#### Managing tails begins with planning

- ... outcomes depend on operations
- ... operations depend on planning
- ... planning depends on simulations of future outcomes



# Managing tails begins with planning

- ... outcomes depend on operations
- ... operations depend on planning
- ... planning depends on simulations of future outcomes



#### This impacts all planning processes

- Transmission expansion
- Generation expansion
- Asset valuation
- Resource adequacy
- Maintenance scheduling
- Production-cost modeling

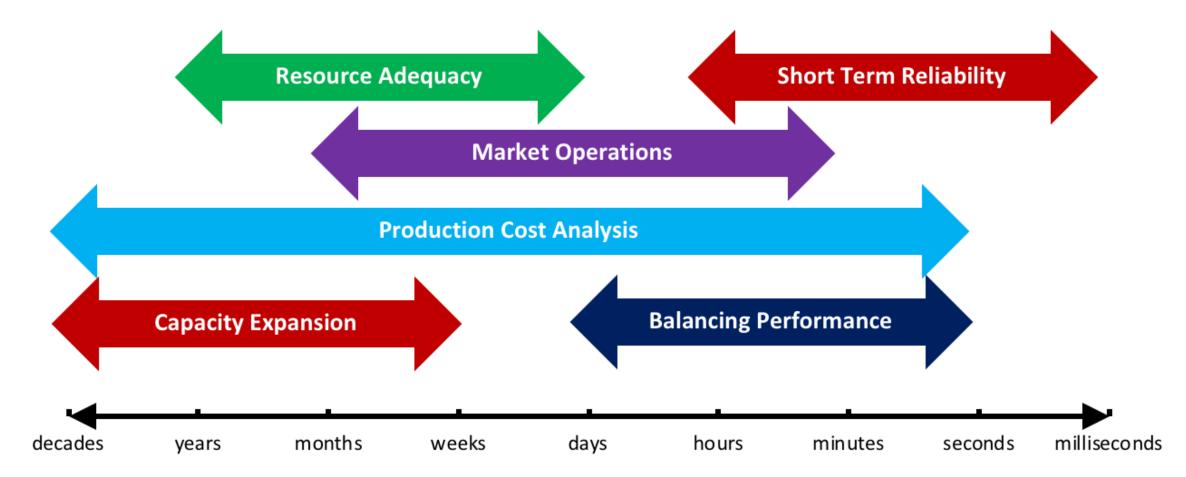
- Market Design
- "Week-ahead" scheduling
- Day-ahead scheduling
- Reliability scheduling
- Real-time scheduling

# ... so why did we develop PSO ?

- Challenges of renewable integration
  - Missing reliability and economic impacts in planning studies
  - Difficult to evaluate new resources and sources of flexibility
  - Difficult to evaluate impact of changing policies (e.g., reliability, incentives)
  - Need to quantify value of flexibility, better forecasts, new policies
- Goals for PSO development
  - Simulation of future markets and utility operations
  - Support effective use of distribution resources
  - Flexible modeling: we don't know what future capabilities look like
  - Flexible deployment: we don't know how problems will be solved

#### Renewable integration impacts all processes

• Coordination and evaluation of resources across all time frames



# Question 1: What are exciting new feature of PSO?

- Growth of PSO capabilities has grown in parallel with ESIG
- Ability to broadly optimize and co-optimize new and existing resources across all time frames (CX, RA, PCM, AGC)
  - Transmission (nodal and zonal)
  - Energy storage (including impacts of efficiency and endurance)
  - Fuel networks and storage
  - Emissions
  - Power-to-fuel (e.g., electrolyzers)
  - Fuel-to-fuel (e.g., hydrogen to ammonia)
  - Nationwide down to distribution level, configurable to user needs

# **Question 2: Exciting case studies**

- Capacity expansion with co-optimized transmission and generation
- Capacity expansion of battery storage and impacts of efficiency and endurance
- Capacity expansion of hydrogen economy for seasonal energy storage
- Operational resource adequacy
- Multi-interconnection models: EI and WECC
- Stochastic modeling