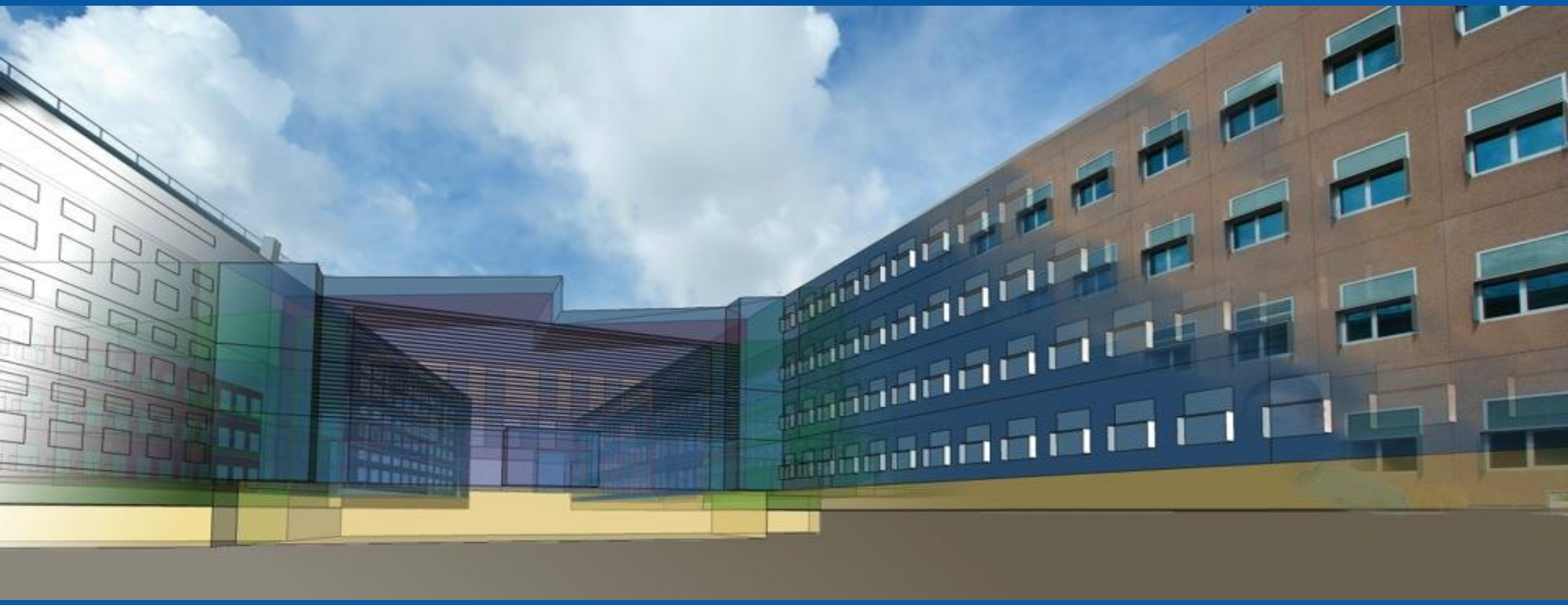
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

# Analysis Spreadsheet Concepts



**Commercial Buildings Controls and Analysis Tools Team**
**April 2015**

# Spreadsheet Overview

The OpenStudio Analysis Spreadsheet is a tool used to apply algorithms to an OpenStudio measure based workflow and run those jobs on Amazons EC2 cloud based computing infrastructure. Typical analyses include the use of sampling algorithms to perform sensitivity studies, optimization algorithms to find an 'optimal' set of measures and/or calibrate a model to metered utility data.

The spreadsheet and basic installation instructions can be found at https://github.com/NREL/OpenStudio-analysis-spreadsheet. The /projects/ folder contains a template.xlsx spreadsheet which can be edited to satisfy the users needs. There are also three SEB spreadsheets which are example sampling and calibration problems related to the Site Entrance Building at NREL. All supporting files for that example can be found the in /Calibration_example/ folder.

The purpose of this document is to explain the functionality of each portion of the spreadsheet. The spreadsheet has three main user tabs: Setup, Variables and Outputs. The Setup tab defines all the algorithmic information, the Amazon EC2 configuration and the directory paths for all the supporting files. The Variables tab defines the measure based workflow to be applied to the seed model as well as defining the variable ranges and configurations for the algorithm. Finally the Outputs tab defines any objective function information, which variables should be available to visualize on the server instance and which variables that should be available in the downloadable database in csv or R-dataframe format.

# Spreadsheet Overview

The Setup tab has several subsections to it, usually delineated by a **green color**. They are:

- Settings
- Running Setup
- Problem Definition
- Algorithm Setup
- Weather Files
- Models
- Other Library Files

The editable fields of the spreadsheet Setup tab are denoted by a **tan color**. There are several excel formulas being used in the Algorithm setup section to make sure that the right algorithmic settings are used for the right algorithms. All supporting data for the drop-down and algorithm section can be found on the Lookups tab of the spreadsheet. It is advised to only change make changes in the tan color sections if there is one for a particular row.

# Setup Tab

## Settings

| | A | B | C | D | E |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | Settings | | | | |
| 3 | Spreadsheet Version | 0.4.2 | | | |
| 4 | User Id | new_user | | | |
| 5 | OpenStudio Server Version | 1.10.0-rc1 | | | |
| 6 | Cluster Name | Default Cluster | | | |
| 7 | Server Instance Type | m3.xlarge | Recommended for Server | 4 Cores with 40 GB | $0.28/hour |
| 8 | Worker Instance Type | c3.8xlarge | Recommended for worker | 32 Cores with 320 GB | $1.68/hour |
| 9 | Worker Nodes | 1 | | Total Cost | $1.96/hour |
| 10 | AWS Tag | org=5500 | | | |
| 11 | | | | | |

- **Spreadsheet Version**: This is the version of the OpenStudio-analysis-gem. Available releases can be found at https://github.com/NREL/OpenStudio-analysis-gem/releases. This gem creates and configures the *analysis.json* files needed for running the OpenStudio Distributed Analysis workflow
- **OpenStudio Server Version**: This is the version of the OpenStudio-server which points to specific AMIs on Amazon. Available releases can be found at: http://developer.nrel.gov/downloads/buildings/openstudio/api/amis_v2.json (JSON plugin viewer for your web browser is recommended). Typical updates to the server include performance updates for the visualization capability, addition of new algorithms and updates to OpenStudio and EnergyPlus.
- **User ID** and **AWS Tag**: are not used outside of NREL

# Setup Tab

http://aws.amazon.com/ec2/instance-types/
http://aws.amazon.com/ec2/pricing/

## Settings

| | A | B | C | D | E |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | Settings | | | | |
| 3 | Spreadsheet Version | 0.4.2 | | | |
| 4 | User Id | new_user | | | |
| 5 | OpenStudio Server Version | 1.10.0-rc1 | | | |
| 6 | Cluster Name | Default Cluster | | | |
| 7 | Server Instance Type | m3.xlarge | Recommended for Server | 4 Cores with 40 GB | $0.28/hour |
| 8 | Worker Instance Type | c3.8xlarge | Recommended for worker | 32 Cores with 320 GB | $1.68/hour |
| 9 | Worker Nodes | | | Total Cost | $1.96/hour |
| 10 | AWS Tag | | | | |
| 11 | | | | | |

m3.large
m3.xlarge
m3.2xlarge
c3.large
c3.xlarge
c3.2xlarge
c3.4xlarge
c3.8xlarge

- **Server and Worker Instance Type**: These are dropdown menus to select the Amazon instance type to spin up. The number of cores and memory for each system is described in column D along with approximate cost information. The official prices and more detailed instance descriptions can be found at http://aws.amazon.com/ec2/instance-types/ and http://aws.amazon.com/ec2/pricing/.
- **Worker Nodes**: This is the number of worker nodes to launch. Select 0 if you only want a server.
- **Cluster Name**: This name will be the filename in the *'filename.json'* at the root of the spreadsheet directory upon starting an analysis and contains the Amazon instance IP addresses. The system will first check if this file exists, and if it does will try to submit the job to this Amazon configuration. To submit a job to a new cluster, simply delete this file or run 'rake clean' as outlined on the spreadsheet github page.

# Setup Tab

## Running Setup

| | | |
|---|---|---|
| 12 | Running Setup | |
| 13 | Analysis Name | Template |
| 14 | Measure Directory | ../measures |
| 15 | Export Directory | ../analysis |
| 16 | Allow Multiple Jobs | TRUE |
| 17 | Use Server As Worker | TRUE |
| 18 | Simulate Data Point Filename | simulate_data_point.rb |
| 19 | Run Data Point Filename | run_openstudio_workflow_monthly.rb |
| 20 | | |

- **Analysis Name**: This is the user defined name of the analysis to be run. This will be the identifier on the server dashboard so make sure its something that differentiates your analysis since several analyses can be run on the same server.
- **Measure Directory**: This is the path to the directory containing the project OpenStudio measures. This is a relative path from the /projects/ folder where the spreadsheet should reside. To include more than one measure directory, just copy / insert and edit the path below the first Measure Directory. In the case of multiple measure directories, search order for finding measures is done top down.
- **Export Directory**: This is the location of the analysis.json file describing the workflow (as created by the OpenStudio-analysis-gem) which is uploaded to the server as well as a .zip file of the measures needed for the analysis.
- **Use Server As Worker**: This is a flag to allow jobs to be run on the server. The default setting is true and must be true for the Optim and Rgenoud algorithms.

# Setup Tab

## Problem Definition

| | | | |
|---|---|---|---|
| 21 | Problem Definition | Problem Type | |
| 22 | Analysis Type | lhs | |
| 23 | | | |
| 24 | Algorithm Setup | | lowed Values and Description |
| 25 | Sample Method | individual_variables | individual_variables / all_variables |
| 26 | Number of Samples | 40 | positive integer (if individual, total simulations is this times each variable) |
| 27 | | | |

lhs
optim
rgenoud
nsga_nrel
preflight
doe
single_run
repeat_run

**Analysis Type**: This is a dropdown listing all available algorithms. Once an algorithm is selected, the algorithmic parameters in the Algorithm Setup section below should change to match the needed inputs for the algorithm. **Changing the default values should be done in the tan section of Column D**. A detailed description of each algorithm follows below.

# Setup Tab

## Algorithm Setup

| | | | | |
|---|---|---|---|---|
| 21 | Problem Definition | Problem Type | | |
| 22 | Analysis Type | preflight | | |
| 23 | | | | |
| 24 | Algorithm Setup | Configuration Values | Allowed Values and Description | Override Defaults (Enter values here to override the Defaults in Column B) |
| 25 | | | | |
| 26 | | | | |

**Preflight**: This is an algorithm that will run three simulations:

1. All variables set to the minimum value
2. All variables set to the maximum value
3. All variables set to the mean value

All other variables will be set to their static or default value. This method is extremely useful for debugging the parameter space before a costly sampling or optimization is run. The assumption here is that if the problem will run at the variable boundaries and at the mean, it should safely run at points in between.

# Setup Tab

## Algorithm Setup

| | | | | |
|---|---|---|---|---|
| 21 | Problem Definition | Problem Type | | |
| 22 | Analysis Type | lhs | | |
| 23 | | | | |
| 24 | Algorithm Setup | Configuration Values | Allowed Values and Description | Override Defaults (Enter values here to override the Defaults in Column B) |
| 25 | Sample Method | individual_variables | individual_variables / all_variables | |
| 26 | Number of Samples | 40 | positive integer (if individual, total simulations is this times each variable) | 40 |
| 27 | | | | |

**LHS**: This is a Latin Hyper Cube algorithm. The actual algorithm implemented can be found at http://cran.r-project.org/web/packages/lhs/lhs.pdf. There are two options for this algorithm:

- **Sample Method**: This has two settings:
  1. 'all_variables' will sample all of your variables all at once.
  2. 'individual_variables' will sample each variable individually while holding the other variables to their static value.

- **Number of Samples**: This is the number of samples to generate.
  1. For the 'all_variables' case this is the total number of simulations to create.
  2. For the 'individual_variables' case, the total number of simulations will be this number times the number of variables.

# Setup Tab

## Algorithm Setup

| | | | | |
|---|---|---|---|---|
| 20 | Problem Definition | Problem Type | | |
| 21 | Analysis Type | morris | | |
| 22 | | | | |
| 23 | Algorithm Setup | Configuration Values | Allowed Values and Description | Override Defaults (Enter values here to override the Defaults in Column B) |
| 24 | r | 10 | individual_variables / all_variables | |
| 25 | levels | 10 | positive integer (if individual, total simulations is this times each variable) | |
| 26 | grid_jump | 1 | | |
| 27 | type | oat | | |

**Morris**: This is the Morris Method algorithm for sensitivity analysis. The actual algorithm implemented can be found at https://cran.r-project.org/web/packages/sensitivity/sensitivity.pdf. Total number of simulations will be r × (p + 1) simulations (where p is the number of variables):

- **Type**: "oat" for Morris's OAT design (Morris 1992)
- **R**: an integer giving the number of repetitions of the design, i.e. the number of elementary effect computed per factor.
- **Levels**: an integer specifying the number of levels of the design.
- **Grid_jump**: an integer specifying the number of levels that are increased/decreased for computing the elementary effects. Notice that this default value of one does not follow Morris's recommendation of levels/2.

# Setup Tab

## Algorithm Setup

| | | | |
|---|---|---|---|
| 21 | Problem Definition | Problem Type | |
| 22 | Analysis Type | doe | |
| 23 | | | |
| 24 | Algorithm Setup | Configuration Values | Allowed Values and Description |
| 25 | Experiment Type | full_factorial | full_factorial |
| 26 | Number of Samples | 2 | positive integer (this discretizes a continous variable) |

**DOE**: This is a design of experiments algorithm. It will generate a full factorial experiment type. This algorithm can work with continuous variables. It will sample or discretize a continuous variable and then create the full factorial design from all the discrete values. The number of samples should be kept to a small number to keep the total number of simulations to a reasonable value. The algorithms implemented are from the DoE.base package http://cran.r-project.org/web/packages/DoE.base/DoE.base.pdf

- **Experiment Type**: 'full_factorial'
- **Number of Samples**: used to discretize a continuous variable.

# Setup Tab

## Algorithm Setup

| | | | | |
|---|---|---|---|---|
| 21 | Problem Definition | Problem Type | | |
| 22 | Analysis Type | single_run | | |
| 23 | | | | |
| 24 | Algorithm Setup | Configuration Values | Allowed Values and Description | Override Defaults (Enter values here to override the Defaults in Column B) |
| 25 | | | | |
| 26 | | | | |
| 27 | | | | |

**Single Run**: This method will run one simulation with all variables set to their static or default value. This method is good for debugging and testing a measure workflow.

note: if the user only intends to do single runs, then select a medium to low cost server instance and set the number of workers to 0.

# Setup Tab

## Algorithm Setup

| | | | |
|---|---|---|---|
| 21 | Problem Definition | Problem Type | |
| 22 | Analysis Type | repeat_run | |
| 23 | | | |
| 24 | Algorithm Setup | Configuration Values | Allowed Values and Description |
| 25 | Number of Runs | 30 | positive integer (if individual, total simulations is this |

**Repeat Run**: This method will run one simulation with all variables set to their static or default value, N number of times. The simulations will be run in parallel, up to the number of cores that are selected by the instance types. This method is good for debugging and testing possible race conditions or non-deterministic errors that may occur.

- **Number of Runs**: total number of the static or default simulation to run.

# Setup Tab

## Algorithm Setup

| | | | | |
|---|---|---|---|---|
| 21 | Problem Definition | Problem Type | | |
| 22 | Analysis Type | optim | | |
| 23 | | | | |
| 24 | Algorithm Setup | Configuration Values | Allowed Values and Description | Override Defaults (Enter values here to override the Defaults in Column B) |
| 25 | epsilonGradient | 0.01 | epsilon in gradient calculation | |
| 26 | pgtol | 0.01 | tolerance on the projected gradient | |
| 27 | factr | 4.5036E+13 | Tolerance on delta_F | |
| 28 | maxit | 100 | Maximum number of iterations | |
| 29 | normType | minkowski | | |
| 30 | pPower | 2 | Lp norm power | |
| 31 | Exit On Guideline14 | 0 | 0 false / 1 true (for use with calibration report) | |

**Optim**: This method will perform a quasi- Newton gradient search. Details can be found at https://stat.ethz.ch/R-manual/R-devel/library/stats/html/optim.html.

- **epsilonGradient**: delta-X in the finite difference gradient calculation.
- **pgtol**: Tolerance on the projected gradient in the current search direction.
- **factr**: Convergence occurs when the reduction in the objective is within this factor of the machine tolerance.
- **maxit**: The maximum number of iterations. (This is not the total number of simulations. That will be more than number of iterations * number of variables * 2.)
- **pPower**: Lp norm power to use on the objective functions. 1 is absolute value, 2 is RMSE.
- **Exit On Guideline14**: For use with the calibration reporting measure. This will terminate the search of any result satisfies guideline 14. Default is 0.

# Setup Tab

## Algorithm Setup

| | | | | |
|---|---|---|---|---|
| 21 | Problem Definition | Problem Type | | |
| 22 | Analysis Type | rgenoud | | |
| 23 | | | | |
| 24 | Algorithm Setup | Configuration Values | Allowed Values and Description | Override Defaults (Enter values here to override the Defaults in Column B) |
| 25 | popSize | 60 | Size of initial population | 60 |
| 26 | Generations | 5 | Number of generations | |
| 27 | waitGenerations | 2 | If no improvement in waitGenerations of generations, then exit | |
| 28 | bfgsburnin | 2 | The number of generations which are run before the BFGS is first used | |
| 29 | gradientcheck | 0 | 0 false / 1 true | 0 |
| 30 | solutionTolerance | 0.01 | Numbers within solutionTolerance are considered | |
| 31 | epsilonGradient | 0.01 | epsilon in gradient calculation | |
| 32 | pgtol | 0.01 | tolerance on the projected gradient | |
| 33 | factr | 4.5036E+13 | Tolerance on delta_F | |
| 34 | maxit | 100 | Maximum number of iterations | |
| 35 | normType | minkowski | | |
| 36 | pPower | 2 | Lp norm power | |
| 37 | Exit On Guideline14 | 0 | 0 false / 1 true (for use with calibration report) | |
| 38 | balance | 1 | 0 false / 1 true (load balancing) | |

**Rgenoud**: This algorithm combines evolutionary search algorithms with derivative-based methods. Details can be found at http://cran.r-project.org/web/packages/rgenoud/rgenoud.pdf. The problem type should be all continuous variables. The algorithm will perform several generations with the evolutionary algorithm and then alternate between the quasi-newton based Optim method and the evolutionary search. The algorithm has a scalar objective function.

# Setup Tab

**Rgenoud continued:**

- **popSize**: This is the size of the population for each evolutionary search.
- **Generations**: This is the maximum number of generations to run.
- **waitGeneration**s: If there is no improvement in the objective function in this number of generations, genoud will think that it has found the optimum.
- **bfgsburnin**: This is the number of generations to perform before the gradient search.
- **gradientcheck**: If this variable is TRUE, genoud will not start counting waitGenerations unless each gradient is solutionTolerance close to zero.
- **solutionTolerance**: Numbers within solutionTolerance are considered to be equal.
- **epsilonGradient**: delta-X in the finite difference gradient calculation.
- **pgtol**: Tolerance on the projected gradient in the current search direction.
- **factr**: Convergence occurs when the reduction in the objective is within this factor of the machine tolerance.
- **maxit**: The maximum number of iterations. (This is not the total number of simulations. That will be more than number of iterations * number of variables * 2.)
- **pPower**: Lp norm power to use on the objective functions. 1 is absolute value, 2 is RMSE.
- **Exit On Guideline14**: For use with the calibration reporting measure. This will terminate the search of any result satisfies guideline 14. Default is 0.
- **balance**: This logical flag controls if load balancing is done across the cluster. This should be set to 1 true.

# Setup Tab

## Algorithm Setup

| | | | | |
|---|---|---|---|---|
| 21 | Problem Definition | Problem Type | | |
| 22 | Analysis Type | nsga_nrel | | |
| 23 | | | | |
| 24 | Algorithm Setup | Configuration Values | Allowed Values and Description | Override Defaults (Enter values here to override the Defaults in Column B) |
| 25 | Number of Samples | 90 | Size of initial population | 90 |
| 26 | Generations | 6 | Number of generations | 6 |
| 27 | cprob | 0.85 | Crossover probability [0,1] | |
| 28 | XoverDistIdx | 5 | Crossover Distribution Index (large values give higher probabilities of offspring close to parent) | |
| 29 | MuDistIdx | 5 | Mutation Distribution Index (large values give higher probabilities of offspring close to parent) | |
| 30 | mprob | 0.8 | Mutation probability [0,1] | |
| 31 | toursize | 2 | Tournament Size | |
| 32 | normType | minkowski | | |
| 33 | pPower | 2 | Lp norm power | |
| 34 | Exit On Guideline14 | 0 | 0 false / 1 true (for use with calibration report) | |

**NSGA2**: This algorithm is a box-constrained multiobjective optimization using the elitist non-dominated sorting genetic algorithm NSGA-II. The version used on the server is a modified version of the R package found at http://cran.r-project.org/web/packages/nsga2R/nsga2R.pdf with changes made to allow for parallelization of simulations for each generation and to allow for mixed continuous and discrete variables.

# Setup Tab

**NSGA2 continued**:

- **Number of Samples**: This is the size of the population for each generation.
- **Generations**: The total number of search generations to perform. Total number of simulations will be number of samples times generations.
- **cprob**: Crossover probability. Should be between [0,1]
- **XoverDistIdx**: Crossover distribution index. Large values give higher probabilities of offspring close to parent.
- **MuDistIdx**: Mutation distribution index. Large values give higher probabilities of offspring close to parent.
- **mprob**: Mutations probability. Should be between [0,1]
- **toursize**: Tournament size.
- **pPower**: Lp norm power to use on the objective functions. 1 is absolute value, 2 is RMSE.
- **Exit On Guideline14**: For use with the calibration reporting measure. This will terminate the search of any result satisfies guideline 14. Default is 0.

# Setup Tab

## Weather Files

| | | | |
|---|---|---|---|
| 39 | Weather Files | Path (relative to this spreadsheet or absolute path) | Weather files in the .zip format. Can list individually or use a wild card |
| 40 | Weather File | ../weather/USA_CO_Denver.Intl.AP.725650_TMY3.epw | |
| 41 | | | |

**Weather File**: This is the relative path to the weather file needed for simulation. A single weather file may be called out specifically as above, or wild cards can be used and the entire directory will be sent to the server as depicted below.

| | | | |
|---|---|---|---|
| 36 | Weather Files | Path (relative to this spreadsheet or absolute path) | Weather files in the .zip format. Can list individually or use a wild card |
| 37 | Weather File | ../weather_65445/* | |
| 38 | | | |

# Setup Tab

## Models

| | | | | | |
|---|---|---|---|---|---|
| 39 | Models | Identifier | File Type | Path (relative to this spreadsheet or absolute path) | If there are more than one seed models, then you will submit the same analysis for each seed |
| 40 | Model | | OSM | ../seeds/EmptySeedModel.osm | na |
| 41 | | | | | |

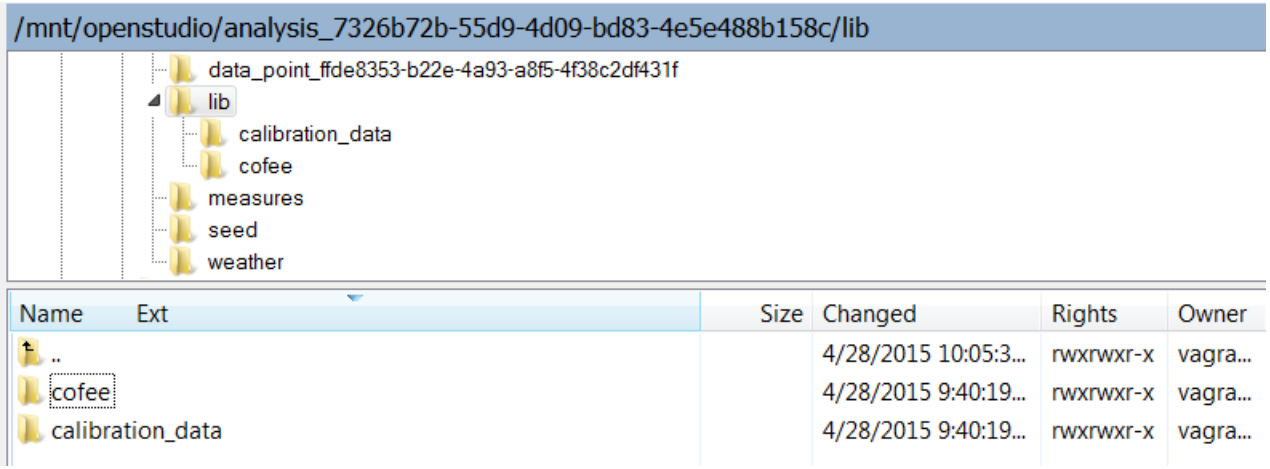
**Model**: This is the relative path to the OSM seed file needed for simulation.

# Setup Tab

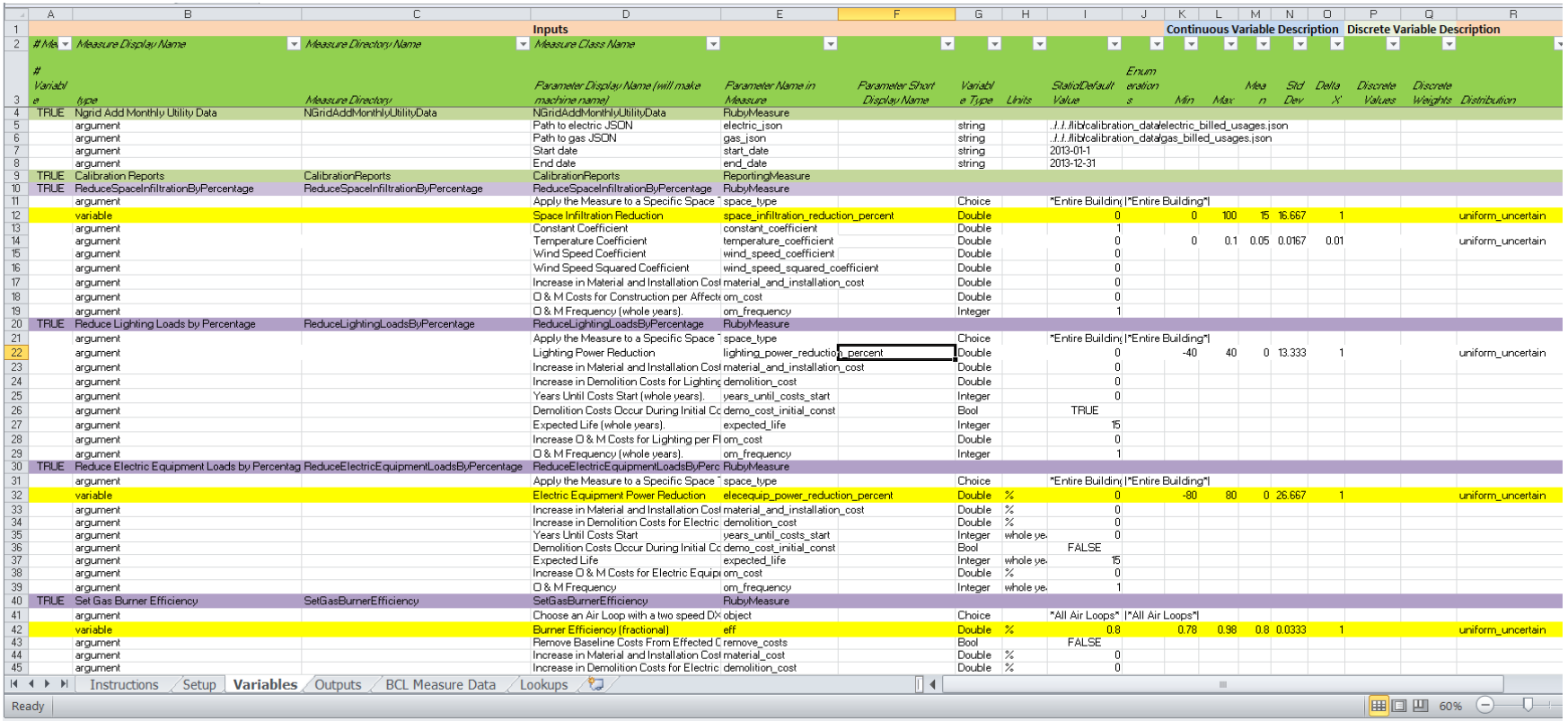
## Other Library Files

| | | | | | |
|---|---|---|---|---|---|
| 42 | Other Library Files | Directory to Unpack to | Files to include (relative to this spreadsheet or absolute path). If a directory then it will include all subfolders and files | | If extra library files are needed then include them here. These are typically preprocessors or postprocessors and require custom measures to use. |
| 43 | Directory | calibration_data | ../Calibration_example/lib | | |
| 44 | | | | | |

**Directory**: This is the relative path to any supporting data or files that any of the measures may need. The directory or files will be copied to the /lib/ folder on the server, which is 3 levels higher than the run directory on the server. As an example, the 'electric_billed_usages.json' file in the '../Calibration_example/lib/' folder would get moved to the '/lib/calibration_data/' folder on the server. Any measure looking for that file would find it at '../../../lib/calibration_data/electric_billed_usages.json' from the run directories on the server.



# Variables Tab



| # Variable | Measure Display Name | Measure Directory Name | Measure Class Name | Parameter Display Name (will make machine name) | Parameter Name in Measure | Parameter Short Display Name | Variable Type | Units | StaticDefault Value | Enumerations | Min | Max | Mean | Std Dev | Delta X | Discrete Values | Discrete Weights | Distribution |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Inputs | | | | | | | | | | | | | Continuous Variable Description | | Discrete Variable Description |
| TRUE | Ngrid Add Monthly Utility Data | NGridAddMonthlyUtilityData | NGridAddMonthlyUtilityData | | RubyMeasure | | | | | | | | | | | | | |
| | argument | | | Path to electric JSON | electric_json | | string | | ../../../lib/calibration_data/electric_billed_usages.json | | | | | | | | | |
| | argument | | | Path to gas JSON | gas_json | | string | | ../../../lib/calibration_data/gas_billed_usages.json | | | | | | | | | |
| | argument | | | Start date | start_date | | string | | 2013-01-1 | | | | | | | | | |
| | argument | | | End date | end_date | | string | | 2013-12-31 | | | | | | | | | |
| TRUE | Calibration Reports | CalibrationReports | | CalibrationReports | ReportingMeasure | | | | | | | | | | | | | |
| TRUE | ReduceSpaceInfiltrationByPercentage | ReduceSpaceInfiltrationByPercentage | | ReduceSpaceInfiltrationByPercentage | RubyMeasure | | | | | | | | | | | | | |
| | argument | | | Apply the Measure to a Specific Space | space_type | | Choice | | *Entire Building* | *Entire Building*\| | | | | | | | | |
| | variable | | | Space Infiltration Reduction | space_infiltration_reduction_percent | | Double | | 0 | | 0 | 100 | 15 | 16.667 | 1 | | | uniform_uncertain |
| | argument | | | Constant Coefficient | constant_coefficient | | Double | | 1 | | | | | | | | | |
| | argument | | | Temperature Coefficient | temperature_coefficient | | Double | | 0 | | 0 | 0.1 | 0.05 | 0.0167 | 0.01 | | | uniform_uncertain |
| | argument | | | Wind Speed Coefficient | wind_speed_coefficient | | Double | | 0 | | | | | | | | | |
| | argument | | | Wind Speed Squared Coefficient | wind_speed_squared_coefficient | | Double | | 0 | | | | | | | | | |
| | argument | | | Increase in Material and Installation Cost | material_and_installation_cost | | Double | | 0 | | | | | | | | | |
| | argument | | | O & M Costs for Construction per Affecte | om_cost | | Double | | 0 | | | | | | | | | |
| | argument | | | O & M Frequency (whole years). | om_frequency | | Integer | | 1 | | | | | | | | | |
| TRUE | Reduce Lighting Loads by Percentage | ReduceLightingLoadsByPercentage | | ReduceLightingLoadsByPercentage | RubyMeasure | | | | | | | | | | | | | |
| | argument | | | Apply the Measure to a Specific Space | space_type | | Choice | | *Entire Building* | *Entire Building*\| | | | | | | | | |
| | argument | | | Lighting Power Reduction | lighting_power_reduction_percent | | Double | | 0 | | -40 | 40 | 0 | 13.333 | 1 | | | uniform_uncertain |
| | argument | | | Increase in Material and Installation Cost | material_and_installation_cost | | Double | | 0 | | | | | | | | | |
| | argument | | | Increase in Demolition Costs for Lighting | demolition_cost | | Double | | 0 | | | | | | | | | |
| | argument | | | Years Until Costs Start (whole years). | years_until_costs_start | | Integer | | 0 | | | | | | | | | |
| | argument | | | Demolition Costs Occur During Initial Co | demo_cost_initial_const | | Bool | | TRUE | | | | | | | | | |
| | argument | | | Expected Life (whole years). | expected_life | | Integer | | 15 | | | | | | | | | |
| | argument | | | Increase O & M Costs for Lighting per Fl | om_cost | | Double | | 0 | | | | | | | | | |
| | argument | | | O & M Frequency (whole years). | om_frequency | | Integer | | 1 | | | | | | | | | |
| TRUE | Reduce Electric Equipment Loads by Percentag | ReduceElectricEquipmentLoadsByPercentage | | ReduceElectricEquipmentLoadsByPerc | RubyMeasure | | | | | | | | | | | | | |
| | argument | | | Apply the Measure to a Specific Space | space_type | | Choice | | *Entire Building* | *Entire Building*\| | | | | | | | | |
| | variable | | | Electric Equipment Power Reduction | elecequip_power_reduction_percent | | Double | % | 0 | | -80 | 80 | 0 | 26.667 | 1 | | | uniform_uncertain |
| | argument | | | Increase in Material and Installation Cost | material_and_installation_cost | | Double | % | 0 | | | | | | | | | |
| | argument | | | Increase in Demolition Costs for Electric | demolition_cost | | Double | % | 0 | | | | | | | | | |
| | argument | | | Years Until Costs Start | years_until_costs_start | | Integer | whole ye | 0 | | | | | | | | | |
| | argument | | | Demolition Costs Occur During Initial Co | demo_cost_initial_const | | Bool | | FALSE | | | | | | | | | |
| | argument | | | Expected Life | expected_life | | Integer | whole ye | 15 | | | | | | | | | |
| | argument | | | Increase O & M Costs for Electric Equipr | om_cost | | Double | % | 0 | | | | | | | | | |
| | argument | | | O & M Frequency | om_frequency | | Integer | whole ye | 1 | | | | | | | | | |
| TRUE | Set Gas Burner Efficiency | SetGasBurnerEfficiency | | SetGasBurnerEfficiency | RubyMeasure | | | | | | | | | | | | | |
| | argument | | | Choose an Air Loop with a two speed DX | object | | Choice | | *All Air Loops* | *All Air Loops*\| | | | | | | | | |
| | variable | | | Burner Efficiency (fractional) | eff | | Double | % | 0.8 | | 0.78 | 0.98 | 0.8 | 0.0333 | 1 | | | uniform_uncertain |
| | argument | | | Remove Baseline Costs From Effected C | remove_costs | | Bool | | FALSE | | | | | | | | | |
| | argument | | | Increase in Material and Installation Cost | material_cost | | Double | % | 0 | | | | | | | | | |
| | argument | | | Increase in Demolition Costs for Electric | demolition_cost | | Double | % | 0 | | | | | | | | | |

Instructions | Setup | Variables | Outputs | BCL Measure Data | Lookups

Ready

The Variables tab describes the measure based workflow to be applied to the seed model, which was defined on the Setup tab. The format of the Variables tab has changed over time and must be consistent with the OpenStudio-analysis-gem version that is set at the top of the Setup tab. The description of the Variables tab used in this document will be for version 0.4.2.

# Variables Tab

The Variables tab lists the measures that are to be applied to the seed model and are applied in top-down order. All OpenStudio or RubyMeasures are applied first (in top-down order), followed by EnergyPlusMeasures and finally ReportingMeasures.

**Column A** is a 'Measure Enabled' flag to turn measures on or off in the workflow. A measure set to 'FALSE' will not be put into the workflow. This feature is useful for debugging if a certain measure is causing errors.

| | A | B | C |
|---|---|---|---|
| 1 | | | |
| 2 | # Meas | Measure Display Name | Measure Directory Name |
| 3 | # Variable | type | Measure Directory |
| 9 | TRUE | Calibration Reports | CalibrationReports |
| 10 | TRUE | ReduceSpaceInfiltrationByPercentage | ReduceSpaceInfiltrationByPercentage |
| 11 | | argument | |
| 12 | | variable | |
| 13 | | argument | |
| 14 | | argument | |
| 15 | | argument | |
| 16 | | argument | |
| 17 | | argument | |
| 18 | | argument | |
| 19 | | argument | |
| 20 | TRUE | Reduce Lighting Loads by Percentage | ReduceLightingLoadsByPercentage |
| 21 | | argument | |
| 22 | | argument | |
| 23 | | argument | |
| 24 | | argument | |
| 25 | | argument | |
| 26 | | argument | |
| 27 | | argument | |
| 28 | | argument | |
| 29 | | argument | |
| 30 | TRUE | Reduce Electric Equipment Loads by Percentage | ReduceElectricEquipmentLoadsByPercentage |

Instructions | Setup | **Variables** | Outputs | BCL Measure Data | Lookups

# Variables Tab

**Column B** is the display name for the measure. This name will be used in plots and must be a unique name (If the same measure is being used more than once, each measure must have a unique distinguishing name). For measures that have arguments, **Column B** is also where the *argument* is turned into a *variable*. When turning an argument into a variable, **Columns K-R** also need to be filled out for the variable row.

**Column D** is the *Measure Class Name* for the measure which is found in the measure.rb file.

```
#start the measure
class ReduceSpaceInfiltrationByPercentage < OpenStudio::Ruleset::ModelUserScript
```

**Column D** is also the *Parameter Display Name* for the measure arguments which will make the machine name for the arguments. These are listed under the *Measure Class Name*. Any variable must have a unique *Parameter Display Name*.

| | A | B | D | E |
|---|---|---|---|---|
| 1 | | | **Inputs** | |
| 2 | *# Meas* | *Measure Display Name* | *Measure Class Name* | |
| 3 | *Variable* | *type* | *machine name)* | *Measure* |
| 9 | TRUE | Calibration Reports | CalibrationReports | ReportingMeasure |
| 10 | TRUE | ReduceSpaceInfiltrationByPercentage | ReduceSpaceInfiltrationByPercentage | RubyMeasure |
| 11 | | argument | Apply the Measure to a Specific Space Type o | space_type |
| 12 | | variable | Space Infiltration Reduction | space_infiltration_reductior |
| 13 | | argument | Constant Coefficient | constant_coefficient |
| 14 | | argument | Temperature Coefficient | temperature_coefficient |
| 15 | | argument | Wind Speed Coefficient | wind_speed_coefficient |
| 16 | | argument | Wind Speed Squared Coefficient | wind_speed_squared_coeffi |
| 17 | | argument | Increase in Material and Installation Costs for | material_and_installation_c |
| 18 | | argument | O & M Costs for Construction per Affected Fl | om_cost |
| 19 | | argument | O & M Frequency (whole years). | om_frequency |

# Variables Tab

**Column E** is the type of measure (RubyMeasure, EnergyPlusMeasure or ReportingMeasure). Underneath the measure type is the *Parameter Name* that's used in the measure. These values can be found in the argument section of the measure.rb file.

```
#make an argument for reduction percentage
space_infiltration_reduction_percent = OpenStudio::Ruleset::OSArgument::makeDoubleArgument("space_infiltration_reduction_percent",true)
space_infiltration_reduction_percent.setDisplayName("Space Infiltration Power Reduction (%).")
space_infiltration_reduction_percent.setDefaultValue(30.0)
args << space_infiltration_reduction_percent
```

The **Column D** *Parameter Display Name* will override the .setDisplayName() that is defined in the measure.rb file.

| | A | B | D | E |
|---|---|---|---|---|
| 1 | | | **Inputs** | |
| 2 | *# Meas* | *Measure Display Name* | *Measure Class Name* | |
| 3 | *Variable* | *type* | *machine name)* | *Measure* |
| 9 | TRUE | Calibration Reports | CalibrationReports | ReportingMeasure |
| 10 | TRUE | ReduceSpaceInfiltrationByPercentage | ReduceSpaceInfiltrationByPercentage | RubyMeasure |
| 11 | | argument | Apply the Measure to a Specific Space Type o | space_type |
| 12 | | variable | Space Infiltration Reduction | space_infiltration_reductior |
| 13 | | argument | Constant Coefficient | constant_coefficient |
| 14 | | argument | Temperature Coefficient | temperature_coefficient |
| 15 | | argument | Wind Speed Coefficient | wind_speed_coefficient |
| 16 | | argument | Wind Speed Squared Coefficient | wind_speed_squared_coeffi |
| 17 | | argument | Increase in Material and Installation Costs for | material_and_installation_c |
| 18 | | argument | O & M Costs for Construction per Affected Fl | om_cost |
| 19 | | argument | O & M Frequency (whole years). | om_frequency |

# Variables Tab

**Column C** is the directory name for the measure. The path to this directory is defined on the Setup tab in the Running Setup section. The name should be machine readable and should not contain any spaces or special characters.

| | A | B | C |
|---|---|---|---|
| 1 | | | |
| 2 | # Meas | Measure Display Name | Measure Directory Name |
| 3 | # Variable | type | Measure Directory |
| 9 | TRUE | Calibration Reports | CalibrationReports |
| 10 | TRUE | ReduceSpaceInfiltrationByPercentage | ReduceSpaceInfiltrationByPercentage |
| 11 | | argument | |
| 12 | | variable | |
| 13 | | argument | |
| 14 | | argument | |
| 15 | | argument | |
| 16 | | argument | |
| 17 | | argument | |
| 18 | | argument | |
| 19 | | argument | |
| 20 | TRUE | Reduce Lighting Loads by Percentage | ReduceLightingLoadsByPercentage |
| 21 | | argument | |
| 22 | | argument | |
| 23 | | argument | |
| 24 | | argument | |
| 25 | | argument | |
| 26 | | argument | |
| 27 | | argument | |
| 28 | | argument | |
| 29 | | argument | |
| 30 | TRUE | Reduce Electric Equipment Loads by Percentage | ReduceElectricEquipmentLoadsByPercentage |

Instructions | Setup | **Variables** | Outputs | BCL Measure Data | Lookups

# Variables Tab

**Column F** is the *Parameter Short Display Name* for the *Parameter Display Name* defined in **Column D**. This is an optional field and if defined will be used in the visualization tools on the server.

| D | E | F |
|---|---|---|
| **Inputs** | | |
| *Measure Class Name* | | |
| *Parameter Display Name (will make machine name)* | *Parameter Name in Measure* | *Parameter Short Display Name* |
| CalibrationReports | ReportingMeasure | |
| ReduceSpaceInfiltrationByPercentage | RubyMeasure | |
| Apply the Measure to a Specific Space Type or t | space_type | |
| Space Infiltration Reduction | space_infiltration_reduction_percent | |
| Constant Coefficient | constant_coefficient | |
| Temperature Coefficient | temperature_coefficient | |
| Wind Speed Coefficient | wind_speed_coefficient | |
| Wind Speed Squared Coefficient | wind_speed_squared_coefficient | |
| Increase in Material and Installation Costs for B | material_and_installation_cost | |
| O & M Costs for Construction per Affected Floo | om_cost | |
| O & M Frequency (whole years). | om_frequency | |
| ReduceLightingLoadsByPercentage | RubyMeasure | |
| Apply the Measure to a Specific Space Type or t | space_type | |
| Lighting Power Reduction | lighting_power_reduction_percent | |
| Increase in Material and Installation Cost for Lig | material_and_installation_cost | |
| Increase in Demolition Costs for Lighting per Flo | demolition_cost | |
| Years Until Costs Start (whole years). | years_until_costs_start | |
| Demolition Costs Occur During Initial Constructi | demo_cost_initial_const | |
| Expected Life (whole years). | expected_life | |
| Increase O & M Costs for Lighting per Floor Area | om_cost | |
| O & M Frequency (whole years). | om_frequency | |

# Variables Tab

**Column G** is the argument or variable type. Possible values are Double, Integer, Bool, Choice and String. These values must match what is in the measure.rb file.

```
#make an argument for reduction percentage
space_infiltration_reduction_percent = OpenStudio::Ruleset::OSArgument::makeDoubleArgument("space_infiltration_reduction_percent",true)
space_infiltration_reduction_percent.setDisplayName("Space Infiltration Power Reduction (%).")
space_infiltration_reduction_percent.setDefaultValue(30.0)
args << space_infiltration_reduction_percent
```

**Column H** is an optional column for defining the units.

| G | H | I | J | K | L | M | N | O |
|---|---|---|---|---|---|---|---|---|
| | | | | Continuous Variable Description | | | | |
| *Variable Type* | *Units* | *Static/Default Value* | *Enumerations* | *Min* | *Max* | *Mean* | *Std Dev* | *Delta X* |
| Choice | | *Entire Building* | \|*Entire Building*\| | | | | | |
| Double | | 0 | | 0 | 100 | 15 | 16.667 | 1 |
| Double | | 1 | | | | | | |
| Double | | 0 | | 0 | 0.1 | 0.05 | 0.0167 | 0.01 |
| Double | | 0 | | | | | | |
| Double | | 0 | | | | | | |
| Double | | 0 | | | | | | |
| Double | | 0 | | | | | | |
| Integer | | 1 | | | | | | |
| Choice | | *Entire Building* | \|*Entire Building*\| | | | | | |
| Double | | 0 | | -40 | 40 | 0 | 13.333 | 1 |
| Double | | 0 | | | | | | |
| Double | | 0 | | | | | | |
| Integer | | 0 | | | | | | |
| Bool | | TRUE | | | | | | |
| Integer | | 15 | | | | | | |
| Double | | 0 | | | | | | |
| Integer | | 1 | | | | | | |

# Variables Tab

**Column I** is the static or default value for the argument. If the argument is turned into a variable, this value will be used when the variable is held constant during an 'individual_variables' LHS sampling or a 'single_run' analysis.

**Column J** is an optional list of enumeration of possible argument values. This column is slated for deprication.

| G | H | I | J | K | L | M | N | O |
|---|---|---|---|---|---|---|---|---|
| | | | | Continuous Variable Description | | | | |
| *Variable Type* | *Units* | *Static/Default Value* | *Enumerations* | *Min* | *Max* | *Mean* | *Std Dev* | *Delta X* |
| Choice | | *Entire Building* | \|*Entire Building*\| | | | | | |
| Double | | 0 | | 0 | 100 | 15 | 16.667 | 1 |
| Double | | 1 | | | | | | |
| Double | | 0 | | 0 | 0.1 | 0.05 | 0.0167 | 0.01 |
| Double | | 0 | | | | | | |
| Double | | 0 | | | | | | |
| Double | | 0 | | | | | | |
| Double | | 0 | | | | | | |
| Integer | | 1 | | | | | | |
| Choice | | *Entire Building* | \|*Entire Building*\| | | | | | |
| Double | | 0 | | -40 | 40 | 0 | 13.333 | 1 |
| Double | | 0 | | | | | | |
| Double | | 0 | | | | | | |
| Integer | | 0 | | | | | | |
| Bool | | TRUE | | | | | | |
| Integer | | 15 | | | | | | |
| Double | | 0 | | | | | | |
| Integer | | 1 | | | | | | |

# Variables Tab

**Column k** is the minimum value for a variable.
**Column L** is the maximum value for a variable.
**Column M** is the mean value for a variable.
**Columns k-m** must be filled out if an argument is turned into a variable, even if the values are discrete.
**Column N** is the standard deviation for the variable. A typical value is (max – min)/6.

| G | H | I | J | K | L | M | N | O |
|---|---|---|---|---|---|---|---|---|
| | | | | Continuous Variable Description | | | | |
| *Variable Type* | *Units* | *Static/Default Value* | *Enumerations* | *Min* | *Max* | *Mean* | *Std Dev* | *Delta X* |
| Choice | | *Entire Building* | \|*Entire Building*\| | | | | | |
| Double | | 0 | | 0 | 100 | 15 | 16.667 | 1 |
| Double | | 1 | | | | | | |
| Double | | 0 | | 0 | 0.1 | 0.05 | 0.0167 | 0.01 |
| Double | | 0 | | | | | | |
| Double | | 0 | | | | | | |
| Double | | 0 | | | | | | |
| Double | | 0 | | | | | | |
| Integer | | 1 | | | | | | |
| Choice | | *Entire Building* | \|*Entire Building*\| | | | | | |
| Double | | 0 | | -40 | 40 | 0 | 13.333 | 1 |
| Double | | 0 | | | | | | |
| Double | | 0 | | | | | | |
| Integer | | 0 | | | | | | |
| Bool | | TRUE | | | | | | |
| Integer | | 15 | | | | | | |
| Double | | 0 | | | | | | |
| Integer | | 1 | | | | | | |

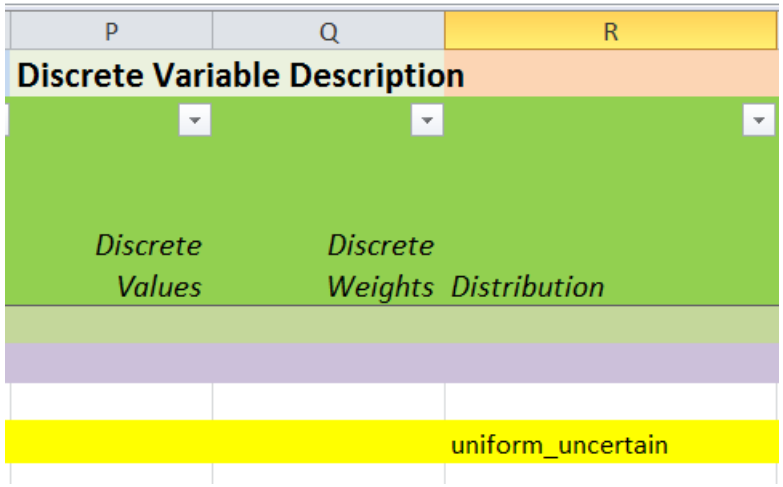
# Variables Tab

**Column O** is the delta X (or change in X) that is used in the gradient calculation (in the Optim and Rgenoud algorithms). The default for this value is 1e-8. If the variable is not sensitive to changes that small, then this value should be changed to a small enough value to where EnergyPlus will result in an output change. This value is optional.

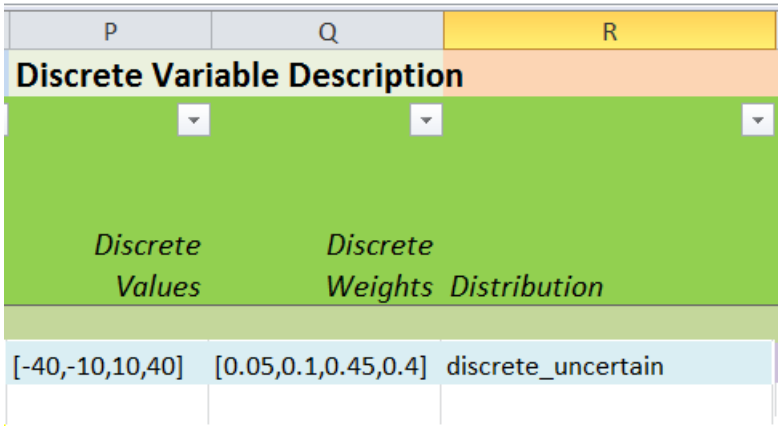
| G | H | I | J | K | L | M | N | O |
|---|---|---|---|---|---|---|---|---|
| | | | | Continuous Variable Description | | | | |
| *Variable Type* | *Units* | *Static/Default Value* | *Enumerations* | *Min* | *Max* | *Mean* | *Std Dev* | *Delta X* |
| Choice | | *Entire Building* | \|*Entire Building*\| | | | | | |
| Double | | 0 | | 0 | 100 | 15 | 16.667 | 1 |
| Double | | 1 | | | | | | |
| Double | | 0 | | 0 | 0.1 | 0.05 | 0.0167 | 0.01 |
| Double | | 0 | | | | | | |
| Double | | 0 | | | | | | |
| Double | | 0 | | | | | | |
| Double | | 0 | | | | | | |
| Integer | | 1 | | | | | | |
| Choice | | *Entire Building* | \|*Entire Building*\| | | | | | |
| Double | | 0 | | -40 | 40 | 0 | 13.333 | 1 |
| Double | | 0 | | | | | | |
| Double | | 0 | | | | | | |
| Integer | | 0 | | | | | | |
| Bool | | TRUE | | | | | | |
| Integer | | 15 | | | | | | |
| Double | | 0 | | | | | | |
| Integer | | 1 | | | | | | |

# Variables Tab

**Column R** is the distribution type for the variable. Valid types are: 'discrete_uncertain', 'uniform_uncertain', 'triangle', 'normal', 'lognormal' (note the '_uncertain' may be omitted).




**Column P** is the allowed values for a discrete variable.
**Column Q** is the corresponding weight for discrete values. If this is blank, the variable will assume to uniformly distributed.



# Outputs Tab

| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | Outputs | | | | | |
| 2 | *Variable Display Name* | *Short Display Name* | *Taxonomy Identifier* | *Name* | *Units* | *Variable Type* | *Visualize* | *Export* | *Objective Funct* | *Objective Functi* |
| 3 | *Display Name for Reports* | *Short display names are used for plots and exported to metadata* | *Machine Name thats Link to Dencity Taxonomy* | *Measure/Variable Unique Name* | | *double, integer, bool* | *true/false* | *true/false* | *true/false* | *double* |
| 4 | Total Site Energy Intensity | | total_site_energy_intensity | standard_report_legacy.total_energy | MJ/m2 | Double | FALSE | TRUE | FALSE | |
| 5 | Total Source Energy Intensity | | total_source_energy_intensity | standard_report_legacy.total_source_energy | MJ/m2 | Double | FALSE | TRUE | FALSE | |
| 6 | Total Natural Gas Intensity | NG EUI | total_natural_gas_intensity | standard_report_legacy.total_natural_gas | MJ/m2 | Double | FALSE | TRUE | FALSE | |
| 7 | Total Electricity Intensity | Elec EUI | total_electricity_intensity | standard_report_legacy.total_electricity | MJ/m2 | Double | FALSE | TRUE | FALSE | |
| 8 | Natural Gas Heating Intensity | | | standard_report_legacy.heating_natural_gas | MJ/m2 | Double | FALSE | TRUE | FALSE | |
| 9 | Cooling Electricity Intensity | | | standard_report_legacy.cooling_electricity | MJ/m2 | Double | FALSE | TRUE | FALSE | |
| 10 | Interior Lighting Electricity Intensity | | | standard_report_legacy.interior_lighting_electricity | MJ/m2 | Double | FALSE | TRUE | FALSE | |
| 11 | Exterior Lighting Electricity Intensity | | | standard_report_legacy.exterior_lighting_electricity | MJ/m2 | Double | FALSE | TRUE | FALSE | |
| 12 | Equipment Electricity Intensity | | | standard_report_legacy.interior_equipment_electricity | MJ/m2 | Double | FALSE | TRUE | FALSE | |
| 13 | Equipment Natural Gas Intensity | | | standard_report_legacy.interior_equipment_natural_gas | MJ/m2 | Double | FALSE | TRUE | FALSE | |
| 14 | Experior Equipment Electricity Intensity | | | standard_report_legacy.exterior_equipment_electricity | MJ/m2 | Double | FALSE | TRUE | FALSE | |
| 15 | Fans Electricity Intensity | | | standard_report_legacy.fans_electricity | MJ/m2 | Double | FALSE | TRUE | FALSE | |
| 16 | Pumps Electricity Intensity | | | standard_report_legacy.pumps_electricity | MJ/m2 | Double | FALSE | TRUE | FALSE | |
| 17 | Heat Rejection Electricity Intensity | | | standard_report_legacy.heat_rejection_electricity | MJ/m2 | Double | FALSE | TRUE | FALSE | |
| 18 | Humidification Electricity Intensity | | | standard_report_legacy.humidification_electricity | MJ/m2 | Double | FALSE | TRUE | FALSE | |
| 19 | Water Systems Electricity Intensity | | | standard_report_legacy.water_systems_electricity | MJ/m2 | Double | FALSE | TRUE | FALSE | |
| 20 | Water Systems Natural Gas Intensity | | | standard_report_legacy.water_systems_natural_gas | MJ/m2 | Double | FALSE | TRUE | FALSE | |
| 21 | Refrigeration Electricity Intensity | | | standard_report_legacy.refrigeration_electricity | MJ/m2 | Double | FALSE | TRUE | FALSE | |
| 22 | Unmet Cooling Hours | | | standard_report.time_setpoint_not_met_during_occupied_cooling | hrs | Double | FALSE | TRUE | FALSE | |
| 23 | Unmet Heating Hours | | | standard_report.time_setpoint_not_met_during_occupied_heating | hrs | Double | FALSE | TRUE | FALSE | |
| 24 | Total Unmet Hours | | | standard_report.time_setpoint_not_met_during_occupied_hours | hrs | Double | FALSE | TRUE | FALSE | |
| 25 | Building Area | | | standard_report.total_building_area | m2 | Double | FALSE | TRUE | FALSE | |
| 26 | Total Electricity Consumption Modeled | | | calibration_reports.electric_bill_consumption_modeled | kWh | Double | FALSE | TRUE | FALSE | |
| 27 | Total Gas Consumption Modeled | | | calibration_reports.gas_bill_consumption_modeled | therms | Double | FALSE | TRUE | FALSE | |
| 28 | Electric RMSE | | | calibration_reports.electric_bill_rmse | % | Double | FALSE | TRUE | FALSE | |
| 29 | Gas RMSE | | | calibration_reports.gas_bill_rmse | % | Double | FALSE | TRUE | FALSE | |
| 30 | Electric CVRMSE | | | calibration_reports.electric_bill_consumption_cvrmse | % | Double | TRUE | TRUE | TRUE | |
| 31 | Electric NMBE | | | calibration_reports.electric_bill_consumption_nmbe | % | Double | TRUE | TRUE | TRUE | |
| 32 | Gas CVRMSE | | | calibration_reports.gas_bill_consumption_cvrmse | % | Double | TRUE | TRUE | TRUE | |
| 33 | Gas NMBE | | | calibration_reports.gas_bill_consumption_nmbe | % | Double | TRUE | TRUE | TRUE | |
| 34 | Electric CVRMSE within limit | | | calibration_reports.electric_bill_cvrmse_within_limit | | Double | TRUE | TRUE | FALSE | |
| 35 | Electric NMBE within limit | | | calibration_reports.electric_bill_nmbe_within_limit | | Double | TRUE | TRUE | FALSE | |

# Outputs Tab

| | A | B | C | D |
|---|---|---|---|---|
| 1 | | | | |
| 2 | *Variable Display Name* | *Short Display Name* | *Taxonomy Identifier* | *Name* |
| 3 | *Display Name for Reports* | *Short display names are used for plots and exported to metadata* | *Machine Name thats Link to Dencity Taxonomy* | *Measure/Variable Unique Name* |
| 4 | Total Site Energy Intensity | | total_site_energy_intensity | standard_report_legacy.total_energy |
| 5 | Total Source Energy Intensity | | total_source_energy_intensity | standard_report_legacy.total_source_energy |
| 6 | Total Natural Gas Intensity | NG EUI | total_natural_gas_intensity | standard_report_legacy.total_natural_gas |
| 7 | Total Electricity Intensity | Elec EUI | total_electricity_intensity | standard_report_legacy.total_electricity |
| 8 | Natural Gas Heating Intensity | | | standard_report_legacy.heating_natural_gas |
| 9 | Cooling Electricity Intensity | | | standard_report_legacy.cooling_electricity |
| 10 | Interior Lighting Electricity Intensity | | | standard_report_legacy.interior_lighting_electricity |
| 11 | Exterior Lighting Electricity Intensity | | | standard_report_legacy.exterior_lighting_electricity |
| 12 | Equipment Electricity Intensity | | | standard_report_legacy.interior_equipment_electricity |
| 13 | Equipment Natural Gas Intensity | | | standard_report_legacy.interior_equipment_natural_gas |
| 14 | Experior Equipment Electricity Intensity | | | standard_report_legacy.exterior_equipment_electricity |

# Outputs Tab

| | D | E | F | G | H | I |
|---|---|---|---|---|---|---|
| 1 | | **Outputs** | | | | |
| 2 | *Name* | *Units* | *Variable Type* | *Visualize* | *Export* | *Objective Funct* |
| 3 | *Measure/Variable Unique Name* | | *double, integer, bool* | *true/false* | *true/false* | *true/false* |
| 26 | calibration_reports.electric_bill_consumption_modeled | kWh | Double | FALSE | TRUE | FALSE |
| 27 | calibration_reports.gas_bill_consumption_modeled | therms | Double | FALSE | TRUE | FALSE |
| 28 | calibration_reports.electric_bill_rmse | % | Double | FALSE | TRUE | FALSE |
| 29 | calibration_reports.gas_bill_rmse | % | Double | FALSE | TRUE | FALSE |
| 30 | calibration_reports.electric_bill_consumption_cvrmse | % | Double | TRUE | TRUE | TRUE |
| 31 | calibration_reports.electric_bill_consumption_nmbe | % | Double | TRUE | TRUE | TRUE |
| 32 | calibration_reports.gas_bill_consumption_cvrmse | % | Double | TRUE | TRUE | TRUE |
| 33 | calibration_reports.gas_bill_consumption_nmbe | % | Double | TRUE | TRUE | TRUE |
| 34 | calibration_reports.electric_bill_cvrmse_within_limit | | Double | TRUE | TRUE | FALSE |
| 35 | calibration_reports.electric_bill_nmbe_within_limit | | Double | TRUE | TRUE | FALSE |
| 36 | calibration_reports.gas_bill_cvrmse_within_limit | | Double | TRUE | TRUE | FALSE |
| 37 | calibration_reports.gas_bill_nmbe_within_limit | | Double | TRUE | TRUE | FALSE |

# Outputs Tab

| | A | B | I | J | K |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | *Variable Display Name* | *Short Display* | *Objective* | *Objective* | *Scale* |
| 3 | *Display Name for Reports* | *Short display names are used for plots* | *true/false* | *double* | *double* |
| 4 | Total Natural Gas Intensity | NG EUI | TRUE | 140 | |
| 5 | Total Electricity Intensity | Elec EUI | TRUE | 590 | 5 |
| 6 | Unmet Cooling Hours | | FALSE | | |
| 7 | Unmet Heating Hours | | FALSE | | |

# Outputs Tab