



U.S. Department of Energy
Energy Efficiency and Renewable Energy

TOTAL QUALITY COMMISSIONING for SUSTAINABLE, HIGH PERFORMANCE HVAC SYSTEMS

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&
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STATE OF THE ART

- USGBC & LEED™ ARE LUCKY TO BE 30% BETTER IN ENERGY EFFICIENCY THAN STANDARD (CODE) DESIGNS.
- THE BEST ARCHITECTS ARE LUCKY TO GET WITHIN 30% OF THEIR PREDICTIONS. (20% BETTER THAN LEED™) AND THEN THE SYSTEMS FALL APART AFTER TEN TO TWENTY YEARS.
- WHAT'S NEEDED - LONG-TERM INCREASE IN PERFORMANCE. 75% PERFORMANCE INCREASE IN ENERGY, MAINTENANCE AND COMFORT.



MEASURE TWICE, CUT ONCE

- THIS METHOD PROBABLY ORIGINATED WITH THE PYRAMIDS, OR BEFORE
- MODERN DESIGNS AND CONSTRUCTION DO NOT HAVE THE SECOND MEASUREMENT



EGO

- THE BIGGEST BARRIER TO SUSTAINABLE, HIGH PERFORMANCE BUILDINGS IS THE EGO OF THE ARCHITECTS AND ENGINEERS



DEFINING SUSTAINABLE, HIGH PERFORMANCE

DICTIONARY DEFINITION OF SUSTAINABLE:

- ABLE TO BE MAINTAINED.
- EXPLOITING NATURAL RESOURCES WITHOUT DESTROYING THE ECOLOGICAL BALANCE OF A PARTICULAR AREA.

- DICTIONARY DEFINITION OF HIGH PERFORMANCE:

- 1. A SYSTEM THAT HAS THE ABILITY TO PROVIDE SUPERIOR FUNCTIONS AND /OR OPERATIONS.



WHAT IS TOTAL QUALITY COMMISSIONING?

- TOTAL QUALITY INITIATIVES REQUIRE TOTAL QUALITY ASSURANCE PROGRAMS - TQC.
- STARTING AT THE BEGINNING OF A PROJECT, WORKING THROUGH ALL THE DESIGN PHASES.
- SIGNIFICANT CONTRIBUTION TO DESIGN. LONGEVITY AND MAINTAINABILITY 1ST FOCUS.
- WORKING THROUGH THE CONSTRUCTION AND AT LEAST THE FIRST YEAR OPERATING.



TQC INITIATIVES

- PERFORMANCE QUALITY CONTROL.
- DETAILED DESIGN INTENT -DEVELOPED FROM 3 QUESTIONS.
- DESIGN FOR LONG-TERM MAINTENANCE AND OPERATIONS.
- DESIGN FOR COMFORT AND PRODUCTIVITY.
- DESIGN FOR LONG-TERM ENERGY EFFICIENCY.



RESULTS FROM USING TOTAL QUALITY COMMISSIONING

- SYSTEMS LAST TWO OR THREE TIMES LONGER.
- SYSTEMS REQUIRE 20% TO 80% LESS MAINTENANCE.
- SYSTEMS WORK 20% TO 80% MORE EFFICIENT AND EFFECTIVE.



WHERE TO FIND THE GREATEST OPPORTUNITIES FOR SAVINGS

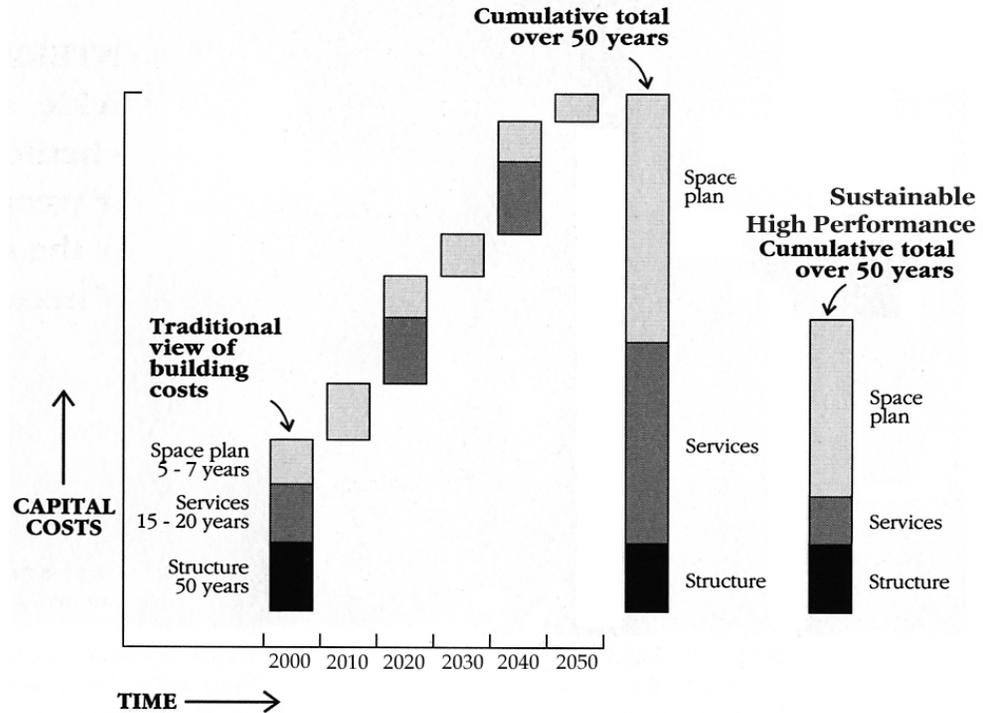
**“THE GREATEST OPPORTUNITIES FOR SAVING COSTS
OVER THE LIFE OF A BUILDING OCCUR AT THE
BEGINNING OF THE DESIGN PHASE”**

- AIA ENERGY DESIGN BOOK



50 YEAR OPERATING COSTS

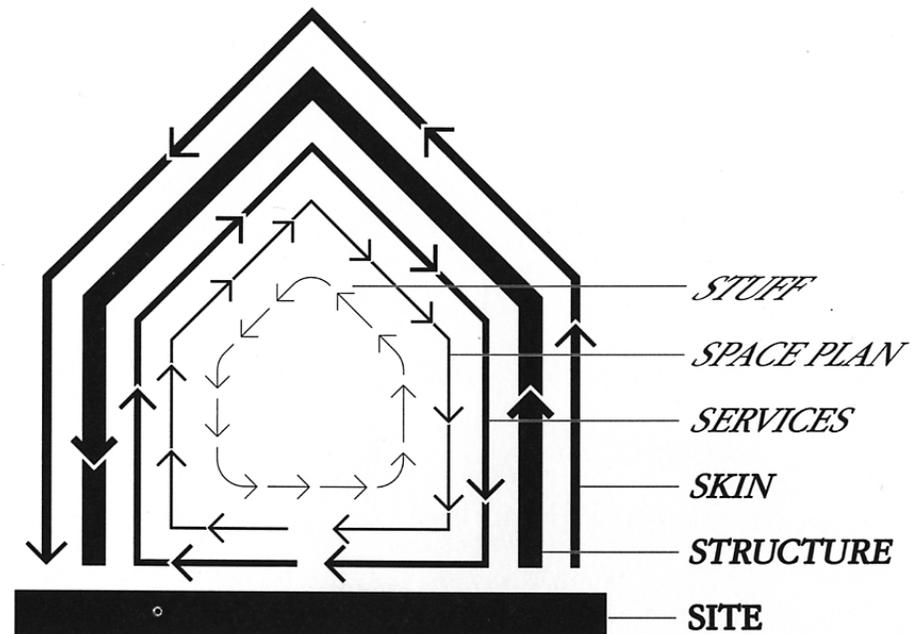
STUART BRANDS
BOOK; “HOW
BUILDINGS
LEARN SHOWED
THIS CHART FOR
A STANDARD
BUILDING. WE
ADDED WHAT
THE
SUSTAINABLE
RESULTS ARE.





SHEARING LAYERS OF A BUILDING

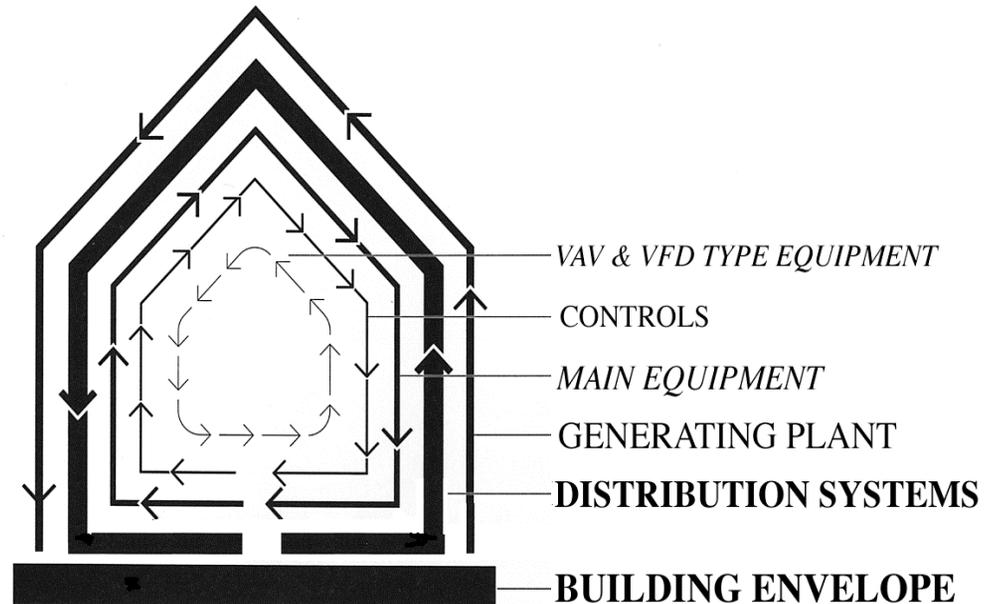
STUART BRANDS
BOOK: "HOW
BUILDINGS LEARN"
SHOWS THE
LONGEVITY OF
PRINCIPAL
BUILDING
COMPONENTS
AND SYSTEMS.





SHEARING LAYERS OF HVAC SYSTEMS

WE CAN ISOLATE THE SHEARING LAYERS OF HVAC COMPONENTS. THIS IS THE FIRST STEP TO UNDERSTANDING HOW WE CAN INCREASE THE LONGEVITY OF THE SYSTEMS.



SHEARING LAYERS OF HVAC SYSTEMS CHANGE



DETERMINE WHAT THE BUILDING OWNER REALLY WANTS AND NEEDS

- WE ASK THREE QUESTIONS THAT ARE NEVER ASKED OR DOCUMENTED ON A PROJECT.
- THE QUESTIONS ARE DESIGNED TO INTERROGATE THE CLIENT TO DETERMINE THE DETAILED, LONG-TERM PURPOSE OF THE BUILDING PROJECT WITHIN THE FACILITY.



THE BIG 3 QUESTIONS

- HOW LONG DO YOU WANT THE HVAC SYSTEM TO WORK FOR AND AT WHAT LEVEL OF EFFICIENCY AND EFFECTIVENESS?
- WHAT LEVEL OF MAINTENANCE DO YOU HAVE AND ANTICIPATE HAVING FOR THE LIFE OF THESE SYSTEMS?
- DO YOU HAVE A FACILITY MASTER PLAN OR ENERGY MASTER PLAN FOR YOUR FACILITY.



THE ANSWERS WE SEEK

- THE QUESTIONS DETERMINE, IN DEPTH AND IN DETAIL, THE HVAC SYSTEM CHARACTERISTICS REQUIRED BY THE CLIENT.
- FLAME³: OUR ACRONYM FOR:
FLEXIBILITY, LONGEVITY, ADAPTABILITY,
MAINTAINABILITY, EXPANDABILITY, EFFICIENCY AND EFFECTIVENESS.
- DESIGNS OFTEN CITE EFFICIENCY & EFFECTIVENESS AS ASHRAE 90, 55, 62, ETC.



HOW AN OWNER ANSWERS

- HVAC SYSTEMS THAT LAST FOR 35 TO 50 YEARS.
- SYSTEMS THAT ARE 40% MORE EFFICIENT AND EFFECTIVE FOR THE WHOLE LIFE CYCLE AND THAT REQUIRE 40% LESS MAINTENANCE.
- NO ENERGY MASTER PLAN BUT WE WANT TO BE A LEADER IN ENERGY EFFICIENCY.
- NO EXTRA CONSTRUCTION COST.



WHAT WILL PLEASE AN OWNER

- A HVAC SYSTEM THAT LASTS FOR OVER 30 YEARS, 25% MORE EFFICIENT AND EFFECTIVE THAN PREVIOUS SYSTEMS - FOR LIFE CYCLE.
- A SYSTEM THAT REQUIRES THE SAME LEVEL OF MAINTENANCE AS THE YEARS GO BY - 25% LESS THAN CURRENT SYSTEMS.
- NO EXTRA CONSTRUCTION COST.



HOW TO SNEAK IN SUSTAINABLE, HIGH PERFORMANCE DESIGNS (WITHOUT ANYONE NOTICING)

- **ADD NO (NOTICABLE) COST TO THE PROJECT.**
- **REDUCE DESIGN AND CONSTRUCTION COSTS .**
- **USE REDUCTIONS FOR SUSTAINABLE FEATURES.**



TOTAL QUALITY COMMISSIONING

USE PROJECT COLLABORATION AND DOCUMENT MANAGEMENT INTERNET BASED SOFTWARE SYSTEM TO REDUCE PROJECT COST BY 10% TO 15%.

USE FLAME³, BUILDING PERFORMANCE SIMULATION AND HVAC EXPERTISE TO REDUCE HVAC SYSTEM SIZE BY 40%, REDUCE ENERGY USE BY 80%, REDUCE MAINTENANCE BY 60%, DOUBLE OR TRIPLE LONGEVITY OF SYSTEMS AND OPTIMIZE COMFORT AND PRODUCTIVITY, THE ADDITIONAL COSTS OF THE SUSTAINABLE BUILDING AND HVAC SYSTEM COMING FROM THE PC & DM SAVINGS ABOVE.



QED!

- ANY QUESTIONS?



TOTAL QUALITY COMMISSIONING --DESIGN PROJECT PROCESS--

- PROJECT DESIGN PROCESSES ARE PRODUCTION BASED.
- TQC IS A TOTALLY PERFORMANCE BASED PROCESS.
- TQC ALSO EXPEDITES A PROJECT BY PROVIDING TENABLE MAJOR DECISIONS QUICKLY.



PROJECT COST SAVING OPPORTUNITIES

- ONLY 8% OF CURRENT PROJECTS USE WEB-ENABLED PC & DM'S.
- PROJECT COLLABORATION AND DOCUMENT MANAGEMENT SOFTWARE HAS BEEN SHOWN TO SAVE BETWEEN 10% AND 15% OF THE TOTAL PROJECT COST - MONSTER SAVINGS!
- CURRENTLY, THE SOFTWARE CO'S ARE STATING SAVINGS IN EXTRAS, SOMETIMES DURING A PROJECT, ETC., BUT THE SYSTEMS ARE REALLY SAVING OODLES OF MONEY ON PROJECTS WHERE THEY ARE BEING USED PROPERLY.
- WHO SHOULD GET THE SAVINGS? THE CLIENT? EXTRA PROFITS FOR THE BUILDER? OR A BETTER BUILDING FOR THE SAME PRICE?



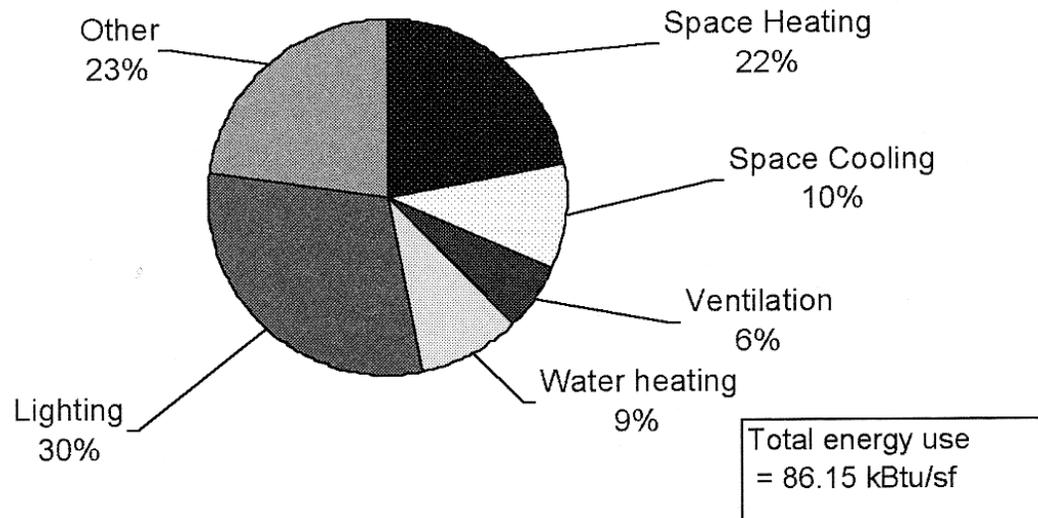
TOTAL QUALITY COMMISSIONING --FOLLOW THE MONEY--

HIGH PERFORMANCE SYSTEMS INCREASE PRODUCTIVITY BY 5%, WORTH \$12.50/FT²/YR IN AN OFFICE BLOCK.

A 75% SAVING IN ENERGY, OPERATION & MAINTENANCE IS WORTH A TOTAL OF \$6.00/FT²/YR.

MOST DESIGNS AND CLIENTS STILL USE PRODUCTIVITY AS AN ARBITRARY PRODUCT.

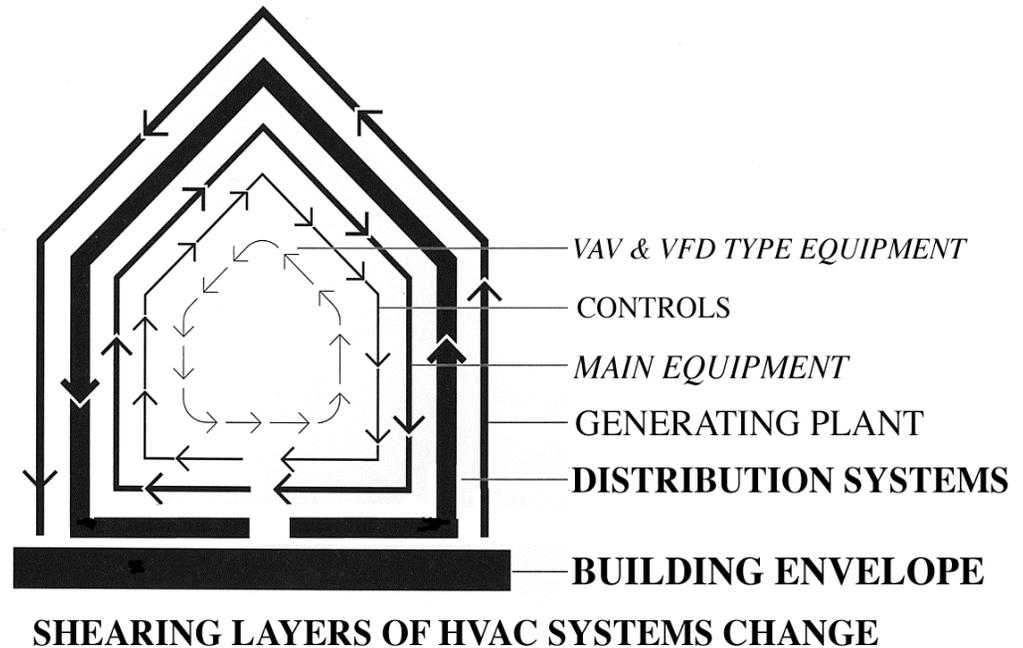
6000 Office Buildings in Climate Zone 3, North Eastern US eg. Philadelphia





TOTAL QUALITY COMMISSIONING --MAINTENANCE AND LONGEVITY--

- SHEARING LAYERS OF HVAC SYSTEMS IDENTIFY DISTRIBUTION SYSTEM AS A CRITICAL COMPONENT.
- MOST HVAC SYSTEMS ARE ARBITRARILY ALL-AIR DISTRIBUTION SYSTEMS.





TOTAL QUALITY COMMISSIONING --ENERGY USE--

WATER IS 10 TIMES MORE EFFICIENT AT MOVING THERMAL ENERGY. USING PIPES FOR DISTRIBUTION MAKES MORE SENSE.

3/4" PIPE = 8" DUCT

1 1/2" PIPE = 24" DUCT

RE-NAMING HVAC SYSTEMS BUILDING ENVIRONMENTAL CONTROL SYSTEMS WOULD HELP CHANGE MIND SETS.

2 1/2" PIPE = 40" DUCT



NO CHANGE IN COST WITH CHANGE IN EFFECTIVENESS

- **ZERO INCREASE IN DESIGN AND CONSTRUCTION COSTS CAN BE ACHIEVED**
- **INCREASED EFFECTIVENESS IN DESIGN AND CONSTRUCTION IN KEY**
- **ALL METHODS AND EQUIPMENT ARE AVAILABLE TODAY**

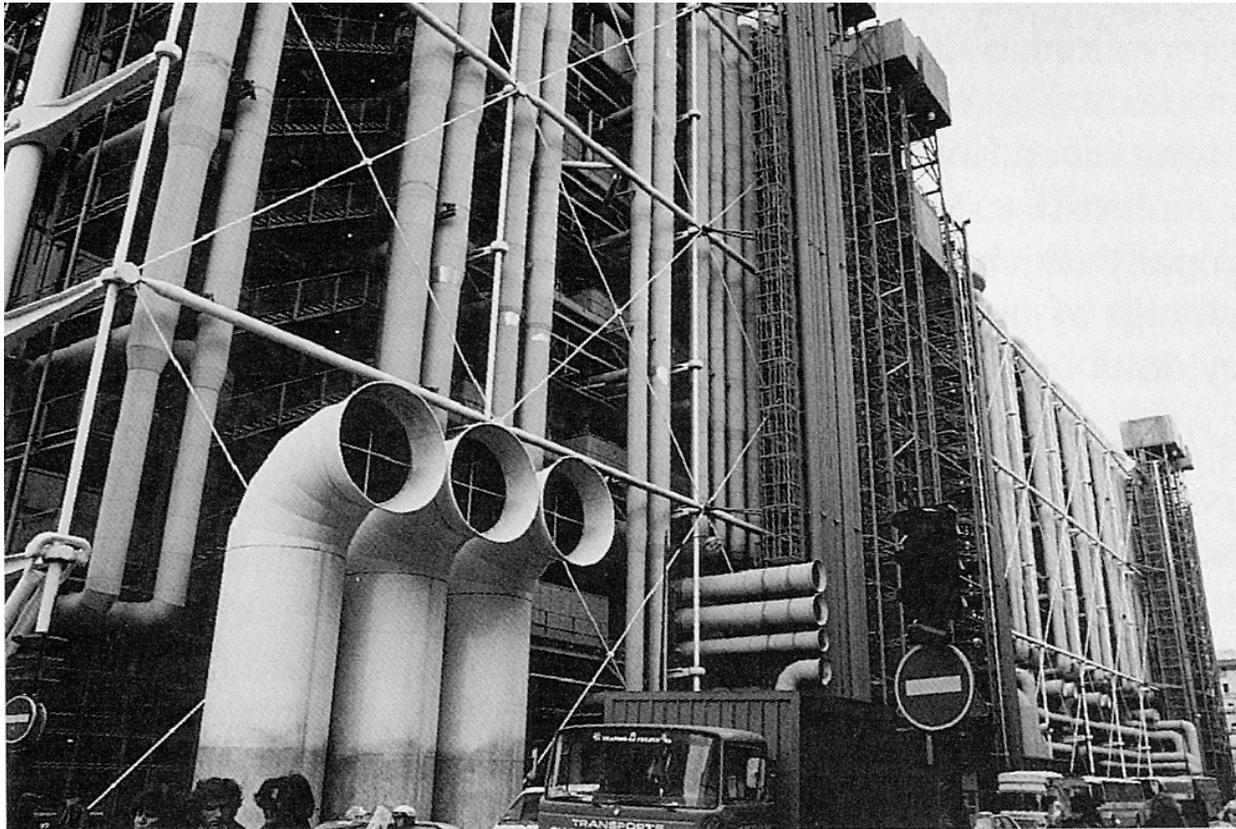


HVAC SYSTEMS COST & PROBLEMS

- DISTRIBUTION OF SYSTEMS
 - 50% OF TOTAL COST
 - USE OVER 50% OF ELECTRICITY - ALWAYS ELECTRIC USE
 - 80% OF TOTAL COST OF REMODELING
 - 90% OF PROBLEMS AFTER REMODELING

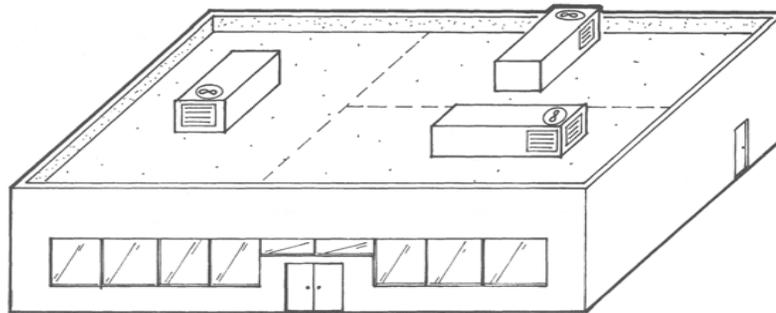
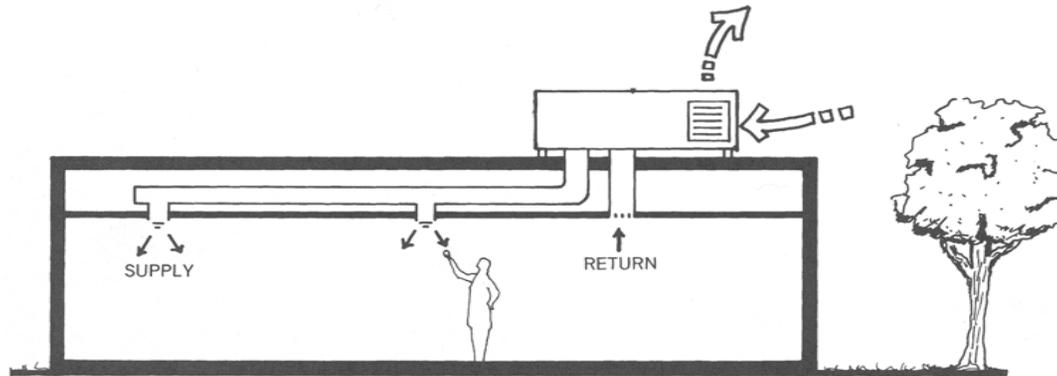


MAINTENANCE NIGHTMARE





POPULAR POOR SELECTIONS





TOTAL QUALITY COMMISSIONING PART #1 - BUILDING PERFORMANCE ANALYSIS

USING A GOOD BUILDING SIMULATION SOFTWARE PACKAGE PROPERLY WILL OPTIMIZE THE BUILDING ORIENTATION, ENVELOPE, DAYLIGHTING AND ENERGY USE. ENERGY 10 FOR RESIDENTIAL AND SMALL BUILDINGS, ENERGY PLUS FOR ANY BUILDING. BUILDING, LIGHTING AND ENERGY USE ARE COVERED.

THE HVAC SIMULATION IS STILL VERY IFFY, BUT ENERGY REQUIREMENTS OF BUILDING IS GOOD.



TOTAL QUALITY COMMISSIONING --ZERO ENERGY OPTIONS--

NATURAL VENTILATION-

GOOD FOR 2 - 6 MONTHS A YEAR. OCCUPANTS “FEEL” GOOD.

USUALLY PENALTY IN BUILDING STRUCTURAL RIGIDNESS
FOR DEEP PLAN BUILDINGS.

DEEP PLAN BUILDINGS SYSTEMS DESTROYED AFTER THE
FIRST CHURN.

STILL REQUIRES FULL HVAC SYSTEM.



TOTAL QUALITY COMMISSIONING --ZERO ENERGY OPTIONS--

SOLAR

PASSIVE DESIGN - NO BRAINER.

PV AND THERMAL -

WHEN ECONOMICALLY FEASIBLE. CURRENT
DESIGNS MUST TAKE FULL ADVANTAGE OF SOLAR
POWER. MINIMIZE ELECTRIC USE, AMBIENT
HEATING AND COOLING TEMPERATURE
REQUIREMENTS.



TOTAL QUALITY COMMISSIONING --ZERO ENERGY OPTIONS--

WIND POWER-

WHEN ECONOMICALLY FEASIBLE.

CLIMATE CHANGE SEEMS TO BE INCREASING WINDS?



TOTAL QUALITY COMMISSIONING --ZERO ENERGY OPTIONS--

GROUND SOURCE OR GROUND COUPLING -

WHERE AVAILABLE ENERGY AT 62⁰F OR BELOW, A NO-BRAINER.

CAN BE A 5 TO 7 YEAR PAYBACK WHEN COMBINED WITH OTHER SYSTEMS.

SYSTEM CAN LAST FOR 60 - 80YEARS.

AGAIN, DESIGN MUST TAKE FULL ADVANTAGE.



TOTAL QUALITY COMMISSIONING PART #2 - INITIAL SIZING OF BECS EQUIPMENT

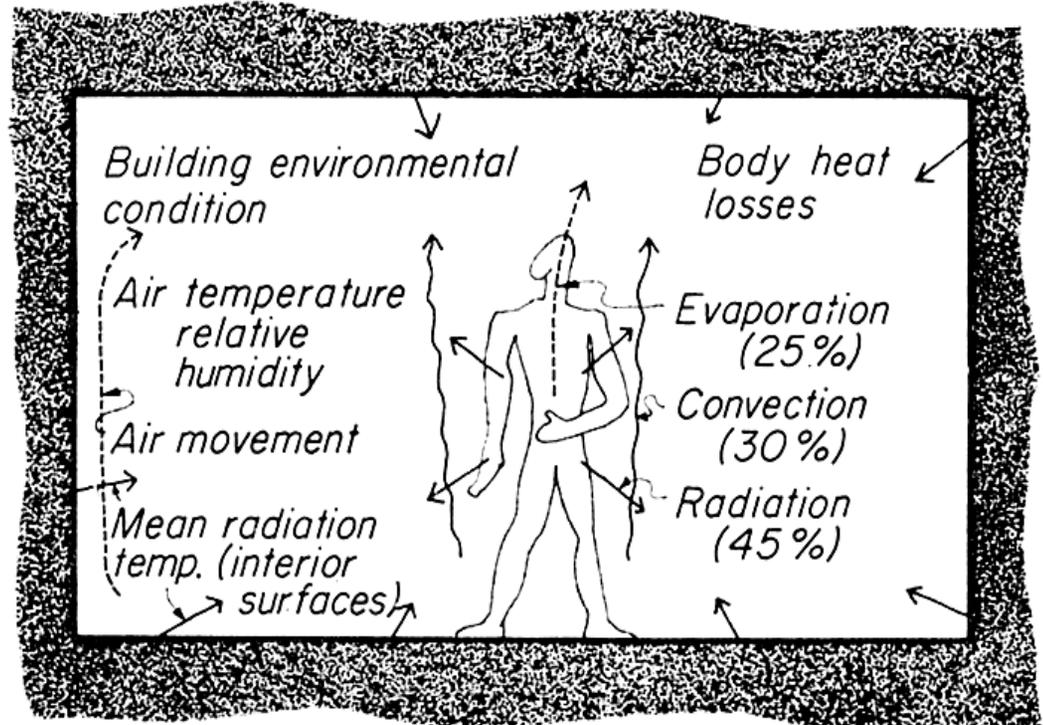
- DYNAMIC BUILDING SIMULATION WILL GENERALLY ALLOW A REDUCTION IN HVAC SYSTEM SIZE OF 40% FROM THE STANDARD DESIGN METHOD OF SUMMER AND WINTER DESIGN LOADS.
- “RIGHT SIZING” SAVES CONSTRUCTION COSTS BUT ALSO SAVES ENERGY AND OPERATING COSTS.
- CARRIER MENTALITY OF OVERSIZED SYSTEMS.



TOTAL QUALITY COMMISSIONING

PART #3 - HIGH PERFORMANCE ANALYSIS

- HIGH PERFORMANCE REQUIRES A DETAILED ANALYSIS OF COMFORT AND PRODUCTIVITY.
- THERMAL COMFORT IS 2/3 RADIANT 1/3 AMBIENT.
- HUMIDITY CONTROL IS ESSENTIAL.
- VENTILATION AIR QUALITY AND QUANTITY IS ESSENTIAL.

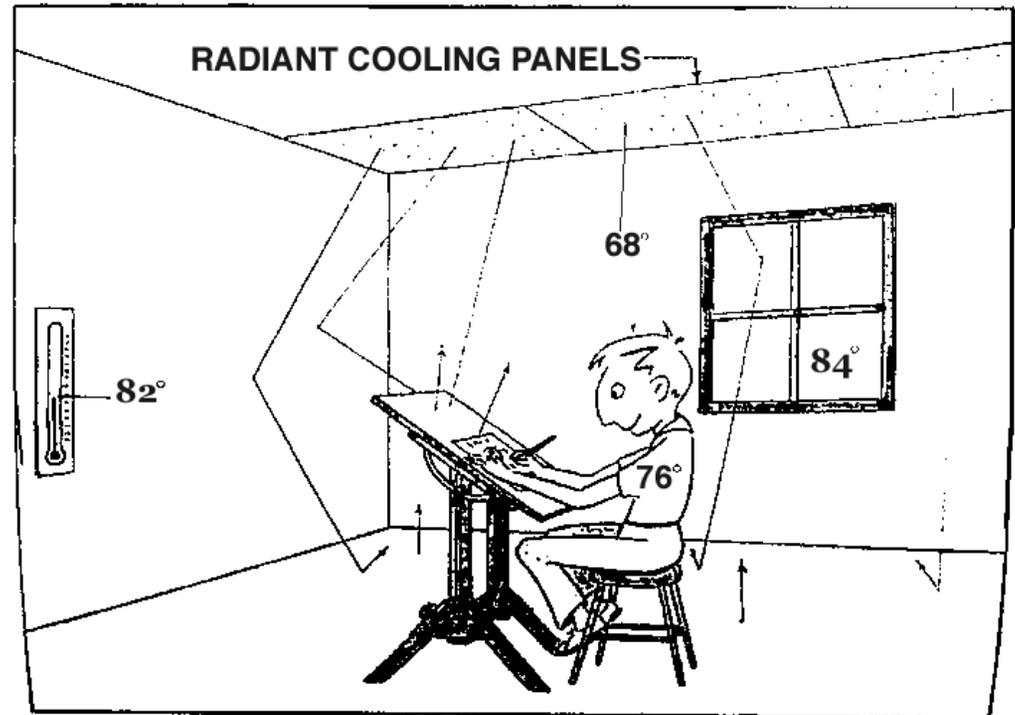




TOTAL QUALITY COMMISSIONING

PART #3A - HIGH PERFORMANCE

ADD
RADIANT
CONTROL.

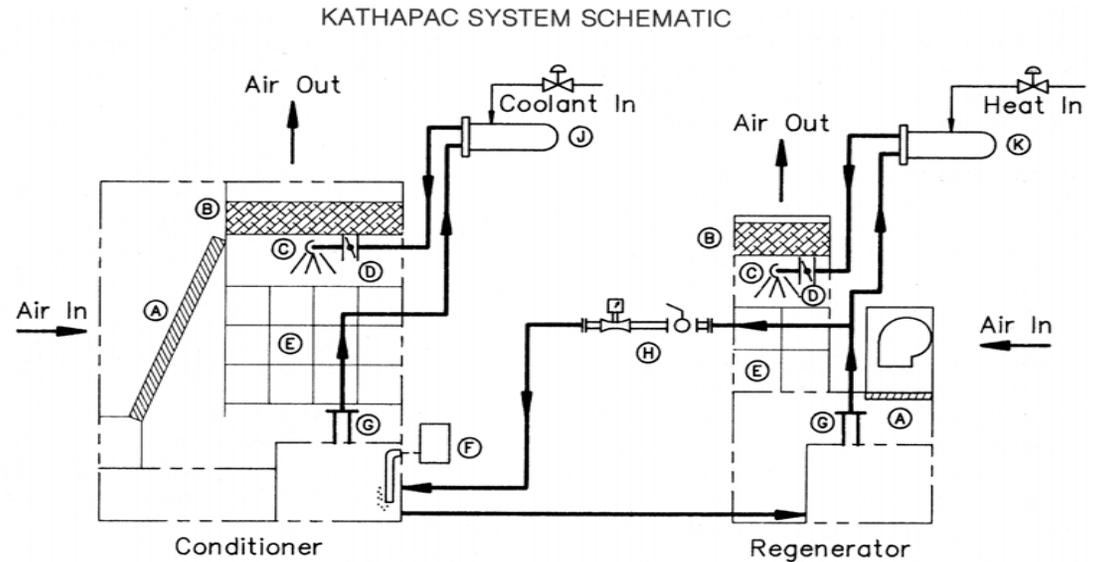




TOTAL QUALITY COMMISSIONING

PART #3B - HIGH PERFORMANCE

ADD
YEAR
ROUND
HUMIDITY
CONTROL.



- | | | | |
|---|------------------------------|---|----------------------------|
| A | Diffuser | F | Level Control Panel |
| B | Mist Eliminator | G | Solution Pump |
| C | Solution Distributing Nozzle | H | Solution Metering Assembly |
| D | Solution Flow Control Valve | J | Solution Cooler |
| E | Packing | K | Solution Heater |



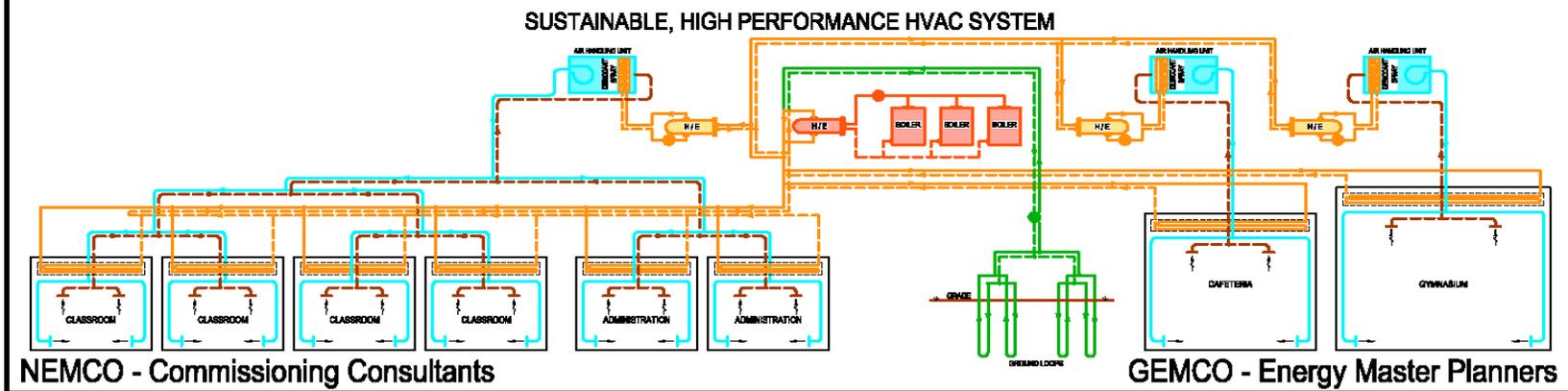
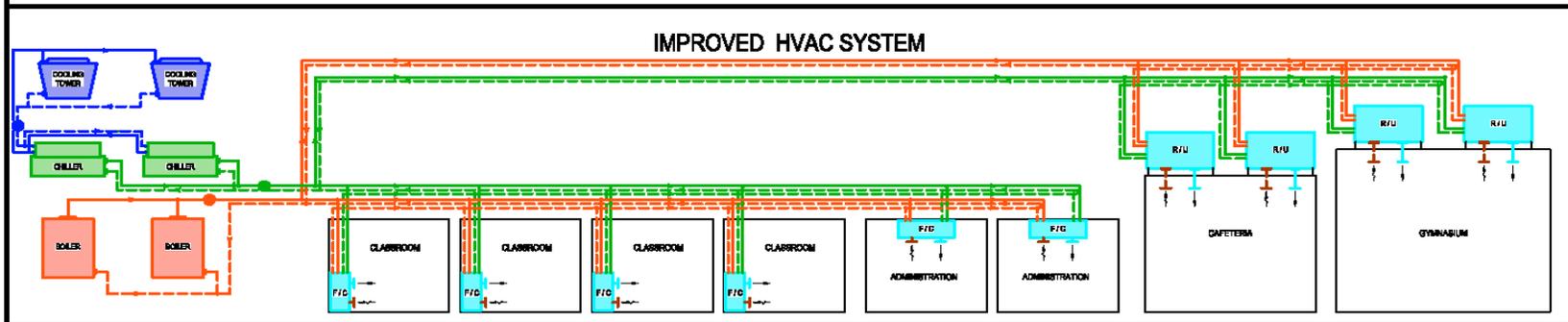
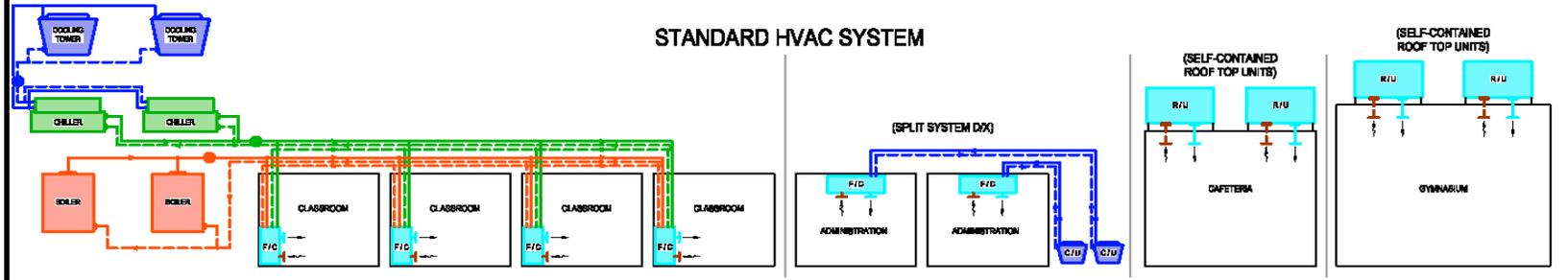
TOTAL QUALITY COMMISSIONING

PART #4 - SYSTEMS SELECTION

- **HIGH PERFORMANCE CHARACTERISTICS SHOULD GUIDE THE DESIGNER TOWARD A SELECTION OF 2 OR 3 SYSTEM TYPES.**
- **THE DISTRIBUTION SYSTEMS ARE THE MAJOR DECISION/INVESTMENT.**

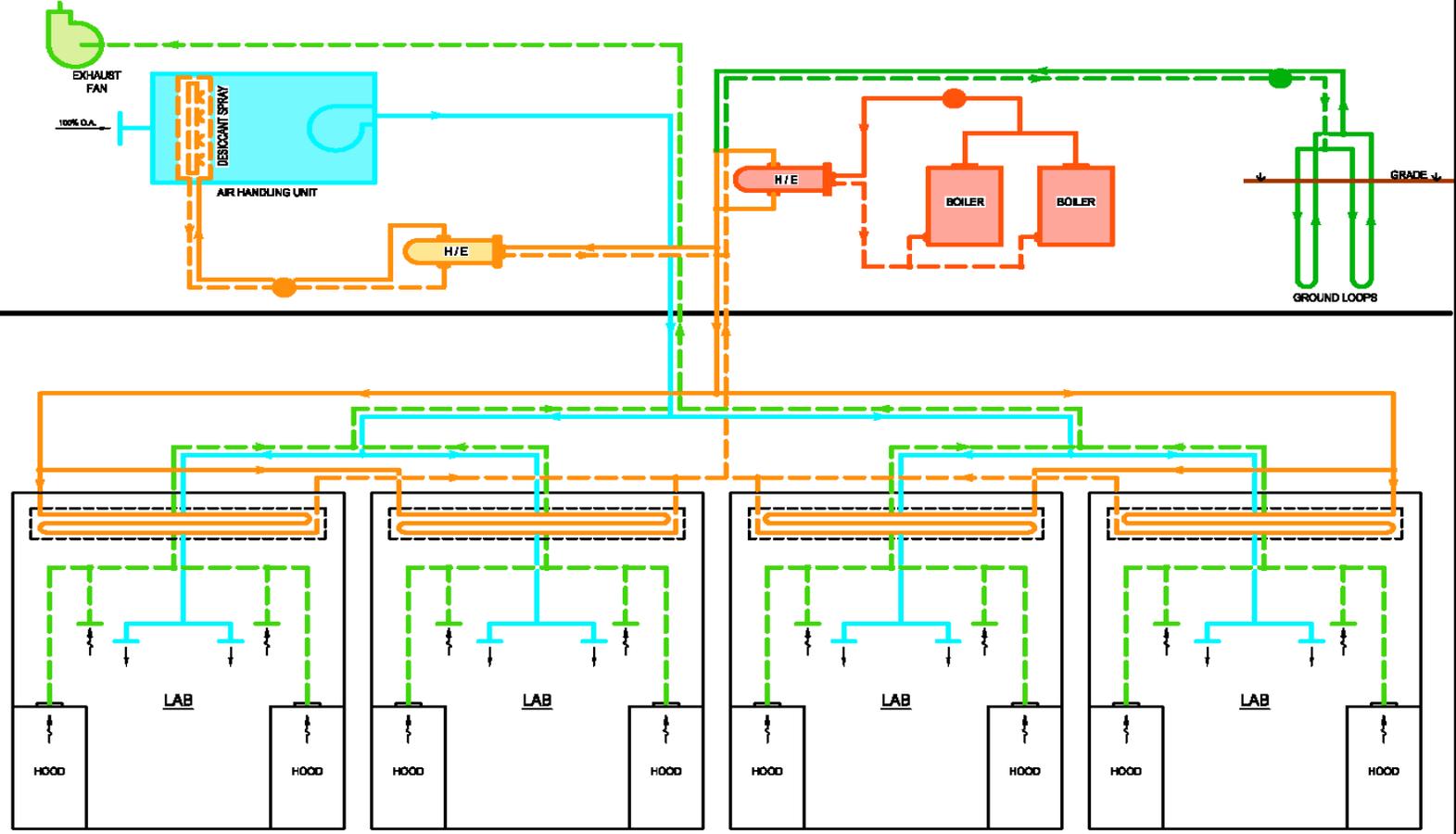


ELEMENTARY SCHOOL SYSTEMS





SUSTAINABLE, HIGH PERFORMANCE HVAC SYSTEM



NEMCO - Commissioning Consultants

GEMCO - Energy Master Planners