US building impacts

- 72% electricity consumption
- 39% energy use
- 38% CO₂ emissions
- 40% raw materials
- 30% waste output
- 14% potable water use

LAURA BLAU AIA LEED BD&C® AP
CPHC (Certified Passive House Consultant)
CPHB (Certified Passive House Builder)
CPHD (Certified Passive House Designer-pending)
Principal BLUPATH

BLUPATH is an award winning architecture and design firm focusing on high-performance building design.

blupath.us

LEARNING OBJECTIVES

1. Learn how science based conservation first strategies and the ‘whole-building’ approach can be implemented to achieve energy efficiency, durability and health benefits in Historic buildings.

2. How to phase and apply both passive conservation strategies and active mechanical reduction strategies appropriately for historical buildings.

3. Apply case study examples of best practices and lessons learned, including hydrothermal issues particular to masonry walls in both custom historic residences and budget constrained affordable housing retrofit projects.

4. Understand possible administrative, design and construction challenges of renovating historic properties in both economically depressed and well-to-do neighborhoods.

AGENDA

1. Set the stage: Building’s global role. Relics or Rejuvenation.

2. Describe the process of assessment to determine opportunities and constraints.

3. Explain the building science issues to be aware of using case study examples.

4. Remind us of the big picture.

5. Discussion and Q & A.
EFFICIENT BUILDINGS ARE LESS EXPENSIVE THAN POWER PLANTS

THE BUILDING SECTOR OFFERS THE GREATEST OPPORTUNITIES TO REALIZE ENERGY SAVINGS

WHAT’S YOUR ENERGY PROFILE???

Site Energy Consumption

- Specific heating demand (TFA-30%)
  - New < 4.75 kBtu/sq ft/yr
  - Retrofit < 8.00 kBtu/sq ft/yr
  - Primary Energy < 38.10 kBtu/sq ft/yr

- Convert to Site energy (factor of 2.71)
  - Primary Energy = 14.1 kBtu/sf/yr

Site energy consumption US single family

- 1975 = 94.5 kBtu/sf/yr
- 2009 = 105 kBtu/sf/yr
- Multi family
  - 2009 = 77.0 kBtu/sf/yr

RESNET HERS Rating Scale

- Passive House – Heat demand (TFA-30%)
  - Typical Standard New Home = 100
  - Typical New Home = 164
  - Typical 1998 Survey = 60
  - Passive House = 0

1998 Survey 1 of 100 houses < 5.0 ACH<sub>50</sub>
20 of 100 houses > 20.0 ACH<sub>50</sub>
Mean of 12,000 buildings = 29.7 ACH<sub>50</sub>
What is Passive House? (PassivHaus)

Science based
Conservation focused
Better built
Cost effective
= SMART DESIGN

Efficient, comfortable, healthy
ZEC - Zero Energy Capable

SINGLE FAMILY ADDITION
Philadelphia, PA
BluPath, Architect
Green Builder Green Home of the Year “Best Life Cycle Extension”

SINGLE FAMILY RENOVATION
Philadelphia, PA
BluPath, Architect
High School Retrofit
Blaeswiler, Germany
Ludwig Rongen, Architect

Multi-family Historic Retrofit
McKeesport YMCA, ACTION-HOUSING
Pittsburgh, PA
Thoughtful Balance, Architect

Renovation of Colonial Hospital
Eschwege, Germany
Willi Krinscher - Partner, Architect

Coffee Analogies
ECONOMICS OF PASSIVE HOUSE
RETURN ON INVESTMENT
LIFE CYCLE ANALYSIS
PRESENT VALUE ANALYSIS

\[
\text{Price of Saved Energy} = \frac{(a_{\text{pan}} \cdot (l_{\text{add}} \cdot R) + Z)}{E_{\text{saved}}}
\]

\[
\text{Net Present Value (NPV)} = K_0 \cdot \frac{1-(1+p)^{-n}}{p}
\]

BENEFITS BEYOND ENERGY SAVINGS
LONG TERM VALUE

Envelope is permanent to the building
Less or smaller mechanical equipment
Lower O&M costs
BENEFITS BEYOND ENERGY SAVINGS

LABOR IS LOCAL

PEOPLE POWER IS A RENEWABLE RESOURCE
Contributes to the local economy

BENEFITS BEYOND ENERGY SAVINGS

LOWER RISK – MORE DURABLE

Studies show most envelope failures are from air leakage and thermal bridging

BENEFITS BEYOND ENERGY SAVINGS

HIGHER PRODUCTIVITY

More comfortable, healthier indoor air quality higher user satisfaction

BENEFITS BEYOND ENERGY SAVINGS

MORE FUTURE-PROOF – SURVIVABLE
Mitigates issues surrounding extreme weather global energy and material availability, cost and scarcity

ASSESSMENT

Know your science facts
Correct tools Prioritize
Be honest Be brave
Future-plan Future-proof

ASSESSMENT

Relic or Rejuvenation
Fabric or Feature
PASSIVE HOUSE CONCEPTS

- Super Insulated Air Tight Shell
  - Blower Door Test for Air Tightness

- Optimized Solar Energy
  - Orientation, wind and rain
  - Opportunities & Constraints

- Continuous Ventilation
  - Building Dynamics and Healthy IAQ
  - (know your science)

- Efficient Appliances
  - Planned and Phased Obsolescence
  - Future Proof and Future Planning

- Accurate and Proven Analysis
  - Hygrothermic Modeling and Testing
  - (every model has a bias)
Passive House + Solar Array = Net Zero Energy

Plan for Future Optimization

25 Years + 55,000 Units (2012)

(Ask us about Brussels 2015)

Typical building  Passive House

EFFICIENT

COMFORTABLE

Minimize Disequilibrium

Masonry moisture testing

4" dense pack cellulose without interior vapor barrier
Energy Retrofit Strategies and Case Studies for Historic Homes

4" dense pack cellulose with smart interior vapor barrier

6" dense pack cellulose with smart interior vapor barrier

8" dense pack cellulose with smart interior vapor barrier

Thermal Bridge Design & Analysis

Why?

Party wall air sealing and blower door test

Tioga United-Home Ownership Program
“Right-Size” the Building
Amputation: lose the leg, save the patient

Seal & Insulate, Use new “Smart Product”

“Right-Size” Equipment, Be a Good Neighbor

Nothing’s Perfect

SINGLE FAMILY HISTORIC RENOVATION
Washington, DC
BluPath, Architect
Pre construction usage = 57.5 kbtu/sf/yr  
Gas, oil heat & electric AC, lights, plug load  
Electric only = 19.22 kbtu/sf/yr

Post construction usage  
Electric usage = 17 kbtu/sf/yr  
Heat pump 2nd & 3rd fl, lights, plug load  
(water usage increased 40%-teenage boys)  
Gas usage ??? kbtu/sf/yr

Extrapolation suggest 50% reduction

Dense pack cellulose  
without a smart vapor barrier

Lapping sill ?!?  
Exterior duct !?!
Air seal and insulate using creative details

1st Solar PV Array on Historically Certified Residence in Philadelphia

Precedent- 3 noisy neighboring air handlers

What you see from the muse

Too many systems

Based on TFA
1st year total usage = 6.29 kbtu/sf/yr
with PV generation = 3.55 kbtu/sf/yr

3rd year total usage = 5.31 kbtu/sf/yr
with PV generation = 2.57 kbtu/sf/yr

Why?

Building reaches equilibrium
**Civic House Feasibility Study**  
*University of Pennsylvania*

**Existing**  
**Passive House**

### ENVELOPE

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<tr>
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<th>X</th>
<th>W</th>
<th>PH</th>
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<tbody>
<tr>
<td>Air Tightness</td>
<td>20.0 ACH50</td>
<td>5.0 ACH50</td>
<td>0.6 ACH50</td>
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<tr>
<td>Windows R</td>
<td>R1</td>
<td>R8</td>
<td>R8+</td>
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<tr>
<td>Crawlspace floor</td>
<td>R4</td>
<td>R53</td>
<td>R53</td>
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<tr>
<td>Basement slab</td>
<td>R1</td>
<td>R1</td>
<td>R20</td>
</tr>
<tr>
<td>Basement walls</td>
<td>R6/R4</td>
<td>R19/R35</td>
<td>R47/R21</td>
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<tr>
<td>Roof</td>
<td>R24/32</td>
<td>R36/R71</td>
<td>R80/R82</td>
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### ENERGY USAGE

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<tr>
<td>Energy Usage (kBTU/gsf/yr)</td>
<td>65.00</td>
<td>17.89</td>
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<td>Carbon emission (Lb/gsf/yr)</td>
<td>10.00</td>
<td>8.00</td>
<td>6.00</td>
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<tr>
<td>Utility Cost ($/gsf/yr)</td>
<td>$1.00</td>
<td>$0.27</td>
<td>$0.19</td>
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<tr>
<td>Savings ($/yr)</td>
<td>$4,512</td>
<td>$5,573</td>
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<tr>
<td>Renovation Costs ($/gsf/yr - $/sf/yr)</td>
<td>$106-129</td>
<td>$144-176</td>
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### CIVIC HOUSE LESSONS LEARNED

- **PH STANDARD WAS MET WITHOUT SOLAR GAIN**
- **POOR SOLAR ORIENTATION**
- **NO FREE ENERGY = HIGHER CONSTRUCTION COSTS**
- **SIZE AND OCCUPANCY**
- **ASSEMBLY SPACE = ADDITIONAL EQUIPMENT**
- **PROJECT SCOPE**
- **ALL COSTS ARE NOT ENERGY RELATED**
- **ACCURACY OF COST ESTIMATE**
- **USE ESTIMATOR FAMILIAR WITH PASSIVE BUILDING METHODS AND MATERIALS**
CIVIC HOUSE LESSONS LEARNED

INSTITUTIONS HAVE NEEDS AND GOALS
GOALS MAY CONFLICT WITH
ACHIEVING PASSIVE HOUSE STANDARD

COMPARATIVELY SMALL ENERGY USE
$8000 ANNUAL ENERGY COST

CAMPUS PLANNING GOALS
BUILDING MAY BE REPLACED IN 20 YEARS

1 YEAR FINANCIAL PAYBACK
ENERGY SAVINGS IS LONG TERM BENEFIT

WHY IS PASSIVE HOUSE GOOD FOR BIGGER BUILDINGS?

SURFACE TO VOLUME RATIO

6 / 1 = 6
24 / 8 = 3
96 / 64 = 1.5

SURFACE TO VOLUME RATIO
LOWER IS BETTER

A skyline of work. One at a time.

Thermal Components:
Performance breakdown towards PH goal
Thermal Components: How much do they cost?

62Msf or 65,000 NYC apts. renovated to PASSIVE HOUSE = A single 1.2MW Coal power plant

ANOTHER PERSPECTIVE ON ENERGY USE

62Msf or 65,000 NYC apts. renovated to PASSIVE HOUSE = A single 1.2MW $2B Coal power plant
60% of the world’s buildings will be rebuilt in the next two decades. “That is a huge opportunity if we do it right.”

– Ed Mazria, Architecture 2030

25-75 years between renovations

Wasted $$

Missed opportunities

**RESOURCES**

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<tr>
<th>PHIUS</th>
<th>Passive House Institute US</th>
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<td>passivehouse.us</td>
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<th>PHAUS</th>
<th>Passive House Alliance US</th>
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<th>PHI</th>
<th>Passive House Institute (Germany)</th>
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<td>passiv.de/en/</td>
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<th>IPHA</th>
<th>International Passive House Association</th>
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<td>passivehouse-international.org</td>
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<th>North American Passive House Network</th>
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<td>northamericanpassivehousenetwork.com</td>
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<th>ZERO ENERGY READY HOMES</th>
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<td>energy.gov/eere/buildings/zero-energy-ready-home</td>
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<th>LEED</th>
<th>Building rating system</th>
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<td>new.usgbc.org/leed</td>
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<th>2000 WATT SOCIETY</th>
<th>Global energy effects</th>
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<td>novatlantis.ch/en/2000-watt-society</td>
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<tr>
<th>THE CLIMATE TRUST</th>
<th>Climate solutions for government, utilities and large businesses</th>
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<td>climatetrust.org</td>
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<th>WORLD CLASS SUPPLY</th>
<th>High performance building supply, worldclasssupply.com</th>
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<th>FOURSEVENFIVE</th>
<th>High performance building supply, foursevenfive.com</th>
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<th>FENTREND</th>
<th>High performance window consultants, fentrend.com</th>
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<th>STRUCTURESdb</th>
<th>Design-build, structuresdb.com</th>
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**RESOURCES**

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**BLUPATH**

Inspiring Design for Places to Thrive

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