Integrated HVAC Energy Efficiency and Demand Response in Commercial Buildings

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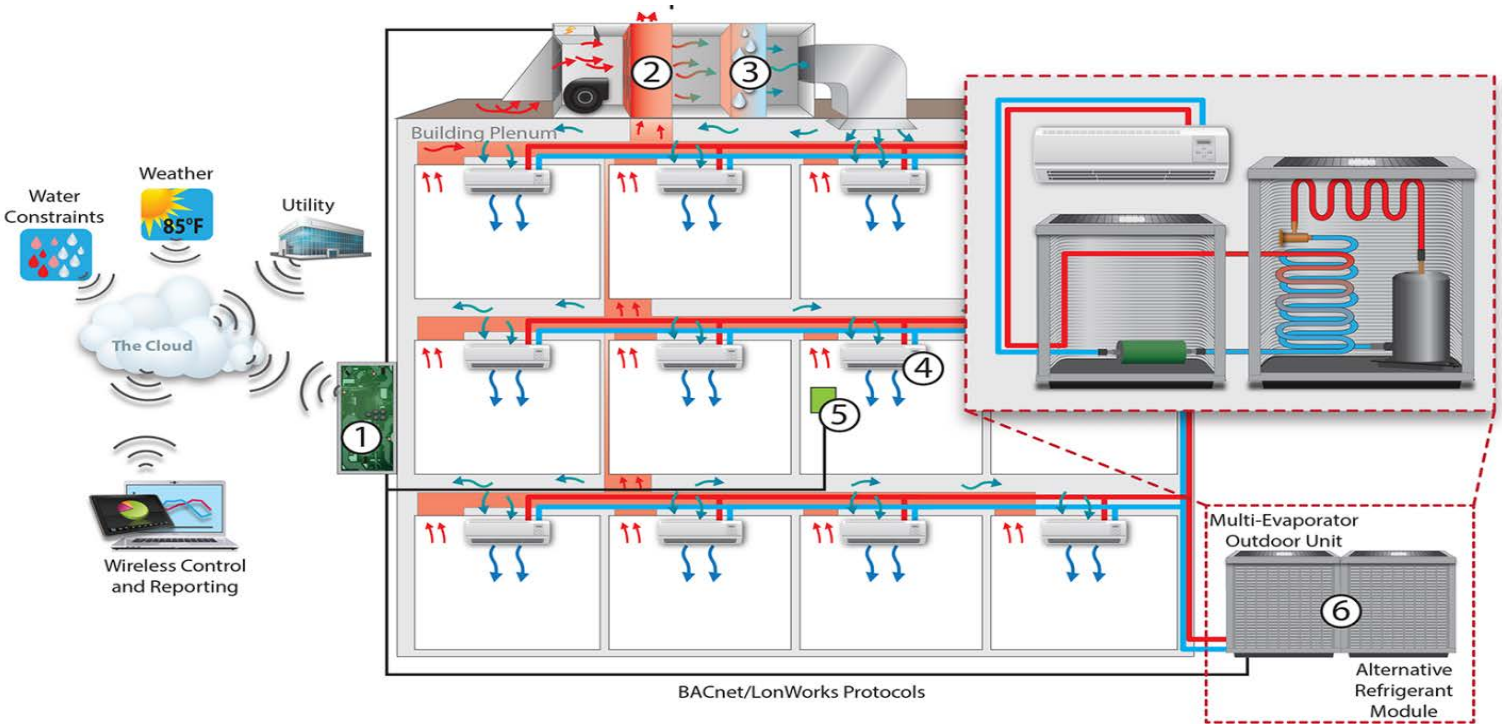
Project Goals

- Enable greater energy efficiency in commercial HVAC systems through integration of occupant tuned controls and natural ventilation enhanced with evaporative cooling
- Demonstrate integrated open standards demand response
- Project to a new refrigerant future with natural refrigerants



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Project Partners

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Problem Statement and proposed solution

- The Problem:
  - Existing commercial buildings have low hanging “energy waste” because controls are not tuned to occupancy
  - Practical implementation issues such as ventilation schema with VRF have been a barrier in achieving benefits predicted by energy models
  - Upcoming refrigerant regulations could have a substantial impact
  - Control systems are not yet DR-ready (plug and play)
- Proposed Solution:
  - VRF systems have a stated advantage in commercial buildings with their ability to concentrate cooling in occupied spaces
  - IDEC systems can meet cooling needs for 80%+ of total hours
  - Integration of complementary benefits using controls with occupant sensing and DR could provide significant energy savings
  - Calibrate energy models with actual operation and feed to Title 24

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Project Objectives

- Calibrate performance of existing commercial buildings with VRF and IDEC with models using existing field data
- Develop integrated HVAC controls that
  - Combine VRF systems with indirect evaporative cooling systems
  - Use cloud based optimization to tune between weather conditions, occupancy and building loads
  - Enhance occupant based sensing and control in commercial spaces
  - Integrate advanced fault detection and diagnostics for continuous operational efficiency
  - Apply embedded open standards BACNet for Energy Efficiency and OpenADR for advanced DR
- Test and evaluate secondary loop natural refrigerant systems for commercial air-conditioning
- Advance new building models and incorporate into Title 24

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Key Technology Development Elements

1. Building Controller :: Integrates data from many sources to optimize system efficiency and occupant comfort. :: Occupancy sensing, adaptive & predictive :: Optimizes multi-system operation :: Advanced fault detection and diagnostics	**2. IEC as DOAS** :: Eliminates ventilation cooling loads at all times :: Operates with EER=50–85+ :: Reduces VRF compressor load (esp. at peak) :: Provides CFC-free cooling
3. Building Sensors :: Provide feedback to the cloud controls for more intelligent delivery of fresh air (DCV) :: Improves occupant comfort and reduces energy consumption	**4. Climate Appropriate VRF Operation** :: VRF controlled to operate with very high sensible heat ratio :: Room-by-room comfort control :: Ductless system reduces distribution losses
5. Novel Secondary Loop Pumped-Refrigerant VRF :: Facilitate the use of non-HFC, non-GWP refrigerants :: Hermetically sealed factory charged refrigerant system located outside of occupied space	**6. Heat-Recovery Ventilation (HRV)** :: Recovers waste heat for ventilation in winter :: Improves efficiency for indirect evaporative cooling

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Technical Approach: Technical Task 1

- Collect existing data on VRF and IDEC field implementations
  - Emerging Tech Evaluations
  - Other field studies from outside CA
  - Manufacturer provided test cases
  - Data includes pre- and post- data
- Model these buildings to calibrate the data with EnergyPlus models compliant with Title 24
- Identify any gaps, and causes for performance deficiency
- Identify if and how integrated hardware with controls can:
  - Right size equipment
  - Reduce energy use

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Technical Approach: Technical Task 2

- Develop integrated controls schema that will help optimize occupancy sensing, with operation of both VRF and IDEC systems
- Implement optimized EE schema in BAS controller using BACNet or other compatible open standards
  - The BAS controller will be a supervisory controller
  - Test both VRF as primary and IEC as primary control schema
- Integrate automated demand response using OpenADR and implement DR optimization (setbacks, etc.) in control system
- Design a secondary loop systems that can isolate high efficiency natural refrigerants outside of occupied spaces using a refrigerant – refrigerant heat exchanger
- Test secondary loop system

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Technical Approach: Technical Task 3

- Identify field test sites and upgrade the existing systems to have both VRF and DOAS/IDEC
  - Convert existing rooftops to DOAS systems with IEC to meet ventilation requirements and to provide free cooling when needed
- Monitor baseline performance of selected sites for 3 seasons before new hardware and controls are implemented
- Implement, monitor and measure performance
- Develop Calibrated models

Site 1: Hotel in Los Angeles area

Site 2: UC Davis campus building

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Benefits to California and beyond

- Potential to reduce energy use and peak demand in existing commercial buildings by up to 40%
  - Enable new mandates to cut energy use in half in existing building
- Estimated CA savings of 2800GWh of energy use and 2 GW of peak demand
- Team that can scale benefits beyond CA and provide manufacturers with international scale solutions
- $50 million in possible annual energy savings based on target building types, and commercial electric rates
- Address research and product gap in integrated systems (vs. individual products)
  - Help reduce risk for manufacturers in market transformation

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