Zero Energy & PHIUS+ Certifications

Charting the path for projects seeking a dual rating

Rocky Mountain Institute Innovation Center
photo credit Tim Griffith, courtesy of ZGF Architects

INTERNATIONAL LIVING FUTURE INSTITUTE℠

PHIUS

Partnering to deliver energy efficient buildings

This document addresses the International Living Future Institute's (ILFI) **Zero Energy** (ZE) certification and **PHIUS+ Certification** developed by the Passive House Institute US (PHIUS). ILFI and PHIUS consider these certification programs to be highly complementary. The energy efficiency requirements of PHIUS+ provide a targeted pathway focused on high energy efficiency for pursuing Zero Energy. The 12-month performance requirements of Zero Energy certification, in turn, provide a mechanism to validate the outcome of anticipated energy savings from PHIUS+.

The following pages offer guidance for buildings seeking to benefit from both certification schemes by choosing the high energy efficiency of a passive building complemented with renewables as a compliance pathway to reach Zero Energy. In general, the PHIUS+ standard provides key thermal and envelope targets for new and retrofitted buildings that lead to substantial reductions in overall building energy consumption. In order to meet the ZE requirements, this remaining energy consumption must be met with measured renewable energy generation. This document provides clarification on how to navigate the different metrics included in each standard.

All guidance in this document is in reference to the PHIUS+ 2018 Standard and International Living Future Institute Zero Energy certification.

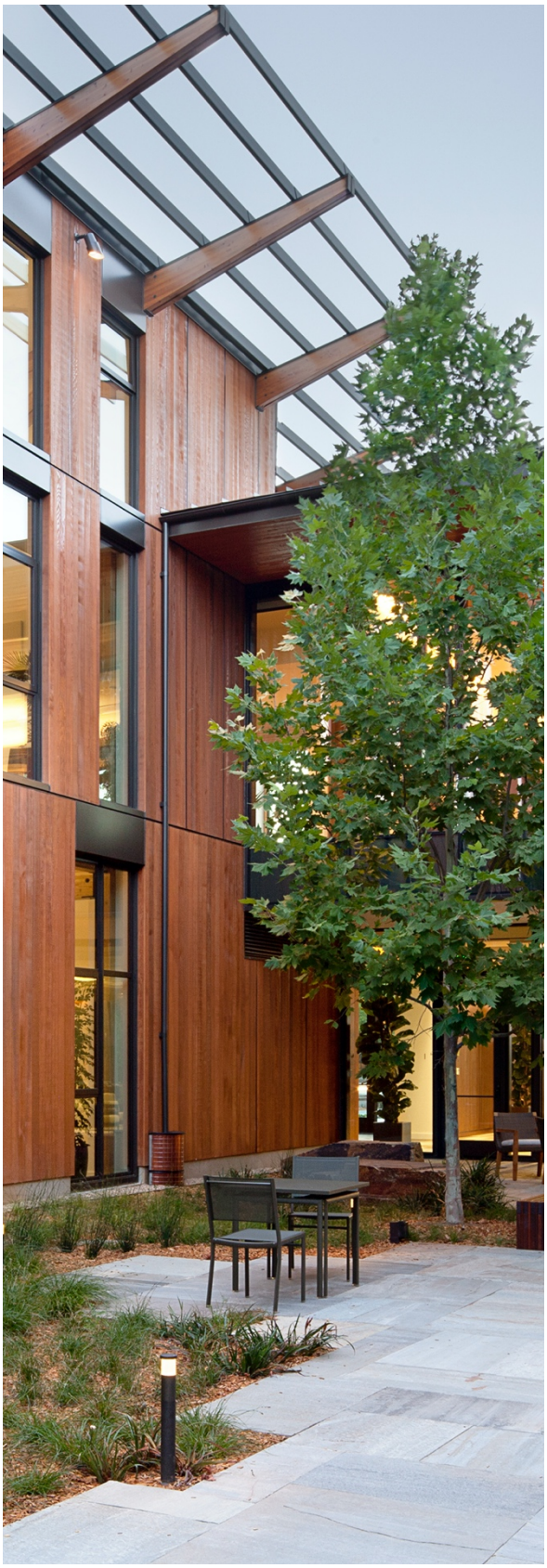
Tierra Linda 6-Flat
photo credit Mark Ballogg

About ILFI Zero Energy

The International Living Future Institute's (ILFI) Zero Energy (ZE) certification was created to recognize projects that demonstrate the highest level of energy performance and spur the creation of renewable energy resources. The program is building an advanced cohort of industry-leading building projects with third-party performance verification.

To achieve ZE certification, one hundred percent of the building's energy needs on a net annual basis must be supplied by on-site renewable energy. Certification is based on actual performance, and achievement is validated after a 12-month performance period. With the aim of contributing to an energy future that is free of fossil fuels, ZE certification does not allow the use of combustion in building operations except in very limited circumstances.

ZE certification evolved out of the Living Building Challenge (LBC), which was first released in 2006, and set a new benchmark for green building by requiring wholistic and proven performance. The LBC Standard is divided into seven issue areas, or Petals, which are subsequently divided into twenty total Imperatives, each of which has a specific focus and set of requirements. Projects achieving LBC Living Certification meet the requirements of all twenty Imperatives, and in so doing generate all of their own energy with renewable resources, capture and treat all water onsite without the use of chemicals, promote health and address inequity, operate efficiently, invoke beauty, and are toxin-free. Through the Energy Petal, the LBC addresses energy performance by requiring net positive performance and energy storage for resiliency. The ZE certification program was developed in 2011 to follow a similar structure as the Energy Petal while setting a streamlined target of a net zero annual balance of energy consumed and generated. In 2017, the ZE certification program was revised to omit all non-energy requirements, focusing exclusively on the energy balance.



Packard Foundation Headquarters
photo credit Jeremy Bittermann

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PHIUS

About PHIUS and the PHIUS+ Standard

PHIUS (Passive House Institute US, Inc.) is a non-profit 501(c)(3) organization committed to making high-performance passive building the mainstream market standard. PHIUS trains and certifies professionals, maintains the PHIUS+ climate-specific passive building standard, certifies and quality-assures passive buildings, and conducts research to advance high-performance building. Buildings that meet the PHIUS+ standard use 40-60 percent less energy for space conditioning than progressive code-built buildings. PHIUS+ buildings provide superior indoor air quality, resilience during power outages, and an extremely quiet, comfortable indoor environment.

Project teams are increasingly adopting passive building principles and the PHIUS+ standard for single-family, multifamily, and commercial buildings to achieve Net Zero buildings.

PHIUS+ is an energy performance standard for buildings. It is intended to guide designers towards high-performance building design, meaning buildings that provide all the amenities of a comfortable and healthy indoor environment without using a great deal of energy to do so. Passive building design is foundational to this high performance. The principles of passive design are:

- Continuous insulation
- Absence of thermal bridging
- High-performance windows to limit heat transmission
- Very airtight building envelope preventing infiltration of outside air and loss of conditioned air
- Balanced ventilation with heat recovery
- Minimal heating/cooling system

(continued)

Madrona House
photo courtesy of Madrona House project team

A critical aspect in both design and delivery of successful passive building is quality assurance throughout design and construction. PHIUS+ Certification ties optimized performance targets with an energy model used to aid in the design and verification of those performance targets. On top of this, on-site quality assurance is required throughout the construction process and for final certification.

PHIUS+ Certification also requires Energy Star, DOE Zero Energy Ready Home, and EPA Indoor airPLUS certification for eligible[1] projects, to ensure best practices for quality elements such as healthy indoor air, water management, etc.

The PHIUS+ Standard can be applied to either new or existing buildings. The criteria for retrofit projects are the same as for new construction, except that on a case-by-case basis, an energy allowance may be made for a foundation perimeter thermal bridge or other such hard-to-fix structural thermal bridges - provided that the design is also “damage-free,” that is, low-risk from a moisture point of view.

Reynolds Residence
photo credit Deborah DeGraffenreid

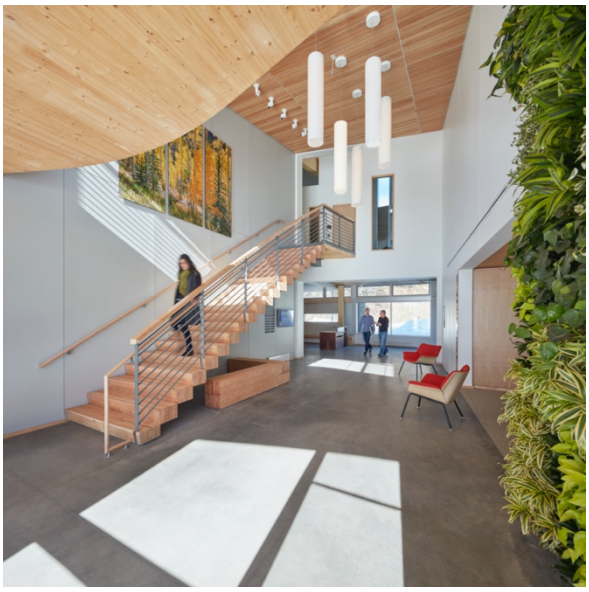
[1] For projects that are not eligible to certify under these programs, some program requirements are still enforced for certification by PHIUS).

How to read this document

This document outlines each requirement in the PHIUS+ standard that is relevant to a net zero energy target, and then states how each will contribute towards the performance verification process of the ZE standard.

Note that this document tracks the alignment of standards with the understanding that most project teams will first pursue PHIUS+ certification. It can be challenging to successfully pursue PHIUS+ post-construction, or after achieving ZE, unless both standards were targeted from the outset.

The guidance provided in this document is of a summary nature; complete details on the requirements are stated in the respective standards. It is also noted that the PHIUS+ standard includes other requirements not directly related to energy (e.g. comfort) that are not stated in this document. Links to the complete requirements for both standards are provided in the References.



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PHIUS+ Standard to Zero Energy Certification

	PHIUS+ 2018 Certification Requirements	Zero Energy Certification Requirements	Alignment
PROJECT SCOPE			
Project Scope	Whole building certification is encouraged, but not required. Certification may be sought for part of the building only as long as most of the building by floor area (50% or more) is within the scope of the planned certification.	New buildings may limit certification to a part of the building only where the ownership, funding, and operation are all distinct from the rest of the building, and the area to be certified is physically and visually distinguishable. Part of an existing building may pursue certification if there is a clear physical and energy boundary.	Allowance of partial building certification under ZE is more restrictive than under PHIUS+.
Combustion	Permitted	Essentially not permitted; exceptions in very limited circumstances, with restrictions	To be eligible for ZE, PHIUS+ projects must not include combustion (with limited exceptions)
Energy Uses Included in the Energy Balance	All energy uses within the thermal envelope are included. Uses outside of the thermal envelope are included if directly connected to the building and the occupants served. Exception: EV charging and parking lighting energy are attributed to the 'transportation sector' and not included in the energy balance.	All equipment and energy-using systems related to any part of the building program (including process energy), with the exception of electrical vehicle charging, which is excluded.	The scope of energy uses in PHIUS+ and ZE is mainly compatible. Compatibility for specific projects should be verified.

(continued)

	PHIUS+ 2018 Certification Requirements	Zero Energy Certification Requirements	Alignment
PERFORMANCE REQUIREMENTS			
Space Conditioning Demand Limits	(a) Annual Heating Demand and Annual Cooling Demand (b) Peak Heating Load and Peak Cooling Load	No limits are specified for heating and cooling demand. Total site energy use as measured from a utility or private meter is reported over 12-month period.	The low energy limits of passive building are advantageous to reaching the measured ZE balance
Thermal Performance of Building Envelope	Determined by modeled achievement of the specified heating/cooling targets above. Additional requirements for window U-value based on comfort and condensation risk.	Building envelope performance requirements are not specified.	Meeting the thermal performance requirements for PHIUS+ is expected to reduce the overall energy use measured over the 12-month performance period for ZE.
Moisture Performance of Building Envelope	Prescriptive requirements outlined for building assemblies. If prescriptive path not met, compliance via performance path required.	Moisture performance requirements are not specified.	The PHIUS + requirements further longevity and durability of the building envelope, goals that are entirely compatible with ZE requirements.
Air-Tightness Threshold	Leakage threshold per square foot of exterior envelope area, measured at 50 Pa or 75 Pa. Both pressurization and depressurization testing required at final construction for compliance.	Air-tightness requirement not specified.	Meeting the airtightness requirements for PHIUS+ is expected to reduce the overall energy use measured over the 12-month performance period for ZE.
Total Energy Demand	Requirement set for 'Net Source Energy Demand.' Target values are per person for residential buildings, and per square foot for non-residential buildings. Relies on nation-wide averages for source energy factors of varying fuel types.	No limits are specified for overall energy demand. Projects must demonstrate that site energy use is equal to, or less than, site energy generation over a 12-month period.	The two standards take different approaches to compliance metrics. Note that the annual site energy demand reported in WUFI Passive can be used to predict potential achievement of ZE when compared to estimates of onsite energy generation.

PHIUS+ Standard to Zero Energy Certification

	PHIUS+ 2018 Certification Requirements	Zero Energy Certification Requirements	Alignment
PERFORMANCE REQUIREMENTS			
Total Energy Generation	Both onsite and offsite renewable generation are accepted to meet the Net Source Energy Demand target. Acceptable offsets are On-site PV, directly owned off-site PV, community renewable energy, virtual power-purchase agreements, and renewable energy certificates (RECs). All on-site and off-site measures have offset factors of 1, except for RECs which have an offset factor of 0.2 (i.e each unit purchased offsets 0.2 of use). “Renewable energy” is defined as photovoltaics, solar thermal, wind turbines.	Minimum not specified Must be equivalent to or greater than the total site energy use over a 12-month period All renewables must be onsite. Offsite renewables are only permitted in limited circumstances Renewable energy generation must be additional, not existing “Renewable energy” is defined as passive solar, photovoltaics, solar thermal, wind turbines, water- powered micro-turbines, direct geothermal or fuel cells powered by hydrogen generated from renewably powered electrolysis.	The two standards take different approaches to compliance metrics. But note that the annual site energy generation reported in WUFI can be used to predict potential achievement of ZE when compared to estimates of annual energy demand. ZE has additional restrictions and criteria for renewables procured offsite. Definitions of acceptable “renewable energy” vary slightly but are not in conflict.
Zero Energy Balance	Based on Net Source Energy. One unit of renewable energy generation offsets the equivalent value in source energy (site energy multiplied by the source energy factor for electricity). Ex: 1 kWh of renewable energy generation offsets 2.8 kWh of source energy.	Net energy balance of site energy use and energy generation over 12 consecutive months, must be zero or better	ZE has additional restrictions and criteria for renewables procured offsite. Compliance for PHIUS+ is based on source energy, whereas for ZE it is based on site energy.

PHIUS+ Standard to Zero Energy Certification

	PHIUS+ 2018 Certification Requirements	ILFI Zero Energy Requirements	Alignment
COMPLIANCE + DOCUMENTATION			
Predictive Modeling	Modeled with WUFI® Passive modeling software. Pre-Certification design review and verified compliance with the performance targets in the energy model is required.	Narrative of design methodology is required, but energy modelling not reviewed as part of required certification documentation	ZE compliance is based on measured performance, so modelling data do not need to be submitted for ZE certification. As noted above, the WUFI Passive modeling process may yield early indication that building has capability to achieve zero energy[1]
Metering	Highly encouraged, not required.	Either utility or private meters must be installed to directly measure or permit calculation of total annual energy generation separately from energy consumption. Net meters alone are not sufficient.	Meter data showing energy generation and consumption for a single 12-month period is required for ZE; it is not required for PHIUS+.
Site Audits	Required by a PHIUS+ trained professional during varying phases throughout construction and for final testing. Including, but not limited to: blower door testing, insulation inspection, infrared imaging, etc.	Not required	PHIUS+ certification requires site audit; ZE certification does not.
Final Verification	All on-site verification documents as well as a compliant WUFI Passive energy model updated to align with as-built building.	Building site documentation (photographs) Design drawings, system schematics and narratives Total energy use data for 12-month performance period	To verify ZE compliance, PHIUS+ projects need to be equipped with utility or private meters and submit 12 consecutive months of data

[1] Note that use-related variables such as different thermostat settings, ventilation habits, occupancy schedules and numbers, and year-to-year weather variations, can all affect actual energy use. These will be observed no matter what model or building standard is applied, and should be accounted for in sizing renewable systems to achieve Zero Energy. The better the energy standard, the lower the absolute fluctuation margins. In the case of PHIUS+ projects, the Passive House Institute US has measured data showing that the overall energy use is within a reasonable margin of predicted see Appendix.

Zero Energy Certification as a path to PHIUS+ Compliance

It is noted that PHIUS+ Certification certifications have rigorous modeled performance requirements to ensure buildings that are future-proof, comfortable, and provide good air quality at a low energy expense. While these strategies are appropriate for achieving the level of efficiency needed to achieve a ZE target, the ZE certification program does not set specific requirements for these metrics. Thus, it cannot be assumed that ZE buildings will automatically qualify for PHIUS+ Certification.

It is not possible to apply for PHIUS+ Certification after completion of a ZE building unless all required on-site quality assurance elements were inspected during construction and can be verified for PHIUS+ Certification.

References

- **Zero Energy Certification**
  Description of the certification program and links to supporting documents.
  https://living-future.org/net-zero/certification/

- **Zero Energy Certification - Documentation Requirements**
  List of documentation requirements for Zero Energy certification.
  https://living-future.org/wp-content/uploads/2018/03/ZE-Documentation-Requirements.pdf

- **International Living Future Institute - Offsite Renewables Exception**
  Requirements related to use of offsite renewables for Zero Energy and Energy Petal certifications.
  https://living-future.org/wp-content/uploads/2018/03/ZE-Documentation-Requirements.pdf

- **International Living Future Institute - Case Studies**
  Descriptions of projects having achieved Zero Energy certification.
  https://living-future.org/lbc/case-studies/?certs=zero-energy
  Note that projects certifying to an earlier version of the standard (Net Zero Energy Building) can be found at
  https://living-future.org/lbc/case-studies/?certs=zero

- **PHIUS+ Certification Guidebook**
  All-encompassing document explaining all building certification requirements, guidance for designers, certification process, energy modeling protocols, etc.
  https://www.phius.org/PHIUS+2018/PHIUS+%20Certification%20Guidebook%20v2.1.pdf

- **PHIUS+ Project Monitored Data**
  Data collected on modeled versus measured energy.
  https://www.phius.org/software-resources/monitoring/monitored-project-results

- **PHIUS+ Certified Projects Database**
  Database of all certified and pre-certified projects. Sort for specifics by heading.
  https://www.phius.org/phius-certification-for-buildings-products/certified-projects-database

Appendix

Definitions

Explanation of important terminology used in the document in alphabetical order.

Passive Building

Passive building is a design methodology defined by a set of principles that prioritize energy conservation and best practices. Together, these principles produce a structure in which the whole is greater than the sum of the parts. Passive building is associated with lower energy use, specifically lower space conditioning loads. However, the methodology produces other benefits: comfort, improved indoor air quality, durability, and resilience. Passive building principles can be applied to all building typologies -- from single-family homes to multi-family apartment buildings, offices, skyscrapers.

WUFI® Passive

WUFI Passive - The building energy modeling tool used for passive building design and verification accepted by the Passive House Institute US for PHIUS+ Certification.

Annual Demand

Total annual heat (or cooling) energy that must be delivered to the space in order to maintain a desired setpoint.

Note: Annual Demand is not the same as site energy. The heating/cooling site energy depends on the amount of heating/cooling that must be delivered to the space (annual demand) and the efficiency of the equipment delivering it.

Peak Load

Space conditioning requirement during the peak climate conditions (average over the worst 24 hours). Determines the size of the mechanical system.

Site Energy

Also referred to as final energy, site energy is essentially the energy reflected in utility bills. It is the energy required to operate the building, reflecting efficiencies of energy-using equipment and fixtures. For example, the electricity needed to operate a heat pump to heat and cool a building, to provide lighting, and to run appliances.

Zero Energy

ILFI defines zero energy as 100% of the building's energy needs being supplied by onsite renewable energy on a net annual basis. At the end of a 12-month performance period, as demonstrated by a utility meter, or where not available a private meter, the total energy generated must be equal to or greater than the total energy consumed. The ILFI Zero Energy standard is based on Site Energy.

Source Energy

Source Energy Use is the total amount of raw fuel that is required to operate a building. In addition to the energy consumed on-site as the building is used, Source Energy includes losses that take place during generation, transmission, and distribution of the energy. Source Energy conversion factors differ for different fuel sources (e.g. electricity or natural gas) and countries. Source Energy Demand is used rather than Site Energy because it serves as a better proxy for carbon emissions.

Comparing energy consumption with modeled energy demand

PHIUS+ Certification requires compliance with performance targets that are verified by an energy model, WUFI® Passive. To certify based on an energy model, the inputs must be standardized, and all modeling protocols must be clearly defined. For example, typical-year climate files are used, set-points for heating and cooling are pre-defined, and plug loads are calculated based on standardized assumptions. Limitations are placed on 'occupant-dependent' inputs such as window opening and the use of window shades.

A standardized energy model ensures that certification is based on the building itself rather than on the people within the building. It also keeps the modeling protocol consistent between what was used to set performance targets and what is used to verify compliance with them. These protocols, combined with a detailed review from PHIUS, limit variability in predicted results between energy modelers – some modelers may be more conservative than others, or use different rules of thumb.

There are a handful of variables that can influence the actual energy use consumed by a building versus what is predicted in an energy model.

For example, changes in weather conditions between the "typical" weather file used for energy models and the actual observed weather conditions during the time data was collected can lead to variances in energy use, most notably for space conditioning. Similarly, when the heating and cooling set-points defined by the occupants do not match what was set in the energy model, actual energy use can vary. However, passive buildings respond slowly to outdoor conditions and can maintain consistent interior temperatures, so variables related to weather and set-points influence a passive building less than they would for their code-built counterpart.

Additionally, plug loads and lighting use vary significantly based on day-to-day habits of the occupants. For example, a senior living facility may have more occupants spending full days at home, whereas a working student may spend most of their time outside of the home. A professional who works from home all week, versus one that works long hours at the office, will use different amounts of energy for just about everything.

Monitoring energy use in buildings is important for a variety of reasons. Actual measured energy use data can verify energy model predictions and help guide protocol for energy modeling moving forward. In turn, this results in more accurate modeling and certification of building performance, which is critical in realizing the savings promised and predicted.

Monitoring actual performance can also provide feedback to occupants regarding their energy use, compared to a neighbor or similar sized dwelling unit, and awareness may lead to changes in occupant behavior. On the other hand, monitoring HVAC systems can indicate whether a system is not functioning properly or may need repair work.

Monitored Data

PHIUS has collected monitored data on certified projects of all sizes in varying climates across North America. **Figure 1** shows the total site energy consumption for these buildings (in kBTU/ft^{2}yr) – both predicted (blue) and measured (red). Multiple red vertical lines for the same project show multiple years of monitored data for that building. This dataset shows that sometimes the certified energy models over-predicted the energy use, while in other cases it under-predicted. And, that even for the same building, year-to-year energy use can vary quite a bit. *(continued)*

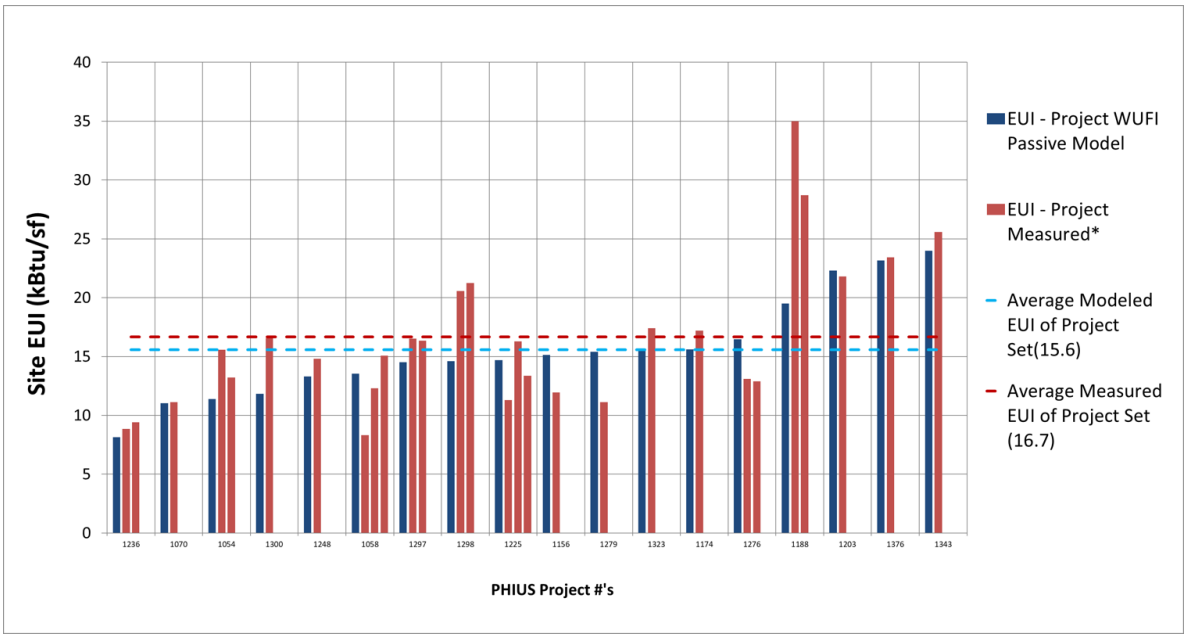

Figure 1: Site energy use of 18 PHIUS+ Certified Projects. The dotted line displays the average energy use of the projects in this dataset (red) and the average predicted (modeled) energy use of this dataset (blue).

On average, the predicted energy use of this set of PHIUS+ Certified projects is within 9% of the actual measured performance of these projects. Again, this may be partially attributed to the PHIUS modeling review and consistency of data inputs, as well as the on-site testing, balancing, and quality assurance requirements outlined above. The average energy use of these buildings is 16.7 kBTU/ft^{2}yr, which is 57% lower in site energy than the average residential building (38.4 kBTU/ft^{2}yr), according to the 2015 Residential Energy Consumption Survey.[2]

PHIUS has received data broken down further for some projects; such as unit by unit data within a multifamily building. The example below is for a 6-flat building in Eugene, OR. The energy use per dwelling unit varied significantly on an annual basis, but the average energy use of all units aligned quite well with the predicted average unit for that building.

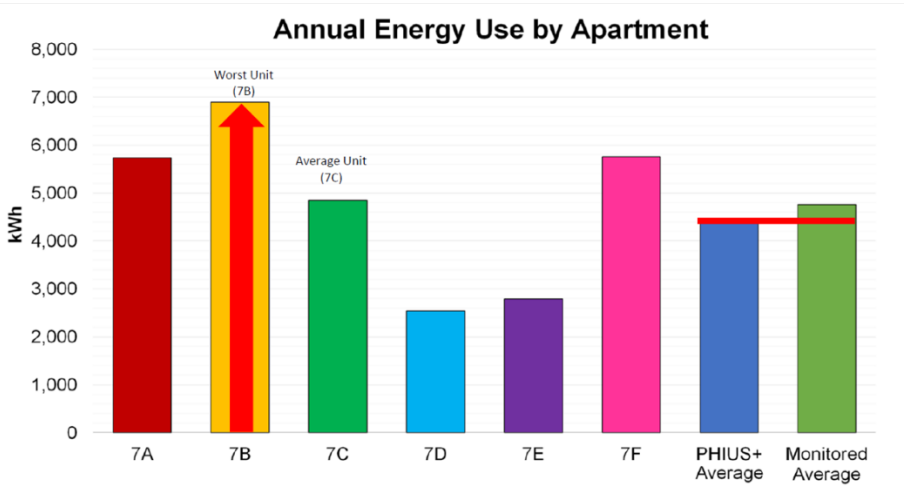

Figure 2: Monitored energy use data by unit within a 6-unit apartment building in Eugene Oregon, along with the monitored average and the average predicted by the certified PHIUS+ model.

This shows that although there will always be discrepancies based on climate, occupant behavior, etc., on average, energy models can be accurate in predicting energy use when looking at a large sample size. This is important for PHIUS because it helps to assess the impact at scale, and validates the assumptions used for certification.

[2] https://www.eia.gov/consumption/residential/data/2015/

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