	72	74	42	11
2016-08-16	16.4	16.2	off	pre	7.0	30.5	37.5	439	434		9		48		69	72	74	39	15
2016-08-17	16.7	16.2	off	pre	7.0	30.5	37.5	439	435		11		40		71	73	74	37	12
2016-08-18	15.5	15.6	off	pre	9.3	39.7	49.0	582	573		13		44		70	72	74	42	13
2016-08-19	16.3	15.7	off	pre	7.4	31.2	38.6	464	454		13		35		70	73	74	44	9
2016-08-20	12.6	11.5	off	pre	5.5	22.2	27.7	345	340		10		34		71	73	74	42	0
2016-08-22	11.0	10.6	off	pre	10.4	32.1	42.5	656	476		10		48		70	72	74	50	10
2016-08-23	11.0	9.9	off	pre	9.1	28.1	37.2	573	427		12		36		72	73	75	48	9
2016-08-24	13.6	12.4	off	pre	11.7	27.3	39.0	742	397		12		33		72	73	74	55	11
2016-08-25	11.4	9.9	off	pre	6.7	27.3	34.0	423	414		13		32		72	73	75	43	16
2016-08-26	12.2	11.6	off	pre	9.5	39.7	49.2	598	590		13		45		71	73	74	43	9
2016-08-27	12.8	12.9	off	pre	10.8	31.9	42.8	684	480		13		37		70	72	73	48	0
2016-08-28	11.7	11.5	off	pre	10.5	23.6	34.0	662	362		12		30		71	72	73	55	0
2016-08-29	11.3	11.2	off	pre	8.9	36.5	45.5	563	555		13		43		71	72	73	46	13
2016-08-30	6.5	6.2	off	pre	8.6	29.4	38.0	544	475		11		43		70	72	74	49	12
2016-09-01	8.3	7.5	off	pre	16.0	33.1	49.1	1008	519		14		37		70	73	76	59	14
2016-09-02	12.5	12.4	off	pre	12.5	35.5	48.0	788	529		14		38		70	72	73	56	7
2016-09-03	15.0	14.8	off	pre	8.0	34.6	42.6	506	500		11		45		70	72	73	47	0
2016-09-04	17.4	17.6	off	pre	7.9	35.0	42.8	497	493		9		55		70	72	73	47	0
2016-09-05	18.7	18.8	off	pre	8.0	36.2	44.2	508	503		9		56		70	72	73	48	0
2016-09-06	9.2	8.2	off	pre	7.1	22.4	29.4	446	345		9		38		70	73	76	51	9
2016-09-07	9.3	8.0	off	pre	13.1	26.2	39.4	834	401		9		45		71	73	75	60	10
2016-09-08	11.4	10.4	off	pre	7.7	32.0	39.7	486	479		12		40		72	73	74	48	9
2016-09-09	15.3	14.5	off	pre	8.3	35.6	43.9	521	512		14		37		71	73	74	45	12
2016-09-10	8.7	8.7	off	pre	7.1	25.7	32.8	442	407		12		34		71	72	73	43	0
2016-09-11	10.4	10.5	off	pre	10.7	21.4	32.2	670	328		10		33		71	72	73	52	0
2016-09-12	15.0	14.7	off	pre	6.3	25.7	32.0	388	382		11		35		71	72	74	44	9
2016-09-13	13.4	12.7	off	pre	8.2	33.6	41.7	507	498		14		36		71	73	74	41	16
2016-09-14	13.7	12.9	off	pre	7.1	26.1	33.2	438	387		10		39		70	73	75	43	9
2016-09-15	14.2	13.2	off	pre	9.3	39.0	48.3	577	568		14		41		71	73	75	45	12
2016-09-16	13.3	12.2	off	pre	8.5	31.8	40.3	531	470		14		34		72	73	74	43	14
2016-09-17	13.1	11.9	off	pre	8.1	25.3	33.3	505	374		13		29		71	73	74	40	0
2016-09-18	14.1	13.0	off	pre	7.6	25.3	32.9	475	377		13		29		71	73	74	40	0
2016-09-19	14.5	13.5	off	pre	9.1	31.0	40.0	567	443		13		34		72	73	74	32	18
2016-09-20	18.1	18.0	off	pre	10.3	46.1	56.4	643	639		14		46		70	72	74	41	7
2016-09-21	18.3	18.8	off	pre	10.1	44.1	54.2	629	619		13		48		70	72	73	43	21
2016-09-22	16.7	16.7	off	pre	9.4	41.2	50.6	588	581		14		42		71	72	74	41	24
2016-09-23	14.9	15.1	off	pre	8.1	34.9	43.0	510	504		12		42		71	72	73	38	24

Air Conditioning: Dry Climate Site 1 (El Paso, TX)

DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C1	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2016-09-24	9.5	9.7	off	pre	7.3	28.8	36.1	458	453		13		35		70	72	73	38	0
2016-09-25	4.8	4.9	off	pre	11.8	17.6	29.4	745	295		14		21		71	72	73	31	0
2016-09-27	2.7	2.4	off	pre	11.3	6.4	17.7	709	107		4		27		71	72	74	39	10
2016-09-28	8.1	8.1	off	pre	12.8	27.4	40.2	804	421		10		42		70	72	74	46	15
2016-09-29	10.3	10.3	off	pre	8.5	20.2	28.7	533	316		10		32		69	72	74	47	14
2016-09-30	4.2	3.3	off	pre	11.1	12.3	23.4	700	198		7		28		72	73	74	51	10
2016-10-01	9.1	8.0	off	pre	8.6	10.8	19.4	542	163		5		33		71	73	74	53	0
2016-10-02	9.5	8.5	off	pre	6.4	12.2	18.6	405	183		6		31		71	73	74	37	0
2016-10-03	11.9	10.8	off	pre	4.7	19.2	23.9	296	291		10		29		72	73	74	40	9
2016-10-04	8.3	7.2	off	pre	7.6	17.2	24.8	482	270		10		27		72	73	74	30	6
2016-10-05	7.0	6.1	off	pre	10.4	13.3	23.6	655	209		7		30		72	73	74	31	7
2016-10-06	8.2	7.2	off	pre	9.4	24.4	33.8	595	376		13		29		72	73	74	32	12
2016-10-07	2.1	1.0	off	pre	15.4	11.9	27.3	975	207		10		21		72	73	74	31	10
2016-10-08	1.9	1.2	off	pre	14.0	4.8	18.8	883	80		3		27		71	73	74	50	0
2016-10-09	5.1	4.2	off	pre	11.1	7.6	18.7	699	123		4		31		72	73	74	53	0
2016-10-10	7.8	6.9	off	pre	9.4	12.1	21.5	593	186		5		37		71	73	74	51	1
2016-10-11	10.8	9.8	off	pre	10.4	19.3	29.7	656	287		8		36		71	73	74	49	6
2016-10-12	10.2	9.0	off	pre	9.7	18.8	28.4	608	285		10		29		71	73	75	42	10
2016-10-13	7.1	5.9	off	pre	8.8	21.3	30.1	556	340		13		26		72	73	74	40	12
2016-10-15	10.1	9.6	on	pre	14.3	18.3	32.6	896	283		21		13		71	72	75	31	0
2016-10-16	10.5	10.1	on	pre	12.8	18.9	31.6	803	290		24		12		70	72	74	27	0
2016-10-17	11.6	10.3	on	pre	12.1	17.4	29.4	765	268		22		12		71	73	74	25	9
2016-10-18	9.6	8.1	on	pre	14.1	19.2	33.2	888	295		21		14		72	74	75	20	11
2016-10-19	8.7	7.2	on	pre	14.5	17.6	32.1	911	276		16		17		72	74	75	22	21
2016-10-20	2.8	0.6	on	pre	16.5	6.9	23.4	1038	125		17		7		73	74	76	26	20
2016-10-21	3.6	1.7	on	pre	12.2	7.5	19.8	768	139		19		7		72	74	75	29	14
2016-10-22	4.9	3.0	on	pre	11.9	3.9	15.7	746	67		10		7		72	74	75	34	0
2016-10-23	7.1	5.2	on	pre	9.7	4.0	13.7	609	66		7		9		72	74	75	31	0
2016-10-24	7.9	6.3	on	pre	14.3	16.7	30.9	898	257		17		15		72	74	75	31	18
2016-10-25	9.1	7.3	on	pre	14.2	20.9	35.1	892	345		34		10		72	74	76	31	14
2016-10-26	8.1	6.5	on	pre	14.8	16.7	31.5	937	269		22		12		72	74	75	32	24
2016-10-27	7.5	5.3	on	pre	14.1	17.0	31.1	888	283		27		10		73	74	75	32	16
2016-10-28	6.1	4.5	on	pre	17.6	18.6	36.2	1113	308		32		10		71	74	76	35	5
2016-10-29	7.2	6.2	on	pre	16.5	15.0	31.5	1038	248		27		9		70	73	75	33	0
2016-10-30	6.8	6.2	on	pre	15.8	12.0	27.8	995	203		23		9		71	73	75	30	0
2016-10-31	7.5	6.2	on	pre	14.6	16.4	30.9	920	275		31		9		72	73	75	29	8
2016-11-01	7.9	6.0	on	pre	11.3	17.1	28.3	711	296		39		8		72	74	75	28	8
2016-11-02	5.1	2.7	on	pre	15.8	12.4	28.3	1000	228		34		7		73	74	76	35	14
2016-11-03	1.2	-0.6	on	pre	21.6	1.6	23.3	1367	32		6		5		73	74	75	44	13
2016-11-04	1.5	0.1	on	pre	21.9	1.2	23.1	1385	23		4		6		73	73	75	53	7
2016-11-07	2.6	1.0	on	pre	11.1	5.3	16.4	694	97		16		6		72	74	75	39	12
2016-11-08	1.0	-0.5	on	pre	14.9	1.3	16.1	927	25		4		6		72	73	75	29	7
2016-11-13	0.8	-0.2	on	pre	6.6	0.4	7.0	413	8		1		8		72	73	74	32	0
2016-11-14	1.6	0.4	on	pre	8.4	3.1	11.5	530	52		3		17		72	73	75	27	15
2016-11-15	1.9	0.5	on	pre	8.4	3.2	11.6	529	53		3		18		72	73	75	22	11
2016-11-16	2.3	0.9	on	pre	10.1	3.3	13.5	643	56		3		19		72	73	75	21	11
2016-11-17	3.8	2.0	on	pre	12.7	6.4	19.1	815	103		4		26		73	74	75	23	13
2016-11-27	0.2	-0.8	on	pre	7.5	0.4	7.9	475	8		1		8		72	73	74	26	0
2016-12-12	0.6	-0.5	on	pre	14.1	2.7	16.7	893	47		4		12		72	73	75	22	10
2016-12-13	1.0	0.7	on	pre	15.0	4.7	19.7	944	80		3		27		71	72	74	27	11
2016-12-14	1.2	0.5	on	pre	10.6	2.9	13.5	667	51		3		17		71	73	75	29	8
2016-12-15	1.5	0.4	on	pre	12.3	3.0	15.4	780	53		3		18		72	73	75	23	11
2016-12-16	2.3	1.1	on	pre	8.6	4.7	13.3	554	80		4		20		72	73	75	15	9
2017-01-09	1.7	0.2	on	pre	11.6	2.8	14.4	740	47		2		24		72	73	75	19	22
2017-01-10	1.2	-0.5	on	pre	11.9	3.8	15.7	760	67		3		22		72	74	76	19	23
2017-01-11	1.3	0.3	on	pre	15.0	10.5	25.5	955	182		7		26		72	73	74	18	23
2017-01-12	0.0	0.1	on	pre	20.6	2.2	22.7	1311	39		2		20		71	72	74	16	30
2017-01-13	0.8	0.4	on	pre	15.8	1.8	17.6	998	33		2		17		71	72	75	19	10
2017-02-01	0.5	-0.8	on	pre	13.8	1.3	15.0	879	25		4		6		72	73	75	15	11
2017-02-02	0.5	-0.7	on	pre	14.3	0.9	15.2	910	18		3		6		72	73	75	15	23
2017-02-03	0.8	-0.3	on	pre	17.7	3.9	21.6	1125	76		12		6		72	73	75	15	13
2017-02-04	1.3	0.8	on	pre	19.5	2.7	22.3	1247	52		8		7		71	72	74	15	0
2017-02-05	1.7	1.4	on	pre	17.1	2.5	19.6	1095	48		7		7		71	72	74	15	0
2017-02-06	0.8	0.1	on	pre	18.0	2.9	20.9	1162	57		9		6		71	73	75	15	12
2017-02-07	0.4	-0.1	on	pre	17.6	2.4	20.0	1133	47		8		6		71	72	75	22	8
2017-02-08	1.1	0.4	on	pre	17.8	4.7	22.5	1139	91		16		6		71	73	75	28	10
2017-02-09	2.6	2.2	on	pre	17.8	7.5	25.3	1135	138		23		6		71	72	75	26	15
2017-02-10	5.2	4.6	on	pre	16.3	11.5	27.8	1039	201		25		8		71	73	74	22	14
2017-02-11	7.2	5.9	on	pre	11.4	10.9	22.2	729	187		26		7		72	73	75	17	0

Air Conditioning: Dry Climate Site 1 (El Paso, TX)

DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C1	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2017-02-20	0.2	-0.1	on	pre	16.5	0.4	16.8	1055	7		1		7		71	72	74	22	2
2017-02-21	2.3	1.5	on	pre	15.5	6.6	22.1	991	129		22		6		71	73	75	23	15
2017-02-22	4.1	3.1	on	pre	14.2	9.9	24.1	916	176		24		7		71	73	74	23	20
2017-02-23	2.0	0.8	on	pre	18.3	7.8	26.1	1186	150		25		6		72	73	75	17	13
2017-02-27	1.2	-0.2	on	pre	15.3	5.4	20.7	986	108		18		6		72	73	75	15	15
2017-02-28	1.7	0.8	on	pre	16.1	3.7	19.8	1042	70		12		6		71	73	75	15	19
2017-03-04	2.3	0.7	on	pre	11.5	2.1	13.6	736	39		6		7		72	74	75	15	1
2017-03-05	4.5	2.8	on	pre	9.2	3.6	12.8	595	68		11		6		72	74	75	20	0
2017-03-06	2.9	0.8	on	pre	16.2	7.5	23.8	1055	140		22		6		73	74	75	23	28
2017-03-07	1.5	0.6	on	pre	19.3	3.3	22.6	1245	62		10		6		71	73	75	15	8
2017-03-08	3.7	2.5	on	pre	14.9	6.7	21.6	956	121		17		7		71	73	75	15	12
2017-03-09	4.9	3.3	on	pre	13.3	10.3	23.7	861	172		17		10		72	74	75	15	14
2017-03-10	6.2	4.4	on	pre	13.2	13.2	26.5	854	214		15		14		72	74	75	15	12
2017-03-11	6.1	4.2	on	pre	11.7	8.4	20.1	758	135		12		11		72	74	75	21	0
2017-03-13	1.7	-0.1	on	pre	15.3	7.3	22.7	992	140		24		6		72	74	75	17	11
2017-03-14	6.4	4.7	on	pre	11.4	12.3	23.6	731	207		22		9		72	74	75	22	12
2017-03-15	7.4	5.5	on	pre	12.7	14.1	26.8	821	227		18		13		72	74	75	15	24
2017-03-16	8.8	6.8	on	pre	11.9	17.5	29.4	768	287		28		10		73	74	75	15	27
2017-03-17	7.6	5.9	on	pre	12.0	17.2	29.2	772	289		30		10		72	74	75	15	4
2017-03-18	9.1	7.3	on	pre	11.3	14.8	26.1	727	233		19		12		72	74	75	15	0
2017-03-19	11.1	8.7	on	pre	12.3	22.7	35.0	790	360		30		12		73	74	76	19	0
2017-03-20	10.2	8.0	on	pre	12.4	24.4	36.8	801	400		39		10		73	74	75	18	13
2017-03-21	10.2	7.8	on	pre	12.9	24.5	37.4	837	383		27		14		73	74	76	18	18
2017-03-22	11.8	9.6	on	pre	12.0	22.2	34.2	778	343		26		13		73	74	76	15	16
2017-03-23	4.8	3.5	on	pre	18.8	19.5	38.3	1216	332		34		10		71	73	76	15	24
2017-03-24	2.2	1.0	on	pre	14.8	3.9	18.8	955	78		12		7		70	73	75	15	15
2017-03-25	5.5	3.8	on	pre	9.1	7.3	16.5	587	125		16		8		72	74	75	15	0
2017-03-26	3.3	0.9	on	pre	14.5	8.2	22.7	942	148		21		7		73	74	76	15	0
2017-03-27	6.1	4.6	on	pre	13.4	18.4	31.7	865	321		42		8		72	73	75	15	9
2017-03-28	0.1	-1.8	on	pre	20.2	6.7	26.9	1321	127		22		6		72	74	75	18	14
2017-03-29	0.3	-0.5	on	pre	20.0	5.4	25.4	1297	107		17		6		72	73	74	24	21
2017-03-30	5.8	4.5	on	pre	10.0	9.2	19.3	644	163		22		7		71	73	75	20	12
2017-03-31	4.8	2.6	on	pre	16.0	9.7	25.6	1040	168		21		8		73	74	75	15	8
2017-04-03	4.6	2.8	on	pre	11.3	9.5	20.8	737	170		20		9		72	74	75	16	8
2017-04-04	2.2	0.6	on	pre	18.2	10.1	28.3	1182	194		32		6		72	74	75	15	14
2017-04-05	0.4	-0.6	on	pre	19.2	3.9	23.1	1236	80		12		7		71	73	75	15	12
2017-04-06	4.2	3.4	on	pre	13.7	8.4	22.1	882	152		23		7		71	73	75	15	9
2017-04-07	8.7	7.8	on	pre	11.9	16.3	28.2	768	256		22		12		71	73	74	15	13
2017-04-08	10.9	9.7	on	pre	11.6	18.9	30.5	751	296		27		11		71	73	74	15	0
2017-04-09	7.8	6.3	on	pre	12.0	20.2	32.2	775	352		40		9		72	74	75	15	0
2017-04-10	5.4	3.9	on	pre	14.9	17.1	32.0	963	295		37		8		72	74	75	15	13
2017-04-11	8.1	6.9	on	pre	15.4	24.2	39.6	992	400		40		10		72	73	75	30	15
2017-04-12	8.6	7.2	on	pre	15.0	26.9	41.9	972	415		16		26		72	73	76	41	12
2017-04-13	7.9	7.4	on	pre	12.0	25.2	37.2	779	391		11		36		71	73	74	40	9
2017-04-14	11.8	12.0	on	pre	11.5	29.2	40.7	748	445		15		30		71	72	73	33	14
2017-04-15	10.5	10.6	on	pre	9.0	28.2	37.3	585	436		15		29		71	72	73	15	0
2017-04-16	10.2	10.3	on	pre	11.6	25.3	36.9	754	384		14		27		70	72	73	15	0
2017-04-17	10.9	11.1	on	pre	13.9	31.0	44.9	900	491		33		15		70	72	73	15	18
2017-04-18	12.0	11.5	on	pre	15.7	33.3	49.0	1013	510		41		12		71	73	74	15	43
2017-04-19	13.7	13.8	on	pre	14.3	40.8	55.1	922	633		51		12		71	72	73	16	NA
2017-04-20	12.6	12.0	on	pre	14.7	33.0	47.7	950	497		33		15		71	73	75	17	NA
2017-04-21	13.2	12.3	on	pre	12.2	29.2	41.5	791	458		35		13		71	73	74	15	NA
2017-04-22	3.3	2.0	on	pre	15.5	10.2	25.7	997	191		30		6		72	73	75	26	NA
2017-04-23	6.2	5.4	on	pre	11.5	12.8	24.2	737	229		34		7		71	73	74	22	NA
2017-04-24	14.1	12.7	on	pre	11.4	27.8	39.2	735	432		35		12		72	73	75	17	NA
2017-04-25	10.6	9.0	on	pre	10.1	22.5	32.6	656	377		37		10		72	74	75	16	NA
2017-04-26	6.3	4.4	on	pre	10.8	15.2	26.0	700	268		33		8		72	74	75	17	NA
2017-04-27	11.9	10.5	on	pre	11.4	27.3	38.7	742	445		42		11		72	73	75	17	NA
2017-04-28	10.5	9.4	on	pre	13.0	26.5	39.5	843	450		52		9		72	73	74	27	NA
2017-04-30	3.6	2.9	on	pre	12.0	3.9	16.0	775	75		11		7		71	73	75	19	NA
2017-05-01	7.1	6.1	on	pre	12.6	14.5	27.1	818	243		25		10		71	73	75	15	NA
2017-05-02	12.3	11.2	on	pre	10.7	19.4	30.1	693	291		19		15		72	73	75	15	NA
2017-05-03	11.4	10.1	on	pre	11.0	29.0	40.0	709	463		38		12		72	73	75	17	NA
2017-05-04	5.9	4.7	on	pre	14.4	16.2	30.6	929	295		46		6		72	73	75	22	NA
2017-05-05	11.4	10.0	on	pre	12.5	22.9	35.4	809	359		29		12		72	73	75	16	NA
2017-05-06	15.4	14.0	on	pre	11.3	27.9	39.2	734	414		28		15		72	73	75	16	NA
2017-05-07	14.4	13.2	on	pre	10.7	31.5	42.2	692	493		42		12		72	73	74	15	NA
2017-05-08	11.4	9.2	on	pre	11.5	26.0	37.5	748	418		32		13		73	74	76	22	NA
2017-05-09	5.2	2.8	on	pre	13.7	17.2	30.9	893	293		29		10		73	74	76	22	NA

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DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C1	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2017-05-10	1.8	-0.1	on	pre	15.5	7.6	23.2	1008	148		25		6		72	74	75	20	NA
2017-05-11	6.8	4.8	on	pre	10.7	15.2	25.9	692	262		32		8		73	74	75	22	NA
2017-05-12	9.7	8.9	on	pre	15.8	31.7	47.5	1022	527		55		10		71	73	76	28	NA
2017-05-13	14.4	14.0	on	pre	13.7	32.8	46.5	892	490		37		13		71	72	75	24	NA
2017-05-14	17.1	17.2	on	pre	11.7	42.6	54.3	764	645		54		12		70	72	73	15	NA
2017-05-15	14.3	13.7	on	pre	10.8	34.8	45.6	704	543		47		12		71	73	74	18	NA
2017-05-16	6.9	5.6	on	pre	14.6	21.6	36.2	954	371		42		9		72	73	75	21	NA
2017-05-17	8.0	7.2	on	pre	11.5	18.1	29.6	751	305		35		9		72	73	74	16	NA
2017-05-18	10.2	8.9	on	pre	13.2	25.3	38.5	863	428		49		9		72	73	75	15	NA
2017-05-19	7.1	5.4	on	pre	14.1	18.1	32.2	920	309		37		8		72	74	75	15	NA
2017-05-20	7.5	6.3	on	pre	12.1	15.3	27.4	792	267		35		8		72	73	75	15	NA
2017-05-21	11.8	10.2	on	pre	13.4	26.9	40.3	865	428		36		12		72	74	76	33	NA
2017-05-22	13.7	12.9	on	pre	14.7	36.0	50.7	950	558		45		12		71	73	75	35	NA
2017-05-23	9.2	8.4	on	pre	14.7	26.9	41.6	960	438		39		11		71	73	75	26	NA
2017-05-24	14.7	13.4	on	pre	12.3	25.9	38.2	803	379		22		17		72	73	75	26	NA
2017-05-25	21.0	19.7	on	pre	8.2	35.7	43.9	531	496		22		23		72	73	74	15	NA
2017-05-26	19.0	18.0	on	pre	8.7	34.1	42.8	565	501		33		15		72	73	74	19	NA
2017-05-27	18.5	17.1	on	pre	7.6	28.3	35.9	498	422		34		12		72	73	74	19	NA
2017-05-28	11.3	9.5	on	pre	12.5	25.1	37.7	816	408		39		10		72	74	76	22	NA
2017-05-29	11.6	9.7	on	pre	13.6	19.8	33.4	885	309		25		12		72	74	76	33	NA
2017-05-31	9.5	8.4	on	pre	18.3	30.3	48.6	1190	510		63		8		71	73	76	44	NA
2017-06-01	10.3	9.4	on	pre	17.6	30.5	48.1	1147	491		42		12		71	73	75	44	NA
2017-06-02	12.4	11.1	on	pre	13.0	25.7	38.7	845	409		34		12		71	73	76	40	NA
2017-06-03	15.1	13.2	on	pre	8.8	21.0	29.8	571	332		29		11		71	74	76	39	NA
2017-06-04	17.4	13.9	on	pre	5.0	18.2	23.2	322	268		19		14		74	76	77	37	NA
2017-06-05	21.2	19.2	on	pre	11.6	52.3	63.9	748	713		25		29		72	74	76	37	NA
2017-06-06	19.2	18.8	on	pre	15.5	57.3	72.8	1000	824		48		17		71	72	74	45	NA
2017-06-08	15.7	15.8	on	post	21.6	48.3	69.9	1406	802		137		6		71	72	73	54	17
2017-06-09	23.4	23.8	on	post	18.1	53.3	71.4	1175	831		133		6		70	72	73	38	8
2017-06-10	26.0	26.2	on	post	18.2	55.0	73.2	1183	822		125		7		71	72	73	28	0
2017-06-11	23.2	23.4	on	post	17.7	49.8	67.5	1149	781		120		7		71	72	73	19	0
2017-06-12	21.1	21.3	on	post	17.3	53.0	70.3	1121	812		123		7		71	72	73	24	14
2017-06-13	21.7	21.7	on	post	17.2	54.4	71.5	1114	841		128		7		71	72	73	20	11
2017-06-14	22.1	22.2	on	post	17.6	55.7	73.3	1144	848		129		7		71	72	73	15	16
2017-06-15	23.7	23.8	on	post	18.4	60.0	78.4	1193	888		135		7		71	72	73	15	12
2017-06-16	24.8	24.9	on	post	19.2	63.7	82.9	1249	926		136		7		71	72	73	15	13
2017-06-17	29.0	29.3	on	post	19.3	61.4	80.7	1253	880		129		7		71	72	72	15	0
2017-06-19	24.4	23.7	on	post	22.2	61.1	83.3	1440	916		127		7		72	73	73	56	13
2017-06-20	26.2	25.7	on	post	21.5	63.0	84.5	1396	921		120		8		71	72	73	54	8
2017-06-21	25.5	25.6	on	post	20.0	61.5	81.5	1298	923		144		6		71	72	73	48	11
2017-06-22	29.7	29.8	on	post	19.4	64.3	83.8	1263	913		140		7		71	72	73	45	12
2017-06-23	31.0	30.8	on	post	18.2	65.4	83.7	1185	910		127		7		71	72	74	34	11
2017-06-24	20.2	20.4	on	post	19.5	44.8	64.4	1270	732		117		6		71	72	73	50	0
2017-06-25	14.9	15.2	on	post	21.1	37.1	58.2	1368	628		99		6		71	72	72	62	0
2017-06-26	16.0	16.1	on	post	19.9	39.2	59.2	1297	660		110		6		71	72	73	60	17
2017-06-27	18.3	18.4	on	post	16.1	38.3	54.4	1049	618		101		6		71	72	74	58	10
2017-06-28	25.7	25.9	on	post	16.5	52.3	68.8	1069	779		120		6		71	72	73	39	10
2017-06-29	28.0	28.0	on	post	17.5	59.6	77.1	1132	861		128		7		71	72	73	31	14
2017-06-30	27.2	27.1	on	post	16.7	57.5	74.2	1086	827		121		7		71	72	73	24	10
2017-07-01	21.2	21.4	on	post	20.1	46.2	66.2	1301	739		118		6		71	72	73	52	0
2017-07-02	21.3	21.6	on	post	19.0	46.2	65.2	1231	725		113		6		71	72	73	49	0
2017-07-03	24.6	24.8	on	post	17.5	50.3	67.7	1136	772		124		6		71	72	73	43	2
2017-07-04	25.6	25.7	on	post	16.6	47.3	63.9	1083	714		110		6		71	72	73	41	0
2017-07-05	21.5	21.1	on	post	15.3	41.3	56.7	996	656		102		6		71	72	75	45	7
2017-07-06	21.9	22.0	on	post	17.4	50.4	67.8	1132	793		129		6		71	72	73	46	8
2017-07-07	18.3	18.5	on	post	18.6	44.2	62.8	1206	730		120		6		71	72	73	53	10
2017-07-08	21.0	21.2	on	post	18.1	41.8	59.9	1178	658		104		6		71	72	73	51	0
2017-07-09	21.4	21.6	on	post	17.4	44.6	62.0	1132	715		112		6		71	72	73	46	0
2017-07-10	22.7	22.8	on	post	17.9	50.4	68.3	1163	801		128		6		71	72	73	47	19
2017-07-11	23.8	23.8	on	post	18.7	54.8	73.6	1217	842		136		6		71	72	73	49	23
2017-07-12	19.2	19.3	on	post	18.9	47.8	66.6	1227	751		114		7		71	72	73	56	19
2017-07-14	13.9	13.8	off	post	8.0	33.2	41.2	516	510		11		46		70	72	75	47	11
2017-07-15	9.1	7.0	off	post	3.3	13.1	16.4	213	212		6		35		72	74	75	48	0
2017-07-16	11.6	9.5	off	post	4.7	19.8	24.6	307	303		8		38		72	74	75	46	0
2017-07-17	16.3	15.2	off	post	9.3	41.9	51.2	600	593		11		54		71	73	75	45	13
2017-07-18	16.5	17.0	off	post	11.7	51.9	63.6	757	746		14		53		70	72	74	46	12
2017-07-19	11.7	12.4	off	post	10.6	42.4	52.9	686	660		42		16		70	71	72	47	13
2017-07-20	14.9	15.2	off	post	10.5	44.2	54.8	682	668		28		24		70	72	73	47	24
2017-07-21	14.4	14.3	off	post	8.7	37.6	46.4	566	558		13		43		71	72	73	46	10

Air Conditioning: Dry Climate Site 1 (El Paso, TX)

DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C1	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2017-07-22	12.1	12.2	off	post	8.4	35.2	43.6	543	536		13		41		70	72	73	46	2
2017-07-23	12.0	12.3	off	post	9.0	38.2	47.3	585	580		12		48		70	72	73	46	0
2017-07-24	15.7	15.7	off	post	9.6	41.8	51.4	622	612		13		47		71	72	74	47	10
2017-07-25	18.8	18.8	off	post	10.2	46.5	56.7	663	655		13		50		70	72	73	47	11
2017-07-26	20.9	20.7	off	post	10.2	48.1	58.2	660	654		12		55		71	72	74	48	12
2017-07-27	12.9	12.4	off	post	10.2	44.0	54.3	664	649		15		43		71	72	74	47	11
2017-07-28	17.3	17.2	off	post	8.7	38.6	47.3	566	558		14		40		71	72	74	46	5
2017-07-29	15.2	15.1	off	post	8.6	29.2	37.8	559	435		11		40		70	72	74	50	1
2017-07-30	17.0	15.6	off	post	6.1	26.7	32.9	397	392		12		33		72	73	74	46	0
2017-07-31	16.3	15.1	off	post	8.0	34.7	42.7	520	513		13		39		72	73	74	46	9
2017-08-01	12.5	12.3	off	post	10.1	42.6	52.8	656	652		14		47		70	72	74	47	18
2017-08-02	15.9	15.8	off	post	8.7	37.7	46.4	566	558		12		47		70	72	74	46	24
2017-08-03	17.3	16.2	off	post	7.7	34.0	41.7	498	494		13		38		72	73	74	43	8
2017-08-04	18.2	17.5	off	post	9.1	41.3	50.4	592	580		14		41		71	73	74	42	10
2017-08-05	19.5	19.6	off	post	8.2	37.6	45.7	529	521		12		43		71	72	73	44	0
2017-08-06	20.7	20.8	off	post	8.9	42.2	51.1	578	576		11		52		70	72	73	44	0
2017-08-07	20.3	20.9	off	post	11.6	54.4	66.0	752	746		12		62		70	71	73	45	5
2017-08-08	17.8	18.3	off	post	10.7	47.8	58.5	692	686		12		57		70	72	72	47	11
2017-08-09	19.6	19.8	off	post	10.4	47.7	58.1	672	664		12		55		70	72	73	46	11
2017-08-10	21.8	21.4	off	post	9.8	45.4	55.1	632	628		13		48		71	72	74	45	10
2017-08-11	17.1	16.6	off	post	11.1	50.1	61.2	720	710		14		51		71	72	74	46	10
2017-08-12	15.0	15.1	off	post	10.6	34.7	45.2	686	509		12		42		71	72	73	52	0
2017-08-13	18.1	18.3	off	post	9.5	42.8	52.3	614	608		12		51		70	72	73	45	0
2017-08-14	18.1	18.2	off	post	11.4	46.2	57.6	740	654		13		50		71	72	73	47	5
2017-08-15	14.3	14.4	off	post	12.5	40.8	53.3	814	590		12		49		71	72	72	55	7
2017-08-16	19.4	19.6	off	post	9.6	44.4	54.0	625	618		12		52		70	72	73	44	7
2017-08-17	18.2	18.4	off	post	9.7	44.7	54.5	631	625		12		52		71	72	73	42	7
2017-08-18	16.4	15.4	off	post	7.7	34.4	42.1	498	491		12		41		71	73	75	45	16
2017-08-19	12.9	10.8	off	post	5.7	23.9	29.6	370	362		10		36		73	74	75	44	0
2017-08-20	7.4	5.4	off	post	11.6	19.0	30.7	757	307		10		31		73	74	75	57	0
2017-08-21	11.9	10.4	off	post	9.0	34.7	43.7	581	522		11		47		72	73	75	48	11
2017-08-22	16.9	16.6	off	post	11.0	49.1	60.1	709	703		13		54		71	72	74	46	15
2017-08-24	11.2	11.1	on	post	20.6	31.5	52.1	1322	548		89		6		71	72	73	64	11
2017-08-25	12.9	13.1	on	post	21.0	35.9	56.9	1348	624		100		6		71	72	72	67	8
2017-08-26	15.1	15.4	on	post	20.5	34.6	55.0	1311	587		98		6		71	72	72	68	0
2017-08-27	15.0	15.2	on	post	18.3	37.1	55.4	1170	618		103		6		71	72	73	60	0
2017-08-28	14.9	15.1	on	post	17.3	39.2	56.5	1107	668		108		6		71	72	73	53	10
2017-08-29	14.0	14.2	on	post	17.6	37.3	54.8	1120	637		106		6		71	72	73	54	10
2017-08-30	13.7	14.1	on	post	19.6	45.9	65.5	1242	782		125		6		71	72	73	44	11
2017-08-31	12.7	13.7	on	post	22.2	48.2	70.3	1403	831		133		6		71	71	72	42	21
2017-09-01	14.6	15.6	on	post	21.3	47.6	68.9	1347	797		122		7		71	71	72	38	8
2017-09-02	15.5	16.6	on	post	21.0	43.1	64.1	1326	719		111		6		71	71	72	37	0
2017-09-03	17.2	18.4	on	post	21.7	48.8	70.5	1371	805		124		6		71	71	71	39	0
2017-09-04	16.1	17.3	on	post	22.5	47.8	70.3	1425	793		126		6		71	71	71	43	0
2017-09-05	15.2	16.2	on	post	22.4	49.6	72.0	1414	847		139		6		71	71	71	45	12
2017-09-06	13.3	14.4	on	post	22.8	45.3	68.1	1440	794		128		6		71	71	71	50	10
2017-09-07	15.8	15.8	on	post	16.7	36.5	53.3	1055	623		101		6		71	72	74	45	12
2017-09-08	15.1	14.8	on	post	17.3	43.3	60.6	1088	728		122		6		71	72	74	47	10
2017-09-09	13.4	13.6	on	post	17.8	38.4	56.2	1122	669		109		6		71	72	73	44	0
2017-09-10	13.5	13.8	on	post	17.3	38.4	55.7	1091	663		111		6		71	72	73	46	0
2017-09-11	14.7	14.9	on	post	17.2	42.6	59.7	1081	718		115		6		71	72	73	40	6
2017-09-12	15.7	15.6	on	post	16.6	42.9	59.4	1044	704		110		6		71	72	73	35	9
2017-09-13	19.3	19.4	on	post	19.0	52.7	71.7	1198	843		130		6		71	72	73	36	13
2017-09-14	20.3	20.4	on	post	19.5	54.8	74.3	1230	868		140		6		71	72	73	40	12
2017-09-15	18.9	19.0	on	post	20.0	52.7	72.7	1256	856		142		6		71	72	73	45	9
2017-09-16	15.4	15.6	on	post	19.2	42.5	61.7	1207	731		119		6		71	72	73	51	0
2017-09-17	15.8	16.1	on	post	18.2	42.5	60.7	1144	710		117		6		71	72	73	50	0
2017-09-18	18.0	18.2	on	post	21.4	54.3	75.7	1346	881		139		6		71	72	73	47	17
2017-09-19	18.8	19.2	on	post	22.9	57.1	80.0	1440	933		158		6		71	72	72	48	25
2017-09-20	18.4	18.8	on	post	23.0	56.7	79.6	1440	942		165		6		71	72	72	44	24
2017-09-21	17.9	18.2	on	post	23.0	56.8	79.8	1440	945		167		6		71	72	73	45	21
2017-09-22	18.5	19.1	on	post	23.0	57.6	80.6	1440	950		166		6		71	71	72	41	23
2017-09-23	15.0	15.7	on	post	23.0	42.7	65.6	1440	769		149		5		71	71	72	52	0
2017-09-24	12.2	13.3	on	post	23.0	43.0	66.0	1440	761		133		6		71	71	71	38	0
2017-09-25	11.5	12.3	on	post	23.0	44.7	67.6	1440	794		143		6		71	71	72	39	20
2017-09-26	6.8	7.0	on	post	23.0	32.7	55.6	1440	614		122		5		71	72	73	47	20
2017-09-27	1.1	0.1	on	post	22.8	5.3	28.1	1438	105		20		5		72	73	74	64	26
2017-09-29	5.8	7.3	off	post	16.1	32.1	48.1	1012	524		18		29		69	70	72	58	15
2017-09-30	5.5	6.5	off	post	14.0	22.1	36.1	887	361		12		30		70	71	71	58	0

Air Conditioning: Dry Climate Site 1 (El Paso, TX)

DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C1	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2017-10-01	11.3	12.5	off	post	12.8	36.4	49.1	805	552		11		50		69	71	72	53	0
2017-10-02	13.1	13.7	off	post	9.8	39.9	49.7	617	585		11		53		70	71	73	41	12
2017-10-03	13.2	13.3	off	post	14.5	56.8	71.4	913	822		9		91		70	72	73	41	19
2017-10-04	13.5	14.9	off	post	15.5	65.4	80.9	975	969		12		81		69	71	73	53	12
2017-10-05	15.9	16.7	off	post	11.3	47.7	59.0	708	699		13		54		69	71	73	49	12
2017-10-06	15.8	15.9	off	post	9.9	42.2	52.1	622	615		13		47		71	72	73	45	5
2017-10-07	7.0	6.9	off	post	12.4	22.6	34.9	779	368		16		23		71	72	73	22	0
2017-10-08	10.8	10.8	off	post	11.7	23.4	35.1	737	352		11		32		71	72	73	21	0
2017-10-09	10.4	10.0	off	post	8.8	27.2	36.1	552	427		13		33		71	72	74	31	3
2017-10-10	0.6	0.1	off	post	20.8	5.2	26.1	1300	96		8		12		71	72	74	26	19
2017-10-11	5.5	4.9	off	post	11.0	16.1	27.1	683	260		9		29		71	73	74	31	14
2017-10-12	10.2	9.1	off	post	12.6	27.5	40.0	787	423		12		35		72	73	74	43	11
2017-10-13	13.6	13.2	off	post	11.9	44.1	56.0	743	658		15		44		71	72	74	43	11
2017-10-14	15.7	15.7	off	post	8.9	36.7	45.6	554	545		13		42		71	72	73	40	0
2017-10-15	2.9	2.9	off	post	13.2	16.4	29.5	820	281		11		26		71	72	73	24	0
2017-10-16	4.3	3.9	off	post	14.0	15.4	29.4	875	260		10		26		71	72	74	25	10
2017-10-17	6.6	6.2	off	post	15.1	25.7	40.8	946	405		11		37		71	72	74	33	29
2017-10-18	7.8	7.9	off	post	13.3	28.4	41.8	838	455		17		27		71	72	73	38	8
2017-10-19	6.5	6.7	off	post	17.2	29.0	46.2	1081	469		17		28		71	72	73	47	27
2017-10-20	8.6	8.0	off	post	11.4	18.1	29.5	719	291		14		21		72	73	74	43	10
2017-10-21	7.3	6.0	off	post	6.8	20.8	27.6	427	338		13		26		72	73	74	34	0
2017-10-22	4.0	2.9	off	post	13.8	9.8	23.6	863	162		6		27		72	73	74	15	0
2017-10-23	6.3	5.5	off	post	14.0	16.6	30.5	871	268		10		27		72	73	74	18	11
2016-05-06	15.9	14.5	on	pre	13.0	31.4	44.4	818	466		33		14		72	73	75	16	12
2016-05-07	8.5	6.9	on	pre	13.1	18.5	31.5	827	313		36		9		72	74	75	15	0
2016-05-08	5.8	3.9	on	pre	16.2	13.6	29.8	1026	244		37		7		72	74	75	15	0
2016-05-09	7.0	5.1	on	pre	13.6	17.9	31.5	859	319		39		8		73	74	75	18	23
2016-05-10	10.7	8.5	on	pre	11.6	24.3	35.9	730	381		28		14		72	74	76	17	23
2016-05-11	12.1	9.9	on	pre	10.1	24.2	34.3	630	375		26		14		73	74	76	15	14
2016-05-12	10.0	7.6	on	pre	13.6	26.1	39.8	846	417		32		13		72	74	76	25	10
2016-05-13	13.3	11.8	on	pre	15.3	35.8	51.1	948	555		44		13		72	74	75	43	13
2016-05-14	8.9	7.0	on	pre	16.1	20.2	36.3	1009	341		38		9		72	74	76	42	0
2016-05-15	12.1	10.1	on	pre	13.1	21.8	34.9	821	340		30		11		71	74	76	37	0
2016-05-16	14.8	13.2	on	pre	10.1	30.5	40.5	628	468		36		13		72	74	75	25	21
2016-05-17	7.4	5.4	on	pre	14.6	22.3	36.9	911	375		37		10		72	74	75	29	18
2016-05-18	1.1	-0.4	on	pre	23.1	4.6	27.7	1440	87		14		6		72	73	74	38	14
2016-05-19	4.9	4.2	on	pre	16.0	14.0	30.0	991	262		42		6		71	73	74	37	23
2016-05-20	13.2	11.5	on	pre	12.6	23.8	36.4	787	357		22		16		72	74	75	29	16
2016-05-21	15.3	13.1	on	pre	8.7	25.5	34.2	540	383		28		14		73	74	76	16	0

D1.2 AIR CONDITIONING DRY CLIMATE SITE 2

Air Conditioning: Dry Climate Site 2 (El Paso, TX)

DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C1	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2016-05-06	15.9	14.6	on	pre	20.0	63.2	83.2	1440	773		67		12		72	73	75	16	50
2016-05-07	8.5	8.1	on	pre	19.2	33.2	52.4	1373	485		78		6		70	72	74	15	13
2016-05-08	5.8	6.0	on	pre	19.6	23.8	43.5	1394	367		65		6		70	72	73	15	17
2016-05-09	7.0	6.6	on	pre	19.8	32.3	52.1	1416	469		68		7		70	72	75	17	48
2016-05-10	10.7	9.7	on	pre	20.0	44.8	64.8	1440	618		80		8		72	73	75	17	48
2016-05-11	12.1	11.1	on	pre	20.1	51.7	71.8	1440	653		58		11		71	73	75	16	44
2016-05-12	10.0	9.2	on	pre	19.6	56.4	76.0	1406	708		58		12		70	73	75	26	47
2016-05-13	13.3	11.4	on	pre	19.9	67.6	87.5	1440	806		50		16		73	74	76	38	53
2016-05-14	8.9	8.1	on	pre	20.1	38.4	58.5	1440	553		89		6		72	73	74	40	13
2016-05-15	12.1	11.5	on	pre	20.1	44.4	64.4	1440	610		93		7		72	73	74	36	27
2016-05-16	14.8	13.9	on	pre	19.8	65.2	85.0	1440	874		102		9		72	73	74	25	54
2016-05-17	7.4	6.5	on	pre	20.0	43.9	63.9	1440	604		72		8		72	73	74	29	52
2016-05-18	1.1	0.9	on	pre	20.2	20.8	41.0	1440	328		59		6		71	72	74	38	50
2016-05-19	4.9	5.4	on	pre	13.9	31.1	45.0	999	431		44		10		67	71	75	38	50
2016-05-20	13.2	12.1	on	pre	19.7	60.2	79.8	1422	741		55		13		70	73	80	26	43
2016-05-21	15.3	14.9	on	pre	19.9	53.8	73.7	1440	708		86		8		71	72	74	15	24
2016-05-22	15.8	15.4	on	pre	19.7	55.5	75.2	1425	741		98		8		71	72	73	15	17
2016-05-23	16.9	16.0	on	pre	19.8	69.4	89.2	1440	893		89		10		72	73	74	16	51
2016-05-24	15.7	14.6	on	pre	19.8	69.7	89.6	1440	893		80		11		72	73	76	15	47
2016-05-25	15.8	14.7	on	pre	19.9	67.1	87.0	1440	854		78		11		72	73	75	17	53
2016-05-26	12.1	11.3	on	pre	19.9	52.1	71.9	1440	737		98		8		72	73	74	17	50
2016-05-27	9.2	8.5	on	pre	20.0	43.3	63.3	1440	598		71		8		72	73	74	15	50
2016-05-28	12.0	11.8	on	pre	19.7	47.4	67.1	1423	593		58		10		70	72	74	15	19
2016-05-29	18.1	17.4	on	pre	19.8	64.6	84.3	1440	796		69		12		72	73	74	15	17
2016-05-30	12.9	12.4	on	pre	19.8	53.5	73.2	1440	730		97		8		72	73	74	29	23
2016-05-31	9.1	7.9	on	pre	19.9	43.8	63.7	1440	583		62		9		72	73	74	42	54
2016-06-01	5.5	4.5	on	pre	20.0	37.5	57.5	1440	498		42		12		71	73	74	37	47
2016-06-02	10.1	9.4	on	pre	18.5	54.8	73.3	1342	671		38		18		70	73	76	40	54
2016-06-03	16.8	14.9	on	pre	19.7	71.6	91.4	1440	830		54		15		72	74	77	33	48
2016-06-04	18.4	17.0	on	pre	19.8	79.9	99.7	1440	936		71		13		72	73	76	33	23
2016-06-05	19.0	18.6	on	pre	19.6	72.5	92.1	1440	893		89		10		72	72	74	38	22
2016-06-06	20.9	19.4	on	pre	19.5	87.6	107.1	1440	1030		80		13		72	73	76	36	52
2016-06-07	21.7	19.7	on	pre	19.4	98.7	118.1	1440	1164		88		13		72	74	77	35	56
2016-06-08	20.1	17.8	on	pre	19.5	95.3	114.7	1440	1128		84		13		72	74	78	36	48
2016-06-09	22.3	19.9	on	pre	19.5	96.1	115.5	1440	1129		85		13		72	74	78	35	52
2016-06-10	22.8	20.4	on	pre	19.5	97.7	117.3	1440	1156		94		12		72	74	78	36	53
2016-06-11	18.6	17.7	on	pre	19.5	75.1	94.6	1440	940		101		9		72	73	75	41	26
2016-06-12	22.4	21.1	on	pre	19.4	89.3	108.7	1440	1049		82		13		72	73	76	39	30
2016-06-13	25.2	23.8	on	pre	19.4	101.6	121.0	1440	1208		103		12		72	73	76	29	58
2016-06-14	20.4	19.1	on	pre	19.4	87.5	106.9	1440	1051		80		13		71	73	76	22	51
2016-06-15	22.8	20.8	on	pre	19.3	92.1	111.4	1440	1045		62		17		72	74	78	21	53
2016-06-16	23.3	21.4	on	pre	19.3	95.3	114.6	1440	1099		72		15		72	74	77	17	54
2016-06-17	24.0	21.9	on	pre	19.3	96.9	116.2	1440	1094		73		15		72	74	77	15	59
2016-06-18	26.7	25.0	on	pre	19.3	98.9	118.2	1440	1090		82		13		72	74	78	15	33
2016-06-19	23.1	21.4	on	pre	19.2	93.2	112.5	1440	1074		75		14		72	74	77	24	26
2016-06-20	20.5	18.8	on	pre	19.3	91.4	110.7	1440	1071		88		12		72	74	77	36	52
2016-06-21	21.5	19.2	on	pre	19.3	94.2	113.5	1440	1097		81		14		72	74	78	40	55
2016-06-22	27.4	24.5	on	pre	19.2	110.9	130.1	1440	1198		68		18		72	75	80	36	58
2016-06-23	26.5	23.4	on	pre	19.1	112.3	131.3	1440	1253		82		15		72	75	80	35	52
2016-06-24	22.6	20.0	on	pre	19.1	100.4	119.5	1440	1133		70		16		73	75	78	42	55
2016-06-25	19.8	18.3	on	pre	19.1	87.3	106.5	1440	1040		86		12		72	73	77	42	31
2016-06-26	16.5	15.8	on	pre	19.3	75.3	94.6	1440	929		81		11		72	73	74	43	30
2016-06-27	17.4	15.6	on	pre	19.2	86.0	105.2	1440	1011		66		15		72	74	77	48	57
2016-06-29	17.5	17.2	off	pre	15.0	99.8	114.8	1139	1139		30		38		70	72	76	44	52
2016-06-30	19.3	18.8	off	pre	15.7	106.4	122.1	1194	1194		26		46		70	72	76	39	56
2016-07-01	13.8	14.6	off	pre	14.3	88.8	103.1	1089	1088		35		31		70	71	74	43	56
2016-07-02	18.5	19.1	off	pre	13.7	88.6	102.3	1039	1036		43		24		70	71	73	46	27
2016-07-03	25.0	24.8	off	pre	14.4	99.4	113.9	1098	1095		34		32		71	72	75	37	29
2016-07-04	27.7	26.9	off	pre	15.4	109.6	125.0	1173	1167		34		34		71	73	76	35	25
2016-07-05	28.1	26.5	off	pre	16.9	120.6	137.5	1287	1281		20		64		71	74	79	32	47
2016-07-06	27.8	26.7	off	pre	17.3	122.7	140.0	1317	1316		18		73		71	73	78	34	45
2016-07-07	25.5	24.5	off	pre	17.6	123.7	141.3	1341	1339		15		89		70	73	76	38	47
2016-07-08	25.1	23.5	off	pre	16.7	117.5	134.2	1271	1270		21		60		70	74	80	37	54
2016-07-09	23.4	22.5	off	pre	15.6	107.9	123.5	1188	1183		34		35		71	73	78	37	12
2016-07-10	27.9	27.2	off	pre	16.0	113.9	130.0	1220	1216		31		39		71	73	76	35	21
2016-07-11	28.9	27.8	off	pre	16.6	119.1	135.7	1264	1262		21		60		71	73	78	33	52

Air Conditioning: Dry Climate Site 2 (El Paso, TX)

DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C1	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2016-07-12	28.9	27.8	off	pre	16.5	117.5	134.0	1255	1252		23		54		70	73	77	31	50
2016-07-13	30.5	28.8	off	pre	16.7	122.7	139.4	1274	1271		20		64		71	74	79	28	49
2016-07-14	30.3	28.4	off	pre	16.9	124.6	141.5	1289	1288		21		61		71	74	79	26	46
2016-07-15	24.2	22.2	off	pre	16.6	116.7	133.3	1265	1264		23		55		71	74	82	31	53
2016-07-16	22.8	22.9	off	pre	14.0	96.3	110.4	1069	1065		38		28		70	72	75	34	16
2016-07-17	25.9	26.1	off	pre	14.4	100.5	114.9	1099	1098		38		29		71	72	74	34	23
2016-07-18	23.4	21.7	off	pre	15.9	111.4	127.3	1211	1211		23		53		71	74	80	37	53
2016-07-20	22.8	20.3	on	pre	19.0	98.4	117.3	1440	1105		73		15		72	75	79	41	49
2016-07-21	24.8	22.2	on	pre	19.0	106.2	125.2	1440	1174		68		17		72	75	79	41	48
2016-07-22	25.7	22.7	on	pre	19.0	106.1	125.0	1440	1179		81		15		72	75	83	37	54
2016-07-23	26.8	24.8	on	pre	18.9	103.5	122.4	1440	1153		88		13		72	74	78	33	19
2016-07-24	27.6	25.8	on	pre	18.8	102.7	121.5	1440	1166		101		12		72	74	78	34	18
2016-07-25	26.0	23.6	on	pre	18.7	105.3	124.0	1440	1180		90		13		72	74	79	38	41
2016-07-26	20.9	17.6	on	pre	18.6	96.2	114.8	1440	1120		72		16		72	75	80	44	41
2016-07-27	17.7	15.6	on	pre	18.6	86.4	105.0	1440	1019		67		15		73	74	77	49	44
2016-07-28	22.3	19.8	on	pre	18.5	99.9	118.5	1440	1112		53		21		72	74	78	45	49
2016-07-29	21.5	18.3	on	pre	18.6	98.5	117.1	1440	1109		67		17		72	75	83	42	46
2016-07-30	20.1	18.1	on	pre	18.6	91.4	110.0	1440	1076		78		14		73	74	76	46	12
2016-07-31	20.4	19.0	on	pre	18.6	84.3	103.0	1440	1012		94		11		72	73	76	44	13
2016-08-01	18.5	16.0	on	pre	18.5	86.5	104.9	1440	1034		78		13		72	74	78	47	48
2016-08-03	16.0	15.7	off	pre	15.3	102.7	118.0	1204	1199		30		40		70	72	77	43	53
2016-08-04	18.1	18.1	off	pre	15.5	105.1	120.6	1218	1213		28		43		70	72	75	43	47
2016-08-05	21.2	19.8	off	pre	15.6	109.7	125.2	1223	1218		25		49		70	73	79	41	52
2016-08-06	21.0	21.6	off	pre	13.2	89.8	103.0	1042	1031		44		23		70	71	73	38	15
2016-08-07	21.5	21.8	off	pre	13.7	93.1	106.8	1081	1060		40		27		70	72	74	37	13
2016-08-08	20.7	19.5	off	pre	15.2	106.6	121.9	1199	1189		28		42		70	73	80	37	51
2016-08-09	17.6	17.6	off	pre	15.2	101.6	116.9	1199	1187		30		40		70	72	74	42	48
2016-08-10	14.4	14.5	off	pre	14.9	97.8	112.7	1172	1164		31		38		70	72	76	46	48
2016-08-11	18.2	17.6	off	pre	15.4	105.4	120.7	1210	1200		27		44		70	73	77	45	45
2016-08-12	20.4	18.9	off	pre	15.9	112.0	127.9	1249	1246		24		52		70	74	81	41	55
2016-08-13	9.8	10.8	off	pre	11.3	69.5	80.8	891	877		50		18		70	71	72	44	17
2016-08-14	11.8	12.4	off	pre	11.7	75.3	87.0	920	908		40		23		70	71	74	42	21
2016-08-15	13.6	13.6	off	pre	12.3	81.6	93.9	970	965		26		37		70	72	76	36	47
2016-08-16	16.4	16.6	off	pre	13.0	87.8	100.8	1020	1015		30		34		70	72	76	33	48
2016-08-17	16.7	16.7	off	pre	12.8	86.8	99.6	1011	1006		29		35		70	72	76	33	46
2016-08-18	15.5	15.4	off	pre	14.0	93.8	107.8	1102	1094		28		39		70	72	76	37	46
2016-08-19	16.3	15.9	off	pre	14.0	94.6	108.6	1102	1095		30		37		70	72	78	41	50
2016-08-20	12.6	13.8	off	pre	10.2	61.0	71.3	805	788		61		13		70	71	71	39	12
2016-08-21	8.6	9.9	off	pre	9.2	53.6	62.8	723	705		53		13		70	71	71	42	15
2016-08-22	11.0	11.1	off	pre	13.2	85.7	98.9	1041	1033		29		36		70	72	75	46	50
2016-08-23	11.0	11.5	off	pre	12.6	80.8	93.4	997	991		35		28		70	71	75	45	50
2016-08-24	13.6	14.6	off	pre	12.4	80.4	92.8	979	969		36		27		70	71	74	42	48
2016-08-25	11.4	11.9	off	pre	12.3	78.7	91.0	969	963		35		28		70	71	76	39	51
2016-08-26	12.2	12.1	off	pre	12.8	84.1	96.9	1007	1004		27		37		70	72	77	40	54
2016-08-27	12.8	13.3	off	pre	12.6	81.1	93.7	995	987		39		25		70	72	74	42	28
2016-08-28	11.7	12.1	off	pre	11.2	72.3	83.5	885	877		36		24		70	72	75	44	21
2016-08-29	11.3	11.4	off	pre	13.3	86.8	100.1	1050	1043		29		36		70	72	76	44	48
2016-08-30	6.5	8.2	off	pre	11.2	64.9	76.1	885	866		50		17		70	70	71	48	43
2016-09-01	8.3	6.5	on	pre	18.5	51.8	70.2	1440	680		60		11		72	74	76	59	51
2016-09-02	12.5	10.3	on	pre	18.3	68.4	86.7	1440	810		46		18		72	74	77	55	41
2016-09-03	15.0	13.1	on	pre	18.3	72.7	91.0	1440	861		56		15		72	74	76	53	16
2016-09-04	17.4	15.7	on	pre	18.3	72.1	90.4	1440	840		61		14		72	74	77	53	15
2016-09-05	18.7	17.1	on	pre	18.3	78.4	96.8	1440	903		58		16		72	74	76	51	27
2016-09-06	9.2	7.4	on	pre	18.5	40.2	58.7	1440	579		82		7		73	74	74	62	41
2016-09-07	9.3	7.4	on	pre	18.4	52.9	71.3	1440	689		58		12		73	74	75	61	43
2016-09-08	11.4	9.7	on	pre	18.4	63.3	81.7	1440	815		66		12		73	74	75	53	43
2016-09-09	15.3	12.8	on	pre	18.3	75.6	93.9	1440	904		62		15		73	74	78	49	45
2016-09-10	8.7	7.7	on	pre	18.6	46.7	65.3	1440	621		68		9		72	73	74	43	18
2016-09-11	10.4	9.3	on	pre	18.5	50.8	69.3	1440	636		52		12		72	73	74	47	10
2016-09-12	15.0	13.3	on	pre	18.3	71.1	89.4	1440	904		76		12		72	74	75	43	46
2016-09-13	13.4	11.7	on	pre	18.3	67.0	85.3	1440	839		68		12		72	74	77	40	45
2016-09-14	13.7	11.4	on	pre	18.3	69.3	87.6	1440	820		45		18		72	74	77	39	42
2016-09-15	14.2	11.9	on	pre	18.1	74.7	92.8	1440	909		67		14		73	74	78	47	43
2016-09-16	13.3	11.4	on	pre	18.2	67.3	85.5	1440	837		64		13		72	74	76	43	50
2016-09-17	13.1	11.7	on	pre	18.3	57.0	75.3	1440	685		47		15		72	73	75	34	28
2016-09-18	14.1	12.4	on	pre	18.2	62.4	80.6	1440	738		48		15		72	74	76	34	18
2016-09-19	14.5	12.8	on	pre	18.1	66.3	84.4	1440	800		59		14		72	74	77	30	45
2016-09-20	18.1	15.9	on	pre	18.0	81.1	99.2	1440	962		64		15		72	74	77	37	45
2016-09-21	18.3	16.1	on	pre	17.9	81.6	99.5	1440	987		75		13		72	74	78	41	47

Air Conditioning: Dry Climate Site 2 (El Paso, TX)																			
DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C1	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2016-09-22	16.7	14.7	on	pre	17.9	78.0	96.0	1440	949		77		12		72	74	77	38	43
2016-09-23	14.9	13.1	on	pre	17.9	72.6	90.5	1440	941		86		11		72	74	77	35	46
2016-09-24	9.5	8.5	on	pre	18.2	48.8	67.0	1440	660		63		10		72	73	74	35	13
2016-09-25	4.8	4.1	on	pre	18.2	30.0	48.2	1440	455		73		6		72	73	74	30	20
2016-09-27	2.7	2.4	on	pre	17.5	28.6	46.2	1384	415		43		10		70	72	75	38	37
2016-09-29	10.3	11.2	off	pre	12.2	78.1	90.3	980	980		32		31		70	71	74	36	46
2016-09-30	4.2	5.5	off	pre	11.2	65.3	76.5	897	897		37		24		70	71	73	42	51
2016-10-01	9.1	10.3	off	pre	9.4	59.3	68.7	758	758		33		23		70	71	73	41	21
2016-10-02	9.5	11.0	off	pre	8.4	52.7	61.1	673	672		35		19		70	71	72	32	11
2016-10-03	11.9	13.1	off	pre	11.7	74.9	86.6	941	941		34		28		70	71	73	35	42
2016-10-06	8.2	9.3	off	pre	10.5	64.3	74.8	841	839		29		29		69	71	74	29	50
2016-10-07	2.1	3.9	off	pre	7.6	42.6	50.2	608	608		34		18		70	70	71	29	41
2016-10-08	1.9	3.8	off	pre	6.4	35.6	41.9	512	510		42		12		70	70	71	39	16
2016-10-09	5.1	6.7	off	pre	8.3	48.9	57.2	668	668		46		15		70	70	71	43	12
2016-10-10	7.8	9.5	off	pre	7.5	45.7	53.2	604	603		39		15		70	70	71	42	26
2016-10-11	10.8	11.8	off	pre	10.5	68.7	79.1	840	840		25		34		70	71	74	38	41
2016-10-12	10.2	11.4	off	pre	9.5	62.0	71.6	764	764		24		32		69	71	73	34	44
2016-10-13	7.1	8.3	off	pre	10.2	63.0	73.2	816	816		32		26		70	71	74	34	42
2016-10-14	7.8	7.8	off	pre	12.2	37.6	49.8	960	487		43		11		70	72	75	37	51
2016-10-15	10.1	10.3	off	pre	14.8	31.7	46.5	1161	419		55		8		69	72	74	31	23
2016-10-16	10.5	10.5	off	pre	16.6	39.0	55.6	1302	515		62		8		70	72	74	26	19
2016-10-17	11.6	10.4	off	pre	18.3	47.1	65.4	1440	609		54		11		72	73	75	23	47
2016-10-18	9.6	8.4	off	pre	18.4	44.3	62.7	1440	575		52		11		72	73	75	19	45
2016-10-19	8.7	8.1	off	pre	17.5	40.3	57.8	1380	529		46		12		69	73	75	22	47
2016-10-20	2.8	1.9	off	pre	18.4	25.8	44.2	1440	390		60		7		71	73	74	25	44
2016-10-21	3.6	3.3	off	pre	15.8	26.9	42.7	1246	382		42		9		69	72	75	28	43
2016-10-22	4.9	5.0	off	pre	14.1	23.6	37.8	1111	318		33		10		69	72	75	33	13
2016-10-23	7.1	7.4	off	pre	12.7	32.7	45.4	1006	418		35		12		69	72	75	31	20
2016-10-24	7.9	7.4	off	pre	16.1	37.6	53.7	1282	486		38		13		69	73	75	30	42
2016-10-25	9.1	7.6	off	pre	18.1	41.7	59.9	1440	553		52		11		73	73	75	29	44
2016-10-26	8.1	6.9	off	pre	18.1	41.3	59.5	1440	538		44		12		72	73	75	31	46
2016-10-27	7.5	6.4	off	pre	18.2	39.0	57.1	1440	508		38		13		71	73	75	31	44
2016-10-28	6.1	4.8	off	pre	18.1	32.4	50.5	1440	435		39		11		71	73	75	32	48
2016-10-29	7.2	6.9	off	pre	17.7	26.9	44.6	1402	364		45		8		70	72	74	31	18
2016-10-30	6.8	6.8	off	pre	16.2	26.4	42.6	1292	365		50		7		70	72	74	29	15
2016-10-31	7.5	6.7	off	pre	18.0	34.5	52.5	1440	470		50		9		71	73	75	29	46
2016-11-01	7.9	6.7	off	pre	17.9	36.7	54.6	1440	560		86		7		72	73	74	29	45
2016-11-02	5.1	3.9	off	pre	18.1	29.2	47.3	1440	434		58		7		72	73	75	35	49
2016-11-03	1.2	0.5	off	pre	18.2	12.2	30.4	1440	203		36		6		72	73	73	43	43
2016-11-04	1.5	0.7	off	pre	18.1	11.4	29.5	1440	180		33		5		72	73	74	51	50
2016-11-05	1.9	1.2	off	pre	18.1	11.0	29.1	1440	166		29		6		72	73	74	54	18
2016-11-06	2.5	3.0	off	pre	14.0	11.4	25.4	1113	187		32		6		69	71	74	48	16
2016-11-07	2.6	2.7	off	pre	13.7	18.8	32.5	1106	274		30		9		69	72	75	39	48
2016-11-08	1.0	1.3	off	pre	15.9	14.9	30.8	1273	241		42		6		69	72	74	31	51
2016-11-11	0.0	2.9	off	pre	2.8	14.8	17.6	230	229		17		13		68	69	70	35	23
2017-02-08	1.1	0.1	on	pre	0.5	1.8	2.3	43	31		5		6		68	73	79	26	53
2017-02-09	2.6	2.3	on	pre	1.1	5.3	6.4	90	76		6		13		66	72	80	25	49
2017-02-10	5.2	5.3	on	pre	2.7	16.5	19.2	233	220		13		17		66	72	76	22	49
2017-02-11	7.2	6.2	on	pre	1.8	11.4	13.3	158	155		15		10		69	73	75	17	17
2017-02-23	2.0	0.2	on	pre	16.8	11.7	28.6	1440	177		19		9		71	74	76	17	49
2017-02-28	1.7	1.6	on	pre	17.0	4.9	21.8	1440	76		10		8		68	72	76	15	51
2017-03-20	10.2	6.6	on	pre	16.1	42.1	58.2	1439	529		7		76		73	76	78	17	44
2017-03-22	11.8	8.7	on	pre	15.9	48.9	64.7	1438	607		10		61		71	75	79	16	43
2017-03-23	4.8	2.7	on	pre	16.1	31.4	47.5	1440	442		25		18		70	74	76	15	48
2017-03-24	2.2	1.6	on	pre	16.3	13.7	30.0	1440	202		16		13		68	73	76	16	44
2017-03-25	5.5	4.7	on	pre	16.3	16.2	32.4	1440	229		16		14		68	73	76	15	25
2017-03-26	3.3	1.4	on	pre	16.3	12.4	28.7	1440	183		18		10		72	74	76	15	20
2017-03-27	6.1	4.5	on	pre	16.2	28.5	44.7	1440	411		29		14		70	74	76	15	45
2017-03-28	0.1	-1.5	on	pre	16.3	4.6	20.9	1440	81		11		7		70	74	76	18	46
2017-03-29	0.3	0.1	on	pre	16.2	3.1	19.4	1440	50		6		8		69	72	76	22	51
2017-03-30	5.8	5.2	on	pre	16.0	17.8	33.8	1434	250		16		16		66	73	76	20	45
2017-03-31	4.8	3.3	on	pre	15.1	28.2	43.3	1375	417		38		11		70	73	75	15	44
2017-04-02	1.1	1.0	on	pre	16.1	6.3	22.4	1432	103		11		9		68	72	76	17	19
2017-04-03	4.6	2.7	on	pre	14.2	18.0	32.2	1280	260		18		14		70	74	76	17	44
2017-04-04	2.2	0.3	on	pre	15.4	10.1	25.5	1390	158		16		10		71	74	76	15	42
2017-04-05	0.4	0.6	on	pre	12.5	17.4	30.0	1142	292		38		8		68	72	76	15	40
2017-04-06	4.2	3.9	on	pre	2.9	18.4	21.3	270	261		15		17		68	72	76	15	47
2017-04-07	8.7	7.5	on	pre	4.9	35.0	39.9	451	450		10		45		68	73	77	15	53
2017-04-08	10.9	9.1	on	pre	4.6	32.3	36.9	424	420		24		18		70	74	76	15	18

Air Conditioning: Dry Climate Site 2 (El Paso, TX)

DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C1	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2017-04-09	7.8	4.9	on	pre	3.6	23.4	27.0	335	333		24		14		73	75	76	15	29
2017-04-10	5.4	3.7	on	pre	4.2	28.8	33.1	392	391		13		30		69	74	76	15	50
2017-04-11	8.1	5.7	on	pre	6.5	44.4	51.0	604	570		14		41		71	74	77	22	41
2017-04-12	8.6	5.7	on	pre	11.1	54.3	65.4	1009	691		22		31		72	75	77	33	40
2017-04-13	7.9	5.8	on	pre	10.5	49.3	59.8	958	636		26		24		71	74	78	33	47
2017-04-14	11.8	9.1	on	pre	8.7	49.9	58.5	794	631		18		35		73	75	77	23	46
2017-04-15	10.5	7.7	on	pre	5.2	36.0	41.1	477	468		22		21		73	75	77	15	21
2017-04-16	10.2	8.2	on	pre	4.8	35.3	40.2	447	447		17		26		70	74	76	15	17
2017-04-18	12.0	9.9	on	pre	10.3	65.7	76.0	945	846		34		25		71	74	77	15	47
2017-04-19	13.7	11.6	on	pre	11.4	74.0	85.4	1045	969		18		54		71	74	78	15	46
2017-04-20	12.6	9.9	on	pre	7.9	50.7	58.6	717	626		20		31		71	75	78	16	46
2017-04-21	13.2	11.3	on	pre	10.3	68.4	78.7	938	879		30		29		71	74	77	15	48
2017-04-22	3.3	1.7	on	pre	5.5	28.9	34.5	501	413		37		11		71	74	76	21	21
2017-04-23	6.2	4.4	on	pre	3.2	22.0	25.2	293	289		23		13		70	74	76	19	14
2017-04-24	14.1	12.2	on	pre	8.6	61.2	69.8	784	768		24		32		73	74	75	16	44
2017-04-25	10.6	9.3	on	pre	9.5	58.9	68.4	866	816		50		16		73	73	74	16	39
2017-04-26	6.3	5.6	on	pre	6.9	42.5	49.4	628	600		30		20		70	73	74	16	47
2017-04-30	3.6	5.3	on	pre	2.1	12.6	14.7	190	186		19		10		66	70	74	20	18
2017-05-01	7.1	6.6	on	pre	6.4	43.2	49.6	579	563		14		40		69	73	75	15	44
2017-05-02	12.3	12.0	on	pre	7.5	54.1	61.6	682	675		19		36		69	72	75	15	43
2017-05-03	11.4	9.6	on	pre	12.0	71.5	83.5	1077	933		50		19		71	74	77	17	48
2017-05-06	15.4	15.5	on	pre	14.7	75.5	90.2	1308	963		66		15		70	72	75	17	24
2017-05-07	14.4	14.7	on	pre	13.3	72.8	86.1	1188	971		79		12		70	72	74	16	16
2017-05-10	1.8	2.7	on	pre	15.4	33.1	48.5	1347	536		62		9		70	71	72	21	43
2017-05-11	6.8	5.5	on	pre	15.5	58.0	73.5	1373	916		23		40		70	73	79	20	46
2017-05-12	9.7	9.0	on	pre	16.1	68.8	85.0	1430	930		54		17		70	73	76	26	49
2017-05-13	14.4	15.2	on	pre	14.8	68.0	82.8	1311	879		54		16		70	71	73	23	16
2017-05-14	17.1	17.2	on	pre	13.8	78.8	92.6	1235	1048		81		13		70	72	74	16	12
2017-05-15	14.3	12.2	on	pre	14.0	77.8	91.8	1255	1137		49		23		71	74	80	17	47
2017-05-16	6.9	6.3	on	pre	16.2	61.4	77.5	1434	1011		45		22		71	73	76	20	43
2017-05-17	8.0	7.6	on	pre	14.4	62.6	77.1	1279	912		21		43		70	72	75	17	48
2017-05-18	10.2	10.3	on	pre	15.8	71.3	87.1	1403	1025		75		14		70	72	74	15	46
2017-05-19	7.1	7.9	on	pre	13.6	53.5	67.2	1207	776		61		13		70	71	73	15	46
2017-05-20	7.5	8.4	on	pre	11.9	50.3	62.2	1046	695		42		17		70	71	74	15	21
2017-05-21	11.8	12.3	on	pre	13.1	65.3	78.3	1158	844		49		17		70	71	74	26	20
2017-05-22	13.7	12.8	on	pre	14.4	74.6	88.9	1273	954		54		18		70	73	77	30	45
2017-05-23	9.2	8.5	on	pre	13.9	69.2	83.1	1235	920		51		18		70	73	77	24	47
2017-05-24	14.7	14.0	on	pre	14.7	74.2	88.9	1300	916		30		31		70	73	77	24	47
2017-05-25	21.0	20.0	on	pre	16.0	101.1	117.1	1436	1289		74		17		71	73	77	15	49
2017-05-26	19.0	16.6	on	pre	15.7	95.2	110.9	1402	1271		59		22		71	74	79	18	40
2017-05-28	11.3	10.2	on	pre	16.0	78.8	94.8	1400	1126		48		23		71	73	77	20	18
2017-05-30	9.8	9.0	on	pre	15.9	71.8	87.7	1368	942		48		20		71	73	77	37	46
2017-05-31	9.5	8.8	on	pre	16.7	74.1	90.8	1423	990		54		18		70	73	76	38	47
2017-06-01	10.3	9.6	on	pre	16.8	73.5	90.2	1416	982		53		19		71	73	76	39	48
2017-06-02	12.4	11.6	on	pre	16.4	77.6	94.1	1374	1027		44		23		70	73	76	35	49
2017-06-03	15.1	15.6	on	pre	16.5	73.5	90.0	1369	971		70		14		71	71	73	34	22
2017-06-04	17.4	16.5	on	pre	15.5	84.5	99.9	1263	1041		36		29		70	73	77	32	23
2017-06-05	21.2	18.8	on	pre	16.7	99.2	115.9	1344	1197		39		31		71	74	80	32	45
2017-06-08	15.7	13.3	on	post	19.0	86.7	105.8	1440	1027		56		18		72	74	79	44	46
2017-06-09	23.4	21.2	on	post	18.9	105.3	124.2	1436	1230		90		14		71	74	80	33	44
2017-06-10	26.0	25.1	on	post	18.8	107.3	126.1	1431	1247		92		14		71	73	76	27	28
2017-06-11	23.2	22.9	on	post	18.4	96.3	114.7	1403	1189		112		11		71	72	74	18	24
2017-06-12	21.1	20.1	on	post	17.5	94.8	112.3	1340	1157		95		12		71	73	77	22	47
2017-06-13	21.7	20.5	on	post	17.3	95.9	113.3	1330	1161		88		13		71	73	77	19	44
2017-06-14	22.1	20.6	on	post	16.0	91.7	107.8	1233	1065		75		14		71	74	79	15	52
2017-06-15	23.7	21.7	on	post	16.1	97.9	114.0	1239	1083		62		17		71	74	80	15	47
2017-06-16	24.8	22.5	on	post	17.5	107.0	124.5	1349	1205		76		16		71	74	80	15	49
2017-06-17	29.0	27.3	on	post	18.6	116.4	135.0	1440	1288		74		17		71	74	79	15	29
2017-06-19	24.4	21.3	on	post	18.7	115.4	134.0	1440	1262		43		29		72	75	82	42	48
2017-06-20	26.2	22.9	on	post	18.7	120.9	139.5	1440	1298		36		36		72	75	81	41	48
2017-06-21	25.5	22.7	on	post	18.6	114.3	132.9	1440	1280		64		20		71	75	81	37	48
2017-06-22	29.7	26.6	on	post	18.7	119.6	138.3	1440	1282		64		20		71	75	81	37	49
2017-06-23	31.0	27.4	on	post	18.7	126.8	145.5	1440	1326		51		26		72	76	82	30	41
2017-06-24	20.2	19.0	on	post	18.8	104.2	122.9	1440	1228		74		17		72	73	76	40	21
2017-06-25	14.9	14.1	on	post	18.5	85.7	104.3	1421	1065		84		13		71	73	76	49	34
2017-06-26	16.0	14.1	on	post	18.7	94.4	113.1	1433	1120		57		20		71	74	79	48	59
2017-06-27	18.3	16.4	on	post	17.7	94.9	112.6	1364	1117		64		17		71	74	79	45	54
2017-06-28	25.7	24.0	on	post	18.6	108.0	126.7	1440	1244		81		15		71	74	78	34	47
2017-06-29	28.0	25.6	on	post	18.5	113.7	132.2	1440	1289		76		17		71	74	79	27	47

Air Conditioning: Dry Climate Site 2 (El Paso, TX)

DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C1	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2017-06-30	27.2	25.0	on	post	18.1	110.6	128.7	1404	1246		78		16		71	74	79	22	52
2017-07-01	21.2	20.0	on	post	18.6	105.1	123.7	1440	1227		74		17		71	73	77	39	18
2017-07-02	21.3	20.7	on	post	17.9	96.6	114.5	1388	1136		85		13		71	73	76	41	25
2017-07-03	24.6	22.1	on	post	18.3	110.2	128.5	1424	1259		75		17		71	75	80	36	49
2017-07-04	25.6	24.6	on	post	18.4	107.1	125.5	1432	1236		95		13		71	73	77	36	21
2017-07-05	21.5	18.9	on	post	18.5	106.8	125.3	1435	1238		75		17		71	75	80	39	53
2017-07-06	21.9	19.4	on	post	18.3	106.6	124.9	1420	1240		78		16		71	74	80	37	51
2017-07-07	18.3	17.0	on	post	18.3	97.4	115.7	1418	1171		82		14		71	73	77	41	52
2017-07-08	21.0	19.9	on	post	17.9	99.8	117.8	1393	1169		77		15		71	73	77	42	36
2017-07-09	21.4	20.2	on	post	17.6	100.2	117.8	1372	1190		82		15		71	73	78	39	38
2017-07-10	22.7	20.0	on	post	18.3	107.7	126.0	1430	1229		62		20		71	75	81	40	58
2017-07-11	23.8	20.8	on	post	18.2	113.9	132.2	1428	1285		36		36		71	75	81	38	54
2017-07-12	19.2	16.6	on	post	18.4	100.0	118.4	1440	1179		57		21		71	75	80	44	52
2017-07-14	13.9	14.0	off	post	15.3	95.9	111.2	1199	1199		30		40		71	72	75	43	48
2017-07-15	9.1	10.2	off	post	11.7	68.6	80.3	921	921		59		16		71	71	71	50	22
2017-07-16	11.6	12.2	off	post	12.5	78.6	91.0	978	978		45		22		71	71	74	49	24
2017-07-17	16.3	15.5	off	post	14.1	95.0	109.0	1105	1105		29		38		71	73	78	44	46
2017-07-18	16.5	15.9	off	post	14.5	95.7	110.2	1142	1142		29		39		71	73	78	42	44
2017-07-19	11.7	11.6	off	post	13.5	85.9	99.4	1062	1062		35		30		70	72	77	45	52
2017-07-20	14.9	14.3	off	post	13.9	91.6	105.6	1095	1095		26		42		71	73	77	42	53
2017-07-21	14.4	13.7	off	post	14.5	94.1	108.7	1140	1140		28		41		70	73	78	45	52
2017-07-22	12.1	12.5	off	post	12.9	81.0	93.9	1010	1010		41		25		70	72	76	48	27
2017-07-23	12.0	12.7	off	post	12.1	75.4	87.5	950	950		44		22		71	71	74	49	26
2017-07-24	15.7	15.9	off	post	13.6	89.3	102.9	1065	1065		31		34		70	72	76	47	48
2017-07-25	18.8	17.7	off	post	15.0	101.5	116.5	1175	1175		25		47		71	73	79	43	51
2017-07-26	20.9	19.5	off	post	15.9	109.4	125.4	1249	1249		26		48		71	73	79	44	51
2017-07-27	12.9	13.1	off	post	13.7	86.8	100.5	1077	1077		41		26		70	72	76	46	54
2017-07-28	17.3	16.4	off	post	14.6	97.8	112.4	1144	1144		28		41		70	73	79	48	52
2017-07-29	15.2	14.9	off	post	13.7	88.9	102.5	1073	1073		37		29		71	72	76	46	28
2017-07-30	17.0	17.4	off	post	13.0	85.6	98.7	1024	1024		39		26		71	72	74	45	27
2017-07-31	16.3	15.8	off	post	15.0	100.8	115.8	1180	1180		30		39		70	72	77	49	54
2017-08-01	12.5	12.4	off	post	14.5	94.1	108.6	1137	1137		31		37		71	72	76	51	56
2017-08-02	15.9	15.3	off	post	15.4	102.5	118.0	1212	1212		27		45		70	73	77	44	56
2017-08-03	17.3	16.4	off	post	14.7	99.4	114.2	1158	1158		29		40		71	73	77	40	59
2017-08-04	18.2	16.9	off	post	15.0	101.5	116.4	1176	1176		25		47		71	73	79	39	61
2017-08-05	19.5	18.9	off	post	15.3	103.1	118.4	1202	1202		30		40		71	73	76	40	31
2017-08-06	20.7	20.5	off	post	14.1	96.3	110.4	1107	1107		35		32		71	72	75	41	23
2017-08-07	20.3	19.3	off	post	15.2	103.7	118.9	1194	1194		28		43		71	73	78	40	56
2017-08-08	17.8	16.7	off	post	15.4	104.5	119.9	1213	1213		27		45		71	73	78	44	52
2017-08-09	19.6	18.0	off	post	15.7	108.7	124.4	1235	1235		25		49		71	74	79	44	52
2017-08-10	21.8	19.7	off	post	15.3	107.1	122.4	1202	1202		25		48		70	74	79	40	53
2017-08-11	17.1	15.2	off	post	15.0	100.8	115.8	1175	1175		24		49		71	74	78	43	47
2017-08-12	15.0	14.8	off	post	14.5	94.4	108.9	1139	1139		34		34		71	72	76	49	29
2017-08-13	18.1	17.7	off	post	14.9	98.4	113.3	1169	1169		34		34		71	72	76	45	30
2017-08-14	18.1	16.5	off	post	15.8	106.8	122.6	1238	1238		25		50		71	74	79	45	49
2017-08-15	14.3	13.2	off	post	13.6	89.1	102.7	1068	1066		31		34		71	73	78	46	44
2017-08-16	19.4	18.5	off	post	15.0	100.3	115.3	1180	1180		28		42		71	73	78	39	46
2017-08-17	18.2	17.5	off	post	14.8	99.8	114.6	1165	1165		27		43		71	73	77	38	47
2017-08-18	16.4	15.2	off	post	15.6	104.3	119.9	1224	1224		27		45		71	73	79	42	52
2017-08-19	12.9	13.4	off	post	13.3	83.2	96.6	1048	1048		44		24		71	71	74	44	22
2017-08-20	7.4	8.4	off	post	11.0	63.7	74.7	860	853		55		16		71	71	72	52	29
2017-08-21	11.9	12.0	off	post	13.5	85.9	99.4	1061	1056		35		30		71	72	76	50	53
2017-08-22	16.9	16.0	off	post	14.5	97.8	112.4	1142	1138		28		41		71	73	78	45	49
2017-08-24	11.2	11.0	on	post	17.0	73.8	90.8	1333	930		54		17		71	72	75	52	49
2017-08-25	12.9	12.2	on	post	17.1	79.8	96.9	1343	983		52		19		71	73	77	52	48
2017-08-26	15.1	15.1	on	post	17.6	79.4	96.9	1379	961		51		19		71	72	75	54	31
2017-08-27	15.0	14.6	on	post	16.5	81.5	98.1	1299	993		72		14		71	72	76	49	27
2017-08-28	14.9	14.2	on	post	15.8	81.4	97.2	1237	1011		73		14		71	73	77	43	54
2017-08-29	14.0	13.2	on	post	16.3	82.7	98.9	1275	1039		72		14		71	73	77	43	47
2017-08-30	13.7	13.2	on	post	14.7	78.5	93.3	1154	981		67		15		71	72	77	37	52
2017-08-31	12.7	12.4	on	post	15.1	78.0	93.1	1182	981		71		14		70	72	76	36	53
2017-09-01	14.6	14.3	on	post	13.6	75.2	88.8	1065	929		64		15		71	72	76	32	47
2017-09-02	15.5	16.0	on	post	14.5	73.2	87.7	1135	948		92		10		71	72	73	32	25
2017-09-03	17.2	17.0	on	post	14.5	79.7	94.2	1142	977		81		12		71	72	76	34	25
2017-09-04	16.1	15.6	on	post	13.7	79.8	93.5	1077	957		53		18		71	73	77	35	20
2017-09-05	15.2	14.6	on	post	15.4	79.8	95.2	1209	999		80		12		71	73	77	37	49
2017-09-06	13.3	12.7	on	post	16.1	80.5	96.5	1260	1029		79		13		71	73	77	41	51
2017-09-07	15.8	14.9	on	post	15.5	83.1	98.6	1219	1018		69		15		71	73	77	37	48
2017-09-08	15.1	14.3	on	post	16.2	82.6	98.8	1276	1056		82		13		71	73	77	40	46

Air Conditioning: Dry Climate Site 2 (El Paso, TX)

DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C1	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2017-09-09	13.4	13.6	on	post	14.6	72.4	87.0	1146	941		85		11		71	72	74	39	23
2017-09-10	13.5	13.8	on	post	14.9	72.0	86.8	1166	923		79		12		71	72	74	40	24
2017-09-11	14.7	14.2	on	post	14.5	73.6	88.1	1139	928		79		12		71	72	77	35	48
2017-09-12	15.7	15.0	on	post	14.5	80.2	94.7	1136	984		65		15		71	73	77	31	51
2017-09-13	19.3	18.0	on	post	15.4	87.9	103.2	1207	1051		69		15		71	73	79	31	53
2017-09-14	20.3	19.1	on	post	16.7	97.4	114.1	1312	1156		58		20		71	73	77	35	53
2017-09-15	18.9	18.0	on	post	17.7	95.3	113.0	1394	1182		64		18		71	73	77	38	51
2017-09-16	15.4	15.3	on	post	17.1	80.6	97.7	1350	1022		64		16		71	72	74	43	32
2017-09-17	15.8	16.0	on	post	15.7	77.1	92.8	1236	973		77		13		71	72	74	43	29
2017-09-18	18.0	17.1	on	post	16.4	87.3	103.7	1289	1083		75		14		71	73	77	39	52
2017-09-19	18.8	18.1	on	post	17.3	92.1	109.5	1363	1144		75		15		71	73	76	39	52
2017-09-20	18.4	17.6	on	post	16.6	90.3	106.9	1307	1142		80		14		71	73	77	37	54
2017-09-21	17.9	16.9	on	post	16.6	89.8	106.4	1305	1122		79		14		71	73	77	37	50
2017-09-22	18.5	17.7	on	post	16.7	91.4	108.1	1315	1137		83		14		71	73	77	35	52
2017-09-23	15.0	15.1	on	post	16.8	78.7	95.6	1328	1030		99		10		71	72	74	41	19
2017-09-24	12.2	12.6	on	post	12.9	63.6	76.5	1019	861		81		11		71	72	74	33	30
2017-09-25	11.5	11.9	on	post	14.2	63.9	78.2	1125	873		77		11		70	72	74	35	51
2017-09-26	6.8	7.0	on	post	12.5	57.2	69.7	987	754		47		16		70	72	75	36	60
2017-09-27	1.1	2.1	on	post	14.9	26.9	41.8	1186	429		67		6		70	71	72	61	55
2017-09-29	5.8	6.9	off	post	11.1	65.5	76.6	871	869		38		23		70	71	73	48	55
2017-09-30	5.5	6.8	off	post	9.0	51.4	60.4	709	707		53		13		70	71	71	49	30
2017-10-01	11.3	12.2	off	post	10.3	63.7	73.9	805	804		36		22		70	71	73	44	28
2017-10-02	13.1	13.8	off	post	11.3	69.9	81.2	885	882		35		25		70	71	75	35	51
2017-10-03	13.2	13.4	off	post	12.4	78.9	91.3	972	972		26		37		70	72	75	35	53
2017-10-04	13.5	13.8	off	post	14.6	92.4	107.1	1149	1149		32		36		70	72	75	47	55
2017-10-05	15.9	15.5	off	post	15.2	98.9	114.1	1195	1195		32		37		70	72	76	48	58
2017-10-06	15.8	15.7	off	post	13.3	85.5	98.8	1044	1044		38		27		71	72	76	44	49
2017-10-07	7.0	8.0	off	post	6.8	40.5	47.3	537	537		26		21		70	71	72	17	35
2017-10-09	10.4	11.6	off	post	9.5	54.8	64.4	747	746		46		16		70	71	72	28	25
2017-10-10	0.6	2.9	off	post	5.3	28.6	34.0	419	419		15		28		67	70	71	28	59
2017-10-11	5.5	7.5	off	post	7.9	46.6	54.6	623	623		18		35		67	70	73	30	52
2017-10-12	10.2	10.6	off	post	10.3	64.4	74.7	810	810		22		37		70	72	76	39	57
2017-10-13	13.6	13.7	off	post	12.3	77.2	89.5	966	966		34		28		70	72	76	40	56
2017-10-14	15.7	16.4	off	post	12.3	76.7	88.9	964	964		44		22		71	71	74	37	35
2017-10-15	2.9	4.5	off	post	6.1	33.2	39.3	481	481		34		14		70	70	71	21	40
2017-10-16	4.3	6.3	off	post	6.9	39.5	46.4	539	539		16		34		68	70	73	25	56
2017-10-17	6.6	8.4	off	post	7.3	43.9	51.2	574	574		17		34		68	70	73	31	56
2017-10-18	7.8	8.9	off	post	9.0	53.8	62.8	707	707		26		27		70	71	73	34	56
2017-10-19	6.5	7.5	off	post	9.4	56.2	65.6	740	740		30		25		70	71	73	40	52
2017-10-20	8.6	10.0	off	post	8.2	49.8	58.0	645	645		25		26		70	71	72	37	52
2017-10-21	7.3	8.4	off	post	7.1	38.6	45.7	555	553		48		12		71	71	71	31	37
2017-10-22	4.0	5.8	off	post	4.5	25.5	30.0	352	351		19		18		69	70	71	17	27

D1.3 AIR CONDITIONING DRY CLIMATE SITE 3

Air Conditioning: Dry Climate Site 3 (El Paso, TX)																				
DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C12	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2016-05-06	15.9	15.6	on	pre	31.2	66.7	97.9	1440	1126	190	62	50	18	4	72	72	73	16	26
2016-05-07	8.5	8.1	on	pre	31.4	32.4	63.8	1440	720	7	99	2	7	4	72	72	73	15	1
2016-05-08	5.8	5.7	on	pre	31.1	20.4	51.5	1440	447	29	88	10	5	3	71	72	72	15	0
2016-05-09	7.0	7.1	on	pre	30.9	27.6	58.5	1440	611	5	87	1	7	5	71	72	72	17	36
2016-05-10	10.7	10.7	on	pre	31.1	44.3	75.4	1440	882	45	74	13	12	3	71	72	72	15	34
2016-05-11	12.1	12.0	on	pre	31.3	50.5	81.8	1440	869	143	47	39	18	4	71	72	72	15	41
2016-05-12	10.0	9.7	on	pre	31.1	55.2	86.3	1440	989	154	42	36	24	4	72	72	73	29	31
2016-05-13	13.3	13.0	on	pre	30.8	67.6	98.4	1440	1128	240	75	34	15	7	72	72	73	45	24
2016-05-14	8.9	8.9	on	pre	30.9	52.7	83.7	1440	1074	80	90	18	12	4	72	72	72	44	23
2016-05-15	12.1	12.2	on	pre	30.9	48.5	79.4	1440	938	36	50	10	19	4	72	72	72	37	0
2016-05-16	14.8	14.8	on	pre	30.6	60.4	91.0	1440	1159	71	85	20	14	4	72	72	72	25	0
2016-05-17	7.4	7.4	on	pre	30.2	41.4	71.6	1440	856	43	78	12	11	4	71	72	72	30	28
2016-05-18	1.1	1.7	on	pre	30.3	10.5	40.8	1440	244	0	48	0	5		71	71	72	40	29
2016-05-19	4.9	5.9	on	pre	30.7	22.3	53.0	1440	475	32	70	9	7	4	69	71	72	37	25
2016-05-20	13.2	13.5	on	pre	30.7	48.9	79.6	1440	873	81	37	22	24	4	71	72	72	27	4
2016-05-21	15.3	15.3	on	pre	30.6	57.1	87.7	1440	1047	89	57	25	18	4	72	72	72	15	0
2016-05-22	15.8	15.7	on	pre	30.8	55.6	86.4	1440	1042	50	53	14	20	4	72	72	72	15	0
2016-05-23	16.9	16.7	on	pre	30.4	69.0	99.4	1440	1217	155	64	40	19	4	72	72	72	15	16
2016-05-24	15.7	15.5	on	pre	30.3	67.2	97.5	1440	1203	150	67	36	18	4	72	72	73	15	29
2016-05-25	15.8	15.6	on	pre	30.5	65.2	95.7	1440	1184	117	63	31	19	4	72	72	72	16	8
2016-05-26	12.1	11.9	on	pre	30.1	52.1	82.2	1440	1103	8	102	2	11	4	72	72	72	17	20
2016-05-27	9.2	9.2	on	pre	30.5	30.0	60.5	1440	648	8	81	3	8	3	71	72	72	15	0
2016-05-28	12.0	12.2	on	pre	30.7	41.8	72.5	1440	782	32	42	9	19	4	71	72	72	15	0
2016-05-29	18.1	17.9	on	pre	30.4	63.4	93.8	1440	1153	113	76	29	15	4	72	72	72	17	0
2016-05-30	12.9	12.9	on	pre	30.4	54.4	84.8	1440	1091	46	92	12	12	4	72	72	72	35	0
2016-05-31	9.1	9.2	on	pre	30.3	43.4	73.7	1440	880	41	68	9	13	5	72	72	72	46	21
2016-06-01	5.5	5.8	on	pre	30.3	27.6	57.9	1440	570	21	47	5	12	4	71	72	72	41	10
2016-06-02	10.1	10.7	on	pre	30.6	43.2	73.8	1440	823	65	48	17	17	4	71	71	72	41	15
2016-06-03	16.8	17.0	on	pre	30.3	67.6	97.9	1440	1048	239	28	58	37	4	72	72	72	32	12
2016-06-04	18.4	18.5	on	pre	30.3	78.0	108.3	1440	1296	224	53	56	24	4	72	72	72	38	0
2016-06-05	19.0	19.2	on	pre	30.4	80.7	111.1	1440	1317	257	49	62	27	4	72	72	72	42	0
2016-06-06	20.9	21.0	on	pre	30.0	97.2	127.2	1440	1359	473	30	84	45	6	72	72	72	38	26
2016-06-07	21.7	21.7	on	pre	30.2	101.0	131.1	1440	1414	500	13	98	109	5	72	72	72	38	22
2016-06-08	20.1	20.2	on	pre	29.9	96.3	126.3	1440	1372	449	28	86	49	5	72	72	72	39	11
2016-06-09	22.3	22.4	on	pre	29.8	102.9	132.7	1440	1399	514	17	86	82	6	72	72	72	38	21
2016-06-10	22.8	22.9	on	pre	30.1	106.0	136.2	1440	1431	534	4	76	358	7	72	72	72	39	17
2016-06-11	18.6	18.8	on	pre	30.1	80.7	110.8	1440	1390	161	17	39	82	4	72	72	72	46	0
2016-06-12	22.4	22.7	on	pre	30.1	85.0	115.1	1440	1356	250	35	59	39	4	72	72	72	44	0
2016-06-13	25.2	25.4	on	pre	29.9	104.8	134.6	1440	1417	502	11	100	129	5	72	72	72	27	21
2016-06-14	20.4	20.4	on	pre	29.7	90.8	120.5	1440	1335	408	40	87	33	5	72	72	72	19	10
2016-06-15	22.8	22.8	on	pre	29.6	102.2	131.8	1440	1306	589	50	96	26	6	72	72	72	18	14
2016-06-16	23.3	23.3	on	pre	29.5	99.2	128.8	1440	1374	485	29	97	47	5	72	72	72	18	0
2016-06-17	24.0	24.0	on	pre	29.4	103.7	133.1	1440	1342	596	43	91	31	7	72	72	72	15	0
2016-06-18	26.7	26.6	on	pre	29.6	113.7	143.2	1440	1366	699	33	50	41	14	72	72	72	15	0
2016-06-19	23.1	23.0	on	pre	29.7	112.0	141.7	1440	1409	672	12	113	117	6	72	72	72	28	0
2016-06-20	20.5	20.5	on	pre	29.9	103.4	133.3	1440	1428	538	3	103	476	5	72	72	72	40	0
2016-06-21	21.5	20.9	on	pre	29.8	100.0	129.8	1440	1246	598	43	42	29	14	72	73	73	47	23
2016-06-22	27.4	27.0	on	pre	29.6	118.6	148.2	1440	1290	750	39	38	33	20	72	72	73	41	19
2016-06-23	26.5	25.9	on	pre	29.5	121.6	151.1	1440	1238	877	47	51	26	17	72	73	73	40	16
2016-06-24	22.6	21.5	on	pre	29.8	109.9	139.7	1440	1319	635	27	27	49	24	72	73	74	47	20
2016-06-25	19.8	19.9	on	pre	30.3	92.1	122.4	1440	1381	377	8	77	173	5	72	72	73	49	0
2016-06-26	16.5	16.8	on	pre	30.4	76.1	106.6	1440	1328	202	45	51	30	4	72	72	72	52	0
2016-06-27	17.4	17.7	on	pre	30.5	89.5	120.0	1440	1395	361	19	62	73	6	71	72	72	57	18
2016-06-29	17.5	17.9	off	pre	30.3	91.7	122.1	1440	1353	451	22	101	62	4	72	72	72	56	16
2016-06-30	19.3	19.7	off	pre	30.6	101.1	131.6	1440	1438	506	2	108	719	5	72	72	72	47	15
2016-07-01	13.8	14.2	off	pre	30.2	83.2	113.4	1440	1427	269	5	71	285	4	72	72	72	57	0
2016-07-02	18.5	19.0	off	pre	30.2	87.6	117.8	1440	1421	267	8	66	178	4	71	72	72	57	0
2016-07-03	25.0	25.3	off	pre	30.2	98.9	129.1	1440	1398	423	17	92	82	5	72	72	72	42	0
2016-07-04	27.7	27.9	off	pre	30.4	110.1	140.5	1440	1424	595	9	104	158	6	72	72	72	36	0
2016-07-05	28.1	28.3	off	pre	30.4	121.3	151.7	1440	1440	742	1	108	1440	7	72	72	72	33	13
2016-07-06	27.8	28.0	off	pre	30.4	132.2	162.6	1440	1440	913	1	125	1440	7	72	72	72	39	16
2016-07-07	25.5	25.7	off	pre	30.4	131.2	161.6	1440	1440	941	1	138	1440	7	72	72	72	46	17
2016-07-08	25.1	25.4	off	pre	30.4	128.6	159.0	1440	1440	903	1	129	1440	7	72	72	72	46	20
2016-07-09	23.4	23.7	off	pre	30.4	113.6	144.0	1440	1440	696	1	132	1440	5	72	72	72	47	0
2016-07-10	27.9	28.3	off	pre	30.4	120.9	151.3	1440	1438	758	2	96	719	8	72	72	72	38	0
2016-07-11	28.9	29.1	off	pre	30.3	137.8	168.1	1440	1440	942	1	103	1440	9	71	72	72	37	26

Air Conditioning: Dry Climate Site 3 (El Paso, TX)

DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C12	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2016-07-12	28.9	29.1	off	pre	30.2	140.9	171.1	1440	1440	978	1	95	1440	10	72	72	72	32	20
2016-07-13	30.5	30.7	off	pre	30.1	143.8	173.9	1440	1440	1008	1	95	1440	11	71	72	72	28	19
2016-07-14	30.3	30.6	off	pre	30.0	143.4	173.4	1440	1440	982	1	74	1440	13	71	72	72	25	15
2016-07-15	24.2	24.6	off	pre	29.9	133.0	162.9	1440	1440	971	1	108	1440	9	71	72	72	39	20
2016-07-16	22.8	23.2	off	pre	29.8	116.6	146.4	1440	1440	726	1	124	1440	6	71	72	72	43	0
2016-07-17	25.9	26.4	off	pre	29.7	121.9	151.6	1440	1440	769	1	117	1440	7	71	72	72	41	0
2016-07-18	23.4	23.9	off	pre	29.6	127.7	157.3	1440	1440	893	1	105	1440	9	71	72	72	47	25
2016-07-20	22.8	22.9	on	pre	29.5	110.2	139.7	1440	1285	693	33	32	39	22	71	72	72	50	26
2016-07-21	24.8	24.7	on	pre	29.4	123.0	152.4	1440	1295	856	28	39	46	22	72	72	73	49	28
2016-07-22	25.7	25.5	on	pre	29.2	129.0	158.2	1440	1324	907	27	33	49	27	72	72	73	41	38
2016-07-23	26.8	27.1	on	pre	29.5	128.0	157.4	1440	1387	889	11	86	126	10	71	72	72	38	0
2016-07-24	27.6	28.1	on	pre	29.6	129.6	159.2	1440	1424	859	7	91	203	9	71	72	72	38	0
2016-07-25	26.0	25.7	on	pre	28.9	127.5	156.4	1440	1338	921	22	51	61	18	72	72	74	44	36
2016-07-26	20.9	20.4	on	pre	29.3	117.0	146.2	1440	1311	827	19	24	69	34	72	72	74	51	39
2016-07-27	17.7	17.3	on	pre	29.4	98.5	127.9	1440	1320	561	20	40	66	14	71	72	73	58	29
2016-07-28	22.3	22.6	on	pre	30.1	110.4	140.5	1440	1437	625	2	82	719	8	71	72	72	52	19
2016-07-29	21.5	22.0	on	pre	29.8	110.4	140.2	1440	1432	649	4	99	358	7	71	72	72	50	14
2016-07-30	20.1	20.5	on	pre	29.9	103.9	133.8	1440	1438	538	2	87	719	6	71	72	72	55	1
2016-07-31	20.4	20.9	on	pre	30.1	100.7	130.8	1440	1407	509	15	86	94	6	71	71	72	53	0
2016-08-01	18.5	18.5	on	pre	29.2	95.1	124.3	1440	1312	484	25	26	52	19	71	72	73	57	16
2016-08-03	16.0	16.5	off	pre	29.3	107.5	136.8	1440	1440	721	1	130	1440	6	71	71	72	61	26
2016-08-04	18.1	18.7	off	pre	29.2	105.0	134.3	1440	1440	620	1	116	1440	5	71	71	72	56	19
2016-08-05	21.2	21.8	off	pre	29.1	119.2	148.3	1440	1440	802	1	118	1440	7	71	71	72	55	24
2016-08-06	21.0	21.5	off	pre	29.0	111.5	140.5	1440	1440	686	1	124	1440	6	71	71	72	52	0
2016-08-07	21.5	22.0	off	pre	28.9	107.9	136.8	1440	1440	612	1	113	1440	5	71	71	72	50	0
2016-08-08	20.7	21.2	off	pre	28.8	119.0	147.8	1440	1440	774	1	91	1440	9	71	72	72	50	25
2016-08-09	17.6	18.1	off	pre	28.7	109.3	138.0	1440	1440	707	1	126	1440	6	71	71	72	56	24
2016-08-10	14.4	14.9	off	pre	28.6	101.6	130.3	1440	1440	636	1	125	1440	5	71	71	72	65	17
2016-08-11	18.2	18.7	off	pre	28.5	112.8	141.3	1440	1440	805	1	140	1440	6	71	71	72	64	19
2016-08-14	11.8	12.4	off	pre	29.2	59.2	88.5	1440	1105	125	51	35	22	4	71	71	72	54	0
2016-08-15	13.6	14.2	off	pre	29.1	70.9	100.1	1440	1178	280	46	62	26	5	71	71	72	43	18
2016-08-16	16.4	17.0	off	pre	29.0	83.8	112.8	1440	1314	371	39	80	34	5	71	71	72	39	21
2016-08-17	16.7	17.2	off	pre	28.9	84.7	113.7	1440	1292	397	37	77	35	5	71	71	72	37	21
2016-08-18	15.5	16.0	off	pre	29.3	99.8	129.1	1440	1425	577	7	101	204	6	71	72	72	49	22
2016-08-19	16.3	16.9	off	pre	29.4	98.9	128.4	1440	1440	549	1	101	1440	5	71	71	72	55	24
2016-08-20	12.6	13.2	off	pre	29.5	78.5	108.0	1440	1428	205	6	59	238	3	71	71	72	55	6
2016-08-21	8.6	9.1	off	pre	29.2	67.2	96.5	1440	1276	193	38	49	34	4	71	71	72	61	10
2016-08-22	11.0	11.5	off	pre	29.2	80.0	109.2	1440	1199	462	30	90	40	5	71	71	72	63	28
2016-08-23	11.0	11.5	off	pre	29.3	86.7	116.0	1440	1368	454	14	75	98	6	71	71	72	64	28
2016-08-24	13.6	14.1	off	pre	29.4	79.3	108.7	1440	1282	350	31	74	41	5	71	71	72	56	33
2016-08-26	12.2	12.7	off	pre	29.0	74.4	103.4	1440	1184	364	37	71	32	5	71	71	72	54	32
2016-08-27	12.8	13.4	off	pre	28.8	74.5	103.4	1440	1287	259	40	59	32	4	71	71	72	59	0
2016-08-28	11.7	12.3	off	pre	28.8	63.3	92.0	1440	1130	188	48	41	24	5	71	71	72	60	7
2016-08-29	11.3	11.8	off	pre	28.8	78.2	107.0	1440	1317	327	30	62	44	5	71	71	72	58	40
2016-08-30	6.5	7.0	off	pre	28.7	62.3	91.0	1440	1254	136	38	37	33	4	71	72	72	66	48
2016-09-01	8.3	8.4	on	pre	28.4	67.8	96.2	1440	1311	120	33	5	40	24	71	72	73	70	52
2016-09-02	12.5	13.0	on	pre	28.3	65.2	93.5	1440	1159	197	66	37	18	5	71	71	72	69	0
2016-09-03	15.0	15.6	on	pre	28.2	75.3	103.5	1440	1268	250	62	43	20	6	71	71	72	67	0
2016-09-04	17.4	18.0	on	pre	28.3	83.7	112.0	1440	1324	326	45	68	29	5	71	71	72	64	0
2016-09-05	18.7	19.2	on	pre	27.6	86.7	114.4	1440	1356	336	33	70	41	5	71	71	72	60	0
2016-09-06	9.2	9.3	on	pre	27.9	65.4	93.2	1440	1371	4	20	1	69	4	71	72	72	67	37
2016-09-07	9.3	9.7	on	pre	27.4	51.1	78.4	1440	1076	0	52	0	21		71	72	72	74	30
2016-09-08	11.4	11.9	on	pre	26.9	57.4	84.3	1440	1198	0	73	0	16		71	72	72	64	32
2016-09-09	15.3	15.8	on	pre	26.9	73.0	99.9	1440	1203	262	53	44	23	6	71	71	72	58	30
2016-09-10	8.7	9.2	on	pre	26.4	49.9	76.3	1440	1013	95	94	25	11	4	71	71	72	52	38
2016-09-11	10.4	11.0	on	pre	26.3	49.9	76.2	1440	893	125	47	20	19	6	71	71	72	58	13
2016-09-12	15.0	15.5	on	pre	25.5	71.3	96.8	1440	1246	199	57	41	22	5	71	71	72	50	25
2016-09-13	13.4	13.9	on	pre	25.6	69.4	95.0	1440	1248	200	68	33	18	6	71	71	72	47	33
2016-09-14	13.7	14.2	on	pre	25.5	74.9	100.5	1440	1201	314	57	45	21	7	71	71	72	47	24
2016-09-15	14.2	14.3	on	pre	24.3	76.5	100.8	1440	1230	292	57	20	22	15	72	72	73	59	24
2016-09-16	13.3	13.8	on	pre	24.4	68.6	93.1	1440	1251	154	55	29	23	5	71	71	72	49	23
2016-09-17	13.1	13.6	on	pre	24.2	59.8	84.0	1440	1109	115	71	26	16	4	71	71	72	44	3
2016-09-18	14.1	14.7	on	pre	24.0	60.7	84.8	1440	1130	105	79	27	14	4	71	71	72	44	3
2016-09-19	14.5	15.1	on	pre	23.3	68.7	91.9	1440	1067	282	50	48	21	6	71	71	72	31	30
2016-09-20	18.1	18.1	on	pre	22.3	88.1	110.4	1440	1245	448	45	29	28	15	72	72	73	47	29
2016-09-21	18.3	18.4	on	pre	22.2	90.6	112.7	1440	1296	428	29	28	45	15	71	72	73	48	33
2016-09-22	16.7	16.9	on	pre	21.7	80.6	102.3	1440	1248	323	50	27	25	12	71	72	73	45	32
2016-09-23	14.9	15.4	on	pre	21.9	73.5	95.4	1440	1294	202	52	31	25	7	71	71	72	39	29
2016-09-24	9.5	10.1	on	pre	21.9	40.1	62.0	1440	884	4	102	1	9	4	71	71	72	41	0

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DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C12	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2016-09-25	4.8	5.6	on	pre	22.0	18.1	40.1	1440	411	18	70	5	6	4	71	71	72	31	0
2016-09-29	10.3	10.9	off	pre	19.8	55.5	75.3	1440	1040	141	62	29	17	5	71	71	72	47	35
2016-10-01	9.1	9.8	off	pre	20.0	34.8	54.8	1440	732	0	62	0	12		71	71	72	54	0
2016-10-02	9.5	10.3	off	pre	20.3	33.7	54.0	1440	717	0	68	0	11		71	71	72	37	0
2016-10-04	8.3	8.9	off	pre	35.0	51.4	86.3	1440	1046	65	85	17	12	4	71	71	72	23	32
2016-10-05	7.0	7.8	off	pre	34.1	45.9	80.0	1440	820	136	33	31	25	4	70	71	72	30	38
2016-10-06	8.2	8.9	off	pre	34.1	47.0	81.1	1440	874	103	40	25	22	4	71	71	72	32	24
2016-10-07	2.1	2.8	off	pre	33.9	12.7	46.6	1440	307	0	52	0	6	-	70	71	72	32	0
2016-10-08	1.9	2.9	off	pre	33.2	13.8	47.0	1440	317	0	41	0	8	-	70	71	72	55	0
2016-10-09	5.1	5.9	off	pre	33.2	36.2	69.5	1440	746	39	30	11	25	4	71	71	72	58	0
2016-10-10	7.8	8.7	off	pre	32.8	43.5	76.3	1440	816	88	23	24	35	4	70	71	72	54	4
2016-10-11	10.8	11.4	off	pre	32.5	68.6	101.2	1440	1057	334	34	60	31	6	71	71	72	51	33
2016-10-12	10.2	10.8	off	pre	30.7	66.2	96.9	1440	1008	310	32	55	32	6	71	71	72	40	38
2016-10-13	7.1	7.6	off	pre	32.1	53.8	85.9	1440	1028	148	73	35	14	4	71	72	72	42	30
2016-10-14	7.8	8.5	off	pre	32.1	44.0	76.1	1440	741	164	34	29	22	6	71	71	72	40	34
2016-10-15	10.1	11.0	off	pre	32.0	39.7	71.7	1440	709	87	41	24	17	4	70	71	71	28	0
2016-10-16	10.5	11.4	off	pre	32.2	41.9	74.1	1440	768	74	40	19	19	4	70	71	71	25	0
2016-10-17	11.6	12.3	off	pre	31.7	56.1	87.7	1440	893	232	32	46	28	5	71	71	72	23	38
2016-10-18	9.6	10.3	off	pre	31.9	51.2	83.1	1440	842	207	35	43	24	5	71	71	72	19	42
2016-10-19	8.7	9.4	off	pre	31.6	47.1	78.7	1440	811	180	52	40	16	5	70	71	72	21	46
2016-10-20	2.8	1.3	off	pre	31.6	5.0	36.6	1440	107	5	22	2	5	3	71	74	76	25	47
2016-10-21	3.6	1.9	off	pre	31.6	9.3	40.9	1440	205	4	35	1	6	4	71	74	76	28	47
2016-10-22	4.9	2.6	off	pre	31.2	11.7	42.9	1440	251	0	35	0	7	-	72	74	76	34	22
2016-10-23	7.1	4.9	off	pre	31.2	17.2	48.4	1440	344	0	39	0	9	-	72	74	76	29	15
2016-10-24	7.9	5.4	off	pre	31.1	16.6	47.7	1440	341	0	42	0	8	-	73	75	76	27	31
2016-10-25	9.1	7.5	off	pre	31.2	30.0	61.2	1440	583	44	51	12	11	4	73	74	74	30	30
2016-10-26	8.1	7.6	off	pre	31.1	26.7	57.9	1440	535	11	45	3	12	4	71	72	73	32	39
2016-10-27	7.5	7.0	off	pre	31.4	29.4	60.8	1440	591	11	36	3	16	4	71	73	73	31	37
2016-10-28	6.1	5.3	off	pre	30.8	24.8	55.6	1440	530	4	60	1	9	4	72	73	73	35	25
2016-10-29	7.2	6.9	off	pre	30.8	20.2	51.0	1440	424	0	59	0	7	-	71	72	73	33	0
2016-10-30	6.8	6.7	off	pre	30.8	19.3	50.1	1440	398	0	44	0	9	-	70	72	74	29	0
2016-10-31	7.5	7.0	off	pre	30.5	23.8	54.3	1440	490	3	57	1	9	3	71	72	73	28	19
2016-11-01	7.9	7.2	off	pre	30.9	22.0	52.9	1440	488	8	73	3	7	3	72	73	73	28	25
2016-11-02	5.1	4.5	off	pre	30.9	14.7	45.6	1440	328	14	58	5	6	3	72	73	73	37	22
2016-11-03	1.2	1.4	off	pre	30.4	3.8	34.2	1440	78	0	19	0	4	-	71	72	73	46	16
2016-11-04	1.5	1.8	off	pre	30.0	6.0	36.0	1440	124	0	27	0	5	-	71	72	73	55	21
2016-11-05	1.9	2.4	off	pre	30.8	3.3	34.1	1440	67	6	15	2	4	3	71	71	73	60	0
2016-11-06	2.5	3.8	off	pre	31.4	1.6	32.9	1440	40	0	10	0	4	-	69	71	73	48	0
2016-11-07	2.6	3.6	off	pre	31.0	5.4	36.4	1440	122	2	31	1	4	2	69	71	73	37	30
2016-11-08	1.0	2.0	off	pre	31.4	1.7	33.1	1440	45	0	12	0	4	-	69	71	73	29	32
2016-11-14	1.6	3.5	off	pre	30.8	3.1	33.9	1440	69	0	18	0	4	-	69	70	73	25	23
2016-11-15	1.9	3.4	off	pre	30.7	4.4	35.1	1440	105	0	26	0	4	-	69	70	73	21	19
2016-11-16	2.3	3.8	off	pre	30.4	3.6	34.0	1440	80	0	20	0	4	-	69	70	73	19	24
2016-11-17	3.8	3.9	off	pre	29.6	8.9	38.5	1440	204	0	47	0	4	-	71	72	73	21	18
2016-11-21	0.3	2.2	off	pre	30.9	0.6	31.4	1440	7	0	2	0	4	-	69	70	73	30	28
2016-12-14	1.2	2.0	off	pre	30.8	0.4	31.2	1440	4	0	1	0	4	-	70	71	74	29	18
2016-12-15	1.5	2.5	off	pre	30.6	1.0	31.5	1440	15	0	4	0	4	-	70	71	74	23	24
2016-12-16	2.3	2.8	off	pre	29.7	3.4	33.1	1440	63	0	15	0	4	-	70	72	74	15	26
2017-06-08	15.7	14.2	on	post	29.3	50.7	80.0	1440	612	410	131	119	5	3	73	73	74	51	11
2017-06-09	23.4	22.3	on	post	29.7	77.2	106.9	1440	927	582	195	157	5	4	73	73	74	37	8
2017-06-10	26.0	25.1	on	post	29.7	78.3	108.0	1440	928	578	192	155	5	4	72	73	73	30	0
2017-06-11	23.2	22.4	on	post	29.8	70.9	100.7	1440	907	507	186	145	5	3	73	73	73	18	0
2017-06-12	21.1	20.3	on	post	29.9	67.0	96.9	1440	891	466	189	137	5	3	73	73	73	21	0
2017-06-13	21.7	20.5	on	post	29.9	74.7	104.6	1440	944	552	198	146	5	4	73	73	74	18	8
2017-06-14	22.1	20.5	on	post	29.9	74.5	104.4	1440	894	526	176	118	5	4	73	74	74	15	7
2017-06-15	23.7	22.1	on	post	29.7	84.6	114.3	1440	949	639	186	147	5	4	73	74	75	15	11
2017-06-16	24.8	23.0	on	post	29.4	83.4	112.8	1440	919	646	181	156	5	4	73	74	75	15	5
2017-06-17	29.0	27.5	on	post	29.8	87.2	117.0	1440	935	673	188	164	5	4	73	74	75	15	2
2017-06-19	24.4	22.0	on	post	29.6	93.5	123.1	1440	950	782	165	165	6	5	73	74	76	47	7
2017-06-20	26.2	24.3	on	post	29.3	101.3	130.6	1440	1016	837	173	172	6	5	73	74	74	50	8
2017-06-21	25.5	23.8	on	post	29.4	102.8	132.2	1440	1037	841	174	174	6	5	73	74	74	45	11
2017-06-22	29.7	27.6	on	post	29.3	113.7	142.9	1440	1063	899	157	155	7	6	73	74	75	41	12
2017-06-23	31.0	28.5	on	post	29.5	127.7	157.1	1440	1144	991	135	135	8	7	73	74	75	32	11
2017-06-24	20.2	18.6	on	post	30.3	82.2	112.4	1440	953	724	211	211	5	3	73	74	74	45	0
2017-06-25	14.9	13.8	on	post	30.5	58.2	88.8	1440	712	514	177	172	4	3	73	73	74	62	0
2017-06-26	16.0	14.6	on	post	30.4	60.9	91.3	1440	732	541	175	175	4	3	73	73	75	61	20
2017-06-27	18.3	17.2	on	post	30.1	67.1	97.3	1440	787	564	174	170	5	3	72	73	74	54	9
2017-06-28	25.7	24.7	on	post	30.0	92.1	122.1	1440	940	765	177	177	5	4	72	73	74	38	12
2017-06-29	28.0	26.2	on	post	29.7	100.6	130.3	1440	1025	804	178	176	6	5	73	74	75	28	11

Air Conditioning: Dry Climate Site 3 (El Paso, TX)																			
DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C12	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2017-06-30	27.2	24.9	on	post	29.8	104.5	134.3	1440	1036	850	169	167	6	5	73	74	75	20	22
2017-07-01	21.2	19.6	on	post	30.2	84.4	114.6	1440	950	737	210	209	5	4	73	74	74	43	0
2017-07-02	21.3	20.4	on	post	30.1	75.0	105.1	1440	862	638	193	189	4	3	73	73	73	47	0
2017-07-03	24.6	23.6	on	post	30.1	84.3	114.3	1440	926	701	197	190	5	4	72	73	74	41	0
2017-07-04	25.6	24.5	on	post	30.0	84.6	114.7	1440	906	699	191	190	5	4	72	73	74	40	0
2017-07-05	21.5	19.4	on	post	30.1	86.9	117.0	1440	953	749	189	189	5	4	73	74	76	44	17
2017-07-06	21.9	20.4	on	post	29.9	88.5	118.4	1440	963	761	191	191	5	4	73	74	74	45	19
2017-07-07	18.3	16.3	on	post	30.2	77.8	108.0	1440	903	684	197	195	5	4	73	74	75	50	20
2017-07-08	21.0	19.9	on	post	29.7	74.2	104.0	1440	844	628	191	190	4	3	73	73	74	49	0
2017-07-09	21.4	20.4	on	post	30.2	75.0	105.1	1440	852	653	190	188	4	3	72	73	74	43	0
2017-07-10	22.7	21.2	on	post	30.1	82.1	112.2	1440	890	702	184	183	5	4	73	74	74	45	16
2017-07-11	23.8	21.8	on	post	30.0	92.0	122.0	1440	977	776	184	182	5	4	73	74	75	45	20
2017-07-12	19.2	17.3	on	post	30.1	75.1	105.2	1440	851	652	186	184	5	4	73	74	75	52	20
2017-07-14	13.9	13.4	off	post	29.6	73.5	103.1	1440	1367	79	23	21	59	4	72	72	73	53	13
2017-07-15	9.1	8.6	off	post	29.7	72.5	102.2	1440	1332	166	25	24	53	7	72	73	73	64	6
2017-07-16	11.6	11.3	off	post	29.9	59.2	89.1	1440	1163	20	72	5	16	4	72	72	73	64	0
2017-07-17	16.3	15.9	off	post	29.6	74.4	103.9	1440	1265	132	31	30	41	4	72	72	73	55	8
2017-07-18	16.5	16.1	off	post	29.8	80.7	110.4	1440	1390	160	14	33	99	5	72	72	73	54	13
2017-07-19	11.7	11.2	off	post	29.6	75.2	104.7	1440	1328	193	27	44	49	4	72	73	73	59	19
2017-07-20	14.9	14.4	off	post	29.7	73.1	102.8	1440	1257	197	47	44	27	4	72	72	73	59	17
2017-07-21	14.4	13.9	off	post	29.7	80.4	110.2	1440	1336	259	30	56	45	5	72	72	73	60	30
2017-07-22	12.1	11.7	off	post	29.6	71.8	101.4	1440	1315	138	39	35	34	4	72	72	73	64	0
2017-07-23	12.0	11.7	off	post	29.1	71.6	100.7	1440	1334	110	32	26	42	4	72	72	72	67	0
2017-07-24	15.7	15.4	off	post	29.7	81.6	111.2	1440	1319	274	33	64	40	4	72	72	72	64	24
2017-07-25	18.8	19.2	off	post	30.0	102.1	132.1	1440	1418	515	7	90	203	6	71	72	73	56	22
2017-07-26	20.9	21.6	off	post	30.1	110.5	140.5	1440	1440	609	1	95	1440	6	71	71	71	55	23
2017-07-27	12.9	13.5	off	post	30.1	88.2	118.3	1440	1409	343	7	74	201	5	71	71	72	59	21
2017-07-28	17.3	17.9	off	post	30.2	83.9	114.0	1440	1355	258	25	51	54	5	71	71	72	60	17
2017-07-29	15.2	15.9	off	post	29.9	84.8	114.7	1440	1418	211	6	44	236	5	71	71	72	58	0
2017-07-30	17.0	17.7	off	post	30.2	89.0	119.2	1440	1415	274	7	58	202	5	71	71	72	55	7
2017-07-31	16.3	16.9	off	post	29.9	99.6	129.5	1440	1440	497	1	92	1440	5	71	71	72	57	15
2017-08-01	12.5	13.1	off	post	29.7	83.5	113.2	1440	1424	246	6	54	237	5	71	71	72	65	16
2017-08-02	15.9	16.7	off	post	29.9	86.8	116.8	1440	1431	271	4	63	358	4	71	71	72	56	13
2017-08-03	17.3	18.0	off	post	29.9	79.7	109.5	1440	1365	154	22	33	62	5	71	71	72	49	7
2017-08-04	18.2	18.9	off	post	29.9	88.2	118.0	1440	1415	239	8	46	177	5	71	71	72	48	8
2017-08-05	19.5	20.2	off	post	30.0	90.8	120.8	1440	1412	280	6	56	235	5	71	71	72	51	0
2017-08-06	20.7	21.5	off	post	30.0	93.3	123.3	1440	1440	272	1	50	1440	5	71	71	72	54	0
2017-08-07	20.3	21.0	off	post	30.0	112.1	142.1	1440	1429	692	5	96	286	7	71	71	72	52	19
2017-08-08	17.8	18.4	off	post	30.0	112.8	142.8	1440	1440	752	1	93	1440	8	71	71	72	55	18
2017-08-09	19.6	20.3	off	post	30.0	112.7	142.7	1440	1440	679	1	95	1440	7	71	71	72	55	24
2017-08-10	21.8	22.5	off	post	30.0	113.1	143.1	1440	1440	672	1	106	1440	6	71	71	71	50	12
2017-08-11	17.1	17.7	off	post	30.0	109.9	139.9	1440	1440	682	1	97	1440	7	71	71	72	53	24
2017-08-12	15.0	15.6	off	post	30.0	79.7	109.6	1440	1397	153	10	33	140	5	71	71	72	65	0
2017-08-13	18.1	18.9	off	post	29.8	85.8	115.6	1440	1418	204	5	44	284	5	71	71	72	57	0
2017-08-14	18.1	18.7	off	post	29.9	98.4	128.3	1440	1415	464	7	83	202	6	71	71	72	55	28
2017-08-15	14.3	14.9	off	post	29.8	83.5	113.3	1440	1328	302	19	61	70	5	71	71	72	59	27
2017-08-16	19.4	20.1	off	post	29.8	92.4	122.2	1440	1402	320	12	58	117	6	71	71	72	46	26
2017-08-17	18.2	18.8	off	post	29.5	95.8	125.4	1440	1388	402	13	79	107	5	71	71	72	45	26
2017-08-18	16.4	17.1	off	post	29.6	89.9	119.6	1440	1430	259	3	53	477	5	71	71	72	51	0
2017-08-19	12.9	13.5	off	post	29.7	79.5	109.2	1440	1404	152	8	36	176	4	71	71	72	55	5
2017-08-20	7.4	8.0	off	post	29.8	59.8	89.6	1440	1201	55	42	14	29	4	71	71	72	67	0
2017-08-21	11.9	12.5	off	post	29.9	77.0	106.9	1440	1316	234	24	51	55	5	71	71	72	64	20
2017-08-22	16.9	17.5	off	post	29.8	100.8	130.6	1440	1440	485	1	93	1440	5	71	71	72	61	16
2017-08-24	11.2	10.1	on	post	30.1	39.5	69.6	1440	502	361	114	114	4	3	73	73	74	60	18
2017-08-25	12.9	11.9	on	post	29.8	53.6	83.4	1440	670	488	161	161	4	3	73	73	74	64	22
2017-08-26	15.1	14.6	on	post	30.2	48.4	78.6	1440	592	445	141	141	4	3	72	73	73	66	0
2017-08-27	15.0	14.6	on	post	30.1	47.3	77.4	1440	585	421	137	137	4	3	72	72	73	59	0
2017-08-28	14.9	14.1	on	post	30.1	55.1	85.2	1440	677	500	162	162	4	3	72	73	74	51	26
2017-08-29	14.0	13.1	on	post	30.1	54.9	85.1	1440	683	497	164	164	4	3	72	73	74	51	28
2017-08-30	13.7	12.9	on	post	30.1	49.4	79.5	1440	606	450	149	149	4	3	72	73	74	39	35
2017-08-31	12.7	11.4	on	post	29.8	52.0	81.8	1440	642	476	158	158	4	3	72	73	75	37	29
2017-09-01	14.6	14.2	on	post	30.1	49.8	79.9	1440	606	451	146	146	4	3	72	72	73	33	0
2017-09-02	15.5	15.0	on	post	30.2	50.9	81.1	1440	625	459	157	156	4	3	72	72	73	33	0
2017-09-03	17.2	16.7	on	post	30.2	54.1	84.3	1440	638	473	149	149	4	3	72	72	73	36	0
2017-09-04	16.1	15.5	on	post	29.9	55.1	85.0	1440	661	500	163	163	4	3	72	73	73	39	0
2017-09-05	15.2	14.1	on	post	29.7	58.7	88.4	1440	726	531	176	176	4	3	72	73	74	41	23
2017-09-06	13.3	12.2	on	post	29.6	50.1	79.8	1440	631	460	156	156	4	3	72	73	74	45	14
2017-09-07	15.8	14.8	on	post	29.7	57.5	87.2	1440	691	527	165	164	4	3	72	73	74	42	22
2017-09-08	15.1	14.2	on	post	30.0	57.1	87.1	1440	705	519	170	170	4	3	72	73	74	46	19

Air Conditioning: Dry Climate Site 3 (El Paso, TX)																				
DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C12	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2017-09-09	13.4	13.0	on	post	30.1	42.4	72.5	1440	545	393	132	131	4	3	72	72	73	45	0
2017-09-10	13.5	13.1	on	post	30.2	41.5	71.6	1440	516	380	128	127	4	3	72	72	73	47	0
2017-09-11	14.7	13.9	on	post	30.0	51.5	81.6	1440	632	462	152	152	4	3	72	73	73	38	29
2017-09-12	15.7	14.9	on	post	29.6	57.3	86.9	1440	672	500	157	157	4	3	72	73	74	33	23
2017-09-13	19.3	18.1	on	post	29.5	68.6	98.1	1440	768	598	166	166	5	4	72	73	74	32	21
2017-09-14	20.3	19.0	on	post	29.4	75.8	105.2	1440	857	652	191	190	4	3	73	73	74	38	21
2017-09-15	18.9	17.4	on	post	29.6	71.4	101.0	1440	860	635	216	216	4	3	73	73	74	43	31
2017-09-16	15.4	14.5	on	post	30.0	55.4	85.4	1440	692	512	171	170	4	3	73	73	73	51	1
2017-09-17	15.8	15.1	on	post	30.1	52.0	82.1	1440	635	459	158	158	4	3	72	73	73	49	0
2017-09-18	18.0	17.0	on	post	29.7	63.5	93.3	1440	762	556	179	179	4	3	72	73	74	45	24
2017-09-19	18.8	17.6	on	post	29.7	67.2	96.9	1440	802	589	193	193	4	3	73	73	74	47	26
2017-09-20	18.4	17.3	on	post	29.7	67.8	97.5	1440	818	617	202	202	4	3	72	73	74	40	22
2017-09-21	17.9	16.8	on	post	29.7	65.6	95.3	1440	791	580	194	194	4	3	72	73	74	41	29
2017-09-22	18.5	17.7	on	post	29.8	64.9	94.7	1440	763	565	185	185	4	3	72	73	74	37	16
2017-09-23	15.0	14.0	on	post	29.9	55.0	84.9	1440	696	501	178	178	4	3	72	73	73	52	8
2017-09-24	12.2	11.8	on	post	29.9	43.9	73.8	1440	564	409	142	142	4	3	72	72	73	36	11
2017-09-25	11.5	10.9	on	post	29.9	37.4	67.3	1440	476	341	120	119	4	3	72	73	74	39	29
2017-09-26	6.8	6.0	on	post	30.0	18.6	48.6	1440	240	171	59	59	4	3	71	73	74	48	24
2017-09-29	5.8	6.6	off	post	29.7	42.3	72.0	1440	772	132	12	31	64	4	71	71	71	61	35
2017-09-30	5.5	6.3	off	post	30.0	30.1	60.0	1440	635	11	34	3	19	4	71	71	72	62	14
2017-10-01	11.3	12.1	off	post	29.7	44.3	74.1	1440	885	19	53	5	17	4	71	71	72	59	12
2017-10-02	13.1	13.8	off	post	29.5	73.0	102.5	1440	1143	375	27	63	42	6	71	71	72	42	26
2017-10-03	13.2	13.9	off	post	28.6	85.9	114.5	1440	1182	574	8	78	148	7	71	71	71	40	21
2017-10-04	13.5	14.1	off	post	28.0	111.5	139.5	1440	1440	903	1	107	1440	8	71	71	72	63	18
2017-10-05	15.9	16.4	off	post	27.5	115.2	142.7	1440	1400	937	4	83	350	11	71	72	72	62	20
2017-10-06	15.8	16.6	off	post	28.5	79.3	107.8	1440	1333	274	12	62	111	4	71	71	72	57	0
2017-10-07	7.0	8.2	off	post	29.7	20.9	50.6	1440	436	0	27	0	16	-	70	71	71	15	0
2017-10-08	10.8	12.2	off	post	29.4	36.5	65.9	1440	711	8	27	2	26	4	70	71	72	18	0
2017-10-09	10.4	11.0	off	post	29.4	47.8	77.1	1440	1018	0	67	0	15	-	71	71	72	31	0
2017-10-10	0.6	2.3	off	post	28.0	7.1	35.1	1440	121	0	22	0	6	-	70	70	71	28	31
2017-10-11	5.5	7.2	off	post	29.9	23.5	53.4	1440	492	11	38	3	13	4	69	70	72	33	20
2017-10-12	10.2	11.1	off	post	29.8	47.3	77.1	1440	865	100	16	22	54	5	70	71	71	48	24
2017-10-13	13.6	14.2	off	post	29.8	70.5	100.4	1440	1175	270	32	50	37	5	71	71	72	50	32
2017-10-14	15.7	16.4	off	post	29.6	72.2	101.8	1440	1372	81	13	22	106	4	71	71	72	46	8
2017-10-15	2.9	4.2	off	post	28.5	16.0	44.5	1440	324	4	29	1	11	4	70	71	71	18	7
2017-10-16	4.3	5.6	off	post	29.9	24.0	53.9	1440	474	63	27	17	18	4	70	71	71	25	19
2017-10-17	6.6	7.8	off	post	29.7	37.7	67.4	1440	683	115	23	27	30	4	70	71	71	31	29
2017-10-18	7.8	8.8	off	post	29.4	41.4	70.8	1440	763	114	26	28	29	4	70	71	72	38	26
2017-10-19	6.5	7.4	off	post	29.4	31.6	61.1	1440	630	18	12	5	53	4	70	71	72	47	25
2017-10-20	8.6	10.0	off	post	29.2	26.9	56.2	1440	566	0	69	0	8	-	70	71	71	44	7
2017-10-21	7.3	8.0	off	post	29.4	29.7	59.1	1440	684	0	94	0	7	-	71	71	72	32	0
2017-10-22	4.0	5.6	off	post	30.1	6.8	36.9	1440	145	0	16	0	9	-	69	70	72	16	0
2017-10-23	6.3	7.3	off	post	30.0	20.1	50.1	1440	427	3	43	1	10	3	69	71	72	15	26

D1.4 AIR CONDITIONING HUMID CLIMATE SITE 4

Air Conditioning: Humid Climate Site 4 (Washington, D.C.)

DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C1	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2016-05-24	7.7	8.3	on	pre		12.4	12.4		142		23		6		69	71	74	55	27
2016-05-25	9.0	8.5	on	pre		23.9	23.9		269		38		7		71	72	74	50	22
2016-05-26	10.3	8.4	on	pre		26.8	26.8		291		42		7		72	74	75	52	23
2016-05-27	13.0	11.7	on	pre		45.1	45.1		470		49		10		72	73	75	49	23
2016-05-30	8.9	8.3	on	pre		21.3	21.3		263		41		6		72	73	73	57	0
2016-05-31	12.2	11.6	on	pre		35.6	35.6		395		51		8		72	73	73	53	23
2016-06-01	12.6	12.0	on	pre		36.9	36.9		414		57		7		72	73	73	52	25
2016-06-02	8.9	8.3	on	pre		28.4	28.4		348		51		7		72	73	73	54	26
2016-06-03	9.4	8.8	on	pre		26.7	26.7		332		53		6		72	73	73	56	24
2016-06-04	10.4	9.8	on	pre		25.1	25.1		301		46		7		72	73	73	57	10
2016-06-05	10.7	10.1	on	pre		25.6	25.6		311		51		6		72	73	73	57	0
2016-06-06	12.7	12.1	on	pre		34.7	34.7		385		51		8		72	73	73	54	27
2016-06-07	11.3	10.8	on	pre		33.6	33.6		393		56		7		72	73	73	49	25
2016-06-09	7.5	7.2	off	pre		20.8	20.8		241		32		8		72	72	73	42	22
2016-06-10	8.4	8.0	off	pre		27.2	27.2		312		41		8		72	72	73	41	22
2016-06-11	16.0	15.5	off	pre		42.8	42.8		435		50		9		72	72	73	61	13
2016-06-12	17.9	17.3	off	pre		44.3	44.3		460		56		8		72	73	73	60	0
2016-06-13	8.0	7.6	off	pre		31.2	31.2		374		49		8		72	72	73	47	26
2016-06-14	9.0	8.6	off	pre		33.4	33.4		395		51		8		72	72	73	49	26
2016-06-15	9.2	8.9	off	pre		30.2	30.2		356		48		7		72	72	73	62	25
2016-06-16	11.2	10.7	off	pre		37.5	37.5		420		51		8		72	72	73	73	23
2016-06-17	7.8	7.4	off	pre		27.3	27.3		320		42		8		72	72	73	68	22
2016-06-18	10.1	9.7	off	pre		30.5	30.5		350		45		8		72	72	73	60	10
2016-06-19	12.9	12.4	off	pre		33.4	33.4		370		48		8		72	72	73	57	0
2016-06-20	15.0	14.5	off	pre		45.1	45.1		471		52		9		72	73	73	60	25
2016-06-21	12.9	11.7	off	pre		34.3	34.3		378		49		8		72	73	75	71	20
2016-06-22	12.4	10.0	off	pre		24.7	24.7		271		40		7		74	74	75	69	20
2016-06-23	10.6	8.9	off	pre		26.8	26.8		313		43		7		72	74	75	74	18
2016-06-24	12.1	12.6	off	pre		43.7	43.7		483		55		9		71	72	72	74	22
2016-06-25	12.1	12.5	off	pre		37.4	37.4		422		52		8		71	72	72	71	8
2016-06-26	11.4	11.8	off	pre		35.7	35.7		405		51		8		71	72	72	65	0
2016-06-27	12.4	12.9	off	pre		44.8	44.8		487		55		9		71	71	72	69	23
2016-06-28	12.0	12.5	off	pre		43.8	43.8		488		56		9		71	72	72	75	23
2016-06-29	10.2	10.7	off	pre		36.7	36.7		414		53		8		71	71	72	71	23
2016-06-30	10.5	11.1	off	pre		35.7	35.7		411		51		8		71	71	72	65	21
2016-07-01	13.1	13.6	off	pre		46.4	46.4		505		56		9		71	72	72	72	25
2016-07-02	10.5	11.0	off	pre		31.1	31.1		365		50		7		71	72	72	66	9
2016-07-03	4.6	5.3	off	pre		19.0	19.0		256		41		6		71	71	72	68	0
2016-07-04	6.3	7.1	off	pre		14.2	14.2		184		33		6		71	71	71	79	0
2016-07-05	15.8	16.3	off	pre		46.6	46.6		478		53		9		71	72	72	76	23
2016-07-06	22.0	22.3	off	pre		59.6	59.6		596		61		10		71	72	72	72	26
2016-07-09	19.1	19.4	on	pre		59.0	59.0		610		65		9		71	72	72	70	8
2016-07-10	16.2	16.6	on	pre		46.0	46.0		503		61		8		71	72	72	68	0
2016-07-11	15.7	16.1	on	pre		49.0	49.0		530		60		9		71	72	72	67	22
2016-07-12	14.8	15.2	on	pre		48.4	48.4		529		61		9		71	72	72	70	21
2016-07-14	21.1	21.6	on	pre		69.1	69.1		668		62		11		71	72	72	71	20
2016-07-15	19.8	20.3	on	pre		61.0	61.0		606		63		10		71	72	72	70	20
2016-07-16	16.0	16.4	on	pre		50.6	50.6		533		60		9		71	72	72	72	6
2016-07-17	16.4	16.8	on	pre		46.2	46.2		474		56		8		71	72	72	73	0
2016-07-18	16.5	16.9	on	pre		56.8	56.8		584		58		10		71	72	72	73	24
2016-07-19	16.3	16.7	on	pre		47.6	47.6		512		58		9		71	72	72	71	24
2016-07-20	14.0	14.4	on	pre		40.6	40.6		446		51		9		71	72	72	71	23
2016-07-21	15.8	16.2	on	pre		44.8	44.8		482		52		9		71	72	72	70	22
2016-07-22	19.2	19.6	on	pre		57.2	57.2		580		56		10		71	72	72	69	22
2016-07-23	24.2	24.4	on	pre		66.0	66.0		626		60		10		71	72	72	68	9
2016-07-24	23.2	23.4	on	pre		62.9	62.9		618		61		10		71	72	72	67	0
2016-07-25	24.5	24.8	on	pre		85.3	85.3		790		57		14		71	72	72	65	25
2016-07-26	22.8	23.7	on	pre		79.0	79.0		754		56		13		70	71	72	64	25
2016-07-27	22.4	22.7	on	pre		65.7	65.7		652		62		11		70	72	74	66	21
2016-07-28	19.0	18.3	on	pre		58.4	58.4		596		60		10		72	73	73	70	21
2016-07-29	17.0	16.3	on	pre		49.5	49.5		527		57		9		72	73	73	72	21
2016-07-30	16.0	15.3	on	pre		43.9	43.9		472		53		9		72	73	73	73	9
2016-07-31	16.9	16.2	on	pre		39.7	39.7		426		51		8		72	73	73	75	0
2016-08-02	16.7	16.0	off	pre		48.3	48.3		507		55		9		72	73	73	72	22
2016-08-03	12.0	9.4	off	pre		21.1	21.1		242		35		7		72	75	78	68	23
2016-08-04	12.8	9.0	off	pre		28.9	28.9		326		38		9		74	76	77	54	23

Air Conditioning: Humid Climate Site 4 (Washington, D.C.)

DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C1	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2016-08-05	12.9	10.3	off	pre		32.1	32.1		389		55		7		74	75	75	45	21
2016-08-06	16.5	13.9	off	pre		33.6	33.6		376		55		7		74	75	75	48	7
2016-08-07	16.9	14.3	off	pre		32.7	32.7		360		51		7		74	75	75	47	0
2016-08-08	13.1	10.6	off	pre		32.2	32.2		367		53		7		74	75	75	47	23
2016-08-09	10.9	8.4	off	pre		22.3	22.3		281		46		6		74	75	75	47	21
2016-08-10	19.7	17.0	off	pre		45.5	45.5		476		56		9		74	75	75	48	18
2016-08-11	22.3	19.6	off	pre		59.3	59.3		584		63		9		74	75	75	47	22
2016-08-12	23.5	20.7	off	pre		67.9	67.9		656		64		10		74	75	75	46	24
2016-08-13	25.0	22.1	off	pre		66.7	66.7		645		69		9		75	75	75	44	7
2016-08-14	24.5	21.7	off	pre		60.7	60.7		605		70		9		75	75	75	43	0
2016-08-15	18.8	16.0	off	pre		57.0	57.0		580		66		9		74	75	75	46	23
2016-08-16	20.1	17.4	off	pre		54.1	54.1		537		62		9		74	75	75	51	24
2016-08-17	20.0	17.4	off	pre		53.8	53.8		551		67		8		74	75	75	50	23
2016-08-18	17.5	14.9	off	pre		45.3	45.3		485		62		8		74	75	75	50	19
2016-08-19	18.0	15.5	off	pre		43.4	43.4		468		60		8		74	75	75	47	21
2016-08-20	17.9	15.3	off	pre		39.7	39.7		435		59		7		74	75	75	45	9
2016-08-21	14.3	11.6	off	pre		32.5	32.5		382		56		7		74	75	75	44	0
2016-08-22	12.4	9.9	off	pre		31.3	31.3		362		51		7		74	74	75	45	24
2016-08-23	10.7	9.1	off	pre		34.5	34.5		408		52		8		71	74	75	45	22
2016-08-24	12.2	11.8	off	pre		37.9	37.9		443		57		8		71	72	75	43	23
2016-08-25	15.0	13.3	off	pre		43.4	43.4		471		52		9		72	74	75	45	20
2016-08-26	21.5	21.8	off	pre		74.2	74.2		728		61		12		69	72	75	45	21
2016-08-27	19.5	21.8	off	pre		71.0	71.0		756		77		10		69	70	70	43	13
2016-08-28	16.0	18.3	off	pre		56.4	56.4		642		75		9		70	70	70	42	0
2016-08-29	17.8	20.3	off	pre		68.2	68.2		725		67		11		68	70	71	43	26
2016-08-30	16.9	17.8	off	pre		48.6	48.6		543		67		8		68	71	73	45	21
2016-08-31	16.9	16.8	off	pre		54.2	54.2		582		63		9		71	72	73	46	25
2016-09-01	12.2	12.5	off	pre		40.9	40.9		483		64		8		71	72	73	47	30
2016-09-02	9.6	10.6	off	pre		35.8	35.8		440		63		7		70	71	72	43	26
2016-09-03	9.8	11.2	off	pre		32.1	32.1		408		61		7		70	71	71	45	12
2016-09-04	9.7	11.2	off	pre		27.0	27.0		339		53		6		70	70	71	43	0
2016-09-05	12.0	13.4	off	pre		30.8	30.8		372		56		7		70	71	71	43	0
2016-09-06	17.4	18.8	off	pre		52.4	52.4		557		67		8		70	71	71	43	26
2016-09-07	16.5	17.9	off	pre		54.3	54.3		584		68		9		70	71	71	44	28
2016-09-09	21.0	22.4	on	pre		71.0	71.0		715		74		10		70	71	71	47	23
2016-09-10	19.7	20.9	on	pre		64.3	64.3		662		74		9		71	71	71	47	12
2016-09-11	15.4	16.7	on	pre		44.4	44.4		517		74		7		70	71	71	47	0
2016-09-12	10.2	10.5	on	pre		26.9	26.9		330		50		7		70	72	74	49	24
2016-09-13	13.3	11.8	on	pre		29.8	29.8		333		47		7		73	74	74	51	22
2016-09-14	16.4	14.9	on	pre		34.3	34.3		362		54		7		73	73	74	48	20
2016-09-15	7.8	6.4	on	pre		22.2	22.2		291		49		6		73	73	74	47	17
2016-09-16	6.8	5.3	on	pre		16.5	16.5		212		41		5		73	74	74	50	20
2016-09-17	10.0	8.4	on	pre		20.7	20.7		255		38		7		73	74	74	50	11
2016-09-18	14.0	12.3	on	pre		28.1	28.1		329		48		7		73	74	74	51	0
2016-09-19	10.0	8.4	on	pre		23.7	23.7		307		50		6		73	74	74	50	22
2016-09-20	9.9	8.4	on	pre		22.5	22.5		281		44		6		73	74	74	52	24
2016-09-21	12.0	10.5	on	pre		25.5	25.5		307		48		6		73	74	74	48	21
2016-09-22	11.8	10.1	on	pre		26.0	26.0		315		46		7		73	74	74	47	20
2016-09-23	11.7	10.0	on	pre		28.6	28.6		333		49		7		74	74	74	47	19
2016-09-24	6.4	4.7	on	pre		17.3	17.3		227		38		6		73	74	74	52	8
2016-09-25	2.7	1.3	on	pre		4.2	4.2		60		13		5		72	73	74	49	0
2016-09-26	2.9	1.2	on	pre		4.7	4.7		72		16		5		73	74	74	53	22
2016-09-27	4.1	2.4	on	pre		8.3	8.3		109		20		5		73	74	74	57	22
2016-09-28	2.9	0.7	on	pre		1.7	1.7		23		4		6		73	74	76	64	15
2016-09-29	3.3	1.4	on	pre		4.5	4.5		61		10		6		73	74	74	68	19
2016-10-02	3.9	3.1	on	pre		2.7	2.7		35		6		6		72	73	74	68	0
2016-10-03	4.9	3.2	on	pre		10.7	10.7		139		22		6		73	74	74	58	23
2016-10-04	2.1	0.8	on	pre		6.9	6.9		91		15		6		72	73	74	57	23
2016-10-05	1.4	0.5	on	pre		3.1	3.1		45		10		5		71	73	74	55	23
2016-10-06	1.3	0.4	on	pre		2.1	2.1		30		5		6		72	73	74	58	20
2016-10-07	2.5	1.4	on	pre		3.8	3.8		51		8		6		72	73	74	62	26
2017-05-26	4.9	4.8	on	post		14.7	14.7		195		36		5		71	72	73	60	22
2017-05-27	3.1	3.0	on	post		10.6	10.6		140		26		5		72	72	72	63	10
2017-05-28	2.4	2.2	on	post		7.7	7.7		103		19		5		72	72	73	68	0
2017-05-29	7.2	6.8	on	post		20.2	20.2		245		45		5		72	72	73	70	0
2017-05-30	2.0	2.2	on	post		13.4	13.4		184		34		5		71	72	72	72	25
2017-05-31	5.6	5.3	on	post		23.8	23.8		300		52		6		71	72	73	73	24
2017-06-01	9.6	9.7	on	post		29.8	29.8		363		69		5		71	72	73	65	26
2017-06-02	8.9	9.2	on	post		31.3	31.3		389		75		5		71	72	73	54	22

Air Conditioning: Humid Climate Site 4 (Washington, D.C.)

DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C1	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2017-06-03	8.9	9.1	on	post		29.2	29.2		363		71		5		71	72	73	52	10
2017-06-04	10.6	10.8	on	post		32.8	32.8		392		75		5		71	72	72	63	0
2017-06-05	8.3	8.7	on	post		28.9	28.9		365		60		6		71	72	72	73	24
2017-06-06	6.6	6.8	on	post		24.9	24.9		319		59		5		71	72	73	64	23
2017-06-07	0.5	0.4	on	post		13.3	13.3		186		35		5		72	72	73	57	21
2017-06-08	3.3	3.3	on	post		16.6	16.6		220		43		5		71	72	73	51	22
2017-06-09	9.0	8.9	on	post		28.0	28.0		342		65		5		71	72	73	53	23
2017-06-10	12.1	12.4	on	post		37.7	37.7		452		87		5		71	72	73	61	9
2017-06-11	17.2	17.6	on	post		47.5	47.5		538		101		5		71	72	73	70	0
2017-06-12	18.9	18.4	on	post		52.5	52.5		549		79		7		71	73	75	72	23
2017-06-13	19.8	18.8	on	post		60.9	60.9		622		93		7		71	73	74	72	24
2017-06-14	17.9	18.1	on	post		58.7	58.7		638		101		6		71	72	73	74	28
2017-06-15	12.8	13.0	on	post		44.1	44.1		526		95		6		71	72	73	72	21
2017-06-16	11.6	11.7	on	post		41.6	41.6		491		84		6		71	72	73	74	21
2017-06-17	13.8	14.0	on	post		43.0	43.0		490		81		6		71	72	73	78	10
2017-06-19	14.9	15.0	on	post		52.0	52.0		579		89		7		71	72	73	77	25
2017-06-20	13.8	13.9	on	post		42.3	42.3		487		86		6		71	72	73	75	21
2017-06-21	15.4	15.6	on	post		45.0	45.0		515		92		6		71	72	73	76	21
2017-06-22	17.4	17.5	on	post		50.0	50.0		556		96		6		71	72	73	76	19
2017-06-23	16.9	16.9	on	post		50.2	50.2		561		94		6		71	72	73	78	22
2017-06-24	16.7	16.9	on	post		47.7	47.7		543		96		6		71	72	73	75	11
2017-06-25	14.7	15.3	on	post		40.5	40.5		471		90		5		71	71	72	69	0
2017-06-26	11.8	12.4	on	post		40.9	40.9		502		97		5		71	71	72	55	26
2017-06-27	9.3	9.8	on	post		34.1	34.1		424		81		5		71	71	72	56	20
2017-06-28	8.4	8.7	on	post		34.2	34.2		429		83		5		71	72	73	52	21
2017-06-29	13.9	14.1	on	post		45.8	45.8		538		102		5		71	72	73	64	22
2017-06-30	17.7	17.7	on	post		53.2	53.2		578		96		6		71	72	73	70	22
2017-07-01	16.5	16.5	on	post		53.4	53.4		597		99		6		71	72	73	76	9
2017-07-02	18.7	19.0	on	post		48.5	48.5		533		98		5		71	72	73	77	0
2017-07-03	19.2	19.4	on	post		55.9	55.9		599		102		6		71	72	73	74	22
2017-07-04	17.5	17.8	on	post		48.6	48.6		553		103		5		71	72	73	76	0
2017-07-05	13.2	13.3	on	post		43.1	43.1		505		88		6		71	72	73	78	22
2017-07-06	11.5	11.6	on	post		35.4	35.4		419		72		6		71	72	73	81	22
2017-07-07	15.6	15.4	on	post		45.6	45.6		512		87		6		71	72	73	78	23
2017-07-08	15.6	15.7	on	post		44.7	44.7		510		96		5		71	72	73	76	8
2017-07-09	13.1	13.6	on	post		39.5	39.5		467		87		5		71	71	72	69	0
2017-07-10	16.4	16.4	on	post		50.5	50.5		560		95		6		71	72	73	72	24
2017-07-12	21.6	22.7	off	post		77.1	77.1		707		66		11		71	71	71	72	22
2017-07-13	22.9	24.0	off	post		86.7	86.7		771		67		12		71	71	71	71	20
2017-07-14	17.8	18.9	off	post		80.6	80.6		756		67		11		71	71	71	71	31
2017-07-15	17.0	18.2	off	post		65.1	65.1		638		69		9		71	71	71	72	14
2017-07-16	15.6	16.9	off	post		52.5	52.5		533		63		8		70	71	71	72	0
2017-07-17	17.3	18.5	off	post		64.4	64.4		634		66		10		71	71	71	73	21
2017-07-20	23.8	24.8	off	post		92.8	92.8		817		71		12		71	71	71	69	20
2017-07-21	24.1	25.2	off	post		91.6	91.6		814		71		11		71	71	71	69	20
2017-07-22	16.6	17.8	off	post		70.6	70.6		685		70		10		71	71	71	73	9
2017-07-23	14.0	15.3	off	post		48.8	48.8		517		64		8		71	71	71	78	0
2017-07-24	17.6	18.8	off	post		60.7	60.7		587		65		9		71	71	71	76	23
2017-07-25	11.6	12.3	off	post		43.4	43.4		463		58		8		70	71	73	71	25
2017-07-26	12.3	12.2	off	post		42.6	42.6		447		53		8		71	72	73	70	23
2017-07-27	14.3	13.7	off	post		44.3	44.3		460		57		8		72	73	73	76	23
2017-07-28	10.9	10.3	off	post		32.6	32.6		350		53		7		72	73	73	82	20
2017-07-29	7.5	7.1	off	post		18.6	18.6		221		38		6		72	72	73	78	12
2017-07-30	9.2	8.7	off	post		24.4	24.4		264		38		7		72	73	73	61	0
2017-07-31	13.4	12.8	off	post		41.1	41.1		415		52		8		72	73	73	68	26
2017-08-01	14.9	14.2	off	post		48.4	48.4		475		56		8		72	73	73	72	21
2017-08-02	15.7	15.0	off	post		53.2	53.2		527		60		9		72	73	73	73	22
2017-08-03	14.1	13.4	off	post		52.7	52.7		519		60		9		72	73	73	75	21
2017-08-05	11.5	10.8	on	post		37.8	37.8		434		81		5		72	73	73	71	10
2017-08-06	10.5	9.8	on	post		30.8	30.8		362		70		5		72	73	73	65	0
2017-08-07	7.2	6.7	on	post		23.5	23.5		278		53		5		72	73	73	78	23
2017-08-08	9.1	8.5	on	post		27.9	27.9		321		62		5		72	73	73	77	24
2017-08-09	10.8	10.1	on	post		33.3	33.3		377		72		5		72	73	74	70	22
2017-08-10	11.3	10.6	on	post		35.1	35.1		405		76		5		72	73	74	70	19
2017-08-11	10.5	9.8	on	post		32.3	32.3		374		71		5		72	73	73	74	23
2017-08-12	11.7	11.0	on	post		36.1	36.1		410		76		5		72	73	73	81	6
2017-08-13	12.2	11.5	on	post		34.0	34.0		386		72		5		72	73	73	78	0
2017-08-14	11.2	10.5	on	post		30.6	30.6		360		66		5		72	73	73	78	25
2017-08-15	12.3	11.6	on	post		34.0	34.0		389		69		6		72	73	73	82	24

Air Conditioning: Humid Climate Site 4 (Washington, D.C.)																			
DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C1	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2017-08-16	16.6	15.7	on	post		50.4	50.4		509		82		6		72	73	74	79	21
2017-08-17	17.0	16.1	on	post		58.4	58.4		597		90		7		72	73	74	77	19
2017-08-18	16.8	15.8	on	post		61.6	61.6		615		82		8		72	73	74	77	23
2017-08-19	17.1	16.3	on	post		49.9	49.9		515		87		6		72	73	73	78	9
2017-08-20	14.1	13.4	on	post		39.1	39.1		432		76		6		72	73	73	75	0
2017-08-21	15.2	14.5	on	post		55.8	55.8		580		93		6		71	73	73	76	26
2017-08-22	18.5	18.2	on	post		68.3	68.3		695		111		6		71	72	74	75	25
2017-08-23	14.8	14.7	on	post		56.1	56.1		612		114		5		71	72	74	73	22
2017-08-24	11.2	11.3	on	post		40.7	40.7		473		91		5		71	72	73	67	23
2017-08-25	8.2	8.5	on	post		35.8	35.8		423		81		5		71	72	73	69	23
2017-08-26	8.2	8.6	on	post		30.9	30.9		368		70		5		71	72	73	67	11
2017-08-27	7.1	7.4	on	post		25.1	25.1		306		57		5		71	72	72	64	0
2017-08-28	5.7	5.9	on	post		28.9	28.9		360		68		5		71	72	73	63	26
2017-08-29	1.9	1.4	on	post		13.5	13.5		190		36		5		71	72	74	69	21
2017-08-30	6.0	5.4	on	post		21.5	21.5		263		52		5		71	73	74	68	24
2017-08-31	11.2	10.9	on	post		28.9	28.9		326		63		5		71	72	73	71	21
2017-09-01	1.0	1.0	on	post		15.2	15.2		205		38		5		71	72	73	57	25
2017-09-03	5.4	5.0	on	post		14.2	14.2		172		31		6		72	72	73	67	0
2017-09-04	8.6	8.5	on	post		23.4	23.4		267		49		5		71	72	73	67	0
2017-09-05	10.4	10.5	on	post		37.9	37.9		420		69		6		71	72	74	75	25
2017-09-06	1.5	1.8	on	post		13.0	13.0		160		25		6		71	72	72	75	23
2017-09-07	3.1	3.3	on	post		14.1	14.1		178		32		6		71	72	72	63	24
2017-09-08	4.2	4.4	on	post		14.4	14.4		179		33		5		71	72	72	56	21
2017-09-09	1.9	1.9	on	post		9.3	9.3		116		22		5		71	72	72	51	9
2017-09-10	2.5	2.8	on	post		8.1	8.1		104		19		5		71	72	72	49	0
2017-09-11	3.3	3.5	on	post		15.4	15.4		194		36		5		71	72	72	53	25
2017-09-12	5.6	5.6	on	post		22.3	22.3		273		51		5		71	72	73	58	25
2017-09-13	7.1	7.0	on	post		21.8	21.8		258		44		6		71	72	73	70	22
2017-09-14	9.7	9.0	on	post		22.8	22.8		265		53		5		72	73	73	69	24
2017-09-16	10.8	12.2	off	post		31.3	31.3		364		56		7		70	71	71	53	10
2017-09-17	10.3	11.7	off	post		29.3	29.3		345		53		7		70	71	71	52	0
2017-09-18	8.0	9.4	off	post		32.6	32.6		381		57		7		70	71	71	54	21
2017-09-19	10.3	11.7	off	post		36.4	36.4		404		57		7		70	71	71	54	23
2017-09-20	12.6	13.6	off	post		36.1	36.1		394		55		7		70	71	72	52	20
2017-09-21	12.9	13.3	off	post		36.0	36.0		385		55		7		71	72	72	51	21
2017-09-22	11.3	11.6	off	post		34.7	34.7		390		56		7		71	72	72	51	22
2017-09-23	11.4	11.9	off	post		29.0	29.0		319		50		6		71	72	72	50	11
2017-09-24	13.8	14.3	off	post		30.1	30.1		329		52		6		71	72	72	51	0
2017-09-25	14.9	15.3	off	post		43.6	43.6		453		60		8		71	72	72	52	22
2017-09-26	11.9	12.2	off	post		38.6	38.6		426		60		7		71	72	72	52	24
2017-09-27	16.1	16.4	off	post		48.9	48.9		493		64		8		72	72	72	54	24
2017-09-28	10.3	10.7	off	post		34.5	34.5		387		60		6		71	72	72	49	21
2017-09-29	2.8	3.3	off	post		18.4	18.4		238		41		6		71	71	72	43	24
2017-09-30	0.7	1.3	off	post		8.0	8.0		111		21		5		71	71	72	42	11
2017-10-01	0.9	2.2	off	post		2.3	2.3		31		6		5		69	71	72	42	0
2017-10-02	2.4	3.4	off	post		10.0	10.0		128		22		6		70	71	72	46	25
2017-10-03	2.8	3.4	off	post		11.5	11.5		145		24		6		71	71	72	47	22
2017-10-04	3.4	4.0	off	post		13.2	13.2		163		27		6		71	71	72	49	19
2017-10-05	5.8	6.4	off	post		17.0	17.0		202		33		6		71	71	72	50	21
2017-10-06	8.1	7.9	off	post		22.0	22.0		248		37		7		71	72	74	51	25
2017-10-08	13.1	11.7	off	post		22.3	22.3		253		45		6		73	73	74	57	0
2017-10-09	13.6	12.2	off	post		22.3	22.3		254		45		6		73	73	74	58	0
2017-10-10	13.4	12.4	off	post		34.5	34.5		378		54		7		72	73	74	53	23
2017-10-11	7.5	7.0	off	post		24.3	24.3		295		51		6		72	72	73	53	23
2017-10-12	0.6	0.2	off	post		9.6	9.6		135		26		5		72	72	72	54	22
2017-10-13	0.1	-0.1	off	post		4.3	4.3		62		12		5		72	72	73	55	24
2017-10-15	5.3	4.9	off	post		6.6	6.6		81		15		5		72	72	73	63	0
2017-10-16	0.4	0.2	off	post		4.8	4.8		67		13		5		71	72	73	49	23

D1.5 AIR CONDITIONING HUMID CLIMATE SITE 5

For this case, fan energy consumption was estimated based on measured fan on/off status and assumed typical power of 1 kW (based on 1 HP fan motor). In the rare cases where fan runtime was apparently less than compressor runtime, this likely reflects the imprecision of the motor sensors.

Air Conditioning: Humid Climate Site 5 (Washington, D.C.)

DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C1	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2016-06-10	8.4	9.5	off	pre	24.0	40.1	64.1	1440	441		49		9		70	71	72	41	34
2016-06-11	16.0	17.0	off	pre	24.0	64.1	88.1	1440	586		53		11		70	71	71	57	0
2016-06-12	17.9	18.9	off	pre	24.0	57.3	81.3	1440	554		62		9		71	71	71	59	1
2016-06-13	8.0	9.1	off	pre	24.0	44.3	68.3	1440	492		53		9		70	71	72	48	41
2016-06-14	9.0	10.0	off	pre	24.0	50.7	74.7	1440	542		56		10		71	71	72	51	28
2016-06-15	9.2	10.3	off	pre	24.0	48.0	72.0	1440	505		54		9		70	71	71	58	43
2016-06-16	11.2	12.1	off	pre	24.0	58.1	82.1	1440	592		57		10		71	71	72	67	40
2016-06-17	7.8	9.0	off	pre	24.0	41.4	65.4	1440	444		51		9		70	71	71	67	31
2016-06-18	10.1	11.4	off	pre	24.0	50.3	74.3	1440	502		49		10		70	71	71	60	6
2016-06-19	12.9	14.1	off	pre	24.0	50.8	74.8	1440	497		49		10		70	71	71	57	0
2016-06-20	15.0	16.0	off	pre	24.0	72.6	96.6	1440	676		50		14		70	71	72	57	39
2016-06-21	12.9	13.9	off	pre	24.0	60.2	84.2	1440	597		53		11		71	71	72	64	38
2016-06-22	12.4	13.5	off	pre	24.0	50.4	74.4	1440	527		55		10		71	71	71	64	43
2016-06-23	10.6	11.7	off	pre	24.0	43.8	67.8	1440	473		57		8		71	71	71	69	34
2016-06-24	12.1	13.2	off	pre	24.0	59.8	83.8	1440	616		58		11		71	71	71	71	30
2016-06-25	12.1	13.2	off	pre	24.0	54.0	78.0	1440	554		60		9		71	71	71	70	2
2016-06-26	11.4	12.6	off	pre	24.0	52.0	76.0	1440	524		53		10		70	71	71	62	0
2016-06-27	12.4	13.3	off	pre	24.0	71.0	95.0	1440	675		49		14		71	71	73	63	40
2016-06-28	12.0	13.1	off	pre	24.0	64.0	88.0	1440	642		56		11		71	71	71	73	30
2016-06-29	10.2	11.3	off	pre	24.0	56.9	80.9	1440	588		49		12		70	71	71	65	41
2016-06-30	10.5	11.6	off	pre	24.0	57.5	81.5	1440	572		49		12		70	71	72	61	43
2016-07-01	13.1	14.1	off	pre	24.0	71.1	95.1	1440	679		53		13		71	71	73	68	37
2016-07-02	10.5	11.8	off	pre	24.0	36.3	60.3	1440	407		54		8		70	71	71	66	1
2016-07-03	4.6	5.9	off	pre	24.0	21.5	45.5	1440	274		42		7		70	71	71	62	1
2016-07-04	6.3	7.7	off	pre	19.1	18.6	37.7	1144	227		41		6		70	71	71	74	3
2016-07-05	15.8	17.1	off	pre	12.1	65.0	77.1	724	628		68		9		71	71	71	80	0
2016-07-06	22.0	23.2	off	pre	20.0	88.7	108.8	1203	797		57		14		71	71	71	74	34
2016-07-08	17.1	18.0	on	pre	23.1	90.5	113.6	1386	840		58		14		71	71	72	70	37
2016-07-09	19.1	20.2	on	pre	20.9	73.0	93.9	1256	697		73		10		71	71	71	75	2
2016-07-10	16.2	17.4	on	pre	24.0	50.9	74.9	1440	535		69		8		71	71	71	71	0
2016-07-11	15.7	16.7	on	pre	24.0	67.8	91.8	1440	664		56		12		71	71	72	65	33
2016-07-12	14.8	15.8	on	pre	23.9	63.6	87.5	1434	621		63		10		71	71	71	67	30
2016-07-14	21.1	22.1	on	pre	19.7	102.4	122.1	1184	870		53		16		71	71	72	71	39
2016-07-15	19.8	20.5	on	pre	23.9	101.2	125.1	1436	901		45		20		71	71	74	66	44
2016-07-16	16.0	17.0	on	pre	23.9	73.3	97.2	1432	690		61		11		71	71	71	68	3
2016-07-17	16.4	17.4	on	pre	22.7	73.0	95.7	1359	687		61		11		71	71	72	69	0
2016-07-18	16.5	17.3	on	pre	21.3	90.9	112.1	1275	819		51		16		71	71	73	69	41
2016-07-19	16.3	17.2	on	pre	22.0	75.0	97.1	1323	710		56		13		71	71	72	70	30
2016-07-20	14.0	14.8	on	pre	22.7	65.0	87.7	1361	632		50		13		71	71	72	67	43
2016-07-21	15.8	16.6	on	pre	23.9	71.1	95.0	1436	662		50		13		71	71	72	64	41
2016-07-22	19.2	19.9	on	pre	23.0	95.5	118.5	1381	843		51		17		71	71	73	67	41
2016-07-23	24.2	25.1	on	pre	22.8	100.0	122.7	1365	873		70		12		71	71	72	70	16
2016-07-24	23.2	24.2	on	pre	23.9	93.3	117.2	1434	809		65		12		71	71	71	71	0
2016-07-25	24.5	24.9	on	pre	22.3	122.7	145.0	1338	993		49		20		71	72	74	68	41
2016-07-26	22.8	23.7	on	pre	22.1	98.0	120.1	1327	869		59		15		71	71	72	68	31
2016-07-27	22.4	23.3	on	pre	23.0	106.1	129.1	1378	934		54		17		71	71	72	66	43
2016-07-28	19.0	19.8	on	pre	20.8	96.1	116.9	1246	867		60		14		71	71	72	68	43
2016-07-29	17.0	18.1	on	pre	14.4	81.9	96.3	864	798		82		10		71	71	71	71	34
2016-07-30	16.0	17.1	on	pre	18.4	59.9	78.3	1103	601		70		9		71	71	71	77	2
2016-07-31	16.9	17.9	on	pre	14.5	69.2	83.7	868	658		62		11		71	71	71	76	0
2016-08-02	16.7	17.8	off	pre	14.3	76.6	90.9	860	740		58		13		71	71	71	72	52
2016-08-03	12.0	13.2	off	pre	19.3	57.8	77.1	1156	602		57		11		71	71	71	69	42
2016-08-04	12.8	14.0	off	pre	22.1	62.4	84.5	1325	627		54		12		71	71	71	66	37
2016-08-05	12.9	14.0	off	pre	18.3	56.8	75.1	1099	592		66		9		71	71	71	70	36
2016-08-06	16.5	17.6	off	pre	5.5	66.7	72.2	333	659		72		9		71	71	71	76	2
2016-08-07	16.9	18.1	off	pre	22.3	64.8	87.2	1340	634		64		10		71	71	71	71	0
2016-08-08	13.1	14.2	off	pre	24.0	60.6	84.6	1439	605		56		11		71	71	71	65	32
2016-08-09	10.9	12.1	off	pre	14.0	42.7	56.8	843	469		61		8		71	71	71	69	43

Air Conditioning: Humid Climate Site 5 (Washington, D.C.)

DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C1	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2016-08-10	19.7	20.7	off	pre	9.5	89.4	98.9	568	799		59		14		71	71	71	73	41
2016-08-11	22.3	23.1	off	pre	15.9	109.6	125.5	956	923		50		18		71	71	72	70	44
2016-08-12	23.5	24.2	off	pre	19.2	120.8	139.9	1151	991		50		20		71	71	73	69	38
2016-08-13	25.0	26.0	off	pre	17.8	113.8	131.6	1066	933		62		15		71	71	71	73	1
2016-08-14	24.5	25.7	off	pre	21.3	102.2	123.5	1278	875		63		14		70	71	71	72	2
2016-08-15	18.8	19.6	off	pre	21.7	97.2	118.9	1302	850		43		20		71	71	73	68	35
2016-08-16	20.1	21.0	off	pre	17.0	96.7	113.7	1018	845		54		16		71	71	72	69	26
2016-08-17	20.0	21.1	off	pre	21.6	94.8	116.4	1298	856		59		15		71	71	71	68	40
2016-08-18	17.5	18.4	off	pre	17.8	89.2	107.0	1066	829		51		16		71	71	73	68	41
2016-08-19	18.0	19.0	off	pre	22.9	79.7	102.5	1371	750		57		13		71	71	71	67	36
2016-08-20	17.9	19.1	off	pre	23.5	65.8	89.3	1409	624		61		10		71	71	71	68	1
2016-08-21	14.3	15.4	off	pre	13.7	50.4	64.1	821	524		62		8		71	71	71	76	0
2016-08-22	12.4	13.6	off	pre	23.8	47.3	71.1	1428	493		54		9		70	71	71	70	8
2016-08-23	10.7	11.9	off	pre	24.0	60.5	84.5	1440	611		45		14		70	71	71	62	41
2016-08-24	12.2	13.3	off	pre	24.0	61.8	85.8	1440	608		47		13		70	71	72	61	38
2016-08-26	21.5	22.3	off	pre	22.3	101.2	123.5	1335	880		45		20		71	71	73	68	41
2016-08-27	19.5	20.5	off	pre	23.7	74.7	98.4	1422	709		66		11		71	71	71	71	1
2016-08-28	16.0	17.0	off	pre	23.0	64.8	87.8	1380	638		64		10		71	71	71	71	0
2016-08-29	17.8	18.9	off	pre	24.0	79.4	103.4	1439	742		52		14		71	71	71	65	42
2016-08-30	16.9	17.8	off	pre	24.0	79.2	103.2	1440	746		47		16		71	71	72	63	46
2016-08-31	16.9	17.8	off	pre	24.0	84.7	108.7	1440	769		43		18		71	71	72	62	42
2016-09-01	12.2	13.3	off	pre	22.6	43.9	66.5	1357	498		64		8		71	71	71	74	30
2016-09-02	9.6	10.9	off	pre	24.0	27.8	51.8	1440	317		44		7		70	71	71	67	2
2016-09-03	9.8	11.1	off	pre	24.0	24.3	48.3	1440	285		41		7		70	71	71	67	0
2016-09-04	9.7	11.0	off	pre	24.0	29.8	53.8	1440	340		44		8		70	71	71	62	1
2016-09-05	12.0	13.2	off	pre	24.0	38.3	62.3	1440	404		47		9		70	71	71	62	4
2016-09-06	17.4	18.4	off	pre	24.0	66.9	90.9	1440	636		46		14		70	71	72	61	40
2016-09-07	16.5	17.5	off	pre	24.0	74.6	98.6	1440	706		46		15		71	71	72	62	41
2016-09-09	21.0	22.0	on	pre	24.0	96.9	120.8	1438	862		57		15		71	71	71	66	41
2016-09-10	19.7	20.8	on	pre	23.9	87.6	111.5	1436	797		62		13		70	71	71	71	2
2016-09-11	15.4	16.6	on	pre	23.9	43.0	66.8	1433	470		61		8		71	71	71	71	3
2016-09-12	10.2	10.9	on	pre	24.0	48.4	72.4	1440	507		41		12		71	71	73	56	45
2016-09-13	13.3	14.1	on	pre	24.0	62.5	86.5	1440	617		47		13		71	71	73	61	38
2016-09-14	16.4	17.3	on	pre	24.0	68.5	92.5	1440	653		45		15		71	71	72	60	45
2016-09-15	7.8	8.8	on	pre	24.0	38.3	62.3	1440	455		56		8		71	71	72	61	40
2016-09-16	6.8	7.5	on	pre	24.0	27.7	51.7	1440	321		38		8		71	71	72	60	13
2016-09-17	10.0	10.9	on	pre	24.0	33.7	57.7	1440	368		45		8		71	71	72	66	5
2016-09-18	14.0	15.0	on	pre	23.5	55.1	78.6	1411	556		58		10		71	71	71	71	2
2016-09-19	10.0	10.6	on	pre	20.2	34.2	54.4	1212	410		65		6		71	71	72	74	39
2016-09-20	9.9	10.4	on	pre	21.2	48.8	70.0	1270	517		40		13		71	72	73	73	44
2016-09-21	12.0	12.8	on	pre	21.4	48.5	69.9	1281	528		51		10		71	71	72	70	45
2016-09-22	11.8	12.4	on	pre	23.9	56.2	80.1	1434	555		32		17		71	71	74	63	37
2016-09-23	11.7	12.6	on	pre	24.0	46.8	70.7	1438	467		43		11		71	71	72	62	15
2016-09-24	6.4	7.3	on	pre	22.7	18.0	40.7	1360	223		34		7		70	71	72	69	6
2016-09-25	2.7	4.1	on	pre	24.0	15.4	39.4	1440	189		25		8		69	71	71	61	1
2016-09-26	2.9	3.4	on	pre	24.0	8.9	32.9	1440	118		19		6		70	71	73	58	40
2016-09-27	4.1	4.4	on	pre	24.0	26.8	50.8	1440	299		24		12		71	72	73	61	39
2016-09-28	2.9	2.8	on	pre	17.5	8.1	25.5	1047	111		18		6		71	72	73	66	42
2016-09-29	3.3	2.7	on	pre	13.2	8.6	21.8	793	114		19		6		72	73	73	72	42
2016-09-30	0.0	-0.1	on	pre	23.4	0.9	24.3	1407	12		2		6		71	72	73	70	41
2016-10-02	3.9	4.8	on	pre	15.9	15.8	31.7	957	186		25		7		70	71	72	74	2
2016-10-03	4.9	5.4	on	pre	24.0	37.7	61.7	1440	403		15		27		71	71	73	62	40
2016-10-04	2.1	3.5	on	pre	23.7	23.4	47.1	1423	272		24		11		70	71	72	59	38
2016-10-05	1.4	2.9	on	pre	24.0	14.8	38.8	1440	187		24		8		69	70	72	59	41
2016-10-06	1.3	2.4	on	pre	23.8	10.1	33.9	1425	133		22		6		70	71	72	61	38
2016-10-07	2.5	3.4	on	pre	19.6	10.6	30.2	1177	136		20		7		70	71	72	66	28
2016-10-08	1.2	1.4	on	pre	23.8	0.9	24.7	1428	13		2		7		71	72	72	69	3
2016-10-09	0.5	2.4	on	pre	24.0	0.4	24.4	1440	5		1		5		69	70	72	53	1
2017-05-26	4.9	6.7	on	post	13.8	10.0	23.8	829	133		24		6		68	70	72	54	8
2017-05-27	3.1	3.6	on	post	24.0	6.7	30.7	1440	84		16		5		70	72	73	58	4
2017-05-28	2.4	2.3	on	post	24.0	6.7	30.7	1440	86		16		5		71	72	73	63	6
2017-05-29	7.2	6.6	on	post	24.0	27.4	51.4	1440	309		61		5		72	73	73	67	9
2017-05-30	2.0	0.8	on	post	24.0	9.5	33.5	1440	122		24		5		72	73	74	66	42
2017-05-31	5.6	3.7	on	post	23.9	34.3	58.2	1436	392		83		5		73	74	76	68	52
2017-06-02	8.9	7.8	on	post	24.0	32.9	56.9	1440	396		71		6		72	73	75	47	46
2017-06-03	8.9	8.9	on	post	24.0	26.8	50.8	1440	311		57		5		71	72	73	47	1
2017-06-04	10.6	9.9	on	post	24.0	37.4	61.4	1440	408		76		5		72	73	73	57	0
2017-06-05	8.3	7.2	on	post	24.0	23.1	47.1	1440	285		53		5		72	73	74	67	42
2017-06-06	6.6	5.5	on	post	24.0	22.0	46.0	1440	275		50		6		72	73	74	59	39

Air Conditioning: Humid Climate Site 5 (Washington, D.C.)

DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C1	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2017-06-07	0.5	-0.3	on	post	24.0	12.7	36.7	1440	169		31		5		72	73	74	52	46
2017-06-08	3.3	3.4	on	post	24.0	20.0	44.0	1440	254		46		6		70	72	73	50	42
2017-06-09	9.0	8.5	on	post	24.0	30.3	54.3	1440	366		66		6		71	73	74	49	22
2017-06-10	12.1	10.9	on	post	24.0	43.8	67.8	1440	473		92		5		73	73	74	56	1
2017-06-11	17.2	15.5	on	post	24.0	57.1	81.1	1440	605		123		5		73	74	75	63	0
2017-06-12	18.9	17.0	on	post	24.0	62.8	86.8	1440	660		133		5		72	74	76	66	41
2017-06-13	19.8	17.8	on	post	24.0	64.1	88.1	1440	678		148		5		73	74	75	70	18
2017-06-14	17.9	15.8	on	post	24.0	58.3	82.3	1440	655		138		5		73	74	76	70	38
2017-06-15	12.8	11.4	on	post	24.0	44.4	68.4	1440	507		104		5		73	73	75	66	38
2017-06-16	11.6	10.0	on	post	24.0	41.6	65.6	1440	489		101		5		73	74	75	69	45
2017-06-17	13.8	12.6	on	post	23.9	42.4	66.3	1433	463		101		5		73	73	74	76	4
2017-06-19	14.9	13.0	on	post	24.0	48.8	72.8	1440	557		123		5		73	74	75	76	40
2017-06-20	13.8	12.0	on	post	24.0	50.8	74.8	1440	565		117		5		73	74	76	71	33
2017-06-21	15.4	13.5	on	post	24.0	50.5	74.5	1440	563		119		5		73	74	76	69	40
2017-06-22	17.4	15.5	on	post	24.0	53.6	77.6	1440	598		131		5		73	74	76	71	43
2017-06-23	16.9	14.9	on	post	23.6	51.2	74.8	1417	576		132		4		73	74	76	76	39
2017-06-24	16.7	15.5	on	post	23.2	38.7	61.9	1392	430		84		5		72	73	74	77	2
2017-06-25	14.7	13.9	on	post	24.0	35.7	59.7	1440	404		75		5		72	73	74	64	5
2017-06-26	11.8	10.5	on	post	24.0	39.3	63.3	1440	453		85		5		72	73	74	50	46
2017-06-27	9.3	8.2	on	post	24.0	31.1	55.1	1440	379		70		5		72	73	74	50	34
2017-06-28	8.4	7.2	on	post	24.0	36.7	60.7	1440	443		81		5		72	73	75	47	43
2017-06-29	13.9	11.9	on	post	24.0	46.1	70.1	1440	496		100		5		73	74	75	58	40
2017-06-30	17.7	15.7	on	post	24.0	56.4	80.4	1440	609		129		5		73	74	75	65	29
2017-07-01	16.5	15.0	on	post	24.0	54.0	78.0	1440	602		131		5		73	74	75	75	0
2017-07-02	18.7	17.0	on	post	24.0	56.5	80.5	1440	620		135		5		73	74	75	73	9
2017-07-03	19.2	18.3	on	post	24.0	51.1	75.1	1440	563		113		5		72	73	73	72	2
2017-07-04	17.5	16.6	on	post	24.0	48.7	72.7	1440	535		111		5		72	73	74	72	5
2017-07-05	13.2	11.4	on	post	22.6	45.9	68.5	1356	545		122		4		73	74	75	74	37
2017-07-06	11.5	9.9	on	post	16.7	32.1	48.8	1002	393		85		5		73	74	74	78	40
2017-07-07	15.6	13.9	on	post	20.7	48.0	68.7	1240	542		121		4		73	74	75	76	39
2017-07-08	15.6	14.7	on	post	24.0	39.1	63.1	1440	436		86		5		72	73	73	72	1
2017-07-09	13.1	12.4	on	post	24.0	36.7	60.7	1440	420		75		6		72	73	73	65	1
2017-07-10	16.4	14.3	on	post	24.0	54.7	78.7	1440	590		124		5		72	74	76	65	32
2017-07-12	21.6	22.5	off	post	24.0	108.1	132.1	1440	1001		42		24		70	71	73	63	43
2017-07-13	22.9	23.4	off	post	24.0	118.2	142.2	1440	1064		40		27		70	71	74	64	42
2017-07-14	17.8	18.7	off	post	24.0	97.6	121.6	1440	944		49		19		70	71	73	65	39
2017-07-15	17.0	18.4	off	post	24.0	70.9	94.9	1440	748		69		11		70	71	71	69	5
2017-07-16	15.6	17.1	off	post	24.0	65.1	89.1	1440	682		62		11		70	71	71	66	0
2017-07-17	17.3	18.7	off	post	24.0	91.5	115.5	1440	926		56		17		70	71	71	66	44
2017-07-22	16.6	16.2	off	post	12.5	77.1	89.7	751	815		70		12		71	72	73	51	1
2017-07-23	14.0	17.5	off	post	13.6	79.8	93.4	815	885		70		13		68	69	69	51	0
2017-07-24	17.6	20.6	off	post	16.0	100.6	116.6	961	1015		49		21		68	69	70	51	43
2017-07-25	11.6	12.2	off	post	8.8	50.3	59.2	529	583		64		9		68	71	73	49	48
2017-07-26	12.3	11.8	off	post	10.9	66.4	77.4	655	691		39		18		72	73	73	50	45
2017-07-27	14.3	14.3	off	post	11.4	69.6	81.1	686	737		51		14		71	72	73	50	45
2017-07-31	13.4	11.4	off	post	24.0	84.2	108.2	1440	859		25		34		71	74	81	49	46
2017-08-01	14.9	15.3	off	post	24.0	86.2	110.2	1440	866		38		23		70	72	75	59	44
2017-08-02	15.7	17.5	off	post	24.0	98.4	122.4	1440	973		40		24		69	70	72	61	41
2017-08-03	14.1	16.2	off	post	24.0	91.0	115.0	1440	929		45		21		69	70	72	62	40
2017-08-05	11.5	12.8	on	post	24.0	38.4	62.4	1440	488		96		5		70	71	71	67	3
2017-08-06	10.5	11.8	on	post	24.0	36.9	60.9	1440	464		91		5		70	71	71	62	2
2017-08-07	7.2	8.0	on	post	24.0	25.9	49.9	1437	358		68		5		70	71	72	71	40
2017-08-08	9.1	10.0	on	post	24.0	35.3	59.3	1440	465		91		5		70	71	72	73	28
2017-08-09	10.8	11.8	on	post	24.0	52.8	76.8	1440	595		73		8		70	71	72	63	5
2017-08-10	11.3	12.4	on	post	24.0	53.1	77.1	1440	616		83		7		70	71	72	61	0
2017-08-11	10.5	11.6	on	post	24.0	44.0	68.0	1440	537		86		6		70	71	72	67	19
2017-08-12	11.7	13.0	on	post	24.0	47.9	71.9	1440	589		117		5		70	71	71	75	1
2017-08-13	12.2	13.5	on	post	24.0	46.6	70.6	1440	577		113		5		70	71	71	73	1
2017-08-14	11.2	12.0	on	post	24.0	44.1	68.1	1440	532		72		7		70	71	72	68	31
2017-08-15	12.3	13.0	on	post	24.0	47.6	71.6	1440	599		106		6		71	71	72	73	45
2017-08-16	16.6	17.1	on	post	24.0	80.9	104.9	1440	831		75		11		71	71	73	69	45
2017-08-17	17.0	17.4	on	post	24.0	91.5	115.5	1440	938		93		10		71	72	73	70	42
2017-08-18	16.8	17.4	on	post	24.0	85.5	109.5	1440	898		111		8		71	71	73	72	41
2017-08-19	17.1	18.1	on	post	24.0	65.0	89.0	1440	756		139		5		71	71	72	73	3
2017-08-20	14.1	15.4	on	post	24.0	48.8	72.8	1440	598		119		5		70	71	71	69	0
2017-08-21	15.2	14.9	on	post	24.0	85.3	109.3	1440	858		66		13		70	72	77	69	30
2017-08-22	18.5	18.6	on	post	24.0	95.3	119.3	1440	944		94		10		71	72	75	69	28
2017-08-23	14.8	15.5	on	post	24.0	76.0	100.0	1440	838		91		9		70	71	72	66	0
2017-08-24	11.2	12.4	on	post	24.0	49.8	73.8	1440	620		101		6		70	71	72	61	18

Air Conditioning: Humid Climate Site 5 (Washington, D.C.)																			
DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C1	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2017-08-25	8.2	9.0	on	post	24.0	47.3	71.3	1440	585		84		7		70	71	72	60	44
2017-08-26	8.2	9.4	on	post	24.0	29.5	53.5	1440	385		74		5		70	71	71	61	1
2017-08-27	7.1	8.3	on	post	24.0	25.5	49.5	1440	332		62		5		70	71	71	60	0
2017-08-28	5.7	3.8	on	post	11.2	6.0	17.2	669	83		13		6		71	74	78	56	42
2017-08-29	1.9	1.2	on	post	18.0	16.9	34.9	1082	254		47		5		71	73	76	66	43
2017-08-30	6.0	6.7	on	post	24.0	36.6	60.6	1440	474		76		6		70	71	72	66	45
2017-08-31	11.2	11.9	on	post	24.0	39.5	63.5	1440	490		91		5		71	71	72	67	24
2017-09-01	1.0	2.3	on	post	24.0	8.4	32.4	1440	124		21		6		70	71	71	56	2
2017-09-03	5.4	6.6	on	post	24.0	18.2	42.2	1440	242		47		5		70	71	71	67	0
2017-09-04	8.6	9.8	on	post	24.0	30.3	54.3	1440	373		75		5		70	71	71	66	0
2017-09-05	10.4	11.1	on	post	24.0	56.9	80.9	1440	622		70		9		71	71	72	68	46
2017-09-06	1.5	2.4	on	post	24.0	16.1	40.1	1440	242		50		5		71	71	72	70	55
2017-09-07	3.1	4.4	on	post	24.0	21.1	45.1	1440	292		55		5		70	71	72	61	43
2017-09-08	4.2	6.0	on	post	24.0	18.4	42.4	1440	251		45		6		69	70	71	55	18
2017-09-09	1.9	3.7	on	post	24.0	12.4	36.4	1440	173		29		6		69	70	71	50	2
2017-09-10	2.5	4.8	on	post	22.4	16.7	39.1	1345	229		39		6		68	70	71	49	12
2017-09-11	3.3	4.9	on	post	24.0	24.0	48.0	1440	326		60		5		69	70	71	52	49
2017-09-12	5.6	6.6	on	post	24.0	31.9	55.9	1440	404		64		6		70	71	71	55	31
2017-09-13	7.1	7.8	on	post	24.0	38.4	62.4	1440	492		83		6		71	71	72	65	31
2017-09-14	9.7	10.3	on	post	24.0	45.8	69.8	1440	564		94		6		71	71	72	69	39
2017-09-16	10.8	14.5	off	post	9.3	52.4	61.7	557	623		68		9		68	68	69	52	7
2017-09-17	10.3	14.0	off	post	9.3	52.5	61.9	561	623		67		9		68	68	69	52	4
2017-09-18	8.0	11.4	off	post	9.6	51.6	61.2	577	640		69		9		68	69	69	52	45
2017-09-19	10.3	12.4	off	post	7.3	40.9	48.2	439	490		60		8		68	70	72	56	33
2017-09-20	12.6	12.8	off	post	9.4	57.3	66.8	566	605		41		15		71	72	74	55	41
2017-09-21	12.9	13.2	off	post	9.5	57.8	67.3	570	606		41		15		71	72	73	52	33
2017-09-22	11.3	11.9	off	post	6.2	35.3	41.5	371	433		58		7		71	71	72	53	9
2017-09-23	11.4	12.1	off	post	5.7	34.3	39.9	340	392		48		8		71	71	72	53	1
2017-09-24	13.8	14.4	off	post	6.7	41.6	48.3	404	462		53		9		71	71	72	52	2
2017-09-25	14.9	16.1	off	post	11.8	73.5	85.3	710	759		50		15		69	71	72	50	40
2017-09-26	11.9	14.4	off	post	10.0	57.7	67.7	603	670		68		10		69	69	70	50	22
2017-09-27	16.1	18.4	off	post	13.1	80.5	93.6	783	840		55		15		69	70	70	54	42
2017-09-28	10.3	12.6	off	post	9.9	55.3	65.3	596	657		65		10		69	70	70	49	43
2017-09-29	2.8	5.2	off	post	5.3	26.3	31.6	316	377		55		7		69	70	70	43	39

D1.6 AIR CONDITIONING HUMID CLIMATE SITE 6

Despite several adjustments, COOLNOMIX did not appear to function at this site for reasons that could not be determined. Data are included for reference only.

Air Conditioning: Humid Climate Site 6 (Washington, D.C.)

DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C1	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2016-07-08	17.1		on	pre	18.9	59.3	72.6	1440	1024		40		26		69	72	74	61	37
2016-07-09	19.1		on	pre	18.8	49.4	60.7	1440	873		47		19		68	71	73	63	26
2016-07-10	16.2		on	pre	19.0	34.0	42.4	1440	640		51		13		72	73	74	60	25
2016-07-11	15.7		on	pre	19.0	34.1	43.0	1440	682		52		13		72	73	74	60	27
2016-07-12	14.8		on	pre	18.9	32.9	41.0	1440	623		51		12		72	73	74	65	30
2016-07-14	21.1		on	pre	18.6	54.5	66.2	1440	912		41		22		72	73	73	65	26
2016-07-15	19.8		on	pre	18.7	44.6	54.6	1440	778		45		17		72	72	73	65	26
2016-07-16	16.0		on	pre	18.7	37.8	46.5	1440	677		44		15		72	72	73	67	15
2016-07-17	16.4		on	pre	18.8	33.7	41.6	1440	617		47		13		72	72	72	69	13
2016-07-18	16.5		on	pre	18.6	58.0	70.6	1440	981		32		31		72	74	77	68	33
2016-07-19	16.3		on	pre	18.6	48.0	58.9	1440	851		47		18		72	73	74	67	28
2016-07-20	14.0		on	pre	18.8	37.1	45.8	1440	678		42		16		71	72	74	67	33
2016-07-21	15.8		on	pre	18.7	37.0	45.6	1440	674		45		15		71	72	74	67	55
2016-07-22	19.2		on	pre	18.5	40.3	49.3	1440	714		55		13		72	73	73	68	32
2016-07-23	24.2		on	pre	18.4	48.6	58.7	1440	804		52		15		72	73	73	66	20
2016-07-24	23.2		on	pre	18.5	46.8	57.0	1440	798		57		14		72	73	74	65	17
2016-07-25	24.5		on	pre	18.4	62.7	75.5	1440	1012		44		23		72	73	74	64	42
2016-07-26	22.8		on	pre	18.4	53.4	64.7	1440	893		48		19		72	73	74	63	31
2016-07-27	22.4		on	pre	18.4	56.6	68.6	1440	945		46		21		72	73	74	63	41
2016-07-28	19.0		on	pre	18.3	50.0	61.0	1440	876		53		17		72	73	74	67	26
2016-07-29	17.0		on	pre	18.3	37.3	45.9	1440	684		52		13		72	73	74	70	38
2016-07-30	16.0		on	pre	18.4	26.2	32.2	1440	486		47		10		74	74	75	73	24
2016-07-31	16.9		on	pre	18.4	29.7	36.6	1440	549		48		11		74	74	75	71	27
2016-08-01	17.5		on	pre	18.4	34.7	42.5	1440	618		47		13		73	74	74	69	26
2016-08-03	12.0		off	pre	18.4	38.7	47.8	1440	726		45		16		68	71	76	64	29
2016-08-04	12.8		off	pre	18.6	45.5	56.7	1440	872		56		16		68	69	70	63	24
2016-08-05	12.9		off	pre	18.4	31.9	39.7	1440	623		56		11		69	70	72	71	22
2016-08-06	16.5		off	pre	18.3	41.1	50.6	1440	760		55		14		70	71	72	71	24
2016-08-07	16.9		off	pre	18.4	36.4	44.9	1440	673		53		13		70	70	72	64	22
2016-08-08	13.1		off	pre	18.5	36.0	44.8	1440	691		54		13		70	71	72	65	27
2016-08-09	10.9		off	pre	18.5	28.6	35.8	1440	574		54		11		70	70	71	71	24
2016-08-10	19.7		off	pre	18.4	47.8	58.5	1440	846		55		15		70	71	71	69	22
2016-08-11	22.3		off	pre	18.3	59.7	72.2	1440	987		44		22		70	71	72	65	30
2016-08-12	23.5		off	pre	18.2	66.6	80.2	1440	1082		39		28		70	71	73	63	24
2016-08-13	25.0		off	pre	18.2	71.1	85.3	1440	1128		37		30		70	71	73	62	28
2016-08-14	24.5		off	pre	18.3	66.1	79.7	1440	1072		46		23		71	71	73	62	26
2016-08-15	18.8		off	pre	18.3	56.0	68.1	1440	959		49		20		70	71	73	63	27
2016-08-16	20.1		off	pre	18.2	59.8	72.5	1440	1013		38		27		67	70	74	64	35
2016-08-17	20.0		off	pre	18.2	55.2	66.9	1440	936		36		26		67	71	74	62	33
2016-08-18	17.5		off	pre	18.2	32.2	39.6	1440	589		48		12		73	73	74	71	26
2016-08-19	18.0		off	pre	18.3	40.2	49.2	1440	719		50		14		71	72	74	65	23
2016-08-20	17.9		off	pre	18.2	43.9	53.7	1440	789		50		16		71	72	72	63	23
2016-08-21	14.3		off	pre	18.1	36.6	45.1	1440	688		53		13		71	71	72	70	25
2016-08-22	12.4		off	pre	18.3	28.8	35.8	1440	567		50		11		71	71	73	65	23
2016-08-23	10.7		off	pre	18.5	26.5	33.1	1440	527		49		11		71	71	72	62	23
2016-08-24	12.2		off	pre	18.4	30.0	37.2	1440	581		51		11		70	71	72	65	29
2016-08-25	15.0		off	pre	18.3	37.0	45.6	1440	692		53		13		71	71	72	69	24
2016-08-26	21.5		off	pre	18.2	49.0	59.5	1440	833		48		17		71	71	72	68	26
2016-08-27	19.5		off	pre	18.3	43.3	52.9	1440	765		51		15		71	71	72	67	24
2016-08-28	16.0		off	pre	18.4	37.3	46.0	1440	686		50		14		71	71	72	67	19
2016-08-29	17.8		off	pre	18.2	33.0	40.5	1440	603		47		13		71	72	74	68	25
2016-08-30	16.9		off	pre	18.3	28.7	35.2	1440	525		48		11		73	74	75	64	27
2016-08-31	16.9		off	pre	18.2	31.9	39.0	1440	576		49		12		73	74	75	66	26
2016-09-01	12.2		off	pre	18.2	24.0	29.7	1440	472		47		10		72	73	74	73	21
2016-09-02	9.6		off	pre	18.5	22.3	27.9	1440	454		44		10		71	72	73	60	26
2016-09-03	9.8		off	pre	18.4	17.7	22.2	1440	366		40		9		71	72	72	64	22
2016-09-04	9.7		off	pre	18.5	17.8	22.2	1440	361		41		9		71	72	72	57	23
2016-09-05	12.0		off	pre	18.4	21.1	26.1	1440	412		41		10		71	72	73	60	28
2016-09-06	17.4		off	pre	18.2	20.3	24.7	1440	369		30		12		71	74	78	59	24
2016-09-07	16.5		off	pre	18.1	30.2	36.7	1440	528		34		16		73	75	78	62	26
2016-09-09	21.0		on	pre	18.0	43.9	53.2	1440	747		47		16		73	73	74	68	22
2016-09-10	19.7		on	pre	18.0	43.8	53.1	1440	752		48		16		73	73	74	67	23

Air Conditioning: Humid Climate Site 6 (Washington, D.C.)

DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C1	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2016-09-11	15.4		on	pre	18.1	27.5	33.8	1440	519		47		11		72	73	74	63	19
2016-09-12	10.2		on	pre	18.4	32.9	40.8	1440	631		44		14		66	71	74	56	29
2016-09-13	13.3		on	pre	18.2	28.3	35.1	1440	550		37		15		66	71	76	62	26
2016-09-14	16.4		on	pre	18.2	24.9	30.4	1440	449		40		11		71	74	77	59	32
2016-09-15	7.8		on	pre	18.4	14.8	18.5	1440	304		32		10		71	72	75	60	24
2016-09-16	6.8		on	pre	18.4	4.8	5.8	1440	90		8		11		70	74	77	54	26
2016-09-17	10.0		on	pre	18.3	18.6	22.8	1440	347		23		15		69	72	77	61	22
2016-09-18	14.0		on	pre	18.1	13.9	17.2	1440	276		30		9		69	73	76	73	21
2016-09-19	10.0		on	pre	18.1	11.3	14.1	1440	234		23		10		70	74	76	76	25
2016-09-20	9.9		on	pre	18.2	4.3	5.3	1440	91		11		8		70	74	77	73	26
2016-09-21	12.0		on	pre	18.2	12.4	15.2	1440	235		19		12		70	74	78	67	24
2016-09-22	11.8		on	pre	18.3	28.7	35.8	1440	563		49		11		69	70	71	66	24
2016-09-23	11.7		on	pre	18.2	22.8	28.1	1440	435		40		11		69	71	74	66	27
2016-09-24	6.4		on	pre	18.2	21.8	27.1	1440	437		29		15		67	71	74	67	20
2016-09-25	2.7		on	pre	18.5	16.8	21.4	1440	371		36		10		68	69	70	57	20
2016-09-26	2.9		on	pre	18.4	5.8	7.3	1440	130		17		8		68	70	73	61	21
2016-09-29	3.3		on	pre	18.3	4.5	5.4	1440	83		1		83		69	72	74	74	33
2016-10-01	0.4		on	pre	18.3	1.6	2.0	1440	34		2		17		67	70	72	74	23
2016-10-03	4.9		on	pre	18.2	2.3	2.7	1440	46		6		8		72	74	76	60	23
2016-10-04	2.1		on	pre	18.3	2.4	2.8	1440	48		7		7		71	74	76	57	28
2016-10-05	1.4		on	pre	18.4	1.2	1.4	1440	26		4		7		71	73	76	54	24
2016-10-18	6.2		off	pre	6.9	7.5	9.2	549	137		6		23		71	74	80	58	31
2016-10-19	9.6		off	pre	1.2	5.1	6.3	100	99		14		7		73	75	76	56	30
2016-10-20	9.5		off	pre	2.1	8.5	10.6	171	171		21		8		74	76	77	54	28
2016-10-21	3.4		off	pre	4.2	17.6	21.9	340	340		11		31		66	71	76	55	26
2017-04-27	7.4		off	pre	6.4	26.8	33.1	525	522		40		13		69	71	74	52	30
2017-04-28	9.7		off	pre	13.0	56.0	68.9	1078	1073		57		19		71	72	74	42	34
2017-04-29	14.3		off	pre	9.8	41.6	51.3	811	797		72		11		71	72	72	47	29
2017-04-30	12.2		off	pre	4.9	20.2	25.1	405	398		48		8		71	74	76	51	34
2017-05-01	10.2		off	pre	5.5	22.8	28.2	453	443		43		10		71	73	75	52	32
2017-05-02	7.4		off	pre	5.0	19.2	24.2	416	409		54		8		71	71	72	44	21
2017-05-03	0.1		off	pre	3.4	11.5	14.8	284	276		39		7		71	71	73	35	26
2017-05-04	0.2		off	pre	0.2	0.5	0.6	13	13		2		7		70	72	75	39	29
2017-05-10	2.7		off	pre	0.8	2.9	3.6	66	63		10		6		67	71	75	39	30
2017-05-15	3.7		off	pre	1.5	5.1	6.6	127	123		20		6		69	72	74	38	31
2017-05-16	5.0		off	pre	3.5	13.1	16.5	287	283		35		8		68	73	74	42	43
2017-05-17	11.6		off	pre	8.9	40.9	49.7	737	731		35		21		67	70	74	47	38
2017-05-18	12.8		off	pre	11.7	51.9	63.5	971	959		56		17		65	67	71	48	33
2017-05-19	14.3		off	pre	10.1	44.7	54.7	841	831		51		16		65	69	71	49	31
2017-05-20	4.2		off	pre	4.9	18.0	22.8	405	395		51		8		69	71	72	49	25
2017-05-22	1.8		off	pre	1.6	5.8	7.4	135	132		20		7		70	71	72	55	31
2017-05-23	0.5		off	pre	1.5	5.1	6.5	123	117		17		7		71	72	75	56	31
2017-05-27	3.1		on	post	17.5	9.2	11.4	1440	198		23		9		70	71	71	64	27
2017-05-28	2.4		on	post	17.4	6.9	8.5	1440	146		12		12		70	72	74	66	36
2017-05-29	7.2		on	post	17.3	24.0	29.3	1440	457		30		15		66	70	74	65	37
2017-05-30	2.0		on	post	17.4	9.5	11.8	1440	209		19		11		66	70	74	69	39
2017-05-31	5.6		on	post	17.3	16.0	19.7	1440	325		29		11		71	72	74	68	32
2017-06-01	9.6		on	post	17.4	21.6	26.6	1440	435		41		11		70	71	72	60	34
2017-06-02	8.9		on	post	17.4	25.9	32.1	1440	523		48		11		70	71	73	51	31
2017-06-03	8.9		on	post	17.4	22.2	27.6	1440	456		46		10		70	71	71	53	22
2017-06-04	10.6		on	post	17.3	22.2	27.2	1440	433		39		11		70	71	72	63	22
2017-06-05	8.3		on	post	10.2	11.6	14.5	857	244		24		10		71	72	75	68	23
2017-06-06	6.6		on	post	9.7	15.4	19.0	807	312		26		12		71	73	79	55	32
2017-06-07	0.5		on	post	17.4	13.1	16.5	1440	298		34		9		68	70	71	58	28
2017-06-10	12.1		on	post	7.0	29.8	36.7	583	575		49		12		69	70	72	46	32
2017-06-11	17.2		on	post	8.1	36.8	44.8	677	671		56		12		71	72	73	45	22
2017-06-12	18.9		on	post	8.7	40.3	48.9	727	719		58		12		71	72	73	46	32
2017-06-13	19.8		on	post	9.2	43.4	52.5	772	763		55		14		71	72	74	47	35
2017-06-14	17.9		on	post	9.6	44.5	54.0	802	794		54		15		71	72	74	48	37
2017-06-15	12.8		on	post	7.6	32.5	40.1	640	632		60		11		71	72	73	45	33
2017-06-16	11.6		on	post	6.7	28.4	35.0	566	554		54		10		71	72	76	48	38
2017-06-17	13.8		on	post	8.6	39.0	47.5	726	718		47		15		67	70	72	50	34
2017-06-19	14.9		on	post	5.9	26.0	31.7	495	486		45		11		71	73	75	54	29
2017-06-20	13.8		on	post	7.2	31.6	38.7	606	597		55		11		71	72	73	49	35
2017-06-21	15.4		on	post	8.7	38.6	47.2	733	722		54		13		70	71	73	48	33
2017-06-25	14.7		on	post	11.0	19.4	23.7	917	373		25		15		66	70	76	59	30
2017-06-26	11.8		on	post	11.7	19.5	23.9	976	377		33		11		71	73	76	48	22
2017-06-27	9.3		on	post	12.4	28.5	35.1	1040	555		44		13		69	71	74	45	27
2017-06-28	8.4		on	post	5.0	19.6	24.6	424	416		48		9		69	72	74	41	31

Air Conditioning: Humid Climate Site 6 (Washington, D.C.)

DATE	CDD_{65} (°F)	CDD_{adj} (°F)	CNMX	TUNE	Energy (kWh) Fan	+ C1	= TOT	Runtime (min.) Fan	C1	C2	Cycles (#) C1	C2	Dur_{typ} (min.) C1	C2	Zone (°F) Min	Avg	Max	(%) RH	(%) OCC
2017-06-29	13.9		on	post	5.0	21.6	26.5	420	414		44		9		73	74	76	46	30
2017-07-02	18.7		on	post	9.8	45.9	55.7	830	823		55		15		67	70	75	48	27
2017-07-03	19.2		on	post	10.6	49.5	60.0	894	888		53		17		67	70	73	46	32
2017-07-04	17.5		on	post	8.5	38.6	46.9	717	704		57		12		69	71	73	48	35
2017-07-05	13.2		on	post	8.5	37.4	45.8	720	711		54		13		68	70	74	50	39
2017-07-06	11.5		on	post	7.1	29.6	36.6	596	590		59		10		67	69	73	54	36
2017-07-07	15.6		on	post	3.7	15.5	19.1	316	307		39		8		68	72	75	55	32
2017-07-08	15.6		on	post	6.5	29.4	35.7	549	538		32		17		61	71	78	50	29
2017-07-09	13.1		on	post	8.2	35.8	44.0	692	687		53		13		69	71	75	46	32
2017-07-10	16.4		on	post	9.9	45.1	54.8	841	828		61		14		69	69	70	47	30
2017-07-12	21.6		off	post	10.6	52.4	63.0	899	895		46		19		69	71	73	48	34
2017-07-13	22.9		off	post	11.2	55.1	66.2	945	941		49		19		69	71	75	48	27
2017-07-14	17.8		off	post	9.1	43.1	52.1	770	762		52		15		72	73	74	50	40
2017-07-15	17.0		off	post	6.0	26.6	32.5	506	497		51		10		73	73	74	50	41
2017-07-16	15.6		off	post	6.9	32.2	39.0	582	578		27		21		68	72	77	46	30
2017-07-17	17.3		off	post	9.1	44.1	53.1	770	765		29		26		67	72	78	49	28
2017-07-18	18.5		off	post	6.8	33.8	40.6	580	577		20		29		67	73	78	49	30
2017-07-20	23.8		off	post	12.7	63.4	76.1	1080	1074		41		26		65	70	73	48	32
2017-07-21	24.1		off	post	10.4	51.5	61.8	881	871		55		16		72	72	74	47	27
2017-07-22	16.6		off	post	6.4	29.8	36.2	548	541		51		11		72	74	76	49	20
2017-07-23	14.0		off	post	8.5	38.8	47.3	727	718		42		17		69	72	76	49	31
2017-07-24	17.6		off	post	11.8	41.2	49.9	1007	747		46		16		67	71	80	55	28
2017-07-25	11.6		off	post	17.0	33.7	41.3	1440	656		44		15		67	70	72	62	28
2017-07-26	12.3		off	post	17.0	37.9	46.1	1440	710		41		17		68	70	75	60	26
2017-07-27	14.3		off	post	16.8	43.0	52.1	1440	803		45		18		67	69	73	65	26
2017-07-28	10.9		off	post	16.7	4.8	5.8	1440	97		10		10		73	76	78	75	34
2017-07-29	7.5		off	post	16.8	3.6	4.2	1440	71		8		9		72	74	76	68	19
2017-07-30	9.2		off	post	16.9	25.5	31.1	1440	490		36		14		66	71	75	55	24
2017-07-31	13.4		off	post	17.0	42.0	51.2	1440	792		47		17		66	68	73	62	32
2017-08-01	14.9		off	post	16.9	32.1	39.1	1440	608		42		14		67	71	74	64	23
2017-08-02	15.7		off	post	16.9	30.8	37.1	1440	555		33		17		69	73	74	65	24
2017-08-03	14.1		off	post	16.8	29.7	35.9	1440	543		40		14		72	73	74	67	22
2017-08-05	11.5		on	post	17.0	49.5	60.4	1440	931		34		27		57	64	68	57	18
2017-08-06	10.5		on	post	17.0	20.0	24.5	1440	399		36		11		66	69	74	65	23
2017-08-07	7.2		on	post	14.9	15.3	19.0	1266	323		33		10		69	71	73	78	24
2017-08-08	9.1		on	post	16.9	18.4	22.7	1440	381		39		10		70	71	72	73	21
2017-08-09	10.8		on	post	10.7	24.3	29.9	909	492		53		9		70	71	72	57	23
2017-08-10	11.3		on	post	6.5	27.6	34.1	560	551		58		10		70	71	72	48	23
2017-08-11	10.5		on	post	5.7	24.1	29.7	492	483		51		9		68	70	76	49	22
2017-08-12	11.7		on	post	7.0	30.7	37.6	603	593		49		12		67	68	73	51	18
2017-08-13	12.2		on	post	6.2	26.0	32.1	533	525		56		9		67	70	73	48	14
2017-08-14	11.2		on	post	4.8	19.3	23.9	410	402		51		8		71	71	72	49	14
2017-08-15	12.3		on	post	4.8	19.7	24.4	414	403		52		8		71	71	72	51	24
2017-08-16	16.6		on	post	6.8	30.3	37.0	580	574		59		10		71	72	73	49	20
2017-08-17	17.0		on	post	8.5	39.3	47.8	728	723		60		12		71	72	73	49	29
2017-08-18	16.8		on	post	7.9	36.7	44.5	681	665		59		11		71	72	73	50	22
2017-08-19	17.1		on	post	10.6	50.6	61.1	908	901		41		22		67	69	73	48	22
2017-08-20	14.1		on	post	6.3	27.2	33.5	541	534		46		12		67	70	74	47	19
2017-08-21	15.2		on	post	5.8	26.4	32.1	499	490		48		10		73	74	75	50	23
2017-08-22	18.5		on	post	7.4	35.4	42.8	639	634		53		12		73	74	75	48	21
2017-08-23	14.8		on	post	7.3	32.9	40.2	627	621		60		10		69	73	74	46	28
2017-08-24	11.2		on	post	5.1	20.8	25.8	437	428		52		8		69	72	74	44	26
2017-08-25	8.2		on	post	7.0	29.4	36.2	599	589		52		11		67	71	76	45	28
2017-08-26	8.2		on	post	5.4	22.0	27.4	467	462		43		11		66	70	73	46	19
2017-08-27	7.1		on	post	2.2	8.9	11.1	189	184		23		8		73	74	75	47	17
2017-08-28	5.7		on	post	2.5	10.0	12.4	214	211		31		7		72	73	76	48	20
2017-08-29	1.9		on	post	1.3	4.9	6.2	114	111		17		7		72	72	72	58	26
2017-08-30	6.0		on	post	3.2	12.6	15.8	278	269		34		8		71	72	73	53	28
2017-08-31	11.2		on	post	4.9	20.9	25.8	425	414		46		9		72	72	73	51	30
2017-09-01	1.0		on	post	2.5	9.0	11.4	215	211		32		7		72	72	72	46	32
2017-09-03	5.4		on	post	1.4	5.3	6.7	118	116		17		7		71	72	72	56	20
2017-09-04	8.6		on	post	2.8	11.7	14.5	239	238		21		11		65	72	73	52	19
2017-09-05	10.4		on	post	3.4	14.8	18.1	295	285		31		9		71	73	76	54	26
2017-09-06	1.5		on	post	2.0	7.7	9.7	176	173		24		7		68	71	72	58	34
2017-09-07	3.1		on	post	2.9	10.8	13.6	247	244		34		7		69	71	74	52	38
2017-09-08	4.2		on	post	3.7	14.1	17.6	319	307		40		8		70	71	72	46	20
2017-09-09	1.9		on	post	1.3	4.4	5.6	108	104		12		9		70	72	74	46	16
2017-09-10	2.5		on	post	0.7	2.5	3.2	59	58		10		6		69	73	76	46	26
2017-09-11	3.3		on	post	1.2	4.5	5.7	104	102		14		7		69	73	76	47	19

Air Conditioning: Humid Climate Site 6 (Washington, D.C.)

DATE	CDD_{65}	CDD_{adj}			Energy (kWh)			Runtime (min.)			Cycles (#)		Dur_{typ} (min.)		Zone (°F)			(%)	(%)
	(°F)	(°F)	CNMX	TUNE	Fan	+ C1	= TOT	Fan	C1	C2	C1	C2	C1	C2	Min	Avg	Max	RH	OCC
2017-09-12	5.6		on	post	0.6	2.4	3.0	53	52		8		7		72	74	75	50	22
2017-09-13	7.1		on	post	1.4	5.9	7.3	123	119		14		9		72	74	75	54	25
2017-09-14	9.7		on	post	3.8	15.7	19.4	326	321		40		8		72	73	74	51	21
2017-09-16	10.8		off	post	2.8	11.5	14.3	243	242		31		8		71	74	76	50	15
2017-09-17	10.3		off	post	2.3	9.4	11.6	195	191		26		7		74	75	76	53	24
2017-09-18	8.0		off	post	1.4	5.7	7.1	124	121		18		7		74	75	75	57	18
2017-09-19	10.3		off	post	1.7	7.3	9.0	150	146		20		7		74	75	76	58	21
2017-09-20	12.6		off	post	2.3	9.8	12.0	196	189		25		8		74	75	76	53	30
2017-09-21	12.9		off	post	5.9	26.5	32.3	503	495		43		12		71	74	77	50	31
2017-09-22	11.3		off	post	3.9	16.3	20.2	338	334		42		8		71	72	74	49	22
2017-09-23	11.4		off	post	2.8	12.2	15.0	244	239		27		9		73	74	77	49	22
2017-09-24	13.8		off	post	3.7	16.6	20.2	318	312		38		8		74	75	77	49	25
2017-09-25	14.9		off	post	3.7	17.3	21.0	316	312		14		22		70	75	78	49	22
2017-09-26	11.9		off	post	5.3	23.6	28.9	457	452		40		11		71	74	77	51	25
2017-09-27	16.1		off	post	8.7	40.8	49.5	752	740		58		13		70	71	73	49	28
2017-09-28	10.3		off	post	6.9	29.2	35.9	590	580		61		10		70	71	73	46	27
2017-09-29	2.8		off	post	2.4	8.8	11.1	206	201		27		7		70	72	74	43	23
2017-09-30	0.7		off	post	0.7	2.5	3.2	62	61		9		7		71	73	76	42	18
2017-10-01	0.9		off	post	0.1	0.4	0.5	10	10		2		5		68	72	78	41	27
2017-10-02	2.4		off	post	1.2	4.5	5.7	100	100		14		7		69	72	78	46	23
2017-10-03	2.8		off	post	1.7	6.4	8.1	146	146		17		9		69	71	73	48	27
2017-10-04	3.4		off	post	1.2	4.3	5.5	99	99		13		8		70	73	76	49	22
2017-10-05	5.8		off	post	1.8	7.1	8.9	155	152		22		7		71	73	75	49	28
2017-10-06	8.1		off	post	2.4	10.1	12.5	210	204		27		8		73	74	76	50	24
2017-10-07	10.1		off	post	5.5	24.4	29.8	472	466		42		11		71	73	75	50	24
2017-10-08	13.1		off	post	3.3	13.6	16.8	282	273		36		8		71	73	75	54	28
2017-10-09	13.6		off	post	1.3	5.3	6.6	111	108		15		7		74	75	76	59	26
2017-10-10	13.4		off	post	4.4	19.3	23.6	375	367		40		9		71	73	75	53	25
2017-10-11	7.5		off	post	1.9	7.6	9.4	162	156		19		8		71	73	76	58	28
2017-10-12	0.6		off	post	0.5	2.2	2.8	45	45		1		45		68	72	74	62	26
2017-10-14	1.2		off	post	0.2	0.6	0.7	13	13		1		13		69	71	73	62	23

D1.7 AIR CONDITIONING HUMID CLIMATE SITE 7

Due to an uncommon two-condenser configuration, COOLNOMIX was deemed inappropriate for this site and it was disabled by a base technician shortly after the experiment began (likely at the end of May). Here, C1 and C2 each represent separate dual-stage condensers connected in-series with a common single air handling unit. Initially, condenser 2 was not functioning due to a leaky valve that was repaired in early May. In June, we removed and relocated the COOLNOMIX units to Site 6. The limited data collected during an initial testing period are included here for reference only, and no deeper analysis was performed.

Air Conditioning: Humid Climate Site 7

DATE	CDD_{65}	Energy (kWh)			Zone (°F)			(%)	(%)
	(°F)	C1	+ C2	= TOT	T_{min}	T_{avg}	T_{max}	RH	OCC
2016-04-28	0.0	19.0	4.0	23.0	71	74	75	35	72
2016-04-29	0.0	5.4	4.0	9.4	71	74	76	33	73
2016-04-30	0.0	4.8	4.0	8.8	72	75	77	33	62
2016-05-01	0.0	4.8	4.0	8.8	73	74	76	35	61
2016-05-02	1.5	4.8	4.0	8.7	73	77	82	39	71
2016-05-03	1.5	6.3	4.0	10.2	76	79	81	40	71
2016-05-04	0.0	139.2	10.0	149.2	71	76	79	36	73
2016-05-05	0.0	85.7	4.0	89.6	69	72	74	35	73
2016-05-06	0.0	19.4	4.0	23.4	70	72	73	36	71
2016-05-07	0.0	91.2	4.0	95.1	69	71	74	35	65
2016-05-08	1.8	100.9	8.1	109.0	69	72	74	34	56
2016-05-09	0.0	58.2	4.0	62.2	69	72	73	33	72
2016-05-10	0.0	106.6	4.0	110.6	69	72	73	35	73
2016-05-11	0.0	58.6	4.0	62.5	69	72	73	37	71
2016-05-12	0.0	109.9	4.0	113.8	70	72	73	40	71
2016-05-13	3.2	169.2	4.9	174.1	69	72	74	42	71
2016-05-14	1.6	116.7	6.8	123.5	69	72	74	37	62
2016-05-15	0.0	16.0	5.6	21.6	68	71	73	29	68
2016-05-16	0.2	60.4	9.4	69.8	68	71	74	25	74
2016-05-17	0.0	38.9	4.0	42.9	69	72	73	32	71
2016-05-18	0.0	98.1	4.5	102.7	69	72	74	35	72
2016-05-19	0.9	170.0	4.0	173.9	69	72	75	34	71
2016-05-20	3.5	194.4	15.8	210.2	68	72	75	34	73
2016-05-21	0.0	94.8	4.0	98.8	69	72	73	35	63
2016-05-22	0.0	21.0	4.0	25.0	70	72	73	38	56
2016-05-23	1.5	142.8	13.2	156.0	69	72	74	39	72
2016-05-24	7.7	217.0	35.6	252.6	69	73	75	38	71
2016-05-25	9.0	282.7	67.4	350.2	69	73	77	36	71
2016-05-26	10.3	319.0	99.9	418.9	69	73	77	37	70
2016-05-27	13.0	391.7	155.6	547.3	69	73	78	38	71
2016-05-28	12.7	386.0	147.8	533.9	69	73	78	37	63
2016-05-29	6.9	342.9	3.9	346.8	69	73	78	40	55
2016-05-30	8.9	321.2	3.9	325.1	69	73	77	41	39
2016-05-31	12.2	362.2	3.9	366.2	69	74	79	41	74
2016-06-01	12.6	387.1	110.9	498.0	70	74	78	38	75
2016-06-02	8.9	363.4	115.0	478.3	69	72	75	36	76
2016-06-03	9.4	369.1	109.5	478.6	68	72	75	38	71
2016-06-04	10.4	375.5	99.4	474.9	67	71	75	39	63
2016-06-05	10.7	378.2	74.6	452.8	68	71	75	39	55
2016-06-06	12.7	385.7	124.9	510.6	67	71	75	38	71
2016-06-07	11.3	389.3	132.5	521.8	68	72	75	36	72
2016-06-08	3.4	328.3	3.9	332.2	67	70	74	33	63

D2.1 REFRIGERATION DRY CLIMATE: SITES 1-3

The labels “C”, “D”, and “E” refer to three different walk-in coolers, each with their own separate evaporators and compressors. All three coolers were located at the same facility.

Refrigeration: Dry Climate Sites 1-3 (El Paso, TX)

DATE	T_{out}	CNMX			Energy (kWh)			Runtime (min.)			Cycles (#)			Dur_{typ} (min.)			T_{return} (°F)			OCC (%)		
	(°F)	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E
2016-05-05	65.8	on	on	on	8.8	11.0	19.3	482	480	826	153	116	107	3	4	8	37	36	36	4	5	22
2016-05-06	67.1	on	on	on	11.3	17.8	20.3	566	700	817	147	126	87	4	6	9	37	36	36	5	7	19
2016-05-07	65.1	on	on	on	6.7	10.0	15.2	416	457	713	142	112	105	3	4	7	36	36	36	1	3	14
2016-05-08	66.9	on	on	on	6.2	7.0	13.7	401	350	687	143	92	110	3	4	6	36	36	36	2	2	13
2016-05-09	64.5	on	on	on	10.9	13.7	17.9	605	634	840	146	124	99	4	5	8	37	36	36	14	14	29
2016-05-10	67.6	on	on	on	7.5	11.0	20.9	426	512	913	140	122	89	3	4	10	37	36	36	4	7	28
2016-05-11	66.8	on	on	on	8.7	11.2	21.7	466	508	934	139	119	94	3	4	10	37	36	36	4	7	28
2016-05-12	68.2	on	on	on	9.0	12.2	18.3	494	545	802	150	122	86	3	4	9	37	36	36	7	8	23
2016-05-13	72.7	on	on	on	11.1	12.1	17.8	543	511	745	128	118	79	4	4	9	37	36	36	6	6	17
2016-05-14	67.9	on	on	on	5.6	7.2	16.6	322	345	764	103	84	107	3	4	7	37	35	36	1	2	14
2016-05-15	65.8	on	on	on	6.4	8.0	15.3	361	364	658	111	91	75	3	4	9	37	36	36	2	2	12
2016-05-16	68.4	on	on	on	11.5	10.8	19.0	573	481	796	134	106	87	4	5	9	37	36	36	7	5	20
2016-05-17	63.7	on	on	on	7.3	9.1	19.4	427	421	910	132	104	108	3	4	8	37	36	36	3	4	29
2016-05-18	60.9	on	on	on	6.1	8.6	15.5	391	432	825	125	104	126	3	4	7	37	36	36	5	7	26
2016-05-19	63.9	on	on	on	8.4	9.2	15.6	478	458	772	127	109	104	4	4	7	37	35	36	9	8	24
2016-05-20	71.4	on	on	NA	9.8	10.4	NA	483	451	NA	107	98	NA	5	5	-	37	36	NA	5	7	NA
2016-05-21	68.8	on	on	on	5.5	7.2	11.9	292	322	568	82	78	123	4	4	5	37	35	35	0	0	1
2016-05-22	68.4	on	on	on	5.4	6.4	11.8	285	289	564	80	72	126	4	4	4	37	35	35	0	0	0
2016-05-23	72.4	on	on	on	9.5	9.7	19.3	460	415	783	111	97	77	4	4	10	37	35	36	9	5	23
2016-05-24	76.1	on	on	on	7.1	8.7	21.0	374	381	839	109	92	50	3	4	17	37	36	36	4	4	25
2016-05-25	77.0	on	on	on	6.2	9.1	16.5	338	407	671	113	97	55	3	4	12	37	35	36	2	2	13
2016-05-26	76.0	on	on	on	7.7	8.0	15.8	407	365	679	114	91	60	4	4	11	37	36	36	4	3	20
2016-05-27	75.8	on	on	on	6.1	8.0	15.1	349	375	656	110	93	51	3	4	13	37	36	37	3	4	18
2016-05-28	76.9	on	on	on	5.9	7.8	15.1	336	348	652	108	88	77	3	4	8	37	36	36	2	2	11
2016-05-29	77.9	on	on	on	7.9	9.8	16.6	410	420	658	129	101	55	3	4	12	36	36	37	2	2	10
2016-05-30	75.9	on	on	on	6.5	7.8	16.4	351	357	677	107	88	54	3	4	13	37	35	37	2	3	12
2016-05-31	75.6	on	on	on	8.1	11.5	17.9	433	508	762	122	111	53	4	5	14	37	36	37	6	6	22
2016-06-01	73.4	on	on	on	9.9	9.7	15.1	522	472	699	128	112	62	4	4	11	37	36	37	6	6	20
2016-06-02	73.7	on	on	on	6.3	8.7	18.9	368	404	797	125	99	50	3	4	16	37	36	37	3	4	21
2016-06-03	78.1	on	on	on	8.5	11.1	19.6	425	462	777	114	105	55	4	4	14	37	36	37	4	5	15
2016-06-04	79.4	on	on	on	6.1	10.9	14.1	310	446	557	90	112	53	3	4	11	37	35	36	0	0	0
2016-06-05	79.9	on	on	on	6.0	8.4	18.6	314	370	703	97	92	47	3	4	15	37	36	36	1	0	4
2016-06-06	81.8	on	on	on	8.6	10.8	24.3	414	443	923	120	110	80	3	4	12	37	35	36	5	5	21
2016-06-07	81.5	on	on	on	8.0	10.8	26.2	396	448	928	119	105	41	3	4	23	36	35	36	3	5	26
2016-06-08	76.6	on	on	NA	8.0	10.8	NA	396	446	NA	129	103	NA	3	4	-	36	36	NA	3	5	NA
2016-06-09	78.9	on	on	NA	10.9	13.1	NA	508	506	NA	133	108	NA	4	5	-	37	36	NA	5	7	NA
2016-06-10	80.6	on	on	NA	10.8	15.7	NA	503	595	NA	142	126	NA	4	5	-	36	36	NA	4	8	NA
2016-06-11	82.3	on	on	on	7.7	10.5	17.9	419	434	687	140	108	55	3	4	12	36	36	36	3	3	13
2016-06-12	85.1	on	on	NA	7.2	10.7	NA	367	431	NA	131	102	NA	3	4	-	36	36	NA	2	3	NA
2016-06-13	81.6	on	on	on	10.2	15.2	26.8	492	578	940	148	126	46	3	5	20	37	36	36	5	11	25
2016-06-14	79.7	on	on	on	8.6	12.0	26.2	438	492	963	143	112	53	3	4	18	36	36	37	5	7	25
2016-06-15	81.0	on	on	NA	13.4	15.9	NA	618	601	NA	158	126	NA	4	5	-	37	36	NA	9	8	NA
2016-06-16	82.3	on	on	NA	9.1	11.5	NA	463	472	NA	137	115	NA	3	4	-	37	36	NA	3	4	NA
2016-06-17	81.3	on	on	on	13.3	10.4	10.0	587	417	403	135	105	78	4	4	5	36	36	36	4	2	0
2016-06-18	83.4	on	on	on	7.5	12.4	9.7	362	493	375	104	120	60	3	4	6	36	36	36	0	0	0
2016-06-19	83.0	on	on	on	6.8	8.5	16.0	337	353	588	99	94	56	3	4	11	36	36	36	1	0	2
2016-06-20	82.7	on	on	on	10.7	14.4	27.5	497	572	987	122	131	37	4	4	27	36	36	37	4	5	20
2016-06-21	82.2	on	on	NA	9.4	13.6	NA	442	548	NA	120	127	NA	4	4	-	36	35	NA	3	4	NA
2016-06-22	84.9	on	on	on	9.9	16.6	32.3	454	604	1076	132	134	34	3	5	32	36	36	37	3	4	24
2016-06-23	83.5	on	on	on	10.4	15.9	28.1	455	562	950	127	118	44	4	5	22	37	36	37	6	7	20
2016-06-24	82.4	on	on	on	9.7	13.2	25.1	470	507	881	139	116	47	3	4	19	37	35	36	3	6	17
2016-06-25	80.9	on	on	on	8.0	10.2	19.9	409	425	745	126	103	43	3	4	17	37	36	36	3	2	14
2016-06-26	78.9	on	on	on	7.7	9.4	19.5	415	423	768	131	102	38	3	4	20	37	36	36	3	3	16
2016-06-29	78.9	off	off	off	12.0	12.3	23.2	509	441	887	67	42	37	8	11	24	37	36	37	9	5	22
2016-06-30	79.9	off	off	off	11.7	14.2	18.0	494	479	674	77	39	50	6	12	13	37	36	38	8	8	15
2016-07-01	78.5	off	off	off	6.0	7.0	7.1	304	282	316	77	36	51	4	8	6	37	36	37	0	0	0
2016-07-02	79.5	off	off	off	6.3	7.4	7.8	304	270	321	73	34	51	4	8	6	37	36	37	0	0	0
2016-07-03	79.8	off	off	off	7.8	8.4	12.0	349	289	450	76	35	64	5	8	7	37	36	37	0	0	2
2016-07-04	82.2	off	off	off	7.4	8.9	10.0	315	292	365	73	34	57	4	9	6	37	36	37	0	0	0
2016-07-05	90.7	off	off	off	12.5	12.6	22.2	475	398	748	79	40	50	6	10	15	37	36	37	6	2	18
2016-07-06	90.3	off	off	off	9.6	12.7	24.3	380	406	818	67	42	45	6	10	18	37	36	37	2	2	18
2016-07-07	87.9	off	off	off	9.3	13.4	24.3	381	436	837	62	42	44	6	10	19	37	36	37	5	4	23

Refrigeration: Dry Climate Sites 1-3 (El Paso, TX)

DATE	T_{out}	CNMX			Energy (kWh)			Runtime (min.)			Cycles (#)			Dur_{typ} (min.)			T_{return} (°F)			OCC (%)		
	(°F)	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E
2016-07-08	86.6	off	off	off	11.3	14.3	21.4	451	469	760	70	41	58	6	11	13	37	36	37	4	4	22
2016-07-09	86.5	off	off	off	8.8	10.1	22.1	360	343	773	58	37	46	6	9	17	37	36	37	2	1	17
2016-07-10	88.1	off	off	off	9.2	11.1	23.0	366	351	776	68	35	64	5	10	12	37	36	37	2	3	13
2016-07-12	86.8	off	off	off	9.7	12.6	27.4	408	396	933	86	35	58	5	11	16	37	36	37	2	2	24
2016-07-13	88.2	off	off	off	9.3	12.8	27.3	371	400	929	71	37	61	5	11	15	37	36	37	3	4	20
2016-07-14	90.7	off	off	off	13.7	15.0	26.2	490	453	887	66	33	70	7	14	13	37	36	37	5	5	22
2016-07-15	87.0	off	off	off	8.0	11.0	17.1	346	369	625	70	38	73	5	10	9	37	36	37	1	3	12
2016-07-16	84.4	off	off	NA	7.2	8.9	NA	314	305	NA	66	36	NA	5	8	-	37	36	NA	0	0	NA
2016-07-17	86.1	off	off	NA	7.7	12.3	NA	326	390	NA	67	36	NA	5	11	-	37	36	NA	1	2	NA
2016-07-18	85.0	off	off	off	11.1	12.1	25.6	451	410	923	70	42	60	6	10	15	37	36	37	4	4	25
2016-07-20	83.4	on	on	off	11.3	11.3	25.2	527	438	894	144	101	49	4	4	18	37	35	37	6	4	24
2016-07-21	85.3	on	on	off	10.0	13.1	26.4	461	485	912	136	105	52	3	5	18	37	35	37	4	6	27
2016-07-22	87.5	on	on	off	11.6	14.7	27.0	543	542	928	159	111	52	3	5	18	37	35	37	4	7	25
2016-07-23	90.5	on	on	off	8.9	12.4	25.2	437	448	862	149	105	55	3	4	16	37	35	36	1	3	18
2016-07-24	90.4	on	on	off	11.0	17.9	24.8	494	638	846	144	126	57	3	5	15	37	36	36	5	4	19
2016-07-25	90.2	on	on	off	8.4	13.7	26.1	412	518	900	152	119	44	3	4	20	36	35	37	1	5	26
2016-07-26	86.9	on	on	off	7.4	11.7	24.2	403	471	898	146	109	42	3	4	21	37	35	36	2	5	26
2016-07-27	85.0	on	on	NA	9.8	11.9	NA	528	503	NA	164	113	NA	3	4	-	37	35	NA	3	7	NA
2016-07-28	85.6	on	on	off	8.0	12.3	24.3	422	495	870	151	121	41	3	4	21	37	36	37	2	5	28
2016-07-29	84.2	on	on	off	10.3	17.0	20.8	529	650	753	164	134	43	3	5	18	37	36	37	4	10	19
2016-07-30	83.0	on	on	off	7.0	8.6	9.9	392	359	389	146	87	52	3	4	7	37	35	36	0	0	0
2016-07-31	83.6	on	on	off	6.9	8.6	13.5	383	349	521	142	86	54	3	4	10	37	35	37	1	0	4
2016-08-01	83.0	on	on	NA	12.1	15.3	NA	594	604	NA	165	129	NA	4	5	-	37	36	NA	5	7	NA
2016-08-03	79.0	off	off	off	10.9	13.4	23.4	502	485	902	107	45	38	5	11	24	37	36	37	4	8	27
2016-08-04	80.5	off	off	off	8.3	11.7	24.2	401	423	897	103	50	45	4	8	20	37	36	37	2	5	28
2016-08-05	82.0	off	off	off	10.3	16.6	25.8	455	547	925	101	41	46	5	13	20	37	36	38	4	6	29
2016-08-06	83.7	off	off	off	8.7	15.4	26.0	421	514	935	111	39	37	4	13	25	36	36	37	1	4	25
2016-08-07	84.2	off	off	off	7.6	14.5	23.1	364	490	845	98	40	49	4	12	17	37	36	36	0	3	19
2016-08-08	81.8	off	off	off	8.8	16.3	25.1	417	544	905	103	41	45	4	13	20	37	36	37	2	8	29
2016-08-09	79.3	off	off	off	7.2	13.1	20.1	355	460	774	100	42	43	4	11	18	37	36	36	1	6	23
2016-08-10	82.0	NA	off	off	NA	13.8	24.9	NA	510	965	NA	45	33	-	11	29	NA	36	37	NA	9	31
2016-08-11	85.3	off	off	off	6.8	10.7	21.6	343	395	839	92	44	52	4	9	16	37	36	37	1	4	25
2016-08-12	87.0	off	off	off	8.4	14.3	16.9	399	485	647	93	35	52	4	14	12	37	36	37	2	6	14
2016-08-13	82.4	off	off	off	5.7	6.9	8.3	319	278	376	88	32	44	4	9	9	37	36	37	0	0	0
2016-08-14	83.1	off	off	off	5.7	7.1	12.6	313	279	535	86	32	37	4	9	14	37	36	37	0	0	5
2016-08-16	83.3	off	off	off	6.8	13.4	22.6	339	481	873	88	45	46	4	11	19	37	36	36	1	8	26
2016-08-17	83.4	off	off	off	8.8	11.4	22.1	424	419	865	100	43	44	4	10	20	37	36	36	4	5	27
2016-08-18	81.5	off	off	off	7.3	12.9	22.6	370	465	863	94	41	41	4	11	21	37	36	36	2	6	27
2016-08-19	82.2	off	off	off	9.4	13.6	23.0	461	493	890	104	45	38	4	11	23	37	36	37	3	8	26
2016-08-20	80.3	off	off	off	6.6	10.0	19.2	351	392	807	95	43	50	4	9	16	37	36	36	0	3	23
2016-08-21	76.4	off	off	off	5.6	9.5	14.8	304	383	656	87	46	54	3	8	12	37	36	36	1	3	17
2016-08-23	75.8	off	off	off	6.9	10.9	17.7	372	419	734	100	43	42	4	10	17	37	36	36	1	4	23
2016-08-24	77.9	off	off	off	8.7	14.0	20.8	418	515	833	90	41	37	5	13	23	37	36	37	2	7	27
2016-08-27	81.1	off	off	off	5.8	7.0	8.5	316	280	363	89	39	40	4	7	9	36	36	36	0	0	0
2016-08-28	78.8	off	off	off	5.4	6.5	7.6	296	265	329	86	39	37	3	7	9	36	36	36	0	0	0
2016-08-29	79.6	off	off	off	9.3	11.2	20.3	473	437	822	111	47	41	4	9	20	36	36	37	4	7	27
2016-08-30	76.7	off	off	off	6.7	9.2	19.3	372	382	864	97	45	48	4	8	18	36	36	37	3	6	31
2016-09-03	77.4	on	on	on	7.5	11.1	19.3	428	465	792	153	111	48	3	4	17	37	35	36	0	2	8
2016-09-04	78.6	on	on	on	6.5	11.3	22.1	366	455	884	136	108	51	3	4	17	37	35	36	0	1	12
2016-09-05	80.3	on	on	on	8.0	13.1	19.2	423	522	725	149	117	58	3	4	13	36	35	37	2	3	11
2016-09-06	78.3	on	on	on	6.4	9.9	16.0	392	474	716	138	112	63	3	4	11	36	35	36	1	5	20
2016-09-07	77.9	on	on	on	6.5	11.2	22.2	377	500	980	128	116	42	3	4	23	37	36	36	2	5	25
2016-09-08	80.8	on	on	on	7.7	12.8	24.2	439	556	1053	143	105	35	3	5	30	37	36	37	3	3	23
2016-09-09	83.1	on	on	on	8.1	11.3	18.5	466	476	816	151	99	49	3	5	17	37	36	36	3	7	15
2016-09-10	79.2	on	on	on	5.5	6.7	7.0	350	311	330	136	76	53	3	4	6	37	35	37	0	0	0
2016-09-11	77.9	on	on	on	5.7	6.9	15.8	349	321	781	135	81	78	3	4	10	37	36	37	1	1	3
2016-09-12	77.6	on	on	on	8.7	11.6	19.5	482	510	828	162	119	54	3	4	15	37	36	37	3	6	19
2016-09-13	78.4	on	on	on	6.6	10.5	21.8	404	456	899	147	107	48	3	4	19	36	35	37	1	5	28
2016-09-15	76.0	on	on	on	7.7	13.3	21.0	434	558	820	156	133	51	3	4	16	36	35	37	2	5	30
2016-09-17	76.5	on	on	on	5.9	10.3	16.8	359	450	690	136	109	51	3	4	14	36	35	37	0	4	15
2016-09-18	79.0	on	on	on	6.3	9.2	19.5	370	402	766	134	98	44	3	4	17	37	35	37	1	3	20
2016-09-19	77.3	on	on	on	6.8	12.6	19.6	397	534	790	139	125	62	3	4	13	36	35	36	3	7	24
2016-09-20	79.0	on	on	on	7.6	12.6	22.6	408	513	852	139	121	53	3	4	16	37	36	37	3	8	24
2016-09-21	80.2	on	on	on	7.7	13.0	21.6	418	539	812	144	126	49	3	4	17	36	36	37	2	6	23
2016-09-22	79.3	on	on	on	6.9	11.0	22.4	382	449	843	137	112	50	3	4	17	36	36	37	2	5	27
2016-09-23	78.3	on	on	on	8.5	11.0	15.7	482	470	655	153	112	44	3	4	15	36	36	36	5	6	15
2016-09-24	72.9	on	on	on	5.5	6.8	8.0	350	325	374	135	89	42	3	4	9	36	36	36	0	0	0
2016-09-25	68.1	on	on	on	5.2	6.3	13.8	341	320	657	131	87	52	3	4	13	36	36	36	1	0	5
2016-09-29	71.8	off	off	off	7.0	11.6	18.3	353	451	765	98	56	51	4	8	15	36	36	36	1	5	22

Refrigeration: Dry Climate Sites 1-3 (El Paso, TX)

DATE	T_{out}	CNMX			Energy (kWh)			Runtime (min.)			Cycles (#)			Dur_{typ} (min.)			T_{return} (°F)			OCC (%)		
	(°F)	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E
2016-10-01	69.3	off	off	off	5.4	8.4	15.0	307	353	652	86	50	54	4	7	12	36	36	36	0	2	10
2016-10-02	71.6	off	off	off	7.3	9.8	19.1	387	394	831	102	55	50	4	7	17	36	36	36	3	2	15
2016-10-04	69.3	off	off	off	7.7	10.9	17.2	420	440	759	100	45	53	4	10	14	36	36	37	5	8	19
2016-10-06	68.5	off	off	off	7.0	11.8	16.5	380	468	714	104	47	49	4	10	15	36	36	36	2	8	28
2016-10-08	65.7	off	off	off	7.9	10.7	16.3	428	443	759	105	41	60	4	11	13	37	36	36	1	5	20
2016-10-09	65.3	off	off	off	7.8	10.5	18.5	408	434	806	97	51	45	4	9	18	37	36	36	3	7	30
2016-10-10	64.3	off	NA	off	11.9	NA	18.3	560	NA	791	91	NA	50	6	-	16	37	NA	37	10	NA	24
2016-10-11	66.2	off	off	off	12.3	12.8	21.2	484	471	868	102	48	53	5	10	16	37	36	37	4	8	29
2016-10-12	67.0	off	off	off	16.6	15.3	22.9	625	565	952	99	56	53	6	10	18	37	36	37	7	12	36
2016-10-13	66.8	off	off	off	11.4	15.7	20.7	465	607	905	96	54	52	5	11	17	37	36	37	3	10	36
2016-10-15	66.0	on	on	on	9.4	13.0	19.3	463	560	810	147	135	64	3	4	13	37	35	36	2	6	21
2016-10-16	68.5	on	on	on	8.5	12.7	16.6	430	557	716	138	132	73	3	4	10	37	35	36	1	7	21
2016-10-18	72.5	on	on	on	10.5	15.5	22.3	521	676	961	163	151	62	3	4	16	37	35	36	4	12	38
2016-10-19	73.5	on	on	on	10.0	13.9	19.2	499	632	859	165	144	77	3	4	11	36	35	36	5	9	34
2016-10-20	70.3	on	on	on	8.0	13.4	19.3	461	631	912	165	143	82	3	4	11	36	36	36	3	6	36
2016-10-21	66.3	on	on	on	11.7	15.8	17.7	582	713	843	173	138	89	3	5	9	37	36	36	7	11	30
2016-10-22	61.3	on	on	on	8.2	11.2	17.1	438	511	777	153	119	71	3	4	11	37	35	36	2	7	22
2016-10-23	63.2	on	on	on	9.2	11.9	18.5	484	523	829	162	120	76	3	4	11	36	35	36	3	9	25
2016-10-24	65.9	NA	on	on	NA	13.8	20.4	NA	604	889	NA	138	63	-	4	14	NA	35	37	NA	8	27
2016-10-25	64.2	NA	on	on	NA	12.3	21.8	NA	558	954	NA	129	66	-	4	14	NA	35	36	NA	8	34
2016-10-26	61.7	NA	on	on	NA	14.4	22.2	NA	618	961	NA	133	53	-	5	18	NA	36	36	NA	10	32
2016-10-27	64.6	NA	on	on	NA	14.3	20.4	NA	627	894	NA	139	56	-	5	16	NA	36	37	NA	8	29
2016-10-28	62.9	NA	on	on	NA	14.3	20.7	NA	655	922	NA	146	62	-	4	15	NA	36	37	NA	10	26
2016-10-29	65.3	NA	on	on	NA	14.1	20.3	NA	631	908	NA	141	63	-	4	14	NA	36	36	NA	7	23
2016-10-30	68.1	NA	on	on	NA	13.1	18.4	NA	591	836	NA	139	77	-	4	11	NA	35	36	NA	7	24
2016-10-31	63.5	NA	on	on	NA	15.5	19.4	NA	656	850	NA	131	57	-	5	15	NA	36	36	NA	11	21
2016-11-01	64.0	NA	on	on	NA	12.1	16.9	NA	549	762	NA	123	66	-	4	12	NA	36	36	NA	8	23
2016-11-02	65.5	NA	on	NA	NA	11.2	NA	NA	526	NA	NA	123	NA	-	4	-	NA	36	NA	NA	6	NA
2016-11-03	66.5	on	on	NA	16.6	10.0	NA	693	489	NA	38	115	NA	18	4	-	39	36	NA	1	4	NA
2016-11-04	61.5	on	on	NA	14.5	11.4	NA	662	528	NA	91	118	NA	7	4	-	37	36	NA	0	3	NA
2016-11-05	60.3	on	on	NA	8.9	6.4	NA	444	312	NA	128	77	NA	3	4	-	36	35	NA	0	0	NA
2016-11-06	60.6	on	on	on	6.7	6.2	14.7	329	306	698	85	75	63	4	4	11	36	35	38	0	0	4
2016-11-08	57.6	on	on	on	11.5	11.3	16.0	545	550	773	157	129	63	3	4	12	37	36	37	3	5	22
2016-11-09	55.4	on	on	on	6.5	10.7	12.0	384	521	600	134	131	76	3	4	8	37	36	36	1	5	17
2016-11-11	56.1	off	off	off	8.5	15.0	12.4	438	618	648	108	50	62	4	12	10	36	36	36	1	5	8
2016-11-12	50.5	off	off	off	5.6	7.5	12.2	296	321	620	85	44	66	3	7	9	37	36	37	0	3	9
2016-11-13	51.7	off	off	off	6.2	8.6	13.6	316	385	687	87	62	67	4	6	10	37	37	36	0	2	13
2016-11-14	53.1	off	off	off	7.8	10.2	12.2	373	444	616	91	65	82	4	7	8	37	37	37	2	6	20
2016-11-15	56.3	off	off	off	6.6	10.6	15.9	331	475	772	86	75	77	4	6	10	37	37	37	1	4	22
2016-11-16	56.6	off	off	off	9.5	11.2	16.2	419	473	780	88	67	67	5	7	12	37	36	37	3	6	20
2016-11-18	54.1	off	off	off	6.5	9.3	10.7	331	415	547	88	69	74	4	6	7	36	36	37	1	7	13
2016-11-19	51.3	off	off	off	5.5	8.6	8.1	290	377	434	78	56	75	4	7	6	36	37	37	0	2	2
2016-11-20	47.6	off	off	off	5.7	6.3	10.6	295	274	522	80	37	67	4	7	8	36	36	36	1	0	5
2016-11-23	47.3	off	off	off	6.1	8.8	14.5	357	396	726	84	62	84	4	6	9	37	36	36	2	7	23
2016-11-24	50.5	off	off	off	4.4	5.5	9.4	262	261	496	74	56	94	4	5	5	37	36	36	0	0	0
2016-11-25	51.4	off	off	off	4.4	5.6	9.5	258	266	501	76	57	81	3	5	6	36	36	36	0	0	0
2016-11-26	51.0	off	off	off	4.5	5.7	10.5	262	265	522	75	56	72	3	5	7	37	36	36	0	0	0
2016-11-28	47.8	off	off	off	8.8	11.6	15.6	479	508	738	92	72	65	5	7	11	37	36	37	8	7	23
2016-11-29	51.1	off	off	off	4.7	7.6	15.6	285	339	740	81	57	77	4	6	10	36	36	37	2	6	21
2016-11-30	50.9	off	off	off	6.3	9.1	13.5	367	411	681	98	65	96	4	6	7	36	36	37	4	6	19
2016-12-01	48.6	off	off	off	5.2	8.3	12.9	320	378	639	89	65	89	4	6	7	36	36	37	2	6	20
2016-12-02	48.8	off	off	off	5.8	8.4	11.6	341	378	566	88	61	70	4	6	8	36	36	36	3	5	18
2016-12-03	44.6	off	off	off	4.4	7.9	12.0	275	368	606	81	69	91	3	5	7	36	36	37	0	3	11
2016-12-04	44.4	off	off	off	4.4	7.6	14.1	270	359	694	78	68	93	3	5	7	36	36	37	1	3	18
2016-12-05	48.2	off	off	off	5.9	9.6	14.1	347	437	684	88	71	85	4	6	8	37	36	37	4	9	20
2016-12-06	49.0	off	off	off	5.1	7.8	16.8	302	357	826	81	64	58	4	6	14	36	36	36	1	6	25
2016-12-07	49.5	off	off	off	6.0	9.4	21.2	334	426	1094	85	72	38	4	6	29	36	36	36	3	7	16
2016-12-08	39.9	off	off	off	4.6	8.3	15.4	275	383	800	76	64	103	4	6	8	36	36	37	2	7	23
2016-12-09	35.7	off	off	off	5.3	10.0	14.9	331	446	757	83	65	94	4	7	8	36	37	36	3	12	20
2016-12-10	38.8	off	off	off	5.3	8.0	16.0	315	365	788	83	60	80	4	6	10	36	36	36	1	4	18
2016-12-11	48.0	off	off	off	5.0	6.8	13.7	284	308	656	75	53	58	4	6	11	37	36	36	1	3	13
2016-12-12	52.4	off	off	off	5.7	9.5	16.5	323	417	818	85	56	58	4	7	14	36	36	36	2	7	18
2016-12-13	51.7	off	off	off	5.7	9.2	15.2	330	403	737	89	57	74	4	7	10	36	36	36	2	8	18
2016-12-15	41.9	off	off	off	5.2	7.8	14.0	308	351	686	83	63	73	4	6	9	36	36	36	1	5	18
2016-12-17	44.2	on	on	on	4.3	5.6	10.9	296	292	568	109	95	110	3	3	5	36	36	36	0	0	0
2016-12-18	44.5	on	on	on	4.2	5.4	8.3	288	287	475	108	92	116	3	3	4	36	36	36	0	0	1
2016-12-19	37.5	on	on	on	4.6	6.7	9.0	322	355	501	117	97	109	3	4	5	36	36	36	1	2	11
2016-12-20	37.9	on	on	on	6.8	6.1	6.6	403	323	395	126	91	95	3	4	4	37	36	36	2	0	1
2016-12-21	45.5	on	on	on	4.5	5.6	5.8	303	294	331	122	83	78	2	4	4	36	36	36	0	0	0

Refrigeration: Dry Climate Sites 1-3 (El Paso, TX)

DATE	T_{out}	CNMX			Energy (kWh)			Runtime (min.)			Cycles (#)			Dur_{typ} (min.)			T_{return} (°F)			OCC (%)		
	(°F)	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E
2016-12-22	46.8	on	on	on	4.4	7.0	7.4	302	344	430	116	93	87	3	4	5	36	36	36	0	1	1
2016-12-23	45.1	on	on	on	4.3	5.5	6.8	292	284	395	113	79	96	3	4	4	36	36	36	0	0	0
2016-12-24	48.7	on	on	on	4.5	5.6	6.1	296	283	338	114	79	86	3	4	4	36	36	36	0	0	0
2016-12-25	43.9	on	on	on	4.1	5.4	6.3	293	280	369	114	79	105	3	4	4	36	36	36	0	0	0
2016-12-26	42.3	on	on	on	4.1	5.4	5.8	286	280	363	111	79	109	3	4	3	36	36	36	0	0	0
2016-12-27	51.4	on	on	on	4.3	5.6	10.6	299	293	574	117	81	106	3	4	5	36	36	36	0	1	4
2016-12-29	44.0	on	on	on	4.6	6.9	12.6	323	351	666	123	95	112	3	4	6	36	36	36	1	2	16
2016-12-30	41.7	on	on	on	5.2	7.4	13.5	355	385	676	135	100	108	3	4	6	36	36	36	2	4	6
2016-12-31	45.0	on	on	on	4.8	7.4	13.8	343	375	690	132	103	93	3	4	7	36	36	36	1	2	10
2017-01-01	47.1	on	on	on	4.3	7.5	13.5	301	378	677	120	104	102	3	4	7	36	36	36	0	2	6
2017-01-02	45.6	on	on	on	4.7	7.3	14.4	332	370	706	129	99	75	3	4	9	36	36	36	1	2	13
2017-01-03	47.3	on	on	on	4.7	7.3	15.3	340	373	754	131	100	89	3	4	8	36	36	36	2	5	20
2017-01-04	52.0	on	on	on	4.7	8.0	14.8	323	402	709	127	112	77	3	4	9	36	36	36	1	4	15
2017-01-05	45.1	on	on	on	4.9	9.3	15.4	338	451	762	131	118	93	3	4	8	36	36	36	1	4	16
2017-01-06	38.9	on	on	on	7.1	7.7	12.8	465	398	634	146	109	86	3	4	7	36	36	36	4	6	13
2017-01-07	30.2	on	on	on	4.4	5.5	6.9	317	292	407	126	88	106	3	3	4	36	36	36	0	0	0
2017-01-08	32.3	on	on	on	4.4	5.6	6.8	302	289	389	124	88	103	2	3	4	36	36	36	0	0	0
2017-01-09	39.0	on	on	on	6.9	9.3	16.5	452	472	812	151	120	83	3	4	10	36	36	36	5	7	17
2017-01-10	46.0	on	on	on	5.5	7.8	17.3	366	394	814	135	102	52	3	4	16	36	36	36	2	5	19
2017-01-12	57.3	on	on	on	5.0	8.2	15.6	344	420	753	130	115	76	3	4	10	36	36	36	2	5	17
2017-01-14	46.7	on	on	on	4.6	6.0	12.1	314	314	584	124	95	61	3	3	10	36	36	36	0	0	0
2017-01-15	43.9	on	on	on	4.3	5.6	14.4	300	301	696	120	93	73	3	3	10	36	36	36	0	0	0
2017-01-16	44.7	on	on	on	4.3	5.9	11.8	304	312	588	119	93	58	3	3	10	36	36	36	0	1	4
2017-01-17	44.9	on	on	on	4.6	9.5	17.4	326	468	830	126	118	84	3	4	10	36	36	36	2	7	23
2017-01-19	48.8	off	off	off	5.7	7.7	18.0	341	330	850	86	35	48	4	9	18	36	36	36	3	7	20
2017-01-21	46.9	off	off	off	4.4	7.1	17.7	271	318	831	76	46	62	4	7	13	37	36	36	1	4	14
2017-01-22	47.8	off	off	off	4.3	7.1	19.7	264	312	949	73	43	52	4	7	18	37	36	36	1	5	19
2017-01-24	47.4	off	off	off	5.8	9.8	22.3	323	421	1029	69	61	44	5	7	23	37	36	36	5	11	26
2017-01-25	47.6	NA	off	off	NA	7.8	19.6	NA	348	920	NA	55	64	-	6	14	NA	36	36	NA	9	23
2017-01-26	45.9	off	off	off	6.2	8.4	18.6	321	383	867	61	67	65	5	6	13	37	36	36	2	7	29
2017-01-28	39.1	off	off	off	5.4	7.9	15.1	293	353	732	59	50	75	5	7	10	37	36	36	1	3	17
2017-01-29	41.3	off	off	off	4.7	6.9	16.9	265	303	799	58	43	60	5	7	13	37	36	36	1	4	18
2017-02-02	47.6	off	off	off	5.9	9.3	18.8	332	413	883	76	62	60	4	7	15	37	36	36	6	10	34
2017-02-04	44.1	off	off	off	5.5	8.4	16.1	329	387	770	92	69	59	4	6	13	37	36	36	2	10	32
2017-02-09	48.1	off	off	off	6.6	10.1	19.7	367	439	921	86	59	51	4	7	18	37	36	36	4	17	32
2017-02-11	57.7	off	off	off	6.7	9.1	21.1	357	370	947	87	46	39	4	8	24	37	36	36	2	8	26
2017-02-12	53.3	off	off	off	5.1	7.5	18.4	304	336	878	80	50	44	4	7	20	37	36	36	2	8	28
2017-02-13	43.0	off	off	off	5.2	9.5	15.9	309	410	762	80	57	73	4	7	10	37	36	36	3	11	27
2017-02-14	42.8	off	off	off	5.1	7.8	18.6	303	335	875	80	43	58	4	8	15	37	36	36	4	10	31
2017-02-16	42.1	off	off	NA	4.8	7.6	NA	281	327	NA	73	40	NA	4	8	-	36	36	NA	1	4	NA
2017-02-18	52.6	off	off	NA	4.8	6.7	NA	268	303	NA	64	49	NA	4	6	-	37	36	NA	0	2	NA
2017-02-19	56.8	off	off	NA	4.7	7.0	NA	268	304	NA	67	43	NA	4	7	-	37	36	NA	0	2	NA
2017-02-21	54.0	off	off	NA	5.4	7.7	NA	304	337	NA	84	50	NA	4	7	-	37	36	NA	1	5	NA
2017-02-22	58.9	off	off	NA	5.7	8.1	NA	305	345	NA	79	47	NA	4	7	-	37	36	NA	4	6	NA
2017-02-24	58.8	off	off	NA	5.2	7.8	NA	304	344	NA	85	56	NA	4	6	-	37	36	NA	2	5	NA
2017-02-25	57.2	off	off	NA	5.1	7.3	NA	305	310	NA	85	37	NA	4	8	-	37	36	NA	0	3	NA
2017-02-26	48.9	off	off	NA	4.4	7.6	NA	259	332	NA	74	48	NA	4	7	-	37	36	NA	0	2	NA
2017-02-27	52.4	off	off	NA	6.5	7.4	NA	367	328	NA	87	47	NA	4	7	-	37	36	NA	4	5	NA
2017-03-01	59.7	off	off	NA	5.8	8.4	NA	346	389	NA	92	71	NA	4	5	-	36	36	NA	1	4	NA
2017-03-02	51.6	off	off	NA	5.1	8.4	NA	302	390	NA	80	67	NA	4	6	-	37	36	NA	2	6	NA
2017-03-03	46.9	off	off	NA	5.3	8.1	NA	307	361	NA	83	53	NA	4	7	-	37	36	NA	1	5	NA
2017-03-07	59.4	off	off	NA	5.7	8.0	NA	334	360	NA	87	70	NA	4	5	-	37	37	NA	1	5	NA
2017-03-08	60.4	off	off	NA	6.6	9.1	NA	365	397	NA	92	64	NA	4	6	-	36	36	NA	3	7	NA
2017-03-09	62.4	off	off	NA	5.9	8.2	NA	330	362	NA	86	65	NA	4	6	-	36	36	NA	2	7	NA
2017-03-10	55.0	off	off	NA	7.0	11.6	NA	379	465	NA	92	61	NA	4	8	-	37	36	NA	3	10	NA
2017-03-11	50.1	off	off	NA	5.0	6.0	NA	277	267	NA	74	48	NA	4	6	-	37	36	NA	0	0	NA
2017-03-14	50.2	off	off	NA	6.0	8.9	NA	330	357	NA	86	38	NA	4	9	-	37	36	NA	1	4	NA
2017-03-16	53.1	off	off	NA	7.0	10.8	NA	365	426	NA	94	43	NA	4	10	-	37	36	NA	3	9	NA
2017-03-17	55.4	off	off	NA	9.2	10.5	NA	472	412	NA	102	42	NA	5	10	-	37	36	NA	4	7	NA
2017-03-18	59.3	off	off	NA	8.7	6.4	NA	448	250	NA	104	29	NA	4	9	-	36	36	NA	0	0	NA
2017-03-19	59.7	off	off	NA	6.4	6.8	NA	344	263	NA	90	30	NA	4	9	-	36	36	NA	1	0	NA
2017-03-20	60.8	off	off	NA	8.9	10.7	NA	442	413	NA	99	44	NA	4	9	-	37	36	NA	5	11	NA
2017-03-21	64.3	off	off	NA	7.6	10.7	NA	383	414	NA	97	48	NA	4	9	-	37	36	NA	2	8	NA
2017-03-22	60.7	off	off	NA	7.6	11.4	NA	382	431	NA	93	46	NA	4	9	-	37	36	NA	4	10	NA
2017-03-24	55.0	off	off	NA	6.9	10.9	NA	394	456	NA	98	51	NA	4	9	-	36	36	NA	3	13	NA
2017-03-25	65.2	off	off	NA	4.7	6.0	NA	262	249	NA	75	33	NA	3	8	-	37	36	NA	0	0	NA
2017-03-26	58.1	off	off	NA	4.7	5.6	NA	269	241	NA	76	33	NA	4	7	-	37	36	NA	0	0	NA
2017-03-27	63.6	off	off	NA	6.7	9.9	NA	361	423	NA	95	63	NA	4	7	-	36	36	NA	3	5	NA
2017-03-28	63.0	off	off	NA	5.2	10.6	NA	310	467	NA	86	59	NA	4	8	-	36	36	NA	1	10	NA

Refrigeration: Dry Climate Sites 1-3 (El Paso, TX)

DATE	T_{out}	CNMX			Energy (kWh)			Runtime (min.)			Cycles (#)			Dur_{typ} (min.)			T_{return} (°F)			OCC (%)		
	(°F)	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E
2017-03-29	59.2	off	off	NA	6.5	9.3	NA	381	407	NA	97	58	NA	4	7	-	36	36	NA	3	6	NA
2017-03-30	57.9	off	off	NA	7.0	11.3	NA	374	466	NA	97	57	NA	4	8	-	36	36	NA	2	9	NA
2017-03-31	58.2	off	off	NA	7.4	10.1	NA	408	419	NA	103	51	NA	4	8	-	36	36	NA	2	4	NA
2017-04-01	55.2	off	off	NA	4.6	5.8	NA	280	249	NA	85	34	NA	3	7	-	36	36	NA	0	0	NA
2017-04-02	57.7	off	off	NA	6.4	8.3	NA	364	366	NA	102	55	NA	4	7	-	36	36	NA	0	1	NA
2017-04-03	63.3	off	off	NA	8.3	10.0	NA	455	431	NA	110	61	NA	4	7	-	36	36	NA	3	9	NA
2017-04-04	67.7	off	off	NA	6.4	9.2	NA	363	407	NA	96	59	NA	4	7	-	36	36	NA	3	5	NA
2017-04-05	61.6	off	off	NA	6.2	10.1	NA	368	443	NA	102	61	NA	4	7	-	36	36	NA	2	11	NA
2017-04-06	59.9	off	off	NA	5.6	8.5	NA	316	370	NA	90	60	NA	4	6	-	37	36	NA	0	3	NA
2017-04-07	58.6	off	off	NA	5.8	11.1	NA	317	445	NA	88	60	NA	4	7	-	37	36	NA	2	4	NA
2017-04-08	63.2	off	off	NA	5.2	6.4	NA	282	263	NA	83	43	NA	3	6	-	37	36	NA	0	0	NA
2017-04-09	65.2	off	off	NA	7.3	8.7	NA	401	370	NA	106	57	NA	4	6	-	36	36	NA	0	0	NA
2017-04-10	67.1	off	off	NA	7.1	11.7	NA	395	483	NA	103	57	NA	4	8	-	36	36	NA	3	7	NA
2017-04-11	71.1	off	off	NA	7.4	11.0	NA	387	430	NA	96	43	NA	4	10	-	36	36	NA	2	6	NA
2017-04-12	71.8	NA	off	NA	NA	12.3	NA	NA	496	NA	NA	59	NA	-	8	-	NA	36	NA	NA	9	NA
2017-04-13	66.6	NA	off	NA	NA	9.6	NA	NA	385	NA	NA	48	NA	-	8	-	NA	36	NA	NA	5	NA
2017-04-14	69.2	off	off	NA	5.2	6.3	NA	277	253	NA	74	33	NA	4	8	-	36	36	NA	0	0	NA
2017-04-15	70.4	off	off	NA	5.0	6.0	NA	267	239	NA	72	33	NA	4	7	-	36	36	NA	0	0	NA
2017-04-16	74.8	off	off	NA	7.7	6.4	NA	393	259	NA	96	35	NA	4	7	-	36	36	NA	1	0	NA
2017-04-18	69.7	on	on	NA	6.9	9.1	NA	401	421	NA	142	110	NA	3	4	-	37	36	NA	3	5	NA
2017-04-19	68.5	on	on	NA	8.5	11.0	NA	471	492	NA	155	125	NA	3	4	-	36	36	NA	4	10	NA
2017-04-20	72.5	on	on	NA	6.3	9.9	NA	365	438	NA	138	110	NA	3	4	-	36	36	NA	2	7	NA
2017-04-21	74.0	on	on	NA	8.3	12.4	NA	458	547	NA	153	136	NA	3	4	-	36	36	NA	4	12	NA
2017-04-22	61.6	on	on	NA	5.0	6.0	NA	318	305	NA	124	89	NA	3	3	-	36	36	NA	0	0	NA
2017-04-23	61.5	on	on	NA	5.2	6.2	NA	323	316	NA	120	90	NA	3	4	-	36	36	NA	1	0	NA
2017-04-24	66.9	on	on	NA	8.3	12.1	NA	446	550	NA	140	136	NA	3	4	-	37	36	NA	6	11	NA
2017-04-25	66.9	on	on	NA	6.1	11.8	NA	361	530	NA	129	128	NA	3	4	-	36	36	NA	2	14	NA
2017-04-26	66.4	on	on	NA	6.9	10.0	NA	415	493	NA	142	129	NA	3	4	-	36	36	NA	4	10	NA
2017-04-27	73.8	on	on	NA	6.2	10.3	NA	363	479	NA	133	121	NA	3	4	-	36	36	NA	3	7	NA
2017-04-28	75.1	on	on	NA	7.0	12.6	NA	405	576	NA	136	135	NA	3	4	-	37	36	NA	4	11	NA
2017-04-29	64.9	on	on	NA	4.4	9.4	NA	307	472	NA	121	127	NA	3	4	-	36	36	NA	0	0	NA
2017-04-30	69.1	on	on	NA	4.9	9.6	NA	329	475	NA	128	126	NA	3	4	-	36	36	NA	1	0	NA
2017-05-01	72.5	on	on	NA	8.0	10.7	NA	466	506	NA	150	127	NA	3	4	-	37	36	NA	5	11	NA
2017-05-02	73.4	NA	on	NA	NA	11.4	NA	NA	518	NA	NA	132	NA	-	4	-	NA	36	NA	NA	9	NA
2017-05-03	69.5	NA	on	NA	NA	12.5	NA	NA	558	NA	NA	132	NA	-	4	-	NA	36	NA	NA	10	NA
2017-05-04	64.3	NA	on	NA	NA	10.1	NA	NA	487	NA	NA	119	NA	-	4	-	NA	36	NA	NA	7	NA
2017-05-05	71.3	NA	on	NA	NA	13.2	NA	NA	548	NA	NA	114	NA	-	5	-	NA	36	NA	NA	7	NA
2017-05-06	68.3	NA	on	NA	NA	9.8	NA	NA	428	NA	NA	108	NA	-	4	-	NA	36	NA	NA	4	NA
2017-05-07	67.6	NA	on	NA	NA	9.8	NA	NA	429	NA	NA	108	NA	-	4	-	NA	36	NA	NA	3	NA
2017-05-08	66.3	NA	on	NA	NA	14.1	NA	NA	617	NA	NA	124	NA	-	5	-	NA	36	NA	NA	15	NA
2017-05-09	63.2	NA	on	NA	NA	9.8	NA	NA	469	NA	NA	119	NA	-	4	-	NA	36	NA	NA	7	NA
2017-05-10	63.1	NA	on	NA	NA	10.7	NA	NA	527	NA	NA	126	NA	-	4	-	NA	36	NA	NA	16	NA
2017-05-11	63.1	NA	on	NA	NA	8.5	NA	NA	400	NA	NA	103	NA	-	4	-	NA	36	NA	NA	8	NA
2017-05-12	64.1	NA	on	NA	NA	12.2	NA	NA	539	NA	NA	117	NA	-	5	-	NA	36	NA	NA	11	NA
2017-05-13	67.0	NA	on	NA	NA	6.9	NA	NA	318	NA	NA	85	NA	-	4	-	NA	36	NA	NA	0	NA
2017-05-14	73.9	NA	on	NA	NA	6.8	NA	NA	306	NA	NA	84	NA	-	4	-	NA	36	NA	NA	0	NA
2017-05-15	72.6	NA	on	NA	NA	9.9	NA	NA	444	NA	NA	108	NA	-	4	-	NA	36	NA	NA	10	NA
2017-05-16	69.6	NA	on	NA	NA	7.9	NA	NA	377	NA	NA	97	NA	-	4	-	NA	36	NA	NA	7	NA
2017-05-17	73.7	NA	on	NA	NA	9.9	NA	NA	464	NA	NA	110	NA	-	4	-	NA	36	NA	NA	12	NA
2017-05-18	76.5	NA	on	NA	NA	11.2	NA	NA	499	NA	NA	112	NA	-	4	-	NA	36	NA	NA	14	NA
2017-05-19	75.6	NA	on	NA	NA	9.3	NA	NA	439	NA	NA	107	NA	-	4	-	NA	36	NA	NA	9	NA
2017-05-20	69.9	NA	on	NA	NA	6.9	NA	NA	343	NA	NA	90	NA	-	4	-	NA	36	NA	NA	2	NA
2017-05-21	70.2	NA	on	NA	NA	7.9	NA	NA	349	NA	NA	90	NA	-	4	-	NA	36	NA	NA	4	NA
2017-05-22	71.7	NA	on	NA	NA	10.2	NA	NA	443	NA	NA	107	NA	-	4	-	NA	36	NA	NA	9	NA
2017-05-23	68.9	NA	on	NA	NA	8.8	NA	NA	404	NA	NA	104	NA	-	4	-	NA	36	NA	NA	10	NA
2017-05-24	70.2	NA	on	NA	NA	10.0	NA	NA	418	NA	NA	99	NA	-	4	-	NA	36	NA	NA	8	NA
2017-05-25	74.7	NA	on	NA	NA	10.0	NA	NA	417	NA	NA	106	NA	-	4	-	NA	36	NA	NA	6	NA
2017-05-26	76.2	NA	on	NA	NA	9.2	NA	NA	382	NA	NA	98	NA	-	4	-	NA	36	NA	NA	3	NA
2017-05-27	75.6	NA	on	NA	NA	9.1	NA	NA	398	NA	NA	102	NA	-	4	-	NA	36	NA	NA	3	NA
2017-05-28	71.6	NA	on	NA	NA	7.6	NA	NA	350	NA	NA	93	NA	-	4	-	NA	36	NA	NA	4	NA
2017-05-29	74.3	NA	on	NA	NA	8.9	NA	NA	406	NA	NA	103	NA	-	4	-	NA	36	NA	NA	6	NA
2017-05-30	70.5	NA	on	NA	NA	10.3	NA	NA	463	NA	NA	118	NA	-	4	-	NA	36	NA	NA	9	NA
2017-05-31	72.6	NA	on	NA	NA	11.4	NA	NA	513	NA	NA	127	NA	-	4	-	NA	36	NA	NA	15	NA
2017-06-01	74.7	NA	on	NA	NA	8.7	NA	NA	404	NA	NA	108	NA	-	4	-	NA	36	NA	NA	6	NA
2017-06-02	75.6	NA	on	NA	NA	8.8	NA	NA	418	NA	NA	104	NA	-	4	-	NA	36	NA	NA	5	NA
2017-06-03	76.6	NA	on	NA	NA	6.9	NA	NA	331	NA	NA	91	NA	-	4	-	NA	36	NA	NA	0	NA
2017-06-04	78.9	NA	on	NA	NA	8.0	NA	NA	353	NA	NA	99	NA	-	4	-	NA	36	NA	NA	0	NA
2017-06-05	79.7	NA	on	NA	NA	12.2	NA	NA	483	NA	NA	119	NA	-	4	-	NA	36	NA	NA	6	NA
2017-06-06	77.9	NA	on	NA	NA	13.7	NA	NA	568	NA	NA	134	NA	-	4	-	NA	36	NA	NA	13	NA

Refrigeration: Dry Climate Sites 1-3 (El Paso, TX)

DATE	T_{out}	CNMX			Energy (kWh)			Runtime (min.)			Cycles (#)			Dur_{typ} (min.)			T_{return} (°F)			OCC (%)		
	(°F)	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E
2017-06-08	73.3	off	off	off	7.6	10.0	35.0	383	391	1428	92	59	13	4	7	110	37	36	37	2	6	28
2017-06-09	80.7	off	off	off	10.2	15.1	34.4	441	515	1382	90	58	58	5	9	24	37	36	37	4	10	22
2017-06-10	84.0	off	off	off	7.5	8.7	30.7	337	307	1342	83	51	99	4	6	14	37	36	36	0	0	1
2017-06-11	85.2	off	off	off	6.8	8.1	30.2	309	306	1352	77	51	89	4	6	15	37	37	37	1	0	2
2017-06-12	85.0	off	off	off	11.1	14.5	35.8	485	504	1416	95	52	25	5	10	57	37	36	37	5	11	27
2017-06-13	85.7	off	off	off	9.1	11.7	35.2	412	407	1404	95	45	36	4	9	39	37	36	37	3	10	31
2017-06-14	85.0	off	off	off	9.4	12.5	35.4	409	433	1398	92	51	41	4	8	34	37	36	37	5	10	28
2017-06-15	83.3	off	off	off	7.9	11.7	35.7	351	404	1384	85	56	53	4	7	26	37	36	37	3	7	25
2017-06-16	83.2	off	off	off	11.5	12.5	35.2	449	441	1377	78	68	58	6	6	24	37	36	37	7	10	25
2017-06-17	86.4	off	off	off	8.0	10.6	34.8	333	369	1361	73	68	77	5	5	18	36	36	37	1	2	17
2017-06-19	84.6	off	off	off	11.5	12.1	37.8	451	413	1408	74	62	31	6	7	45	37	36	37	7	6	29
2017-06-20	85.0	off	off	NA	10.0	12.0	NA	396	401	NA	79	60	NA	5	7	-	36	36	NA	6	6	NA
2017-06-21	85.5	off	off	NA	12.5	15.8	NA	480	518	NA	79	62	NA	6	8	-	37	36	NA	6	8	NA
2017-06-22	88.5	off	off	NA	14.6	13.9	NA	523	452	NA	68	58	NA	8	8	-	37	36	NA	12	9	NA
2017-06-23	88.9	NA	off	off	NA	15.2	39.8	NA	478	1402	NA	57	37	-	8	38	NA	37	37	NA	6	28
2017-06-24	83.4	off	off	off	8.9	12.0	35.5	380	445	1415	65	71	26	6	6	54	37	36	36	2	2	18
2017-06-25	79.8	off	off	off	7.5	9.4	35.6	334	367	1422	58	63	19	6	6	75	37	36	36	2	2	21
2017-06-26	78.9	off	off	off	13.8	11.6	36.4	563	446	1425	57	67	16	10	7	89	37	36	38	10	8	31
2017-06-27	78.8	off	off	off	12.2	11.6	36.8	476	430	1411	56	66	27	9	7	52	37	36	37	13	8	33
2017-06-28	81.9	off	off	off	11.1	14.8	37.4	446	510	1395	64	73	43	7	7	32	37	36	37	9	10	29
2017-06-29	85.8	off	off	off	12.0	11.6	37.6	455	390	1401	62	59	40	7	7	35	37	36	37	6	7	31
2017-06-30	87.4	off	off	off	9.8	11.1	35.6	376	385	1372	56	62	66	7	6	21	36	36	37	7	6	24
2017-07-01	83.9	off	off	off	6.7	8.2	32.1	282	310	1367	49	55	72	6	6	19	37	36	37	0	0	0
2017-07-02	85.0	off	off	off	6.8	8.4	31.3	282	306	1337	47	55	99	6	6	14	37	36	37	0	0	0
2017-07-03	86.9	off	off	off	9.3	10.1	28.2	370	360	1286	58	60	142	6	6	9	36	36	37	1	1	0
2017-07-04	86.6	off	off	off	8.0	9.8	33.0	325	341	1346	53	57	95	6	6	14	36	36	37	1	1	4
2017-07-05	82.3	off	off	off	12.7	13.3	37.5	490	461	1424	59	60	17	8	8	84	37	36	37	8	10	29
2017-07-06	81.8	off	off	off	10.8	11.5	36.8	438	411	1415	67	54	25	7	8	57	37	36	37	9	7	29
2017-07-07	82.0	off	off	off	11.7	10.5	35.7	485	387	1414	70	60	27	7	6	52	37	36	37	6	6	27
2017-07-08	83.3	off	off	off	9.7	10.8	34.9	397	394	1393	67	63	48	6	6	29	37	36	37	2	2	16
2017-07-09	82.3	off	off	off	8.2	9.0	34.1	346	332	1380	57	56	59	6	6	23	37	36	37	2	2	13
2017-07-10	84.5	off	off	NA	11.9	12.7	NA	477	438	NA	72	58	NA	7	8	-	37	36	NA	8	9	NA
2017-07-11	85.9	off	off	off	9.3	11.3	38.0	381	390	1415	69	54	25	6	7	57	37	36	37	4	6	28
2017-07-12	85.4	off	off	NA	11.1	11.5	NA	457	420	NA	68	57	NA	7	7	-	37	36	NA	9	8	NA
2017-07-14	80.9	on	on	on	9.5	10.8	35.2	487	484	1429	139	117	12	4	4	119	37	36	37	5	8	23
2017-07-15	78.1	on	on	on	6.5	8.3	34.0	383	408	1424	124	104	17	3	4	84	37	36	36	3	3	18
2017-07-16	78.6	on	on	on	6.8	9.2	35.0	378	410	1416	124	107	25	3	4	57	37	36	36	3	3	19
2017-07-17	81.8	on	on	NA	9.8	11.1	NA	475	458	NA	131	109	NA	4	4	-	37	36	NA	6	8	NA
2017-07-18	82.5	on	on	NA	7.7	10.0	NA	408	439	NA	128	109	NA	3	4	-	37	36	NA	5	6	NA
2017-07-20	84.4	on	on	NA	7.6	10.1	NA	421	446	NA	134	111	NA	3	4	-	37	36	NA	4	8	NA
2017-07-21	84.2	on	on	on	9.8	10.0	35.4	507	449	1415	153	107	25	3	4	57	37	36	37	4	6	18
2017-07-22	79.4	on	on	on	7.7	6.7	33.7	433	306	1403	149	87	37	3	4	38	36	36	36	0	0	0
2017-07-23	78.0	on	on	on	6.0	6.6	32.9	360	309	1401	124	87	40	3	4	35	37	36	36	1	0	3
2017-07-24	81.6	on	on	NA	10.8	11.6	NA	542	493	NA	139	118	NA	4	4	-	37	36	NA	7	9	NA
2017-07-25	80.2	on	on	NA	9.8	12.4	NA	474	503	NA	129	116	NA	4	4	-	37	36	NA	13	11	NA
2017-07-26	81.6	on	on	NA	11.5	12.4	NA	538	505	NA	138	120	NA	4	4	-	37	36	NA	6	8	NA
2017-07-27	78.6	on	on	NA	8.3	10.8	NA	448	492	NA	134	124	NA	3	4	-	37	36	NA	6	11	NA
2017-07-28	79.1	on	on	NA	9.4	11.5	NA	479	481	NA	139	118	NA	3	4	-	37	36	NA	5	10	NA
2017-07-29	76.3	on	on	on	7.4	9.8	35.5	397	420	1408	124	112	33	3	4	43	37	36	36	2	4	15
2017-07-30	78.0	on	on	on	6.5	9.1	35.1	346	401	1405	116	111	35	3	4	40	37	36	36	2	2	17
2017-07-31	79.9	on	on	NA	12.7	12.4	NA	587	523	NA	136	132	NA	4	4	-	37	36	NA	13	13	NA
2017-08-01	78.7	on	on	NA	7.5	9.1	NA	416	423	NA	123	114	NA	3	4	-	37	36	NA	6	7	NA
2017-08-02	80.8	on	on	NA	10.4	11.6	NA	517	504	NA	138	125	NA	4	4	-	37	36	NA	7	12	NA
2017-08-03	80.7	on	on	NA	8.4	10.9	NA	416	467	NA	129	116	NA	3	4	-	37	36	NA	7	9	NA
2017-08-04	82.3	on	on	NA	12.5	12.8	NA	574	525	NA	149	125	NA	4	4	-	37	36	NA	6	10	NA
2017-08-05	80.5	on	on	on	7.5	8.5	37.1	389	361	1412	126	94	29	3	4	49	37	36	37	1	2	23
2017-08-06	80.6	on	on	on	8.4	10.1	35.9	421	413	1385	128	105	52	3	4	27	37	36	37	2	3	18
2017-08-07	78.8	on	on	NA	14.1	13.9	NA	622	556	NA	138	126	NA	5	4	-	37	36	NA	8	13	NA
2017-08-08	78.5	on	on	NA	8.4	11.4	NA	431	494	NA	134	117	NA	3	4	-	37	36	NA	5	9	NA
2017-08-09	80.2	on	on	NA	10.8	13.3	NA	521	534	NA	143	124	NA	4	4	-	37	36	NA	8	10	NA
2017-08-10	81.5	on	on	NA	10.4	11.7	NA	477	471	NA	125	117	NA	4	4	-	37	36	NA	4	7	NA
2017-08-11	78.8	on	on	NA	9.7	11.7	NA	464	471	NA	125	115	NA	4	4	-	37	36	NA	7	9	NA
2017-08-12	78.3	on	on	on	5.9	7.6	32.3	312	344	1382	95	91	56	3	4	25	37	36	37	0	1	3
2017-08-13	80.1	on	on	on	6.6	8.2	34.1	343	363	1405	103	95	36	3	4	39	37	36	37	1	1	9
2017-08-14	79.6	on	on	NA	11.9	10.9	NA	544	462	NA	129	113	NA	4	4	-	37	36	NA	9	10	NA
2017-08-15	78.3	on	on	NA	6.7	8.9	NA	352	392	NA	103	104	NA	3	4	-	37	36	NA	2	7	NA
2017-08-16	83.0	on	on	NA	10.7	10.8	NA	499	446	NA	121	111	NA	4	4	-	37	36	NA	8	10	NA
2017-08-17	82.6	on	on	on	8.0	10.4	37.7	390	431	1420	115	107	21	3	4	68	37	36	37	4	8	29
2017-08-18	81.6	on	on	NA	10.6	10.2	NA	494	433	NA	126	106	NA	4	4	-	37	36	NA	5	5	NA

Refrigeration: Dry Climate Sites 1-3 (El Paso, TX)

DATE	T_{out}	CNMX			Energy (kWh)			Runtime (min.)			Cycles (#)			Dur_{typ} (min.)			T_{return} (°F)			OCC (%)		
	(°F)	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E
2017-08-19	80.0	on	on	on	6.9	8.0	34.8	358	365	1412	99	96	29	4	4	49	37	36	37	3	3	21
2017-08-20	75.8	on	on	on	5.7	6.9	34.4	328	343	1423	101	93	18	3	4	79	37	36	37	2	2	16
2017-08-21	78.5	on	on	on	11.4	10.0	35.2	566	450	1426	141	113	15	4	4	95	37	36	37	9	7	30
2017-08-22	82.7	on	on	NA	8.7	10.6	NA	449	449	NA	130	115	NA	3	4	-	37	36	NA	5	7	NA
2017-08-24	76.2	off	off	NA	6.8	9.7	NA	346	403	NA	80	59	NA	4	7	-	37	36	NA	5	8	NA
2017-08-25	75.5	off	off	off	9.4	10.4	35.2	445	418	1421	93	60	20	5	7	71	36	36	37	4	7	25
2017-08-26	76.6	off	off	off	6.5	7.3	32.5	317	300	1390	76	54	50	4	6	28	37	36	36	0	1	1
2017-08-27	76.0	off	off	off	8.1	10.3	34.5	375	403	1400	79	67	41	5	6	34	37	36	37	2	2	7
2017-08-28	75.3	off	off	NA	9.6	11.6	NA	450	455	NA	91	65	NA	5	7	-	36	36	NA	6	9	NA
2017-08-29	72.9	off	off	off	7.8	10.5	35.8	374	411	1413	87	62	27	4	7	52	37	36	37	4	8	30
2017-08-30	74.5	off	off	off	10.0	13.0	36.8	460	488	1424	93	60	17	5	8	84	37	36	37	5	11	29
2017-08-31	76.9	off	off	off	7.0	10.0	35.7	341	392	1414	81	56	26	4	7	54	36	36	37	2	8	26
2017-09-01	72.5	off	off	off	9.5	10.5	33.6	434	394	1390	86	54	51	5	7	27	37	36	37	3	5	17
2017-09-02	71.1	off	off	off	6.9	8.6	32.9	327	337	1382	75	49	56	4	7	25	37	36	37	2	3	20
2017-09-03	76.0	off	off	off	6.5	7.9	33.9	307	300	1390	70	44	49	4	7	28	37	36	36	1	2	14
2017-09-04	77.1	off	off	off	11.6	11.2	36.2	500	417	1414	88	57	27	6	7	52	37	36	37	3	4	19
2017-09-05	77.8	NA	off	off	NA	9.4	37.7	NA	366	1432	NA	54	9	-	7	159	NA	36	38	NA	5	36
2017-09-06	72.0	NA	off	NA	NA	11.3	NA	NA	431	NA	NA	56	NA	-	8	-	NA	36	NA	NA	11	NA
2017-09-07	73.6	NA	off	NA	NA	10.4	NA	NA	389	NA	NA	54	NA	-	7	-	NA	36	NA	NA	9	NA
2017-09-08	73.4	NA	off	off	NA	10.3	33.9	NA	407	1399	NA	61	42	-	7	33	NA	36	37	NA	9	20
2017-09-09	71.5	NA	off	off	NA	7.2	31.6	NA	298	1377	NA	54	62	-	6	22	NA	36	36	NA	1	1
2017-09-10	71.2	NA	off	off	NA	8.1	33.4	NA	329	1396	NA	58	45	-	6	31	NA	36	37	NA	1	6
2017-09-11	72.9	NA	off	NA	NA	13.0	NA	NA	493	NA	NA	63	NA	-	8	-	NA	36	NA	NA	12	NA
2017-10-01	68.5	NA	on	on	NA	15.6	9.3	NA	673	407	NA	151	52	-	4	8	NA	36	36	NA	14	0
2017-10-02	70.9	NA	on	on	NA	11.7	18.3	NA	508	746	NA	123	49	-	4	15	NA	36	36	NA	9	20
2017-10-03	71.6	NA	on	on	NA	9.7	19.4	NA	435	793	NA	107	50	-	4	16	NA	36	36	NA	5	26
2017-10-04	72.3	NA	on	on	NA	10.8	19.6	NA	487	817	NA	118	53	-	4	15	NA	36	36	NA	6	23
2017-10-05	75.2	NA	on	on	NA	10.0	19.0	NA	429	780	NA	110	57	-	4	14	NA	36	36	NA	6	23
2017-10-06	76.9	NA	on	on	NA	9.3	13.6	NA	399	583	NA	103	61	-	4	10	NA	36	36	NA	2	1
2017-10-07	73.3	NA	on	on	NA	6.3	12.0	NA	310	539	NA	85	61	-	4	9	NA	36	36	NA	0	0
2017-10-08	75.7	NA	on	on	NA	6.8	12.0	NA	321	530	NA	87	60	-	4	9	NA	36	36	NA	0	0
2017-10-09	76.7	NA	on	on	NA	9.1	13.7	NA	435	595	NA	114	58	-	4	10	NA	36	36	NA	0	3
2017-10-10	68.7	NA	on	on	NA	8.1	17.2	NA	408	754	NA	108	54	-	4	14	NA	36	36	NA	5	24
2017-10-11	69.5	NA	on	on	NA	8.2	17.2	NA	400	740	NA	107	51	-	4	15	NA	36	36	NA	6	21
2017-10-12	69.6	NA	on	on	NA	8.5	19.5	NA	391	819	NA	102	52	-	4	16	NA	36	37	NA	5	21
2017-10-13	70.8	NA	on	on	NA	11.2	18.9	NA	491	793	NA	114	54	-	4	15	NA	36	36	NA	7	20
2017-10-14	73.1	NA	on	on	NA	8.0	16.5	NA	371	701	NA	99	53	-	4	13	NA	36	36	NA	2	13
2017-10-15	68.0	NA	on	on	NA	7.2	14.8	NA	349	659	NA	98	56	-	4	12	NA	36	36	NA	2	12
2017-10-16	64.2	NA	on	on	NA	9.4	16.1	NA	470	720	NA	120	53	-	4	14	NA	36	36	NA	6	19
2017-10-17	61.7	NA	on	on	NA	8.0	16.5	NA	384	726	NA	104	57	-	4	13	NA	36	36	NA	4	19
2017-10-18	65.0	NA	on	on	NA	9.4	17.1	NA	440	751	NA	115	52	-	4	14	NA	36	36	NA	7	20
2017-10-19	65.4	NA	on	on	NA	8.1	18.9	NA	377	808	NA	103	49	-	4	16	NA	36	36	NA	4	20
2017-10-20	68.6	NA	on	on	NA	8.8	15.1	NA	408	673	NA	112	59	-	4	11	NA	36	36	NA	5	15
2017-10-21	68.2	NA	on	on	NA	6.3	10.8	NA	318	498	NA	90	59	-	4	8	NA	36	36	NA	0	0
2017-10-22	65.5	NA	on	on	NA	6.2	12.4	NA	317	572	NA	92	59	-	3	10	NA	36	36	NA	0	1
2017-10-23	68.0	NA	on	NA	NA	9.9	NA	NA	461	NA	NA	119	NA	-	4	-	NA	36	NA	NA	9	NA

D2.2 REFRIGERATION HUMID CLIMATE: SITES 4-6

The labels “A”, “B”, and “C” refer to three different walk-in coolers, each with their own separate evaporators and compressors. Coolers “A” and “B” were at the same facility.

Flags indicate the cooler setpoint status: H = Too Hot, C = Too Cold, and G = Good. Initially, although COOLNOMIX was configured and enabled, setpoints on the coolers were too high. High setpoints prevented COOLNOMIX from cycling the compressors very often. This was eventually noted and corrected. Consequently, only days with “good” setpoints corresponding to COOLNOMIX activity were used in the actual analysis.

Refrigeration: Humid Climate Sites 4-6 (Washington, D.C.)

DATE	T_{out}	CNMX			FLAG			Energy (kWh)			Runtime (min.)			Cycles (#)			Dur_{typ} (min.)			T_{return} (°F)			OCC (%)		
	(°F)	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
2016-04-29	58.3	on	on	on	H	H	H	3.5	1.8	5.0	178	93	481	30	17	79	6	5	6	42	42	40	30	15	7
2016-04-30	60.6	on	on	on	H	H	H	3.5	1.4	4.7	172	72	445	30	12	77	6	6	6	42	42	40	35	6	5
2016-05-01	56.7	on	on	on	H	H	H	2.6	1.8	4.6	132	93	442	25	17	76	5	5	6	42	42	40	31	18	2
2016-05-02	59.7	on	on	on	H	H	H	4.0	2.3	5.3	189	114	496	22	13	64	9	9	8	42	42	40	10	13	6
2016-05-03	66.9	on	on	on	H	H	H	3.8	2.3	5.4	189	109	511	37	15	81	5	7	6	42	42	40	27	13	6
2016-05-04	64.7	on	on	on	H	H	H	3.5	2.7	5.2	179	134	488	33	21	82	5	6	6	42	42	40	20	4	6
2016-05-05	65.8	on	on	on	H	H	H	3.4	2.1	5.5	169	105	523	32	17	80	5	6	7	42	42	40	19	10	8
2016-05-06	67.1	on	on	on	H	H	H	3.4	1.6	5.1	165	75	471	28	10	71	6	8	7	42	42	40	62	14	8
2016-05-07	65.1	on	on	on	H	H	H	3.1	0.7	4.5	154	36	430	27	6	72	6	6	6	42	42	40	NA	NA	4
2016-05-08	66.9	on	on	on	H	H	H	4.3	2.5	4.9	202	127	458	30	27	76	7	5	6	42	41	40	31	13	0
2016-05-09	64.5	on	on	on	H	H	H	2.3	1.7	5.4	117	96	506	23	26	79	5	4	6	42	41	40	0	0	6
2016-05-10	67.6	on	on	on	H	H	H	2.9	2.1	5.2	143	113	492	27	27	83	5	4	6	42	41	40	27	2	5
2016-05-11	66.8	on	on	on	H	H	H	3.1	2.4	5.2	154	126	493	29	25	81	5	5	6	42	41	40	19	3	6
2016-05-12	68.2	on	on	on	H	H	H	4.0	3.8	5.1	194	183	484	34	32	82	6	6	6	42	41	40	39	8	6
2016-05-13	72.7	on	on	on	H	H	H	4.5	4.1	5.8	221	202	541	41	36	85	5	6	6	42	41	40	35	9	5
2016-05-14	67.9	on	on	on	H	H	H	3.3	1.8	5.4	169	99	514	34	25	84	5	4	6	42	41	40	19	0	5
2016-05-15	65.8	on	on	on	H	H	H	2.6	1.8	4.6	132	92	442	26	18	78	5	5	6	42	42	40	33	8	2
2016-05-16	68.4	on	on	on	H	H	H	1.7	0.9	4.8	86	51	460	18	13	79	5	4	6	42	42	40	0	0	4
2016-05-17	63.7	on	on	on	H	H	H	2.8	0.8	5.2	139	41	500	27	9	81	5	5	6	42	41	40	23	5	5
2016-05-18	60.9	on	on	on	H	H	H	3.4	2.2	5.1	170	109	484	31	16	79	5	7	6	42	42	40	36	10	5
2016-05-19	63.9	on	on	on	H	H	H	3.9	3.1	5.2	197	151	484	39	21	81	5	7	6	42	41	40	23	16	5
2016-05-20	71.4	on	on	on	H	H	H	4.5	3.9	6.2	215	183	575	39	29	82	6	6	7	42	41	40	29	14	8
2016-05-21	68.8	on	on	on	H	H	H	3.5	2.6	5.4	174	136	512	29	29	85	6	5	6	42	41	40	25	4	7
2016-05-22	68.4	on	on	on	H	H	H	2.9	2.3	5.0	143	121	478	26	26	80	6	5	6	42	41	40	26	6	1
2016-05-23	72.4	on	on	on	H	H	H	2.3	2.1	5.5	114	110	515	21	24	83	5	5	6	42	41	40	0	0	4
2016-05-24	76.1	on	on	on	H	H	H	3.7	2.5	5.8	184	124	525	36	23	82	5	5	6	42	41	40	32	7	4
2016-05-25	77.0	on	on	on	H	H	H	4.2	2.7	6.4	202	120	578	41	19	84	5	6	7	42	41	40	25	8	6
2016-05-26	76.0	on	on	on	H	H	H	6.0	4.1	6.8	276	187	603	50	36	84	6	5	7	42	41	40	26	3	7
2016-05-27	75.8	on	on	on	H	H	H	5.3	6.3	6.9	244	278	612	46	47	89	5	6	7	42	41	40	16	2	3
2016-05-28	76.9	on	on	on	H	H	H	5.8	5.5	7.0	256	239	624	40	41	86	6	6	7	42	41	40	52	20	3
2016-05-29	77.9	on	on	on	H	H	H	3.2	3.4	6.4	164	176	584	35	36	82	5	5	7	42	41	40	0	0	1
2016-05-30	75.9	on	on	on	H	H	H	3.1	3.3	6.1	156	170	563	39	38	87	4	4	6	42	41	40	0	0	0
2016-05-31	75.6	on	on	on	H	H	H	5.3	5.1	4.9	241	220	424	38	34	49	6	6	9	42	42	43	9	5	7
2016-06-01	73.4	on	on	on	H	H	H	6.6	5.9	8.0	294	247	665	42	35	48	7	7	14	42	41	44	23	17	7
2016-06-02	73.7	on	on	on	H	H	H	6.3	4.9	7.6	289	215	673	44	29	88	7	7	8	42	41	40	43	16	6
2016-06-03	78.1	on	on	on	H	H	H	6.8	4.3	7.6	312	199	681	46	29	91	7	7	7	42	41	40	39	6	5
2016-06-04	79.4	on	on	on	H	H	H	5.9	4.2	7.0	271	192	627	44	29	91	6	7	7	42	41	40	56	9	5
2016-06-05	79.9	on	on	on	H	H	H	4.6	4.8	6.7	219	220	605	40	33	93	5	7	7	42	41	40	19	14	2
2016-06-06	81.8	on	on	on	H	H	H	3.9	4.1	7.2	189	187	643	40	31	92	5	6	7	42	41	40	0	0	4
2016-06-07	81.5	on	on	on	H	H	H	4.9	4.9	6.9	233	225	624	45	38	91	5	6	7	42	41	40	17	2	6
2016-06-09	78.9	off	off	off	H	H	H	5.5	4.1	6.3	266	187	570	45	23	90	6	8	6	42	41	40	40	14	8
2016-06-10	80.6	off	off	off	H	H	H	4.1	3.3	6.8	212	150	612	51	20	92	4	8	7	42	41	40	22	12	5
2016-06-11	82.3	off	off	off	H	H	H	4.7	4.8	7.4	222	202	637	44	24	88	5	8	7	42	41	40	19	5	5
2016-06-12	85.1	off	off	off	H	H	H	4.7	5.1	6.7	217	206	592	43	24	91	5	9	7	42	41	40	30	16	1
2016-06-13	81.6	off	off	off	H	H	H	2.9	2.6	6.5	145	119	601	34	17	94	4	7	6	42	41	40	0	0	6
2016-06-14	79.7	off	off	off	H	H	H	4.6	4.0	6.4	225	181	594	47	24	90	5	8	7	42	41	40	38	14	4
2016-06-15	81.0	off	off	off	H	H	H	5.7	4.0	7.0	279	184	642	55	27	91	5	7	7	42	41	40	21	6	7
2016-06-16	82.3	off	off	off	H	H	H	5.7	5.2	7.3	269	235	657	47	32	91	6	7	7	42	41	40	33	6	7
2016-06-17	81.3	off	off	off	H	H	H	5.4	5.2	6.8	261	229	618	47	27	91	6	8	7	42	41	40	43	30	7
2016-06-18	83.4	off	off	off	H	H	H	5.2	3.6	6.4	236	157	585	43	18	90	5	9	7	42	41	40	18	7	6
2016-06-19	83.0	off	off	off	H	H	H	3.8	3.0	6.5	173	132	582	32	18	91	5	7	6	42	41	40	18	4	2

Refrigeration: Humid Climate Sites 4-6 (Washington, D.C.)

DATE	T_{out}	CNMX			FLAG			Energy (kWh)			Runtime (min.)			Cycles (#)			Dur_{typ} (min.)			T_{return} (°F)			OCC (%)		
	(°F)	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
2016-06-20	82.7	off	off	off	H	H	H	4.5	3.7	7.0	214	156	620	43	21	91	5	7	7	42	41	40	36	19	5
2016-06-21	82.2	off	off	off	H	H	H	6.4	5.4	7.5	285	226	672	48	26	93	6	9	7	42	41	40	34	18	4
2016-06-22	84.9	off	off	off	H	H	H	4.6	4.9	7.0	233	213	638	53	25	90	4	9	7	42	41	40	11	7	6
2016-06-23	83.5	off	off	off	H	H	H	6.4	4.3	7.3	301	193	653	53	25	88	6	8	7	42	41	40	26	8	7
2016-06-24	82.4	off	off	off	H	H	H	6.6	5.3	7.9	309	233	696	54	31	91	6	8	8	42	41	40	22	7	5
2016-06-25	80.9	off	off	off	H	H	H	6.6	4.6	7.0	302	203	637	53	27	89	6	8	7	42	41	40	38	1	6
2016-06-26	78.9	off	off	off	H	H	H	4.7	4.0	6.4	224	176	584	44	25	87	5	7	7	42	41	40	20	NA	2
2016-06-27	79.9	off	off	off	H	H	H	4.3	3.4	7.2	212	153	648	51	25	89	4	6	7	42	41	40	0	0	5
2016-06-28	76.4	off	off	off	H	H	H	4.8	4.6	7.3	237	210	649	47	35	87	5	6	7	42	40	40	13	1	5
2016-06-29	78.9	off	off	off	H	H	H	6.1	4.4	7.1	296	198	637	57	28	88	5	7	7	42	41	40	31	7	7
2016-06-30	79.9	off	off	off	H	H	H	5.3	4.8	8.4	255	211	746	47	24	82	5	9	9	42	41	40	26	10	10
2016-07-01	78.5	off	off	off	H	H	H	7.4	4.7	8.1	330	210	716	52	32	87	6	7	8	42	41	40	34	2	5
2016-07-02	79.5	off	off	off	H	H	H	4.5	4.6	6.7	220	205	608	51	24	86	4	9	7	42	41	40	36	3	3
2016-07-03	79.8	off	off	off	H	H	H	4.6	4.7	6.3	224	212	584	38	23	86	6	9	7	42	41	40	33	15	3
2016-07-04	82.2	off	off	off	H	H	H	4.7	4.8	7.1	232	221	639	43	29	82	5	8	8	42	41	40	35	8	5
2016-07-05	90.7	off	off	off	H	H	H	5.6	6.1	7.5	247	253	642	41	32	80	6	8	8	42	41	40	17	18	5
2016-07-06	90.3	off	off	off	H	H	H	6.8	8.6	8.7	299	328	725	49	31	82	6	11	9	42	41	41	27	8	8
2016-07-08	86.6	on	on	on	H	H	H	7.5	7.2	8.2	335	296	710	54	40	89	6	7	8	42	41	40	27	5	6
2016-07-09	86.5	on	on	on	H	H	H	7.1	7.0	8.0	303	290	694	50	37	92	6	8	8	42	41	40	43	10	5
2016-07-10	88.1	on	on	on	H	H	H	4.2	4.2	6.9	202	203	615	41	39	90	5	5	7	42	41	40	9	0	1
2016-07-11	88.3	on	on	on	H	H	H	3.2	3.5	7.2	157	165	649	33	37	91	5	4	7	42	41	40	0	NA	4
2016-07-12	86.8	on	on	on	H	H	H	5.2	5.4	7.1	247	243	638	45	50	89	5	5	7	42	41	40	20	NA	5
2016-07-13	88.2	on	on	on	H	H	H	6.8	7.3	8.0	298	314	694	44	53	80	7	6	9	NA	41	40	16	NA	6
2016-07-14	90.7	on	on	on	H	H	H	7.5	7.5	9.0	315	322	744	48	61	84	7	5	9	NA	41	40	54	NA	8
2016-07-15	87.0	on	on	on	H	H	H	7.6	7.9	9.1	323	341	760	50	62	87	6	6	9	NA	41	40	31	NA	7
2016-07-16	84.4	on	on	on	H	H	H	6.9	5.3	8.0	305	243	701	53	50	95	6	5	7	NA	41	40	37	NA	5
2016-07-17	86.1	on	on	on	H	H	H	5.4	4.9	6.9	244	226	618	43	46	92	6	5	7	NA	41	40	25	NA	1
2016-07-18	85.0	on	on	on	H	H	H	4.6	5.8	7.9	216	276	695	45	58	94	5	5	7	NA	40	40	2	NA	4
2016-07-19	83.4	on	on	on	H	H	H	6.2	6.1	7.7	281	265	683	50	43	92	6	6	7	NA	41	40	22	NA	4
2016-07-20	83.4	on	on	on	H	H	H	7.3	7.3	7.6	322	317	671	47	44	92	7	7	7	NA	41	40	15	NA	6
2016-07-21	85.3	on	on	on	H	H	H	7.5	6.5	7.9	325	278	695	48	46	94	7	6	7	NA	41	40	31	NA	7
2016-07-22	87.5	on	on	on	H	H	H	7.4	7.3	8.3	313	311	723	44	58	93	7	5	8	NA	41	40	20	NA	5
2016-07-23	90.5	on	on	on	H	H	H	9.0	6.0	8.9	358	238	738	47	44	86	8	5	9	NA	41	40	43	NA	4
2016-07-24	90.4	on	on	on	H	H	H	6.4	6.4	7.5	263	275	647	44	56	89	6	5	7	NA	40	40	12	NA	1
2016-07-25	90.2	on	on	on	H	H	H	NA	7.8	9.2	391	331	763	51	73	88	8	5	9	NA	40	40	23	NA	5
2016-07-26	86.9	on	on	on	H	H	H	7.5	6.9	9.5	321	302	789	50	64	87	6	5	9	NA	40	40	16	NA	7
2016-07-27	85.0	on	on	on	H	H	H	7.5	7.6	10.0	313	320	819	46	59	87	7	5	9	NA	40	40	14	NA	7
2016-07-28	85.6	on	on	on	H	H	H	7.3	6.8	9.3	316	299	793	52	60	90	6	5	9	NA	40	40	28	NA	6
2016-07-29	84.2	on	on	on	H	H	H	5.7	7.8	8.9	256	337	766	41	56	89	6	6	9	NA	41	40	17	NA	6
2016-07-30	83.0	on	on	on	H	H	H	3.8	4.6	9.3	178	224	804	35	49	75	5	5	11	NA	40	41	0	NA	6
2016-07-31	83.6	on	on	on	H	H	H	5.0	5.7	7.3	231	262	644	41	55	92	6	5	7	NA	40	40	27	NA	1
2016-08-01	83.0	on	on	on	H	H	H	5.1	6.2	8.5	228	282	727	39	52	91	6	5	8	NA	41	40	3	NA	6
2016-08-03	79.0	off	off	NA	H	H	NA	6.8	5.2	NA	318	230	NA	52	29	NA	6	8	-	NA	NA	40	NA	NA	7
2016-08-04	80.5	off	off	off	H	H	H	5.8	4.8	7.6	257	213	679	43	28	90	6	8	8	NA	41	-	23	NA	NA
2016-08-05	82.0	off	off	off	H	H	H	6.6	5.5	7.0	302	247	638	48	33	93	6	7	7	NA	41	40	24	NA	7
2016-08-06	83.7	off	off	off	H	H	H	6.1	5.6	7.2	275	235	646	46	30	91	6	8	7	NA	41	40	46	NA	4
2016-08-07	84.2	off	off	off	H	H	H	4.8	4.4	11.8	221	194	893	39	26	68	6	7	13	NA	41	40	21	NA	2
2016-08-08	81.8	off	off	off	H	H	H	3.3	3.4	7.4	170	152	671	41	23	95	4	7	7	NA	41	42	18	NA	18
2016-08-09	79.3	off	off	off	H	H	H	4.5	4.4	6.8	224	207	624	41	31	93	5	7	7	NA	41	40	0	NA	4
2016-08-10	82.0	off	off	off	H	H	H	7.4	6.3	7.6	317	258	660	47	32	90	7	8	7	NA	41	40	10	NA	6
2016-08-11	85.3	off	off	off	H	H	H	8.6	7.5	8.4	354	292	708	52	34	89	7	9	8	NA	41	40	21	NA	5
2016-08-12	87.0	off	off	off	H	H	H	8.2	8.0	10.4	327	307	856	43	35	80	8	9	11	NA	41	40	44	NA	7
2016-08-13	82.4	off	off	off	H	H	H	8.8	8.4	9.1	343	303	745	44	29	80	8	10	9	NA	41	40	21	NA	6
2016-08-14	83.1	off	off	off	H	H	H	7.5	7.3	8.5	304	282	701	44	32	84	7	9	8	NA	40	40	34	NA	3
2016-08-15	81.2	off	off	off	H	H	H	4.7	4.8	8.1	216	200	688	43	29	80	5	7	9	NA	40	40	28	NA	1
2016-08-16	83.3	off	off	off	H	H	H	5.9	7.5	8.3	259	298	700	43	35	77	6	9	9	NA	40	40	12	NA	6
2016-08-17	83.4	off	off	off	H	H	H	7.0	5.5	9.1	298	228	757	44	31	82	7	7	9	NA	40	40	24	NA	6
2016-08-18	81.5	off	off	off	H	H	H	6.6	5.3	8.5	292	231	726	44	34	87	7	7	8	NA	41	40	15	NA	8
2016-08-19	82.2	off	off	off	H	H	H	7.7	5.4	7.8	336	224	685	49	27	84	7	8	8	NA	41	40	54	NA	6
2016-08-20	80.3	off	off	off	H	H	H	7.0	4.8	7.3	293	194	649	43	23	87	7	8	7	NA	41	40	56	NA	6
2016-08-21	76.4	off	off	off	H	H	H	5.3	4.6	6.8	246	203	615	41	28	91	6	7	7	NA	41	40	NA	NA	5
2016-08-22	76.7	off	off	off	H	H	H	3.1	2.8	7.0	149	128	626	30	18	92	5	7	7	NA	40	40	26	NA	2
2016-08-23	75.8	off	off	off	H	H	H	4.7	5.0	7.1	228	218	639	42	26	85	5	8	8	NA	41	40	0	NA	4
2016-08-24	77.9	off	off	off	H	H	H	3.0	3.7	7.0	140	167	624	24	21	82	6	8	8	NA	41	40	26	NA	7
2016-08-25	78.2	off	off	off	H	H	H	8.1	5.7	8.1	339	243	710	40	29	84	8	8	8	NA	41	40	21	NA	6
2016-08-26	81.9	off	off	off	H	H	H	7.2	7.0	9.6	304	281	785	47	34	76	6	8	10	NA	41	40	26	NA	7
2016-08-27	81.1	off	off	off	H	H	H	7.0	5.6	7.9	288	232	676	42	32	78	7	7	9	NA	41	40	29	NA	6

Refrigeration: Humid Climate Sites 4-6 (Washington, D.C.)

DATE	T_{out}	CNMX			FLAG			Energy (kWh)			Runtime (min.)			Cycles (#)			Dur_{typ} (min.)			T_{return} (°F)			OCC (%)		
	(°F)	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
2016-08-28	78.8	off	off	off	H	H	H	4.7	4.7	7.3	211	211	649	35	32	85	6	7	8	NA	40	40	36	NA	4
2016-08-29	79.6	off	off	off	H	H	H	3.8	4.4	8.0	170	192	682	31	29	81	5	7	8	NA	41	39	27	NA	NA
2016-08-30	76.7	off	off	off	H	H	H	4.7	4.6	7.6	214	199	664	35	29	80	6	7	8	NA	41	39	0	NA	5
2016-08-31	78.2	off	off	off	H	H	H	6.1	7.1	7.6	262	302	666	41	40	86	6	8	8	NA	41	39	9	NA	6
2016-09-02	76.0	on	on	on	H	H	H	5.6	6.2	6.9	259	305	640	45	59	91	6	5	7	NA	42	40	15	NA	6
2016-09-03	77.4	on	on	on	H	H	H	6.9	4.1	6.7	319	208	615	49	42	91	7	5	7	NA	41	40	41	NA	4
2016-09-04	78.6	on	on	on	H	H	H	2.9	2.3	6.6	140	114	606	26	28	86	5	4	7	NA	41	40	41	NA	3
2016-09-05	80.3	on	on	on	H	H	H	4.1	2.6	6.6	186	128	598	33	29	83	6	4	7	NA	41	40	0	NA	2
2016-09-06	78.3	on	on	on	H	H	H	6.3	5.9	7.7	283	265	664	44	52	79	6	5	8	NA	41	40	2	NA	0
2016-09-07	77.9	on	on	on	H	H	H	5.5	4.7	8.0	252	220	680	49	50	77	5	4	9	NA	41	40	59	NA	6
2016-09-08	80.8	on	on	on	H	H	H	7.7	5.8	9.0	306	240	745	42	45	79	7	5	9	NA	40	40	NA	NA	6
2016-09-09	83.1	on	on	on	H	H	H	6.6	6.7	8.9	281	283	747	44	54	89	6	5	8	NA	41	40	24	NA	7
2016-09-10	79.2	on	on	on	H	H	H	5.1	3.9	8.3	219	179	711	37	45	78	6	4	9	NA	41	40	30	NA	7
2016-09-11	77.9	on	on	on	H	H	H	5.8	4.0	7.3	277	196	636	49	43	74	6	5	9	NA	40	40	32	NA	6
2016-09-12	77.6	on	on	on	H	H	H	4.9	3.1	7.0	234	157	634	42	35	81	6	4	8	NA	41	40	NA	NA	2
2016-09-13	78.4	on	on	on	H	H	H	5.6	4.0	7.5	256	187	661	43	41	86	6	5	8	NA	41	40	NA	NA	5
2016-09-14	80.0	on	on	on	H	H	H	6.7	5.0	8.0	295	222	679	48	45	85	6	5	8	NA	41	40	NA	NA	6
2016-09-15	76.0	on	on	on	H	H	H	7.9	4.6	7.5	373	225	675	50	44	88	7	5	8	NA	41	40	62	NA	5
2016-09-16	75.0	on	on	on	H	H	H	5.9	3.7	7.2	271	186	662	42	39	90	6	5	7	NA	41	40	NA	NA	9
2016-09-17	76.5	on	on	on	H	H	H	4.3	3.8	7.1	210	187	639	36	40	84	6	5	8	NA	41	40	NA	NA	6
2016-09-18	79.0	on	on	on	H	H	H	4.9	4.7	6.6	223	224	600	37	47	85	6	5	7	NA	41	40	29	NA	6
2016-09-19	77.3	on	on	on	H	H	H	4.2	3.5	6.9	200	177	634	36	38	88	6	5	7	NA	41	40	17	NA	1
2016-09-20	79.0	on	on	on	H	H	H	6.7	5.4	7.2	307	262	661	44	47	90	7	6	7	NA	NA	40	0	NA	4
2016-09-21	80.2	on	on	on	H	H	H	8.1	4.8	7.2	366	228	656	46	43	93	8	5	7	NA	NA	40	30	NA	7
2016-09-22	79.3	on	on	on	H	H	H	7.2	5.5	7.7	321	258	691	42	45	92	8	6	8	NA	NA	40	24	NA	8
2016-09-23	78.3	on	on	on	H	H	H	5.5	3.4	8.3	243	172	723	37	34	86	7	5	8	42	41	40	58	8	8
2016-09-24	72.9	on	on	on	H	H	H	5.7	2.8	6.9	262	139	637	37	30	91	7	5	7	42	41	40	NA	2	8
2016-09-25	68.1	on	on	on	H	H	H	3.4	2.2	6.2	167	117	569	28	28	85	6	4	7	42	41	40	25	4	3
2016-09-26	64.1	on	on	on	H	H	H	3.2	1.8	6.2	157	97	577	30	24	87	5	4	7	42	41	40	19	1	2
2016-09-27	66.9	on	on	on	H	H	H	5.7	4.7	6.4	265	226	590	39	39	88	7	6	7	42	41	40	0	0	5
2016-09-28	69.8	on	on	on	H	H	H	4.2	4.9	6.9	204	248	631	35	49	93	6	5	7	42	41	40	34	18	7
2016-09-29	71.8	on	on	on	H	H	H	6.2	6.1	6.2	287	295	579	39	46	95	7	6	6	42	41	40	18	14	9
2016-09-30	66.1	on	on	on	H	H	H	5.2	3.8	6.8	248	195	626	38	42	96	7	5	7	42	41	40	38	12	6
2016-10-01	69.3	on	on	on	H	H	H	4.8	4.4	6.7	233	221	615	39	42	91	6	5	7	42	41	40	23	10	6
2016-10-02	71.6	on	on	on	H	H	H	3.9	2.9	5.9	188	153	555	32	34	91	6	5	6	42	41	40	51	16	7
2016-10-03	73.3	on	on	on	H	H	H	2.7	2.0	6.2	130	102	574	24	24	88	5	4	7	42	41	40	28	2	2
2016-10-04	69.3	on	on	on	H	H	H	4.0	3.6	6.1	195	181	568	35	37	87	6	5	7	42	42	40	0	0	5
2016-10-05	67.0	on	on	on	H	H	H	4.4	2.8	6.3	216	147	581	37	34	84	6	4	7	42	41	40	16	9	6
2016-10-06	68.5	on	on	on	H	H	H	3.8	3.5	6.4	185	177	595	32	34	84	6	5	7	42	42	40	40	8	7
2016-10-07	66.3	on	on	on	H	H	H	5.6	4.8	7.0	269	243	645	41	47	89	7	5	7	42	41	40	44	0	7
2016-10-08	65.7	on	on	on	H	H	H	5.0	2.8	6.3	236	145	586	38	35	90	6	4	7	41	41	40	NA	NA	7
2016-10-09	65.3	on	on	on	H	H	H	2.2	1.3	5.7	109	71	541	21	17	89	5	4	6	42	41	40	47	NA	5
2016-10-10	64.3	on	on	on	H	H	H	1.7	1.0	5.6	89	55	530	17	14	89	5	4	6	42	42	40	0	NA	3
2016-10-11	66.2	on	on	on	H	H	H	2.7	1.8	5.6	137	92	538	25	20	84	5	5	6	42	42	40	0	NA	3
2016-10-12	67.0	on	on	on	H	H	H	3.1	2.0	5.9	153	107	552	28	25	84	5	4	7	42	42	40	22	NA	5
2016-10-13	66.8	on	on	on	H	H	H	3.8	2.7	6.2	182	136	576	32	30	87	6	5	7	42	41	40	12	NA	6
2016-10-14	64.3	on	on	on	H	H	H	3.0	1.3	5.7	146	63	538	28	12	85	5	5	6	42	41	40	40	NA	6
2016-10-15	66.0	on	on	on	H	H	H	2.7	0.6	5.7	133	34	540	26	9	87	5	4	6	42	42	40	23	NA	5
2016-10-16	68.5	on	on	on	H	H	H	3.1	2.1	5.5	152	115	518	28	26	87	5	4	6	42	42	40	0	NA	6
2016-10-18	72.5	off	off	off	H	H	H	4.9	3.9	6.9	230	179	614	37	23	84	6	8	7	42	42	40	24	NA	2
2016-10-19	73.5	off	off	off	H	H	H	6.5	4.3	7.2	290	186	635	41	22	82	7	8	8	42	41	40	24	NA	8
2016-10-20	70.3	off	off	off	H	H	H	5.8	3.5	6.8	263	156	616	43	21	87	6	7	7	42	41	40	33	NA	7
2016-10-21	66.3	off	off	off	H	H	H	4.9	3.8	7.6	231	170	686	36	18	93	6	9	7	41	41	40	57	NA	5
2016-10-22	61.3	off	off	off	H	H	H	2.8	1.2	6.1	142	61	569	26	10	89	5	6	6	42	42	40	41	NA	6
2016-10-23	63.2	off	off	off	H	H	H	2.2	1.5	5.4	116	73	517	21	12	86	6	6	6	42	42	40	2	NA	5
2016-10-24	65.9	off	off	off	H	H	H	2.1	1.8	5.7	105	89	534	19	14	88	6	6	6	42	42	40	33	NA	1
2016-10-25	64.2	off	off	off	H	H	H	1.0	3.3	5.2	54	152	509	10	17	86	5	9	6	42	42	40	0	NA	3
2016-10-26	61.7	off	off	off	H	H	H	3.6	1.6	5.1	176	77	490	28	11	84	6	7	6	45	42	40	12	NA	6
2016-10-27	64.6	off	off	off	H	H	H	4.1	2.3	5.2	197	112	493	32	14	86	6	8	6	44	42	40	17	NA	7
2016-10-28	62.9	off	off	off	H	H	H	2.6	1.5	5.2	131	72	495	25	11	84	5	7	6	42	42	40	33	NA	8
2016-10-29	65.3	off	off	off	H	H	H	3.4	1.4	5.5	163	67	518	26	10	82	6	7	6	42	42	40	19	NA	4
2016-10-30	68.1	off	off	off	H	H	H	3.3	2.1	5.6	160	99	526	28	14	85	6	7	6	42	42	40	63	NA	6
2016-10-31	63.5	off	off	off	H	H	H	2.0	1.4	5.4	100	72	519	20	11	86	5	7	6	42	42	40	NA	NA	NA
2016-11-01	64.0	off	off	off	H	H	H	2.9	2.7	5.3	147	133	496	26	17	80	6	8	6	42	42	40	0	NA	5
2016-11-02	65.5	off	off	off	H	H	H	4.0	2.7	5.3	197	127	502	33	17	83	6	7	6	42	42	40	19	NA	8
2016-11-03	66.5	off	off	off	H	H	H	5.5	3.2	6.5	248	143	598	37	16	82	7	9	7	42	42	40	24	NA	5
2016-11-04	61.5	off	off	off	H	H	H	3.6	2.5	5.5	177	121	521	32	17	86	6	7	6	42	41	40	47	NA	9

Refrigeration: Humid Climate Sites 4-6 (Washington, D.C.)

DATE	T_{out}	CNMX			FLAG			Energy (kWh)			Runtime (min.)			Cycles (#)			Dur_{typ} (min.)			T_{return} (°F)			OCC (%)		
	(°F)	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
2016-11-05	60.3	off	off	off	H	H	H	2.5	1.9	5.3	128	94	501	25	15	85	5	6	6	42	41	40	46	NA	8
2016-11-06	60.6	off	off	off	H	H	H	2.6	1.9	5.0	134	92	480	31	21	114	4	4	4	42	42	40	0	NA	5
2016-11-07	57.2	off	off	off	H	H	H	1.6	1.6	4.8	87	79	471	18	13	79	5	6	6	42	42	40	33	NA	3
2016-11-08	57.6	off	off	off	H	H	H	2.5	2.6	5.0	125	124	481	23	17	78	5	7	6	42	42	40	0	NA	5
2016-11-09	55.4	off	off	off	H	H	H	3.0	1.0	5.3	151	50	502	29	7	83	5	7	6	42	42	40	23	NA	7
2016-11-10	53.2	off	off	off	H	H	H	3.2	1.3	5.2	160	65	494	30	9	82	5	7	6	42	42	40	37	NA	6
2016-11-11	56.1	off	off	off	H	H	H	2.4	0.0	5.3	123	0	498	24	0	81	5		6	42	42	40	NA	NA	6
2016-11-12	50.5	off	off	off	H	H	H	2.6	1.0	4.8	138	52	463	27	9	76	5	6	6	42	42	40	0	NA	3
2016-11-13	51.7	off	off	off	H	H	H	2.0	1.2	4.6	107	63	453	23	11	75	5	6	6	42	42	40	56	NA	6
2016-11-14	53.1	off	off	off	H	H	H	1.4	1.1	4.5	71	56	445	16	9	75	4	6	6	42	42	40	NA	NA	NA
2016-11-15	56.3	off	off	off	H	H	H	2.7	1.5	4.5	141	73	442	27	11	79	5	7	6	42	42	40	0	NA	6
2016-11-16	56.6	off	off	off	H	H	H	3.2	1.1	4.9	157	47	469	30	4	79	5	12	6	42	41	40	21	NA	6
2016-11-17	60.2	off	off	off	H	H	H	3.9	1.1	5.1	185	54	491	28	7	80	7	8	6	42	42	40	25	NA	7
2016-11-18	54.1	off	off	off	H	H	H	3.3	1.0	5.4	161	47	523	27	6	85	6	8	6	42	42	40	39	NA	8
2016-11-19	51.3	off	off	off	H	H	H	2.6	0.7	5.0	125	35	488	24	5	84	5	7	6	42	42	40	32	NA	7
2016-11-20	47.6	off	off	off	H	H	H	1.4	0.4	4.2	77	20	420	17	3	76	5	7	6	42	42	40	28	NA	4
2016-11-21	48.6	off	off	off	H	H	H	0.9	0.7	4.3	52	34	443	13	5	84	4	7	5	42	42	40	32	NA	NA
2016-11-22	49.2	off	off	off	H	H	H	2.3	2.1	4.4	122	106	454	27	18	85	5	6	5	42	42	40	0	NA	5
2016-11-23	47.3	off	off	off	H	H	H	2.6	2.1	4.5	135	103	464	28	16	88	5	6	5	42	42	40	22	NA	5
2016-11-24	50.5	off	off	off	H	H	H	2.3	3.7	4.4	122	172	443	25	20	82	5	9	5	42	42	40	32	NA	4
2016-11-25	51.4	off	off	off	H	H	H	2.2	0.8	4.5	112	37	444	23	6	78	5	6	6	42	42	40	26	NA	0
2016-11-26	51.0	off	off	off	H	H	H	2.0	0.6	4.7	103	32	441	21	5	74	5	6	6	42	42	40	0	NA	3
2016-11-27	52.6	off	off	off	H	H	H	1.4	0.7	3.9	77	38	393	16	6	70	5	6	6	42	42	40	0	NA	10
2016-11-28	47.8	off	off	off	H	H	H	1.3	1.4	4.7	69	70	455	15	11	76	5	6	6	42	42	40	5	NA	3
2016-11-29	51.1	off	off	off	H	H	H	3.1	2.0	4.3	150	93	411	25	13	74	6	7	6	42	42	40	0	NA	4
2016-11-30	50.9	off	off	off	H	H	H	4.7	3.8	5.2	223	168	486	34	18	78	7	9	6	42	42	40	21	NA	7
2016-12-01	48.6	off	off	off	H	H	H	3.9	2.2	4.7	182	102	442	28	12	76	7	9	6	42	41	40	19	NA	8
2016-12-02	48.8	off	off	off	H	H	H	2.5	0.9	4.5	130	43	441	24	7	74	5	6	6	42	41	40	33	NA	7
2016-12-03	44.6	off	off	off	H	H	H	2.2	0.1	4.3	115	5	421	24	1	72	5	5	6	42	42	40	51	NA	6
2016-12-04	44.4	off	off	off	H	H	H	1.8	0.7	4.0	95	35	402	21	6	67	5	6	6	42	41	40	NA	NA	5
2016-12-05	48.2	off	off	off	H	H	H	2.2	1.6	3.9	110	81	388	21	13	68	5	6	6	42	42	40	34	NA	NA
2016-12-06	49.0	off	off	off	H	H	H	2.6	1.6	4.0	142	85	399	27	15	69	5	6	6	42	42	40	1	NA	5
2016-12-07	49.5	off	off	off	H	H	H	2.9	2.1	4.1	149	106	402	28	17	68	5	6	6	41	42	40	61	NA	7
2016-12-08	39.9	off	off	off	H	H	H	2.0	0.6	3.9	102	34	409	20	6	72	5	6	6	42	42	40	NA	NA	7
2016-12-09	35.7	off	off	off	H	H	H	1.2	0.0	3.5	71	0	376	18	0	67	4	-	6	42	41	40	35	NA	7
2016-12-10	38.8	off	off	off	H	H	H	1.1	0.0	3.6	64	0	383	18	0	69	4	-	6	42	40	40	55	NA	5
2016-12-11	48.0	off	off	off	H	H	H	1.3	0.0	3.5	70	0	378	16	0	71	4	-	5	42	39	40	NA	NA	5
2016-12-12	52.4	off	off	off	H	H	H	1.6	0.3	4.1	86	15	414	20	2	74	4	8	6	42	40	40	10	NA	NA
2016-12-13	51.7	off	off	off	H	H	H	2.1	0.7	3.7	107	38	379	22	7	69	5	5	5	42	41	40	0	NA	4
2016-12-14	50.4	off	off	off	H	H	H	1.8	0.6	4.0	96	32	416	20	6	79	5	5	5	42	42	40	24	NA	7
2016-12-16	44.1	on	on	on	H	H	H	0.6	0.0	2.9	42	0	346	15	0	56	3	-	6	42	42	40	9	NA	9
2016-12-17	44.2	on	on	on	H	H	H	1.4	0.0	3.3	81	2	352	22	2	61	4	1	6	42	42	40	16	NA	6
2016-12-18	44.5	on	on	on	H	H	H	2.4	1.5	3.6	125	85	357	27	20	69	5	4	5	42	41	40	16	NA	4
2016-12-19	37.5	on	on	on	H	H	H	0.7	0.0	3.6	46	0	377	13	0	66	4	-	6	42	42	40	33	NA	2
2016-12-20	37.9	on	on	on	H	H	H	1.4	0.5	3.8	86	31	410	25	10	64	3	3	6	42	42	40	0	NA	6
2016-12-21	45.5	on	on	on	H	H	H	2.0	1.8	3.7	114	99	388	28	26	67	4	4	6	42	42	40	21	NA	7
2016-12-22	46.8	on	on	on	H	H	H	2.1	2.1	3.4	118	124	348	30	33	68	4	4	5	42	42	40	27	NA	7
2016-12-23	45.1	on	on	on	H	H	H	2.4	1.5	3.9	138	89	406	36	25	69	4	4	6	42	41	40	32	NA	3
2016-12-24	48.7	on	on	on	H	H	H	2.2	1.7	3.8	125	101	377	33	29	58	4	3	7	42	42	40	20	NA	4
2016-12-25	43.9	on	on	on	H	H	H	2.1	1.8	3.7	114	106	369	28	32	55	4	3	7	42	42	40	0	NA	0
2016-12-26	42.3	on	on	on	H	H	H	2.1	1.8	3.7	117	110	363	29	34	54	4	3	7	41	42	40	0	NA	0
2016-12-27	51.4	on	on	on	H	H	H	2.6	2.4	4.7	131	129	423	29	34	58	5	4	7	42	42	40	0	NA	0
2016-12-28	47.0	on	on	on	H	H	H	2.1	1.7	3.8	118	93	376	29	28	64	4	3	6	42	41	40	0	NA	8
2016-12-29	44.0	on	on	on	H	H	H	1.8	1.1	4.1	100	67	402	26	19	63	4	4	6	42	42	40	0	NA	5
2016-12-30	41.7	on	on	on	H	H	H	1.7	0.8	3.9	99	46	387	25	13	67	4	4	6	42	42	40	0	NA	6
2016-12-31	45.0	on	on	on	H	H	H	1.8	1.4	3.8	106	86	383	28	28	67	4	3	6	42	42	40	16	NA	5
2017-01-01	47.1	on	on	on	H	H	H	1.4	0.2	3.8	81	13	376	21	4	70	4	3	5	42	42	40	15	NA	2
2017-01-02	45.6	on	on	on	H	H	H	1.3	0.5	3.8	75	24	381	21	4	67	4	6	6	42	42	40	NA	NA	NA
2017-01-03	47.3	on	on	on	H	H	H	2.4	2.0	3.9	126	108	385	28	21	64	5	5	6	42	42	40	0	NA	0
2017-01-04	52.0	on	on	on	H	H	H	2.8	2.0	3.9	144	107	380	30	23	63	5	5	6	42	42	40	26	NA	7
2017-01-05	45.1	on	on	on	H	H	H	1.9	0.7	3.5	111	38	373	28	9	65	4	4	6	42	42	40	38	NA	8
2017-01-06	38.9	on	on	on	H	H	H	1.6	0.9	3.5	96	55	390	27	14	65	4	4	6	42	42	40	22	NA	5
2017-01-07	30.2	on	on	on	H	H	H	1.2	0.7	3.3	84	44	384	32	12	56	3	4	7	42	42	40	17	NA	6
2017-01-08	32.3	on	on	on	H	H	H	0.5	0.3	3.0	43	25	347	16	9	51	3	3	7	42	42	40	0	NA	6
2017-01-09	39.0	on	on	on	H	H	H	0.4	0.0	2.9	30	0	344	11	0	53	3	-	6	42	43	40	30	NA	NA
2017-01-10	46.0	on	on	on	H	H	H	1.3	1.6	2.7	83	95	302	27	28	52	3	3	6	42	43	40	0	NA	4
2017-01-11	52.7	on	on	on	H	H	H	2.7	2.1	3.2	140	120	316	32	33	60	4	4	5	42	42	40	22	NA	6

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DATE	T_{out}	CNMX			FLAG			Energy (kWh)			Runtime (min.)			Cycles (#)			Dur_{typ} (min.)			T_{return} (°F)			OCC (%)		
	(°F)	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
2017-01-12	57.3	on	on	on	H	H	H	3.5	2.3	3.9	175	127	362	33	33	65	5	4	6	42	42	40	14	NA	6
2017-01-13	54.3	on	on	on	H	H	H	3.0	1.8	4.2	157	107	404	33	29	66	5	4	6	42	41	40	30	NA	6
2017-01-14	46.7	on	on	on	H	H	H	1.8	1.4	3.8	101	81	393	24	24	63	4	3	6	42	41	40	28	NA	6
2017-01-15	43.9	on	on	on	H	H	H	1.9	1.5	3.5	104	90	359	25	31	65	4	3	6	42	42	40	0	NA	5
2017-01-16	44.7	on	on	on	H	H	H	1.9	1.6	3.6	101	101	375	24	32	68	4	3	6	42	42	40	0	NA	NA
2017-01-17	44.9	on	on	on	H	H	H	2.7	1.9	4.3	136	115	421	31	32	68	4	4	6	42	42	40	0	NA	3
2017-01-18	48.6	on	on	on	H	H	H	2.4	0.9	3.9	124	53	382	25	15	69	5	4	6	42	42	40	15	NA	9
2017-01-19	48.8	on	on	on	H	H	H	2.5	1.3	4.1	131	77	402	29	20	67	5	4	6	42	42	40	10	NA	7
2017-01-20	48.1	on	on	on	H	H	H	1.4	1.3	3.7	77	84	370	17	25	65	5	3	6	42	42	40	39	NA	6
2017-01-21	46.9	on	on	on	H	H	H	1.6	1.7	3.9	85	98	383	18	28	67	5	4	6	42	42	40	0	NA	0
2017-01-22	47.8	on	on	on	H	H	H	2.2	1.6	3.6	115	90	344	24	24	63	5	4	5	42	42	40	0	NA	4
2017-01-23	48.7	on	on	on	H	H	H	1.4	0.8	3.9	71	49	386	16	14	66	4	4	6	42	42	40	24	NA	NA
2017-01-24	47.4	on	on	on	H	H	H	2.1	1.3	3.7	117	74	364	26	21	64	5	4	6	42	42	40	0	NA	4
2017-01-25	47.6	on	on	on	H	H	H	2.7	1.9	4.0	141	102	381	32	24	68	4	4	6	42	42	40	26	NA	4
2017-01-26	45.9	on	on	on	H	H	H	3.2	1.4	3.9	167	77	381	35	20	68	5	4	6	42	42	40	23	NA	6
2017-01-27	40.0	on	on	on	H	H	H	2.1	0.8	3.8	122	51	385	30	14	72	4	4	5	42	42	40	52	NA	6
2017-01-28	39.1	on	on	on	H	H	H	2.1	1.1	3.6	120	63	373	31	16	71	4	4	5	42	42	40	18	NA	7
2017-01-29	41.3	on	on	on	H	H	H	1.6	0.9	3.4	90	55	362	24	17	72	4	3	5	42	42	40	42	NA	7
2017-01-30	40.0	on	on	on	H	H	H	1.1	0.0	3.7	58	0	398	15	0	74	4	-	5	42	42	40	14	NA	NA
2017-01-31	46.7	on	on	on	H	H	H	1.9	1.4	3.7	111	81	392	28	23	70	4	4	6	42	42	40	0	NA	4
2017-02-01	47.5	on	on	on	H	H	H	2.5	1.4	3.6	138	86	364	33	26	62	4	3	6	42	42	40	15	NA	8
2017-02-02	47.6	on	on	on	H	H	H	2.3	1.3	3.6	128	82	365	33	24	64	4	3	6	42	41	40	29	NA	7
2017-02-03	44.9	on	on	on	H	H	H	1.7	0.7	3.6	105	40	375	29	11	62	4	4	6	42	42	40	30	NA	6
2017-02-04	44.1	on	on	on	H	H	H	1.4	0.2	3.3	91	11	361	28	4	59	3	3	6	42	41	40	38	NA	6
2017-02-05	49.2	on	on	on	H	H	H	2.1	1.6	3.1	116	93	324	31	28	59	4	3	5	42	41	40	0	NA	6
2017-02-06	54.1	on	on	on	H	H	H	2.4	1.7	3.6	132	99	372	33	30	67	4	3	6	42	42	40	46	NA	NA
2017-02-07	59.7	on	on	on	H	H	H	3.4	2.1	4.2	171	112	404	35	32	68	5	4	6	42	41	40	21	NA	4
2017-02-08	60.0	on	on	on	H	H	H	3.6	1.6	4.5	177	78	415	33	17	70	5	5	6	42	41	40	33	NA	6
2017-02-09	48.1	on	on	on	H	H	H	2.4	0.6	4.3	132	38	435	30	11	72	4	3	6	42	41	40	35	NA	7
2017-02-10	47.9	on	on	on	H	H	H	1.6	0.6	3.3	102	37	363	31	11	62	3	3	6	42	42	40	42	NA	7
2017-02-11	57.7	on	on	on	H	H	H	2.5	1.4	3.4	133	80	342	31	23	65	4	3	5	42	42	40	15	NA	5
2017-02-12	53.3	on	on	on	H	H	H	2.5	1.8	3.5	129	109	352	28	33	71	5	3	5	42	42	40	31	NA	6
2017-02-13	43.0	on	on	on	H	H	H	1.2	0.5	3.6	68	29	376	17	7	72	4	4	5	42	41	40	29	NA	NA
2017-02-14	42.8	on	on	on	H	H	H	2.0	1.6	3.3	116	95	357	28	26	68	4	4	5	42	42	40	0	NA	6
2017-02-16	42.1	off	off	off	H	H	H	2.1	0.6	3.7	117	35	378	29	7	68	4	5	6	42	43	-	48	NA	5
2017-02-17	47.8	off	off	off	H	H	H	1.9	0.6	3.2	108	35	347	27	9	66	4	4	5	42	42	40	52	5	9
2017-02-18	52.6	off	off	off	H	H	H	2.7	1.4	3.6	139	72	364	29	16	73	5	5	5	42	42	40	21	2	7
2017-02-19	56.8	off	off	off	H	H	H	2.1	1.4	3.9	107	73	380	22	15	76	5	5	5	42	42	40	33	2	4
2017-02-20	55.8	off	off	off	H	H	H	1.9	1.6	4.0	98	82	385	20	16	73	5	5	5	42	42	40	0	0	4
2017-02-21	54.0	off	off	off	H	H	H	2.9	2.2	3.8	154	118	386	28	22	72	6	5	5	42	41	40	0	0	3
2017-02-22	58.9	off	off	off	H	H	H	3.8	2.5	4.0	182	133	392	31	23	70	6	6	6	42	41	40	21	9	4
2017-02-23	62.8	off	off	off	H	H	H	4.8	3.6	4.8	228	168	458	38	21	69	6	8	7	41	41	40	24	1	5
2017-02-24	58.8	off	off	off	H	H	H	4.4	2.7	6.6	216	125	604	40	17	75	5	7	8	41	41	40	45	20	7
2017-02-25	57.2	off	off	off	H	H	H	3.2	2.1	5.3	155	101	498	30	14	77	5	7	6	41	41	40	26	7	9
2017-02-26	48.9	off	off	off	H	H	H	2.0	0.9	4.1	109	52	398	24	9	68	5	6	6	42	41	40	65	10	6
2017-02-27	52.4	off	off	off	H	H	H	2.3	1.6	4.2	121	78	416	25	12	70	5	7	6	42	42	40	NA	6	2
2017-02-28	59.5	off	off	off	H	H	H	2.8	1.9	4.4	136	94	429	28	14	75	5	7	6	42	42	40	1	NA	4
2017-03-01	59.7	off	off	off	H	H	H	3.6	2.1	4.7	174	98	443	31	14	76	6	7	6	42	41	40	18	12	6
2017-03-02	51.6	off	off	off	H	H	H	2.4	1.0	4.2	124	53	413	26	10	74	5	5	6	42	41	40	15	4	7
2017-03-03	46.9	off	off	off	H	H	H	2.0	0.9	4.2	111	49	418	25	9	74	4	5	6	42	41	40	44	7	6
2017-03-04	47.3	off	off	off	H	H	H	1.5	0.3	3.8	86	18	398	23	4	68	4	5	6	42	42	40	39	19	7
2017-03-05	48.6	off	off	off	H	H	H	1.1	0.4	3.6	71	25	387	21	7	64	3	4	6	42	42	40	NA	0	6
2017-03-06	55.1	off	off	off	H	H	H	1.2	0.1	3.9	65	6	397	16	2	72	4	3	6	42	42	40	31	16	3
2017-03-07	59.4	off	off	off	H	H	H	3.1	1.8	4.2	152	88	390	30	11	67	5	8	6	42	42	40	0	0	6
2017-03-08	60.4	off	off	off	H	H	H	3.6	1.4	4.4	177	68	410	35	11	67	5	6	6	42	41	40	29	10	6
2017-03-09	62.4	off	off	off	H	H	H	3.7	1.7	4.8	183	84	454	35	13	76	5	6	6	41	41	40	42	13	5
2017-03-10	55.0	off	off	off	H	H	H	3.1	1.1	4.4	161	58	440	31	9	81	5	6	5	42	41	40	31	20	7
2017-03-11	50.1	off	off	off	H	H	H	1.5	0.4	3.8	95	24	403	28	6	71	3	4	6	42	42	40	42	9	6
2017-03-12	48.4	off	off	off	H	H	H	1.5	0.4	3.5	93	26	373	28	6	64	3	4	6	42	42	40	30	5	5
2017-03-13	48.6	off	off	off	H	H	H	1.6	0.4	3.3	91	25	357	25	7	65	4	4	5	42	42	40	32	6	2
2017-03-14	50.2	off	off	off	H	H	H	1.8	0.4	3.2	111	29	345	27	6	61	4	5	6	42	42	40	0	0	5
2017-03-15	48.8	off	off	off	H	H	H	1.3	0.4	2.9	82	21	318	22	6	50	4	4	6	42	42	40	26	10	2
2017-03-16	53.1	off	off	off	H	H	H	1.5	0.7	3.3	93	44	347	27	9	59	3	5	6	42	43	40	23	6	6
2017-03-17	55.4	off	off	off	H	H	H	1.8	1.0	3.8	105	52	404	29	12	72	4	4	6	42	42	40	33	5	6
2017-03-18	59.3	off	off	off	H	H	H	2.2	1.6	3.9	116	89	396	24	19	72	5	5	6	42	42	40	23	22	7
2017-03-19	59.7	off	off	off	H	H	H	2.0	0.8	3.4	110	47	340	23	10	65	5	5	5	42	42	40	4	4	8
2017-03-20	60.8	off	off	off	H	H	H	1.4	0.5	3.7	82	29	370	19	6	71	4	5	5	42	42	40	29	1	2

Refrigeration: Humid Climate Sites 4-6 (Washington, D.C.)

DATE	T_{out}	CNMX			FLAG			Energy (kWh)			Runtime (min.)			Cycles (#)			Dur_{typ} (min.)			T_{return} (°F)			OCC (%)		
	(°F)	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
2017-03-21	64.3	off	off	off	H	H	H	2.6	1.8	4.0	134	91	391	28	18	69	5	5	6	42	42	40	0	0	6
2017-03-22	60.7	off	off	off	H	H	H	2.3	1.2	3.8	121	64	379	28	13	71	4	5	5	42	42	40	27	5	6
2017-03-23	52.8	off	off	off	H	H	H	2.2	1.0	4.1	125	56	420	30	12	72	4	5	6	42	42	40	16	3	7
2017-03-24	55.0	off	off	off	H	H	H	2.3	1.1	4.0	119	61	407	25	12	76	5	5	5	42	42	40	47	1	7
2017-03-25	65.2	off	off	off	H	H	H	2.5	1.9	4.4	129	94	411	30	17	74	4	6	6	42	42	40	25	11	5
2017-03-26	58.1	off	off	off	H	H	H	2.8	1.5	4.0	146	77	395	30	16	70	5	5	6	42	42	40	6	4	5
2017-03-27	63.6	off	off	off	H	H	H	2.8	1.3	4.3	145	67	402	31	13	69	5	5	6	42	42	40	33	17	3
2017-03-28	63.0	off	off	off	H	H	H	4.3	3.1	5.6	206	149	512	39	22	72	5	7	7	42	42	40	0	0	5
2017-03-29	59.2	off	off	off	H	H	H	3.9	2.5	4.7	189	120	441	34	17	76	6	7	6	42	41	40	22	8	8
2017-03-30	57.9	off	off	off	H	H	H	3.2	1.7	4.6	162	82	438	32	14	77	5	6	6	42	41	40	24	5	6
2017-03-31	58.2	off	off	off	H	H	H	3.5	1.9	5.0	177	97	470	30	17	73	6	6	6	42	42	40	37	13	6
2017-04-01	55.2	off	off	off	H	H	H	3.5	2.8	4.8	173	134	443	31	19	63	6	7	7	42	42	40	38	17	8
2017-04-02	57.7	off	off	off	H	H	H	2.4	1.4	4.0	124	72	386	24	14	64	5	5	6	42	42	40	41	17	7
2017-04-03	63.3	off	off	off	H	H	H	3.0	1.2	4.8	149	61	444	31	12	69	5	5	6	42	42	40	59	16	2
2017-04-04	67.7	off	off	off	H	H	H	4.4	3.3	5.4	215	155	485	41	20	69	5	8	7	42	42	40	NA	0	5
2017-04-05	61.6	off	off	off	H	H	H	4.2	2.9	5.7	205	139	513	37	18	72	6	8	7	42	41	40	NA	12	5
2017-04-06	59.9	off	off	off	H	H	H	3.8	2.5	5.2	180	119	478	32	17	72	6	7	7	42	41	40	21	0	7
2017-04-07	58.6	off	off	off	H	H	H	3.1	1.2	4.7	159	62	445	31	9	71	5	7	6	42	41	40	54	NA	6
2017-04-08	63.2	off	off	off	H	H	H	2.9	0.9	4.3	144	44	412	27	7	69	5	6	6	42	42	40	45	NA	8
2017-04-09	65.2	off	off	off	H	H	H	2.3	1.2	4.3	117	59	412	26	11	67	5	5	6	42	42	40	29	NA	6
2017-04-10	67.1	off	off	off	H	H	H	2.0	1.1	5.1	97	55	466	20	10	67	5	6	7	42	42	40	33	NA	2
2017-04-11	71.1	off	off	off	H	H	H	4.2	1.8	5.8	202	83	523	41	11	69	5	8	8	42	42	40	0	NA	5
2017-04-12	71.8	off	off	off	H	H	H	4.9	3.5	5.8	241	158	530	48	17	67	5	9	8	42	41	40	57	NA	6
2017-04-13	66.6	off	off	off	H	H	H	4.4	1.6	5.8	207	75	530	31	10	72	7	8	7	42	41	40	NA	NA	6
2017-04-14	69.2	off	off	off	H	H	H	3.6	2.1	5.2	173	94	494	34	11	78	5	9	6	42	42	40	26	NA	7
2017-04-15	70.4	off	off	off	H	H	H	3.1	1.6	5.7	160	82	524	34	12	81	5	7	6	42	42	40	46	NA	5
2017-04-16	74.8	off	off	off	H	H	H	5.0	4.4	5.4	224	189	510	37	22	80	6	9	6	42	42	40	11	NA	5
2017-04-17	71.3	off	off	off	H	H	H	3.9	2.2	5.5	188	105	506	35	16	79	5	7	6	42	41	40	59	NA	0
2017-04-18	69.7	off	off	off	H	H	H	3.6	2.3	5.3	175	111	496	31	17	78	6	7	6	42	41	40	NA	NA	4
2017-04-19	68.5	off	off	off	H	H	H	3.8	2.0	5.0	187	97	477	31	14	77	6	7	6	42	41	40	NA	NA	5
2017-04-20	72.5	off	off	off	H	H	H	5.0	4.2	5.8	240	186	530	44	20	78	5	9	7	42	41	40	58	NA	4
2017-04-21	74.0	off	off	off	H	H	H	4.1	3.6	6.4	207	172	581	41	28	78	5	6	7	42	41	40	NA	NA	6
2017-04-22	61.6	off	off	off	H	H	H	3.0	2.6	5.9	147	130	546	28	22	76	5	6	7	42	41	40	17	NA	5
2017-04-23	61.5	off	off	off	H	H	H	2.8	1.8	4.8	143	90	443	27	16	72	5	6	6	42	41	40	0	NA	NA
2017-04-24	66.9	off	off	off	H	H	H	2.1	1.1	5.1	105	56	468	21	10	72	5	6	7	42	42	40	25	NA	NA
2017-04-25	66.9	off	off	off	H	H	H	3.4	2.3	5.2	165	114	483	30	19	70	6	6	7	42	42	40	0	NA	5
2017-04-26	66.4	off	off	off	H	H	H	3.9	2.8	5.2	191	135	476	33	19	71	6	7	7	42	42	40	23	NA	5
2017-04-27	73.8	off	off	off	H	H	H	5.7	3.5	6.1	264	158	545	41	23	71	6	7	8	42	42	40	19	NA	5
2017-04-28	75.1	off	off	off	H	H	H	6.0	4.3	7.5	276	188	668	44	24	73	6	8	9	42	41	40	33	NA	6
2017-04-29	64.9	off	off	off	H	H	H	5.9	3.7	7.9	263	163	675	43	25	69	6	7	10	42	41	40	47	NA	6
2017-04-30	69.1	off	off	off	H	H	H	4.8	2.9	6.2	219	127	558	36	19	80	6	7	7	42	41	40	NA	NA	8
2017-05-01	72.5	off	off	off	H	H	H	3.1	1.8	7.3	149	83	646	28	15	78	5	6	8	42	41	41	19	NA	1
2017-05-02	73.4	off	off	off	H	H	H	4.3	3.9	7.5	212	172	660	39	18	80	5	10	8	42	42	41	0	NA	6
2017-05-03	69.5	off	off	off	H	H	H	4.1	2.2	5.9	193	102	546	32	15	86	6	7	6	42	41	41	31	NA	6
2017-05-04	64.3	off	off	off	H	H	H	3.8	2.0	5.3	189	95	495	33	14	82	6	7	6	42	41	40	25	NA	5
2017-05-05	71.3	off	off	off	H	H	H	5.0	3.3	6.3	236	157	576	37	25	80	6	6	7	42	42	40	41	NA	4
2017-05-06	68.3	off	off	off	H	H	H	4.3	2.3	5.6	209	108	522	33	17	80	6	6	7	41	41	40	54	NA	5
2017-05-07	67.6	off	off	off	H	H	H	2.5	1.5	4.9	124	73	467	24	13	80	5	6	6	42	41	40	46	NA	4
2017-05-08	66.3	off	off	off	H	H	H	1.9	1.0	4.9	99	50	461	20	9	82	5	6	6	42	42	40	33	NA	2
2017-05-09	63.2	off	off	off	H	H	H	2.7	1.7	4.7	134	83	444	26	14	82	5	6	5	42	42	40	0	NA	4
2017-05-10	63.1	off	off	off	H	H	H	3.3	1.9	4.9	165	93	465	31	14	79	5	7	6	42	42	40	16	NA	5
2017-05-11	63.1	off	off	off	H	H	H	5.1	2.7	5.4	241	121	502	35	12	81	7	10	6	42	41	40	29	NA	5
2017-05-12	64.1	off	off	off	H	H	H	5.5	5.0	8.5	260	222	803	37	17	66	7	13	12	42	41	40	51	NA	5
2017-05-13	67.0	off	off	off	C	C	C	4.0	4.3	6.7	199	204	657	35	24	76	6	9	9	40	37	37	38	NA	5
2017-05-14	73.9	off	off	off	C	C	C	4.5	6.4	6.2	208	300	613	35	37	79	6	8	8	38	34	35	29	NA	4
2017-05-15	72.6	off	off	off	C	C	C	2.7	3.1	6.7	132	148	653	24	23	82	6	6	8	38	33	35	35	NA	2
2017-05-16	69.6	off	off	off	C	C	C	4.7	6.1	7.0	223	270	683	38	30	79	6	9	9	38	33	35	0	NA	6
2017-05-17	73.7	off	off	off	C	C	C	7.4	7.7	8.0	306	316	740	42	38	72	7	8	10	38	33	34	19	NA	4
2017-05-18	76.5	off	off	off	C	C	C	9.7	9.0	9.0	405	359	816	41	34	66	10	11	12	38	33	34	24	NA	5
2017-05-19	75.6	off	off	off	C	C	C	NA	10.3	9.2	427	406	1130	49	35	34	9	12	33	38	33	34	53	NA	5
2017-05-20	69.9	off	off	off	C	C	C	7.6	6.3	5.3	342	287	1440	42	28	1	8	10	-	37	32	36	36	NA	6
2017-05-21	70.2	off	off	off	C	C	C	3.9	4.8	5.0	180	226	1440	28	24	1	6	9	-	38	33	43	29	NA	4
2017-05-22	71.7	off	off	off	C	C	C	3.4	3.9	5.0	161	191	1440	30	30	1	5	6	-	38	33	46	7	NA	1
2017-05-23	68.9	off	off	off	C	C	C	5.6	4.5	6.8	260	219	1237	43	37	26	6	6	48	38	33	48	0	NA	5
2017-05-24	70.2	off	off	off	C	C	C	5.2	5.2	5.7	242	244	523	40	32	85	6	8	6	38	33	48	61	NA	NA
2017-05-26	76.2	on	on	on	G	G	G	6.0	4.4	6.8	326	234	660	88	56	125	4	4	5	38	33	42	NA	NA	5
2017-05-27	75.6	on	on	on	G	G	G	6.1	4.9	5.7	335	261	586	93	63	139	4	4	4	38	38	40	73	8	6

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DATE	T_{out}	CNMX			FLAG			Energy (kWh)			Runtime (min.)			Cycles (#)			Dur_{typ} (min.)			T_{return} (°F)			OCC (%)		
	(°F)	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
2017-05-28	71.6	on	on	on	G	G	G	4.9	4.2	5.3	269	224	521	76	54	102	4	4	5	38	38	40	NA	1	3
2017-05-29	74.3	on	on	on	G	G	G	6.2	5.5	5.5	332	280	515	93	67	83	4	4	6	38	38	40	NA	0	0
2017-05-30	70.5	on	on	on	G	G	G	4.5	5.0	6.0	246	255	592	63	57	129	4	4	5	38	38	40	NA	0	0
2017-05-31	72.6	on	on	on	G	G	G	6.4	6.1	6.3	330	301	624	72	65	139	5	5	4	43	38	40	NA	7	5
2017-06-01	74.7	on	on	on	G	G	G	7.3	6.3	7.3	380	299	704	99	64	150	4	5	5	45	38	40	20	7	6
2017-06-02	75.6	on	on	on	G	G	G	7.2	6.8	6.7	372	342	656	98	75	139	4	5	5	38	38	40	43	8	6
2017-06-03	76.6	on	on	on	G	G	G	7.0	5.8	7.9	360	291	752	95	69	140	4	4	5	38	38	40	29	20	5
2017-06-04	78.9	on	on	on	G	G	G	5.5	6.2	5.8	283	304	566	80	73	115	4	4	5	38	38	41	67	23	5
2017-06-05	79.7	on	on	on	G	G	G	4.5	5.6	6.0	251	296	608	72	70	134	3	4	5	38	38	40	NA	1	1
2017-06-06	77.9	on	on	on	G	G	G	7.0	7.3	6.7	379	379	662	94	86	142	4	4	5	38	38	40	0	1	3
2017-06-07	72.8	on	on	on	G	G	G	5.3	6.0	5.6	283	317	573	81	72	126	3	4	5	38	38	40	23	16	4
2017-06-08	73.3	on	on	on	G	G	G	4.6	4.6	5.9	251	237	597	72	56	130	3	4	5	38	38	40	16	NA	4
2017-06-09	80.7	on	on	on	G	G	G	7.6	5.5	6.9	400	275	657	102	63	127	4	4	5	38	38	40	23	NA	5
2017-06-10	84.0	on	on	on	G	G	G	7.8	7.1	5.9	384	343	579	96	80	123	4	4	5	38	38	40	37	NA	7
2017-06-11	85.2	on	on	on	G	G	G	6.6	7.0	6.5	315	322	585	85	77	104	4	4	6	38	38	40	31	NA	3
2017-06-12	85.0	on	on	on	G	G	G	6.1	7.2	8.0	300	333	736	78	79	144	4	4	5	38	38	40	12	NA	1
2017-06-13	85.7	on	on	on	G	G	G	9.1	9.7	9.5	417	420	823	105	94	132	4	4	6	38	38	40	0	NA	6
2017-06-14	85.0	on	on	on	G	G	G	7.9	8.4	7.7	397	387	719	102	90	143	4	4	5	38	38	41	24	NA	6
2017-06-15	83.3	on	on	on	G	G	G	6.8	7.2	7.0	351	348	674	95	83	134	4	4	5	38	38	40	7	NA	4
2017-06-16	83.2	on	on	on	G	G	G	7.8	7.5	7.6	403	368	740	106	89	151	4	4	5	38	38	40	17	NA	5
2017-06-17	86.4	on	on	on	G	G	G	8.4	7.6	7.6	424	371	726	109	89	139	4	4	5	38	38	40	25	NA	6
2017-06-18	86.5	on	on	on	G	G	G	6.9	8.2	6.5	337	384	610	86	88	107	4	4	6	38	38	40	17	NA	4
2017-06-19	84.6	on	on	on	G	G	G	5.7	6.0	6.9	292	299	678	81	71	140	4	4	5	38	38	40	21	NA	2
2017-06-20	85.0	on	on	on	G	G	G	7.6	7.1	7.5	392	328	722	99	68	142	4	5	5	38	38	40	0	NA	5
2017-06-21	85.5	on	on	on	G	G	G	8.5	7.2	7.5	426	347	717	108	81	142	4	4	5	38	38	40	NA	NA	8
2017-06-22	88.5	on	on	on	G	G	G	8.9	8.4	7.9	442	406	732	115	91	133	4	4	6	38	38	40	NA	NA	7
2017-06-23	88.9	on	on	on	G	G	G	9.6	11.3	9.4	462	526	859	110	112	141	4	5	6	38	38	40	NA	NA	7
2017-06-24	83.4	on	on	on	G	G	G	7.4	7.8	7.6	370	372	724	97	90	148	4	4	5	38	38	41	NA	NA	8
2017-06-25	79.8	on	on	on	G	G	G	6.1	6.2	6.6	311	302	612	84	72	99	4	4	6	38	38	40	NA	NA	3
2017-06-26	78.9	on	on	on	G	G	G	3.9	4.4	6.5	211	219	627	58	54	130	4	4	5	38	38	41	NA	NA	2
2017-06-27	78.8	on	on	on	G	G	G	6.6	4.2	7.7	356	212	733	92	48	142	4	4	5	38	38	41	NA	NA	4
2017-06-28	81.9	on	on	on	G	G	G	5.9	4.7	6.4	306	238	628	80	58	136	4	4	5	38	38	41	NA	NA	5
2017-06-29	85.8	on	on	on	G	G	G	9.8	6.4	8.2	467	306	771	94	74	149	5	4	5	38	38	40	NA	NA	4
2017-06-30	87.4	on	on	on	G	G	G	##	8.2	8.5	885	373	781	59	77	142	15	5	6	38	38	41	NA	NA	7
2017-07-01	83.9	on	on	on	G	G	G	4.9	6.5	7.5	259	311	733	73	75	152	4	4	5	41	38	41	NA	NA	8
2017-07-02	85.0	on	on	on	G	G	G	4.7	6.3	7.0	241	301	636	65	72	109	4	4	6	38	38	40	NA	NA	3
2017-07-03	86.9	on	on	on	G	G	G	4.7	6.0	8.4	243	284	772	67	68	141	4	4	5	38	38	41	NA	NA	1
2017-07-04	86.6	on	on	on	G	G	G	6.1	6.9	8.5	307	318	774	84	78	129	4	4	6	38	38	41	NA	NA	5
2017-07-05	82.3	on	on	on	G	G	G	9.9	6.8	7.1	502	342	685	124	81	139	4	4	5	38	38	41	NA	NA	4
2017-07-06	81.8	on	on	on	G	G	G	8.8	6.3	7.9	462	324	772	120	78	150	4	4	5	38	38	41	NA	NA	5
2017-07-07	82.0	on	on	on	G	G	G	##	8.7	8.5	539	413	795	135	94	154	4	4	5	38	38	41	NA	NA	6
2017-07-08	83.3	on	on	on	G	G	G	7.6	5.6	7.1	385	265	679	107	65	147	4	4	5	38	38	40	NA	NA	5
2017-07-09	82.3	on	on	on	G	G	G	7.6	6.3	6.4	388	316	606	105	75	104	4	4	6	38	38	40	NA	NA	2
2017-07-10	84.5	on	on	on	G	G	G	6.9	5.7	7.7	340	266	725	94	65	136	4	4	5	38	38	40	NA	NA	1
2017-07-12	85.4	off	off	off	G	G	G	##	8.0	8.7	436	310	713	53	36	78	8	9	9	38	38	40	NA	NA	4
2017-07-13	86.3	off	off	off	G	G	G	##	10.8	10.7	485	396	853	52	44	68	9	9	13	38	35	41	NA	NA	6
2017-07-14	80.9	off	off	off	G	G	G	##	10.1	8.8	433	393	760	64	42	80	7	9	10	40	35	41	NA	NA	NA
2017-07-15	78.1	off	off	off	G	G	G	5.2	6.2	8.7	243	264	738	45	35	79	5	8	9	38	35	41	NA	NA	5
2017-07-16	78.6	off	off	off	G	G	G	8.7	6.9	6.9	381	295	610	57	39	82	7	8	7	38	35	41	NA	NA	4
2017-07-17	81.8	off	off	off	G	G	G	6.2	6.9	7.8	278	291	680	48	42	79	6	7	9	38	35	41	NA	NA	1
2017-07-18	82.5	off	off	off	G	G	G	7.1	5.2	7.8	316	220	678	50	30	80	6	7	8	38	35	41	NA	NA	6
2017-07-19	81.5	off	off	off	G	G	G	6.3	6.1	9.0	268	229	755	44	25	77	6	9	10	38	35	41	NA	NA	4
2017-07-20	84.4	off	off	off	G	G	G	8.7	9.6	10.1	348	354	820	50	35	72	7	10	11	38	36	40	NA	NA	7
2017-07-21	84.2	off	off	off	G	G	G	##	8.9	10.6	419	334	850	51	40	76	8	8	11	38	35	40	NA	NA	7
2017-07-22	79.4	off	off	off	G	G	G	6.9	6.9	7.7	304	293	685	45	41	90	7	7	8	38	34	41	NA	NA	6
2017-07-23	78.0	off	off	off	G	G	G	6.6	7.1	6.9	296	312	629	46	44	89	6	7	7	38	34	41	NA	NA	4
2017-07-24	81.6	off	off	off	G	G	G	6.9	6.0	7.4	299	261	658	43	37	86	7	7	8	38	34	40	NA	NA	1
2017-07-25	80.2	off	off	off	G	G	G	6.9	4.3	7.0	312	186	629	45	22	88	7	8	7	38	35	41	NA	NA	3
2017-07-26	81.6	off	off	off	G	G	G	6.2	5.3	7.3	272	229	663	43	31	86	6	7	8	38	35	40	NA	NA	4
2017-07-27	78.6	off	off	off	G	G	G	7.2	7.4	7.6	321	308	679	47	37	85	7	8	8	38	35	41	NA	NA	5
2017-07-28	79.1	off	off	off	G	G	G	6.8	6.7	7.2	314	296	652	48	38	91	7	8	7	38	35	41	NA	NA	6
2017-07-29	76.3	off	off	off	G	G	G	5.4	5.5	7.8	260	249	705	44	31	88	6	8	8	38	35	41	NA	NA	4
2017-07-30	78.0	off	off	off	G	G	G	4.7	4.5	6.2	219	198	573	37	25	89	6	8	6	38	37	41	NA	NA	6
2017-07-31	79.9	off	off	off	G	G	G	5.1	5.2	6.9	227	221	620	38	31	92	6	7	7	39	36	41	NA	NA	1
2017-08-01	78.7	off	off	off	G	G	G	6.7	5.9	7.5	289	251	650	45	33	91	6	8	7	39	35	41	NA	NA	4
2017-08-02	80.8	off	off	off	G	G	G	7.0	4.6	7.1	308	193	642	46	24	92	7	8	7	38	35	41	NA	NA	5
2017-08-03	80.7	off	off	off	G	G	G	9.2	9.7	7.4	397	382	646	55	34	87	7	11	7	38	35	41	NA	NA	5

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DATE	T_{out}	CNMX			FLAG			Energy (kWh)			Runtime (min.)			Cycles (#)			Dur_{typ} (min.)			T_{return} (°F)			OCC (%)		
	(°F)	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
2017-08-04	82.3	off	off	off	G	G	G	8.2	6.8	9.2	356	281	785	50	36	82	7	8	10	38	35	41	NA	NA	6
2017-08-05	80.5	off	off	off	G	G	G	7.1	5.8	7.2	320	262	656	49	32	91	7	8	7	38	35	41	NA	NA	7
2017-08-06	80.6	off	off	off	G	G	G	5.2	4.9	6.3	242	219	576	42	32	84	6	7	7	38	36	41	NA	NA	3
2017-08-07	78.8	off	off	off	G	G	G	5.5	4.9	6.6	270	233	608	46	37	87	6	6	7	38	35	41	NA	NA	1
2017-08-08	78.5	off	off	off	G	G	G	6.5	3.9	6.5	304	182	597	50	26	83	6	7	7	38	35	41	NA	NA	4
2017-08-09	80.2	off	off	off	G	G	G	5.4	4.4	6.9	250	192	611	43	25	79	6	8	8	38	36	40	NA	NA	4
2017-08-10	81.5	off	off	off	G	G	G	5.7	6.3	6.4	266	273	590	46	33	81	6	8	7	38	36	40	NA	NA	6
2017-08-11	78.8	off	off	off	G	G	G	6.2	6.7	6.8	285	293	617	49	37	78	6	8	8	38	36	40	NA	NA	6
2017-08-12	78.3	off	off	off	G	G	G	5.8	5.8	6.4	266	256	582	47	35	78	6	7	7	38	35	40	NA	NA	6
2017-08-13	80.1	off	off	off	G	G	G	5.9	5.4	6.4	275	240	577	48	33	80	6	7	7	38	35	40	NA	NA	3
2017-08-14	79.6	off	off	off	G	G	G	5.2	5.2	6.5	250	240	590	45	38	81	6	6	7	38	35	40	NA	NA	1
2017-08-15	78.3	off	off	off	G	G	G	7.2	5.5	6.9	333	244	623	51	25	79	7	10	8	38	35	40	NA	NA	3
2017-08-16	83.0	off	off	off	G	G	G	7.6	5.0	7.4	333	205	641	51	23	79	7	9	8	38	35	40	NA	NA	5
2017-08-17	82.6	off	off	off	G	G	G	8.1	11.0	9.6	348	424	803	52	33	72	7	13	11	38	35	40	NA	NA	5
2017-08-18	81.6	off	off	off	G	G	G	7.6	7.4	8.6	333	310	747	52	36	76	6	9	10	38	36	41	NA	NA	6
2017-08-19	80.0	off	off	off	G	G	G	6.2	5.8	7.2	272	246	637	44	33	86	6	7	7	38	35	40	NA	NA	4
2017-08-20	75.8	off	off	off	G	G	G	5.7	6.7	6.6	258	284	608	43	35	93	6	8	7	38	36	41	NA	NA	NA
2017-08-21	78.5	off	off	off	G	G	G	6.1	4.6	7.7	271	200	688	45	29	87	6	7	8	38	36	41	NA	NA	1
2017-08-22	82.7	off	off	off	G	G	G	8.1	6.0	8.3	345	247	703	51	32	76	7	8	9	38	36	40	NA	NA	5
2017-08-23	79.7	off	off	off	G	G	G	7.1	5.9	8.1	326	259	704	51	32	77	6	8	9	38	36	40	NA	NA	4
2017-08-24	76.2	off	off	off	G	G	G	6.6	5.1	7.7	307	233	692	48	28	76	6	8	9	38	36	40	NA	NA	7
2017-08-25	75.5	off	off	off	G	G	G	6.4	4.9	7.5	303	221	675	47	26	80	6	9	8	38	35	40	NA	NA	6
2017-08-26	76.6	off	off	off	G	G	G	5.9	4.9	6.4	282	223	602	47	30	88	6	7	7	38	35	40	NA	NA	5
2017-08-27	76.0	off	off	off	G	G	G	5.1	4.5	6.5	240	211	600	44	31	91	5	7	7	38	35	40	NA	NA	2
2017-08-28	75.3	off	off	off	G	G	G	4.6	2.4	6.8	220	110	632	41	11	90	5	10	7	38	36	41	NA	NA	2
2017-08-29	72.9	off	off	off	G	G	G	5.8	4.6	6.8	283	209	631	49	24	88	6	9	7	38	36	41	NA	NA	4
2017-08-30	74.5	off	off	off	G	G	G	6.9	4.6	6.5	324	204	594	54	23	80	6	9	7	38	36	40	NA	NA	4
2017-08-31	76.9	off	off	off	G	G	G	6.9	5.2	7.8	319	232	682	52	27	81	6	9	8	38	36	40	NA	NA	NA
2017-09-01	72.5	off	off	off	G	G	G	5.3	4.5	6.7	258	209	615	43	27	87	6	8	7	38	36	40	NA	NA	7
2017-09-02	71.1	off	off	off	G	G	G	3.6	2.7	5.8	182	130	543	35	17	85	5	8	6	38	36	40	NA	NA	5
2017-09-03	76.0	off	off	off	G	G	G	4.2	2.9	5.9	206	139	543	39	21	85	5	7	6	39	36	40	NA	NA	2
2017-09-04	77.1	off	off	off	G	G	G	3.9	3.1	5.9	189	139	549	36	18	86	5	8	6	39	36	40	NA	NA	1
2017-09-05	77.8	off	off	off	G	G	G	6.6	7.0	6.8	302	288	613	48	26	89	6	11	7	39	36	41	NA	NA	0
2017-09-06	72.0	off	off	off	G	G	G	6.3	3.8	6.6	301	176	604	51	22	86	6	8	7	39	36	40	NA	NA	4
2017-09-07	73.6	off	off	off	G	G	G	6.1	4.0	6.5	289	190	595	48	27	82	6	7	7	38	36	40	NA	NA	5
2017-09-08	73.4	off	off	off	G	G	G	5.8	6.8	6.7	278	306	613	47	31	82	6	10	7	38	36	40	NA	NA	7
2017-09-09	71.5	off	off	off	G	G	G	4.8	4.4	6.3	239	206	576	41	29	81	6	7	7	38	36	40	NA	NA	6
2017-09-10	71.2	off	off	off	G	G	G	4.5	4.0	5.7	213	191	533	40	29	80	5	7	7	38	36	40	NA	NA	4
2017-09-11	72.9	off	off	off	G	G	G	4.3	3.8	6.2	215	185	568	39	29	84	6	6	7	38	36	40	NA	NA	1
2017-09-12	75.4	off	off	off	G	G	G	6.3	4.9	6.4	295	230	598	48	35	85	6	7	7	39	36	40	NA	NA	4
2017-09-13	78.1	off	off	off	G	G	G	6.4	5.8	6.8	296	261	612	47	32	84	6	8	7	38	36	40	NA	NA	6
2017-09-14	80.0	off	off	off	G	G	G	5.8	4.7	6.7	271	217	622	44	27	89	6	8	7	38	35	40	NA	NA	7
2017-09-16	78.1	on	on	on	G	G	G	6.5	5.6	7.6	356	286	744	101	69	153	4	4	5	38	36	40	NA	NA	6
2017-09-17	78.1	on	on	on	G	G	G	6.8	6.3	6.2	358	323	596	100	77	105	4	4	6	38	38	40	NA	NA	5
2017-09-18	78.0	on	on	on	G	G	G	6.3	4.8	6.2	341	257	622	96	61	131	4	4	5	39	38	40	NA	NA	1
2017-09-19	79.7	on	on	on	G	G	G	8.3	6.0	7.2	442	309	708	119	74	146	4	4	5	39	38	40	NA	NA	4
2017-09-20	80.5	on	on	on	G	G	G	7.4	5.4	6.9	392	278	661	109	64	135	4	4	5	38	38	40	NA	NA	6
2017-09-21	80.4	on	on	on	G	G	G	8.2	6.2	8.2	419	308	776	112	73	149	4	4	5	38	38	40	NA	NA	5
2017-09-22	79.9	on	on	on	G	G	G	7.9	6.0	8.1	416	304	777	115	74	154	4	4	5	38	38	40	NA	NA	5
2017-09-23	78.2	on	on	on	G	G	G	7.3	6.0	8.0	384	300	770	103	71	159	4	4	5	38	38	40	NA	NA	6
2017-09-24	78.0	on	on	on	G	G	G	6.2	6.6	6.8	320	315	628	92	76	110	3	4	6	38	38	40	NA	NA	4
2017-09-25	78.2	on	on	on	G	G	G	7.3	8.2	8.1	377	406	766	106	99	147	4	4	5	39	38	40	NA	NA	1
2017-09-26	74.0	on	on	on	G	G	G	6.8	7.4	7.1	361	381	691	100	88	141	4	4	5	38	36	41	NA	NA	6
2017-09-27	73.2	on	on	on	G	G	G	8.2	7.7	7.7	419	380	718	108	91	136	4	4	5	38	35	40	NA	NA	5
2017-09-28	71.8	on	on	on	G	G	G	6.6	6.3	7.6	360	333	724	101	81	145	4	4	5	38	35	40	NA	NA	6
2017-09-29	68.6	on	on	on	G	G	G	6.2	7.3	7.1	342	367	702	96	77	148	4	5	5	38	35	40	NA	NA	8
2017-09-30	66.9	on	on	on	G	G	G	5.2	3.7	6.9	285	199	683	83	44	143	3	5	5	38	35	40	NA	NA	7
2017-10-01	68.5	on	on	on	G	G	G	3.8	2.9	5.3	218	159	518	67	39	99	3	4	5	38	35	40	NA	NA	6
2017-10-02	70.9	on	on	on	G	G	G	3.2	2.8	5.8	188	148	592	60	37	127	3	4	5	39	35	40	NA	NA	1
2017-10-03	71.6	on	on	on	G	G	G	4.8	4.9	6.4	277	262	643	80	63	143	3	4	4	39	36	40	NA	NA	5
2017-10-04	72.3	on	on	on	G	G	G	5.1	4.9	6.5	281	261	652	85	65	137	3	4	5	39	36	40	NA	NA	7
2017-10-05	75.2	on	on	on	G	G	G	5.9	6.0	7.1	329	307	693	94	67	138	4	5	5	39	35	40	NA	NA	8
2017-10-06	76.9	on	on	on	G	G	G	6.7	5.9	7.3	363	298	717	104	74	153	3	4	5	38	35	40	NA	NA	8
2017-10-07	73.3	on	on	on	G	G	G	7.3	5.8	6.6	391	307	656	104	74	143	4	4	5	38	36	40	NA	NA	6
2017-10-08	75.7	on	on	on	G	G	G	6.3	5.3	6.2	340	282	604	98	72	114	3	4	5	38	36	41	NA	NA	4
2017-10-09	76.7	on	on	on	G	G	G	6.5	5.0	6.9	352	270	673	102	70	134	3	4	5	39	36	41	NA	NA	1
2017-10-10	68.7	on	on	on	G	G	G	9.1	5.1	7.6	455	252	738	116	54	148	4	5	5	39	36	41	NA	NA	4

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DATE	T_{out}	CNMX			FLAG			Energy (kWh)			Runtime (min.)			Cycles (#)			Dur_{typ} (min.)			T_{return} (°F)			OCC (%)		
	(°F)	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
2017-10-11	69.5	on	on	on	G	G	G	8.2	8.0	6.9	436	413	683	112	92	139	4	4	5	38	36	40	NA	NA	8
2017-10-12	69.6	on	on	on	G	G	G	6.8	6.8	6.5	378	361	650	103	79	135	4	5	5	38	35	40	NA	NA	5
2017-10-13	70.8	on	on	on	G	G	G	6.0	5.3	6.7	335	279	668	96	66	140	3	4	5	39	35	40	NA	NA	7
2017-10-14	73.1	on	on	on	G	G	G	6.2	5.5	6.2	339	288	618	93	71	137	4	4	5	38	36	40	NA	NA	9
2017-10-15	68.0	on	on	on	G	G	G	5.1	5.3	6.1	277	284	583	81	70	106	3	4	6	38	36	40	NA	NA	3
2017-10-16	64.2	on	on	on	G	G	G	4.0	3.2	5.8	232	179	580	68	45	128	3	4	5	39	36	40	NA	NA	2
2017-10-17	61.7	on	on	on	G	G	G	4.0	1.3	5.6	224	70	569	68	18	129	3	4	4	39	36	40	NA	NA	4