LOW ENERGY BUILDING
DESIGN MORPHOLOGY

Process and case studies

Richard Pedranti, AIA

Richard Pedranti Architect

September 21, 2018
TIMELINE OF BUILDING MORPHOLOGY
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CLIMATE AND FORM

Climate and Form diagram from chapter 1

Heating, Cooling, and Lighting as Form Givers in Architecture
Norbert Lechner
2015
Heating, Colling, Lighting : sustainable design methods for architects
DESIGN METHODOLOGY

RPA DESIGN METHODOLOGY DIAGRAM

SITE AND FORM

ENERGY EFFICIENCY
- INSULATION
- AIR SEALING
- WINDOWS
- THERMAL BRIDGE FREE

CONSERVATION
- CLIMATE ZONE
- ORIENTATION
- BUILDING MORPHOLOGY
- SHADING

ENCLOSURE

CLIMATE

BUILDING ENERGY PYRAMID

HERS INDEX

BUILDING STANDARDS

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DESIGN METHODOLOGY

RPA DESIGN METHODOLOGY DIAGRAM

SITE AND FORM

BUILDING ENERGY PYRAMID

SMART SYSTEMS
- RENEWABLE ENERGY
- WATER DISTRIBUTION
- HEATING & COOLING
- VENTILATION

ENERGY EFFICIENCY
- INSULATION
- AIR SEALING
- WINDOWS
- THERMAL BRIDGE FREE

CONSERVATION
- CLIMATE ZONE
- ORIENTATION
- BUILDING MORPHOLOGY
- SHADING

SYSTEMS

ENCLOSURE

CLIMATE

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RPA DESIGN METHODOLOGY

RPA DESIGN METHODOLOGY DIAGRAM

SYSTEMS

ENCLOSURE

CLIMATE

SITE AND FORM

BUILDING ENERGY PYRAMID

HERS INDEX

BUILDING STANDARDS

PEB (POSITIVE ENERGY BUILDING)

ZEB (ZERO ENERGY BUILDING)

PH

PASSIVE HOUSE

ZERH

ENERGY STAR

REFERENCE HOME

EXISTING HOMES

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Case Study 1

Scranton Passive House

OUR FIRST PASSIVE HOUSE
Site: Urban neighborhood
SCRANTON PASSIVE HOUSE

- Mechanical core
- Environmental separator
- Daylighting core
SCRANTON PASSIVE HOUSE

SOUTH
SCRANTON PASSIVE HOUSE

MORPHOLOGY

SVR 0.32
GLASS 14%
SOUTH GLASS 47%

5KW PV

ROOF R=91
WALL R=61
SLAB R=76

ENVELOPE R VALUE = 36.2

GENERAL INFO
SCRANTON, PA
2,153 SQFT
CLIMATE ZONE 5/6
HERS 28
PV TO ZERO 5KW

MECHANICAL
BALANCED VENTILATION
HEAT / COOL
HOT WATER
WINDOWS

RENEWAIRE ERV
MITSUBISHI ASHP
GE HWHP
INTUS EFORTE

PASSIVE HOUSE METRICS
ANNUAL HEAT DEMAND 4.52 KBTU/(FT2YR)
HEAT LOAD 2.75 KBTU/(FT2YR)
PRIMARY ENERGY 31.5 KBTU/(FT2YR)
AIR TIGHTNESS 0.47ACH@50PA
TREATED FLOOR AREA 1,750 SQFT.
SCRANTON PASSIVE HOUSE

2017 PASSIVE HOUSE OF THE YEAR
This simple, traditional, PHIUS design offers a clear path to a solid sustainable home.

GREEN BUILDER MAGAZINE
OPTIMIZED BUILDING MORPHOLOGY

WEST

Optimized solar orientation

EAST
Efficient geometry

Optimized solar orientation

WEST

EAST
Efficient geometry

Compact volume (Form)

Air tight volume

Optimized solar orientation

EAST

WEST
Efficient geometry
Compact volume (Form)
Air tight volume
Optimized solar orientation

High R value enclosure (TB free)
Efficient geometry
Compact volume (Form)
Air tight volume
High R value enclosure (TB free)
Optimized solar orientation
Careful window placement and ratios
Careful shading
Optimized building morphology
Efficient geometry
Compact volume (Form)
Air tight volume
Optimized solar orientation
High R value enclosure (TB free)
Careful window placement and ratios
Mechanical core
Careful shading

WEST

EAST
Efficient geometry

Compact volume (Form)

Air tight volume

High R value enclosure (TB free)

Simple ventilation layout
DHW Heating

Careful window placement and ratios

Mechanical core

Careful shading

Optimized solar orientation

Optimized building morphology
Efficient geometry
Compact volume (Form)
Air tight volume
Optimized solar orientation
Renewables
High R value enclosure (TB free)
Simple ventilation layout
DHW Heating
Careful window placement and ratios
Mechanical core
Careful shading
Optimized building morphology
Efficient geometry

Compact volume (Form)

Air tight volume

Optimized solar orientation

High R value enclosure (TB free)

Simple ventilation layout

DHW Heating

Careful window placement and ratios

Mechanical core

Daylighting core

Careful shading

Renewables

Optimized building morphology
Science / Quantitative

Orientation
Compact volume (Form)
Efficient geometry (SVR)
R value
Glazing placement
Glazing ratios
Shading
Thermal bridging
Air tightness
Ventilation
Water management
Vapor management
System design
Equipment efficiency
Renewables
DESIGN PARAMETERS

A  Science / Quantitative
Orientation
Compact volume (Form)
Efficient geometry (SVR)
R value
Glazing placement
Glazing ratios
Shading
Thermal bridging
Air tightness
Ventilation
Water management
Vapor management
System design
Equipment efficiency
Renewables

B  Architecture / Qualitative
Place
Landscape
Aesthetics
Order
Technology
Social patterns
Culture
Structure
Materials
Experience
Comfort
Health
Light
Sound
Space
LOW ENERGY BUILDING DESIGN MAP

A  Science / Quantitative
- Orientation
- Compact volume (Form)
- Efficient geometry (SVR)
- R value
- Glazing placement
- Glazing ratios
- Shading
- Thermal bridging
- Air tightness
- Ventilation
- Water management
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- System design
- Equipment efficiency
- Renewables

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LOW ENERGY BUILDING DESIGN MAP

A  Science / Quantitative
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B  Architecture / Qualitative
- Place
- Landscape
- Aesthetics
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- Social patterns
- Culture
- Structure
- Materials
- Experience
- Comfort
- Health
- Light
- Sound
- Space
A  Science / Quantitative

Orientation
Compact volume (Form)
Efficient geometry (SVR)
R value
Glazing placement
Glazing ratios
Shading
Thermal bridging
Air tightness
Ventilation
Water management
Vapor management
System design
Equipment efficiency
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B  Architecture / Qualitative

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Landscape
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Health
Light
Sound
Space

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The art of optimizing BOTH “sides” is where successful Passive House design separates itself from simply achieving energy efficiency.
Quantitative

1. SOLAR ORIENTATION
2. HIGH INSULATION
3. HIGH PERFORMANCE WINDOWS
4. AIR TIGHT CONSTRUCTION
5. BALANCED VENTILATION

Experience

1. COMFORT
2. AIR QUALITY
3. SOUND AND DAYLIGHT
4. SIMPLICITY
5. BEAUTY
Case Study 2

Soeder Passive House

A HOME IN THE COUNTRY
Site: Rural farm country with views
SOEDER PASSIVE HOUSE

- **Mechanical core**
- **Environmental separator**
- **Daylighting core**
GENERAL INFO
BECHTELSVILLE, PA
2,600 SQFT
CLIMATE ZONE 5/6
HERS 30
PV TO ZERO 6KW

MECHANICAL
BALANCED VENTILATION
ZEHNDE 350
HEAT / COOL
MITSUBISHI ASHP
HOT WATER
GE HWHP
WINDOWS
INTUS EFORTE

PASSIVE HOUSE METRICS
ANNUAL HEAT DEMAND 4.75 KBTU/(FT2YR)
HEAT LOAD 2.84 KBTU/(FT2YR)
PRIMARY ENERGY 34.5 KBTU/(FT2YR)
AIR TIGHTNESS 0.22 ACH@50PA
TREATED FLOOR AREA 2,440 SQFT.

SVR 0.32
GLASS 14%
SOUTH GLASS 51%

WALL R=60
FOUNDATION R=42

ROOF R=100

ENVELOPE R VALUE = 38.5

SOEDER PASSIVE HOUSE
This is a great performing home… The design of the home was also very well executed, with plenty of room for the family and a sense of space in a small footprint.

*Chris McTaggart*
*BER, HERS manager*
*PHIUS+ QA manager*
SOEDER PASSIVE HOUSE
Diagram of Passive House Envelope Calculations

Major Comfort Criteria
- 68°F during heating season
- 72°F during the cooling season
- 64°F surface temperature
- Max AT: 7.2°F
- 68°F = 1W/ft²
- 40% - 50% humidity on inside

Calculation of the Interior Surface Temperature of an Assembly
- RSI = U - U' + R' - (R' - R)

Calculation of the Specific Transmission Loss
- H = ∑ A/μ + ∑ V/μ + ∑ X

Below grade
- RSI = 0.0
- FC = 55

Thermal Bridge Free Construction
- H = 2 A μ + Δ H

Diagram created by Alan Benoît and Richard Pedranti during CPHC training at Yestermorrow in 2012
It’s a box
It’s not
a box
Frank Lloyd Wright and the Destruction of the Box
H. Allen Brooks
March 1979
Journal of the Society of Architectural Historians
Fig. 10. A: typical room with walls joined at four corners. B: Wright's first step: eliminate the corners, thus turning the walls into freestanding, movable slabs. C: Wright's second step: define, by reassembling segments of these slabs, a new spatial context that integrates the former functions of the demolished rooms; this is the schematic plan of a Usonian house (author after Wright).
Case Study 3

Keffer Passive House

BREAKING THE BOX
Site: In a forest on a lake
Site: In a forest on a lake
KEFFER PASSIVE HOUSE

Daylighting core
Box 1

Mechanical core
Box 2

Environmental separator

Green box is Kitchen volume
"Passive House" is today's most energy efficient building standard. Buildings that meet the Passive House standard use 80% less energy for heating and cooling than conventional buildings and are markedly more comfortable and healthy than traditional buildings. A Passive House conserves energy by creating a virtually air-tight, super insulated, compact building envelope that uses the sun and heat emitted from people and equipment to achieve a comfortable indoor environment. A ventilation system including what is called a heat recovery ventilator or HRV is used to provide a continuous supply of filtered fresh air. Added all together, Passive House offers a triple bottom line: (1) personal health and comfort, (2) energy efficiency, and (3) affordability.
KEFFER PASSIVE HOUSE
KEEFFER PASSIVE HOUSE

MORPHOLOGY

SVR 0.34
GLASS 15%
SOUTH GLASS 67%

GENERAL INFO
HAWLEY, PA
2,900 SQFT
CLIMATE ZONE 5
HERS 32
PV TO ZERO 7KW

MECHANICAL
BALANCED VENTILATION
ZEHNDE 350
HEAT / COOL
MITSUBISHI ASHP
HOT WATER
NYLES GEYSER
WINDOWS
INTUS EFORTE

PASSIVE HOUSE METRICS
ANNUAL HEAT DEMAND 4.65 KBTU/(FT2YR)
HEAT LOAD 2.93 KBTU/(FT2YR)
PRIMARY ENERGY 27.3 KBTU/(FT2YR)
AIR TIGHTNESS 0.29 ACH@50PA
TREATED FLOOR AREA 2,304 SQFT.

ROOF R=100
WALL R=62
SLAB R=76

ENVELOPE R VALUE = 38.5
“The passive house structure’s large south-facing windows provide lots of natural light.”

Lynn Keffer
LESSONS LEARNED

1. SITE

Site: Urban neighborhood

Site: Rural farm country with views

Site: In a forest on a lake
LESSONS LEARNED

1. SITE

- Site: Urban neighborhood
- Site: Rural farm country with views
- Site: In a forest on a lake

2. FORM

- Site
- Form
LESSONS LEARNED

1. SITE

Site: Urban neighborhood
Site: Rural farm country with views
Site: In a forest on a lake

2. FORM

3. SPACE
RESOURCES

Heating, Cooling, Lighting
Sustainable Design Methods for Architects
Norbert Lechner
Wiley 2015

Frank Lloyd Wright and the Destruction of the Box
H. Allen Brooks
Journal of the Society of Architectural Historians 1979

Design With Climate
Biolclimatic approach to architectural regionalism
Victor Olgyay
Princeton University Press 1963

Transparency: Literal and Phenomenal
Colin Rowe and Robert Slutzky
Perspecta, Volume 8 1963
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