EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Multi-Zone Testing of VRF Systems

Ron Domitrovic

&

Harshal Upadhye

February 22, 2012

Collaborative VRF Performance Testing

-Construct performance maps of multiple manufacturers' VRF heat pump & heat recovery VRF systems

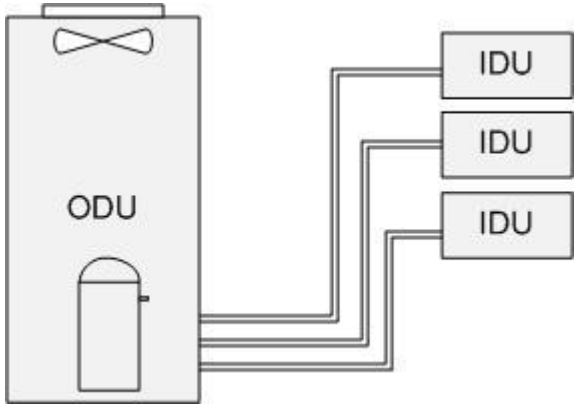
-Work with software modeling developers to support their data needs

-Provide field test data for model vetting

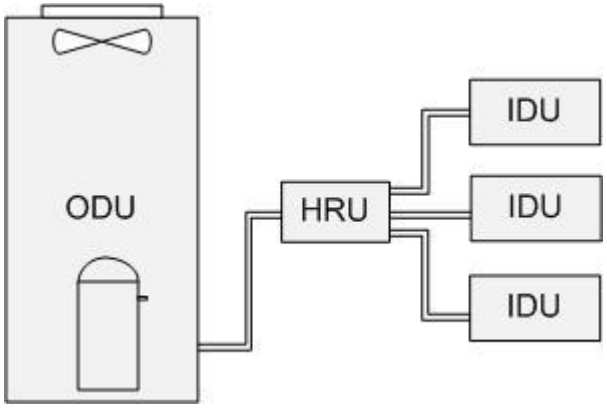
2

VRF System

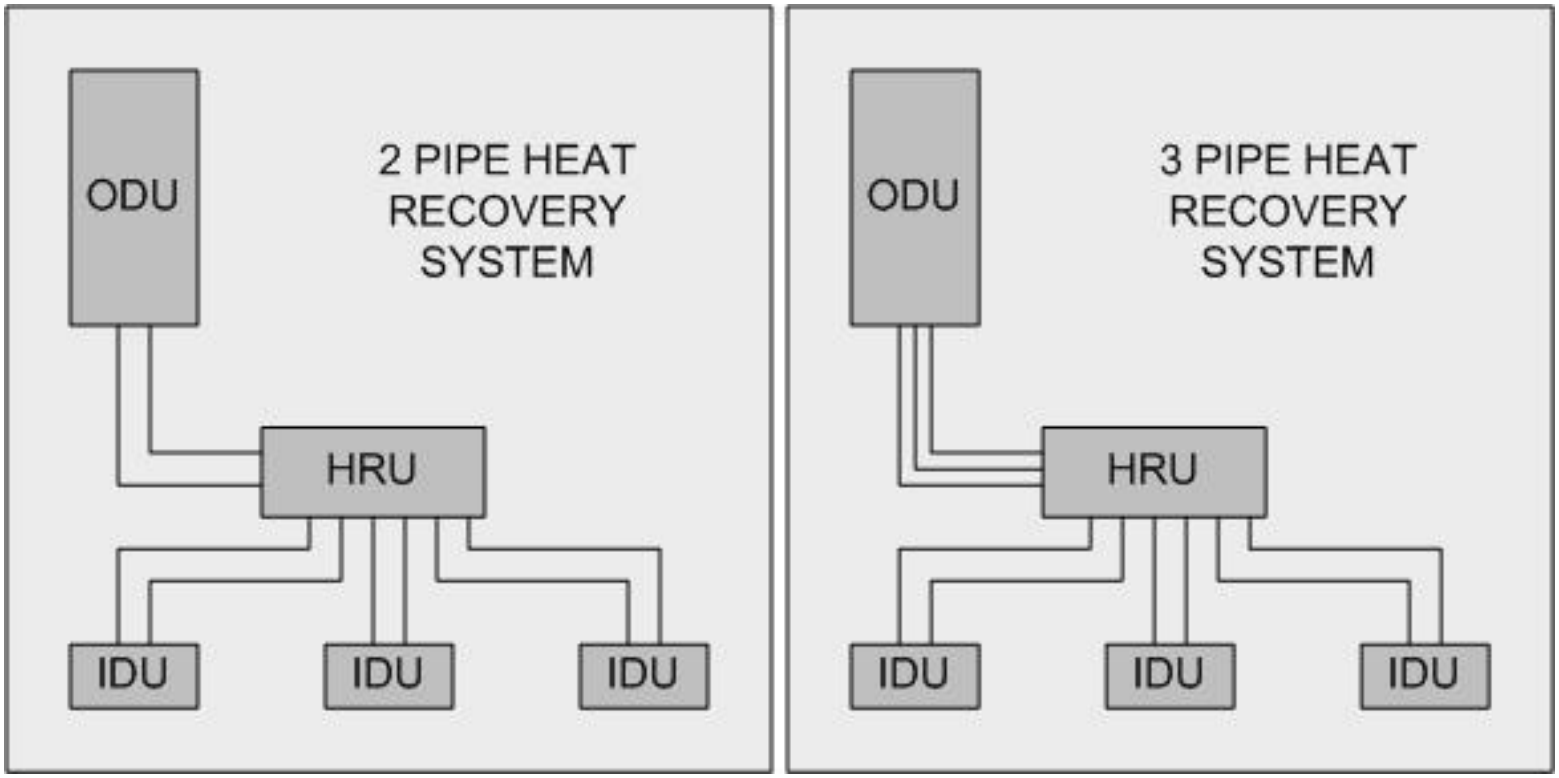
- Variable Refrigerant Flow (VRF) System
  - DX multi-split system, multiple indoor fan coil units (IDU)
  - Each IDU is capable of individual zone temperature control
  - At least one variable capacity compressor
  - VRF implies three or more steps of control on inter-connecting piping



- VRF Heat Recovery Multi-Split System (VRF-HR)
  - Split system capable of operating in AC mode or as a heat pump
  - System capable of providing simultaneous cooling and heating
  - Energy from IDU's operating in one mode can be transferred to IDU's operating in the other mode



VRF-HR Systems: 2-pipe and 3-pipe



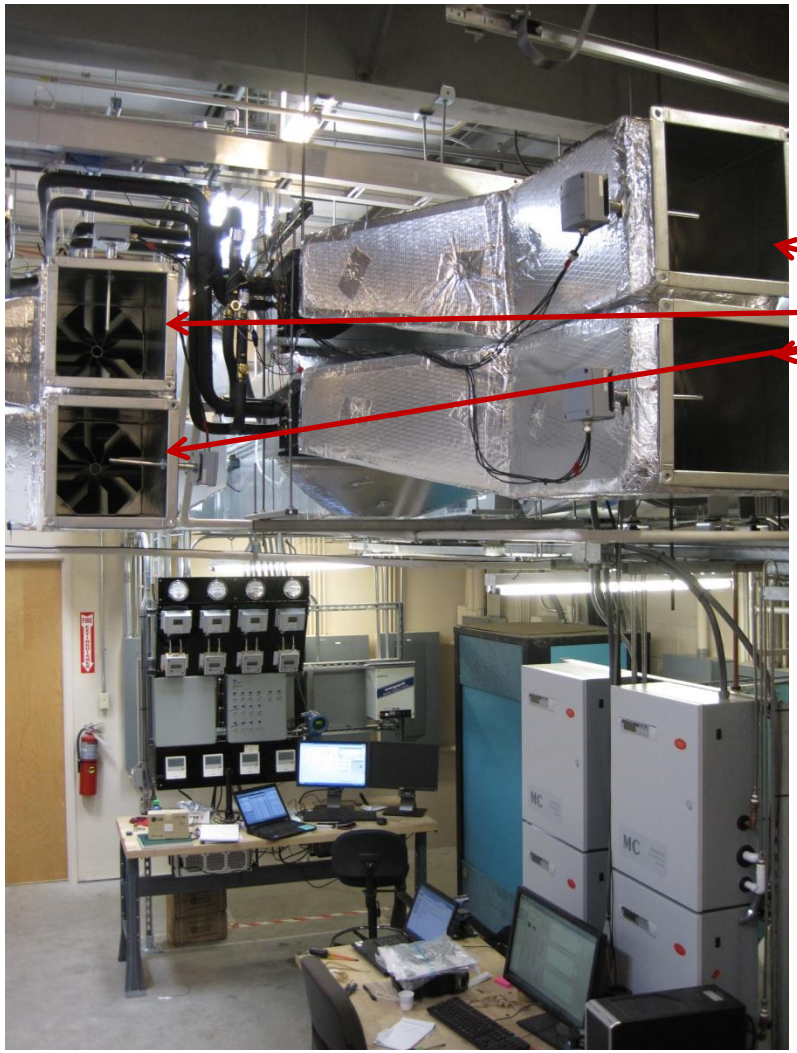
Need for Lab Test Data

- ANSI / AHRI Standard 1230 specifies rating test conditions for VRF systems
- Provide comprehensive performance map based on independent lab testing
- Building energy modeling software's are incorporating VRF simulation capabilities
- Simulation tools require reliable and accurate data

Test Stand Design

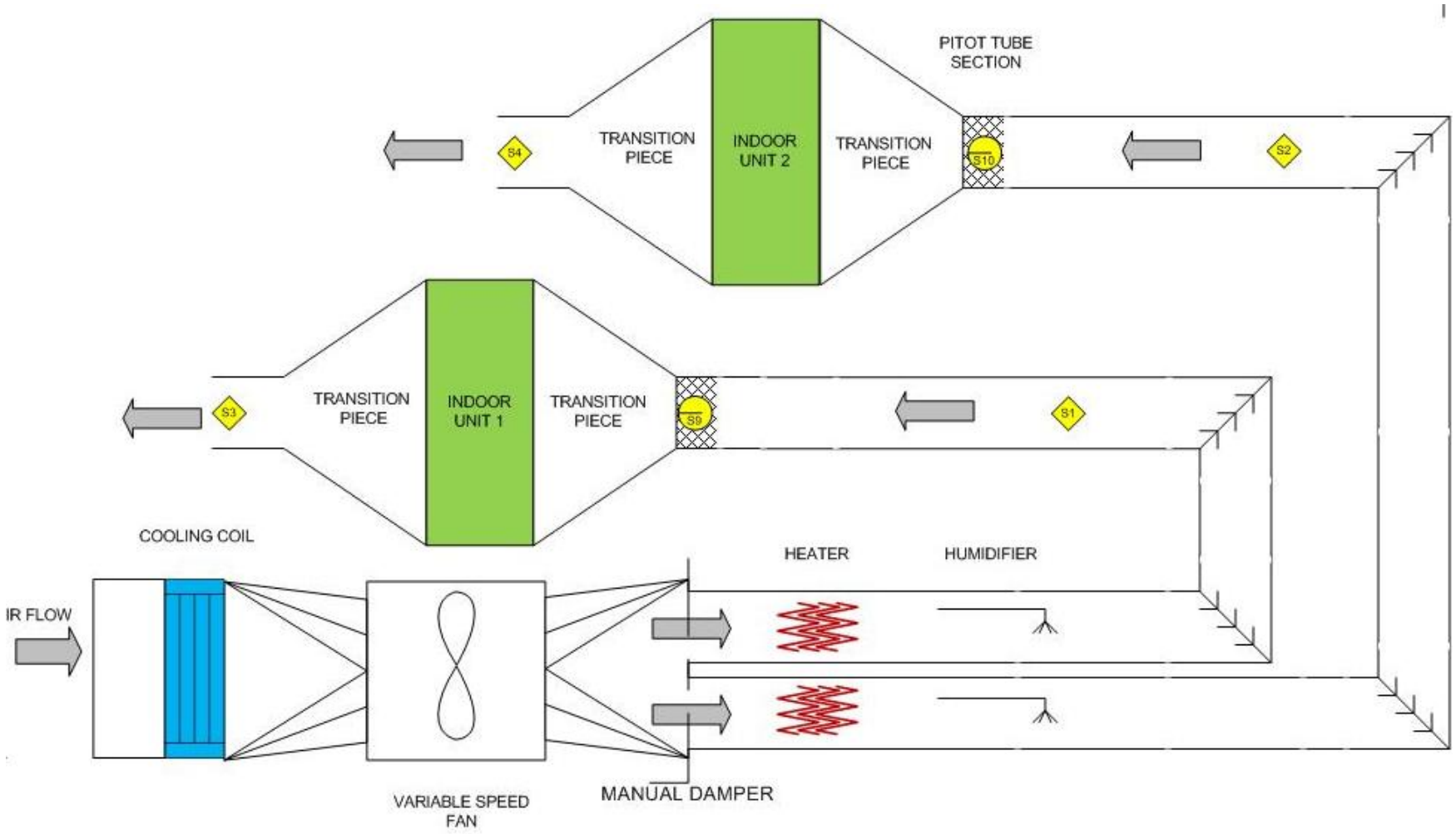
- VRF systems are multi-zone systems
- Thermal Environmental Lab has dual zone climate chambers
- The indoor chamber can simulate one air condition at a time (T and RH)
- Each zone in multi-zone system will have different return air conditions

Multi-zone Test Stand

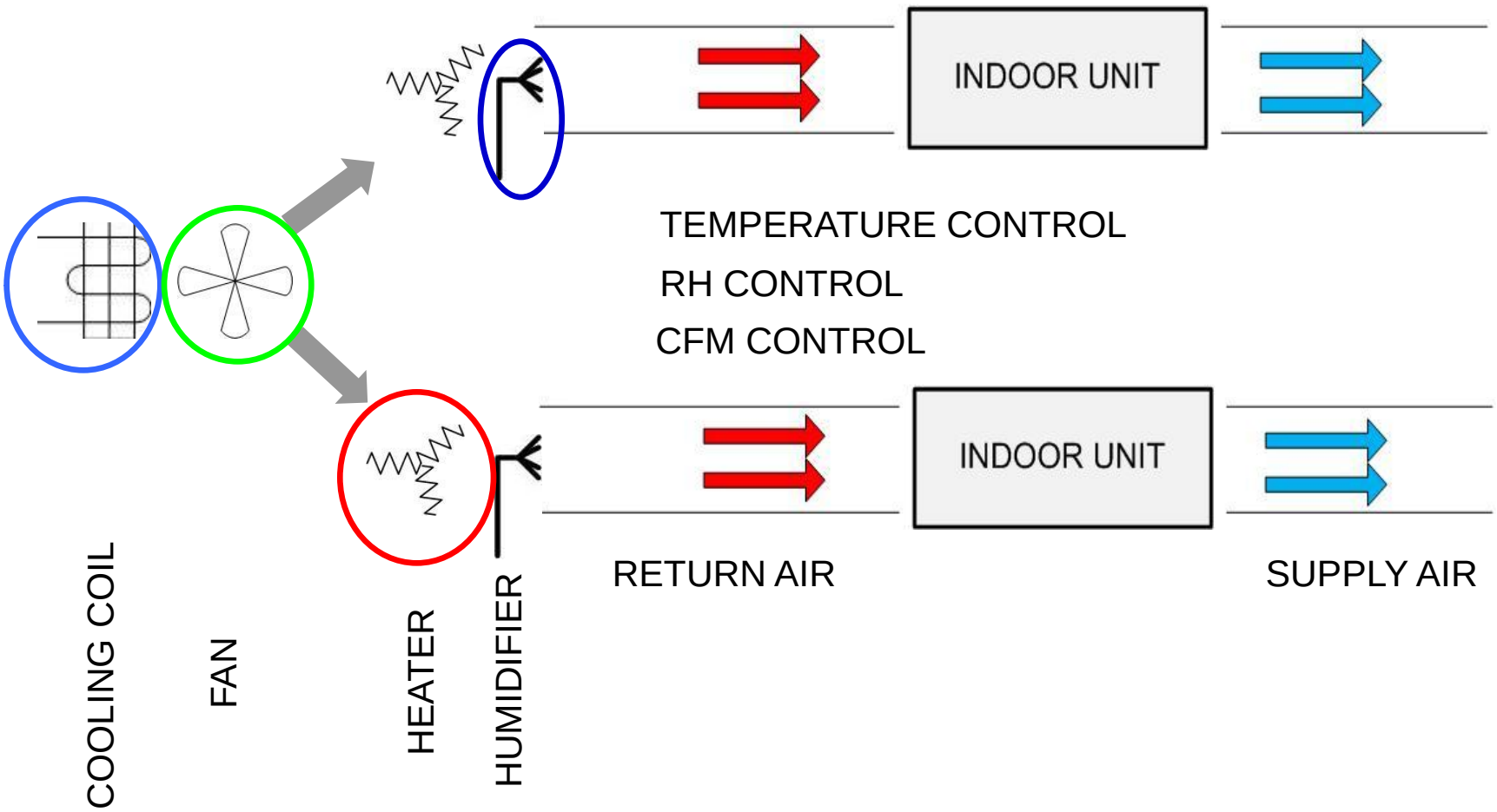


- Design & Construction of VRF HR Test Stand
  - Unique system capable of independent control of four indoor zones

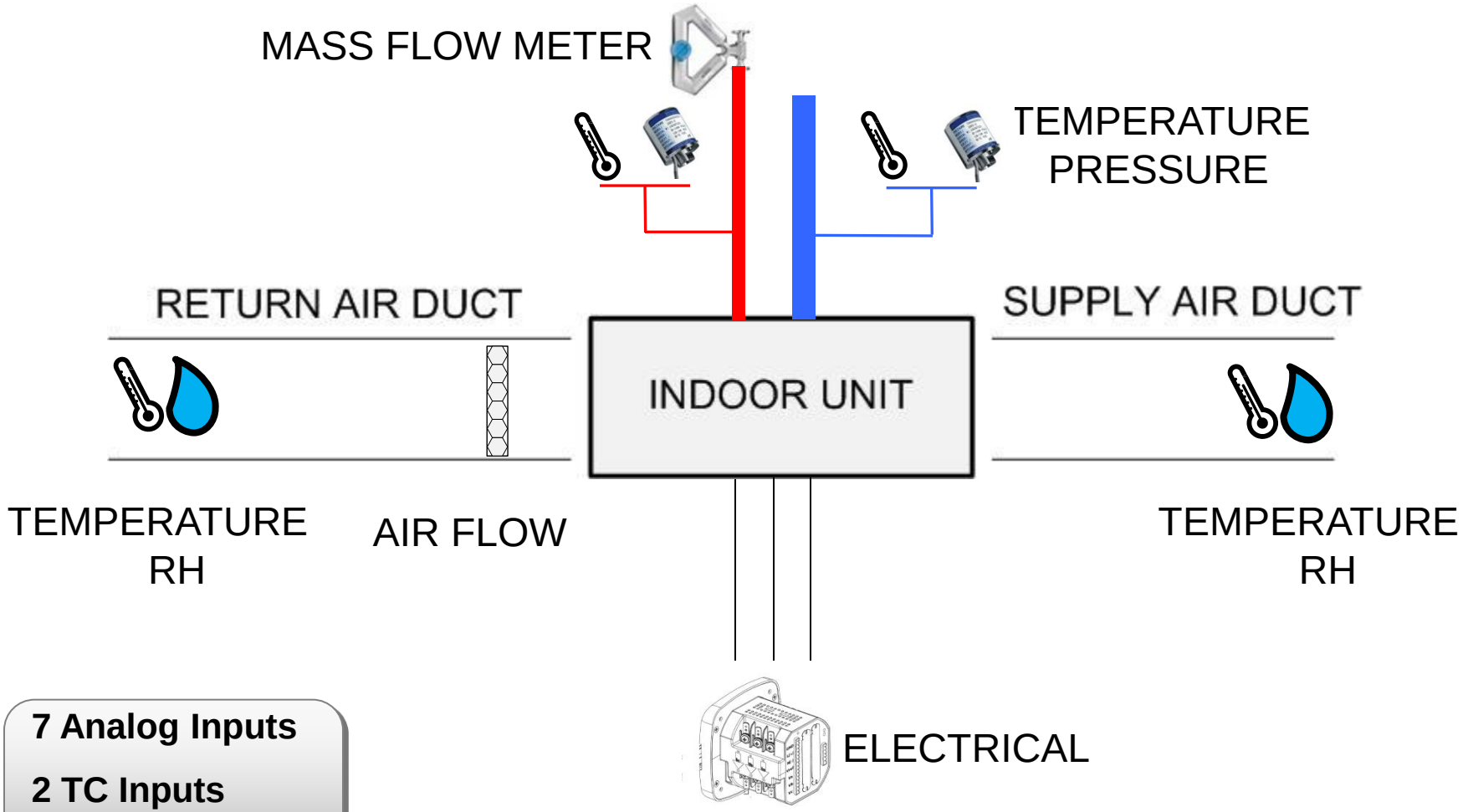
Schematic of Indoor Unit Test Setup



Multi-Zone Test Setup



Instrument Locations (Indoor Unit)



7 Analog Inputs

2 TC Inputs

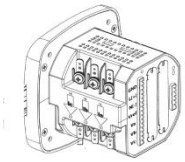
8 MODBUS Inputs

Instrument Locations (Outdoor Unit)

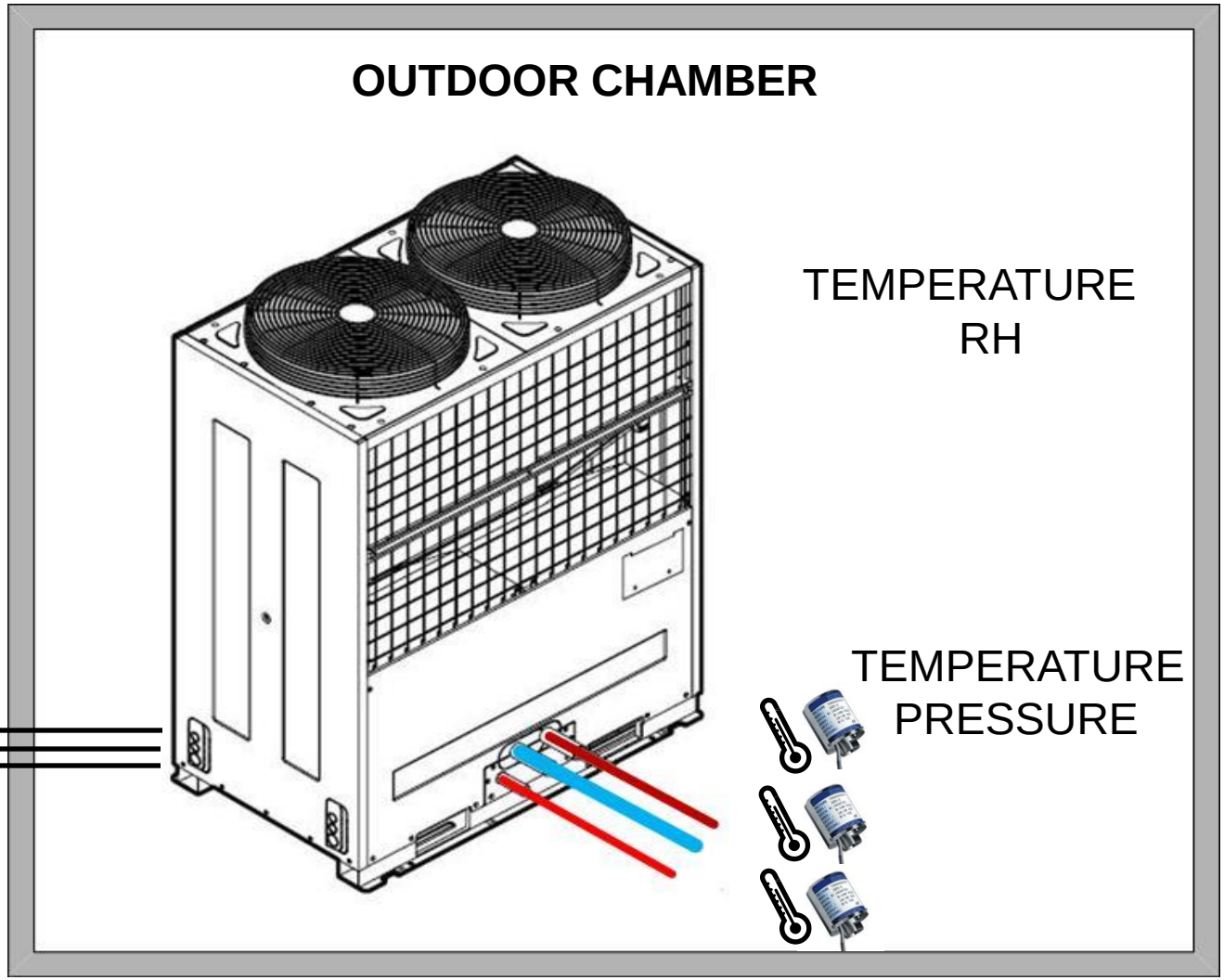
5 Analog Inputs

3 TC Inputs

8 MODBUS Inputs



ELECTRICAL



Air Side Calculation

$$\Delta h = h_1 - h_2 \ (BTU/lb_{da})$$

$$\textbf{Capacity} = \dot{m} * \Delta h$$

Test Procedure – Cooling Mode

- The outdoor chamber is controlled to a set dry bulb temperature (for example 95ºF)
- The return air is controlled to a set dry bulb and wet bulb temperature (for example 80ºF DBT / 67ºF WBT)
- The VRF system temperature controller is set to the lowest allowable temperature (example 64ºF DBT)
- Data for various combination ratios is obtained by turning indoor units ‘OFF’

Test Procedure – Heating Mode

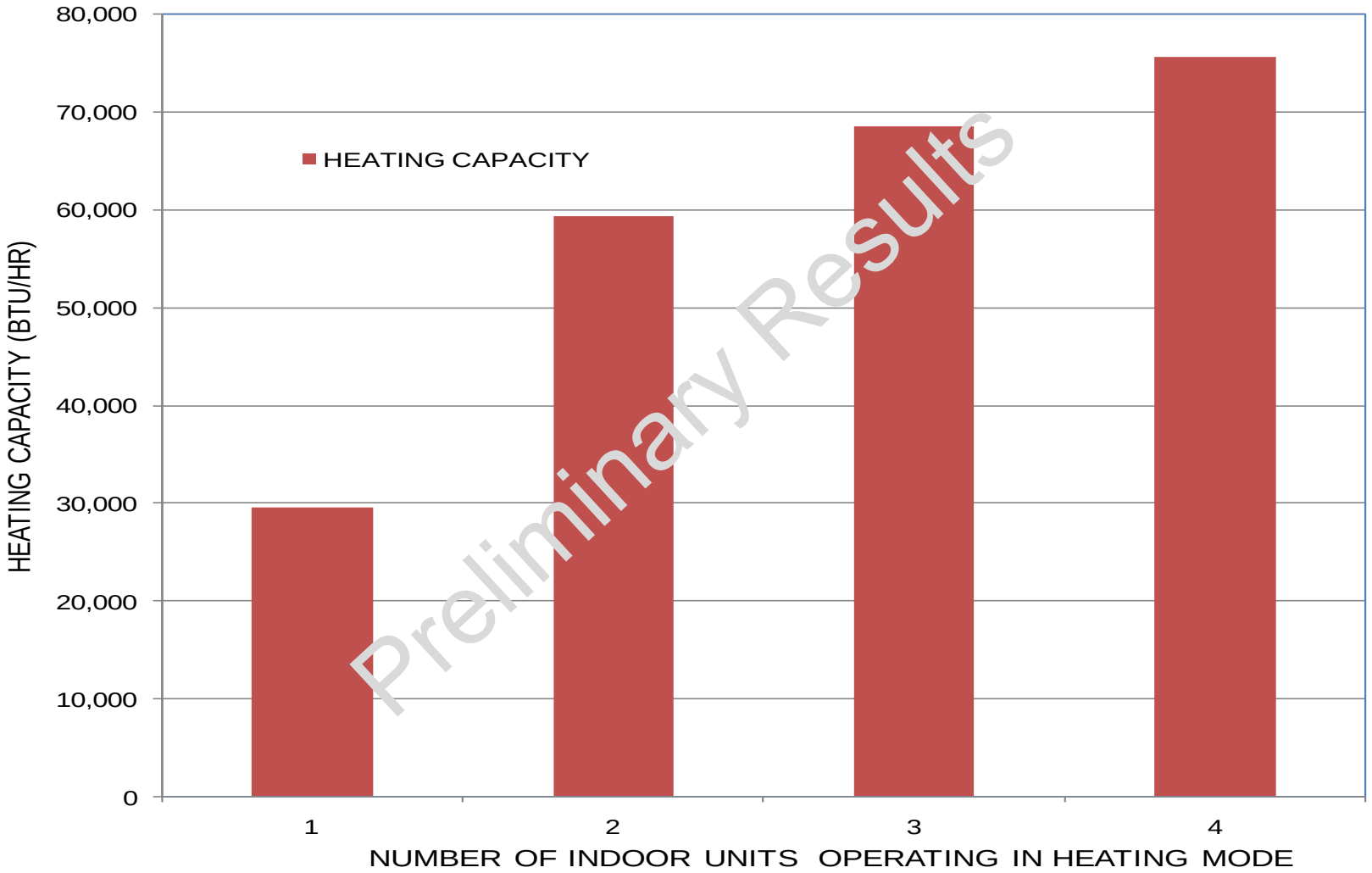
- The outdoor chamber is controlled to a set dry bulb and wet bulb temperature (for example 47ºF DBT / 43ºF WBT)
- The return air is controlled to a set dry bulb temperature (for example 70ºF DBT)
- The VRF system temperature controller is set to the highest allowable temperature (example 84ºF DBT)
- Data for various combination ratios is obtained by turning indoor units ‘OFF’

Test Procedure – Simultaneous Cooling and Heating Mode

- The outdoor chamber is controlled to a set dry bulb and wet bulb temperature (for example 47ºF DBT / 43ºF WBT)
- Depending on the mode (cooling or heating) a particular indoor unit is in, return air is controlled to the set DBT and WBT
- The temperature controller on each indoor unit is set in accordance to the mode it is in
- A performance map is generated by changing indoor and outdoor conditions as well as the mode each indoor unit is operating in

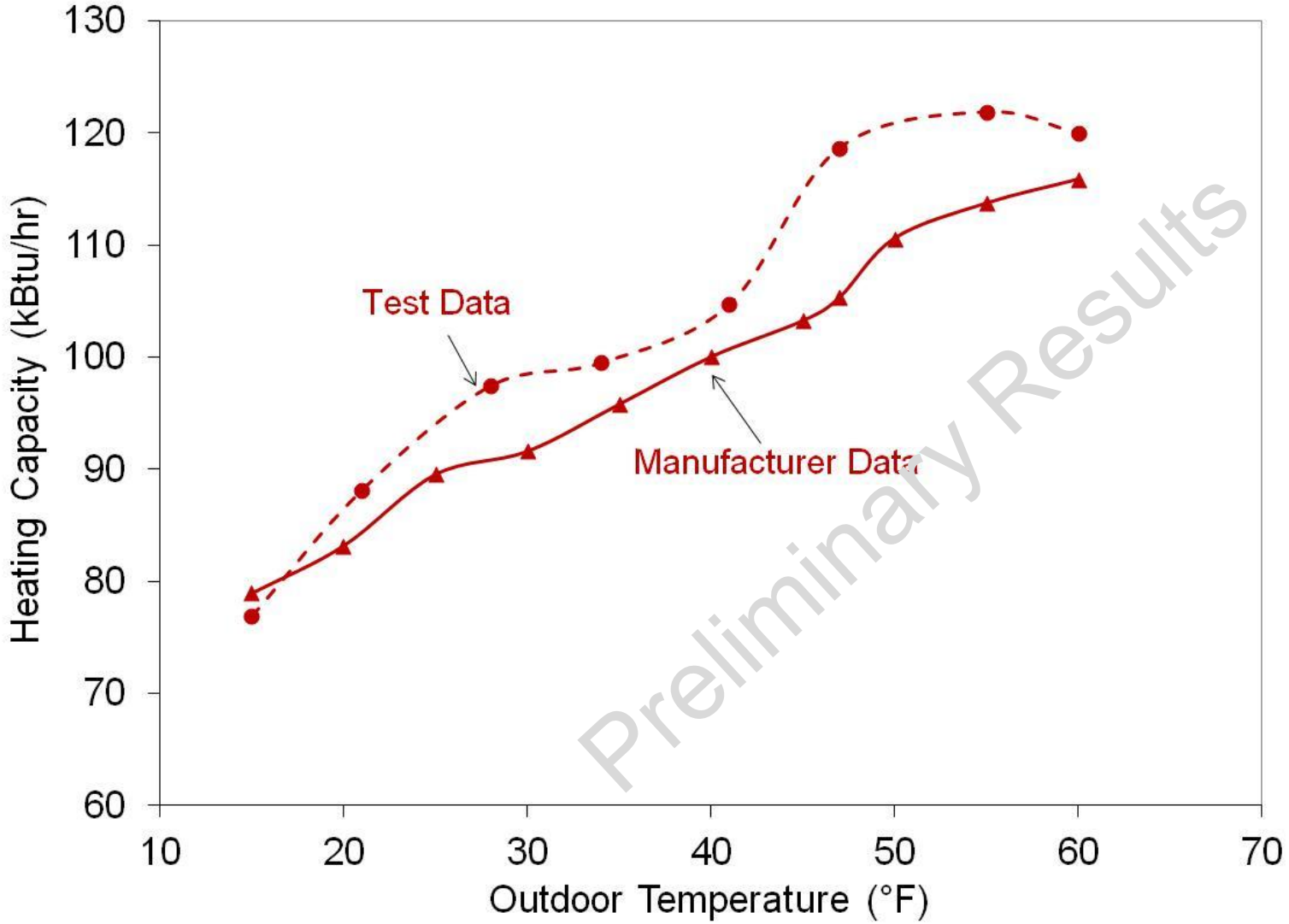
Example Heating Capacity

70 deg F return air; 47 deg F outdoor air

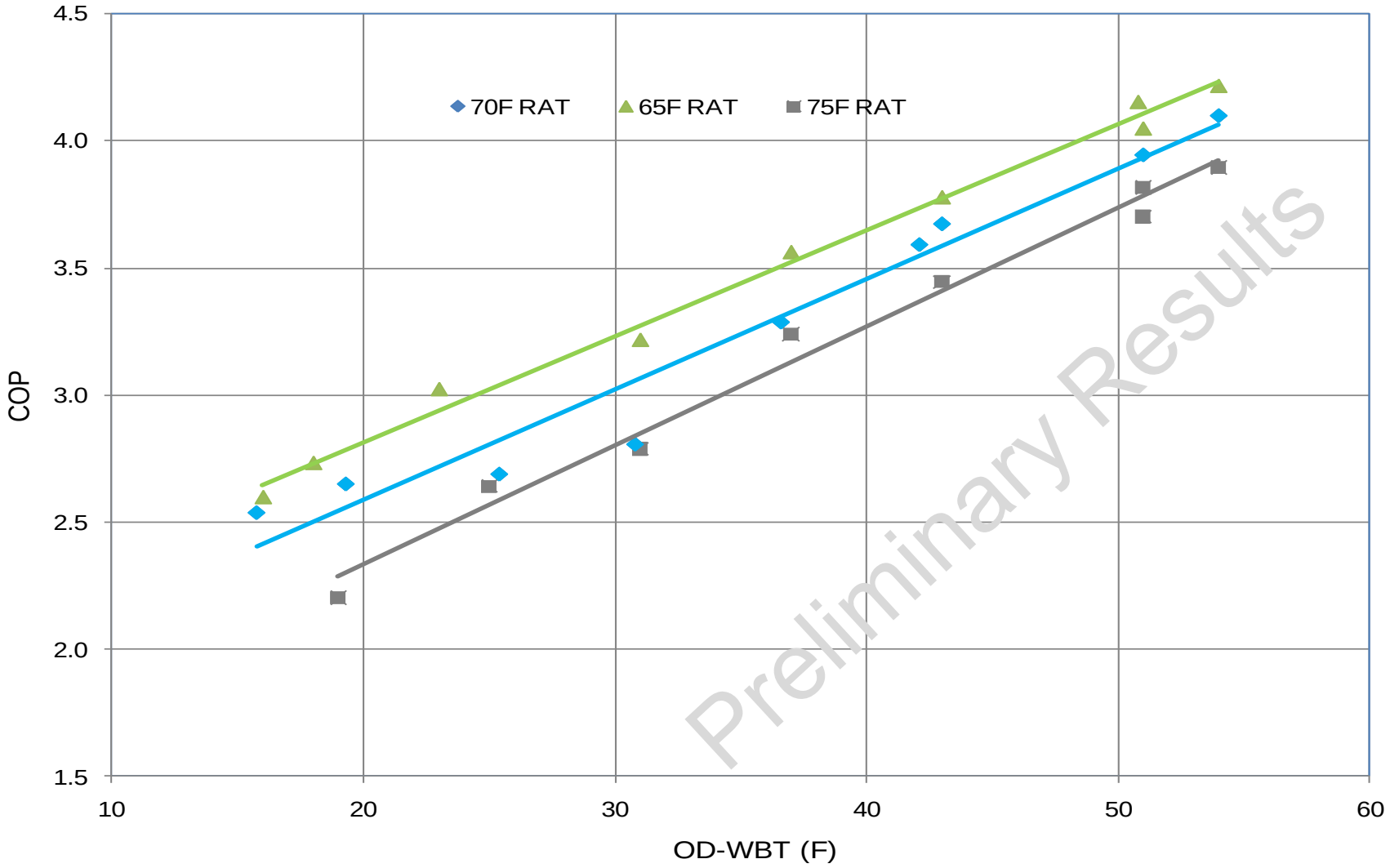


Example Results

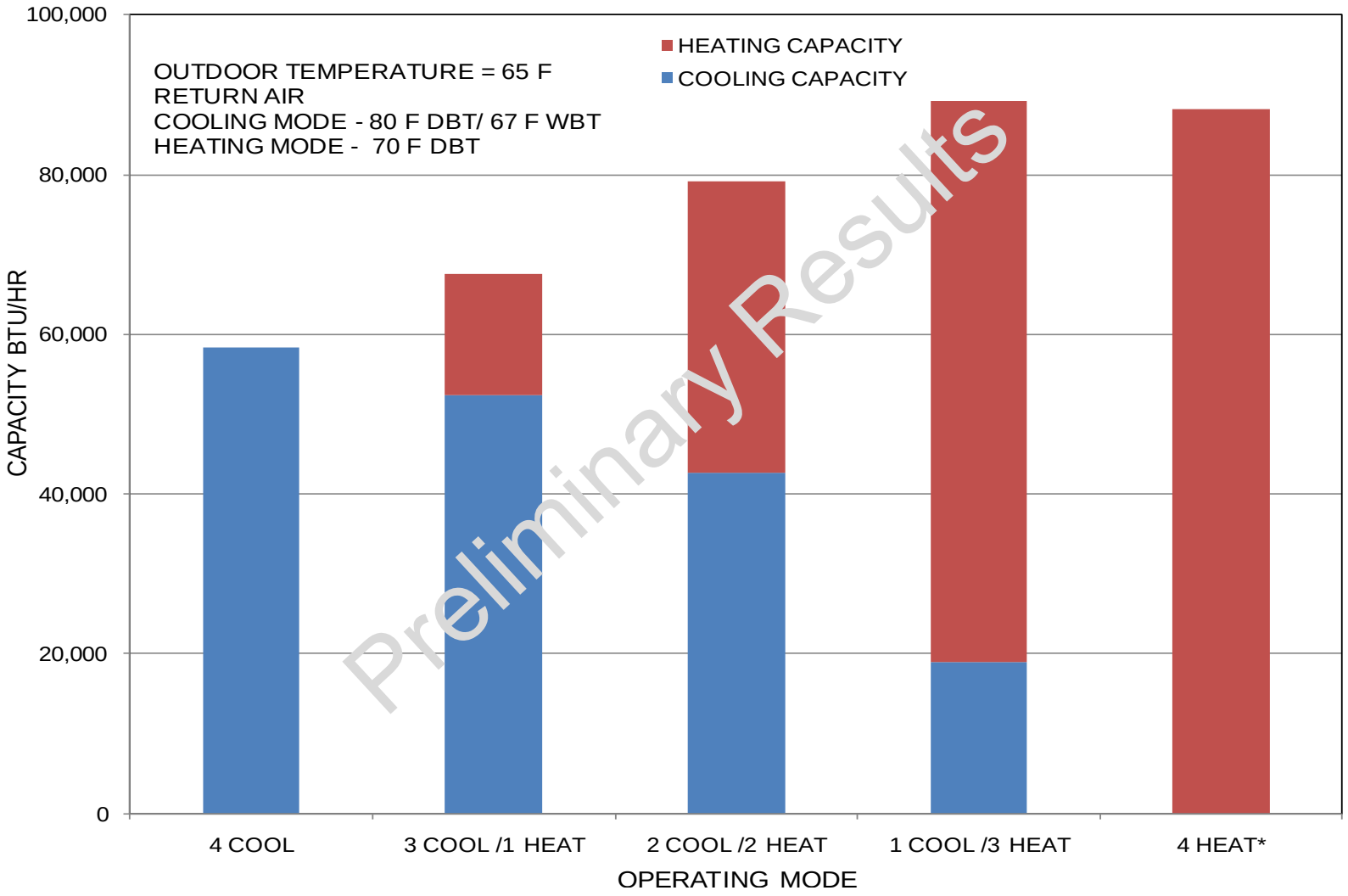
-System heating capacity (70°F return air)



Example Results



Example Results



Questions?