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Apples to Apples: Equivalent-reliability power systems across diverse resource mix scenarios

Gord Stephen, Bethany Frew, Devon Sigler, Wesley Jones

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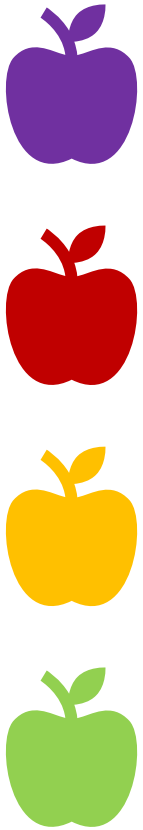
Contents

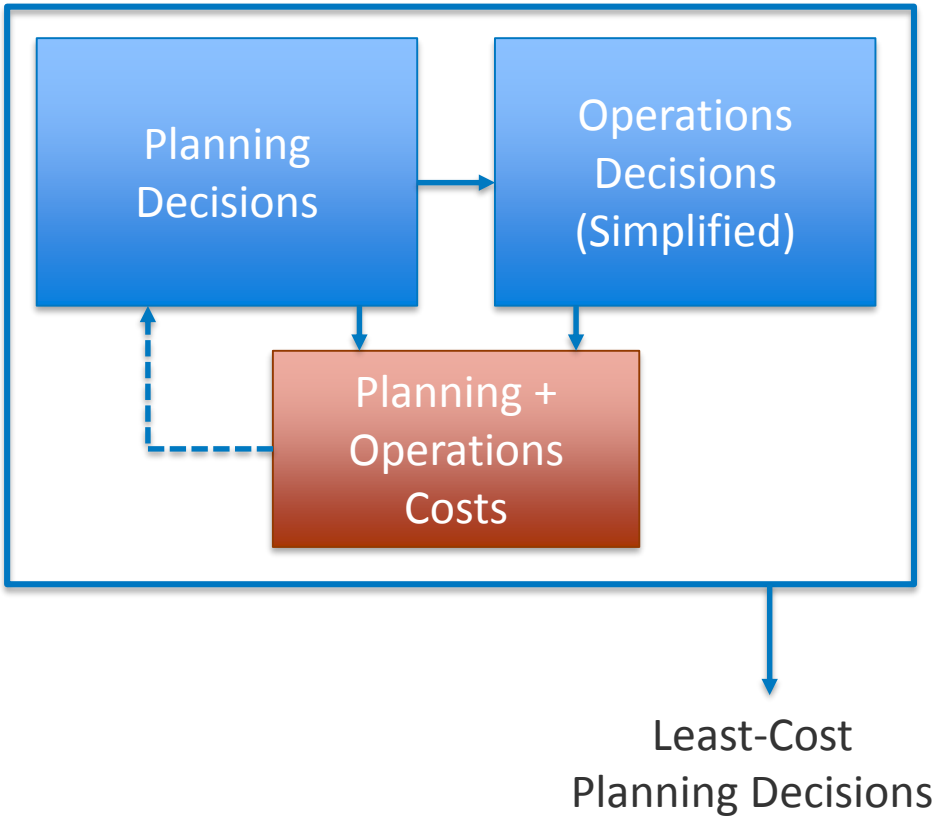
Motivation and Objective

- Electricity market research is highly price-sensitive
- Prices are strongly influenced by balance of supply and demand
- Often higher-VG scenarios simply add new wind, solar, etc onto an existing system
  - But now system is overbuilt!
  - In reality some capacity becomes uneconomical and retires (or doesn't get built), subject to desired reliability level
- How can we generate systems that allow for apples-to-apples market comparisons?
  - Capacity Expansion Models provide system buildouts
  - Reliability Assessment informs resource adequacy
  - Can we use the best of both of these tools?



Background: Capacity Expansion Modelling

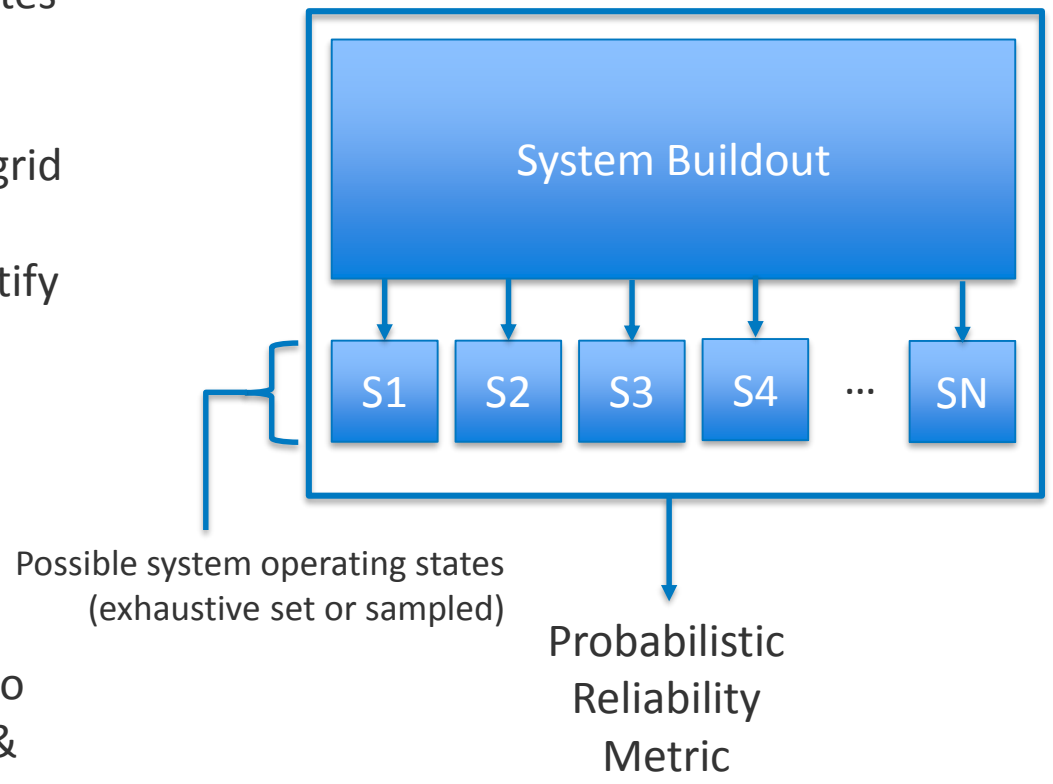
- Determines least-cost power system expansion options subject to constraints (physical, regulatory, etc)
- Requires (usually very simple) grid operations representation to balance capital vs operating costs
- System reliability traditionally governed by planning reserve margin (requires assigning static capacity value to VG & other non-dispatchable resources)



Models at NREL include ReEDS, RPM, SPEED

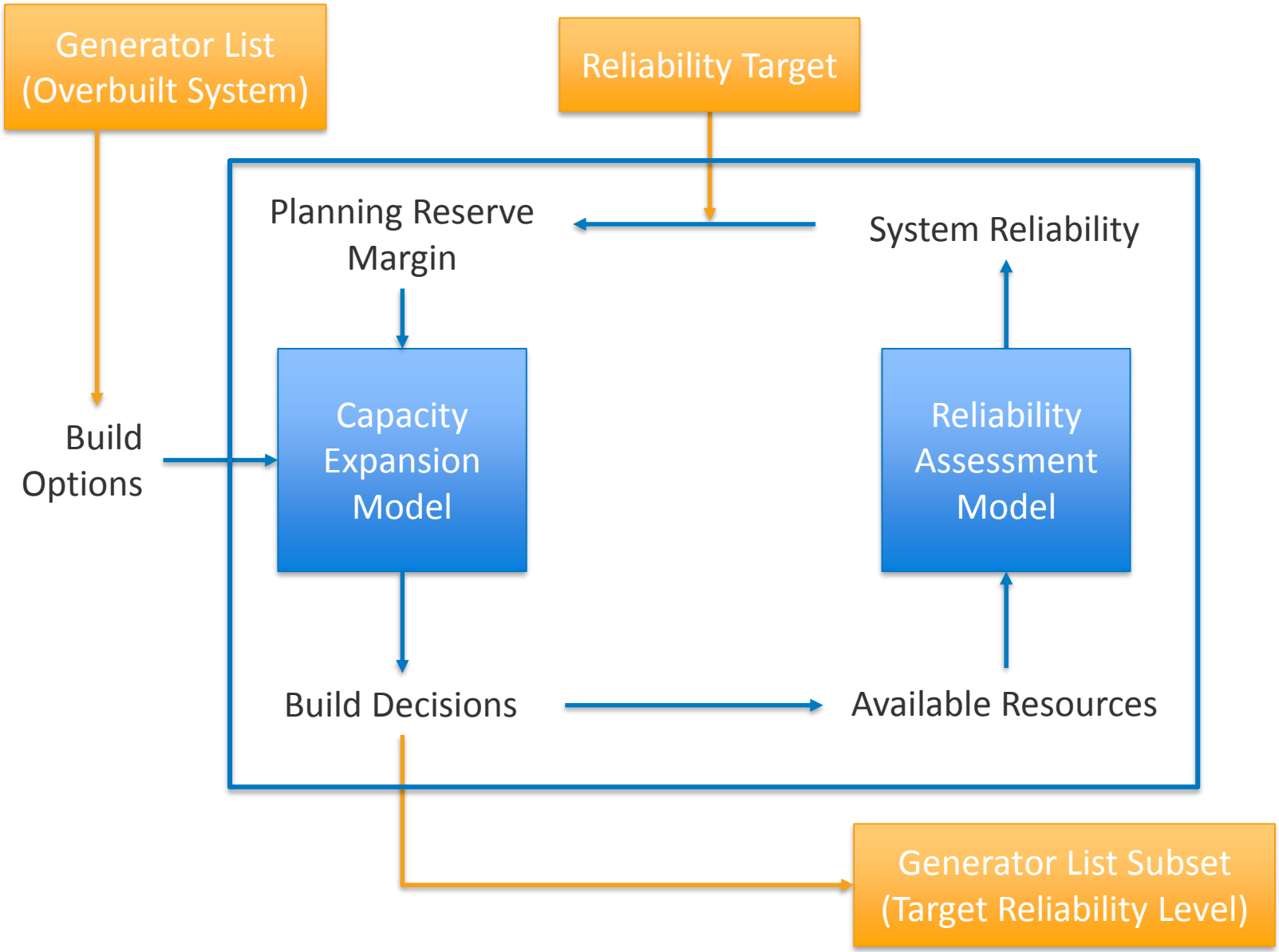
Background: Reliability Assessment

- Explores range of operating states in a predetermined system
- Requires (usually very simple) grid operations representation to identify failure scenarios, quantify unserved energy, etc
- Purely descriptive tool: no decision-making, economic considerations, etc
- Can be applied comparatively to calculate capacity value of VG & other non-dispatchable resources



NREL's Resource Adequacy Suite (RAS) provides multiple implementations (e.g. REPRA-T)

Combining CEM and RA



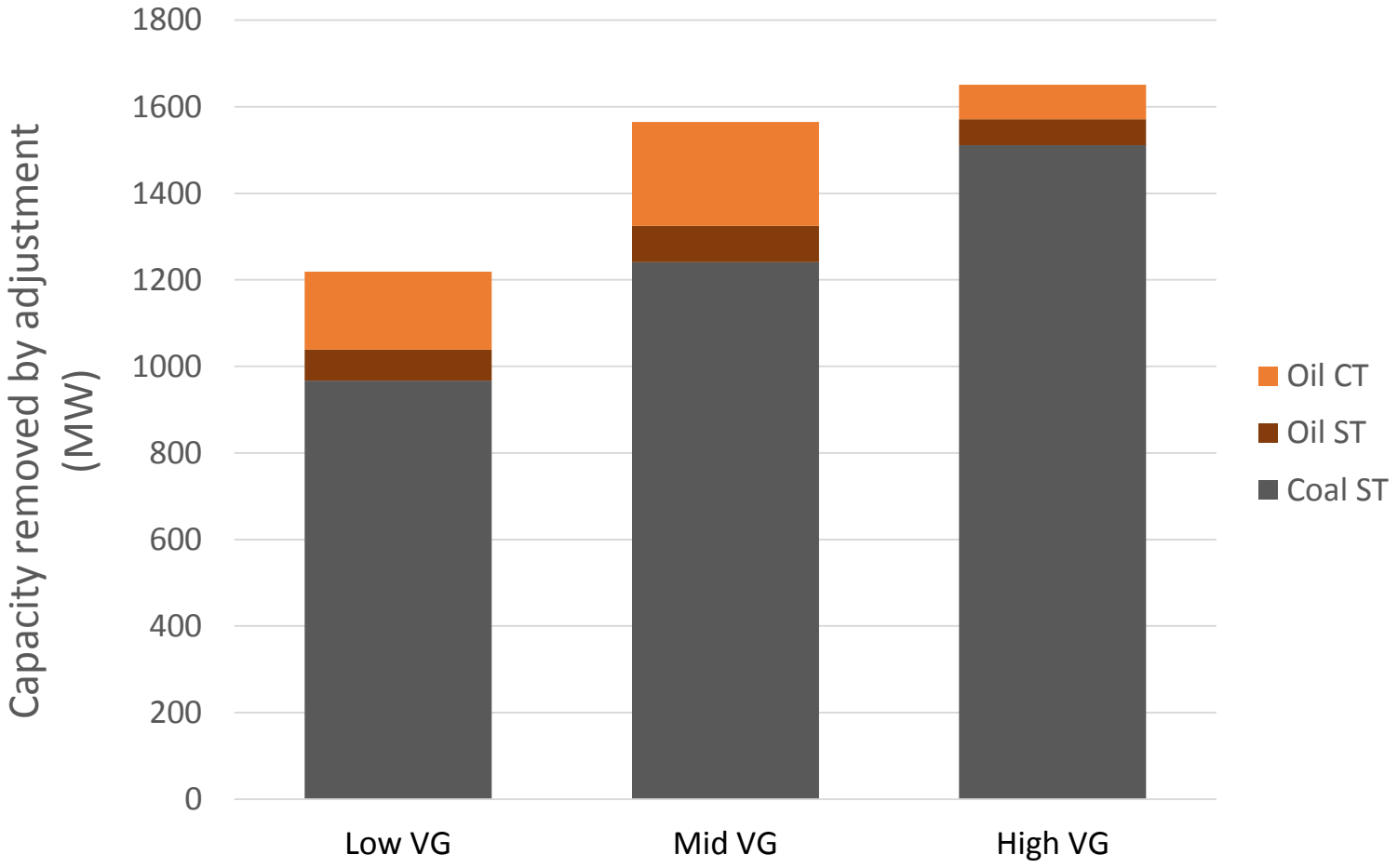
Developing reliability-equivalent scenarios

CEM-RA iterations to adjust system to ~2.4 h/year target reliability (LOLE):

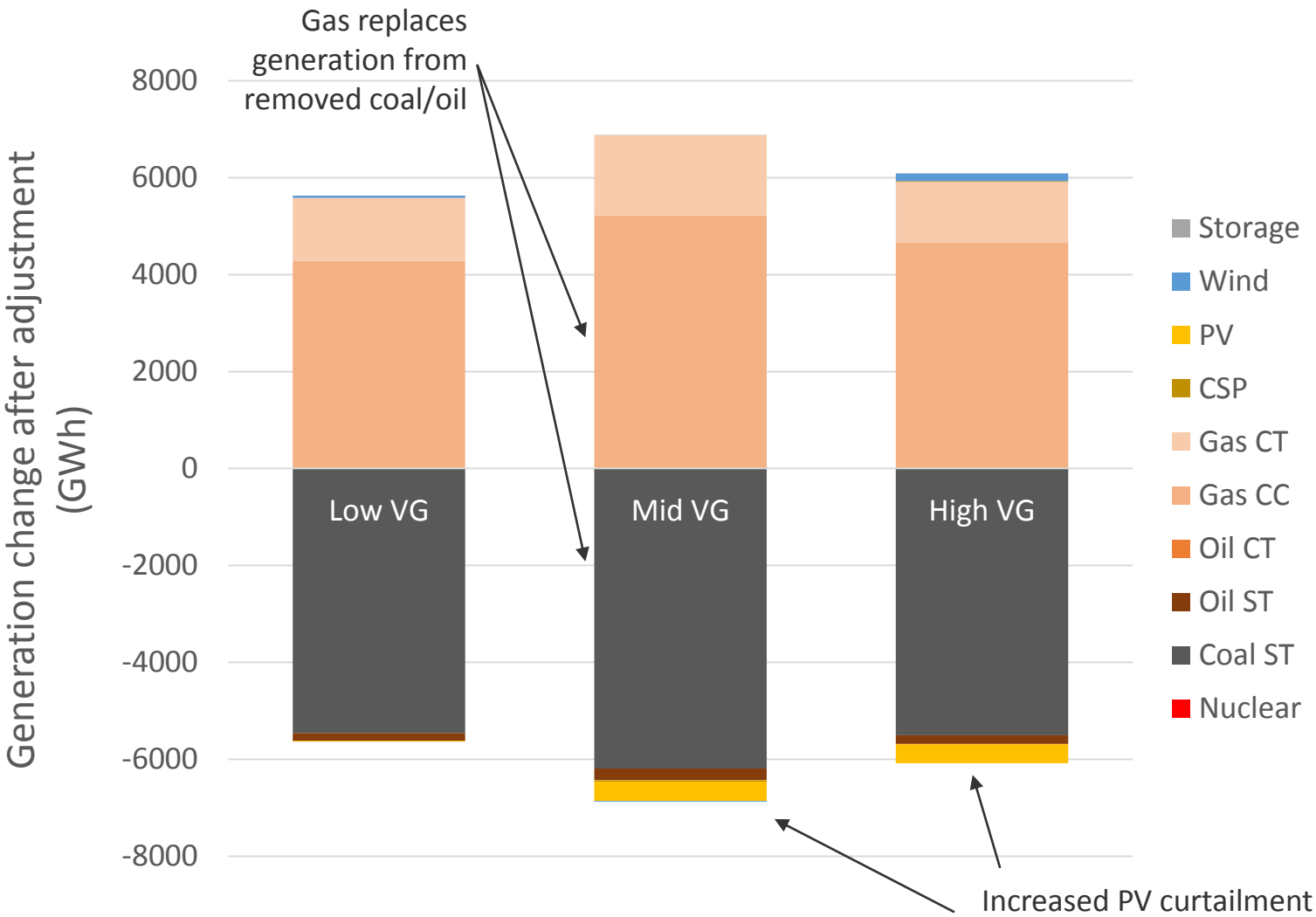
	Low VG	Mid VG	High VG
Nameplate Wind	847 MW	1646 MW	3073 MW
Nameplate PV	1286 MW	3913 MW	8876 MW
Unadjusted LOLE	2.9×10^{-3} h/year	3.7×10^{-4} h/year	1.2×10^{-4} h/year
Adjusted LOLE	3.1 h/year	2.7 h/year	2.4 h/year
Adjusted thermal capacity	-1219 MW	-1565 MW	-1651 MW

- RTS-GMLC test system with new wind/PV added
- SPEED (early version) for CEM and REPRA-T for RA
- Wind and solar buildouts predetermined (not decided by CEM)
- Forced CEM to build nuclear and hydro units (capital costs often too high otherwise)
- Artificially increased capital costs of oil units (to mitigate shortcomings in operational representation)

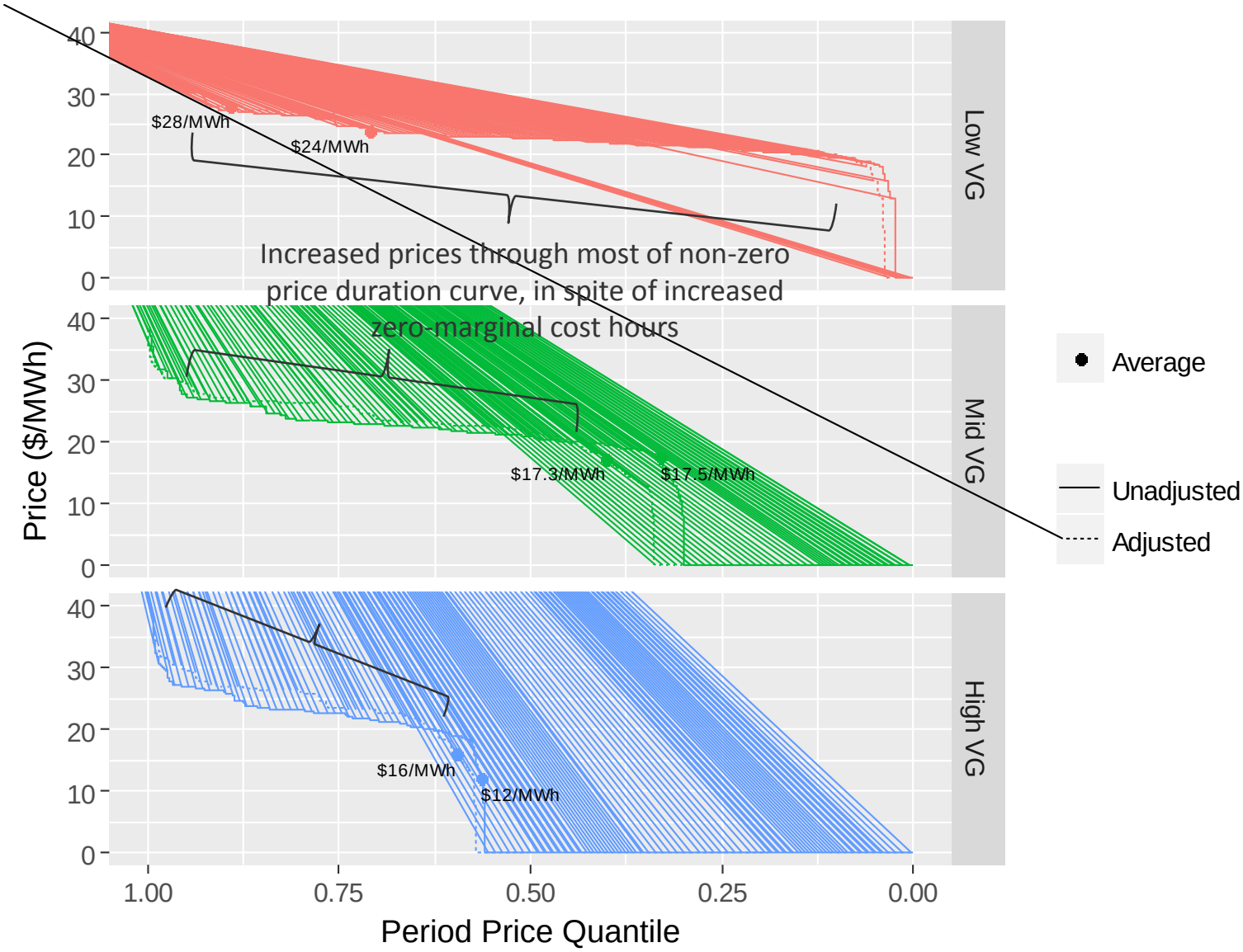
Results: Buildout decision comparison



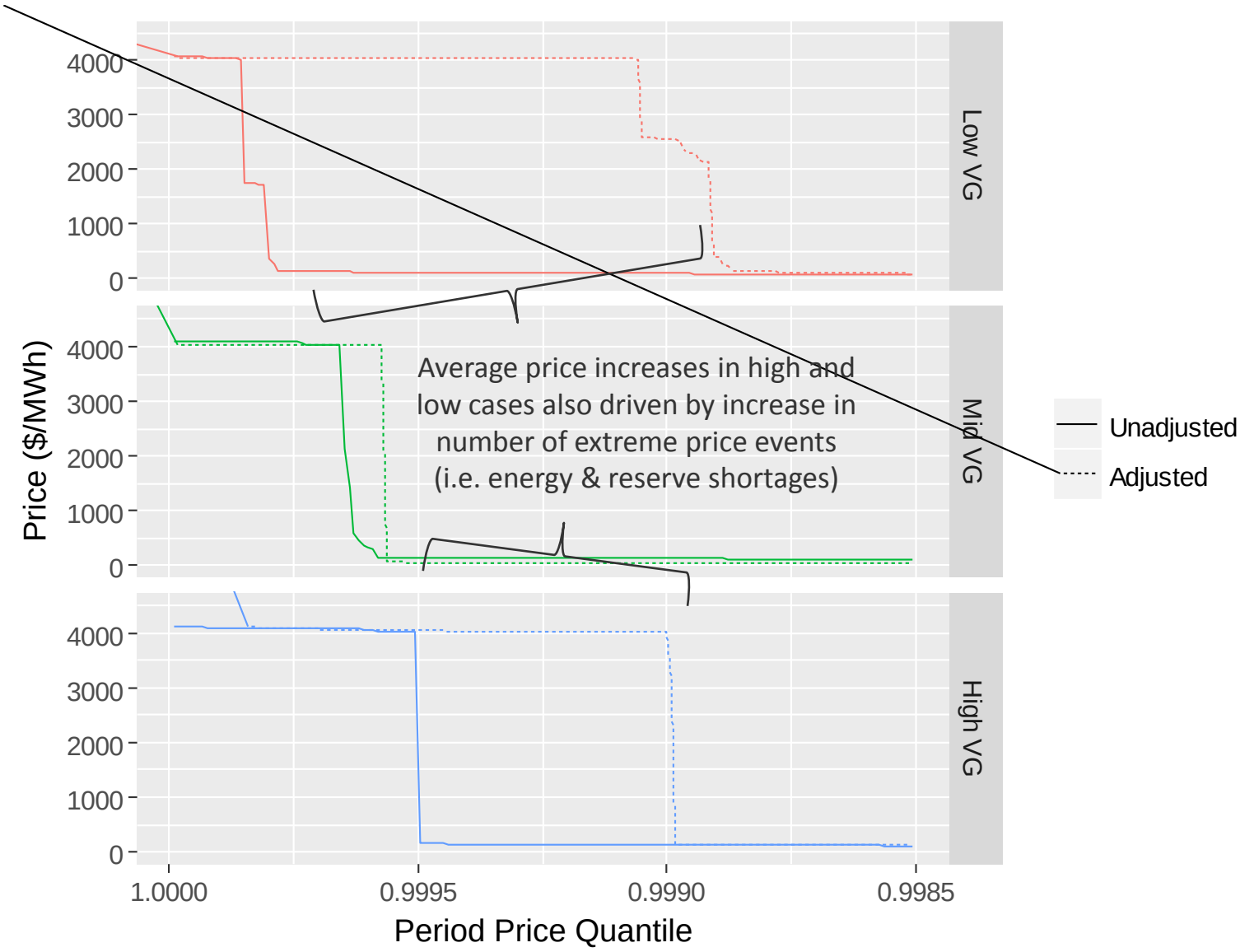
Results: Generation comparison (PLEXOS)



Results: Price comparison (PLEXOS)



Results: Price comparison (PLEXOS)



Existing Gaps / Shortfalls

Capacity Expansion Modelling

- 576-period operations model – naïve averaging eliminates extreme events (peak load days, etc), restricts information for build decisions
- No temporal linking (ramp constraints, min up/down times, etc)
- RTS capital cost inputs still need tuning

Reliability Assessment

- Reliability contribution of time/sequence-dependent resources (storage, reservoir hydro, demand response, etc)

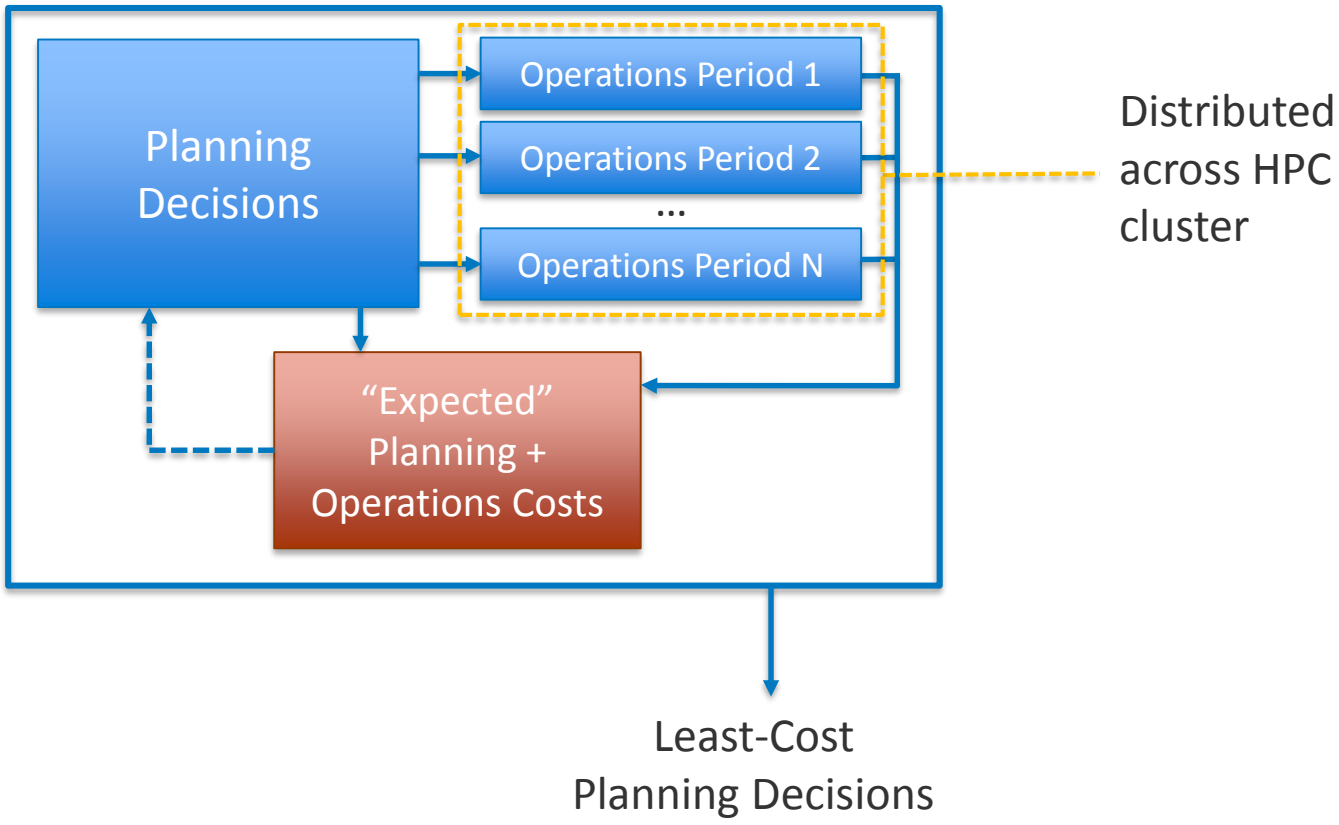
CEM + RA

- Reliability target convergence: Reliability (at economic optimal buildout) as a function of planning reserve margin is neither smooth nor monotonic

Next Steps: Scaling Computations Out

SPEED: ***S**calable* **P**ower System **E**conomic **E**xpansion & **D**ispatch

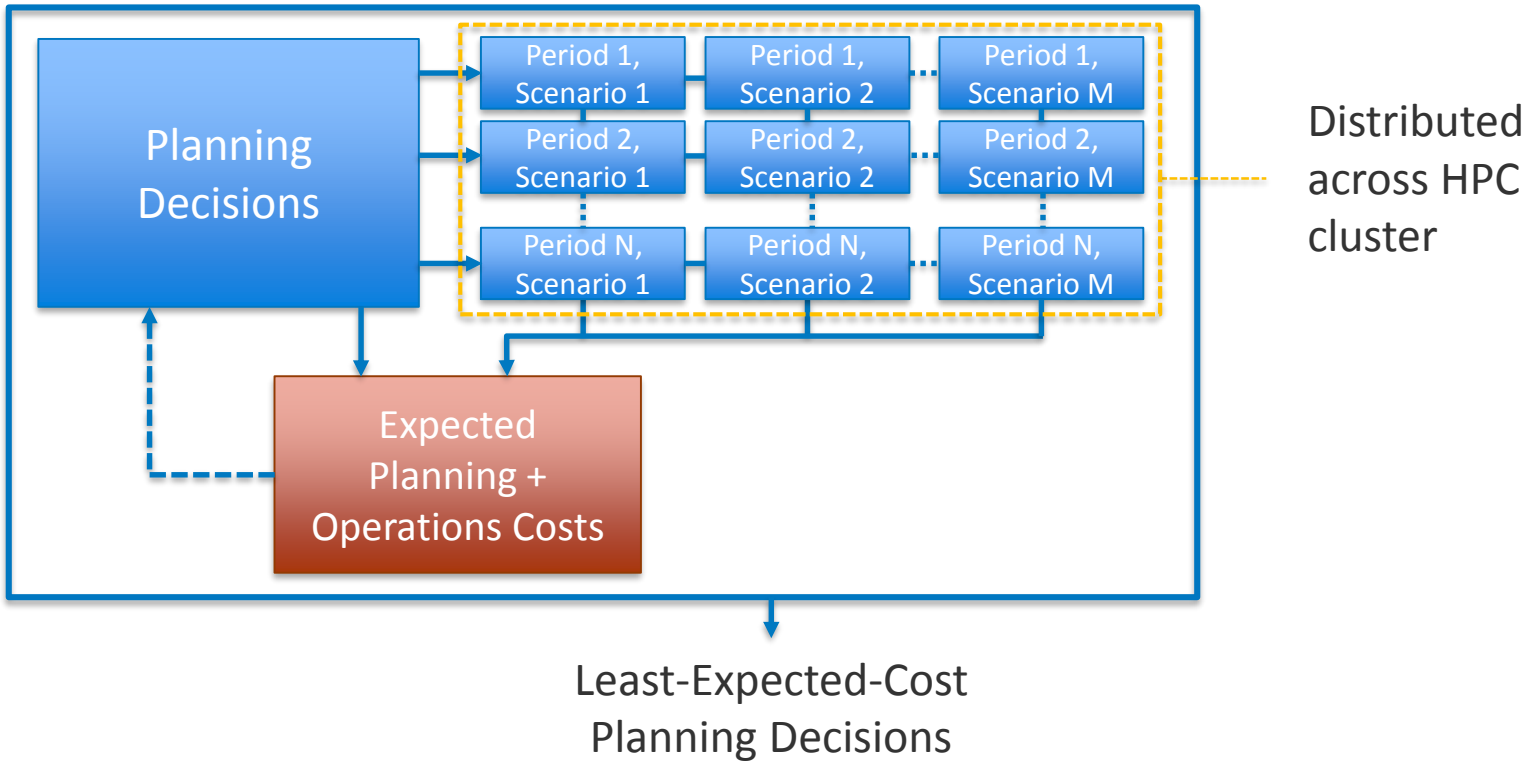
- Decomposes capacity expansion as two-stage stochastic optimization



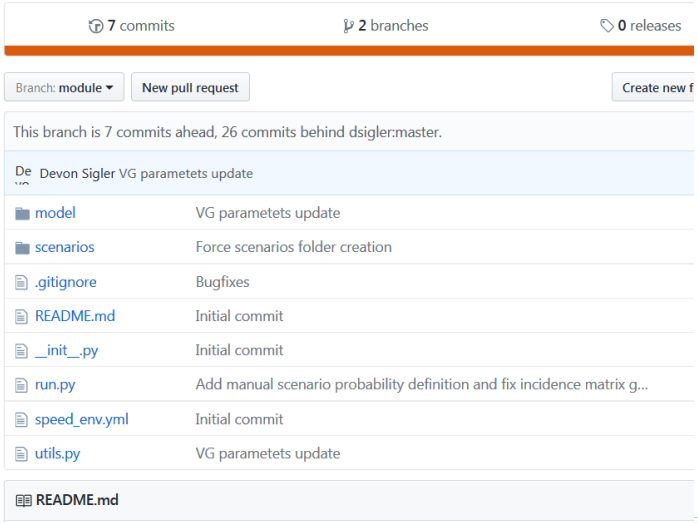
Next Steps: Embedding RA directly inside CEM

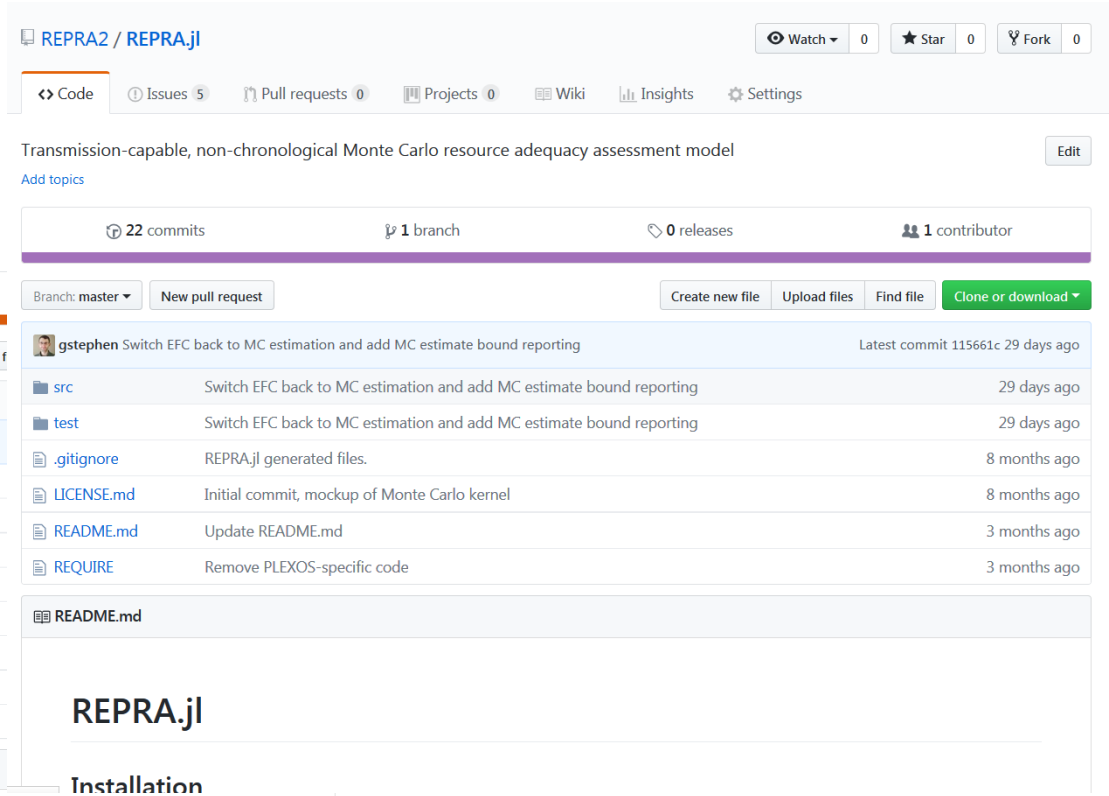
RAW-SPEED: Reliability-Aware SPEED

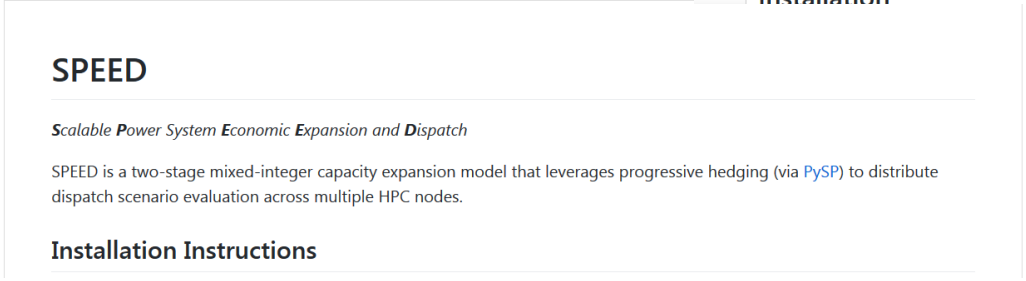
- Embeds reliability assessment scenarios in capacity expansion model
- Eliminates planning reserve margin and need for resource capacity values
- Endogenously co-optimizes capacity investment with expected operations + unserved energy (value of lost load) costs



Stay tuned…







… open-sourced tools coming soon.

Gord Stephen
Grid Systems Analysis Group
303-384-7317
gord.stephen@nrel.gov

www.nrel.gov

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