

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

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Gord Stephen, Bethany Frew, Devon Sigler, Wesley Jones  
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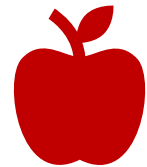
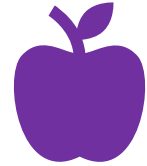
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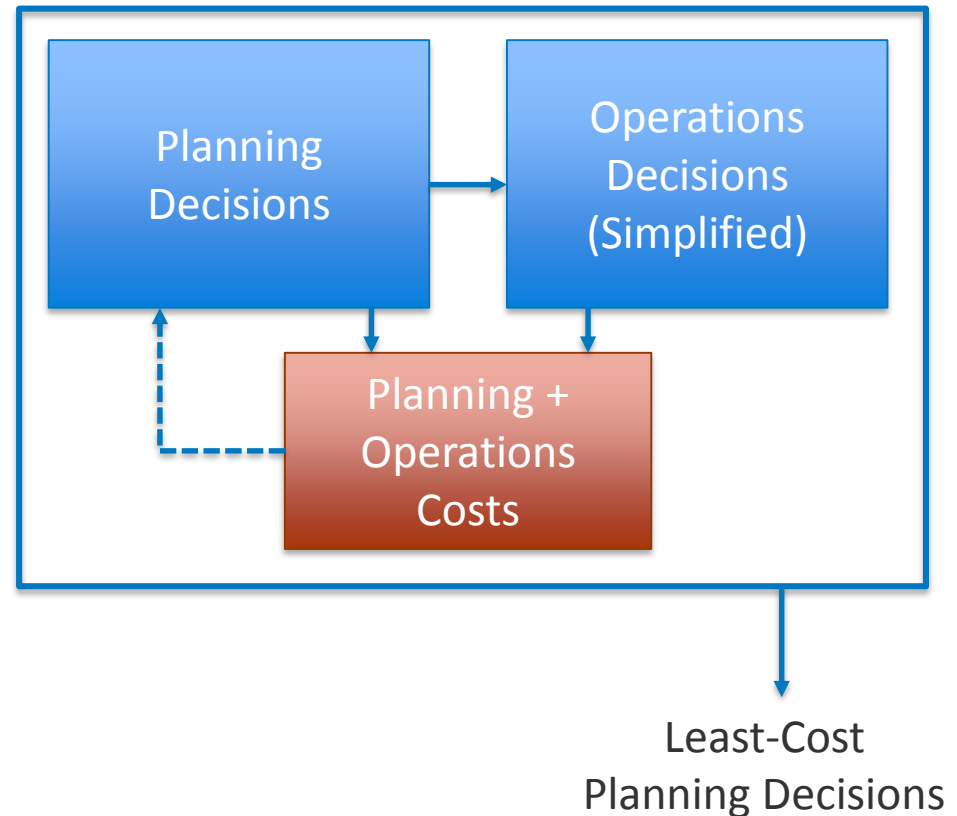
# Motivation and Objective

- 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

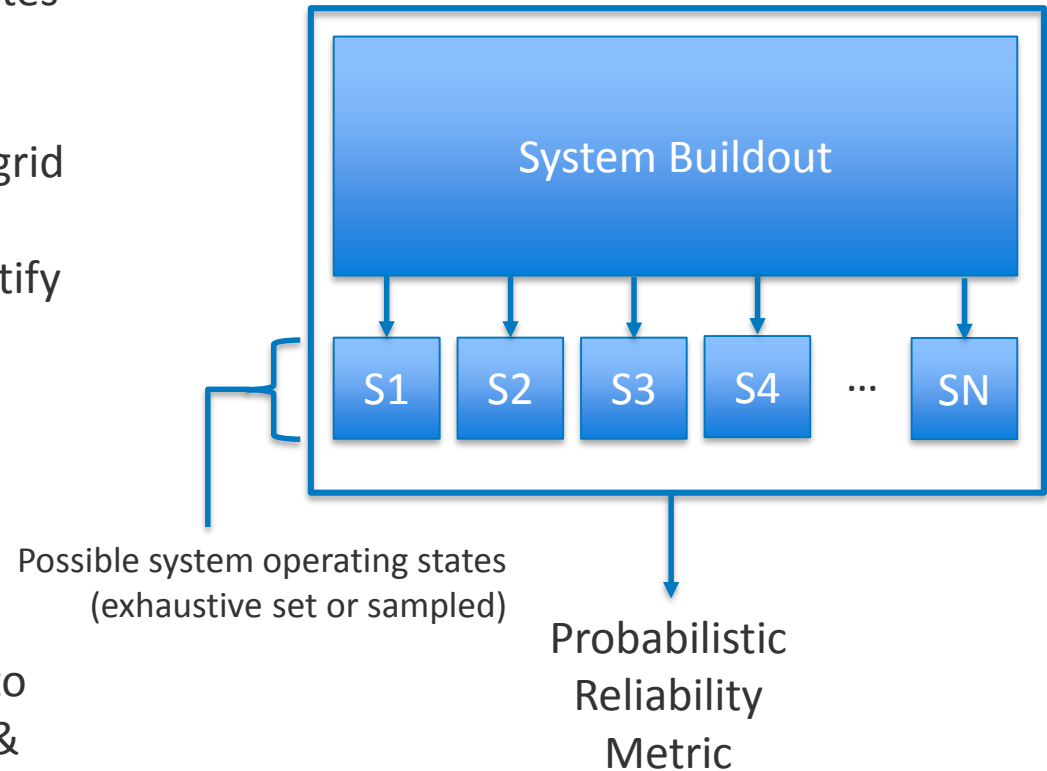
- Determines least-cost power system expansion options subject to constraints (physical, regulatory, etc)
- Requires (usually very simple) grid operations representation to balance capital vs operating costs
- System reliability traditionally governed by planning reserve margin (requires assigning static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



*Models at NREL include ReEDS, RPM, SPEED*

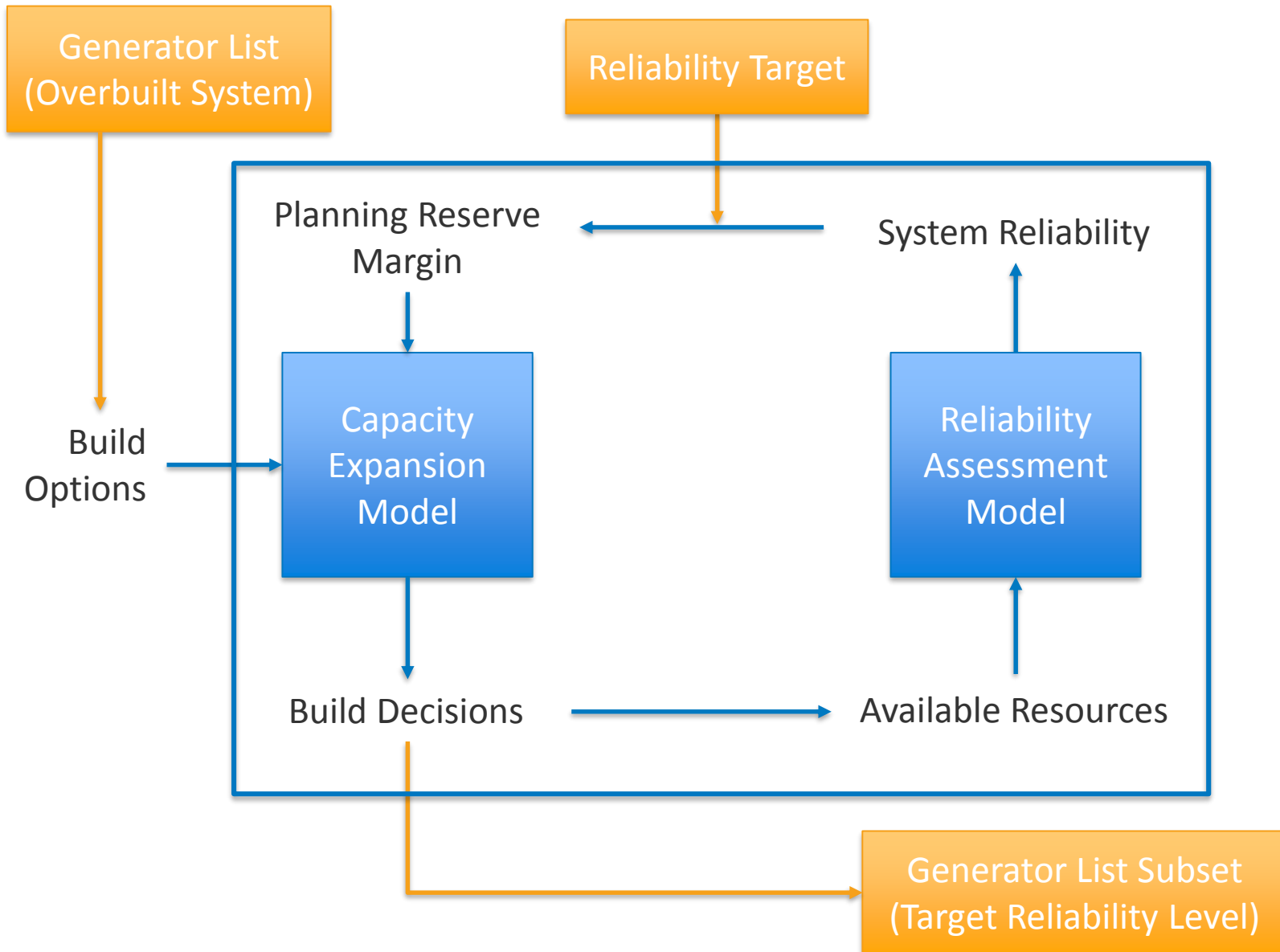
# Background: Reliability Assessment

- 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



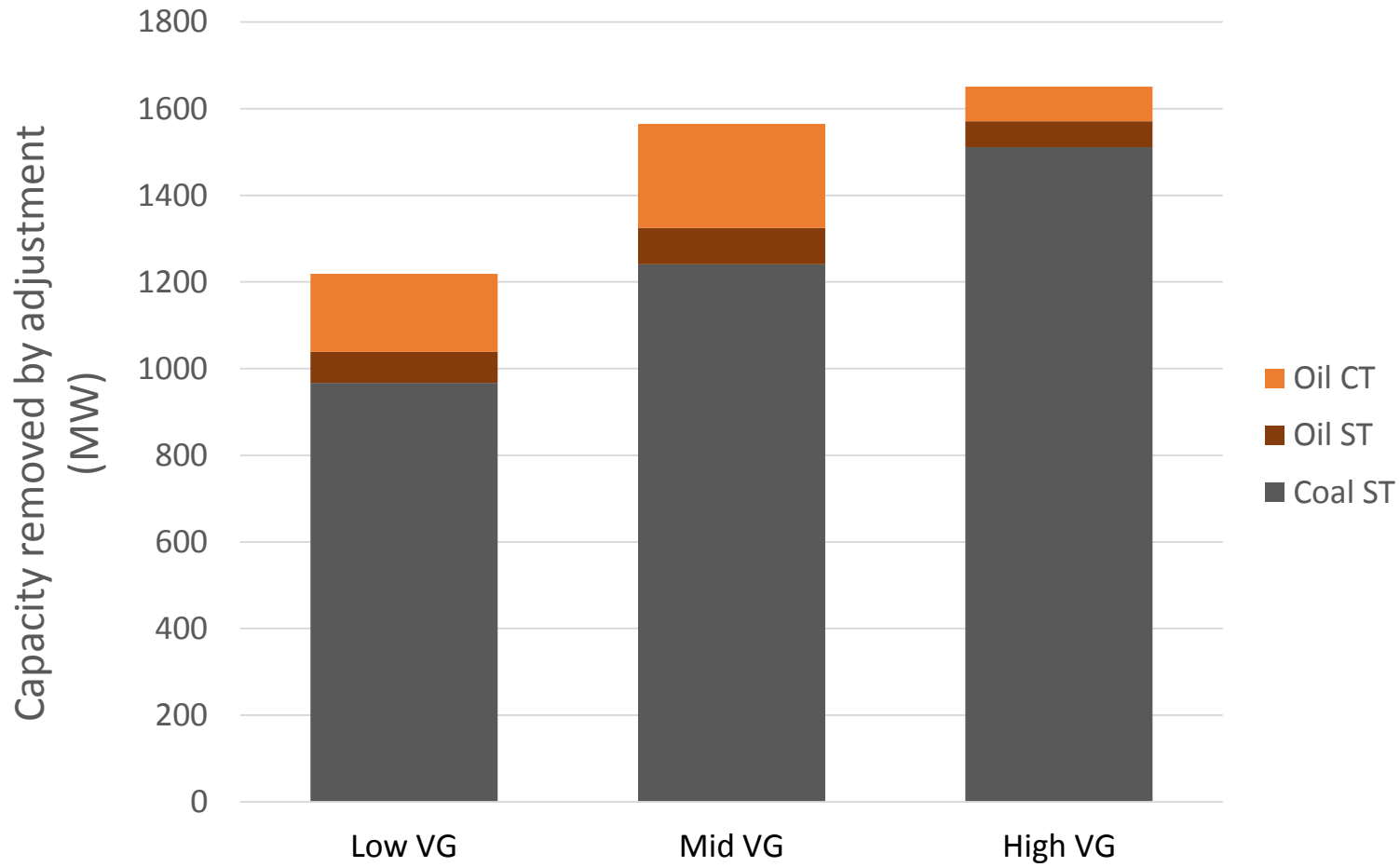
# Developing reliability-equivalent scenarios

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	$2.9 \times 10^{-3}$ h/year	$3.7 \times 10^{-4}$ h/year	$1.2 \times 10^{-4}$ 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

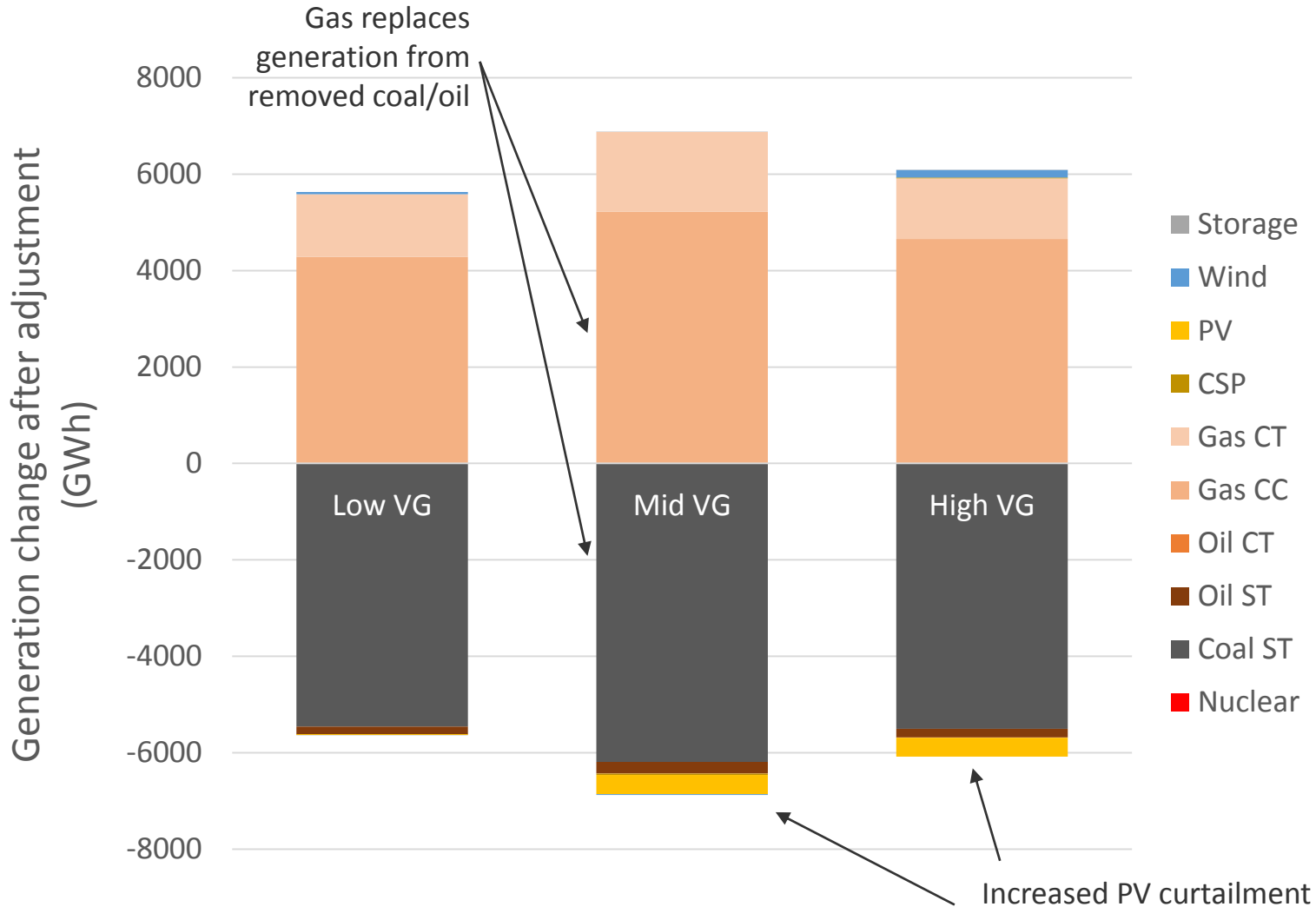
- RTS-GMLC test system with new wind/PV added
- SPEED (early version) for CEM and REPRAT for RA
- Wind and solar buildouts predetermined (not decided by CEM)
- Forced CEM to build nuclear and hydro units (capital costs often too high otherwise)
- Artificially increased capital costs of oil units (to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

# Results: Buildout decision comparison

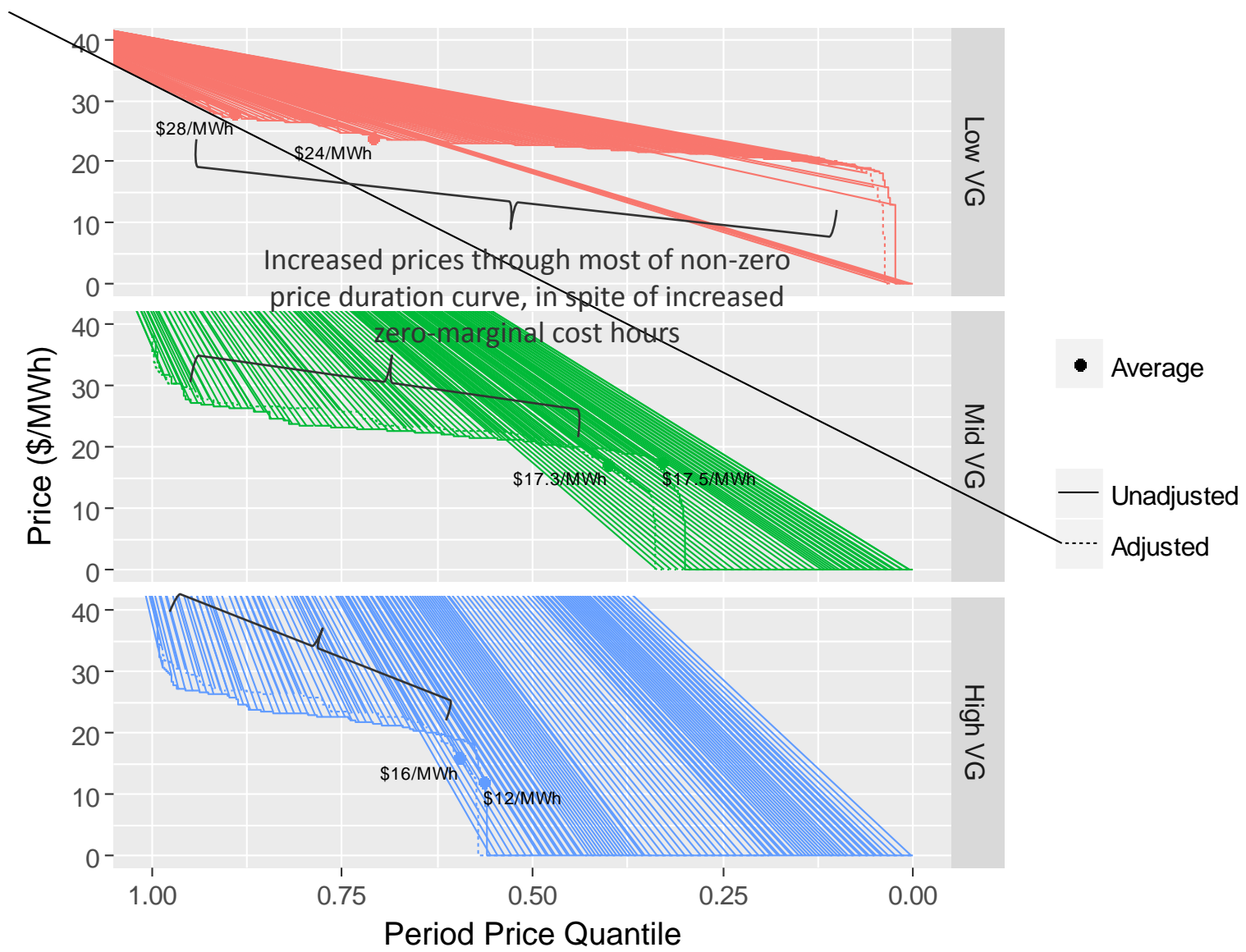




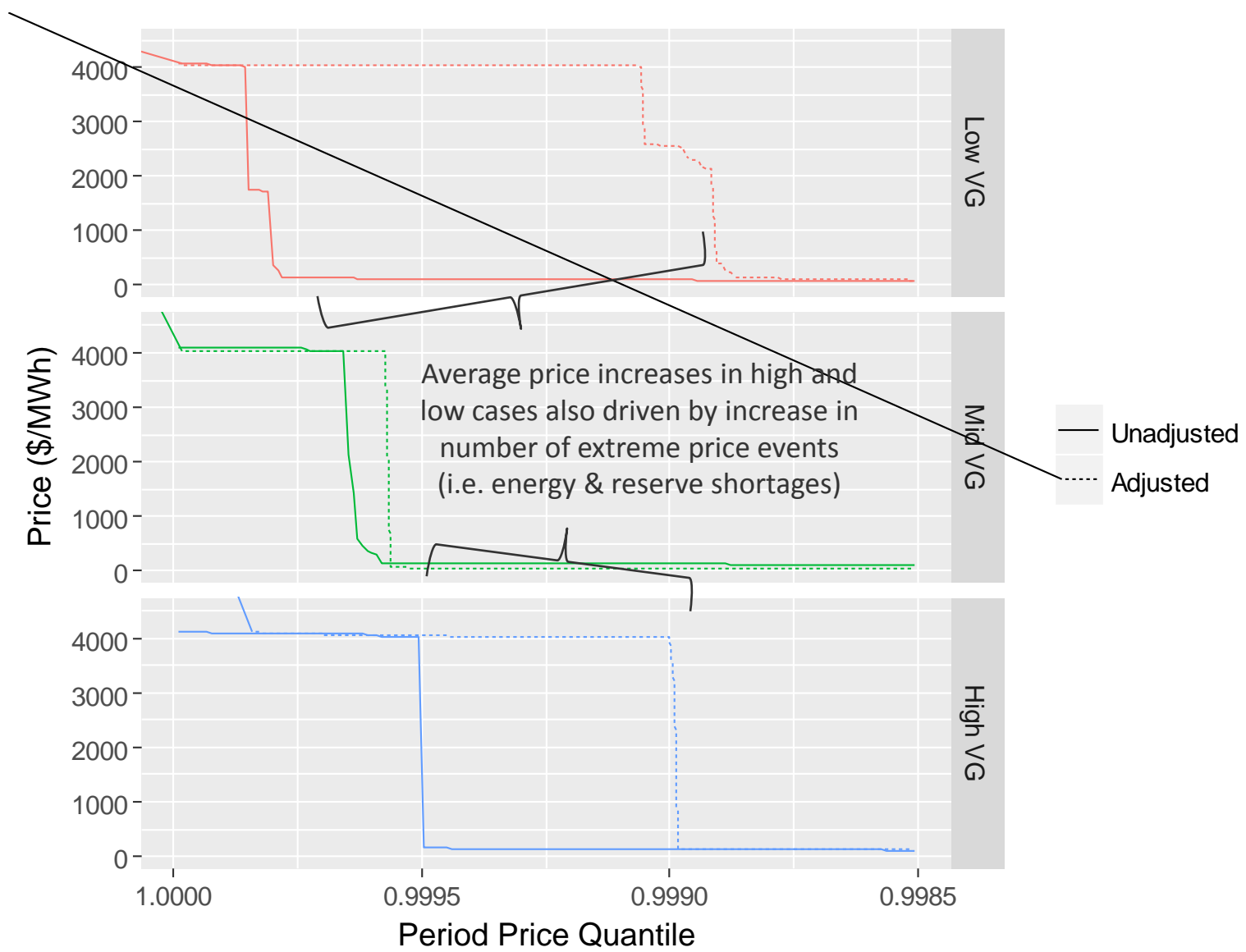
# Results: Generation comparison (PLEXOS)



# 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)

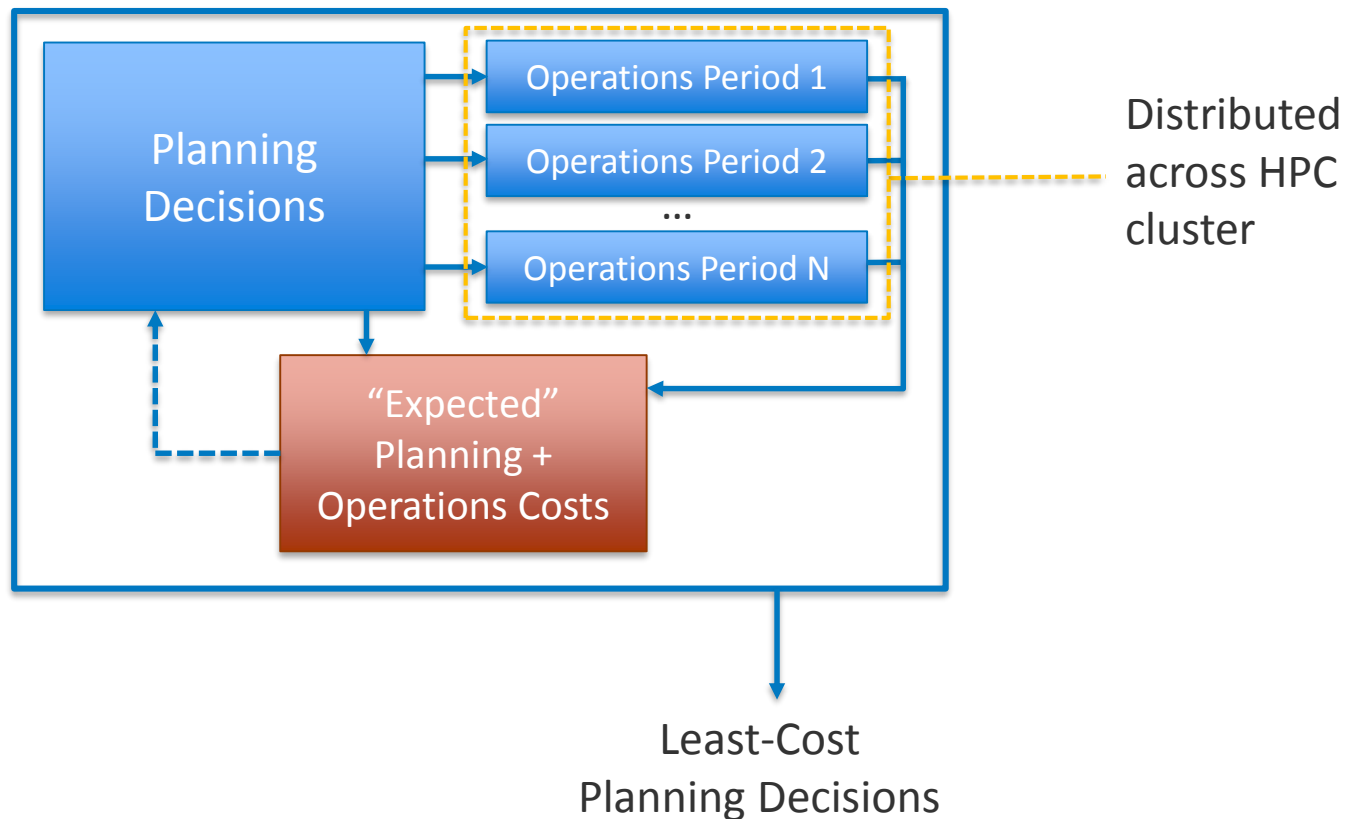
## CEM + RA

- 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

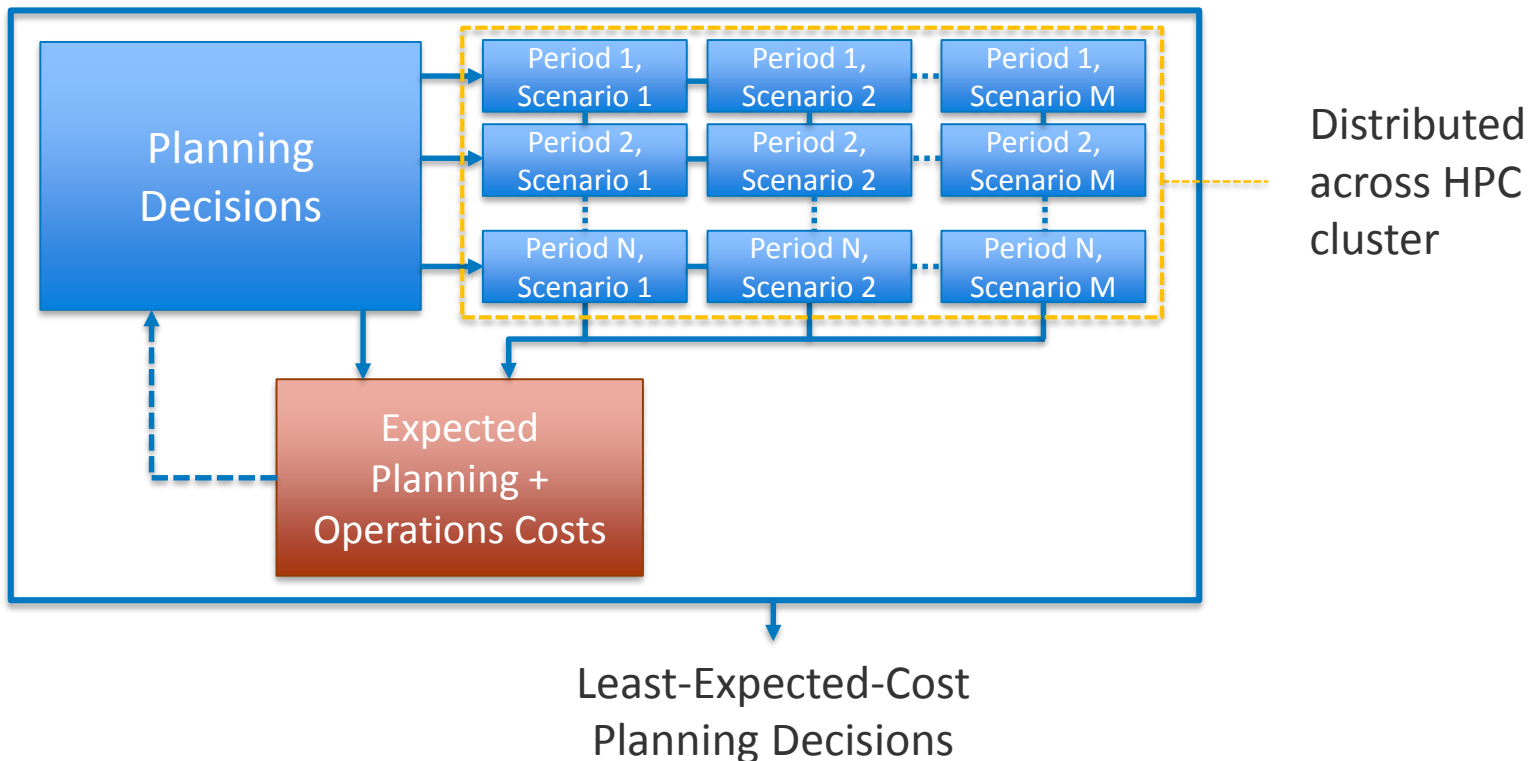
- Decomposes capacity expansion as two-stage stochastic optimization



# 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\_env.yml Initial commit
- utils.py VG parametets update

README.md

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Transmission-capable, non-chronological Monte Carlo resource adequacy assessment model Edit

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 REPA.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
- REMOVE Remove PLEXOS-specific code 3 months ago

README.md

## REPA.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.

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

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