Analysis of Improved AC & HP Designs for Hot/Dry Climates

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AC Performance in Hot/Dry Climates

- In CA and SW climates, little dehumidification is required of ACs
  - Result is reduced efficiency (>5%) from colder supply and evap. temps under dry coil conditions
  - And even more loss of SEER potential
    - from limits of dehumidifying design
- Typically the indoor coil is undersized
  - to dehumidify properly
- What if units were designed for minimal dehumidification at design conditions
  - Larger airflows and coils to raise supply and evaporator temperatures
  - and thus performance
- and to dehumidify only as needed?
Hot/Dry Climate AC Design

- Optimum indoor coil HX size for dry coil is near 45% of total HX area
  - vs 20-25% generally used for standard ACs (although above 35%, the returns are diminishing)
- More efficient blowers allow higher airflow (+15%) and higher evaporator temps
  - Increasing dry coil evap temp from 41F to 51F max (from the higher airflow and larger coil)
- Compressor is reduced by one size or more
- Suggests pairing larger air handlers with smaller capacity, high SEER ODUs
Effect of Larger Indoor HX Area and Flow

Effect of Relative Indoor-to-Outdoor Coil Size
75/57F DB/WB Indoor Condition, Optimum Airflow, Fixed Fan Effs
Constant Capacity and Total HX Area

Effect of +37% Total HX Area with SOA Fans, +15% airflows
Effect of +37% Total HX Area, Std. Fans
Base Total HX Area, Std. Fans

Opt. IDU, Orig. ODU, SOA Fans
+37% Tot. HX Area, SOA Fans
Opt. IDU, Orig. ODU, Std. Fans
+37% Tot. HX Area, Std. Fans
Base HXs and Fans
Base IDU, Orig. ODU
HDAC EER Gains from 12 SEER

HDAC EER Gains @ 115F Amb, 80/63F DB/WB from Design Options Relative to 12 SEER Unit

Indoor Air-Side Area Increase (%) vs. EER Increase @ 115F (%)

- 13 SEER Unit
- SOA IDU, Scaled Cab
- Opt. IDU, Scaled Cab
- BC IDF, Best Cab
- SOA Fans

Legend:
- Blue diamond: 13 SEER Unit
- Red square: SOA IDU, Scaled Cab
- Green triangle: Opt. IDU, Scaled Cab
- Red circle: SOA IDU, Best Cab
- Green circle: BC IDF, Best Cab
IDU Designs at 2x Base Unit

EER Trends vs Fin Spacing
Fixed Area Indoor Coil, 2x Base

EER @ 95F Amb

Fin Spacing (FPI)

1500 cfm

1300 cfm

Best Cabinet

Scaled Cabinet

Airflow

FPI

Oak Ridge National Laboratory
U. S. Department of Energy
HDAC Peak Power Savings @115F Amb, 80/63F DB/WB from Design Options, Relative to 12 SEER Unit
Initial LBNL Payback Analysis, 6/04

- 12 SEER baseline
- With intermediate and optimum HX sizes
- SEER 12 fans and best fan cases
- Found that all four HDAC designs
  - “provided LCC savings and relatively short payback periods” in CA and SW climates
- Recommended further analysis vs 13 SEER baseline
HDAC Performance vs 13 SEER Baseline Unit

Selected 13 SEER baseline unit has:

- Same compressor
- Larger indoor coil
- Better ID blower
- Better OD fan but same outdoor coil

vs 12 SEER baseline by same manuf

(Conservative case for comparison as some manufs first increase only outdoor unit performance)
HDAC EER Gains from 13 SEER

HDAC EER Gains @ 115F Amb, 80/63F DB/WB from Design Options Relative to 13 SEER Unit

- Scaled Cab
- Best Cab
- BC IDF
- SOA IDF
- SOA Fans
- 13 SEER Fans

Indoor Air-Side Area Increase (%)

EER Increase @ 115F (%)
HDAC Peak Power Savings @115F Amb, 80/63F DB/WB from Design Options, Relative to 13 SEER Unit

- Scaled Cab
- Best Cab
- BC IDF
- SOA Fans
- SOA IDF
- SOA IDU, Scaled Cab
- Opt. IDU, Scaled Cab
- SOA IDU, Best Cab
- BC IDF, Best Cab

Indoor Air-Side Area Increase (%) vs Peak Power Savings @115F (%)
Hot/Dry Climate AC Designs

- Suggests that ½ -1½ ton larger air handlers be paired with ½ -1 ton smaller compressors, as cost effective
- Use BDC blower motors for high-efficiency and dehumidify as needed.
  - Reducing blower speed with RH signal
- Analysis suggests that HDAC designs possible with existing equipment
  - Using existing oversized premium air handlers matched with undersized high SEER ODUs
Summary -- HDAC Designs

- EER gains over 20% and peak reductions of 17% at high ambients
  - with best combinations of existing equipment
- EER gains nearing 30% and peak reductions over 22%
  - With designs using adv. blowers and fans
- Energy savings close in size to peak reductions
- SEER increases only slightly smaller than those in EER (benefits over full ambient range)
Summary -- HDAC Designs

- Assumes duct system sized to give rated external static of 0.15” at elevated airflow
  - effic. gains reduced at higher ΔPs
- More restrictive duct systems
  - Increase blower power
    - almost linearly with increase in static
  - Limit optimal airflow to lesser degree (e.g. 1400 vs 1500 cfm)
  - So reduces effic. potential somewhat
Heating Benefits of Hot/Dry Design

- Large indoor coil boosts heating COP
  - Heating mode condensing is most loaded HX

- Availability of VS Blower
  - Reduces blower power significantly
  - Allows supply temp. control to customer preference

- Evaluated case of optimum indoor HX size
  - DOE Region II
HDHP Performance Change

Heating Performance Effects of Hot/Dry Design

- Performance Change (%)
- Ambient (F)
- COP
- Capacity
- Power
Heating Benefits of Hot/Dry Design
DOE Region II

• For case of optimum indoor HX size
  – HSPF increase of 27.5%
  – HSPF gain was 70% of SEER gain
  – No backup heat required

• Heating savings
  – 66% of cooling mode savings
  – Shortens payback time by 40% over AC only
HDHP Indoor Airflow

Heat Pump Blower Airflow

Airflow (cfm)

Ambient (F)

Base Design

Hot/Dry Design
HDHP Blower Power

Heat Pump Blower Power

- Base Design
- Hot/Dry Design

Power (W)

Ambient (F)

0 50 100 150 200 250 300 350 400 450 500

7 12 17 22 27 32 37 42 47 52 57
AC/HP Performance in Hot/Dry Climates

- Hot/Dry regional designs show potential for significant performance improvement
- Improved blowers and fans enable higher airflows needed to maximize these gains
- Restrictive duct systems limit potential performance gain for hot/dry designs
  - Most eff. potential in houses with well sized ducts
  - Or in houses where envelope improvements allow unit downsizing leaving more rightsized ducts
- HP rather than AC-only designs have more potential to payback higher equipment costs