Tables with Site Data

Site

Attribute	Format	Comments
name	**Required** **Unique** **Syntax** Max 50 characters	Recommended to be the M&V Program Management Identifier without personally identifiable information
city	**Required** **Syntax** Max 60 characters	The name of the city or town in which the site is located.
state	**Required** **ForeignKey** State.name	The two-character state abbreviation in which the site is located.
description	Optional **Syntax** Text field	An optional field for additional information and/or comments.
application	**Required** **Syntax** Max 60 characters	Typically used to denote whether renewable thermal system is for new construction or retrofit.
uuid	**Required** **Syntax** RFC 4122 uuid4() automatically generated	Automatically generated universal unique identifier for the site.
thermal_load	**Optional** **ForeignKey** thermal_load.name	Reference to entry in thermal_load table describing the overall heating and cooling loads for the site.
weather_station	**Required** **ForeignKey** weather_station.nws_id	Four-character code for National Weather Service station to be used for site weather data.

Equipment

Attribute	Format	Comments
name	**Required** **Unique** **Recommended format** [site.name]_thermal-load **Syntax** Max 40 characters	Name for the thermal load table entry. This is useful when assigning a thermal load to a site. In the initial release, a site can only have one thermal load table entry
description	**Optional** **Syntax** Text field	An optional field for additional information and/or comments.
conditioned_area	**Required** **Syntax** Float field Units = 'Sq Ft'	The total floor area of the conditioned space served by the renewable thermal system. Future releases may include zones.
heating_design_load	**Required** **Syntax** Float field Units = 'MBtuH'	The peak heating load required to meet the indoor design temperature when the outdoor temperature is the heating_design_oat. Typically determined from an ACCA Manual J analysis.
cooling_design_load	**Required** **Syntax** Float field, Units: 'MBtuH'	The peak cooling load required to meet the indoor design temperature when the outdoor temperature is the cooling_design_oat. Typically determined from an ACCA Manual J analysis.
heating_design_oat	**Required** **Syntax** Float field Units: 'Degrees F'	The outdoor air temperature for which the peak heating load is designed. Typically determined for the location from ASHRAE table.
cooling_design_oat	**Required** **Syntax** Float field Units: 'Degrees F'	The outdoor air temperature for which the peak cooling load is designed. Typically determined for the location from ASHRAE table.
uuid	**Required** **Syntax** RFC 4122 uuid4() automatically generated	Automatically generated universal unique identifier for the thermal load table entry.

Equipment Monitoring System Specification

Maps a pre-defined monitoring system to an existing piece of renewable thermal equipment.

Attribute	Format	Comments
equip_id	**Required** **ForeignKey** equipment.id	ID for the equipment that has a monitoring system attached.
monitoring_system_spec	**Required** **ForeignKey** monitoring_system_spec	id for the monitoring system that is attached to equipment. More than one monitoring system may be associated with a piece of equipment
start_date	**Optional** **Syntax** DateField	date that the monitoring system went into operation
end_date	**Optional** **Syntax** DateField	date that the monitoring system was no longer installed or operating. If a change is made to a monitoring system, the change would be recorded with a new monitoring system with a new start date.

Equipment Maintenance History

Attribute	Format	Comments
equip_id	**Required** **ForeignKey** equipment.id	ID for the equipment that is serviced
description	**Required** **Syntax** Text field	description of service done
service_date	**Required** **Syntax** DateField	date that the equipment was serviced
contractor	**Optional** **Syntax** Max 50 characters	The name of the contracting company that performed the service.
technician	**Optional** **Syntax** Max 50 characters	The name or initials of the technician(s) that performed the service.

Source

Attribute	Format	Comments
name	**Required** **Unique** **Recommended format** [site.name]_[source.type] **Syntax** Max 50 characters	Name for a thermal source located at a site and associated with one or more pieces of equipment. A site must have at least one thermal source and can have more than one.
description	**Optional** **Syntax** Text field	An optional field for additional information and/or comments.
type	**Required** **ForeignKey** source.type	The type of thermal source, e.g. vertical borehole heat exchanger.
spec	**Required** **ForeignKey** source.spec	The specifications of the thermal source, based on type.

Source Specification

Attribute	Format	Comments
uuid	**Required** **Syntax** RFC 4122 uuid4() automatically generated	Automatically generated universal unique identifier for the site.
name	**Required** **Unique** **Syntax** Max 50 characters	The name of the source specification for the site. While a source spec can be used for multiple site, it is most often specific to a site.
description	**Optional** **Syntax** Text field	An optional field for additional information and/or comments.
type	**Required** **ForeignKey** source.type	The type of thermal source, e.g. vertical borehole heat exchanger.

Vertical Loop Specification (Source subclass)

Attribute	Format	Comments
formation_conductivity	**Optional** **Syntax** Float field	The formation thermal conductivity in units of Btu/hr-ft-F.
grout_conductivity	**Optional** **Syntax** Float field	The grout thermal conductivity in units of Btu/hr-ft-F.
grout_type	**Optional** **Syntax** Max 50 characters	The of grout used in the borehole heat exchanger
freeze_protection	**Optional** **Syntax** Float	The lowest temperature at which antifreeze will prevent freezing. Report in degrees F.
formation_type	**Optional** **Syntax** Max 50 characters	The type of geologic material in which the heat exchanger is installed.
ghex_pipe_spec	**Optional** **Foreign Key** ghex_pipe_specification	Mapping to the table with the ground heat exchanger pipe specification.

Air Source Spec

Attribute	Format	Comments
compressor_location	**Optional** **Syntax** Max 25 characters	An optional field to describe the location of the air-source heat pump compressor. For example, ground-mount, wall-mount, roof, etc.
duct_configuration	**Optional** **Syntax** Max 35 characters	An optional field to describe the duct configuration of the air-source heat pump. For example., 'single-zone ducted', etc.

Thermal Load

Attribute	Format	Comments
name	**Required** **Unique** **Recommended format** [site.name]_thermal-load **Syntax** Max 40 characters	Name for the thermal load table entry. This is useful when assigning a thermal load to a site. In the initial release, a site can only have one thermal load table entry
description	**Optional** **Syntax** Text field	An optional field for additional information and/or comments.
conditioned_area	**Required** **Syntax** Float field Units = 'Sq Ft'	The total floor area of the conditioned space served by the renewable thermal system. Future releases may include zones.
heating_design_load	**Required** **Syntax** Float field Units = 'MBtuH'	The peak heating load required to meet the indoor design temperature when the outdoor temperature is the heating_design_oat. Typically determined from an ACCA Manual J analysis.
cooling_design_load	**Required** **Syntax** Float field, Units: 'MBtuH'	The peak cooling load required to meet the indoor design temperature when the outdoor temperature is the cooling_design_oat. Typically determined from an ACCA Manual J analysis.
heating_design_oat	**Required** **Syntax** Float field Units: 'Degrees F'	The outdoor air temperature for which the peak heating load is designed. Typically determined for the location from ASHRAE table.
cooling_design_oat	**Required** **Syntax** Float field Units: 'Degrees F'	The outdoor air temperature for which the peak cooling load is designed. Typically determined for the location from ASHRAE table.
uuid	**Required** **Syntax** RFC 4122 uuid4() automatically generated	Automatically generated universal unique identifier for the thermal load table entry.

Multiple Site Tables

Equipment Type

Attribute	Format	Comments
name	**Required** **Unique** **Syntax** Max 20 characters	The type of equipment provided by manufacturer. These are general classes of equipment, such as ASHP, GSHP, etc.
description	**Optional** **Syntax** Text field	An optional field for additional information and/or comments.

GHEX Pipe Specification

Attribute	Format	Comments
uuid	**Required** **Syntax** RFC 4122 uuid4() automatically generated	Automatically generated universal unique identifier for the thermal load table entry.
name	**Required** **Unique** **Syntax** Max 50 characters	A descriptive name of the GHEX pipe specification so that it may be reused on multiple sites.
dimension_ratio	**Optional** **Syntax** Max 50 characters	The of ratio of the outer pipe diameter to the minimum wall thickness. For example, DR11.
no_flowmeter_flowrate	**Optional** **Syntax** Float field	The ground loop flow rate (in gallons per minute) for fixed flow systems without an installed flowmeter.
n_pipes_in_circuit	**Optional** **Syntax** Integer field	The number of pipes in individual circuits. For a single u-tube, the value is 1.
n_circuits	**Optional** **Syntax** Integer field	The number of circuits in the ground loop. For example, for 2 boreholes with split flow, enter 2.
total_pipe_length	**Optional** **Syntax** Float	Enter value in units of feet. For a single u-tube in a 200 foot bore, the total pipe length would be 400 feet.

Manufacturer

Attribute	Format	Comments
name	**Required** **Unique** **Syntax** Max 20 characters	Name of the equipment manufacturer. This will typically include manufacturers of renewable thermal equipment and associated monitoring systems. For manufacturers that provide both heat pumps and monitoring systems, enter a separate record for each (e.g. Waterfurnace_hp and Waterfurnace_ms)
description	**Optional** **Syntax** Text field	An optional field for additional information and/or comments.
equipment_type	**Required** **Foreign Key** equipment_type	The type of equipment provided by manufacturer. Separate records are required for manufacturers that provide multiple types of equipment

Measurement Location

Attribute	Format	Comments
name	**Required** **Unique** **Syntax** Max 20 characters **Examples** ▪ 'in-pipe' ▪ 'heat pump' ▪ 'service panel'	Name of the measurement location for a specific sensor of a montirong system. For example, an electrical measurement may be made in the electrical panel or in the heat pump. Temperature measurements may be made with in-pipe sensors or on-pipe sensor affixed the exterior of a pipe. equipment manufacturer.
Description	**Optional** **Syntax** Text field	An optional field for additional information and/or comments.

Measurement Specification

Attribute	Format	Comments
name	**Required** **Unique** **Syntax** Max 30 characters **Examples** See comments	Name of the measurement for a specific sensor of a monitoring system. This name should be informative so that when a measurement specification is added to a monitoring system, the correct measurement specification can be identified from a list of options. For example, a measure of leaving water temperature made on metal pipe in units of Celsius with an accuracy of 0.1C may be 'LWT OMP 0.1 C'
description	**Optional** **Syntax** Text field	An optional field for additional information and/or comments.
type	**Required** **Foreign Key** measurement_type	Mapping of measurement spec to obtain oTherm name, possible MSP names, units.
accuracy	**Recommended** **Syntax** Decimal Field 10 digits, 5 decimal	When available, numeric accuracy should be reported. If a % of reading value, the accuracy_pct attribute should be set to TRUE. Otherwise, accuracy will be interpreted as sensor error in units of measurement_type.
accuracy_pct	**Recommended** **Syntax** Boolean	Denotes whether accuracy is reported as a percent of reading (TRUE) or in units of measurement_type (FALSE)
meas_bias_abs	**Required** **Syntax** Float field	Measurement bias, other than sensor bias. This may due to an incorrect monitoring system setting. Default = 0.0 Reported as absolute or percent.
meas_bias_pct	**Required** **Syntax** Float field	Measurement bias, other than sensor bias. This may due to an incorrect monitoring system setting. Default = 0.0 Reported as absolute or percent.
location	**Optional** **Foreign Key** measurement_location.location	Th location of a measurement.

Measurement Type

Attribute	Format	Comments
name	**Required** **Unique** **Syntax** Max 20 characters **Examples** ▪ 'heatpump_power' ▪ 'heatpump_aux' ▪ 'source_supplytemp'	oTherm measurement type name for a specific sensor of a monitoring system. These should coincide with names in Table 3 of the Device Level Data Dictionary.
description	**Optional** **Syntax** Text field	An optional field for additional information and/or comments.
msp_colunns	**Optional** **Syntax** Array field	An optional list of coinciding column names for data provided by monitoring system provider (msp).
unit	**Required** **Foreign Key** Measurement_unit.name	The abbreviation of measurement unit, such as "C" for Celsius, "W" for Watts, etc.

Measurement Unit

Attribute	Format	Comments
name	**Required** **Unique** **Syntax** Max 10 characters **Examples** ▪ 'C', 'F', 'W', 'gpm', etc.'	Measurement unit abbreviation
description	**Optional** **Syntax** Text field	An optional field for additional information and/or comments.

Model

Attribute	Format	Comments
name	**Required** **Unique** **Syntax** Max 20 characters	Name of the equipment manufacturer. This will typically include manufacturers of renewable thermal equipment and associated monitoring systems. For manufacturers that provide both heat pumps and monitoring systems, enter a separate record for each (e.g. Waterfurnace_hp and Waterfurnace_ms)
description	**Optional** **Syntax** Text field	An optional field for additional information and/or comments.
equipment_type	**Required** **Foreign Key** equipment_type	The type of equipment provided by manufacturer. Separate records are required for manufacturers that provide multiple types of equipment

Monitoring System

Attribute	Format	Comments
name	**Required** **Unique** **Syntax** Max 40 characters	Name of the monitoring system should be sufficient so that user can select correct one when associating a monitoring system with a piece of equipment.
description	**Optional** **Syntax** Text field	An optional field for additional information and/or comments. Notes on known measurement bias should be included here.
manufacturer	**Required** **Foreign Key** manufacturer	The manufacturer of the monitoring system.

Source Type

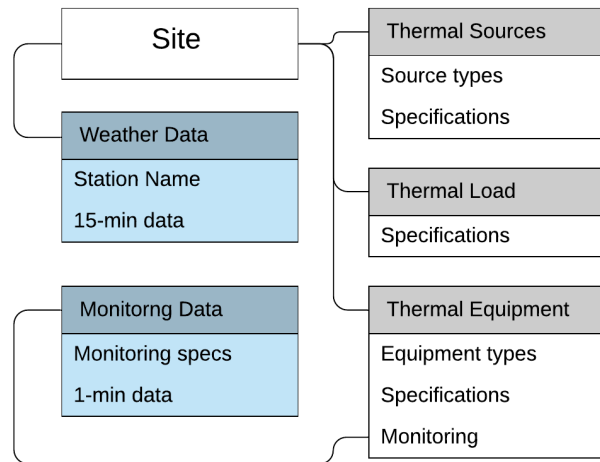| Attribute	Format	Comments
name	**Required** **Unique** **Syntax** Max 50 characters	The name of the general type of thermal source, for example, air source, ground source, district, etc.
description	**Optional** **Syntax** Text field	An optional field for additional information and/or comments.

Weather Station

Attribute	Format	Comments
nws_id	**Required** **Unique** **Syntax** Max 30 characters **Example** 'KPSM' for Portsmouth NH	The National Weather Service station identifier that is most representative of weather conditions at the site.
description	**Optional** **Syntax** Text field	An optional field for additional information and/or comments.
lat	**Required** **Syntax** Float field Units: Decimal Degrees	The latitude of the NWS station.
lon	**Required** **Syntax** Float field Units: Decimal Degrees	The longitude of the NWS station. For North America, typically reported in negative degrees relative to the prime meridian.

Time Series Data (No-SQL)

While we often associate the term 'measurement' with a single instance. In the context of time series data, a measurement is a collection of tags, fields, and timestamps.

In oTherm, the heat pump operating data for all heat pumps and all times is considered a measurement 'monitoring-data' and the weather data is considered a separate measurement ('weather-data'). The elements for each of these measurements are described in the tables below.

Monitoring Data

Data Element	Format	Comments

timestamp	**Required**
	
	Format on input
	epoch (unix timestamp)
	Example:
	`1577836800`
	
	Format on output
	RFC3339
	Example:
	`2020-01-01T00:00:00.00Z`
	
	Precision
	seconds
		When inputting time series data with a text file, the line protocol format requires that time is entered in epoch time. In oTherm, the precision is defined as 'seconds'

tag	**Required**
	
	tag key:
	`'equipment-uuid'`
	
	tag value:
	`equipment.uuid`
		Each time series record for heat pump operating is tagged with the equipment uuid.

field	**Required** **field key:** name of measurement type Example: 'source_supplytemp' **field value:** `float`	Name of measurement type for monitoring system. MeasurementType.name Each record must have least one field and most records will have multiple fields constituting a 'field set'.

Weather Data

Data Element	Format	Comments

timestamp	**Required**
	
	Format on input
	epoch (unix timestamp)
	Example:
	`1577836800`
	
	Format on output
	RFC3339
	Example:
	`2020-01-01T00:00:00.00Z`
	
	Precision
	seconds
		When inputting time series data with a text file, the line protocol format requires that time is entered in epoch time. In oTherm, the precision is defined as 'seconds'

tag	**Required** **tag key:** National Weather Service Station ID (e.g, 'KPSM') **tag value:** `weather_station.name`	Each time series record for weather data is tagged with the weather station name.
field	**Required** **field key:** name of weather measurement Example: 'temperature_c' **field value:** `float`	Name of weather measurement type Each record must have least one field and most records will have multiple fields constituting a 'field set'.

Line Protocol Input

In some cases, it may be necessary to upload time series data into the database. This can be done using text files with data in a 'line protocol' format. Each line represents a collection of (1) measurement name, (2) tag key:value pair, (3) a set of field key:value pairs, and (4) a time stamp in epoch time   Single spaces delimit each of these elements. Key value pairs in a field set are delimited by commas.   It is important that spaces are not included after commas.