RTU Suite of Projects

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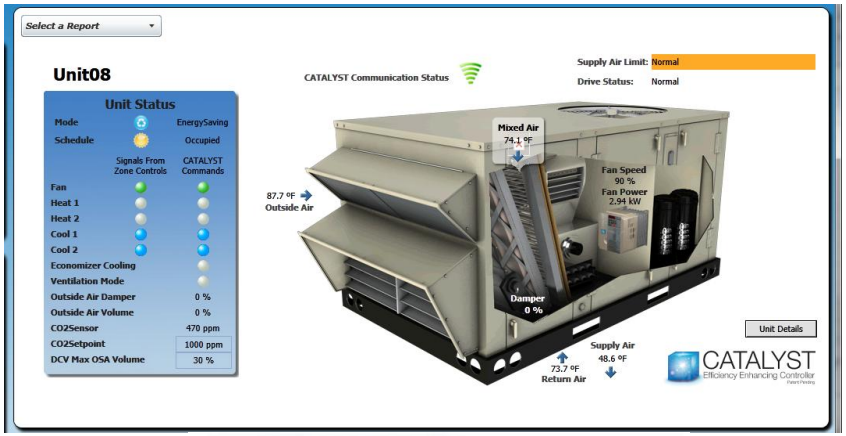

McQuay International
a member of DAIKIN group

Carrier
turn to the experts

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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

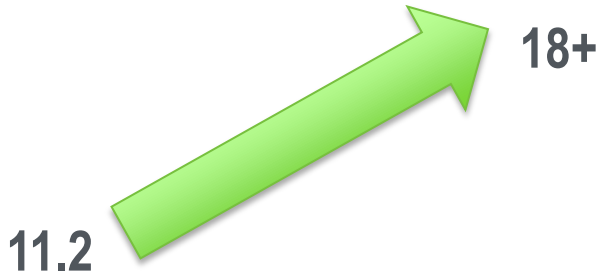
**Energy Savings Potential and RD&D Opportunities for Commercial Building HVAC Systems*, NCI, Sept. 2011

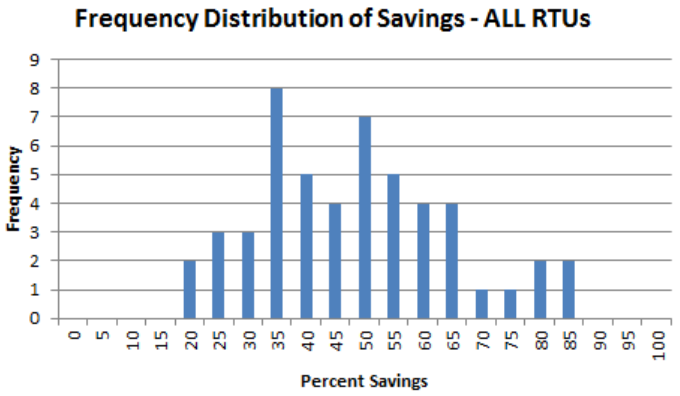
RTU Suite of Projects

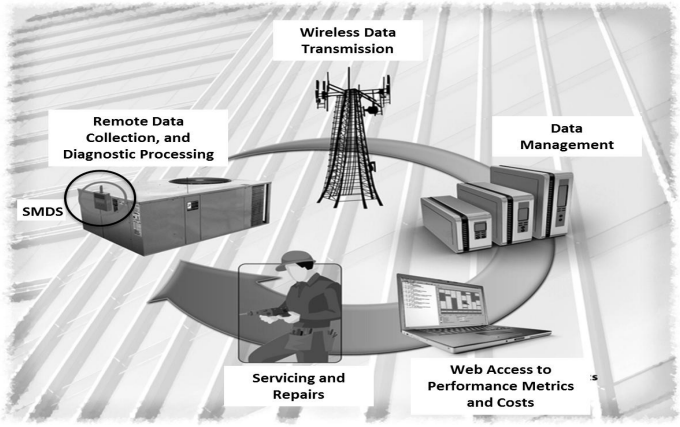
- The large energy use of packaged equipment, combined with their low rated and operating efficiencies, makes them a major opportunity for improvement via targeted DOE actions
- Department of Energy's Commercial Building Integration (CBI) team initiated three projects to address the low efficiency of 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 retrofitable 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

McQuay International a member of DAIKIN group

Carrier turn to the experts

LENNOX

RTU Challenge Approach and Status

Manufacturer	Technical Support	Test Plan	Laboratory Testing	RTU Challenge Recommendation	Part Load Performance Curves	Impact Assessment	Tech Support Field Site Selection	Conduct Field Demonstrations
McQuay	On going	√	√	√	√	Started	On going	
Carrier	On going	√	√	√			On going	
Lennox	On going	Draft						

A measurement, monitoring and energy savings verification plan has been drafted

Project Collaborations and Next Steps

Partners, Subcontractors, and Collaborators: Better Building Alliance, Daikin McQuay, Carrier and Lennox

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

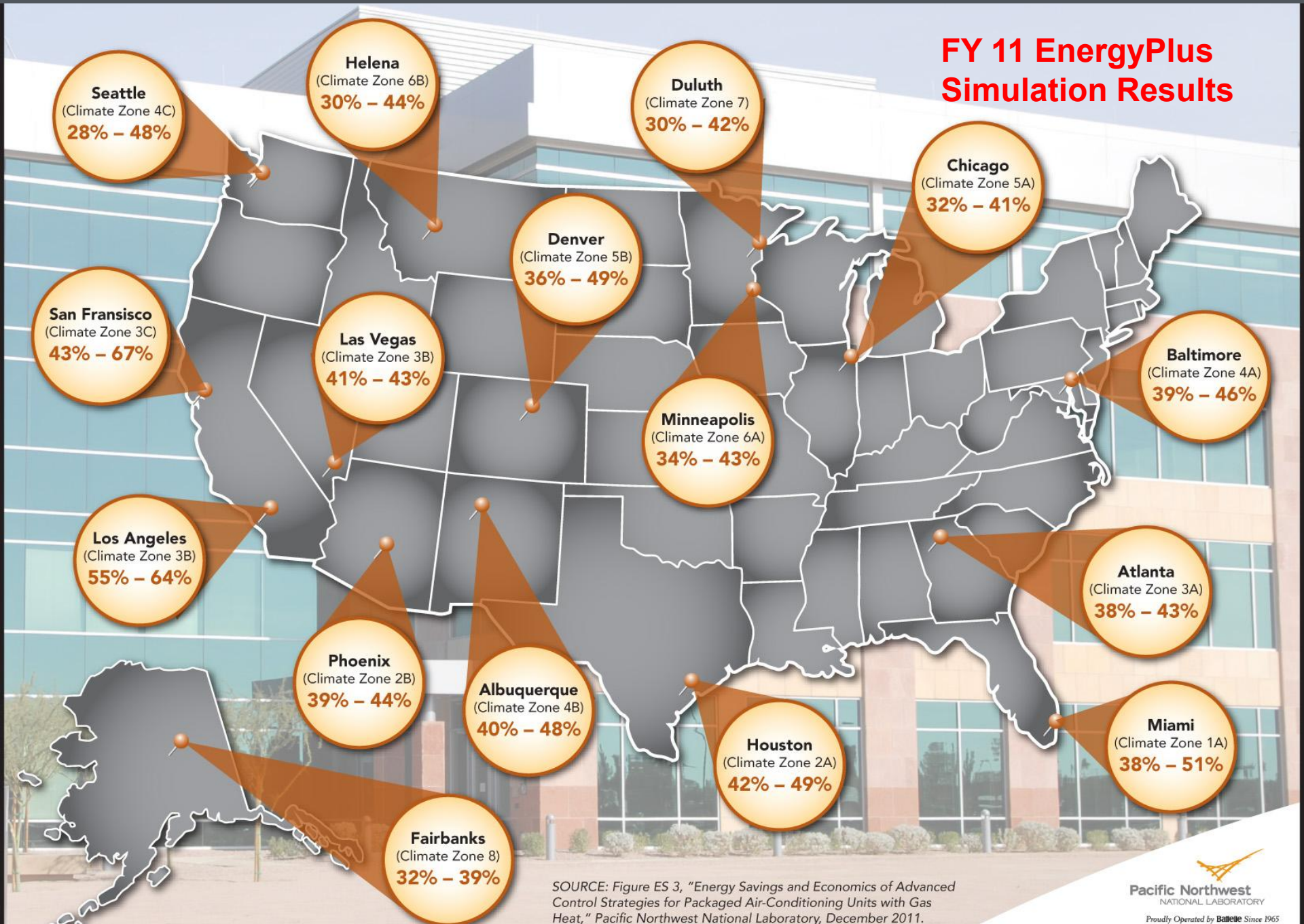
- Most RTUs operate inefficiently
  - **lack of advanced controls**
    - **constant supply speed fan and constant ventilation**
  - lack of equipment maintenance
- Therefore, even a small improvement in operational efficiency through use of advanced controls can lead to significant reduction in energy 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

RTU Advanced Controls Project Objective and Approach

- **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

*http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-20955.pdf
*http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-21944.pdf

ESTIMATED COST SAVINGS FOR COMMERCIAL BUILDINGS WITH ADVANCED RTU CONTROLS



SOURCE: Figure ES 3, "Energy Savings and Economics of Advanced Control Strategies for Packaged Air-Conditioning Units with Gas Heat," Pacific Northwest National Laboratory, December 2011.

Pacific Northwest NATIONAL LABORATORY

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RTU Advanced Controls Accomplishments and Progress

- 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

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BONNEVILLE POWER ADMINISTRATION

transformative wave TECHNOLOGIES

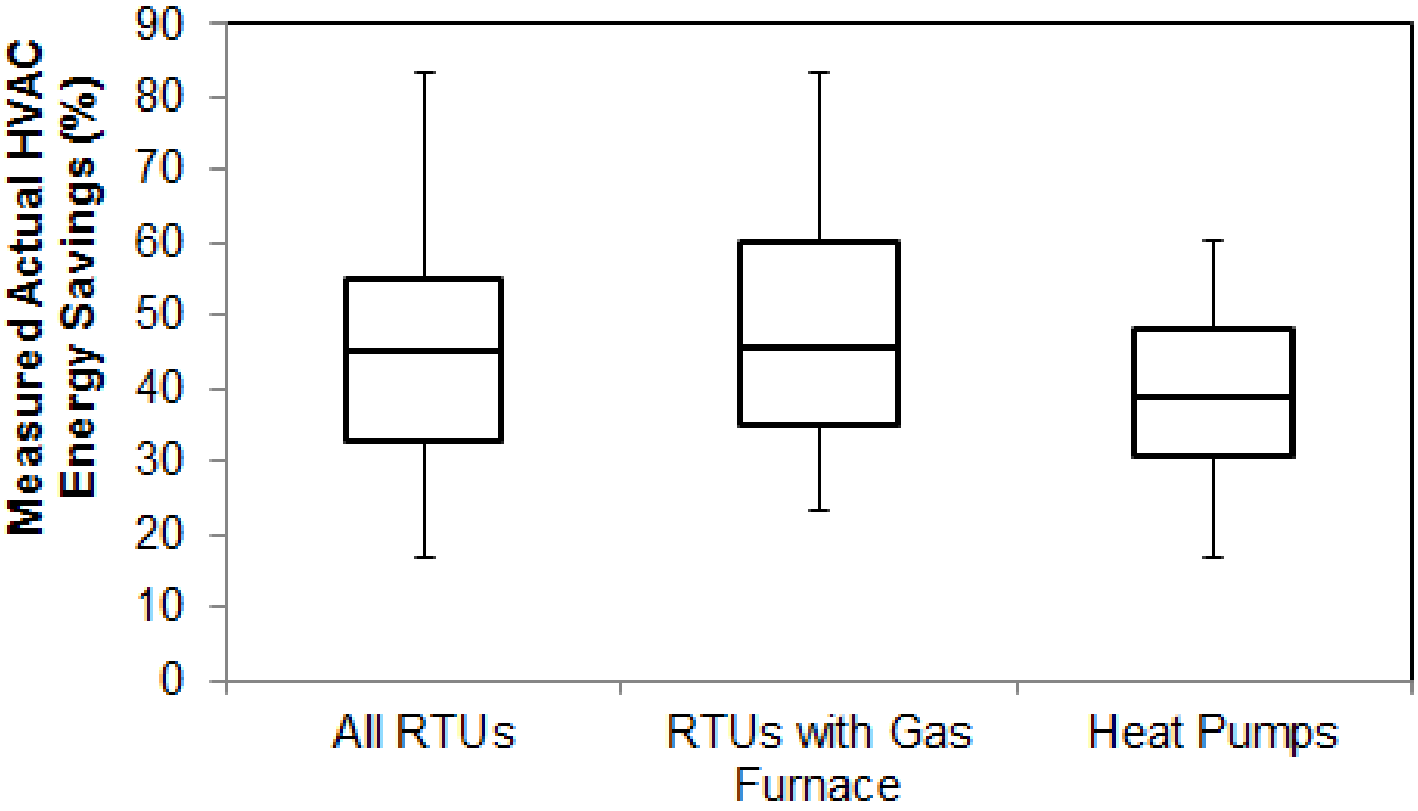
cee
Center for Energy and Environment

RTU Advanced Controls Field Installation Details

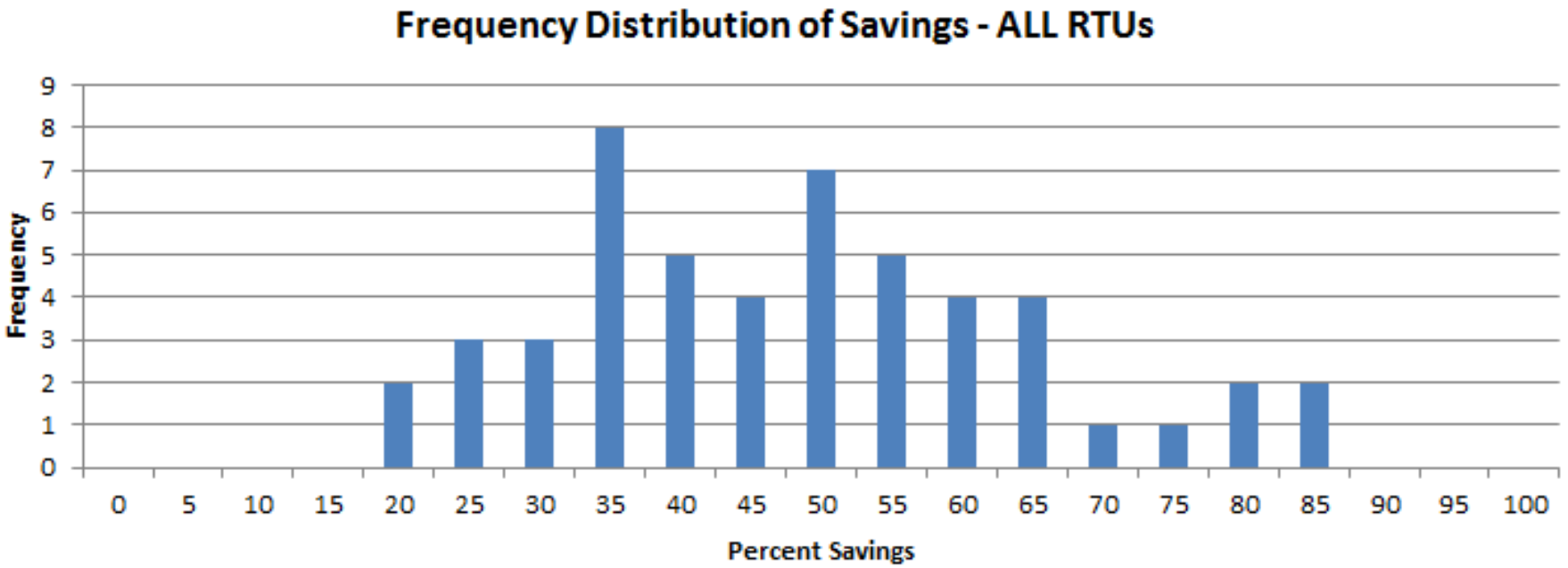
- For BTO portion of the work, it was joint effort between BTO/PNNL, vendor and the building owner
- DOE funding covered
  - One controller at each site
  - Instrumentation and data acquisition cost for up to 12 months
  - Instrumentation on additional RTUs
- Vendor provided additional controllers
- Owner paid the installation cost ($500 to $700 per unit)

RTU Advanced Controls Electricity Savings from Field Measurements

- Preliminary electricity consumption from 51 RTUs were analyzed
  - 17 RTUs are heat pumps and the rest are air conditioners with gas furnaces



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

Project Collaboration & Next Steps

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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

RTU Suite: Smart Monitoring and Diagnostic System Demonstration

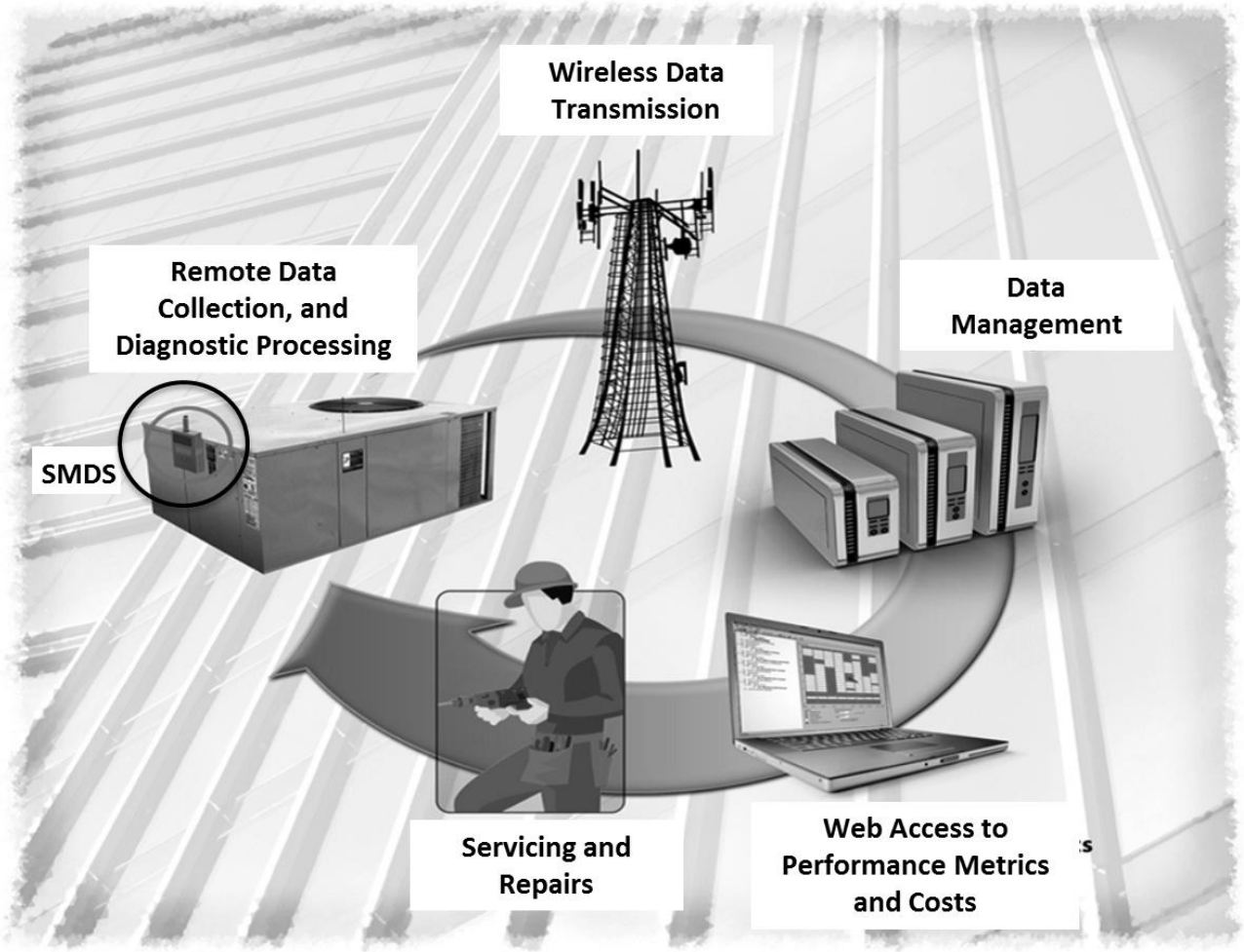
Purpose & Objectives - Problem Statement:

- 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
  - Retrofitable 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

Smart Monitoring and Diagnostic System (SMDS)



Purpose & Objectives – Project Impact

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)

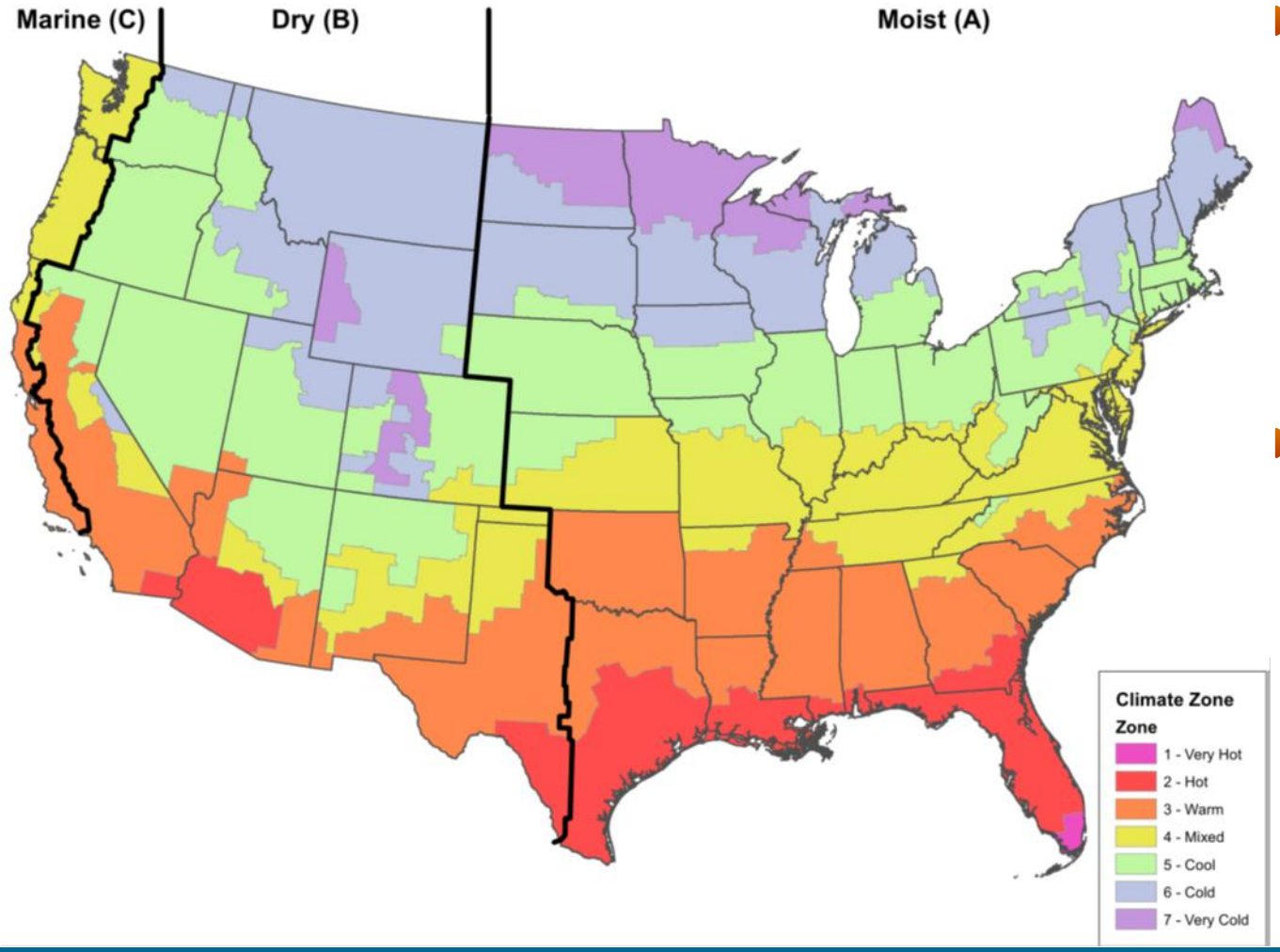
Purpose & Objectives – Project Focus

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 and Progress

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!

Project Integration, Collaboration & Market Impact

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

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

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Summary	
CBI_PNNL-FY13: -97 (Challenge), -03 (Controller), -02 (Dx Unit)	
CPS Agreement # 19991 (Challenge, Controller), # 25559 (Dx Unit)	

Legend

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

Task / Event	FY2012 Q1 (Oct-Dec)	FY2012 Q2 (Jan-Mar)	FY2012 Q3 (Apr-Jun)	FY2012 Q4 (Jul-Sep)	FY2013 Q1 (Oct-Dec)
Prior Year Activities					
Challenge					
Test plan describing monitoring, quantification of performance & validation of FDD with spec			◆		
Presentation to DOE and Alliance members on performance and FDD feature validation test results				◆	
Letter report showing spec-compliant RTU performance curves compatible with E+				◆	
Report documenting field performance of spec-compliant unit & lessons learned from field tests					◆
Contribute, review and provide feedback on RTU deployment plan				◆	
Controller					
Report documenting the analysis of energy & cost savings impacts of advanced controller options for RTUs		◆			
Plant to test advanced controller in the field			◆		
Initiate field test to verify performance of advanced controller & submit summary presentation on testing details			◆	◆	
Complete extended impact analysis of advanced controller options for RTUs & submit draft report to DOE				◆	◆
Complete initial field tests of advanced controller & deliver an executive summary presentation of results to DOE					◆
Dx Unit					
End-to-end test of SMDS in data-collection-only mode		◆			
Complete development of SMDS software			◆		
Installation of 15 SMDS units in test sites					◆

RTU Suite: Project Plans & Schedules

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Summary
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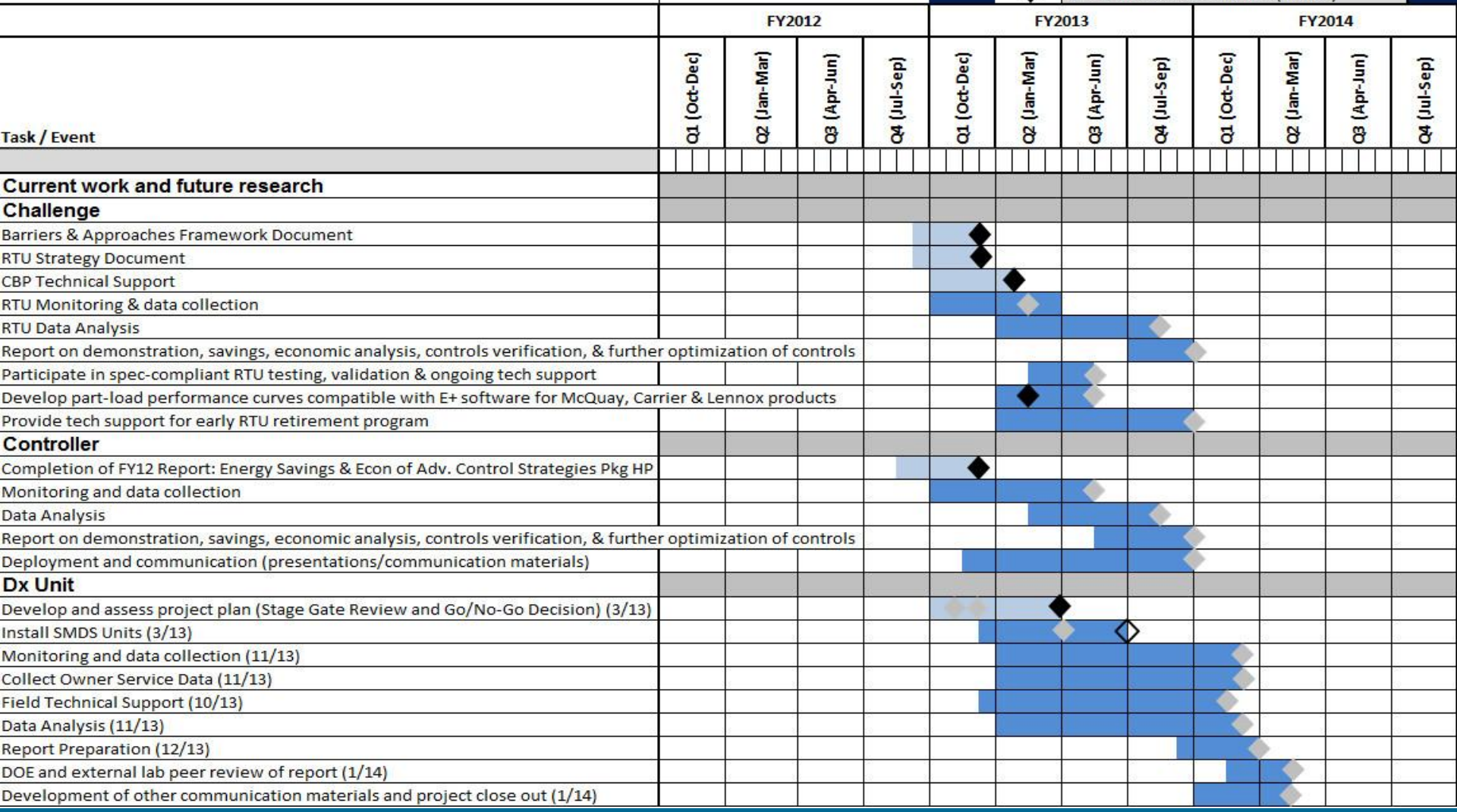

RTU Suite: Project Budgets

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FY 2013				
Project	**Budget**	**Variances**	**Cost to Date (3/1/2013)**	**Additional Funding**
Challenge	$196K	0	$31K	0
Controller	$172K	0	$97K	$80K (BPA)
Dx Unit (SMDS)	$408K	0	$98K	$48K

	Budget History					
	FY2010		FY2011		FY2012	
	DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
Challenge	$0K	$0K	$0K	$0K	$203K	$0K
Controller	$0K	$0K	$125K	$0K	$372K	$141K (BPA)
Dx Unit (SMDS)	$0K	$0K	$687K	$95K (NorthWrite)	$563K	$33K (NorthWrite)