Technology View

Smart Internet Connected Controls
and
Variable Capacity Heat Pumps

New technologies need new M&V

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May 16th, 2014

Presentation Outline

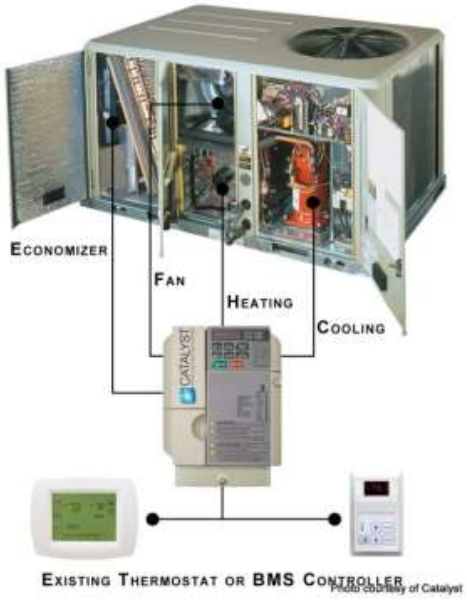


Photo courtesy of Catalyst

1. Smart Connected Devices
   - Technology
   - M&V

Photo courtesy of Digital Lumens

2. Variable Capacity Heat Pumps
   - Technology
   - M&V

VRF Systems

Ductless Heat Pump

3. New Japanese HVAC Technology

Smart Connected Devices

- Low cost, high resolution, real-time, large scale performance data.
- Feedback used by manufacturers and providers for performance improvements.

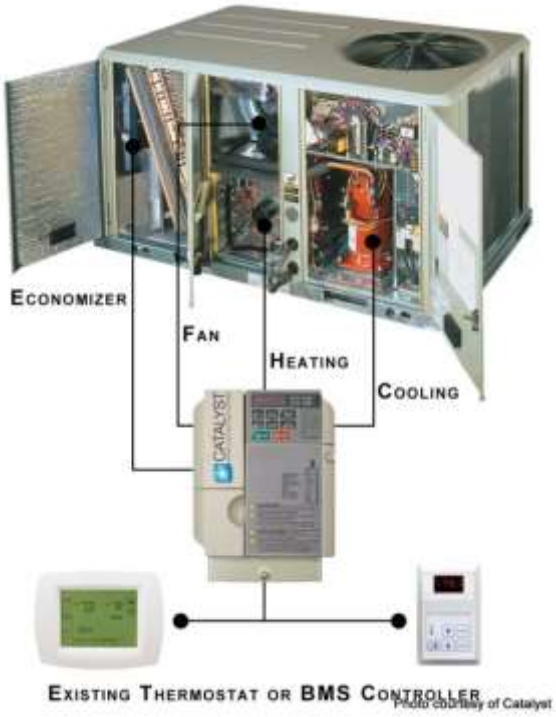


Photo courtesy of Catalyst

Photo courtesy of Digital Lumens

Smart Thermostats

The Hype

Intelligent, Internet connected thermostats promise deeper and more persistent energy savings.

…but will these savings occur in the real world?

…and how will we know?

The Hope

M&V Challenges for Smart Connected Devices

- Software-based performance
- Rapid improvement and update cycles
- Relatively small savings – *controls and behavior*
- Challenges to EM&V approaches that rely on:
  - large scale end-use or billing-analysis field studies
  - Product specs with deemed-savings

➢ *Need faster timelines and lower costs*

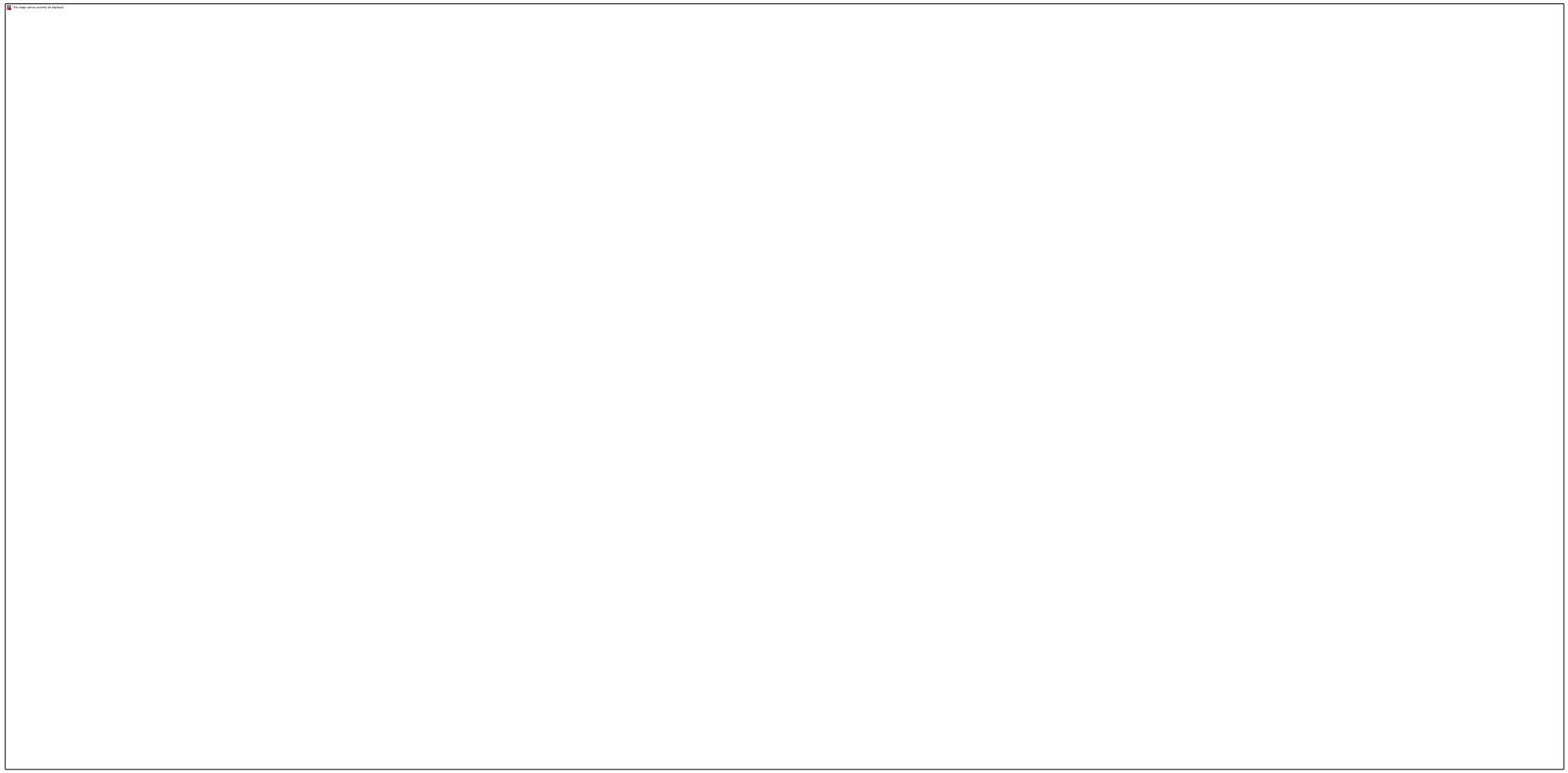
➢ *Need ongoing performance monitoring*

Proposed M&V Approach for Smart Connected Devices

Leverage low cost, high resolution, large scale performance data.

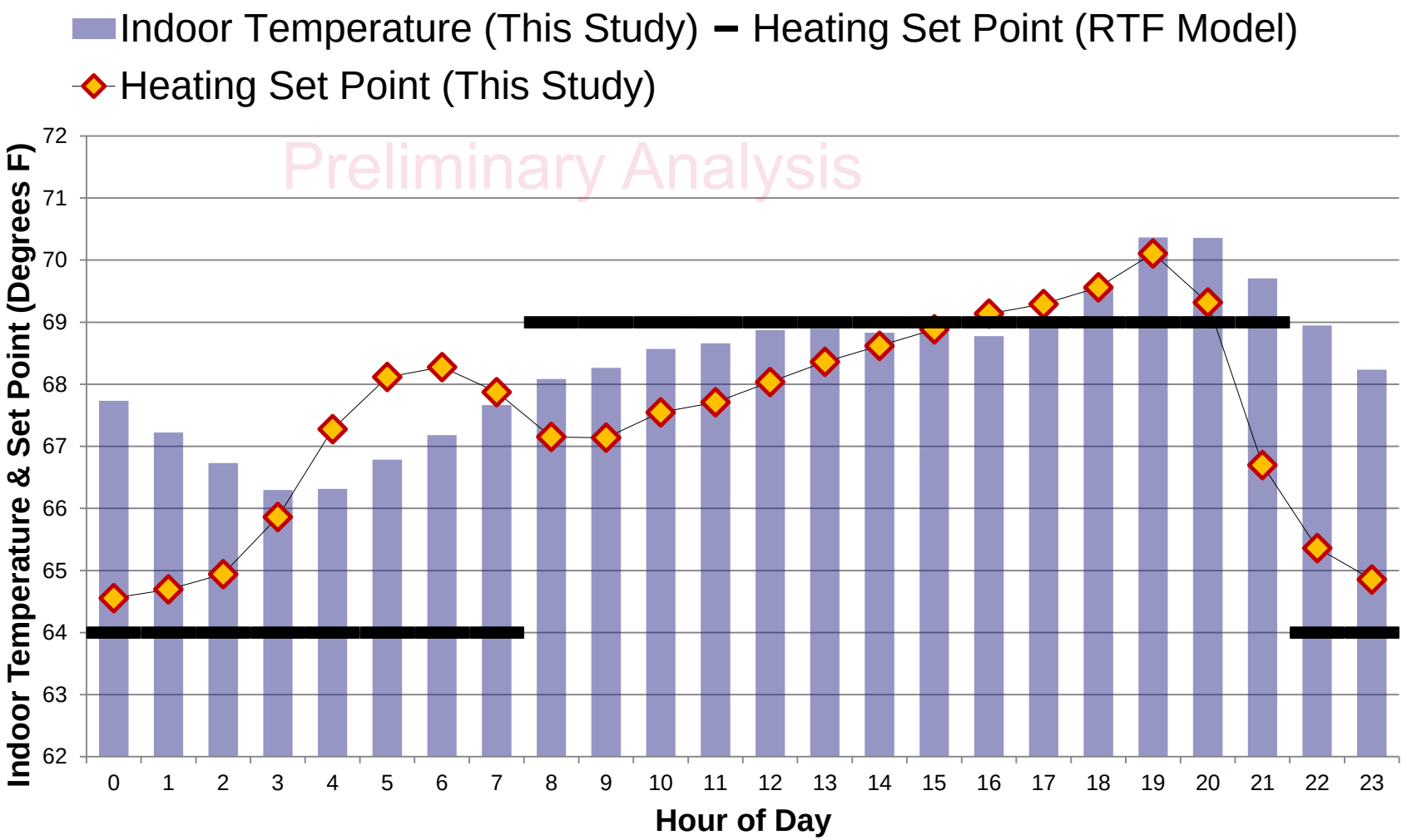
1. Establish standard ways to access and aggregate data from various vendors.
2. Develop M&V techniques utilizing vendor supplied data.
3. Verify performance with active monitoring of groups of installed smart thermostats

Single Home Hourly Time Series Thermostat Data



Aggregated Thermostat Data

for 900 networked thermostats in the Pacific Northwest by hour of day, 2/1/14 to 2/28/14



Variable Capacity Heat Pumps

Ductless Heat Pump:

- Manufactured Homes
- Forced Air homes
- Cold Climates

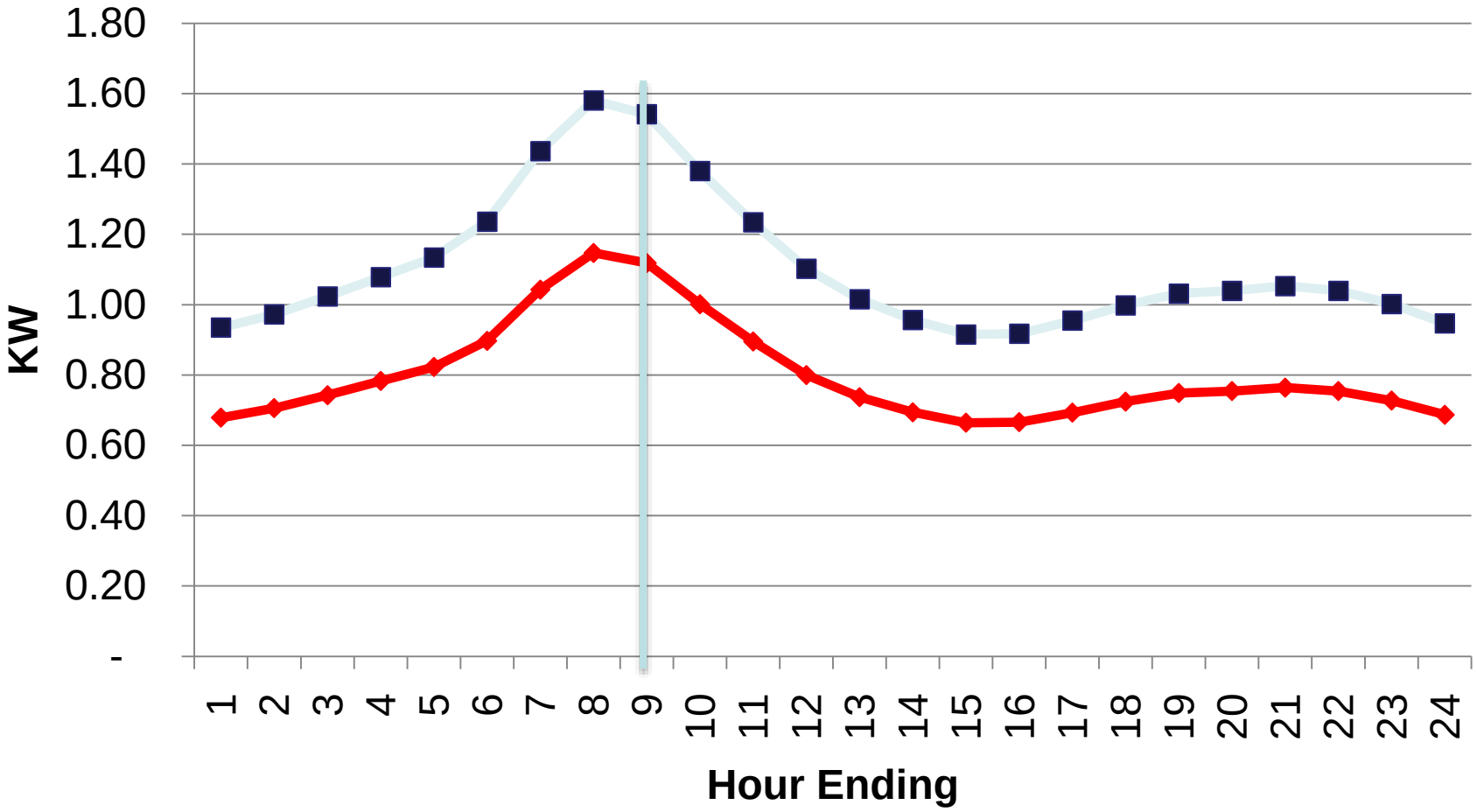
Residential Variable Capacity Heat Pump

VRF Systems

Advanced Rooftop Units

CO2 HPWH

Ductless Heat Pumps Energy and Capacity Benefits



Source: Northwest Power and Conservation Council

BPA Current and Recent Field and Lab Tests

- Expanded ductless heat pump applications
  - Residential Zonal electric displacement
  - Residential forced air displacement
  - Colder climates
  - Manufactured homes
  - Small Commercial
- Residential variable speed heat pump –
  - *Lab tests, lab home tests, field tests, modeling (e.g. Carrier Greenspeed)*
- Advanced Rooftop Unit (Daikin Rebel, Aaon)
- Multi-family DHW heat pumps
- Next Generation HPWH Development
- HPWH Demand Response Pilots

Residential Variable Capacity Heat Pump

Advanced Rooftop HVAC

Reverse Cycle Chiller For Multi Family

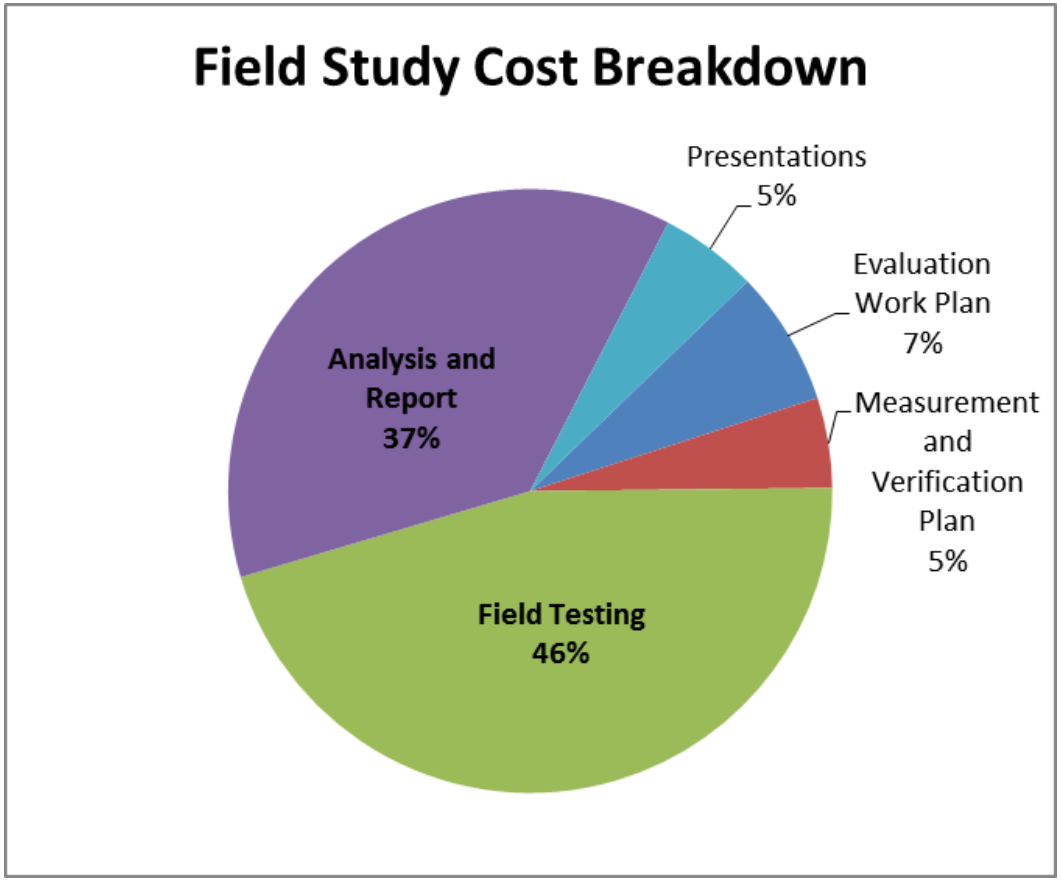
Ductless Heat Pump

VRF Systems

CO2 HPWH

Typical Field Study of Commercial or Residential Technologies

- $10,000 - $20,000+ per site
- Requires 30 to 100+ sites
- Typical takes 12-18 months or more to complete



Current Practice for Quantifying Annual Energy Savings of HVAC Equipment

- **Lab Tests**
  - Provides standard ratings, some performance curves
- **Field Testing**
  - Includes “real world” variability.
  - Expensive and long timelines (Typical $20k per site, 1 + years)
- **Analysis and Energy Modeling**
  - Apply lab and field data to make predictions.
- **Approved Basis for Incentives**
- **EM&V to Validate Energy Savings**

Advanced Rooftop HVAC

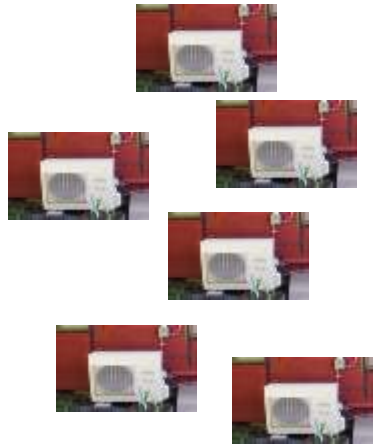
Residential Variable Capacity Heat Pump

Ductless Heat Pump

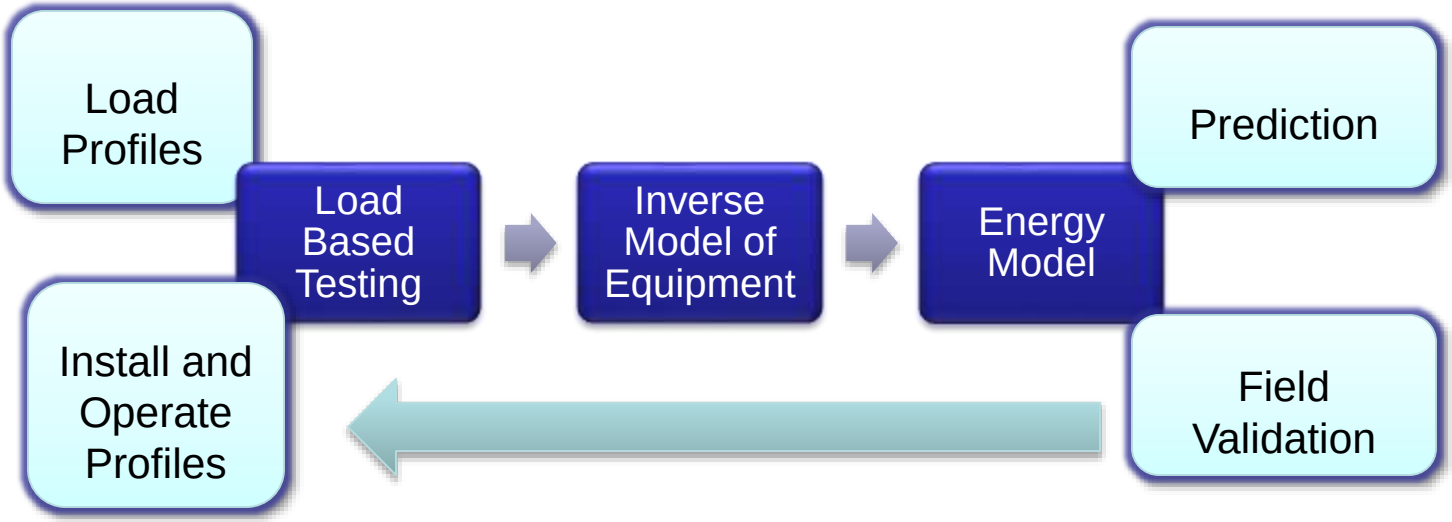
VRF Systems

New Approach

Test one system in the lab, instead of many of one system in the field



1. Load based lab testing
   - Testing total system dynamic response
   - Using full range of independent variables
   - Produce performance maps for energy models
2. Better integration of lab/field/modeling



EPRI / BPA / Duke Energy / Southern Company

Energy Efficient Technology Review Trip to Japan

Daikin, Mitsubishi, Mayekawa, Sanden

April 14-19, 2014

Personal Observations on Japanese HVAC Manufacturers

- Global markets
- Environmental responsibility
- Energy efficiency
- Many international products not available in the US.
- Products must match particular markets.
- Expecting more Japanese HVAC technologies in the US HVAC market.

Some Key Technologies

- Inverter driven heat pumps
- EcoCute Transcritical CO2 Cycle Heat Pump Water Heaters
- Low GWP Refrigerants – CO2, R 32, Ammonia
- Innovative Technology
  - Better Compressors and Heat Exchangers
  - Hybrid systems
  - Adaptive control with occupancy and infrared sensors

Products of Interest for EE

2015

1. Sanden Eco Cute CO2 residential split-system HPWH
2. Residential forced air inverter heat pump (Daikin/Goodman)
3. Commercial/Industrial Eco Cute (air-to-air, and water-to-water)
4. Mitsubishi Hyper Heat (100% Capacity 5 degrees F)
5. Packaged Ammonia/CO2 Supermarket Refrigeration
6. Hybrid VRF / water loop fan coil
7. CO2 refrigerant grocery display case
8. Residential DHW / DHP combo unit
9. Ammonia Heat Pump for commercial applications

Conclusions

1. Promising New Technologies for energy efficiency:
   - Smart Connected Devices
   - Variable Capacity HVAC
2. Smart Connected Devices M&V approach:
   - Self-reported data for performance verification
3. Variable Capacity Heat Pumps M&V approach:
   - Load-based testing with better integration of lab/model/ field tests.

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