Interactive Power Flow in the Browser

Samuel Talkington

with Frederik Geth, Qian Zhang, Le Xie, and Skyler Liu

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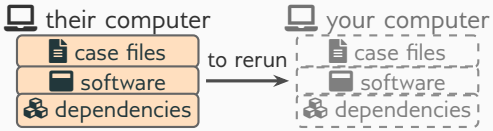
October 29, 2026



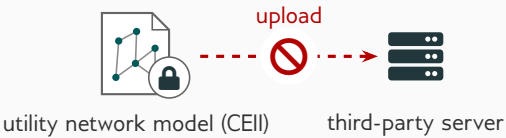
Harvard John A. Paulson
School of Engineering
and Applied Sciences



Motivation



- Rerunning someone else's power flow study requires their software, its dependencies, and their case files.

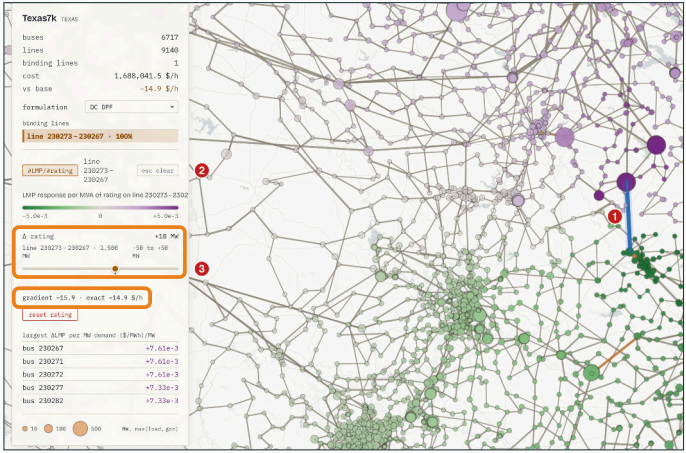


- Utility network models are CEII. They generally cannot be uploaded to a third-party server.

Approach

Compile the case parser and the solvers to WebAssembly and run them in the browser. The case file stays on the user's computer.

CEII: Critical Energy/Electric Infrastructure Information, 18 CFR 388.113.

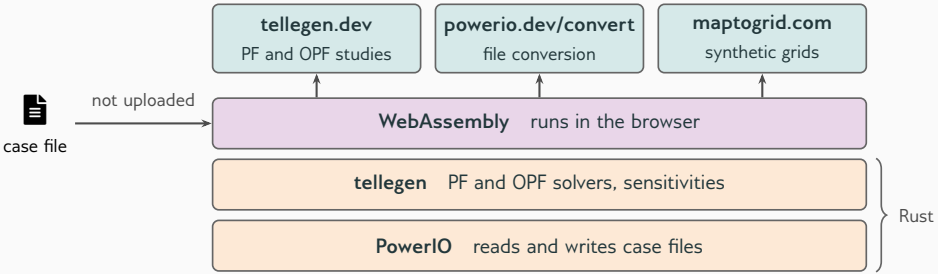


Texas7k, one line's rating raised by 10 MW. Cost change: estimated −15.9 $/h, re-solved −14.9 $/h.

tellegen.dev

- DC OPF, AC power flow, and a second-order cone relaxation.
- Moving a slider shows an estimate from OPF sensitivities. Releasing it re-solves.

How it runs



The server hosts static files only. Case files are parsed and solved on the user's computer, so no case data, and no CEII, is sent to a server.

Running locally avoids a server-side copy of the case; it does not make the model less sensitive. The same Rust code also builds a Python package and a command line tool.

Validation

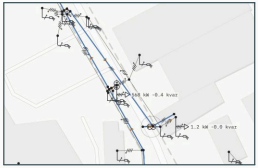
Check	Reference	Result
DC OPF, 153 feasible PGLib runs	PowerModels.jl	148 within 1%
AC OPF, PGLib 14 to 6,468 buses	published objectives	within 10^{-4}
Distribution PF, 128 ENWL feeders	OpenDSS	127 within 1.2×10^{-7} V
Browser vs. native solve time	same code	25–43% slower

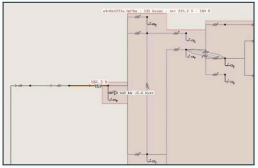
Medians for the timing row. AC OPF: PGLib cases 14, 30, 300 and 6468, interior point solver POUNCE. Details in the paper.

Multiconductor distribution networks

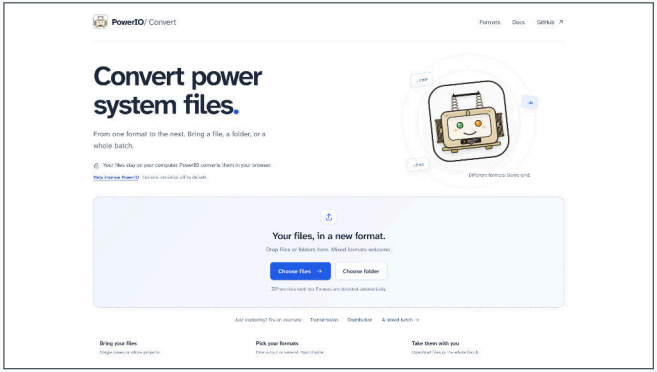


- Norwood network, SA Power Networks: 25,456 buses.
- Phases and neutral drawn per conductor, in geographic or schematic layout.
- A load edit on a 9,950-bus feeder re-solves in 15.6 ms.





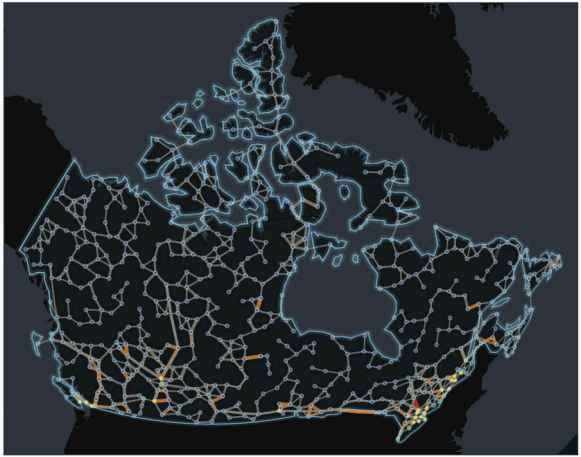
Visualization by Frederik Geth. Norwood is a provisional study model. Latency: 95th percentile, Chromium.



powerio.dev/convert

- Reads 25 case formats and writes 21.
- Lists what each conversion drops.
- Runs in the browser. Also a Rust, Python, and Julia library.

MapToGrid



Canada: 613 buses, generated and solved in the browser in about 15 s.

maptogrid.com

github.com/eigenergy/maptogrid

- Synthetic transmission grid for a country or a drawn region.
- Built from public data only, so it contains no CEII.
- Exports 14 case formats through PowerIO.

Summary

- Power flow and OPF studies can run in a web page,
  with the case file kept on the user's computer.
- Next: multiconductor OPF in the browser, and comparison with PSS/E.

tellegen.dev

powerio.dev/convert

maptogrid.com

github.com/eigenergy

Samuel Talkington, talks@umich.edu. With Frederik Geth, Qian Zhang, Le Xie, and Skyler Liu.
PowerIO with Frederik Geth, Burhan Abdullah, and Mohamed Numair.