# HPXML Import for Home Energy Score Documentation

***Release 6.2.0***

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**May 14, 2021**

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CHAPTER 1

# Introduction

*HPXML* is a flexible way to transfer home energy audit and retrofit data via a standardized schema. This flexibility, one if its greatest strengths, is also a weakness. Home Energy Score (*HEScore*) requires very specific data points to be reported as inputs to the *API*. Many of those data points can be represented in the *HPXML* syntax in multiple ways due to the flexibility of the standard. The purpose of this guide is to document the assumptions that are made in the translation of *HPXML* data elements into *HEScore* software inputs.

# CHAPTER 2

# Usage Instructions

The HPXML to Home Energy Score (HEScore) translator can be run hosted through the *HEScore API* or *directly on your local machine*. Most users will find that the HEScore API is the preferred method since it easily fits into the API workflow and automates the process. The stand alone method is mostly for developers needing to debug and track down problems in the translation as well as for those who want to make modifications to the translation assumptions and code.

## 2.1 Home Energy Score API

The HEScore API provides the most generally applicable way use HPXML to generate a Home Energy Score. Generally in the API is used by doing the following steps, calling each API method in order:

1. `submit_address` - Creates a new building and assessment date.
2. `submit_inputs` - Submit a detailed house description in a format specific to Home Energy Score.
3. `calculate_base_building` - Calculates the energy use of the as-described building.
4. `commit_results` - Locks the inputs and marks them as being accurate by the Qualified Assessor.
5. `calculate_package_building` - Analyzes a set of retrofit upgrades that are screened against standardized costs, and determines the most cost effective ones.
6. `generate_label` - Creates a PDF and PNG Home Energy Score label.

There are other options and reports available, but that is the general gist of it. The HPXML translator is made available through a separate API method: `submit_hpxml_inputs`. It replaces the first two steps above, alleviating the need to translate data elements from your data structure into the HEScore data structure.

`submit_hpxml_inputs` accepts an HPXML file as a Base64 encoded payload, so you will need to convert it. An example of how to do this in Python is:

```
import base64

with open('path/to/hpxmlfile.xml','r') as f:
    hpxml_as_base64 = base64.standard_b64encode(f.read())
```

Similar libraries and functionality exist in many languages.

Much more information on how to use the HEScore API including the `submit_hpxml_inputs` method is available on the Home Energy Scoring Tool API Documentation site.

## 2.2 Stand Alone

The HPXML to HEScore translator that is used within the *Home Energy Score API* can be used independently as well. It is a Python script that accepts an HPXML file as input and returns a JSON file with HEScore inputs arranged like the HEScore API call `submit_inputs` expects. It it useful to run it this way for debugging a translation of your particular flavor of HPXML file or for development of the translator.

### 2.2.1 Set Up

The program runs using Python 2.7. The instructions below will help you set up Python on your platform and get the translator installed.

#### Windows

1. Download Python 2.7.x (not the 3.x version) from python.org and Install.
2. Add `C:\Python27` to your path. Here's how.
3. Follow instructions for *All Platforms*.

#### Mac OS X

1. Install Homebrew.
2. Open a terminal.
3. Install Python 2.7 using homebrew: `brew install python`
4. Follow instructions for *All Platforms*.

#### Linux

1. Install Python 2.7 using the package manager for your platform.
2. Follow instructions for *All Platforms*.

#### All Platforms

Optionally install and activate a virtual environment. Instructions here.

Install the package using `pip`:

```
pip install hescore-hpxml
```

Alternatively, you can install the latest and greatest directly from GitHub, which is useful if you're going to do some development on the translator. To do so, get a copy of the source code from GitHub, using your preferred method. If you're not sure, just click "Download ZIP".

Open a terminal and use `pip` to install it in developer mode:

```
cd path/to/hescore-hpxml
pip install -e .[dev]
```

### 2.2.2 Running the Translator

The best way to figure out how to run the translator is to call it with the `-h` flag.

```
hpxml2hescore -h
```

CHAPTER 3

# Translation Assumptions

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## 3.1 Address and Requesting a New Session

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The first step in starting a HEScore transaction is to call the `submit_address` *API* call.

### 3.1.1 Address

The building address is found in HPXML under the `Building/Site/Address` element. The sub elements there easily translate into the expected address format for HEScore.

```
<HPXML>
   ...
   <Building>
      <Site>
         <SiteID id="id1"/>
         <Address>
            <Address1>123 Main St.</Address1>
            <Address2></Address2>
            <CityMunicipality>Anywhere</CityMunicipality>
```

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```
            <StateCode>CA</StateCode>
            <ZipCode>90000</ZipCode>
         </Address>
      </Site>
   </Building>
</HPXML>
```

HPXML allows for two lines of address elements. If both are used, the lines will be concatenated with a space between for submission to the HEScore `building_address.address` field. All of the HPXML elements shown in the above code snippet are required with the exception of `Address2`

### 3.1.2 Assessment Type

To begin a HEScore session an assessment type must be selected. The assessment type is determined from HPXML via the `XMLTransactionHeaderInformation/Transaction` and `Building/ProjectStatus/EventType` element using the following mapping:

Table 1: Assessment Type mapping

| XML Transaction Type | HPXML Event Type | HEScore Assessment Type |
|---|---|---|
| create | audit | initial |
| | proposed workscope | alternative |
| | approved workscope | alternative |
| | construction-period testing/daily test out | test |
| | job completion testing/final inspection | final |
| | quality assurance/monitoring | qa |
| | preconstruction | preconstruction |
| update | *any* | corrected |

#### Mentor Assessment Type

In v2015 HEScore introduced a new assessment type called "mentor". It is used for new assessors in training when an assessment is supervised by a more qualified assessor. There is no equivalent way to communicate this scenario in HPXML. To work around this issue, the translator will look for a specifically named element in the `extension` of `Building/ProjectStatus`:

```
<ProjectStatus>
    <EventType>audit</EventType>
    <Date>2014-12-18</Date>
    <extension>
        <HEScoreMentorAssessment/>
    </extension>
</ProjectStatus>
```

Upon finding this `HEScoreMentorAssessment` element, the HEScore assessment type will be set to "mentor" regardless of the mapping *above*.

## 3.2 Home Performance with Energy Star

Inputs for the Home Energy Score submit_hpwes API call can be retrieved from an HPXML file as described below.

### 3.2.1 Identifying HPwES Projects

To trigger data collection for HPwES project, the following elements need to be included depending on HPXML version used.

#### HPXML v2

To translate the HPwES fields, the `Project/ProgramCertificate` must be present and equal to `Home Performance with Energy Star`.

#### HPXML v3

In HPXML v3.0+, `ProgramCertificate` no longer exists and a new element of path `Building/BuildingDetails/GreenBuildingVerifications/GreenBuildingVerification` is used. Similarly, `GreenBuildingVerification` must be present as `Home Performance with ENERGY STAR`.

### 3.2.2 Project

To get the Home Performance with Energy Star (HPwES) data from an HPXML file a `Project` node needs to be included. The following elements are required under the `Project` node:

```
<Project>
    <ProjectDetails>
        <ProjectSystemIdentifiers id="projectid"/>
        <!-- HPXML v2 only --><ProgramCertificate>Home Performance with Energy Star</
↪ProgramCertificate>
        <StartDate>2018-08-20</StartDate>
        <CompleteDateActual>2018-12-14</CompleteDateActual>
    </projectDetails>
</Project>
```

If more than one `Project` element exists, the first one will be used. The user can override this by passing the `--projectid` argument to the translator command line.

The project fields are mapped as follows:

| HPXML `ProjectDetails` | submit_hpwes API value |
|---|---|
| `StartDate` | `improvement_installation_start_date` |
| `CompleteDateActual` | `improvement_installation_completion_date` |

### 3.2.3 Contractor

A `Contractor` element is also required with at minimum the following elements:

```
<Contractor>
    <ContractorDetails>
        <SystemIdentifier id="contractor1"/>
        <BusinessInfo>
            <SystemIdentifier id="contractor1businessinfo"/>
            <BusinessName>My HPwES Contractor Business</BusinessName>
            <extension>
                <ZipCode>12345</ZipCode>
```

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```
            </extension>
        </BusinessInfo>
    </ContractorDetails>
</Contractor>
```

If there are more than one `Contractor` elements, the contractor with the id passed in the `--contractorid` command line argument is used. If no contracter id is specified by the user, the contractor listed in the `Building/ContractorID` will be used. If that element isn't available, the first `Contractor` element will be used.

The contractor fields are mapped as follows:

| HPXML `Contractor` | submit_hpwes API value |
|---|---|
| `ContractorDetails/BusinessInfo/BusinessName` | `contractor_business_name` |
| `ContractorDetails/BusinessInfo/extension/ZipCode` | `contractor_zip_code` |

## 3.3 About

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### 3.3.1 Assessment Date

HEScore requires an assessment date. If a date is stored in the element `Building/ProjectStatus/Date`, that date is used. If not, the current date is used.

### 3.3.2 External Building ID

The value of `Building/extension/HESExternalID` or `Building/BuildingID/SendingSystemIdentifierValue`, if present, is copied into the `building.about.external_building_id` field in HEScore. Preference is given to the *extension* element if both are present. This is optional, but may be useful for those wanting to pass an additional building identifier for their own tracking purposes.

### 3.3.3 Building Shape

HEScore requires specifying whether the building is a detached house or a town house through their `building.shape` input. HPXML can specify this (and a variety of other house types) through the `Building/BuildingSummary/BuildingConstruction/ResidentialFacilitytype` data element. Not all facility types in HPXML can be modeled in HEScore. The table below shows how the possible enumerations of the HPXML field are translated into HEScore.

Table 2: HPXML Facility Types to HEScore Building Shape

| HPXML | HEScore |
|---|---|
| single-family detached | rectangle |
| single-family attached | town_house |
| manufactured home | *not translated* |
| 2-4 unit building | *not translated* |
| 5+ unit building | *not translated* |
| multi-family - uncategorized | *not translated* |
| multi-family - town homes | town_house |
| multi-family - condos | *not translated* |
| apartment unit | *not translated* |
| studio unit | *not translated* |
| other | *not translated* |
| unknown | *not translated* |

**Note:** For enumerations that are *not translated* the HPXML file will fail to run in HEScore.

For town houses HEScore requires a `town_house_walls` input to be specified. This is available in HPXML in the `Building/BuildingSummary/Site/Surroundings` element. The translation of the enumerations is as follows:

Table 3: Mapping for shared walls in town houses

| HPXML | HEScore |
|---|---|
| stand-alone | *not translated* |
| attached on one side | back_right_front or back_front_left |
| attached on two sides | back_front |
| attached on three sides | *not translated* |

If the HPXML enumeration of `attached on one side` is present the translation will determine which HEScore enumeration to select based on which side of the house is missing windows.

**Warning:**

- If windows are found on a shared town house wall, the translation will fail.
- HEScore cannot model townhouses that are "attached on three sides" or "stand-alone". Using one of those inputs will result in a translation error.

### 3.3.4 Year Built, Stories, Bedrooms, Floor Height, and Floor Area

The HEScore inputs `year_built`, `number_bedrooms`, `num_floor_above_grade`, `floor_to_ceiling_height`, and `conditioned_floor_area` are each retrieved from their corresponding HPXML elements shown below.

```
<HPXML>
   ...
   <Building>
     ...
     <BuildingDetails>
         <BuildingSummary>
             <BuildingConstruction>
                 <YearBuilt>1998</YearBuilt>
                 <ConditionedFloorArea>2400</ConditionedFloorArea>
                 <NumberofConditionedFloorsAboveGrade>2</
↪NumberofConditionedFloorsAboveGrade>
                 <AverageCeilingHeight>8</AverageCeilingHeight>
                 <NumberofBedrooms>3</NumberofBedrooms>
             </BuildingConstruction>
         </BuildingSummary>
     </BuildingDetails>
   </Building>
</HPXML>
```

The HEScore input `floor_to_ceiling_height` will be calculated by dividing `ConditionedBuildingVolume` by `ConditionedFloorArea` if `AverageCeilingHeight` is omitted.

### 3.3.5 House Orientation

In HPXML the orientation of a house and orientations in general can be specified as either a compass direction ('North','Southwest',etc.) or an azimuth measured in degrees clockwise from North. HEScore requires a compass direction for the orientation of the front of the house. If the azimuth is available in `Building/BuildingDetails/BuildingSummary/Site/AzimuthOfFrontOfHome` the nearest compass direction is chosen. If the azimuth is omitted from HPXML but the `OrientationOfFronOfHome` element exists, the orientation is used.

### 3.3.6 Infiltration

HPXML allows the specification of multiple `Building/BuildingDetails/Enclosure/AirInfiltration/AirInfiltrationMeasurement` elements, which can contain either a blower door test or a qualitative assessment of "leakiness". HEScore can be used with either a measurement from a blower door test or by specifying whether the house has been air sealed or not (boolean). Preference is given to a blower door test measurement when it is available in HPXML.

#### Blower Door Test

The translator first looks for a blower door test (not an estimate) with units of *CFM50*. If more than one of the `AirInfiltrationMeasurement` elements have units in *CFM50*, the last one to appear in the document is used. If there are no measurements in *CFM50*, it will look for one in *ACH50*. If more than one of the `AirInfiltrationMeasurement` elements have units in *ACH50*, the last one to appear in the document is used. If the `UnitofMeasure` element has a value of ACH, then the value is converted to CFM using the building volume calculated by the floor area and floor height.

An example of the minimum expected elements in HPXML follows:

```
<AirInfiltrationMeasurement>
   <SystemIdentifier id="infilt1"/>
   <TypeOfInfiltrationMeasurement>blower door</TypeOfInfiltrationMeasurement>
   <HousePressure>50</HousePressure><!-- Must be 50 -->
   <BuildingAirLeakage>
      <UnitofMeasure>CFM<!-- or ACH --></UnitofMeasure>
      <AirLeakage>1234</AirLeakage>
   </BuildingAirLeakage>
</AirInfiltrationMeasurement>
```

#### Air Sealing Present

When a blower door test is not available the translator looks for an AirInfiltrationMeasurement that specifies an estimate of leakage. An example of the minimum expected elements in that case looks like:

```
<AirInfiltrationMeasurement>
   <SystemIdentifier id="infilt2"/>
   <TypeOfInfiltrationMeasurement>estimate</TypeOfInfiltrationMeasurement>
   <LeakinessDescription>tight</LeakinessDescription>
</AirInfiltrationMeasurement>
```

If more than one AirInfiltrationMeasurement is found that have the above elements, the last one to appear in the document is used. Whether the house is marked as having air sealing present is determined according to the following mapping from LeakinessDescription:

Table 4: HPXML LeakinessDescription to HEScore Air Sealing Present

| Leakiness Description | Air Sealing Present |
|---|---|
| very tight | True |
| tight | True |
| average | False |
| leaky | False |
| very leaky | False |

If none of the AirInfiltrationMeasurement elements meet the criteria above to specify an estimate, the building is assumed to not have air sealing present.

**Note:** If a building has no AirInfiltrationMeasurement elements in the HPXML document, the house is assumed to not be air sealed.

### 3.3.7 Comments

The hpxml-hescore translator allows passing through comments. Since there's no equivalent way to communicate this information in HPXML under the Building node, the translator will look for a specifically named element in extension of Building:

```
<Building>
    <extension>
        <Comments>Any comment</Comments>
```

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```
    </extension>
</Building>
```

If there's no comment found in `extension` element, the translator will look for the `Project/ProjectDetails/Notes` element for comments. Only the first `Project` node will be selected. For complicated cases where buildings are assigned to multiple projects, using the extension element is recommended.

## 3.4 Roof and Attic

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HPXML allows the specification of multiple `Attic` elements, each of which relates to one (HPXML v2) or more (HPXML v3) `Roof` elements. That relation is optional in HPXML, but is required for HEScore when there is more than one `Attic` or `Roof` because it is important to know which roof relates to each attic space. An area is required for each Attic if there is more than one `Attic` element.

- In HPXML v2, areas can be specified directly by `Attic/AtticArea`.
- In HPXML v3, translator first searches all the `Area` of `FrameFloor` whose id is the same as what referred in `Attic/AttachedToFrameFloor`, and sums all areas up. Otherwise, the `Area` of `Roof` whose id is the same as what referred in `Attic/AttachedToRoof` will be searched and summed for each attic.

If there is only one `Attic` element, the footprint area of the building is assumed. If there's only one roof in HPXML, it will be automatically attached to attic.

### 3.4.1 Attic/Roof Type

Each `Attic` is considered and the `AtticType` is mapped into a HEScore roof type according to the following mapping.

Table 5: HPXML Attic Type to HEScore Roof type mapping (HPXML v2)

| HPXML | HEScore |
|---|---|
| cape cod | cath_ceiling |
| cathedral ceiling | cath_ceiling |
| flat roof | cath_ceiling |
| unvented attic | vented_attic |
| vented attic | vented_attic |
| venting unknown attic | vented_attic |
| other | *see note below* |

Table 6: HPXML Attic Type to HEScore Roof type mapping (HPXML v3)

| HPXML | HEScore |
|---|---|
| CathedralCeiling | cath_ceiling |
| FlatRoof | cath_ceiling |
| Attic/CapeCod = 'true' | cath_ceiling |
| Attic/Conditioned = 'true' | cond_attic |
| Attic | vented_attic |
| Other | *not translated* |

**Note:** Prior to HPXML v3, there's no existing HPXML element capturing a conditioned attic. The only way to model a HEScore `cond_attic` is to specify HPXML Attic Type to be `other` with an extra element `Attic/extension/Conditioned` to be `true`.

Otherwise, HPXML Attic Type `other` will not be translated and will result in a translation error.

HEScore can accept up to two attic/roof constructions. If there are more than two specified in HPXML, the properties of the `Attic` elements with the same roof type are combined. For variables with a discrete selection the value that covers the greatest combined area is used. For R-values a calculation is performed to determine the equivalent overall R-value for the attic. This is discussed in more detail in *Roof R-value*.

**Note:** Starting from HPXML v3, HPXML allows multiple floors/roofs attached to a single attic. The properties of the floors/roofs attached to the same attic are combined into a single one.

### 3.4.2 Roof Color

Roof color in HEScore is mapped from the HPXML `Roof/RoofColor` element according to the following mapping.

Table 7: HPXML to HEScore roof color mapping

| HPXML | HEScore |
|---|---|
| light | light |
| medium | medium |
| medium dark | medium_dark |
| dark | dark |
| reflective | white |

If the `Roof/SolarAbsorptance` element is present, the HEScore roof color is set to "cool_color" and the recorded absorptance will be sent to HEScore under the "roof_absorptance" element.

**Note:** Starting from HPXML v3, if there're more than one roof attached to the same attic, the roof color of that covers greatest area will be selected.

### 3.4.3 Exterior Finish

HPXML stores the exterior finish information in the `Roof/RoofType` element. This is translated into the HEScore exterior finish variable according to the following mapping.

Table 8: HPXML Roof Type to HEScore Exterior Finish mapping

| HPXML | HEScore |
|---|---|
| shingles | composition shingles |
| slate or tile shingles | concrete tile |
| wood shingles or shakes | wood shakes |
| asphalt or fiberglass shingles | composition shingles |
| metal surfacing | composition shingles |
| expanded polystyrene sheathing | *not translated* |
| plastic/rubber/synthetic sheeting | tar and gravel |
| concrete | concrete tile |
| cool roof | *not translated* |
| green roof | *not translated* |
| no one major type | *not translated* |
| other | *not translated* |

**Note:** Items where the HEScore translation indicates *not translated* above will result in a translation error.

### 3.4.4 Rigid Foam Sheathing

If the `AtticRoofInsulation` element has a `Layer` with the "continuous" `InstallationType`, `InsulationMaterial/Rigid`, and a `NominalRValue` greater than zero, the roof is determined to have rigid foam sheathing and one of the construction codes is selected accordingly. Otherwise one of the standard wood frame construction codes is selected.

#### HPXML v2

```xml
<Attic>
    <SystemIdentifier id="attic5"/>
    <AttachedToRoof idref="roof3"/>
    <AtticType>cathedral ceiling</AtticType>
    <AtticRoofInsulation>
        <SystemIdentifier id="attic5roofins"/>
        <Layer>
            <InstallationType>continuous</InstallationType>
            <InsulationMaterial>
                <Rigid>eps</Rigid>
```

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```
            </InsulationMaterial>
            <NominalRValue>10</NominalRValue>
        </Layer>
    </AtticRoofInsulation>
    <Area>2500</Area>
</Attic>
```

### HPXML v3

```
<Atics>
   <Attic>
      <SystemIdentifier id="attic5"/>
      <AtticType>
         <CathedralCeiling/>
      </AtticType>
      <AttachedToRoof idref="roof3"/>
   </Attic>
</Attics>
<Roofs>
   <Roof>
      <SystemIdentifier id="roof3"/>
      <Area>2500</Area>
      <Insulation>
           <SystemIdentifier id="attic5roofins"/>
           <Layer>
               <InstallationType>continuous</InstallationType>
               <InsulationMaterial>
                   <Rigid>eps</Rigid>
               </InsulationMaterial>
               <NominalRValue>10</NominalRValue>
           </Layer>
       </Insulation>
   </Roof>
<Roofs>
```

## 3.4.5 Radiant Barrier

If the `Roof/RadiantBarrier` element exists and has a "true" value, the attic is assumed to have a radiant barrier and no roof deck insulation is assumed according to the construction codes available in HEScore.

## 3.4.6 Roof R-value

R-values for the roof deck are added up by summing the values of the `Layer/NominalRValue`. If the roof construction was determined to have *Rigid Foam Sheathing*, an R-value of 5 is subtracted from the roof R-value sum to account for the R-value of the sheathing in the HEScore construction.

Starting from HPXML v3, multiple roofs are allowed to be attached to the same attic, if the attic has more than one `Roof` element with roof insulation, the insulation values are combined by first selecting the nearest roof center-of-cavity R-value for each roof area from the table below.

Table 9: Roof Center-of-Cavity Effective R-values

| Exterior | Composition or Metal | Wood Shakes | Clay Tile | Concrete Tile | Tar and Gravel |
|---|---|---|---|---|---|
| R-value | Effective R-value | | | | |
| **Standard** | | | | | |
| R-0 | 2.7 | 3.2 | 2.2 | 2.3 | 2.3 |
| R-11 | 13.6 | 14.1 | 13.2 | 13.2 | 13.2 |
| R-13 | 15.6 | 16.1 | 15.2 | 15.2 | 15.2 |
| R-15 | 17.6 | 18.1 | 17.2 | 17.2 | 17.2 |
| R-19 | 21.6 | 22.1 | 21.2 | 21.2 | 21.2 |
| R-21 | 23.6 | 24.1 | 23.2 | 23.2 | 23.2 |
| R-27 | 29.6 | 30.1 | 29.2 | 29.2 | 29.2 |
| R-30 | 32.6 | 33.1 | 32.2 | 32.2 | 32.2 |
| **w/ Radiant Barrier** | | | | | |
| R-0 | 5 | 5.5 | 4.5 | 4.6 | 4.6 |
| **w/ foam sheeting** | | | | | |
| R-0 | 6.8 | 7.3 | 6.4 | 6.4 | 6.4 |
| R-11 | 17.8 | 18.3 | 17.4 | 17.4 | 17.4 |
| R-13 | 19.8 | 20.3 | 19.4 | 19.4 | 19.4 |
| R-15 | 21.8 | 22.3 | 21.4 | 21.4 | 21.4 |
| R-19 | 25.8 | 26.3 | 25.4 | 25.4 | 25.4 |
| R-21 | 27.8 | 28.3 | 27.4 | 27.4 | 27.4 |

Then a weighted average is calculated by weighting the U-values by area. This averaged Center-of-Cavity Effective R value is combined from all roofs attached to the same attic. The highest weighted roof construction type is selected to represent properties of the attic.

$$U_i = \frac{1}{R_i}$$

$$U_{eff,avg} = \frac{\sum_i U_i A_i}{\sum_i A_i}$$

$$R_{eff,avg} = \frac{1}{U_{eff,avg}}$$

If the house has more than two attics specified, the attics of the same roof types are combined. Therefore, the same weighted average calculation is performed (taking roof-level averaged R as $R_i$ and attic area determined in *attic area* as $A_i$) to combine multiple attics.

Then the R-0 effective center-of-cavity R-value ($R_{offset}$) is selected for highest weighted roof construction type for the attic represented in the calculation and is subtracted from $R_{eff,avg}$.

$$R = R_{eff,avg} - R_{offset}$$

Finally the R-value is rounded to the nearest insulation level in the enumeration choices for the highest weighted roof construction type for the attic is included in the calculation.

### 3.4.7 Attic R-value

Determining the attic floor insulation levels uses the same procedure as *Roof R-value* except the lookup table is different. The attic floor center-of-cavity R-values are each R-0.5 greater than the nominal R-values in the enumeration list.

If the primary roof type is determined to be a cathedral ceiling, then an attic R-value is not calculated.

### 3.4.8 Knee Walls

In HPXML v2, knee walls are specified via the `Attic/AtticKneeWall` element.

Starting from HPXML v3, knee walls are specified via wall attachment in `Attic/AttachedToWall`. The attached wall must have `AtticWallType` of "knee wall". See below an example:

```xml
<Attics>
   <Attic>
      <SystemIdentifier id="attic5"/>
      <AtticType>
         <Attic>
            <Vented>true</Vented>
         </Attic>
      </AtticType>
      <AttachedToRoof idref="roof3"/>
      <AttachedToWall idref="kneewall"/>
      <AttachedToFrameFloor idref="framefloor"/>
   </Attic>
</Attics>
<Walls>
   <Wall>
      <SystemIdentifier id="kneewall"/>
      <ExteriorAdjacentTo>attic</ExteriorAdjacentTo>
      <AtticWallType>knee wall</AtticWallType>
      <WallType>
         <WoodStud/>
      </WallType>
      <Area>200</Area>
      <Insulation>
           <SystemIdentifier id="kneewallins"/>
           <Layer>
               <InstallationType>cavity</InstallationType>
               <NominalRValue>10</NominalRValue>
           </Layer>
       </Insulation>
   </Wall>
<Walls>
```

If an attic has knee walls specified, the area of the knee walls will be added to the attic floor area. The knee walls center-of-cavity R-value is R-1.8 greater than the nominal R-value. The knee walls center-of-cavity R-value will be reflected in the area weighted center-of-cavity effective R-value of the attic floor. This averaged center-of-cavity effective R value is combined from all knee walls and attic floors attached to the same attic. The highest weighted attic floor construction type is selected.

## 3.5 Foundation Insulation

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### 3.5.1 Determining the primary foundation

HEScore permits the specification of two foundations. The two foundations that cover the largest area are selected. This is determined by summing up the area of the `FrameFloor` or `Slab` elements (depending on what kind of foundation it is). `Area` elements are required for all foundations unless there is only one foundation, then it is assumed to be the footprint area of the building. If there are more than two foundations, the areas of the largest two are scaled up to encompass the area of the remaining foundations while maintaining their respective area fractions relative to each other.

### 3.5.2 Foundation Type

Once a foundation is selected, the HEScore foundation type is selected from HPXML according to the following table.

Table 10: HPXML to HEScore foundation type mapping

| HPXML Foundation Type | | HEScore Foundation Type |
|---|---|---|
| Basement | Conditioned=”true” | cond_basement |
| | Conditioned=”false” or omitted | uncond_basement |
| Crawlspace | Vented=”true” | vented_crawl |
| | Vented=”false” or omitted | unvented_crawl |
| SlabOnGrade | | slab_on_grade |
| Garage | | unvented_crawl |
| AboveApartment | | *not translated* |
| Combination | | *not translated* |
| Ambient | | vented_crawl |
| RubbleStone | | *not translated* |
| Other | | *not translated* |

**Warning:** For foundation types that are *not translated* the translation will return an error.

### 3.5.3 Foundation wall insulation R-value

If the foundation type is a basement or crawlspace, an area weighted average R-value is calculated for the foundation walls. The area is obtained from the `Area` element, if present, or calculated from the `Length` and `Height` elements. The R-value is the sum of the `FoundationWall/Insulation/Layer/NominalRValue` element values for each foundation wall. For each foundation wall, an effective R-value is looked up based on the nearest R-value in the following table.

Table 11: Basement and crawlspace wall effective R-values

| Insulation Level | Effective R-value |
|---|---|
| R-0 | 4 |
| R-11 | 11.6 |
| R-19 | 16.9 |

Then a weighted average R-value is calculated by weighting the U-values by area.

$$U_i = \frac{1}{R_i}$$
$$U_{eff,avg} = \frac{\sum_i U_i A_i}{\sum_i A_i}$$
$$R_{eff,avg} = \frac{1}{U_{eff,avg}}$$

The effective R-value of the R-0 insulation level is then subtracted.

$$R = R_{eff,avg} - 4.0$$

Finally, the nearest insulation level is selected from the enumeration list.

### 3.5.4 Slab insulation R-value

If the foundation type is a slab on grade, an area weighted average R-value is calculated using the value of `ExposedPerimeter` as the area. (The units work out, the depth in the area drops out of the equation.) The R-value is the sum of the `Slab/PerimeterInsulation/Layer/NominalRValue` element values for each foundation wall. For each slab, an effective R-value is looked up based on the nearest R-value in the following table.

Table 12: Slab insulation effective R-values

| Insulation Level | Effective R-value |
|---|---|
| R-0 | 4 |
| R-5 | 7.9 |

Then a weighted average R-value is calculated by weighting the U-values by area.

$$U_i = \frac{1}{R_i}$$
$$U_{eff,avg} = \frac{\sum_i U_i A_i}{\sum_i A_i}$$
$$R_{eff,avg} = \frac{1}{U_{eff,avg}}$$

The effective R-value of the R-0 insulation level is then subtracted.

$$R = R_{eff,avg} - 4.0$$

Finally, the nearest insulation level is selected from the enumeration list.

### 3.5.5 Floor insulation above basement or crawlspace

If the foundation type is a basement or crawlspace, for each frame floor above the foundation, a weighted average using the floor area and R-value are calculated. The area is obtained from the `Area` element. The R-value is the sum of the `FrameFloor/Insulation/Layer/NominalRValue` element values for each frame floor. The effective R-value is looked up in the following table.

Table 13: Floor center-of-cavity effective R-value

| Insulation Level | Effective R-value |
|---|---|
| R-0 | 4 |
| R-11 | 15.8 |
| R-13 | 17.8 |
| R-15 | 19.8 |
| R-19 | 23.8 |
| R-21 | 25.8 |
| R-25 | 31.8 |
| R-30 | 37.8 |
| R-38 | 42.8 |

Then a weighted average R-value is calculated by weighting the U-values by area.

$$U_i = \frac{1}{R_i}$$

$$U_{eff,avg} = \frac{\sum_i U_i A_i}{\sum_i A_i}$$

$$R_{eff,avg} = \frac{1}{U_{eff,avg}}$$

The effective R-value of the R-0 insulation level is then subtracted.

$$R = R_{eff,avg} - 4.0$$

Finally, the nearest insulation level is selected from the enumeration list.

## 3.6 Walls

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### 3.6.1 Wall Orientation

The flexibility of HPXML allows specification of any number of walls and windows facing any direction. HEScore expects only one wall/window specification for each side of the building (front, back, left, right).

Each wall in the HPXML document that has an `ExteriorAdjacentTo='ambient'` (HPXML v2) or `ExteriorAdjacentTo='outside'` (HPXML v3) or is missing the `ExteriorAdjacentTo` subelement (assumed to be ambient/outside) is considered for translation to HEScore. This excludes attic knee walls (see *Knee Walls*), interior walls, walls between living space and a garage, etc. since HEScore does not model those walls. The translator then attempts to assign each wall to the nearest side of the building, which is relative to the orientation of the front of the building. The wall construction and exterior finish of the largest wall by area on each side of the building are used to define the properties sent to HEScore. An area weighted R-value of all the walls on each side of the building is calculated as well as described in *Area Weighted Wall R-value*. If there is only one wall on any side of the house, the area is not required for that side. If a wall falls exactly between two sides of the house the area of the wall is divided by two and half of the wall is assigned to either side.

HEScore also allows the specification of one wall for all sides of the building. If none of the walls in HPXML have orientation (or azimuth) data, the wall construction and exterior finish of the largest wall by area on each side of the building are used to define the properties sent to HEScore. An area weighted R-value of all the walls on each side of the building is calculated as well as described in *Area Weighted Wall R-value*. If there is only one wall and no area specified, that wall is used to determine the wall construction.

**Note:** The following conditions must be met for the wall translation to succeed:

- If there is more than one wall on each side of the building each wall on that side of the building must have an `Area` specified.
- Either all walls must have an `Azimuth` and/or `Orientation` or none of them must.

### 3.6.2 Wall Construction

HEScore uses a selection of construction codes to describe wall construction type, insulation levels, and siding. HPXML, as usual, uses a more flexible approach defining wall types: layers of insulation materials that each include an R-value, thickness, wall cavity information, etc. To translate the inputs from HPXML to HEScore approximations need to be made to condense the continuous inputs in HPXML to discrete inputs required for HEScore.

#### Wood Frame Walls

If `WallType/WoodStud` is selected in HPXML, each layer of the wall insulation is parsed and if a rigid and continuous layer is found, or if the subelement `WallType/WoodStud/ExpandedPolyStyreneSheathing` is found, the wall is specified in HEScore as “Wood Frame with Rigid Foam Sheathing.”

```
<Wall>
   <SystemIdentifier id="wall1"/>
   <WallType>
       <WoodStud>
           <!-- Either this element needs to be here or continuous insulation below --
↪>
           <ExpandedPolystyreneSheathing>true</ExpandedPolystyreneSheathing>
       </WoodStud>
   </WallType>
   <Insulation>
       <SystemIdentifier id="wall1ins"/>
       <Layer>
           <InstallationType>continuous</InstallationType>
           <InsulationMaterial>
               <Rigid>eps</Rigid>
               <!-- This can have any of the valid enumerations for this element,
```

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```
                    it only cares if the Rigid element is present. -->
            </InsulationMaterial>
            <NominalRValue>5</NominalRValue>
        </Layer>
        ...
    </Insulation>
</Wall>
```

Otherwise, if the `OptimumValueEngineering` boolean element is set to `true`, the “Wood Frame with Optimal Value Engineering” wall type in HEScore is selected.

```
<Wall>
    <SystemIdentifier id="wall2"/>
    <WallType>
        <WoodStud>
            <OptimumValueEngineering>true</OptimumValueEngineering>
        </WoodStud>
        <Insulation>
            ...
        </Insulation>
    </WallType>
</Wall>
```

---

**Note:** The `OptimumValueEngineering` flag needs to be set in HPXML to translate to this wall type. The translator will not infer this from stud spacing.

---

Finally, if neither of the above conditions are met, the wall is specified as simply “Wood Frame” in HEScore.

In all cases the R-value is summed for all insulation layers and the nearest discrete R-value from the list of possible R-values for that wall type is used. For walls with rigid foam sheathing, R-5 is subtracted from the nominal R-value sum to account for the R-value of the sheathing in the HEScore construction assembly.

Siding is selected according to the *siding map*.

### Structural Brick

If `WallType/StructuralBrick` is found in HPXML, one of the structural brick codes in HEScore is specified. The nearest R-value to the sum of all the insulation layer nominal R-values is selected.

```
<Wall>
    <SystemIdentifier id="wall3"/>
    <WallType>
        <StructuralBrick/>
    </WallType>
    <Insulation>
        <SystemIdentifier id="wall3ins"/>
        <Layer>
            <NominalRValue>5</NominalRValue>
        </Layer>
        <Layer>
            <NominalRValue>5</NominalRValue>
        </Layer>
        <!-- This would have a summed R-value of 10 -->
```

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```
  </Insulation>
</Wall>
```

#### Concrete Block or Stone

If `WallType/ConcreteMasonryUnit` or `WallType/Stone` is found, one of the concrete block construction codes is used in HEScore. The nearest R-value to the sum of all the insulation layer nominal R-values is selected. The siding is translated using the *same assumptions as wood stud walls* with the exception that vinyl, wood, or aluminum siding is not available and if those are specified in the HPXML an error will result.

#### Straw Bale

If `WallType/StrawBale` is found in the HPXML wall, the straw bale wall assembly code in HEScore is selected.

#### Exterior Finish

Siding mapping is done from the `Wall/Siding` element in HPXML. Siding is specified as the last two characters of the construction code in HEScore.

Table 14: Siding type mapping

| HPXML | HEScore |
|---|---|
| wood siding | wo |
| stucco | st |
| synthetic stucco | st |
| vinyl siding | vi |
| aluminum siding | al |
| brick veneer | br |
| asbestos siding | wo |
| fiber cement siding | wo |
| composite shingle siding | wo |
| masonite siding | wo |
| other | *not translated* |

**Note:** *not translated* means the translation will fail for that house.

### 3.6.3 Area Weighted Wall R-value

When more than one HPXML `Wall` element must be combined into one wall construction for HEScore, the wall construction code is determined for each HPXMl `Wall` as described in *Wall Construction*. The wall construction and exterior finish that represent the largest combined area are used to represent the side of the house.

A weighted R-value is calculated by looking up the center-of-cavity R-value for the wall construction, exterior finish, and nominal R-value for each `Wall` from the following table.

Table 15: Wall center-of-cavity R-values

| Exterior | Wood Siding | Stucco | Vinyl | Aluminum | Brick Veneer | None |
|---|---|---|---|---|---|---|
| R-value | Effective R-value | | | | | |
| **Wood Frame** | | | | | | |
| R-0 | 3.6 | 2.3 | 2.2 | 2.1 | 2.9 | |
| R-3 | 5.7 | 4.4 | 4.3 | 4.2 | 5.0 | |
| R-7 | 9.7 | 8.4 | 8.3 | 8.2 | 9.0 | |
| R-11 | 13.7 | 12.4 | 12.3 | 12.2 | 13.0 | |
| R-13 | 15.7 | 14.4 | 14.3 | 14.2 | 15.0 | |
| R-15 | 17.7 | 16.4 | 16.3 | 16.2 | 17.0 | |
| R-19 | 21.7 | 20.4 | 20.3 | 20.2 | 21.0 | |
| R-21 | 23.7 | 22.4 | 22.3 | 22.2 | 23.0 | |
| **Wood Frame w/insulated sheathing** | | | | | | |
| R-0 | 6.1 | 5.4 | 5.3 | 5.2 | 6.0 | |
| R-3 | 9.1 | 8.4 | 8.3 | 8.2 | 9.0 | |
| R-7 | 13.1 | 12.4 | 12.3 | 12.2 | 13.0 | |
| R-11 | 17.1 | 16.4 | 16.3 | 16.2 | 17.0 | |
| R-13 | 19.1 | 18.4 | 18.3 | 18.2 | 19.0 | |
| R-15 | 21.1 | 20.4 | 20.3 | 20.2 | 21.0 | |
| R-19 | 25.1 | 24.4 | 24.3 | 24.2 | 25.0 | |
| R-21 | 27.1 | 26.4 | 26.3 | 26.2 | 27.0 | |
| **Optimum Value Engineering** | | | | | | |
| R-19 | 21.0 | 20.3 | 20.1 | 20.1 | 20.9 | |
| R-21 | 23.0 | 22.3 | 22.1 | 22.1 | 22.9 | |
| R-27 | 29.0 | 28.3 | 28.1 | 28.1 | 28.9 | |
| R-33 | 35.0 | 34.3 | 34.1 | 34.1 | 34.9 | |
| R-38 | 40.0 | 39.3 | 39.1 | 39.1 | 39.9 | |
| **Structural Brick** | | | | | | |
| R-0 | | | | | | 2.9 |
| R-5 | | | | | | 7.9 |
| R-10 | | | | | | 12.8 |
| **Concrete Block** | | | | | | |
| R-0 | | 4.1 | | | 5.6 | 4.0 |
| R-3 | | 5.7 | | | 7.2 | 5.6 |
| R-6 | | 8.5 | | | 10.0 | 8.3 |
| **Straw Bale** | | | | | | |
| R-0 | | 58.8 | | | | |

Then a weighted average is calculated by weighting the U-values values by area.

$$U_i = \frac{1}{R_i}$$

$$U_{eff,avg} = \frac{\sum_i U_i A_i}{\sum_i A_i}$$

$$R_{eff,avg} = \frac{1}{U_{eff,avg}}$$

The R-0 center-of-cavity R-value ($R_{offset}$) is selected for the highest weighted wall construction type represented in the calculation and is subtracted from $R_{eff,avg}$. For construction types where there is no R-0 nominal value, the lowest nominal R-value is subtracted from the corresponding effective R-value.

$$R = R_{eff,avg} - R_{offset}$$

Finally the R-value is rounded to the nearest insulation level in the enumeration choices for the highest weighted roof construction type included in the calculation.

## 3.7 Windows and Skylights

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### 3.7.1 Window Orientation

HEScore requires that a window area be specified for each side of the building. To determine the window area on each side of the building, each `Window` element in HPXML must have an `Area` subelement. The `Area` subelement is assumed to mean the sum of the areas of the windows that the `Window` element represents. Each `Window` is then assigned to a side of the building in one of two ways:

1. By inspecting the azimuth or orientation of the window.
2. By association with a particular wall.

If there is an `Orientation` or `Azimuth` element, the side is determined via the one of those elements with preference given to the `Azimuth` if present. If the window falls between two sides of the house, the window area is divided between the sides of the house evenly.

If `Orientation` or `Azimuth` are missing and the HPXML window has the `AttachedToWall` element, the id reference in that element is used to find the associated wall and the side of the building that the window faces is inferred from the *wall orientation*. If the window is attached to a foundation wall, the orientation/azimuth must be provided on the `Window` element because foundation walls do not have orientation or azimuth elements available.

The areas on each side of the house are summed and the *Window Properties* are determined independently for each side of the house. Since HPXML requires that window properties be assigned to each direction, the `window_construction_same` option in HEScore will always be false and all windows will be specified separately.

Skylights in HEScore do not have an orientation that can be set, therefore orientation/azimuth information about skylights is ignored. Use *AttachedToRoof* to specify which HPXML roof each skylight is attached to. If not specified, skylights will be assigned to the first hescore roof.

### 3.7.2 Window Properties

Windows can be specified in one of two different ways in HEScore:

1. NFRC rated window specifications U-Factor and Solar Heat Gain Coefficient (SHGC)
2. Generic window types defined by the number of panes of glass, frame material, and glazing type.

Preference is given to the first choice above if those values are available in the HPXML document. If U-Factor and SHGC are not available, then one of the window codes is chosen based on the other properties of the windows. Since HPXML stores the window properties for each window, the properties for the windows on each side of the house must be aggregated across all of the windows on that side. The processes described below are done independently for the windows on each side of the house.

#### Defining windows using NFRC specifications

When there is at least one window on a side of the house that has U-Factor and SHGC values available, those are used. The values are aggregated across all the windows on a particular side of the house by taking an area weighted average omitting any windows that do not have U-Factor and SHGC values.

#### Defining windows by selecting a window type

When none of the windows on a side of the house have U-Factor and SHGC data elements, a window code is selected based on other properties of each window. Then the most predominant window code by area on each side of the house is selected.

Unfortunately there is not a 1-to-1 correlation of the HPXML data elements to HEScore for these selections and it is possible to define windows in HPXML that are impossible to input into HEScore. In these cases the translation will fail.

Windows are first sorted by frame type. The mapping of HPXML `FrameType` to HEScore frame type is performed thusly.

Table 16: Window frame type mapping

| HPXML | HEScore |
|---|---|
| Aluminum | Aluminum |
| Composite | Wood or Vinyl |
| Fiberglass | Wood or Vinyl |
| Metal | Aluminum |
| Vinyl | Wood or Vinyl |
| Wood | Wood or Vinyl |
| Other | *not translated* |

**Warning:** If a `FrameType` of `Other` is selected in HPXML, the translation will fail.

Both the `Aluminum` and `Metal` frame types in HPXML have optional `ThermalBreak` subelements that specify whether there is a thermal break in the frame. If `ThermalBreak` is true then the "Aluminum with Thermal Break" frame type is selected.

Depending on the frame type selected in HEScore, different options become available for number of panes and glass type. The following sections explain the logic for each frame type.

### Aluminum

The aluminum frame type allows for single- and double-paned windows, but not more than that. According to the HEScore documentation, single-pane windows with storm windows should be considered double-pane.

Table 17: Window pane mapping for Aluminum frame types (HPXML v2)

| HPXML Glass Layers | HEScore |
|---|---|
| single-pane | single-pane |
| double-pane | double-pane |
| triple-pane | *not translated* |
| multi-layered | *not translated* |
| single-paned with storms | double-pane |
| single-paned with low-e storms | double-pane |
| other | *not translated* |

Table 18: Window pane mapping for Aluminum frame types (HPXML v3)

| HPXML Glass Layers | HEScore |
|---|---|
| single-pane | single-pane |
| double-pane | double-pane |
| triple-pane | *not translated* |
| multi-layered | *not translated* |
| other | *not translated* |

**Note:** Starting from HPXML v3, "single-paned with storms" and "single-paned with low-e storms" enumerations are removed. Instead, translator searches `Window/StormWindow` element for storm existence. If the storm window is a low-e window, specify `Window/StormWindow/GlassType` to be equal to "low-e". `StormWindow` is only used when `single-pane` window is specified.

**HPXML v2 "single-paned with storms" equivalence(mapped to double-pane) in HPXML v3:**

- `Window/GlassLayers` "single-pane" + `Window/StormWindow`.

**HPXML v2 "single-paned with low-e storms" equivalence(mapped to double-pane) in HPXML v3:**

- `Window/GlassLayers` "single-pane" + `Window/StormWindow/GlassType` to be "low-e".

**Warning:** If a window has the "Aluminum" frame type, the `GlassLayers` must be single-pane, double-pane, or a single-pane with storm windows (or specify `Window/StormWindow` with "single-pane" in HPXML v3+) or the translation will fail.

### Single-pane

Single-paned windows can be either tinted or clear. If the `GlassType` element is either “tinted” or “tinted/reflective”, “Single-pane, tinted” is selected. Otherwise, “Single-pane, clear” is selected.

Table 19: Single-pane window mapping for Aluminum frame types

| HPXML Glass Type | HEScore Glazing Type |
| --- | --- |
| low-e | Single-pane, tinted |
| tinted | Single-pane, tinted |
| reflective | Single-pane, clear |
| tinted/reflective | Single-pane, tinted |
| other | Single-pane, clear |
| *element missing* | Single-pane, clear |

### Double-pane

Double-paned windows have a solar control low-e option in addition to the tinted and clear options.

Table 20: Double-pane window mapping for Aluminum frame types

| HPXML Glass Type | HEScore Glazing Type |
| --- | --- |
| low-e | Double-pane, solar-control low-E |
| tinted | Double-pane, tinted |
| reflective | Double-pane, solar-control low-E |
| tinted/reflective | Double-pane, solar-control low-E |
| other | Double-pane, clear |
| *element missing* | Double-pane, clear |

### Aluminum with Thermal Break

Only double paned window options are available for the aluminum with thermal break frame type. According to the HEScore documentation, single-pane windows with storm windows should be considered double-pane.

Table 21: Window pane mapping for Aluminum with Thermal Break frame types (HPXML v2)

| HPXML Glass Layers | HEScore |
| --- | --- |
| single-pane | *not translated* |
| double-pane | double-pane |
| triple-pane | *not translated* |
| multi-layered | *not translated* |
| single-paned with storms | double-pane |
| single-paned with low-e storms | double-pane |
| other | *not translated* |

Table 22: Window pane mapping for Aluminum with Thermal Break frame types (HPXML v3)

| HPXML Glass Layers | HEScore |
|---|---|
| single-pane | *not translated* |
| double-pane | double-pane |
| triple-pane | *not translated* |
| multi-layered | *not translated* |
| other | *not translated* |

**Note:** Starting from HPXML v3, "single-paned with storms" and "single-paned with low-e storms" enumerations are removed. Instead, translator searches `Window/StormWindow` element for storm existence. If the storm window is a low-e window, specify `Window/StormWindow/GlassType` to be equal to "low-e". `StormWindow` is only used when `single-pane` window is specified.

**HPXML v2 "single-paned with storms" equivalence(mapped to double-pane) in HPXML v3:**

- `Window/GlassLayers` "single-pane" + `Window/StormWindow`.

**HPXML v2 "single-paned with low-e storms" equivalence(mapped to double-pane) in HPXML v3:**

- `Window/GlassLayers` "single-pane" + `Window/StormWindow/GlassType` to be "low-e".

**Warning:** If a window has the "Aluminum with Thermal Break" frame type, the `GlassLayers` must be double-pane or single-pane with storms (or specify `Window/StormWindow` with "single-pane" in HPXML v3+) or the translation will fail.

### Double-pane

To get the "Double-pane, insulating low-E, argon gas fill" option, you need to specify the window elements as highlighted below. Storm windows will not work because it is impossible to have an argon gas fill between the window and the storm window.

```
<Window>
   <SystemIdentifier id="id1"/>
   <Area>30</Area>
   <Orientation>east</Orientation>
   <FrameType>
       <Aluminum><!-- or Metal -->
           <ThermalBreak>true</ThermalBreak>
       </Aluminum>
   </FrameType>
   <GlassLayers>double-pane</GlassLayers>
   <GlassType>low-e</GlassType>
   <GasFill>argon</GasFill>
</Window>
```

"Double-pane, solar-control low-E" can be specified as highlighted in the following code block. Using "reflective" in `GlassType` is assumed to be the same as solar control low-e.

```
<Window>
   <SystemIdentifier id="id2"/>
```

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```
    <Area>30</Area>
    <Orientation>east</Orientation>
    <FrameType>
        <Aluminum><!-- or Metal -->
            <ThermalBreak>true</ThermalBreak>
        </Aluminum>
    </FrameType>
    <GlassLayers>double-pane</GlassLayers><!-- or other double-pane mapped options␣
↪mentioned above -->
    <GlassType>reflective</GlassType>
</Window>
```

**Warning:** Is "reflective" the same as solar control low-e or close enough? I'm running on the assumption that low-e means insulating low-e.

To specify the "Double-pane, tinted" option in HEScore, the `GlassType` needs to be either "tinted" or "tinted/reflective."

```
<Window>
    <SystemIdentifier id="window1"/>
    <Area>30</Area>
    <Orientation>east</Orientation>
    <FrameType>
        <Aluminum>
            <ThermalBreak>true</ThermalBreak>
        </Aluminum>
    </FrameType>
    <GlassLayers>double-pane</GlassLayers><!-- or 'single-paned with storms', 'single-
↪paned with low-e storms' -->
    <GlassType>tinted</GlassType><!-- or tinted/reflective -->
</Window>
```

All other *double-pane* windows will be translated as "Double-pane, clear."

### Wood or Vinyl

In HEScore wood or vinyl framed windows can have 1, 2, or 3 panes. According to the HEScore documentation, single-pane windows with storm windows should be considered double-pane. The HPXML `GlassLayers` maps into HEScore number of panes as follows:

Table 23: Window pane mapping for Wood or Vinyl frame types (HPXML v2)

| HPXML Glass Layers | HEScore |
|---|---|
| single-pane | single-pane |
| double-pane | double-pane |
| triple-pane | triple-pane |
| multi-layered | *not translated* |
| single-paned with storms | double-pane |
| single-paned with low-e storms | double-pane |
| other | *not translated* |

Table 24: Window pane mapping for Wood or Vinyl frame types (HPXML v3)

| HPXML Glass Layers | HEScore |
|---|---|
| single-pane | single-pane |
| double-pane | double-pane |
| triple-pane | triple-pane |
| multi-layered | *not translated* |
| other | *not translated* |

**Note:** Starting from HPXML v3, "single-paned with storms" and "single-paned with low-e storms" enumerations are removed. Instead, translator searches `Window/StormWindow` element for storm existence. If the storm window is a low-e window, specify `Window/StormWindow/GlassType` to be equal to "low-e". `StormWindow` is only used when `single-pane` window is specified.

**HPXML v2 "single-paned with storms" equivalence(mapped to double-pane) in HPXML v3:**

- `Window/GlassLayers` "single-pane" + `Window/StormWindow`.

**HPXML v2 "single-paned with low-e storms" equivalence(mapped to double-pane) in HPXML v3:**

- `Window/GlassLayers` "single-pane" + `Window/StormWindow/GlassType` to be "low-e".

### Single-pane

Single-pane windows can be either tinted or not. If the `GlassType` element is either "tinted" or "tinted/reflective", "Single-pane, tinted" is selected. Otherwise, "Single-pane, clear" is selected.

Table 25: Single-pane window mapping for Wood or Vinyl frame types

| HPXML Glass Type | HEScore Glazing Type |
|---|---|
| low-e | Single-pane, tinted |
| tinted | Single-pane, tinted |
| reflective | Single-pane, clear |
| tinted/reflective | Single-pane, tinted |
| other | Single-pane, clear |
| *element missing* | Single-pane, clear |

### Double-pane

Double-pane windows can be either clear, tinted, insulating low-E with or without argon gas fill, and solar control low-E with or without argon gas fill. According to the HEScore documentation, single-pane windows with storm windows should be considered double-pane. The double-pane mapping is a bit more complicated as it needs to use multiple elements to determine the glazing type for HEScore. We will address each possible HEScore combination and how it is expected to be represented in HPXML.

To get a insulating low-E double-pane wood or vinyl framed window, `GlassLayers` needs to be "double-pane" and the `GlassType` needs to be "low-e" or `GlassLayers` needs to be "single-paned with low-e storms" (or GlassLayers "single-pane" + `Window/StormWindow/GlassType` equal to "low-e" in HPXML v3+). If `GasFill` is argon, it will be argon filled. For instance, to get a double-pane low-E with argon fill, the HPXML window element would look like:

```xml
<Window>
   <SystemIdentifier id="window1"/>
   <Area>30</Area>
   <Orientation>east</Orientation>
   <FrameType>
       <Vinyl/>
   </FrameType>
   <GlassLayers>double-pane</GlassLayers>
   <GlassType>low-e</GlassType>
   <GasFill>argon</GasFill>
</Window>
```

Translating a Single-pane window with a low-E storm window into the HEScore type of double-pane with insulating low-E the HPXML window element would look like:

- HPXML v2:

```xml
<Window>
   <SystemIdentifier id="window53"/>
   <Area>30</Area>
   <Orientation>east</Orientation>
   <FrameType>
       <Vinyl/>
   </FrameType>
   <GlassLayers>single-paned with low-e storms</GlassLayers>
</Window>
```

- HPXML v3:

```xml
<Window>
   <SystemIdentifier id="window53"/>
   <Area>30</Area>
   <Orientation>east</Orientation>
   <FrameType>
       <Vinyl/>
   </FrameType>
   <GlassLayers>single-pane</GlassLayers>
   <StormWindow>
      <SystemIdentifier id="windowstorm"/>
      <GlassType>low-e</GlassType>
   </StormWindow>
</Window>
```

Note the missing `GlassType` element. It is ignored when it's a single-paned window with low-e storms. The translation will also ignore `GasFill` for single-paned window because it's impossible to have argon between a single pane window and storm window.

To specify a solar-control low-E double-pane wood or vinyl framed window a `GlassType` of "reflective" must be specified. Setting `GasFill` as "argon" or not indicates whether the argon gas fill type is chosen in HEScore.

**Warning:** The HPXML `GlassType` of reflective is assumed to mean solar control low-E when translated into HEScore parlance.

For instance, to get a "Double-pane, solar-control low-E" glazing type, the HPXML window element would look like:

```xml
<Window>
   <SystemIdentifier id="window53"/>
   <Area>30</Area>
   <Orientation>east</Orientation>
   <FrameType>
       <Wood/>
   </FrameType>
   <GlassLayers>double-pane</GlassLayers>
   <GlassType>reflective</GlassType>
</Window>
```

For argon filled, you would add `<GasFill>argon</GasFill>` before the `</Window>`.

If the `GlassType` is "tinted" or "tinted/reflective" the "Double-pane, tinted" HEScore glazing type is selected.

Finally, if the window is double-pane (or single-pane with storm window) and doesn't meet the above criteria, then the "Double-pane, clear" glazing type is chosen for HEScore.

#### Triple-pane

If the `GlassLayers` in HPXML specifies a "triple-paned" window, the HEScore "Triple-pane, insulating low-E, argon gas fill" glazing type is selected. The `GlassType` and `GasFill` elements are not considered since this is the only triple-pane glazing option in HEScore.

### 3.7.3 Solar Screens

For each side of the house in HEScore, solar screens may be present. To determine if solar screens should be specified, the translator looks for either of the following subelements of `Window` or `Skylight`:

HPXML v2:

- `<ExteriorShading>solar screens</ExteriorShading>`
- `<Treatments>solar screen</Treatments>`

HPXML v3:

- `<ExteriorShading><Type>solar screens</Type></ExteriorShading>`

If the majority of the window area on a side of the house (or skylights facing upwards) meet that criteria, that side of the house will have solar screens in the HEScore model. This determination is made independent of whether the other window properties were set using NFRC specifications or inferred based on window type.

## 3.8 HVAC Systems

HEScore allows the definition of up to two HVAC systems which can each include a heating system, cooling system, and duct system. To determine which HPXML elements are associated, the `DistributionSystem` subelement of `HeatingSystem`, `CoolingSystem`, `HeatPump` is used to find the link to `HVACDistributionSystem`. Systems that share the same `HVACDistributionSystem` are determined to be the same HVAC system for HEScore.

Sometimes an HVAC system will not share ducts, for instance a central air conditioner and boiler. In that case, if each of those systems serve a fraction of the home's load within 5% of each other they will be combined into the same HVAC system for HEScore. If a `HeatingSystem` and `CoolingSystem` that are associated with the same `HVACDistributionSystem` serve differing portions of the house's heating and cooling load, that weight is averaged to find the combined system weight.

If either a heating or cooling system meets all of the load and two systems of the opposite (cooling or heating, respectively) are required to meet the same fraction of the load, the larger system is split into two for input into HEScore.

To determine the fraction of the home's heating and cooling load each system serves, each HPXML heating and cooling system is required to have `FloorAreaServed` or, alternatively `FracLoadServed`. The two combined HVAC systems that serve the greatest portion of the house's load are sent to HEScore.

For details about how each kind of `HeatingSystem`, `CoolingSystem`, `HeatPump`, and `HVACDistributionSystem` are translated into HEScore inputs, see the appropriate subsection:

### 3.8.1 Heating

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#### Heating system type

HPXML provides two difference HVAC system elements that can provide heating: `HeatingSystem` that only provides heating and `HeatPump` which can provide heating and cooling.

#### Heat Pump

The `HeatPump` element in HPXML can represent either an air-source heat pump or ground source heat pump in HEScore. Which is specified in HEScore is determined by the `HeatPumpType` element in HPXML according to the following mapping.

Table 26: Heat Pump Type mapping

| HPXML Heat Pump Type | HEScore Heating Type |
| --- | --- |
| water-to-air | gchp |
| water-to-water | gchp |
| air-to-air | heat_pump |
| mini-split | mini_split |
| ground-to-air | gchp |

The primary heating fuel is assumed to be electric.

**Note:** Prior to HEScore v2016 mini-split heat pumps were translated as ducted air-source heat pumps with ducts in conditioned space. With the addition of mini split heat pumps in HEScore v2016, they are now categorized appropriately.

If a heat pump has a *FractionCoolLoadServed* set to zero, the heat pump is assumed to provide only space heating. If the heat pump is connected to the same distribution system as a separate cooling system and serves the same portion of the house, the house will translate but fail in Home Energy Score because that configuration is not supported.

### Heating System

The `HeatingSystem` element in HPXML is used to describe any system that provides heating that is not a heat pump. The `HeatingSystemType` subelement is used to determine what kind of heating system to specify for HEScore. This is done according to the following mapping.

Table 27: Heating System Type mapping

| HPXML Heating System Type | HEScore Heating Type |
|---|---|
| Furnace | central_furnace |
| WallFurnace | wall_furnace |
| FloorFurnace | wall_furnace |
| Boiler | boiler |
| ElectricResistance | baseboard |
| Stove | wood_stove |

**Note:** HPXML supports other values for the `HeatingSystemType` element not in the list above, but HEScore does not. Other heating system types will result in a translation error.

A primary heating fuel is selected from the `HeatingSystemFuel` subelement of the primary heating system. The fuel types are mapped as follows.

Table 28: Primary Heating System Fuel mapping

| HPXML | HEScore |
|---|---|
| electricity | electric |
| renewable electricity | electric |
| natural gas | natural_gas |
| renewable natural gas | natural_gas |
| fuel oil | fuel_oil |
| fuel oil 1 | fuel_oil |
| fuel oil 2 | fuel_oil |
| fuel oil 4 | fuel_oil |
| fuel oil 5/6 | fuel_oil |
| propane | lpg |
| wood | cord_wood |
| wood pellets | pellet_wood |

**Warning:** HPXML supports other fuel types that could not be mapped into existing HEScore fuel types (i.e. coal, wood). Encountering an unsupported fuel type will result in a translation error.

#### Heating Efficiency

Heating efficiency can be described in HEScore by either the rated efficiency (AFUE, HSPF, COP), or if that is unavailable, the year installed/manufactured from which HEScore estimates the efficiency based on shipment weighted efficiencies by year. The translator follows this methodology and looks for the rated efficiency first and if it cannot be found sends the year installed.

Wood stoves and electric furnaces and baseboard heating do not use the efficiency input in HEScore. Therefore, for these heating types an efficiency is not determined.

#### Rated Efficiency

HEScore expects efficiency to be described in different units depending on the heating system type.

Table 29: HEScore heating type efficiency units

| Heating Type | Efficiency Units |
|---|---|
| heat_pump | HSPF |
| mini_split | HSPF |
| central_furnace | AFUE |
| wall_furnace | AFUE |
| boiler | AFUE |
| gchp | COP |

The translator searches the `HeatingSystem/AnnualHeatingEfficiency` or `HeatPump/AnnualHeatEfficiency` (HPXML v2) or `HeatPump/AnnualHeatingEfficiency` (HPXML v3) elements of the primary heating system and uses the first one that has the correct units.

#### Shipment Weighted Efficiency

When an appropriate rated efficiency cannot be found, HEScore can accept the year the equipment was installed and estimate the efficiency based on that. The year is retrieved from the `YearInstalled` element, and if that is not present the `ModelYear` element.

### 3.8.2 Cooling

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### Cooling system type

HPXML provides two difference HVAC system elements that can provide cooling: `CoolingSystem` that only provides cooling and `HeatPump` which can provide heating and cooling.

#### Heat Pump

The `HeatPump` element in HPXML can represent either an air-source heat pump or ground source heat pump in HEScore. Which is specified in HEScore is determined by the `HeatPumpType` element in HPXML according to the following mapping.

Table 30: Heat Pump Type mapping

| HPXML Heat Pump Type | HEScore Cooling Type |
|---|---|
| water-to-air | gchp |
| water-to-water | gchp |
| air-to-air | heat_pump |
| mini-split | mini_split |
| ground-to-air | gchp |

**Note:** Prior to HEScore v2016 mini-split heat pumps were translated as ducted air-source heat pumps with ducts in conditioned space. With the addition of mini split heat pumps in HEScore v2016, they are now categorized appropriately.

If a heat pump has a *FractionHeatlLoadServed* set to zero, the heat pump is assumed to provide only space cooling. If the heat pump is connected to the same distribution system as a separate heating system and serves the same portion of the house, the house will translate but fail in Home Energy Score because that configuration is not supported.

#### Cooling System

The `CoolingSystem` element in HPXML is used to describe any system that provides cooling that is not a heat pump. The `CoolingSystemType` subelement is used to determine what kind of cooling system to specify for HEScore. This is done according to the following mapping.

Table 31: Cooling System Type mapping

| HPXML Cooling System Type | HEScore Cooling Type |
|---|---|
| central air conditioner (HPXML V3) | split_dx |
| central air conditioning (HPXML V2) | split_dx |
| room air conditioner | packaged_dx |
| mini-split | mini_split |
| evaporative cooler | dec |
| other | *not translated* |

**Warning:** If an HPXML cooling system type maps to *not translated* the translation will fail.

**Note:** Prior to v2016, HEScore did not have an evaporative cooler type and these were translated as high efficiency split_dx systems. Now that evaporative cooling has been added in HEScore v2016, they are categorized accordingly.

**Note:** Starting from HPXML version 3.0, the enumeration "central air conditioning" is renamed as "central air conditioner". They're equivalent in translation.

#### Cooling Efficiency

Cooling efficiency can be described in HEScore by either the rated efficiency (SEER, EER), or if that is unavailable, the year installed/manufactured from which HEScore estimates the efficiency based on shipment weighted efficiencies by year. The translator follows this methodology and looks for the rated efficiency first and if it cannot be found sends the year installed. Evaporative coolers do not require an efficiency input in HEScore, and it is therefore omitted.

#### Rated Efficiency

HEScore expects efficiency to be described in different units depending on the cooling system type.

Table 32: HEScore cooling type efficiency units

| Cooling Type | Efficiency Units |
|---|---|
| split_dx | SEER |
| packaged_dx | EER |
| heat_pump | SEER |
| mini_split | SEER |
| gchp | EER |

The translator searches the `CoolingSystem/AnnualCoolingEfficiency` or `HeatPump/AnnualCoolEfficiency` (HPXML v2) or `HeatPump/AnnualCoolingEfficiency` (HPXML v3) elements of the primary cooling system and uses the first one that has the correct units.

#### Shipment Weighted Efficiency

When an appropriate rated efficiency cannot be found, HEScore can accept the year the equipment was installed and estimate the efficiency based on that. The year is retrieved from the `YearInstalled` element, and if that is not present the `ModelYear` element.

### 3.8.3 HVAC Distribution

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– *Duct Sealing*

In HPXML multiple `HVACDistribution` elements can be associated with a heating or cooling system. For the purposes of this translator, it is required that only one `HVACDistribution` element be linked. That element can then describe a ducted system, a hydronic system, or an open ended other system. For the translation to HEScore, only `HVACDistribution` elements that are ducted are considered.

### Duct Location Mapping

For each `Ducts` element in each air distribution system, the location of the duct mapped from HPXML enumerations to HEScore enumerations according to the following mapping.

Table 33: Duct Location mapping (HPXML v2)

| HPXML | HEScore |
|---|---|
| conditioned space | cond_space |
| unconditioned space | *not translated* |
| unconditioned basement | uncond_basement |
| unvented crawlspace | unvented_crawl |
| vented crawlspace | vented_crawl |
| crawlspace | *not translated* |
| unconditioned attic | uncond_attic |
| interstitial space | *not translated* |
| garage | vented_crawl |
| outside | *not translated* |

Table 34: Duct Location mapping (HPXML v3)

| HPXML | HEScore Hierarchy |
|---|---|
| living space | cond_space |
| unconditioned space | uncond_basement, vented_crawl, unvented_crawl, uncond_attic |
| under slab | vented_crawl |
| basement | uncond_basement, cond_space |
| basement - unconditioned | uncond_basement |
| basement - conditioned | cond_space |
| crawlspace - unvented | unvented_crawl |
| crawlspace - vented | vented_crawl |
| crawlspace - unconditioned | vented_crawl, unvented_crawl |
| crawlspace - conditioned | cond_space |
| crawlspace | vented_crawl, unvented_crawl, cond_space |
| exterior wall | *not translated* |
| attic | uncond_attic, cond_space |
| attic - unconditioned | uncond_attic |
| attic - conditioned | cond_space |
| attic - unvented | uncond_attic |
| attic - vented | uncond_attic |
| interstitial space | *not translated* |
| garage | vented_crawl |
| garage - conditioned | cond_space |
| garage - unconditioned | vented_crawl |
| roof deck | vented_crawl |
| outside | vented_crawl |

**Warning:** If an HPXML duct location maps to *not translated* above, the translation for the house will fail.

### Duct Fractions

For each `Ducts` element in an air distribution system the `FracDuctArea` is summed by HEScore *duct location*.

### Duct Insulation

If the any of the `Ducts` elements in a particular *location* have a `DuctInsulationRValue` or `DuctInsulationThickness` that is greater than zero, all of the ducts in that location are considered insulated.

### Duct Sealing

Duct leakage measurements are not stored on the individual `Ducts` elements in HEScore, which means they are not directly associated with a duct location. They are instead associated with an `AirDistribution` element, which can have many ducts in many locations. Duct sealing information is therefore associated with all ducts in an `AirDistribution` element.

To specify that the ducts in an `AirDistribution` system are sealed, the translator expects to find either of the following elements:

- `DuctLeakageMeasurement/LeakinessObservedVisualInspection` element with the value of "connections sealed w mastic".
- `HVACDistribution/HVACDistributionImprovement/DuctSystemSealed` element with the value of "true".

The `DuctLeakageMeasurement` can hold values for actual measurements of leakage, but since HEScore cannot do anything with them, they will be ignored. Therefore the following will result in an "unsealed" designation:

```
<DuctLeakageMeasurement>
   <DuctType>supply</DuctType>
   <!-- All of this is ignored -->
   <DuctLeakageTestMethod>duct leakage tester</DuctLeakageTestMethod>
   <DuctLeakage>
       <Units>CFM25</Units>
       <Value>0.000000001</Value><!-- exceptionally low leakage -->
   </DuctLeakage>
</DuctLeakageMeasurement>
```

and the following will result in a "sealed" designation:

```
<DuctLeakageMeasurement>
   <DuctType>supply</DuctType>
   <LeakinessObservedVisualInspection>connections sealed w mastic</
↪LeakinessObservedVisualInspection>
</DuctLeakageMeasurement>
```

## 3.9 Domestic Hot Water

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### 3.9.1 Determining the primary water heating system

HPXML allows for the specification of several `WaterHeatingSystem` elements. HEScore only allows one to be specified. If there are more than one water heaters present in the HPXML file, the one that serves the largest fraction of the the load is selected based on the value of `FractionDHWLoadServed`. If not all of the `WaterHeatingSystem` elements have `FractionDHWServed` subelements (or if none of them do), the first `WaterHeatingSystem` is selected.

### 3.9.2 Water heater type

The water heater type is mapped from HPXML to HEScore accordingly:

Table 35: HPXML to HEScore water heater type mapping

| HPXML | HEScore | |
|---|---|---|
| WaterHeaterType | DHW Category | DHW Type |
| storage water heater | unit | storage |
| dedicated boiler with storage tank | | |
| instantaneous water heater | unit | tankless |
| heat pump water heater | unit | heat_pump |
| space-heating boiler with storage tank | combined | indirect |
| space-heating boiler with tankless coil | combined | tankless_coil |

The fuel type is mapped according to the same mapping used in *Primary Heating System Fuel mapping*.

### 3.9.3 Water heating efficiency

If the `WaterHeating/UniformEnergyFactor` element exists, that is passed to HEScore with an efficiency method of “uef”. Otherwise if the `WaterHeatingSystem/EnergyFactor` element exists, that energy factor is sent to HEScore along with an efficiency method of “user”, which tells it that to interpret it as a traditional energy factor. When an energy factor cannot be found, HEScore can accept the year the equipment was installed and estimate the efficiency based on that. The year is retrieved from the `YearInstalled` element, and if that is not present the `ModelYear` element.

If the DHW type is tankless, only energy factor or unified energy factor could be used to describe efficiency, the estimation based on installed year is no longer available.

## 3.10 Generation

### 3.10.1 Solar Electric

HEScore allows for a single photovoltaic system to be included as of v2016. In HPXML, multiple `PVSystem` elements can be specified to represent the PV systems on the house. The translator combines multiple systems and generates the appropriate HEScore inputs as follows:

#### Capacity Known

If each `PVSystem` has a `MaxPowerOutput`, this is true. If each `PVSystem` has a `CollectorArea`, this is false. Preference is given to known capacity if both are available. Either a `MaxPowerOutput` must be specified for every `PVSystem` or `CollectorArea` must be specified for every `PVSystem`.

#### DC Capacity

If each `PVSystem` has a `MaxPowerOutput`, the system capacity is known. The `system_capacity` in HEScore is calculated by summing all the `MaxPowerOutput` elements in HPXML.

#### Number of Panels

If `MaxPowerOutput` is missing from any `PVSystem`, `CollectorArea` is required on every PVSystem and the system capacity is not known. The number of panels is calculated by summing all the collector area, dividing by 17.6 sq.ft., and rounding to the nearest whole number.

#### Year Installed

For each `PVSystem` the `YearInverterManufactured` and `YearModulesManufactured` element values are retrieved, and the greater of the two is assumed to be the year that system was installed. When there are multiple `PVSystem` elements, a capacity or area-weighted average of the assumed year installed is calculated and used.

#### Panel Orientation (Azimuth)

For each `PVSystem` the `ArrayAzimuth` (degrees clockwise from north) is retrieved. If `ArrayAzimuth` is not available, `ArrayOrientation` (north, northwest, etc) is converted into an azimuth. A capacity or area-weighted average azimuth is calculated and converted into the nearest cardinal direction (north, northwest, etc) for submission into the `array_azimuth` HEScore input (which expects a direction, not a numeric azimuth).

# CHAPTER 4

## Glossary of Terms

**ACH50** Air changes per hour at 50 Pascals pressure.

**API** Application Programming Interface. An API is a documented way for different software to interact with each other. In the context of this document, the API referred to specifically is the *HEScore* API. Specific documentation is available on the LBNL website.

**CFM50** Cubic feet per minute at 50 Pascals pressure.

**HEScore** Home Energy Scoring Tool. The Home Energy Score is similar to a vehicle's mile-per-gallon rating. The Home Energy Score allows homeowners to compare the energy performance of their homes to other homes nationwide. It also provides homeowners with suggestions for improving their homes' efficiency. The process starts with a Home Energy Score Qualified Assessor collecting energy information during a brief home walk-through. Using the Home Energy Scoring Tool, developed by the Lawrence Berkeley National Laboratory, the Qualified Assessor then scores the home on a scale of 1 to 10. A score of 10 indicates that the home has excellent energy performance. A score of 1 indicates the home needs extensive energy improvements. In addition to providing the Score, the Qualified Assessor provides the homeowner with a list of recommended energy improvements and the associated cost savings estimates.[1]

**HPXML** Home Performance *XML*. BPI-2100 is designed to facilitate communication and the exchange of information and data among all actors in the home performance industry by providing an extensible mark-up language (XML) standard for transferring information related to whole-house energy efficiency upgrades. The standard is informally known as Home Performance XML, or HPXML. BPI-2100 is a companion standard to BPI-2200 (Standard for Home Performance-Related Data Collection). Each of the data elements defined in BPI-2200 can be transferred via HPXML.[2]

**XML** eXtensible Markup Language. XML is a markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable. It is defined in the XML 1.0 Specification produced by the W3C, and several other related specifications, all free open standards.[3]

[1] http://energy.gov/eere/buildings/home-energy-score
[2] http://hpxmlonline.com/
[3] http://en.wikipedia.org/wiki/XML

CHAPTER 5

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