



RLM Model User Guide

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1. OPENING REMARKS

This User Guide is intended to assist in the correct use of the Relevant Level Method Model, prepared in accordance with the draft Amending Rules in the Draft Rule Change Report for RC_2019_03: Method used for the assignment of Certified Reserve Capacity to Intermittent Generators (Draft Amending Rules). This model uses a combination of Microsoft Excel files and Python scripts, and as such compatible software is required to correctly run this model. A brief guide on how to run the Python components of the model is presented in section 1.4 of this User Guide.

2. REQUIRED INPUTS – DATA¹

The following data is required to populate the input files of the RLM model:

- System demand (Observed Demand) for each Trading Interval in the Reference Period,²
- The capacity factors (irradiance) for behind-the meter (BTM) PV (BTM capacity factor) for every Trading Interval in the Reference Period – the capacity factors for this analysis have been provided by Solcast ([Solar Irradiance Data Suppliers](#)),
- The quantity of installed capacity of BTM PV (BTM installed capacity) in the SWIS for each month of the Reference Period,
- For each Candidate Facility:
 - the actual output for each Trading Interval of the Reference Period from the Facility's full operational date;
 - AEMO's estimate of the Facility's output for each Trading Interval where the Facility's output has been reduced and AEMO is required to provide an estimate (for Trading Intervals from the full operational date);
 - the estimated output provided through independent expert reports of the Facility for each Trading Interval in the Reference Period that falls before the Facility's full operational date;

¹ For the avoidance of confusion, please note that some datasets described in this user guide and used in the RLM model are MWh values, whereas the Draft Amending Rules use MW values. This is due to the conversion from MWh to MW happening at a later stage in the RLM model than in the Draft Amending Rules. This will not alter the results of the model.

² The model is capable of being run for any reference period, including forecasts. The current model has been set up to run the period from 1 April 2013 to 1 April 2020, however this can be easily altered by changing the input data used for the model.

- The expected Certified Reserve Capacity (**CRC**) for the Capacity Year for which the RLM is run for every non-Candidate Facility;^{3 4} and
- The Forced Outage Rates of the previous three years of all non-Candidate Facilities that are expected to receive CRC for the Capacity Year for which the RLM is run.⁵

Some of these data series require access to confidential data, as well as significant cleaning or manipulation before they can be used in the model. Care should be taken during these steps as any mistakes in the data preparation stage will cause the outputs from the model to be incorrect.

³ Please note that the calculation of the 2020 Reserve Capacity Cycle is backwards looking therefore the actual Capacity Credits are used for the non-Candidate Facilities.

⁴ The CRC's for all non-candidate facilities must be adjusted such that the sum equals the Reserve Capacity Requirement, as per the Draft Amending Rules. This adjustment has already been made to the input data provided,

⁵ This data will not be available for new Facilities – AEMO has provided the Rule Change Panel with estimated Forced Outage rates for these Facilities for the purpose of the analyses for RC_2019_03. However, these estimates are confidential and cannot be published and stakeholders will have to use their own estimates. As this only affects a small number of Facilities the impact is expected to be negligible.

3. REQUIRED INPUTS – MODEL FILES

The RLM model is made up of several input and output files (Excel spreadsheets) and two Python scripts (which manage most calculation steps). These files are arranged in a folder structure to enable ease of use of the model. The following files are required to run the model correctly:

- **Demand_Adjustment.xlsx** – This file takes the Observed Demand, BTM capacity factors and BTM installed capacity values as inputs and adjusts the system demand for the impact of BTM PV, as per the method.⁶
- **Candidate_Facility_Outputs.xlsx** – This file contains the consolidated output traces for all Candidate Facilities (using SCADA data), as per steps 2a and 2b below.⁷
- **Input_EFOR.xlsx** – This file takes the expected CRC and Forced Outage rates of non-Candidate Facilities and is used in the calculation of the COPT.
- **Create_COPT.py** – This is a Python script which takes Input_EFOR.xlsx as an input and calculates the corresponding COPT. It produces this as the Working_COPT.xlsx file.⁸
- **Load_2013-20-EY.xlsx** – This file takes as inputs the Relevant Base Demand Profile (i.e. the Observed Demand adjusted for BTM PV and the historical output of Candidate Facilities if applicable (i.e. for the calculation of Last-In ELCCs)), as well as the historical output of the Candidate Facility (or group of Facilities) for which the ELCC is to be calculated. This file is used in the calculation of the ELCC for a given Facility (or group of Facilities). A suffix should be added to the file name to denote the facility being examined.
- **Create_LOLP_Results.py** – This is a Python script which takes the Working_COPT.xlsx file as well as all Load_2013-20-EY.xlsx files present in the same folder (i.e. the script will process multiple input files in the same run) and calculates the LOLE and ELCC corresponding to each Facility (or group of Facilities) included in the load input files. It will create an Output_LOLP_Load_2013-20-EY.xlsx file for each load input file used. This output file contains the LOLE and ELCC results.

⁶ Please note that under the draft decision, the Adjusted Demand will then be amended to account for the contribution of small ESR based on the expected CRC assigned to these Facilities. However, as no CRC and no Capacity Credits have been assigned to ESR for the 2020 Reserve Capacity Cycle this step is not included in this user guide.

⁷ Please note that the analyses in the Draft Rule Change Report were undertaken using meter data provided by AEMO instead of SCADA data. However, the Rule Change Panel cannot publish the metered data so SCADA data is provided as an approximation.

⁸ Please note that, although the draft decision is to use multiple COPTs for different types of Trading Intervals to reflect that the non-Candidate Facilities have different availability requirements, to reduce complexity the model uses only one COPT.

- **RLM_2013-2020_RESULTS.xlsx** – This file is used for the final steps in the method. The user should enter the results for each Facility (or group of Facilities) from the output file above into this file. When done correctly, this file adjusts for the interaction effect and calculates the final ELCC values for each Facility.

4. RUNNING THE MODEL

4.1. STEP 1 – ADJUSTING THE DEMAND ⁹

The preparation of the input data for the model is a crucial step of the model process and has the most room for human error. As such, care should be taken when following these steps and when handling input data in general.

Step 1a – To correctly adjust the Observed Demand for the effect of BTM PV, open the Demand_Adjustment.xlsx file, as well as the files containing the Observed Demand, BTM capacity factors and BTM installed capacity data.

Step 1b – In column B of the ‘Capacity Factors’ tab, insert the BTM capacity factor data, ensuring that it aligns with the correct date and time stamp.

Step 1c – In column E of the ‘Installed Capacity of BTM PV’ tab, insert the BTM installed capacity data, again ensuring the correct date and time stamps are aligned.

Step 1d – In column D of the ‘Demand Adjustment’ tab, insert the observed system demand. If done correctly, the spreadsheet will adjust the system demand such that installed BTM capacity was static across the Reference Period at the level of the final time interval. This will be produced in column G of the ‘Demand Adjustment’ tab. Any future references to system demand should be assumed to be the *adjusted* system demand.

4.2. STEP 2 – PREPARING CANDIDATE FACILITY TRACES (HISTORICAL OUTPUT)

Step 2a¹⁰ – For each Candidate Facility¹¹ the user must calculate a ‘consolidated’ output. To do this, open the files containing the actual and estimated Candidate Facility outputs.

⁹ Please note that this step has already been completed and the results are available in the ‘Demand Adjustment’ tab of the Demand_Adjustment.xlsx file.

¹⁰ Please note that Steps 2a and 2b have already been completed and the results are available in the Candidate_Facility_Outputs.xlsx file.

¹¹ Please note that Facilities with a name plate capacity smaller than 10 MW are grouped either in the biogas group or the small wind and solar group. These groups are treated like Candidate Facilities in the model.

Step 2b – For each Candidate Facility, and for each Trading Interval in the Reference Period, find the consolidated output as either:

1. If the Facility was not in full operation (i.e. before the full operation date), the expert report estimated output for that Facility; and
2. If the Facility was in full operation (i.e. from the full operation date):
 - a. The actual output of that Facility; or
 - b. If the Facility's output was reduced by AEMO, the estimated output for that Facility.

Step 2c – At this stage, the user should also prepare the Baseline Demand Profiles for the calculations of the Last-In ELCCs. To do this, open the file containing the *adjusted* system demand.

Step 2d – For each Candidate Facility, calculate a Baseline Demand Profile for its Last-In ELCC calculation as the *adjusted* demand, less the consolidated output from all *other* Candidate Facilities, for each Trading Interval across the Reference Period. To do this, firstly create a sheet with a separate column for each candidate facility. Secondly, for each candidate facility and time interval, subtract the sum of all *other* candidate facility outputs in that time interval from the adjusted demand in that time interval.

Step 2e – Finally, the user should also prepare a 'Fleet' output trace. This is simply the sum of all consolidated Candidate Facility outputs, for any given Trading Interval. This should be done across the full Reference Period. This will simply create a new column, which is the sum across all columns containing candidate facility outputs.

4.3. STEP 3 – PREPARING THE LOAD SHEETS

Step 3a – Several load sheets will be created to correctly run the model. Specifically, the user will need one input load sheet to determine the Fleet ELCC and two input load sheets to determine each Candidate Facility's First-In ELCC and Last-In ELCC. To do this the user should have prepared the inputs explained in step 2, as well as opened the Load_2013-20-EY.xlsx.

Step 3b – For a 'First In' load sheet, or the load sheet for the Fleet, in column B of the Load_2013-20-EY.xlsx file, insert the *observed* demand for the full Reference Period, and in column C, insert the consolidated output trace for a chosen facility (or the fleet as a whole). Save the file and add an appropriate suffix to the file name.

Step 3c – For a 'Last In' load sheet, in column B of the Load_2013-20-EY.xlsx file, insert the 'Last In' Baseline Demand Profile prepared in step 2d, for the chosen Candidate Facility. In column C, insert the consolidated output trace for the same Candidate Facility. Save the file and add an appropriate suffix to the file name.

4.4. STEP 4 – CREATING THE COPT

Step 4a – To create the COPT, the user should open the Input_EFOR.xlsx file, as well as the files containing the resource capacity and Forced Outage rate data for the non-Candidate Facilities. This includes Scheduled Generators and DSPs (note, DSPs are assigned a Forced Outage Rate of 0).

Step 4b – In the Input_EFOR.xlsx, in column B, insert the expected CRC (in integer form) for each scheduled facility.¹²

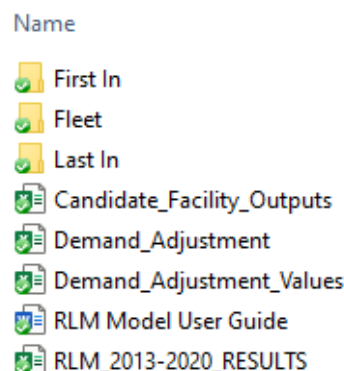
Step 4c – In column C of the same file, insert the Forced Outage rate (in decimal form) for each non-Candidate Facility. Save this file.

Step 4d – Open the Create_COPT.py file, ensure it is in the same folder as the Input_EFOR.xlsx file (and only one such file is in that folder), and run the script. This will generate the Working_COPT.xlsx file and will save it in the same folder.

4.5. STEP 5 – ORGANISING THE FOLDER STRUCTURE

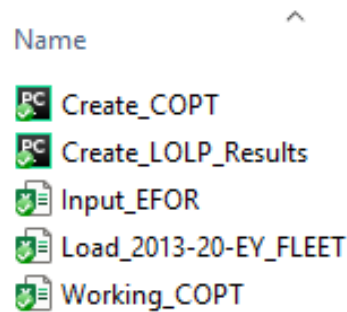
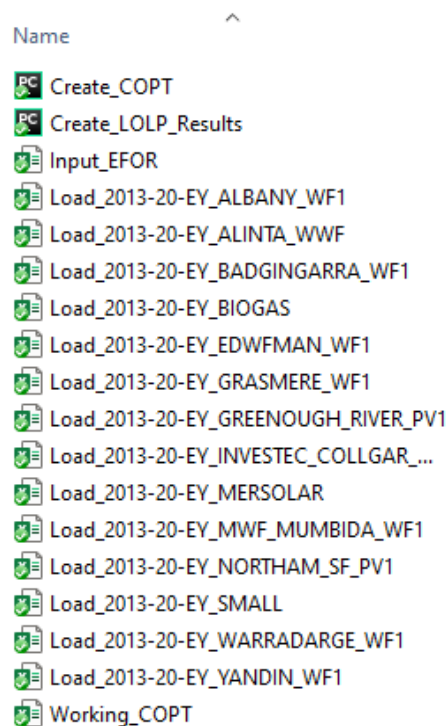
Although there are multiple ways to organise the file structure of the model and produce correct results, it is worth trying to arrange files in a logical way. The model has been prepared with a specific folder structure. The figures below show examples of the proposed folder structure.

Figure 1: Global Folder Structure



¹²

Note that the Draft Amending Rules propose changing the granularity of the model to 0.1 MW, however the model operates on a 1 MW granularity.

Figure 2: Fleet Folder Structure**Figure 3: First In Folder Structure¹³**

Step 5a – The ‘global folder’ containing all model files should have the following sub-folders and files:

- ‘First In’ Folder – This will contain all model files associated with ‘First In’ ELCC calculations.
- ‘Fleet’ Folder – This will contain the model files associated with the Fleet ELCC calculations.
- ‘Last In’ Folder – This will contain all model files associated with ‘Last In’ ELCC calculations.

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Note that the First In and Last In folder should have the same file structure.

- Candidate_Facility_Outputs.xlsx
- Demand_Adjustment.xlsx
- Demand_Adjustment_Values.xlsx – This is the same file as Demand_Adjustment.xlsx, however all cells are formatted as values (rather than formulas) to reduce size.
- RLM_2013-2020_RESULTS.xlsx
- RLM Model User Guide

Step 5b – Each of the ‘First In’, ‘Last In’ and ‘Fleet’ folders have the same folder structure, and should all include the following:

- Create_COPT.py
- Create_LOLP_Results.py
- Input_EFOR.xlsx
- Working_COPT.xlsx
- All ‘Load_2013-20-EY.xlsx’ files associated with a unique type of run (i.e. Last In or First In) and candidate facility. Note that the Fleet load sheet is in the same format as a First In run, in this context. Each of these files within a folder should have a unique name, with no spaces. An example of an appropriate filename is ‘Load_2013-20-EY_FACILITY1.xlsx’.

4.6. STEP 6 – CREATING THE LOLP RESULTS

Step 6a – Organise the folders and sub-folders of the model as described above and open the Create_LOLP_Results.py file within the ‘First In’ sub-folder.

Step 6b – If the folders have been arranged correctly, simply run the Create_LOLP_Results.py script. It will create an Output_LOLP_Load_2013-20-EY.xlsx file for each load input file used.

Step 6c – Repeat step 6b for the ‘Fleet’ and ‘Last In’ folders.

4.7. STEP 7 – USING THE OUTPUTS

Step 7a – To produce final results, the user should open the RLM_2013-2020_RESULTS.xlsx.

Step 7b – Cycle through opening each Output_LOLP_Load_2013-20-EY.xlsx file, produced in step 6, and move to the ‘LOLE Results’ tab.

Step 7c – For the corresponding Candidate Facility, copy the ELCC in cell D3 in the output file into either column B or D of the results file (depending on whether it is a First In or Last In result). In the case of the Fleet result, copy this value in cell B17 of the results file.

Step 7d – For the corresponding Candidate Facility, copy the LOLE in cell B3 in the output file into either column C or E of the results file (depending on whether it is a First In or Last In result). These values do not enter the calculations in the results file but can be used to verify results. Once filled, the values in column C should be the same (to a rounding error) and the values in column E should be different and proportional to the ELCCs in column D.

Step 7e – If the number of Candidate Facilities being assessed has been changed, the user should ensure all formulas in the results file references all required cells. Such formulas exist in columns F, G and H as well as in cell B18. If each step has been followed correctly, the final ELCC for each Candidate Facility is shown in column H of the results file.

5. RUNNING PYTHON SCRIPTS

The following guides briefly outline how to run the model Python scripts on Windows and Mac. These are not intended to be comprehensive; troubleshooting can be done via online guides and tutorials.

The user will firstly need to install Python on their machines, this can be done through the following link: <https://www.python.org/downloads/>. Several Python packages will also need to be installed. There are many useful online guides for doing this and as such it is not detailed below. The command line or terminal will prompt the user if a specific package is required and yet to be installed.

5.1. WINDOWS

1. Ensure you have the latest version of Python and all required packages properly installed (in particular, the 'openpyxl' package and the 'pandas' package will be required). There are many useful online guides on how to do this.
2. Navigate in Windows Explorer to the folder which contains the Python script you want to run.
3. Click on the location bar in Windows Explorer and type 'cmd'. This will open the command line from that folder location.
4. Enter the command 'python Create_COPT.py' into the command line and press enter. This will run the Create_COPT.py script. If you want to run the Create_LOLP_Results.py script instead, simply substitute in its file name instead.
5. The command line will show progress updates and output files will be generated and saved into the folder the user opened the command line from.

5.2. MAC

1. Ensure you have the latest version of Python and all required packages properly installed (in particular, the 'openpyxl' package and the 'pandas' package will be required). There are many useful online guides on how to do this.
2. Navigate in Finder to the folder which contains the Python script you want to run.
3. Instead of opening the folder, right-click on it and select 'New Terminal at Folder'. If that option does not appear, system preferences must be changed. Online guides can help do this.
4. Once the terminal is open, enter the command 'python Create_COPT.py' into the terminal and press enter. This will run the Create_COPT.py script. If you want to run the Create_LOLP_Results.py script instead, simply substitute in its file name instead.
5. The terminal will show progress updates and output files will be generated and saved into the folder the user opened the terminal from.