RTU Suite of Projects

RTU Suite: RTU Challenge, RTU Advanced Controls and RTU Smart Monitoring and Diagnostic System

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Why is there a Need for RTU Projects?

• Packaged air conditioners and heat pumps (RTUs) are used in about 58% of all cooled commercial buildings, serving about 69% of the cooled commercial building floor space (EIA 2003)
  – Navigant estimates that packaged air conditioners use 0.9 quads and heat pumps use 0.4 quads of primary (source) energy annually*

• Installed efficiency of RTUs is low

• Operating efficiency is also low due to lack of:
  – advanced controls to improve part load performance
  – equipment maintenance

RTU Suite of Projects

• The large energy use of packaged equipment, combined with their low rated and operating efficiencies, makes them a major opportunity for improvement via targeted DOE actions.

• Department of Energy’s Commercial Building Integration (CBI) team initiated three projects to address the low efficiency of the installed base of packaged RTUs:
  – Issuing an industry challenge to develop higher efficiency RTUs
  – Evaluating and demonstrating an RTU controller that will increase the operating part-load efficiency of the RTUs, and
  – Developing a low-cost RTU diagnostic module to improve operation and maintenance of RTUs already installed.

• RTU suite of projects contributes to the BTO goal to reduce the energy required to operate existing commercial buildings by 40 percent, at less than the cost of the energy saved.

• Bring needed technologies and practices to market delivering:
  – Annual savings of 1,600 trillion BTUs by 2020
  – Annual savings of 6,000 trillion BTUs by 2030
RTU Suite Highlights

- RTU Challenge units will have IEERs over 60% greater than the current Federal minimum standard

- RTU advanced controls can lead to significant reduction in energy consumption
  - Measured (preliminary) average reductions in RTU electricity consumption of 46%

- The retrofittable smart monitoring and diagnostic system (SMDS) should provide energy savings of 10% to 20% for existing RTUs through condition-based maintenance
RTU Suite: RTU Challenge

- Installed efficiency of the RTUs is low and the current ASHRAE standard 90.1-2010 and the Federal minimum standard are modest improvements over the existing RTU stock.
- Part load efficiency of RTUs is also low, where the RTUs operate most of the year.
  - Current ASHRAE 90.1-2010 Standard requires an energy efficiency ratio (EER) of 11.0 and integrated EER (IEER) of 11.2
  - IEER approximates seasonal efficiency.
RTU Challenge Project Objective

• Encourage the industry to develop a more efficient RTU
  – Once the RTU Challenge units are manufactured, DOE intends to encourage Better Building Alliance (BBA) members and other building owners to replace older (and low efficiency) units with newer, higher efficiency units – those that meet DOE’s RTU Challenge specification

• This will lead to significant increases in the efficiency of installed RTUs, thereby lowering energy use and reducing costs, both for building owners and, at scale, at the national level
Potential RTU Challenge Project Impact

- Packaged equipment consume approximately 1.3 Quads/year
- The target market is all existing packaged air conditioners and heat pumps that are 10 years or older
- Potential savings can be up to 80 trillion Btus/year
- With concerted effort by DOE, BBA and utility partners to encourage adoption, a significant portion of the technical potential can be achieved in 3 to 5 years
RTU Challenge Approach

• **Approach:** Developed an RTU Challenge specification, continuing to provide technical support to manufacturers and analyzed test data.

• **Key Issues:** Goal of the specification was to encourage industry to develop a high performance RTU with an IEER of 18 or higher.

• **Distinctive Characteristics:** In 2011, PNNL along with NREL and ORNL coordinated the development of RTU Challenge specification led by the U.S. DOE’s BTO, with help from the BBA members.
## RTU Challenge Approach and Status

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Technical Support</th>
<th>Test Plan</th>
<th>Laboratory Testing</th>
<th>RTU Challenge Recommendation</th>
<th>Part Load Performance Curves</th>
<th>Impact Assessment</th>
<th>Tech Support Field Site Selection</th>
<th>Conduct Field Demonstrations</th>
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A measurement, monitoring and energy savings verification plan has been drafted
<table>
<thead>
<tr>
<th>Partners, Subcontractors, and Collaborators: Better Building Alliance, Daikin McQuay, Carrier and Lennox</th>
</tr>
</thead>
</table>

| Next Steps and Future Plans: Help BTO/CBI to promote the use of high performance RTU Challenge units thru RTU replacement campaign initiated by CBI |
RTU Suite: RTU Advanced Controls

• Most RTUs operate inefficiently
  – lack of advanced controls
    • constant supply speed fan and constant ventilation
  – lack of equipment maintenance

• Therefore, even a small improvement in operational efficiency through use of advanced controls can lead to significant reduction in energy use and carbon emissions

• Operating efficiency can be improved significantly with the use of advanced control strategies, such as:
  – integrated economizers
  – variable or multiple speed fan
  – variable capacity control and
  – demand controller ventilation
Objective:
- The main objective of the multi-year RTU advanced controls project is to show that use of advanced controls on RTUs can result in significant savings.

Approach:
- Estimated potential savings from use of advanced control strategies with RTUs through detailed simulations*
- Initiated extensive field tests to demonstrate the control strategies
- Currently in the process of validating savings from advanced controls through field tests

Key Issues:
- Show that significant savings are possible with advanced controls retrofit of existing RTUs through field demonstrations

Distinctive Characteristics:
- Leveraging BTO and BPA funding to further DOE goals

ESTIMATED COST SAVINGS FOR COMMERCIAL BUILDINGS WITH ADVANCED RTU CONTROLS

FY 11 EnergyPlus Simulation Results

- **Seattle** (Climate Zone 4B): 28% - 48%
- **Helena** (Climate Zone 6B): 30% - 44%
- **Duluth** (Climate Zone 7): 30% - 42%
- **Chicago** (Climate Zone 5A): 32% - 41%
- **San Francisco** (Climate Zone 3C): 43% - 67%
- **Las Vegas** (Climate Zone 3B): 41% - 43%
- **Denver** (Climate Zone 5B): 36% - 49%
- **Minneapolis** (Climate Zone 6A): 34% - 43%
- **Baltimore** (Climate Zone 4A): 39% - 46%
- **Los Angeles** (Climate Zone 3B): 55% - 64%
- **Phoenix** (Climate Zone 2B): 39% - 44%
- **Albuquerque** (Climate Zone 4B): 40% - 48%
- **Houston** (Climate Zone 2A): 42% - 49%
- **Fairbanks** (Climate Zone 8): 32% - 39%
- **Atlanta** (Climate Zone 3A): 38% - 43%
- **Miami** (Climate Zone 1A): 38% - 51%

• Installation of all controllers for both DOE and BPA projects complete
• Continuing to monitor RTUs in the field
• Preliminary savings analysis completed and final report will be released in August 2013 after DOE review
• Also, coordinating work with Center for Energy and Environment in Minnesota, which is also evaluating advanced control products
• For BTO portion of the work, it was joint effort between BTO/PNNL, vendor and the building owner

• DOE funding covered
  – One controller at each site
  – Instrumentation and data acquisition cost for up to 12 months
  – Instrumentation on additional RTUs

• Vendor provided additional controllers

• Owner paid the installation cost ($500 to $700 per unit)
Preliminary electricity consumption from 51 RTUs were analyzed

- 17 RTUs are heat pumps and the rest are air conditioners with gas furnaces

![Box plot showing energy savings for different categories of RTUs.](image)
Preliminary Electricity Savings and Expected Payback

- Installed cost of advanced controls:
  - 1 to 3 hp motor (up to 10-ton capacity) is approximately $3,000
  - 5 to 10 hp motor (up to 25-ton capacity) is approximately $3,600
- Based on the preliminary results from the field, units with 7.5 ton capacity and higher likely will have less than 3 year payback with no utility incentives
  - Smaller units (<7.5 ton) will have slightly higher payback
Partners, Subcontractors, and Collaborators: Better Building Alliance, Bonneville Power Administration, Center of Energy and Environment, Transformative Wave Technologies

BPA cost-share paid for retrofitting 44 RTUs with advanced controllers and for analyzing their performance

Next Steps and Future Plans: Develop a deployment and communication plan and help BTO/CBI (and BPA) promote the use of advanced controls for existing RTUs thru RTU replacement campaign initiated by BTO’s Commercial Buildings Integration Program
Purpose & Objectives - Problem Statement:

• Packaged air conditioners and heat pumps (RTUs) condition about 58% of all cooled commercial buildings, serving about 69% of the cooled commercial building floor space (EIA 2003)

• RTUs are generally poorly maintained, operating at degraded efficiency and capacity with faults present
  – Example: 60% and 90% of the economizers on RTUs are not functioning properly.

• Servicing, when done at all, is generally performed on a semi-annual basis but often is inadequate to correct all important faults.

• Operational faults are pervasive across the commercial buildings sector, increasing energy costs by up to about 30%.
Purpose & Objectives – Solution

• A low-cost smart remote condition monitoring and diagnostic system
  – Retrofittable to existing and new packaged units
  – Provides continuous condition monitoring and fault detection
  – Identifies and quantifies degradation in performance
  – Quantifies increases in operating cost (and savings from repairs)
  – Provides results via the web on any device with a web browser
  – Supports owner and service provider decisions about servicing the equipment
Purpose & Objectives – Solution

Smart Monitoring and Diagnostic System (SMDS)

- Wireless Data Transmission
- Data Management
- Web Access to Performance Metrics and Costs
- Servicing and Repairs
- Remote Data Collection, and Diagnostic Processing
Impact of Project

• SMDS technology will accelerate transformation of RTU maintenance from low-quality, failure-driven to high-quality and condition-based
• Project will demonstrate the value (energy savings, cost savings, and reduced negative environmental impacts) of the technology through field testing
• Results will support commercialization of the SMDS technology and support end-user specification of it
• Final product: Field tested/demonstrated retrofitable hardware/software system that detects and quantifies degradation in performance of RTUs
• Potential for energy savings of 24 billion kWh/site/yr valued at approx. $2.4 billion/yr (based on 15% savings)
Project Focus:

• Demonstration
  • Test performance under real-world conditions
  • Identify any issues and correct them
  • Estimate energy, cost and environmental impacts based on field data
  • Provide basis for both commercializer and end-user decisions

• Lead to commercialization by private project partners
Approach

• Deploy SMDS on 30 to 40 operating RTUs across 8 climate zones for field testing

▶ Climate zones with existing installations
  - 3b (warm dry)
    Portland, OR
  - 3c (warm marine)
    Menlo Park, CA
  - 4c (mixed marine)
    Irvine, CA

▶ Additional climate zones targeted:
  - 2A (Hot moist)
  - 3A (Warm moist)
  - 4A (Mixed moist)
  - 5A (cool moist)
  - 5B (cool dry)
Approach

• Use partner resellers to recruit sites and install units
  – Begin commercial deployment
  – Give resellers training and experience with installation and service
• Collect and analyze actual operation data – better quantify the savings potential per unit
• Obtain feedback from end users

Key Issues:
• Targets improving the maintenance of the enormous number of RTUs used in the commercial sector

Distinctive Characteristics:
• No other tool or product exists that provides continuous monitoring and detection of overall RTU performance degradation
• Low cost ~$200
Accomplishments

• Developed methodology for detecting overall refrigerant-side RTU performance degradation
• Developed hardware and integrated software for field deployment costing ~$200 per RTU
• Deployed initial set of SMDSs on 15 RTUs in the field

Progress on Goals:
• The demonstration, which will lead to savings measured in the field, is in progress.

Awards/Recognition: Stay tuned!
Partners, Subcontractors, and Collaborators:
- NorthWrite, Inc. and Universal Devices
- Other potential collaborators are Federal facilities (GSA and DoD), heating, ventilating and air-conditioning (HVAC) contractors, building management firms, and building owners and operators.

Technology Transfer, Deployment, Market Impact:
- NorthWrite is expected to commercialize the SMDS with Universal Devices serving as the hardware provider
- Potential savings per RTU: 10% to 20% of energy use
- National technical potential savings:
  - 57 to 114 trillion Btu(site elec)/yr worth $1.6 to $3.2 billion/yr
  - 180 to 360 trillion Btu(source)/yr
Next Steps and Future Plans:

- Demonstration project will end in March 2014
- Potential future activities
  - Development of Cloud version of SMDS software and integration of the SMDS into the DOE RTU Network (underway)
  - Technical support for commercialization by additional companies
## RTU Suite: Project Plans & Schedules

### Summary
- CBI_PNML-FY13: -97 (Challenge), -03 (Controller), -02 (Dx Unit)
- CPS Agreement #19951 (Challenge, Controller), # 25559 (Dx Unit)

### Legend
- Work completed
- Active Task
- Milestones & Deliverables (Original Plan)
- Milestones & Deliverables (Actual)

### FY2012

<table>
<thead>
<tr>
<th>Task / Event</th>
<th>Q1 (Oct-Dec)</th>
<th>Q2 (Jan-Mar)</th>
<th>Q3 (Apr-Jun)</th>
<th>Q4 (Jul-Sep)</th>
<th>Q1 (Oct-Dec)</th>
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<td><strong>Prior Year Activities</strong></td>
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<td><strong>Challenge</strong></td>
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<tr>
<td>Test plan describing monitoring, quantification of performance &amp; validation of FDD with spec</td>
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<td>Presentation to DOE and Alliance members on performance and FDD feature validation test results</td>
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<td>Letter report showing spec-compliant RTU performance curves compatible with E+</td>
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<tr>
<td>Report documenting field performance of spec-compliant unit &amp; lessons learned from field tests</td>
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<tr>
<td>Contribute, review and provide feedback on RTU deployment plan</td>
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<td><strong>Controller</strong></td>
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<td>Report documenting the analysis of energy &amp; cost savings impacts of advanced controller options for RTUs</td>
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<tr>
<td>Plant to test advanced controller in the field</td>
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<tr>
<td>Initiate field test to verify performance of advanced controller &amp; submit summary presentation on testing details</td>
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<tr>
<td>Complete extended impact analysis of advanced controller options for RTUs &amp; submit draft report to DOE</td>
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<tr>
<td>Complete initial field tests of advanced controller &amp; deliver an executive summary presentation of results to DOE</td>
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<td><strong>Dx Unit</strong></td>
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<tr>
<td>End-to-end test of SMDS in data-collection-only mode</td>
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<tr>
<td>Complete development of SMDS software</td>
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<tr>
<td>Installation of 15 SMDS units in test sites</td>
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# RTU Suite: Project Plans & Schedules

<table>
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<tr>
<th>Summary</th>
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<tr>
<td>CBI_PNNL-FY13: -97 (Challenge), -03 (Controller), -02 (Dx Unit)</td>
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<td>CPS Agreement # 19991 (Challenge, Controller), # 25559 (Dx Unit)</td>
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## FY2012
<table>
<thead>
<tr>
<th>Task / Event</th>
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<tbody>
<tr>
<td>Current work and future research</td>
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</table>

### Challenge

- Barriers & Approaches Framework Document
- RTU Strategy Document
- CBP Technical Support
- RTU Monitoring & data collection
- RTU Data Analysis
  - Report on demonstration, savings, economic analysis, controls verification, & further optimization of controls
  - Participate in spec-compliant RTU testing, validation & ongoing tech support
  - Develop part-load performance curves compatible with E+ software for McQuay, Carrier & Lennox products
  - Provide tech support for early RTU retirement program

### Controller

- Monitoring and data collection
  - Data Analysis
    - Report on demonstration, savings, economic analysis, controls verification, & further optimization of controls
    - Deployment and communication (presentations/communication materials)

### Dx Unit

- Develop and assess project plan (Stage Gate Review and Go/No-Go Decision) (3/13)
- Install SMDS Units (3/13)
- Monitoring and data collection (11/13)
- Collect Owner Service Data (11/13)
- Field Technical Support (10/13)
- Data Analysis (11/13)
- Report Preparation (12/13)
- DOE and external lab peer review of report (1/14)
- Development of other communication materials and project close out (1/14)

## FY2013
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## FY2014
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### RTU Suite: Project Budgets

#### FY 2013

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<th>Project</th>
<th>Budget</th>
<th>Variances</th>
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#### Budget History

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