NET POSITIVE SYMPOSIUM: PASSIVE HOUSE DEEP DIVE

Primary Energy Renewable (PER): Strategies for Staying within Limits

Monte Paulsen
PHI-accredited Building Certifier

Five strategies to lower PER in taller Passive House buildings

→ Primary Energy Renewable
  → EUI, PE, PER
  → Can large buildings achieve PER?

→ Five strategies to lower PER
  → Design for cooling
  → Minimize ventilation
  → Restrict recirculation
  → Whittle every load
  → Plan for PV
Energy Use Intensity (EUI)

Total energy use per year ÷ floor area = EUI
9,000 kWh per year ÷ 200 m² = 45 kWh/m²a

Primary Energy (PE)

EUI x PE factor = PE
45 kWh/m²a x 2.6 (grid electricity) = 117 kWh/m²a
Primary Energy Renewable (PER)

EUI × PER factor = PER

45 kWh/m²a × 1.3 (typical) = 58 kWh/m²a

PER in a single-family Passive House

<table>
<thead>
<tr>
<th>Site Energy kWh/m²a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating</td>
</tr>
<tr>
<td>Cooling</td>
</tr>
<tr>
<td>Hot Water</td>
</tr>
<tr>
<td>Electric</td>
</tr>
</tbody>
</table>

Primary Energy Renewable = 43

- Achieves Passive House Classic limit of 60 kWh/m²a
- Add renewables = Passive House Plus
- Meets most definitions of “Net Zero”
PER is extremely difficult for large buildings

→ Large Passive House projects find it relatively easy to achieve the 15 kWh/m²a thermal demand limits due to efficient form factor.

→ Most large Passive House projects struggle to achieve the 60 kWh/m²a Primary Energy Renewable limit.

PER in multi-unit: …but not every tall Passive House can do it
**Strategy #1: Design for cooling**

Design for the lowest possible combined demand

**Small Passive House buildings rely on heat from the sun**

- Solar Heat Gains: 70%
- Internal Heat Gains: 30%
Large Passive House buildings run on internal heat gains

Typical single-family home
- Solar Heat Gains: 70%
- Internal Heat Gains: 30%

Typical apartment building
- Solar Heat Gains: 70%
- Internal Heat Gains: 30%

Those IGHs translate into higher PER, and trigger need for cooling
Don’t be fooled by PHPP!

Many large Passive House buildings will require active cooling even when PHPP indicates otherwise

→ When IHGs likely to exceed PHPP defaults, run hourly models of individual suites or localized sections of building

Example: Dynamic model of single suite in five-storey building
Case 1: Internal gains per PHPP
→ 1% of hours over 25°C annually

![Bar chart showing hours at operative temperature](RUN_4A_AS_DESIGN.png)

Case 2: Internal gains per NECB
→ PHPP based on Passive House Institute assumptions
   → assumes lower plug loads, lower lighting loads
   → based on European usage over past 20 years
→ National Energy Code for Buildings (NECB)
   → relatively newer modelling standard
   → based on expected “median” usage
      › more plug load
      › more lighting
      › more dhw
Case 2: Internal gains per NECB

→ 14% of hours over 25°C annually

RUN 3: AS DESIGNED
NECB INTERNAL GAINS

→ If continuous, would equal 31 days

Case 3: High internal heat gains
Case 3: Higher internal heat gains

→ 70% of hours over 25°C annually

PHI maximum heating & cooling demand

15 kWh/m²/year heat plus...

<table>
<thead>
<tr>
<th>PHI Climate File</th>
<th>Total Annual Cooling Demand (sensible + latent) kWh/m²·yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vancouver</td>
<td>15</td>
</tr>
<tr>
<td>Toronto</td>
<td>16</td>
</tr>
<tr>
<td>New York</td>
<td>17</td>
</tr>
<tr>
<td>Beijing</td>
<td>19</td>
</tr>
<tr>
<td>Miami</td>
<td>52</td>
</tr>
</tbody>
</table>
But no large building has enough spare PER to use these limits

\[ 15 \text{ kWh/m}^2/\text{a Heating} + 15 \text{ kWh/m}^2/\text{a Cooling} = 30 \text{ kWh/m}^2/\text{a PER} \]

Better strategy: Leverage the biomass budget

- PER allots a lower factor of 1.1 for the first 20 kWh/m²a of heat and DHW
- The lower the heat demand, the more biomass budget available for DHW

Design for lowest combined heat/cool demand

---

NET POSITIVE SYMPOSIUM: PASSIVE HOUSE DEEP DIVE

Strategy #2: Minimize ventilation

Slow the flow, minimize the fan power
Central systems are appealing

Swegon Gold RX
Central systems bring new challenges

- Difficulty of local control leads to “always boost” option
- Higher pressure drop requires more fan power

Distributed HRVs may be more efficient
Strategy #3: Restrict recirculation

Heat pump water heaters and minimal recirculation

Multi-unit buildings cannot meet PER with gas-fired DHW

- PER factor of 1.75 renders gas unworkable in most multi-unit residential buildings
- Gas-fired buildings may certify under PE system
  - Best strategy is usually to use gas for both heat and hot water
CO2 air-water heat pumps cut PER dramatically

Single-family systems

Large-building systems

Recirc losses hit multi-unit PER twice: Lost energy & added cooling
Strategy #4: Whittle every load
Question every fan, pump, plug, fixture, appliance...

Light & appliance loads in a multi-unit Passive House high-rise

- Refrigeration
- Laundry
- Corridor Lighting
- Cooking
- Plug Loads
- Dishwashing
- Elevator
- Unit Lighting
Extremely efficient elevators are essential

- Low standby power
- Efficient motors
- Regenerative braking
- Use PHI elevator calculator

Figure 8: Passive House MURB (EUI 42 kWh/m².a)

- **DHW -15%**
  - Heat pump heating
  - Low flow fixtures

- **Fans and Pumps -20%**
  - HRVs, Natural Ventilation in the summer, premium efficiency motors on fans and pumps all aid in reducing these loads

- **Equipment, Appliances and Plug Loads -35%**
  - High efficiency appliances including Dishwasher, Fridges, Stove, Washer/Dryer etc.
  - Elevators with minimal standby loads

- **Heating -17%**
  - High performance enclosures, heat pump heating, and allowing winter solar gains reduces heating demands

- **Cooling -7%**
  - Cooling may be minimized through use of shading and natural ventilation strategies

- **Lighting -8%**
  - Lighting load can be reduced using LED fixtures in suites and Common areas
Develop a PER budget early in schematic design

<table>
<thead>
<tr>
<th>End-Use</th>
<th>EUI kWh/m²GFA</th>
<th>PER (kWh/m²TFA)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MURB</td>
<td>Low-Rise Office</td>
</tr>
<tr>
<td>Heating</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Cooling</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Lighting</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>Equipment, Appliances, and Plug Loads</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>Fans and Pumps</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>DHW</td>
<td>8</td>
<td>5</td>
</tr>
</tbody>
</table>

NET POSITIVE SYMPOSIUM: PASSIVE HOUSE DEEP DIVE

Strategy #5: Plan for PV
The PER system allows 15 kWh claw-back
Offset with renewables

→ A building with PER of 75 kWh/m²a could achieve PER of 60 kWh/m²a by installing photovoltaic

→ Consider sizing this amount of PV from the start, enabling a 75 kWh/m²a PER budget

Renewables not restricted to building rooftop

→ Renewable energy generation not spatially connected to the building may also be taken into account.

→ Systems must be new, and owned by the building owner
PER still too high?
Talk to your Certifier about negotiating a new limit

PHI recognizes commercial spaces use more energy per m²

→ Residential, office, schools
  → Expected to meet existing PER limits in most instances

→ Supermarkets, restaurants, other intensive usages...
  → First demonstrate exemplarily mechanical design
  → Set an achievable PER budget
  → Approach PHI via Certifier to discuss project-specific limits
NET POSITIVE SYMPOSIUM: PASSIVE HOUSE DEEP DIVE

mpaulsen@rdh.com