

# 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>

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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

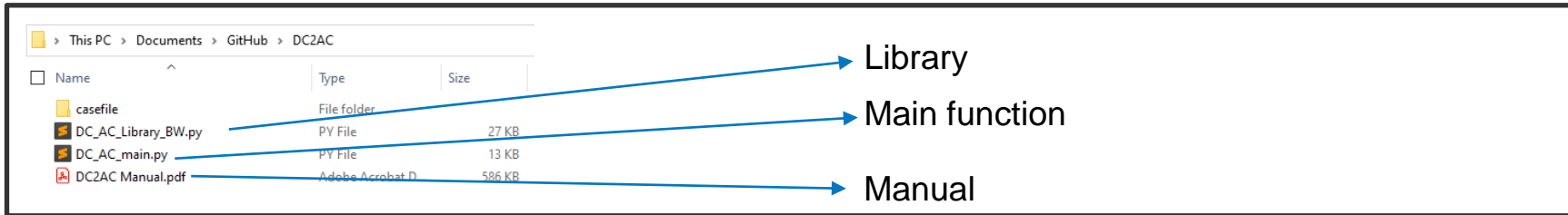
- DC-AC Tool requires the following inputs from users:
  - Power flow RAW/SAV files in PSS/E v34 format
  - A spreadsheet containing a list of buses to add temporary fictitious generators
- The DC-AC Tool can
  - Process each of the power flow RAW/SAV files, and categorize them into one of the following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

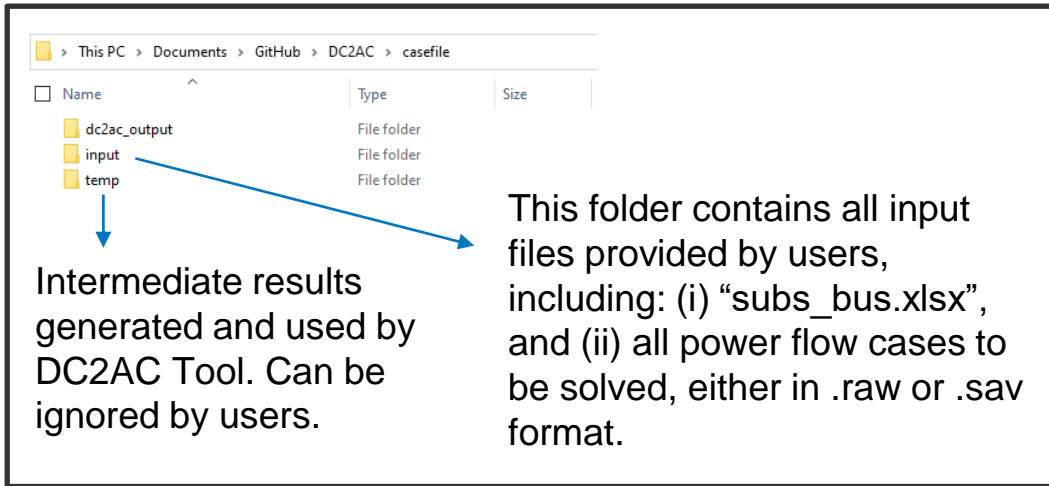


File Explorer view of the DC2AC folder:

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

Arrows point from the following items to labels:

- DC\_AC\_Library\_BW.py → Library
- DC\_AC\_main.py → Main function
- DC2AC Manual.pdf → Manual

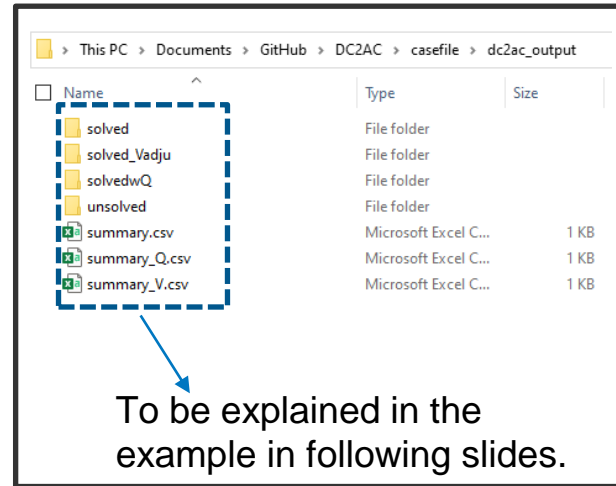


File Explorer view of the casefile folder:

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

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.



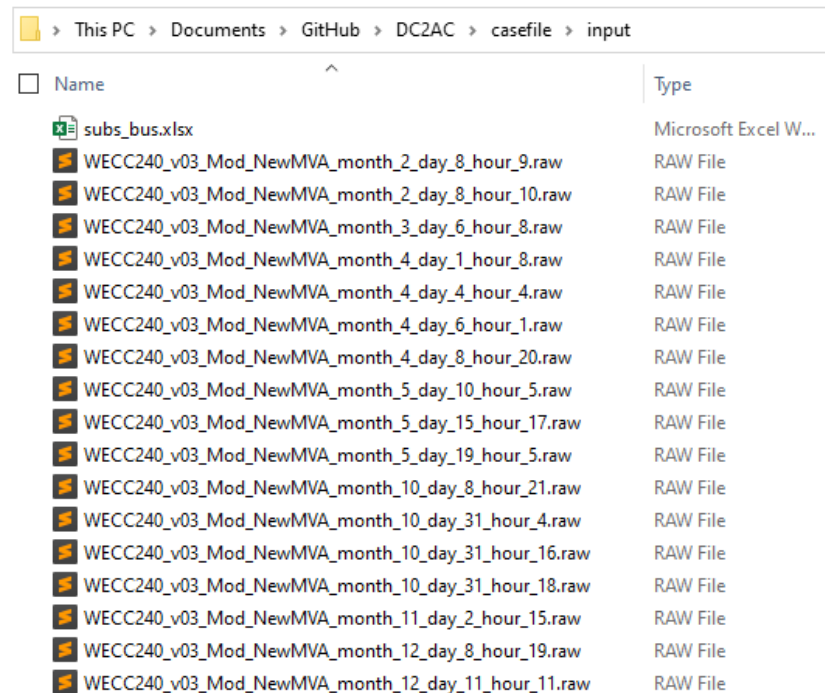
File Explorer view of the dc2ac\_output folder:

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

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/`

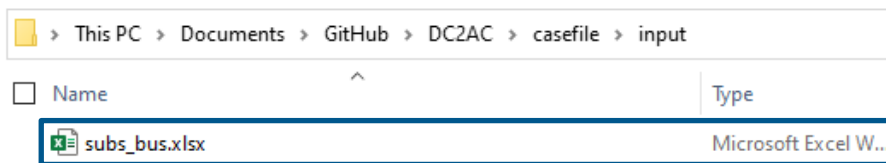


Name	Type
subs_bus.xlsx	Microsoft Excel W...
WECC240_v03_Mod_NewMVA_month_2_day_8_hour_9.raw	RAW File
WECC240_v03_Mod_NewMVA_month_2_day_8_hour_10.raw	RAW File
WECC240_v03_Mod_NewMVA_month_3_day_6_hour_8.raw	RAW File
WECC240_v03_Mod_NewMVA_month_4_day_1_hour_8.raw	RAW File
WECC240_v03_Mod_NewMVA_month_4_day_4_hour_4.raw	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



# 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!)
```

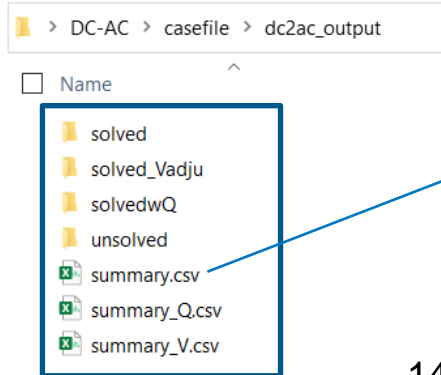
```
casefile\input\WECC240_v03_Mod_NewMVA_month_12_day_8_hour_19.raw
Orig PF cannot converge at target loading.
PF (w added gens) converged.
Trying to remove added generators..
Orig PF converged (w adjusted remote Vset). (Success!)
```

```
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.



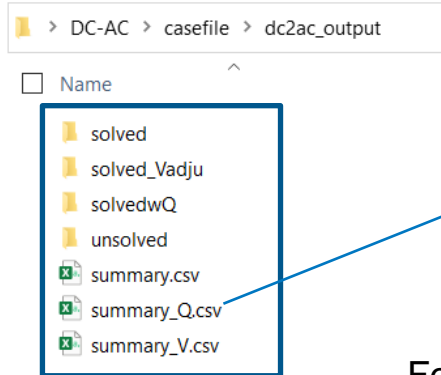
Case names	Solved directly	Solved with Q support	Solved with Vset adjusted	Unsolved/Solved with reduced Pload
WECC240_v03_Mod_NewMVA_month_10_day_31_hour_16.raw	1	0	0	0
WECC240_v03_Mod_NewMVA_month_10_day_31_hour_18.raw	1	0	0	0
WECC240_v03_Mod_NewMVA_month_10_day_31_hour_4.raw	1	0	0	0
WECC240_v03_Mod_NewMVA_month_10_day_8_hour_21.raw	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.

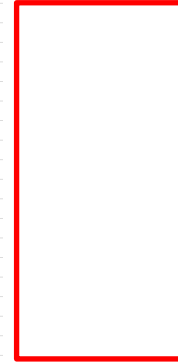
3 cases solved after adjusting the voltage set point of generator(s).

# 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.



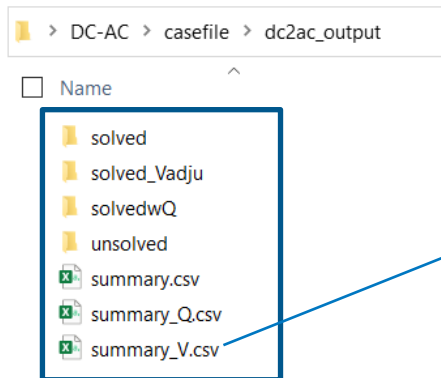
Case names	# of buses requiring Q support
WECC240_v03_Mod_NewMVA_month_10_day_31_hour_16.raw	0
WECC240_v03_Mod_NewMVA_month_10_day_31_hour_18.raw	0
WECC240_v03_Mod_NewMVA_month_10_day_31_hour_4.raw	0
WECC240_v03_Mod_NewMVA_month_10_day_8_hour_21.raw	0
WECC240_v03_Mod_NewMVA_month_11_day_2_hour_15.raw	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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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.

