Order of Magnitude Mechanical Estimating

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Topics for Today

- Estimate Goals
- A Concept for Accurate Conceptual Estimating
- HVAC Systems – Common System Types and Rules of Thumb Pricing
- Example Estimate
- Managing the Budget During Design

Project Delivery Methods

- Conceptual Estimating applies to each type of delivery.
  - Plan and Spec. – Lump Sum Bid
  - Design-Assist
    - Lump Sum, GMP, T&M
  - Design-Build
    - Lump Sum, GMP, T&M
  - IPD – Integrated Project Delivery

Order of Magnitude Estimate Goal

Determine today what the job will cost tomorrow.

Questions for Client

First Question:
What will you do with the information?

General Discovery Questions

- Occupancy
- Owner
- End User
- Design Team
- Building Square Footage
- Small or Disadvantaged Business Goals
- Schedule
- Jobsite Logistics
- Overall project budget
- Sole Sourced Vendors or Subs
Mechanical Discovery Questions

- Desired Systems
- % of Glass
- Building Orientation
- Desired Conditions (temp & humidity)
- Outside Air Requirements
- Specialty Areas
- Energy Code Compliance
- BIM Requirements
- LEED / Sustainable Design

LEED Design

- Over 1/3 of LEED points can be mechanical related

Estimating Concepts and Relative Accuracy

- Estimate based on “final” construction documents
  - Accuracy = +/- 0% to 5%
- Good conceptual estimate evaluating all system components
  - Accuracy = +/- 5% to 10%
- $/square foot or $/building unit (bed, cell, etc.)
  - Accuracy = +/- 10% to 20%

“The Concept” of Accurate Conceptual Estimating

- Quantities and capacities of all HVAC equipment & systems
- Quantities and capacities of all plumbing fixtures, equipment, and systems
- Apply established unit values to quantities and capacities
- Accuracy is very dependent upon understanding of systems and accuracy/application of the unit values

Required Information

- Specifications establishing required materials and equipment quality
- Conceptual drawings or systems narrative
  - Types of systems
  - System capacities
  - System layout
- Specifications (be careful of assumptions)
  - Types of piping for each application
  - Types of insulation
  - Quality of plumbing fixtures
  - Quality and type of equipment
  - Accepted manufacturers
  - Trade responsibilities
**Required Information**

- Specifications
  - Specialty requirements
    - Process systems
    - Owner furnished equipment connections
    - Vibration or sound isolation
    - Temporary heating/cooling provisions
    - Custom equipment
    - Water filtration
    - Interface between HVAC controls and other building systems

**Developing the Estimate**

- Equipment – utilize rule of thumb or actual cost from vendors
- Equipment labor – utilize established unit values for labor hours per piece of equipment
- Piping – utilize established unit values which include material and labor per linear foot
- Ductwork – utilize established unit values which include material and labor per cfm or pound

**Indirect Costs**

- Unit values need to consider indirect costs
  - Tools, equipment rental, trucks
  - Testing
  - Delivery and hoisting
  - Detailing/BIM Modelling
  - Material handling
  - Safety
  - Consumeables
  - Supervision
  - Start-Up and Functional Testing
  
  Indirect costs can add 20% to 40% to the direct cost

**Developing the Estimate Plumbing**

- Roof drainage
  - Quantity of drains
  - Overflow drains or scuppers
  - Separate overflow system or connected to primary drainage system
  - Utility connections

**Developing the Estimate Plumbing**

- Fixtures
  - Back to Back?
  - Level of finish?
- Equipment
  - Quantity and type of water heaters
  - Recirculation system concept
  - Mixing valve requirements
  - Water booster pump requirements
  - Sewage ejector (lift station) requirements
  - Water softening equipment
  - Water filtration equipment
  - Ground water pumping equipment

**Developing the Estimate Plumbing**

- Special Systems
  - Generator fuel system
  - Boiler fuel oil system
  - Medical Gas
  - Laboratory Gas
  - Special drainage requirements
    - Interceptors and traps
    - Acid waste piping
    - Grease waste piping
### Developing the Estimate HVAC

#### Heating Plant
- Boiler capacity
- Pumping scheme & sizes
- Pump VFDs
- Specialties
  - Expansion tanks, air separators, triple duty valves, gauges
- Water treatment

#### Cooling Plant
- Chiller type & capacity
- Pumping scheme & sizes
- Pump and/or chiller VFDs
- Cooling tower type & capacity
- Water treatment
- Specialties
- Free cooling heat exchanger(s)

#### Air Handling Equipment
- RTU or AHU capacity (tons/cfm)
- Unit specifications
  - Casing construction
  - Heat recovery
  - Integral return/exhaust fans
  - Economizer cycle
  - If RTU – type of roof curb

#### Piping Mains
- Establish unit values for each type of pipe which consider:
  - Hanger requirements
  - Pipe routing / available ceiling space
  - Material specification/joining method

#### Piping Branches
- Establish $/connection for each type of coil
- Review piping connection details if available
- Gauges, isolation valves, balancing valves
- Large coils may require multiple connections

#### Sheet Metal
- Terminal boxes (fan powered and vav)
- Ductwork Specifications
- Exhaust fans
- Air devices types (grilles, registers, diffusers, louvers)
- Specialty ductwork (kitchens, labs, process)
Developing the Estimate

- Insulation
  - Plumbing
  - HVAC piping & equipment
  - Ductwork
- Estimate as $/l.f. by size, or % of piping and ductwork (6% to 12%)

Developing the Estimate

- Temperature Controls
  - Operator interface terminal (PC)
  - Cooling plant
  - Heating plant
  - Air handling units
  - VAV / Fan powered boxes
  - Fan coil units / heat pumps
  - Terminal devices (unit heaters, etc.)
  - Make-up air and Exhaust systems

Other Items to Consider

- Commissioning
- LEED Certification
- Security Requirements
- Design Responsibility
- Site Logistics
- Local Jurisdiction/Code Requirements

Mechanical Systems

Rule of Thumb Prices

HVAC & Plumbing Cost as % of Overall Budget

- Standard/Office Bldg – 15%-20%
- Hospital – 20%-25%
- Data Center – 30%-40%
- Laboratory – 30%-35%
- Apartment/Hotel – 15%-20%
- Prison/Correctional Facility – 15%-20%

Mechanical Cost by System Type (Ballpark Ranges - $/s.f.)

- Recreational Buildings
  - Plumbing $5 to $7 per s.f.
  - HVAC $17 to $22 per s.f.
- Office Buildings
  - Plumbing $5 to $7 per s.f.
  - HVAC (2 pipe) $15 to $23 per s.f.
  - HVAC (4 pipe) $23 to $28 per s.f.
**HVAC – Rules of Thumb**

- **Insulation**
  - 6% to 12% of total HVAC and plumbing cost

- **Sheet Metal**
  - $4/cfm to $8/cfm

- **Temperature Controls**
  - Very large range, ($0.75/sf to $5.00/sf)

- **Test and Balance**
  - $0.20/sf to $.50/sf

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**Plumbing Rules of Thumb**

- **Roof drainage**
  - $0.75/s.f. to $2.00/s.f.
  - Depends greatly on building height, roof configuration, quantity of drains
  - Method of overflow is important

- **Waste/vent & domestic water**
  - $2k to $4k per fixture
  - Includes water heaters – not specialty items
  - Depends on type of building/quantity of fixtures
  - Don’t forget non-typical/specialty items!!

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**Mechanical Cost by System Type (Ballpark Ranges - $/s.f.)**

- **Hospitals (new construction)**
  - Plumbing $25 to $30 per s.f.
  - HVAC (4 pipe) $45 to $55 per s.f.

- **Prisons**
  - Plumbing $13 to $18 per s.f.
  - HVAC (4 pipe) $30 to $40 per s.f.

- **Hotel/Condo – High Rise**
  - Plumbing $11 to $15 per s.f.
  - HVAC (2 pipe) $15 to $18 per s.f.
  - HVAC (4 pipe) $18 to $21 per s.f.

- **Hotel/Condo – Low Rise**
  - Plumbing $9 to $12 per s.f.
  - HVAC (d/x) $5 to $8 per s.f.

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**HVAC – Rules of Thumb**

- **Boiler Plant**
  - $9/MBH to $13/MBH

- **Chiller Plant**
  - $750/ton to $1200/ton

- **Piping Mains – can vary greatly**
Common System Types

**HVAC Systems**

**Single Zone, Constant Volume**

- Packaged DX Rooftop System
- Sheet metal supply duct
- Diffuser
- Modulating damper
- System-level controller
- Bypass damper
- VAV terminals

**Rules of Thumb for System Selection**

- Single Story < 25,000 s.f.
  - DX Split or Rooftop Unit
- Single Story > 25,000 s.f.
  - VAV System – Water Source / Geothermal Heat Pump
- Two Story < 25,000 s.f.
  - VAV System – Water Source / Geothermal Heat Pump
- Two Story and Greater > 25,000 s.f.
  - VAV System – Water Source / Geothermal Heat Pump
  - Under floor Air
- Multi-Story
  - VAV System – Under floor or Overhead Air – Unitary or Chilled Water System, Boiler System or Electric Heat,
  - Specialty systems (dedicated outside air, chilled beams, etc.)
Multiple Zones, Constant Volume

Multizone Air Handler

Multiple Zones, Variable Volume

DX Rooftop VAV System

Self-Contained DX VAV System

Split VAV Distribution System
Small Chilled-Water System

Central Chilled-Water VAV System

Dedicated Outdoor-Air System

Water-Source Heat-Pump System

Water-Source Heat-Pump System

Ground-Source Heat-Pump System
**Underfloor Air Distribution**

- Return @ 80-82°F
- Heat Source
- Boundary Layer
- Induced Room Air
- Supply @ 60-64°F

**System Make-up**

- Perimeter Zones
- Interior Zone
- High Induction Floor
- Diffusers – Manual or Zoned

**Budgetary Estimate Example**

- New Office Building
- Kansas City Metro Area
- 178,000 s.f.
- Completely Finished (not core-shell)
- Standard Office Plumbing PLUS Commercial Kitchen/Cafeteria
- Chilled water system serving large air handling units
- Underfloor air distribution

**Budgetary Estimate Example**

- Based on square footage alone:
  - Plumbing: $5 to $7 per s.f.
  - HVAC (2 pipe): $15 to $23
- Range is $3,916,000 to $5,162,000
- Average is $4,539,000 or $25.50/s.f.
- Range/Average = 27% spread

**Budgetary Estimate Example**

- Roof Drainage
  - 2 story building
  - Flat roof
  - Overflow scuppers
  - $1.00/s.f. x 178,000 = $178,000

**Budgetary Estimate Example**

- Plumbing Fixtures
  - 138 fixtures
  - Fixtures are spread out due to bldg. layout
  - 138 x $3,000 = $414,000
**Budgetary Estimate Example**

- **Commercial Kitchen/Cafeteria**
  - Historical Cost??
  - Number of Connections??
  - 100 Connections x $1,500 = $150,000

- **Chilled Water Plant**
  - Water cooled with cooling towers
  - 900 tons
  - Free cooling heat exchanger
  - LEED Silver project = efficient chillers
  - Cooling towers adjacent to chillers
  - 900 tons x $800/ton = $720,000

- **HVAC Piping**
  - Air handling units spread out
  - Pipe quantities known??
  - $1.00 to $3.00 per s.f.
  - 178,000 s.f. x $1.50/s.f. = $267,000

- **Air Handling Units**
  - 200,000 cfm (includes kitchen make-up air)
  - Large capacity units – 40,000 cfm for major units
  - 200,000 cfm x 1.75/cfm = $350,000

- **Sheet Metal**
  - Underfloor air system
  - Perimeter electric heat terminal units under floor
  - Perimeter automatically controlled zones
  - Interior manually controlled zones
  - Commercial kitchen systems
  - 200,000 cfm x $6.00/s.f. = $1,200,000

- **Insulation**
  - $3,279,000 x 5% = $163,950

- **Temperature Controls**
  - 178,000 s.f. x $1.50 = $267,000

- **Test & Balance**
  - 178,000 x $0.25/s.f. = $44,500
Budgetary Estimate Example

- Subtotal = $3,774,075
  - OH&P (15%) = $452,889
  - Total = $4,226,964
    - $23.75/s.f.
- Actual Estimate on Completed Documents
  - $3,880,000 or $21.80/s.f.
  - 8% lower than budget

Managing to the Budget

- How do you make the budget real?
- What accurate today can change quickly during design.
- Must get control of the things that are out of your control.

How GC can help?

- Clear scope of work issued with bid documents
- General conditions requirements
  - Clean up
  - Temporary utilities
  - Use of tower crane
  - Supervision requirements
  - Safety requirements
  - QA/QC staff requirements
  - Temporary conditioning

How GC can help?

- Define the Schedule
- Define the Schedule
- Overtime expectations
- Clean up requirements
- Coordination requirements and plan
- Billing method (schedule of values versus cost plus fee)
- Site logistics plan
- Avoid bid day!

Questions?

Thank You!