



The Sun Devil In The Details: Lessons Learned from Residential HVAC Programs in the Desert Southwest



Introduction

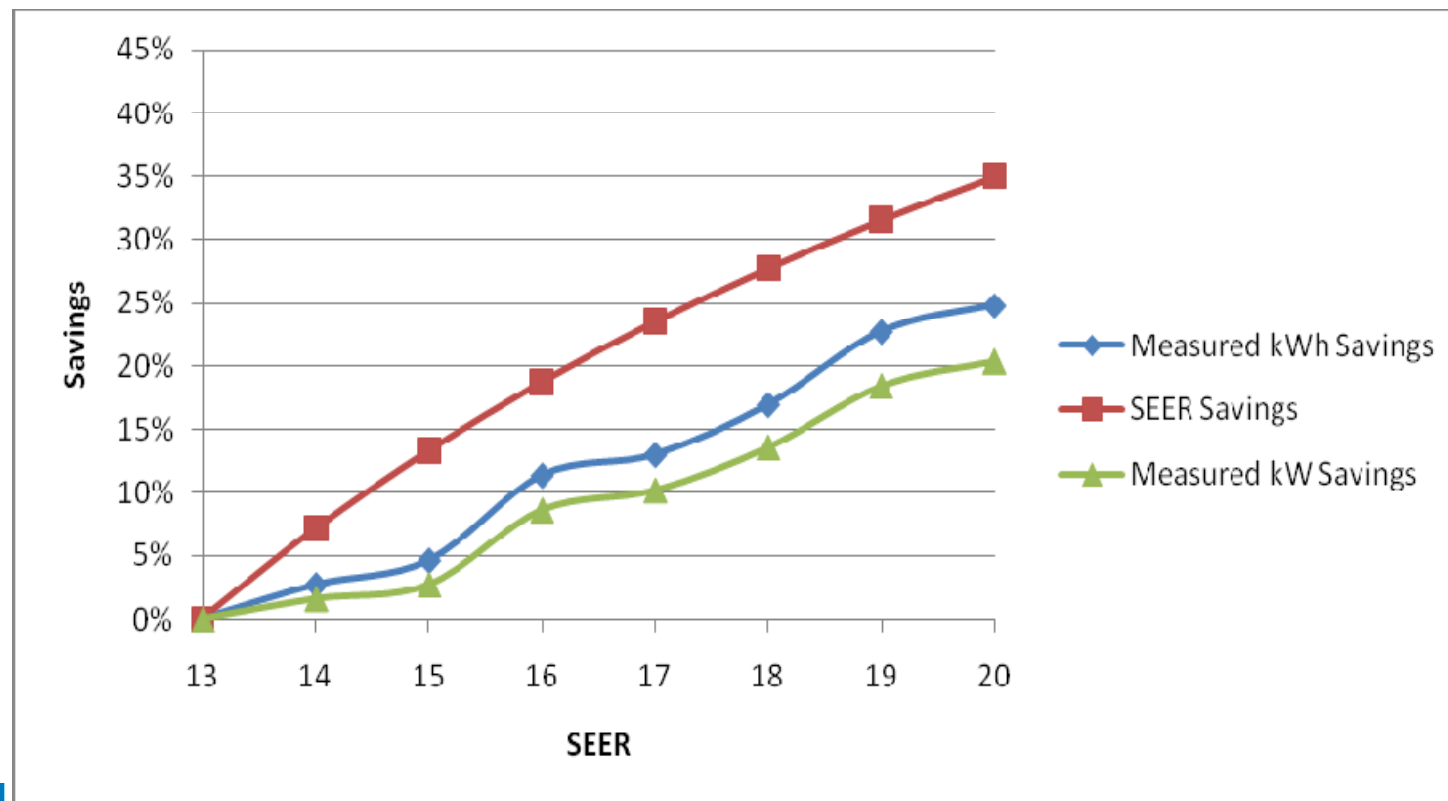
- » Navigant Consulting conducted three studies of new Residential HVAC equipment in the Desert Southwest last summer
 - › Summer logging of energy consumption of high efficiency air conditioners at 28 sites in Phoenix, AZ
 - › Summer logging of energy consumption of HVAC early retirements at 34 sites in Palm Desert, CA
 - › Logging of HVAC runtime during peak weather (late July, early August) at 13 new homes in Phoenix, AZ
- » The results of these studies show lower than expected savings associated with:
 - › high SEER air conditioners,
 - › large savings from early retirement of air conditioners, and
 - › significant opportunities for equipment size reduction in new construction in hot, dry climate

Phoenix High Efficiency HVAC Equipment: Study Background

- » Arizona Public Service has a highly successful residential HVAC program that incentivizes the purchase of high efficiency HVAC equipment
- » Equipment includes both single stage (generally SEER 14-SEER 15) and dual stage (generally SEER 16+)
- » Primary Study Objective: Derive energy and peak demand savings for high efficiency HVAC systems
- » Methodology
 - › Develop SEER-specific equipment model based on manufacturer performance data
 - › Adjust equipment model based on measured power consumption
 - › Develop *typical* annual hourly runtime profile with hourly simulation model calibrated to logged operation
 - › Run adjusted equipment model with *typical* annual hourly runtime profile

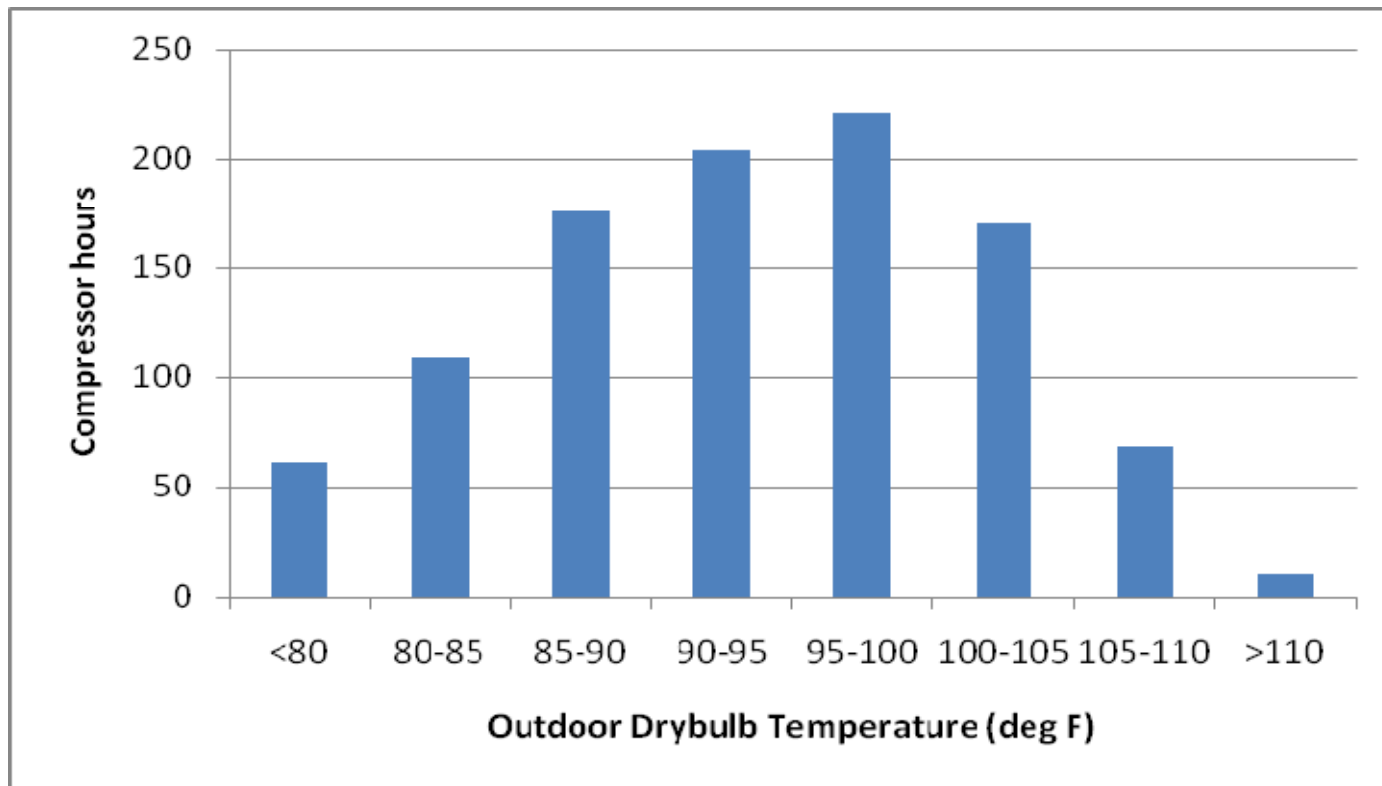
Phoenix High Efficiency HVAC Equipment: Results

- » $SEER = (\text{Part Load Cooling Capacity (82 deg F)}) / (\text{Part Load Energy Consumption (82 deg F)})$
- » Savings are much lower than Energy $\sim 1/SEER$ predicts



Phoenix High Efficiency HVAC Equipment: Results

- » Average operating temperatures in Phoenix are much higher than SEER rating condition



Phoenix High Efficiency HVAC Equipment: Discussion and Conclusions

- » SEER is not a good predictor of savings for high efficiency HVAC equipment in hot dry climates
- » Part load performance at 95 degrees F would give a better prediction of energy savings in this climate
- » High part load performance at 110 degrees F would give a better prediction of peak demand savings in this climate
- » Savings derived using purely 1/SEER and 1/EER should be treated with some suspicion wherever operating conditions vary significantly from the SEER and EER rating conditions.

Palm Desert HVAC Early Retirement: Study Background

- » The Palm Desert Partnership Program includes an HVAC early retirement program that realizes large energy savings from replacing inefficient existing HVAC systems that are still in service
- » Key differences between early retirement (ER) and replace-on-burnout (ROB) HVAC programs:
 - › Lower program baseline – SEER 9-10 for ER *vs.* SEER 13 for ROB
 - › Larger savings due to lower baseline efficiency
 - › Higher incremental cost
- » Objective was to determine annual energy and peak demand impacts of HVAC early retirements and high efficiency units
- » Results of study were used to determine utility program savings and will inform decisions regarding future EE portfolio planning

Palm Desert HVAC Early Retirement: Results

- » Replaced equipment was on average 19 years old with SEER = 9.7
- » Remaining useful life derived was 6 years
- » Net to Gross (NTG) was established through surveys at 0.74
- » Savings associated with SEER 9.7 to SEER 13 upgrade was much higher than savings associated with SEER 13 to SEER 14.8
 - » Phoenix high efficiency HVAC study had higher SEER and higher estimated savings, due to prevalence of dual stage equipment

Measure Category	Unit Energy Savings (kWh/ton)	Peak Demand Savings (kW/ton)
Early Retirement (Existing up to Code minimum)	326	0.21
High Efficiency Equipment (Code up to High Efficiency)	68	0.03
Total	394	0.24

Palm Desert HVAC Early Retirement: Discussion and Conclusions

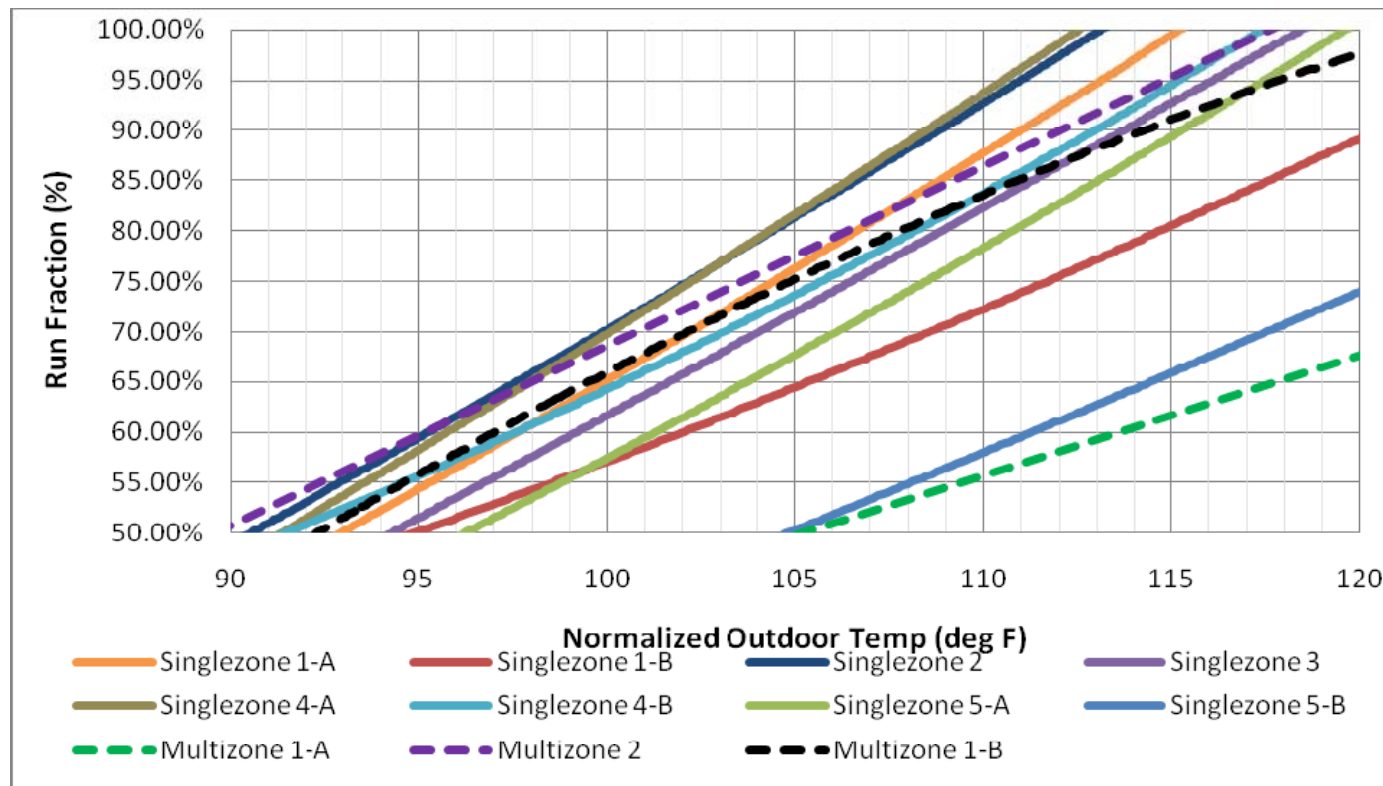
- » Freeridership reduced the net program savings (NTG = 0.74)
- » Savings associated with early retirement were much higher than savings associated with high efficiency equipment
 - › Energy consumption tracks much better with $1/\text{SEER}$ in the SEER 8 – SEER 13 range than in the SEER 13 – SEER 15 range
- » Remaining Useful Life is higher than one would expect
 - › *equipment that has lasted a long time is likely to keep running....*

Phoenix New Construction HVAC Sizing: Study Background

- » Arizona Public Service has a highly successful *EnergyStar Homes* program, where they provide incentives to builders who meet *EnergyStar* guidelines
- » In order to capture the full benefits of envelope improvements, builders need to right size HVAC equipment
- » Placed runtime loggers on HVAC systems and temperature loggers on thermostats at 13 high efficiency new homes in the Phoenix area during peak temperature period (typically 110 degrees F)
- » Actual runtime measured during peak conditions and then corrected for thermostat settings
- » Oversizing ratio determined by fitting hourly runtime against outdoor temperature

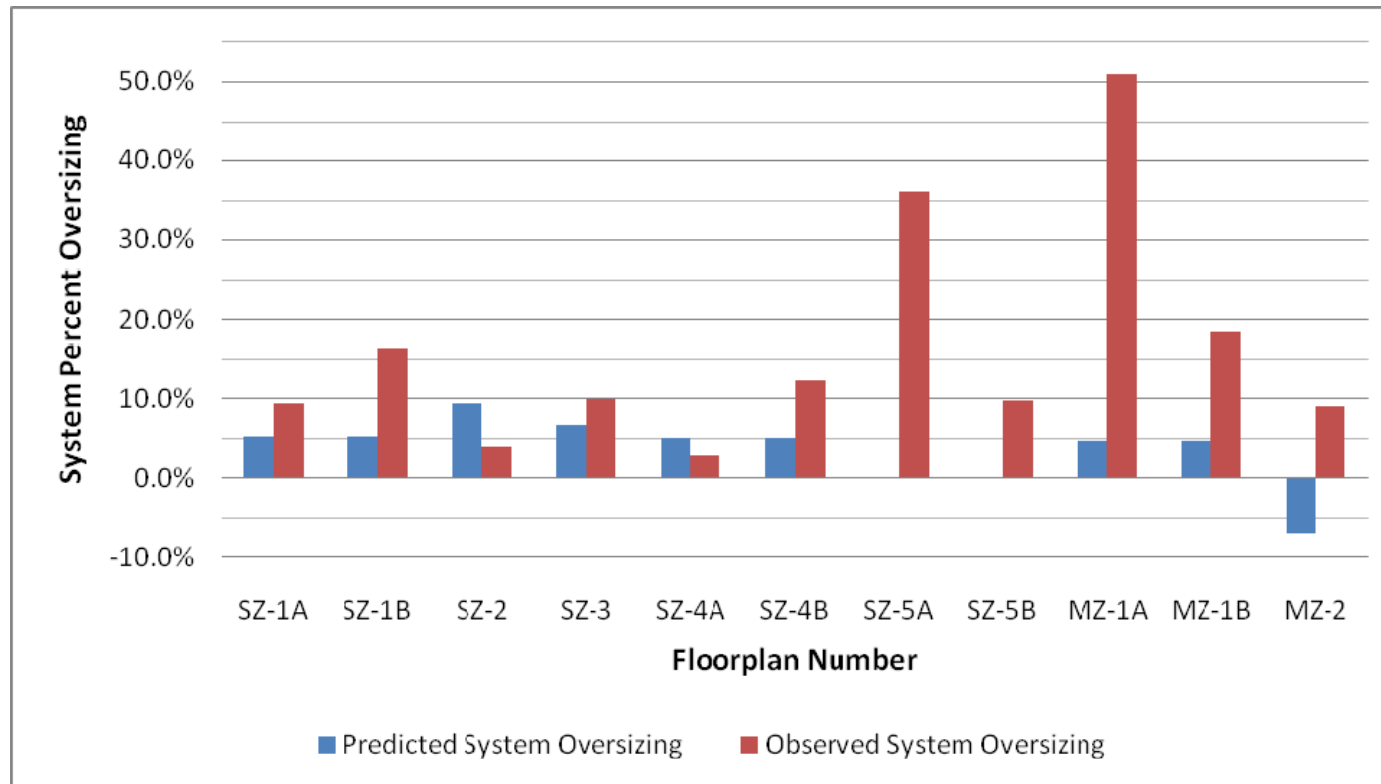
Phoenix New Construction HVAC Sizing: Results

- » None of the units were undersized
 - › this is not surprising - units come in incremental sizes



Phoenix New Construction HVAC Sizing: Results

- » All units except 2 had more oversizing than the contractor calculation predicted
- » The average contractor sizing calculation error was 14%



Phoenix New Construction HVAC Sizing: Conclusions

- » HVAC systems in energy efficient new homes are likely being oversized
- » Oversizing covers up problems with installations – additional investigation was done at the one site that appeared to be properly sized and revealed a collapsed seam in the supply plenum
- » Oversizing also drives up the cost of energy efficient equipment
- » Sizing reductions can create peak demand savings and help pay for other EE program elements
- » Proper sizing according to *Manual J* may not be what customers want
 - › if a daytime tstat setback is used, people want the unit capacity to exceed the peak load so that the house can stay cooled

Conclusions

- » High efficiency HVAC ROB programs are popular, *but*
 - › they regularly experience problems with high freeridership and show lower than expected savings in hot climates
- » Single stage high efficiency HVAC units perform worse than expected in hot dry climates, *while*
 - › two stage high efficiency HVAC units performed closer to what is expected
- » HVAC early retirements offer opportunities for larger savings and lower freeridership, but
 - › their ultimate cost-effectiveness relies heavily on the near term utility avoided costs
- » Oversizing of equipment remains a common practice
- » A climate-specific SEER and high temperature EER would be highly useful in getting climate-optimized HVAC equipment installed

Questions??



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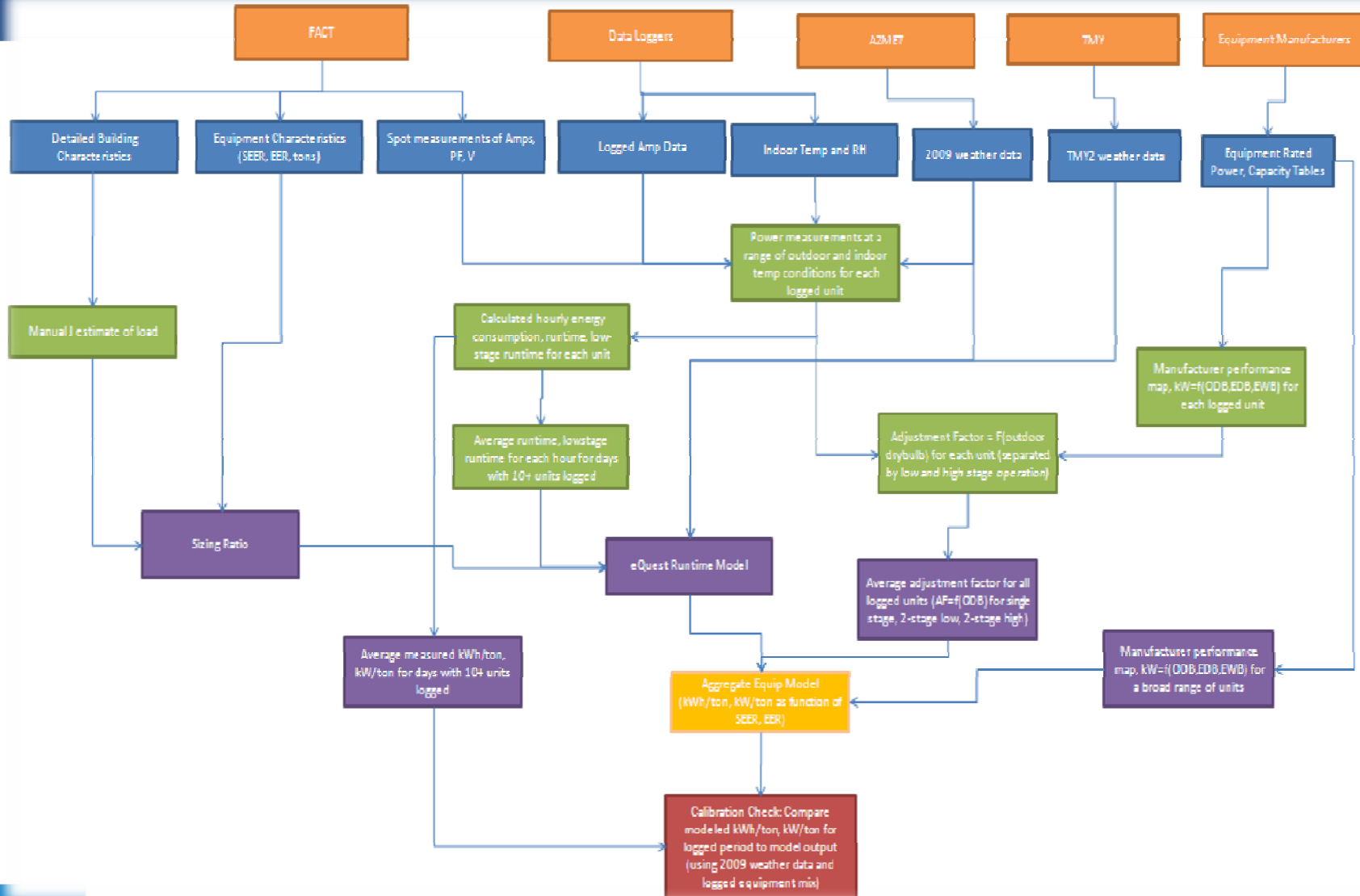
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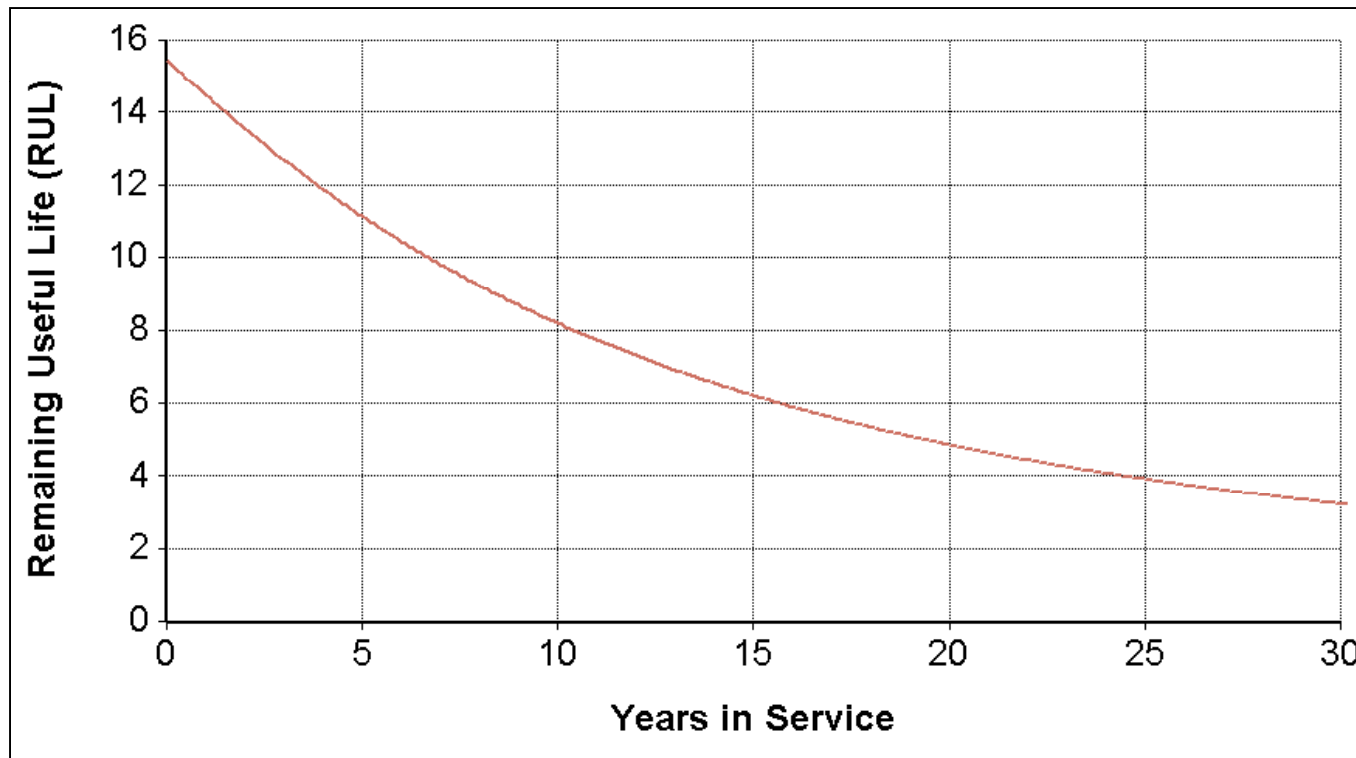


Additional High Efficiency HVAC Slides



Additional Early Retirement Slides

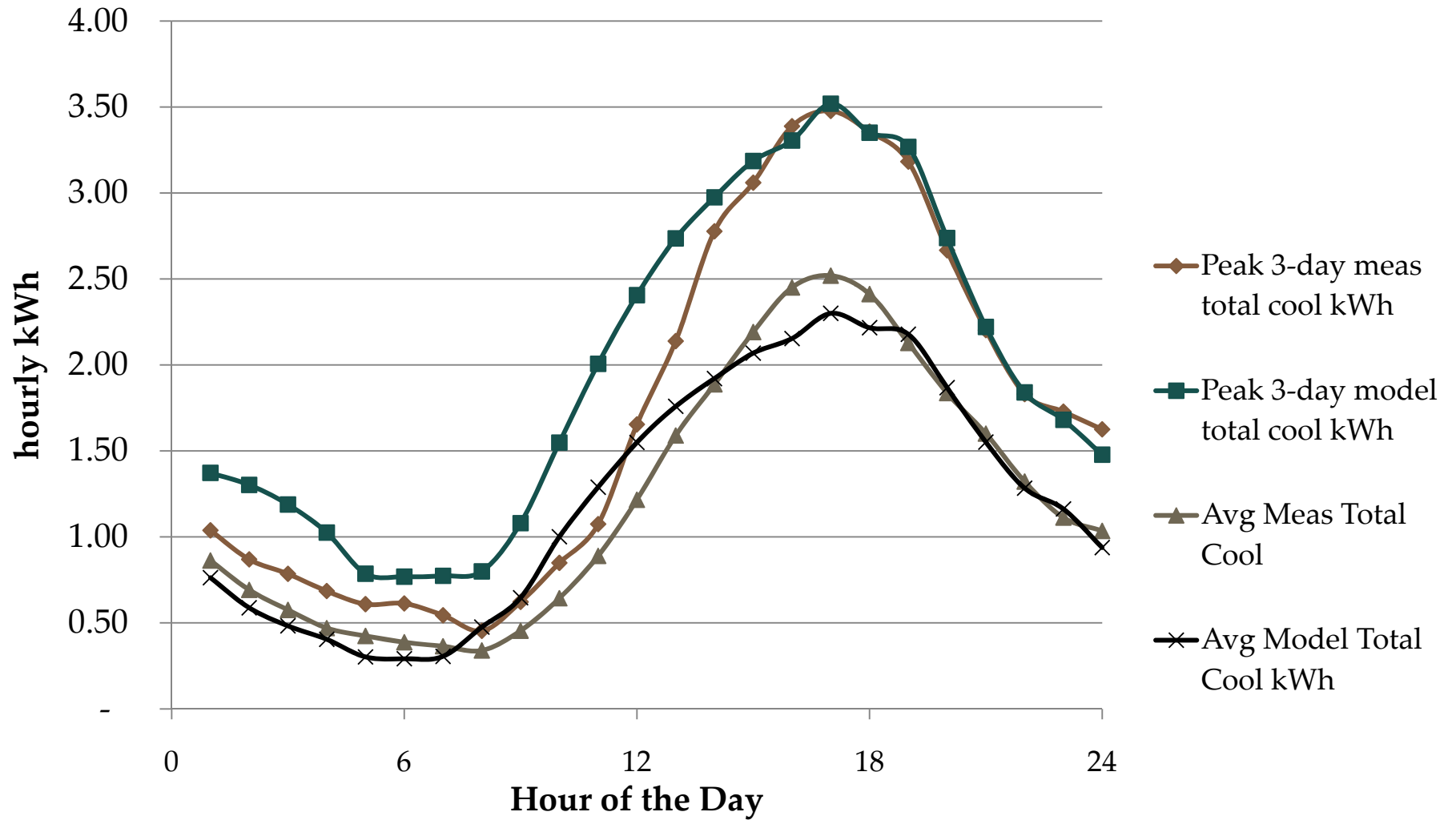
- » Remaining Useful Life Curve derived using Weibull distribution and fitting to shipment data and census data



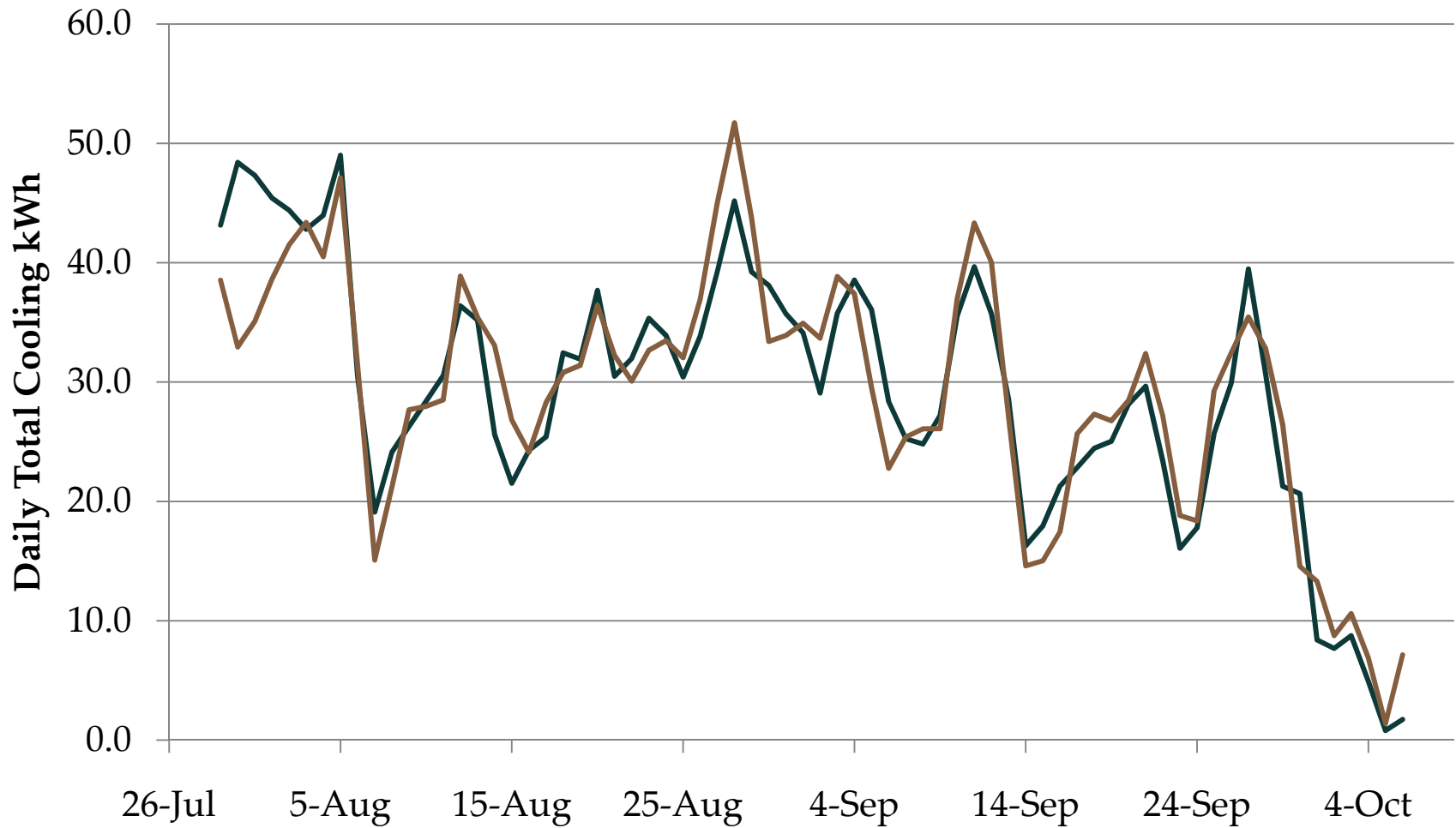
Additional Early Retirement Slides

- » Calibrated model with dual primary objectives:
 - › Match hourly energy consumption during peak period
 - › Match daily energy consumption over summer cooling period
- » Made small adjustments to model parameters to derive calibrated model
 - › Thermostat schedule
 - › Window operations
 - › Duct leakage

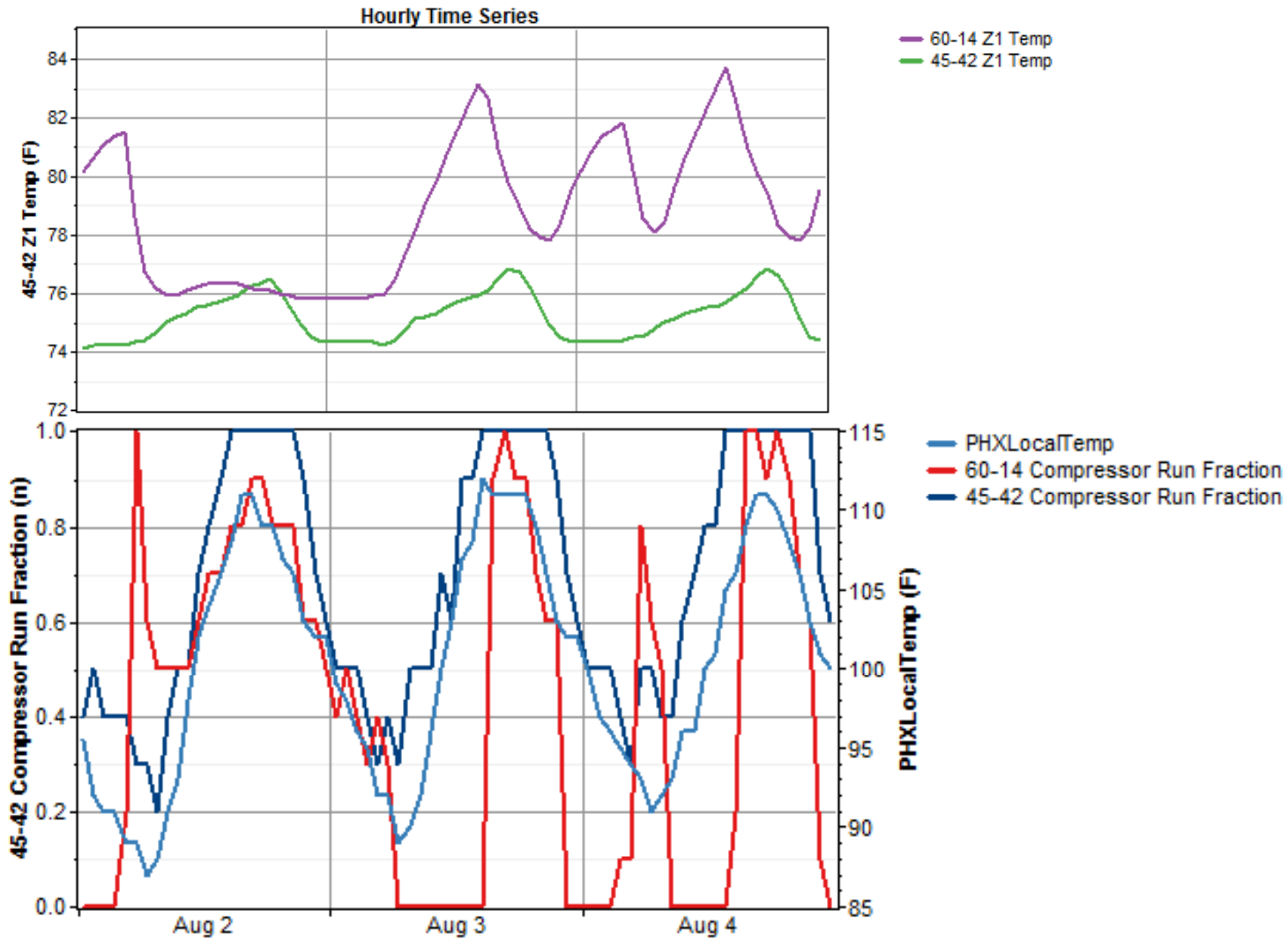
Additional Early Retirement Slides



Additional Early Retirement Slides



Additional HVAC Sizing Slides



Additional HVAC Sizing Slides



- » Large duct leakage on the only unit that consistently showed maximum runtime at high temperatures