The New PHPP Version 9: Project Specific Cause & Effect

Prepared and presented by:

André Harrmann
Dipl.-Ing. (FH), MHP, CPHD, LEED AP
What is Zero?
How to rate environmental impact

Primary Energy (PE)
→ Primary Energy Renewable (PER)

Classic + Plus + Premium
How to rate environmental impact

Thermal quality of the building
→ Energy Demand for Heating \( Q \leq 15 \text{ kWh}/(\text{m}^2\text{a}) \)  ↩️ GOOD INDICATOR

Overall energy performance of the building
→ Primary Energy Demand \( PE \leq 120 \text{ kWh}/(\text{m}^2\text{a}) \)  ↩️ RETHINK!

1 kWh Oil / Gas + 0.1 kWh = 1.1 kWh  → PE 1.1

1 kWh Resource to generate Electricity Mix + 1.6 kWh  → PE 2.6...2.4↓

1 kWh Wood + 0.2 kWh = 1.2 kWh  → PE 0.2 ...

1 kWh Ethanol + 0.5 kWh for production & losses  → PE 1.5?
(... PE 0.5 if produced on site from waste organic matter)

1 kWh Photovoltaic Inverter Output + manufacturing / grid / storage losses = 1.03...4.23 kWh  → PE ??  → PE 0.7 ... for on-site generation

New Indicator needed  → Primary Energy Renewable (PER)

Source: PHI
Net Zero Definitions

- Site autonomy
- On-site carbon neutral
- **Net-zero carbon** \( \leftarrow \) UK
- **Net-zero energy** \( \leftarrow \) CHBA Net Zero Energy Council
- **Net-zero primary energy** \( \leftarrow \) DOE
- Net Zero ready
- **Nearly Zero Energy Buildings** \( \leftarrow \) European Union
- Green tariff
- Additionality
- Upgrading existing
- Near-site zero carbon
- Carbon offsetting
Net Zero Definitions

- Nearly Zero Energy Buildings ← European Union

“a building that has a very high energy performance... The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby”

⇒ All new buildings by 2020!

Source: DIRECTIVE 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
ENERGY IN - ENERGY OUT ≤ ZERO? It is more complicated than that ...

... because there are STORAGE LOSSES
California: Net-load with renewables

Net load - March 31

13,000 MW / 2.0 kW = 6,500,000 Tesla Powerwalls

Source: California Independent System Operator (CAISO), Tesla
California: Net-load with renewables

13,000 MW / 2.0 kW = 6,500,000 Tesla Powerwalls

x 80 years x 365 days / 5,000 cycles
= 37,960,000 Tesla Powerwalls over the life time of the building

x $5,000 = $189,800,000,000 for Elon

(Not even considering further increase of renewables from 12% to 50% by 2030)
Solar panels were developed to better identify which neighbor has the highest income.

Source: The Onion
Renewable Energy for Passive House

Source: PHI
Primary Energy Renewable (PER)

\[
\text{PER} = \frac{\text{Energy supply from renewable source}}{\text{Final energy demand at the building}}
\]

Source: PHI
PER Factor for each source and application [kWh$_{\text{PER}}$/kWh]

- $E_{\text{dir}}$: Electricity generated by RES used directly
- $E_{\text{MS}}$: Electricity from short/medium term storage
- $E_{\text{SS}}$: Electricity generated from energy in seasonal storage
- $E_{\text{DL}}$: Distribution and other losses

Efficiencies of storage processes (whole chain) for:

- $\eta_{\text{MS}}$
- $\eta_{\text{SS}}$

\[ \text{PER} = \frac{E_{\text{dir}} + \frac{E_{\text{MS}}}{\eta_{\text{MS}}} + \frac{E_{\text{SS}}}{\eta_{\text{SS}}} + E_{\text{DL}}}{E_{\text{dir}} + E_{\text{MS}} + E_{\text{SS}}} \]
Primary Energy Renewable (PER)

PER Factor are project location-specific – based on locally available renewable primary power production from PV, wind and hydro.

\[ \text{PER} = \frac{\text{Energy supply from renewable source}}{\text{Final energy demand at the building}} \]

Demand profile of the individual energy application:
- Heating
- Cooling
- Dehumidification
- Domestic Hot Water
- Lighting and plug loads

Source: PHI
<table>
<thead>
<tr>
<th>Application / Final Energy</th>
<th>PE in v9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Germany</td>
</tr>
<tr>
<td>Heating degree hours [kKh/a]:</td>
<td></td>
</tr>
<tr>
<td>Heat Elec.</td>
<td>2.4</td>
</tr>
<tr>
<td>Heat Gas (Nat. &amp; RE),LPG</td>
<td>1.1</td>
</tr>
<tr>
<td>Heat Oil, Coal, Methanol</td>
<td>1.1</td>
</tr>
<tr>
<td>Heat Biomass</td>
<td>0.2</td>
</tr>
<tr>
<td>Cool Elec.</td>
<td>2.4</td>
</tr>
<tr>
<td>DHW Elec.</td>
<td>2.4</td>
</tr>
<tr>
<td>other Elec.</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Source: PHI
### PHPPv9: PE Factors + PER Factors

<table>
<thead>
<tr>
<th>Application / Final Energy</th>
<th>PE in v9</th>
<th>PER</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Germany</td>
<td>Canada / US</td>
<td>PHPP Default</td>
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<tr>
<td>Heating degree hours [kKh/a]:</td>
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<td></td>
<td></td>
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<tr>
<td>Heat Elec.</td>
<td>2.4</td>
<td>2.6</td>
<td>1.81</td>
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<tr>
<td>Heat Gas (Nat. &amp; RE), LPG</td>
<td>1.1</td>
<td>1.1</td>
<td>1.75</td>
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<tr>
<td>Heat Oil, Coal, Methanol</td>
<td>1.1</td>
<td>1.1</td>
<td>2.3</td>
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<tr>
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</table>

Source: PHI
### PHPPv9: PE Factors + PER Factors

<table>
<thead>
<tr>
<th>Application / Final Energy</th>
<th>PE in v9</th>
<th>PER</th>
<th>PER: Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>69</td>
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* Biomass is budgeted to max. 20kWh/m²

Source: PHI
# PHPPv9: PE Factors + PER Factors

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<thead>
<tr>
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<th>PER: US</th>
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<tr>
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<td>Germany</td>
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<td>PHPP Default</td>
<td>Vancouver</td>
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<td>Heating degree hours [kKh/a]:</td>
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<td>94</td>
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* Biomass is budgeted to max. 20kWh/m²

Source: PHI
What is the boundary condition?

- Building?
- Site?
- Street?
- Neighbourhood?
- City?
- Province, Country, Continent?
- The most correct boundary →
• The **net-zero** and **plus-energy** idea is leading to optimization in the **wrong direction**

• **Multi story buildings** are discriminated by this system, because they have less available surface for PV per TFA

➔ Take the **building ground as reference** for energy production

Source: PHI
The New Passive House Classes

**Classic**
- Renewable energy generation
  \[\text{[kWh}_{\text{PER}}/(m^2_{\text{ground}} \times \text{a})]\]
  \[\geq 60\]

**Plus**
- Renewable energy generation
  \[\text{[kWh}_{\text{PER}}/(m^2_{\text{ground}} \times \text{a})]\]
  \[\geq 120\]

**Premium**
- Renewable primary energy demand
  \[\text{[kWh}_{\text{PER}}/(m^2_{\text{TFA}} \times \text{a})]\]
  \[\leq 30\]

**Certified Passive House**
- Various certifications available

Source: PHI
Export → Import

Internal Heat Gains (IHG)

Occupancy Density
Spec. power $q_I = \text{Nachweis!K28}$

$= \text{IF}(Z20=2,'\text{IWQ NiWo'!I6,IWQ!I6})$

$= \text{P(AC2,Daten!A142:C144,3,0),Q7)}$

$= \text{Nachweis!F28/Flächen!N8,4.1),4.1)}$
PHPPv9: Internal Heat Gains

\[
\text{IHG} = 2.1 + 50 \times \frac{\text{UNITS}}{\text{TFA}} \leq 4.1 \text{W/m}^2
\]

Source: PHPPv9
PHPPv9: Internal Heat Gains

Source: PHI, PHPPv9, Elemental Solutions
PHPPv9: Internal Heat Gains & Occupants

- **Occupants PHPPv8**
- **Occupants PHPPv9**

**Internal Heat Gains (IHG)**
- **IHG for Demand Q (PHPPv9)**
- **IHG for Demand Q (PHPPv8)**
- **IHG for Load P (PHPPv9)**
- **IHG for Load P (PHPPv8)**

Source: PHI, PHPPv9

Harrmann Consulting
Project Specific Effects –
Germany vs. Canada vs. US

Classic + Plus + Premium
The New Passive House Classes

- **Classic**
  - $\geq 60$
  - Renewable energy generation
    - $[\text{kWh}_\text{PER}/(\text{m}^2\text{_{ground}} \cdot \text{a})]$

- **Plus**
  - $\geq 120$

- **Premium**
  - $\leq 30$
  - Renewable primary energy demand
    - $[\text{kWh}_\text{PER}/(\text{m}^2\text{TFA} \cdot \text{a})]$
  - $\leq 45$

- **Certified**
  - $\leq 60$

Source: PHI
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**PHPPv9: Internal Heat Gains & Occupants**

- **Occupants PHPPv8**
- **Occupants PHPPv9**

**Source:** PHI, PHPPv9
Project #1: Darmstadt-Kranichstein, Germany

TFA: 156m² | Units: 1 | $G_t = 82$ kWh/a | $n_{50} = 0.2$ ACH
Heating / DHW: Gas → Heat Pump | PV & Solar Thermal
Walls 0.14 | Roof 0.11 | Windows 0.78 W/m²K
Certified 25 years ago!
Project #1: Darmstadt-Kranichstein, Germany

Source: PHPP

Gas Boiler
5m² Solar = 1.7 mWh/a
Heat Pump
5m² Solar = 1.7 mWh/a
5m² Solar = 1.7 mWh/a
82m² PV = 9 mWh/a

Graph showing PER-Verbrauch (kWh/(m² EBF* a)) vs. PER-Erzeugung (kWh/(m² Grund* a))

- Premium
- Plus
- Classic

Gas Boiler
no PV
no Solar Thermal
Project #2: Nelson, BC

TFA: 50+50+100m²  |  Units: 3  |  $G_t = 94$ kKh/a  |  Heating / DHW: Propane

n50 = 0.2ACH  |  Walls 0.10 W/m²K  |  Roof 0.05 W/m²K  |  Windows 0.8 W/m²K

Prepared for PV / Solar thermal
Certified 2014  |  Team:
Cover Architectural Collaborative
Harrmann Consulting
LOCAL Design/Build
ReNü Building Science Inc.
Project #2: Nelson, BC

TFA: 50+50+100m² | Units: 3 | $G_t = 94$ kKh/a | Heating / DHW: Propane

$n_{50} = 0.2$ACH | Walls $0.10$ W/m²K | Roof $0.05$ W/m²K | Windows $0.8$ W/m²K

Prepared for PV / Solar thermal

Certified 2014 | Team:

Cover Architectural Collaborative
Harrmann Consulting
LOCAL Design/Build
ReNü Building Science Inc.

Source: Cover Architectural Collaborative
Project #2: Nelson, BC

Graph showing Energy Performance Indicators (PE and PER) in kWh/m²a, with blue triangles representing Q in kWh/m²a and black squares representing P in W/m².

Data table:

- PHPPv8 as certified: 5.8 with 2.1 for Occupants, 2.8 for IHG [W/m²].
- v9: 5.4 with 2.8 for Occupants, 2.8 for IHG [W/m²].
- + Shower Drain HR: 5.4 with 2.8 for Occupants, 2.8 for IHG [W/m²].
- ... all Electric: 5.4 with 2.8 for Occupants, 2.8 for IHG [W/m²].
- ... Heat Pump + PV, Solar: 5.4 with 2.8 for Occupants, 2.8 for IHG [W/m²].
Project #2: Nelson, BC

- Propane boiler
- Shower Drain HR
- Heat Pump
- 36m² PV = 6 mWh/a
- 4m² Solar = 2 mWh/a
- All direct electric
- Shower Drain HR
gen 11 mWh/a generation
= 61m² > 57m² roof
- Current case in v9: Propane boiler

Source: PHPP
Harrmann Consulting
Project #3: Cottonwood, Edmonton, AB

TFA: 247m² | Units: 1 (+1) | Gₜ = 123 kKh/a | Heating / DHW: Gas Boiler
n₅₀ = 0.3ACH | Walls 0.08 W/m²K | Roof 0.06 W/m²K | Windows 0.75 W/m²K

Location: Fort Saskatchewan (Edmonton climate set)

David Zeibin | ReNü Building Systems | Harrmann Consulting
Project #3: Cottonwood, Edmonton, AB

Source: PHI

All Electric
Shower Drain HR
84m² PV = 11 mWh/a
4m² Solar = 2.3 mWh/a

All Electric
Shower Drain HR
84m² PV = 11 mWh/a

All Electric
Shower Drain HR

Gas Boiler
Shower Drain HR

Current case in v9:
Gas boiler

PER- Erzeugung [kWh/(m²_Grund*a)]

PER- Bedarf [kWh/(m²_EBF*a)]

Premium

Plus

Classic

Project #3: Cottonwood, Edmonton, AB

Source: PHI

All Electric
Shower Drain HR
84m² PV = 11 mWh/a
4m² Solar = 2.3 mWh/a

All Electric
Shower Drain HR
84m² PV = 11 mWh/a

All Electric
Shower Drain HR

Gas Boiler
Shower Drain HR

Current case in v9:
Gas boiler

PER- Erzeugung [kWh/(m²_Grund*a)]

PER- Bedarf [kWh/(m²_EBF*a)]

Premium

Plus

Classic

Harrmann Consulting
Project #4: W21st, Vancouver, BC

TFA: 78+147m²  |  Units: 2  |  Heating / DHW: Electric / Heat Pump
n50 = 0.6ACH assumed  |  scheduled for 2016
Walls 0.11 W/m²K  |  Roof 0.10 W/m²K  |  Windows 0.85 W/m²K

Team: One SEED Architecture  |  Harrmann Consulting  |  CertiPHIers

Erik Olofsson Construction
Project #4: W21st, Vancouver, BC

Current case in v9: Direct electric

Heat Pump
Shower HR
42m² PV = 6.6mWh/a
6m² Solar = 1.7mWh/a
(on garage roof)

Heat Pump
Shower HR
42m² PV = 6.6mWh/a
(with and without Shower Heat Recovery)

Current case in v9: Direct electric

Source: PHPP
Project #5: Feeney Residence, Portland, Maine

TFA: 123m² | Units: 1 |
Heating / DHW: Sanden Heat Pump
n50 = 0.26ACH | built 2015
Walls 0.11 W/m²K | Roof 0.05 W/m²K
Windows 0.68 W/m²K

Team: ECOCOR | CertiPHIers
CERTIFICATE
Certified Passive House Component
ID: 0842we03 valid until 31. December 2016

Passive House Institute
Dr. Wolfgang Feist
64342 Darmstadt
GERMANY

Harrmann Consulting
Source: ECOCOR

Project #5: Feeney Residence, Portland, Maine

<table>
<thead>
<tr>
<th>Category</th>
<th>Construction system</th>
<th>Timber frame construction</th>
</tr>
</thead>
</table>
| Manufacturer              | ECOCOR High Performance Buildings
|                           | Searsmont
|                           | UNITED STATES OF AMERICA |
| Product name              | ECOCOR Passiv       |

This certificate for the cool, temperate climate zone was awarded based on the following criteria:

### Hygiene criterion
The minimum temperature factor of the interior surfaces is:

\[ f_{\text{min}} = 0.70 \]

### Comfort criterion
The U-value of the installed windows is:

\[ U_{\text{win}} \leq 0.85 \text{ W/(m}^2\text{K)} \]

### Efficiency criteria
- Heat transfer coefficient of building envelope:
  \[ U_{\text{heat}} \leq 0.15 \text{ W/(m}^2\text{K)} \]
- Temperaturfactor of opaque junctions:
  \[ f_{\text{tj}} = 0.86 \]
- Thermal bridge free design for key connection details:
  \[ \Psi \leq 0.01 \text{ W/(m}^2\text{K)} \]

An air tightness concept for all components and connection details was provided.

<table>
<thead>
<tr>
<th>Thermal heat transfer coefficient</th>
<th>Dimension [m]</th>
<th>U-Wert [W/(m²K)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>EW01 - External Wall</td>
<td>0.04</td>
<td>0.106</td>
</tr>
<tr>
<td>RD01 - Roof</td>
<td>0.60</td>
<td>0.085</td>
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<tr>
<td>FS01 - Floor Slab</td>
<td>0.53</td>
<td>0.118</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Thermal bridge coefficient opaque envelop</th>
<th>U/a [W/(m²K)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>EWCE01 - External Wall</td>
<td>0.09</td>
</tr>
<tr>
<td>EWPA01 - External Wall Party wall</td>
<td>0.07</td>
</tr>
<tr>
<td>EWWE01 - External Wall Internal Ceiling</td>
<td>0.07</td>
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<tr>
<td>EWWE02 - External Wall Internal Ceiling</td>
<td>0.07</td>
</tr>
<tr>
<td>BCCW01 - Basement Ceiling External Wall</td>
<td>0.08</td>
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<tr>
<td>BCCW02 - Basement Ceiling Party wall</td>
<td>0.09</td>
</tr>
<tr>
<td>ROE01 - Roof Verge</td>
<td>0.07</td>
</tr>
<tr>
<td>ROE02 - Roof Elaves</td>
<td>0.06</td>
</tr>
</tbody>
</table>

www.passivehouse.com

Source: ECOCOR
Harrmann Consulting
Project #5: Feeney Residence, Portland, Maine

Source: ECOCOR
Project #5: Feeney Residence, Portland, Maine

Source: ECOCOR

- PE [kWh/m²a]
- PER [kWh/m²a]
- Q [kWh/m²a]
- P [W/m²]

v8 with HP → v9 + PV ++ PV 0.27 ACH

occupants
IHG [W/m²]

Harrmann Consulting
Project #5: Feeney Residence, Portland, Maine

- Heat Pump + 23m² PV
- Heat Pump + 59m² PV

Source: PHI
Project #6: Kaplan Residence, San Francisco

TFA: 255m²  |  Units: 1  |  Heating / DHW: Natural Gas
n50 = 0.6ACH  |  2014
Walls 0.28...0.65 W/m²K  |  Roof 0.08...0.18 W/m²K  |  Windows 1.30 W/m²K
Team: Essential Habitat Architecture | CertiPHIlers

Source: Essential Habitat Architecture
Project #6: Kaplan Residence, San Francisco

Source: Essential Habitat Architecture

- PE [kWh/m²a]
- PER [kWh/m²a]
- Q [kWh/m²a]
- P [W/m²]

- Occupants
- IHG [W/m²]
Project #6: Kaplan Residence, San Francisco

- PE [kWh/m²a]
- PER [kWh/m²a]
- Q [kWh/m²a]
- P [W/m²]

Source: Essential Habitat Architecture
Project #6: Kaplan Residence, San Francisco

- PE [kWh/m²a]
- PER [kWh/m²a]
- Q [kWh/m²a]
- P [W/m²]

Source: Essential Habitat Architecture
Project #6: Kaplan Residence, San Francisco

- Gas Boiler + 6m² Solar Thermal (current status)
- Gas Boiler + 6m² Solar Thermal + 23m² PV
- Gas Boiler + 6m² Solar Thermal + 114m² PV

Source: PHI
Primary Energy (PE) \[\downarrow\]
Primary Energy Renewable (PER)

Fossil Fuel \[\uparrow\] Electricity \[\downarrow\]
Electricity in Canada \[\downarrow\ \downarrow\]