Part 1: MASControl3 Simulations and Results Processing

MASControl3 Simulations

Follow these steps to install and run MASControl3:

1. Install the MASControl3 (MC3) software. This is done by expanding the contents of MASControl3.zip into a folder on the computer. There is some flexibility as to the name of the destination folder and its path structure, but the maximum number of characters in the path must not exceed 39. This limit includes the MASControl3 folder, which can be renamed, if desired.

2. Edit the MASControl3.ini file, which is located in the MASControl3 sub folder, so that the paths match your install location.

3. The MASControl3 input database is named MC2020.db, and is located in \MASControl3\mc3_db\. Using a SQLite interface, edit the msrs2proc table of MC2020.db to have the value TRUE for any measure that is to be activated for simulation.

4. Run the MASControl3.exe file, which is also in the MASControl3 sub folder.

5. Actions in the Setup Tab:

    - Run "Expand Database"; this will take a couple of minutes. Note that this creates several large tables in the database. If you want to share the input database, you can run the "Drop Expanded Tables" routine to remove these large tables before sharing. The "Expand Database" function than then be re-run in the destination folder.

    - Run "Build Full Measure List"; this will create a file called All_Measures.csv in the MASControl3\mc3_db\mc3_result folder. Each line in All_Measures.csv represents a single measure, which includes up to 3 technology runs

    - Now you can manually build your run list by copying the runs that you want to do from All_Measures.csv to Run_Measures.csv. Note that this step can be done without closing the MC3 interface, but if you edit the CSV files in Excel, you will need to close Run_Measures.csv before you start a run.

    - Filters in the Setup tab can be used to run a subset of the items that are listed in the Run_Measures.csv file. For example if the first filter box has "CZ14 CZ15", only climate zones 14 and 15 will run. Each box can contain a space separated list of one type of filter (building type, climate, vintage, HVAC type, Tstat). There is also a possibility of filtering on TechID with multiple space separated strings.

6. Actions in the Operations tab

    - Run "Load Sim Run List".

    - Sim Input and Output Files Saved: determines which simulation files are to be saved in \MASControl3\InpFiles\. Options are none, ".INP" files only, and all files, which include ".INP", ".BDL", ".SIM" and the binary results files.

    - Save Results options: multiple selections for various combinations of annual results, whole building (WB) hourly, and end use (EU) hourly results.

- Load Only Missing Runs prevents re-running simulations for cases where results already exist in the database.
- Show Run List makes full run list appear in the display window below when "Load Sim Run List" is pressed.
- "Run Simulations" starts the loaded simulation set.
- "Stop Simulations" interrupts a running simulation set. There will be a delay after pressing the button while the current simulation completes.

7. Results will go into the file \MASControl3\mc3_db\MC2020_results.db. A different file can be used for results, but the alternate name must be entered in the MASControl.INI file or in the Setup tab.

8. The simulations are complete when the status scroll box indicates "Simulation Complete". If any simulations did not succeed, the status scroll box will indicate "Failed" for those simulations, and the "Failed" line in "Run Status" will show the number of failed runs. A list of failed runs will also appear in the MASControl3.log file in the MASControl3 folder.

9. Results can be viewed by examining the SQLIte MC2020.db file.

- Use the free "DB Browser for SQLite" interface or use your favorite database browser compatible with SQLite.
- Results are written to one or more tables for annual results, hourly whole building results, and hourly end use results. Single family building results are written to separate tables because of the use of two sets of energy meters for that prototype.

Results Processing

The MC3 program creates all the initialized prototype results and individual technology results that are needed to determine measure energy impacts. These simulation results must be processed to determine measure energy impacts and converted into a format compatible with the ex ante database. The DEER team has chosen to do this processing in the PostgreSQL database that houses the Ex Ante database. The processing could also be done within SQLite using a SQLite programming interface such as SQLite Java or SQLite Python or in other database servers.

The database used to process the simulation results must contain the annual and hourly data tables created by MC3, along with a number of support tables used to calculate the peak period demand values and weighted results. As the commercial building and residential building processing require different sets of support tables and processing steps, it is recommended that MC3 be used to create either commercial building results or residential building results in a single session.

For the commercial buildings, the following tables must be transferred from the SQLite results database created by MC3 to the processing database:
- sim_annual; this table contains the annual simulation values and has a primary key of building type, vintage, location and HVAC type,
- sim_hourly_wb; this table contains the hourly whole-building electric demand values determined by the simulation, with a primary key of building type, vintage, location, HVAC type and day number. Each row contains the demand values for each hour of the day number.

- sim_hourly_eu; this table, when utilized by the measure definition, contains the demand values for an end-use, such as lighting or equipment. The format is the same as the whole-building hourly demand table.

The simulation results created by MC3 for single-family buildings are written to different data tables, as they contain information for the one-story prototype and the two-story prototype separately, so that the results can be weighted by the typical number of stories. For simulations that include the single-family building type, these additional data table must be transferred to the processing database:

- sfm_annual; this table contains the annual simulation values for two meters and has a primary key of building type, vintage, location and HVAC type,
- sfm_hourly_wb; this table contains the hourly whole-building electric demand values for two meters, with a primary key of building type, vintage, location, HVAC type and day number. Each row contains two sets of the demand values for each hour of the day number.
- sfm_hourly_eu; this table, when utilized by the measure definition, contains the demand values for an end-use for each of two meters, such as lighting or equipment. The format is the same as the whole-building hourly demand table.

In addition to the tables from the SQLite results database, the following tables are needed to support the results processing. An SQL version of these tables can be found in the support documents.

Support tables for Commercial Building processing:

- Measure Definition table (curr_msr_mat)
  This table defines which technologies are involved in a measure definition for a specific building type, vintage, location and HVAC type. The specified technologies include the pre-existing, code/standard and measure technology. The table is created by MC3 when a set of measures are loaded into the MC3 program and can be found in the MC3 main database (i.e. not the results database). Note: if only a subset of the measures that are enabled in the MC3 database are actually simulated, the measure definition table used in post-processing should be edited to only include the measures being processed.

- Peak Period Specification (peakperspec),
  This table specifies the first day of the three-day heat wave used for the determination of peak demand values. The table lists the first day for each of the 16 climate zones used in the DEER data development.

- Vintage Weights (wts_com_vintage)
  This table lists the commercial building stock area by utility, building type, location, building vintage and era. These data are used to create the standard vintages (old, median, recent and new) from more detailed vintages used in the simulation results development.

- Location Weights (wts_com_loc)
  This table list the building stock by utility, building type, location and vintage. The table can be created from the wts_com_vintage table by summing across all vintages for each era and by assigning the vintage weights for the 2020 vintage to the "new" era . The location weights table is used to create the IOU-territory location results based on the results for the individual climate zones.

- Building Weights (wts_com_bldg)

Similar to the location weights table, this table is created from the vintage weights table by summing across all vintages for each era and adding an IOU territory location as well. The table is used to create the "Com" building type from the individual building type results.

- Optional Cross-Measure Weights (wts_com_bldg)
  As with previous versions of DEER, some measures are created by weighting the results of other measures. This table specifies the new MeasureID, the existing EnergyImpactIDs that make up the new measure and the weights associated with the existing energy impacts.

Support tables for Residential Building processing

The residential simulation results processing requires a version of all of the support tables described for the commercial building processing as well as the following support tables:

a. Thermostat Weights (reststatwt)
   To capture occupant diversity and simulate the targeted annual heating and cooling consumption in residences, each prototype utilizes five thermostat schedules. The results from each of the five thermostat scenarios are weighted together to arrive at the typical energy consumption. The thermostat weights vary by building type, location, vintage and thermostat scenario.

b. Single-Family Stories Weights (NumStor)
   This table specifies the average number of stories for single-family prototypes by location and building vintage. These data are used to weight the simulation results from the two-story residence and the one-story residence into the typical number of stories for the simulation location and vintage.

c. Number of Buildings (NumBldgs)
   The simulation results from MC3 are based on multiple dwellings, typically set at differing orientations to capture the average solar impacts on the building energy use. The results must be normalized by dividing the results by the appropriate number of dwellings. This table is utilized by the processing queries to normalize the results.

d. HVAC Weights (wts_res_hvac)
   Some measures, such as shell insulation and duct leakage measures, are simulated for multiple HVAC systems. The results for each HVAC type are weighted together to create the impacts for a typical HVAC system. This table assigns weights to each residential HVAC type by utility, building type and location.

After the SQLite results database tables and measure definition table are transferred to the processing database and the support tables are created, processing the results into measure savings and weighted measure savings involves the application of a number of queries in a specific order. Each query creates new data sets that can be inspected to verify expected results. An example of these queries for both commercial and residential processing can be found in the support documents.

Steps for Processing Commercial Simulation Results

The following steps should be followed in order to develop the final measure savings values. The queries can be found in the support documents.

1. Create Peak Period values (P1-CreateSimPeakTable)
   For each record in annual results table, a peak period value is determined from the hourly results table and the peak period definition table. The result of this query is a new table (sim_peakper) with the peak period demand value for each of the primary keys in the annual results table. Note: for large data sets, this process can take a few minutes.

2. Create Measure Impacts (P2-Calc_MsrImpacts)
   This query uses the measure definition table, the annual results table and the peak period demand table created in step 1 to determine the above pre-existing and above code/standard energy impacts for the measure. The result of this query is a new table (meas_impacts) with end-use impacts for all measures in the measure definition table and each combination of building type, vintage, location and HVAC type in the results files.

3. Create Vintage-weighted Results (P3-VintMult, P4-SimVint)
   These queries use the newly created meas_impacts table and the vintage weights table to create the vintage-weighted results. The first query creates a table of results based on the meas_impacts table multiplied by the associated weight. The second query sums the values from the temporary table and creates a new table of measure impacts (meas_impacts_wtd).

4. Create Location-weighted Results (P5-LocMult, P6-SumLoc)
   These queries use the newly created meas_impacts_wtd table and the location weights table to create the location-weighted results. The first query creates a temporary table of results based on the meas_impacts_wtd table multiplied by the associated weight. The second query sums the values from the temporary table and adds the data to the meas_impacts_wtd table.

5. Create Building-weighted Results (P7-BldgMult, P8-SumBldg)
   These queries use the meas_impacts_wtd table and the building weights table to create the building-weighted results. The first query creates a temporary table of results based on the meas_impacts_wtd table multiplied by the associated weight. The second query sums the values from the temporary table and adds the data to the meas_impacts_wtd table.

6. Create the Ex-Ante formatted Results (P9-roundDEER)
   This query takes data from the meas_impacts_wtd table and formats the data using three-significant digits for energy impacts. This query also adds impact load shape information when appropriate, either by specifying it directly or by linking to a table that has impact profile specifications by MeasureID.

Steps for Processing Residential Simulation Results

Before the processing steps described above for commercial buildings can be executed with residential results, the hourly and annual data must first be weighted for the thermostat scenarios and, for single-family buildings, for the number of stories. The following steps should be followed in order prior to the steps described above to develop the final measure savings values. The additional queries can be found in the support documents.

1. Weight the Annual Results (R1-WtTstat-Annual)
   The five thermostat scenarios associated with every residential simulation result in five separate sets of both annual and hourly results. These results must be weighted together to create the typical thermostat scenario. Also, results from two meter for the single-family building type must be weighted to create the results for the typical number of stories for each location and vintage.
   This query uses the thermostat weights table and the number of stories table along with the two annual results table to create a single temporary table that has multi-family and mobile home

results multiplied by the appropriate thermostat weights and has single-family result multiplied by the thermostat weights and adjusted for the number of stories.

2. Weight the Hourly Results (R2-WtTstat-HourlyWB)
   This query performs a similar function of the previous query, only on the hourly results tables instead of the annual results tables. A single temporary table is created that has the results for all building types multiplied by the thermostat weight and adjusted for number stories. Note: for large data sets (e.g. when processing many measures), this process can take a few hours.

3. Create the Thermostat weighted Annual Results (R3-SumTstat-Annual)
   This query sums the records in the temporary table created under step 1 to create a new results table (sim_annual_wtd) containing results that are the weighted by thermostat scenario and adjusted for number of stories.

4. Create the Thermostat weighted Hourly Results (R4-SumTstat-HourlyWB)
   This query sums the records in the temporary hourly results table created under step 2 to create a new results table (sim_hourly_wb_wtd) containing results that are the weighted by thermostat scenario and adjusted for number of stories.

Once these steps are completed and verified, the standard processing described for commercial buildings can be applied to the new residential annual and hourly results.

Part 2: MASControl3 Technology and Measure Development

Setup

Before making changes to the MASControl3 input database, the input data files need to be copied to the computer. From the ZIP file MC3_Workbooks.ZIP, extract the folder MC3_Workbooks and all of its sub folders into the C:\MASControl3\ folder. It is possible to place MC3_Data in another location, but the subfolders need to be kept in the same structure as they are found in the ZIP file. If an alternate location is used, the RootFolder in the file \MC3_Workbooks\Tools\ImportTablesToDB.xlsm, sheet Main, needs to be changed to reflect the alternate location.

Background

Measures are comprised of Technologies, which are assigned to up to three measure cases:

1. Measure Case: this is the improved efficiency condition.
2. Pre-Existing Baseline Case: this is the condition of the building before measure installation.
3. Code/Standard Baseline Case: this is the condition where the measure technology is changed to just meet the energy code or industry standard practice.

Each case is defined by one or more Technology IDs (TechID).

A Technology is a collection of data that defines aspects of a building component that are relevant to specific measures. Each Technology is assigned to a TechType. Each data item that defines the technology is defined by a Technology Parameter.

A TechType is a category of Technologies. The rule list that implements the technology data into the model is defined in the TechType. If a new TechType is created, new Parameters may also need to be defined.

The VariTech table is used to allow for baselines that depend on building vintage or other variables.

Create New Measures where TechTypes Already Exist

1. First check to see if Technologies already exist to support the new measures
   a. In database, the Technology table lists all existing Technology definitions
      i. Filter by TechTypeID to see a list for a specific tech type.
   b. If new Technologies need to be added, follow instructions in "Add New Technologies"
   c. Run macro in the workbook /Tools/ImportTablesToDB.xlsm (sheet Main) to Transfer Tech Tables to database

        i. This will completely rebuild the following database tables: ParamDefn, Technology, TechID2Param, TechType

2. Add new measures to the appropriate measure workbook
   a. Follow instructions in "AddMeasure"
   b. Run macro in the workbook /Tools/ImportTablesToDB.xlsm (sheet Main) to Transfer Measure Tables to database
      i. This will completely rebuild the Measures, TechLists, and MeasureApplicibility tables in the database
      ii. After this step, the function "Convert Msr Tbl Nulls" must be run from the Setup tab of the MASControl3 program before running "Expand Database".

Add New Technologies

1. Identify the appropriate Technology workbook to contain the new technologies:

Workbook	Technologies
TechData_PkgHVAC.xlsm	DX AC and HP efficiencies
TechData_MscHVAC.xlsm	Miscellaneous HVAC, incl. fan control, economizer
TechData_DHW2.xlsm	Domestic water heating
TechData_Envelope.xlsm	Windows, walls, roofs
TechData_ResApplianceLtg.xlsm	Residential appliances and lighting
TechData_NonResLtgPlugs.xlsm	Nonresidential plug loads and lighting
TechData_Plant.xlsm	Central plant
TechData_Msc.xlsm	Miscellaneous

2. Check the TechTypeDefinitions tab of the Technology workbook to see if there is an existing TechType that works for the new technology.
   a. If a new TechType is needed, then follow the instructions to "Add a new TechType".
3. Find the appropriate TechData tab of the Technology workbook. In some workbooks there is only one of these, while in others there are more, each with the suffix "TechData" in the tab name.
4. TechData tabs that include multiple TechTypes have a drop-down box near the top that can be used to select the TechType of interest. The only function of this drop-down is to reset the header values for Technology Parameter names to correspond with the TechType of interest.
5. Add rows to the TechData sheet to make space for the new Technologies
6. Copy formulas from an existing Technology for TechType#, GroupCode, and Tech Type Description
7. Enter TechTypeID
8. Enter TechID (this is typically built with a formula based on key Parameter values)
9. Enter Parameter values

Add New Measures

Measure Case

1. Each measure can have up to three cases
   a. Measure case (Msr) is always required; this is the measure level
   b. Pre-existing case (Pre) is optional
   c. Code/Standard case (Std) is optional

Technology Assignments

1. If a measure for this TechType(s) does not already exist
   a. Need to establish layout for the TechType in the Measures workbook
      i. Use ID_part## columns to enter data to differentiate measures
      ii. Use formulas to build MeasureID, Description and TechIDs from the ID_parts
   b. TechIDs are assigned by one or more of three methods
      i. Direct assignment of TechID in the Measures workbook; use this if:
         1. There is only one technology in the measure
         2. The technology does not change with BldgType, Climate, Vintage, or HVAC type
      ii. Assignment of VariTech reference IDs
         1. Use this if a measure case varies by climate, vintage, BldgType or HVAC
         2. Use of MultiTech reference IDs (can be used in conjunction with VariTech reference IDs)
         3. Use this if a measure case is defined as a combination of technologies (e.g. HVAC Maintenance = Refrigerant Charge Adjustment + Duct Sealing)
      iii. Use of MultiTech reference IDs (can be used in conjunction with VariTech reference IDs)
         1. Use this if a measure case is defined as a combination of technologies (e.g. HVAC Maintenance = Refrigerant Charge Adjustment + Duct Sealing)
2. Applicabilities
   a. A measure can be specified as applicable based on BldgType, Vintage, HVAC type, and Climate Zone
      i. Each category has an "Any" column to select all items in that group

Add VariTech data to NonTech Workbooks

The VariTech data is established in the NonTechWorkbooks

1. Find the appropriate NonTechWorkbooks/Worksheets to add the VariTech columns
   a. If the appropriate workbook/worksheet can't be easily found by browsing the workbooks, follow these steps for the input database tables
      i. Find the TechTypeID in the TechType table

1. Filter the Technology table for that TechTypeID (e.g. ResWin for residential windows)
2. Filter the TechInit table for records that contain the common string from the TechID (e.g. "ResWin-" for residential windows)

2. Open the appropriate NonTechWorkbook/worksheet
3. Next to the existing Tech column for the given TechType, insert a new column for the VariTech
4. Generally the new column will have the same data as the existing Tech column
5. The VarName row of the column will generally have a different title
   a. (e.g. ResGlassTypePre for residential windows for the Pre-existing VariTech)
6. Write the new VariTech entries to the database
7. Open the file \Tools\ImportTablesToDB.xlsm
   a. Select "Build Initialization Tables", "Transfer Data Tables" and "Import Data to DB" in sheet "Main"
   b. Set "Include" to "X" for Parameters, TechInit, and VariTech
   c. Run the macro "Transfer Data Tables" in sheet "Main"

Add New TechTypes

1. Add new row to appropriate TechType table (see "Add New Technologies")
2. Check if desired Technology Parameters already exist
   a. If the desired Parameter name is defined in a different Technology workbook, the definition needs to be the same for the new implementation
   b. If a new Parameter is needed, add it to the ParamDefn tab of the Technology workbook. These are ordered alphabetically for convenience, but this is not required.
3. Fill in values in the TechType table for the new TechType
4. Changes may be needed in the prototypes to support functionality of new TechTypes