Flexibility and uncertainty are related
Traditional simulation approach used in planning does not capture impact of uncertainty.

- Operators do not have perfect foresight
- Monte Carlo methods do not solve the problem
- Operations paradigm: “recourse” and “non-recourse” decisions
Simulated Prices Fail to Capture Real-World Volatility

Modeled:
68% of intervals within +/- $5/MWh from median; 93% of intervals within $10/MWh

Actual:
54% of intervals within +/- $5/MWh from median; 73% within $10/MWh

PLEXOS Simulated LMPs
Median = $28.8/MWh

Actual EIM LMP in PACW:
Nov 2014-Oct 2015
Median = $23.6/MWh
What Drives Differences?

Uncertainty
- Operators make decisions using available forecasts (i.e., “imperfect foresight”).
- Many decisions must be made early, in spite of greater uncertainty.
- Uncertainty decreases as we get closer to real time, but options decrease.
- Impacts of flexibility from provisional “recourse” decisions is key.

Variability
- Courser (e.g., hourly) period lengths used in day ahead cycle smear out and hide greater variability seen in real time.

Outages
- Not forecastable in same manner as load and variable generation.
- Forced outages and failed startups not seen until actual operations.
- Simulation of control actions should anticipate impacts only as appropriate.
What Drives Differences?

Reserve Deployment
- Must simulate control actions of releasing ancillary services to provide energy
- Key simulating reliability and understanding of prices in tail events
- Many actions are informal and subject to operator discretion

Ad-Hoc Decisions
- Many operational processes are not formalized or are subject to operator discretion
- Simulation must mimic operator actions, even when not formal
- Requires heuristic policies (i.e., constraints and costs) even if optimization is not heuristic
- Even where formalized, processes may not be broadly understood

Other Issues
- Congestion price management
- Reliability commitment
- Topology changes
View Assumptions from New Perspective

Reliability always first priority?

Not a firm resource?

Load not sensitive to system needs?

Undifferentiated level of service?

Fixed decision process?

Not dispatchable?

Fixed operating rules?

Fixed resource limits?
How to Attack the Problem?
Mk-48 torpedo attack on HMAS Torrens, a decommissioned Australian destroyer (http://telstarlogistics.typepad.com)
Institutional Factors (Markets, Regs, Policies, Standards)

Institutional factors present the biggest barriers.

- Stake-holder process is difficult
- Even with bigger pie, there are winners and losers
- Change is HARD!

As an engineer, how to help?

- Make it easier for decision makers: Quantify impacts
  - Analysis of costs and benefits must be rigorous and defendable
  - Everyone has an opinion: Don’t let the discussion become subjective
- Find and define the “unknown unknowns”
  - Lots of scenarios, lots of analysis
Traditional Relationships Between Planning and Ops

- Decades
  - Capacity
    - Reliable cap.
      - Maintenance
        - Inflexible ops
          - DA market
            - DA reliability
              - Intra-day UC
                - AS allocation
                  - RT market
                    - AGC
                      - Actuals
New Relationships Between Planning and Ops

- Decades: Capacity
- Years: Reliable cap.
- Months: Maintenance
- Weeks: Inflexible ops
- Days: DA market
- Hours: DA reliability
- Minutes: Intra-day UC
- Seconds: AS allocation, RT market, AGC, Actuals
Rolling Horizon Modeling in PSO

Horizon 1 minimizes costs for decision periods

Horizon 2 minimizes costs for decision periods

Horizon 3 minimizes costs for decision periods

Horizon 4 minimizes costs for decision periods

“non-recourse” decisions = final
“recourse” decisions = provisional

Applicable to intra-day operations, day-ahead unit commitment or multi-year capacity expansion
Use of decision cycles is essential for proper modeling of variable generation, storage and distributed energy resources. Example configuration:

Day-ahead hourly modeling

Intra-day sub-hourly modeling

Hour-ahead cycle, 15 min time step

Real-time cycle, 5 min time step

Flexible set-up, easy to add or remove cycles (USER DEFINED)
Flexible designation of decision variables as “final” vs. “provisional” between cycles
Rich data structures to model how information changes from cycle to cycle
Agenda

Motivation
• Need for operational simulation

Operational simulation demo
• Demo of operational impacts in 5-bus multi-cycle simulation

PSO key and unique features
• Functional models
• ENELYTIX services

Next Steps
• PSCo goals
• EnerNex proposal
Uncertain area load (other uncertainty ignored)
Units committed in different decision cycles: DA, HA and RT
Dispatch targets established in RT except for regulating unit
Reserves procured DA; requirements reduced in later cycles
1-Cycle Results (INPUTS)

Live Demo
1-Cycle Results
2-Cycle Results

Live Demo
4-Cycle Results

Live Demo
4-Cycle With Dispatchable Wind (INPUTS)
4-Cycle With Dispatchable Wind
4-Cycle With Fixed Wind
4-Cycle With Forced Outages
1-Cycle With Battery Storage
Contact

Russ Philbrick

_Polaris Systems Optimization, Inc._

Russ.Philbrick@psopt.com

(206) 409-7130

http://www.psopt.com