Architectural Technology III

ARCH 523 | Environmental Controls

Last week... Our Preconceptions

We discussed certain perceptions we have, as well as certain dissatisfactions we can easily articulate about our architecture and our designed environment.

... Challenges to Comfort
... Challenges to Logistics
... Challenges to Efficient Use of Resources
... Challenges to Economy of Means

Last week... <u>Our Preconceptions</u>

Worksheet #1

... 1) *List three ways in which the building we currently occupy controls our environment to provide our comfort.*

> Cooling and Heating
> Lighting
> Protection against Elements (Enclosure)
> Drainage (Waste Removal)
> Vertical Transport

> Psychological Support

Last week... Our Preconceptions

Worksheet #1

... 2) *According to The Architecture of the Well-Tempered Environment, how might a purely massive or structural environmental solution fail to provide for comfort? Give two examples.*

> Structural solution does not provide heating, cooling, or dehumidification;
> Structural solution does not provide nighttime illumination;
> Structural solution is inflexible over time;
> Structural solution may not provide ventilation.

Last week... Our Preconceptions

Worksheet #1

... 3) Based on examples illustrated in Design E^2 / The Green Apple, how might the design and construction of a new skyscraper benefit the air quality of the surrounding neighborhood?

> Filtration of air intake and subsequent exhaust;
> At a smaller scale: Green-roofs provide additional organic respiration

(Reduction of CO_2 during manufacture is a different concept.)

Last week... <u>Our Preconceptions</u>

Worksheet #1

... *4) In the context of designing buildings, how do you understand the phrase: "Being Less Bad is No Good"?*

> Toxic practices, even when reduced, remain toxic;
> Reducing irresponsible use of resources may mitigate short-term effects; but long-term effects remain inevitable.
> Confusing positive practices with simple efficiencies muddles the technical understanding with which we can design better solutions.

(The trade-offs between benefits and costs is a different concept.)

This week... Some Introductory Concepts

Cradle to Cradle: Introduction

McDonough's Rhetorical Flourish: **Look Around You!**

> Your Chair! Your Computer! Your Shoes!

> Your Textbook...?

Durable, waterproof, and a "technical" nutrient: A product which can be broken down and circulated infinitely in industrial cycles -- made and remade as paper or other products.

Nutrient as a paradigm for the design of manufactured products -- including both small-scale goods and large-scale items, such as buildings -- to serve both "nature" and "commerce."

This week... <u>Some Introductory Concepts</u>

Cradle to Cradle: Introduction

What were the author's different biographies?

Bill McDonough: Architect
Michael Braungart: Chemist, Political Activist

How did their individual efforts challenge the typical methods of investigation?

What was their point of connection? **Shoes**. (And Ants.)

This week... Some Introductory Concepts

Cradle to Cradle: Why Being "Less Bad is No Good"

The drive to make industry less destructive:
Reduce, avoid, minimize, sustain, limit, halt.

Examples of calls to control growth:
Malthus' message of population explosion;
American writers, such as Thoreau, Muir, and Marsh.

Rachel Carson's book, Silent Spring (1962) tied appreciation for the intrinsic qualities of the natural environment with scientific data describing its degradation. It documented the effect of pesticides upon bird communities and related ecological participants -- including humans.

This week... Some Introductory Concepts

Cradle to Cradle: Why Being "Less Bad is No Good"

Subsequent reaction to environmental pressures emphasized the need to limit growth, consumption, waste.

Concept of Eco-Efficiency: Doing More with Less.

Reduce, avoid, minimize, sustain, limit, halt.

Slowly adopted by many industries as a model for their future development, Eco-Efficiency is comprehensible to them since the problem remains defined in quantitative, efficiency-related terms.

What are examples of "eco-efficiency" in the building industry?

This week... Some Introductory Concepts

Cradle to Cradle: Why Being "Less Bad is No Good"

The Four R's: **Reduce, Reuse, Recycle -- and Regulate**.

C+C's explicit objections to these approaches:

Reduce: *May not alleviate negative impacts of toxic substances.*

Reuse: *Only displaces toxins and may only place waste in a different waste stream.*

Recycle: *Actually DownCycling, which degrades materials and increases contamination of the biosphere...*

Regulate: *Typically defined as punishment, not reward; more significantly, regulation is "a signal of design failure... a license to harm."*

This week... Some Introductory Concepts

Cradle to Cradle: Why Being “Less Bad is No Good”

“Eco-efficiency only works to make the old, destructive system a bit less so... this is the ultimate failure of the ‘be less bad’ approach: a failure of the imagination.”

“What would it mean to be 100 percent good?”

Next week’s reading (Chapter 3): Eco-Effectiveness

This week... Some Introductory Concepts

MEEB: Design Process

Malcolm Wells: **The Absolutely Constant Incontestably Stable Architectural Value Scale**

Creates or Destroys / Encourages or Discourages:

Pure Air, Pure Water, Rainwater, Food, Rich Soil, Solar Energy, Silence, Wastes, Maintenance, Natural Cycles, Wildlife Habitat, Human Habitat, Local Weather, Beauty.

The significance of this proposal seems not only to be the criteria which Wells deems important, but also the proposition that a quantitative assessment is a useful exercise in the first place!

This week... Some Introductory Concepts

MEEB: Design Process

Predesign: Assessment, Feasibility, Need... Program;

Conceptual Design:	Fundamental decisions;
Schematic Design:	Development and refinement;
Design Development:	All design decisions are finalized;
CD's and Specification:	Elaboration of those decisions.
Construction Phase	
Occupancy Phase	Continued Feedback to Design Phase

Why have we repeated an emphasis on process?

Because the earliest phases of the process determine the strategic success an environmental design.

This week... Some Introductory Concepts

MEEB: Design Intent, Design Criteria, and Tools/Methods
Each of these elements contribute to a successful project.

Design Intent: *A statement that outlines the desired or expected high-level outcomes of the design process. (Examples: Outstanding comfort, use of passive systems, &c.)*

Design Criteria: *The benchmark against which the success or failure in meeting Design Intent is measured. (Examples: Design to conform to ASHRAE 55-2004; LEED Silver rating; Sound levels at RC-35 or lower...)*

Methods and Tools: *The means and techniques through which Design Intent is realized. (Examples: Heat-Loss Calculator; Specified Equipment)*

This week... Some Introductory Concepts

MEEB: Design Intent, Design Criteria, and Tools/Methods

Sample Relationship Matrix

TABLE 1.1 Relationships Between Design Intent, Design Criteria, and Design Tools/Methods

Issue	Design Intent	Possible Design Criterion	Potential Design Tools	Potential Implementation Method
Thermal comfort	Acceptable thermal comfort	Compliance with ASHRAE Standard 55	Standard 55 graphs/tables or comfort software	Passive climate control and/or active climate control
Lighting level (illuminance)	Acceptable illuminance levels	Compliance with recommendations in the *IESNA Lighting Handbook*	Hand calculations or computer simulations	Daylighting and/or electric lighting
Energy efficiency	Minimal energy efficiency	Compliance with ASHRAE Standard 90.1	Handbooks, simulation software, manufacturer's data, experience	Envelope strategies and/or equipment strategies
Energy efficiency	Outstanding energy efficiency	Exceed the minimum requirements of ASHRAE Standard 90.1 by 25%	Handbooks, simulation software, manufacturer's data, experience	Envelope strategies and/or equipment strategies
Green design	Obtain green building certification	Meet the requirements for a LEED gold rating	LEED materials, handbooks, experience	Any combination of approved strategies to obtain sufficient rating points

This week... Some Introductory Concepts

Example Design Criteria: ASHRAE Standard 55-2004

Standard 55 deals exclusively with thermal comfort in the indoor environment. The scope is not limited to any specific building type, so it may be used for residential or commercial buildings and for new or existing buildings. It also can apply to occupied spaces such as transportation means (e.g., cars, trains, planes and ships).

The standard specifies conditions acceptable to a majority of a group of occupants exposed to the same conditions within a space. The body of the standard clearly defines "majority" such that the requirements are based on 80% overall acceptability, while specific dissatisfaction limits vary for different sources of local discomfort. A space that meets the criteria of the standard likely will have individual occupants that are not satisfied due to large individual differences in preference and sensitivity.

See B. W. Olesen & G. S. Brager, A Better Way to Predict Comfort: The New ASHRAE Standard 55-2004

This week... Some Introductory Concepts

Example Design Criteria: ASHRAE Standard 55-2004

The requirements for providing thermal comfort are all contained in Section 5 of Standard 55-2004. Section 5.2 represents the primary methodology for determining acceptable thermal conditions for most applications. It includes the PMV-PPD method for determining acceptable operative temperature for general thermal comfort (5.2.1), followed by additional requirements for humidity (5.2.2), air speed (5.2.3), local discomfort (5.2.4), and temperature variations with time (5.2.5).
When Section 5.2 is used, all of the requirements of these subsections must be met. Section 5.3 presents a new alternative compliance method applicable for naturally conditioned buildings, based on an adaptive model of thermal comfort. Each of these sections gives specific requirements for thermal comfort, and defines the relevant limitations of applicability.

See B. W. Olesen & G. S. Brager, A Better Way to Predict Comfort: The New ASHRAE Standard 55-2004

This week... Some Introductory Concepts

Example Design Criteria: ASHRAE Standard 55-2004

PMV (Predicted Mean Vote) is an index that expresses the quality of the thermal environment as a mean value of the votes of a large group of persons on the ASHRAE seven-point thermal sensation scale (+3 hot, +2 warm, +1 slightly warm, 0 neutral, –1 slightly cool, –2 cool, –3 cold). PPD (Predicted Percentage Dissatisfied) is an index expressing the thermal comfort level as a percentage of thermally dissatisfied people, and is directly determined from PMV. The PPD index is based on the assumption that people voting ±2 or ±3 on the thermal sensation scale are dissatisfied, and the simplification that PPD is symmetric around a neutral PMV (=0). Both PMV and PPD are based on general (whole body) thermal comfort.

See B. W. Olesen & G. S. Brager, A Better Way to Predict Comfort: The New ASHRAE Standard 55-2004

This week… Some Introductory Concepts

Example Design Concept Tools: Solar Savings Fraction (SSF)

*In discussing solar energy, the **solar savings fraction** or **solar fraction** (f) is the amount of energy provided via the solar technology divided by the total energy required.*

The solar savings fraction thus is zero for no solar energy utilization, to 1.0 for all energy provided via solar. The solar savings fraction of a particular system is dependent on many factors such as the load, the collection and storage sizes, the operation, and the climate.

As an example, the same solar-thermal water heating system installed in a single family house in Arizona might have f=0.75, while in a much colder and cloudier climate, like Pittsburg, PA, might only have a solar fraction of 30% or so.

This week... Some Introductory Concepts

MEEB: Validation and Evaluation

(a) Conventional validation/evaluation approaches
Design Validation vs. Building Validation (POE)
(b) Commissioning
(c) Case studies

This week... Some Introductory Concepts

MEEB: Influences on the Design Process

(a) Codes and standards
(b) Costs
(c) Passive and active approaches
(d) Energy efficiency
(e) Green building design strategies
(f) Design strategies for sustainability
(g) Regenerative design strategies

This week... Some Introductory Concepts

MEEB: Influences on the Design Process

(a) Codes and standards

TABLE 1.2 Codes, Standards, and Other Design Guidance Documents

Document Type	Characteristics	Examples
Code 	Government-mandated and government-enforced (typically via the building and occupancy permit process); may be a legislatively adopted standard	Florida Building Code; California Title 24; Chicago Building Code; International Building Code (when adopted by a jurisdiction)
Standard 	Usually a consensus document developed by a professional organization under established procedures with opportunities for public review and input	ASHRAE Standard 90.1 (*Energy Standard for Buildings Except Low-Rise Residential Buildings*); ASTM E413-87 (*Classification for Rating Sound Insulation*); ASME A17.1—2000 (*Safety Code for Elevators and Escalators*)
Guideline 	Development is typically by a professional organization, but within a looser structure and with less public involvement	ASHRAE Guideline 0 (*The Commissioning Process*); *IESNA Advanced Lighting Guidelines:* NEMA LSD 12-2000 (*Best Practices for Metal Halide Lighting Systems*)
Handbook, design guide 	Development can vary widely—involving formal committees and peer review or multiple authors without external review	*IESNA Lighting Handbook; ASHRAE Handbook—Fundamentals;* NFPA *Fire Protection Handbook*
General practice 	The prevailing norm for design within a given community or discipline; least formal of all modes of guidance	System sizing approximations; generally accepted flashing details

This week... Some Introductory Concepts

MEEB: Influences on the Design Process

(b) Costs *(First Costs vs. Lifecycle Costs)*

(c) Passive and active approaches

TABLE 1.3 Defining the Characteristics of Passive and Active Systems

Characteristic	Passive System	Active System
Energy source	Uses no purchased energy (electricity, natural gas, fuel oil, etc.)—example: daylighting system	Uses primarily purchased (and nonrenewable) energy —example: electric lighting system
System components	Components play multiple roles in system and in larger building—example: concrete floor slab that is structure, walking surface, and solar collector/storage	Components are commonly single-purpose elements—example: gas furnace
System integration	System is usually tightly integrated (often inseparably) with the overall building design—example: natural ventilation system using windows	System is usually not well integrated with the overall building design, often seeming an add-on—example: window air-conditioning unit
Passive and active systems represent opposing philosophical concepts. Design is seldom so straightforward as to permit the exclusive use of one philosophy. Thus, the hybrid system. Hybrid systems are a composite of active and passive approaches, typically leaning more toward the passive. For example, single purpose, electricity-consuming (active) ceiling fans might be added to a natural ventilation (passive) cooling system to extend the performance of the system and thus reduce energy usage that would otherwise occur if a fully active air-conditioning system were turned on instead of the fans.		

This week... Some Introductory Concepts

MEEB: Influences on the Design Process

(d) Energy efficiency:
Code Requirements, Legal Mandates

(e) Green building design strategies:
Concern for the health and well-being of building occupants and respect for the larger, global environment.

(f) Design strategies for sustainability:
Meeting the needs of today's generations without detracting from the ability of future generations to meet their needs.

(g) Regenerative design strategies:
Net positive environmental impact.

This week... Some Introductory Concepts

MEEB: Philosophy of Design

John Lyle, Regenerative Design for Sustainable Development

(a) Let nature do the work.
(b) Consider nature as both model and context.
(c) Aggregate rather than isolate.
(d) Match technology to the need.
(e) Seek common solutions to disparate problems.
(f) Shape the form to guide the flow.
(g) Shape the form to manifest the process.
(h) Use information to replace power.
(i) Provide multiple pathways.
(j) Manage storage.

This week... Some Introductory Concepts

MEEB: Case Study

McDonough+Partners, Gilman Ordway Campus, Woods Hole

Which environmental design tactics can you identify?

Which environmental design systems can you identify?

Which architectural design decisions relate to the theme of "sustainability"?

This week... Some Introductory Concepts

MEEB: Case Study

McDonough+Partners, Gilman Ordway Campus, Woods Hole

Design Intent: *A modern building can "harmonize with a habitable earth," while providing a healthy, comfortable, and enjoyable workplace.*

Additional explicit goals: Enhanced productivity, far-beyond-code-minimum energy performance.

Design Criteria and Validation: *Use of ENERGY 10* computer simulations, an energy systems design consultant, and an independant authority for building commissioning.*

ENERGY 10 is a software package developed collaborative project of the NREL Center for Building and Thermal Systems, the Sustainable Buildings Industry Council (SBIC), Lawrence Berkeley National Laboratory, and the Berkeley Solar Group.

This week... Some Introductory Concepts

MEEB: Case Study

McDonough+Partners, Gilman Ordway Campus, Woods Hole

Key Design Features:

Extensive Daylighting

Operable Windows

Exceptionally tight and detailed building envelope, including triple-glazed windows and Icynene foam insulation.

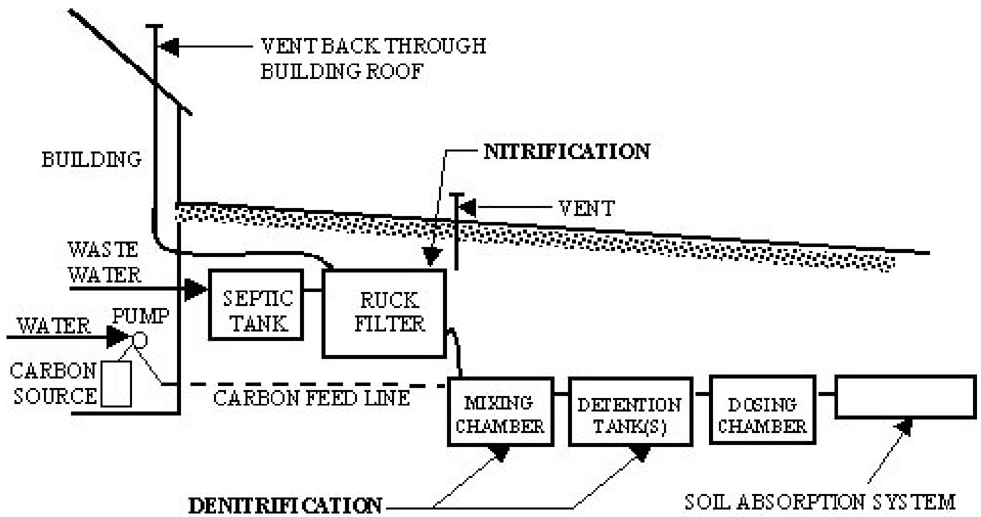
*Ruck * wastewater system, 95% on-site stormwater retention and rainwater collection for irrigation.*

A ground-source heat pump system for heating/cooling

A rooftop, net-metered photovoltaic array.

** RUCK wastewater treatment system: separate sewage (blackwater) from other wastewater (greywater from kitchens, laundry, showers) and treat each type of effluent separately. RUCK systems are used to remove additional nitrogen and phosphorous, up to 90%, from wastewater.*

RUCK: But what does that mean???



DESCRIPTION

RUCK® CFT systems are the most advanced type of RUCK® systems and offer the highest treatment available. RUCK® CFT provide tertiary treatment for the most economical construction compared to other technologies. RUCK® CFT systems require Piloting approval as an alternative innovative septic system by the Massachusetts Department of Environmental Protection (DEP). RUCK® CFT systems are different than traditional RUCK® systems because RUCK® CFT systems require energy, a part-time operator and the addition of a carbon source. A schematic of a typical RUCK® CFT is shown above.

Traditional RUCK® Systems require that the wastewater flows be separated into black water and gray water. The black water flow, after the black water septic tank, passes through a RUCK® filter. The effluent from the RUCK® filter is then piped into the gray water septic tank. The gray water septic tank is the site of denitrification. Early designs of RUCK® systems for commercial use based on the same treatment scheme as Traditional RUCK® systems were a failure because of a lack of available carbon in the wastewater. Rein Laak Ph.D. invented commercial RUCK® or RUCK® CFT systems and that invention was awarded a patent, (Patent No. 5,588,777). If carbon was lacking, then a carbon source could be added. In RUCK® CFT systems, the carbon source is manufactured gray water inserted in the flow at an appropriate location in the wastewater treatment stream. In these designs, all wastewater is piped into a RUCK® filter. Effluent from the RUCK® filter is piped into a mixing chamber where soapy water is added. Denitrification takes place in the mixing chamber. In this design, denitrification is very efficient; removal rates can exceed 90%. The treated effluent is discharged into a soil absorption system. The soil absorption system for RUCK® CFT systems proposed under the Piloting provisions of Title 5 need not be the required size normally required by code. Soil Absorption systems may be approximately half that required for a traditional subsurface septic system.

This design was called the Commercial RUCK® but the name implies that the design cannot be used in a residential setting. The name in Massachusetts will be RUCK® CFT for these systems for all types of flows including residential uses.

This week... Some Introductory Concepts

MEEB: Case Study

McDonough+Partners, Gilman Ordway Campus, Woods Hole

Post-Occupancy Validation Methods:

Extensive energy monitoring for study optimization.

Performance Data:

Energy Consumption: 20,000 BTU/ft^2,
~25% typical office building;
Installation of additional photovoltaic panels will provide 37,000 kWh/year (~40% Annual Usage)
All woodwork certified FSC (Forest Stewardship Council)
Paint and coatings meet low VOC standards; no carpet.

... Less Bad, Dude!

This week... Some Introductory Concepts

Worksheet #2: Design Process

This week... Metrics and Technique

What does "metrics" mean in this context?

"... the measure of a quantity
(or quality, in quantitative terms)"

Why measure in the context of Environmental Design?

... Objective analysis;
... Reasoned conclusions.

*How else can **we** convince **others** that we know what we're talking about...!*

This week... Metrics and Technique: Sun Wind and Light

Part I: Analysis Techniques
Part II: Design Strategies
Part III: Strategies for Supplementing Passive Systems

IA: Climate as Context
IB: Program and Use
IC: Form and Envelope
ID: Combining Climate, Program, and Form
IE: Electric and Hot Water Loads.

This week... Metrics and Technique: Sun Wind and Light

Part I: ***Analysis Techniques:*** Why Analysis?

\> To understand, *before* the building is designed, how the building is likely to use energy;

\> To understand the problem *and* the context;

\> To identify and characterize important variables;

\> To establish their relative importance.

"...(E)valuation techniques have tended to play a more important role than either design strategies or analysis tools as it relates to energy use. Therefore, energy considerations have played a less formative role in the initial conception of a design than they potentially could." p. 3

This week... Metrics and Technique: Sun Wind and Light

Part IA: Analysis Techniques *Climate as Context*

Sun, Wind, Sun and Wind Together, Light, Comfort

Described Techniques:

Sun: Sundial, Sun Path Diagram, Solar Radiation Chart
Wind: Wind Rose, Wind Square, Air Movement Adj.
Sun and Wind: Site Microclimates
Light: Sky Cover, Daylight Availability,
Daylight Obstructions
Comfort: Bioclimatic Chart

This week... Metrics and Technique: Sun Wind and Light

Part IB: Analysis Techniques *Program and Use*

"Knowing how and when a building is used is critical in determining the building's heating and cooling requirements." p.38

Occupancy, Electric Lighting

Described Techniques:

> Occupancy Heat Gain
> Electric Lighting Heat Gain

This week... Metrics and Technique: Sun Wind and Light

Part IC: Analysis Techniques *Form and Envelope*

"The building itself is the third factor that influences the heating and cooling requirements." p.45.

Described Techniques:

- Skin Heat Flow / Envelope Heat Transfer
- Window Solar Gain
- Ventilation or Infiltration Gain and Loss

This week... Metrics and Technique: Sun Wind and Light

Part ID: Analysis Techniques *Combining Climate, Program, and Form*

Described Techniques:

- > Building Bioclimatic Chart
- > Earth Contact
- > Shading Calendar
- > Total Heat Gains
- > Balance Point Temperature
- > Balance Point Profiles

This week... Metrics and Technique: Sun Wind and Light

Part IE: Analysis Techniques *Electric and Hot Water Loads*

Described Techniques:

- Electric Loads
- Service Hot Water Loads

This week... <u>Metrics and Technique: Sun Wind and Light</u>

The moral of this week's reading:

Think | Study | Design

The Color of Thought

PBS Video Series: ***Design E²***

This week's showing: Deeper Shades of Green

Last century... <u>Our History</u>

<u>The Architecture of the Well-Tempered Environment</u>
Chapter 4: The Kit of Parts

“It is important to establish the changes in the type of environmental power that would be delivered into an inhabited space.” p.45

In the mid 1800’s, “the nature of that power was still ... primitive, its basic characteristic was that fuel was burned more or less at the point where power had to be applied.”

Coal, gas, wood, oil, tallow, etc. Power affected only the immediate environment. Power had yet to develop a systematic form of *distribution.*

Last century... <u>Our History</u>

<u>The Architecture of the Well-Tempered Environment</u>
Chapter 4: The Kit of Parts

Innovations in two types of power allowed a fundamental shift in the paradigm of delivery: From the “fireplace” to the “telegraph.”

> Electrical Power (Edison)
> Steam Power (Birdsill Holly)

Power could now be distributed over long distances.

Last century... Our History

The Architecture of the Well-Tempered Environment
Chapter 4: The Kit of Parts

Ironically, a paradigm shift had already occurred in the local consumption of heat energy:

The Franklin Stove

The innovation was this: Convecting warm air was separated from the smoke, fumes, and other products of combustion.

Doing so allowed the heat-generating mechanism to be distanced from the consumption of that energy; doing so also allowed *ventilation* to be provided simultaneously with heated air.

Last century... <u>Our History</u>

<u>The Architecture of the Well-Tempered Environment</u>
Chapter 4: The Kit of Parts

Together with the possibility of “broadcasting” energy for local consumption, the introduction of forced air and ventilation effected a revolution upon the space-defining patterns of home builders and architects.

Doing so also paved the way for the introduction of air “conditioning,” which both tempered the air and reduced humidity.

Last century... Our History

The Architecture of the Well-Tempered Environment
Chapter 4: The Kit of Parts

An additional innovation, due also to Edison, had an important impact on interior air quality: **The Electric Light Bulb.**

By removing the presence of combustion in the making of interior light, a significant source of interior air pollutants was removed. It's hard to imagine now, but until the Electric Light Bulb, many characteristics of interior design were influenced by the need to anticipate the soot and dirt caused by candles, gas lamps, &c.

This suggestion by Banham is significant for its implication that all environmental systems are interconnected, sometimes in counter-intuitive ways.

Last century... <u>Our History</u>

<u>The Architecture of the Well-Tempered Environment</u>
Chapter 4: The Kit of Parts

The impact of electric lighting extended, too, to the wiring of buildings and city-scapes to deliver the necessary power. A dilemma arose concerning which model to adopt:

Telegraphy | Plumbing

Edison: "... you don't lift water pipes and gas-pipes up on stilts."
p61

Nevertheless, the almost-simultaneous emergence of the telephone network seemed to convince Edison's successors otherwise.

Last century... Our History

The Architecture of the Well-Tempered Environment
Chapter 4: The Kit of Parts

The impact upon architects' visual palette was, eventually, made apparent to designers; in this manner, architect's "visual thinking" came quickly to dominate all discussion of environmental systems.

"Electric lighting thus put the challenge of environmental technology to architects in direct terms of the art of architecture, because the sheer abundance of light, in conjunction with large areas of transparent or translucent material, effectively reversed all established visual habits by which buildings were seen." p. 70