http://bigladdersoftware.com/epx/docs/8-3/input-output-reference/group-electric-load-center.html#group-electric-load-center-generator-specifications

The ElectricLoadCenter:Generators object allows generators to be grouped together so they can be operated in different ways (controlled by the ElectricLoadCenter:Distribution object):

```
ElectricLoadCenter:Generators,
       \memo List of electric power generators to include in the
simulation including the name and
       \memo type of each generators along with availability
schedule, rated power output,
       \memo and thermal-to-electrical power ratio.
       \extensible:5 - repeat set of five fields, remembering to
remove ; from "inner" fields.
       \min-fields 6
  A1 , \field Name
       \required-field
       \reference GeneratorLists
  A2 , \field Generator 1 Name
       \begin-extensible
       \required-field
       \type object-list
       \object-list GeneratorNames
  A3 , \field Generator 1 Object Type
       \required-field
       \type choice
       \key Generator:InternalCombustionEngine
       \key Generator:CombustionTurbine
       \key Generator:Photovoltaic
       \key Generator:FuelCell
       \key Generator:MicroCHP
       \key Generator:MicroTurbine
       \key Generator:WindTurbine
  N1 , \field Generator 1 Rated Electric Power Output
       \type real
       \units W
  A4 , \field Generator 1 Availability Schedule Name
       \note Availability schedule name for this generator. Schedule
value > 0 means the generator is available.
       \note If this field is blank, the generator is always
available.
       \type object-list
       \object-list ScheduleNames
  N2 ; \field Generator 1 Rated Thermal to Electrical Power Ratio
```

ElectricLoadCenter:Distribution is needed to describe the connection of generators to the grid, this object could potentially subsume ElectricLoadCenter:Generators. This object is also needed to support inverters. We will want to implement with limited capability to support PV only for the first round.

```
ElectricLoadCenter:Distribution,
       \memo a list of meters that can be reported are available
after a run on
       \memo the meter dictionary file (.mdd) if the
Output:VariableDictionary has been requested.
  A1 , \field Name
       \required-field
  A2 , \field Generator List Name
       \type object-list
       \object-list GeneratorLists
  A3,  \field Generator Operation Scheme Type
       \note required if Generator List is entered.
       \type choice
       \key Baseload
       \key DemandLimit
       \key TrackElectrical
       \key TrackSchedule
       \key TrackMeter
       \key FollowThermal
       \key FollowThermalLimitElectrical
  N1,  \field Demand Limit Scheme Purchased Electric Demand Limit
       \type real
       \units W
  A4,  \field Track Schedule Name Scheme Schedule Name
       \note required when Generator Operation Scheme
Type=TrackSchedule
       \type object-list
       \object-list ScheduleNames
  A5,  \field Track Meter Scheme Meter Name
       \note required when Generator Operation Scheme Type=TrackMeter
       \type external-list
       \external-list autoRDDmeter
  A6,  \field Electrical Buss Type
       \type choice
       \key AlternatingCurrent
       \key AlternatingCurrentWithStorage
       \key DirectCurrentWithInverter
       \key DirectCurrentWithInverterDCStorage
       \key DirectCurrentWithInverterACStorage
       \default AlternatingCurrent
  A7,  \field Inverter Object Name
       \note required when Electrical Buss
Type=DirectCurrentWithInverter, DirectCurrentWithInverterDCStorage,
       \note or DirectCurrentWithInverterACStorage
       \type object-list
       \object-list InverterList
  A8,  \field Electrical Storage Object Name
```

```
       \note required when Electrical Buss
Type=AlternatingCurrentWithStorage,
DirectCurrentWithInverterDCStorage,
       \note or DirectCurrentWithInverterACStorage
       \type object-list
       \object-list ElecStorageList
  A9;  \field Transformer Object Name
       \note required when power needs to be output from on-site
generation to the grid via transformer
       \type object-list
       \object-list TransformerNames
```

We probably want to include inverter models for use with PV:

```
ElectricLoadCenter:Inverter:Simple,
        \memo Electric power inverter to convert from direct current
(DC) to alternating current
        \memo (AC) in an electric load center that contains
photovoltaic modules. This input
        \memo object is for the simplest inverter model and uses a
fixed efficiency.
   A1 , \field Name
        \reference InverterList
   A2 , \field Availability Schedule Name
        \note Availability schedule name for this system. Schedule
value > 0 means the system is available.
        \note If this field is blank, the system is always available.
        \type object-list
        \object-list ScheduleNames
   A3 , \field Zone Name
        \note enter name of zone to receive inverter losses as heat
        \note if blank then inverter is assumed to be outdoors
        \type object-list
        \object-list ZoneNames
   N1 , \field Radiative Fraction
        \minimum 0
        \maximum 1.0
   N2 ; \field Inverter Efficiency
        \minimum 0
        \maximum 1.0

ElectricLoadCenter:Inverter:FunctionOfPower,
        \memo Electric power inverter to convert from direct current
(DC) to alternating current
        \memo (AC) in an electric load center that contains
photovoltaic modules. This input
        \memo object is for an inverter model where efficiency is a
function of normalized
```

```
        \memo power.
   A1 , \field Name
        \reference InverterList
   A2 , \field Availability Schedule Name
        \note Availability schedule name for this system. Schedule
value > 0 means the system is available.
        \note If this field is blank, the system is always available.
        \type object-list
        \object-list ScheduleNames
   A3 , \field Zone Name
        \note Enter name of zone to receive inverter losses as heat
        \note if blank then inverter is assumed to be outdoors
        \type object-list
        \object-list ZoneNames
   N1 , \field Radiative Fraction
   A4 , \field Efficiency Function of Power Curve Name
        \note curve describes efficiency as a function of power
        \note curve is normalized relative to rated power in next
field
        \type object-list
        \object-list LinearCurves
        \object-list QuadraticCurves
        \object-list CubicCurves
        \object-list UniVariateTables
   N2,  \field Rated Maximum Continuous Input Power
        \units W
   N3 , \field Minimum Efficiency
        \minimum 0
        \maximum 1.0
   N4 , \field Maximum Efficiency
        \minimum 0
        \maximum 1.0
   N5 , \field Minimum Power Output
        \units W
   N6 , \field Maximum Power Output
        \units W
   N7 ; \field Ancillary Power Consumed In Standby
        \units W

ElectricLoadCenter:Inverter:LookUpTable,
        \memo   California Energy Commission tests and publishes data
on inverters
        \memo   This inverter model interpolates using CEC test data
        \memo   Input data are at
http://www.gosolarcalifornia.org/equipment/inverter_tests/summaries
   A1 , \field Name
        \reference InverterList
   A2 , \field Availability Schedule Name
```

```
        \note Availability schedule name for this system. Schedule
value > 0 means the system is available.
        \note If this field is blank, the system is always available.
        \type object-list
        \object-list ScheduleNames
   A3 , \field Zone Name
        \note Enter name of zone to receive inverter losses as heat
        \note if blank then inverter is assumed to be outdoors
        \type object-list
        \object-list ZoneNames
   N1 , \field Radiative Fraction
        \minimum 0
        \maximum 1.0
   N2 , \field Rated Maximum Continuous Output Power
        \units W
   N3 , \field Night Tare Loss Power
        \units W
   N4 , \field Nominal Voltage Input
        \units V
   N5 , \field Efficiency at 10% Power and Nominal Voltage
        \minimum 0
        \maximum 1.0
   N6 , \field Efficiency at 20% Power and Nominal Voltage
        \minimum 0
        \maximum 1.0
   N7 , \field Efficiency at 30% Power and Nominal Voltage
        \minimum 0
        \maximum 1.0
   N8 , \field Efficiency at 50% Power and Nominal Voltage
        \minimum 0
        \maximum 1.0
   N9 , \field Efficiency at 75% Power and Nominal Voltage
        \minimum 0
        \maximum 1.0
   N10; \field Efficiency at 100% Power and Nominal Voltage
        \minimum 0
        \maximum 1.0
```

This is the main PV object, it points to a performance object

```
Generator:Photovoltaic,
        \memo Describes an array of photovoltaic (PV) modules.  A
series of different PV arrays
        \memo can be connected to a single electric load center (and
inverter) by listing them all
        \memo in an ElectricLoadCenter:Generator object. PV
performance is taken from the
        \memo referenced PhotovoltaicPerformance:* object. Array
tilt, azimuth, and gross area
```

```
        \memo are taken from the referenced building surface or
shading surface. The array
        \memo surface participates normally in all shading
calculations.
   A1 , \field Name
        \required-field
        \reference GeneratorNames
        \reference PVGeneratorNames
   A2 , \field Surface Name
        \required-field
        \type object-list
        \object-list AllShadingAndHTSurfNames
   A3 , \field Photovoltaic Performance Object Type
        \type choice
        \key PhotovoltaicPerformance:Simple
        \key PhotovoltaicPerformance:EquivalentOne-Diode
        \key PhotovoltaicPerformance:Sandia
   A4 , \field Module Performance Name
        \note PV array modeling details
        \type object-list
        \object-list PVModules
   A5 , \field Heat Transfer Integration Mode
        \type choice
        \key Decoupled
        \key DecoupledUllebergDynamic
        \key IntegratedSurfaceOutsideFace
        \key IntegratedTranspiredCollector
        \key IntegratedExteriorVentedCavity
        \key PhotovoltaicThermalSolarCollector
        \default Decoupled
   N1 , \field Number of Modules in Parallel
        \default 1
        \units dimensionless
        \minimum 1
   N2 ; \field Number of Modules in Series
        \default 1
        \units dimensionless
        \minimum 1
```

The options for PV performance

```
PhotovoltaicPerformance:Simple,
        \memo Describes a simple model of photovoltaics that may be
useful for early phase
        \memo design analysis. In this model the user has direct
access to the efficiency with
        \memo which surfaces convert incident solar radiation to
electricity and need not specify
```

```
        \memo arrays of specific modules.
   A1 , \field Name
        \reference PVModules
   N1 , \field Fraction of Surface Area with Active Solar Cells
        \required-field
        \type real
        \units dimensionless
        \minimum 0.0
        \maximum 1.0
   A2 , \field Conversion Efficiency Input Mode
        \type choice
        \key Fixed
        \key Scheduled
   N2 , \field Value for Cell Efficiency if Fixed
        \note Efficiency = (power generated [W])/(incident solar[W])
        \type real
        \minimum 0.0
        \maximum 1.0
   A3 ; \field Efficiency Schedule Name
        \type object-list
        \object-list ScheduleNames

PhotovoltaicPerformance:EquivalentOne-Diode,
        \memo Describes the performance characteristics of
Photovoltaic (PV) modules to be modeled
        \memo using an equivalent one-diode circuit.  This model is
also known as
        \memo the 4- or 5-parameter TRNSYS model for photovoltaics.
   A1 , \field Name
        \reference PVModules
   A2 , \field Cell type
        \type choice
        \key CrystallineSilicon
        \key AmorphousSilicon
   N1 , \field Number of Cells in Series
         \default 36
         \type integer
         \units dimensionless
         \minimum 0
   N2 , \field Active Area
         \note The total power output of the array is determined by
the
         \note number of modules (see above).  The Active Area is
only
         \note used to calculate the PV Array Efficiency output
variable.
         \default 0.89
         \type real
```

```
       \units m2
       \minimum 0.1
   N3 , \field Transmittance Absorptance Product
       \default 0.95
       \type real
       \units dimensionless
       \minimum 0.0
       \maximum 1.0
   N4 , \field Semiconductor Bandgap
       \default 1.12
       \type real
       \units eV
       \minimum 0.0
   N5 , \field Shunt Resistance
       \default 1000000.0
       \type real
       \units ohms
       \minimum 0.0
   N6 , \field Short Circuit Current
       \default 6.5
       \type real
       \units A
       \minimum 0.0
   N7, \field Open Circuit Voltage
       \default 21.6
       \type real
       \units V
       \minimum 0.0
   N8, \field Reference Temperature
       \default 25
       \type real
       \units C
       \minimum 0.0
   N9, \field Reference Insolation
       \default 1000
       \type real
       \units W/m2
       \minimum 0.0
   N10, \field Module Current at Maximum Power
       \note Single module current at the maximum power point
       \note and reference conditions.  Module Current, Module
Voltage,
       \note Number of Modules in Parallel and Number of Modules in
Series
       \note determine the maximum power output of the array.
       \default 5.9
       \type real
       \units A
```

```
         \minimum 0.0
   N11, \field Module Voltage at Maximum Power
         \note Single module voltage at the maximum power point
         \note and reference conditions.  Module Current, Module
Voltage,
         \note Number of Modules in Parallel and Number of Modules in
Series
         \note determine the maximum power output of the array.
         \default 17
         \type real
         \units V
         \minimum 0.0
   N12, \field Temperature Coefficient of Short Circuit Current
         \default 0.02
         \type real
         \units A/K
   N13, \field Temperature Coefficient of Open Circuit Voltage
         \default -0.079
         \type real
         \units V/K
   N14, \field Nominal Operating Cell Temperature Test Ambient
Temperature
         \default 20
         \type real
         \units C
         \minimum 0.0
   N15, \field Nominal Operating Cell Temperature Test Cell
Temperature
         \default 40
         \type real
         \units C
         \minimum 0.0
   N16, \field Nominal Operating Cell Temperature Test Insolation
         \default 800
         \type real
         \units W/m2
         \minimum 0.0
   N17, \field Module Heat Loss Coefficient
         \default 30
         \type real
         \units W/m2-K
         \minimum 0.0
   N18; \field Total Heat Capacity
         \default 50000
         \type real
         \units J/m2-K
         \minimum 0.0
```

```
PhotovoltaicPerformance:Sandia,
       \memo Describes performance input data needed for specific
makes and models of production
       \memo PV panels using the empirical coefficients assembled by
Sandia National Laboratory.
   A1 , \field Name
        \reference PVModules
   N1 , \field Active Area
        \note (m2, single module)
        \default 1.0
        \type real
        \units m2
        \minimum 0.0
   N2 , \field Number of Cells in Series
        \default 1
        \type integer
        \units dimensionless
        \minimum 1
   N3 , \field Number of Cells in Parallel
        \default 1
        \type integer
        \units dimensionless
        \minimum 1
   N4 , \field Short Circuit Current
        \note (Amps)
        \type real
        \units A
   N5 , \field Open Circuit Voltage
        \note (Volts)
        \type real
        \units V
   N6 , \field Current at Maximum Power Point
        \note (Amps)
        \type real
        \units A
   N7 , \field Voltage at Maximum Power Point
        \note (Volts)
        \type real
        \units V
   N8 , \field Sandia Database Parameter aIsc
        \note (1/degC)
        \type real
        \units 1/K
   N9 , \field Sandia Database Parameter aImp
        \note (1/degC)
        \type real
        \units 1/K
   N10 , \field Sandia Database Parameter c0
```

```
      \type real
      \units dimensionless
N11 , \field Sandia Database Parameter c1
      \type real
      \units dimensionless
N12 , \field Sandia Database Parameter BVoc0
      \note (Volts/degC)
      \type real
      \units V/K
N13 , \field Sandia Database Parameter mBVoc
      \note (Volts/degC)
      \type real
      \units V/K
N14 , \field Sandia Database Parameter BVmp0
      \note (Volts/degC)
      \type real
      \units V/K
N15 , \field Sandia Database Parameter mBVmp
      \note (Volts/degC)
      \type real
      \units V/K
N16 , \field Diode Factor
      \type real
      \units dimensionless
N17 , \field Sandia Database Parameter c2
      \type real
      \units dimensionless
N18 , \field Sandia Database Parameter c3
      \type real
      \units dimensionless
N19 , \field Sandia Database Parameter a0
      \type real
      \units dimensionless
N20 , \field Sandia Database Parameter a1
      \type real
      \units dimensionless
N21 , \field Sandia Database Parameter a2
      \type real
      \units dimensionless
N22 , \field Sandia Database Parameter a3
      \type real
      \units dimensionless
N23 , \field Sandia Database Parameter a4
      \type real
      \units dimensionless
N24 , \field Sandia Database Parameter b0
      \type real
      \units dimensionless
```

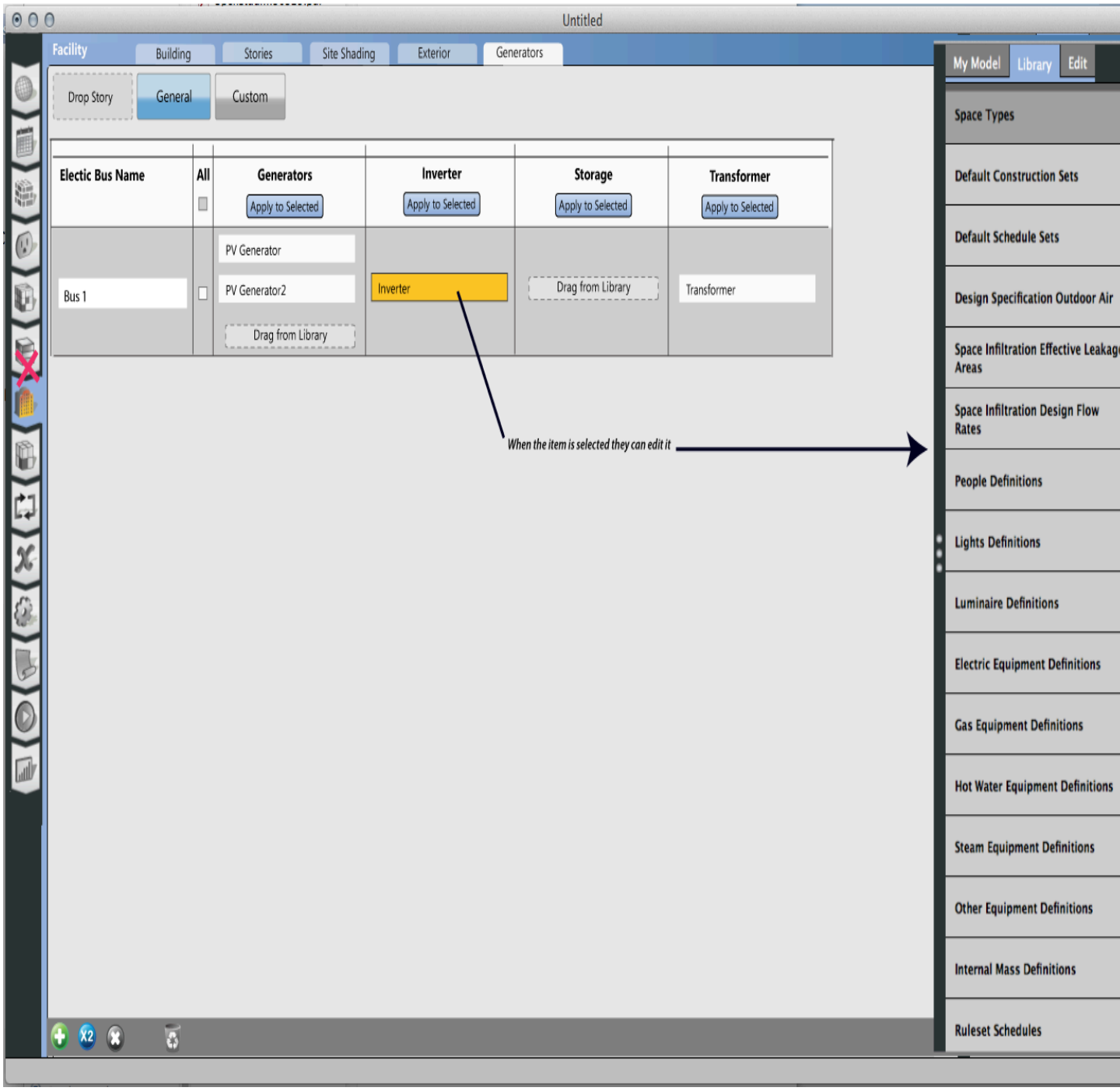
```
N25 , \field Sandia Database Parameter b1
      \type real
      \units dimensionless
N26 , \field Sandia Database Parameter b2
      \type real
      \units dimensionless
N27 , \field Sandia Database Parameter b3
      \type real
      \units dimensionless
N28 , \field Sandia Database Parameter b4
      \type real
      \units dimensionless
N29 , \field Sandia Database Parameter b5
      \type real
      \units dimensionless
N30 , \field Sandia Database Parameter Delta(Tc)
      \note (deg C)
      \type real
      \units deltaC
N31 , \field Sandia Database Parameter fd
      \note (nondimensional)
      \type real
      \units dimensionless
N32 , \field Sandia Database Parameter a
      \type real
      \units dimensionless
N33 , \field Sandia Database Parameter b
      \type real
      \units dimensionless
N34 , \field Sandia Database Parameter c4
      \type real
      \units dimensionless
N35 , \field Sandia Database Parameter c5
      \type real
      \units dimensionless
N36 , \field Sandia Database Parameter Ix0
      \note (Amps)
      \type real
N37 , \field Sandia Database Parameter Ixx0
      \note (Amps)
      \type real
N38 , \field Sandia Database Parameter c6
      \type real
N39 ; \field Sandia Database Parameter c7
      \type real
```

Questions

- Do we want to share PV performance objects or not? Answer driven by GUI.

GUI

For the GUI, I envision a grid of ElectricLoadCenter:Distribution objects in the model. Not sure where to put this tab? You can drag and drop Generators (for now only Generator:Photovoltaic) onto the distribution list. You can drag an inverter onto the distribution list.



Testing

Will need simulation tests, need to make sure to create a simulation test for the solar collector photovoltaic system.