SAFER, SMARTER, GREENER

# CPUC MASControl3 Instruction Manual

**For Building Simulation Modeling of Deemed Measures**

July 3, 2021

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# 1 Historical background

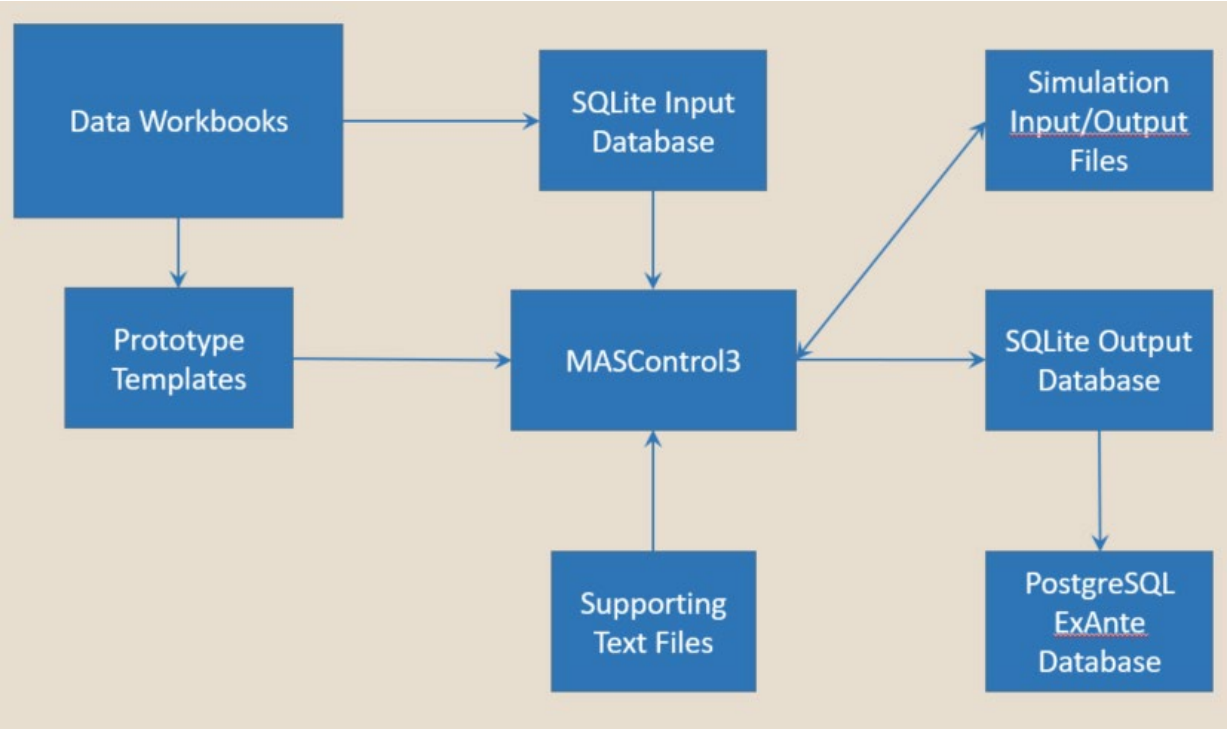



**Figure 1. MASControl3 Overall Ecosystem Flow Chart**

DEER building energy modeling batch tool was upgraded to MASControl3 from the two older versions for the following reasons:

- Original MASControl depended on eQUEST rulesets and hard-coding which has a complicated structure and is difficult to expand.
- MASControl2 moved away from the eQUEST ruleset, but the alternative BDL ruleset was slow.

MASControl3 uses simplified coding, with rules embedded in input files using the DOE2 macro language. This is relatively simple to program and easier to use to add measures or components. That said, there are many moving parts for this ecosystem. Figure 1 illustrates the overall flowchart of how every component works revolving the MASControl3 engine. MASControl3 takes input from a series of tables from an input database (the SQLite Input Database), performs simulation runs using DOE2 engine according to specifications indicated by the input tables (e.g., which measures to run, which configurations to run, etc.), and outputs annual and hourly results in a separate output database (the SQLite Output Database)[1]. The input database is constructed by an array of Excel workbooks (Data Workbooks) which contains more extensive information

[1] The input and output database file format is ".db", which can be viewed/opened/edited using a SQLite database viewer. For many demonstrations / screenshots on this document, "DB Browser for SQLite" is used. This is a free software downloadable from: https://sqlitebrowser.org/dl/

for each measure, respective technologies, intermediate calculations, and related building prototype information. Lastly, a set of queries is used to translate the SQLite output database into the correct formats for the Measure and EnergyImpact tables within the PostgreSQL[2] PEAR and ExAnte databases.

[2] For many demonstrations / screenshots on this document on this process done in PostgreSQL, the opensource pgAdmin is used. Download link: https://www.pgadmin.org/download/

# 2 MASControl3 building simulations

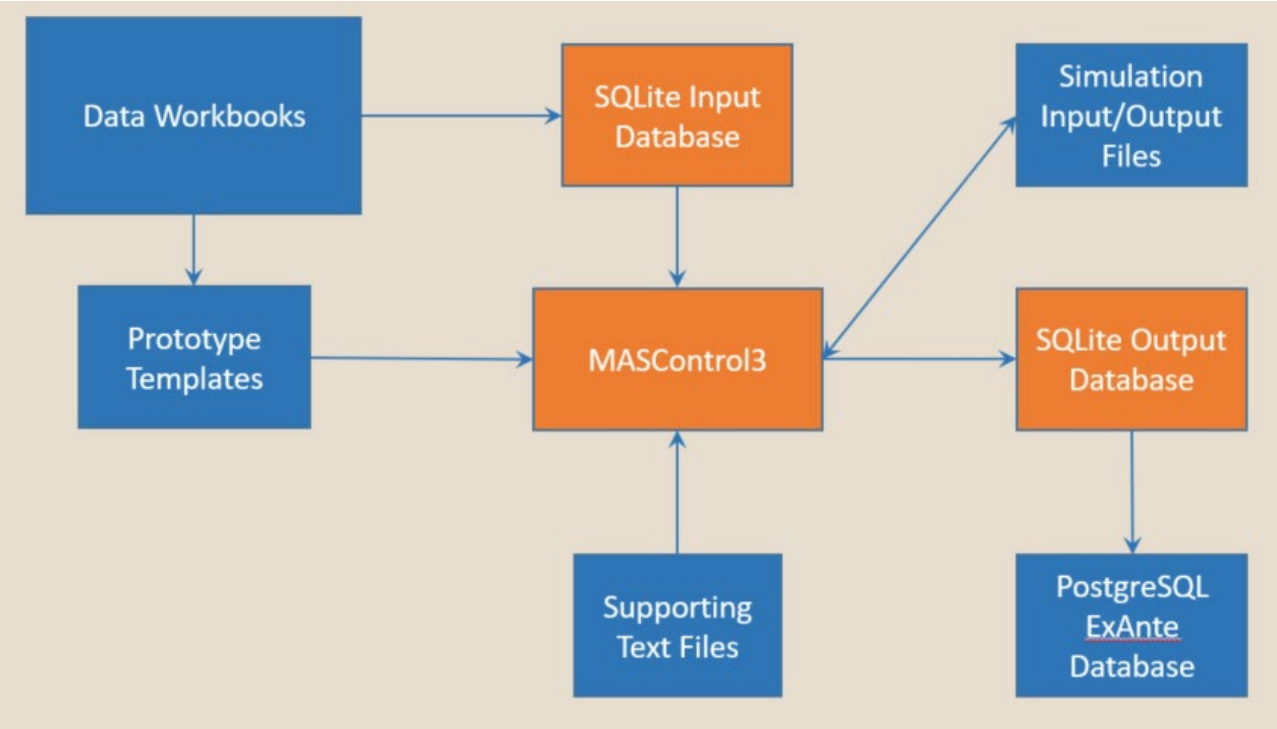



**Figure 2. MASControl3 Flow Chart: Simulation Process**

## 2.1 Installation and set-up

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 (default location is C:\DEER2020).[3] Users can customize 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. The contents of the MASControl3 zip file are shown in Figure 3.

[3] MASControl3.zip can be downloaded from here: http://deeresources.com/index.php/mascontrol3-resources

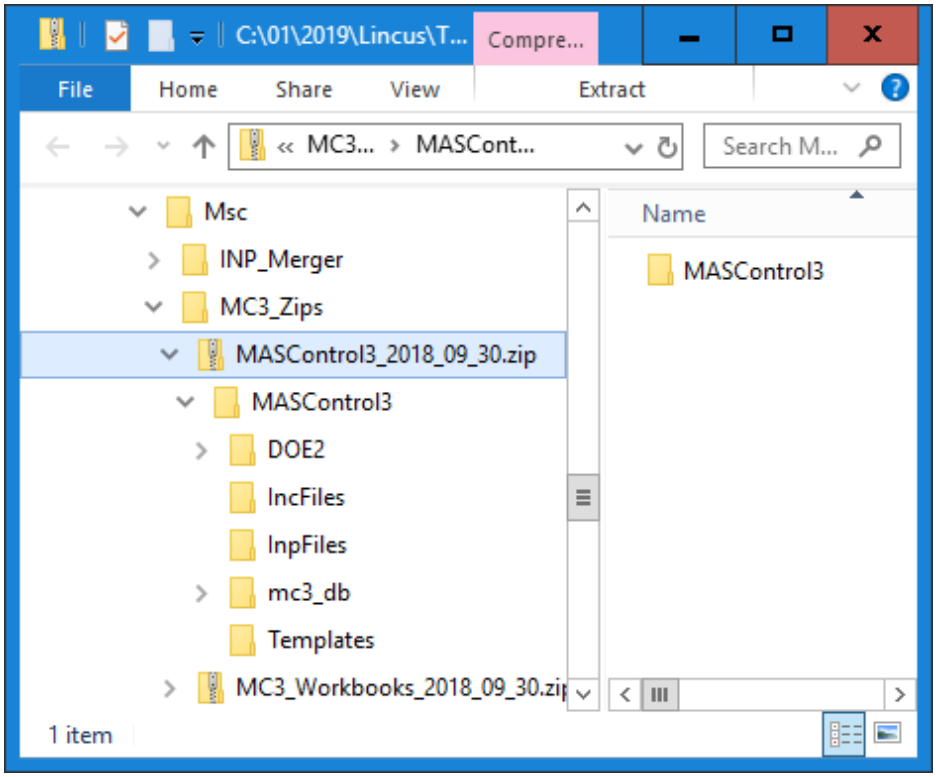



**Figure 3. Contents of the MASControl3 package**

2. Edit the MASControl3.ini file, which is located in the MASControl3 sub folder, so that the paths match your install location. A default setup is shown in Figure 4.
    a. The default path is C:\DEER2020\MASControl3, with corresponding sub-folders
        i. To set your desired file path, put the "MASControl3" folder in that location, and replace "C:\DEER2020" with the corresponding path.
        ii. Change all path strings to match installation location

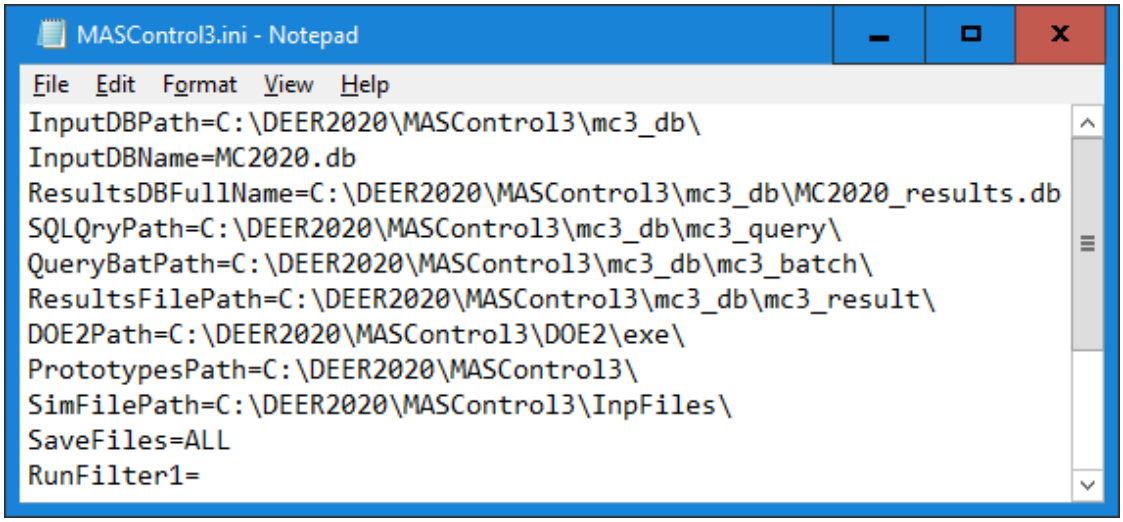



**Figure 4. Setting up correct path in the .ini file**

### 2.1.1 Measure run(s) set-up

1. Use the free "DB Browser for SQLite" interface or use your favorite database browser compatible with SQLite.
2. The MASControl3 input database is named **MC2020.db** and is located in \MASControl3\mc3_db\. The **MC2020.db** input database contains a list of the tables interacting with MASControl3 engine. A portion of that list is shown in Figure 5. 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. Two examples of picking which measures to run in the msrs2proc list are shown in Figure 6 and Figure 7.
3. Save changes to the .db file. (Note: specifically, for the interface "**DB Browser for SQLite**", click on "Write Changes"

after finalizing msrs2proc. This will save the changes made to this list )

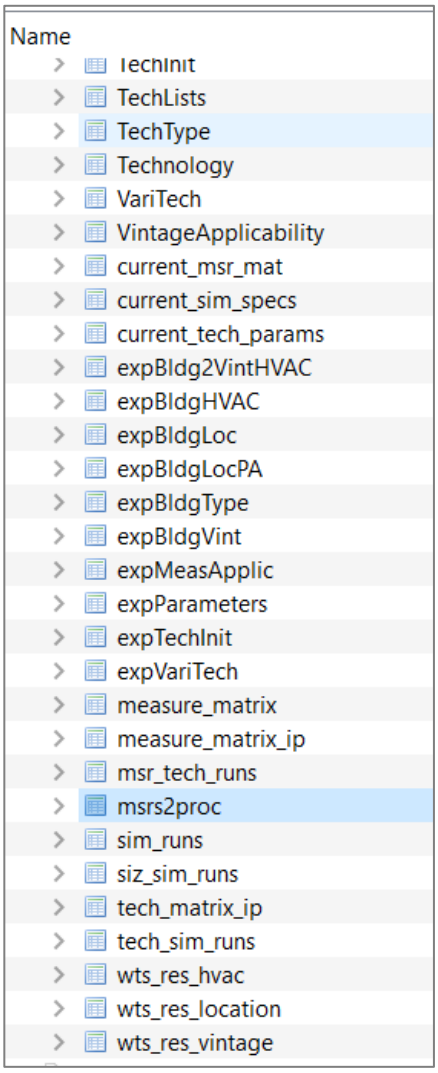



**Figure 5. tables in MC2020_db**

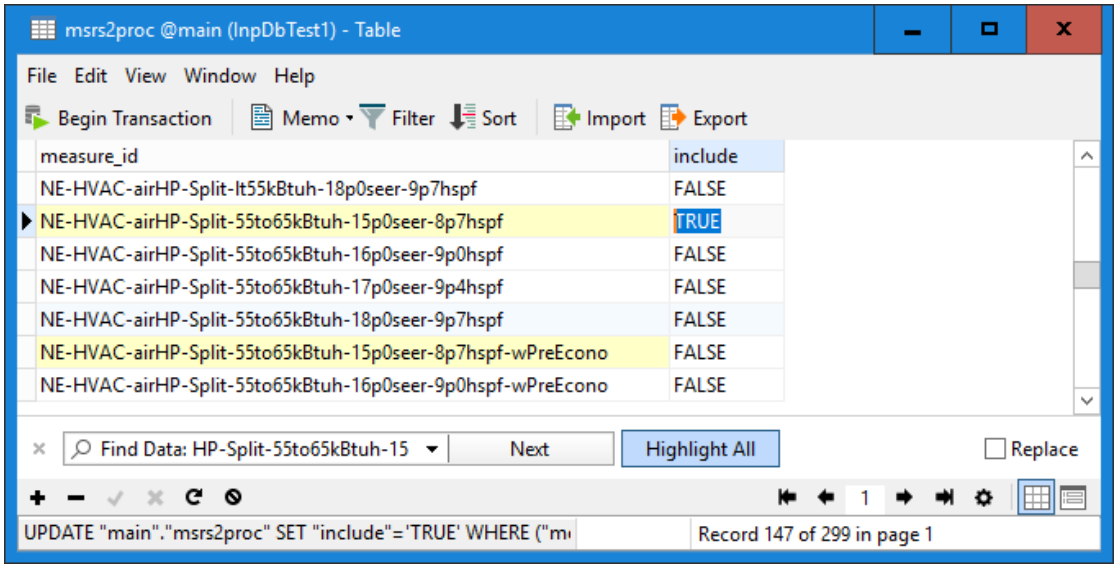



**Figure 6. msrs2proc example 1 using Navicat SQLite software**

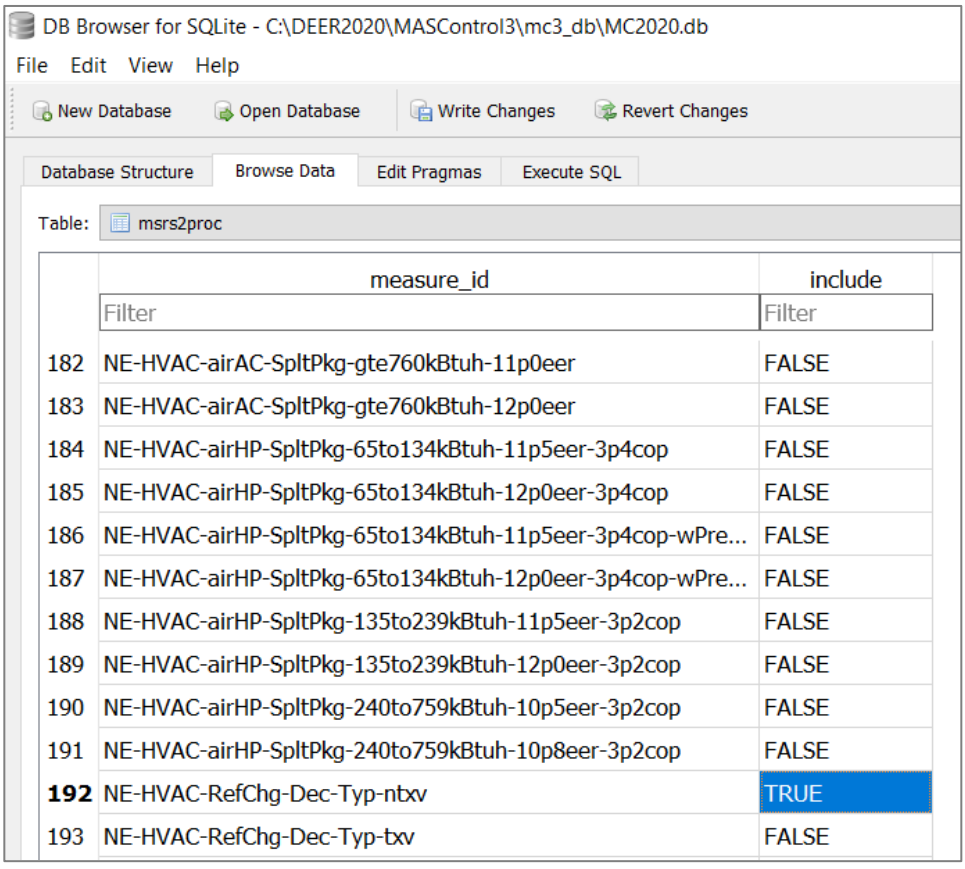



**Figure 7. msrs2proc example 2 using DB Browser for SQLite**

4. Run the MASControl3.exe file, which is also in the MASControl3 sub-folder.
5. Once in the MASControl3 interface, go to the Setup Tab as shown in Figure 8.

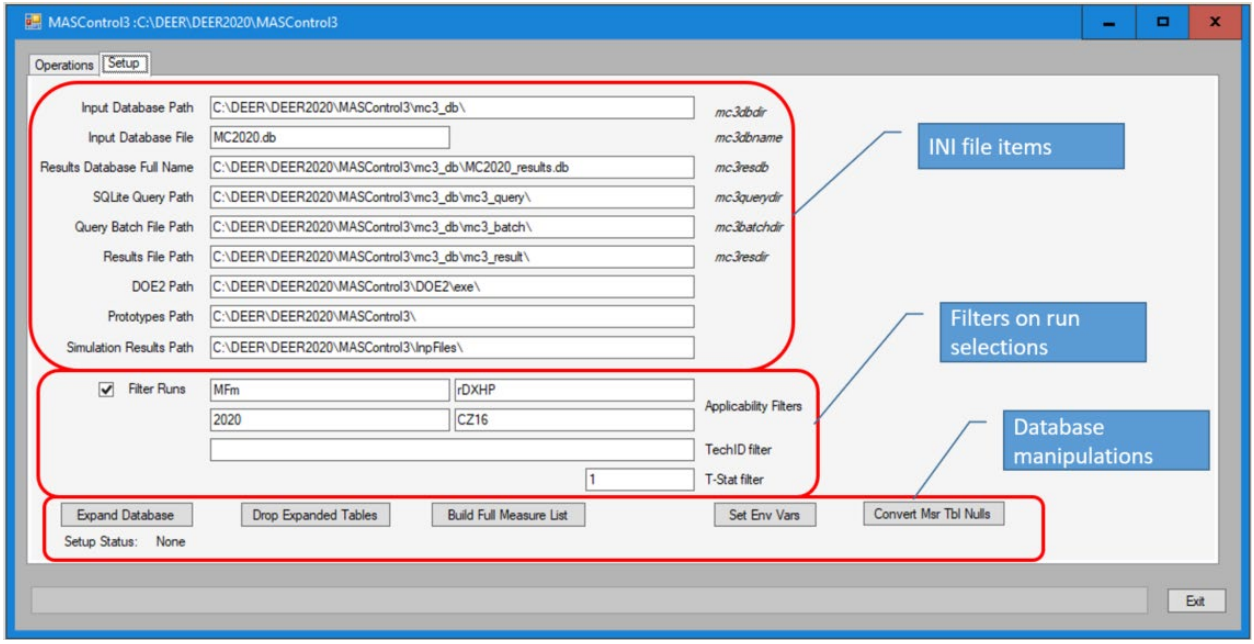



**Figure 8. The Setup tab in MASControl3**

6. 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 can then be re-run in the destination folder. See Figure 9 for this button labelled as step "1".
7. 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 run, which includes up to 3 technology runs. **All_Measures.csv** contains every combination of building type, vintage and climate zone runs for the measures selected in the **msrs2proc** list previously in step 3. See Figure 9 for this button labelled as step "2".

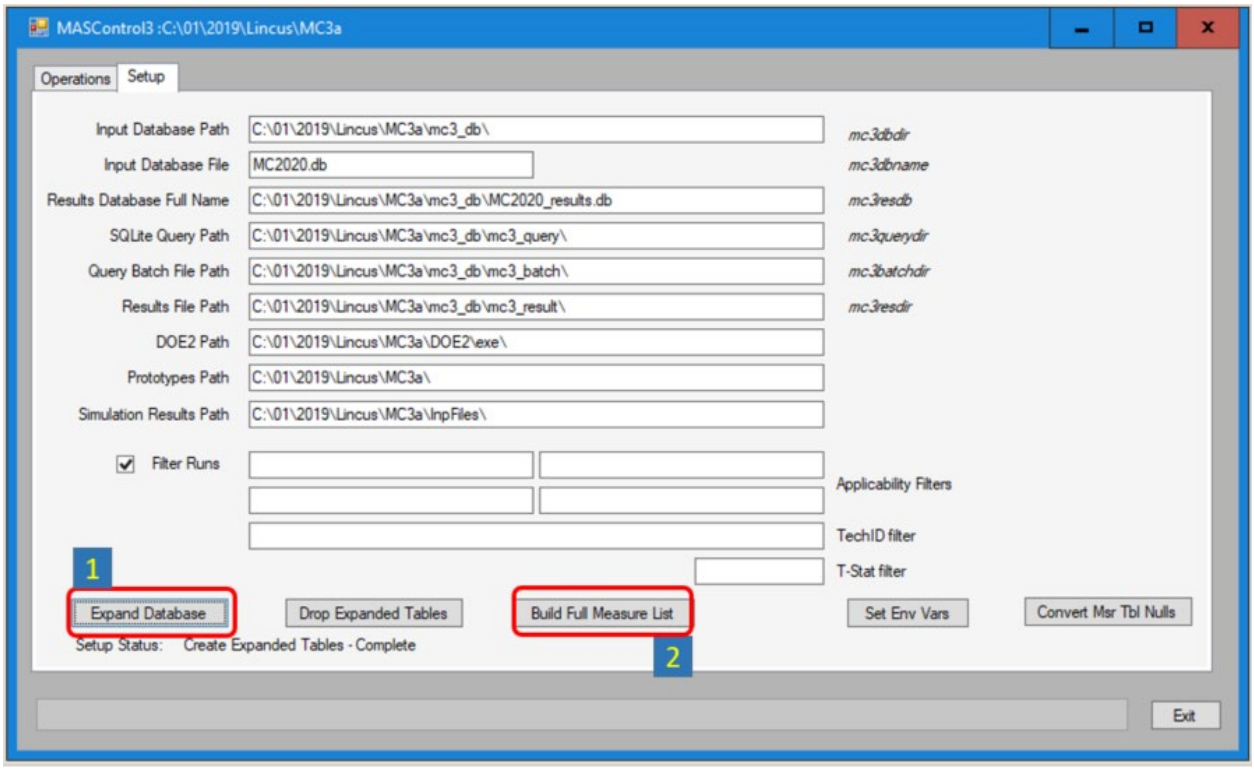



**Figure 9. Sequence of Operation in the Setup tab**

8. If desired, you can now 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. The location of the two tables are shown in Figure 10.

   Note: The only files involved in this process are All_Measures.csv and Run_Measures.csv; the other csv files in the mc3_results folder are legacy files that were produced for testing purposes by Doug Maddox.

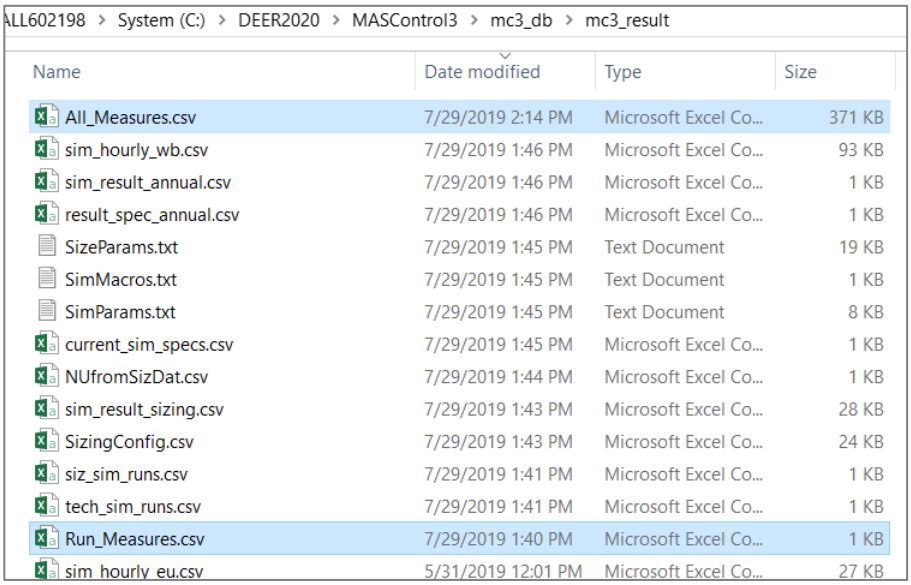



**Figure 10. All_Measures.csv and Run_Measures.csv**

9. 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. (This part is optional)

10. After setting up **Run_Measures.csv**, go back to the MASControl3 interface and switch over to the Operations tab (shown in Figure 11):

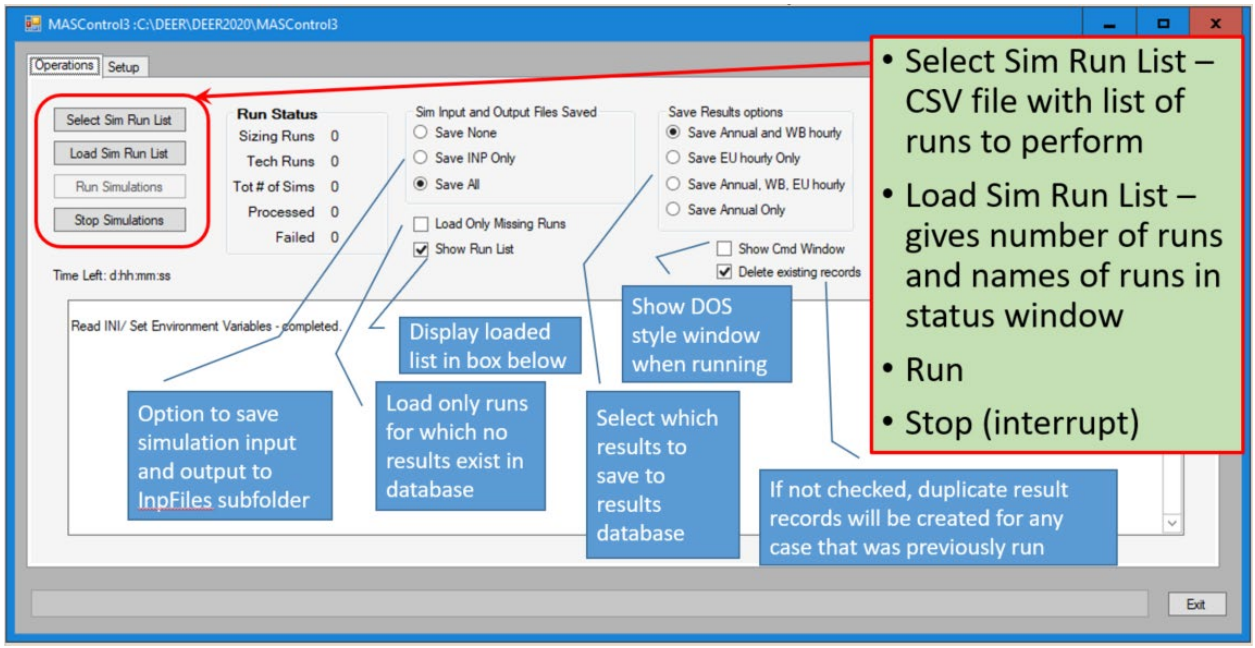



**Figure 11. The Operations tab in MASControl3**

11. Run "Load Sim Run List" (see Figure 12 below). This will read in all the measure runs that exists in **Run_Measures.csv**.

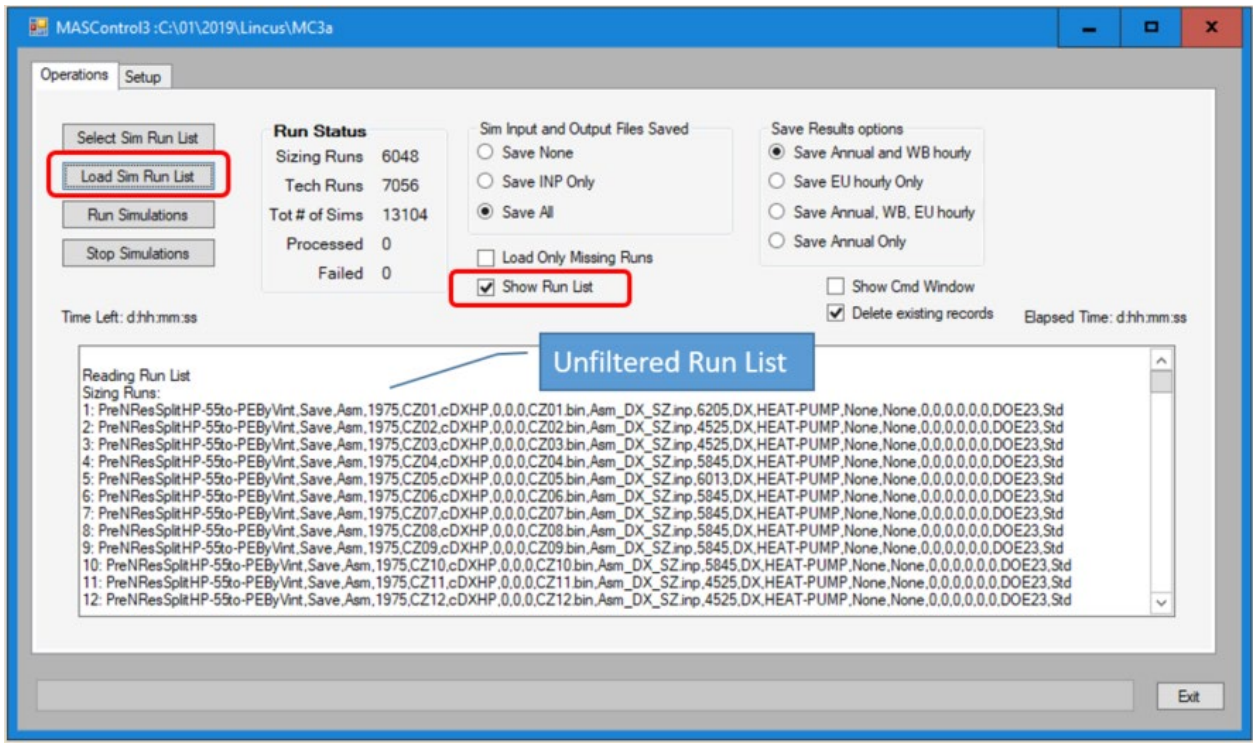
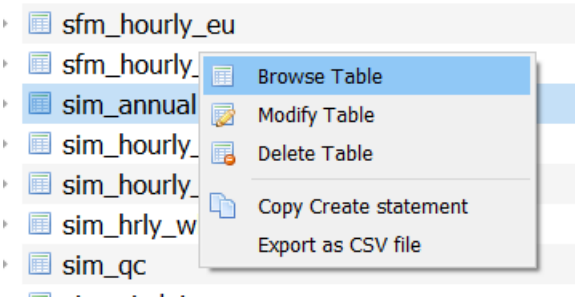


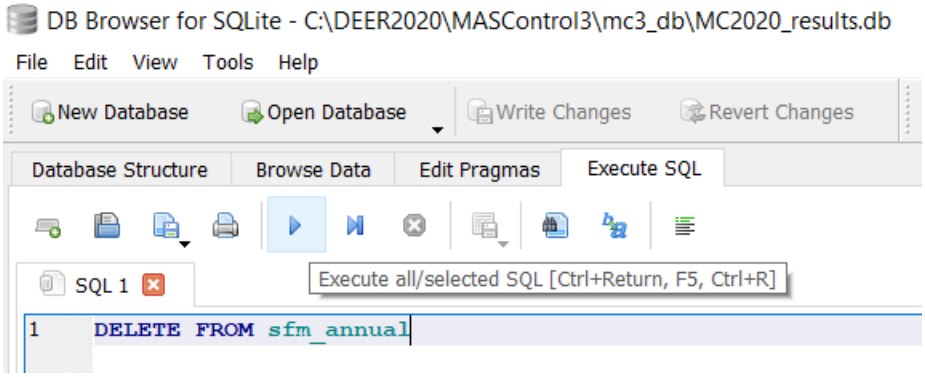

**Figure 12. Using "Load Sim Run List" to load the measure runs**

12. Before Clicking "Run Simulation", consider the following options:

    a. Make sure **MC2020_results.db** does not already have records in the output tables (described in step 17). To check, simply right click on a table, and click "Browse Table", like shown in screenshot below. If there are existing results data in these tables, it is recommended to empty them out before commencing on a new simulation. This prevents new simulation results being added to tables already with simulation results for other measures (and cause confusion).




    b. To empty a table in the .db file in DB Browser for SQLite, use the "Execute SQL" tab below the menu bar, and execute the command "DELETE FROM (table name)", like shown below.




    c. Save and close **MC2020_results.db**

    d. Radio button options *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. For large number of runs, it is not recommended to use "Save All", as this would take toll on disk space, since the files are generated for each run.

    e. Radio button options *Save Results options*: multiple selections for various combinations of annual results, whole building (WB) hourly, and end use (EU) hourly results. For completeness, usually the third option is selected (Save Annual, WB, and EU hourly)

    f. Check box option *Load Only Missing Runs*: prevents re-running simulations for cases where results already exist in the database.

    g. Check box option *Show Run List*: makes full run list appear in the display window below when "Load Sim Run List" is pressed.

13. After every option is confirmed to be the desired setting, "Run Simulations" starts the loaded simulation set.

14. "Stop Simulations" interrupts a running simulation set. There will be a delay after pressing the button while the current simulation completes.

15. 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.

16. 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. Example of a finished run is shown in Figure 13.

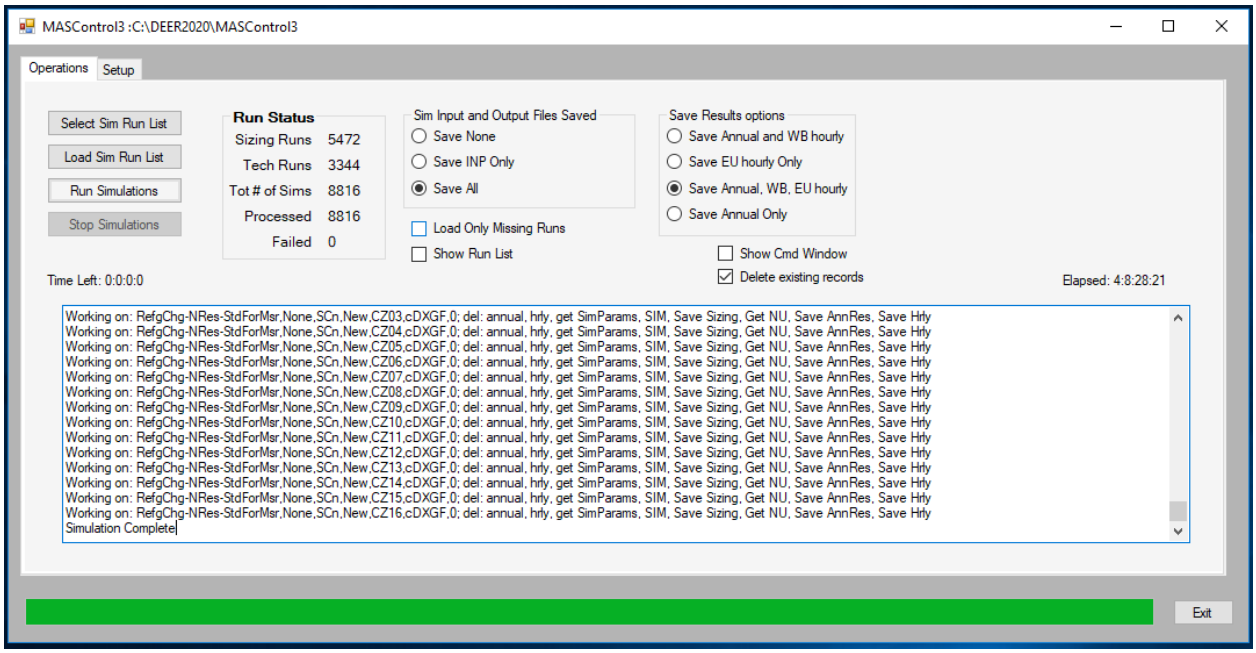



**Figure 13. Screen after simulation run is finished**

17. Results can be viewed by examining the SQLite **MC2020_results.db** file.

18. 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.

19. Contents (tables) from the two databases (input database, **MC2020.db** and output database, **MC2020_results.db**) that will be used in the results processing (will be explained in more detail in the "Results Processing" section) are as follows:

a. Sim_annual – from **MC2020_results.db**

b. Sim_hourly_wb – from **MC2020_results.db**

c. Sim_hourly_eu – from **MC2020_results.db**

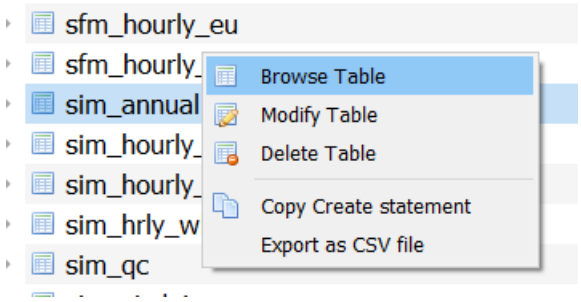
d. Sfm_annual – from **MC2020_results.db** (if residential measure)

e. Sfm_hourly_wb – from **MC2020_results.db** (if residential measure)

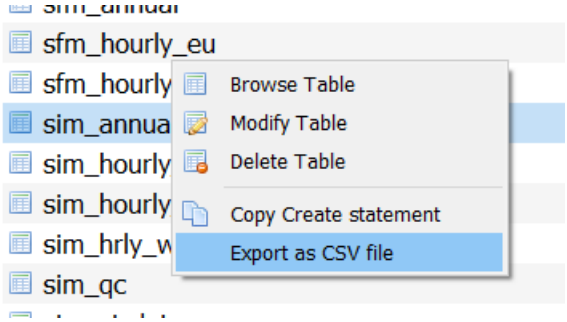
f. Sfm_hourly_eu – from **MC2020_results.db** (if residential measure)

g. Curr_msr_mat (Measure Definition Table) – from **MC2020.db**

20. Before exporting these tables, it is often good to view them in the .db file. To view a table on the for "DB Browser for SQLite", right-click on a table name and select "Browse Table". This is a quick way to check if an output table is actually populated before exporting any table.




21. Export and save these tables into a folder. These will be used in the subsequent result-processing step. Note: specifically for "**DB Browser for SQLite**": to export a table, right click on a table name in the list, and select "Export Table". Then press "Save" and save to an appropriate directory.



## 2.2 MASControl3 results processing

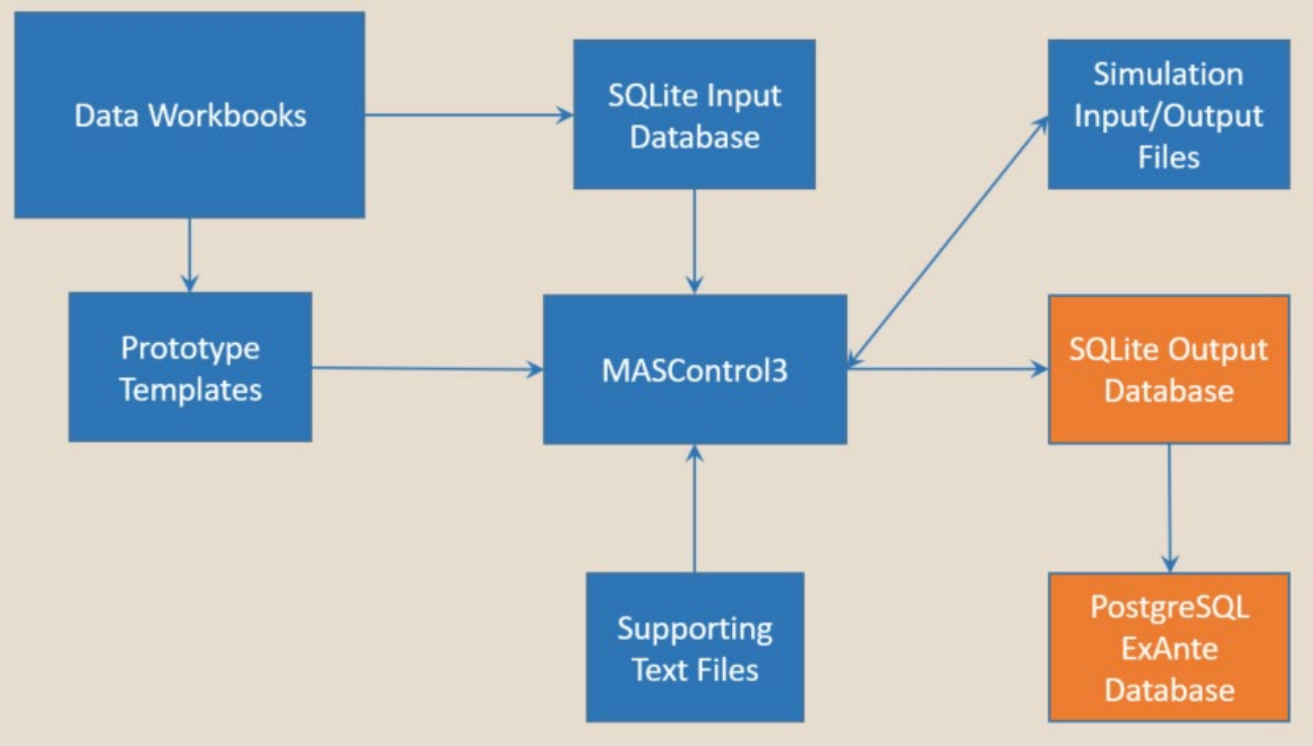



**Figure 14. MASControl3 Flow Chart: Results Processing**

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 PostgreSQL scripts for this process are available in the *DEER_Tools_2019_07_26* zip file (Provided on the "MASControl3 Resources" tab on deeresources.com), under the folder *PostProcess*.[4] 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. Example set up steps will be demonstrated here using the PostgreSQL platform pgAdmin. (https://www.pgadmin.org/download/)

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.**

[4] http://deeresources.com/index.php/mascontrol3-resources

A high-level comparison between the MASControl3 output database and the processed database:

- MASControl3 Output Database
  - Automatically populated by MASControl3
  - SQLite Format
  - Annual and hourly results for each technology
  - Unweighted
- Post-Processed Database
  - Requires setup and execution of post-processing queries
  - CPUC version is PostgreSQL
  - Measure impacts (difference between baseline and measure technology)
  - Weighted averages (vintage, location, etc.)

### 2.2.1 Set up PostgreSQL environment for post processing

Before doing post-processing, the environment to host the data tables must be set up. Note that the steps below are shown using pgAdmin (https://www.pgadmin.org/download/). Using another SQL environment may involve slightly different setup steps.

#### 2.2.1.1 Connect to a database and schema

1. After opening the PostgreSQL interface, connect to a server. Figure 15 and Figure 16 shows the way to set it up in pgAdmin.

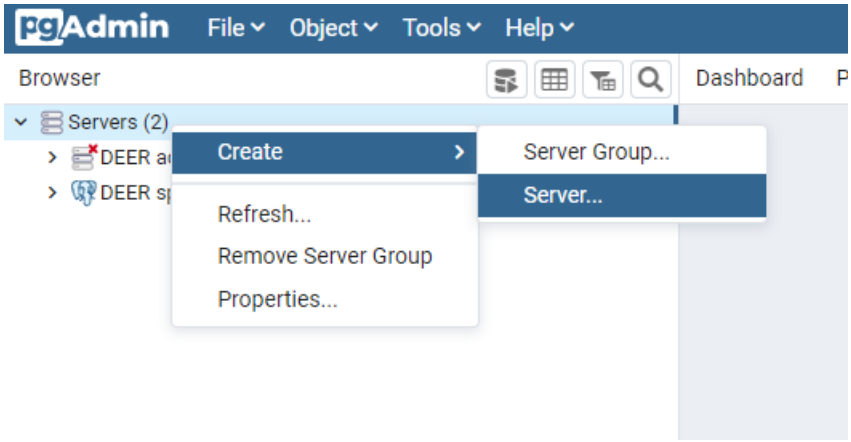



**Figure 15. PostgreSQL Setup – Create Connection**

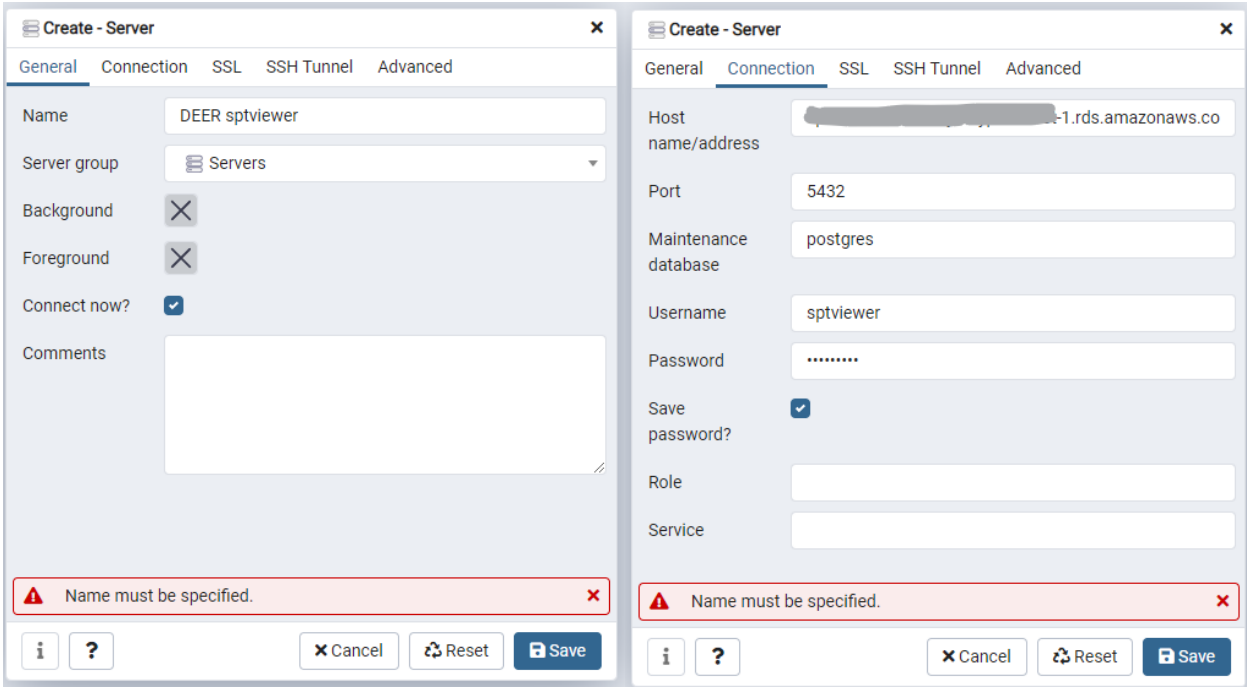



**Figure 16. PostgreSQL Connection Setup and Credentials**

2. The credentials (Host/Address, Username, Password) are usually associated with the particular SQL database, and they are needed in order to gain access an SQL database.

3. After creating a connection, designate a database, and a schema within that database to be used for this process.[5] Figure 17 shows an example of the list of different databases. In this case, the database "sg_test" is used as the database designated for the results-processing steps.

[5] A PostgreSQL connection usually has several databases, and each **database** usually consists of a list of schemas. A **schema** is a group of tables within a database.

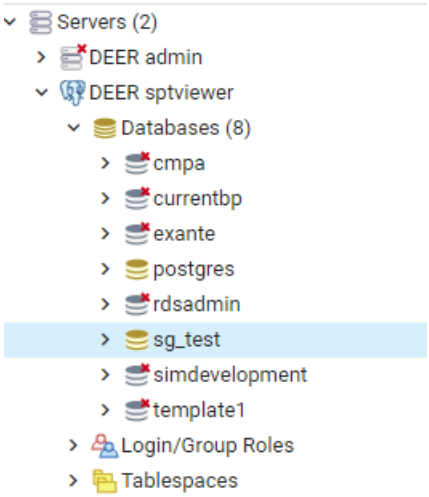



**Figure 17. Databases**

4. Figure 18 shows the list of schemas under this database. Different set of tables are organized in each schema. In this case, the schema called "MC_results_database" is used as the schema designated for the results-processing steps. This is the main "environment" for which the MC3 simulation results tables will be housed in for the SQL queries. A new schema can be created if needed to prevent mixing data tables with existing content.

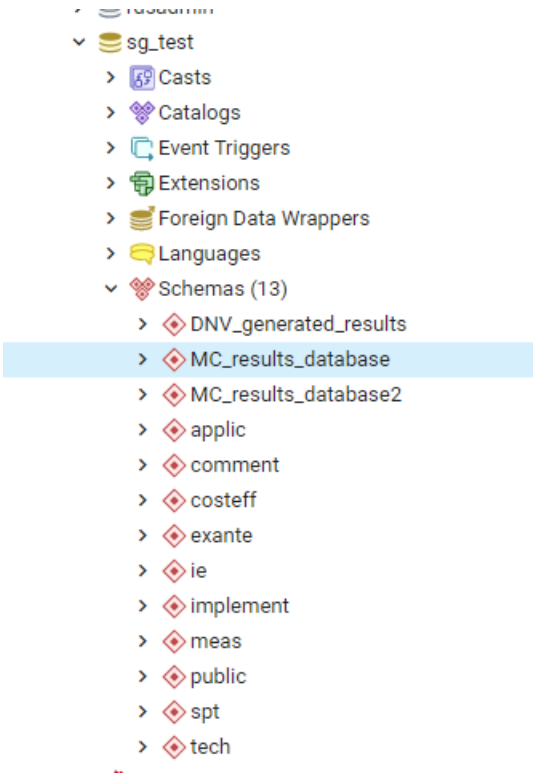



**Figure 18. Schemas**

5. Figure 19 shows some tables within that schema. Within these tables, there exists **support tables** which are of constant values (usually contain weights, peak definitions, etc., mentioned in section 2.2.2 and 2.2.3); there also exists the **input data tables**, which consists of tables listed in step 17 of section 2.1.1 (a.k.a. the simulation results); and lastly there are **output data tables**, which are the intermediate tables and resulting tables generated during or after applying the SQL results post-processing steps. The input and output data tables will be constantly changing when processing simulation results for different measures[6].

[6] This means the whole schema will be set up to process one measure at a time. If another measure needs to be processed, all the input tables will need to be emptied out before loading in simulation data of the new measure.

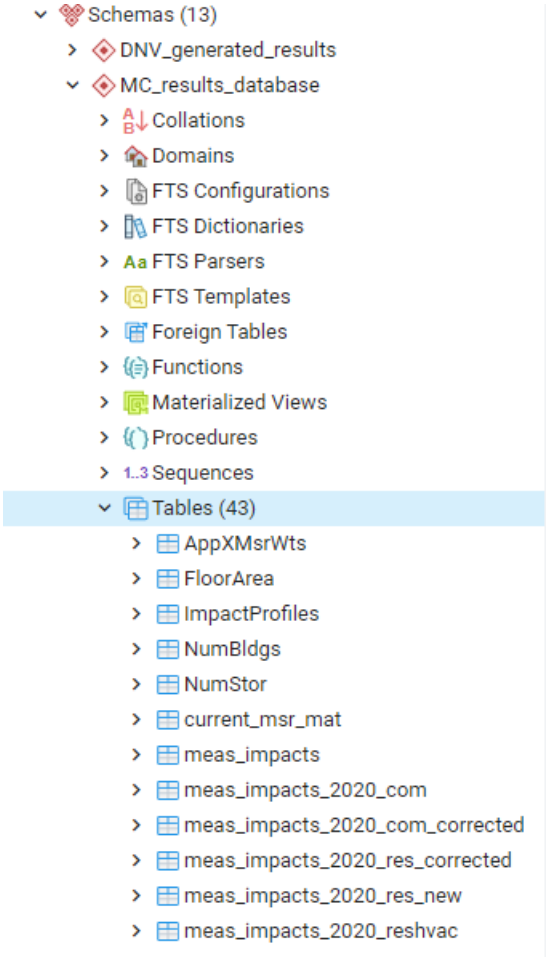



**Figure 19. Tables within a schema**

6. To get started, all the simulation output tables (see the list from step 17 of section 2.1.1 of this document) need to be imported into this database. When doing this for the first time in pgAdmin (when there are no existing tables in the schema), all the field names and specifications of each table must be created before uploading each table from the simulation outputs (See Figure 20 and Figure 21 for reference). All filed names created need to fit the table being uploaded, otherwise the data will not be uploaded successfully.

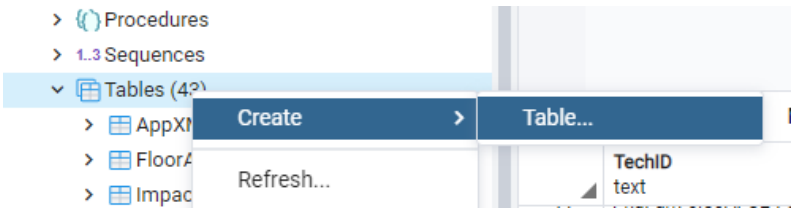



**Figure 20. Create a table in PostgreSQL**

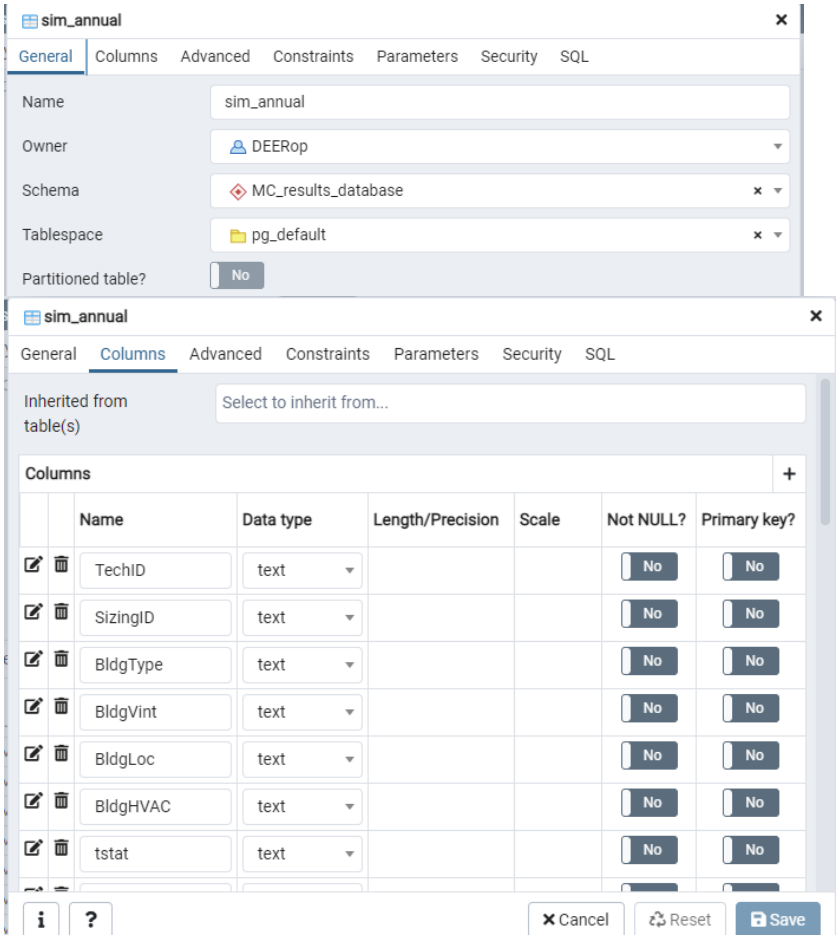



**Figure 21. Table Creation settings in PostgreSQL**

7. When working with a schema already populated with these tables, there is no need to recreate the table field names each time. One only need to empty out all the records in each table and re-import a set of new data values in its place.

8. To empty out an existing table, simply execute a "DELETE FROM" command, shown in Figure 22. Where the particular table is right-clicked, and the "DELETE script" is selected. This automatically generates a SQL command shown in Figure 23. Since all content of the table needs to be deleted, there is no need for the "WHERE" clause, so delete that portion of the command, but keep the semi-colon, which is an important syntax (Figure 24). Run/execute this command by clicking . This will empty out the specific table. This needs to be done for every input table (simulation results table) housed in this environment for this process. **For clarity: This action does NOT delete the whole table, it essentially "empty-out" all the contents within that table but retains the "shell", in other words the table structure and all the field names. The result will be an empty table but with all the field names intact. This is not to be confused with the "Delete/Drop" function when right-clicking a table. The "Delete/Drop" function WILL actually delete the whole table.**

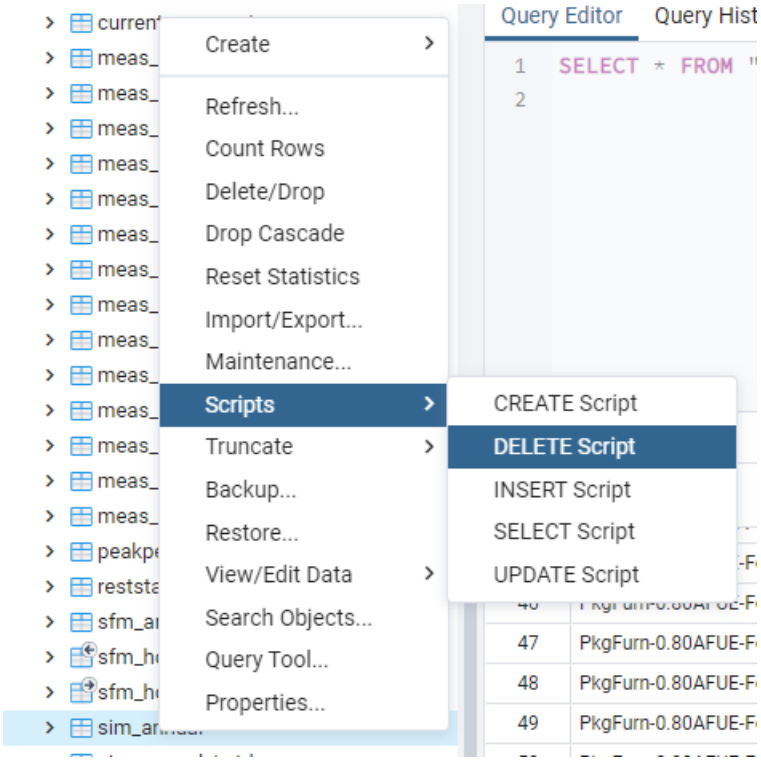



**Figure 22. Initialize DELETE Script**

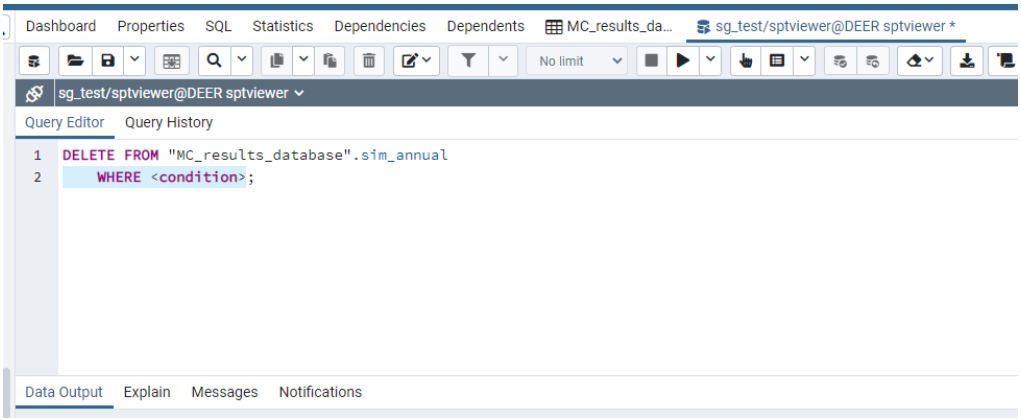



**Figure 23. The WHERE Clause**

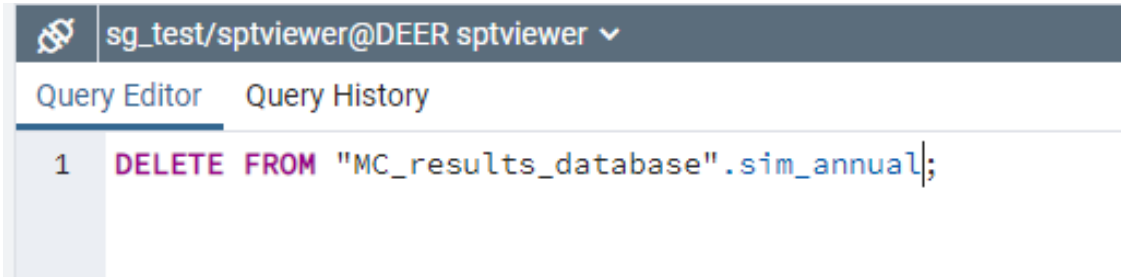



**Figure 24. DELETE Script for All Records**

### 2.2.1.2 Assemble output and support tables for results processing

Again, export output results tables from MASControl3 simulation and save these at a directory. They include the following (details of each will be explained in section 2.2.1.3 and 2.2.1.4):

- Sim_annual – from **MC2020_results.db**
- Sim_hourly_wb – from **MC2020_results.db**
- Sim_hourly_eu – from **MC2020_results.db**
- Sfm_annual – from **MC2020_results.db** (only if residential measure, and simulation includes the "Single Family" building type, where BldgType = SFm)
- Sfm_hourly_wb – from **MC2020_results.db** ((only if residential measure, and simulation includes the "Single Family" building type, where BldgType = SFm)
- Sfm_hourly_eu – from **MC2020_results.db** (only if residential measure, and simulation includes the "Single Family" building type, where BldgType = SFm)
- Current_msr_mat (Measure Definition Table) – from **MC2020.db**

After one batch of successful simulation run in MASControl3, it is recommended to copy the "MC2020_results.db" from the installed location (usually C:/ ) and save the copy somewhere else for storage as the tables get exported (a way of backup). As the content in the main db file in the installed location will be constantly cleared out and repopulated if different measures need to be run to prevent different measure data mixing one another.

Typical workflow after a simulation of a measure is completed:

i. Make a copy of the MC2020_results.db from its main location (usually the C:/ directory) and save it in another directory (for backup purposes).

ii. From that MC2020_results.db, export all appropriate output tables. All the tables should be in .csv format. (See step 19 in Section 2.1.1 on how to export)

iii. An example directory with all the outputs for a residential measure, is shown in Figure 25.

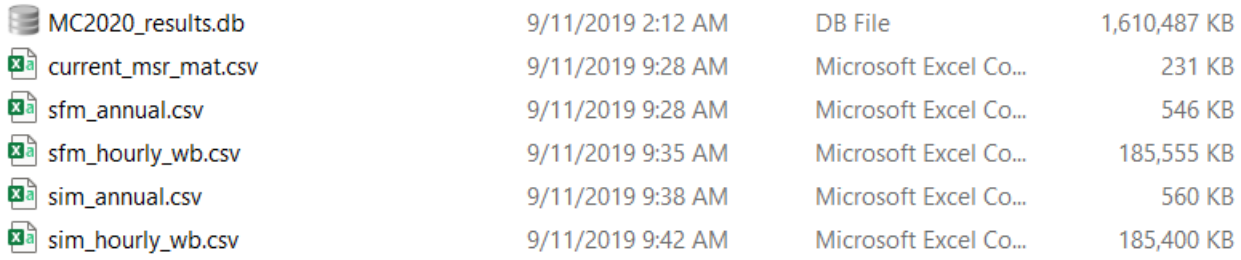



**Figure 25. MC3 Output Tables**

To load a table into the PostgreSQL database before post-processing (specifically for the PostgreSQL interface pgAdmin):

1. Before loading a corresponding table, it is recommended to check if that table already has content in it and needs to be emptied before importing results from a new simulation run for a measure. To check a table, right-click on the table name, and select "View/Edit Data"-"First 100 Rows" or "All Rows" (if the table isn't that big in size). See Figure 26. This will display some contents of the table (Figure 27), if any. If there are no contents but there are field names shown, this means it is good to proceed to import data into this table (Figure 28).

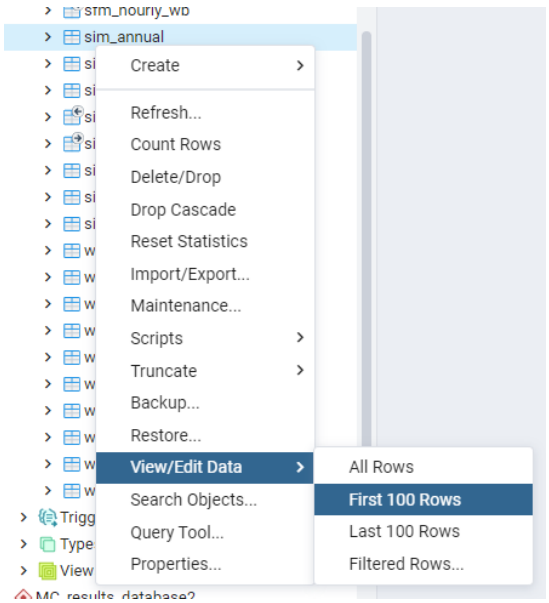
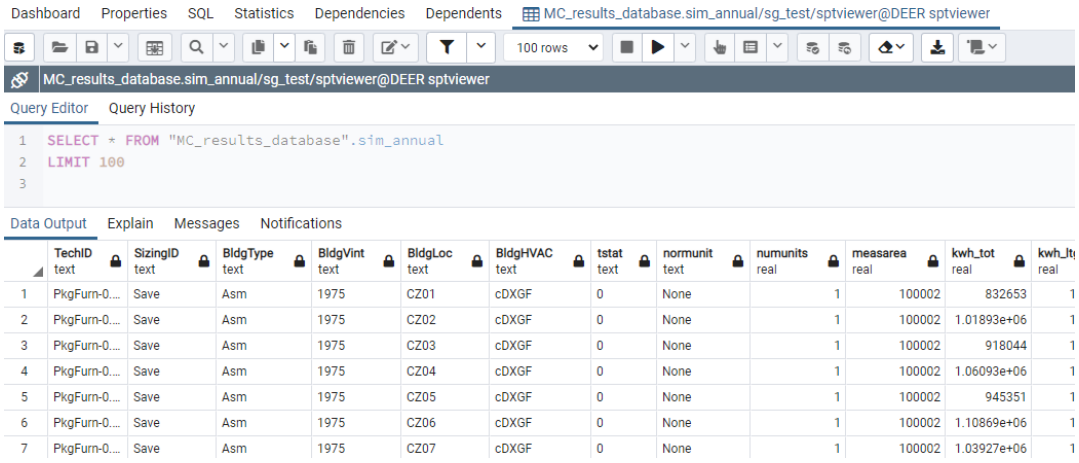



**Figure 26. View Data**




| | TechID text | SizingID text | BldgType text | BldgVint text | BldgLoc text | BldgHVAC text | tstat text | normunit text | numunits real | measarea real | kwh_tot real | kwh_lt real |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | PkgFurn-0.... | Save | Asm | 1975 | CZ01 | cDXGF | 0 | None | 1 | 100002 | 832653 | 1 |
| 2 | PkgFurn-0.... | Save | Asm | 1975 | CZ02 | cDXGF | 0 | None | 1 | 100002 | 1.01893e+06 | 1 |
| 3 | PkgFurn-0.... | Save | Asm | 1975 | CZ03 | cDXGF | 0 | None | 1 | 100002 | 918044 | 1 |
| 4 | PkgFurn-0.... | Save | Asm | 1975 | CZ04 | cDXGF | 0 | None | 1 | 100002 | 1.06093e+06 | 1 |
| 5 | PkgFurn-0.... | Save | Asm | 1975 | CZ05 | cDXGF | 0 | None | 1 | 100002 | 945351 | 1 |
| 6 | PkgFurn-0.... | Save | Asm | 1975 | CZ06 | cDXGF | 0 | None | 1 | 100002 | 1.10869e+06 | 1 |
| 7 | PkgFurn-0.... | Save | Asm | 1975 | CZ07 | cDXGF | 0 | None | 1 | 100002 | 1.03927e+06 | 1 |

**Figure 27. View Data Results**

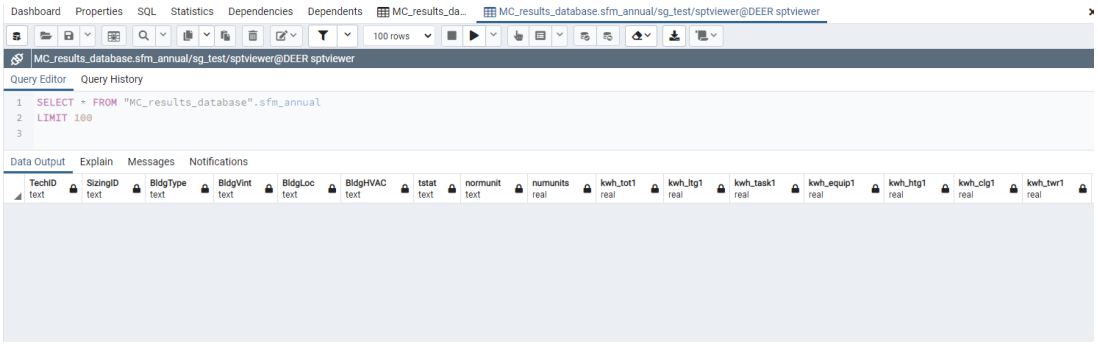



**Figure 28. View Data Results (if Empty)**

2. To load data into a table, right-click on the table name, and select "Import/Export" (Figure 29). Make sure the "Import/Export" option is set to "Import". Select the appropriate table from the appropriate directory (as saved earlier after the simulation). Toggle the "header" option to "Yes", and set "Delimiter" to comma (,). leave all other options as default. See Figure 30 for the settings described in this step.

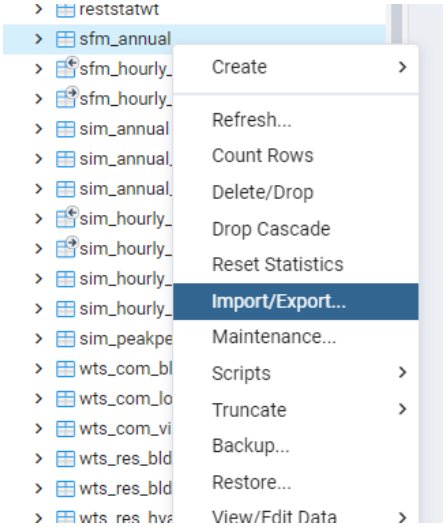



**Figure 29. Import/Export**

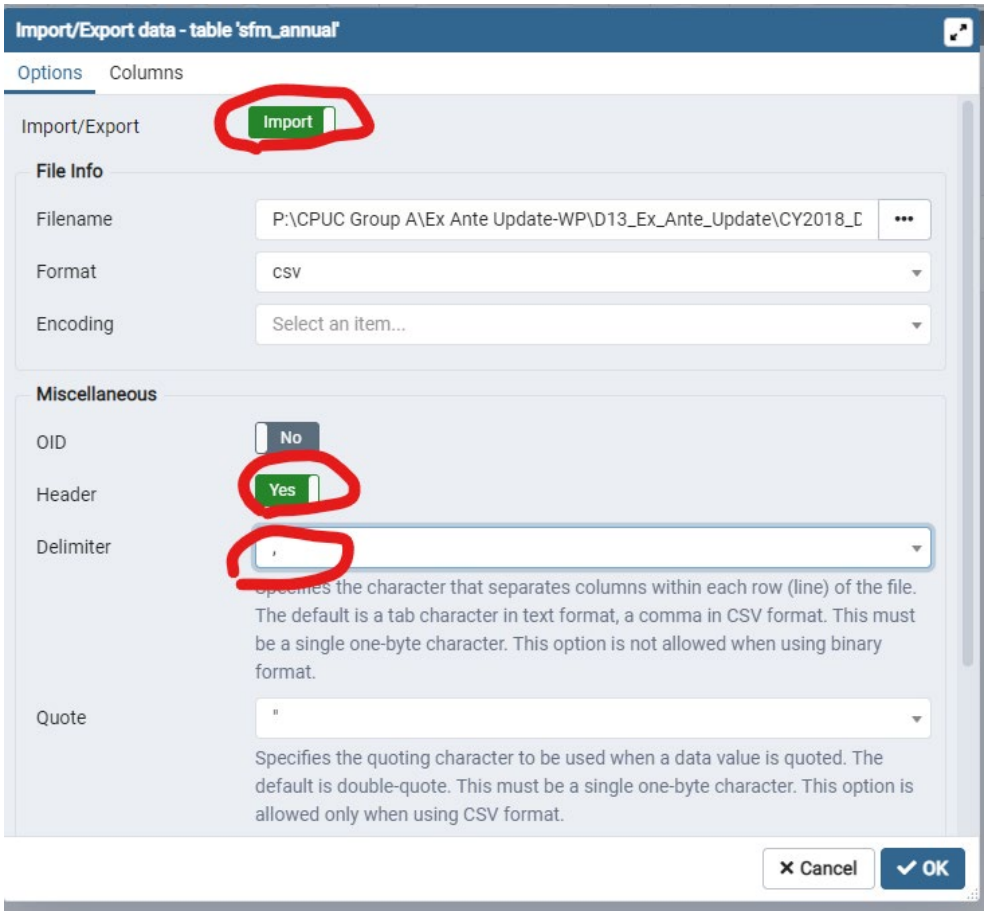



**Figure 30. Import Data Settings**

3. A progress/status window should pop-up and indicate that the import is in-progress/complete, as shown in Figure 31.

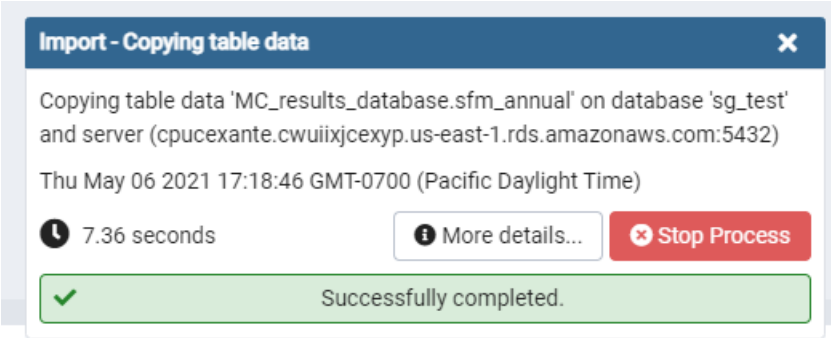



**Figure 31. Import Status Window**

4. All of the simulation output tables plus the measure definition table "current_msr_mat" should be imported in this manner before post-processing.

5. For the support tables (mentioned in section 2.2.2 and 2.2.3, which included weights/peak definitions/etc.), there are pre-defined SQL commands (file names that end with .sql) that generate

these tables, provided in the "PostProcess"-"SupportTable" folder of the MC3 package. These support tables are generated by merely running the SQL commands. These tables usually do not need to be re-imported once created, unless the weights / peak-definitions need to be updated. An example of such script is shown in Figure 32.

**Figure 32. Support Table .SQL script**

6. To run a SQL command/query, right-click on "Table" (or left-click on "Tools" on top menu bar), and select "Query Tool" (Figure 33). A window/tab for SQL query input will be created (Figure 34). The scripts to create (or re-create) certain support-tables as shown in the previous step, and post-processing scripts mentioned in section 2.2.5 and 2.2.6, are run using this query tool.

7. Follow section 2.2.4, 2.2.5, and 2.2.6 in order to run each designated post-processing step in order, and proceed with post-processing.

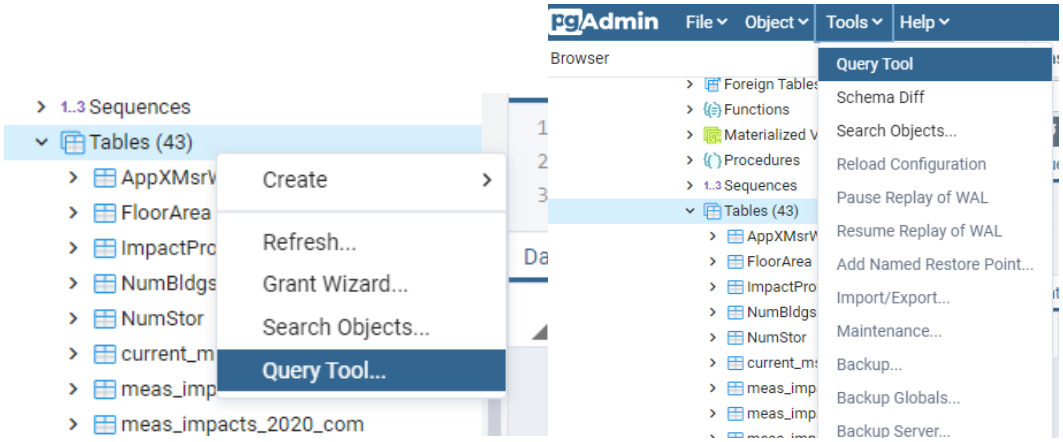



**Figure 33. Initialize Query Tool**

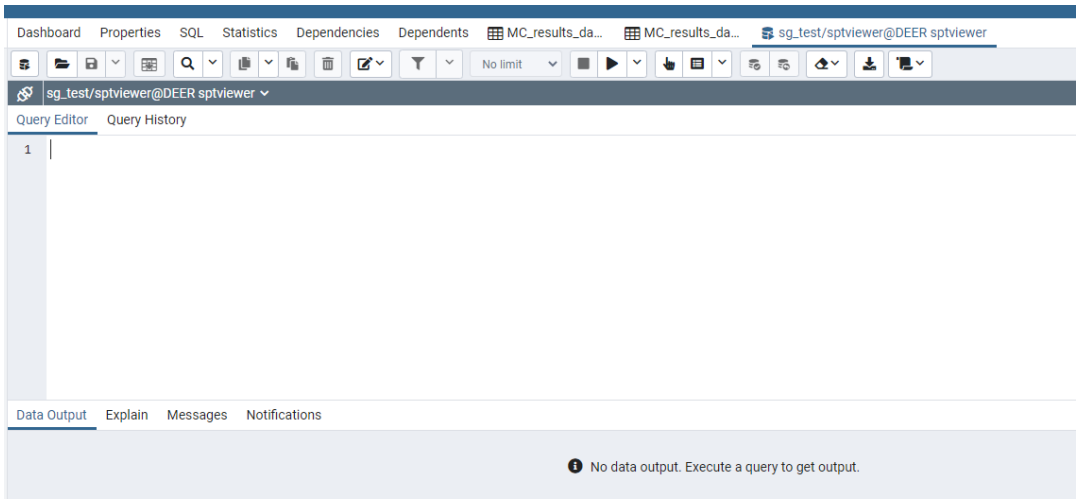



**Figure 34. Query Tool**

### 2.2.1.3 Commercial buildings Simulation Outputs

For the commercial buildings, the following tables must be transferred from the SQLite results database created by MC3 to the processing database. This process is detailed in section 2.2.1.2

- **sim_annual**: this table contains the annual simulation values and has a primary key of building type, vintage, location and HVAC type. Shown in Figure 35.

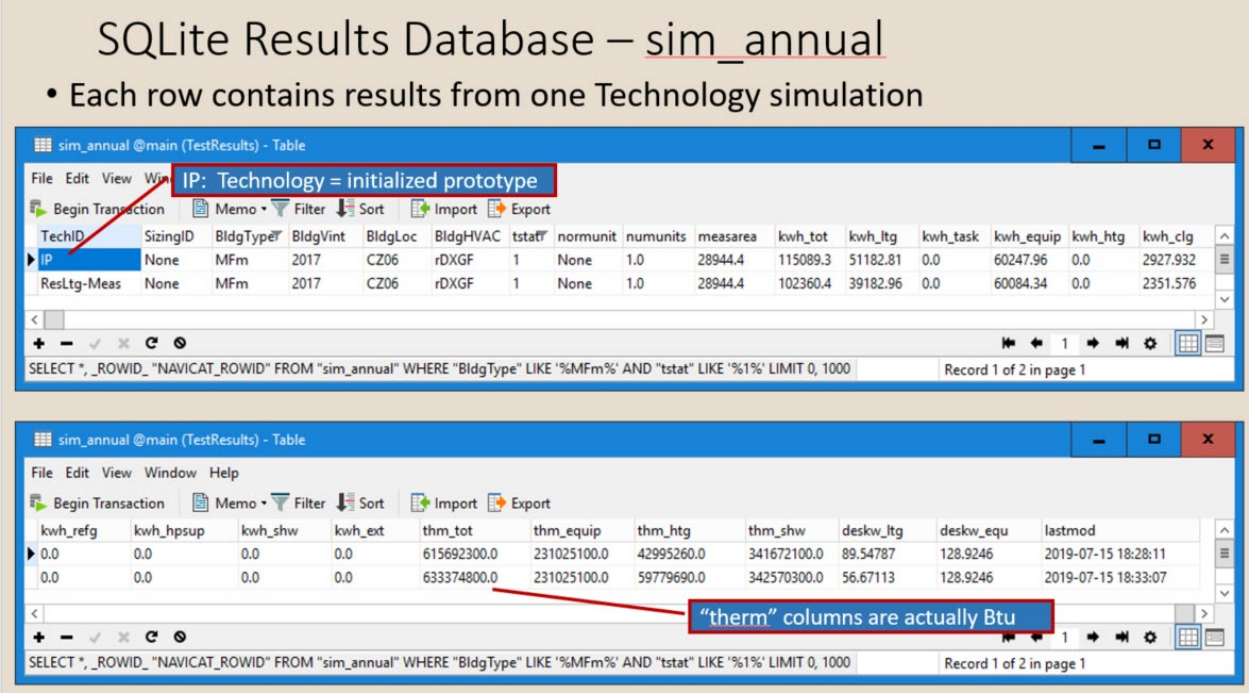



**Figure 35. sim_annual**

- **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 one day of the year. Shown in Figure 36.

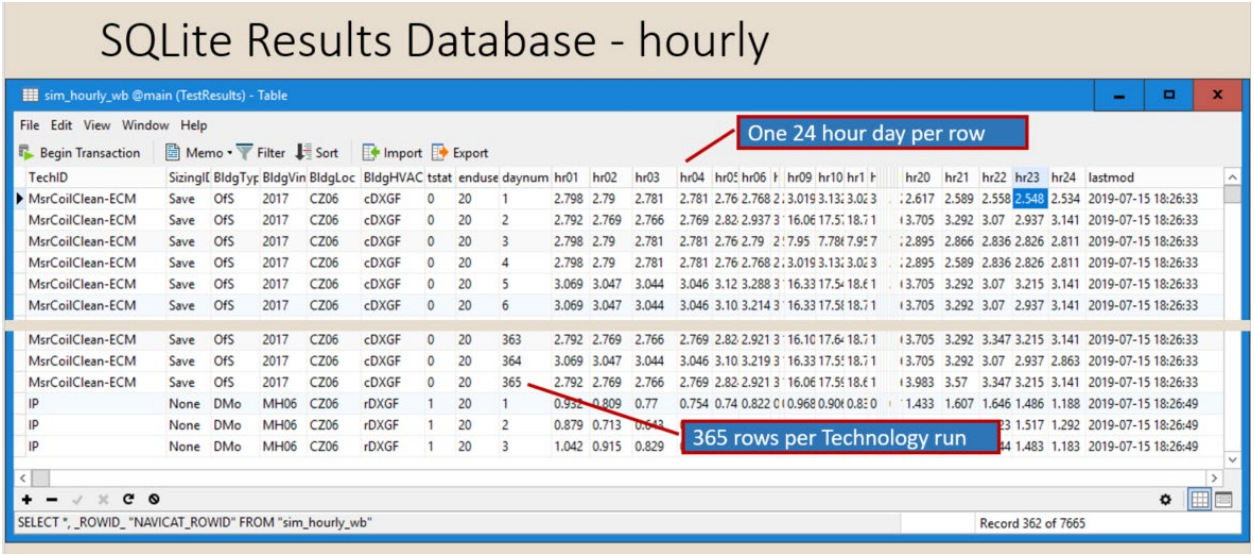



**Figure 36. sim_hourly_wb**

- **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. This table is often not populated if the measure only simulated whole-building effects, but it is always good to check it.

### 2.2.1.4 Residential buildings Simulation Outputs

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 tables 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. Shown in Figure 37.

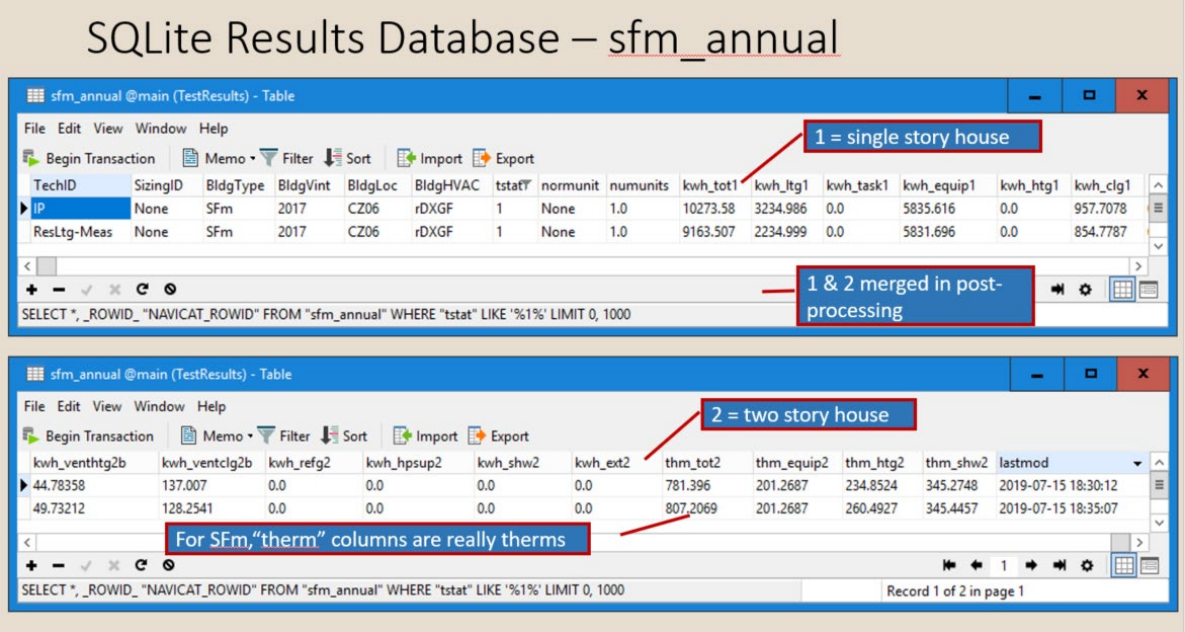



**Figure 37. sfm_annual**

- **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.

### 2.2.2 Commercial building post-processing support tables

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 DEER_Tools_2019_07_26 zip file (Provided on the "MASControl3 Resources" page on deeresources.com), under the folder PostProcess.

- Measure Definition table (**curr_msr_mat**) (located in MC2020.db): 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 period used for the determination of peak demand values. The table lists the first day for each of the 16 climate zones used for the DEER peak period definition.

- 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 (**AppXMsrWts**): 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.

The above tables are used as described in Table 2-1.

### 2.2.3 Residential building post-processing support tables

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:

1. Measure Definition table (**curr_msr_mat**) (located in MC2020.db) (same definition, see section 2.2.2)
2. Thermostat Weights[7] (**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.
3. 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.
4. 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.
5. 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

[7] Each location, vintage, and building type has its own set of five heating/cooling schedules. The use of multiple schedules was based on the behavior-based thermostat analysis done for circa. DEER 2008 update. A single set of five weights for each combination of location/vintage/building type are derived such when the annual heating and cooling simulation results for each of the five sets of schedules are multiplied by the weights, the target annual heating and cooling values are met.

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.

6. Vintage Weights (**wts_res_vintage**): Similar to **wts_com_vintage** but for residential.
7. Location Weights (**wts_res_loc**): Similar to **wts_com_loc** but for residential.
8. Building Weights (**wts_res_bldg**): Similar to **wts_com_bldg** but for residential.

The above tables are used as described in Table 2-2.

### 2.2.4 Before Post-Processing check

In summary, before performing results processing after MASControl3 simulation, assemble the following output and supporting tables in the same database (for PostgreSQL, all of these are assembled in the same schema), and perform the corresponding queries-set on them.

For commercial:

- sim_annual
- sim_hourly_wb
- sim_hourly_eu
- curr_msr_mat
- peakperspec
- wts_com_vintage
- wts_com_loc
- wts_com_building
- AppXMsrWts (optional)

For residential:

- sfm_annual
- sfm_hourly_wb
- sfm_hourly_eu
- sim_annual
- sim_hourly_wb
- sim_hourly_eu
- curr_msr_mat
- peakperspec
- wts_res_vintage
- wts_res_loc
- wts_res_building
- wts_res_hvac

- NumStor
- NumBldg
- AppXMsrWts (optional)

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 set 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.

The default schema name provided in the queries is "MC_Results_Database." If a different schema name is used, replace this with the correct name. An example script setup for P1 is shown in Figure 38 with the schema name "MC_Results_Database".

Example: Residential P1-Create-sim_peakper.sql

```
-- Create the simulation peak period demand value table from the hourly data table.
-- Whole Building kw: PeakDay 2 - 5 (previous DEER), 4 - 9 (DEER2020) on 3-day
Heatwave
-- Time Estimate: 600 seconds
SET search_path TO "MC_results_database";
DROP TABLE IF EXISTS sim_peakper;
CREATE TABLE sim_peakper AS
SELECT "TechID","SizingID","BldgType","BldgVint",sim_hourly_wb_wtd."BldgLoc" as
"BldgLoc","BldgHVAC",
       round(((Sum(hr14)+Sum(hr15)+Sum(hr16))/9)::NUMERIC(15,3),3) as bldg_kw25,

round(((Sum(hr16)+Sum(hr17)+Sum(hr18)+Sum(hr19)+Sum(hr20))/15)::NUMERIC(15,3),3) as
bldg_kw49
 FROM sim_hourly_wb_wtd
 JOIN peakperspec ON sim_hourly_wb_wtd."BldgLoc" = peakperspec."BldgLoc"
 WHERE ((daynum::smallint = "PkDay"::smallint) or (daynum::smallint =
"PkDay"::SMALLINT+1) or (daynum::smallint = "PkDay"::SMALLINT+2))-- and
enduse::SMALLINT = 20
 GROUP BY
"TechID","SizingID","BldgType","BldgVint",sim_hourly_wb_wtd."BldgLoc","BldgHVAC";
```

"MC_results_database" = name of Schema in PostgreSQL database

**Figure 38. schema name in the query example**

The following steps should be followed in order to develop the final measure savings values. **Refer to Step 6 and Step 7 of section 2.2.1.2 on using the query tool to run these scripts.** The queries can be found in the support documents. **Note: that there are two different sets of P1 thru P9 queries: one set is for commercial measures and the other is for residential measures. The two query-sets are provided in commercial and residential folders, respectively.**

### 2.2.5 Commercial building post-processing steps

The following steps should be followed in order to develop the final measure savings values. (**Refer to Step 6 and Step 7 of section 2.2.1.2 on using the query tool to run these scripts.**) The queries can be found in the support documents. **Note: that there are two different sets of P1 thru P9 queries: one set is for commercial measures and the other is for residential measures. The two query-sets are provided in commercial and residential folders, respectively.**

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** and **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** and **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** and **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.

7. PA-Consolidation (**P10_PA_correction_electric** or **P10_PA_correction_gas**): This is an added step since DNV started to manage the DEER database. This query picks certain PA/Utility that represent a climate-zone for all climate-zones and changes the PA flag to "Any". This creates PA/Utility agnostic records and eliminates PA-specific records. These updated PA-agnostic records are inserted into the existing output of the previous script. Using the "electric" or "gas" script will

depend if the measure is predominately impacting electric savings or gas savings. The MeasureID is usually an indicator, where it starts with "NE-" if electric, "NG-" if gas.

Table 2-1 organizes the above steps in tabular format, with each step's detail input and output noted.

**Table 2-1. Descriptions of SQLite Post-processing Scripts for Commercial DEER2020 MASControl3 Measures**

| Script | Purpose | Input(s) | Weight(s) | Output(s) |
|---|---|---|---|---|
| **P1** | Determine peak kW usage for each *TechID* | **sim_hourly_wb.csv** (MC3 output file 1 of 3) contains hourly usage data (24w x 365h array) for each combination (*TechID*, *BldgType*, *BldgLoc*, *BldgVint*, & *BldgHVAC*) | **peakperspec** table that defines peak days for each climate zone and peak period between 5 - 9 p.m. | **sim_peakper** table contains kW usage for each combination (*TechID*, *BldgType*, *BldgLoc*, *BldgVint*, & *BldgHVAC*) |
| **P2** | Generate *TechID* permutations for future **EnergyImpact** table | **sim_annual.csv** (MC3 output file 2 of 3) and **current_msr_mat.csv** (MC3 output file 3 of 3) and **sim_peakper** table | | **meas_impacts** table that mimics the **EnergyImpact** table for each combination (*BldgType*, *BldgLoc*, *BldgVint*, & *BldgHVAC*), but without any weighted records |
| **P3** | Generate weighted UES at the *BldgVint*=Era level (part 1 of 2) | **meas_impacts** table | **wts_com_vintage** contains combinations of *pa*, *BldgType*, *BldgLoc*, *BldgVint*, *Era*, and *wt_vint* | **meas_impacts_tmp** table (includes temporary field called *wt_vint*) contains the product of the weights and impacts |
| **P4** | Generate weighted UES at the *BldgVint*=Era level (part 2 of 2) | **meas_impacts_tmp** table | | **meas_impacts_wtd** table (with **meas_impacts_tmp**—divided by sum of *wt_vint*—recorded added as *BldgVint=Era*) |
| **P5** | Generate weighted UES at the *BldgLoc*=Any level (part 1 of 2) | **meas_impact_wtd** table | **wts_com_loc** contains combinations of *pa*, *BldgType*, *BldgLoc*, *Era* and *sum_loc* (later named *wt_loc*) | **meas_impacts_tmp2** table (includes temporary field called *wt_loc*) contains the product of the weights and the impacts |
| **P6** | Generate weighted UES at the *BldgLoc*=Any level (part 2 of 2) | **meas_impact_tmp2** table | | **meas_impacts_wtd** table (with **meas_impacts_tmp2**—divided by sum of *wt_loc*—records added as *BldgLoc*=Any) |
| **P7** | Generate weighted UES at the *BldgType*=Any level (part 1 of 2) | **meas_impacts_wtd** table | **wts_com_bldg** contains *pa*, *BldgType*, *era*, *BldgLoc*, and *sum_bldg* (later named *wt_bldg)* | **meas_impacts_tmp3** table (includes temporary field called *wt_bldg*) contains the product of the weights and the impacts |
| **P8** | Generate weighted UES at the *BldgType*=Any level (part 1 of 2) | **meas_impacts_tmp3** table | | **meas_impacts_wtd** table (with **meas_impacts_tmp3**—divided by sum of *wt_bldg*—records added as *BldgType*=Com) |
| **P9** | Round all UES values to three significant digits | **meas_impacts_wtd** table | | **meas_impacts_2020_com** table |
| **P10** | Generate weighted UES at the *PA* = Any level (PA-consolidation) | **meas_impacts_2020_com** table | | **meas_impacts_2020_com** table |

### 2.2.6 Residential building post-processing steps

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. (**Refer to Step 6 and Step 7 of section 2.2.1.2 on using the query tool to run these scripts.**) The additional queries can be found in the support documents. **Note: for the residential process, R1 thru R4 should be run first, then P1 to P9. The P1 thru P9 in this case, is specific to the residential results. The two different sets of P1 thru P9 are organized in commercial and residential folder, respectively.**

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.
5. Create Peak Period values (**P1-CreateSimPeakTable**)
6. Create Measure Impacts (**P2-Calc_MsrImpacts**)
7. Create Vintage-weighted Results (**P3-VintMult** and **P4-SimVint**)
8. Create Location-weighted Results (**P5-LocMult** and **P6-SumLoc**)
9. Create Building-weighted Results (**P7-BldgMult** and **P8-SumBldg**)
10. Create the Ex-Ante formatted Results (**P9-roundDEER**)

11. (only applies for certain measures with different BldgHVAC types) Create HVAC-weighted Results (**P10-1, HVAC_weighted_mult** and **P10-2, HVAC_weighted_sum**): This is an added step since DNV started to manage the DEER database. These queries use the meas_impacts_2020_reshvac table and the HVAC weights table to create the HVAC-weighted results. The first query creates a temporary table of results based on the meas_impacts_2020_reshvac table multiplied by the associated weight. The second query sums the values from the temporary table and adds that data to new table called meas_impacts_2020_res_new (along with the original data in meas_impacts_2020_reshvac).

12. PA-Consolidation (**P11_PA_correction_electric** / **P11_PA_correction_gas**): This is an added step since DNV started to manage the DEER database. This query picks certain PA/Utility that represent a climate-zone for all climate-zones and changes the PA flag to "Any". This creates PA/Utility agnostic records and eliminates PA-specific records. These updated PA-agnostic records are inserted into the existing output of the previous script. Using the "electric" or "gas" script will depend if the measure is predominately impacting electric savings or gas savings. The MeasureID is usually an indicator, where it starts with "RE-" if electric, "RG-" if gas.

Table 2-2 organizes the above steps in tabular format, with each step's detail input and output noted.

**Table 2-2. Descriptions of SQLite Post-processing Scripts for Residential DEER2020 MASControl3 Measures**

| Script | Purpose | Input(s) | Weight(s) | Output(s) |
|---|---|---|---|---|
| **R1** | Generates weighted average of single- and two-story SFm annual kWh records and combines those with the records for DMo and MFm annual kWh records. Then all records are permuted and multiplied by the T-stat weights. | **sfm_annual** table includes total annual energy usage for single- and two-story SFm homes; **sim_annual** table includes only single-story DMo and MFm homes | **reststatwt** and **numstor** tables | **sim_annual_twtd** table |
| **R2** | Generates weighted average of single- and two-story SFm hourly kW and combines those with the records for DMo and MFm hourly kW records. Then all records are permuted and multiplied by the T-stat weights. | **sfm_hourly_wb** and **sim_hourly_wb** tables contain hourly usage data (24w x 365h array) for each combination (*TechID*, *BldgType*, *BldgLoc*, *BldgVint*, & *BldgHVAC*) | **reststatwt** and **numstor** tables | **sim_hourly_twtd** table |
| **R3** | Averages the annual kWh records across the five T-stats and divides by the number of modeled dwellings. | **sim_annual_twtd** table | **numbldgs** table | **sim_annual_wtd** table produced by dividing **sim_annual_twtd** records by **numbldgs** weights. |
| **R4** | Averages the hourly kW records across the five T-stats and divides by the number of modeled dwellings. | **sim_hourly_twtd** table | **numbldgs** table | **sim_hourly_wtd** table produced by dividing |

| Script | Purpose | Input(s) | Weight(s) | Output(s) |
|---|---|---|---|---|
| **P1** | Determine peak kW usage for each *TechID* | **sim_hourly_wtd** table | **peakperspec** table that defines peak days for each climate zone and peak period between 5 - 9 pm | **sim_peakper** table contains kW usage for each combination (*TechID*, *BldgType*, *BldgLoc*, *BldgVint*, & *BldgHVAC*) |
| **P2** | Generate *TechID* permutations for future **EnergyImpact** table | **sim_annual.csv** (MC3 output file 2 of 3) and **current_msr_mat.csv** (MC3 output file 3 of 3) and **sim_peakper** table | | **meas_impacts** table that mimics the **EnergyImpact** table for each combination (*BldgType*, *BldgLoc*, *BldgVint*, & *BldgHVAC*), but without any weighted records |
| **P3** | Generate weighted UES at the *BldgVint*=Era level (part 1 of 2) | **meas_impacts** table | **wts_res_vintage** contains combinations of *pa*, *BldgType*, *BldgLoc*, *BldgVint*, *Era*, and *wt_vint* | **meas_impacts_tmp** table (includes temporary field called *wt_vint*) contains the product of the weights and impacts |
| **P4** | Generate weighted UES at the *BldgVint*=Era level (part 2 of 2) | **meas_impacts_tmp** table | | **meas_impacts_wtd** table (with **meas_impacts_tmp**—divided by sum of *wt_vint*—recorded added as *BldgVint*=*Era*) |
| **P5** | Generate weighted UES at the *BldgLoc*=Any level (part 1 of 2) | **meas_impact_wtd** table | **wts_res_loc** contains combinations of *pa*, *BldgType*, *BldgLoc*, *Era* and *sum_loc* (later named *wt_loc*) | **meas_impacts_tmp2** table (includes temporary field called *wt_loc*) contains the product of the weights and the impacts |
| **P6** | Generate weighted UES at the *BldgLoc*=Any level (part 2 of 2) | **meas_impact_tmp2** table | | **meas_impacts_wtd** table (with **meas_impacts_tmp2**—divided by sum of *wt_loc*—records added as *BldgLoc*=Any) |
| **P7** | Generate weighted UES at the *BldgType*=Any level (part 1 of 2) | **meas_impacts_wtd** table | **wts_res_bldg** contains *pa*, *BldgType*, *era*, *BldgLoc*, and *sum_bldg* (later named *wt_bldg)* | **meas_impacts_tmp3** table (includes temporary field called *wt_bldg*) contains the product of the weights and the impacts |
| **P8** | Generate weighted UES at the *BldgType*=Any level (part 1 of 2) | **meas_impacts_tmp3** table | | **meas_impacts_wtd** table (with **meas_impacts_tmp3**—divided by sum of *wt_bldg*—records added as *BldgType*=Com) |
| **P9** | Round all UES values to three significant digits | **meas_impacts_wtd** table | | **meas_impacts_2020_reshvac** table |
| **P10-1, P10-2** | Generate weighted UES at the *BldgType*=Any level | **meas_impacts_2020_reshvac** table | **wts_res_hvac** contains *pa*, *BldgType*, *BldgLoc*, *BldgHVAC*, and *wtval* (later named *wt_hvac*) | **meas_impacts_2020_res_new** table |
| **P11** | Generate weighted UES at the *PA* = Any level (PA-consolidation) | **meas_impacts_2020_res_new** table | | **meas_impacts_2020_res_new** table |

### 2.2.7 Output Table Export from PostgreSQL Post-processing

After the post-processing has been finished, the desired output from the final step of the last query applied should be exported into csv format.

To export a table out of PostgreSQL environment (specifically for the pgAdmin interface), execute the following steps.

1. In the desired directory, create a new excel file by right-clicking, and rename it to the designated output table, with the .csv suffix. This essentially creates a "blank" excel csv file, with the desired filename. (Figure 39)

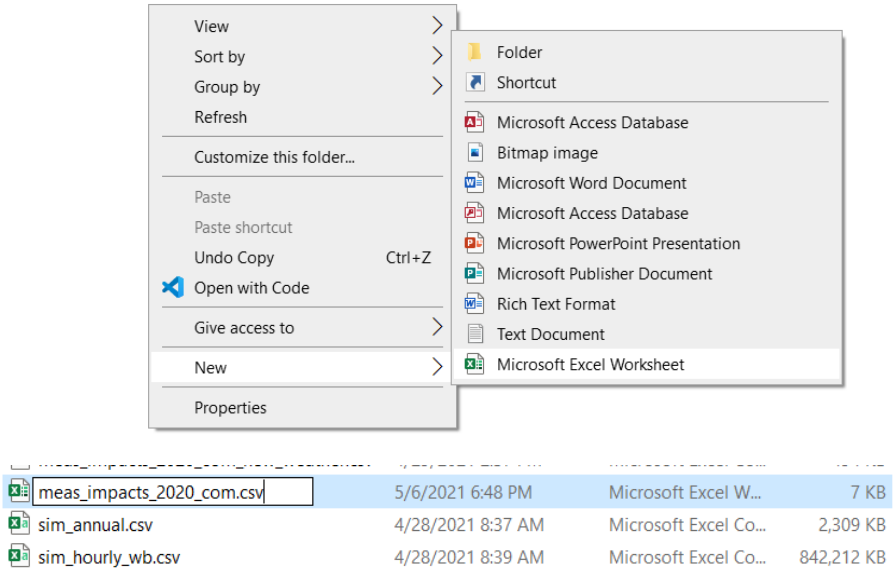



**Figure 39. Create a Blank Excel File for export**

2. In the PostgreSQL interface, right-click on the table name and select "Import/Export" (Figure 40). This time make sure the "Import/Export" option is set to "Export". Select the "blank" table from the appropriate directory created in the previous step. When the prompt asked "Are you sure you want to replace this file", click "Yes" (Figure 41).

3. Toggle the "header" option to "Yes", and set "Delimiter" to comma (,), leave all other options as default. See Figure 42 for the settings described in this step.

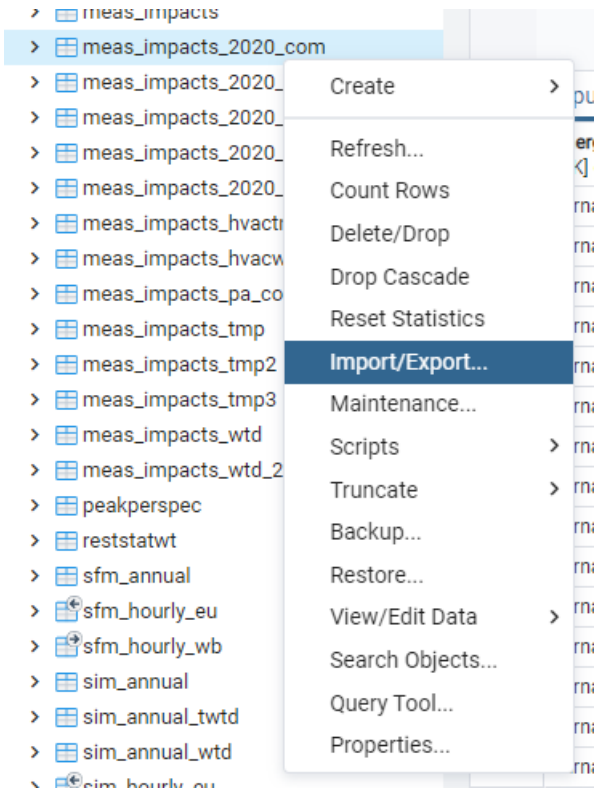



**Figure 40. Import/Export option**

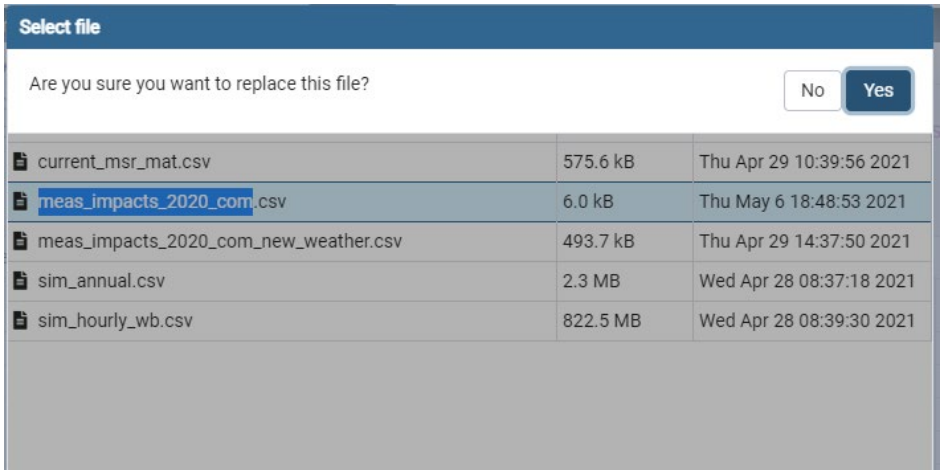



**Figure 41. Overwrite Confirmation**

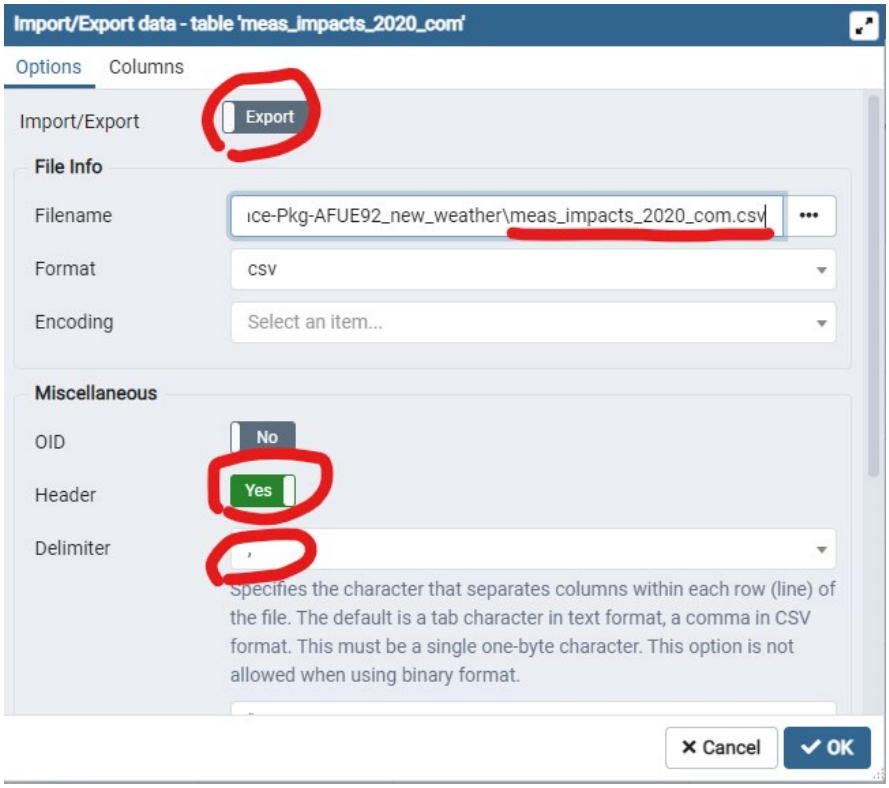



**Figure 42. Export Data Settings**

4. A progress/status window should pop-up and indicate that the export is in-progress/complete, as shown in Figure 43. The blank table created previously will be then "overwritten" with the data from the designated table from the PostgreSQL environment, thus completing the data export.

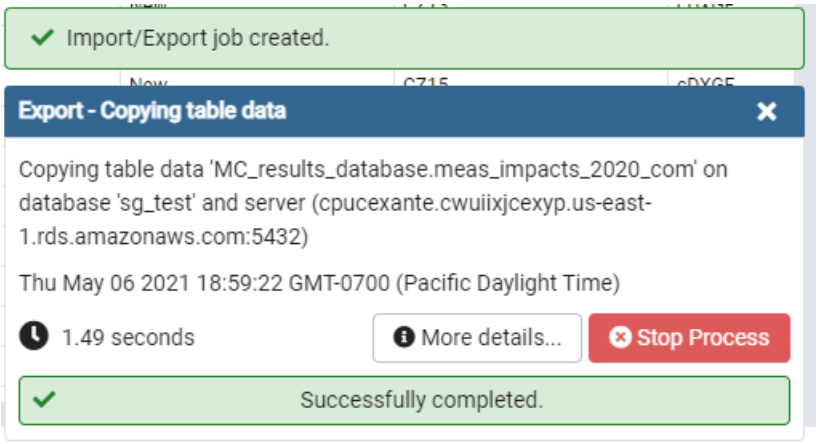



**Figure 43. Export Status Window**

5. Any table in the PostgreSQL schema can be exported into csv format using this manner, if the need arises.

# 3
# 3

# 3 MASControl3 technology and measure development

## 3.1 Set-up

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_Workbooks 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.

## 3.2 Background

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

- Measure Case: this is the improved efficiency condition.
- Pre-Existing Baseline Case: this is the condition of the building before measure installation.
- 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 list of parameters that are applicable to a TechType is defined in the TechType sheet of the tech data workbooks. 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.

## 3.3 Creating new measures using existing TechTypes

1. First check to see if Technologies already exist to support the new measures
    a. In the MC2020.db 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 MeasureApplicability 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".

## 3.4 Adding new technologies

1. Identify the appropriate Technology workbook to contain the new technologies as shown in Table 3-1

**Table 3-1. Workbooks and Technologies**

| Workbook | Technologies |
|---|---|
| TechData_PkgHVAC.xlsm | DX AC and HP efficiencies |
| TechData_MscHVAC.xlsm | Miscellaneous HVAC, incl. fan control, economizer |
| TechData_DHW.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.
3. If a new TechType is needed, then follow the instructions to "Add a new TechType".
4. 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.
5. 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.
6. Add rows to the TechData sheet to make space for the new Technologies
7. Copy formulas from an existing Technology for TechType#, GroupCode, and Tech Type Description
8. Enter TechTypeID

9. Enter TechID (this is typically built with a formula based on key Parameter values)
10. Enter Parameter values

## 3.5 Adding new measures

### 3.5.1 Measure and baseline cases

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

### 3.5.2 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)
    c. Use of MultiTech reference IDs (can be used in conjunction with VariTech reference IDs)
    d. Use this if a measure case is defined as a combination of technologies (e.g. HVAC Maintenance = Refrigerant Charge Adjustment + Duct Sealing)

### 3.5.3 Applicabilities

1. A measure can be specified as applicable based on BldgType, Vintage, HVAC type, and Climate Zone
    a. Each category has an "Any" column to select all items in that group

## 3.6 Adding VariTech data to non-Tech 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"

## 3.7 Adding new TechTypes

1. Add new row to appropriate TechType table (see "Add New Technologies")
2. Check if desired Technology Parameters already exist

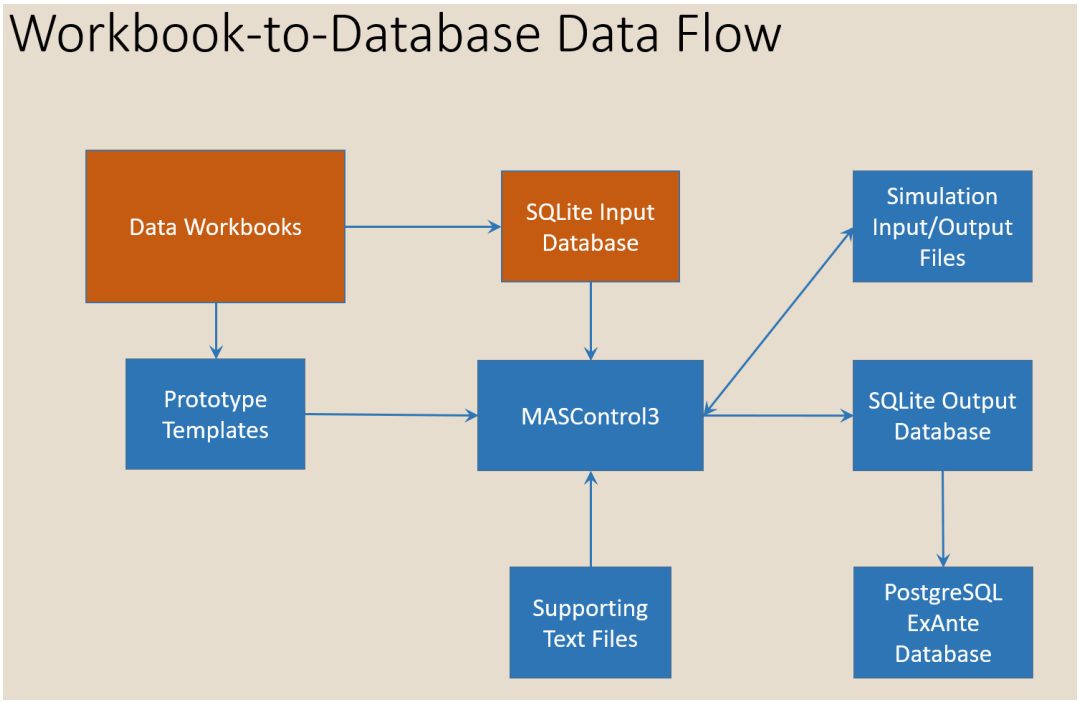
a. If the desired Parameter name is defined in a different Technology workbook, the definition needs to be the same for the new implementation

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

## 3.8 Adding a new DEER measure (with existing measure type)

A high-level overview of the data workflow is provided in Figure 44.



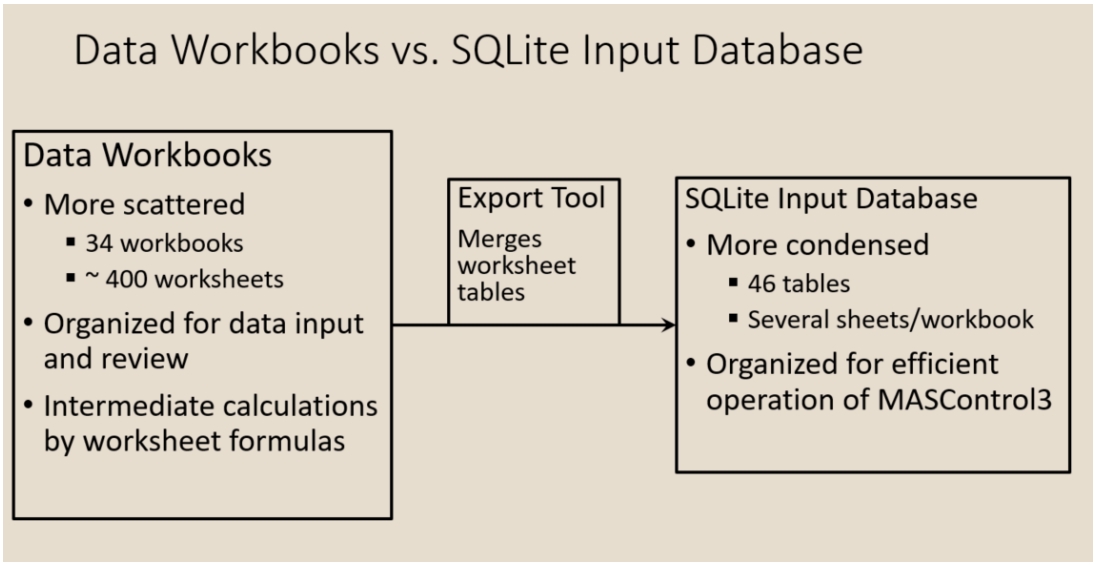




**Figure 44. Data flow, high level view**

A lot of the detailed parameters and data resides in the data workbook side, which are all contained in the package "MC3_Workbooks". Data in the workbooks are more scattered, detailed, and arranged categorically. The database site is more abstract/linear and is set up to be optimized for MasControl3 runs. Data from workbooks get translated to the SQLite input database (MC2020.db) via an excel-macro tool. Within "MC3_Workbooks", there are several sub-folders, each containing data workbooks (shown in Figure 45):

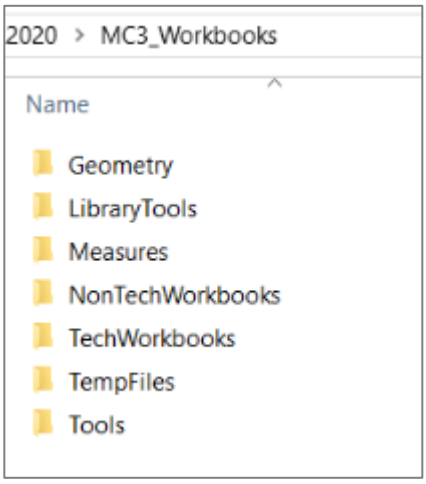



**Figure 45. MASControl3 Workbooks**

- **Geometry**: create prototype templates
- **LibraryTools**: Utilities to create UsrLib.dat file
- **Measures**
  - Technology assignments for each measure
  - Applicability of measures (Bldg. Type, Location, Climate, HVAC type)
  - Normalization units
- **NonTechWorkbooks**
  - Build list of non-tech parameters for prototypes
  - Build list of TechIDs for prototypes
  - Build VariTech lists of TechIDs for measures
- **TechWorkbooks**
  - Contain data for all Technologies
- **TempFiles**: location for temporary intermediate files for data transfer
- **Tools**: Utility workbook to transfer data to SQLite database

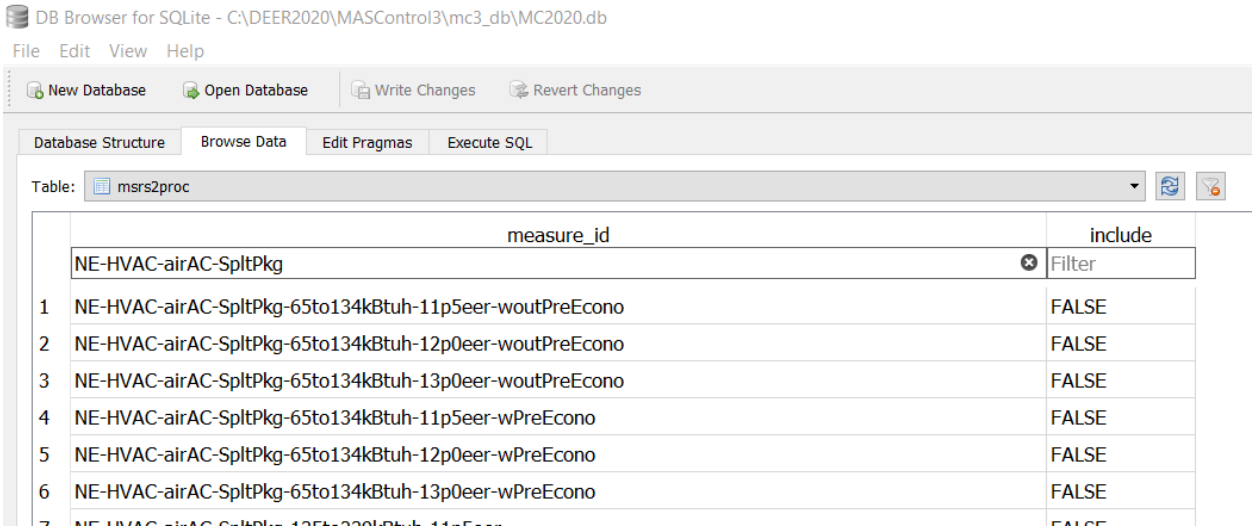
Example measures to be added:

- NE-HVAC-airAC-SpltPkg-65to134kBtuh-12p5eer-woutPreEcono
- NE-HVAC-airAC-SpltPkg-65to134kBtuh-12p5eer-wPreEcono

These two new measures are not in the original MC3 database and needed to be added and simulated as part of the DEER2020 effort, the process is described here for documentation.

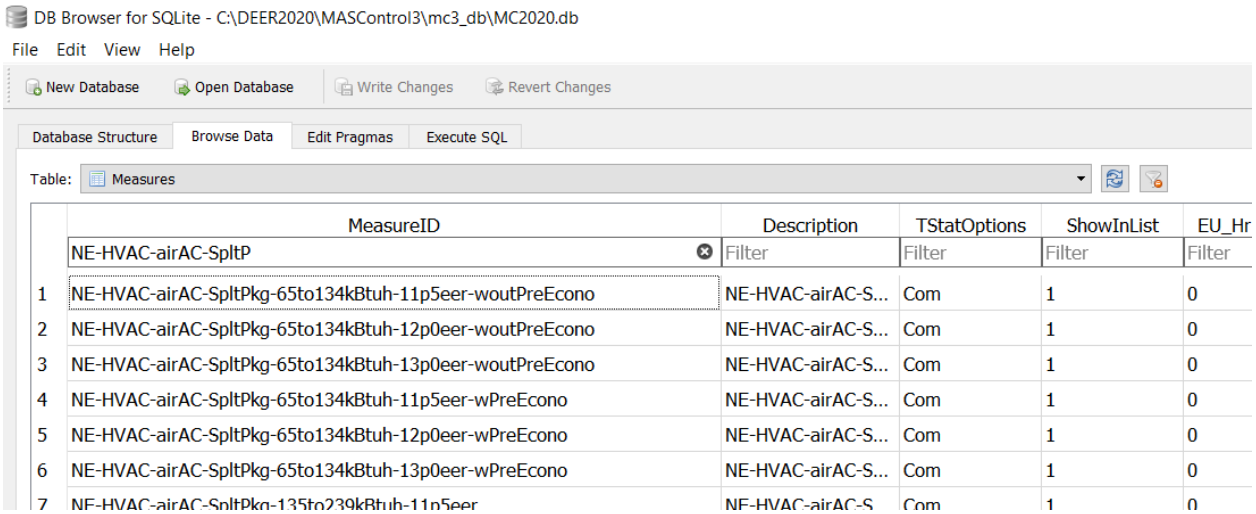
Note: for adding new measures where new technology is not already in the database, refer to the **MASControl3_Training_AF.pptx** slides, slide #72.

A quick check from the msrs2proc table (Figure 46) and Measures table (Figure 47) in the input database MC2020.db shows similar measure but with different metrics (the 12p0eer variants) exists in the database. Therefore, new technology types do not need to be created prior to creating the new measure run.




| | measure_id | include |
|---|---|---|
| | NE-HVAC-airAC-SpltPkg | Filter |
| 1 | NE-HVAC-airAC-SpltPkg-65to134kBtuh-11p5eer-woutPreEcono | FALSE |
| 2 | NE-HVAC-airAC-SpltPkg-65to134kBtuh-12p0eer-woutPreEcono | FALSE |
| 3 | NE-HVAC-airAC-SpltPkg-65to134kBtuh-13p0eer-woutPreEcono | FALSE |
| 4 | NE-HVAC-airAC-SpltPkg-65to134kBtuh-11p5eer-wPreEcono | FALSE |
| 5 | NE-HVAC-airAC-SpltPkg-65to134kBtuh-12p0eer-wPreEcono | FALSE |
| 6 | NE-HVAC-airAC-SpltPkg-65to134kBtuh-13p0eer-wPreEcono | FALSE |

**Figure 46. msrs2proc table, similar measures**




| | MeasureID | Description | TStatOptions | ShowInList | EU_Hr |
|---|---|---|---|---|---|
| | NE-HVAC-airAC-SpltP | Filter | Filter | Filter | Filter |
| 1 | NE-HVAC-airAC-SpltPkg-65to134kBtuh-11p5eer-woutPreEcono | NE-HVAC-airAC-S... | Com | 1 | 0 |
| 2 | NE-HVAC-airAC-SpltPkg-65to134kBtuh-12p0eer-woutPreEcono | NE-HVAC-airAC-S... | Com | 1 | 0 |
| 3 | NE-HVAC-airAC-SpltPkg-65to134kBtuh-13p0eer-woutPreEcono | NE-HVAC-airAC-S... | Com | 1 | 0 |
| 4 | NE-HVAC-airAC-SpltPkg-65to134kBtuh-11p5eer-wPreEcono | NE-HVAC-airAC-S... | Com | 1 | 0 |
| 5 | NE-HVAC-airAC-SpltPkg-65to134kBtuh-12p0eer-wPreEcono | NE-HVAC-airAC-S... | Com | 1 | 0 |
| 6 | NE-HVAC-airAC-SpltPkg-65to134kBtuh-13p0eer-wPreEcono | NE-HVAC-airAC-S... | Com | 1 | 0 |
| 7 | NE-HVAC-airAC-SpltPkg-135to239kBtuh-11p5eer | NE-HVAC-airAC-S | Com | 1 | 0 |

**Figure 47. Measures table, similar measures**

A general workflow for adding a new commercial measure goes like this:

1. Add row to TechData sheet in Technology workbook
2. Add row to DEER_NonRes_Measures.xlsm
    a. Use existing similar SpltPkg measure as starting point
    b. Enter alternate TechID in new row (if needed)

c. Change applicabilities (if needed)

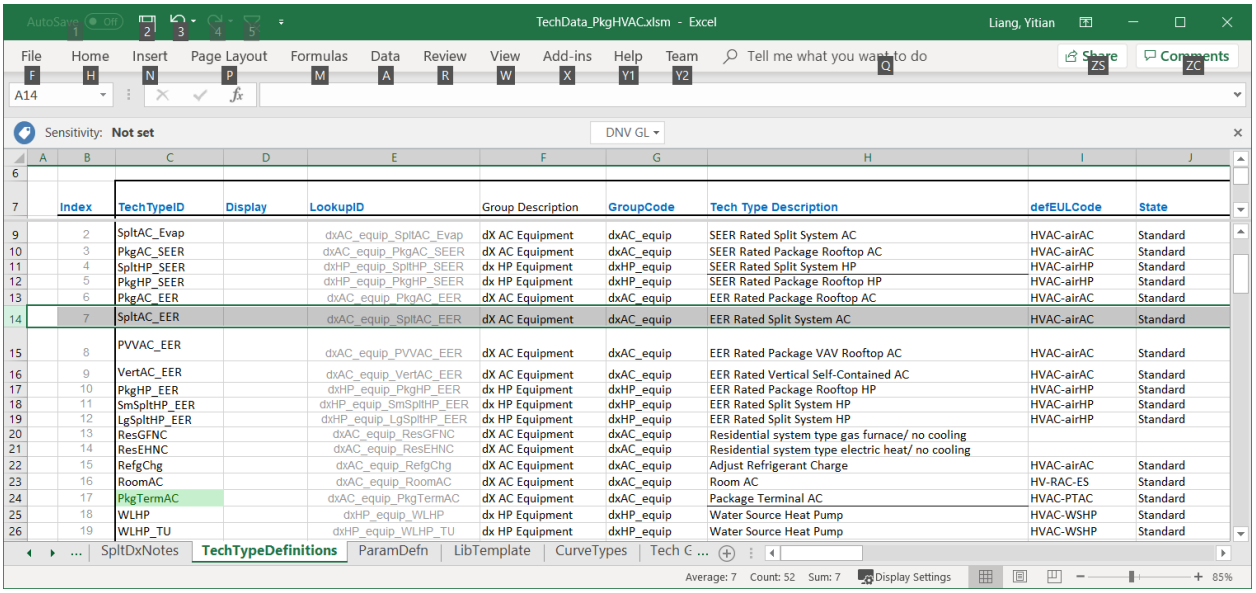
3. Import from workbooks to database
    a. Tech Tables
    b. Measure Tables
4. Update msrs2proc
5. Re-build Database from MASControl3
    a. Convert Msr Nulls
    b. Expand Database

These steps are described in the following sections in more detail.

### 3.8.1 Adding New Technology

Referring to "Add New Technologies" section, the specific measure(s) of interest would have relevant technologies in the "TechData_PkgHVAC.xlsm" workbook in the TechWorkbooks folder.

In this workbook, check the "TechTypeDefinitions" tab (shown in Figure 48) to see whether the desired measure technology already exists as a tab in this workbook. In this case, EER Rated Split System AC does exist here.




| Index | TechTypeID | Display | LookupID | Group Description | GroupCode | Tech Type Description | defEULCode | State |
|---|---|---|---|---|---|---|---|---|
| 2 | SpltAC_Evap | | dxAC_equip_SpltAC_Evap | dX AC Equipment | dxAC_equip | SEER Rated Split System AC | HVAC-airAC | Standard |
| 3 | PkgAC_SEER | | dxAC_equip_PkgAC_SEER | dX AC Equipment | dxAC_equip | SEER Rated Package Rooftop AC | HVAC-airAC | Standard |
| 4 | SpltHP_SEER | | dxHP_equip_SpltHP_SEER | dx HP Equipment | dxHP_equip | SEER Rated Split System HP | HVAC-airHP | Standard |
| 5 | PkgHP_SEER | | dxHP_equip_PkgHP_SEER | dx HP Equipment | dxHP_equip | SEER Rated Package Rooftop HP | HVAC-airHP | Standard |
| 6 | PkgAC_EER | | dxAC_equip_PkgAC_EER | dX AC Equipment | dxAC_equip | EER Rated Package Rooftop AC | HVAC-airAC | Standard |
| 7 | SpltAC_EER | | dxAC_equip_SpltAC_EER | dX AC Equipment | dxAC_equip | EER Rated Split System AC | HVAC-airAC | Standard |
| 8 | PVVAC_EER | | dxAC_equip_PVVAC_EER | dX AC Equipment | dxAC_equip | EER Rated Package VAV Rooftop AC | HVAC-airAC | Standard |
| 9 | VertAC_EER | | dxAC_equip_VertAC_EER | dX AC Equipment | dxAC_equip | EER Rated Vertical Self-Contained AC | HVAC-airAC | Standard |
| 10 | PkgHP_EER | | dxHP_equip_PkgHP_EER | dx HP Equipment | dxHP_equip | EER Rated Package Rooftop HP | HVAC-airHP | Standard |
| 11 | SmSpltHP_EER | | dxHP_equip_SmSpltHP_EER | dx HP Equipment | dxHP_equip | EER Rated Split System HP | HVAC-airHP | Standard |
| 12 | LgSpltHP_EER | | dxHP_equip_LgSpltHP_EER | dx HP Equipment | dxHP_equip | EER Rated Split System HP | HVAC-airHP | Standard |
| 13 | ResGFNC | | dxAC_equip_ResGFNC | dX AC Equipment | dxAC_equip | Residential system type gas furnace/ no cooling | | |
| 14 | ResEHNC | | dxAC_equip_ResEHNC | dX AC Equipment | dxAC_equip | Residential system type electric heat/ no cooling | | |
| 15 | RefgChg | | dxAC_equip_RefgChg | dX AC Equipment | dxAC_equip | Adjust Refrigerant Charge | HVAC-airAC | Standard |
| 16 | RoomAC | | dxAC_equip_RoomAC | dX AC Equipment | dxAC_equip | Room AC | HV-RAC-ES | Standard |
| 17 | PkgTermAC | | dxAC_equip_PkgTermAC | dX AC Equipment | dxAC_equip | Package Terminal AC | HVAC-PTAC | Standard |
| 18 | WLHP | | dxHP_equip_WLHP | dx HP Equipment | dxHP_equip | Water Source Heat Pump | HVAC-WSHP | Standard |
| 19 | WLHP_TU | | dxHP_equip_WLHP_TU | dx HP Equipment | dxHP_equip | Water Source Heat Pump | HVAC-WSHP | Standard |

**Figure 48. TechType Definition**

In the same workbook, the worksheet "EERDxTechData" contains the relevant technologies for the measure(s) of interest (NE-HVAC-airAC-SpltPkg-65to134kBtuh-12p5eer), therefore, no new technology row needs to be added. This is shown in Figure 49.

For other measures which require new technologies to be added, refer to the "Add New Technologies" section.

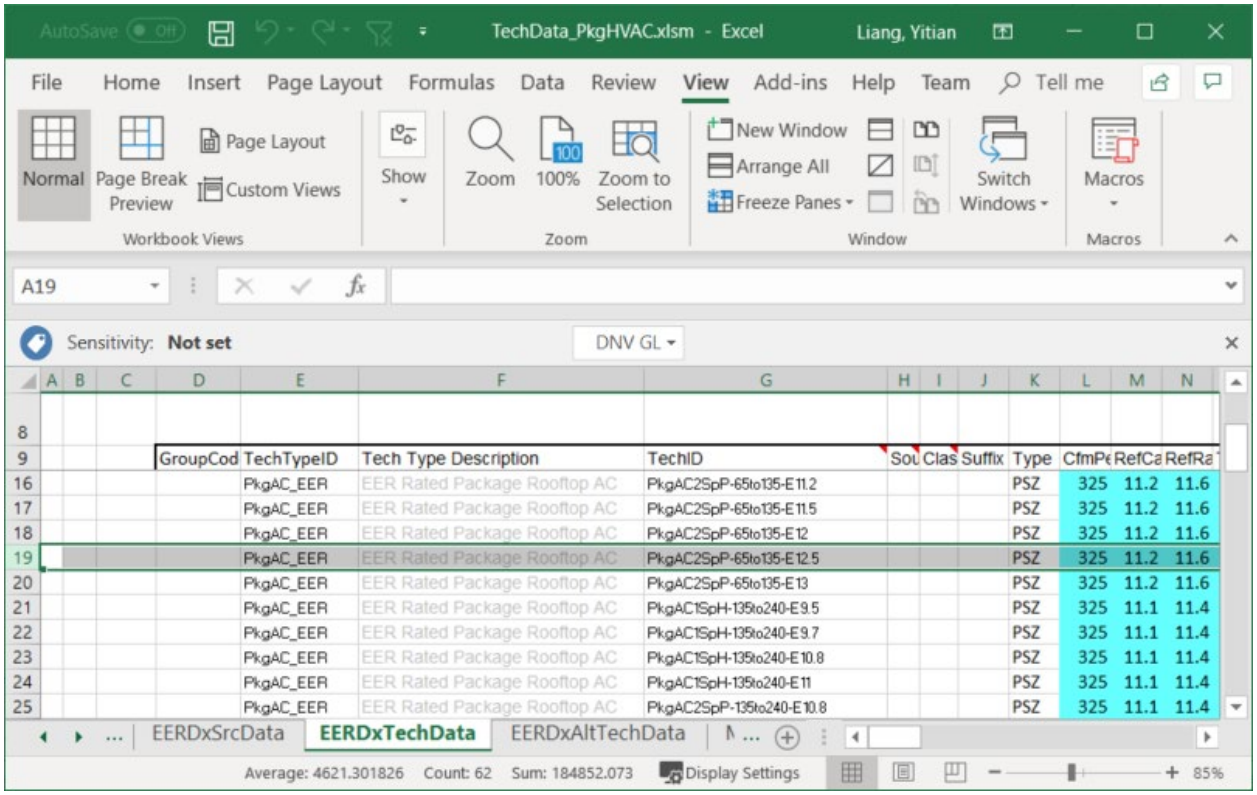



**Figure 49. TechData_PkgHVAC to check for existing technologies**

### 3.8.2 Adding Row to DEER_NonRes_Measures.xlsm

The DEER_NonRes_Measures.Xlsm workbook is in the Measures folder. In this workbook, go to the Measures tab, which shows the list of current NonRes measures in the database, and all of their corresponding technology parameters, IDs, etc.

To add the two new measures variants, it is best to copy rows of existing measures and edit the varying parameters as needed. Here, we locate the existing 12p0 EER measures (Figure 50) :

| | | | Use these columns for text strings to build into Msr IDs and TechIDs | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | ID_part1 | ID_part2 | ID_part3 | ID_part4 | ID_part5 | ID_part6 | ID_part7 | |
| Name | MeasureID | Description | | | | | | | | |
| | Com-lltg-dWatt-LF-All | Com Lighting Non-IE Basis-LF-All | All | LF | | | | | | |
| | NE-HVAC-airHP-Pkg-55to65kBtuh-16p0seer-8p5hspf-wPreEcono | NE-HVAC-airHP-Pkg-55to65kBtuh-16p | Pkg | HP | 55to65 | 2 | 16 | Yes | Yes | 8.5 |
| | NE-HVAC-airHP-Pkg-55to65kBtuh-17p0seer-9p0hspf-wPreEcono | NE-HVAC-airHP-Pkg-55to65kBtuh-17p | Pkg | HP | 55to65 | 2 | 17 | Yes | Yes | 9 |
| | | | | | msr sz | pmap sz | EER | PreEcono | msr mot | pmap type |
| | NE-HVAC-airAC-SpltPkg-65to134kBtuh-11p5eer-woutPreEcono | NE-HVAC-airAC-SpltPkg-65to134kBtuh | SpltPkg | AC | 65to134 | 65to135 | 11.5 | ByVint | P | Pkg |
| | NE-HVAC-airAC-SpltPkg-65to134kBtuh-12p0eer-woutPreEcono | NE-HVAC-airAC-SpltPkg-65to134kBtuh | SpltPkg | AC | 65to134 | 65to135 | 12 | ByVint | P | Pkg |
| | NE-HVAC-airAC-SpltPkg-65to134kBtuh-13p0eer-woutPreEcono | NE-HVAC-airAC-SpltPkg-65to134kBtuh | SpltPkg | AC | 65to134 | 65to135 | 13 | ByVint | P | Pkg |
| | NE-HVAC-airAC-SpltPkg-65to134kBtuh-11p5eer-wPreEcono | NE-HVAC-airAC-SpltPkg-65to134kBtuh | SpltPkg | AC | 65to134 | 65to135 | 11.5 | Yes | P | Pkg |
| | NE-HVAC-airAC-SpltPkg-65to134kBtuh-12p0eer-wPreEcono | NE-HVAC-airAC-SpltPkg-65to134kBtuh | SpltPkg | AC | 65to134 | 65to135 | 12 | Yes | P | Pkg |
| | NE-HVAC-airAC-SpltPkg-65to134kBtuh-13p0eer-wPreEcono | NE-HVAC-airAC-SpltPkg-65to134kBtuh | SpltPkg | AC | 65to134 | 65to135 | 13 | Yes | P | Pkg |
| | NE-HVAC-airAC-SpltPkg-135to239kBtuh-11p5eer | NE-HVAC-airAC-SpltPkg-135to239kBtu | SpltPkg | AC | 135to239 | 135to24( | 11.5 | NA | P | Pkg |

**Figure 50. Similar measures and parameters noted in DEER_NonRes_Measures.xlsm.**

The only difference between the "wPreEcono" and "woutPreEcono" variant is the field ID_part6 column, dubbed "PreEcono" for this specific set of measures, where if the measure does not include the pre-economizer, the field will be "ByVint", otherwise, the field will be "Yes". Also, for a 12p5 variant, the "EER" field will need to be changed from 12 to 12.5.

To add the new measure rows, copy these two existing rows and make the appropriate edits to EER and PreEcono field. (Keep all other fields the same). The MeasureID should update to fit the EER/Economizer settings. (Figure 51)

| Notes | | | Use these columns for text strings to build into Msr IDs and TechIDs | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Notes | | | ID_part1 | ID_part2 | ID_part3 | ID_part4 | ID_part5 | ID_part6 | ID_part7 | |
| VarName | MeasureID | Description | | | | | | | | |
| | Com-lltg-dWatt-LF-All | Com Lighting Non-IE Basis-LF-All | All | LF | | | | | | |
| | NE-HVAC-airHP-Pkg-55to65kBtuh-16p0seer-8p5hspf-wPreEcono | NE-HVAC-airHP-Pkg-55to65kBtuh-16p | Pkg | HP | 55to65 | 2 | 16 | Yes | Yes | 8.5 |
| | NE-HVAC-airHP-Pkg-55to65kBtuh-17p0seer-9p0hspf-wPreEcono | NE-HVAC-airHP-Pkg-55to65kBtuh-17p | Pkg | HP | 55to65 | 2 | 17 | Yes | Yes | 9 |
| | | | | | msr sz | pmap sz | EER | PreEcono | msr mot | pmap type |
| | NE-HVAC-airAC-SpltPkg-65to134kBtuh-11p5eer-woutPreEcono | NE-HVAC-airAC-SpltPkg-65to134kBtuh | SpltPkg | AC | 65to134 | 65to135 | 11.5 | ByVint | P | Pkg |
| | NE-HVAC-airAC-SpltPkg-65to134kBtuh-12p0eer-woutPreEcono | NE-HVAC-airAC-SpltPkg-65to134kBtuh | SpltPkg | AC | 65to134 | 65to135 | 12 | ByVint | P | Pkg |
| | NE-HVAC-airAC-SpltPkg-65to134kBtuh-12p5eer-woutPreEcono | NE-HVAC-airAC-SpltPkg-65to134kBtuh | SpltPkg | AC | 65to134 | 65to135 | 12.5 | ByVint | P | Pkg |
| | NE-HVAC-airAC-SpltPkg-65to134kBtuh-13p0eer-woutPreEcono | NE-HVAC-airAC-SpltPkg-65to134kBtuh | SpltPkg | AC | 65to134 | 65to135 | 13 | ByVint | P | Pkg |
| | NE-HVAC-airAC-SpltPkg-65to134kBtuh-11p5eer-wPreEcono | NE-HVAC-airAC-SpltPkg-65to134kBtuh | SpltPkg | AC | 65to134 | 65to135 | 11.5 | Yes | P | Pkg |
| | NE-HVAC-airAC-SpltPkg-65to134kBtuh-12p0eer-wPreEcono | NE-HVAC-airAC-SpltPkg-65to134kBtuh | SpltPkg | AC | 65to134 | 65to135 | 12 | Yes | P | Pkg |
| | NE-HVAC-airAC-SpltPkg-65to134kBtuh-12p5eer-wPreEcono | NE-HVAC-airAC-SpltPkg-65to134kBtuh | SpltPkg | AC | 65to134 | 65to135 | 12.5 | Yes | P | Pkg |
| | NE-HVAC-airAC-SpltPkg-65to134kBtuh-13p0eer-wPreEcono | NE-HVAC-airAC-SpltPkg-65to134kBtuh | SpltPkg | AC | 65to134 | 65to135 | 13 | Yes | P | Pkg |
| | NE-HVAC-airAC-SpltPkg-135to239kBtuh-11p5eer | NE-HVAC-airAC-SpltPkg-135to239kBtu | SpltPkg | AC | 135to239 | 135to24( | 11.5 | NA | P | Pkg |

**Figure 51. Added desired measure rows based on existing measures**

For other measures, need to check the corresponding field for the desired variant.

### 3.8.3 Transferring from Workbooks to Database

Go into the "Tools" folder and open ImportTablestoDB.xlsm. This is the macro-tool to transfer workbook data to the MASControl3 input database. This is shown in Figure 52.

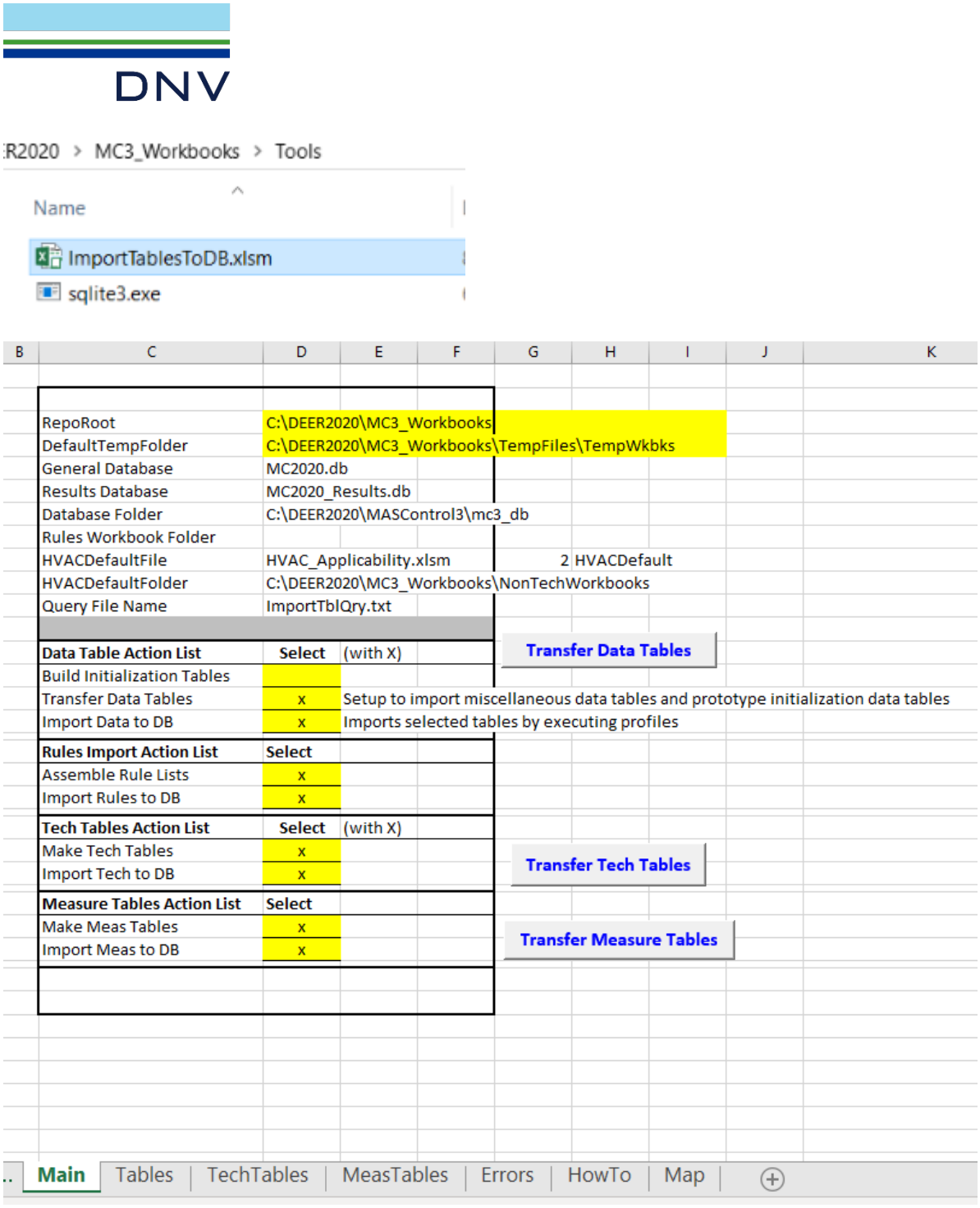



**Figure 52. ImportTablesToDb. Xlsm main tab**

In the "Main" tab, make sure the "RepoRoot" (top level of the workbook repository), "DefaultTempFolder" (folder for temporary files to be transferred), "General Database" (name of the MASControl3 input SQLite database, default is "MC2020.db"), "Results Database" (name of the MASControl3 output SQLite database, default is "MC2020_results.db") , "Database Folder"(location of the MASControl3 input database), and "HVACDefaultFolder" entries have the correct file path connecting to the specific location.

1. Then run the "Transfer Tech Tables" button

a. This rebuilds the Technology data tables in the input database (TechType, Technology, TechLists, TechID2Param)

2. And then the "Transfer Measure Tables" button

    a. Rebuilds the Measures and MeasureApplicabilities tables in the input database

### 3.8.4 Updating msrs2proc

Open "Msrs2Proc.xlsm" from the NonTechWorkbooks folder. This table will need to be manually updated with the corresponding new Measure ID's added in. Save the table after adding in the two new Measure IDs. This is shown in Figure 53.

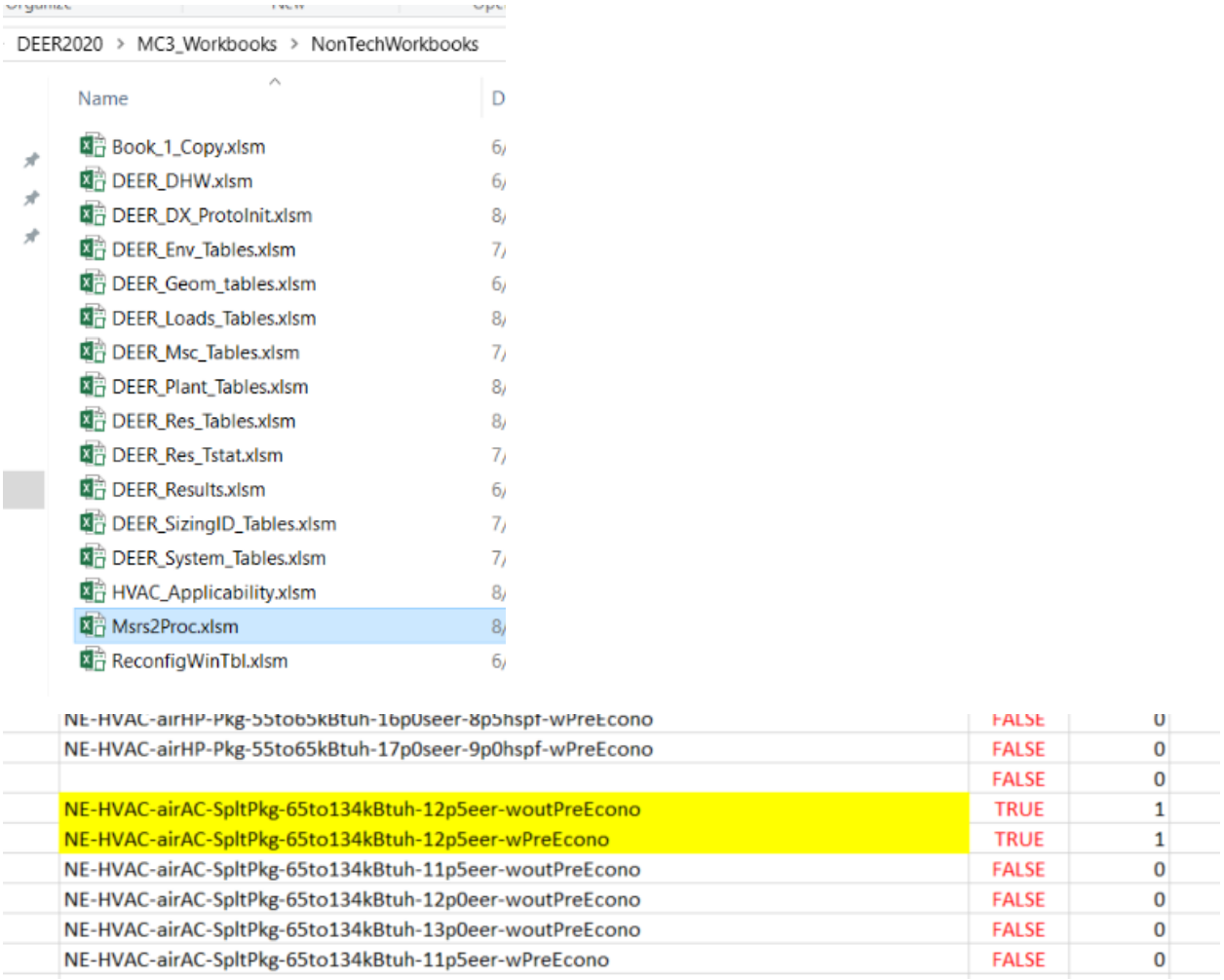



**Figure 53. msrs2proc manually update in NonTechWorkbooks**

Go back to excel macro-tool ImportTablestoDB.xlsm, in the "Tables" tab, make sure to clear the "include" column of "x"s for all, EXCEPT for msrs2proc. (the "x" needs to be there for msrs2proc). This is shown in Figure 54.

ListOfDataTables

| SourceSheet | SourceFile | Include | Make Temp File | SourceFilePath |
|---|---|---|---|---|
| Parameters | ProtoInitParams1.XLSX | | | C:\DEER2020\MC3_Worl |
| TechInit | ProtoInitTechs1.XLSX | | | C:\DEER2020\MC3_Worl |
| VariTech | VariTech1.XLSX | | | C:\DEER2020\MC3_Worl |
| fHVAC | DEER_Msc_Tables.xlsm | | x | C:\DEER2020\MC3_Worl |
| fHVAC_SubComp | DEER_Msc_Tables.xlsm | | x | C:\DEER2020\MC3_Worl |
| fBldgType | DEER_Msc_Tables.xlsm | | x | C:\DEER2020\MC3_Worl |
| fBldgTypeHvacType | HVAC_Applicability.xlsm | | x | C:\DEER2020\MC3_Worl |
| expBldgHVAC | HVAC_Applicability.xlsm | | x | C:\DEER2020\MC3_Worl |
| fVintage | DEER_Msc_Tables.xlsm | | x | C:\DEER2020\MC3_Worl |
| fClimate | DEER_Msc_Tables.xlsm | | x | C:\DEER2020\MC3_Worl |
| fIOU | DEER_Msc_Tables.xlsm | | x | C:\DEER2020\MC3_Worl |
| fCase | DEER_Msc_Tables.xlsm | | x | C:\DEER2020\MC3_Worl |
| fSector | DEER_Msc_Tables.xlsm | | x | C:\DEER2020\MC3_Worl |
| HVACDefault | HVAC_Applicability.xlsm | | x | C:\DEER2020\MC3_Worl |
| SizingID | DEER_SizingID_Tables.xlsm | | x | C:\DEER2020\MC3_Worl |
| TstatParam_SFm | DEER_Res_Tstat.xlsm | | x | C:\DEER2020\MC3_Worl |
| TstatParam_MFm | DEER_Res_Tstat.xlsm | | x | C:\DEER2020\MC3_Worl |
| TstatParam_DMo | DEER_Res_Tstat.xlsm | | x | C:\DEER2020\MC3_Worl |
| msrs2proc | Msrs2Proc.xlsm | X | x | C:\DEER2020\MC3_Worl |

**Figure 54. import tool set up on "Tables" tab**

Finally, go to the "Main" tab, uncheck "Build Initialization Tables", and run the "Transfer Data Tables" option. This imports the updated msrs2proc table in the MC2020.db input database. This is shown in Figure 55.

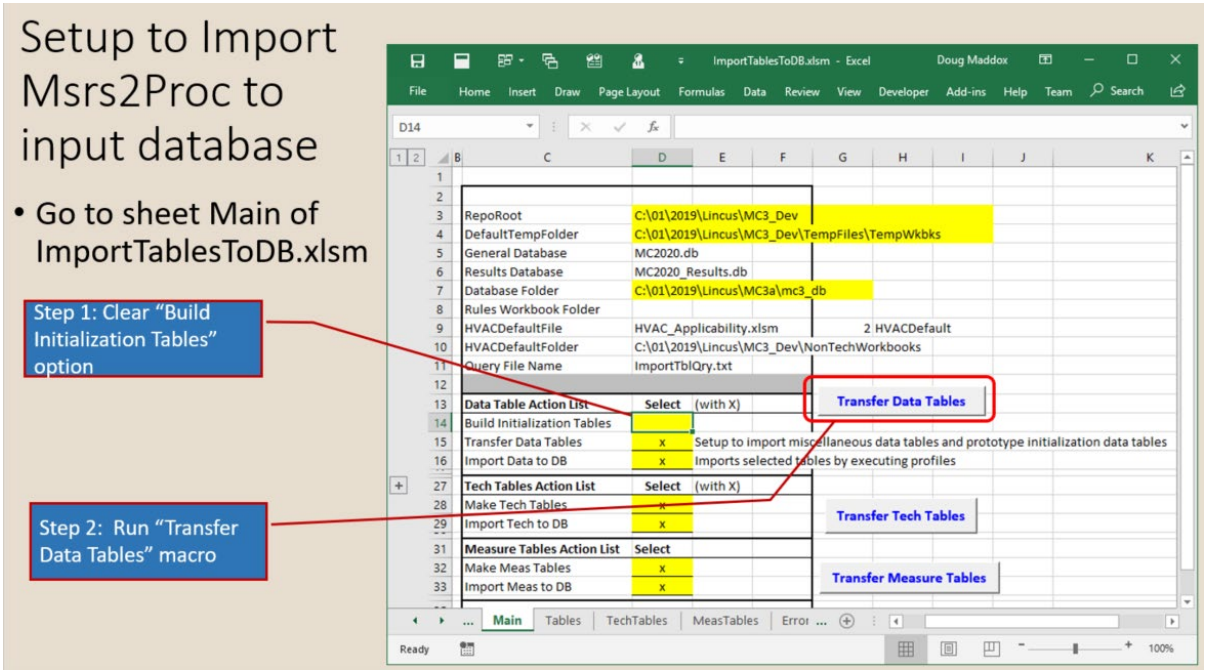
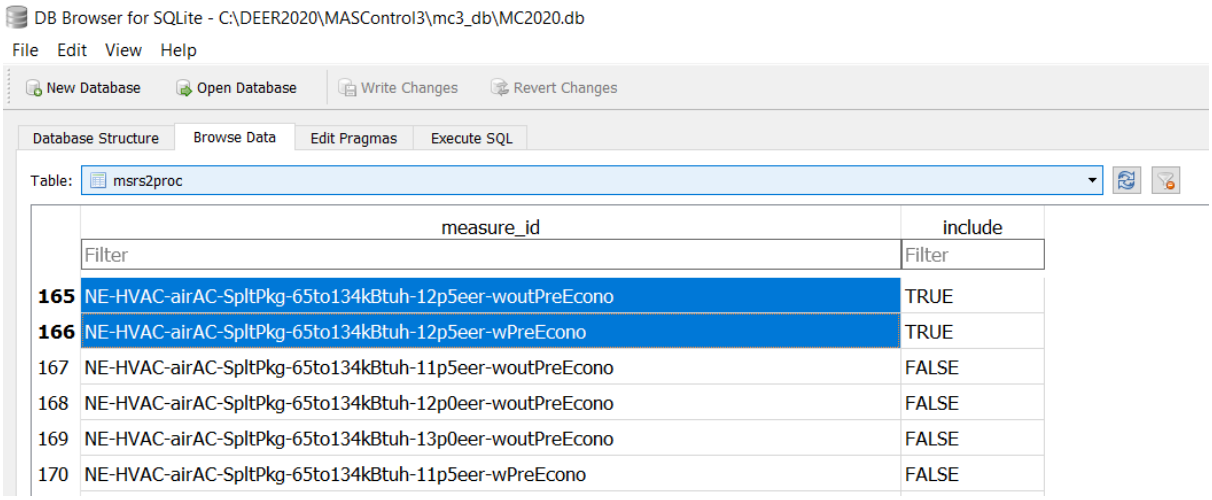



**Figure 55. ImportTablesToDb.xlsm main tab, update data tables**

### 3.8.5 Re-building Database from MASControl3

When initiating the measure runs for MASControl3, first check that it is "TRUE" in the "include" field in the updated msrs2proc table in the now MC2020.db (Figure 56):




| | measure_id | include |
|---|---|---|
| | Filter | Filter |
| **165** | NE-HVAC-airAC-SpltPkg-65to134kBtuh-12p5eer-woutPreEcono | TRUE |
| **166** | NE-HVAC-airAC-SpltPkg-65to134kBtuh-12p5eer-wPreEcono | TRUE |
| 167 | NE-HVAC-airAC-SpltPkg-65to134kBtuh-11p5eer-woutPreEcono | FALSE |
| 168 | NE-HVAC-airAC-SpltPkg-65to134kBtuh-12p0eer-woutPreEcono | FALSE |
| 169 | NE-HVAC-airAC-SpltPkg-65to134kBtuh-13p0eer-woutPreEcono | FALSE |
| 170 | NE-HVAC-airAC-SpltPkg-65to134kBtuh-11p5eer-wPreEcono | FALSE |

**Figure 56. Updated msrs2proc table in DEER2020.db**

Open MASControl3, and first click on "Convert Msr Tbl Nulls", then run "Expand Database", and lastly "Build Full Measure List". After this step, follow step 5 and subsequent steps in the "MASControl3 Simulations" section. (Figure 57)

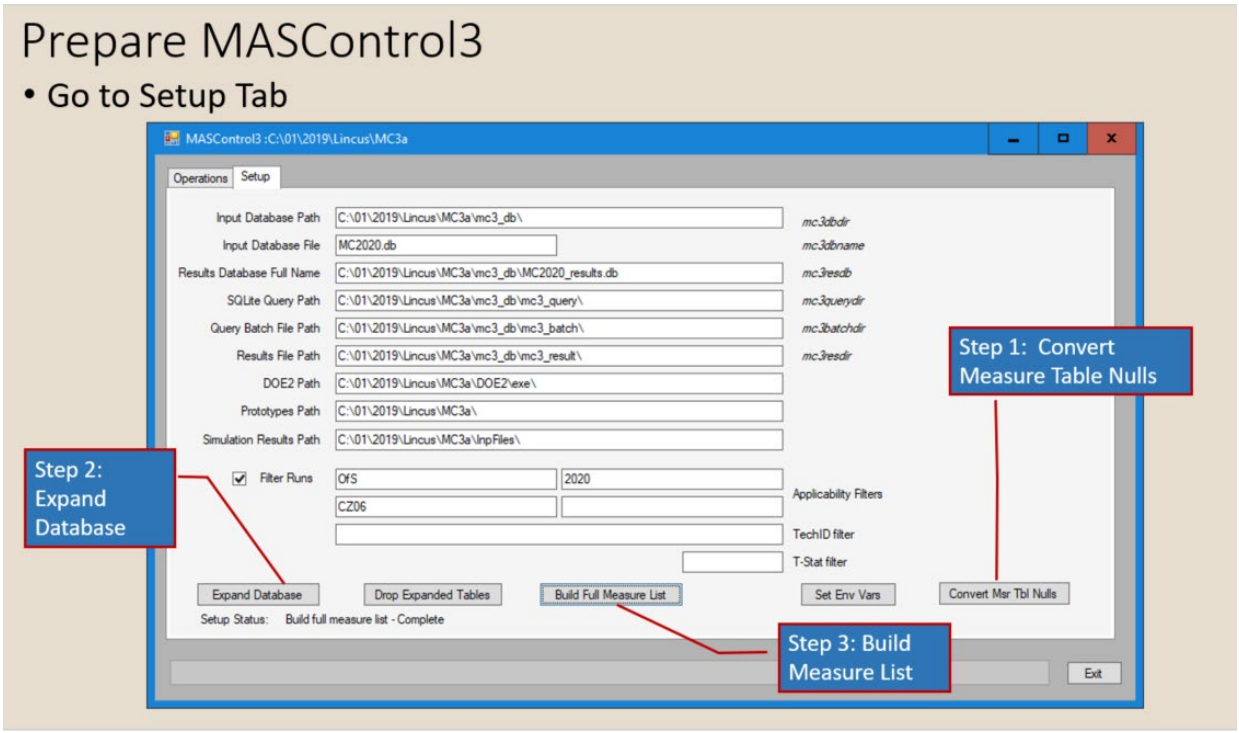



**Figure 57. Steps before "Expand Database"**

## 3.9 Simulation input/output file development

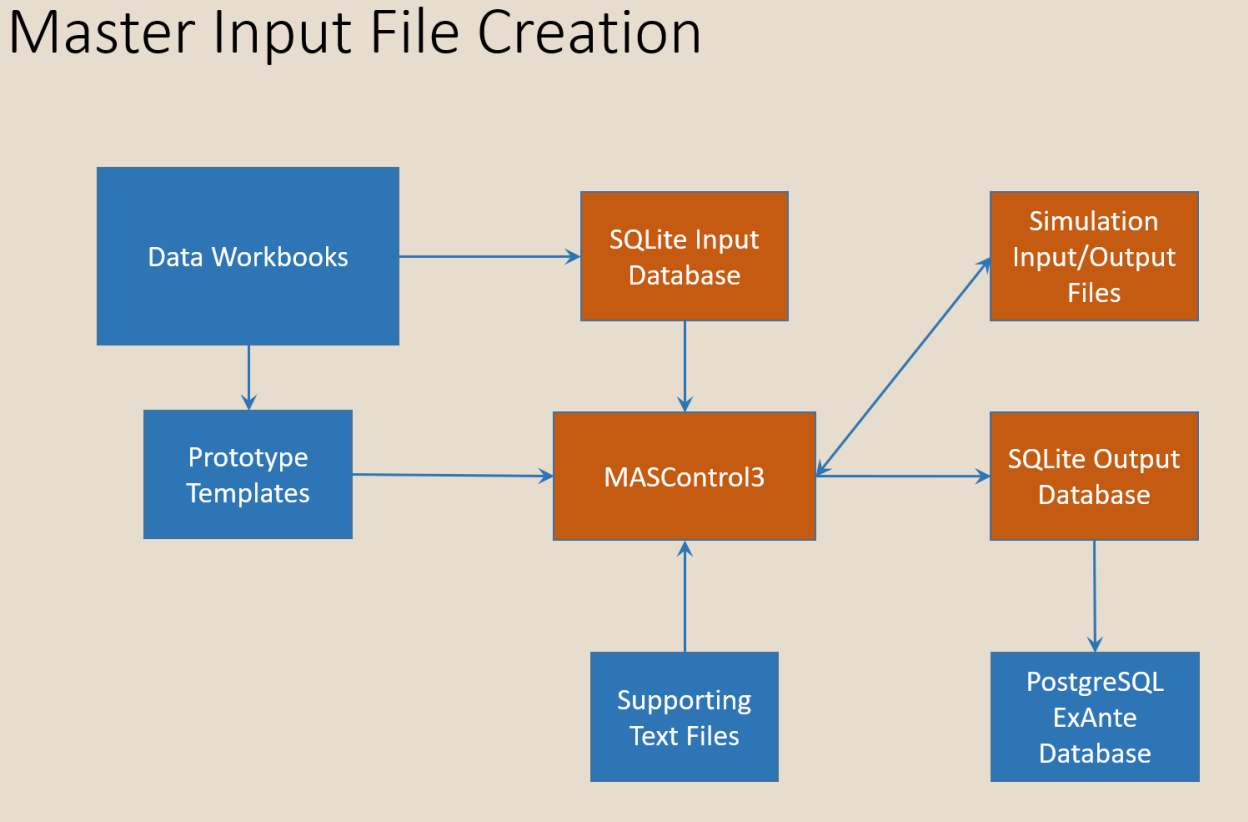



**Figure 58. Master Input File Creation**

For more information on this, refer to the **MASControl3_Training_AF.pptx**[8] slides, slide #26 to #36.

[8] http://deeresources.com/files/DEER2020/download/MC3_training_July_2019/MASControl3_Training%2C%20AF.pptx

# 4 GLOSSARY

ADDITIONS - Changes to an existing building that increase both conditioned floor area and volume. These were excluded from the study. Installations that involved additions at the same time as the HVAC changeout were also excluded from this study.

AIRFLOW - The volume of air per minute that central, forced-air system fans maintain across the return air intake; it is measured in cubic feet per minute (cfm). When entirely when new or replacement HVAC system changeouts (including new/replacement duct systems) are installed in climate zones 10-15, the system must be tested and field-verified to have an airflow greater than 350 cfm per nominal ton of cooling capacity to comply with the Standards. This requirement does not apply, however, when only some of the HVAC components are new/replaced—a more common occurrence than changeouts. Additionally, a separate protocol dictates that the airflow must be greater than 300 cfm when measuring and verifying refrigerant charge. Therefore, at projects with new/replacement components that have less than 300 cfm of airflow, the project is—by definition—out of compliance with the refrigerant charge requirement.

ALTERATIONS - These are not additions, but rather changes to a building's envelope, space conditioning system, water heating system or lighting system. This building modification category was the focus of this study.

BASELINE MODEL - The set of arithmetic factors, equations or data used to describe the relationship between energy use or demand and other baseline data. A model may also be a simulation process involving a specified simulation engine and set of input data.

BASELINE PERIOD - The period of time selected as representative of facility operations before retrofit.

BRITISH THERMAL UNIT (Btu or BTU) - The standard measure of heat energy. It takes one Btu to raise the temperature of one pound of water by one degree Fahrenheit at sea level. For example, it takes about 1,000 BTUs to make a pot of coffee. One Btu is equivalent to 252 calories, 778 foot-pounds, 1055 joules and 0.293 watt-hours. Note: the abbreviation is seen as "Btu" or "BTU" interchangeably.

BUILDING ENERGY EFFICIENCY STANDARDS - California Code of Regulations, Title 24, Part 2, Chapter 2-53; regulating the energy efficiency of buildings constructed in California.

BUILDING ENERGY SIMULATION MODEL - Computer models based on physical engineering principals and/or standards used to estimate energy usage and/or savings. These models do not make use of billing or metered data, but usually incorporate site-specific data on customers and physical systems. Building Simulation Models usually require such site-specific data as square footage, weather, surface orientations, elevations, space volumes, construction materials, equipment use, lighting and building occupancy. Building simulation models can usually account for interactive effects between end-uses (e.g., lighting and HVAC), part-load efficiencies and changes in external and internal heat gains/losses. Examples of building simulation models include ADM2, BLAST and DOE-2.

BUILDING ENVELOPE - The assembly of exterior partitions of a building that enclose conditioned spaces, through which thermal energy may be transferred to or from the exterior, unconditioned spaces or the ground. (See California Code of Regulations, Title 24, Section 2-5302.)

CALIFORNIA PUBLIC UTILITIES COMMISSION (CPUC) - A state agency created by constitutional amendment in 1911 to regulate the rates and services of privately owned utilities and transportation companies. The CPUC is an administrative agency that exercises both legislative and judicial powers; its decisions and orders may be appealed only to the California Supreme Court. The major duties of the CPUC are to regulate privately owned utilities, securing adequate service to the public at rates that are just and reasonable both to customers and shareholders of the utilities; including rates, electricity transmission lines and natural gas pipelines. The CPUC also provides electricity and natural gas forecasting, and analysis and planning of energy supply and resources. Its headquarters are in San Francisco.

CAPACITY - The amount of electric power for which a generating unit, generating station or other electrical apparatus is rated either by the user or manufacturer. The term is also used for the total volume of natural gas that can flow through a pipeline over a given amount of time, considering such factors as compression and pipeline size.

CLIMATE REGION - A region made up of combined California climate zones (defined below) for the purpose of this study. Each region is made up of groups of climate zones that have relatively similar characteristics related to heating and cooling needs. For the top-down permit rate estimation, we used five climate regions: North Coast (zones 1, 2, and 5), North Inland (zones 2, 11, and 16), Central Inland (4, 12, and 13), South coast (6 and 7), and South Inland (8, 9, 10, 14, and 15). To evaluate the smaller on-site sample, we further consolidated the zones into two regions comprised of similar climate characteristics: a Coastal region (zones 1, 3, 5, 6, and 7) and an Inland region (zones 2, 4, and 8-16).

CLIMATE ZONE (CZ) - One of the 16 geographic areas of California for which the CEC has established for use with the California Building Energy Efficiency Standards. Typical weather data, prescriptive requirements, and energy budgets are established for each climate zone. Climate zones are defined by ZIP code: http://www.energy.ca.gov/maps/renewable/building_climate_zones.html.CLIMATE THERMAL ZONE (CTZ) – A geographical area in the state that has particular weather patterns. These zones are used to determine the type of building standards that are required by law.

CLTD – See COOLING LOAD TEMPERATURE DIFFERENCE.

COINCIDENT DEMAND - The metered demand of a device, circuit or building that occurs at the same time as the peak demand of the building or facility or at the same time as some other peak of interest, such as a utility's system load. This should properly be expressed so as to indicate the peak of interest, e.g., "demand coincident with the building peak."

CONDITIONED FLOOR AREA - The floor area of enclosed conditioned spaces on all floors measured from the interior surfaces of exterior partitions for nonresidential buildings and from the exterior surfaces of exterior partitions for residential buildings. (See California Code of Regulations, Title 24, Section 2-5302.)

CONDITIONED SPACE - Enclosed space that is either directly or indirectly conditioned. (See California Code of Regulations, Title 24, Section 2-5302.)

CONDITIONED SPACE, DIRECTLY - An enclosed space that is provided with heating equipment that has a capacity exceeding 10 Btus/(hr-ft2) or with cooling equipment that has a capacity exceeding 10 Btus/(hr-ft2). An exception is if the heating and cooling equipment is designed and thermostatically controlled to maintain a process environment temperature less than 65° F or greater than 85° F for the whole space the equipment serves. (See California Code of Regulations, Title 24, Section 2- 5302.)

CONDITIONED SPACE, INDIRECTLY - Enclosed space that: (1) has a greater area weighted heat transfer coefficient (u-value) between it and directly conditioned spaces than between it and the outdoors or unconditioned space; (2) has air transferred from directly conditioned space moving through it at a rate exceeding three air changes/hour.

COOLING DEGREE DAYS - The cumulative number of degrees in a month or year by which the mean temperature is above 18.3°C /65° F.

CPUC - See CALIFORNIA PUBLIC UTILITIES COMMISSION.

CTZ – See CLIMATE THERMAL ZONE.

DATABASE FOR ENERGY-EFFICIENT RESOURCES (DEER) – A database sponsored by the CEC and CPUC designed to provide well-documented estimates of energy and peak demand savings values, measure costs, and effective useful life (EUL) all with one data source. The users of the data are intended to be program planners, regulatory reviewers and planners, utility and regulatory forecasters, and consultants supporting utility and regulatory research and evaluation efforts. DEER has been designated by the CPUC as its source for deemed and impact costs for program planning.

DAYLIGHTING - The use of sunlight to supplement or replace electric lighting.

DEER – See DATABASE FOR ENERGY-EFFICIENT RESOURCES.

DEMAND - The time rate of energy flow. Demand usually refers to electric power and is measured in kW (equals kWh/h) but can also refer to natural gas, usually as Btu/hr, kBtu/hr, therms/day or ccf/day.

DEMAND (Utility) - The rate or level at which electricity or natural gas is delivered to users at a given point in time. Electric demand is expressed in kilowatts (kW). Demand should not be confused with load, which is the amount of power delivered or required at any specified point or points on a system.

DEMAND SAVINGS - The reduction in the demand from the pre-retrofit baseline to the post-retrofit demand, once independent variables (such as weather or occupancy) have been adjusted for. This term is usually applied to billing demand, to calculate cost savings or to peak demand, for equipment sizing purposes.

DEMAND SIDE MANAGEMENT (DSM) - The methods used to manage energy demand including energy efficiency, load management, fuel substitution and load building. See LOAD MANAGEMENT.

DIRECT ENERGY SAVINGS (DIRECT PROGRAM ENERGY SAVINGS) - The use of the words "direct savings" or "direct program savings" refers to the savings from programs that are responsible for the achievement of specific energy efficiency goals. Typically these are thought of as resource acquisition programs or programs that install or expedite the installation of energy-efficient equipment and which directly cause or help to cause energy efficiency to be achieved. Rebate, incentive or direct install programs provide direct energy savings.

DIRECT INSTALL or DIRECT INSTALLATION PROGRAMS - These types of programs provide free energy efficiency measures and their installation for qualified customers. Typical measures distributed by these programs include low flow showerheads and compact fluorescent bulbs.

DIRECTLY COOLED SPACE is an enclosed space that is provided with a space-cooling system that has a capacity exceeding 5 Btu/(hr×ft²), unless the space-cooling system is designed and thermostatically

controlled to maintain a space temperature less than 55°F or to maintain a space temperature greater than 90°F for the whole space that the system serves.

DIRECTLY HEATED SPACE is an enclosed space that is provided with wood heating or is provided with a space-heating system that has a capacity exceeding 10 Btu/(hr×ft²) unless the space-heating system is designed and thermostatically controlled to maintain a space temperature less than 55°F or to maintain a space temperature greater than 90°F for the whole space that the system serves.

DRY-BULB TEMPERATURE - A measure of the sensible temperature of air.

DSM - See DEMAND SIDE MANAGEMENT.

DUCT INSULATION – An insulating material that is wrapped around or integral with all ductwork in located in unconditioned spaces. Unless ducts are installed entirely within conditioned spaces, the minimum duct insulation allowed by the Standards is R-4.2.

DUCT LEAKAGE - The air leaked from the duct system when it is tested as required by the Standards. When a HVAC system is altered by the installation or replacement of components (including replacement of the air handler, outdoor condensing unit of a split system air conditioner or heat pump, cooling or heating coil, or the furnace heat exchanger), or if at least 40 feet of ductwork in unconditioned space is replaced, or if the entire duct system is new/replaced, the duct system must be tested and confirmed through field verification to have no more air leakage than is allowed by the Standards. Compliance requirements for the 2008 building code cycle include: either ⩽6% total leakage (for new ducts), ⩽15% total leakage (for existing ducts), ⩽10% leakage to outside, ⩾60% measured improvement compared with existing leakage conditions, or demonstration—confirmed through a smoke test—that all accessible leaks have been sealed. See Section 152(b)E (CZs 2 and 9-16) for the 2008 Standards.

EFFICIENCY - The ratio of the useful energy delivered by a dynamic system (such as a machine, engine or motor) to the energy supplied to it over the same period or cycle of operation. The ratio is usually determined under specific test conditions.

EMISSIVITY - The property of emitting radiation; possessed by all materials to a varying extent.

EMITTANCE - The emissivity of a material, expressed as a fraction. Emittance values range from 0.05 for brightly polished metals to 0.96 for flat black paint.

END-USE (MEASURES/GROUPS) - Refers to a broad or sometimes narrower category that the program is concentrating efforts upon. Examples of end-uses include refrigeration, food service, HVAC, appliances, envelope and lighting.

ENERGY CONSUMPTION - The amount of energy consumed in the form in which it is acquired by the user. The term excludes electrical generation and distribution losses.

ENERGY EFFICIENCY - Using less energy to perform the same function. Programs designed to use energy more efficiently - doing the same with less. For the purpose of this paper, energy efficiency programs are distinguished from DSM programs in that the latter are utility-sponsored and financed, while the former is a broader term not limited to any particular sponsor or funding source. "Energy conservation" is a term that has also been used but it has the connotation of doing without in order to save energy rather than using less energy to perform the same function and so is not used as much today. Many people use these terms interchangeably.

ENERGY EFFICIENCY IMPROVEMENT - Reduced energy use for a comparable level of service, resulting from the installation of an energy efficiency measure or the adoption of an energy efficiency practice. Level of service may be expressed in such ways as the volume of a refrigerator, temperature levels, production output of a manufacturing facility or lighting level/square foot.

ENERGY EFFICIENCY MEASURE - Installation of equipment, subsystems or systems, or modification of equipment, subsystems, systems or operations on the customer side of the meter, for the purpose of reducing energy and/or demand (and, hence, energy and/or demand costs) at a comparable level of service.

ENERGY EFFICIENCY OF A MEASURE - A measure of the energy used to provide a specific service or to accomplish a specific amount of work (e.g., kWh/cubic foot of a refrigerator, therms/gallon of hot water).

ENERGY EFFICIENCY OF EQUIPMENT - The percentage of gross energy input that is realized as useful energy output of a piece of equipment.

ENERGY SAVINGS - The reduction in use of energy from the pre-retrofit baseline to the post-retrofit energy use, once independent variables (such as weather or occupancy) have been adjusted for.

ENGINEERING APPROACHES - Methods using engineering algorithms or models to estimate energy and/or demand use.

EX-ANTE SAVINGS ESTIMATE – Administrator-forecasted savings used for program and portfolio planning purposes as filed with the CPUC, from the Latin for "beforehand."

FAN POWER INDEX - The measure of wattage drawn by the central system air handler fans divided by the airflow at the return air intake, in W/cfm. To comply with the Standards at entirely new or replacement duct systems, the system must be tested and field-verified to have an air-handler fan power index of less than 0.58 W/cfm for CZs 10-15. The requirement does not apply to the much more common occurrence of replacement of the entire duct system.

GLAZING - A covering of transparent or translucent material (typically glass or plastic) used for admitting light.

GROSS AREA - The area of a surface including areas not belonging to that surface (such as windows and doors in a wall).

GROSS LOAD IMPACT - The change in energy consumption and/or demand that results directly from program-related actions taken by participants in a DSM program, regardless of why they participated. Related to Gross Energy Impact and Gross Demand Protocols.

HEAT CAPACITY - The amount of heat necessary to raise the temperature of a given mass one degree. Heat capacity may be calculated by multiplying the mass by the specific heat.

HEAT GAIN - An increase in the amount of heat contained in a space, resulting from direct solar radiation, heat flow through walls, windows and other building surfaces, and the heat given off by people, lights, equipment and other sources.

HEAT LOSS - A decrease in the amount of heat contained in a space, resulting from heat flow through walls, windows, roof and other building surfaces and from exfiltration of warm air.

HEAT PUMP - An air conditioning unit which is capable of heating by refrigeration, transferring heat from one (often cooler) medium to another (often warmer) medium and which may or may not include a capability for cooling. This reverse-cycle air conditioner usually provides cooling in summer and heating in winter.

HEAT TRANSFER - Flow of heat energy induced by a temperature difference. Heat flow through a building envelope typically flows from a heated or hot area, to a cooled or cold area.

HORSEPOWER (HP) - A unit for measuring the rate of doing work. One horsepower equals about three-fourths of a kilowatt (745.7 watts).

HVAC - Heating Ventilation and Air Conditioning.

HVAC SYSTEM - The equipment, distribution network and terminals that provides either collectively or individually the processes of heating, ventilating or air conditioning to a building.

INDEPENDENT VARIABLES - The factors that affect the energy and demand used in a building but cannot be controlled (e.g., weather or occupancy).

INSULATION, THERMAL - A material having a relatively high resistance of heat flow and used principally to retard heat flow. See R-VALUE.

INTEGRATED PART-LOAD VALUE (IPLV) - A single number figure of merit based on part-load EER or COP expressing part-load efficiency for air conditioning and heat pump equipment on the basis of weighted operation at various load capacities for the equipment.

JOULE - A unit of work or energy equal to the amount of work done when the point of application of force of 1 Newton is displaced 1 meter in the direction of the force. It takes 1,055 joules to equal a British thermal unit. It takes about 1 million joules to make a pot of coffee.

kBtu – One thousand (1,000) British Thermal Units (Btu). See also BRITISH THERMAL UNIT.

KILOWATT (kW) - One thousand (1,000) watts. A unit of measure of the amount of electricity needed to operate given equipment. On a hot summer afternoon a typical home with central air conditioning and other equipment in use might have a demand of four kW each hour.

KILOWATT-HOUR (kWh) - The most commonly used unit of measure indicating the amount of electricity consumed over time; one kilowatt of electricity supplied for one hour.

LOAD - The amount of electric power supplied to meet one or more end-user's needs. The amount of electric power delivered or required at any specified point or points on a system. Load originates primarily at the power-consuming equipment of the customer. Load should not be confused with demand, which is the rate at which power is delivered to or by a system, part of a system, or a piece of equipment.

LOAD FACTOR - The ratio of the amount of electricity a consumer used during a given time span and the amount that would have been used if the usage had stayed at the consumer's highest demand level during the whole time. The term also is used to mean the percentage of capacity of an energy facility - such as a power plant or gas pipeline - that is utilized in a given period of time. The ratio of the average load to peak load during a specified time interval.

LOAD IMPACT - Changes in electric energy use, electric peak demand or natural gas use.

LOAD SHAPE - The time-of-use pattern of customer or equipment energy use. This pattern can be over a day (24 hours) or over a year (8760 hours).

LOAD SHAPE IMPACTS - Changes in load shape induced by a program.

LOW-E - A special coating that reduces the emissivity of a window assembly, thereby reducing the heat transfer through the assembly.

LUMEN - A measure of the amount of light available from a light source equivalent to the light emitted by one candle.

LUMENS/WATT - A measure of the efficacy of a light fixture; the number of lumens output/watt of power consumed.

MEASURE (noun) - A product whose installation and operation at a customer's premises results in a reduction in the customer's on-site energy use, compared to what would have happened otherwise. See also ENERGY EFFICIENCY MEASURE.

MEASURE (verb) - Use of an instrument to assess a physical quantity or use of a computer simulation to estimate a physical quantity.

MEASURED SAVINGS - Savings or reductions in billing determinants, which are determined using engineering analysis in combination with measured data or through billing analysis.

MEGAWATT (MW) - One thousand kilowatts (1,000 kW) or one million (1,000,000) watts. One megawatt is enough energy to power 1,000 average California homes.

MEGAWATT HOUR (MWh) - One thousand kilowatt-hours. This amount of electricity would supply the monthly power needs of 1,000 typical homes in the Western U.S. (This is a rounding up to 8,760 kWh/year/home based on an average of 8,549 kWh used/household/year. (U.S. DOE EIA, 1997 annual/capita electricity consumption figures.))

METRIC - A point of measurement. Any point of measurement that can be defined, quantified and assessed.

MODEL - A mathematical representation or calculation procedure that is used to predict the energy use and demand in a building or facility or to estimate efficiency program savings estimates. Models may be based on equations that specifically represent the physical processes or may be the result of statistical analysis of energy use data.

NEW CONSTRUCTION - Residential and nonresidential buildings that have been newly built or have added major additions subject to California Code of Regulation Title 24, the California building standards code.

NONRESIDENTIAL – Used to describe facilities used for business, commercial, agricultural, institutional and industrial purposes.

NONRESIDENTIAL BUILDING - Any building which is heated or cooled in its interior and is of an occupancy type other than Type H, I or J, as defined in the Uniform Building Code, 1973 edition, as adopted by the International Conference of Building Officials.

OCCUPANCY SENSOR - A control device that senses the presence of a person in a given space, commonly used to control lighting systems in buildings.

ORIENTATION - The position of a building relative to the points of a compass.

PEAK DEMAND - The maximum level of metered demand during a specified period, such as a billing month or during a specified peak demand period.

PEAK DEMAND PERIOD - Five to 9 p.m. Monday through Friday, June, July, August and September.

PEAK LOAD - The highest electrical demand within a particular period of time. Daily electric peaks on weekdays occur in late afternoon and early evening. Annual peaks occur on hot summer days.

PROGRAMMABLE CONTROLLER - A device that controls the operation of electrical equipment (such as air conditioning units and lights) according to a pre-set time schedule.

REFRIGERANT CHARGE - The amount of refrigerant gas that a cooling system must contain. For a cooling system to perform properly, the correct refrigerant charge is required. To comply with the Standards, proper refrigerant charge must be tested and field-verified (home energy rating system or HERS) and diagnostic testing using procedures in the Reference Residential Appendix SA3.2 or the cooling unit must have a charge indicator display. HERS verification of refrigerant charge is required only in CZ 2, and CZs 8-15. The refrigerant charge verification includes requirement for verification of minimum system airflow rate. For alterations, a 300 cfm/ton minimum is required and 350 cfm/ton is required for entirely new or complete replacement systems.

REGRESSION MODEL - A mathematical model based on statistical analysis where the dependent variable is regressed on the independent variables which are said to determine its value. In so doing, the relationship between the variables is estimated statistically from the data used.

REMODELING – Modifications to or the act of modifying the characteristics of an existing residential or nonresidential building or energy-using equipment installed within it.

RENOVATION - Modification to the characteristic(s) of an existing residential or nonresidential building, including but not limited to windows, insulation and other modifications to the building shell.

REPLACEMENT - Refers to the changing of equipment either due to failure, move to more efficient equipment or other reasons near the end of product life or earlier. Often used to refer to a move to a more energy-efficient product that replaces an inefficient product.

RESIDENTIAL BUILDING - Means any hotel, motel, apartment house, lodging house, single dwelling or other residential building that is heated or mechanically cooled.

RETROFIT - Energy efficiency activities undertaken in existing residential or nonresidential buildings where existing inefficient equipment is replaced by efficient equipment.

SETBACK THERMOSTAT - See THERMOSTAT, SETBACK.

SHADING - The protection from heat gains due to direct solar radiation. Shading is provided by permanently attached exterior devices, glazing materials, and adherent materials applied to the glazing or an adjacent building for nonresidential buildings, hotels, motels and high rise apartments, and by devices affixed to the structure for residential buildings. (See California Code of Regulations, Title 24, Section 2-5302.)

SHADING COEFFICIENT (SC) - The ratio of solar heat gain through fenestration, with or without integral shading devices, to that occurring through unshaded 1/8 in. thick clear double strength glass. See also SOLAR HEAT GAIN COEFFICIENT.

SHGC - See SOLAR HEAT GAIN COEFFICIENT.

SIMPLIFIED ENGINEERING MODEL - Engineering equations used to calculate energy usage and/or savings. These models are usually based on a quantitative description of physical processes that describe the transformation of delivered energy into useful work such as heat, lighting or motor drive. In practice, these models may be reduced to simple equations that calculate energy usage or savings as a function of measurable attributes of customers, facilities or equipment (e.g., lighting use = watts X hours of use). These models do not incorporate billing data and do not produce estimates of energy savings to which tests of statistical validity can be applied.

SOLAR HEAT GAIN - Heat added to a space due to transmitted and absorbed solar energy.

SOLAR HEAT GAIN COEFFICIENT (SHGG) - The ratio of the solar heat gain entering the space through the fenestration area to the incident solar radiation.

SOLAR HEAT GAIN FACTOR - An estimate used in calculating cooling loads of the heat gain due to transmitted and absorbed solar energy through 1/8”-thick, clear glass at a specific latitude, time and orientation.

SOLAR HEATING AND HOT WATER SYSTEMS - Solar heating or hot water systems provide two basic functions: (1) capturing the sun’s radiant energy, converting it into heat energy and storing this heat in insulated storage tank(s); and (2) delivering the stored energy as needed to either the domestic hot water or heating system. These components are called the collection and delivery subsystems.

SYSTEM - A combination of equipment and/or controls, accessories, interconnecting means and terminal elements by which energy is transformed so as to perform a specific function, such as HVAC, service water heating or illumination.

TEMPERATURE - Degree of hotness or coldness measured on one of several arbitrary scales based on some observable phenomenon (such as the expansion).

THERM - One hundred thousand (100,000) British thermal units (1 therm = 100,000 Btu).

THERMOSTAT - An automatic control device designed to be responsive to temperature and typically used to maintain set temperatures by cycling the HVAC system.

THERMOSTAT, SETBACK - A device containing a clock mechanism, which can automatically change the inside temperature maintained by the HVAC system according to a pre-set schedule. The heating or cooling requirements can be reduced when a building is unoccupied or when occupants are asleep. (See California Code of Regulations, Title 24, Section 2- 5352(h).)

TOTAL FLOOR AREA is the floor area (in square feet) of enclosed space on all floors of a building, as measured at the floor level of the exterior surfaces of exterior walls enclosing the space.

UA - A measure of the amount of heat that would be transferred through a given surface or enclosure (such as a building envelope) with a 1° F temperature difference between the two sides. The UA is calculated by multiplying the U-value by the area of the surface (or surfaces).

UNCONDITIONED SPACE - A space that is neither directly nor indirectly conditioned space, which can be isolated from conditioned space by partitions and/or closeable doors. (See California Code of Regulations, Title 24, Section 2-5302.)

U-VALUE or U-FACTOR - A measure of how well heat is transferred by the entire window - the frame, sash and glass - either into or out of the building. U-value is the opposite of R-value. The lower the U-factor number, the better the window will keep heat inside a home on a cold day.

VENTILATION - The process of supplying or removing air by natural or mechanical means to or from any space. Such air may or may not have been conditioned or treated.

WATT - A unit of measure of electric power at a point in time, as capacity or demand. One watt of power maintained over time is equal to one joule/second. Some Christmas tree lights use one watt. The watt is named after Scottish inventor James Watt and is capitalized when shortened to W and used with other abbreviations, as in kWh.

WATT-HOUR - One watt of power expended for one hour. One thousandth of a kilowatt-hour.

WEATHERSTRIPPING - Specially designed strips, seals and gaskets installed around doors and windows to limit air leakage.

WET-BULB TEMPERATURE - The temperature at which water, by evaporating into air, can bring the air to saturation at the same temperature. Wet-bulb temperature is measured by a wet-bulb psychrometer.

ZONE - A space or group of spaces within a building with any combination of heating, cooling or lighting requirements sufficiently similar so that desired conditions can be maintained throughout by a single controlling device.