An Introduction to Passive House:
Cornerstone of Our Post Carbon Future

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www.naphnetwork.org
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Regional Groups Working in Cooperation

NAPHN: A Continental Network

in support of professionals working with the international Passive House Standard
2 - THE PASSIVE HOUSE STANDARD

THE INTERNATIONAL LEADING LOW ENERGY BUILDING STANDARD

1st Modern Passive House: 1990

A reliable method to design new constructions & retrofit existing buildings

26-Story Passive House Building: 2017

More than 85,000 buildings of all kinds around the world in every climate zone
Comfort Drives Performance

Business as usual

Passive House
PASSIVE HOUSE FUNDAMENTALS

A Passive House is a building that requires very little heating or cooling energy to deliver a high level of occupant comfort.

Primary Features:
1. Highly Efficient
2. Excellent Comfort
3. Superior Health

Outcomes are:
1. Energy affordability
2. Resiliency
3. Grid Stability
4. Very low emissions
5. Supports renewables
RESULTING IN DRAMATIC ENERGY SAVINGS

Approx 90% reduction in heating & cooling

Up to 75% reduction in total energy usage.

![Graph comparing energy consumption of old buildings, low energy buildings, and passive houses](chart.png)

- Old buildings: 180 kWh/m²a
- Low energy buildings: 66 kWh/m²a
- Passive houses: 13.4 kWh/m²a

**Examples:**
- 63 row houses in Heidelberg (Bj. 1962)
- 41 low energy houses Niedernhausen 1991
- 27 low energy houses, Hessia
- 22 houses, PH settlement Wiesbaden 1997
- 32 passive houses Kronsberg 1998
2000:

250 dwelling units in 14 different building projects as Passive House Buildings
FROM PUBLIC POLICY TO CODES: Example

New York: 80 x 50 adopted by city & state
Incentives & Mandates:
Affordable Housing
City owned buildings
Vancouver, British Columbia: Plan to decarbonize
Incentives & Mandates – Zoning
Building codes
**BOLD IMPLEMENTATION**

**BRUSSELS, 2015:** All buildings, private, public, new and retrofitted *mandated* Passive House performance.

**EUROPE, 2020:**
Nearly zero-energy buildings.
NOT A TYPICAL “COST-PLUS” PARADIGM

Brussels: City Block Multi-Use Complex – Competitive Design-Build Bids

eu 1,225/m² vs. eu 1,362/m² average
NOT A TYPICAL “COST-PLUS” PARADIGM

PHFA Multifamily Housing Around Philadelphia Region = 17 Buildings

$206/sf vs. $208/sf average
HOW IS THIS POSSIBLE?

Integrated Goals & Methodology:

1. Focus on Passive Elements:
   - Orientation
   - Massing
   - Insulation
   - Airtightness
   - Windows
   - Doors
   - Passive Heat Gains

2. Fixed Performance Goals:
   - **Heating**: 4.75Kbtu/sf2*a demand or 3.17 btu/hr*sf peak load
   - **Cooling & Dehumidification**: 4.75Kbtu/sf2yr + climate specific dehumidification
   - **Primary Energy**: ~38Kbtu/ft2yr*
   - **Airtightness**: tested limit 0.6 ACH50

3. Calculated Energy Balance:
   - **Passive House Planning Package** (PHPP)

"Peak Load Equivalent"
For 1,000 sq ft house

* This is the original “Source EUI” metric. The calculation now is for Primary Energy Renewable (PER) and is no longer directly comparable to EUI but still roughly corresponds to this original number for Passive House Classic certification.
QUALITY ASSURANCE

Tools enabling predictability:

Certified Professionals:

Energy Model Design Tool & Manual:

Certified Components:

Certified Buildings:

Reference Materials:

Global Research:

www.passivehouse.com
METRICS FOR NEW-BUILD CERTIFICATION

...for energy efficiency and renewables

38

Energy generation [kBtu/ft²/yr]

plus

19

Energy demand [kBtu/ft²/yr]

9.50

14.25

19.00

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PER-factor = \frac{\text{Energy supplied from RE sources}}{\text{Finaly energy demand}}
Most of what will be, has already been built.
INTEGRATED METHODOLOGY

Five Key Principles:

1. Climate Specific Insulation Levels
2. Thermal Bridge Free Connections
3. High-Performance Windows/Doors
4. Airtightness
5. High Efficiency Heat Recovery Ventilation
1. CONTINUOUS INSULATION

Insulation levels are climate dependent.

(Think of temperature rated sleeping bags.)

Surrounding enclosed space like a parka.
CALCULATING R-VALUES (HETEROGENEOUS ASSEMBLIES)

\[ R_{\text{overall}} = \left( \frac{R_{\text{Parallel Path}} + R_{\text{Isothermal Planes}}}{2} \right) \]

**Parallel Path Method:**

- \( R_{\text{si}} \)
- \( R_{\text{GWB}} \)
- \( R_{\text{insul.}} \)
- \( R_{\text{OSB}} \)
- \( R_{\text{se}} \)

**Isothermal Planes Method:**

- \( R_{\text{si}} \)
- \( R_{\text{GWB}} \)
- \( R_{\text{Wood}} \)
- \( R_{\text{OSB}} \)
- \( R_{\text{se}} \)
2. NO THERMAL BRIDGES

Prevents:
• Condensation & moisture damages
• Thermal discomfort
• Energy losses

Not included in traditional energy models.

Eliminate and calculate: lowers risks and increases predictability.
The Pencil Rule

Thermal-bridge-free designing

Ψ < 0.006 Btu/(hr.ft. °F)

Source: PHI, Author: JS
3. INTEGRATED WINDOWS & DOORS

- Performance criteria are climate dependent.

Must maintain enclosure continuity of airtightness and insulation.
WINDOWS & SHADING
4. CONTINUOUS AIRTIGHTNESS

Tested airtightness limit of 0.6 ACH50

Airtightness is a driving force of performance.
PHI REQUIREMENT FOR PERLITA HOUSE

TYPICAL NEW CONSTRUCTION (x10)
5. VENTILATION

Characteristics:
• High efficiency heat recovery
• Balanced
• Distributed
• Continuous
• Low flow rates

Controlled high indoor air quality possible using very little energy.
The distribution of ventilation (fresh air supply and stale air extraction) should use as little ductwork as possible but still provide air flow through the entire building:

In the transfer zone – not supplying, not extracting – just ‘passing through’

Openings for transferred air
**Introduction to Passive House**

**H/ERV**

- **Outdoor air intake:** fresh air into unit
- **Exhaust:** post-recovery air to outside
- **Supply air:** fresh air into living rooms, offices, classrooms
- **Extract air:** stale air from baths/kitchens/stores

[Diagram of H/ERV system showing airflow directions and components.]
It is happening in California
Why a Passive House Reach Code?

2013 Study found **PH delivers 39% to 83% reduction** in heating & cooling in **all sixteen California Climate Zones**

Source: 2013 Study by PHCA Member, Graham Irwin, Essential Habitat.
PHPP is now ASHRAE 140 verified

Results of PHPP version 9.6 compared to the reference tools and the confidence range in green, arranged according to magnitude of the results.

Introduction to Passive House

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Why a Passive House Reach Code?

- Requested by City of Santa Monica
- PHCA Strategic Plan led to focus on: Low-rise Multifamily

California’s 2019 Reach Code: A Passive House Pathway

December 18, 2018

Source:
http://www.passivehousecal.org/sites/default/files/media/PHCA%202019%20Reach%20Code%20Report_FINAL.pdf
Why a PH Multifamily Reach Code?

- Bigger buildings are more cost effective
- Larger buildings are easier to air-seal
- Larger buildings need less insulation (lower embodied energy)
- Multifamily buildings support transit & lower vehicle emissions
- Multifamily buildings address our housing crisis
- Other regions are having GREAT SUCCESS with MF.

### 268 Proposals to Pennsylvania Housing Finance Agency (2015-2018)

**DATA SOURCE:** Pennsylvania Housing Finance Agency

- CONVENTIONAL (Total=194)
- AVG. CONVENTIONAL = $175/SF
- PASSIVE HOUSE (Total=74)
- AVG. PASSIVE HOUSE = $173/SF
Results are VERY EXCITING!

"In almost all cases, the EDR Margins achieved by the Passive House designs exceed the EDR Margin targets, and in most cases, the Passive House EDR Margin is significantly higher than the target EDR Margins defined in the report."

CBECC-Res vs PHPP output differences:

- Infiltration
- Heat Recovery Ventilation
- Duct Leakage assessment
- Attic Design
### Results are VERY EXCITING!

#### Mixed Fuel EDR Margin

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>2019 Reach Code Targets</th>
<th>Passive House Model</th>
<th>% Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Arcata</td>
<td>2</td>
<td>10</td>
<td>400%</td>
</tr>
<tr>
<td>2 – Santa Rosa</td>
<td>1.5</td>
<td>5.6</td>
<td>273%</td>
</tr>
<tr>
<td>3 - Oakland</td>
<td>0.5</td>
<td>3.6</td>
<td>620%</td>
</tr>
<tr>
<td>4 – San Jose</td>
<td>1</td>
<td>3.2</td>
<td>220%</td>
</tr>
<tr>
<td>5 – Santa Maria</td>
<td>0.5</td>
<td>3.5</td>
<td>600%</td>
</tr>
<tr>
<td>6 – Torrance</td>
<td>1</td>
<td>1.5</td>
<td>50%</td>
</tr>
<tr>
<td>7 – San Diego</td>
<td>0.5</td>
<td>0.5</td>
<td>0%</td>
</tr>
<tr>
<td>8 – Fullerton</td>
<td>1</td>
<td>1</td>
<td>0%</td>
</tr>
<tr>
<td>9 – Burbank</td>
<td>1.5</td>
<td>1.6</td>
<td>7%</td>
</tr>
<tr>
<td>10 – Riverside</td>
<td>1.5</td>
<td>2.2</td>
<td>47%</td>
</tr>
<tr>
<td>11 – Red Bluff</td>
<td>2.5</td>
<td>6.4</td>
<td>156%</td>
</tr>
<tr>
<td>12 – Sacramento</td>
<td>1.5</td>
<td>5.2</td>
<td>247%</td>
</tr>
<tr>
<td>13 – Fresno</td>
<td>3</td>
<td>8.2</td>
<td>173%</td>
</tr>
<tr>
<td>14 – Palmdale</td>
<td>3</td>
<td>6</td>
<td>100%</td>
</tr>
<tr>
<td>15 – Palm Springs</td>
<td>4</td>
<td>11.5</td>
<td>188%</td>
</tr>
<tr>
<td>16 – Blue Canyon</td>
<td>2</td>
<td>9.8</td>
<td>390%</td>
</tr>
</tbody>
</table>

#### All-Electric EDR Margin

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>2019 Reach Code Targets</th>
<th>Passive House Model</th>
<th>% Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Arcata</td>
<td>3</td>
<td>11.1</td>
<td>270%</td>
</tr>
<tr>
<td>2 – Santa Rosa</td>
<td>1.5</td>
<td>7.4</td>
<td>393%</td>
</tr>
<tr>
<td>3 - Oakland</td>
<td>0.00</td>
<td>3.6</td>
<td>NA</td>
</tr>
<tr>
<td>4 – San Jose</td>
<td>1</td>
<td>4</td>
<td>300%</td>
</tr>
<tr>
<td>5 – Santa Maria</td>
<td>0.5</td>
<td>4</td>
<td>700%</td>
</tr>
<tr>
<td>6 – Torrance</td>
<td>1</td>
<td>2.8</td>
<td>180%</td>
</tr>
<tr>
<td>7 – San Diego</td>
<td>0.5</td>
<td>1.3</td>
<td>160%</td>
</tr>
<tr>
<td>8 – Fullerton</td>
<td>1</td>
<td>1.4</td>
<td>40%</td>
</tr>
<tr>
<td>9 – Burbank</td>
<td>1.5</td>
<td>2.6</td>
<td>73%</td>
</tr>
<tr>
<td>10 – Riverside</td>
<td>1.5</td>
<td>3.5</td>
<td>133%</td>
</tr>
<tr>
<td>11 – Red Bluff</td>
<td>3.5</td>
<td>8.2</td>
<td>134%</td>
</tr>
<tr>
<td>12 – Sacramento</td>
<td>2.5</td>
<td>6.3</td>
<td>152%</td>
</tr>
<tr>
<td>13 – Fresno</td>
<td>3</td>
<td>8.8</td>
<td>193%</td>
</tr>
<tr>
<td>14 – Palmdale</td>
<td>3.5</td>
<td>7.1</td>
<td>103%</td>
</tr>
<tr>
<td>15 – Palm Springs</td>
<td>4</td>
<td>11.8</td>
<td>195%</td>
</tr>
<tr>
<td>16 – Blue Canyon</td>
<td>3</td>
<td>13.8</td>
<td>360%</td>
</tr>
</tbody>
</table>
Mixed Fuel RESULTS:

*Only CZ’s 7 & 8 do not exceed the 2019 EDR requirements*
All-Electric RESULTS:

Supports electrification - and ADDS THE MISSING EFFICIENCY!
Why support a PH Reach Code?

100% CALIFORNIA

A vision for the transition to 100% wind, water & solar energy

2050

PROJECTED ENERGY MIX

- Residential rooftop solar: 7.5%
- Solar plants: 26.5%
- Concentrating solar plants: 15%
- Onshore wind: 25%
- Offshore wind: 10%
- Commercial & government rooftop solar: 5.5%

Reducing Energy Demand

Improving energy efficiency and powering the grid with electricity from the sun and wind positively reduces the overall energy demand.

Current demand

Wind, water, solar

44%
Why numbers matter

EUI = the buildings’ MPG

EUI: Energy Use Intensity

LA Average: 39.7 kBtu/ft²
ASHRAE: 28 kBtu/ft²
PH Max: 14.8 kBtu/ft²
Perlita: 12.5 kBtu/ft²

T24 Min: 20 kBtu/ft²
T24 Max: 35 kBtu/ft²

PV* = Number of Photovoltaic panels for the Perlita House to reach Net Zero Energy

EUI = the buildings' MPG

EUI: Energy Use Intensity

Perlita PH
PH Max
ASHRAE
Average LA Buildings
Title-24 Minimum
Title-24 Maximum

Perlita PH
PH Max
ASHRAE
Average LA Buildings
Title-24 Minimum
Title-24 Maximum

PV* = Number of Photovoltaic panels for the Perlita House to reach Net Zero Energy
City & Utility Leadership: Pathways to Adoption?

**PROVIDE CARROTS (CITIES):**
- Increased FAR for projects that target PH
- Increased HEIGHT allowances for projects that target PH
- UPZONING for projects that target PH
- Initiate a City-Owned PH Pilot project
- Promote PH on your city website
- Train City Staff and Workforce
- Support & host PHCA trainings & events

**PROVIDE EDUCATION (UTILITIES):**
- Support GRANT subsidies for Passive House courses
- Provide incentives for Passive House pilot projects ($$$ & promotion)
- Support PHCA & NAPHN events

Example Policies: [https://drive.google.com/file/d/1x49Xmev6qaqfG-XDhzvq4TfdTqhviOa/view](https://drive.google.com/file/d/1x49Xmev6qaqfG-XDhzvq4TfdTqhviOa/view)
Resources:

City of Vancouver General Info: https://vancouver.ca/green-vancouver/build-a-passive-house.aspx

NYC General Info: https://www1.nyc.gov/site/hpd/developers/passive-house.page


Contact us: info@passivehousecal.org
Get Trained
Architects, Engineers, Consultants, Owners, Contractors, Real Estate Brokers, Policymakers…

Certified Passive House Designer/Consultant

> Los Angeles – January 27-31, 2020

> Los Angeles – May 30, 31 & June 5-7, 2020

www.passivehousecal.org