

The JSON Data Schema That Encodes Energy3D Design Processes

(Updated on 9/15/2016, subject to change in the future)

This specification defines the JSON data schema for the process data stream logged by the Energy3D CAD software. A typical engineering design process captured by Energy3D includes construction, revision, analysis, viewing, and documentation (and the iteration among these steps), as well as necessary software supports such as undoing, redoing, opening file, saving file, and so on. The coding of these activities is listed in the table below.

The logging frequency is set to be 5 Hz (i.e., five times a second), sufficient to catch most quick actions.

As a convention, anything within a pair of angle brackets represents a value of the specified type. For example, when you see *x*: <number> in the schema, you should expect to see something like “*x*”: 3.14 in real data. The angle brackets do not show up in the real data – they are just used to indicate that “*x*”: should be followed by a number, not the word *number*. When a word is not enclosed within a couple of angle brackets in the schema, it should be used literally and delimited by a couple of double quotation marks in the real data, such as the attribute name *x*. Primitive values such as *true*, *false*, and *null*, however, should be written literally without any quotation marks, just like numbers (e.g., “*Clicked*”: *true*). More info about the format is provided after the table.

Categories	Actions	Attributes
Construction Actions that change the form of a design	Add/Remove/Edit Door	<pre>{Building: <integer>, ID: <integer>, Coordinates: [{x: <number>, y: <number>, z: <number>}, ...] }</pre> ¹ Coordinates of four vertices
	Add/Remove/Edit Floor	<pre>{Building: <integer>, ID: <integer>, Coordinates: [{x: <number>, y: <number>, z: <number>}] }</pre> Coordinates of the center
	Add/Remove/Edit Foundation	<pre>{Building: <integer>, Coordinates: [{x: <number>, y: <number>, z: <number>}, ...] }</pre> Coordinates of eight vertices

¹ A complete building is defined as a building that has no gap in its walls (i.e., all of its walls are connected to form an enclosed space). A building’s ID is identical to its foundation’s ID.

Add/Remove/Edit Wall	<pre>{Building: <integer>, ID: <integer>, Coordinates: [{x: <number>, y: <number>, z: <number>}, ...] }</pre> <p>Coordinates of four vertices</p>
Add/Remove/Edit/Paste Window	<pre>{Building: <integer>, ID: <integer>, Coordinates: [{x: <number>, y: <number>, z: <number>}, ...] }</pre> <p>Coordinates of four vertices</p>
Add/Remove/Edit CustomRoof	<pre>{Building: <integer>, ID: <integer>, Coordinates: [{x: <number>, y: <number>, z: <number>}, ...] }</pre> <p>Coordinates of $N+1$ control points (N is the number of walls)</p>
Add/Remove/Edit HipRoof	<pre>{Building: <integer>, ID: <integer>, Coordinates: [{x: <number>, y: <number>, z: <number>}, ...] }</pre> <p>Coordinates of three control points</p>
Add/Remove/Edit PyramidRoof	<pre>{Building: <integer>, ID: <integer>, Coordinates: [{x: <number>, y: <number>, z: <number>}] }</pre> <p>Coordinates of one control point</p>
Add/Remove/Edit ShedRoof	<pre>{Building: <integer>, ID: <integer>, Coordinates: [{x: <number>, y: <number>, z: <number>}] }</pre> <p>Coordinates of three control points</p>

Add/Remove/Edit GambrelRoof	<pre>{Building: <integer>, ID: <integer>, Coordinates: [{x: <number>, y: <number>, z: <number>}] }</pre> <p>Coordinates of seven control points</p>
Convert to Gable	<pre>{Type: <string>, Building: <integer>, ID: <integer>, Coordinates: [{x: <number>, y: <number>, z: <number>}] }</pre>
Add/Remove/Edit/Paste SolarPanel	<pre>{Building: <integer>, ID: <integer>, Coordinates: [{x: <number>, y: <number>, z: <number>}] }</pre> <p>Coordinates of the center</p>
Add/Remove/Edit/Paste Mirror	<pre>{Building: <integer>, ID: <integer>, Coordinates: [{x: <number>, y: <number>, z: <number>}] }</pre> <p>Coordinates of the center</p>
Rotate Solar Panel	<pre>{Building: <integer>, ID: <integer>, New Value: <number>}</pre>
Add/Remove/Edit Sensor	<pre>{Building: <integer>, ID: <integer>, Coordinates: [{x: <number>, y: <number>, z: <number>}] }</pre> <p>Coordinates of the sensor</p>
Add/Remove/Move/Paste Human	<pre>{ID: <integer>, Name: <string>, Coordinates: [{x: <number>, y: <number>, z: <number>}] }</pre> <p>Name is "Jane," "Jeni," "Jill," "Jack," "John," or "Jose." Coordinates are those of the foot position.</p>

	Add/Remove/Move/Paste Tree	{ID: <integer>, Species: <string>, Coordinates: [{x: <number>, y: <number>, z: <number>}] } Species is "Cottonwood," "Dogwood," "Elm," "Linden," "Oak," "Maple," or "Pine." Coordinates are those of the trunk bottom.
	Add Parts	{Import: <string>} Add parts through importing from a prefab or an existing file. String is the URL of the imported file.
	Move Building	{Building: <integer>, CenterX: <number>, CenterY: <number>} Coordinates of the center of the floor
	Resize Building	{Building: <integer>, Height: <number>, Area: <number>, Volume: <number>, CenterX: <number>, CenterY: <number>} Coordinates of the center of the floor
	Rotate Building	{Building: <integer>, Angle: <number>}
	Remove Building	{Building: <integer>, Displacement: (<number>, <number>)} Displacement on the land
	Remove All SolarPanels/Mirrors/Windows /Roofs/Trees/Floors/Foundations	
	Overhang Change for Selected Roof	{Building: <integer>, ID: <integer>, Old Value: <number>, New Value: <number>}
	Rescale	{Old Value: <number>, New Value: <number>}
	Rescale Building	{Building: <integer>, Old X Length: <number>, New X Length: <number>, Old Y Length: <number>, New Y Length: <number>, Old Z Length: <number>, New Z Length: <number>}
	Add SolarPanel Array	{Foundation: <integer>, Old Array Size: <number>, New Array Size: <number>}
	Add Mirror Array	{Foundation: <integer>, Old Array Size: <number>, New Array Size: <number>}
Analysis	Show Shadow	<boolean>
	Show Heliodon	<boolean>
	Show Heat Flux Vectors	<boolean>
	Animate Sun	<boolean>

Actions that evaluate the function of a design	Graph Tab	<string> String is "Basics", "Cost", or "Energy".
	AnnualEnvironmentalTemperature	{}
	DailyEnvironmentalTemperature	{}
	Solar Potential ²	[{Building: <integer>, Daily: <number>}, ...] Enumeration of total daily solar radiation on each building
	Cost	[{Building: <integer>, Amount: <number>}...] When no building is selected, list the costs of all the buildings. Otherwise, only the cost of the selected one.
EnergyAnnualAnalysis ³	<pre>{Months: <integer>, Building: <integer>, Net: { Monthly: [<number>, ...], Total: <number> }, AC: { Monthly: [<number>, ...], Total: <number> }, Heater: { Monthly: [<number>, ...], Total: <number> }, Windows: { Monthly: [<number>, ...], Total: <number> }, Solar Panels: { Monthly: [<number>, ...], Total: <number> } }</pre> <p>Analyze the whole building. Note: The monthly values represent the results picked from one day of each month, not the sum of all the days in each month. But the total values are the sums of all the 365 days.</p> <pre>{Months: <integer>, Part: <string>, Solar: { Monthly: [<number>, ...], Total: <number> } Heat Gain: { Monthly: [<number>, ...], Total: <number> } }</pre> <p>Analyze the selected part. Note: Same as above.</p>	

² When the "Calculate energy of the day" button is checked, an array that records the solar energy gains of all the complete buildings is logged when the building labels are shown. These attributes are useful for analyzing the Solar Urban Design Challenge.

³ For an annual analysis, the results only include the total energy from each type. Monthly data are not included. If the annual analysis isn't complete, the "Months" attribute represents the number of months that have been calculated.

	<p>EnergyDailyAnalysis DailyEnergyGraph⁴</p>	<pre>{Building: <integer>, Net: { Hourly: [<number>, ...], Total: <number> }, AC: { Hourly: [<number>, ...], Total: <number> }, Heater: { Hourly: [<number>, ...], Total: <number> }, Windows: { Hourly: [<number>, ...], Total: <number> }, Solar Panels: { Hourly: [<number>, ...], Total: <number> } }</pre> <p>Analyze the whole building</p>
		<pre>{Part: <string>, Solar: { Hourly: [<number>, ...], Total: <number> }, Heat Gain: { Hourly: [<number>, ...], Total: <number> } }</pre> <p>Analyze the selected part</p>
	<p>EnergyAngularAnalysis</p>	<pre>{Angles: <integer>, Increment: <number>, Building: <integer>, Net: { Data: [<number>, ...] }, AC: { Data: [<number>, ...] }, Heater: { Data: [<number>, ...] }, Windows: { Data: [<number>, ...] }, Solar Panels: { Data: [<number>, ...] } }</pre> <p>Analyze the whole building</p>

⁴ DailyEnergyGraph is invoked when the button on the tool bar for calculating the energy of the day is clicked. EnergyDailyAnalysis is invoked when the corresponding menu item under the Analysis Menu is selected. The latter shows the energy graph in a pop-up window whereas the former shows it in the panel to the right of the 3D view window.

	<pre>{Angles: <integer>, Increment: <number>, Part: <string>, Solar: { Data: [<number>, ...] }, Heat Gain: { Data: [<number>, ...] } }</pre> <p>Analyze the selected part</p>
SolarAnnualAnalysis	<pre>{Months: <integer>, Panel: <string> Solar: { Monthly: [<number>, ...], Total: <number> } }</pre> <p>List monthly solar panel outputs that have been computed; Panel parameter is the name of the selected solar panel, the selected foundation that represents a building, or "All" for all the solar panels.</p>
SolarDailyAnalysis	<pre>{Panel: <string> Solar: { Hourly: [<number>, ...], Total: <number> } }</pre> <p>List hourly solar panel outputs of the selected day; Panel parameter is the name of the selected solar panel, the selected foundation that represents a building, or "All" for all the solar panels.</p>
GroupAnnualAnalysis	<pre>{Type: <string>, Months: <integer>, Solar <integer>: { Monthly: [<number>, ...], Total: <number> }, Heat Gain <integer>: { Monthly: [<number>, ...], Total: <number> } }</pre> <p>Type is "Roof," "Solar Panel," "Wall," or "Window." List monthly solar or heat gains of each element in the group of the same type. Windows have both solar and heat gains.</p>
GroupDailyAnalysis	<pre>{Type: <string> Solar <integer>: { Hourly: [<number>, ...], Total: <number> }, Heat Gain <integer>: { Hourly: [<number>, ...], Total: <number> } }</pre> <p>Type is "Roof," "Solar Panel," "Wall," or "Window." List hourly solar or heat gains of</p>

		each element in the group of the same type. Windows have both solar and heat gains.
	AnnualSensorData	{Months: <integer>, Data: [Id: <integer>, Light: [<number>, ...], HeatFlux: [<number>, ...]] } List monthly sensor data of all types that have been collected
	DailySensorData	{Hours: <integer>, Data: [Id: <integer>, Light: [<number>, ...], HeatFlux: [<number>, ...]] } List hourly sensor data of all types that have been collected
	Show Curve	{Graph: <string>, Name: <string>, Shown: <boolean>} Graph is "PartEnergyDailyGraph," "PartEnergyAnnualGraph," "PartEnergyAngularGraph," "BuildingEnergyDailyGraph," "BuildingEnergyAnnualGraph," or "BuildingEnergyAngularGraph." Name is "All," "AC," "Heater," "Solar Panels," "Windows," "Net," "Solar," "Heat Gain," "Light," or "Heat Flux."
	Show Run	{Graph: <string>, ID: <string>, Shown: <boolean>} Graph is "PartEnergyDailyGraph," "PartEnergyAnnualGraph," "PartEnergyAngularGraph," "BuildingEnergyDailyGraph," "BuildingEnergyAnnualGraph," or "BuildingEnergyAngularGraph." ID is "All" or an integer number string.
	Clear Graph Data	<string> String is "PartEnergyDailyGraph," "PartEnergyAnnualGraph," "PartEnergyAngularGraph," "BuildingEnergyDailyGraph," "BuildingEnergyAnnualGraph," or "BuildingEnergyAngularGraph."
Parameter Changes that result in the change of the physical performance of a design	Change City	{Old City: <string>, New City: <string>}
	Change Latitude	{Old Value: <number>, New Value: <number>}
	Change Date	{Old Date: <string>, New Date: <string>} Format: is "<month>/<day>," e.g., "12/31"
	Change Time	{Old Time: <string>, New Time: <string>} Format: is "<hour>:<minute>," e.g., "10:30"

Adjust Thermostat	{Building: <integer> Flag when the "Adjust Thermostat" button is clicked or the "Thermostat" item of the popup menu of a building is selected
Delete Utility Bill	{Building: <integer>}
Change Background Albedo	{Old Value: <number>, New Value: <number>}
Change Ground Thermal Diffusivity	{Old Value: <number>, New Value: <number>}
Change Atmospheric Dust Loss	{Old Value: <number>, New Value: <number>}
U-Factor Change for Selected Part	{Building: <integer>, ID: <integer>, Type: <string>, Old Value: <number>, New Value: <number>} Type is "Door", "Foundation", "Roof", "Wall", or "Window".
U-Factor Change for Whole Building	{Building: <integer>, Type: <string>, New Value: <number>} Type is "Door", "Foundation", "Roof", "Wall", or "Window".
Volumetric Heat Capacity Change for Selected Part	{Building: <integer>, ID: <integer>, Type: <string>, Old Value: <number>, New Value: <number>} Type is "Foundation", "Roof", or "Wall".
Choose Size for Selected Solar Panel	{Building: <integer>, ID: <integer>, Old Width: <number>, New Width: <number>, Old Height: <number>, New Height: <number>}
Change Tilt Angle	{Foundation: <integer>, ID: <integer>, Old Value: <number>, New Value: <number>} This applies to solar panels and mirrors.
Change Tilt Angle for All Solar Panels on Selected Foundation	{Foundation: <integer>, New Value: <number>}
Change Tilt Angle for All Solar Panels	{New Value: <number>}
Change Azimuth	{Foundation: <integer>, ID: <integer>, Old Value: <number>, New Value: <number>} This applies to solar panels and mirrors.
Change Azimuth for All Solar Panels on Selected Foundation	{Foundation: <integer>, New Value: <number>}
Change Azimuth for All Solar Panels	{New Value: <number>}
Solar Cell Efficiency Change for Selected Solar Panel	{Building: <integer>, ID: <integer>, Old Value: <number>, New Value: <number>}
Solar Cell Efficiency Change for All Solar Panels on Selected Foundation	{Building: <integer>, New Value: <number>}

Solar Cell Efficiency Change for All Solar Panels	{New Value: <number>}
Inverter Efficiency Change for Selected Solar Panel	{Building: <integer>, ID: <integer>, Old Value: <number>, New Value: <number>}
Inverter Efficiency Change for All Solar Panels on Selected Foundation	{Building: <integer>, New Value: <number>}
Inverter Efficiency Change for All Solar Panels	{New Value: <number>}
Choose High/Partial/No Shade Tolerance for Selected Solar Panel	{Building: <integer>, ID: <integer>, Old Value: <number>, New Value: <number>}
Choose High/Partial/No Shade Tolerance for All Solar Panels on Selected Foundation	{Building: <integer>, New Value: <number>}
Choose High/Partial/No Shade Tolerance for All Solar Panels	{New Value: <number>}
Enable/Disable Solar Tracker	{Building: <integer>, ID: <integer>}
Enable/Disable Tracker for All Solar Panels on Selected Foundation	{Building: <integer>}
Enable/Disable Tracker for All Solar Panels	
Reflectivity Change for Selected Mirror	{Foundation: <integer>, ID: <integer>, Old Value: <number>, New Value: <number>}
Reflectivity Change for All Mirrors on Selected Foundation	{Foundation: <integer>, New Value: <number>}
Reflectivity Change for All Mirrors	{New Value: <number>}
Set Size for Selected Mirror	{Foundation: <integer>, ID: <integer>, Old Width: <number>, New Width: <number>, Old Height: <number>, New Height: <number>}
Set Size for All Mirrors on Selected Foundation	{Foundation: <integer>, New Width: <number>, New Height: <number>}
Set Size for All Mirrors	{New Width: <number>, New Height: <number>}
Change Tilt Angle for All Mirrors on Selected Foundation	{Foundation: <integer>, New Value: <number>}
Change Tilt Angle for All Mirrors	{New Value: <number>}
Change Azimuth for All Mirrors on Selected Foundation	{Foundation: <integer>, New Value: <number>}
Change Azimuth for All Mirrors	{New Value: <number>}
Change Target	
Change Target for All Mirrors on Selected Foundation	
Change Target for All Mirrors	
Change Base Height	{Foundation: <integer>, ID: <integer>, Old Value: <number>, New Value: <number>}
	<i>This applies to solar panels and mirrors.</i>
Change Base Height for All Mirrors on Selected Foundation	{Foundation: <integer>, New Value: <number>}
Change Base Height for All Mirrors	{New Value: <number>}

Change Base Height for All Solar Panels on Selected Foundation	{Foundation: <integer>, New Value: <number>}
Change Base Height for All Solar Panels	{New Value: <number>}
SHGC Change for Selected Window	{Building: <integer>, ID: <integer>, Old Value: <number>, New Value: <number>}
SHGC Change for All Windows of Selected Building	{Building: <integer>, New Value: <number>}
Color Change for Selected Part	{Building: <integer>, ID: <integer>, Old Color: <string>, New Color: <string>}
Color Change for Whole Building	{Building: <integer>, Type: <string>, New Color: <string>} Type is "Door", "Foundation", "Floor", "Roof", "Wall", or "Window". Color is hex code (e.g., "#ff0000" for red).
Type Change of Wall	{Building: <integer>, ID: <integer>, Old Value: <integer>, New Value: <integer>}
Change Thickness for Selected Wall	{Building: <integer>, ID: <integer>, Old Value: <integer>, New Value: <integer>}
Change Thickness for Walls on Selected Foundation	{Foundation: <integer>, New Value: <integer>}
Change Thickness for All Walls	{New Value: <integer>}
Change Height for Selected Wall	{Building: <integer>, ID: <integer>, Old Value: <integer>, New Value: <integer>}
Change Height for Walls on Selected Foundation	{Foundation: <integer>, New Value: <integer>}
Change Height for All Walls	{New Value: <integer>}
Change Height for Connected Walls	{New Value: <integer>}

View Actions that do not affect the physical performance of a design	Camera	{Position: { x: <number>, y: <number>, z: <number> }, Direction: { x: <number>, y: <number>, z: <number> } Mode: <string> } Direction vector is normalized. Mode is "Rotate," "Pan," or "Zoom."
	Zoom	<boolean> If this boolean is true, it is a Zoom In action; otherwise, it is a Zoom Out action.
	Top View	<boolean>
	Spin View	<boolean>
	Show Axes	<boolean>
	Show Annotation	<boolean>
	Field Border	<boolean>
	Change Solar Heat Map Color Contrast	{Old Value: <integer>, New Value: <integer>}
	Texture Change	{Old Value: <string>, New Value: <string>} String is "Full", "Simple", or "None".
	Land Color Change	{Old Color: <string>, New Color: <string>}
Theme Change	{Old Value: <integer>, New Value: <integer>}	
Documentation	Note	Compact <i>ad hoc</i> string format for tracking changes (see a later section for more information)
Others	Undo	<string> Action name
	Redo	<string> Action name
	Save	<string> The location of the saved file
	Timestamp	<string> Format is "<year>-<month>-<day><hour>:<minute>:<second>", e.g., "2015-04-27 12:57:57"
	File	<string> The file name
	Project	<string> The project name (that does not change when a file is renamed).

Note: There may be some redundancy of attributes in the actual data – the above schema defines the attributes as succinctly as possible. We only need to process what is defined in this schema.

JSON Syntax Rules

- Data is in name/value pairs
- Data is separated by commas

- Curly braces hold objects
- Square brackets hold arrays

JSON Values

- A number (integer or floating point)
- A string (in double quotes)
- A boolean (true or false)
- An array (in square brackets)
- An object (in curly brackets)
- null

Escape Characters

In JSON, double quotes and back slashes need to be escaped. So " becomes \" and \ becomes \\ in the data. In addition, line breaks are replaced with a string literal "-linebreak-" for formatting reasons.

Track Changes in Notes

An *ad hoc* data format is used to track changes in student notes. This is based on logging the insertion and deletion events while students are writing notes. For example, `I(239,0)I(240,K)` records the insertion of a word "OK" into location 239 in the document and `D(264,e)D(263,h)D(262,t)` records the deletion of a word "the" from location 264 (backward). This syntax applies to the insertion or deletion of multiple characters at the same time such as pasted or deleted segments.

View Data Using Chrome

The sample data is best viewed in Chrome. Go to Chrome Web Store to install JSONView as an extension to Chrome. Then type "chrome://extensions/" in Chrome's address field. In JSONView, check "Enabled" and "Allow access to file URLs." This viewer allows the reader to expand and collapse each item. You can also view the data in its original compact format using the "View source" link at the upper-right corner of the page.