Keys to Successful Passive House Implementation
Group B, Deliverable 33 Case Study 5

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Imagine buildings that are …

• So well constructed they need virtually no heating or cooling and can cut normal utility bills by 50%–80%.
• So airtight there is almost no air leakage or outside street noise, yet they provide healthy, fresh, filtered air throughout the day whether windows or doors are open or not.
• Light, bright, spacious structures with modern architectural design.
• Designed to produce nearly zero carbon emissions when paired with high efficiency all electric appliances and on-site photovoltaics (PV).
• Can be residential or commercial, new construction or retrofit, and adaptable to historic, traditional, and contemporary aesthetics as well.
Passive House (PH) buildings aren’t pipe dreams.

- These “passive house” buildings are common in some parts of the world
  - Built worldwide for over 30 years
  - Applicable to all types of residential and commercial buildings
- Helpful for California for many resiliency challenges
  - Extreme weather conditions
  - Wildfire smoke
  - Antiviral air handling
  - Energy grid outages
- Despite these many advantages, buildings of this type are rare in the State of California

Passive House Design Principles

• To achieve these results, Passive Houses utilize five primary design strategies:

1. An airtight building envelope
2. Exceptionally high levels of insulation
3. Well insulated window frames and glazing
4. Thermal bridge free design and construction
5. Ventilation systems with high efficiency heat- and energy-recovery
Research Approach

– Assess status in California
– Conduct literature review
  • Find best examples of successful PH implementations throughout North America, Europe, and Australasia
  • Identify similarities across these disparate locations
– Interview 19 subject matter experts to understand the context, activities and outcomes associated with successful PH endeavors in their regions
Four Major Tools
to increase Passive House construction in California

1. Enacting Policy
2. Passing Codes
3. Catalyzing the Market
4. Building Capacity
Tool 1: Policy

- Set framework for planning strategies, codes, and other regulations
  - Top-down alignment of goals and policies
  - Bold policies and plans
Tool 2: Codes

- Codes support policy by establishing minimum standards, metrics, and methods for measuring compliance
  - Energy modeling alignment
  - Passive House code compliance path
  - Step codes with time-dependent performance targets
  - Compliance targets based on performance metrics. The three most important PH performance metrics include:
    - **Energy Use Intensity (EUI)** – measures total amount of energy externally provided to the structure for all end uses
    - **Greenhouse Gas Intensity (GHGI)** – measures total amount of energy supplied to the building multiplied by that energy’s carbon intensity
    - **Thermal Energy Demand Intensity (TEDI)** – measures building envelope performance based on the amount of heating or cooling that is required to maintain the building at a comfortable temperature
Tool 3: Catalysts

- Catalysts stimulate market action through financial means or via other incentives
  - Lead by example
  - Financial incentives
  - Nonfinancial incentives
  - Competitions for cash and other awards
  - Early examples of success
Tool 4: Building Capacity

• Capacity Building strives to ensure the availability of people and resources necessary for the accomplishment of the goal
  – Outreach and awareness
  – Workforce education and training
  – Expert advisors
  – Supply chain development
## Passive House Best Practices In Action

### Four Mini Case Studies

<table>
<thead>
<tr>
<th>Tools</th>
<th>Key Element</th>
<th>Brussels</th>
<th>New York</th>
<th>Vancouver</th>
<th>Pennsylvania</th>
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<td><strong>Policy</strong></td>
<td>Top-down alignment of goals and policies</td>
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<td>Compliance targets based on performance metrics</td>
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<td>Energy modeling alignment</td>
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<td><strong>Catalysts</strong></td>
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<td><strong>Capacity</strong></td>
<td>Outreach and awareness</td>
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<td>Workforce education and training</td>
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<td>Supply chain development</td>
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Top-down alignment of goals and policies, Bold policies and plans, Step codes with time-dependent performance targets, Passive House code compliance path, Compliance targets based on performance metrics, Energy modeling alignment, Leading by example, Financial incentives, Nonfinancial incentives, Competitions for cash and other awards, Early examples of success, Outreach and awareness, Workforce education and training, Expert advisors, Supply chain development.
Brussels Passive House Projects

GRAPHIC SOURCE: Sebastian Moreno-Vacca, A2M+M2A
Brussels, Belgium: All the Right Moves

*Brussels went from among Europe’s “worst to first” in building energy use in under ten years*

- In 2007 – Brussels set out to build very low energy, economical, and beautiful “Exemplary Buildings”
- In 2015 – Brussels became the first municipality in the world to require all new and renovated buildings conform to Passive House standards

**Highlights:**

1. Coordinated energy policy and building codes
2. Annual competitive design process
3. Subsidies, tax credits and green loans
4. Required sharing of performance and cost data
5. Capacity-building training and education programs
6. Technical expertise and support for obstacles
7. Support market for necessary PH building components
Median EUI of NYC Buildings – Built to Code Compared to Passive House (kBtu/SF/Year)

New York: An Integrated State and Local Effort

New York State and New York City work in tandem to reach tough climate goals

• Highlights:
  1. Aligned state and local goals, policy directives, and strategic plans
  2. Performance-based step codes – AND – alternative, compliance path for PH
  3. Time-dependent targets with penalties for noncompliance
  4. Outreach and stakeholder engagement
  5. Training and education funding
  6. Knowledgeable advisors
  7. Commitment to passive house strategies for all new and retrofit buildings
  8. Financial and non-financial incentives
  9. Requirement to provide performance and cost data
  10. Supply chain / market transformation support
### BC Step Codes

<table>
<thead>
<tr>
<th>Step</th>
<th>Airtightness</th>
<th>Equipment and Systems</th>
<th>Envelope</th>
<th>Approximate Equivalency</th>
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<tbody>
<tr>
<td><strong>Step 1:</strong> enhanced compliance</td>
<td>3.5 ACH&lt;sub&gt;50&lt;/sub&gt;</td>
<td>BCRC using 9.36.5 or ERS v15 ref. house (MEUI of 80 kWh/m²/year is likely, not required)</td>
<td>Report on TEDI and PTL (TEDI 50 kWh/m²/year is likely, not required)</td>
<td>Energy Guide Rating System, Built Green Bronze</td>
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<td><strong>Step 2:</strong> 10% beyond code</td>
<td>3.0 ACH&lt;sub&gt;50&lt;/sub&gt;</td>
<td>10% better than ERS v15 or MEUI – 60 kWh/m²/year</td>
<td>TEDI 45 kWh/m²/year or PTL – 35 W/ m²</td>
<td>Built Green Silver</td>
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<td><strong>Step 3:</strong> 20% beyond code</td>
<td>2.5 ACH&lt;sub&gt;50&lt;/sub&gt;</td>
<td>20% better than ERS v15 or MEUI – 45 kWh/m²/year</td>
<td>TEDI 40 kWh/m²/year or PTL – 30 W/ m²</td>
<td>ENERGY STAR®, Built Green Gold and Platinum</td>
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<td><strong>Step 4:</strong> 40% beyond code</td>
<td>1.5 ACH&lt;sub&gt;50&lt;/sub&gt;</td>
<td>40% better than ERS v15 or MEUI – 35 kWh/m²/year</td>
<td>TEDI 25 kWh/m²/year or PTL – 25 W/ m²</td>
<td>R2000</td>
</tr>
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<td><strong>Step 5:</strong> 50% beyond code</td>
<td>1.0 ACH&lt;sub&gt;50&lt;/sub&gt;</td>
<td>No ERS option</td>
<td>TEDI 15 kWh/m²/year or PTL – 10 W/ m²</td>
<td>Passive House, Net-Zero Energy-Ready</td>
</tr>
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Vancouver, Canada: An Orchestrated Approach

Vancouver leaders studied Brussels and New York and executed a comprehensive climate strategy

- Highlights:
  1. Climate goals aligned with strategic plans
  2. Performance-based step codes with clear targets and dates
  3. Key metrics for measuring building performance (GHGI, TEDI, EUI)
  4. Formal alternative compliance pathways, including PH
  5. Walk the talk with city buildings and procurement practices
  6. Financial and non-monetary incentives
  7. Extensive outreach and awareness efforts
  8. Subsidized training for AECO community
  9. Removing barriers by empowering staff and hiring experts

Cost Comparison of Passive House and Conventional Projects in Pennsylvania

GRAPHIC SOURCE: Data from PFHA. Graphic provided by Tim McDonald (Onion Flats Architecture) and Zach Semke (Semke Studio).
Pennsylvania: Aligning Incentives Yields Big Results

Pennsylvania’s approach was less comprehensive but innovative: their efforts have been emulated across the nation

- Motivated professionals saw an opportunity to ensure Low Income Housing (LIH) developers and occupants were fully engaged in the state’s energy/carbon/comfort transition. They:
  1. Engaged the right market players (PHFA, developers, industry professionals)
  2. Developed a QAP policy approach: no additional funding; rewarded creative proposals from LIH developers
  3. Competition drove cost-effective solutions to meet market needs
- In six years, Pennsylvania showed that PH LIH projects could be delivered at cost parity to conventional projects, yield significant energy bill reductions, and improve occupant comfort
  - Half the states in the U.S. are trying to mimic the success of the Pennsylvania PH QAP experiment
- Next step for PA: see if the LIH sector success can be translated over to other building sectors
  - This will require a focus on additional tools and key elements to drive PH market transformation throughout the state
# Contributors

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