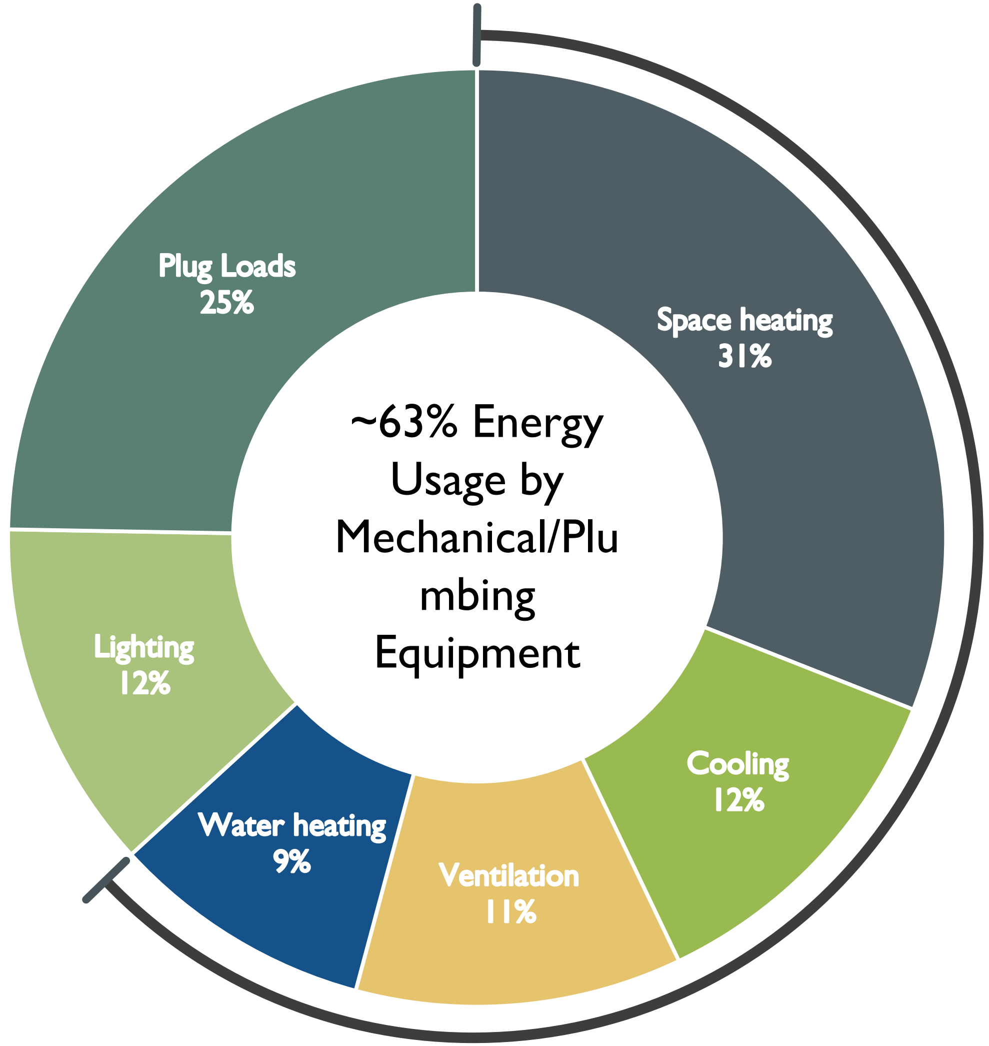
REDUCING ENERGY CONSUMPTION IN HISTORIC BUILDINGS, FROM A MECHANICAL PERSPECTIVE

SUMMER
CONSULTANTS
INCORPORATED

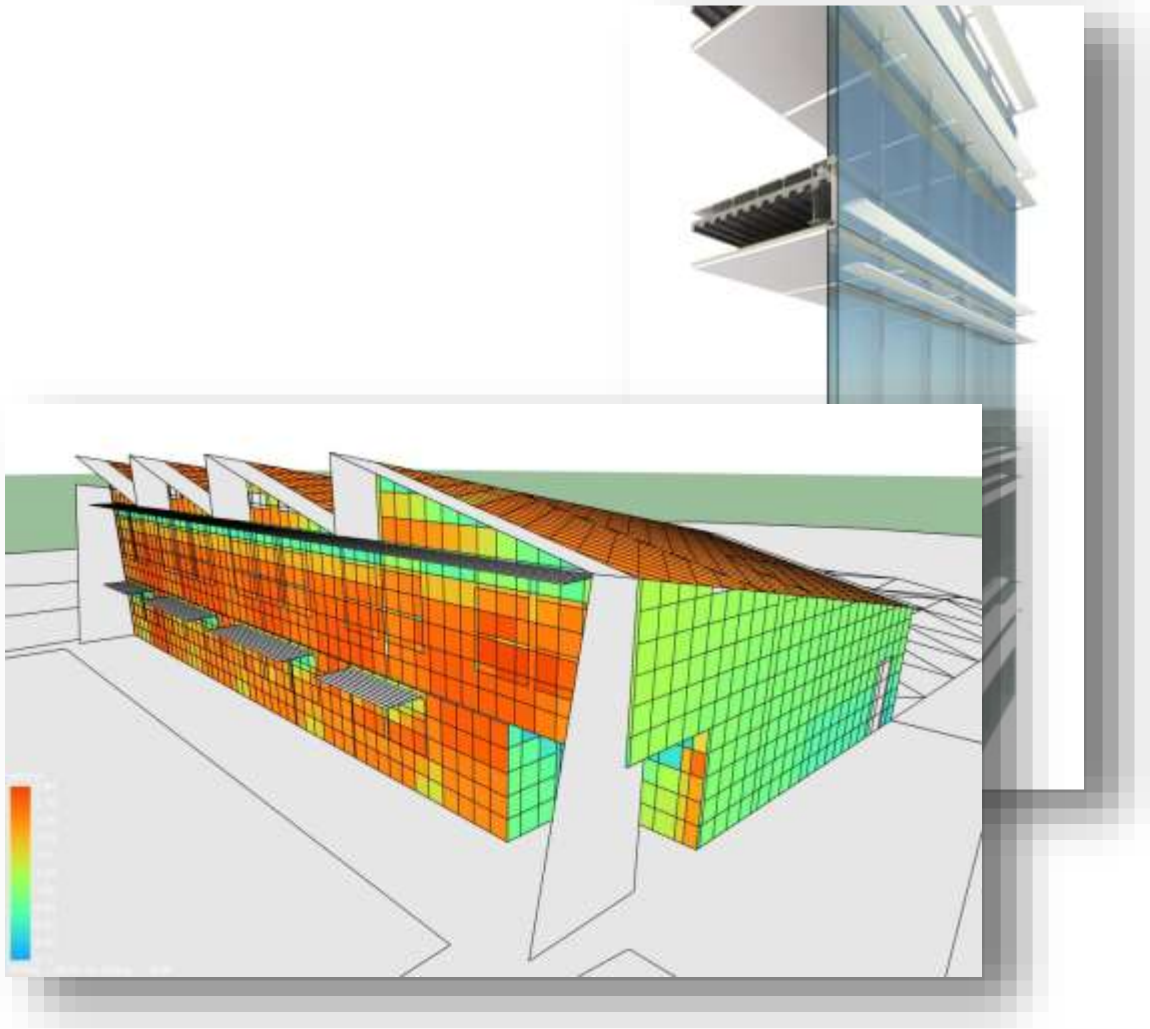
ENERGY USAGE IN BUILDINGS

- From The US Energy Information Administration's Commercial Buildings Energy Consumption Survey (CBECS 2012)



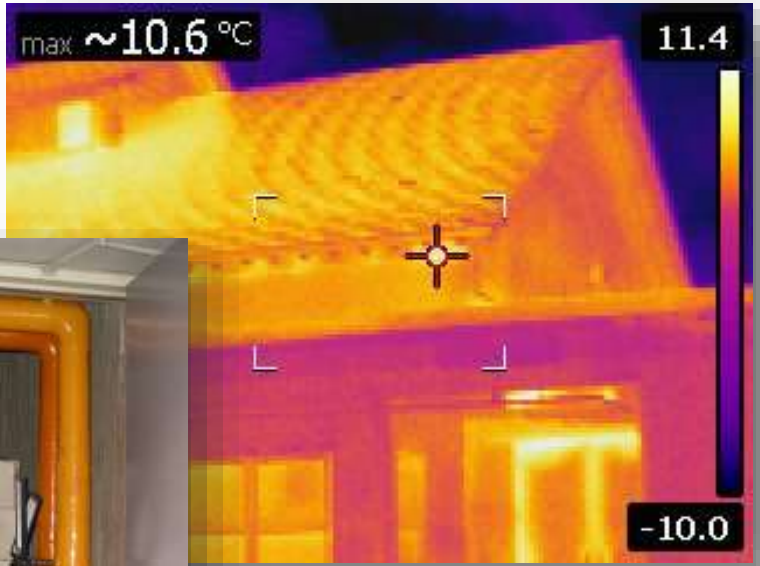
ENERGY SAVINGS IN NEW CONSTRUCTION

- Envelope
  - New walls and windows with modern materials
  - Tight building construction
  - Optimized orientation and shape
  - Energy modelling provides early feedback
- MEP Design
  - Systems incorporate high efficiency equipment
  - Distribution can be incorporated into the overall aesthetic



ENERGY SAVINGS IN EXISTING BUILDINGS

- Envelope
  - Can't pick a new location or orientation (most of the time)
  - It is difficult to add insulation or replace windows
  - Vapor barrier
  - Payback for envelope upgrades is typically long
- MEP Systems must fit within the existing building constraints
- Maintenance budgets are generally small



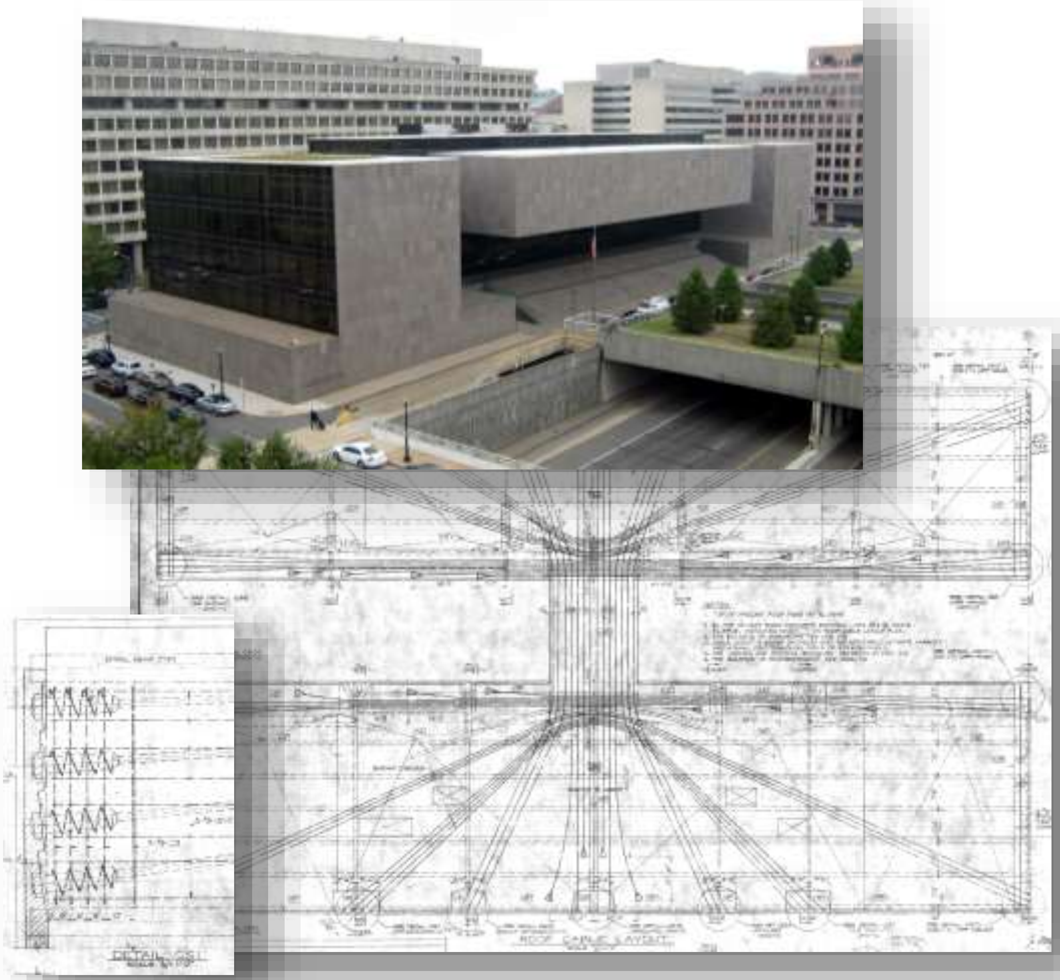
THE US TAX COURT BUILDING

THE US TAX COURT BUILDING - BACKGROUND

- Originally created by the Revenue Act of 1924, the "US Board of Tax Appeals" was located within the IRS.
- Victor Lundy designed a new home for the US Tax Court. Construction was completed in 1974.
- The building houses 19 presidentially appointed judges and Tax Court staff.
- The US Tax Court Building was added to the National Register of Historic Places in 2008

THE US TAX COURT BUILDING - BACKGROUND

- 1974 is not *that* historic, however
  - Post-tensioned concrete structure
  - Cast-in-place, exposed concrete throughout
  - Concealed ductwork in plaster bulkheads in corridor
- While the building is architecturally and structurally stunning,
  - The building is using a significant amount of energy
  - The occupants are not comfortable
  - The original building systems are showing their age



THE US TAX COURT BUILDING - EXISTING SYSTEMS

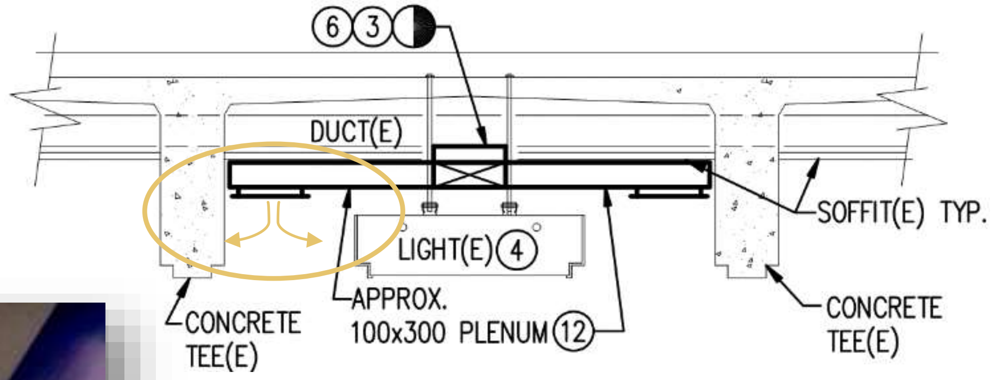
- Systems were largely original to the 1974 era construction
- Airside
  - Constant Volume AHUs provide supply air
  - Inadequate building pressurization in Great Hall
  - Air devices located above architectural pendant light fixtures
  - No individual zone control
- Waterside
  - Primary secondary chilled water system
  - 4 cooling towers on the roof provide condenser water
  - Heating water is generated from district steam

THE US TAX COURT BUILDING - DESIGN

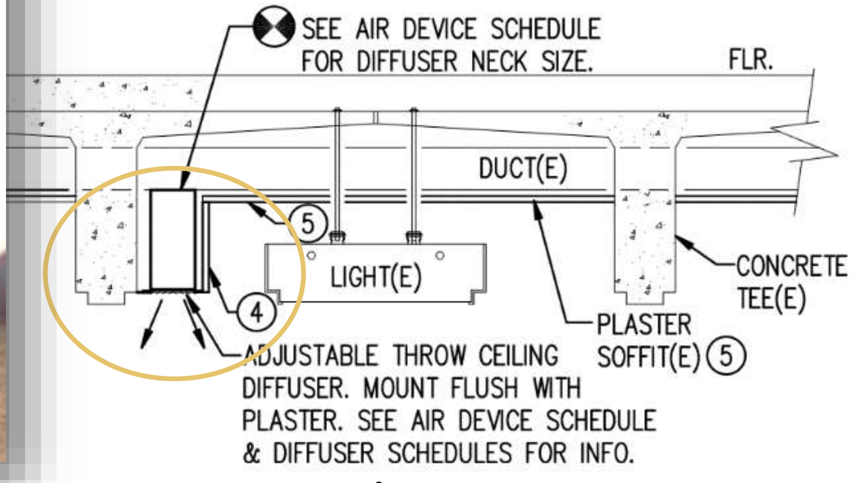
- Great hall
  - Replace constant volume AHUs with variable volume single zone AHUs
    - 3 AHUs, total of 36,800 cfm supply
  - Improve outside air delivery and monitoring
    - Adequate pressurization

THE US TAX COURT BUILDING - DESIGN

- Judges' Suites
  - Provide variable volume AHUs
  - Control zone airflow using variable air volume boxes
  - Relocate diffusers to below luminaires and structure
- Modifications increase airflow in suites
- The bulk of the modifications reuse existing ductwork, limiting the disturbance to the building finishes.



Before



After

THE US TAX COURT BUILDING - DESIGN

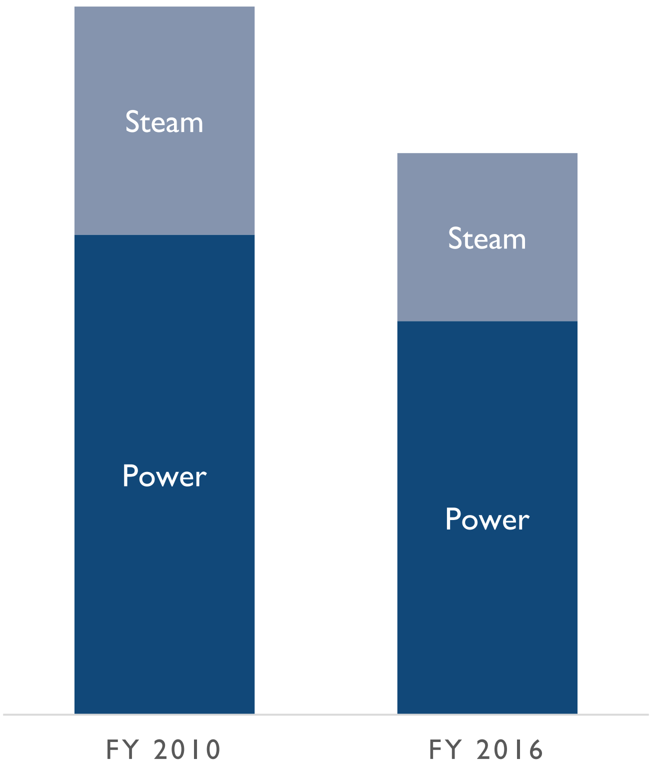
- Waterside
  - Increase plant capacity with larger chillers
  - Provide cooling towers with greater capacity that fit within existing enclosure (SHPO)
  - Variable primary chilled water piping

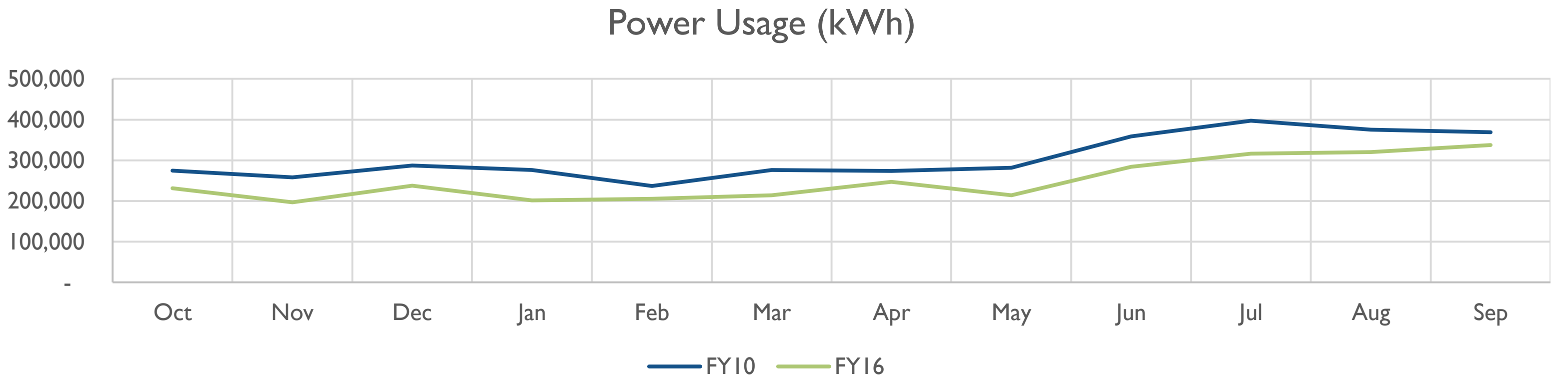
THE US TAX COURT BUILDING - IMPLEMENTATION

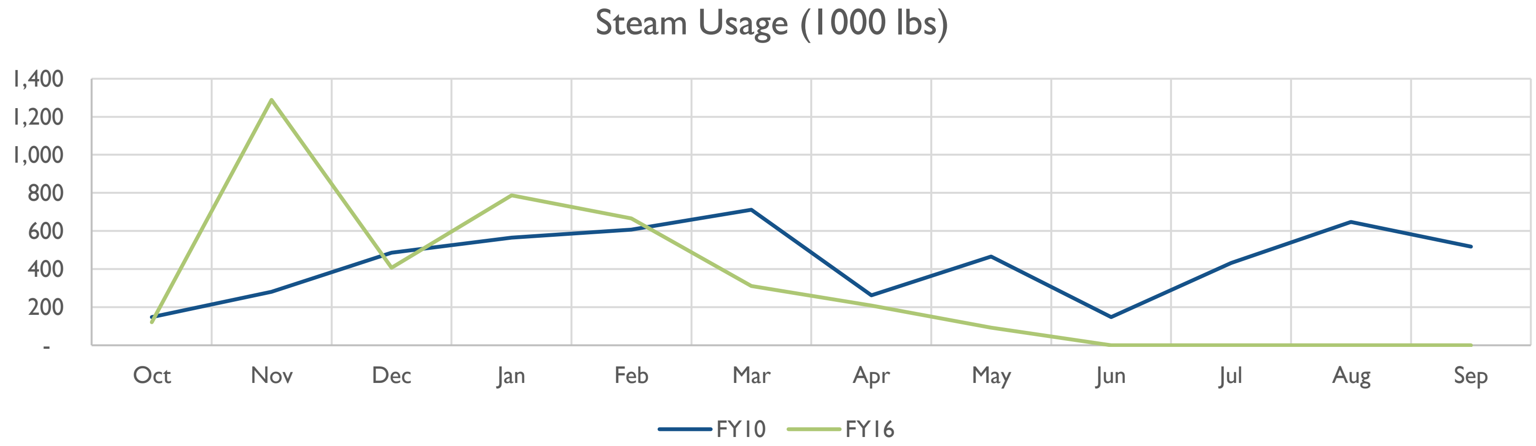
- The US Tax Court was unable to vacate during construction
  - Phased occupied implementation of design
  - All construction occurred during off hours
  - Only outages occurred over weekend
- Whole building HVAC Controls Upgrade
  - Enhanced space and system monitoring
  - Improved system diagnostics
- After completion, maintained relationship with Facilities Manager to collect system performance data

THE UNITED STATES TAX COURT - RESULTS

- Metered energy savings: 21% energy savings, 26% savings by cost







THE BLAIR HOUSE

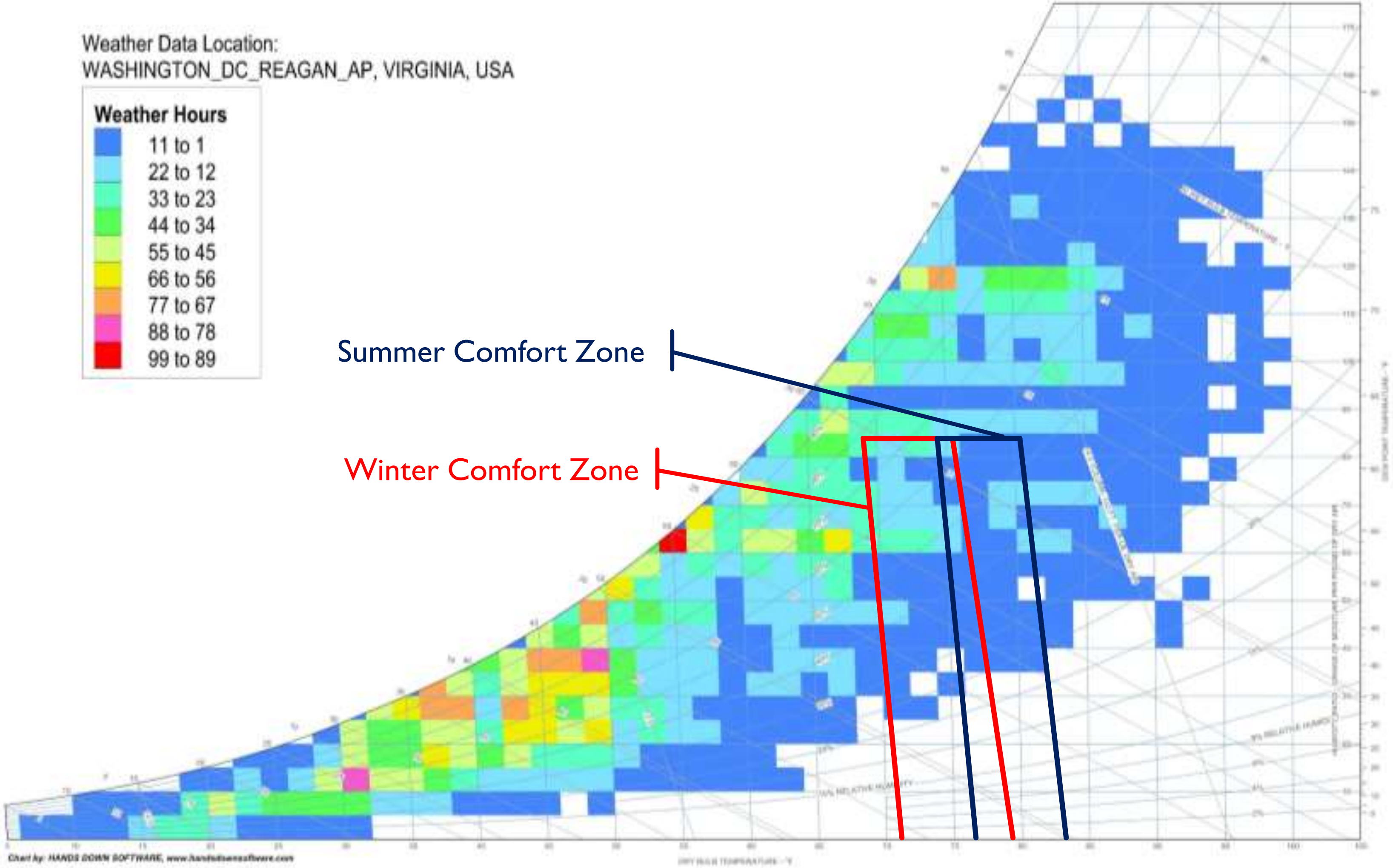
BLAIR HOUSE - BACKGROUND

- Original townhomes constructed 1824-1860
- Designated a National Historic Landmark in 1973
- Townhomes merged into one complex in 1988
- Despite significant renovations, the historic nature of the building has been preserved
- Serves as a venue and guest house
- 70,000 GSF, 119 rooms

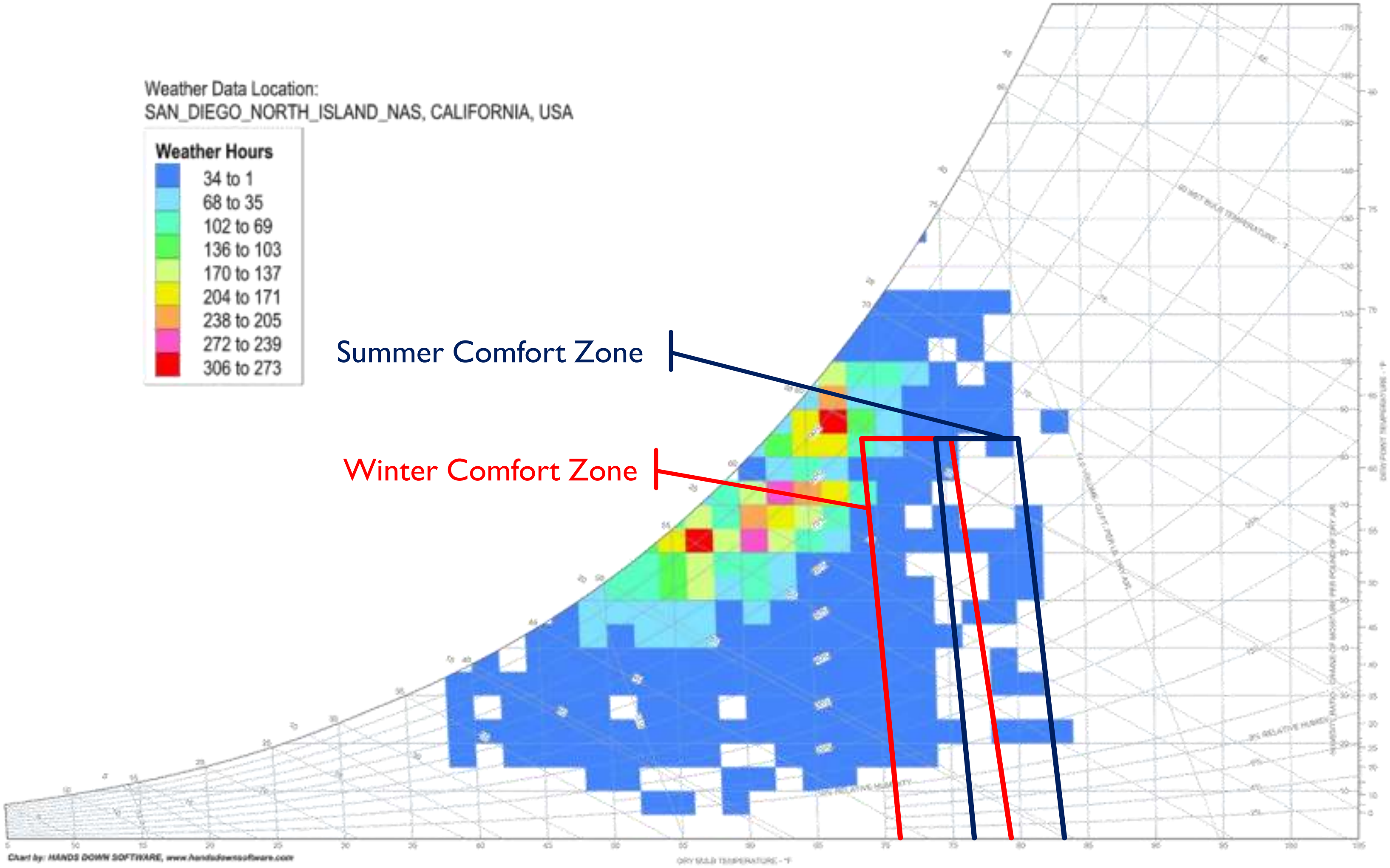
BLAIR HOUSE, JACKSON ROOM – EXISTING SYSTEM

- Serves as conference room and event space
- During events, the room is uncomfortable
- The AHU is constant volume
- Air delivered through slot diffusers in ceiling, coordinated with accents
- Drafty conditions when the door is opened

HUMIDITY CONTROL



HUMIDITY CONTROL

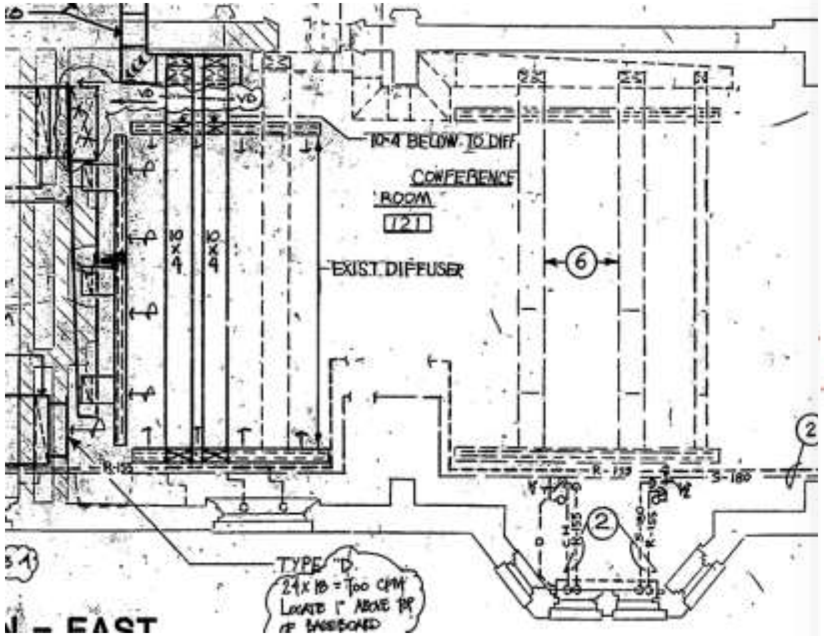


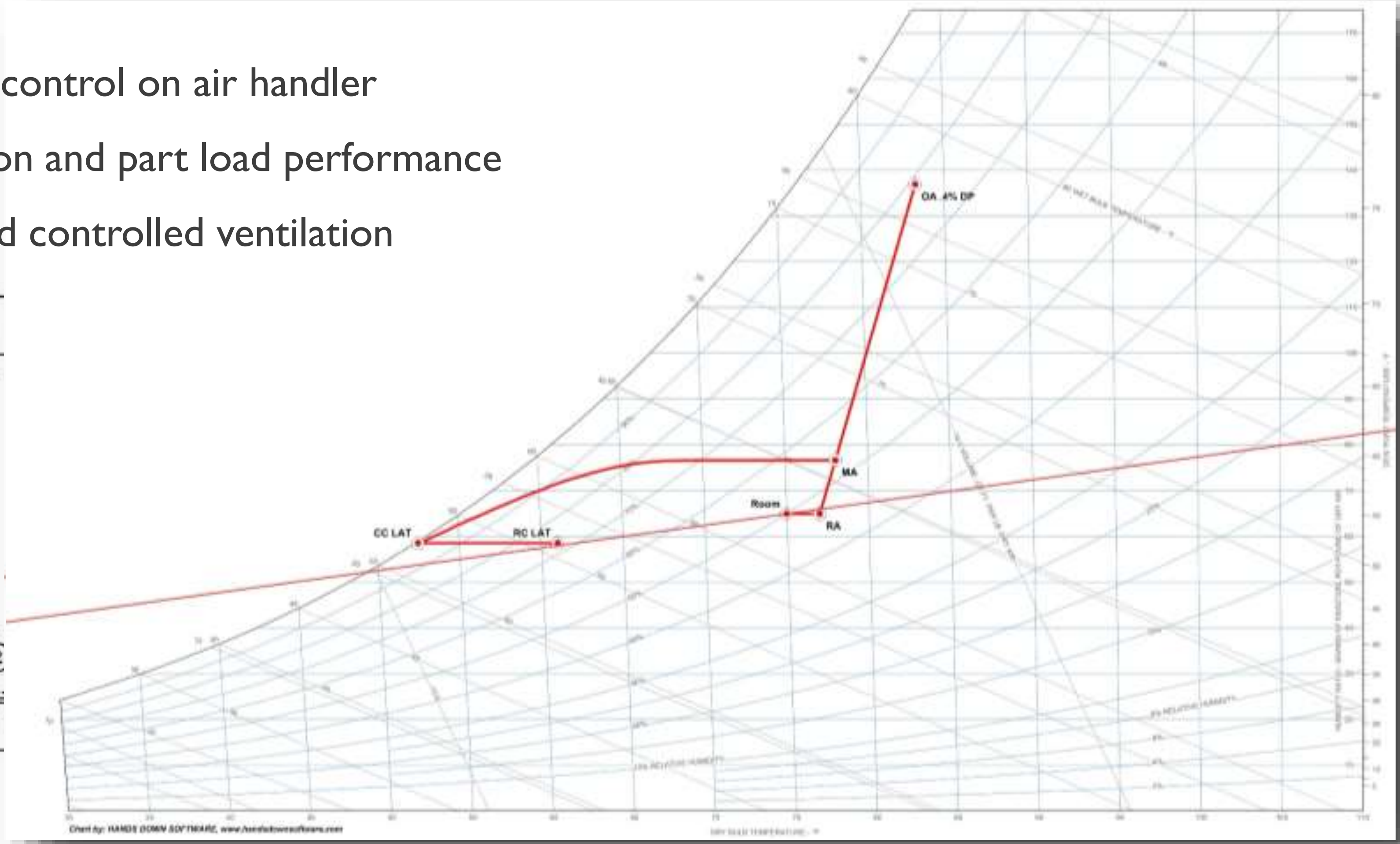
HUMIDITY CONTROL

- Historic buildings
  - Generally "leaky"
  - Contain artifacts and historic finishes
  - "Museum quality space" requires a vapor barrier and insulation
  - Goals:
    - Treat air for high humidity
    - Add humidification for dry conditions
    - Prevent rapid cycling of conditions

BLAIR HOUSE, JACKSON ROOM - DESIGN

- Provide single zone variable volume control on air handler
- Provide adequate space pressurization and part load performance
- Incorporate economizer and demand controlled ventilation





BLAIR HOUSE, JACKSON ROOM - DESIGN

- System Selection – Maximum Load
  - Doesn't account for swing season (Spring and Fall)
  - Doesn't account for changing occupancy
  - Runs longer, less efficiently
- System Selection – Part Load
  - Cools and dehumidifies for a range of outdoor conditions
  - Adjusts for occupancy
  - Maintains space comfort, runs more efficiently
  - Saves energy

OLD STONE HOUSE

OLD STONE HOUSE

- Original Construction 1765
- Added to the National Register of Historic Places in 1973
- Currently operated as a museum by the National Park Service

OLD STONE HOUSE

- Stone construction and single pane windows allow infiltration year-round
- Existing direct expansion system cycles to treat air at part load
- Humidity control and part load cooling are inadequate for the building

OLD STONE HOUSE

- Provide specialized direct expansion unit with hot gas reheat
  - Provides part load dehumidification control, using waste heat for reheat
  - Well suited for the transient occupancy of the building
  - Standalone digital control allows moderate diagnostics and monitoring
- Additionally, LED lighting reduces the load on the mechanical system

SUMMARY

- Each existing building is unique
- Common approach
  - Where possible, vary the airflow with load, (designing for part load conditions)
  - Be conscious of building pressurization
  - Provide energy efficient systems that meet the space requirements