Stochastic Optimization for Reservoir Optimization Using Streamflow Forecasts

Jery R. Stedinger

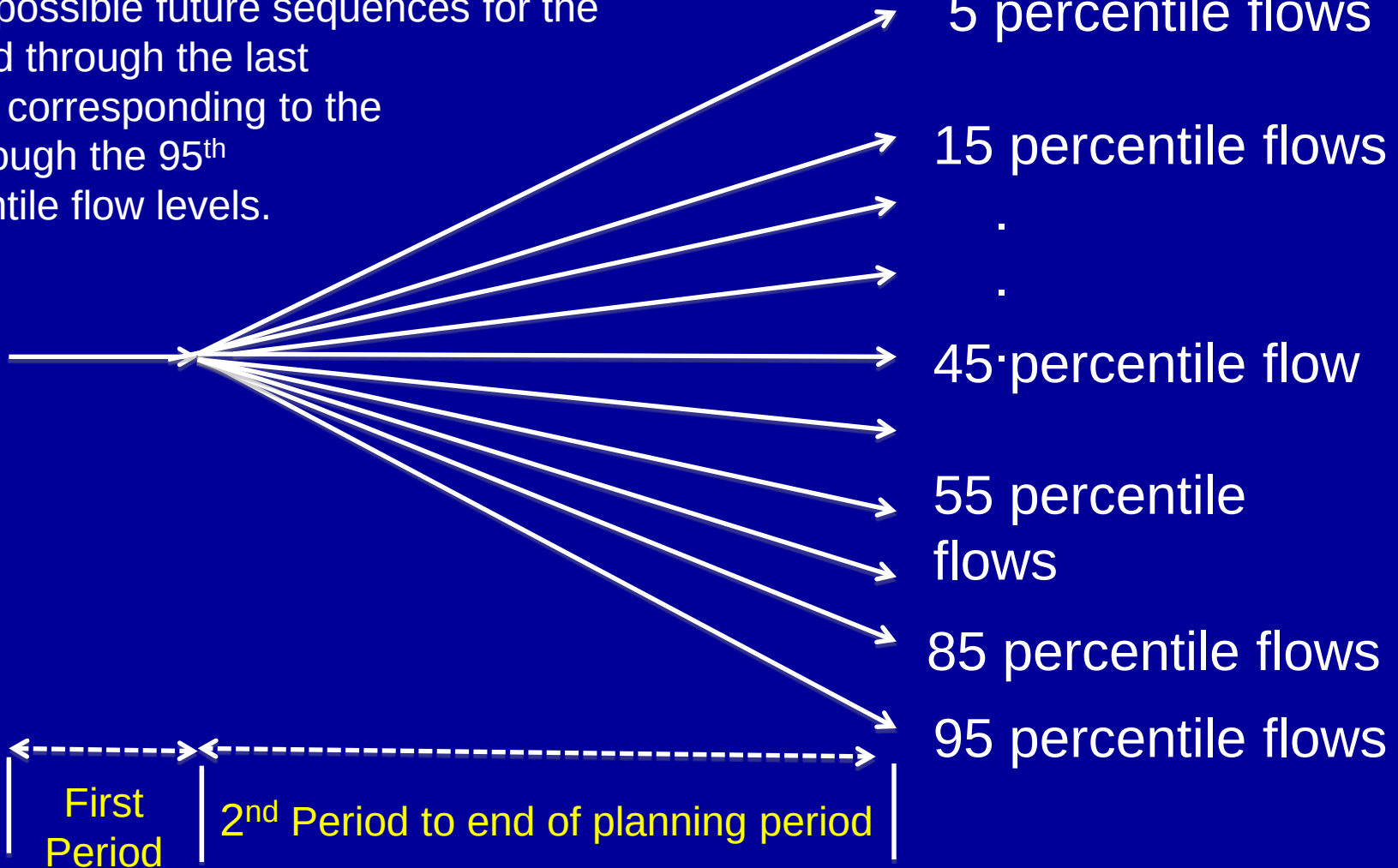
Civil & Environmental Engineering

Cornell University, UNITED STATES

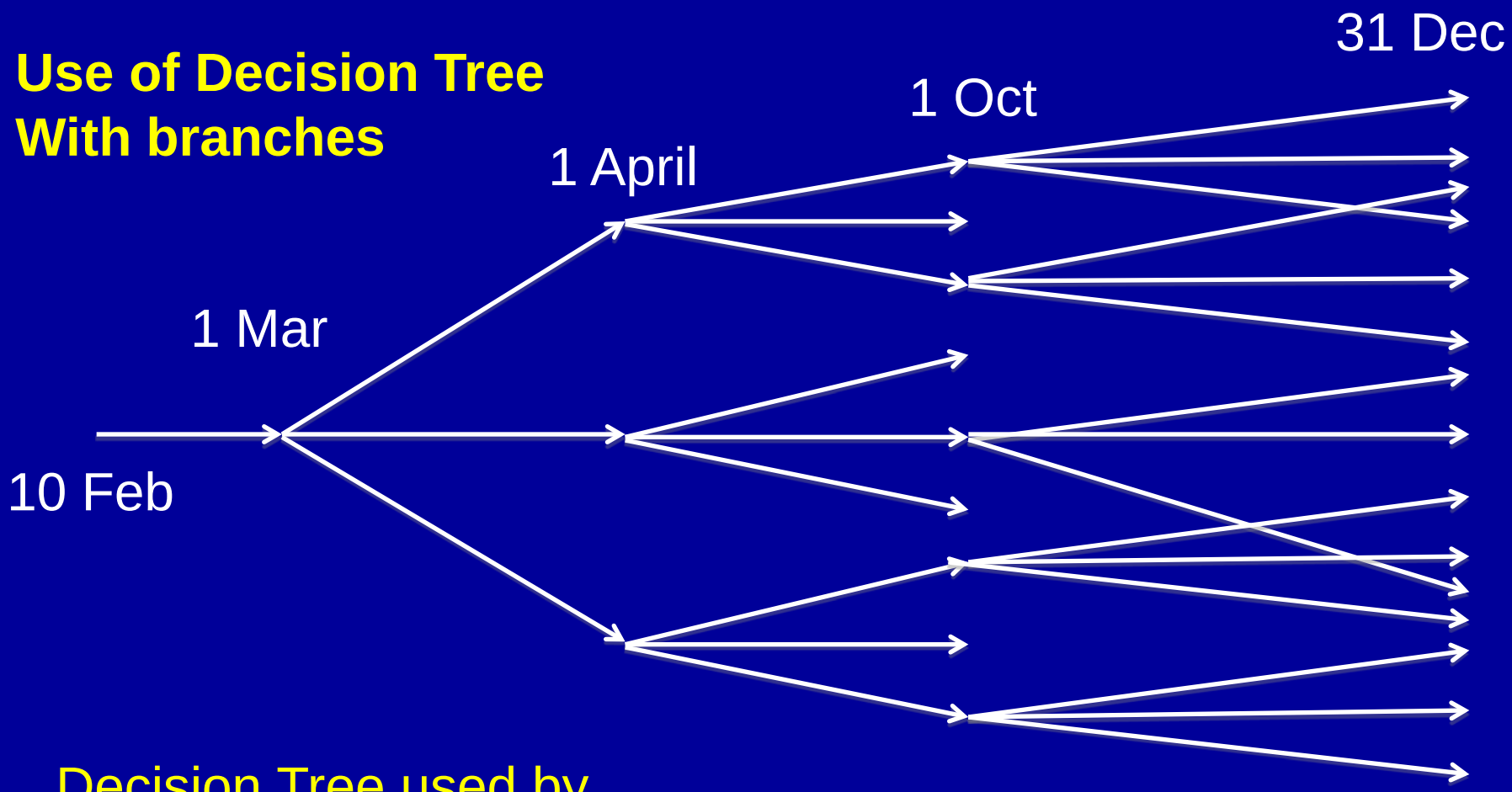
with help from Sharon Johnson,

Alberto Tejada, Beth Faber, & Jon Lamontagne

Charles Howard -- Current and future hydrology is represented by a single flow in the first period, followed by 10 possible future sequences for the second through the last period corresponding to the 5th through the 95th percentile flow levels.



Use of Decision Tree
With branches



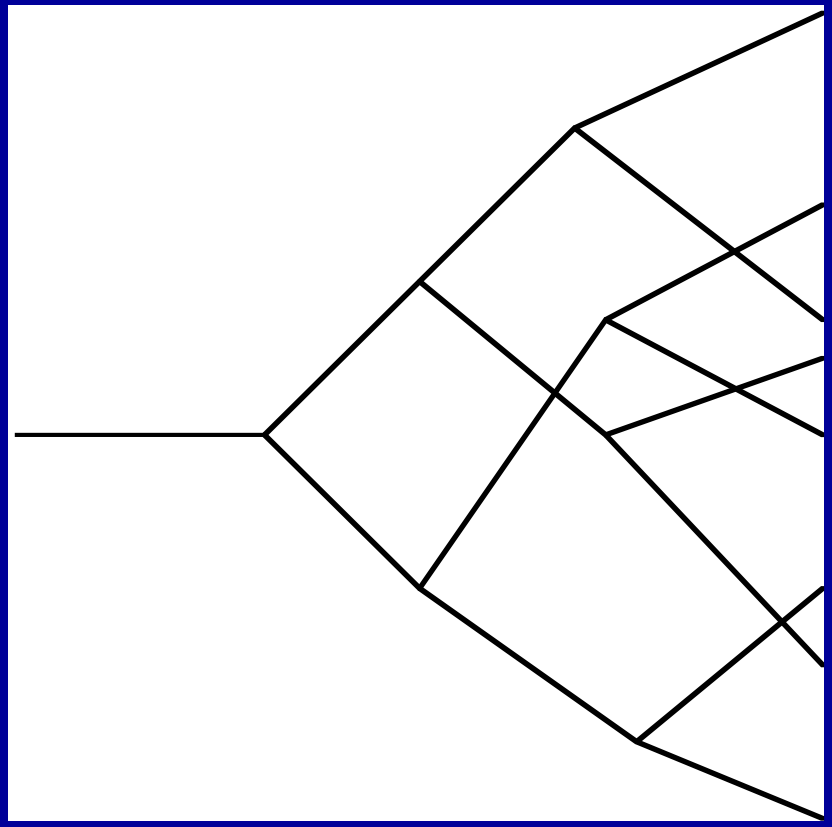
Decision Tree used by
PG&E to plan hydropower
Generation during spring snow-melt period
(Jacobs et al.1995)

Math Programming, Trees and Benders Dual DP

Use a multi-stage tree with 2 branch per node.

Randomly generated two flows at each nodes at each iteration.

Generates piecewise linear approximation to future value function at state-space points visited by forward simulation. Pereira & Pinto(1985)



Benders Dual DP

- Multi-stage model used successfully with Brazilian hydrosystem system,

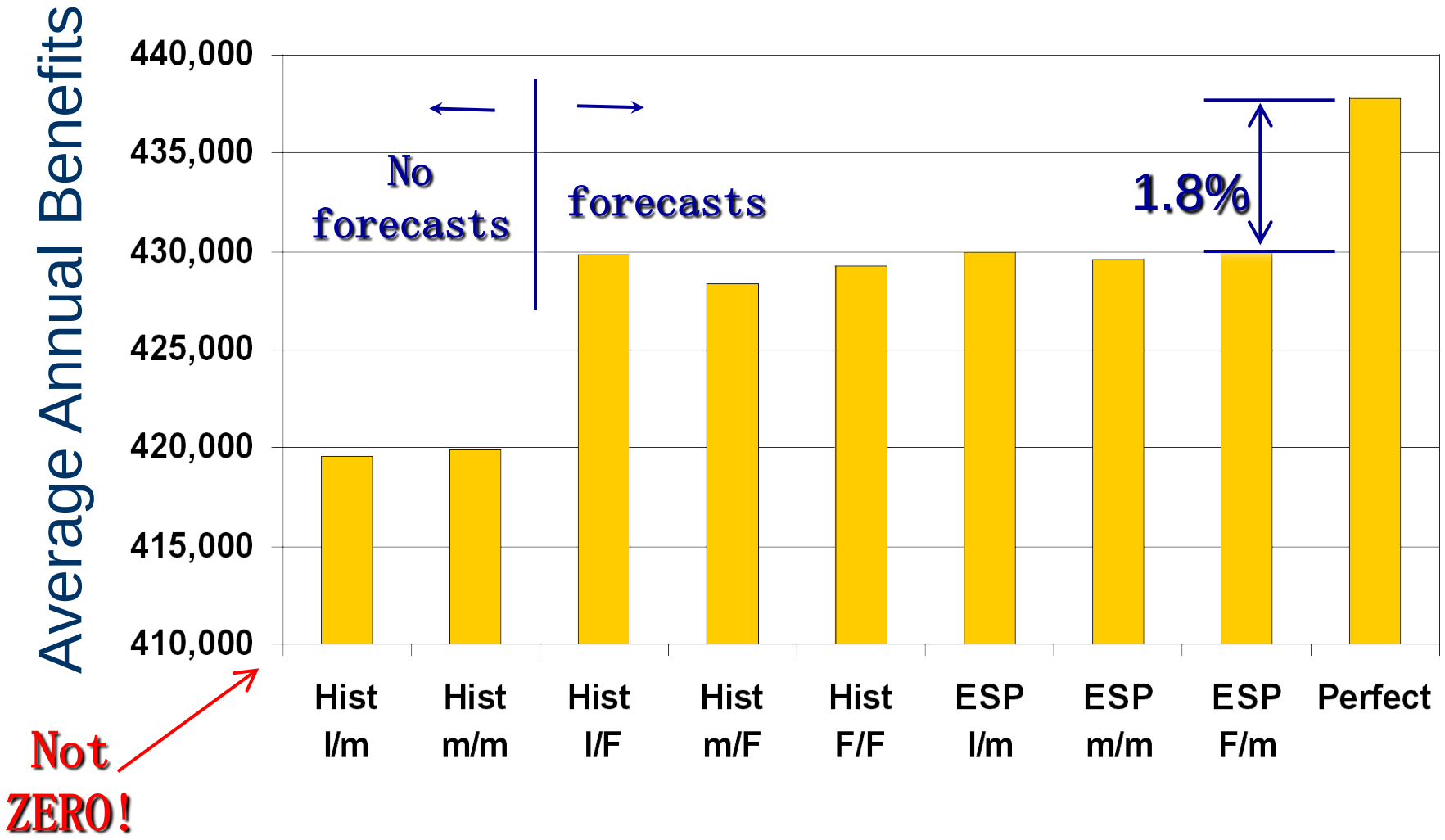
  20+ reservoirs
- Bender's Decomposition optimizes system operations.
- Iteratively work forward to generate solutions, and backwards to generate cuts defining value function.

Pereira & Pinto (1985)

Forecasting

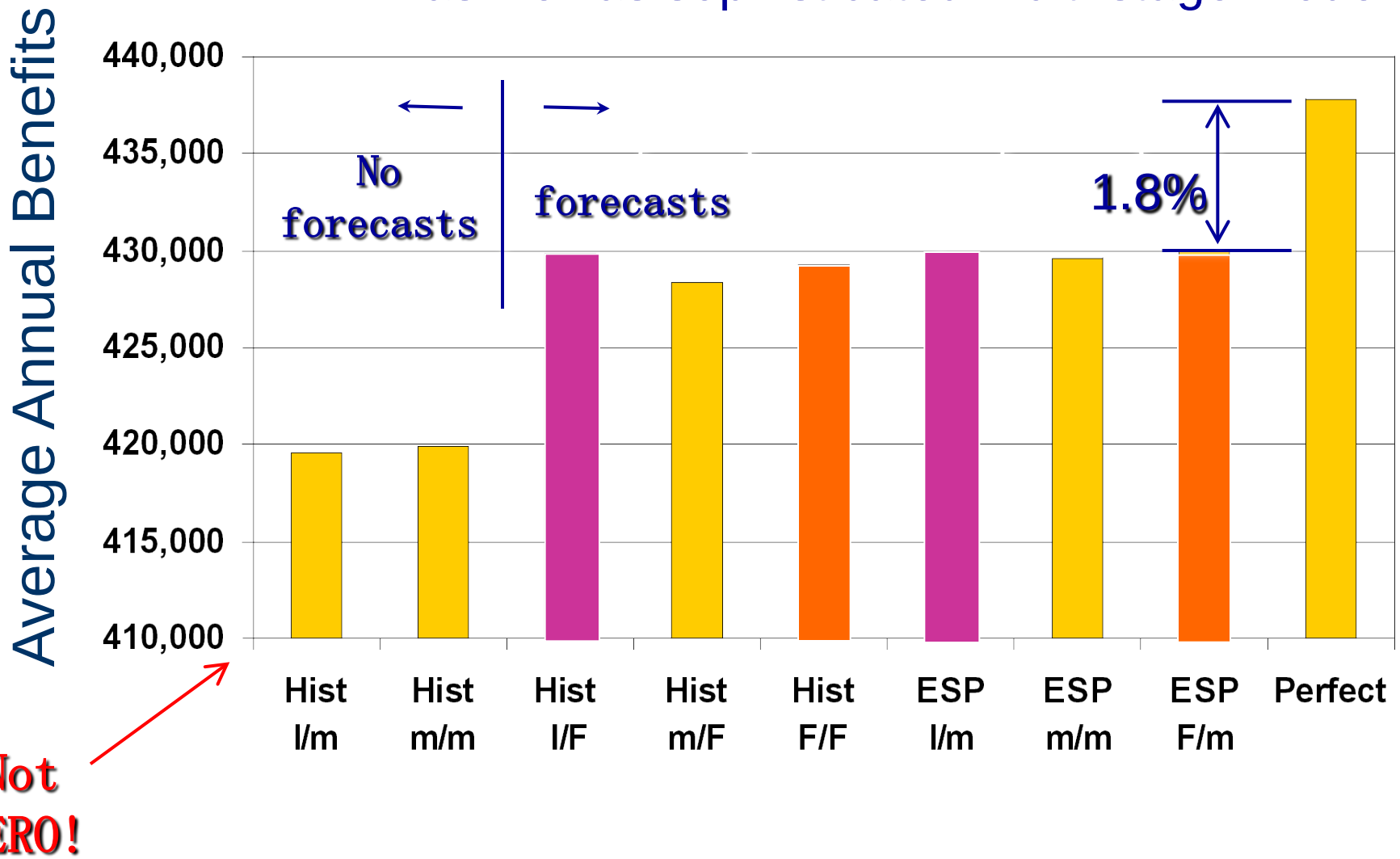
- Uncertainty is real.
- Uncertainty can be complex
  with spatial-temporal relationships among many streamflows, forecasts, snow, etc.
- Uncertainty is often important

Realistic Demand, Prices and Penalties

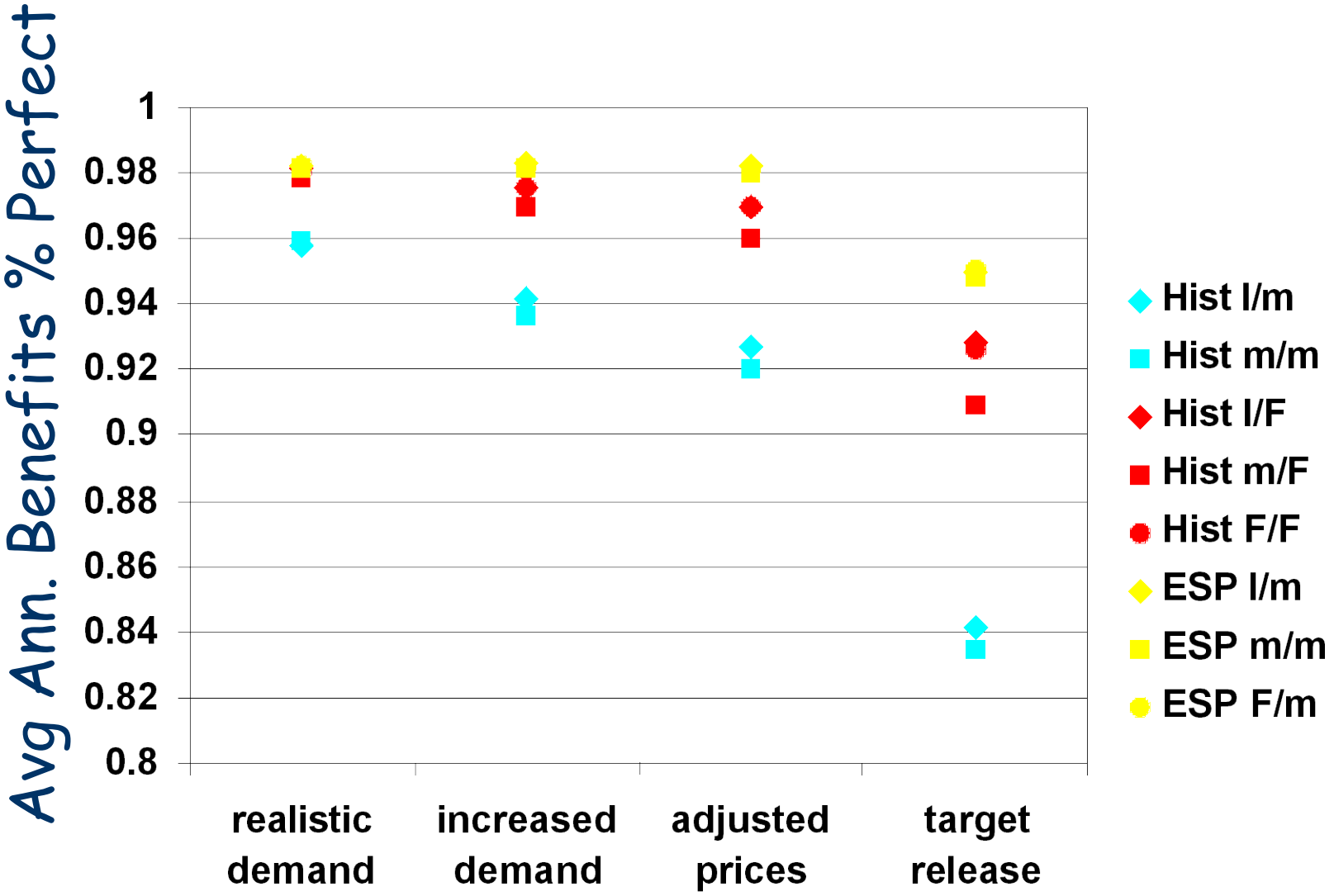


Realistic Demand, Prices and Penalties

Just first-stage stochastic optimization did as well as sophisticated multi-stage model!



Simulation with “Challenges”



Guardrails

When driving leave a safety margin depending on terrain.

Discussion?

— Modeling Strategies —

- Why not SDP/SSDP – computational capability has increased a million fold since concluded too computationally intensive. And we are smarter. SDP-SSDP attractive for systems of modest dimension.
- Will SSDP give me better operating decisions?
  - Better than deterministic
  - Simple models (Benders-branching) may be able to do as well
  - Can have confidence it is close to best possible
- How do we make SDP-SSDP work better?
  - Pick appropriate time step for decisions and for simulation
  - Pick storage units to reflect needed spatial scale of system
  - Select traces so as to model extremes of importance
  - Use good guess of initial value function to avoid wasting time
    - Use old solution
    - Neglect hydrologic state variable or start with longer time steps
    - Use heuristic approximation of future value function: water to energy?
  - Use higher order interpolation scheme (splines, polynomials etc.)