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AC Convergence for Future Interconnect Wide Planning Cases: PNNL's Experience with WECC and C-PAGE

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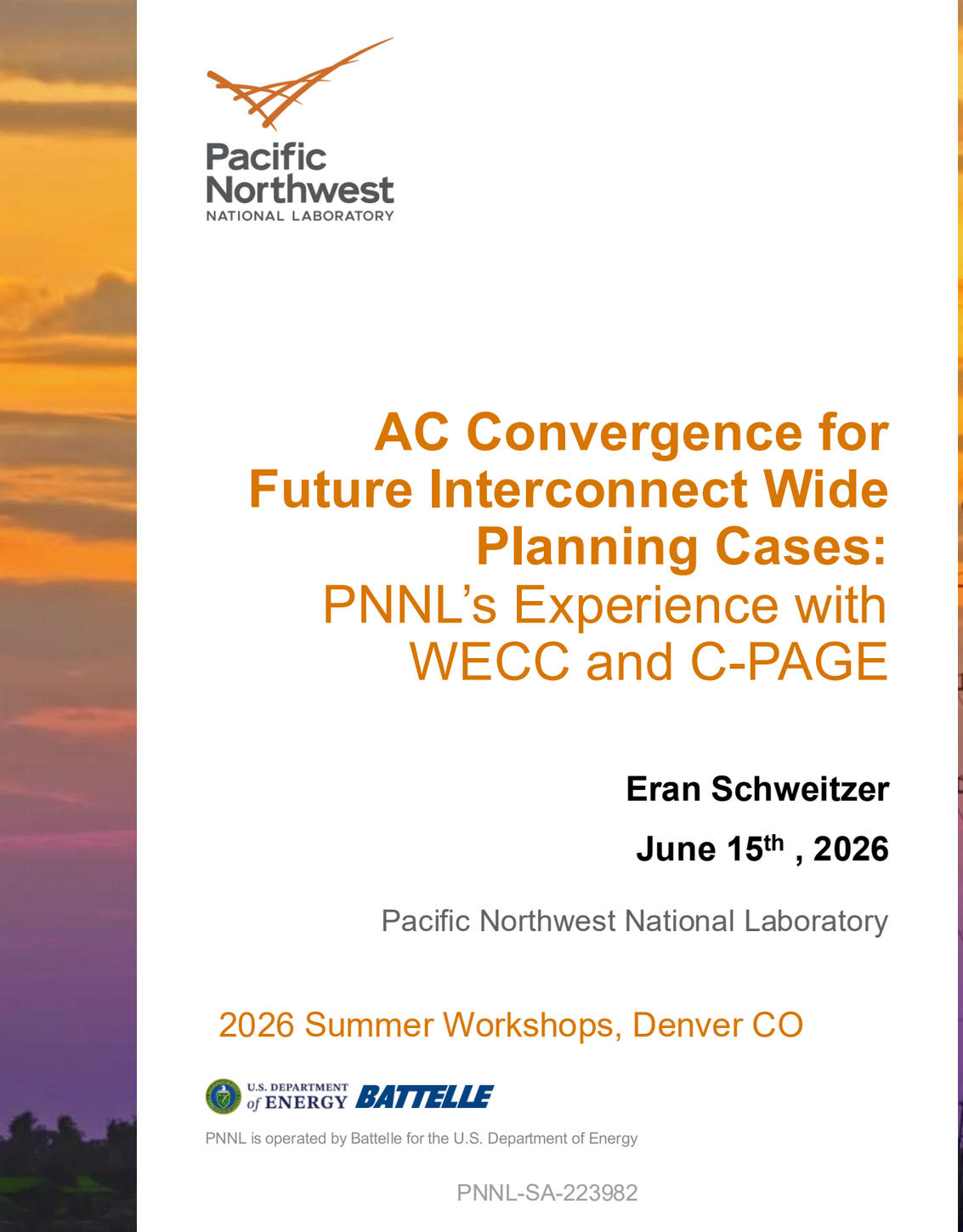
Pacific Northwest National Laboratory

2026 Summer Workshops, Denver CO



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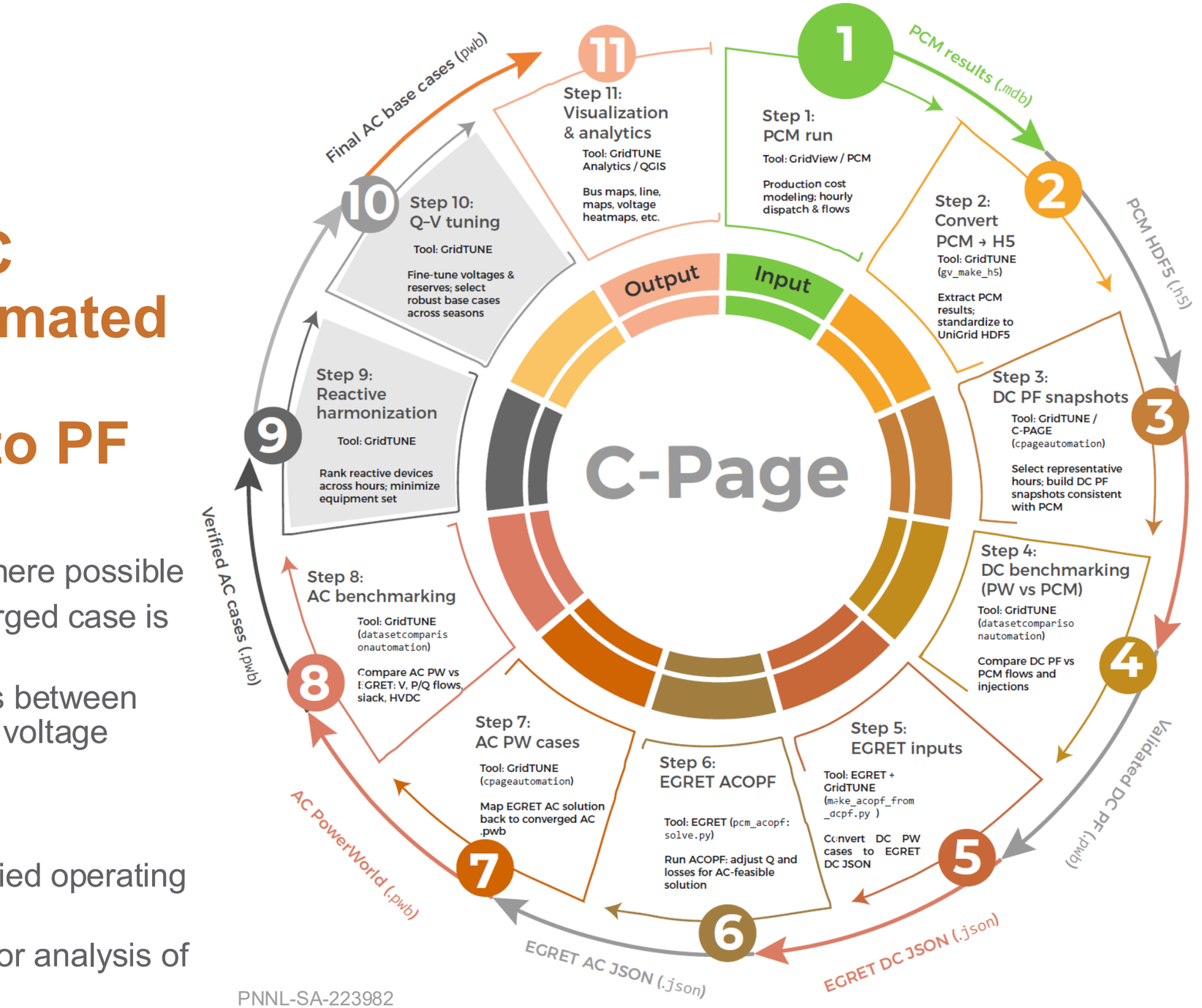
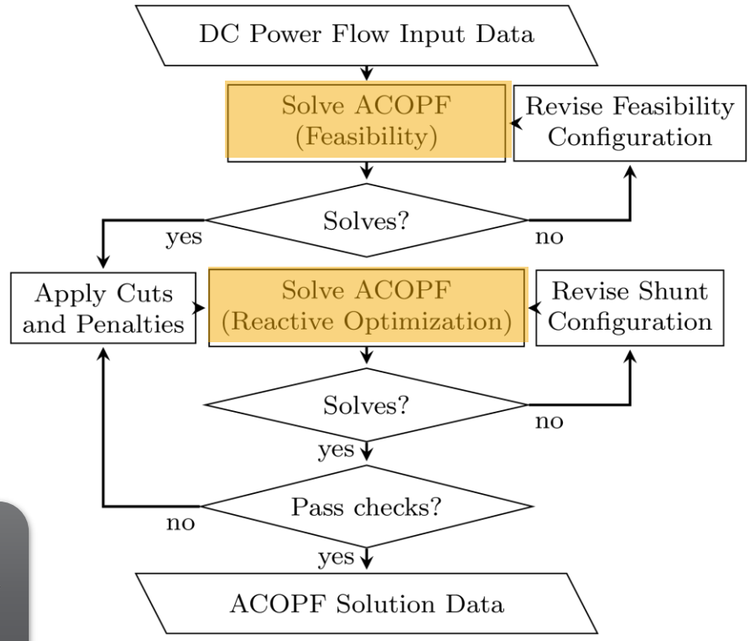
Chronological AC Power Flow Automated Generation Tool (C-PAGE) : PCM to PF

- Design Principles:
  - Use commercial tools where possible
  - Getting the “next” converged case is easier
  - Focus on matching flows between models while respecting voltage bounds
- Study Objectives:
  - Reliability studies on varied operating points
  - Sequential cases allow for analysis of cascading dynamics

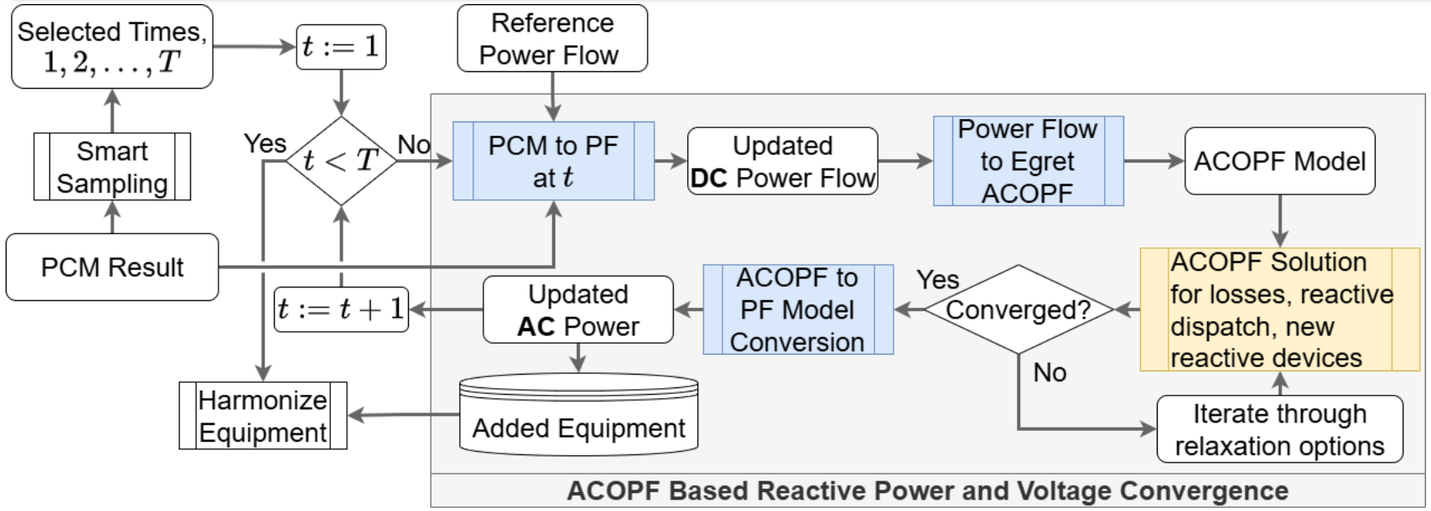


Obtaining (initial) convergence

- We use a modified AC-Optimal Power Flow formulation that fixes generation and solves for reactive power and voltages
- Two main steps:
  - Load adjustment for losses (losses are initially in the area-wide loads of the PCM)
  - Improve voltage profile while minimizing reactive device addition (see note)



Objective:
Obtain an initial condition (V, θ, Q) through optimization that is *sufficiently* close that Newton-Raphson will converge in an AC-Power Flow Tool

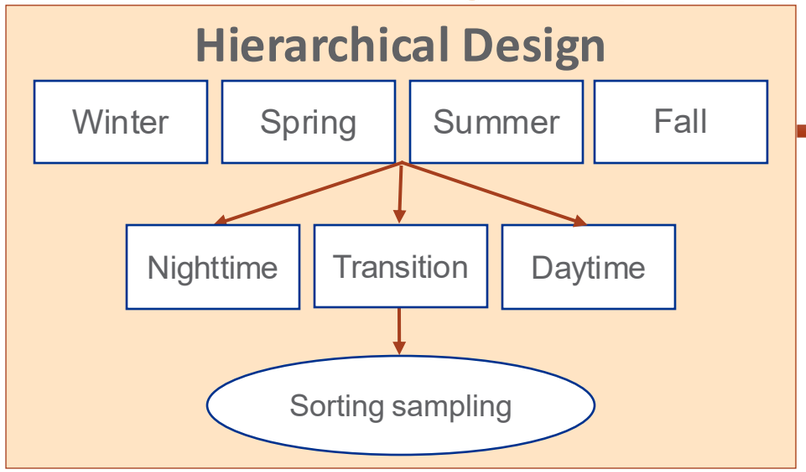


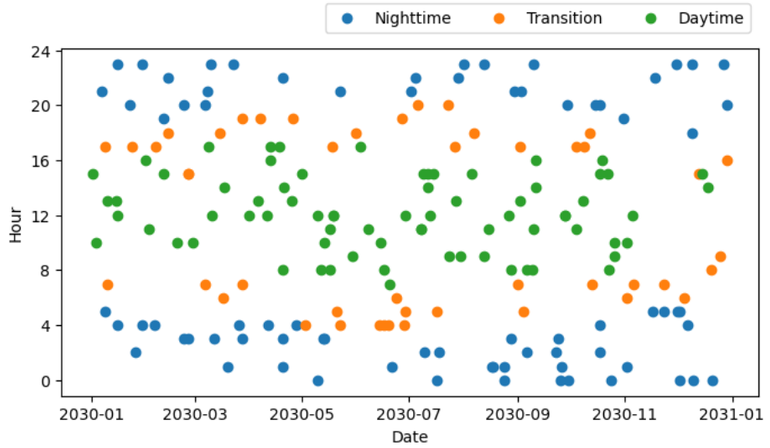
Note:
As these are **future planning cases** we allow the addition of reactive support.

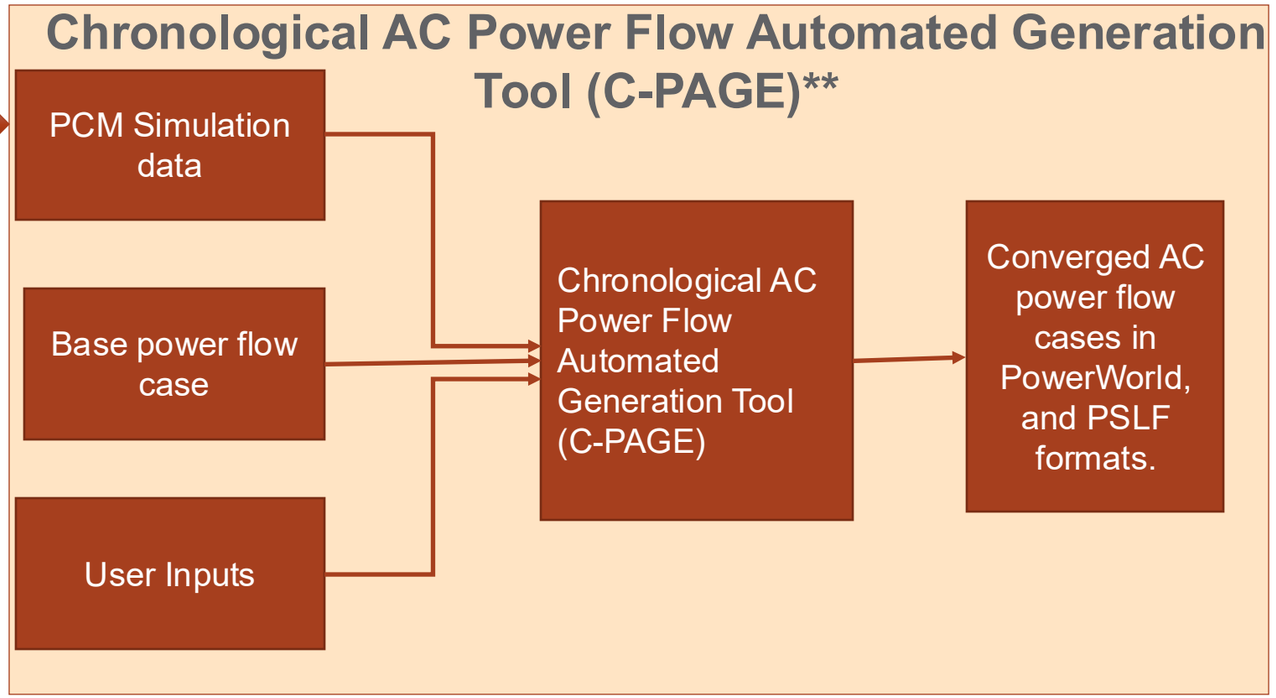
E. Schweitzer, B. Eldridge, M. Abdelmalak, and N. Samaan, "Converged AC Power Flow Cases from Linear Production Cost Models via ACOPF," (*to appear*) in 2026 IEEE Power & Energy Society General Meeting (PESGM).

Scenario case reduction technique + C-PAGE

Scenario case sampling technique*







*T.-C. Chen et al., "Smart Sampling of Representative Hourly Power Generation Scenario with High Renewable Penetration," IEEE Access, vol. 12, pp. 115319–115328, 2024, doi: 10.1109/ACCESS.2024.3445409.

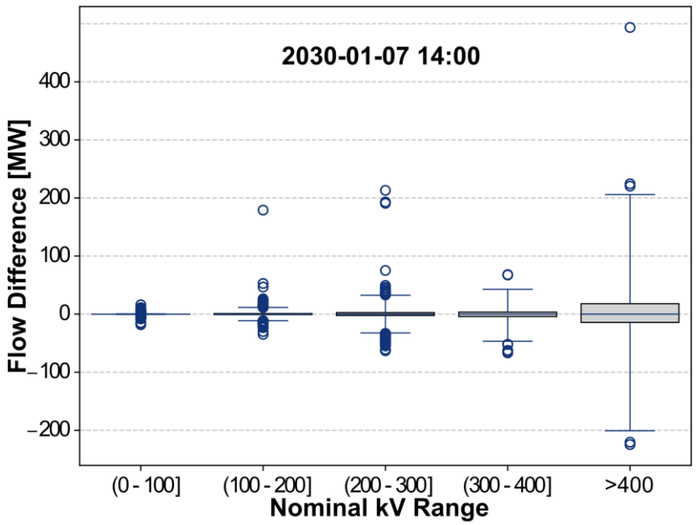
**B. Vyakaranam et al., "Automated Tool to Create Chronological AC Power Flow Cases for Large Interconnected Systems," IEEE Open Access Journal of Power and Energy, vol. 8, pp. 166–174, 2021, doi: 10.1109/OAJPE.2021.3075659.

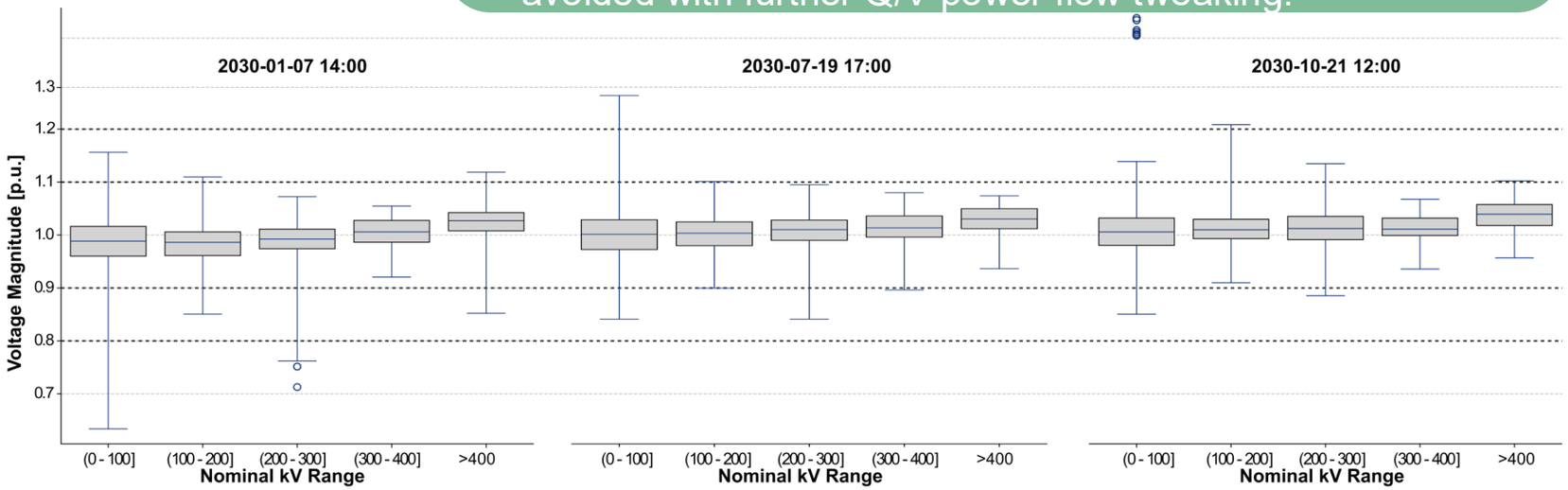
Results using the WECC 2030 ADS Model

- 20 converged cases generated.
- The largely match the initial PCM simulation, with some outliers.
- Voltages in the Power World are within reasonable ranges.
- Loss adjustments are within typical ranges for the west.

Season	Cases	Total Time (min)	Added Shunts	Loss Adj.
Winter (Jan)	5	6.6 - 16.2	95 - 99	4.3 - 5.0%
Spring (Apr)	6	16.0 - 31.5	103 - 118	5.2 - 6.3%
Summer (Jul)	4	7.9 - 22.5	77 - 81	3.2 - 3.4%
Fall (Oct)	5	5.8 - 24.8	81 - 98	3.7 - 5.5%

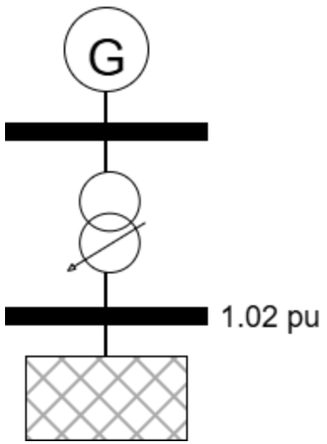
Notes:
- Solve times are non-trivial
- Reactive support is needed to achieve a reasonable voltage profile. More work on harmonizing these additions.
- Many of the added shunts are very small and can likely be avoided with further Q/V power flow tweaking.

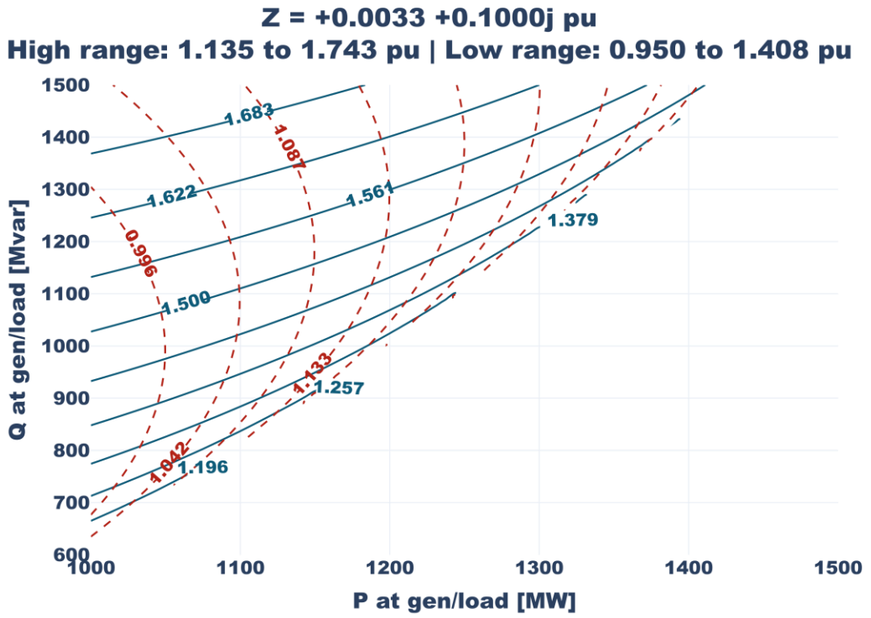


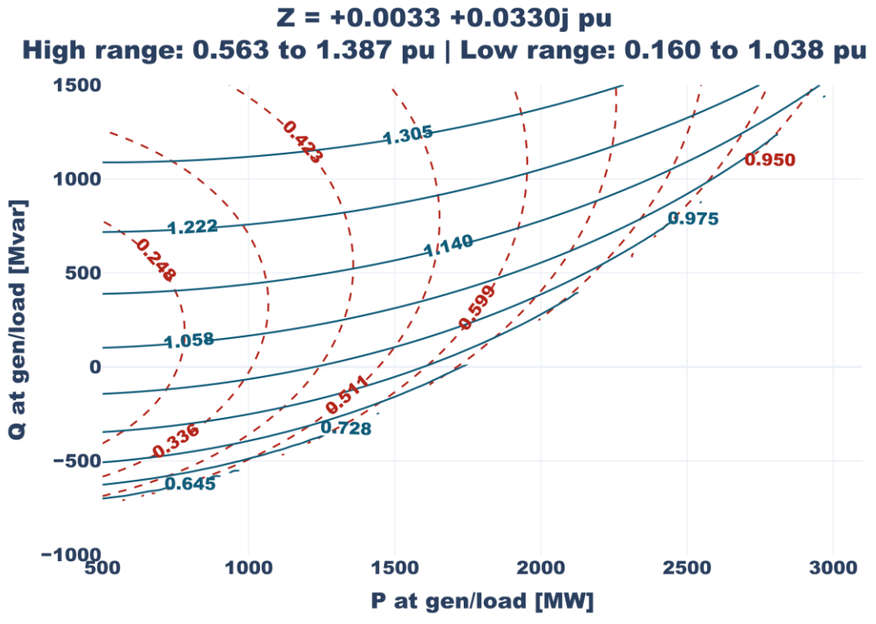


WECC 2034 ADS Work and Remaining Challenges

- PNNL has been working with WECC on developing the 2034 ADS round-trip cases*.
- One of the selected dispatch points required >2000 MW of generation from a future project to flow over an impedance that can support a maximum of ~1400 MW.
  - *Consequence:* ACOPF finds a “low voltage” solution at ~1.2 pu and the case diverges in power flow.
  - *Solution:* fix the impedance (this is bad data).
- Some AC cases generate, but the process reveals the importance of data cleaning to enabling this kind of model-domain translation. Also reveals that these kinds of pipelines **expose** bad data.







*WECC, “Round-trip fact sheet,” Jul. 2024. [Online]. Available: https://www.wecc.org/wecc-document/3556

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Thank you

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