HVAC System Design Process

Establish design intents/criteria (including code/standard compliance)
Establish zoning requirements
Make preliminary system selection
Calculate design heating/cooling loads
Select appropriate source equipment
Select appropriate distribution and delivery equipment
Coordinate HVAC components with other building systems
Run energy analyses to optimize selections
Final-size equipment (fans, pumps, valves, dampers, pipes, ducts, condensers, air-handlers, tanks, …)
Coordinate individual equipment selections into a cohesive whole
Develop appropriate control strategies and logic
Develop commissioning tests and checklists
Witness systems installation and verification
Develop systems manuals for owner

red = architect leads; blue = architect participates; black = consultant leads
HVAC System *Selection* Process

- Identify issues of concern
- Clearly define design intents
- Establish viable design criteria
- Compare potential systems against criteria
- Select best system
- Validate system selection

Common HVAC Selection Issues

- First cost
- Life-cycle cost
- Durability
- Maintainability
- Reliability
- Appearance
- Zoning capabilities
- Flexibility
- Energy efficiency
- Green-ness
- Noise
- Space requirements
- Smoke control capabilities
- Fuel(s)
- Owner dictates
- Many others
Common HVAC Design Intents

- “Provide” thermal comfort
- “Provide” acceptable IAQ
- Low first cost
- Good energy efficiency
- No equipment located in occupied spaces
- A “green” system
- Highly reliable operation
- Easily maintained equipment
- Low life-cycle costs
- And such …

Assign Design Criteria to Each Intent

- Low first cost means no more than $xx.xx / sq ft
- Energy efficient means 30% better than the requirements of ASHRAE Standard 90.1
- Provide thermal comfort means meets the requirements of ASHRAE Standard 55 (“bettering” this standard is not necessarily meaningful)
- Provide good IAQ means meets the requirements of ASHRAE Standard 62.1 (“bettering” is expensive to verify and may be energy intensive)
- Easy to maintain means janitorial staff can do the job
- No equipment in occupied spaces means as stated
- Aesthetically pleasing means meets three precedents
Selection Matrix (a design tool)

<table>
<thead>
<tr>
<th>INTENT</th>
<th>WEIGHT</th>
<th>SCORE SYSTEM A</th>
<th>WEIGHTED SCORE SYSTEM A</th>
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<td>7</td>
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<td>High Flexibility</td>
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<tr>
<td>Good IAQ Capabilities</td>
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<td>OVERALL RATING</td>
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</table>

* Most important attribute/intent; ** second most important; etc.

Key HVAC Coordination Issues

- **Equipment Locations**
  - Source equipment (noise, maintenance access, access for replacement, connection to utilities)
  - Condenser (is exterior, noise, appearance, air flow, spray)
  - Air-handlers (air supply and return paths, outdoor air access, noise, vibration)
  - Terminal devices (maintenance access, noise)
  - Outdoor air intakes (provide clean fresh air)
- **Floor Area for Equipment**
  - Mechanical room(s), satellite fan room(s), condenser
- **Volume for Distribution (and Equipment)**
  - Ductwork (by itself and in coordination with beams, lighting fixtures, sprinkler piping, electrical/data runs)
- **Aesthetics**
  - Exposed elements (especially diffusers)
Desired Equipment Locations

a joint architectural/mechanical decision

these examples all “work” … but one will usually make more sense in a given project context

Required Equipment Locations

diffusers laid out for reasonable air distribution

The Architect’s Studio Companion: 3rd Ed.
Large Equipment Areas

schematic planning: can estimate central plant at 7% +/- of conditioned floor area

Air Handling Unit Areas

The Architect’s Studio Companion: 3rd Ed.
Consider Volume (not just floor area)

SECTION THROUGH CEILING/FLOOR ASSEMBLY

The Architect’s Studio Companion, 3rd Ed.

Volume
Volume

Provide for Access
Estimating Duct Sizes

• Assume 1 cfm per square foot (for an all-air system)

• Duct volume (in ft\(^3\)) = air flow (in cfm) / air speed (in fpm)

• Assume (as a starting point) 1000 fpm air speed
  – cfm = cubic feet per minute (air flow rate)
  – fpm = feet per minute (air speed in ducts)
  – higher air speed is both possible and common, but uses more energy and generates more noise

• Estimate duct dimensions as needed for area served by a given duct (main ducts, branch ducts, …)

Example: a 200 sq ft office
  – (200 sq ft)(1 cfm/sq ft) = 200 cfm
  – 200 cfm / 1000 fpm = 0.2 sq ft
  – duct size might be around 12” x 3” or 6” x 6” or ….
  – and a similar size return air duct may be required

Example: a 3000 sq ft classroom wing
  – (3000 sq ft)(1 cfm/sq ft) = 3000 cfm
  – 3000 cfm / 1000 fpm = 3 sq ft
  – duct size might be 36” x 12”
  – and a similar size return air duct may be required
The Devices and Aesthetics of Air Delivery

diffuser

The Aesthetics of Delivery

grille

register

diffuser

grille
The Devices/Aesthetics of Water Delivery

- fan-coil unit
- recessed convecto
- baseboard radiator
- chilled beams
- radiant floor
Messy Central Stuff (usually hidden)

Big Stuff (source components)

- chiller
- cooling tower
Sheer Volume of Stuff

outdoor air duct

exhaust fan

Aesthetic Potential of Exposed Systems
Creative Design

student work: Oklahoma State University

Creative Design

student work: Oklahoma State University