

Apples to Apples: Equivalent-Reliability Power Systems Across Diverse Resource Mix Scenarios

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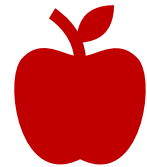
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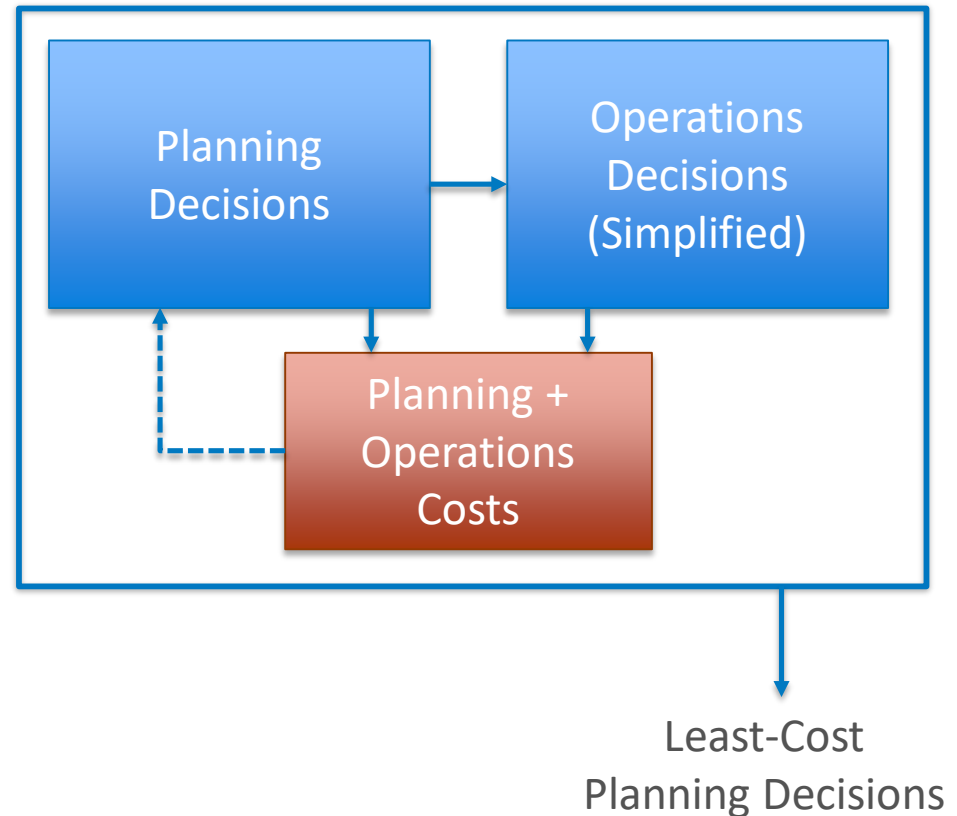
Motivation and Objective

- 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

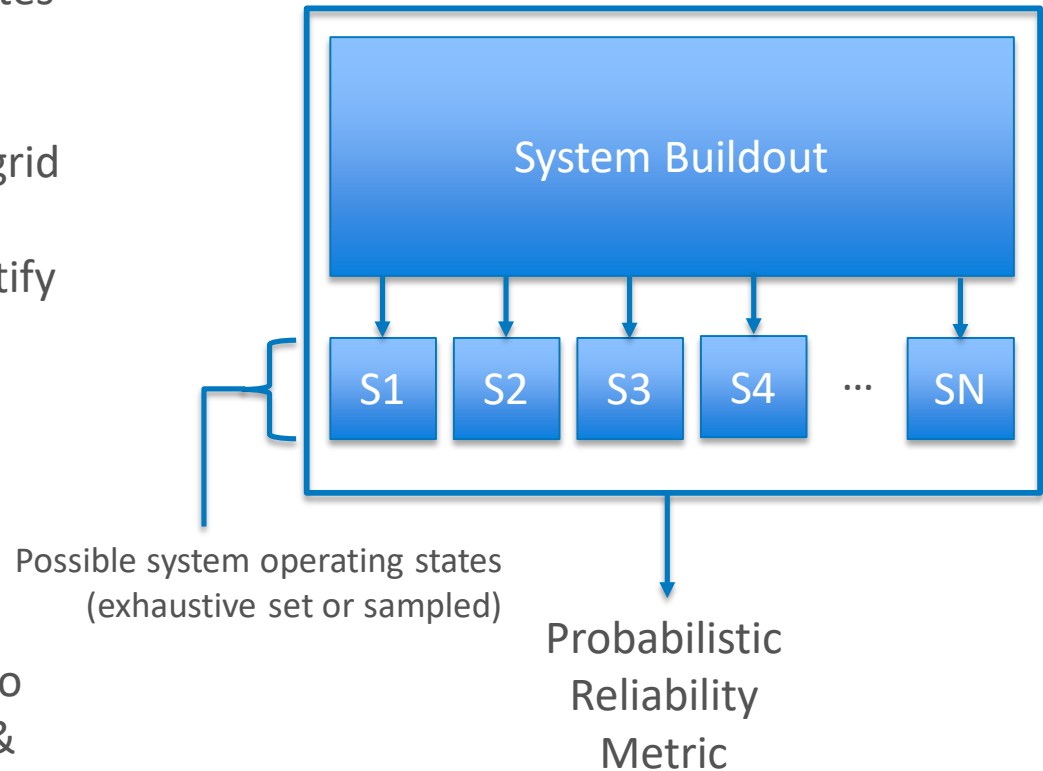
- Determines least-cost power system expansion options subject to constraints (physical, regulatory, etc)
- Requires (usually very simple) grid operations representation to balance capital vs operating costs
- System reliability traditionally governed by planning reserve margin (requires assigning static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



Models at NREL include ReEDS, RPM, SPEED

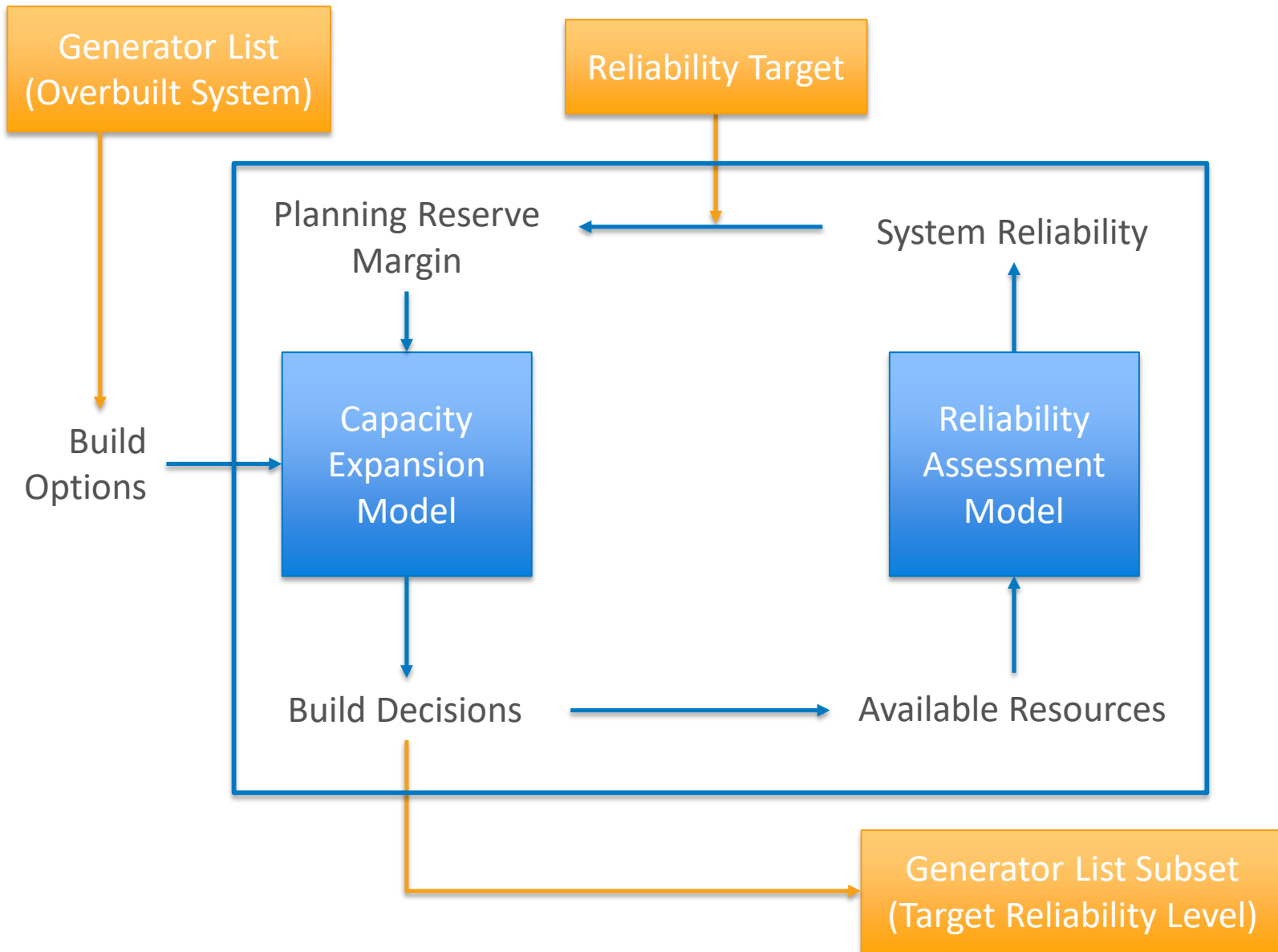
Background: Reliability Assessment

- 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



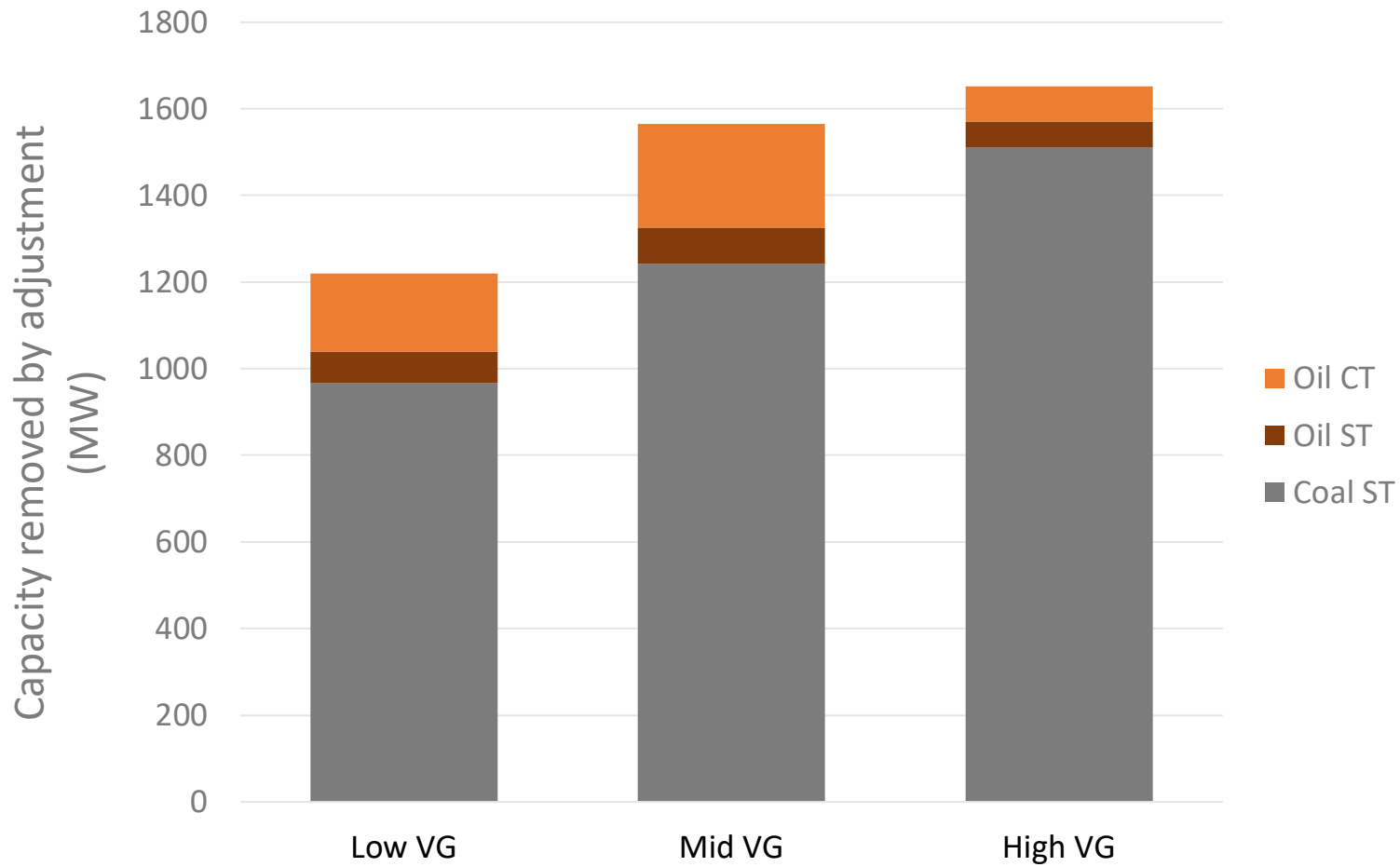
Developing reliability-equivalent scenarios

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

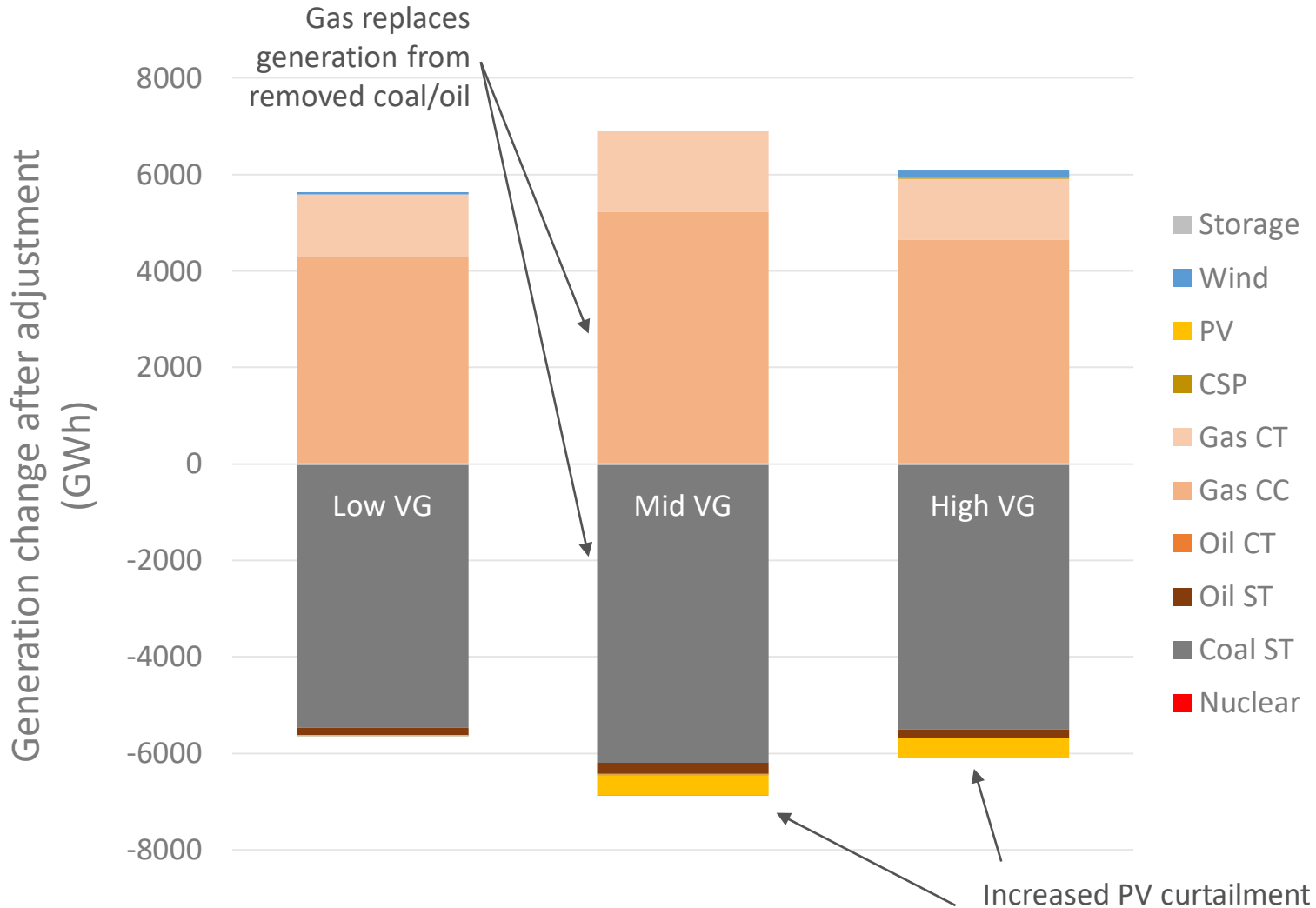
	Low VG	Mid VG	High VG
Nameplate Wind	847 MW	1646 MW	3073 MW
Nameplate PV	1286 MW	3913 MW	8876 MW
Unadjusted LOLE	2.9×10^{-3} h/year	3.7×10^{-4} h/year	1.2×10^{-4} h/year
Adjusted LOLE	3.1 h/year	2.7 h/year	2.4 h/year
Adjusted thermal capacity	-1219 MW	-1565 MW	-1651 MW

- RTS-GMLC test system with new wind/PV added
- SPEED (early version) for CEM and REPRAT 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)

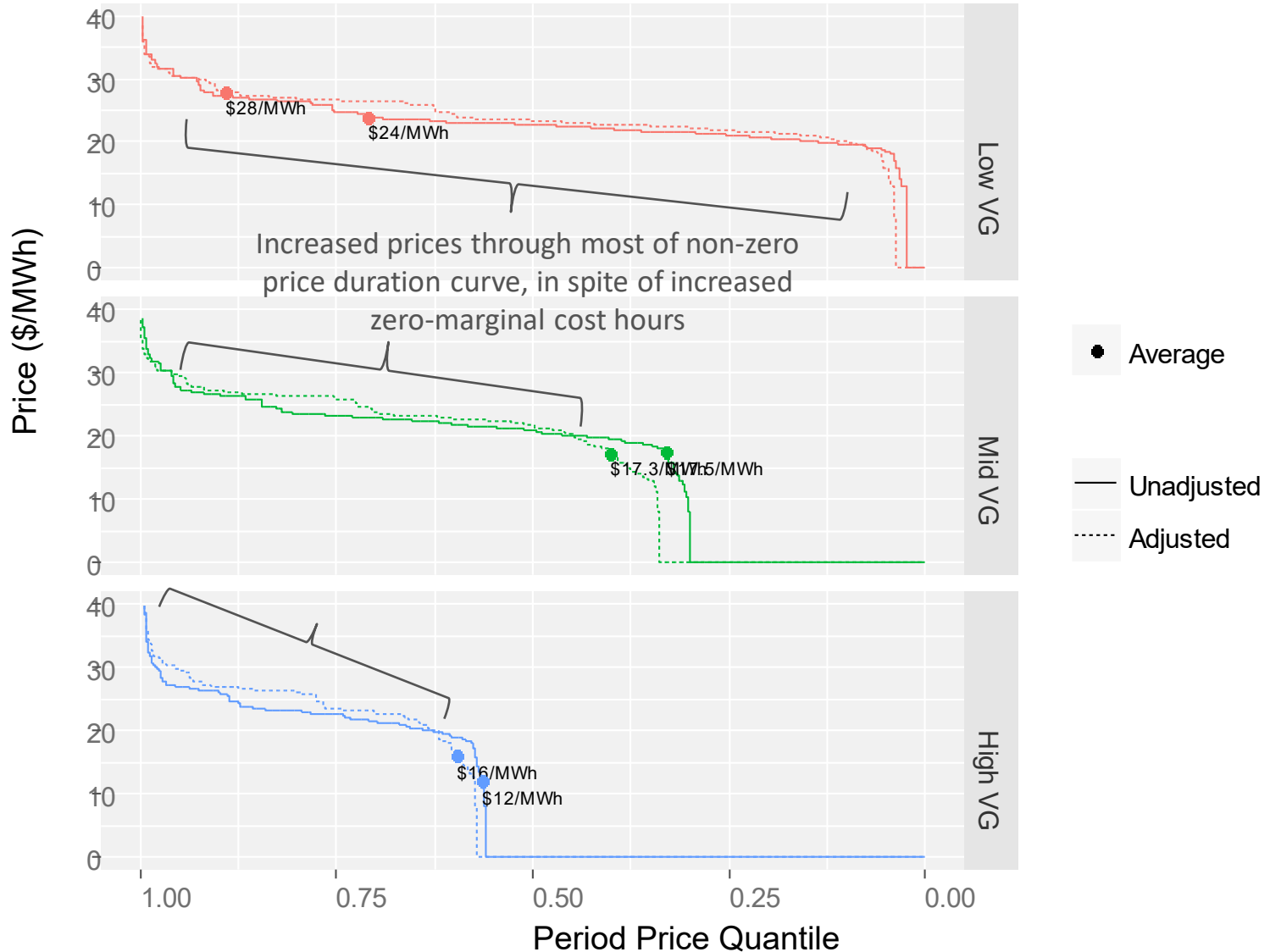
Results: Buildout decision comparison



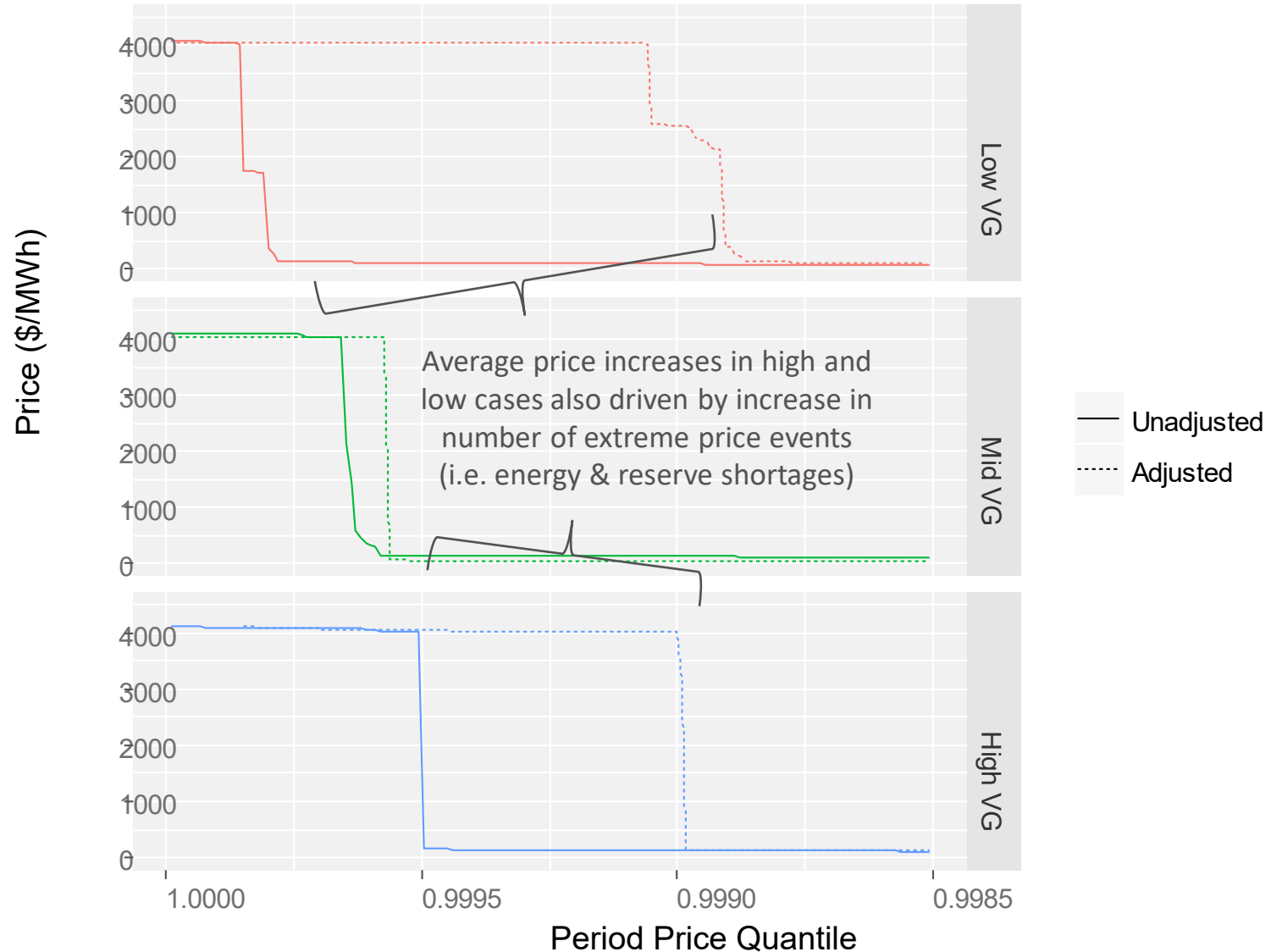
Results: Generation comparison (PLEXOS)



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)

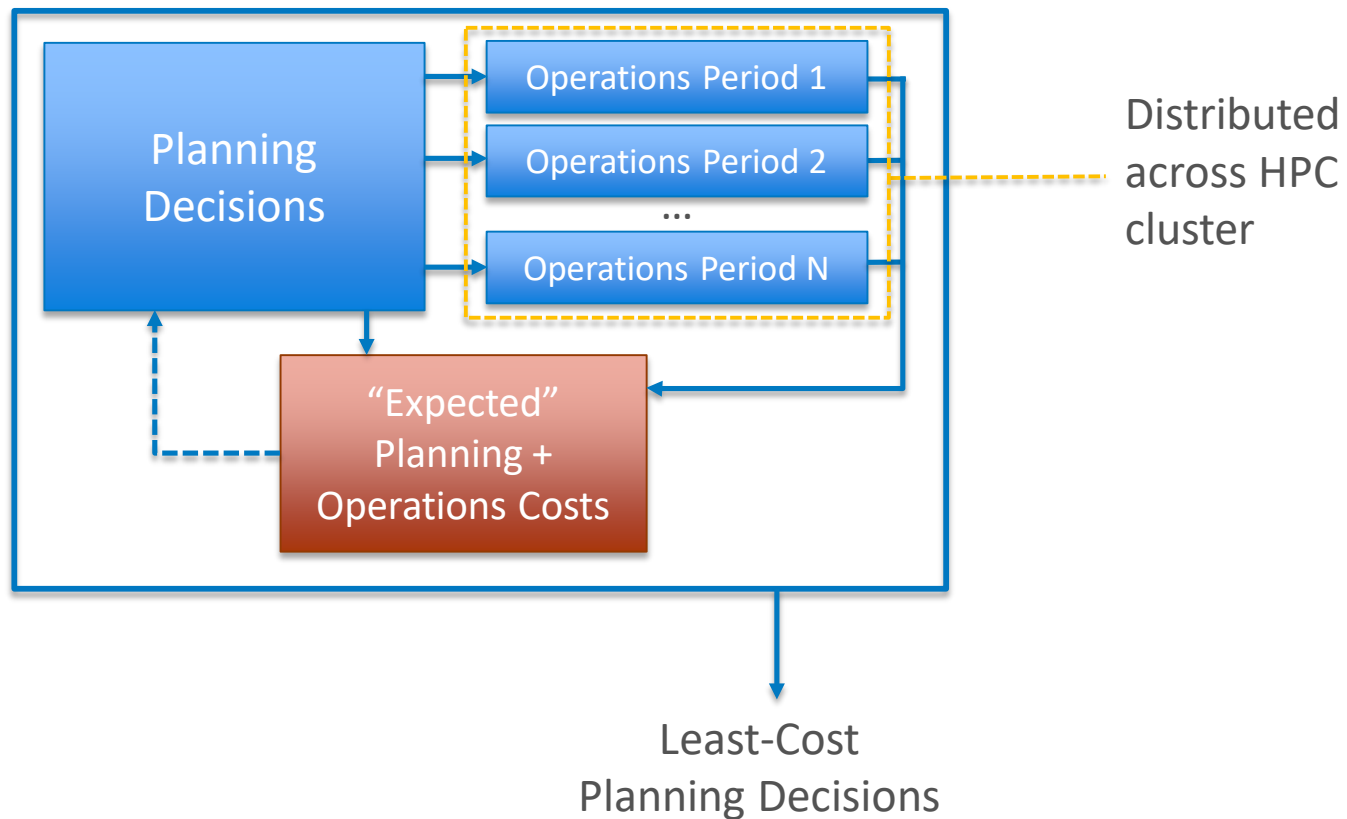
CEM + RA

- 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: Scalable Power System Economic Expansion & Dispatch

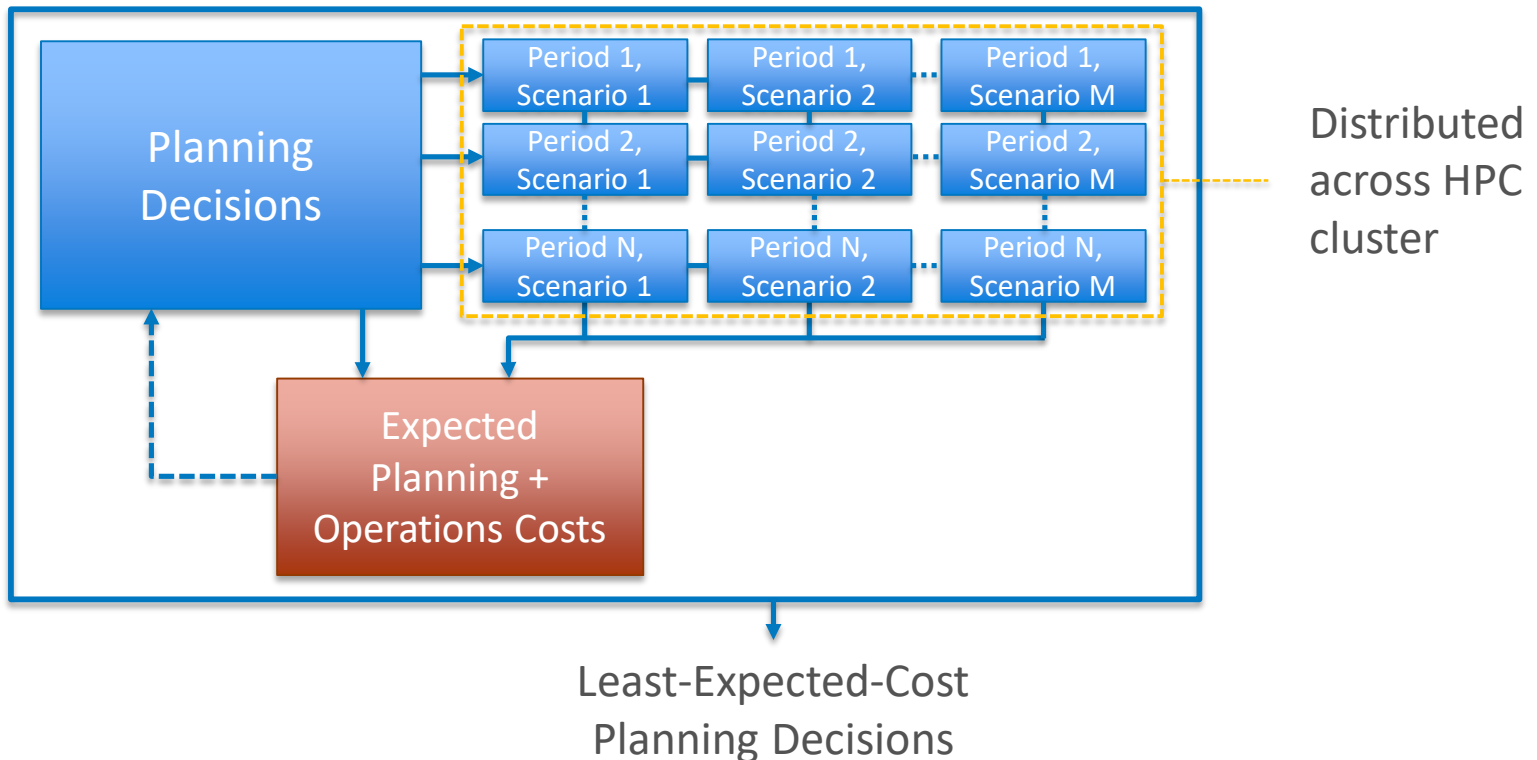
- Decomposes capacity expansion as two-stage stochastic optimization



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...

7 commits 2 branches 0 releases

Branch: module New pull request Create new file

This branch is 7 commits ahead, 26 commits behind dsigler:master.

Devon Sigler VG parametets update

- model VG parametets update
- scenarios Force scenarios folder creation
- .gitignore Bugfixes
- README.md Initial commit
- _init_.py Initial commit
- run.py Add manual scenario probability definition and fix incidence matrix g...
- speed_enw.yml Initial commit
- utils.py VG parametets update

README.md

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22 commits 1 branch 0 releases 1 contributor

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gstephen Switch EFC back to MC estimation and add MC estimate bound reporting Latest commit 115661c 29 days ago

- src Switch EFC back to MC estimation and add MC estimate bound reporting 29 days ago
- test Switch EFC back to MC estimation and add MC estimate bound reporting 29 days ago
- .gitignore REPRE.jl generated files. 8 months ago
- LICENSE.md Initial commit, mockup of Monte Carlo kernel 8 months ago
- README.md Update README.md 3 months ago
- REQUIRE Remove PLEXOS-specific code 3 months ago

README.md

REPRE.jl

Installation

SPEED

Scalable Power System Economic Expansion and Dispatch

SPEED is a two-stage mixed-integer capacity expansion model that leverages progressive hedging (via [PySP](#)) to distribute dispatch scenario evaluation across multiple HPC nodes.

Installation Instructions

... open-sourced tools coming soon.

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