TCEQ Contract 582-19-90502
TCEQ Work Order 582-22-31630-008
ERG Deliverable 6.2

Eastern Research Group, Inc.

Update to Reporting of Automated RFP Results in TexN2.2 and Pollutant Selections in the Graphical User Interface

Final Report

Prepared for:

Texas Commission on Environmental Quality
Air Quality Division

Prepared by:

Eastern Research Group, Inc.

June 22, 2022

ERG No. 0433.00.009

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June 22, 2022

Table of Contents

List of Tables

List of Figures

ACRONYMS

BSFC – Brake-Specific Fuel Consumption

CO – Carbon Monoxide

CO_2 – Carbon Dioxide

COG – Council of Government

CH_4 – Methane

DBs – Databases

DFW – Dallas-Fort Worth

EI – Emission Inventory

ERG – Eastern Research Group

GUI – Graphical User Interface

HAPs – Hazardous Air Pollutants

HC – Hydrocarbons

HGB – Houston-Galveston-Brazoria

HTML – HyperText Markup Language

JSON – JavaScript Object Notation

MOVES – Motor Vehicle Emissions Simulator

NH_3 – Ammonia

NO_x – Nitrogen Oxides

PAH – Polycyclic Aromatic Hydrocarbons

PM – Particulate Matter

PM_{10} – Particulate Matter (less than 10 microns)

$PM_{2.5}$ – Particulate Matter (less than 2.5 microns)

QA – Quality Assurance

QAPP – Quality Assurance Project Plan

RFG – Reformulated Gasoline

RFP – Reasonable Further Progress

SCC – Source Classification Code

SIP – State Implementation Plan

SO_2 – Sulfur Dioxide

SQL – Structured Query Language

TCEQ – Texas Commission on Environmental Quality

TOG – Total Organic Gases

TPD – Tons Per Day

TexN2 – Texas Non-road version 2 utility, compatible with MOVES model

TxLED – Texas Low Emission Diesel

VOC – Volatile Organic Compounds

EXECUTIVE SUMMARY

The Texas Commission on Environmental Quality (TCEQ) previously contracted with Eastern Research Group, Inc. (ERG) to develop the Texas Non-road version 2 (TexN2) utility, a tool for estimating Texas-specific emissions from non-road mobile sources, excluding commercial marine vessels, locomotives, drilling rigs, and aircraft. The TCEQ has frequently updated the utility with Texas-specific data and enhanced the utility's function to improve inventory accuracy.

At the completion of this project, the new utility version is TexN2.3 and it has two major updates from the prior version TexN2.2. The first update is enhanced pollutant choice flexibility. It is now possible to run TexN2 for a single pollutant, such as sulfur dioxide (SO_2) only for an El Paso State Implementation Plan (SIP), without including a larger default group of pollutants. TexN2 may be run with other combinations of pollutants as well. The ability to run fewer pollutants than before saves utility computation time because the databases are smaller, and the MOtor Vehicle Emission Simulator (MOVES) model also runs significantly faster with fewer pollutants. The second update is a new automated RFP report that is a one-click approach to generating SIP-ready emission tables for Reasonable Further Progress (RFP) analyses. The automated RFP report may be initiated from a new button on the `Reports` screen of the utility, and TexN2 performs calculations to subtract the appropriate RFP scenarios from one another and writes the results to an Excel file in the output directory. The new RFP report also documents the scenario year, meteorology data year, and the period of the RFP analysis, and it lists the emissions benefits by RFP control strategy as well as providing the fully-controlled and fully-uncontrolled emissions inventory (EI) cases.

I. INTRODUCTION

Purpose

The first objective for this project was to add user pollutant choice flexibility to the TexN2 utility graphical user interface (GUI) so that users can select any combination of pollutants when creating an EI. In particular, the ability to select fewer pollutants than was possible with prior versions of TexN2 saves computation time in the MOVES runs, reduces the amount of disk space required by TexN2 for an application, and saves time creating output summary reports.

The second and final objective of this project was to streamline the TexN2 utility's reporting of RFP applications generated by the automated RFP function in the utility. In prior versions of TexN2, nearly all the effort required to create an RFP run summary fell to the user. The new automated RFP report requires just a click by the user, and TexN2 computes all emissions differences among the various RFP scenarios and produces an Excel file in the output directory that summarizes the benefits of each RFP control strategy. The new report also includes the scenario year, meteorological year, and period (e.g., Ozone Season Day – Weekday) corresponding to the results. The report not only saves time but also removes the chance of human errors such as copy and paste mistakes or other typos.

The resulting TexN2 utility with these two improvements is called TexN2.3.

Background

The TCEQ contracted with ERG to develop the TexN2.2 utility, a tool for estimating Texas-specific emissions from non-road mobile sources, excluding commercial marine vessels, locomotives, drilling rigs, and aircraft. The TexN2.2 utility uses the most recent version of the United States Environmental Protection Agency's (US EPA) MOVES version 3 model (MOVES3; US EPA, 2022) for developing emissions estimates for SIP development, federal EI requirements such as the Air Emissions Reporting Requirements, and emissions trend analyses. Since the initial development of the TexN utility, the TCEQ has frequently updated the Texas-specific data and enhanced the utility's function to improve inventory accuracy.

Report Structure

This report presents a comprehensive overview of the activities undertaken during the project. The report highlights major activities, quality assurance (QA) results, instructions for how to replace the previous TexN2.2 utility, and recommendations for further improvements. The updated utility, named TexN2.3, and associated supporting files will be provided to the TCEQ electronically. Directions on how users can update to the latest version, TexN2.3, are provided in Section IV and can be found in the utility User's Guide available from the TCEQ upon request.

II. TEXN2 SOURCE CODE AND INTERFACE UPDATES

This section is organized into four subsections. The first subsection documents the starting point version of TexN2 for the update work and discusses version naming conventions for TexN2. The second subsection briefly describes the developer environment for current and future work on TexN2. The third and fourth subsection describes each change made to the TexN2 utility to make it compatible with MOVES3. Additional changes to TexN2 are documented separately in Section III and V.

Starting Point TexN2 Utility and Software Naming Conventions

The utility name "TexN2" is a generic name for TexN version 2 that works with MOVES. TexN2 is a fundamentally different utility than the "TexN" utility which worked with EPA's standalone NONROAD model. The most recent version of TexN2 prior to this project was "TexN2.2" with a source code version of 2.2.1 and TexN2 database version TexN2_30jul21.sql. These were the starting points for the current project. The utility database was not updated as part of this project, so the database version is still TexN2_30jul21.sql; however, this file has been renamed to TexN2_15jul22.sql to match the delivery date of the TexN2.3 utility.

ERG electronically delivered a new version of TexN2 resulting from this project called "TexN2.3" with a source code version 2.3.0. The three positions in the version correspond to Major.Minor.Patch and indicate the significance of revisions. If any patches to TexN2.3 are needed in the future, the TexN2 version 2.3.0 will be updated using the third position (for example: 2.3.1 for the first patch). This software naming convention is consistent with what US EPA has adopted for MOVES3. At the time of writing, the MOVES3 source code is version 3.0.3. TexN2 users can always verify their TexN2 utility version from the GUI main menu bar by selecting About, then Version.

Software Development Environment

ERG stores the TexN2 source code on the Git-based source code repository hosting service website called Bitbucket. The ERG TexN2 development team members each have local developer environments on our Windows PCs with all software components needed to build TexN2, including:

- The file version tracking software Git[1],
- Bitbucket[2] accounts,
- Python interpreter (64-bit version Python 3.7 for Windows)[3],
- Python modules that support data manipulation, Excel file writing, reporting, Structured Query Language (SQL) connectors, etc., and

[1] http://gitforwindows.org

[2] https://bitbucket.org/

[3] http://www.python.org/downloads

- Qt Creator[4] software to develop the TexN2 GUI.

Enhanced Pollutant Flexibility

Prior to this project, the TexN2 utility ran by default by always including a set of 14 pollutants that included total gaseous hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NO_X), methane (CH_4), ammonia (NH_3), SO_2, non-methane HC, non-methane organic gases, total organic gases (TOG), volatile organic compounds (VOC), carbon dioxide (CO_2), particulate matter (PM) with an aerodynamic diameter of 10 microns (PM_{10}) and 2.5 microns ($PM_{2.5}$), and brake-specific fuel consumption (BSFC). While not an air pollutant, the MOVES-Nonroad model treats BSFC as a "pollutant" entity, rather than as a parameter related to the total equipment activity (i.e., hours of operation and population). Utility users could not easily prevent including pollutants from the default group of 14, though it was easy to add on pollutant groups of different hazardous air pollutants (HAPs) or NonHAPTOG onto a run.

The new utility allows selection of an individual pollutant or any combination of pollutants through the `Run` tab of the TexN2 GUI. Figure 1 shows 13 new checkboxes added to support selecting individual pollutants. Figure 1 also illustrates what happens when a user selects VOC alone. Upon checking the box for VOC, the utility automatically selects the other two pollutants shown in Figure 1 (Non-Methane Hydrocarbons and Total Gaseous Hydrocarbons) because they are required by MOVES3 to calculate VOC. ERG implemented a set of precursor rules for the checkboxes to ensure that any required precursor pollutants for MOVES are always included in the run. While not shown in Figure 1, BSFC is automatically included in all TexN2 EI runs. An EI type of run refers to the actions of initiating a TexN2 run by clicking either the "Run all steps" button at the top of Figure 1, or the individual substeps "1: Create Runs" through "4: Post-Process."

If the user does not make any pollutant selections on the `Run` tab and then performs an EI run, only BSFC will appear in the outputs. If the user unchecks a required precursor (e.g., Non-Methane Hydrocarbons), the TexN2 GUI will automatically deselect any dependent pollutants (e.g., VOC). Once finished making pollutant selections, the user should carefully review choices prior to launching an EI run.

[4] https://download.qt.io/official_releases/online_installers/

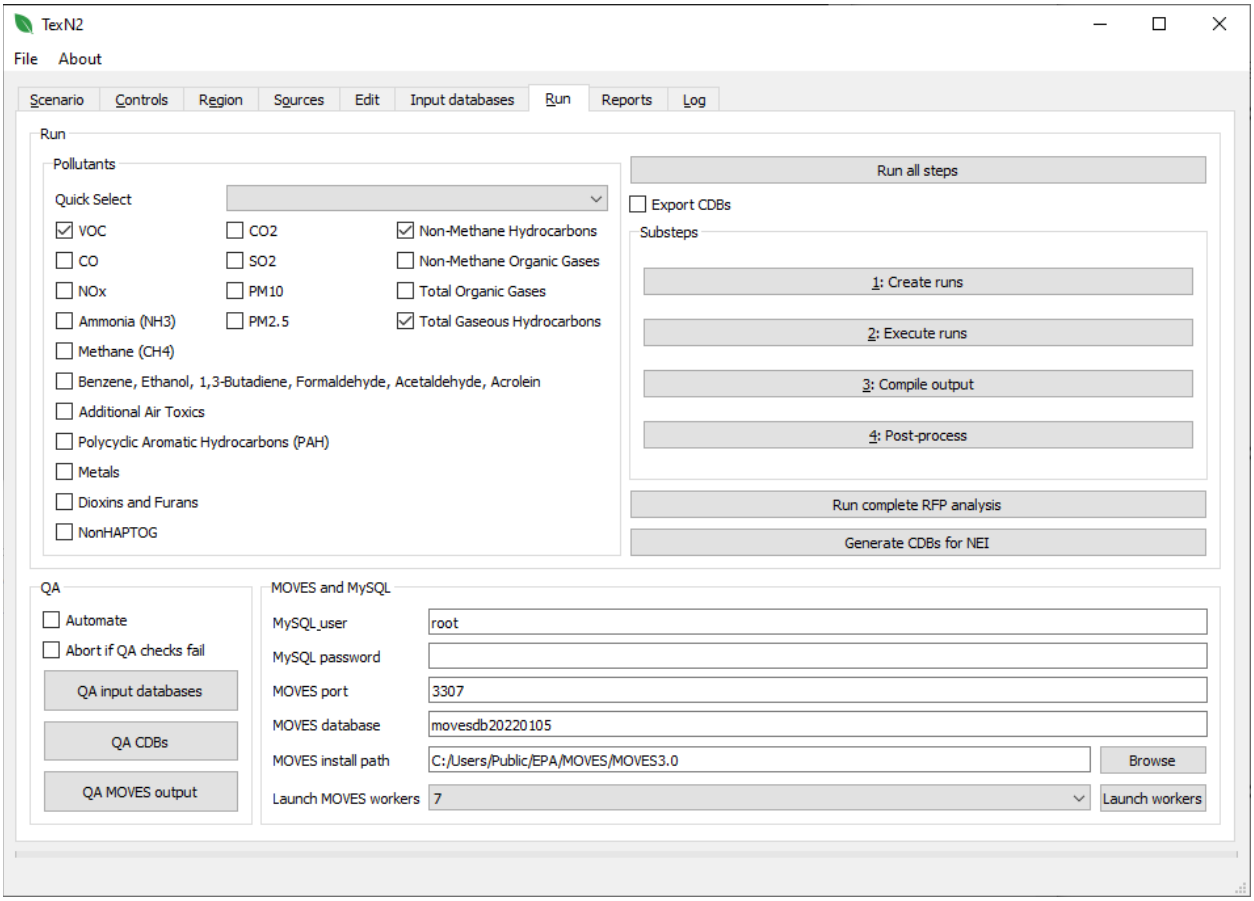


Figure 1. Screenshot showing the new pollutant options.

The user's pollutant settings in the GUI are saved in two places. TexN2 saves the user's pollutant selections in the scenario run specification file, which is the input for TexN2 with a file extension type of JavaScript Object Notation (JSON). The second place TexN2 saves pollutant settings is the utility configuration file C:\Users***YourUserName***\AppData\Local\ERG\TexN2.ini. Saving the settings in the configuration file means that TexN2 "remembers" the last pollutant settings used when next opening the utility.

ERG also added a Quick Select dropdown menu to the GUI (Figure 2) with several options to aid the user in making pollutant selections. The utility doesn't directly use the display in the Quick Select in any run; it is merely a tool to help the user check and uncheck boxes more easily. There are five (5) Quick Select options provided – Default, CAPs, HAPs, All, and Clear All. The Default option automatically checks the boxes of 13 pollutants that, in addition to BSFC, make up the 14 pollutants that were standard with all runs from the prior utility (TexN2.2 and earlier). The CAPs option automatically selects the boxes for VOC, CO, NO_X, Ammonia, SO_2, PM_{10}, $PM_{2.5}$, and two VOC precursors. The HAPs option automatically selects the following pollutant group boxes and their precursor pollutants:

- Benzene, Ethanol, 1,3-Butadiene, Formaldehyde, Acetaldehyde, Acrolein
- Additional Air Toxics
- Polycyclic Aromatic Hydrocarbons (PAH)
- Metals
- Dioxins and Furans

The All option automatically selects every pollutant check box, and the Clear All option removes all pollutant selections.

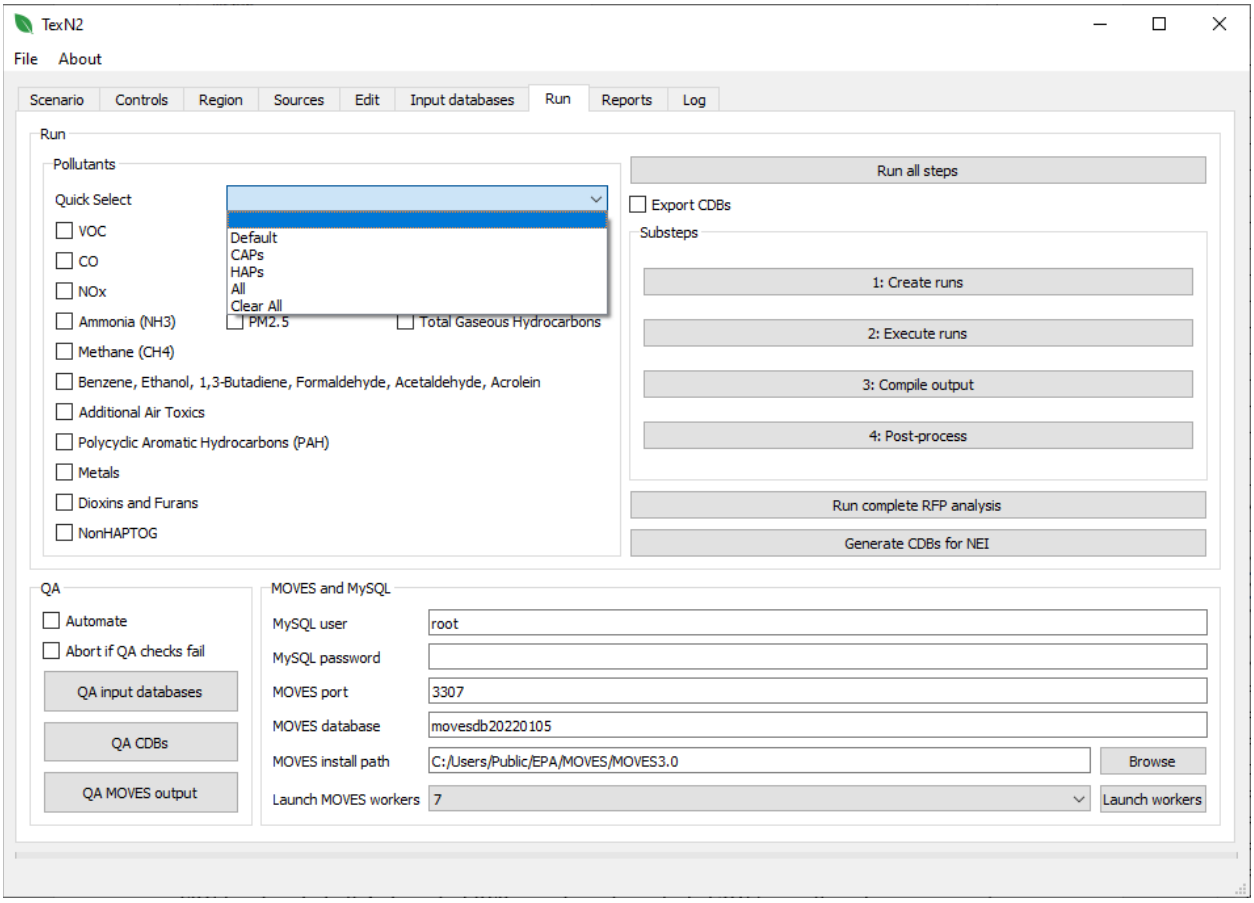


Figure 2. Screenshot showing the pollutant quick select box.

The utility uses the pollutant settings saved in the TexN2 run specification JSON file to insert the appropriate HyperText Markup Language (HTML) blurbs necessary for the MOVES3 run specification file. The HTML blurbs specify the MOVES pollutant ID codes and names, as well as all applicable emission processes (e.g., running exhaust, evaporative hose permeation, etc.).

Pollutants for Automated RFP Runs

ERG hard-coded all Automated RFP runs to only include VOC (as well as its precursors) and NO_X. If the user initiates a TexN2 run by clicking the button "Run complete RFP analysis," the utility ignores all pollutant settings.

Automated RFP Report

Prior to this project, the TexN2 utility did not have an automated summary report to accompany the automated RFP function. The automated RFP function was and still is a one-click approach to initiate a set of ten TexN2 runs that begins with an uncontrolled EI scenario, then incrementally introduces successive federal and state emission control strategies, culminating in a final, fully controlled emissions scenario. The prior TexN2 reporting capabilities applied equally to standard EI runs and automated RFP runs, which meant the user had to click ten times to export the ten runs' reports. After performing ten file exports, users then needed to manually compile the ten reports into an Excel spreadsheet and subtract emissions among the scenarios to understand the benefits of each emission control. The new automated RFP report is a one-click approach that replaces all previous labor to understand emission control benefits.

ERG implemented the automated RFP report as a new Python module that processes the output scenario databases (DBs) produced by the TexN2 utility. The new report does not affect the setup or execution of automated RFP runs, aside from passing a new variable through to the outputs – meteorology year. The new report only impacts the structure of the compiled output scenario DBs (due to adding meteorology year information) and prepares an entirely new and separate report that doesn't affect any existing TexN2 reports.

To use the new automated RFP report, TexN2 users must have already completed an automated RFP run (i.e., a run generated by clicking the "Run complete RFP analysis" button on the utility's `Run` tab). Users must then use the Scenario dropdown box in the `Reports` tab (see Figure 3) to select any of the ten RFP runs. Finally, after selecting any RFP scenario from the desired analysis, users must click the new button, "Generate Automated RFP Report," highlighted in yellow in Figure 3.

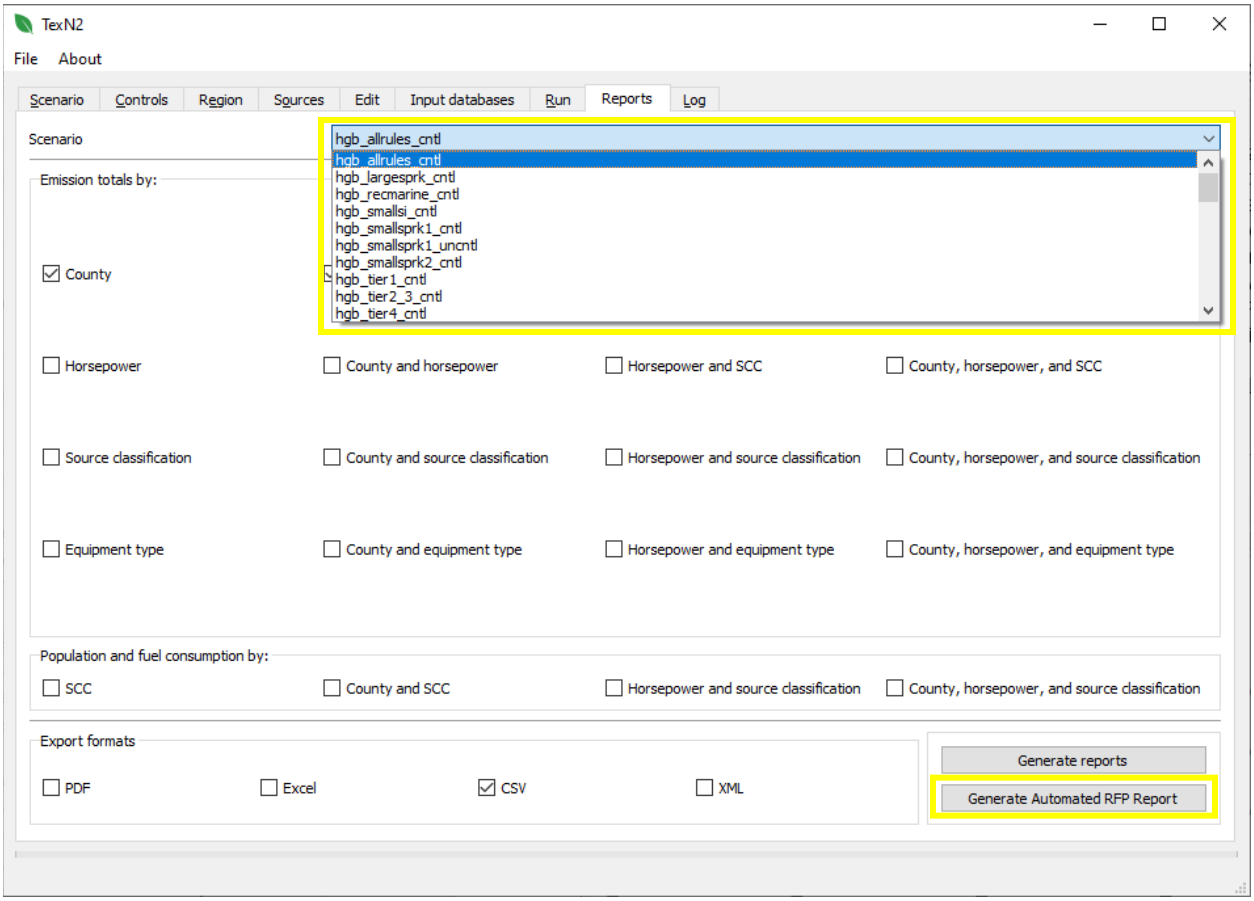
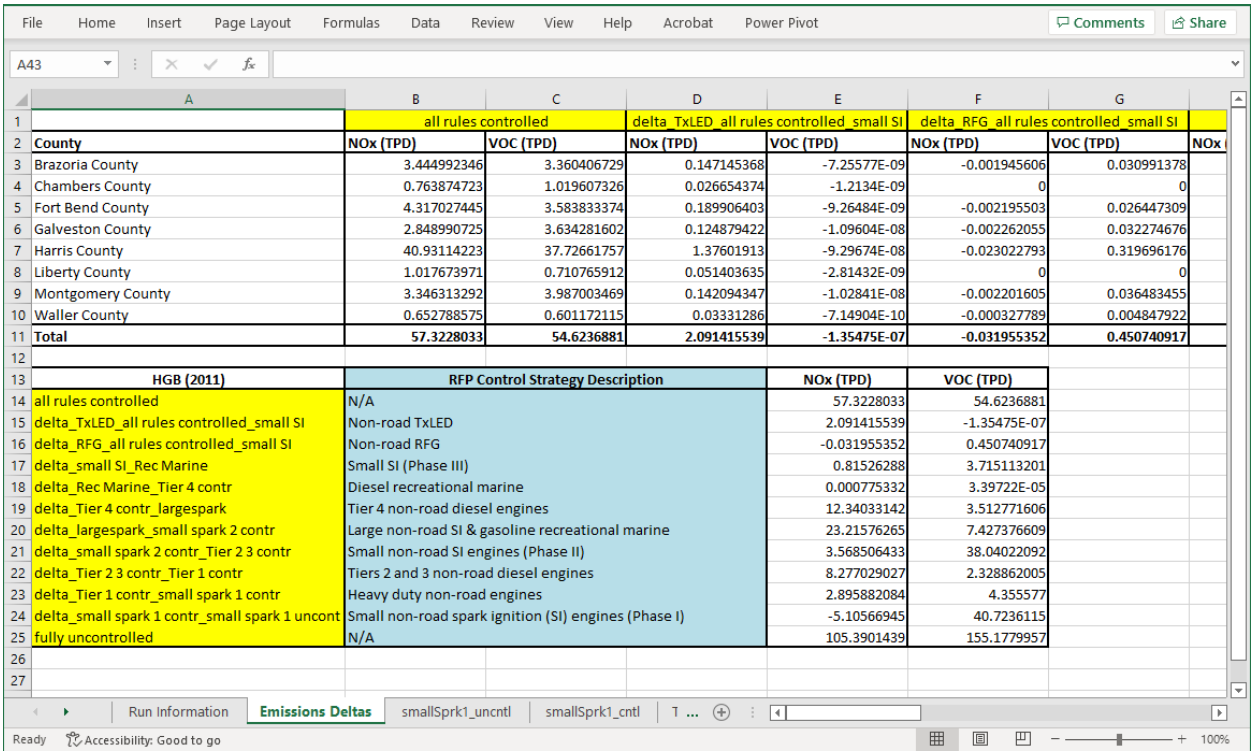


Figure 3. Screenshot showing the `Reports` tab of the GUI and the new RFP report button highlighted.

The example above in Figure 3 shows the user selection of the final RFP scenario: the fully-controlled EI (allrules_cntl) for the Houston-Galveston-Brazoria (HGB) automated RFP run. Clicking the "Generate Automated RFP Report" button instructs TexN2 to check whether the selected run is part of a complete set of ten RFP scenarios. If the check passes, then TexN2 generates an Excel report containing the emissions deltas associated with each RFP control strategy and the full EI for the fully-controlled and fully-uncontrolled cases. If any of the ten RFP scenarios are missing, TexN2 will send a popup window to the screen containing a message indicating which scenarios are missing. This upfront check for completeness will prevent TexN2 users from accidentally running the new automated RFP report on a standard EI run.

Figure 4 shows a screenshot of the county and areawide summary from the new RFP report. There are multiple tabs in the spreadsheet, beginning with "Run Information" (not shown). The Run Information tab lists the scenario name ("HGB" in this example), the scenario year (2011), the meteorology data year (2011) and the period of the run (Ozone Season Day – Weekday).



	A	B	C	D	E	F	G
1		all rules controlled		delta_TxLED_all rules controlled_small SI		delta_RFG_all rules controlled_small SI	
2	**County**	**NOx (TPD)**	**VOC (TPD)**	**NOx (TPD)**	**VOC (TPD)**	**NOx (TPD)**	**VOC (TPD)**
3	Brazoria County	3.444992346	3.360406729	0.147145368	-7.25577E-09	-0.001945606	0.030991378
4	Chambers County	0.763874723	1.019607326	0.026654374	-1.2134E-09	0	0
5	Fort Bend County	4.317027445	3.583833374	0.189906403	-9.26484E-09	-0.002195503	0.026447309
6	Galveston County	2.848990725	3.634281602	0.124879422	-1.09604E-08	-0.002262055	0.032274676
7	Harris County	40.93114223	37.72661757	1.37601913	-9.29674E-08	-0.023022793	0.319696176
8	Liberty County	1.017673971	0.710765912	0.051403635	-2.81432E-09	0	0
9	Montgomery County	3.346313292	3.987003469	0.142094347	-1.02841E-08	-0.002201605	0.036483455
10	Waller County	0.652788575	0.601172115	0.03331286	-7.14904E-10	-0.000327789	0.004847922
11	**Total**	**57.3228033**	**54.6236881**	**2.091415539**	**-1.35475E-07**	**-0.031955352**	**0.450740917**
12							

13	HGB (2011)	RFP Control Strategy Description	NOx (TPD)	VOC (TPD)
14	all rules controlled	N/A	57.3228033	54.6236881
15	delta_TxLED_all rules controlled_small SI	Non-road TxLED	2.091415539	-1.35475E-07
16	delta_RFG_all rules controlled_small SI	Non-road RFG	-0.031955352	0.450740917
17	delta_small SI_Rec Marine	Small SI (Phase III)	0.81526288	3.715113201
18	delta_Rec Marine_Tier 4 contr	Diesel recreational marine	0.000775332	3.39722E-05
19	delta_Tier 4 contr_largespark	Tier 4 non-road diesel engines	12.34033142	3.512771606
20	delta_largespark_small spark 2 contr	Large non-road SI & gasoline recreational marine	23.21576265	7.427376609
21	delta_small spark 2 contr_Tier 2 3 contr	Small non-road SI engines (Phase II)	3.568506433	38.04022092
22	delta_Tier 2 3 contr_Tier 1 contr	Tiers 2 and 3 non-road diesel engines	8.277029027	2.328862005
23	delta_Tier 1 contr_small spark 1 contr	Heavy duty non-road engines	2.895882084	4.355577
24	delta_small spark 1 contr_small spark 1 uncont	Small non-road spark ignition (SI) engines (Phase I)	-5.10566945	40.7236115
25	fully uncontrolled	N/A	105.3901439	155.1779957
26				
27				

Figure 4. Screenshot showing an example automated RFP report for the eight-county HGB area.

The "Emissions Deltas" tab of the spreadsheet contains two sections. Rows 1 to 11 contains results by individual county on separate rows and the NO_x and VOC emissions totals or deltas in units of tons per day (TPD) on separate columns. Rows 13 to 25 represent the areawide emissions totals associated with each RFP control strategy. The areawide summary has two descriptive columns, highlighted in yellow and blue. The first column in yellow lists the scenario or delta of scenarios corresponding to the adjacent NO_x and VOC columns. The blue-highlighted column titled "RFP Control Strategy Description," are the categories used in Texas's SIP documentation tables for non-road mobile sources. ERG added this crosswalk to the automated RFP report at the request of the TCEQ to remove any ambiguity about applicability of the TexN2 categories. The areawide summary from Figure 4 is reproduced below as Table 1 for further discussion.

The first and final rows in Table 1 represent emissions from the fully-controlled and fully-uncontrolled EI, respectively. All other rows correspond to emissions deltas that TexN2 calculated by subtracting one RFP scenario from another, as indicated in the first column. The final row in the table came from an independent TexN2 run without any emission controls implemented, but these emissions also equal the sum of all preceding rows.

Table 1. Example RFP Report Results for the HGB Area, Ozone Season Day Weekday, 2011

HGB (2011) *TexN2 Description*	**RFP Control Strategy Description**	**NOx (TPD)**	**VOC (TPD)**
all rules controlled	N/A	57.3228033	54.6236881
delta_TxLED*_all rules controlled_small SI	Non-road TxLED	2.091415539	-1.35475E-07
delta_RFG**_all rules controlled_small SI	Non-road RFG	-0.031955352	0.450740917
delta_small SI_Rec Marine	Small SI (Phase III)	0.81526288	3.715113201
delta_Rec Marine_Tier 4 contr	Diesel recreational marine	0.000775332	3.39722E-05
delta_Tier 4 contr_largespark	Tier 4 non-road diesel engines	12.34033142	3.512771606
delta_largespark_small spark 2 contr	Large non-road SI & gasoline recreational marine	23.21576265	7.427376609
delta_small spark 2 contr_Tier 2 3 contr	Small non-road SI engines (Phase II)	3.568506433	38.04022092
delta_Tier 2 3 contr_Tier 1 contr	Tiers 2 and 3 non-road diesel engines	8.277029027	2.328862005
delta_Tier 1 contr_small spark 1 contr	Heavy duty non-road engines	2.895882084	4.355577
delta_small spark 1 contr_small spark 1 uncont	Small non-road spark ignition (SI) engines (Phase I)	-5.10566945	40.7236115
fully uncontrolled	N/A	105.3901439	155.1779957

* Texas Low Emission Diesel (TxLED) is a blend of diesel fuel that reduces NO_X emissions and is required in 110 counties in east Texas.

** Reformulated gasoline (RFG) is gasoline blended to burn more cleanly than conventional gasoline and is required for eight counties in the HGB area (Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller) and voluntarily adopted in four additional counties in the Dallas-Fort Worth (DFW) area (Collin, Dallas, Denton, and Tarrant).

In general, the emissions deltas are positive numbers, indicating an emissions benefit from the control strategy. However, numbers can be negative for explainable reasons. The NO_X emissions delta associated with the "Small non-road spark ignition (SI) engines (Phase I)" control strategy can be a negative number (a NO_X disbenefit) because under the small SI rule, some equipment had their standards defined in terms of combined hydrocarbons plus NO_X, allowing minor increases in NO_X while the hydrocarbons decline. There can also be small negative NO_X emissions deltas associated with the "Non-road RFG" control strategy due to the MOVES model's fuel effects on NO_X for the RFG versus conventional gasoline formulations. Note that the automated RFP report may output a very small VOC emissions delta associated with "Non-road TxLED" control strategy on the order of 1E-7; this small value is due to computer rounding and should be interpreted as a zero (0) for SIP reporting purposes.

III. QUALITY ASSURANCE

QA for the Enhanced Pollutant Flexibility

The primary focus of testing the pollutant flexibility was ensuring that each check box produces output results for the intended pollutants. ERG set up a small test run case for a few non-road equipment source category codes (SCC) and a single county to test each check box independently. By running TexN2 separately for each of the 19 pollutant check boxes, TCEQ can be certain that no prerequisite pollutants were overlooked, and that the new functionality propagates fully through the utility for EI type runs. As noted previously, TexN2 does not use any check boxes in automated RFP runs; instead, it includes only NO_x, VOC, and VOC precursors. Table 2 documents each test, which all had a positive outcome. This approach caught an initial mistake for CH_4, but ERG corrected it and re-tested successfully.

Table 2. List of QA Test Runs for the New Pollutant Options in TexN2.3

Test of the Enhanced Pollutant Flexibility
Run TexN2 with no pollutants
Run TexN2 using Quick Select: CAPs
HAPs
Default
All
Run TexN2 for individual pollutants: VOC
CO
NOx
Ammonia (NH3)
Methane (CH4)
CO2
SO2
PM10
PM2.5
Non-Methane Hydrocarbons
Non-Methane Organic Gases
Total Organic Gases
Total Gaseous Hydrocarbons
Run TexN2 for additional groups: Benzene, Ethanol, 1,3-Butadiene, Formaldehyde, Acetaldehyde, Acrolein
Additional Air Toxics
Polycyclic Aromatic Hydrocarbons (PAH)
Metals
Dioxins and Furans
NonHAPTOG

The test runs and their outputs were provided to the TCEQ as a separate electronic file in Deliverable 6.3.

QA for the Automated RFP Report

As mentioned previously, ERG implemented the new automated RFP report as a separate Python module that does not impact the automated RFP runs themselves, nor does it impact any of the existing reports. Therefore, the QA focuses on accuracy of the new calculations. In addition to the new calculations, ERG made a minor change in TexN2.3 to place an existing variable (meteorology data year) in a new location (the compiled output scenario DBs) for it to be available for the new RFP report.

The accuracy of the new report was evaluated by running it on older TexN2.2 output databases from the prior development of RFP EIs for the HGB eight-county and DFW ten-county ozone nonattainment areas (ERG, 2021) to ensure the new report replicated the prior results.

The new report is backward-compatible with automated RFP run scenario DBs created with older versions of TexN2. One minor detail to be aware of is that prior versions of TexN2 did not track the meteorology year in the scenario DBs, and so the automated RFP report will leave that data field blank in the "Run Information" tab of the Excel report. All RFP EIs generated with the updated utility do track the meteorology year, as specified in the Work Order for the project.

To test the new report, ERG first updated the prior large RFP EIs in two ways. First, ERG manually added the meteorological data year to the scenario output DB's `texn2scenario` table, which is an action that TexN2 now performs for all scenario databases. Second, ERG split the former scenario DBs from 18 counties into two separate sets of output DBs – one for the HGB eight-county area and one for the DFW ten-county area. The reason for this is so the areawide totals in the automated RFP report are specific to a meaningful area (a single nonattainment area). Going forward, the recommended standard operating procedure for an automated RFP is to run a single geographic area of interest (for example, the HGB nonattainment area) as one run execution.

Tables 3 and 4 show the calendar year 2011 results for the prior Final Report (TexN2.2 with MOVES3, which had manually-calculated RFP control strategy benefits; from ERG, 2021) and the new automated RFP report output. All emissions units are TPD rounded to two decimal places, and the difference columns represent the new minus prior report's emissions.

Table 3. Differences in NOX and VOC for Year 2011 Ozone Season Day Weekday RFP EIs by Scenario for the HGB Eight-County Area

RFP Control Strategy Description	Prior Report NO_X (TPD)	New Report NO_X (TPD)	Difference NO_X (TPD)	Prior Report VOC (TPD)	New Report VOC (TPD)	Difference VOC (TPD)
All Rules Controlled*	57.32	57.32	0%	54.62	54.62	0%
Non-road TxLED	2.09	2.09	0%	0.00	0.00	0%
Non-road RFG	-0.03	-0.03	0%	0.45	0.45	0%
Small SI (Phase III)	0.82	0.82	0%	3.72	3.72	0%
Diesel recreational marine	0.00	0.00	0%	0.00	0.00	0%
Tier 4 non-road diesel engines	12.34	12.34	0%	3.51	3.51	0%
Large non-road SI & gasoline recreational marine	23.22	23.22	0%	7.43	7.43	0%
Small non-road SI engines (Phase II)	3.57	3.57	0%	38.04	38.04	0%
Tiers 2 and 3 non-road diesel engines	8.28	8.28	0%	2.33	2.33	0%
Heavy duty non-road engines	2.90	2.90	0%	4.36	4.36	0%
Small non-road spark ignition (SI) engines (Phase I)	-5.11	-5.11	0%	40.72	40.72	0%
Fully Uncontrolled*	105.39	105.39	0%	155.18	155.18	0%

* The scenarios "All Rules Controlled" and "Fully Uncontrolled" are not control strategies but are listed because they are two of the required scenarios included in a TexN2 Automated RFP analysis.

Table 4. Differences in NOX and VOC for Year 2011 Ozone Season Day Weekday RFP EIs by Scenario for the DFW Ten-County Area

RFP Control Strategy Description	Prior Report NO_X (TPD)	New Report NO_X (TPD)	Difference NO_X (TPD)	Prior Report VOC (TPD)	New Report VOC (TPD)	Difference VOC (TPD)
All Rules Controlled*	62.08	62.08	0%	60.09	60.09	0%
Non-road TxLED	2.36	2.36	0%	0.00	0.00	0%
Non-road RFG	-0.03	-0.03	0%	0.62	0.62	0%
Small SI (Phase III)	0.88	0.88	0%	4.49	4.49	0%
Diesel recreational marine	0.00	0.00	0%	0.00	0.00	0%
Tier 4 non-road diesel engines	13.28	13.28	0%	3.58	3.58	0%
Large non-road SI & gasoline recreational marine	23.08	23.08	0%	7.80	7.80	0%
Small non-road SI engines (Phase II)	3.97	3.97	0%	44.08	44.08	0%
Tiers 2 and 3 non-road diesel engines	8.83	8.83	0%	2.39	2.39	0%
Heavy duty non-road engines	3.16	3.16	0%	3.08	3.08	0%
Small non-road spark ignition (SI) engines (Phase I)	-5.67	-5.67	0%	47.11	47.11	0%
Fully Uncontrolled*	111.93	111.93	0%	173.23	173.23	0%

* The scenarios "All Rules Controlled" and "Fully Uncontrolled" are not control strategies but are listed because they are two of the required scenarios included in a TexN2 Automated RFP analysis.

The output databases from ERG (2021) and the corresponding new automated RFP reports for the HGB and DFW areas were provided to the TCEQ as separate electronic files in Deliverable 6.3.

QA Audit

As documented separately in the Quality Assurance Project Plan (QAPP), the TexN2 utility update project qualifies as Level III: Software Evaluation, Software Related Research, Software Maintenance, or Software Development. Level III QAPPs require a "ten percent" audit, which is exceeded by the QA checks outlined above. The checks covered 100 percent of all the new pollutant options by running TexN2; the inputs and output reports are included in Deliverable 6.3. The automated RFP report was tested by running the new report on prior databases from Task 5, year 2011 RFP analysis from the final report "Development of the Non-road Model RFP Emissions Inventories for the HGB Eight-County and DFW Ten-County Ozone Nonattainment Areas" (ERG, 2021) and calculating the differences from 100 percent of the values in the summary spreadsheets. The prior RFP analysis scenario DBs, new RFP results, and QA comparison spreadsheet are all included in Deliverable 6.3.

IV. GETTING STARTED USING TEXN2.3

The information presented in this section is intended for TexN2 users who are familiar with a recent prior utility, TexN2.2 with MOVES3 or TexN2.1 with MOVES2014b. ERG has included this same information in the User's Guide for TexN2.3.

To get started, users should perform the following actions in order:

1. Download and Unzip the TexN2.3 Utility

Download and unzip the utility TexN2_v2_3_0_*.zip to your local machine where * is the date. ERG provided this file electronically to the TCEQ. Unzip the package, and the top-level directory should show a "dist" directory and a file with a ".sql" extension.

C:\TexN2_v2_3_0_15jul22\dist
C:\TexN2_v2_3_0_15jul22\TexN2_15jul22.sql

2. Download and Install MOVES3

MOVES3 is available from the US EPA website https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves.

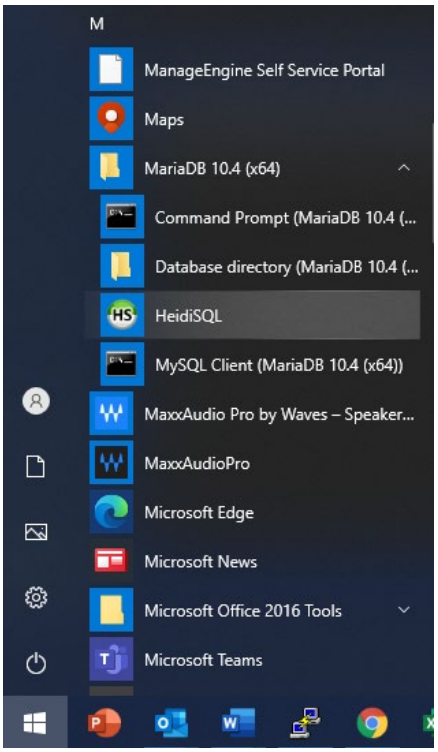
> **Note:** The TexN2.3 utility requires MOVES3.0.0 or later. It will not run with prior versions of MOVES (i.e., MOVES2014b and earlier). At the time of writing, the latest version of MOVES is MOVES3.0.3.
>
> **Important**: The US EPA installer for MOVES3 automatically installs MariaDB. During the MariaDB installation process, you will be asked to set a MariaDB root user password. Write this password down; it is not recoverable later. The root user password is needed in Step 3. If you currently have a version of MOVES3 installed on the machine you are configuring for TexN2.3 and are merely upgrading to the latest MOVES3 patch version, MariaDB was already installed during a prior version of MOVES3, and you will not need to set up a password.

3. Configure the "moves" User

These Step 3 instructions apply only to TexN2 users who are installing MOVES3 for the first time on the machine you are configuring for TexN2.3. If you previously ran TexN2 with MOVES3 (i.e., TexN2.2) on the machine you are configuring for TexN2.3, you can skip this step and proceed to Step 4.

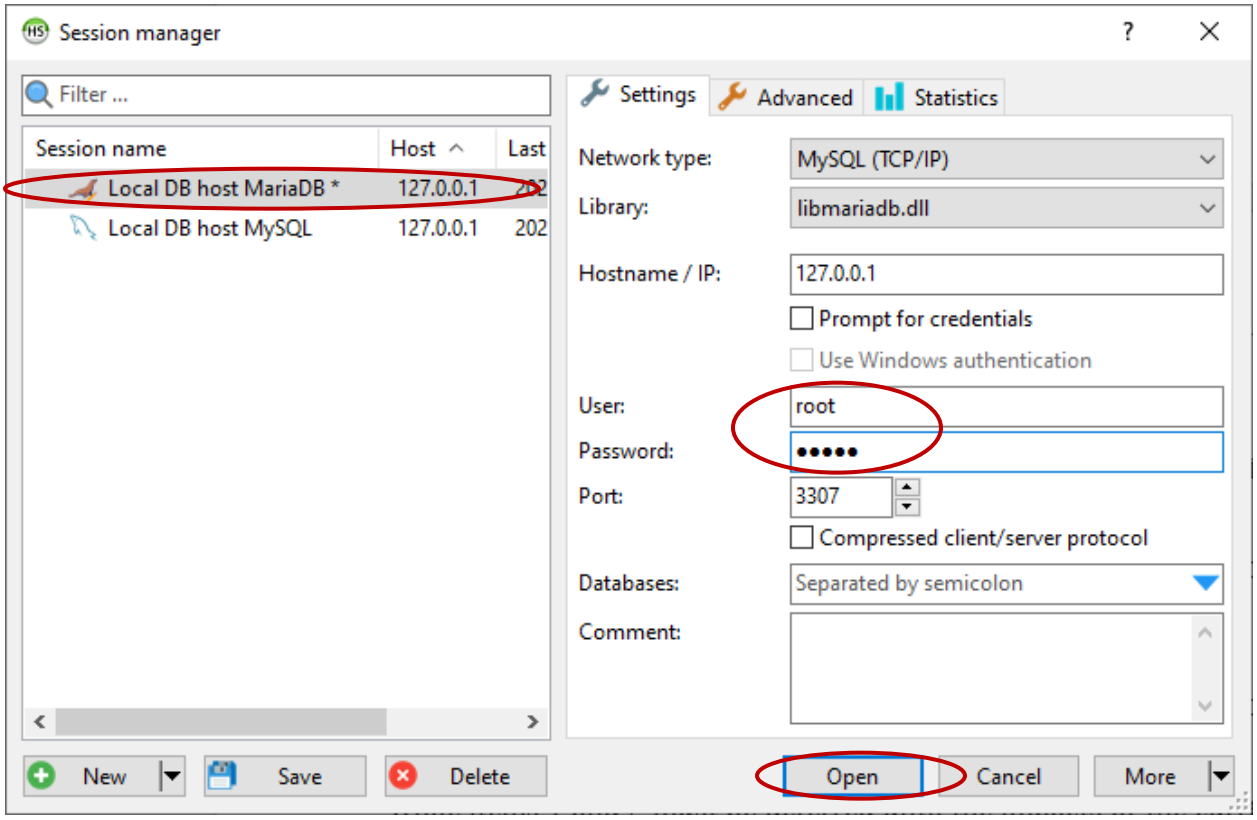
Open HeidiSQL from the start menu. HeidiSQL is a GUI for MariaDB provided with the MOVES3 package, analogous to MySQL Workbench for MySQL.

Launch HeidiSQL:

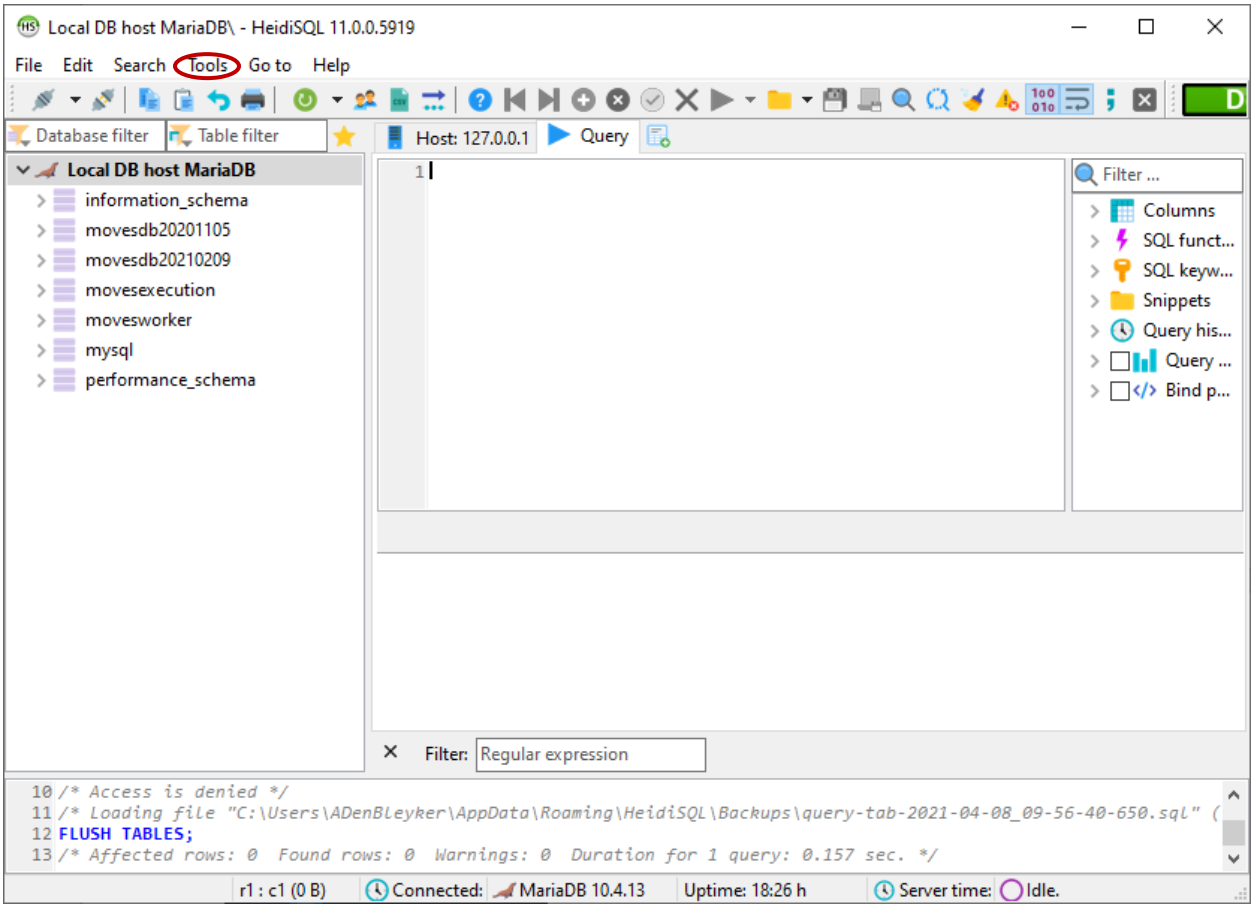


Click on a connection and log in. The MOVES3 installer should have set up a connection named "MOVES Connection" for the MariaDB port. In the image below, 3307 is the port number, but your port may be different.

> **Important**: For this particular log-in session, update the user to "root" and the root user password you set earlier during the MariaDB configuration during the MOVES3 installation.
>
> **Note:** the screenshot below has custom named connection set up "Local DB host MariaDB." Unless you already have custom connections setup, select the default "MOVES Connection", change the user to root, enter the password, then click Open.

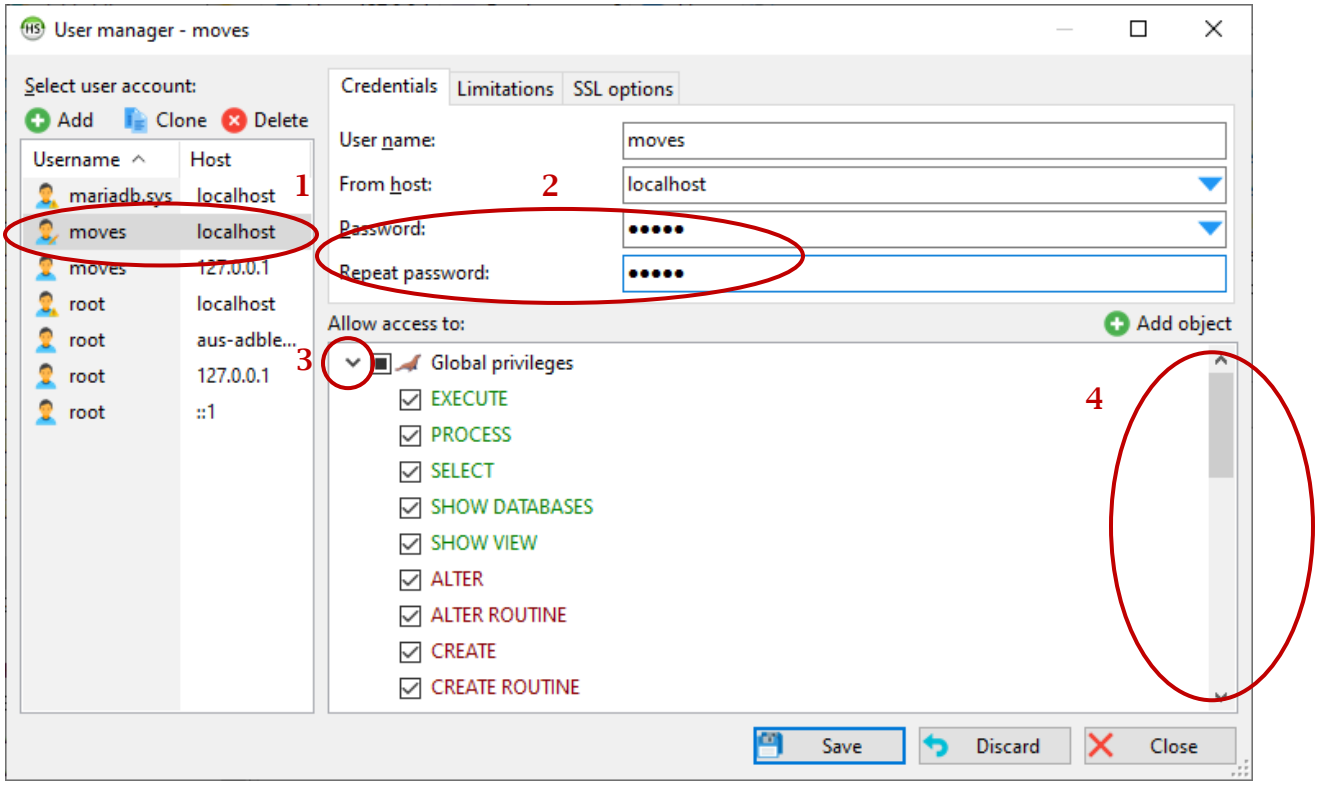


After logging in, you should see a screen similar to the image below. On the left are the MySQL databases currently on the machine and on the right is a workspace where you can execute MySQL queries. On the top menu bar, select Tools > User Manager.

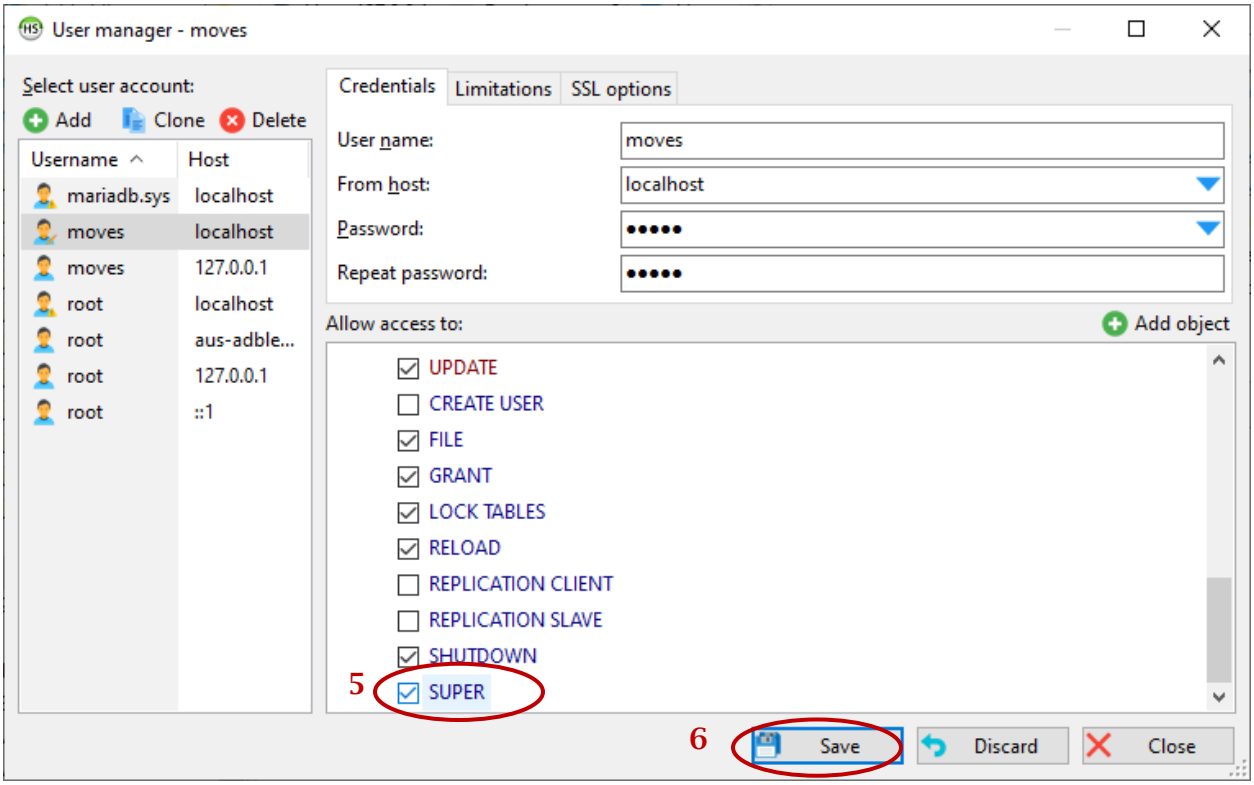


In the User Manager, follow the directions in bullets below; they are also overlaid onto a screenshot of the User Manager.

- (1) Select “moves” user so the manager highlights it in grey.
- (2) Provide the Password and Repeat password.
- (3) Click the dropdown next to Global privileges and
- (4) scroll down to “SUPER.”



- (5) Check SUPER.
- (6) Click Save.



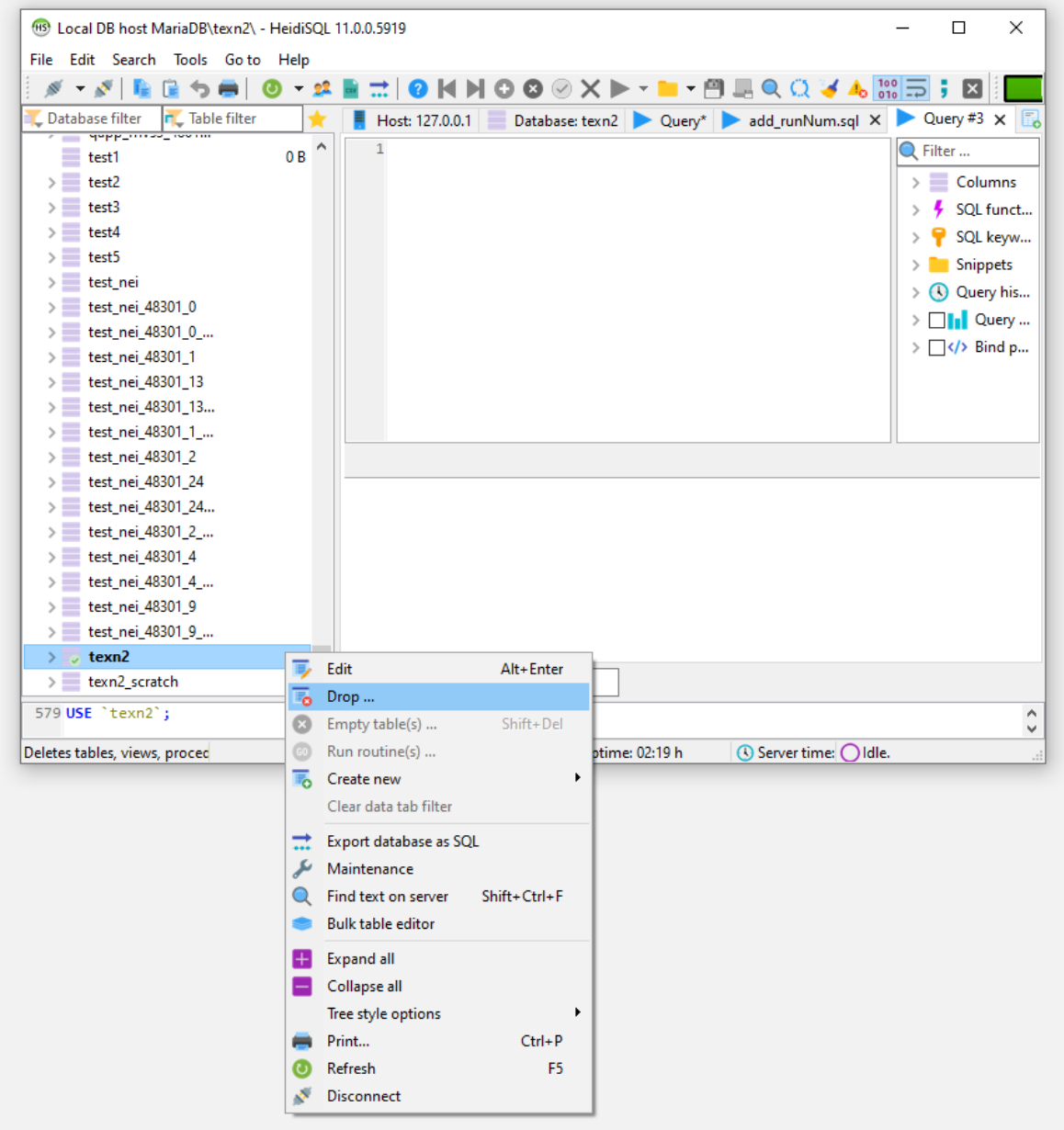
Important: Repeat steps 1-6 for all "moves" users.

Close out of the User Manager when finished updating the moves user privileges.

4. Remove Remnants of the Prior Utility

If you created a TexN2 shortcut associated with the old utility, navigate to it, Right-click and select "Delete."

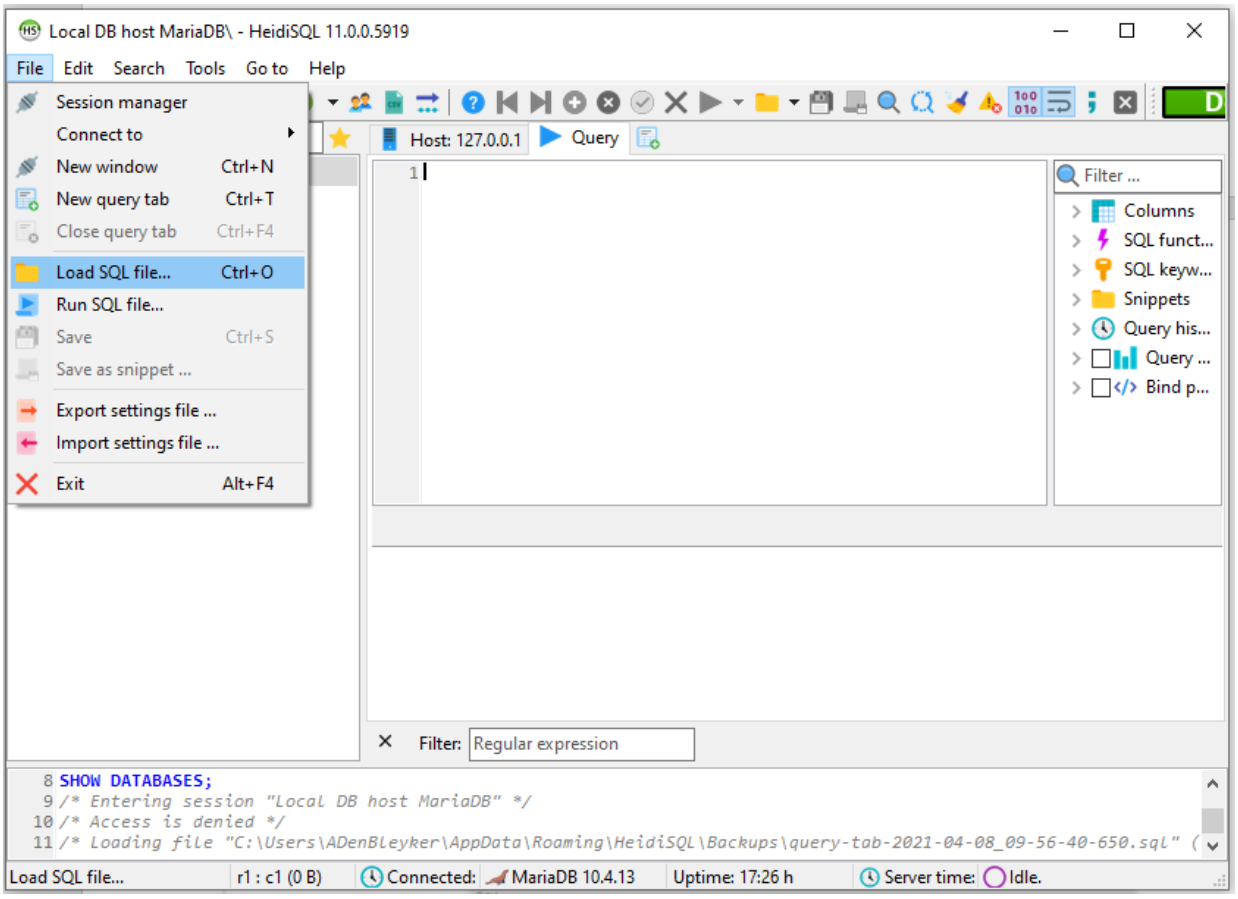
If you have a prior TexN2 database already in your MariaDB data directory, delete it using HeidiSQL as shown below. **Note:** you might not necessarily have a prior TexN2 database. If there is no TexN2 database, proceed to Step 5. Otherwise, Right-click on TexN2 in HeidiSQL and select the option "Drop" as shown below.



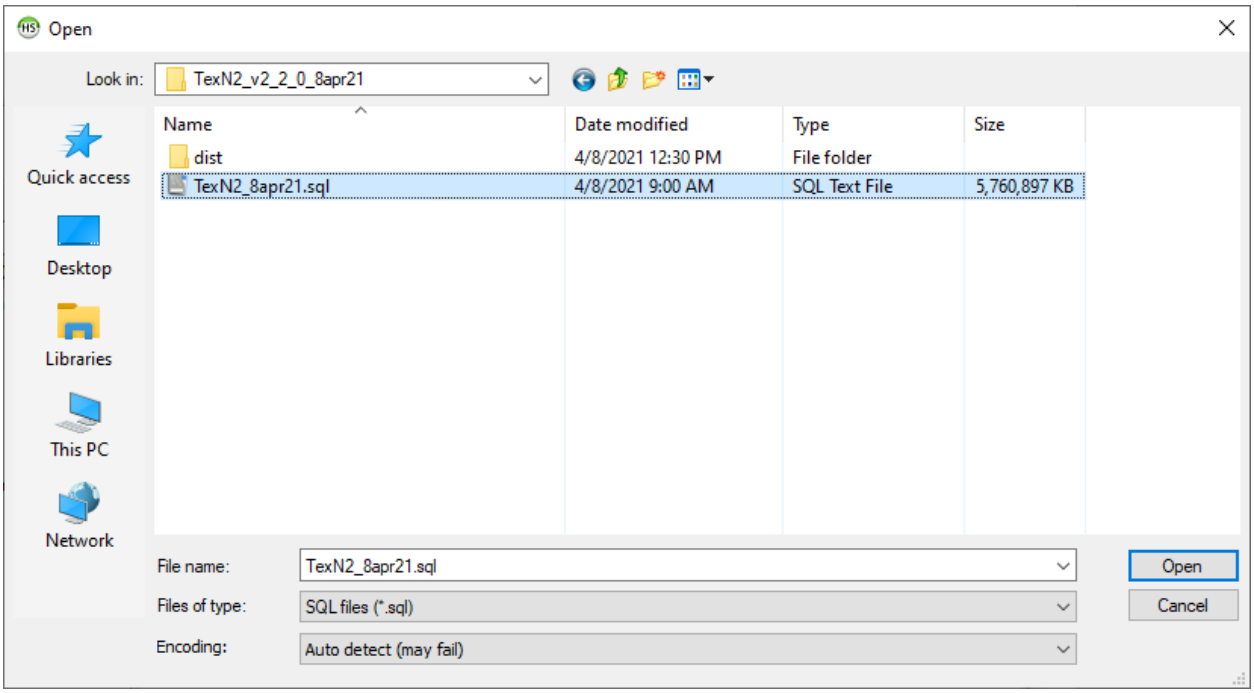
5. Import the New TexN2 Database

The next manual step that must be performed prior to launching the utility for the first time, is to import the new TexN2 database. The database file should have been provided with the utility, and will have a name like TexN2_*.sql, where "*" is a date stamp.

From the File menu at the top of the HeidiSQL screen, choose "Load SQL file":

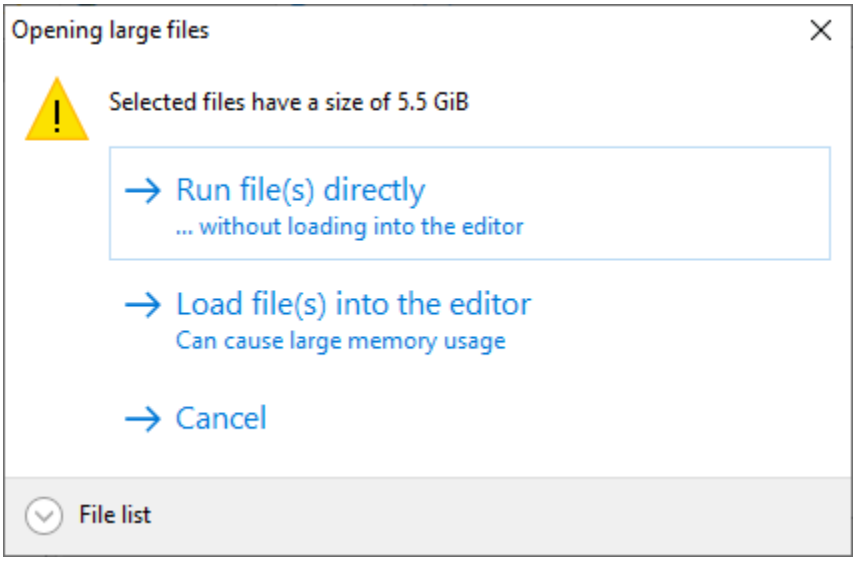


Navigate to the TexN2 database file (TexN2_*.sql) and select it and click Open:

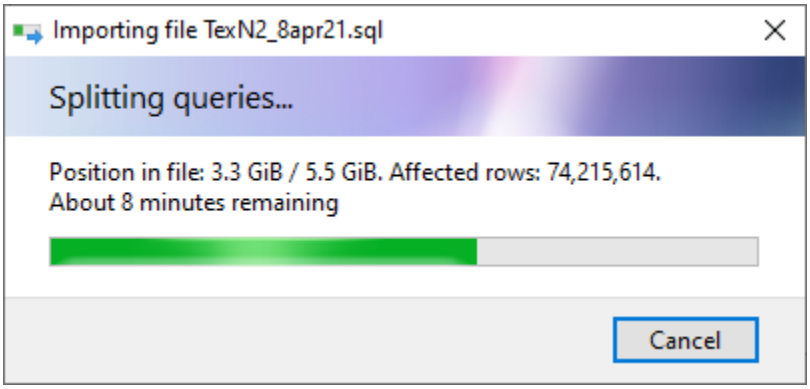


Note: The date on this database in the screenshot is not the current version. The screenshot is for illustrative purposes only.

You may see a warning that you are opening a large file. Select the option "Run file(s) directly without loading into the editor."

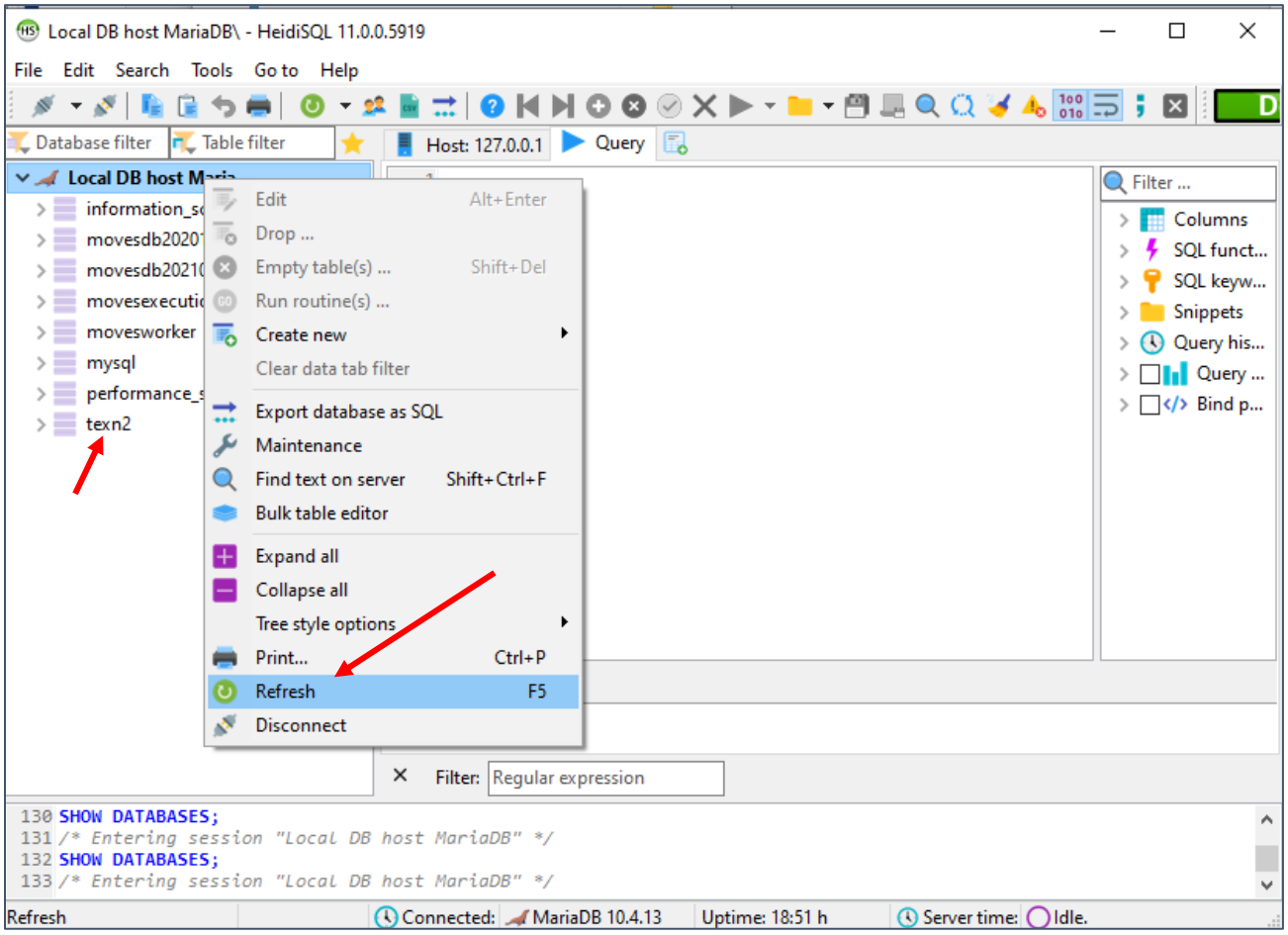


Now wait for the data import process to complete. This can take a while (around 30 minutes), so be patient.



> **Note:** The date on this database in the screenshot is not the current version. The screenshot is for illustrative purposes only.

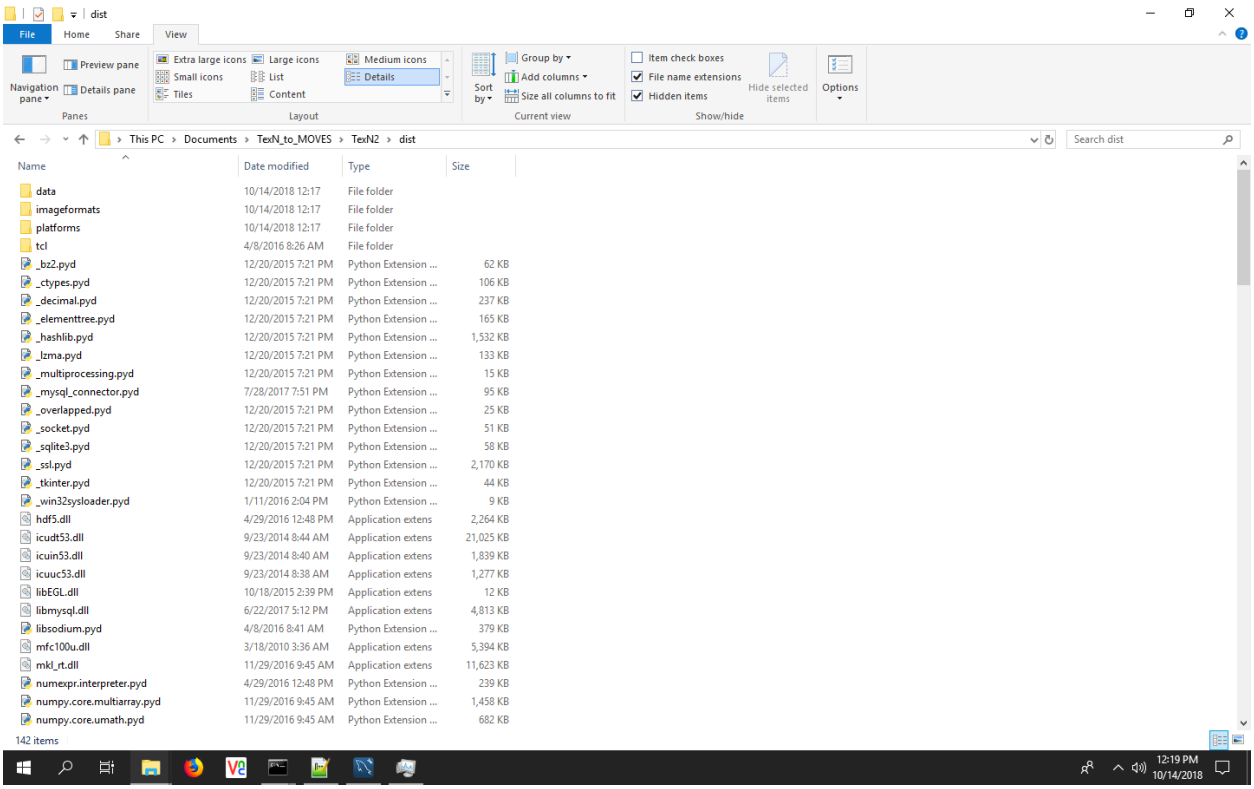
Right-click on your connection name and select refresh to verify that the database has been imported. If it has been imported successfully, you should see "texn2" listed in the left-hand pane:



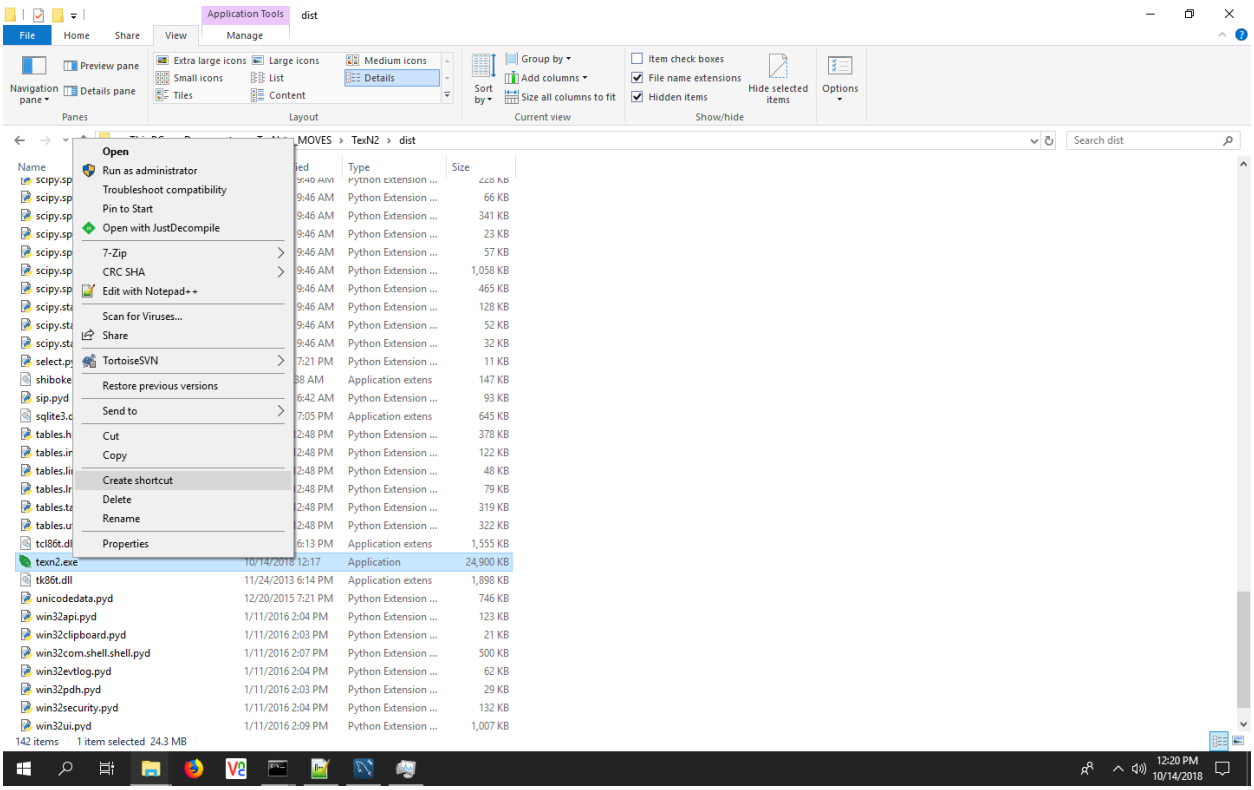
After the database import completes, you are ready to launch TexN2.3 for the first time.

6. Creating a Shortcut to TexN2

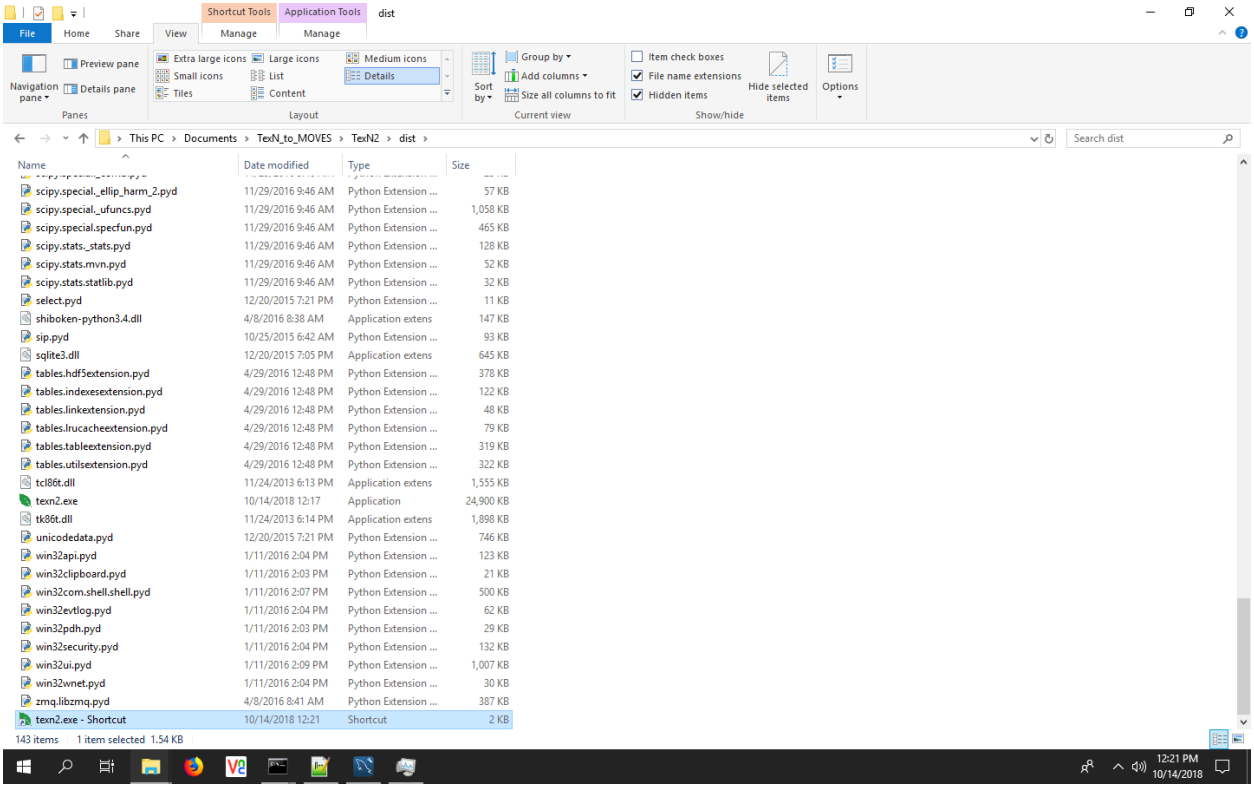
Because TexN2 is designed to work without an installer, it is launched by directly double-clicking the executable file, *texn2.exe*. However, the executable resides in a folder along with a number of other required files, so it is strongly recommended to create a shortcut to the TexN2 executable to avoid the need to open the containing folder to launch the utility; any manipulation of files in this directory runs the risk of deleting or corrupting files that the utility requires to function properly. Creating a shortcut will also make launching the utility more convenient. The contents of the folder containing the executable will resemble the image below:


dist
File
Home
Share
View
Navigation pane
Preview pane
Details pane
Panes
Extra large icons
Large icons
Medium icons
Small icons
List
Details
Tiles
Content
Layout
Sort by
Group by
Add columns
Size all columns to fit
Current view
Item check boxes
File name extensions
Hidden items
Hide selected items
Show/hide
Options
This PC › Documents › TexN_to_MOVES › TexN2 › dist
Search dist
Name
Date modified
Type
Size
data 10/14/2018 12:17 File folder
imageformats 10/14/2018 12:17 File folder
platforms 10/14/2018 12:17 File folder
tcl 4/8/2016 8:26 AM File folder
_bz2.pyd 12/20/2015 7:21 PM Python Extension ... 62 KB
_ctypes.pyd 12/20/2015 7:21 PM Python Extension ... 106 KB
_decimal.pyd 12/20/2015 7:21 PM Python Extension ... 237 KB
_elementtree.pyd 12/20/2015 7:21 PM Python Extension ... 165 KB
_hashlib.pyd 12/20/2015 7:21 PM Python Extension ... 1,532 KB
_lzma.pyd 12/20/2015 7:21 PM Python Extension ... 133 KB
_multiprocessing.pyd 12/20/2015 7:21 PM Python Extension ... 15 KB
_mysql_connector.pyd 7/28/2017 7:51 PM Python Extension ... 95 KB
_overlapped.pyd 12/20/2015 7:21 PM Python Extension ... 25 KB
_socket.pyd 12/20/2015 7:21 PM Python Extension ... 51 KB
_sqlite3.pyd 12/20/2015 7:21 PM Python Extension ... 58 KB
_ssl.pyd 12/20/2015 7:21 PM Python Extension ... 2,170 KB
_tkinter.pyd 12/20/2015 7:21 PM Python Extension ... 44 KB
_win32sysloader.pyd 1/11/2016 2:04 PM Python Extension ... 9 KB
hdf5.dll 4/29/2016 12:48 PM Application extens 2,264 KB
icudt53.dll 9/23/2014 8:44 AM Application extens 21,025 KB
icuin53.dll 9/23/2014 8:40 AM Application extens 1,839 KB
icuuc53.dll 9/23/2014 8:38 AM Application extens 1,277 KB
libEGL.dll 10/18/2015 2:39 PM Application extens 12 KB
libmysql.dll 6/22/2017 5:12 PM Application extens 4,813 KB
libsodium.pyd 4/8/2016 8:41 AM Python Extension ... 379 KB
mfc100u.dll 3/18/2010 3:36 AM Application extens 5,394 KB
mkl_rt.dll 11/29/2016 9:45 AM Application extens 11,623 KB
numexpr.interpreter.pyd 4/29/2016 12:48 PM Python Extension ... 239 KB
numpy.core.multiarray.pyd 11/29/2016 9:45 AM Python Extension ... 1,458 KB
numpy.core.umath.pyd 11/29/2016 9:45 AM Python Extension ... 682 KB
142 items
12:19 PM
10/14/2018

Find the *texn2.exe* file in the folder, right click, and choose "Create Shortcut":

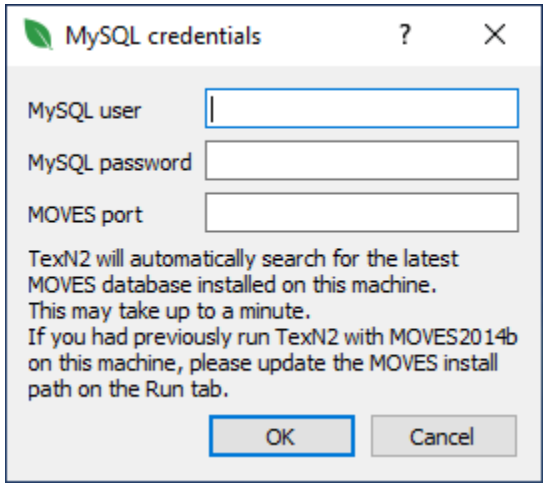


Find the shortcut that was created and drag it to the Desktop or other convenient location:



7. Launch TexN2.3

Navigate to your TexN2 shortcut and double-click to launch. The first time you launch TexN2.3, it may or may not display a dialog box requesting your MySQL username and password and the "MOVES port" which MariaDB uses. If TexN2.3 requests the information, enter lower case "moves" and "moves" for the MySQL user and MySQL password, and enter your MariaDB port number (if uncertain, open a new HeidiSQL instance from the Start Menu and make note of the port number for "MOVES Connection").



There is a note in the MySQL credentials box about two separate issues:

First, TexN2 will look for the latest version of the MOVES default database on your machine. For example, if you have both MOVES databases *movesdb20210209* and *movesdb20220105*, TexN2 will connect automatically to the latter when launching for the first time. The MOVES default database may be changed in the Run tab of the GUI, and the utility will automatically remember (and quickly connect to) the most recent MOVES database used. However, during the first launch the utility may take up to a minute for the utility to find a MOVES database.

The second issue is meant to alert the user to verify the "MOVES install path" in the Run tab after the first launch, because the utility may remember the MOVES2014b install path for the initial launch if the prior version of TexN2 on this machine was TexN2.1 or TexN2.0. Users should navigate to the Run tab now in the TexN2 GUI and ensure the MOVES install path reflects MOVES3. Subsequent launches of TexN2 will remember the MOVES3 installation path. Note: TexN2.3 will not run with MOVES2014b. Your most likely MOVES3 installation path will be C:\Users\Public\EPA\MOVES\MOVES3.0.

After clicking "OK" on the above dialog box, if needed, and reviewing the MOVES install path on the Run tab, you are ready to run TexN2.3. This concludes the "Getting started" guide; please refer to the user's guide for any general information on running TexN2.

V. RECOMMENDATIONS

ERG recommends the following TexN2 improvements for consideration for possible future updates. These are intended to improve the ease of use of the TexN2 utility both for TCEQ staff and others outside the agency.

1. **Add TexN2 Database Export Capability.** The purpose of this first recommendation is to make it easy for TCEQ staff to extract information about non-road equipment stored inside the utility into an easy-to-read Excel format file at a level of detail useful for comparisons with alternative sources of non-road data. The TCEQ could use the exported data summaries from TexN2 to evaluate any new studies performed by consultants or a Texas council of government (COG) describing non-road equipment operation in Texas.

   ERG would add a new summary report that filters and queries the large utility database to extract information including, but not limited to: (1) equipment populations, (2) annual hours of operation, (3) load factors, and (4) rated/average horsepower. The specifics of the report capability would be designed in consultation with the TCEQ Project Manager, and the report would be customizable to report either granular data or more aggregate information for a specific year(s), county(ies), and equipment type(s) of interest.

2. **Reducing TexN2 computation time and disk space requirements.** In response to comments from the TCEQ and users including at least one COG, the utility takes a long time to run, and it requires significant disk space on a computer, particularly so for statewide runs with all 254 counties or even multi-county areas if an annual period is required.

   ERG would reduce the disk space requirements by changing the order of some of the TexN2 internal calculations, such that intermediate database files (i.e., input and output DBs from MOVES) may be dropped while the larger TexN2 run is in progress. ERG would reduce the runtime by post-processing individual output databases as they become available, and then compile them into the scenario database. The post-processing calculations will run much faster on smaller tables that correspond to a single county and diesel construction subsector. In addition, ERG will explore incorporating more “multi-threading” to reduce runtime. Multi-threading is a programming concept whereby a piece of code can be used by several processors, concurrently, on the same computer. Multi-threading is an option for calculations that do not depend on one another, such as performing a specific calculation on many counties.

As always, ERG welcomes feedback from TCEQ on TexN2 to incorporate future improvements to the utility.

REFERENCES

US EPA, 2022. "MOVES3: Latest Version of Motor Vehicle Emission Simulator." Available online (as of 6/10/2022) https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves.

ERG, 2021. "Development of the Non-road Model RFP Emissions Inventories for the HGB Eight-County and DFW Ten-County Ozone Nonattainment Areas." Prepared for the Texas Commission on Environmental Quality, Air Quality Division, Austin, TX 78711-3087. July 28.