DC-AC Manual

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April 28, 2021

Citing DC-AC Tool

- **If you use DC-AC Tool for research or consulting, please cite the following paper in your publication that uses DC-AC Tool.**

Wang, Bin, and Jin Tan. 2022. DC-AC Tool: Fully Automating the Acquisition of AC Power Flow Solution. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A40-80100. https://www.nrel.gov/docs/fy22osti/80100.pdf

Content

Introduction

- **DC-AC Tool** is an automated tool for achieving a converged AC power flow solution from any dispatch determined using a DC model-based optimal power flow. The entire process is free of human intervention. This tool first achieves a solvable AC power flow case by modifying the power flow condition and then to try to track the AC power flow solution while gradually removing the adopted changes. If all adopted changes can be completely removed, then the original AC power flow solution is obtained. Otherwise, insights into actionable controls are derived to help in operation and planning. Currently, this tool has been implemented in Python using Siemens PTI PSS/E as the power flow solver. Detailed development and validation process of the tool can be found in [1].

[1] Wang, Bin, and Jin Tan. 2022. DC-AC Tool: Fully Automating the Acquisition of AC Power Flow Solution. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A40-80100. https://www.nrel.gov/docs/fy22osti/80100.pdf

Introduction

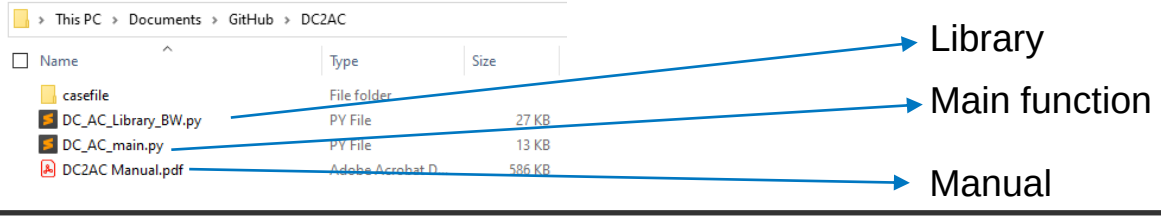
- DC-AC Tool requires the following inputs from users:
  - Power flow RAW/SAV files in PSS/E v34 format
  - A spreadsheet containing a list of buses to add temporary fictitious generators
- The DC-AC Tool can
  - Process each of the power flow RAW/SAV files, and categorize them into one of the following situations
    - Original power flow is solved
    - Original power flow is solved after adjusting voltage set point(s) at some generator(s)
    - Original power flow is solved with Q compensation(s) at some location(s)
    - Original power flow is insolvable, but can be solved with reduced loading
  - Save the solved power flow into new RAW/SAV files, and summarize the changes, if any, made to achieve the solvability.
- This manual contains (i) installation guideline, and (ii) a brief tutorial.

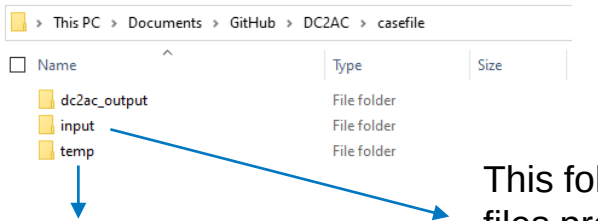
Installation and configuration

- **DC-AC Tool** is free and open-sourced on GitHub: https://github.com/NREL/DC2AC.
- **Python** and **PSS/E v34** need to be installed and licensed, if necessary. (Python 2.7 was used for developing this tool, while other versions have not been tested)
- Create a Python project folder, and put all files/folders in DC2AC-main in that project folder.
- In the Project Interpreter, install packages: xlrd, numpy and natsort.
- Specify path to PSS/E in rows 14 and 16 of the python file named “DC_AC_main.py”.
- Copy PSS/E power flow RAW/SAV files in this directory: .\casefile\input\
- Specify whether RAW or SAV format is used in row 37 of the python file named “DC_AC_main.py”: 1 – RAW, 2 – SAV.
- Specify the bus numbers in a .xlsx spreadsheet file named “subs_bus.xlsx” and put it in this directory: .\casefile\input\
- Run Python scripts “DC_AC_main.py”
- Find output files in folders “.\casefile\dc2ac_output”.

Installation and configuration

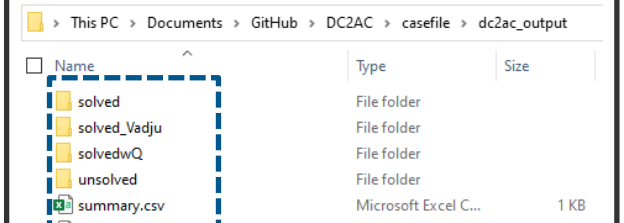
- Here's what the folders/files look like:





Intermediate results generated and used by DC2AC Tool. Can be ignored by users.

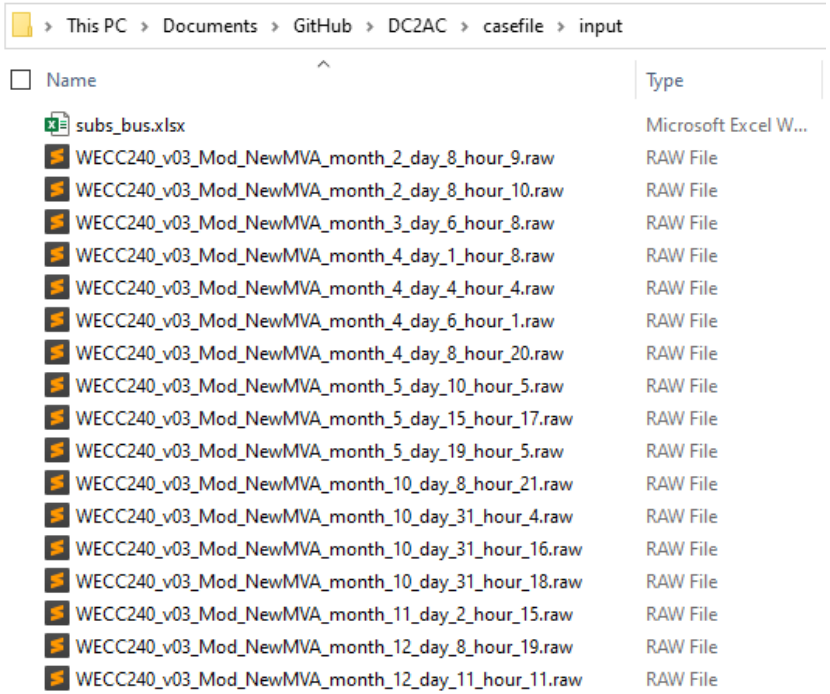
This folder contains all input files provided by users, including: (i) "subs_bus.xlsx", and (ii) all power flow cases to be solved, either in .raw or .sav format.



To be explained in the example in following slides.

Examples on 240-Bus Case [1]

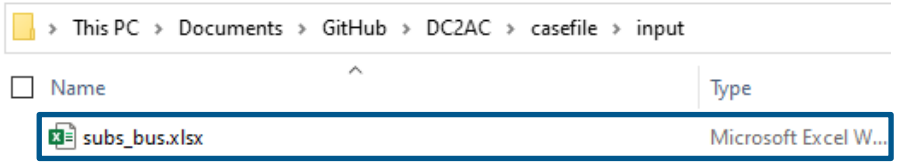
- The 17 power flow cases in Table 3 of ref. [1] are used in this example.
- ➢ Step 1: Set up the project based on slides 6 and 7.
- ➢ Step 2: Put the .raw files of these 17 power flow cases in the folder: ./casefile/input/

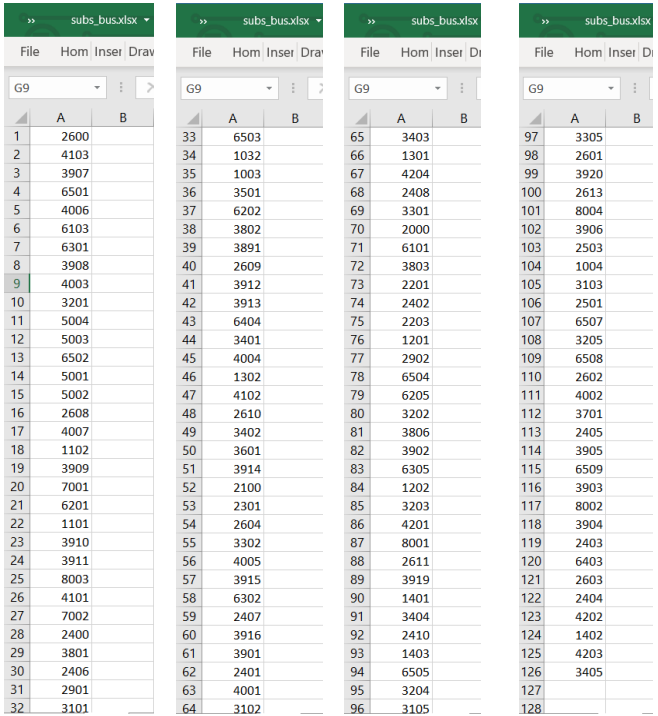


[1] Wang, Bin, and Jin Tan. 2022. DC-AC Tool: Fully Automating the Acquisition of AC Power Flow Solution. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A40-80100. https://www.nrel.gov/docs/fy22osti/80100.pdf

Example on 240-Bus Case [1]

- The 17 power flow cases in Table 3 of ref. [1] are used in this example.
- ➢ Step 3: Prepare the .xlsx spreadsheet file as shown on the right based on Table 2 of ref [1]. And then put this .xlsx file in the folder: ./casefile/input/.





[1] Wang, Bin, and Jin Tan. 2022. DC-AC Tool: Fully Automating the Acquisition of AC Power Flow Solution. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A40-80100. https://www.nrel.gov/docs/fy22osti/80100.pdf

Example on 240-Bus Case [1]

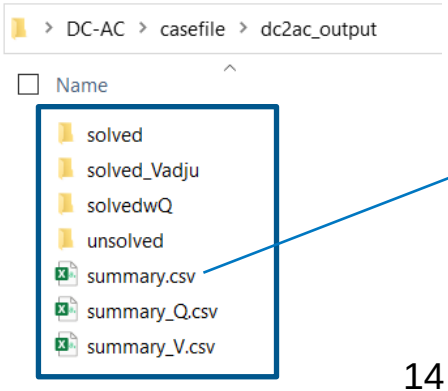
- The 17 power flow cases in Table 3 of ref. [1] are used in this example.
- ➢ Step 4: Run “DC_AC_main.py”. The message below should be observed in Terminal, and the output should be generated, shown in next slides.

```
casefile\input\WECC240_v03_Mod_NewMVA_month_2_day_8_hour_9.raw
Orig PF cannot converge at target loading.
PF (w added gens) converged.
Trying to remove added generators..
Orig PF converged at target loading. (Success!)

casefile\input\WECC240_v03_Mod_NewMVA_month_2_day_8_hour_10.raw
Orig PF cannot converge at target loading.
PF (w added gens) converged.
Trying to remove added generators..
Orig PF converged at target loading. (Success!)

casefile\input\WECC240_v03_Mod_NewMVA_month_3_day_6_hour_8.raw
Orig PF cannot converge at target loading.
PF (w added gens) converged.
Trying to remove added generators..
Orig PF converged at target loading. (Success!)

casefile\input\WECC240_v03_Mod_NewMVA_month_4_day_1_hour_8.raw
Orig PF cannot converge at target loading.
PF (w added gens) converged.
Trying to remove added generators..
Orig PF converged at target loading. (Success!)

casefile\input\WECC240_v03_Mod_NewMVA_month_4_day_4_hour_4.raw
Orig PF cannot converge at target loading.
PF (w added gens) converged.
Trying to remove added generators..
Orig PF converged at target loading. (Success!)

casefile\input\WECC240_v03_Mod_NewMVA_month_4_day_6_hour_1.raw
Orig PF cannot converge at target loading.
PF (w added gens) converged.
Trying to remove added generators..
Orig PF converged at target loading. (Success!)

casefile\input\WECC240_v03_Mod_NewMVA_month_4_day_8_hour_20.raw
Orig PF cannot converge at target loading.
PF (w added gens) converged.
Trying to remove added generators..
Orig PF converged at target loading. (Success!)

casefile\input\WECC240_v03_Mod_NewMVA_month_5_day_10_hour_5.raw
Orig PF cannot converge at target loading.
PF (w added gens) converged.
Trying to remove added generators..
Orig PF converged at target loading. (Success!)

casefile\input\WECC240_v03_Mod_NewMVA_month_5_day_15_hour_17.raw
Orig PF converged at target loading. (Success!)

casefile\input\WECC240_v03_Mod_NewMVA_month_5_day_19_hour_5.raw
Orig PF cannot converge at target loading.
PF (w added gens) converged.
Trying to remove added generators..
Orig PF converged at target loading. (Success!)

casefile\input\WECC240_v03_Mod_NewMVA_month_10_day_8_hour_21.raw
Orig PF cannot converge at target loading.
PF (w added gens) converged.
Trying to remove added generators..
Orig PF converged (w adjusted remote Vset). (Success!)

casefile\input\WECC240_v03_Mod_NewMVA_month_10_day_31_hour_4.raw
Orig PF cannot converge at target loading.
PF (w added gens) converged.
Trying to remove added generators..
Orig PF converged at target loading. (Success!)

casefile\input\WECC240_v03_Mod_NewMVA_month_10_day_31_hour_16.raw
Orig PF cannot converge at target loading.
PF (w added gens) converged.
Trying to remove added generators..
Orig PF converged (w adjusted remote Vset). (Success!)

casefile\input\WECC240_v03_Mod_NewMVA_month_10_day_31_hour_18.raw
Orig PF cannot converge at target loading.
PF (w added gens) converged.
Trying to remove added generators..
Orig PF converged at target loading. (Success!)

casefile\input\WECC240_v03_Mod_NewMVA_month_11_day_2_hour_15.raw
Orig PF cannot converge at target loading.
First power flow (with added generators) cannot converge! Investigating solvability...
PF (w added gens) converged.
Trying to remove added generators..
Orig PF converged at target loading. (Success!)

casefile\input\WECC240_v03_Mod_NewMVA_month_12_day_8_hour_19.raw
Orig PF cannot converge at target loading.
PF (w added gens) converged.
Trying to remove added generators..
Orig PF converged (w adjusted remote Vset). (Success!)

casefile\input\WECC240_v03_Mod_NewMVA_month_12_day_11_hour_11.raw
Orig PF cannot converge at target loading.
PF (w added gens) converged.
Trying to remove added generators..
Orig PF converged at target loading. (Success!)

Summary: (14, 0, 3, 0)
```

[1] Wang, Bin, and Jin Tan. 2022. DC-AC Tool: Fully Automating the Acquisition of AC Power Flow Solution. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A40-80100. https://www.nrel.gov/docs/fy22osti/80100.pdf

Example on 240-Bus Case [1]

- The 17 power flow cases in Table 3 of ref. [1] are used in this example.
- ➢ Step 5: Checking the results.



	Case names	Solved directly	Solved with Q support	Solved with Vset adjusted	Unsolved/Solved with reduced Pload
2					
3	WECC240_v03_Mod_NewMVA_month_10_day_31_hour_16.raw	1	0	0	0
4	WECC240_v03_Mod_NewMVA_month_10_day_31_hour_18.raw	1	0	0	0
5	WECC240_v03_Mod_NewMVA_month_10_day_31_hour_4.raw	1	0	0	0
6	WECC240_v03_Mod_NewMVA_month_10_day_8_hour_21.raw	1	0	0	0
7	WECC240_v03_Mod_NewMVA_month_11_day_2_hour_15.raw	1	0	0	0
8	WECC240_v03_Mod_NewMVA_month_12_day_11_hour_11.raw	1	0	0	0
9	WECC240_v03_Mod_NewMVA_month_12_day_8_hour_19.raw	1	0	0	0
10	WECC240_v03_Mod_NewMVA_month_2_day_8_hour_10.raw	1	0	0	0
11	WECC240_v03_Mod_NewMVA_month_2_day_8_hour_9.raw	1	0	0	0
12	WECC240_v03_Mod_NewMVA_month_3_day_6_hour_8.raw	1	0	0	0
13	WECC240_v03_Mod_NewMVA_month_4_day_1_hour_8.raw	0	0	1	0
14	WECC240_v03_Mod_NewMVA_month_4_day_4_hour_4.raw	1	0	0	0
15	WECC240_v03_Mod_NewMVA_month_4_day_6_hour_1.raw	0	0	1	0
16	WECC240_v03_Mod_NewMVA_month_4_day_8_hour_20.raw	1	0	0	0
17	WECC240_v03_Mod_NewMVA_month_5_day_10_hour_5.raw	1	0	0	0
18	WECC240_v03_Mod_NewMVA_month_5_day_15_hour_17.raw	0	0	1	0
19	WECC240_v03_Mod_NewMVA_month_5_day_19_hour_5.raw	1	0	0	0

14 cases solved after (i) adding and removing temporary generators, and/or (ii) load reduction and recovery.

3 cases solved after adjusting the voltage set point of generator(s).

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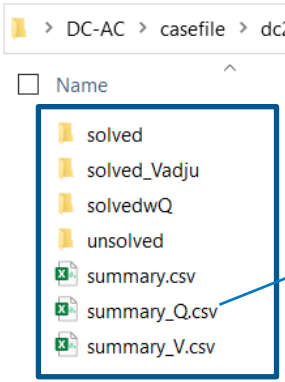

	Case names	# of buses requiring Q support
3	WECC240_v03_Mod_NewMVA_month_10_day_31_hour_16.raw	0
4	WECC240_v03_Mod_NewMVA_month_10_day_31_hour_18.raw	0
5	WECC240_v03_Mod_NewMVA_month_10_day_31_hour_4.raw	0
6	WECC240_v03_Mod_NewMVA_month_10_day_8_hour_21.raw	0
7	WECC240_v03_Mod_NewMVA_month_11_day_2_hour_15.raw	0
8	WECC240_v03_Mod_NewMVA_month_12_day_11_hour_11.raw	0
9	WECC240_v03_Mod_NewMVA_month_12_day_8_hour_19.raw	0
10	WECC240_v03_Mod_NewMVA_month_2_day_8_hour_10.raw	0
11	WECC240_v03_Mod_NewMVA_month_2_day_8_hour_9.raw	0
12	WECC240_v03_Mod_NewMVA_month_3_day_6_hour_8.raw	0
13	WECC240_v03_Mod_NewMVA_month_4_day_1_hour_8.raw	0
14	WECC240_v03_Mod_NewMVA_month_4_day_4_hour_4.raw	0
15	WECC240_v03_Mod_NewMVA_month_4_day_6_hour_1.raw	0
16	WECC240_v03_Mod_NewMVA_month_4_day_8_hour_20.raw	0
17	WECC240_v03_Mod_NewMVA_month_5_day_10_hour_5.raw	0
18	WECC240_v03_Mod_NewMVA_month_5_day_15_hour_17.raw	0
19	WECC240_v03_Mod_NewMVA_month_5_day_19_hour_5.raw	0

For the tested 17 cases, Q compensation is not necessary for achieving power flow convergence. If there is a case requiring Q compensation, then info about location and size of Q compensation will be shown in the third column.

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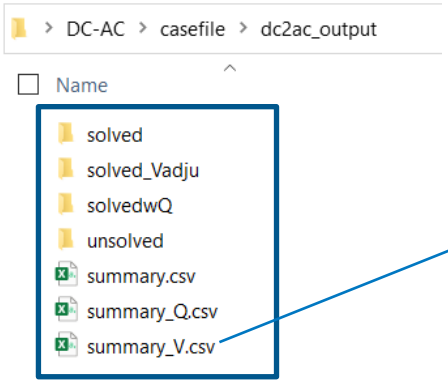
Example on 240-Bus Case [1]

- The 17 power flow cases in Table 3 of ref. [1] are used in this example.

➢ Step 5: Checking the results.



	Case names	# of PV buses with adjusted Vset
3	WECC240_v03_Mod_NewMVA_month_10_day_31_hour_16.raw	0
4	WECC240_v03_Mod_NewMVA_month_10_day_31_hour_18.raw	0
5	WECC240_v03_Mod_NewMVA_month_10_day_31_hour_4.raw	0
6	WECC240_v03_Mod_NewMVA_month_10_day_8_hour_21.raw	0
7	WECC240_v03_Mod_NewMVA_month_11_day_2_hour_15.raw	0
8	WECC240_v03_Mod_NewMVA_month_12_day_11_hour_11.raw	0
9	WECC240_v03_Mod_NewMVA_month_12_day_8_hour_19.raw	0
10	WECC240_v03_Mod_NewMVA_month_2_day_8_hour_10.raw	0
11	WECC240_v03_Mod_NewMVA_month_2_day_8_hour_9.raw	0
12	WECC240_v03_Mod_NewMVA_month_3_day_6_hour_8.raw	0
13	WECC240_v03_Mod_NewMVA_month_4_day_1_hour_8.raw	1.0,2438.0,1.041918359870804
14	WECC240_v03_Mod_NewMVA_month_4_day_4_hour_4.raw	0
15	WECC240_v03_Mod_NewMVA_month_4_day_6_hour_1.raw	1.0,6335.0,1.0955168514032758
16	WECC240_v03_Mod_NewMVA_month_4_day_8_hour_20.raw	0
17	WECC240_v03_Mod_NewMVA_month_5_day_10_hour_5.raw	0
18	WECC240_v03_Mod_NewMVA_month_5_day_15_hour_17.raw	1.0,2438.0,1.0227431774908369
19	WECC240_v03_Mod_NewMVA_month_5_day_19_hour_5.raw	0

DC-AC Tool found that in this power case, **1** voltage set point needs to be modified to achieve power flow convergence. The change includes: changing Vset = **1.0419** at bus **2438**.

[1] Wang, Bin, and Jin Tan. 2022. DC-AC Tool: Fully Automating the Acquisition of AC Power Flow Solution. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A40-80100. https://www.nrel.gov/docs/fy22osti/80100.pdf

Thank you!

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This work was authored in part by Alliance for Sustainable Energy, LLC, the manager and operator of the National Renewable Energy Laboratory for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Solar Energy Technologies Office(#34224). The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.