

# Part 1: MASControl2 Technology and Measure Development

## Setup

Before making changes to the MASControl2 input database, the input data files need to be copied to the computer. From the ZIP file MS2\_SupportFiles.ZIP, extract the folder MC2\_SupportFiles and all of its sub folders into the C:\MASControl2\ folder. It is possible to place MC2\_SupportFiles 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 \MC2\_Data\Utilities\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.

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 /Utilities/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 /Utilities/ImportTablesToDB.xlsm (sheet Main) to Transfer Measure Tables to database
    - i. This will completely rebuild the Measures, TechLists, and MeasureApplicability tables in the 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_MschHVAC.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)
  - a. Note max number of characters for TechID is 32
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
2. The columns "Pre", "Std" and "Msr" are used to indicate whether the given case is to be included in the measure

### 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 \Utilities\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. Create a new Technology rule list for the TechType, if needed. It is allowed for two or more TechTypes to use the same TechRuleList.
5. Create measure area rule list and/or normalization rule list, if needed. These can be common to multiple TechTypes

# Part 2: MASControl2 Simulations and Results Processing

## MASControl2 Simulations

Follow these steps to run MASControl2 for the modified rules database created in Part 1:

1. Install the MASControl2 (MC2) software. If the previous version of MASControl has been installed on the computer, reinstall the MC2 software and allow the installation process to "fix" the installation.
2. Copy the relevant version of DEER\_Rules\_ProtoDB.db to the MASControl2\DEERBDLRules directory.
  - Optionally, copy the original version of the empty results database file (DEER\_Results.db ) to the same directory, backing up the previous set of results if needed. This step will clear all previous simulation results from the processing.
3. Start MASControl2 (MC2) and make the desired selections from the [Selections] tab of the interface.
  - Keep in mind that the mobile home simulations require the "MH:" vintages to be selected.
  - For residential measures, select all the residential HVAC types. Only the HVAC types applicable to the selected measures will be simulated.
  - Select all Cases; only the applicable cases for each measure will be simulated.
  - For residential measures, be sure to select only Tstat Indices 1 through 5.
4. Set the desired options on the MC2 [Configuration] tab.
  - Do not select "Over Write Sim Files" or "Overwrite Initialized Protos" unless you are making corrections to previous simulation results with the current MC2 session. Selecting these options will slow down the process.
  - Select "Abort All Simulations" in the error options group. This is the easiest way to be alerted to and deal with potential errors in the simulation process.
  - If you want to inspect the resulting DOE2 input files or DOE2 output files, select one of the first two options in the Files Deletion group. Otherwise, select the "Delete All Simulation Files" option, especially if you are embarking on 1000s of simulations.
  - Finally, press the [Simulate Selections] button on the [Selections] tab to start the process.
5. The simulations are complete when the status bar indicates "Processing Complete for All Selections". The run history text box will indicate if any errors occurred during processing.
6. Results can be viewed by examining the SQLite DEER\_Results.db file.
  - Use the free "[DB Browser for SQLite](#)" interface or use your favorite database browser compatible with SQLite.
  - Results are written to two tables; the ip\_results table holds the simulation results for all initialized prototypes and the tech\_results table holds the simulation results for

technology-specific simulation runs. Depending on the measure definition, the initialized prototype results (from the ip\_results table) may serve as the base-case for a measure; alternatively, a specific technology simulation (from the tech\_results table) may be the base-case for the measure.

## Results Processing

The MC2 program creates all the initialized prototype results and individual technology results that are needed to determine measures 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.

Follow the following steps to create data formatted for the ex ante database:

### 1. Expansion of Measure Definitions

The exact technology references involved in each measure savings calculation are determined by expanding the measure definitions and underlying technologies, enumerating all specific building types, vintages, climate zones and HVAC types applicable to each technology of interest. Note: the specification of measure and technology applicability in the rules database tables use both specific references, such as "CZ01" for a location, and general references such as "Any". To process the individual results, all general references need to be expanded to specific references.

This process utilizes the measure definition table along with a number of tables that define the application of technologies to each simulation model. The result of this process is a table (measure\_matrix\_ip) that lists the three technology IDs associated with each measure definition for all applicable building types, vintages, climate zones, HVAC types and thermostat options. Another table is created (tech\_matrix\_ip) that lists each simulation run that is required for the given set of measures. This table can be used to check for missing results during the simulation process.

Follow these steps to create the [measure\\_matrix\\_ip](#) table. The additional tables and queries used in this process ([marked in green](#)) are available for download on the DEEResources.com web site.

- A. Copy the tables listed below from DEER Common Rules database to a PostgreSQL database. Use a schema name of "support" to be compatible with the supplied queries:
  - Measures  
Note: run the query [[Update Measure Table with NULLs](#)] after copying the Measures table to update certain fields from blank to NULL. Also, set the value of the field "ShowInList" to 0 for all measures that you are not currently processing.
  - MeasureApplicability
  - TechInit
  - VariTech

B. Add these tables used to support expansion of measure applicability to the same database schema:

- expBldg2VintHVAC
- expBldgHVAC
- expBldgLoc
- expBldgType
- expBldgVint

C. Run these queries in this order to create the expanded applicability tables:

- [aProc 1 - Create Expanded MeasApplic], creates the expMeasApplic table
- [aProc 2 - Create Expanded TechInit], creates the expTechInit table
- [aProc 3 - Create Expanded VariTech], creates the expVariTech table
- [aProc 4 - Create Measure Matrix], creates the measure\_matrix table
- [aProc 5 - Create Measure Matrix with IPSpecs], creates the measure\_matrix\_ip table
- [aProc 6 - Create Tech Matrix], creates the tech\_matrix\_ip table.

## 2. Residential Thermostat Weighting

The five thermostat options for residential simulations in MC2 result in five separate sets of simulation results. These five sets of results need to be weighted into a single weighted thermostat data set that represents the calibrated result. This process utilizes a table of thermostat weights that applies to each residential building type, vintage and location.

A. Copy the results tables (both ip\_results and tech\_results) from the MC2 SQLite database to the PostgreSQL database. Use a schema name of "simresults" to be compatible with the supplied queries. If you are using multiple computers to runs the MC2 simulations, consolidate the results from each computer into these two PostgreSQL results tables.

B. Assure that there are no duplicate records in these tables by retaining only the results with the latest time stamps. Also, update the simqual field in the tech\_results table from "NA" to "None" to be compatible with other tables. You can use these two queries to remove duplicates and rename the simqual field:

- [Delete Duplicated records in ip\_results]
- [Delete Duplicated records in tech\_results]

C. Run the PostgreSQL functions to weight the individual thermostat results:

- ResTstatWtg-Tech()
- ResTstatWtg-IP()

D. The weighted results are written to a table called tech\_results\_wtd. This table will include the thermostat weighted results from both the ip\_results table and the tech\_results table.

Note: SQL for creating this new table definition is included in the support documents ([tech\\_results\\_wtd.sql](#)).

- E. Note: it is often helpful to query for missing records in the various results tables. You can use the tech\_matrix\_ip table created earlier in the process to check for missing records, using SQL like the following:

```
SELECT * FROM support.tech_matrix_ip WHERE techid = 'IP' AND
bldgtype||bldgvint||bldgloc||bldghvac||tstat NOT IN(Select
bldgtype||bldgvint||bldgloc||bldghvac||tstat from
simresults.ip_results)
```

or

```
SELECT * FROM support.tech_matrix_ip WHERE techid <> 'IP' AND
techid||simqual||bldgtype||bldgvint||bldgloc||bldghvac||tstat NOT
IN (Select DISTINCT
techrefid||simqual||bldgtype||bldgvint||bldgloc||bldghvac||tstat
from simresults.tech_results)
```

### 3. Create Measure Energy Impacts

Measures energy impacts by building type, vintage, climate zone and HVAC type are determined by comparing the relevant pre-existing, code/standard and measure technology simulations results. The measure\_matrix\_ip table, created earlier in the process, is utilized to determine the exact simulation results to compare. The results are then formatted to be compatible with the Ex Ante database.

- A. You can use the [[CalcImpactsForMeasID\\_Wtd](#)] function and specify a specific measure ID to process, or use the [[CalcImpactsForMeasList\\_Wtd](#)] function and specify multiple measure IDs in a separate table. The results are written to the meas\_impacts\_wtd table; SQL for creating this new table definition is included in the support documents ([meas\\_impacts\\_wtd.sql](#)).
- B. The meas\_impacts\_wtd table includes end-use energy impact data not included in the ex ante EnergyImpact table. The data from this table are typically exported to a workbook to review and format the data for import into the ex ante database. An example of a workbook that reviews and formats the data for the ex ante database is included in the support documents ([Example-WindowMeasure-Results.xlsx](#)).

### 4. Weighted Measure Energy Impacts

Measure energy impacts for specific building types, vintages, climate zones and HVAC types are processed to determine the weighted HVAC type, the existing vintage impacts and the IOU territory impacts. This process can be performed within READI (with administrative privilege) or by SQL functions and queries that utilize additional tables of weight values:

- Function: [[Res-ImpWtg-01-HVAC](#)], creates the residential weighted HVAC type (rWtd) for measures that have multiple HVAC types. Uses the table [[wts\\_res\\_hvac](#)] for the weights.

- Function: [Res-ImpWtg-02-Vint-for-rWtd], creates the residential weighted Vintage type (Ex) for measures that have multiple vintages and that have an HVAC type of rWtd. Uses the table [wts\_res\_vintage] for the weights.
- Function: [Res-ImpWtg-03-Loc-for-rWtd], creates the residential weighted location (IOU) for measures that have multiple locations and that have an HVAC type of rWtd. Uses the table [wts\_res\_location] for the weights.