Collaborative Review of Planning Models

Pacific Gas and Electric Company
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Topics For Today's Presentation

- **Questions planning models can help answer**
- **Handling of uncertainty and variability in models**
- **Metrics that models produce**
- **Model results useful to determine flexibility need**
- **Standardization of outputs to facilitate comparison of models results**

Background: Purpose of Collaborative Effort

Improve understanding of current planning models – how they work, how they've been used, how they can help us understand future system needs – not to select a model

Thanks to all participants!

The CAISO and SCE models reviewed in this collaborative effort were used to analyze 2012 LTPP scenarios, and may not be the same models used by the CAISO and SCE inthe 2014 LTPP.

Questions Models Can Help Answer

1. How do we evaluate the future performance of a system?
2. What is the frequency, duration, and magnitude of projected shortfalls or deficiencies, if any?
3. What is causing projected deficiencies?
4. What is the effectiveness and cost/benefit of alternative solutions to deficiencies found?
5. What metrics, standards, and system requirements should be adopted?

General Process for Answering Questions

1. **Simulate system operation as realistically as possible**
    - Unit commitment/dispatch decisions
    - Resource capabilities/limitations, transmission constraints, imports/exports limitations
    - Uncertainty/variability affecting operating decisions
2. **Measure deficiencies, if any**
3. **Evaluate cost-effectiveness of solutions to deficiencies**
4. **Decide whether/how to mitigate deficiencies**
    - Authorize procurement if needed
    - Refine definition of flexibility requirements as needed
    - Adopt flexibility standards if appropriate

Handling of Uncertainty and Variability - Overview

Models/Approaches	Scenario(s) Considered	Simulating Operating Decisions
Deterministic (CAISO Deterministic)	A single "base case" or "stress" scenario at a time	Assumes perfect foresight, considers operating cost
Stochastic, statistical (SCE)	Many scenarios, enables calculation of probability metrics (e.g. LOLE)	Assumes perfect foresight, caps resource outages to 1000 MW
Stochastic + uncertainty + recourse (REFLEX, SERVM)		Considers uncertainty, operating costs, and ability to adjust decisions (recourse)
Physics-based weather uncertainty + stochastic unit commitment (LLNL)		Considers physics-based weather uncertainty, operating costs, stochastic unit commitment

Approaches vary:

- **One vs. multiple scenarios at a time**
- **A range vs. a cap of resource outages**
- **Various degrees of forecast error and variability**
- **Recourse**

Modeling Scenarios – Capturing Long Term Variance

	CAISO D.	SCE Model	REFLEX	SERVM
Weather scenarios	Single, 365-day annual deterministic scenarios	1,000s of single days drawn (high load/ramp) from 30 years of load "shuffled" within month with 1 year of wind and solar	1,000s of 3-days drawn from 30 years of load, wind and solar, "shuffled" within month and day-type.	1,000s of whole year iterations (~30 weather years x 5 load multipliers for economic uncertainty x 100 iterations)

- **CAISO Deterministic and SERVM draw and simulate whole years**
- **SCE and REFLEX draw and simulate individual days**
- **SERVM models load forecast uncertainty as an option**

Capturing Uncertainty & Variability in Operating Decisions

	CAISO D.	SCE Model	REFLEX	SERVM
Unit commitment & dispatch	Perfect foresight cost optimization, hourly dispatch	Perfect foresight, 5-min dispatch, costs not considered.	Optimal commitment with forecast error, 5-min dispatch capability	Commitment adjusted as uncertainty unfolds, 5-min dispatch capability

- **CAISO and SCE simulate operations assuming operator has perfect foresight**
- **REFLEX and SERVM incorporate uncertainty into operating decision**
- **All except SERVM use mixed integer optimization; SERVM adjusts commitment/dispatch decisions as uncertainty resolves**

Demand or Requirements for Operating Reserves

	CAISO D.	SCE Model	REFLEX	SERVM
Contingency reserves	6% of load requirement	Minimum 3% of load	Minimum 3% of load	Minimum 1.5% of load
Regulation reserves	Hourly input	1.5% of load	Hourly input	1.5% of load
Load following reserves	Hourly input	Calculated from 5-minute variability of net load	Procured economically based on assumed cost of load shed and over-gen	Fixed % of load or hourly input. Procured economically based on demand curve for reserves

- **Critical to accurately model operating reserves since they are a key source of flexibility**
- **CAISO treats reserves as firm requirements that must be satisfied; others assume a minimum 3% operating reserves to calculate LOLE/EUE metrics**
- **REFLEX and SERVM procure reserves above minimum 3% based on risk/cost tradeoffs**

Metrics: Measuring Deficiencies, If Any

Modeling Approach	Reliability Metrics	Flexibility Metrics
CAISO Deterministic	Unserved energy in scenario	Shortage of various reserves Dump/over-generation energy
E3's REFLEX	Calculates traditional reliability metrics (LOLE ignores commitment, resource constraints)	EUE, EOG
SCE's Approach	LOLE with resource flexibility constraints	LOLE with resource flexibility constraints, EOG
LLNL-CEC Project	Same as CAISO Deterministic	Same as CAISO Deterministic
SERVM	LOLE with or without load growth uncertainty and with or without resource flexibility constraints	LOLE with or without load growth uncertainty and with resource flexibility constraints, EOG

Models calculate similar but not identical metrics. Differences are due to:
- **Different inputs; inputs can be changed in most cases**
- **Different treatment of uncertainty (often intrinsic to model design)**

Lack of distinction between "reliability metrics" & "flexibility metrics" is confusing

All stochastic models estimate loss of load expectation (LOLE) or expected number of Stage3 events (less than 3% total reserves)..
EUE = expected unserved energy; EOG = expected over generation amounts.

Need: Mitigating Deficiencies

Step 1: Evaluate effectiveness and cost/benefit of potential solutions

- Various solutions may be available depending on deficiency found
- The fixed cost of alternatives is considered outside of model to complete evaluation; models only consider productions costs

Step 2: Decide whether deficiencies require new resources

- Trade offs between the cost of deficiencies and new resources
- Decision-makers' risk preferences, appetite for shortfalls
- Compliance with NERC/WECC requirements

Step 3: Mitigate deficiencies if determined necessary

- Procurement authorization
- Final decision may inform future analyses underpinning flexible procurement requirements

Flexibility Metrics and Standards

- **In past, metrics (e.g. PRM/LOLE) and standards (e.g. 15-17% PRM/0.1 LOLE) guided planning**
- **Increased operational flexibility challenges may require new/additional planning metrics and standards**
- **Models that enable systematic evaluation of system performance, drivers of deficiencies, and of solutions to remedy deficiencies, should help update planning metrics/standards**

Suggestions for Comparing Results

- Use similar inputs if possible: loads, resources, outages, transmission and import/export assumptions
- Select specific reference and stress scenarios to compare commitment and dispatch under different conditions
- Select consistent metrics to determine deficiencies; e.g.
  - Measure LOLE at x% operating reserves, considering flexibility constraints of resources
  - Adjust metrics for known differences (e.g., reduce LOLE where capacity is available but not committed, adjust EOG for differences in export assumptions)
- Evaluate the effectiveness and cost/benefit of alternative solutions

* Note that characterization of uncertainty and system constraints may vary because of differences in modelingapproaches.

Questions?