
HPXML Import for Home Energy Score Documentation

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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 of 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.

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. See the [Home Energy Scoring Tool API Documentation](#) for details on how to do that.

The HPXML translator is made available through the API method `submit_hpxml_inputs`, which 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.

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 is 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 3.x](#). The instructions below will help you set up Python on your platform and get the translator installed.

Windows

1. Download [Python 3.x](#) from [python.org](#) and Install.
2. Add `C:\Python3X` 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 3.x using homebrew: `brew install python`
4. Follow instructions for *All Platforms*.

Linux

1. Install Python 3.x 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
```


Translation Assumptions

Contents:

3.1 Address and Requesting a New Session

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- *Address and Requesting a New Session*
 - *Address*
 - * *Mentor Assessment Type*
 - *External Building ID*

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`. Additionally, if a zip plus 4 code is entered in HPXML, it will be trimmed to just the 5 digit zip code before being passed to HEScore.

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*.

3.1.2 External Building ID

The value of `Building/extension/HESExternalID` or `Building/BuildingID/SendingSystemIdentifierValue`, if present, is copied into the `building_address.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.

3.2 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>
      </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 contractor 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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- *About*
 - *Assessment Type*
 - *Assessment Date*
 - *Building Dwelling Unit Type*
 - *Manufactured Home Sections*
 - *Year Built, Stories, Bedrooms, Floor Height, and Floor Area*
 - *House Orientation*
 - *Infiltration*
 - * *Blower Door Test*
 - * *Air Sealing Present*
 - *Comments*

3.3.1 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

3.3.2 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.

3.3.3 Building Dwelling Unit Type

HEScore requires specifying whether the building is a detached house, a town house, an apartment unit, or a manufactured house through their `building.dwelling_unit_type` 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 Dwelling Unit Type

HPXML	HEScore
single-family detached	single_family_detached
single-family attached	single_family_attached
manufactured home	manufactured_home
2-4 unit building	<i>not translated</i>
5+ unit building	<i>not translated</i>
multi-family - uncategorized	<i>not translated</i>
multi-family - town homes	single_family_attached
multi-family - condos	<i>not translated</i>
apartment unit	apartment_unit
studio unit	<i>not translated</i>
other	<i>not translated</i>
unknown	<i>not translated</i>

Note: For enumerations that are *not translated* the HPXML file will fail to run in HEScore. `Building/BuildingDetails/BuildingSummary/Site/Surroundings` is no longer used for shared walls mapping in town houses. Each Wall is considered and the `ExteriorAdjacentTo` is mapped into a HEScore `adjacent_to`. See [Wall ExteriorAdjacentTo](#)

3.3.4 Manufactured Home Sections

HEScore requires specifying manufactured home sections if `building.dwelling_unit_type` is a `manufactured_home`. HPXML can specify this through the `Building/BuildingDetails/BuildingSummary/BuildingConstruction/extension/ManufacturedHomeSections` element.

Note: `CrossMod` manufactured home will be treated as a single-family detached home in HEScore.

3.3.5 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.

3.3.6 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 `OrientationOfFrontOfHome` element exists, the orientation is used.

3.3.7 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". HPXML also allows the specification of multiple `Building/BuildingDetails/Enclosure/AirInfiltration/AirSealing` elements, which can contain a qualitative assessment of "leakiness". Either of the elements above is required. 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 an `AirInfiltrationMeasurement` 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="infiltr1"/>
  <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` or `AirSealing` that specifies an estimate of leakage. An example of the minimum expected elements in that case looks like:

```

<AirInfiltrationMeasurement>
  <SystemIdentifier id="infiltr2"/>
  <LeakinessDescription>tight</LeakinessDescription>
</AirInfiltrationMeasurement>

```

```

<AirSealing>
  <SystemIdentifier id="infiltr3"/>
</AirSealing>

```

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 3: 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 `AirSealing` is found, the enclosure of the house is assumed to be air-sealed.

3.3.8 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>
  </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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- *Roof and Attic*
 - *Attic/Roof Type*
 - *Attic and Roof Area*
 - * *Vented Attic*
 - * *Cathedral Ceiling and Flat Roof*
 - *Roof Color*
 - *Exterior Finish*
 - *Rigid Foam Sheathing*
 - * *HPXML v2*
 - * *HPXML v3*
 - *Radiant Barrier*
 - *Roof R-value*
 - *Attic R-value*
 - *Knee Walls*

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 because it is important to know which roof relates to each attic space.

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

HPXML	HEScore
cape cod	cath_ceiling
cathedral ceiling	cath_ceiling
flat roof	flat_roof
unvented attic	vented_attic
vented attic	vented_attic
venting unknown attic	vented_attic
other	<i>not translated</i>

Table 5: HPXML Attic Type to HEScore Roof type mapping (HPXML v3)

HPXML	HEScore
CathedralCeiling	cath_ceiling
FlatRoof	flat_roof
Attic/CapeCod = 'true'	cath_ceiling
Attic/Conditioned = 'true'	cath_ceiling
Attic	vented_attic
BelowApartment	below_other_unit
Other	<i>not translated</i>

Note: The attic/roof type `cond_attic` has been removed from HEScore as of Q1 2022. Homes with conditioned attics should be described in a way that translates to a cathedral ceiling. In HPXML v3, the conditioned attic type is automatically translated to cathedral ceiling. In HPXML v2, the extension workaround to specify a conditioned attic has been removed and the user will need to identify the house as having an attic type that translates to cathedral ceiling to achieve the desired effect.

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 Attic and Roof Area

Home Energy Score needs to know the area of the thermal boundary between the living space and unconditioned spaces. The areas needed depend on which [Attic/Roof Type](#) is selected.

It's best practice to provide areas for all roof and attic floor surfaces regardless of Attic/Roof type.

Vented Attic

The thermal boundary for a vented attic is at the floor of the attic. In **HPXML v2** that area is attached to the `Building/BuildingDetails/Enclosure/AtticAndRoof/Attics/Attic` element:

```
<SystemIdentifier id="attic1"/>
<AttachedToRoof idref="roof1"/>
<AtticType>vented attic</AtticType>
<AtticFloorInsulation>
  <SystemIdentifier id="attic1flrins"/>
  <Layer>
    <NominalRValue>49</NominalRValue>
  </Layer>
</AtticFloorInsulation>
<AtticRoofInsulation>
  <SystemIdentifier id="attic1roofins"/>
  <Layer>
```

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```

        <NominalRValue>0</NominalRValue>
      </Layer>
    </AtticRoofInsulation>
    <Area>1200</Area>
  </Attic>
</Attics>

```

In **HPXML v3** that area is retrieved from a referenced `FrameFloor` element from the `Building/BuildingDetails/Enclosure/Attics/Attic` element:

```

    <SystemIdentifier id="attic1"/>
    <AtticType>
      <Attic>
        <Vented>true</Vented>
      </Attic>
    </AtticType>
    <AttachedToRoof idref="roof1"/>
    <AttachedToFrameFloor idref="framefloor1"/>
  </Attic>
</Attics>

```

```

<FrameFloors>
  <FrameFloor>
    <SystemIdentifier id="framefloor1"/>
    <Area>1200</Area>
    <Insulation>
      <SystemIdentifier id="attic1flrins"/>
      <Layer>
        <NominalRValue>49</NominalRValue>
      </Layer>
    </Insulation>
  </FrameFloor>
</FrameFloors>

```

If there are more than one `Roof` elements attached to an attic (HPXML v3 since HPXML v2 only allows one roof to be referenced per `Attic`), you will need to provide an area for each one so that the most common roof color and exterior finishes may be selected.

Cathedral Ceiling and Flat Roof

The thermal boundary for a cathedral ceiling and a flat roof is the roof deck, so the area of the roofs attached to the attic are used.

In **HPXML v2** a single `Roof` can be referenced by the `Attic` and the area of that roof is used.

```

<AtticAndRoof>
  <Roofs>
    <Roof>
      <SystemIdentifier id="roof1"/>
      <RoofColor>medium</RoofColor>
      <RoofType>slate or tile shingles</RoofType>
      <RoofArea>679</RoofArea>
    </Roof>
  </Roofs>
  <Attics>
    <Attic>
      <SystemIdentifier id="attic1"/>

```

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```

        <AttachedToRoof idref="roof1"/>
        <AtticType>cathedral ceiling</AtticType>
        <AtticRoofInsulation>
          <SystemIdentifier id="ceilins1"/>
          <Layer>
            <NominalRValue>15</NominalRValue>
          </Layer>
        </AtticRoofInsulation>
      </Attic>
    </Attics>
  </AtticAndRoof>

```

In **HPXML v3** multiple `Roof` elements can be referenced by the `Attic` and the sum of those areas is used. The properties of the roofs will be area weighted as described below.

```

<Enclosure>
  <Attics>
    <Attic>
      <SystemIdentifier id="attic1"/>
      <AtticType>
        <CathedralCeiling/>
      </AtticType>
      <AttachedToRoof idref="roof1"/>
    </Attic>
  </Attics>
  <Roofs>
    <Roof>
      <SystemIdentifier id="roof1"/>
      <Area>679</Area>
      <RoofType>slate or tile shingles</RoofType>
      <RoofColor>medium</RoofColor>
      <Insulation>
        <SystemIdentifier id="ceilins1"/>
        <Layer>
          <NominalRValue>15</NominalRValue>
        </Layer>
      </Insulation>
    </Roof>
  </Roofs>
</Window>

```

3.4.3 Roof Color

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

Table 6: 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.

3.4.4 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 7: 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	<i>not translated</i>
plastic/rubber/synthetic sheeting	tar and gravel
concrete	concrete tile
cool roof	<i>not translated</i>
green roof	<i>not translated</i>
no one major type	<i>not translated</i>
other	<i>not translated</i>

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

3.4.5 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

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

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```

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

```

HPXML v3

```

<Attics>
  <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>

```

3.4.6 Radiant Barrier

If the `Roof/RadiantBarrier` element exists and has a “true” value and roof deck insulation R-value is 0, the attic is assumed to have a radiant barrier according to the construction codes available in HEScore. If the `Roof/RadiantBarrier` element exists and has a “true” value but roof deck insulation R-value greater than 0, the roof will be modeled as a roof with no radiant barrier.

3.4.7 Roof R-value

The roof R-value can be described by using `NominalRValue` or `AssemblyRValue`. If a user wishes to use a nominal R-value, `NominalRValue` elements for all layers need to be provided. Otherwise, `AssemblyRValue` elements for each layer need to be provided.

If nominal R-value is used, the R-value is summed for all insulation layers. 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. The nearest discrete R-value from the list of possible R-values for that roof type is used to determine an assembly code. Then, the assembly R-value of the corresponding assembly code from the lookup table is used. The lookup table can be found at [hescorehpxml\lookups\lu_roof_eff_rvalue.csv](#).

If assembly R-value is used, the discrete R-value nearest to assembly R-value from the lookup table is used. The lookup table can be found at [hescorehpxml\lookups\lu_roof_eff_rvalue.csv](#).

If the attic has more than one `Roof` element and/or if multiple attics of the same type and their associated roofs are to be combined, a weighted average assembly R-value is determined by weighting the U-values by area. Then the discrete R-value nearest to the weighted average assembly R-value from the lookup table is used.

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

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

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

Then the nearest discrete R-value to the weighted average R-value from the lookup table is used. The lookup table can be found at [hescorehpxml\lookups\lu_roof_eff_rvalue.csv](#).

3.4.8 Attic R-value

Determining the attic floor insulation levels uses the same procedure as *Roof R-value* except the lookup table is different.

If nominal R-value is used, the attic floor center-of-cavity R-values are each R-0.5 greater than the nominal R-values in the enumeration list.

If assembly R-value is used, the lookup table at [hescorehpxml\lookups\lu_ceiling_eff_rvalue.csv](#) is used.

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

3.4.9 Knee Walls

The Home Energy Score Q1 2022 release includes the ability to directly model knee walls. As such, the workaround of adding knee wall area to attic floor area is no longer used. Knee walls are now directly translated and passed to Home Energy Score as follows:

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

In **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:

```
<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>
```

(continues on next page)

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```

<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>11</NominalRValue>
  </Layer>
</Insulation>
</Wall>
<Walls>

```

The knee walls R-value can be described by nominal R-value or assembly R-value.

If nominal R-value is used, the nearest assembly code by R-value *in the code* is selected and the assembly R-value is looked up for that code.

If assembly R-value is used, the nearest assembly code *by assembly R-value* is looked up from that table.

Table 8: Knee Wall Assembly Codes and R-values

doe2code	U-value	Eff-R-value
kwwf00	0.346	2.9
kwwf03	0.154	6.5
kwwf07	0.101	9.9
kwwf11	0.083	12.1
kwwf13	0.075	13.4
kwwf15	0.068	14.7
kwwf19	0.055	18.1
kwwf21	0.050	20.1

If an attic has more than one knee wall and/or if multiple attics of the same type need to be combined, the area weighted average assembly effective R-value is calculated from all the associated knee walls. The areas of all the knee walls are summed. The assembly code with the nearest assembly effective R-value is chosen to represent the knee walls.

3.5 Foundation Insulation

Table of Contents

- *Foundation Insulation*
 - *Determining the primary foundation*
 - *Foundation Type*
 - *Foundation wall insulation R-value*
 - *Slab insulation R-value*

– *Floor insulation above basement or crawlspace*

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 9: 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		above_other_unit
Combination		<i>not translated</i>
Ambient		vented_crawl
RubbleStone		<i>not translated</i>
Other		<i>not translated</i>

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 10: 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 11: 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 floor R-value can be described by using `NominalRValue` or `AssemblyRValue`. If a user wishes to use a nominal R-value, `NominalRValue` elements for all layers need to be provided. Otherwise, `AssemblyRValue` elements for each layer need to be provided.

If nominal R-value is used, the R-value is the sum of the `FrameFloor/Insulation/Layer/NominalRValue` element values for each frame floor. The nearest discrete R-value from the list of possible R-values for that floor type is used to determine an assembly code. Then, the assembly R-value of the corresponding assembly code from the lookup table is used. The lookup table can be found at [hescorehpxml\lookups\lu_floor_eff_rvalue.csv](#).

If assembly R-value is used, the discrete R-value nearest to assembly R-value from the lookup table is used. The lookup table can be found at [hescorehpxml\lookups\lu_floor_eff_rvalue.csv](#).

When more than one HPXML `FrameFloor` element must be combined into one floor construction for HEScore, a weighted average assembly R-value is determined by weighting the U-values by area.

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

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

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

Then the discrete R-value nearest to the weighted average assembly R-value from the lookup table is used.

3.6 Walls

Table of Contents

- *Walls*
 - *Wall Orientation*
 - *Wall Construction*
 - * *Wood Frame Walls*
 - * *Structural Brick*
 - * *Concrete Block or Stone*
 - * *Straw Bale*
 - * *Exterior Finish*
 - *Area Weighted Wall R-value*
 - *Wall ExteriorAdjacentTo*

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 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.
 - All walls must have ExteriorAdjacentTo.
-

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.

The wall R-value can be described by using nominal R-value or assembly R-value. If a user wishes to use a nominal R-value, nominal R-value for all layers need to be provided. Otherwise, assembly R-values for each layer need to be provided.

If nominal R-value is used, the R-value is summed for all insulation layers. If the wall construction was determined to have [Rigid Foam Sheathing](#), an R-value of 5 is subtracted from the wall R-value sum to account for the R-value of the sheathing in the HEScore construction. The nearest discrete R-value from the list of possible R-values for that wall type is used to determine an assembly code. Then, the assembly R-value of the corresponding assembly code from the lookup table is used. The lookup table can be found at [hescorehpxml\lookups\lu_wall_eff_rvalue.csv](#).

If assembly R-value is used, the discrete R-value nearest to assembly R-value from the lookup table for that wall type is used. The lookup table can be found at [hescorehpxml\lookups\lu_wall_eff_rvalue.csv](#).

Wood Frame Walls

If WallType/WoodStud is selected in HPXML, each layer of the wall insulation is parsed and if a 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 -->
    </WoodStud>
    <ExpandedPolystyreneSheathing>true</ExpandedPolystyreneSheathing>
  </WallType>
  <Insulation>
```

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```

    <SystemIdentifier id="wall1ins"/>
    <Layer>
      <InstallationType>continuous</InstallationType>
      <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.

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.

```

<Wall>
  <SystemIdentifier id="wall13"/>
  <WallType>
    <StructuralBrick/>
  </WallType>
  <Insulation>
    <SystemIdentifier id="wall13ins"/>
    <Layer>
      <NominalRValue>5</NominalRValue>
    </Layer>
    <Layer>
      <NominalRValue>5</NominalRValue>
    </Layer>
    <!-- This would have a summed R-value of 10 -->
  </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 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 12: 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	<i>not translated</i>

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.

Whether nominal R-value or assembly R-value is used, a weighted average R-value is calculated using assembly R-value for each `Wall`. The weighted average is calculated by weighting the U-values by area.

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

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

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

Then the nearest discrete R-value to the weighted average R-value from the lookup table is used. The lookup table can be found at `hescorehpxml\lookups\lu_wall_eff_rvalue.csv`.

3.6.4 Wall ExteriorAdjacentTo

Each `Wall` is considered and the `ExteriorAdjacentTo` is mapped into a HEScore `adjacent_to` according to the following mapping. HPXML options not included in the mapping will not be translated and an error will be returned if they are used.

Table 13: HPXML ExteriorAdjacentTo to HEScore adjacent_to mapping (HPXML v2)

HPXML	HEScore	Description	Dwelling Unit Type
ambient	outside	ambient environment	Any
other housing unit	other_unit	e.g., conditioned adjacent unit or conditioned corridor	single_family_attached/apartment_unit Only

Table 14: HPXML ExteriorAdjacentTo to HEScore adjacent_to mapping (HPXML v3)

HPXML	HEScore	Description	Dwelling Unit Type
outside	outside	ambient environment	Any
other housing unit	other_unit	e.g., conditioned adjacent unit or conditioned corridor	single_family_attached/apartment_unit Only
other heated space	other_heated_space	e.g., shared laundry/equipment space	single_family_attached/apartment_unit Only
other multifamily buffer space	other_multifamily_buffer_space	enclosed unconditioned stairwell	single_family_attached/apartment_unit Only
other non-freezing space	other_non_freezing_space	e.g., shared parking garage ceiling	single_family_attached/apartment_unit Only

Warning:

- If windows are found on a wall not adjacent to *outside*, the translation will fail.

3.7 Windows and Skylights

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- *Windows and Skylights*
 - *Window Orientation*
 - *Window Properties*
 - * *Defining windows using NFRC specifications*
 - * *Defining windows by selecting a window type*
 - *Aluminum*

- *Single-pane*
- *Double-pane*
- *Aluminum with Thermal Break*
- *Double-pane*
- *Wood or Vinyl*
- *Single-pane*
- *Double-pane*
- *Triple-pane*

– *Solar Screens*

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 15: 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	<i>not translated</i>

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

HPXML Glass Layers	HEScore
single-pane	single-pane
double-pane	double-pane
triple-pane	<i>not translated</i>
multi-layered	<i>not translated</i>
single-paned with storms	double-pane
single-paned with low-e storms	double-pane
other	<i>not translated</i>

Table 17: Window pane mapping for Aluminum frame types (HPXML v3)

HPXML Glass Layers	HEScore
single-pane	single-pane
double-pane	double-pane
triple-pane	<i>not translated</i>
multi-layered	<i>not translated</i>
other	<i>not translated</i>

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 18: 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
<i>element missing</i>	Single-pane, clear

Double-pane

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

Table 19: 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
<i>element missing</i>	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 20: Window pane mapping for Aluminum with Thermal Break frame types (HPXML v2)

HPXML Glass Layers	HEScore
single-pane	<i>not translated</i>
double-pane	double-pane
triple-pane	<i>not translated</i>
multi-layered	<i>not translated</i>
single-paned with storms	double-pane
single-paned with low-e storms	double-pane
other	<i>not translated</i>

Table 21: Window pane mapping for Aluminum with Thermal Break frame types (HPXML v3)

HPXML Glass Layers	HEScore
single-pane	<i>not translated</i>
double-pane	double-pane
triple-pane	<i>not translated</i>
multi-layered	<i>not translated</i>
other	<i>not translated</i>

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"/>
  <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 22: 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	<i>not translated</i>
single-paned with storms	double-pane
single-paned with low-e storms	double-pane
other	<i>not translated</i>

Table 23: 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	<i>not translated</i>
other	<i>not translated</i>

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 24: 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
<i>element missing</i>	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:

```
<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:

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

- HPXML v3:

```
<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:

```
<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

Table of Contents

- *Heating*
 - *Heating system type*
 - * *Heat Pump*
 - * *Heating System*
 - *Heating Efficiency*
 - * *Rated Efficiency*
 - * *Shipment Weighted Efficiency*

Heating system type

HPXML provides two different 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 25: 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 26: 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 27: 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, HSPF2, 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 28: HEScore heating type efficiency units

Heating Type	Efficiency Units
heat_pump	HSPF2, HSPF
mini_split	HSPF2, 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.

Both `AnnualHeatingEfficiency(or AnnualHeatEfficiency)/Units` and `AnnualHeatingEfficiency(or AnnualHeatEfficiency)/Value` are searched and expected to match the above table, with precedence to first/newer 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

Table of Contents

- *Cooling*
 - *Cooling system type*
 - * *Heat Pump*
 - * *Cooling System*
 - *Cooling Efficiency*
 - * *Rated Efficiency*
 - * *Shipment Weighted Efficiency*

Cooling system type

HPXML provides two different 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 29: 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 *FractionHeatLoadServed* 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 30: 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	<i>not translated</i>

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, SEER2, EER, CEER), 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 31: HEScore cooling type efficiency units

Cooling Type	Efficiency Units
split_dx	SEER2, SEER
packaged_dx	CEER, EER
heat_pump	SEER2, SEER
mini_split	SEER2, 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.

Both `AnnualCoolingEfficiency(or AnnualCoolEfficiency)/Units` and `AnnualCoolingEfficiency(or AnnualCoolEfficiency)/Value` are searched and expected to match the above table, with precedence to first/newer 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

Table of Contents

- *HVAC Distribution*
 - *Duct Location Mapping*
 - *Duct Fractions*
 - *Duct Insulation*
 - *Duct Leakage Measurements*

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 32: Duct Location mapping (HPXML v2)

HPXML	HEScore
conditioned space	cond_space
unconditioned space	<i>not translated</i>
unconditioned basement	uncond_basement
unvented crawlspace	unvented_crawl
vented crawlspace	vented_crawl
crawlspace	<i>not translated</i>
unconditioned attic	uncond_attic
interstitial space	<i>not translated</i>
garage	unvented_crawl
outside	outside

Table 33: Duct Location mapping (HPXML v3)

HPXML	HEScore Hierarchy
living space	cond_space
unconditioned space	uncond_basement, vented_crawl, unvented_crawl, uncond_attic
under slab	under_slab
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	exterior_wall
attic	uncond_attic, cond_space
attic - unconditioned	uncond_attic
attic - conditioned	cond_space
attic - unvented	uncond_attic
attic - vented	uncond_attic
interstitial space	<i>not translated</i>
garage	unvented_crawl
garage - conditioned	cond_space
garage - unconditioned	unvented_crawl
roof deck	outside
outside	outside

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

Duct Fractions

For each `Ducts` element with the same insulation level 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 or have a `DuctInsulationMaterial` that is not `None`, all of the ducts in that location are considered insulated.

Duct Leakage Measurements

Duct leakage measurements are associated with an `AirDistribution` element. It can be specified quantitatively or qualitatively.

To quantitatively specify the duct leakage to outside in CFM25 of an `AirDistribution` system (e.g., duct blaster measurement), the translator expects to find the following elements:

- `DuctLeakageMeasurement [not (DuctType)] /DuctLeakage [TotalOrToOutside="to outside" and Units="CFM25"] /Value` element with the numeric value
- If the above element is not found, the values of the elements `DuctLeakageMeasurement [DuctType="supply"] /DuctLeakage [TotalOrToOutside="to outside" and Units="CFM25"] /Value` and `DuctLeakageMeasurement [DuctType="return"] /DuctLeakage [TotalOrToOutside="to outside" and Units="CFM25"] /Value` will be summed and used.

If quantitative duct leakage measurement is not specified, the translator expects to find either of the following qualitatively specified duct leakage measurement elements:

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

If neither qualitative nor quantitative element is specified, it will result in an “unsealed” designation.

3.9 Domestic Hot Water

Table of Contents

- *Domestic Hot Water*
 - *Determining the primary water heating system*
 - *Water heater type*
 - *Water heating efficiency*

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 34: 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 `NumberOfPanels` or if each has `CollectorArea`, this is false. Preference is given to known capacity if 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, the translator will check to see if every system has NumberOfPanels and calculate the total number of panels.

If NumberOfPanels isn't available on every system, the translator will look for CollectorArea on every PVSystem. 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.

Weighted Averages

The below quantities are calculated using weighted averages. The weights used are in priority order:

- MaxPowerOutput
- NumberOfPanels
- CollectorArea

Which is the same data elements used to determine the PV sizing inputs above.

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 weighted average 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 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).

Panel Tilt

For each PVSystem the ArrayTilt (in degrees from horizontal) is retrieved. A weighted average tilt is calculated and submitted to the array_tilt HEScore input (which expects an enumeration, not a numeric tilt). The tilt is mapped to HEScore as follows:

Table 35: Tilt mapping

HPXML	HEScore
0 - 7°	flat
8 - 22°	low_slope
23 - 37°	medium_slope
38 - 90°	steep_slope

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>

5.1 v7.0 to v2023.05.0

5.1.1 What's New

The only change in this version is a [reorganization of the JSON schema](#) to work with the latest version of OpenStudio-HEScore.

5.2 v6.2 to v7.0

This release is coordinated with [OpenStudio-HEScore v2.0](#).

5.2.1 What's New

Envelope

- EPS wall type will now be selected if there is any continuous insulation on the wall, not just if it has the `InsulationMaterial/Rigid` subelement. See [Wood Frame Walls](#).
- Assembly R-values can be used in for *floors*, *attics*, *roofs*, and *walls*.
- More R-values are now available in the HEScore construction codes for floors, attics, roofs, and walls. No action is required. Existing HPXML elements will be translated accordingly.
- A blower door test no longer requires the `AirInfiltrationMeasurement/TypeOfInfiltrationMeasurement` element. If a CFM50 or ACH50 value is reported, it will be used. See [Blower Door Test](#).
- Added support for knee walls. See [Knee Walls](#).
- Either an `AirInfiltrationMeasurement` or `AirSealingMeasurement` element is now required.

- Ducts in the garage will now be translated to unvented crawlspace in HEScore. See [Duct Location Mapping](#).

HVAC

- Insulated ducts can now be specified by either the `DuctInsulationThickness` or the `DuctInsulationMaterial` elements. See [Duct Insulation](#).
- Additional duct locations are now available. See [Duct Location Mapping](#).
- Duct blaster measurements can be used to describe duct leakage. See [Duct Leakage Measurements](#).

Water Heating

- The maximum allowed EF for a tank type water heater is now 0.95, and the maximum allowed EF for a tankless water heater is 0.99. Electric heat pump water heaters will continue to allow EFs between 1.0 and 4.0 inclusive.

PV

- PV Tilt is translated and used in HEScore. See [Panel Tilt](#).
- Number of Panels is now being translated from HPXML v3 files. See [Number of Panels](#).

5.2.2 Changelog

- Move `external_building_id` to `building_address` element by [@bpark1327](#) in #149
- Update issue templates by [@nmerket](#) in #153
- Adding github workflow for CI by [@nmerket](#) in #154
- Ignoring gable walls in hpxml v3 files by [@nmerket](#) in #152
- JSON Schema by [@bpark1327](#) in #144
- Failing CI on broken tests for all versions by [@nmerket](#) in #159
- Wall translation fixes and water heater EF rounding by [@bpark1327](#) in #164
- Update duct insulation mapping by [@bpark1327](#) in #163
- JSON Schema, take 2 by [@bpark1327](#) in #161
- Handle zip+4 in hpxml by [@nmerket](#) in #169
- not allowing R-value to go past zero for walls with XPS by [@nmerket](#) in #170
- PV Tilt by [@shorowit](#) in #172
- Update schema for townhouse walls by [@bpark1327](#) in #175
- PV Number of Panels by [@nmerket](#) in #179
- Additional duct locations by [@shorowit](#) in #177
- Duct blaster measurements by [@bpark1327](#) in #168
- Update hpxml2hescore duct validation by [@bpark1327](#) in #173
- Update duct blaster measurement by [@bpark1327](#) in #183
- Adding effective R-value lookup by [@nmerket](#) in #160

- Low-e storms by @bpark1327 in #176
- CEE HVAC efficiency levels by @yzhou601 in #185
- Increase granularity of construction codes by @bpark1327 in #187
- Improve air infiltration measurement translation by @bpark1327 in #190
- Knee walls by @nmerket in #184
- Fix inappropriate water heater EFs by @bpark1327 in #191
- Remove old wall construction codes by @bpark1327 in #195
- Improve multiple ducts translation by @bpark1327 in #194
- Improve air infiltration measurement translation, Take 2 by @bpark1327 in #193
- Updating garage duct location to unvented_crawl by @nmerket in #197

Full Changelog: <https://github.com/NREL/hescore-hpxml/compare/v6.2..v7.0>

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