Large buildings + Cold Climates + Passive Building = recipe for cost efficient low energy

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What Makes it So Attractive?

Passivhaus Principles

Scale

COLD

AR&T Architects

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First Step
Understanding the Problem

- What is holding us back?
  - Understanding the basic physics

### Energy Transfer Equations

\[ Q = H_c A (T_{\text{Hot}} - T_{\text{Cold}}) \]
\[ Q = m \times c \times \Delta T \]
\[ Q = \sigma (T_{\text{Hot}}^4 - T_{\text{Cold}}^4) A \]
\[ Q = \frac{kA}{d} (T_{\text{Hot}} - T_{\text{Cold}}) t \]
Passivhaus Principles

Basic Building Physics

- William Shurcliff - 1979
  - Truly superb insulation. Not just thick, but clever and thorough
  - Envelope of house is practically airtight.
  - No provision of extra-large thermal mass.
  - No provision of extra-large south windows.
  - No conventional furnace. Merely steal a little heat, when and if needed, from the domestic hot water system. Or use a minuscule amount of electrical heating.
  - No conventional distribution system for such auxiliary heat. Inject the heat at one spot and let it diffuse throughout the house.
  - No weird shape of house, no weird architecture.
  - No big added expense.
  - The passive solar heating is very modest — almost incidental.
  - Room humidity remains near 50 percent all winter. No need for humidifiers.
  - In summer the house stays cool automatically. There is no tendency for the south side to become too hot.
Passivhaus Principles

Basic Building Physics

- Passive House Concept developed in the early 1990s by Dr. Wolfgang Feist and Professor Bo Adamson as optimization of early superinsulation work in North America and China
- First optimized Passive House Prototype built in 1990 in Kranichstein, Germany
- 60-70% reduction in overall energy consumption (compared to code base line), 90-95% reduction of heating and cooling energy
- Passivhaus Institut (PHI) founded in 1996
Passivhaus Principles

Basic Building Physics

- Minimize losses through envelope
  - Increased insulation levels
  - Air tight
  - Thermal bridge free
- Maximize and balance gains
  - High performance glazing
  - Shading
  - Passive ventilation
  - Interior gains
- Use efficient systems
  - Fresh air heat (& energy) recovery
  - High performance mechanical equipment
  - Highly efficient electrical systems (lighting, appliances, etc.)
Step Two
Understanding the Problem

- What is holding us back?
  - Understanding the basic physics ✓
  - Understand how to use this knowledge.

"Those who have the privilege to know have the duty to act."

— Albert Einstein (1879-1955)

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Synergy & Leverage

Buildings are viewed as functional wholes, with synergies inherent in the function and form

- Synergy is the interaction of multiple elements in a system to produce an effect different from or greater than the sum of their individual effects.
  - The term synergy comes from the Greek word synergia, συνέργια from synergos, συνεργός, meaning "working together".
- Leverage (verb) is to use (something) to maximum advantage.
- As an industry, we pay lip service to the concept, but to cost effectively meet the climate change imperative, we must understand this at a visceral level.
- We can do this today if we understand:
  - Program, use, occupancy, site, form, structure, MEP systems, process energy, cost
- **AND**
  - All are analyzed and all considered in the design process from day 1.
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Scale

Interior Heat Gain (Function)

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Scale
Interior Heat Gain (Function)

- Getting the heat balance right
  - Example: Dorm Room
    - Refrigerator - Y / N, #, type
    - Microwave - Y / N, #, type, usage
    - Tea Kettle - Y / N, #, type, usage
    - Hair Dryer - Y / N, #, type, usage
    - TV – Y/N, #, usage
    - Gaming systems – Y/N, #, usage
    - Peripherals - Y/N, #, type, usage
    - Task lighting – Y/N, #, type, usage
    - Bodies??
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Scale
Commercial Construction – We are so close already

Think quality!
Do it right the first time
The first one is on me, all the others are all you!

No cost
Scale
Commercial Construction – We are so close already

simple is beautiful.

Everything should be made as simple as possible, but not simpler.
Albert Einstein

THE PERFECT FIT

COST SAVINGS

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Step Three
Understanding the Problem

• What is holding us back?
  • Understanding the basic physics
  • Understand how to use this knowledge
  • Understand the implications of the use of this knowledge
**Passivhaus Principles**

**Basic Building Physics**

- **Balance point**: Space heating is not required until outdoor temperature drops to a point at which building's heat gains are insufficient to provide the heating needs. This outdoor temperature is called the balance point temperature. Building's heat loss matches its gains at this point.
- Heating dominated vs cooling dominated buildings
Passivhaus + Large Buildings + Cold Climate

Free cooling

Air-side free cooling map

Estimate of full air-side economizer hours for data centers

- Fully populated EcoBreeze (40th Frame, 8 modules)
- Supply air setpoint of 27°C
- Temperature change across EcoBreeze 17°C
- Full Airflow Capacity 370 kW
- Operating Load of 217 kW (2/3 Full Airflow)

EcoBreeze based upon the above provides full Econ for ambient conditions of 27°C DB and 13°C DBEP.

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Step Four
Understanding the Problem

What is holding us back?

- Understanding the basic physics
- Understand how to use this knowledge
- Understand the implications of the use of this knowledge
- Understanding the obstacles

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Physical Obstacles
Materials & Systems

- North American Obstacles
  - Curtain wall
  - Handicapped compliant doors
  - Fire rated doors
  - Mechanical systems
    - Fresh air
    - Integrated
    - Correctly sized
  - Standard monitoring & control

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Physical Obstacles
Materials & Systems

- North American Obstacles can be easily overcome
  - Time
  - Market scale
  - Creativity

"Imagination is more important than knowledge."
— Albert Einstein
Mental Obstacles
Changing the way we do business

• The difference in the process changes the product
  • Design - The building is designed to work as a holistic system, working symbiotically with the occupants use pattern. The fresh air, cooling, dehumidification, heating, hot water system and usage are all considered in the design of the systems.
  • Construction – Passive Building goes beyond the typical commissioning of the mechanical systems, the building envelope is extensively commissioned with air tightness and thermal image testing to quality assure the built project.
Mental Obstacles
Changing the way we do business

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Mental Obstacles
Changing the way we do business

Late 19th and 20th Century buildings -
• Industrialization, globalization and innovation frees designers from climatic constraints.
• In wealthy nations, form and function no longer require climatic responses
• Many designs depend on energy input and thus fossil fuel to function long term

Seagram Building, New York City (1954-58), Mies van der Rohe & Philip Johnson

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Mental Obstacles
Changing the way we do business

Architects no longer have to have an intimate knowledge of climate responsive design as engineering becomes the architect’s crutch.

- Design takes precedence over sustainability and adaptability
- Architects become less master builder and more artist
- Reflected in the North American architectural education system until recently
- Even now sustainability is discussed without truly being understood and thus implemented in both education and the field.
Mental Obstacles
Changing the way we do business

- Traditional Project Delivery
  - Information and design is siloed
    - Integration of information is based on assumptions
    - This can work for traditional buildings, but it will lead to waste
  - This waste is assumed and built into the project costs
  - Standard way of doing business

Waste in the building industry is estimated at over 50%

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Mental Obstacles
Changing the way we do business

THE BIG PICTURE

North American PASSIVE HOUSE Conference Chicago, IL Sept. 9-13, 2015

BUILD SMART
Energy efficiency made simple

PASSIVSCIENCE
Knowledge over power
Mental Obstacles
Changing the way we do business

Integrated Project Delivery

Owner’s Business Case

Commissioning & Performance

Architecture / Engineering

Estimating / Purchasing

Project Management

Construction Means and Methods

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Why is Integrated Project Delivery Different?

Integrated information flow leads to Fiscal Control

- **Predesign**
- **Schematic Design**
- **Design Development**
- **Construction Documents**
- **Bidding**
- **Construction**

**Design effort / effect**

- Ability to impact cost & function
- Cost of design changes

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**Why is Integrated Project Delivery Different?**

Integrated information flow leads to Fiscal Control

- **Validation Phase**
  - Predesign & Schematic Design

- **Design/Preconstruction Phase**
  - Design Development & Construction Documents

- **Construction Phase**
  - Bidding & Construction

- **Ability to impact cost & function**
  - Cost of design changes

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**North American PASSIVE HOUSE Conference**
**BuildSmart**
**Quantum Architects**

Energy efficiency made simple
Mental Obstacles
Changing the way we do business

Delivery Method
• A no cost strategy for truly sustainable design and construction
• Integrated Project Delivery
  • Integrated team based on trust and mutually beneficial relational contracts
    • Process is not *bid based* but **objective driven**
  • Fully and truly functional BIM
    • Model functions through design, construction & operations
  • Lean construction principles
    • Just in time delivery of information and materials
• *New Paradigm* is really and olde way of doing what we do

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Solutions
Understanding the Problem

- What is holding us back?
  - Understanding the basic physics ✔
  - Understand how to use this knowledge ✔
  - Understand the implications of the use of this knowledge ✔
  - Understanding the obstacles ✔
“Investing in value instead of energy consumption requires little financial efforts but rather creativity and intelligent solutions”

~ Wolfgang Feist
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Questions & Contact

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