# Case Study: Smart Monitoring and Diagnostic System (SMDS) for RTUs

**BETTER BUILDINGS ALLIANCE**

## Overview

The Smart Monitoring and Diagnostic System (SMDS) is a low-cost technology that helps building owners and managers keep rooftop air conditioner and heat pump units (RTUs) operating properly at peak efficiency. The SMDS technology has the potential to significantly benefit small commercial buildings, which predominately use RTUs for space conditioning. SMDS employs condition-based maintenance to monitor and provide real-time information on equipment degradation and its impacts on energy consumption. Monitoring data based on actual performance can help decrease energy losses and reduce operating costs of up to 30 percent. Additionally, SMDS's ability to automatically detect waste and maintenance needs can help extend the lifetime of RTUs by several years.

The Department of Energy (DOE) is developing the SMDS technology and seeks partners to further test and deploy the SMDS to the small commercial buildings sector and other users of RTUs. Through the Better Buildings Alliance, a field demonstration was conducted at four sites using two SMDS prototypes:

- **The Hardware SMDS** consists of a hardware package installed on each RTU that collects and processes data onsite.
- **The Cloud SMDS** uses off-the-shelf sensing and a commercially available cell modem that transmits raw data to a Cloud service to be processed
- Hardware and Cloud SMDS allow users to access information about their RTUs from a website, keeping users informed on conditions and the energy cost impacts for space conditioning.

*12.5-ton, two-stage RTU at an office building in Beltsville, MD, after installing the Hardware SMDS (outlined in red)*

| SMDS FIELD TEST RESULTS | |
|---|---|
| **Energy Savings** | 4,200 kWh of energy losses detected due to degraded RTU performance. |
| **Utility Savings** | Losses of $511 in utility costs were detected over the study period; unresolved faults over longer periods can lead to higher losses. |
| **Installation and Maintenance** | Installers of the SMDS at the sites reported installation difficulties, as the prototype hardware and the firmware were being used in the field for the first time. |
| **Overall Performance** | Challenges were found in interacting with the interface related to slow response by the web server. |

## The Problem

RTUs are typically the most poorly maintained of all HVAC equipment and often operate at below peak efficiency. Building owners have no feedback on the performance of RTUs until the units fail to operate. This results in extra expenditures on energy and damage to the equipment if operation continues under impaired conditions.

## How does SMDS work?

The SMDS can be retrofitted to new and existing RTUs. The technology collects data on system conditions, monitors performance and detects common operational faults. After a unit is serviced, the SMDS shows whether servicing eliminates the degradation, as well as its cost impacts, enabling building management to distinguish between successful servicing and unsuccessful servicing.

**Table1. SMDS Field Demonstration at Four Sites**

| Field Site | SMDS Type | # of RTUs | RTU System | Days Tested |
|---|---|---|---|---|
| Small Office Building<br>Beltsville, MD | Hardware | 3 | Packaged air conditioners (PACs); capacities of 6.5-12.5 tons of refrigeration with gas heat | 121 |
| Restaurant<br>San Juan, Puerto Rico | Hardware | 3 | PACs; capacities of 5-10 tons, without heat | 105 |
| Hardware Store<br>Rome, NY | Cloud | 3 | PACs; capacities of 5-10 tons, with gas heat | 81 |
| Fast Food Restaurant<br>Suffern, NY | Cloud | 3 | PACs; capacities of 5-10 tons, with gas heat | 61 |

## Results

The SMDS technology detected performance degradation on two of the 12 RTUs tested. The Hardware SMDS identified degradation on a RTU in Maryland. The estimated cumulative electricity cost impact of the degradation was $456 (3650 kWh) based on a blended electric rate of $0.125/kWh from the time of detection on May 31 until the end of October.[1] Operating faults were also detected on nearly all of the six RTUs retrofitted with Hardware SMDS. This was due to the RTU not providing ventilation when the unit was not cooling.

The Cloud SMDS detected degradation on a second unit located in Rome, NY. It had an estimated additional energy cost impact of $55 (550 kWh) based on a blended electric rate of $0.10/kWh for the period from September 8 through October 20. The Cloud SMDS also detected two operational faults on about half of the RTUs due to the supply fan running continuously for 24 hours a day and the RTUs short cycling, corresponding to the unit starting to cool too soon after having stopped actively cooling, which can lead to damage resulting in shortened equipment lifespan.

Ten of the 12 RTUs tested did not detect degradation. This was to be expected as degradation occurs gradually over time and faults do not occur at a predictable rate. Monitoring over more time with a greater sample of units is needed to better understand the fault rate and overall success of the SMDS in detecting performance degradation.

## Conclusions

The SMDS prototypes successfully identified degradation and operational faults, and were able to quantify the additional electricity use associated with the performance degradation. The findings revealed that obtaining a reliable estimate for the savings-to-cost ratio will require estimates of both the rate at which degradation is detected across RTUs, and the average energy cost impact of the degradations detected. This can only be obtained from a much larger sample of RTUs monitored for several months.

Installers of the Hardware SMDS reported a somewhat lengthy and difficult installation process. This was expected given that the prototype hardware and the firmware were being used in the field for the first time. Other issues that need to be resolved before the SMDS is rolled out commercially to customers include ensuring fast response by the web server. One of the commercial partners collaborating on this project is planning to adapt the Cloud SMDS as part of its commercial service offerings.

## Learn More

Learn more and view the full Smart Monitoring and Diagnostic Systems Demonstration report at http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-24000.pdf

Join the Advanced RTU Campaign (ARC) to take advantage of other advanced RTU technologies. ARC is an initiative supported by the DOE that encourages commercial building owners and operators to replace old RTUs with more efficient units or to retrofit RTUs with advanced controls.

[1] The impacts from June 19 to August 28, the hottest time of the year, when the SMDS was removed for servicing were not included.