BPI-2100-S-2013

STANDARD FOR HOME PERFORMANCE-RELATED DATA TRANSFER v2.3.0

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Introduction (Informative)

BPI-2100-S-2013 *Standard for Home Performance-Related Data Transfer v.2.3.0* (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-S-2013 *Standard for Home Performance-Related Data Collection v.2.3.0* (BPI-2200). Each of the data elements defined in BPI-2200 can be transferred via HPXML.

The HPXML schema is hosted online on a site maintained by the National Renewable Energy Laboratory (NREL). A link to the website is provided in Annex A of this standard.

1. Scope

This standard provides requirements for an XML standard data transfer protocol that can be used to transfer any home performance-related data between any actor involved in a home performance program, including contractors, program administrators, utilities, U.S. Department of Energy (DOE) and Environmental Protection Agency (EPA), etc. The scope of this standard is limited to existing detached single-family dwellings and townhouses that have independent mechanical systems for each dwelling unit (heating, cooling, water heating, and ventilation); direct access to outdoors for each dwelling unit; and were designed to have continuous party walls with no penetrations to adjacent units, with such party walls extending from ground to roof where the dwelling unit is attached to one or more adjacent single-family dwelling units.

2. Objective

BPI-2100 provides extensible mark-up language (xml) schemas that allow all data elements identified in BPI-2200 to be transferred between software systems. The standard is intended to reduce the transactional costs associated with collecting and transferring data by making communication between systems easier, and by reducing the need for the development of a data transfer protocol each time two systems need to communicate.

3. Required Use of HPXML

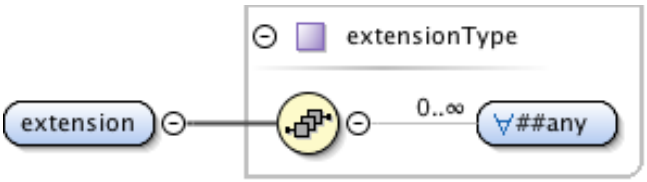
To comply with BPI-2100, HPXML shall be used to transfer all data that can be adequately represented by the HPXML vocabulary. Data can be “adequately represented” by HPXML if HPXML data elements, singly or in combination, can provide a representation of the thing or person to be described that a) could reasonably be understood by other home performance

professionals, and b) does not result in significant loss of information or create significant risks of miscommunication.

For example, using a non-HPXML data element entitled **NumberofPanes** to describe the number of layers of glass in a window would not be HPXML-compliant because the HPXML element **NumberofLayers** could be used. In the context of a description of a window, this would be understood by home performance professionals, and would not result in miscommunication. However, in some contexts, it may not be sufficient to use the **Door** element to describe an attic or crawlspace hatchway.

4. Non-HPXML Data

HPXML allows incorporation of non-HPXML data through use of the extension element, which is a child element of more than one hundred elements in the schema. The extension element allows the addition of data elements from any namespace to be added as child elements, facilitating transfer of data that is not included in the schema.



5. HPXML in Other Schemas

BPI-2200 does not require that HPXML be the root element of a schema; HPXML namespaces can be incorporated into XML documents with non-HPXML root elements. If a non-HPXML element is the root element of a schema, the schema shall not use non-HPXML data elements to describe persons, characteristics, concepts, or other things that can be adequately represented by HPXML. To the greatest extent possible, use of HPXML in documents with non-HPXML root elements shall be limited to uses in which HPXML elements are contained as a unit within a non-HPXML envelope.

6. Validation

Validation is conducted against the entire HPXML schema. Because very few elements in HPXML are required, files should be validated provided that they are well formed and include the utilized data elements in the proper document context and order.

Software developers may validate HPXML files by going to the HPXML Toolbox at https://hpxml.nrel.gov/.

Annex A: BPI-2100 HPXML Schema (Normative)

The latest release of the HPXML schema is located on NREL's website at https://github.com/hpxmlwg/hpxml/releases.

Annex B: HPXML User's Guide (Informative)

This Informative Annex is designed to provide an overview of some of the most important features of HPXML. It is not an exhaustive review of all of the elements in the standard.

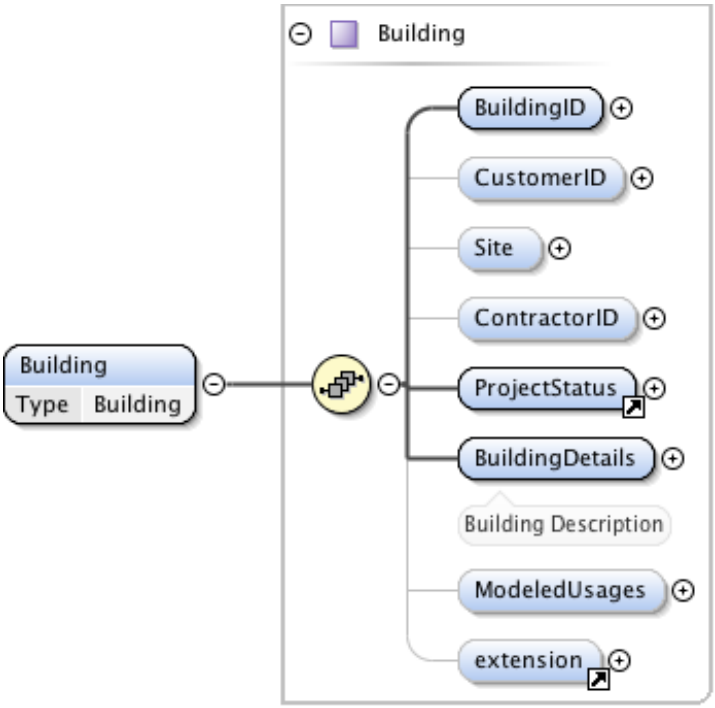
BPI-2100 (HPXML) includes six schemas, each of which has a title that indicates its purpose:

- Building
- Project
- Customer
- Contractor
- Utility
- Consumption

The most important, and most complex, of these schemas are Building and Project, each of which is described in greater detail below.

B.1 Building

Building is designed to describe the physical characteristics of a building.



A building can be given a unique **BuildingID** that can be used by a program, contractor or other entity to distinguish it from other buildings.

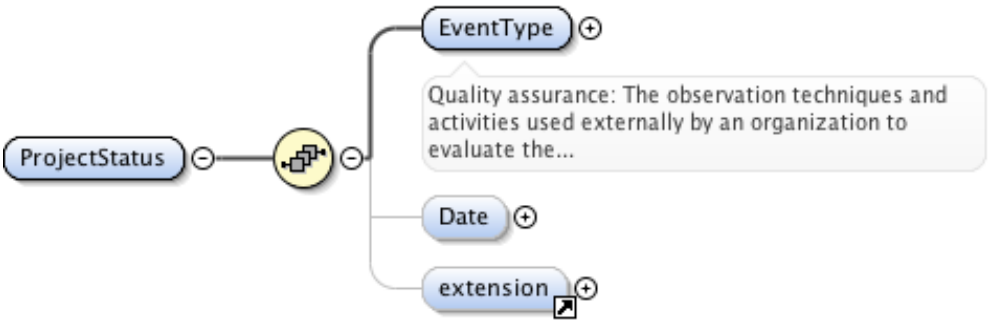
A customer described in a Customer file can be linked to a Building file through a unique **CustomerID**.

The **Site** element provides a way to describe general information about the building site, including its address, school district and e-grid region.

B.1.1 ProjectStatus

Multiple Building files may be needed to fully describe a whole-house upgrade. For example, a Building file containing data collected at the time of the initial audit could provide baseline information about the project, and a Building file created at the completion of a job could provide information about the building's more energy-efficient state following the upgrade.

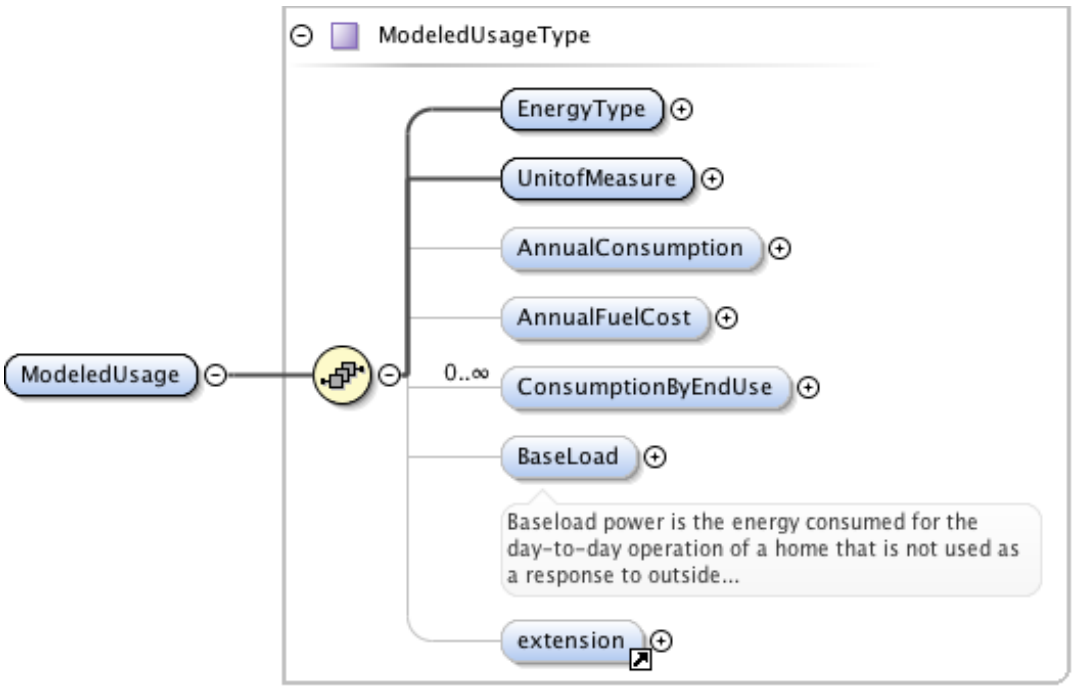
ProjectStatus provides a way to indicate when the elements in a Building file were captured. The **Date** element of ProjectStatus allows the date on which the data was collected to be recorded.



EventType, a child element of ProjectStatus, describes the stage within the overall whole-house upgrade process to which the data in a Building file pertains: audit, proposed work scope, approved work scope, construction-period testing/daily test out, job completion testing/final inspection, and quality assurance/monitoring. The differences between Building files for the same Building with different ProjectStatus enumerators would reflect improvements made through the upgrade.

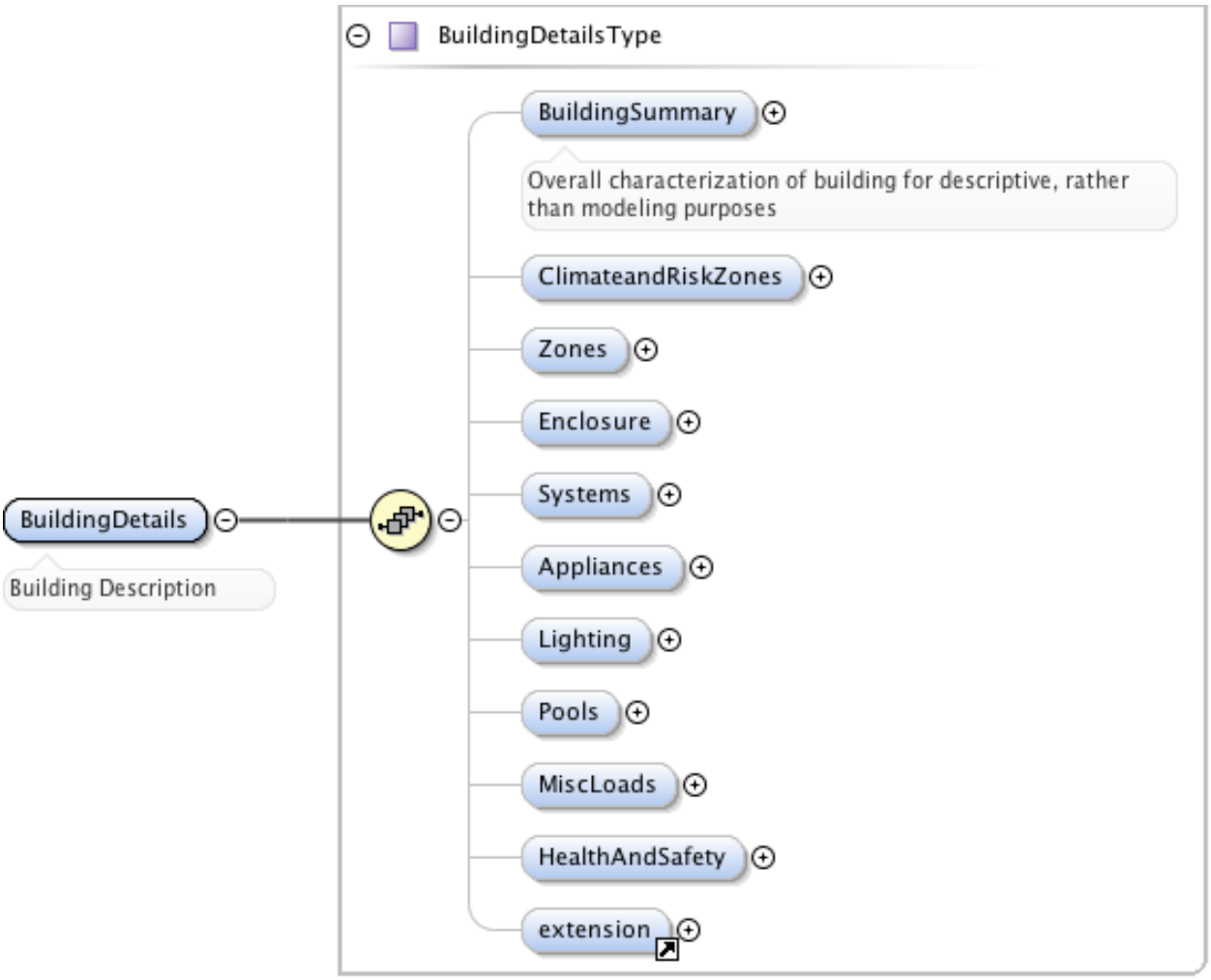
B.1.2 ModeledUsage

ModeledUsage can be used to provide information about the energy consumption of a building. In addition to describing the type of energy, the unit of measurement and the annual consumption for that particular fuel, elements within ModeledUsage can be used to indicate energy consumption by end use.



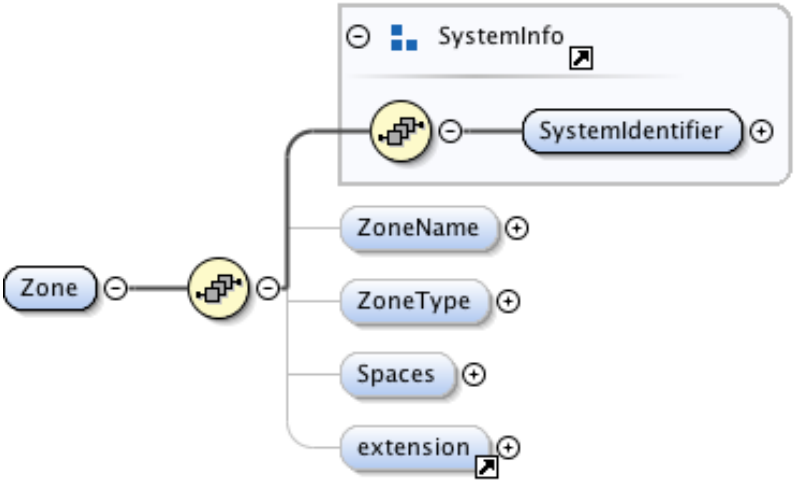
B.1.3 BuildingDetails

BuildingDetails can be used to describe a building in considerable detail. The child elements within BuildingDetails include a **BuildingSummary** element for providing high-level information about a building, a **ClimateandRiskZones** element for describing several different types of climate zones, and eight general types of building components: enclosure (the building envelope), systems (including HVAC, combustion and ventilation), appliances, lighting, pools, miscellaneous loads, health and safety, and zones (the zones within a building).



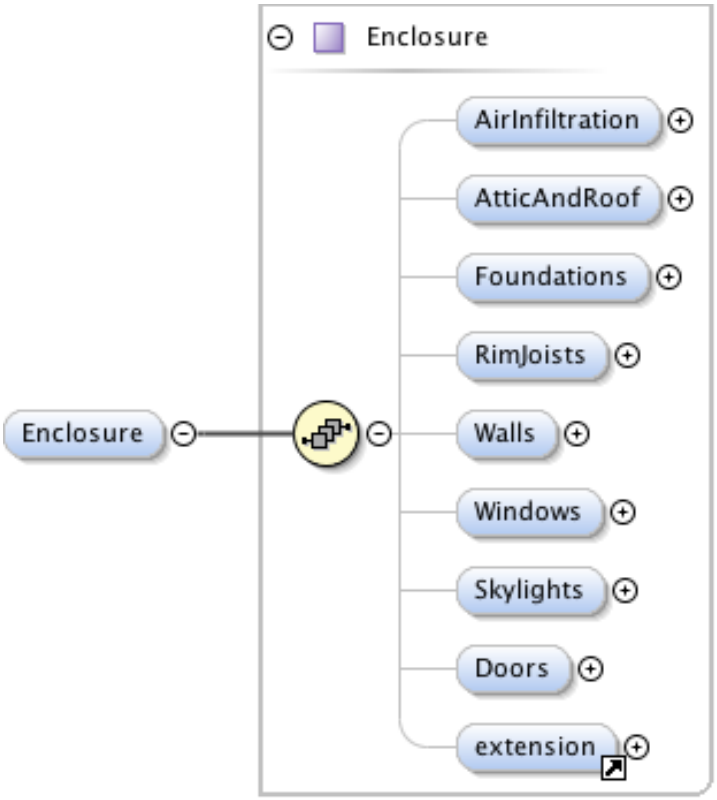
B.1.3.1 Zones

The **Zones** element provides a way to describe how an HVAC system serves a building. The **ZoneType** element allows indication of whether the zone is conditioned or unconditioned. The child element **Spaces** allows description of some of the basic characteristics of the zone.

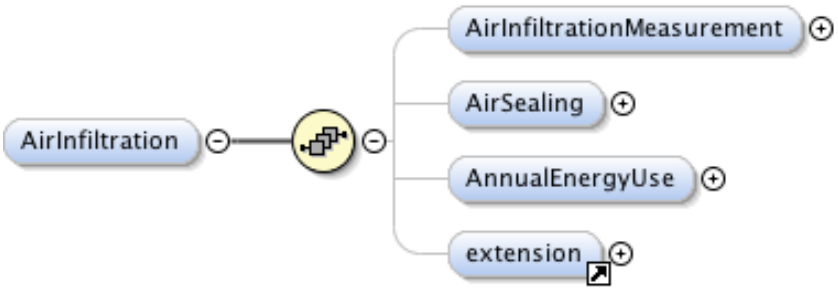


B.1.3.2 Enclosure

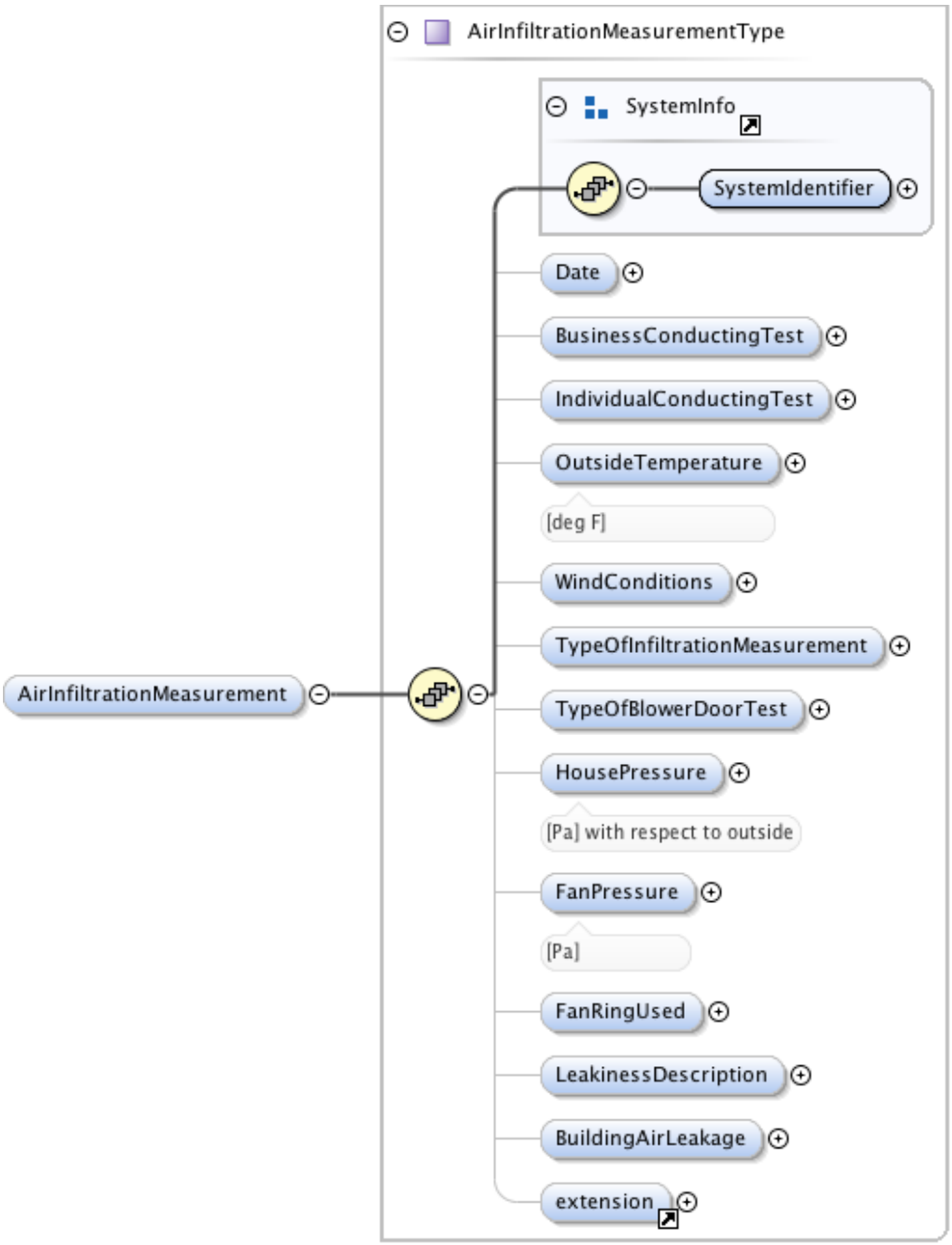
The **Enclosure** element allows description of a building envelope. It allows a level of detail about the envelope to be provided, although minimal information can be transmitted if extensive detail is not required.



AirInfiltration allows description of air infiltration and air sealing through the child elements **AirInfiltrationMeasurement** and **AirSealing**. Energy consumption can be indicated with the **AnnualEnergyUse** element.



AirInfiltrationMeasurement provides a way to describe blower door readings. Each reading can be given a **SystemIdentifier** for reference purposes, if necessary.



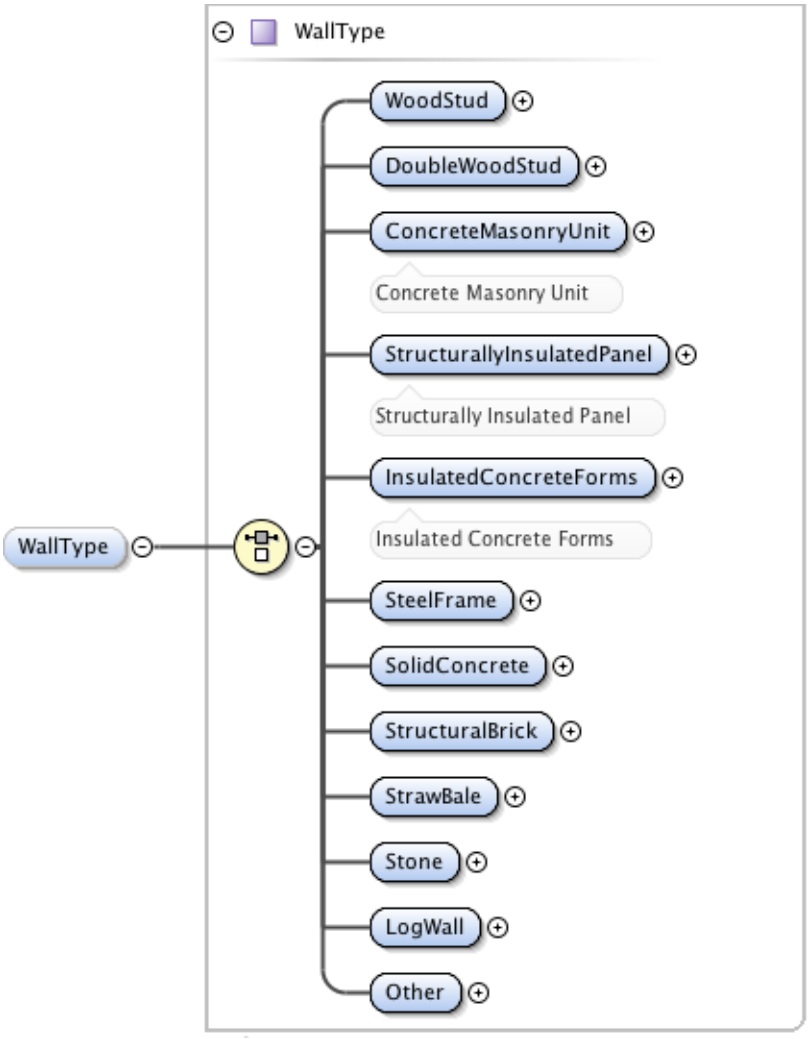
AirSealing allows identification of areas air sealed in the home. The **ComponentsAirSealed** element (a child of the AirSealing element) has three child elements, **Attic**, **BasementCrawlspace** and **LivingSpace**, each of which contain enumerators detailing specific areas that may be air sealed. The list of enumerators for the Attic element, for example, are attic floor, top plates, kneewall transitions, plumbing wet walls, chimney/flue chases, recessed lights, attic access, dropped soffit, attic level transitions, mechanical chases, and other.

Attic and Roof, **Foundations**, **Rim Joists**, and **Walls** can each be described in considerable or little detail, depending on the requirements of the specific use case. Foundations can be

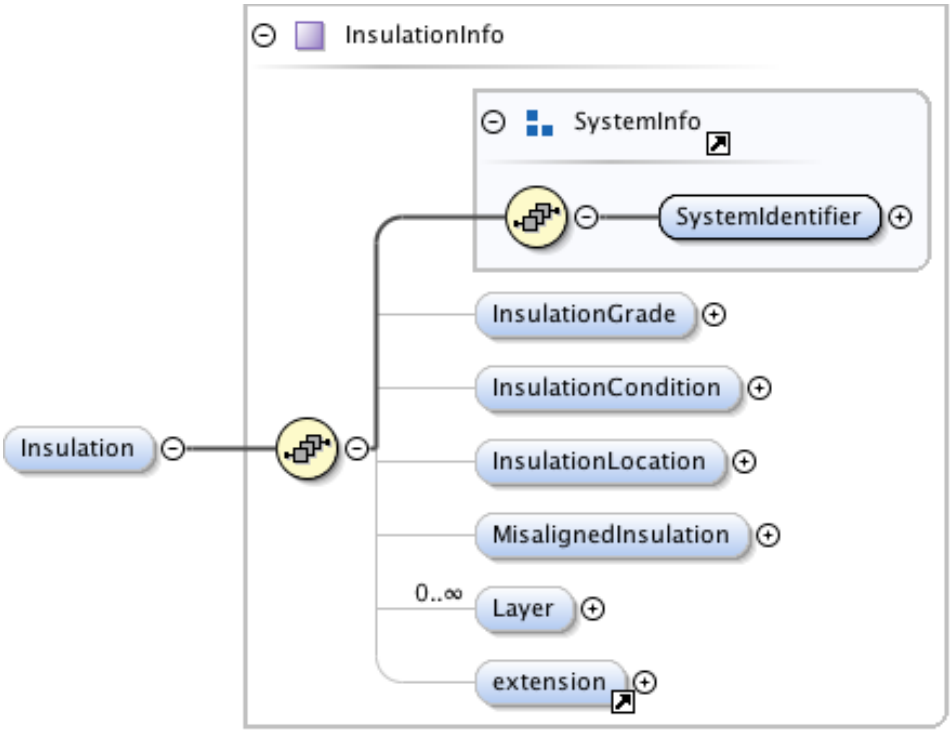
described by the **FoundationType** element, which allows description of crawlspaces, slabs, garages, etc.

Multiple Attic and Roofs, Foundations, Rim Joists, and Walls can be created, and each can be given a **SystemIdentifier** so that they can be distinguished from one another. Each attic, foundation, etc., can also be linked to a specific **Space** (a characteristic of a Zone) with the **AttachedtoSpace** element.

One of the most significant characteristics of Attic and Roof, Foundations, Rim Joists, and Walls is that they are used to describe insulation. The Wall element, as shown below, contains a child **Insulation** element.



The **Insulation** element contains a **Layer** element that allows description of multiple layers of insulation. Each layer can be described in terms of multiple characteristics, including insulation type, material, thickness and R-value.

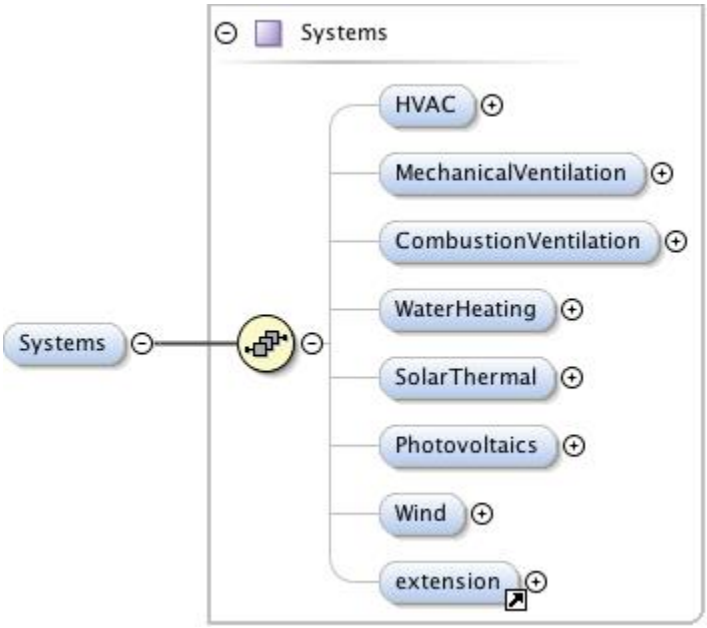


Windows, **Skylights** and **Doors** are all child elements of **Enclosure**. Each contains child elements that allow detailed descriptions of these building components. Each of these building components can be identified with a **SystemIdentifier**. Each can also be grouped into sets with the same or similar characteristics (frame type, number of layers, U-factor, etc.).

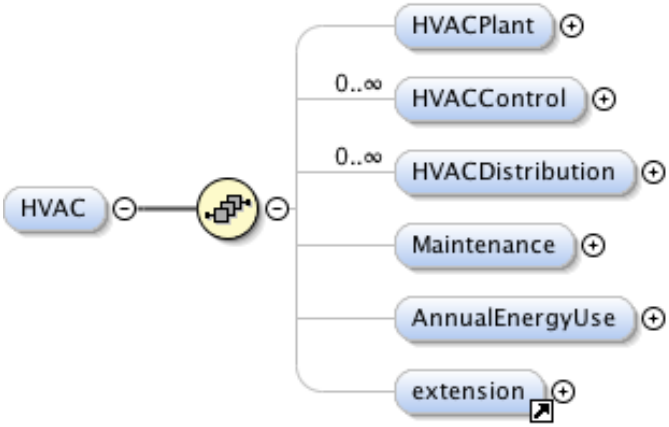
As with walls, foundations, etc., windows, skylights and doors can be located in the building through the **AttachedToWall** and **AttachedToRoof** elements, if necessary.

B.1.3.3 Systems

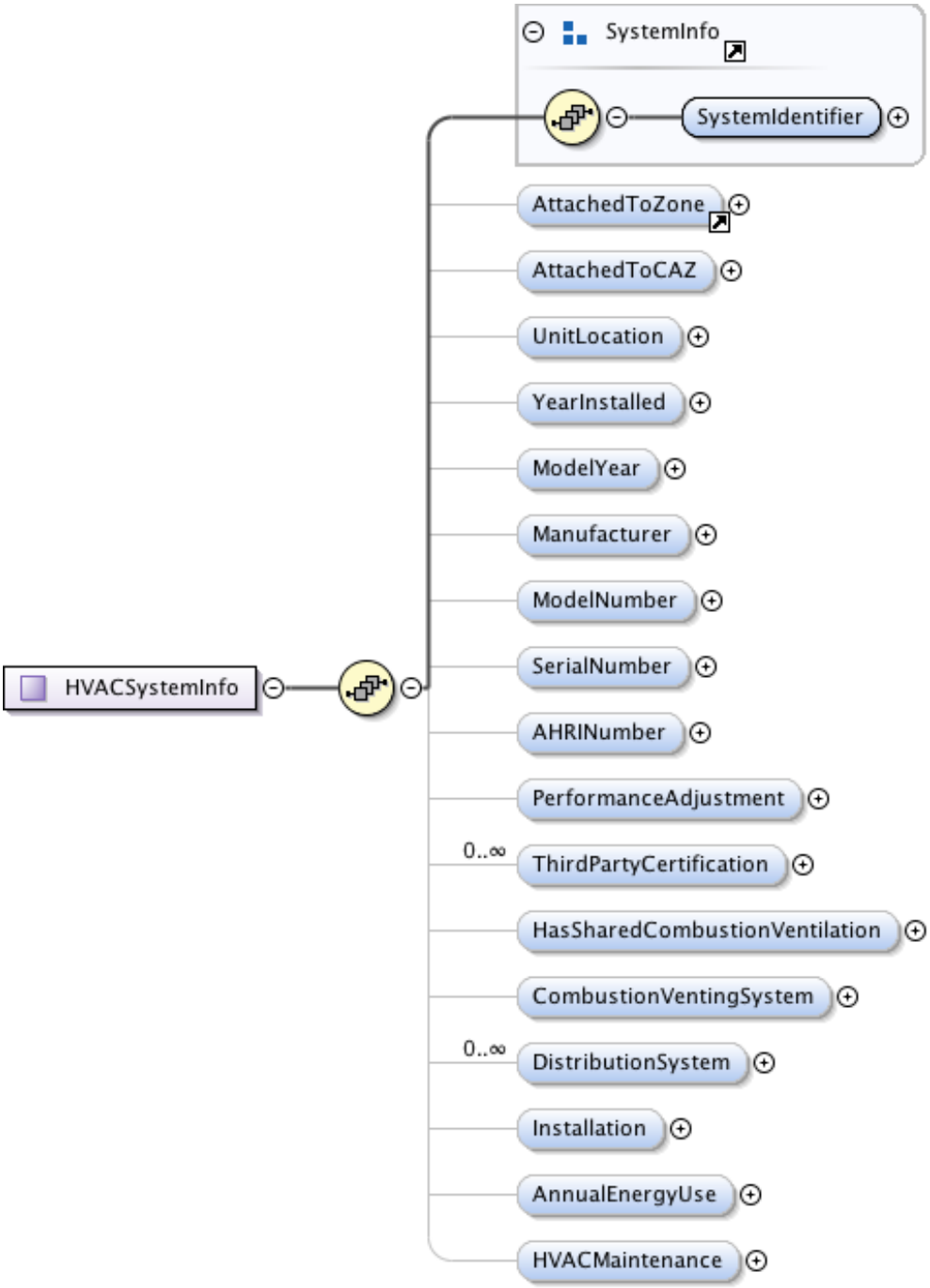
Systems can be used to provide detail about a number of types of building systems, including HVAC, ventilation, water heating, photovoltaic, and wind systems.



The **HVAC** element is the parent of a set of elements common to all HVAC systems, including controls, distribution systems, maintenance, and annual energy use.



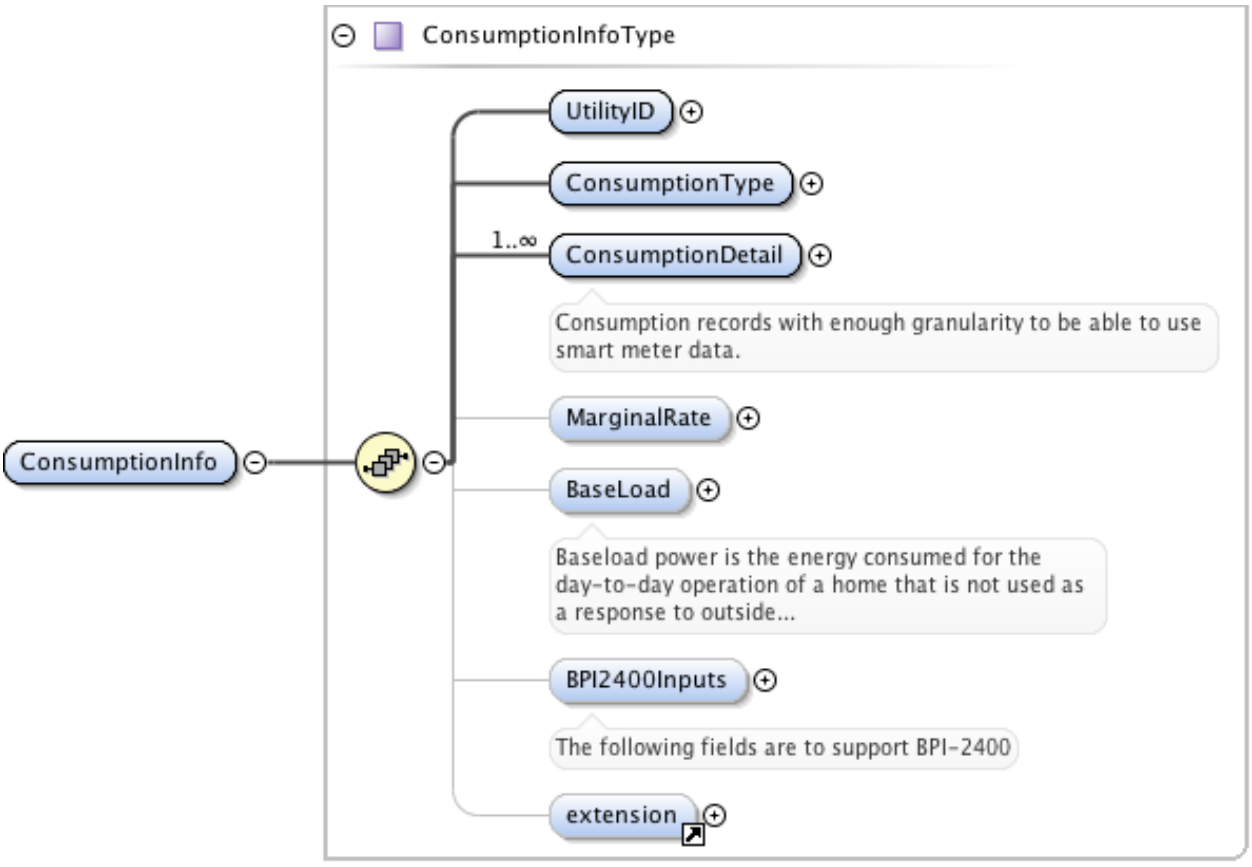
HVACPlant is the parent of three elements corresponding to types of HVAC systems: **HeatingSystem**, **CoolingSystem** and **HeatPump**. **HVACSystemInfo** is a child of each of these elements: it provides detailed information common to all HVAC systems. **HVACSystemInfo** contains a **SystemIdentifier** element that allows each HVAC system to be individually identified and referenced in the schema.



HeatingSystem, **CoolingSystem** and **HeatPump** each contain elements specific to that HVAC type: CoolingSystem, for example, has an **AnnualCoolingEfficiency** element with enumerators pertaining to cooling systems (SEER, EER, COP and kWperTon).

ConsumptionInfo is a child of **AnnualEnergyUse**, which is a child element of a number of building components. ConsumptionInfo can be used to describe the energy consumption of the component to which it is a child. AnnualEnergyUse measurements from two different Building

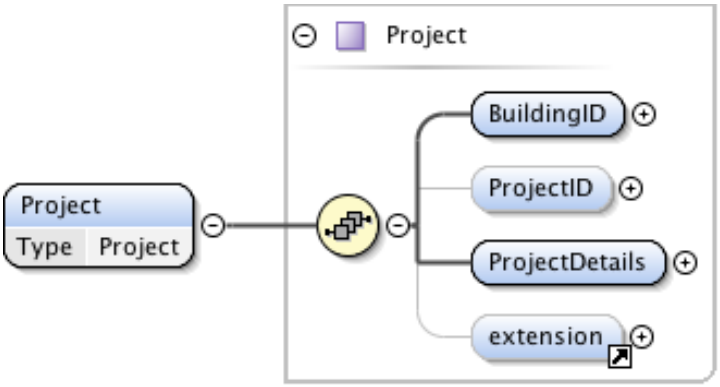
files corresponding to an initial audit and a completion report following completion of an upgrade would be expected to show different numbers.



B.2 Project

The Building schema is designed to provide a description of a building at a particular point in time. The differences between two Building files created at two different Project Status instances would reflect changes resulting from upgrade work. Determining the measures implemented through a whole-house upgrade through a comparison between Building files, however, could be cumbersome and impractical.

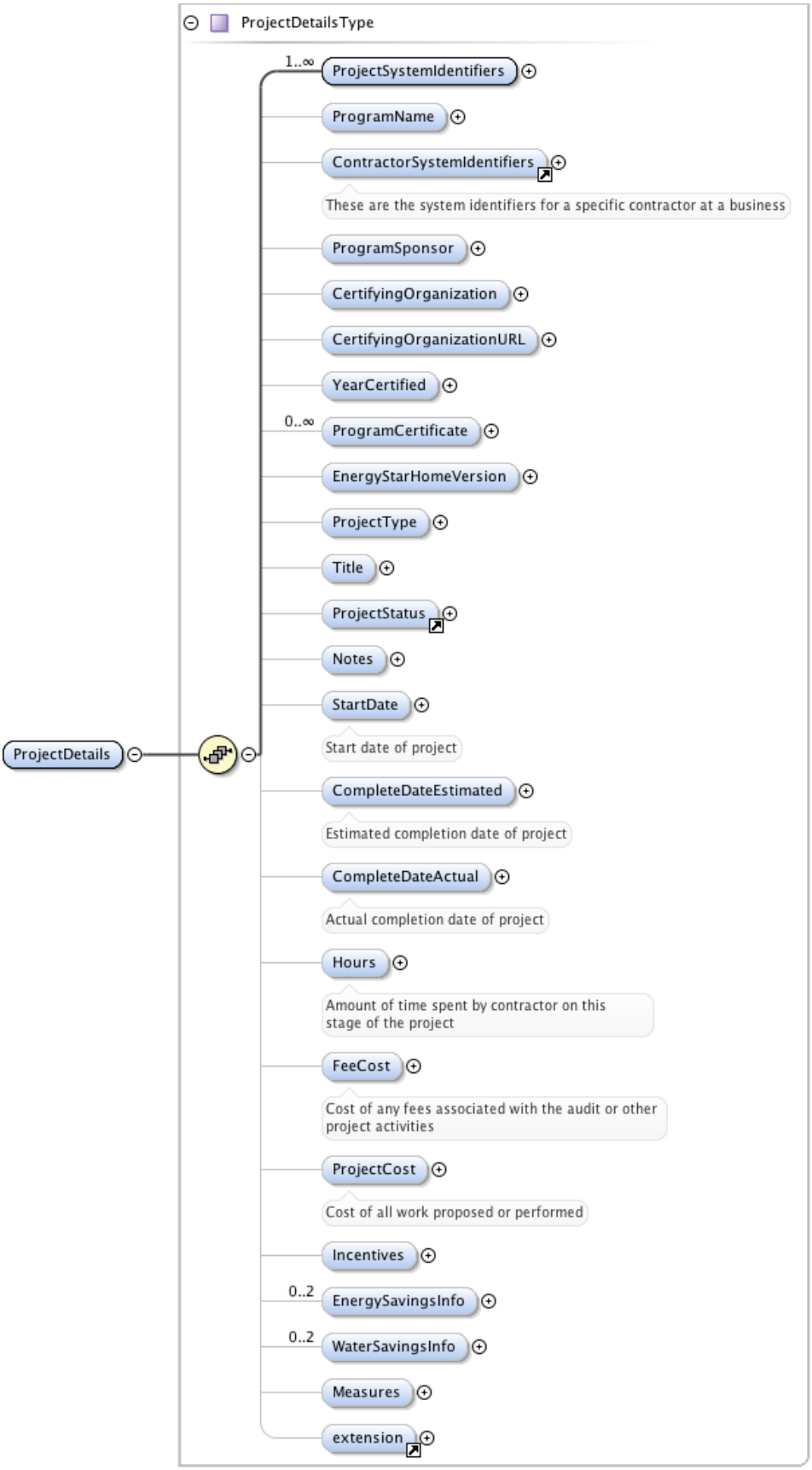
The **Project** element is designed to describe the measures implemented in a whole-house upgrade more directly. The schema contains the same **BuildingID** and **ProjectID** elements as the Building schema, allowing identification of files pertaining to the same building or project.



B.2.1 ProjectDetails

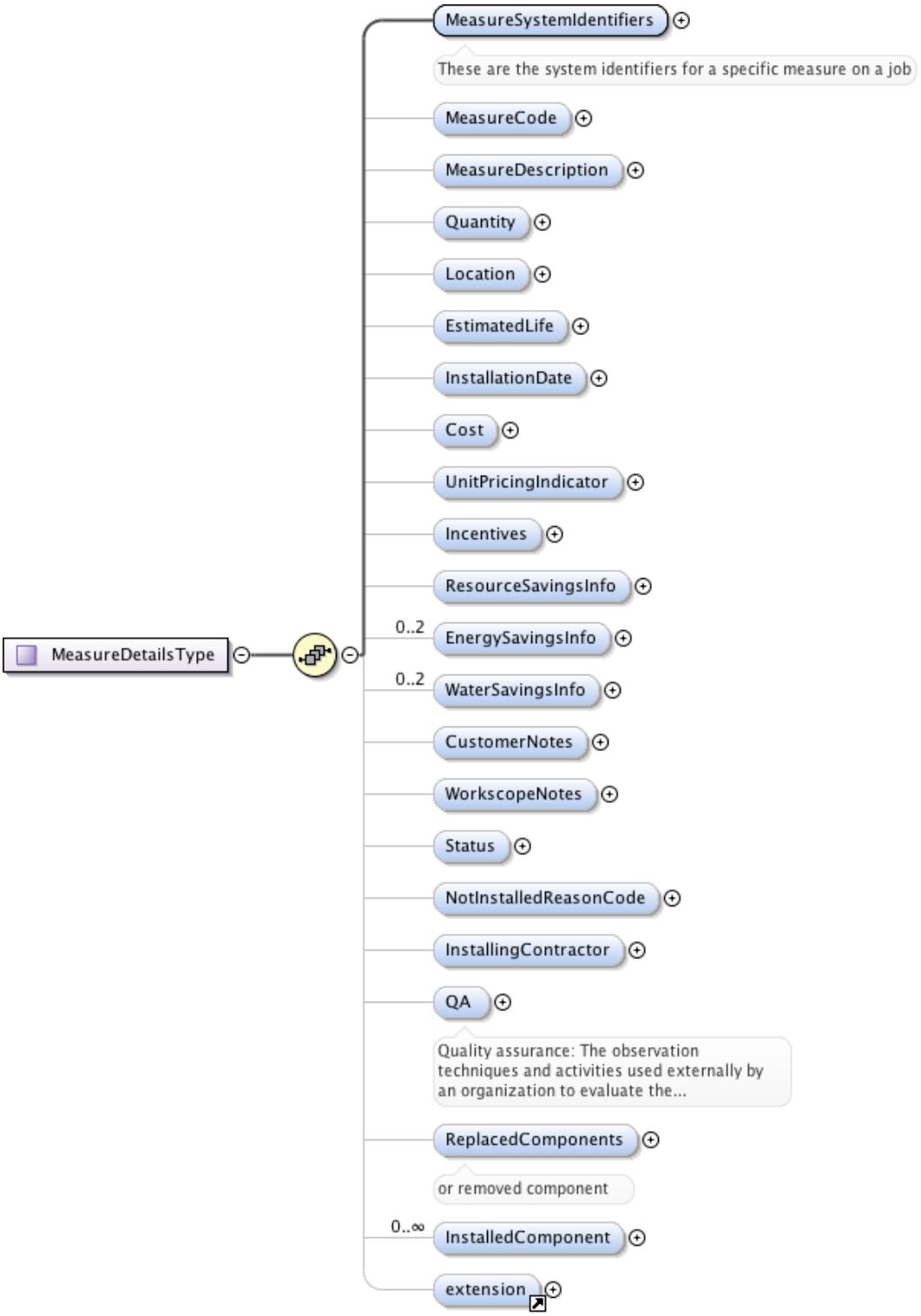
The **ProjectDetails** element allows description of a number of characteristics of an upgrade project, including:

- The name of the program through which the upgrade is conducted;
- The program sponsor;
- The name(s) of the contractor(s) implementing the work;
- Project start and completion dates;
- Costs associated with the project;
- Incentives associated with the project; and
- Energy and water savings associated with the project as a whole


ProjectDetailsType
1..∞
ProjectSystemIdentifiers
ProgramName
ContractorSystemIdentifiers
These are the system identifiers for a specific contractor at a business
ProgramSponsor
CertifyingOrganization
CertifyingOrganizationURL
YearCertified
0..∞
ProgramCertificate
EnergyStarHomeVersion
ProjectType
Title
ProjectStatus
Notes
StartDate
ProjectDetails
Start date of project
CompleteDateEstimated
Estimated completion date of project
CompleteDateActual
Actual completion date of project
Hours
Amount of time spent by contractor on this stage of the project
FeeCost
Cost of any fees associated with the audit or other project activities
ProjectCost
Cost of all work proposed or performed
Incentives
0..2
EnergySavingsInfo
0..2
WaterSavingsInfo
Measures
extension

B.2.2.1 Measures

The **Measures** element provides the way to describe all measures implemented through an upgrade.



The element allows for description of a number of characteristics of each measure, including:

- Quantity
- Location
- Estimated life
- Unit pricing
- Incentives (for the individual measure, rather than the project as whole)
- Resource and energy savings (for the individual measure, rather than the project as a whole)
- The name of the contractor responsible for the work

The **MeasureCode** allows identification of measures through a specific code. It is envisioned that codes would be program-specific as of this version of BPI-2100.

The **NotInstalledReasonCode** element allows an explanation of why a specific measure was not installed.

InstalledComponent and **ReplacedComponent** elements are crucial to the Measure element. These elements point to measures in the **Building** schema. This is done via the sending and receiving **SystemIdentifier** as agreed upon by both the sending and receiving systems.

Annex C: Change Log (Informative)

The Change Log provides a description of the changes to HPXML since its publication as a BPI Standard in June 2013. A link to the latest version of HPXML (version 2.3.0) is provided in *BPI-2100-S-2013 Annex A: BPI-2100 Schemas – HPXML (Normative)* and is also available here: https://github.com/hpxmlwg/hpxml/releases.

Version 2.3.0

HPXML 2.3.0 is a backwards compatible release that adds several new features to the standard:

- Clarifying documentation for `BPI2400Inputs/CalibrationQualification`
- Adding the `FloorFurnace` heating system type
- Adding optional reference to a `HeatingSystem` from a `HeatPump` to indicate that it provides backup heat
- Adding `ModeledUsage/ElectricityDemandKW`
- Adding `ExternalResource` element
- Adding 2x3 stud size enumeration
- Adding 'medium dark' to `WallAndRoofColor`
- Adding solar absorptance and emittance for non-foundation walls and roofs
- Adding WMO Station Number
- Adding Slab/Thickness
- Adding `UniformEnergyFactor` for water heaters
- Additional vent fan types
- Adding drain water heat recovery `extension` element
- Clarify hot water distribution fields
- Adding appliance fields
- Adding `FuelTypesAvailable`

Version 2.2.1

This is a minor (backwards compatible) patch release to provide the following change:

- Added "preconstruction" event type to support Home Energy Score

Version 2.2.0

This is a minor (mostly backwards compatible) release that includes the following changes:

Breaking changes

- Enforced AirInfiltrationMeasurement/HousePressure to be positive)[1]

Non-breaking changes

- Added “underside of rafters” enumeration to RadiantBarrierLocation
- Allow zero for NumberOfBedrooms
- Added “supervised audit” enumeration to EventType
- Allow multiple WaterHeatingSystem/ThirdPartyCertification elements
- Documented window areas as the total surface area for a group of windows
- Added HotWaterDistribution element
- Added Energy Star Most Efficient enumeration to HVACThirdPartCertification
- Added AirDistributionInfo/TotalExternalStaticPressureMeasurement elements
- Added example HPXML files from HPXML Toolbox
- Added BuildingSummary/SiteVerticalSurroundings element
- Added “sauna” and “well pumps” enumerations to PlugLoadType
- Added VentilationFan/ThirdPartyCertification element
- Added HVACDistributionImprovement/DuctSystemSealedYearMonth element
- Added HVACMaintenance/TuneAndRepairYearMonth element
- Added HVACMaintenance/AirFilter element
- Added WaterHeatingSystem/HasGeothermalDesuperheater element
- Added Systems/Wind element
- Added YearInstalled, AnnualOutput, and LevelizedCostOfEnergy to PV
- Added “power purchase agreement,” “utility owned,” and “other” enumerations to PVSystemOwnership
- Added “NEEP Cold-Climate Air-Source Heat Pump Specification” enumeration to HVACThirdPartyCertification
- Added PlugLoad/Location element
- Removed trailing space from WaterType enumeration "indoor water", leave original
- Added EnergyScore/OtherScoreType and EnergyScore/ScoreDate elements
- Provided an equivalent unified xsd in addition to the current xsds

Version 2.1.0

This is a minor (backwards compatible) release that includes the following changes:

Bug fixes

- Allowing a non-integer and zero number of residents
- Added extension sub-element to ambient and rubble stone foundation types

[1] Although this change technically breaks backwards compatibility with the schema, this change did not negatively impact current users of the schema. Therefore, this change is included in this minor version release.

Non-breaking changes

- Added weather station used in model simulation or utility bill regression analysis
- Added flag to indicate whether duct leakage was total or to outside
- Updated BPI 2400 elements to include simplified bias errors by end use
- Added water fixture element
- Added first hour rating, gallons per minute to water heaters
- Added emissions rate to wood stove
- Added "direct expansion" enumeration to geothermal loop
- Added pipe R-value under HVAC distribution
- Added lighting fixture
- Added moveable insulation R-value to windows
- Added Temperature-initiated shower flow restriction valve
- Added HoursPerDay under PoolPump/PumpSpeed and deprecated it under PoolPump

Version 2.0.0

Breaking changes

- Removed deprecated Maintain*.xsd schemas so that all implementations will be using the same HPXML.xsd.
- Moved the BPI-2400 elements and renamed/reorganized them.
- Renamed element AttachedToCAZ under water heater to fix a typo.
- Removed "batch heater" from SolarCollectorLoopType in lieu of the previously added "integrated collector storage" enumeration on SolarThermalCollectorType.

Non-breaking changes

- Added swimming pool elements.
- Added Assembly R-Value to the Insulation element.
- Added element to ventilation fans to specify that it is a whole house fan used for seasonal cooling.
- Added Distribution System Efficiency for heating and cooling systems.
- Added a performance adjustment to water heaters.

Version 1.1.1

Bug fix release

- EnergySavingsType/AnnualPercentReduction now allows negative savings values.

- Extension element: the xs:any now has a processContents set to skip, which tells schema validators to skip those elements.
- Bug fix for schemaVersion attribute on root element. Namespace issues cleared up.
- Fixed typo in name of InsulationLocation.*

*This is *technically* a breaking change, but was included here as a minor bug fix. Make sure your implementation expects this.

Version 1.1.0

This is a minor (backwards compatible) release that includes the following changes:

- Added a version number to the schema and instance documents.-
- Multiple installed components are allowed in a measure.-
- Add ability to select "unknown" as insulation material type sub-selection after the main selection.-
- Allow for more than one duct leakage measurement and be able to specify whether it was for the supply or return ducts.-
- Allowing multiple ConsumptionInfo elements under BuildingSummary/AnnualEnergyUse.
- Allowing multiple ThirdPartyCertifications under ceiling fans.
- Augmented the solar thermal system element to include integral collector storage systems and passive thermosyphons.
- Added SolarThermal and PV as end uses to modeled energy use, documented that their values should be recorded as negative to indicate production of energy.-
- Changed type of all temperatures from integer to float.
- Added Elements
    - ModeledUsageType/AnnualFuelCost
    - HealthAndSafety/Stoves/TimeofCOReading
    - CeilingFan/AirFlow/FanSpeed, Airflow, and Efficiency as well as ThirdPartyCertification
    - Lighting/LightingGroup/AverageLumens HealthAndSafety/General/TestsCompleted, TestsPassed
    - EnergyAndWaterUseTypeDescription/Energy/EnergyUseIntensity
    - Systems/Photovoltaics/PVSystem/YearModulesManufactured
    - InsulationInfo/InsulationLocation
    - FoundationWall/AdjacentToFoundation
    - Project/ProjectDetails/YearCertified,CertifyingOrganizationURL,EnergyStarHomeVersion
    - Skylight/SolarTube
    - WallType/LogWall
    - WindowInfo/FrameType/Wood (used in both windows and skylights)
    - WindowInfo/FrameType/ThermalBreak (used in both windows and skylights)
    - Window/GasFill

    - HVACPlant/PrimarySystems with PrimaryHeatingSystem, PrimaryCoolingSystem subelements
    - SolarThermal/Manufacturer, ModelNumber
    - Measure/WaterSavingsInfo
    - AirDistributionInfo/NumberofReturnRegisters
    - AirDistributionInfo/Ducts/DuctType
    - HealthAndSafety/MechanicalVentilation/VentilationFans/VentilationFan/TotalRecoveryEfficiency, SensibleRecoveryEfficiency, FanPower
    - Wall/Thickness
- Added Enumerations
    - Energy Star Home to CertifyingOrganization
    - Mini-split to HeatPumpType
    - Ground-to-air to HeatPumpType
    - Other to DoorMaterial
    - Several fluorescent lighting tube types to FluorescentTubeType
    - Several stud dimensions to StudDimensions
    - Other housing unit to AdjacentTo
    - Crawlspace to DuctLocation. (Previously either vented crawlspace or unvented crawlspace had to be selected.)
- Modified Schema Documentation
    - CAZApplianceReading/CurrentCondition
    - CombustionApplianceZone/CombustionApplianceTest/StackTemperature
    - CombustionApplianceZone/BaselineTest
    - CombustionApplianceZone/NetPressureChange
    - MeasureDetailsType/ResourceSavingsInfo/ResourcesSavedLoadProfile
    - HeatingSystemInfoType/HeatingCapacity to indicate it is input capacity
    - Wall/Area defined as gross wall area
    - LightingGroup/AverageWattage defined as per unit (lamp)
    - AtticFloorInsulation
    - CombustionApplianceZone/PoorCaseTest
    - AirInfiltrationMeasurementType/EffectiveLeakageArea
- Bug fixes:
    - Removed redundant multiplicity of EmailInfoType.
    - Allowing fuel savings percentages to be negative.
    - Removed union from enumerations in ConsumptionType because it confused some XML schema processors.
    - Made TelephoneType optional

Version 1.0.2

This is a bug fix release and incorporates the following changes:

- Added sameas attribute to SystemIdentifier, which permits linking components on the before and after building description that were not removed or replaced in a measure.
- Added a SystemIdentifier to AirSealing for referencing in measures. Also set maxOccurs on AirSealing and AirInfiltrationMeasurement to unbounded to allow for multiple air sealing and infiltration measurements on a building.*
- Added TuneAndRepair to HVACSystemInfo/HVACMaintenance
- Added InsulationInfo/MisalignedInsulation (boolean)
- Corrected a typo on VentilationFan/UsedForWholeBuildingVentilation*
- Added notes field to CombustionApplianceZone
- Set maxOccurs to unbounded on heating and cooling efficiencies to permit specifying multiple different efficiency types.

*This is *technically* a breaking change, but was included here as a minor bug fix. Make sure your implementation expects this.

Version 1.0.1 and before

Pre-standard development.