LABS FOR THE 21ST CENTURY

Labs21 Advanced Course Series

Optimizing Laboratory Ventilation Rates

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Goal: Optimize a Laboratory's Ventilation Rate

Objectives: At the end of this session, you will be able to:

- Delineate a balanced design process
- Differentiate levels of design practice
- Evaluate design features
- Explain relative safety and performance benefits
- Resolve a sustainable, energy-efficient ventilation rate

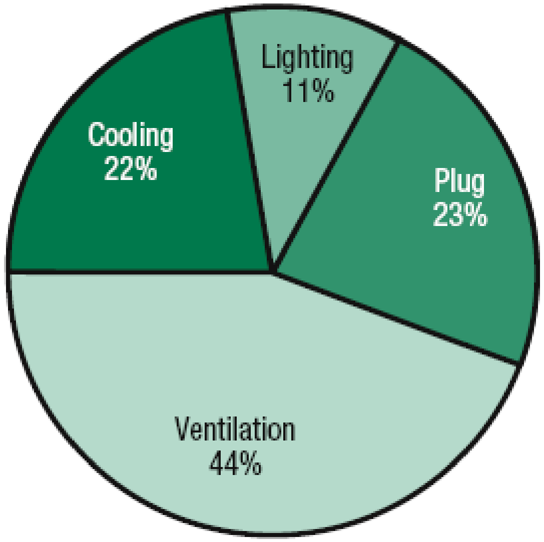
Outline

- Introduction
- Process Description
- Standard Practice
- Good Practice
- Better Practice
- Conclusion

Introduction

- **Ventilation Energy in Laboratories**
  - Typically 40 to 60% of energy use
  - Small reductions have large impact
  - Affects cost to build and maintain facility

Maximize Effectiveness; Minimize Energy Use



Annual electricity use in Louis Stokes Laboratory, National Institutes of Health , Bethesda, MD

Introduction

- **Why ventilation?**
  - Worker Safety
  - Space conditioning
- **What is "optimizing"?**
  - Air Change Rate
  - Air Dilution
  - Air Circulation

When dealing with hazards, an optimized laboratory design both safely handles the "worst" emergency (possible) and efficiently manages "routine" incidents (probable).

Process Description

Programming

1. Review Design Intent Document

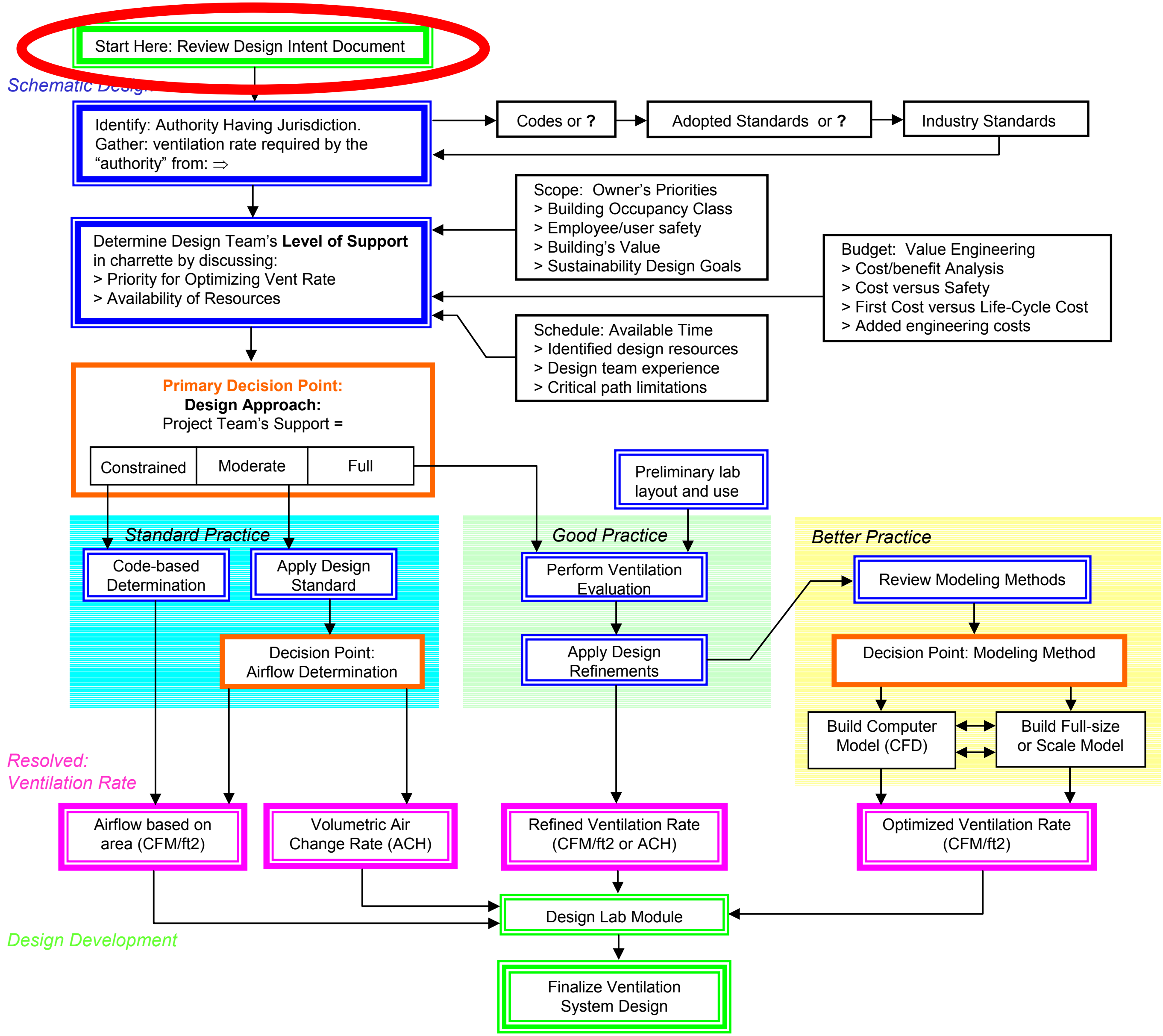
Schematic Design

2. Identify Authority Having Jurisdiction
3. Determine Level of Design Support
4. Primary Decision Point: Design Approach
5. Resolve: Ventilation Rate

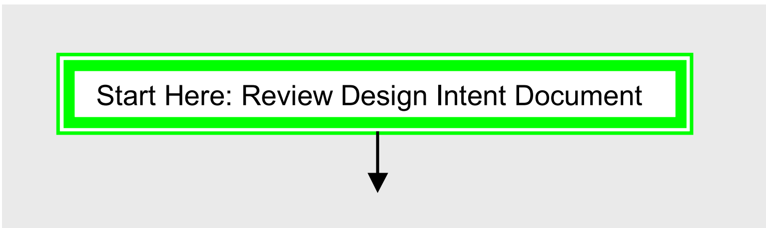
Design Development

6. Develop Laboratory Module Design
7. Finalize Ventilation System Design

Process Flowchart



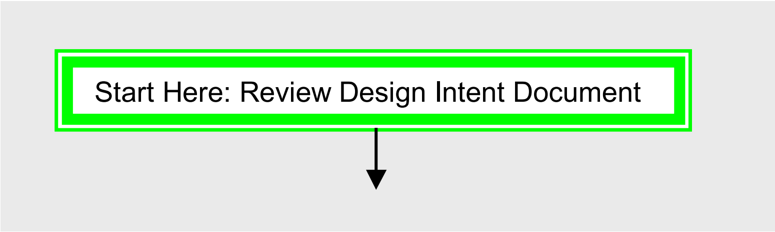
Step 1: Review Design Intent Document



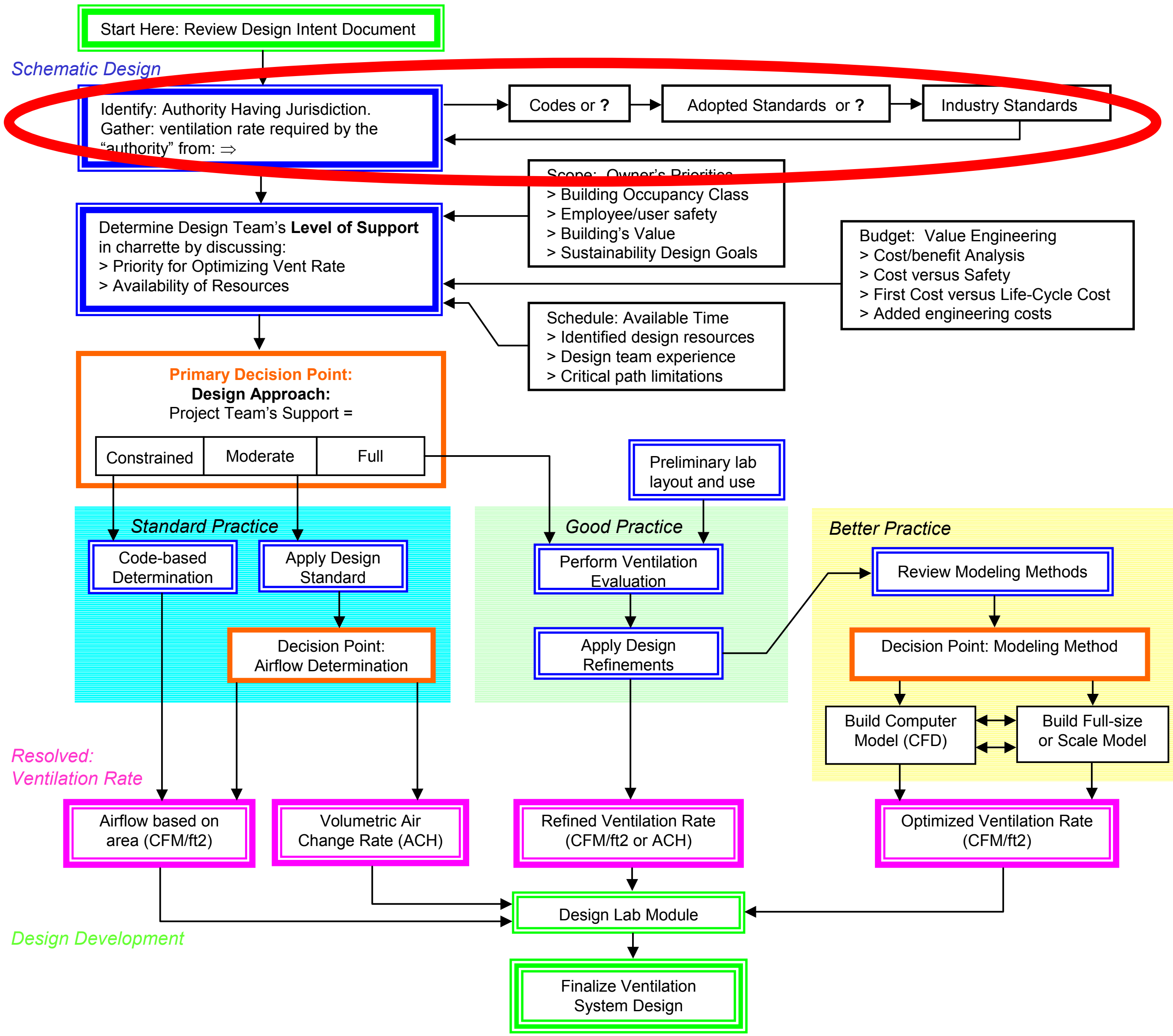
- **What is a Design Intent Document...?**
  - Narrative describing building's mission
  - Outlines delicate balance between "needs" and "wants"
  - Includes main design elements and features
  - Provides "boundaries" for design
- **Lab designer role and responsibility...?**
  - Proactive or reactive...?
  - Feedback or feed-forward...?

Step 1: Review Design Intent Document

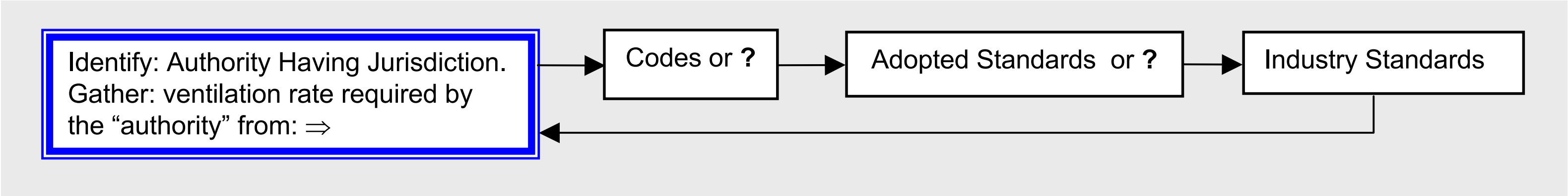
- **Narrative elements to look for…**
  - Client programming
  - User interviews
  - Mission statements
  - Research goals
  - Architectural synopses
  - Engineering approaches



Process Flowchart



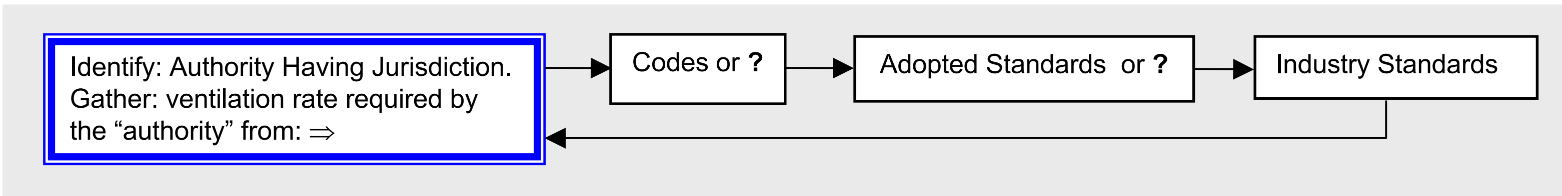
Step 2. Identify Authority having Jurisdiction



Authority having jurisdiction

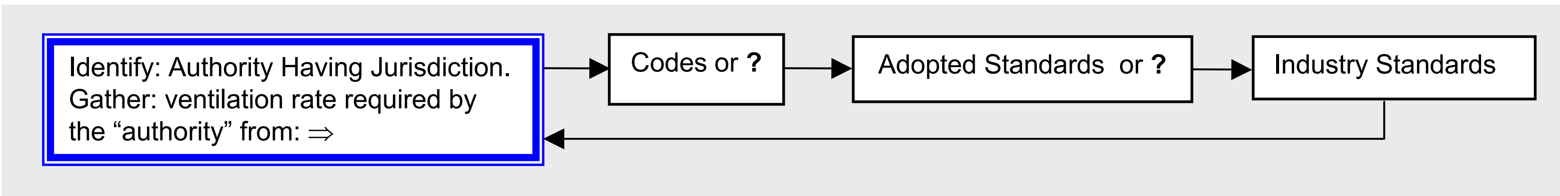
- **Codes**
  - Have "force of law"
  - Are restrictive
  - Require compliance
- **Adopted standards**
  - May be based on sound judgment
  - Could be biased or reflect entrenched doctrine
  - Possibly be archaic and not reflect latest technology or practices
- **Industry standards**
  - Are open to interpretation
  - Have a wide span of acceptable values
  - Subject to manipulation

Step 2. Identify Authority having Jurisdiction



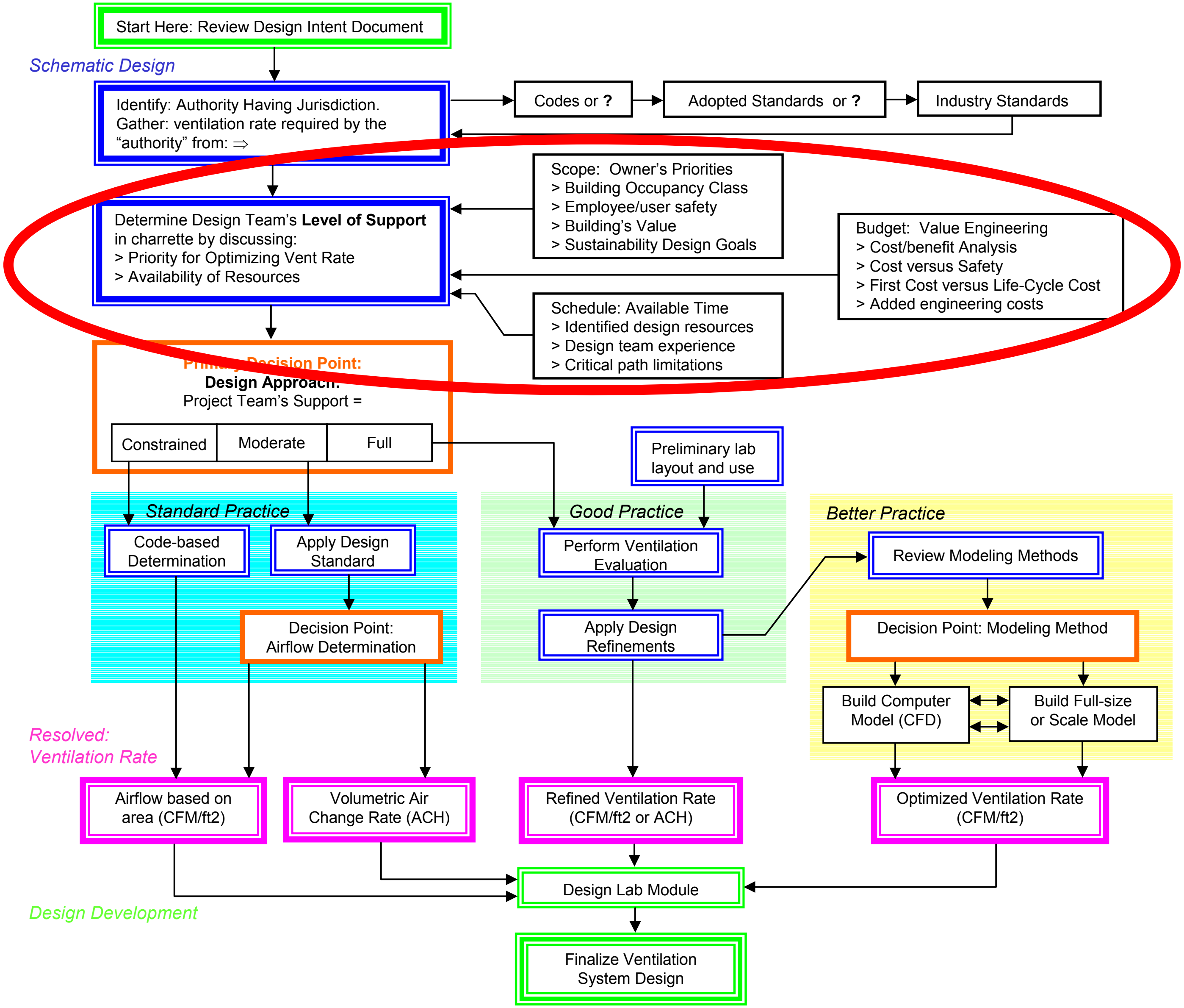
- **Codes**
  - Study municipality’s building code
  - Understand occupancy classification requirements
  - Analyze energy-use impacts
  - Relate findings to project design team

Step 2. Identify Authority having Jurisdiction



- **Standards**
  - ANSI/AIHA Z9.5 – 2003
  - NFPA-45 – 2000
  - ACGIH - Industrial Ventilation – 24th Ed. – 2001
  - ASHRAE Laboratory Design Guide – 2001
  - OSHA - 29 CFR - Part 1910.1450

Process Flowchart



Step 3. Determine Level of Design Support

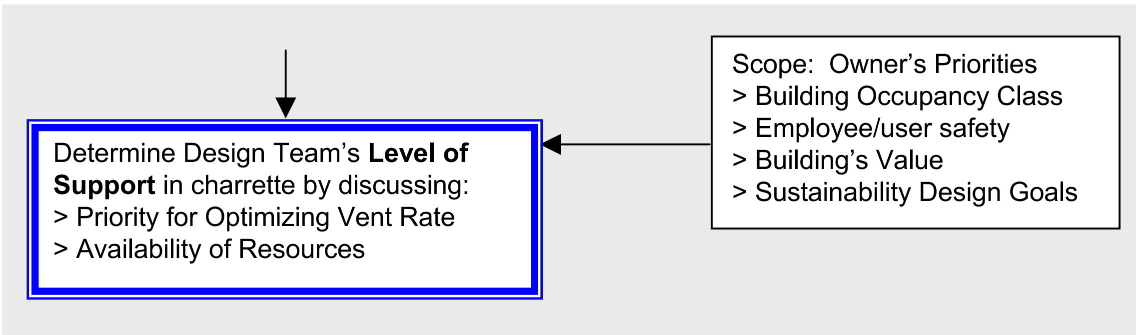
Determine Design Team's **Level of Support** in charrette by discussing:
> Priority for Optimizing Vent Rate
> Availability of Resources

Use a Design Charrette…

All stakeholders help identify Design Goals & Issues…

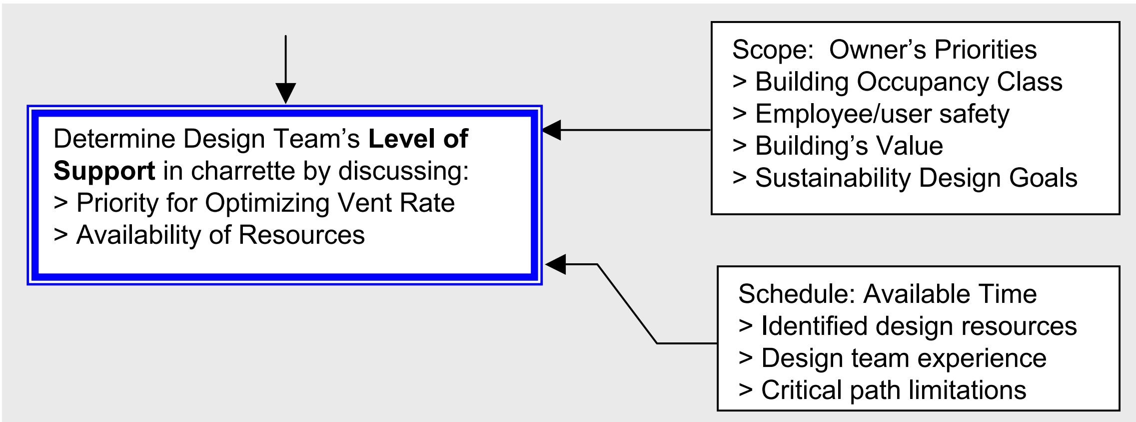
- ✓ Laboratory mission
- ✓ Right-sizing HVAC
- ✓ Hazardous material inventory
- ✓ Spill scenario
- ✓ User interface
- ✓ Building legacy
- ✓ Energy use
- ✓ Sustainability goals

Step 3. Determine Level of Design Support



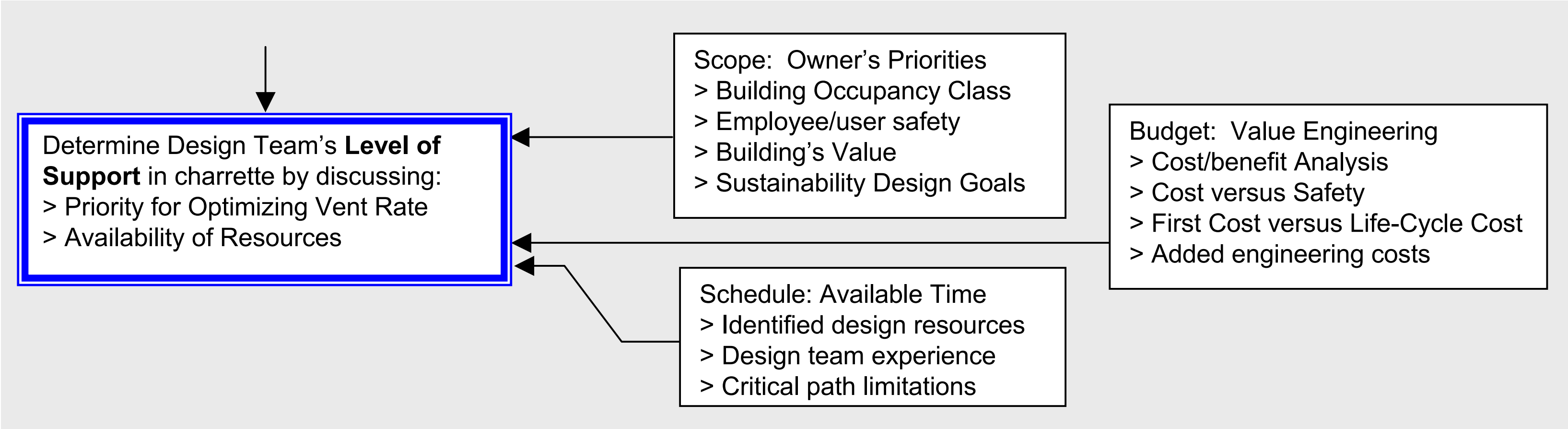
- **Scope: Owner's Priorities**
  - Building occupancy class by UBC or IBC
  - Employee/user safety considerations,
    - e.g., professionals vs. students
  - Building's value; long-term use
  - Sustainability design goals; possible LEED certification

Step 3. Determine Level of Design Support



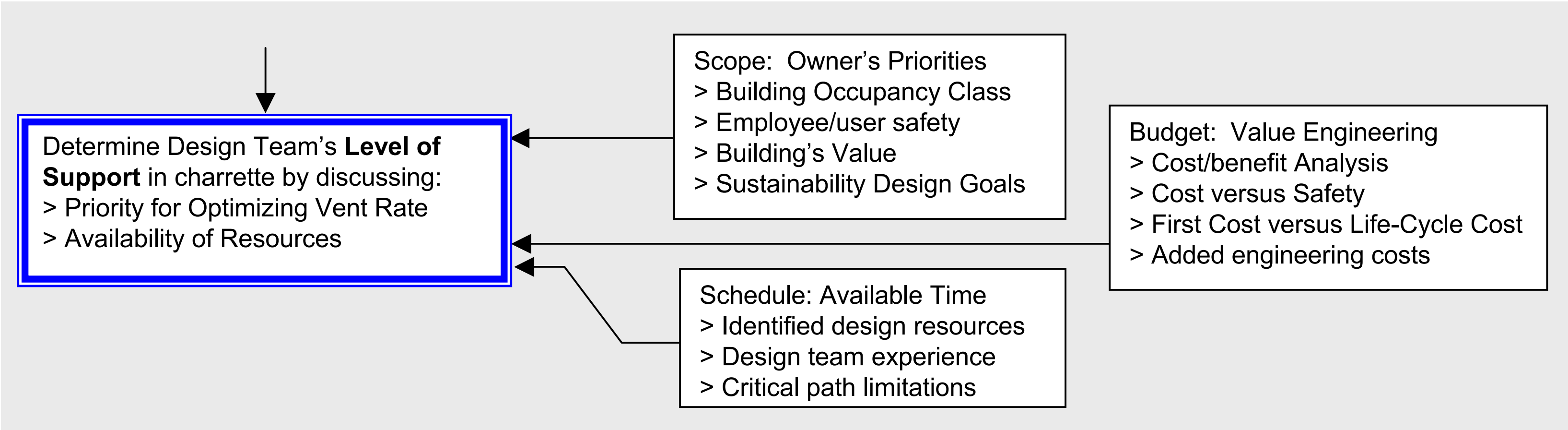
- **Schedule: Available Time**
  - Identify design resources; outside LEED help available?
  - Design team experience; experienced personnel desirable
  - Critical path limitations; avoid specialty, long-lead items

Step 3. Determine Level of Design Support



- **Budget: Value Engineering**
  - Cost/Benefit Analysis; choose best options
  - First cost versus Life-cycle cost
  - Added engineering design fees
  - Cost versus safety; there are always tradeoffs

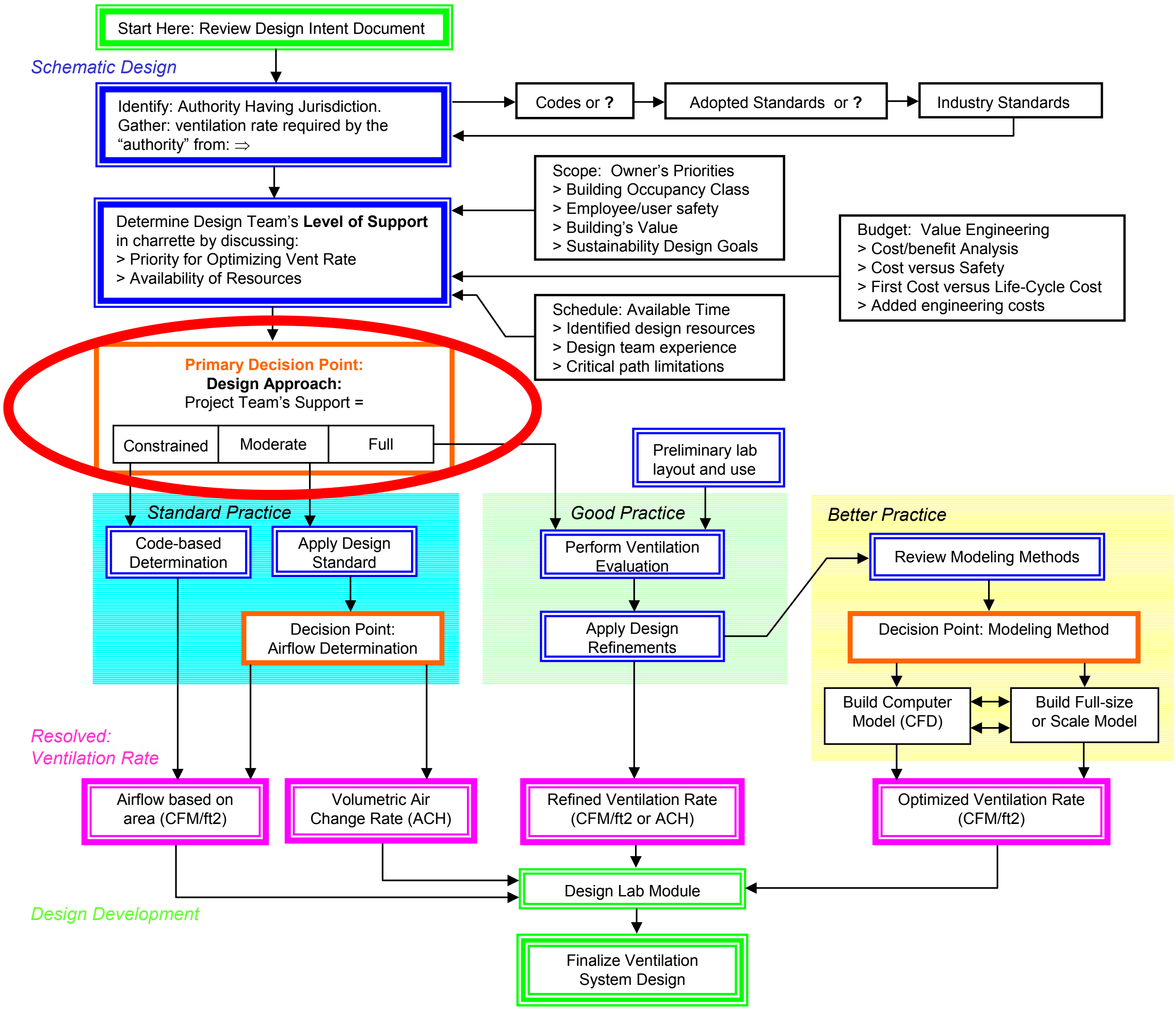
Step 3. Determine Level of Design Support



After considering Scope, Schedule, and Budget Limits …

- **Prepare for Decision Point: Design Approach**
  - Design team must prioritize by importance
    - e.g., low, medium, high…
  - Design team must allot resources
    - e.g., small, medium, large…

Process Flowchart



Step 4. Choose a Design Approach

Primary Decision Point:
Design Approach:
Project Team's Support =

Constrained	Moderate	Full

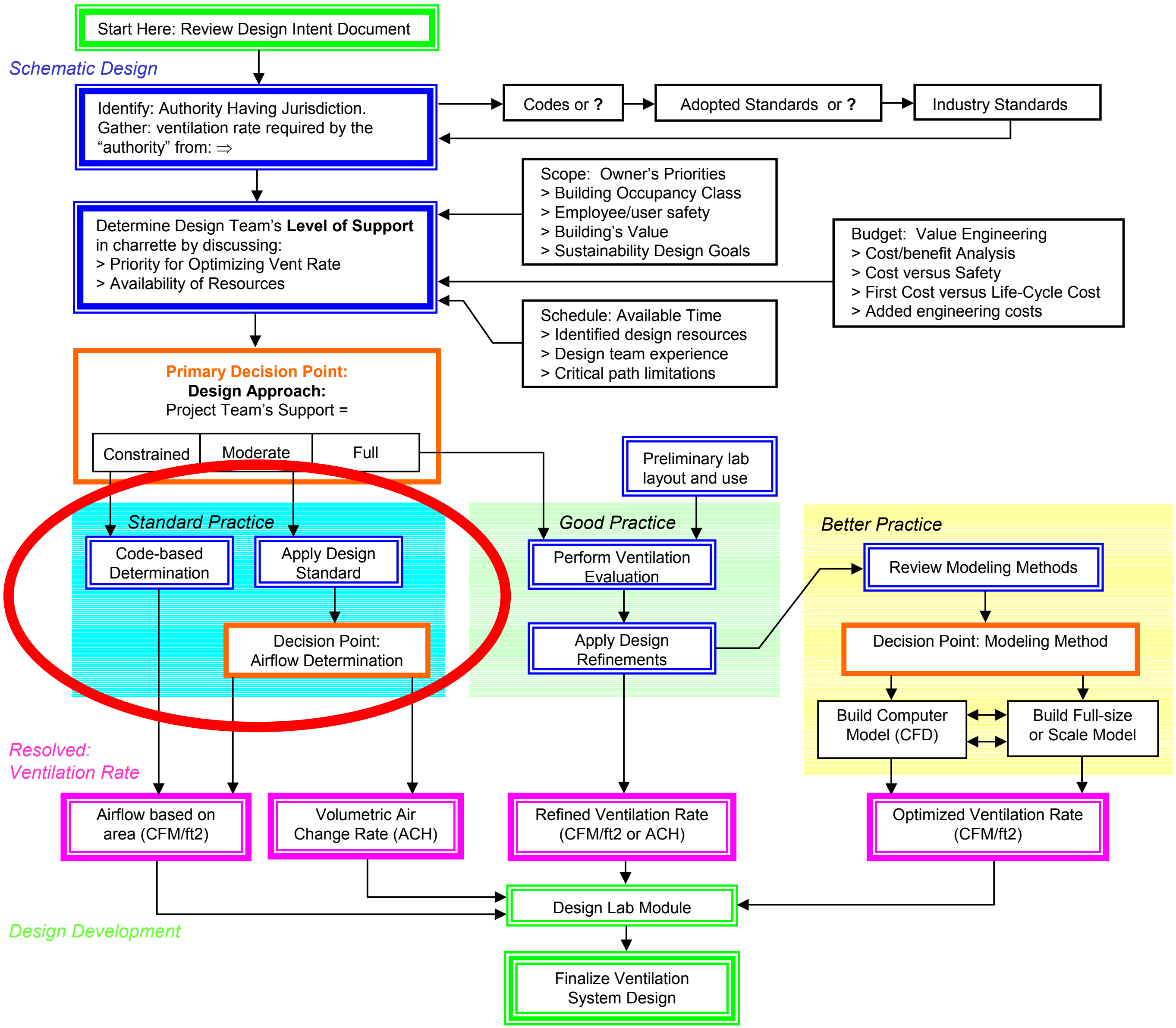
Decision by Project Team

- Constrained Support
- Moderate Support
- Full Support

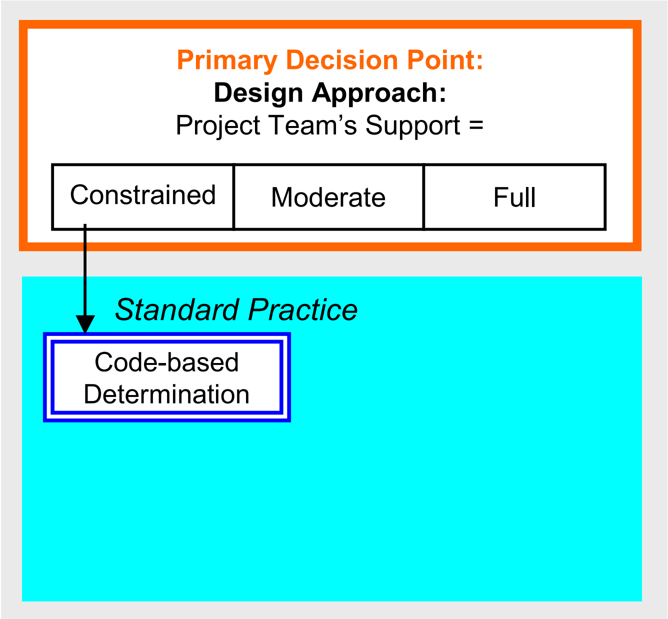
Resulting Design Approach…

- ✓ Use Standard Design Practice
- ✓ Use Standard Design Practice
- ✓ Use Good or Better Design Practice

Process Flowchart



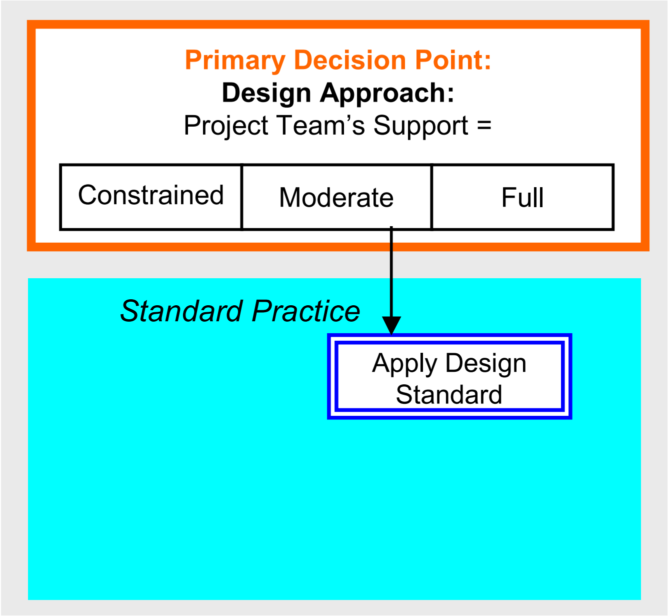
Standard Practice: Code-Based Determination



- **Code-based…**
  - Occupancy classification has code requirements
  - Design approach constrained by "force of law"
- **Determination…**
  - Ventilation rate stipulated by code
  - Resolving rate is straightforward

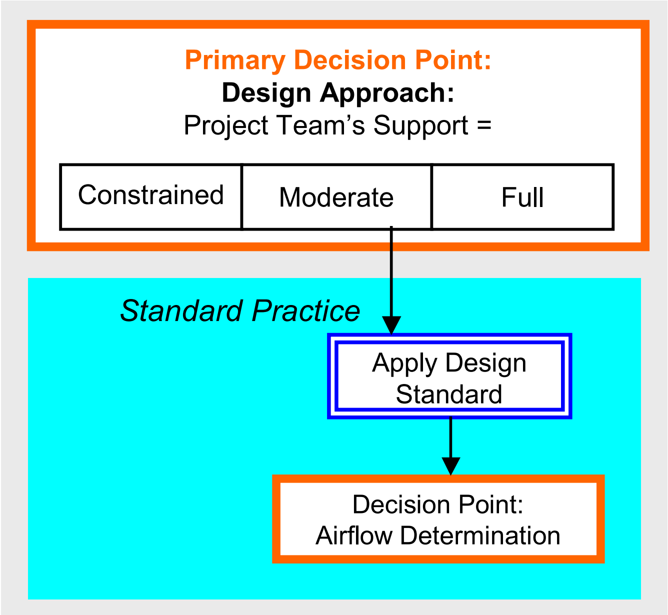
Note: Authority having jurisdiction provides code information

Standard Practice: Apply Design Standard



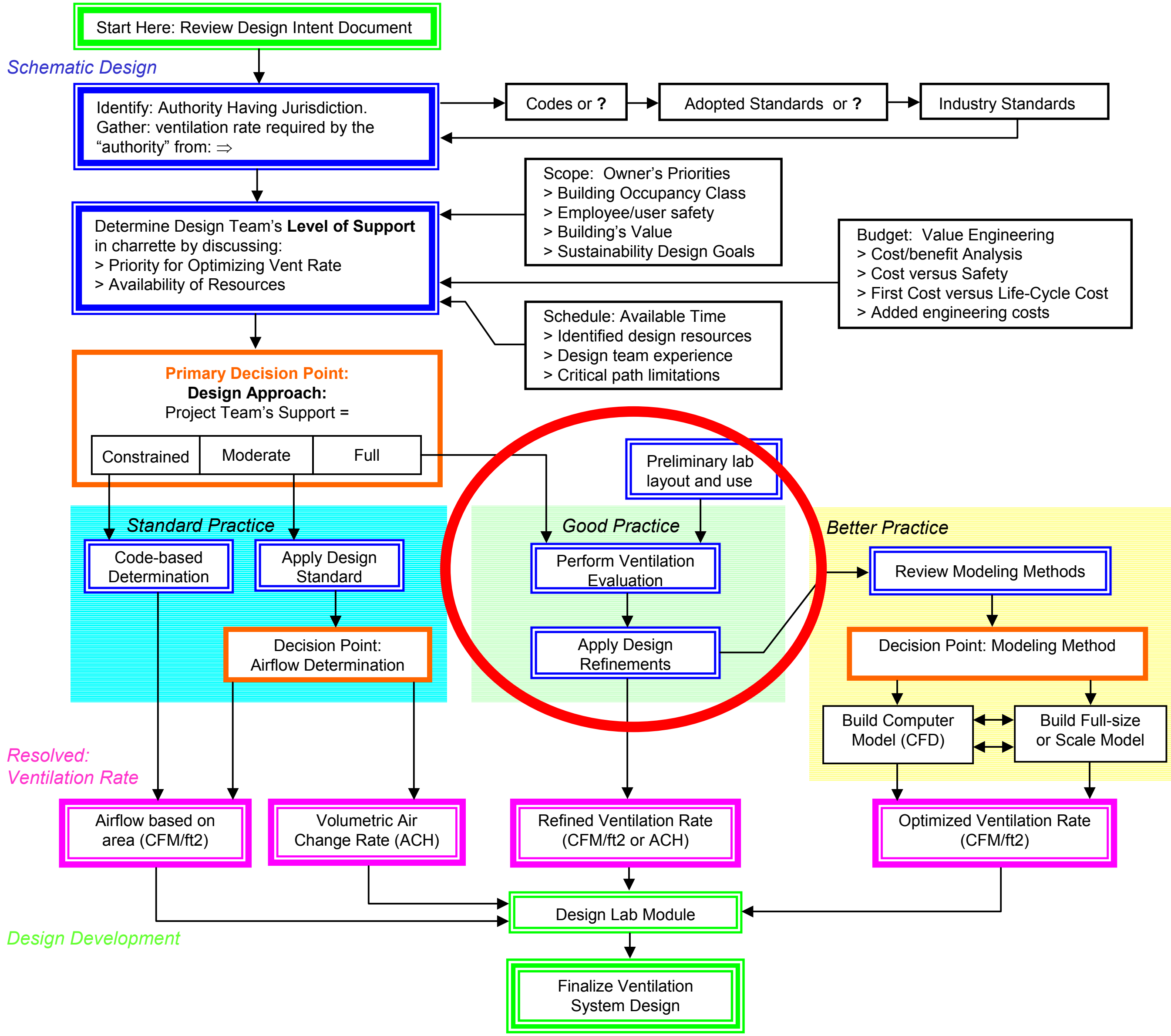
- **Application:**
  - "Typical" project with moderate level of support
  - Limited design resources
- **Relies on prior experience or industry standards**
  - Standard-making organizations e.g., ASHRAE, "prescribes" ventilation rate(s)
- **Wide range of "acceptable" ventilation rates**

Standard Practice: Apply Design Standard

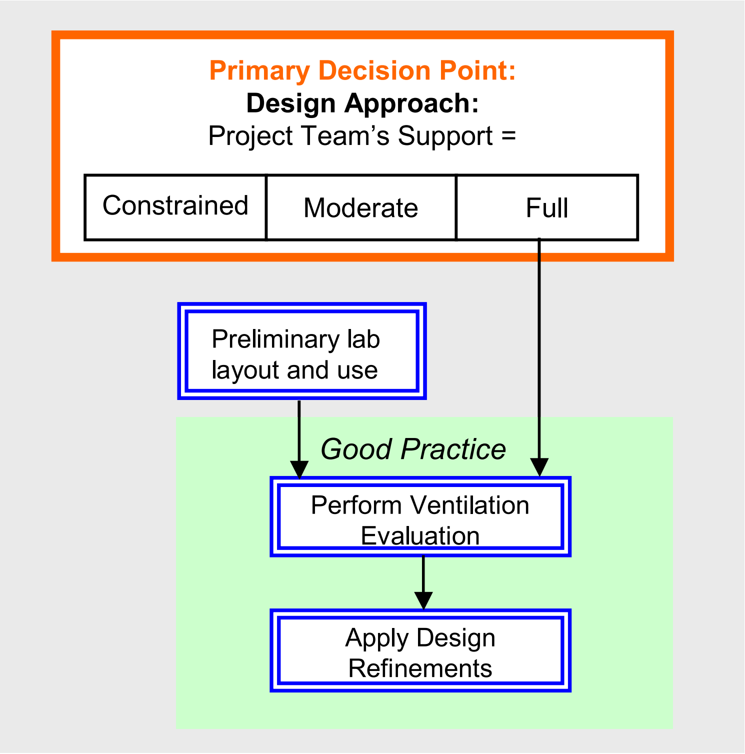


- **Decision Point: Airflow Determination…**
  - Apply available resources to decide within range
  - Ventilation rate based lab area or volume

Process Flowchart

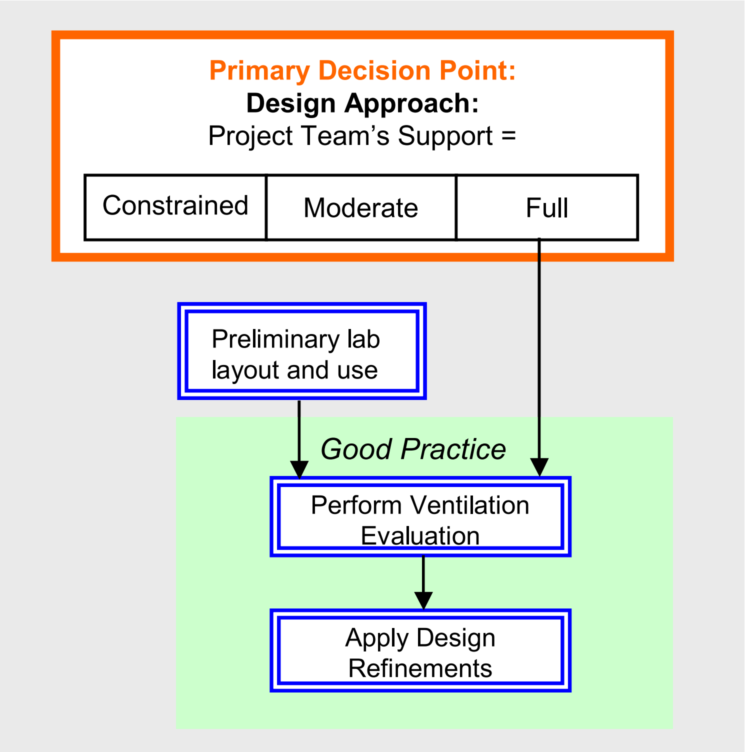


Good Practice:
Perform Ventilation Evaluation – Safety



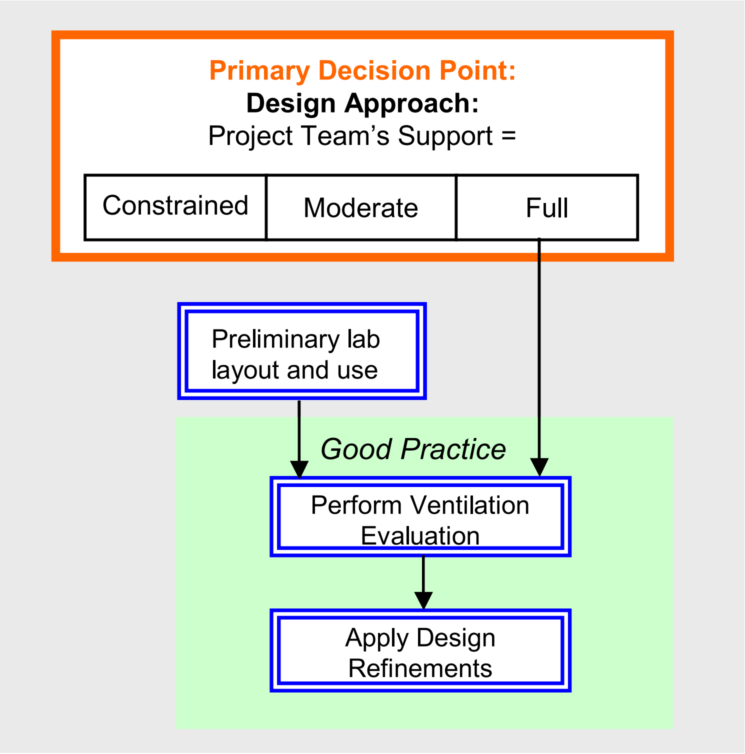
- **Lab layout and use**
  - Lab mission
  - User/operator skills and experience
  - Egress pathways
- **Coping with hazardous pollutants**
  - Pollutant sources
  - Spill scenarios
- **Control banding**
  - Catalog potential pollutants
  - Grouping pollutant hazards
- **Risk assessment matrix**
  - Lab Hazard classification
  - Pollutants versus ??

Good Practice:
Perform Ventilation Evaluation – Environment



- **Meeting cooling load requirements**
  - Lab equipment: type and quantity
  - Layout arrangement
  - Load assessment: profile-of-use
- **Exhaust devices**
  - Hood type and quantity
  - Hood exhaust flow versus general exhaust flow
- **Airflow distribution**
  - Supply Diffuser type and placement
  - Exhaust grill location and quantity
- **Energy-use assessment**
  - Apply Diversity Factor
  - Minimize differential pressure airflow between spaces

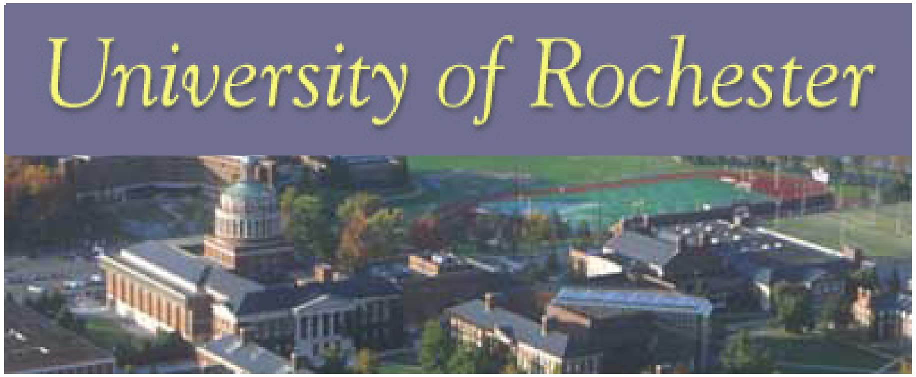
Good Practice: Apply Design Refinements



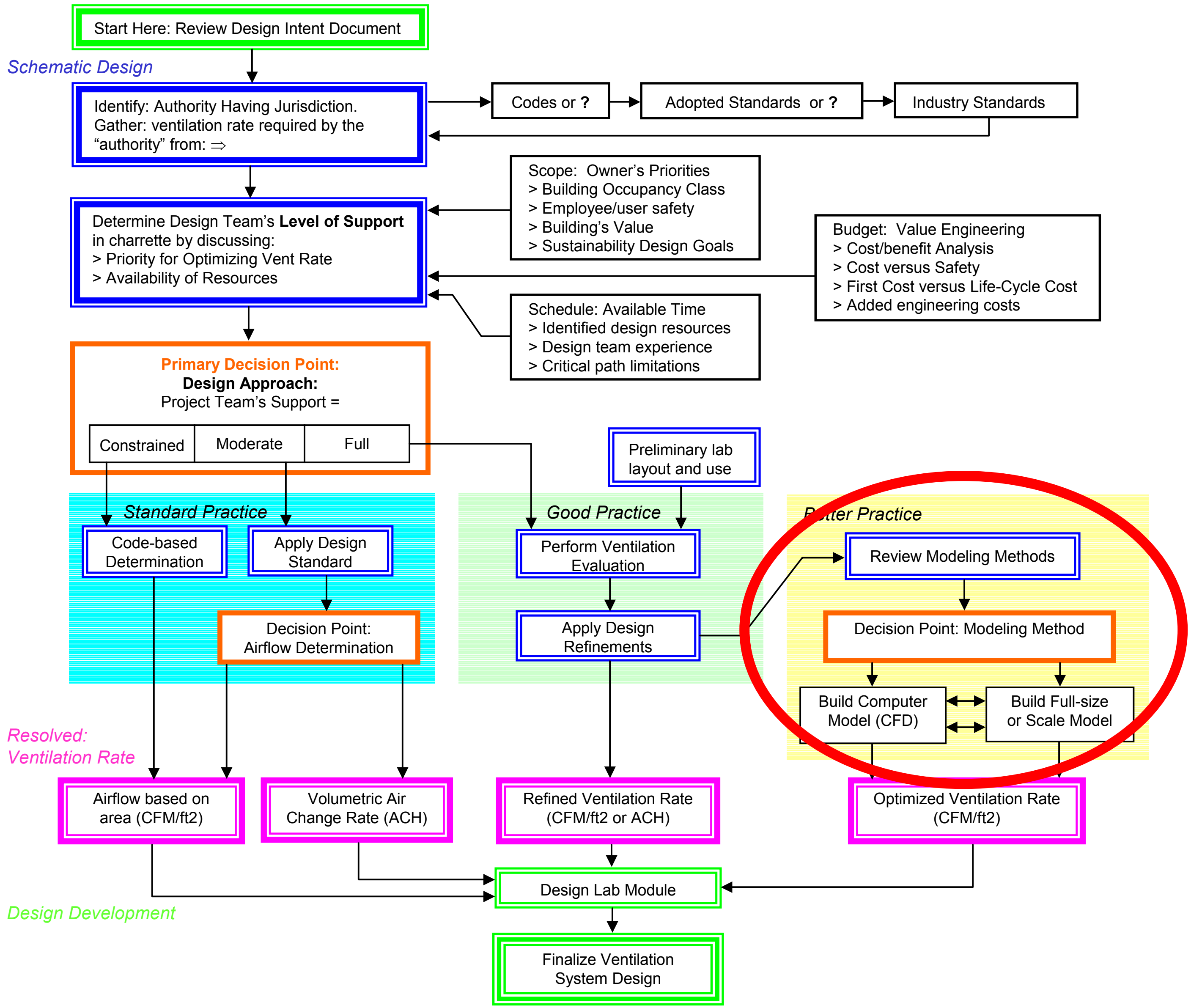
- **Occupied vs. unoccupied vent rates**
  - Setback control strategies
  - Reduce nighttime and weekend airflow
- **Emergency overrides**
  - Emergency push-button increases local airflow, sounds alarm
  - Send notification to Environmental, Health & Safety staff
  - Size HVAC for a lab's emergency airflow increase
- **Control banding: classify chemicals and hazards**
  - Source control: just-in-time chemical delivery
  - Ventilation dilution control
  - Removal control
- **Special case requirements**
  - Animal cage ventilation
  - Cleanroom requirements

Good Practice: Apply Design Refinements

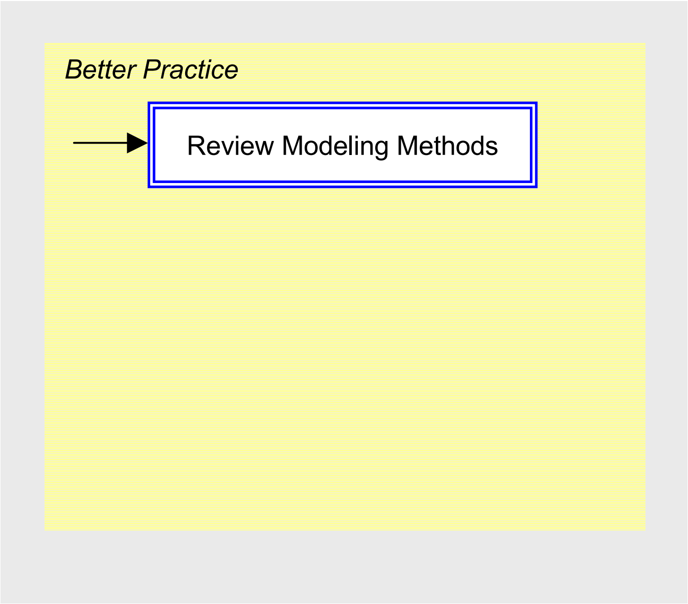
- **Control banding: classify lab hazard**
  - Original standard of 10 ACH reviewed
  - New standard defines Hazard Level A, B & C
- **Occupied versus unoccupied vent rates**
  - Setback control strategy by lab's hazard classification
  - Unoccupied air change rate reduced by 2 ACH
- **Results…**
  - Lab "A" – 8/6 ACH
  - Lab "B" – 6/4 ACH
  - Lab "C" – 4/2 ACH



Process Flowchart



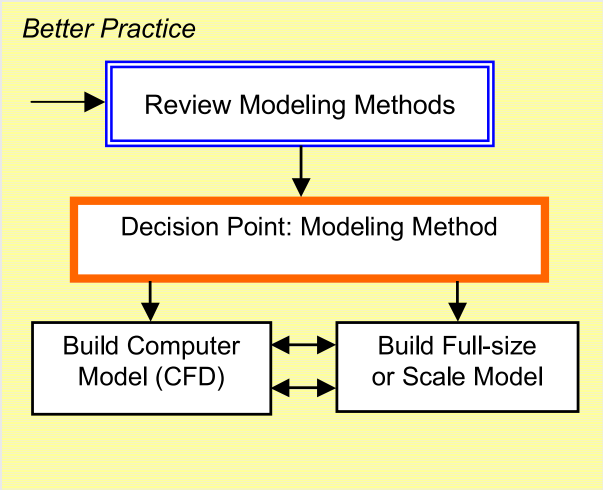
Better Practice – Performance Evaluation



Review Modeling Methods…

- **Computational Fluid Dynamics (CFD)**
  - Includes major design-elements: hoods, benches, registers
  - Numerous "what-if" scenarios can be studied
  - Use experienced modeling company
- **Tracer Gas Evaluations**
  - Requires full-scale model, or existing lab
  - Tracer gas rate-of-decay provides actual air change rate
- **Neutrally-buoyant helium bubble evaluations**
  - Requires full-scale model, or existing lab
  - Airflow patterns can be studied and adjusted
  - Diffuser placement can be optimized

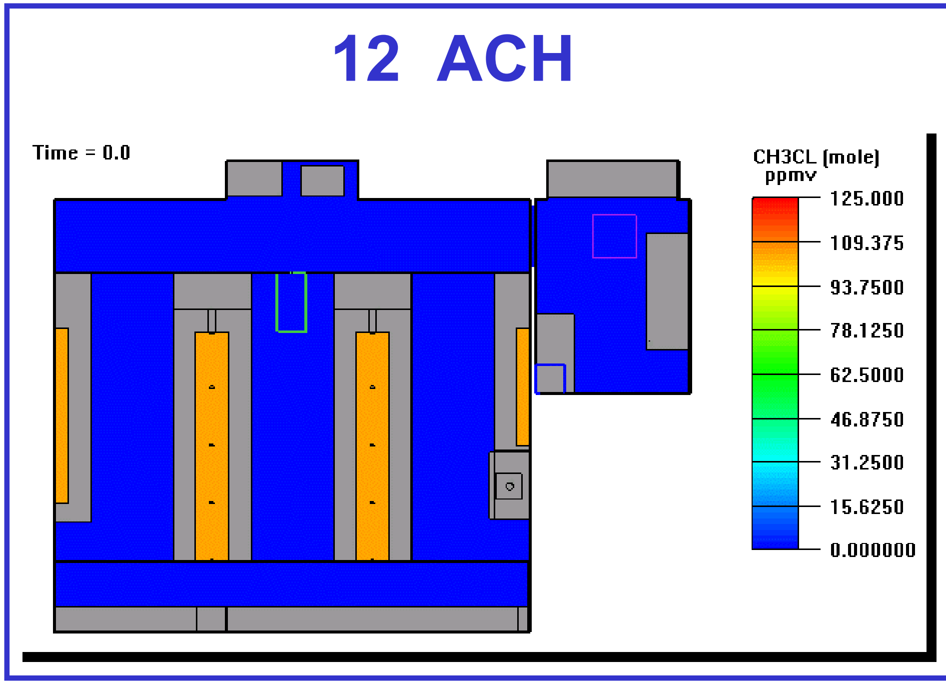
Better Practice – Performance Evaluation

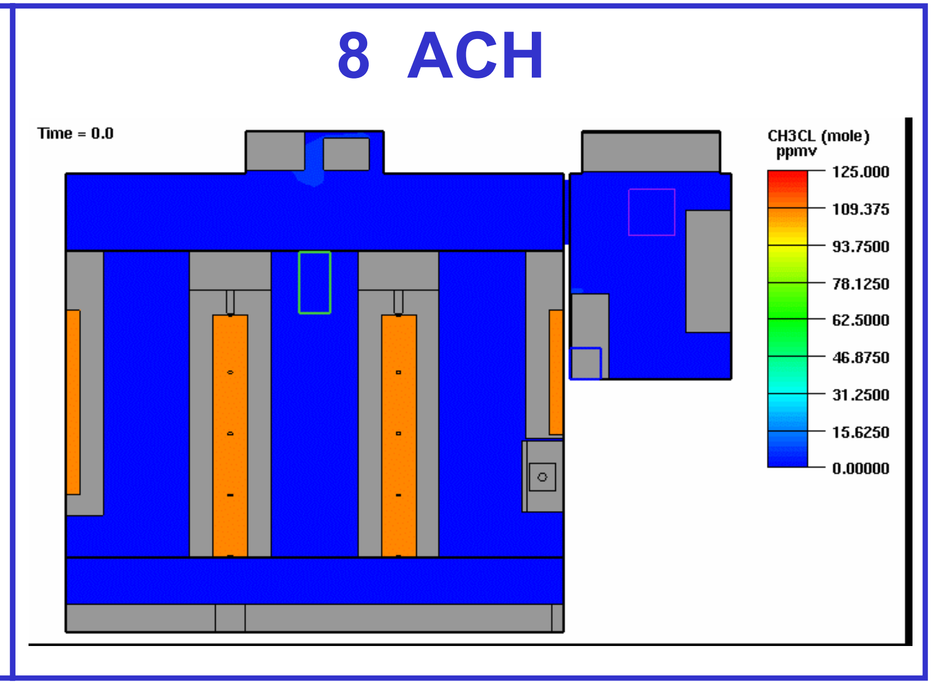


Decision Point: Modeling Method

- **Choose CFD or Full-size model or both!**
- **Ventilation modeling will optimize rate…**

Better Practice – Performance Example



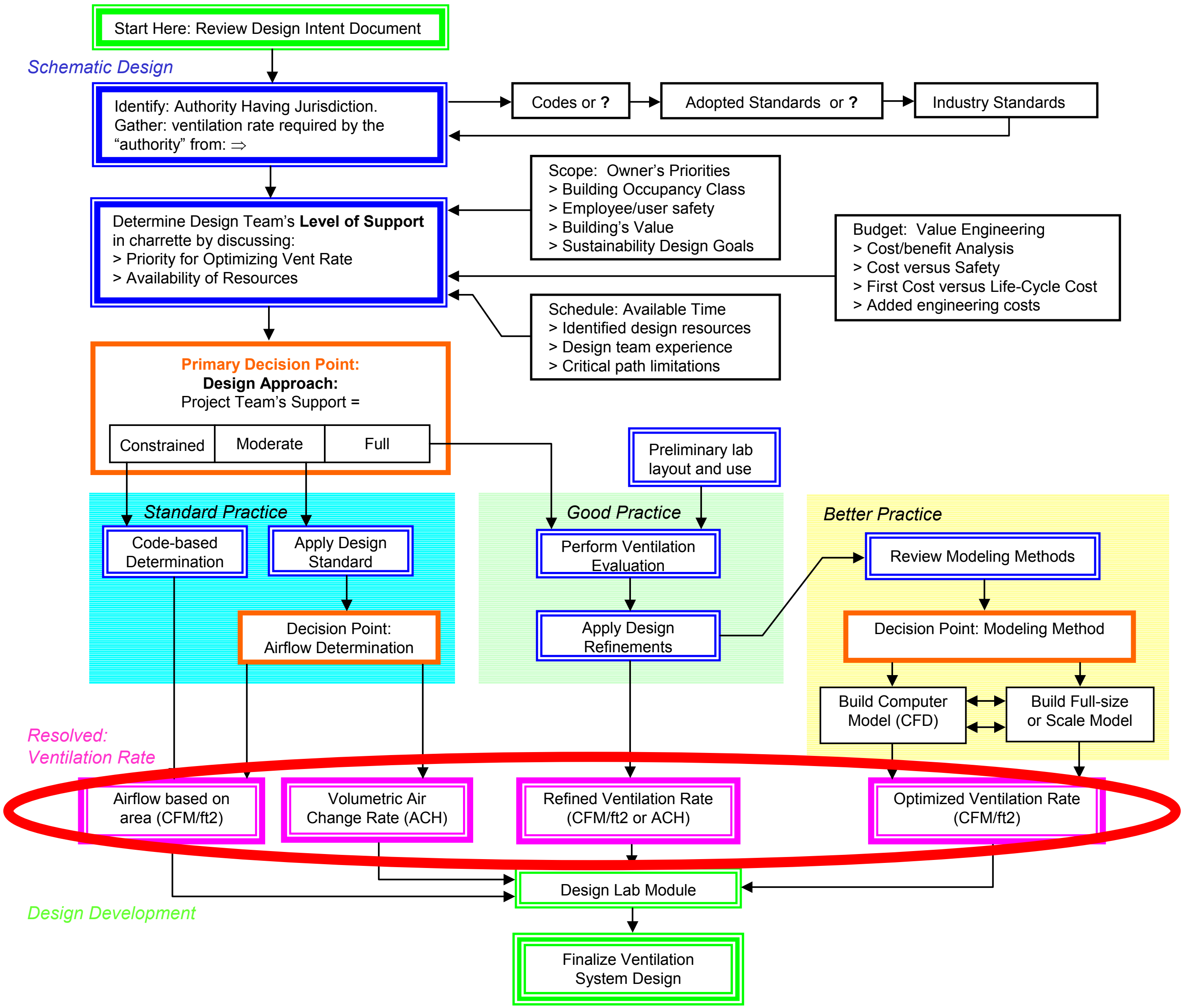


CFD Modeling courtesy Fluent

CFD modeling of pharmaceutical lab

- 1-liter liquid methyl chloride spill in isolation room
- 9 sq.ft. spill area
- Vaporization occurs over 600 seconds at constant rate

Process Flowchart

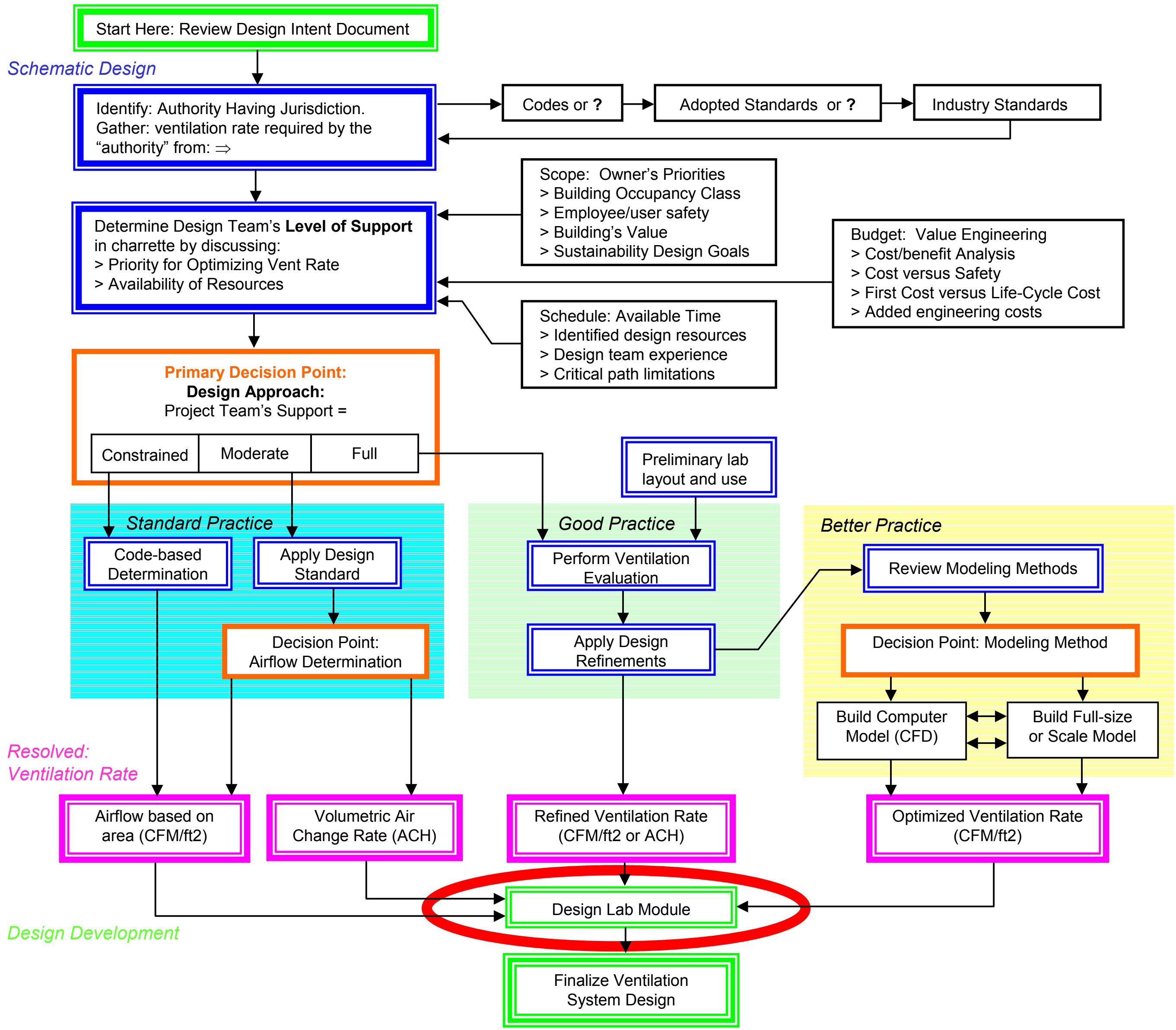


Step 5. Resolve Ventilation Rate

Airflow based on area (CFM/ft2)	Volumetric Air Change Rate (ACH)	Refined Ventilation Rate (CFM/ft2 or ACH)	Optimized Ventilation Rate (CFM/ft2)

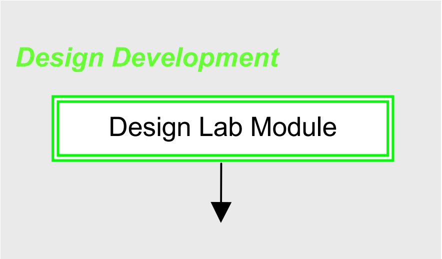
- **Volumetric air change rate**
  - Uses Standard Practice
- **Airflow based on area**
  - Uses Standard Practice and hazardous occupancy classification
- **Refined ventilation rate**
  - Uses Good Practice
- **Optimized ventilation rate**
  - Uses Better Practice

Process Flowchart



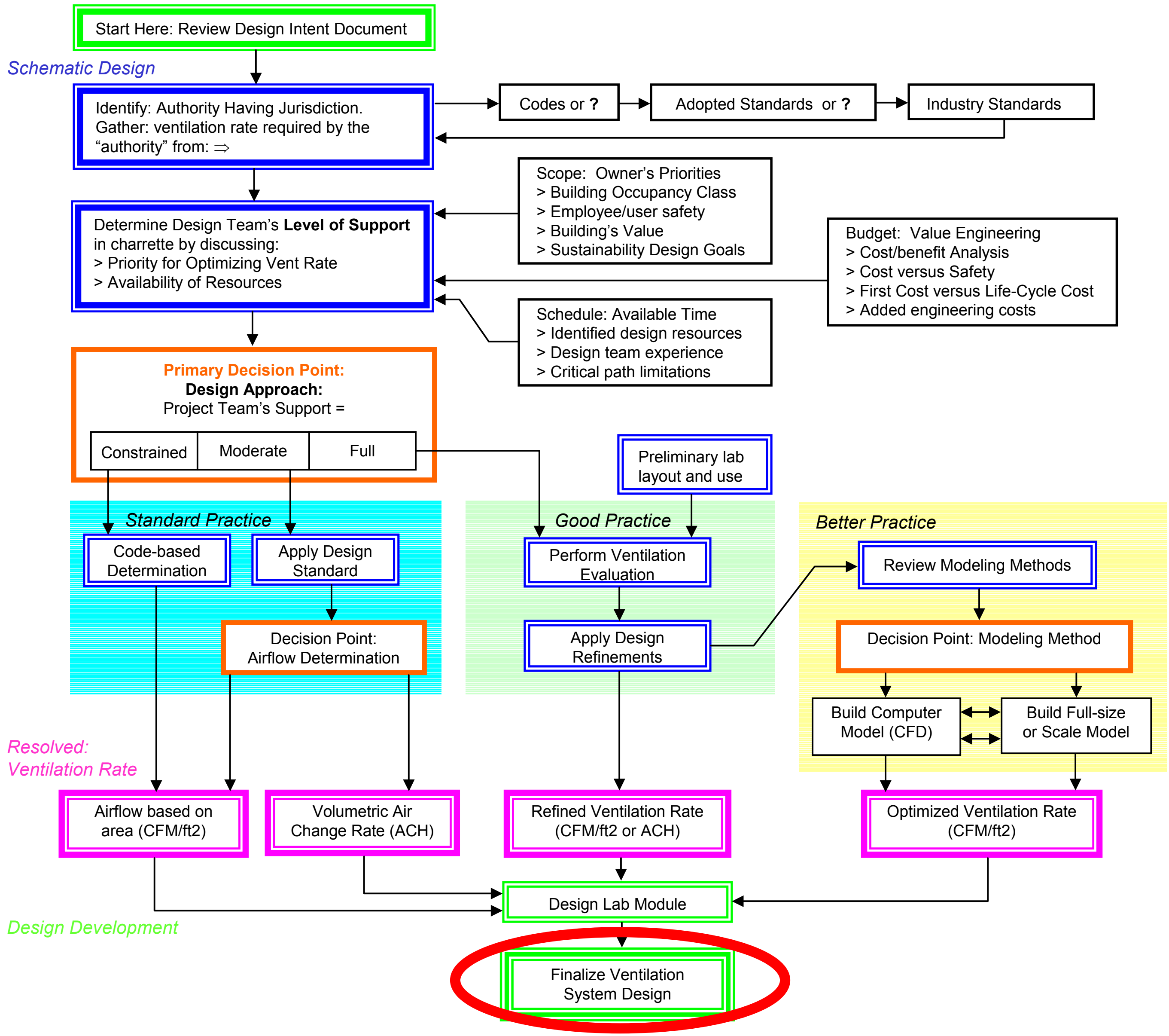
Step 6. Develop Laboratory Module

Developing lab module is an iterative process…

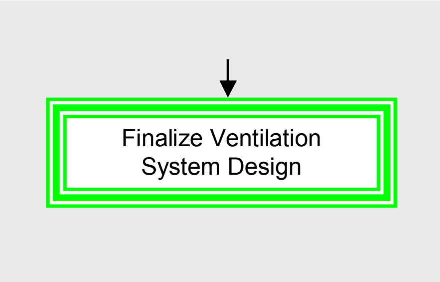


- **Arrange elementary module per available requirements**
- **Determine suitability of HVAC design for lab mission**
- **Consider utility access for energy efficiency**
- **Confirm design team approval**
- **Verify impact of approved module-layout on airflow design**

Process Flowchart



Step 7. Finalize Ventilation Design



Right-size HVAC system and distribution…

- **Apply Right-sizing techniques**
- **Review central plant options**
- **Ensure efficient distribution of supply and exhaust**
- **Carefully arrange and specify diffusers**
- **Evaluate effluent dispersion**

Conclusion

- **Design Mission a Success…?**
  - Increased lab safety and efficiency
  - Advanced ventilation rate analysis methods
  - Minimized energy waste
  - Provided optimum research environment within budget

Performance bottom line…

- **Optimized lab ventilation rate**
  - For mission hazards
  - With priority for worker safety
  - Thus reducing HVAC system first cost and life-cycle cost

Conclusion

- **Primary Issues**
  - Safety - Crucial reason for lab ventilation; Removal of hazard
  - Temperature and humidity control – heat gain from equipment, computers, people
  - Productivity of facility – support mission
  - Cost to design; to Build; to Operate
- **Design Approach**
  - Code-constrained design
  - Standard practice
  - Good practice
  - Better practice

For More Information

Main Labs21 web site:

http://www.labs21century.gov

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