

DC-AC Manual

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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>

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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].

Introduction

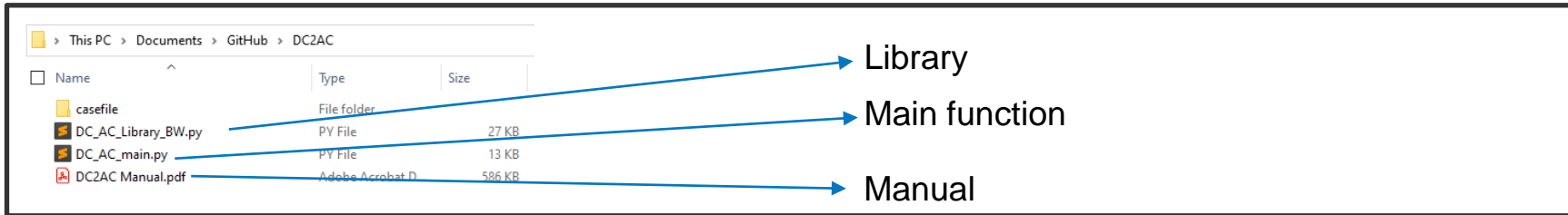
- DC-AC Tool requires the following inputs from users:
 - Power flow RAW/SAV files in PSS/E v34 format
 - A spreadsheet containing a list of buses to add temporary fictitious generators
- The DC-AC Tool can
 - Process each of the power flow RAW/SAV files, and categorize them into one of the following 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:

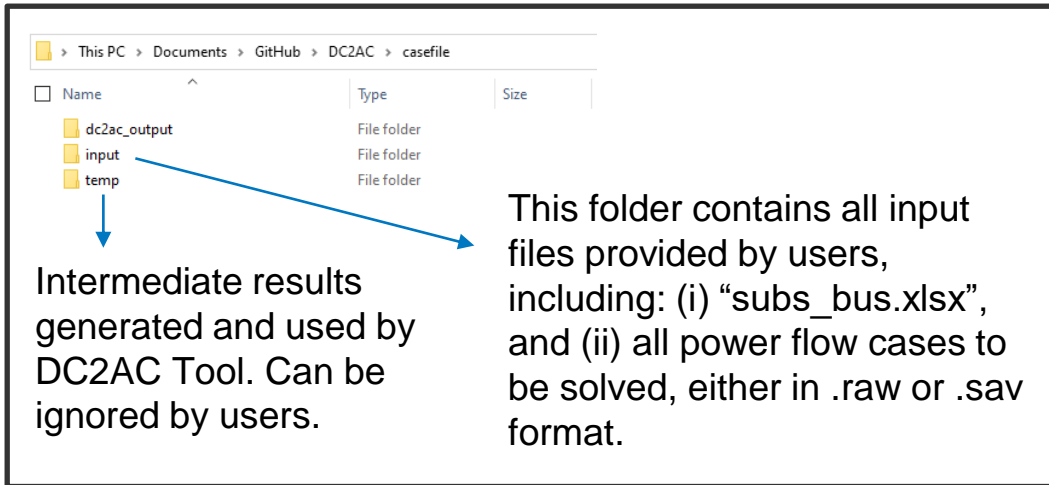


A screenshot of a Windows File Explorer window showing the contents of the 'DC2AC' folder. The path is 'This PC > Documents > GitHub > DC2AC'. The table below lists the files and folders:

Name	Type	Size
casefile	File folder	
DC_AC_Library_BW.py	PY File	27 KB
DC_AC_main.py	PY File	13 KB
DC2AC Manual.pdf	Adobe Acrobat D	586 KB

Annotations with arrows point from the following text to the corresponding items in the screenshot:

- Library** points to `DC_AC_Library_BW.py`.
- Main function** points to `DC_AC_main.py`.
- Manual** points to `DC2AC Manual.pdf`.

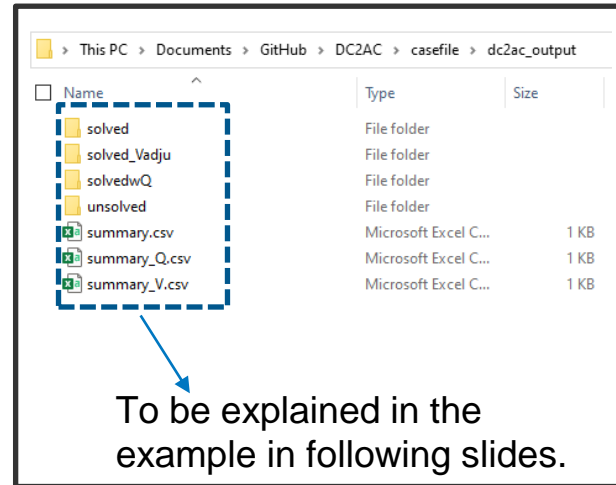


A screenshot of a Windows File Explorer window showing the contents of the 'casefile' folder. The path is 'This PC > Documents > GitHub > DC2AC > casefile'. The table below lists the files and folders:

Name	Type	Size
dc2ac_output	File folder	
input	File folder	
temp	File folder	

Annotations with arrows point from the following text to the corresponding items in the screenshot:

- Intermediate results generated and used by DC2AC Tool. Can be ignored by users.** points to the `temp` folder.
- 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.** points to the `input` folder.



A screenshot of a Windows File Explorer window showing the contents of the 'dc2ac_output' folder. The path is 'This PC > Documents > GitHub > DC2AC > casefile > dc2ac_output'. The table below lists the files and folders:

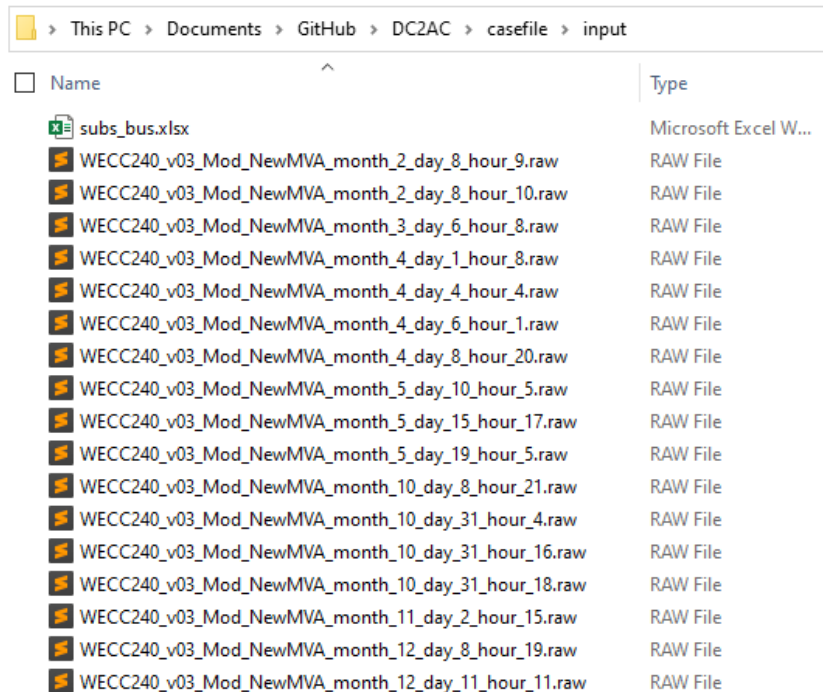
Name	Type	Size
solved	File folder	
solved_Vadju	File folder	
solvedwQ	File folder	
unsolved	File folder	
summary.csv	Microsoft Excel C...	1 KB
summary_Q.csv	Microsoft Excel C...	1 KB
summary_V.csv	Microsoft Excel C...	1 KB

An annotation with an arrow points from the following text to the 'summary' files:

- To be explained in the example in following slides.**

Example 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/`

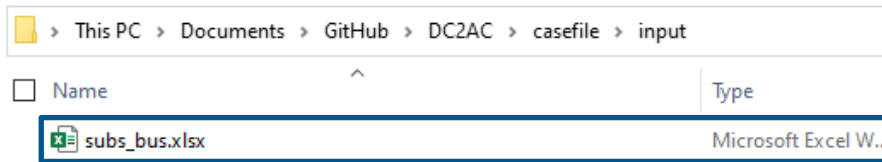


Name	Type
subs_bus.xlsx	Microsoft Excel W...
WECC240_v03_Mod_NewMVA_month_2_day_8_hour_9.raw	RAW File
WECC240_v03_Mod_NewMVA_month_2_day_8_hour_10.raw	RAW File
WECC240_v03_Mod_NewMVA_month_3_day_6_hour_8.raw	RAW File
WECC240_v03_Mod_NewMVA_month_4_day_1_hour_8.raw	RAW File
WECC240_v03_Mod_NewMVA_month_4_day_4_hour_4.raw	RAW File
WECC240_v03_Mod_NewMVA_month_4_day_6_hour_1.raw	RAW File
WECC240_v03_Mod_NewMVA_month_4_day_8_hour_20.raw	RAW File
WECC240_v03_Mod_NewMVA_month_5_day_10_hour_5.raw	RAW File
WECC240_v03_Mod_NewMVA_month_5_day_15_hour_17.raw	RAW File
WECC240_v03_Mod_NewMVA_month_5_day_19_hour_5.raw	RAW File
WECC240_v03_Mod_NewMVA_month_10_day_8_hour_21.raw	RAW File
WECC240_v03_Mod_NewMVA_month_10_day_31_hour_4.raw	RAW File
WECC240_v03_Mod_NewMVA_month_10_day_31_hour_16.raw	RAW File
WECC240_v03_Mod_NewMVA_month_10_day_31_hour_18.raw	RAW File
WECC240_v03_Mod_NewMVA_month_11_day_2_hour_15.raw	RAW File
WECC240_v03_Mod_NewMVA_month_12_day_8_hour_19.raw	RAW File
WECC240_v03_Mod_NewMVA_month_12_day_11_hour_11.raw	RAW File

[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/`.



A	B
1	2600
2	4103
3	3907
4	6501
5	4006
6	6103
7	6301
8	3908
9	4003
10	3201
11	5004
12	5003
13	6502
14	5001
15	5002
16	2608
17	4007
18	1102
19	3909
20	7001
21	6201
22	1101
23	3910
24	3911
25	8003
26	4101
27	7002
28	2400
29	3801
30	2406
31	2901
32	3101

A	B
33	6503
34	1032
35	1003
36	3501
37	6202
38	3802
39	3891
40	2609
41	3912
42	3913
43	6404
44	3401
45	4004
46	1302
47	4102
48	2610
49	3402
50	3601
51	3914
52	2100
53	2301
54	2604
55	3302
56	4005
57	3915
58	6302
59	2407
60	3916
61	3901
62	2401
63	4001
64	3102

A	B
65	3403
66	1301
67	4204
68	2408
69	3301
70	2000
71	6101
72	3803
73	2201
74	2402
75	2203
76	1201
77	2902
78	6504
79	6205
80	3202
81	3806
82	3902
83	6305
84	1202
85	3203
86	4201
87	8001
88	2611
89	3919
90	1401
91	3404
92	2410
93	1403
94	6505
95	3204
96	3105

A	B
97	3305
98	2601
99	3920
100	2613
101	8004
102	3906
103	2503
104	1004
105	3103
106	2501
107	6507
108	3205
109	6508
110	2602
111	4002
112	3701
113	2405
114	3905
115	6509
116	3903
117	8002
118	3904
119	2403
120	6403
121	2603
122	2404
123	4202
124	1402
125	4203
126	3405
127	
128	

[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!)
```

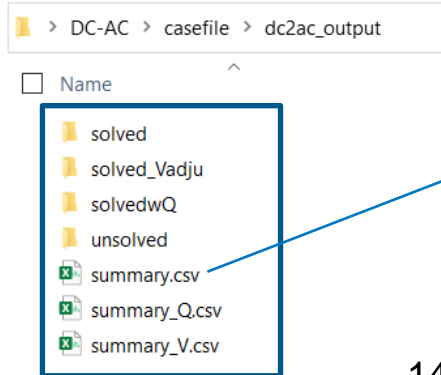
```
casefile\input\WECC240_v03_Mod_NewMVA_month_12_day_8_hour_19.raw
Orig PF cannot converge at target loading.
PF (w added gens) converged.
Trying to remove added generators..
Orig PF converged (w adjusted remote Vset). (Success!)
```

```
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)

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.



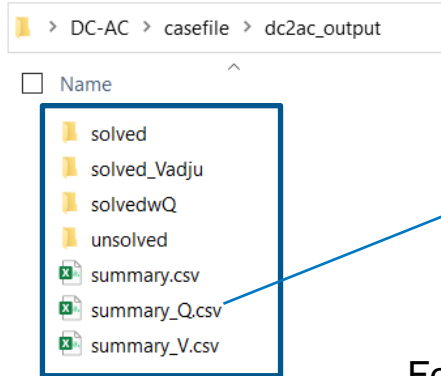
Case names	Solved directly	Solved with Q support	Solved with Vset adjusted	Unsolved/Solved with reduced Pload
WECC240_v03_Mod_NewMVA_month_10_day_31_hour_16.raw	1	0	0	0
WECC240_v03_Mod_NewMVA_month_10_day_31_hour_18.raw	1	0	0	0
WECC240_v03_Mod_NewMVA_month_10_day_31_hour_4.raw	1	0	0	0
WECC240_v03_Mod_NewMVA_month_10_day_8_hour_21.raw	1	0	0	0
WECC240_v03_Mod_NewMVA_month_11_day_2_hour_15.raw	1	0	0	0
WECC240_v03_Mod_NewMVA_month_12_day_11_hour_11.raw	1	0	0	0
WECC240_v03_Mod_NewMVA_month_12_day_8_hour_19.raw	1	0	0	0
WECC240_v03_Mod_NewMVA_month_2_day_8_hour_10.raw	1	0	0	0
WECC240_v03_Mod_NewMVA_month_2_day_8_hour_9.raw	1	0	0	0
WECC240_v03_Mod_NewMVA_month_3_day_6_hour_8.raw	1	0	0	0
WECC240_v03_Mod_NewMVA_month_4_day_1_hour_8.raw	0	0	1	0
WECC240_v03_Mod_NewMVA_month_4_day_4_hour_4.raw	1	0	0	0
WECC240_v03_Mod_NewMVA_month_4_day_6_hour_1.raw	0	0	1	0
WECC240_v03_Mod_NewMVA_month_4_day_8_hour_20.raw	1	0	0	0
WECC240_v03_Mod_NewMVA_month_5_day_10_hour_5.raw	1	0	0	0
WECC240_v03_Mod_NewMVA_month_5_day_15_hour_17.raw	0	0	1	0
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.

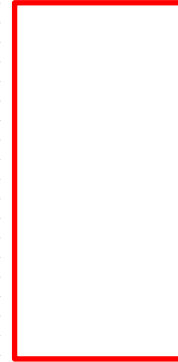
3 cases solved after adjusting the voltage set point of generator(s).

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.



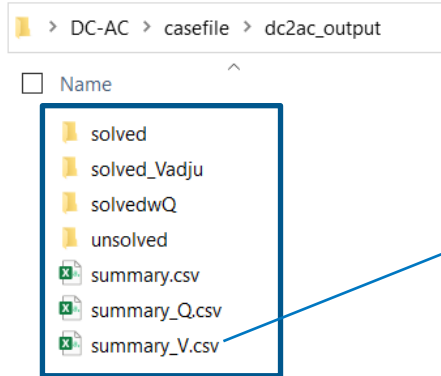
Case names	# of buses requiring Q support
WECC240_v03_Mod_NewMVA_month_10_day_31_hour_16.raw	0
WECC240_v03_Mod_NewMVA_month_10_day_31_hour_18.raw	0
WECC240_v03_Mod_NewMVA_month_10_day_31_hour_4.raw	0
WECC240_v03_Mod_NewMVA_month_10_day_8_hour_21.raw	0
WECC240_v03_Mod_NewMVA_month_11_day_2_hour_15.raw	0
WECC240_v03_Mod_NewMVA_month_12_day_11_hour_11.raw	0
WECC240_v03_Mod_NewMVA_month_12_day_8_hour_19.raw	0
WECC240_v03_Mod_NewMVA_month_2_day_8_hour_10.raw	0
WECC240_v03_Mod_NewMVA_month_2_day_8_hour_9.raw	0
WECC240_v03_Mod_NewMVA_month_3_day_6_hour_8.raw	0
WECC240_v03_Mod_NewMVA_month_4_day_1_hour_8.raw	0
WECC240_v03_Mod_NewMVA_month_4_day_4_hour_4.raw	0
WECC240_v03_Mod_NewMVA_month_4_day_6_hour_1.raw	0
WECC240_v03_Mod_NewMVA_month_4_day_8_hour_20.raw	0
WECC240_v03_Mod_NewMVA_month_5_day_10_hour_5.raw	0
WECC240_v03_Mod_NewMVA_month_5_day_15_hour_17.raw	0
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**.

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
WECC240_v03_Mod_NewMVA_month_10_day_31_hour_16.raw	0
WECC240_v03_Mod_NewMVA_month_10_day_31_hour_18.raw	0
WECC240_v03_Mod_NewMVA_month_10_day_31_hour_4.raw	0
WECC240_v03_Mod_NewMVA_month_10_day_8_hour_21.raw	0
WECC240_v03_Mod_NewMVA_month_11_day_2_hour_15.raw	0
WECC240_v03_Mod_NewMVA_month_12_day_11_hour_11.raw	0
WECC240_v03_Mod_NewMVA_month_12_day_8_hour_19.raw	0
WECC240_v03_Mod_NewMVA_month_2_day_8_hour_10.raw	0
WECC240_v03_Mod_NewMVA_month_2_day_8_hour_9.raw	0
WECC240_v03_Mod_NewMVA_month_3_day_6_hour_8.raw	0
WECC240_v03_Mod_NewMVA_month_4_day_1_hour_8.raw	1,0,2438,0,1.041918359870804
WECC240_v03_Mod_NewMVA_month_4_day_4_hour_4.raw	0
WECC240_v03_Mod_NewMVA_month_4_day_6_hour_1.raw	1,0,6335,0,1.0955168514032758
WECC240_v03_Mod_NewMVA_month_4_day_8_hour_20.raw	0
WECC240_v03_Mod_NewMVA_month_5_day_10_hour_5.raw	0
WECC240_v03_Mod_NewMVA_month_5_day_15_hour_17.raw	1,0,2438,0,1.0227431774908369
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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