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HYDRO-ECONOMICS TRADEOFF SURFACES TO GUIDE UNIT COMMITMENT IN PRODUCTION COST MODELS

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04/28/2021
Chicago, IL

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PRODUCTION COST MODELS (PCM) FOR POWER SYSTEMS

- Based on an optimization model
- Identify an optimal production schedule of several power plants simultaneously
- To minimize a total **production cost**
- Subject to a set of constraints (e.g. power plant maximum/minimum production capacity, maximum ramp-up/ramp-down)

$$Min \; z = \sum_{g,t} c_g P_{g,t} + c'_g u_{g,t}$$

$$s.t.$$

$$\sum_g P_{g,t} = d_t$$

$$u_{g,t} \underline{P_g} \leq P_{g,t} \leq u_{g,t} \overline{P_g}$$

$$-\underline{P_g^r} \leq P_{g,t} - P_{g,t-1} \leq \overline{P_g^r}$$

$$u_{g,t} \in \{0,1\}$$

$$...$$

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HYDRO SCHEDULING TOOLS (HST)

$$P_t = \eta \cdot \rho \cdot g \cdot Q_t \cdot H_t$$
$$H_t = f(V_t)$$
$$V_{t+1} = V_t - Q_t + I_t$$

$$Q_t \geq Q_{min}$$
$$-M \leq Q_t - Q_{t+\Delta t} \leq M,$$
$$0 \leq \Delta t \leq 24$$

- Power production depends on:
  - Physical constraints:
    - Turbine efficiency η
    - Hydraulic head H
    - Water release Q
  - Environmental constraints:
    - Minimum release rate
    - Maximum 24-hr release change
    - …

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MODEL ADEQUACY

Model	PCM	HST
Spatial scope	Potentially large power systems	Limited to a small fleet of hydropower plants (HPPs)
Flexibility of HPP generation	Very flexible	Limited by physical and environmental constraints
Representation of physical water constraints	Limited	Detailed
Representation of environmental constraints	Limited	Detailed

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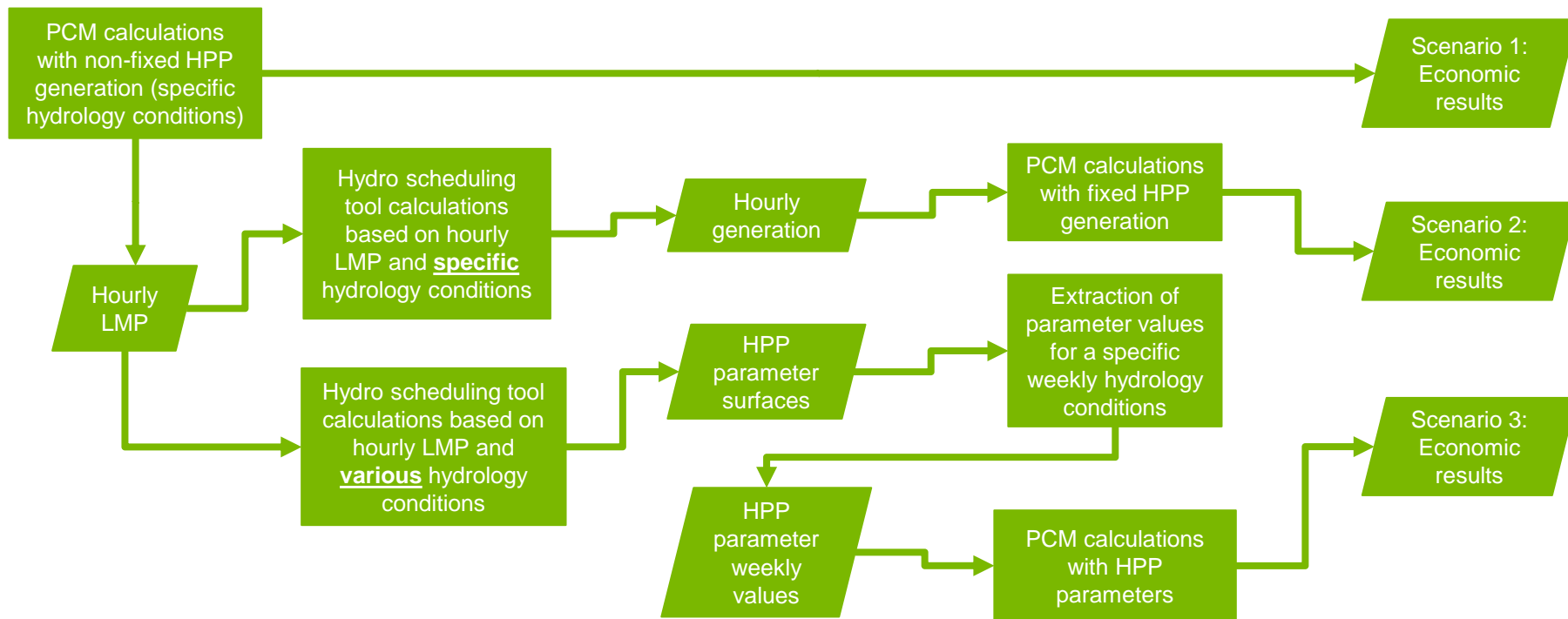
RESEARCH OBJECTIVES

- Assess the discrepancy in hydropower representation between conventional PCMs and hydro scheduling tools

- Propose a new method to account for hydrological and environmental aspects in PCMs by using parameter surfaces derived from hydro scheduling tool results

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PROPOSED ANALYSIS

Scenarios to compare

- Scenario 1: HPP generation and economic results are calculated solely with the PCM

- Scenario 2: Locational marginal prices (LMPs) are first calculated with PCM. LMPs are used by the HST as HPP generation drivers.
  Finally, HPP generation from the HST are used as fixed generation by the PCM in order to calculate economic results.

- Scenario 3: Locational marginal prices (LMPs) are first calculated with PCM. LMPs are used by the HST as HPP generation drivers for multiple hydrology conditions: water releases and forebay elevations. This is used to generate surfaces (i.e. bivariate functions) for various HPP parameters: P_min, P_max, Generation, Ramp_min, Ramp_max.
  These surfaces are used to deduce weekly parameter values for specific hydrology conditions.
  These weekly parameter values are then used by the PCM to refine its economic results

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PROPOSED ANALYSIS

PCM calculations with non-fixed HPP generation (specific hydrology conditions)

Scenario 1: Economic results

Hourly LMP

Hydro scheduling tool calculations based on hourly LMP and **specific** hydrology conditions

Hourly generation

PCM calculations with fixed HPP generation

Scenario 2: Economic results

Hydro scheduling tool calculations based on hourly LMP and **various** hydrology conditions

HPP parameter surfaces

Extraction of parameter values for a specific weekly hydrology conditions

Scenario 3: Economic results

HPP parameter weekly values

PCM calculations with HPP parameters

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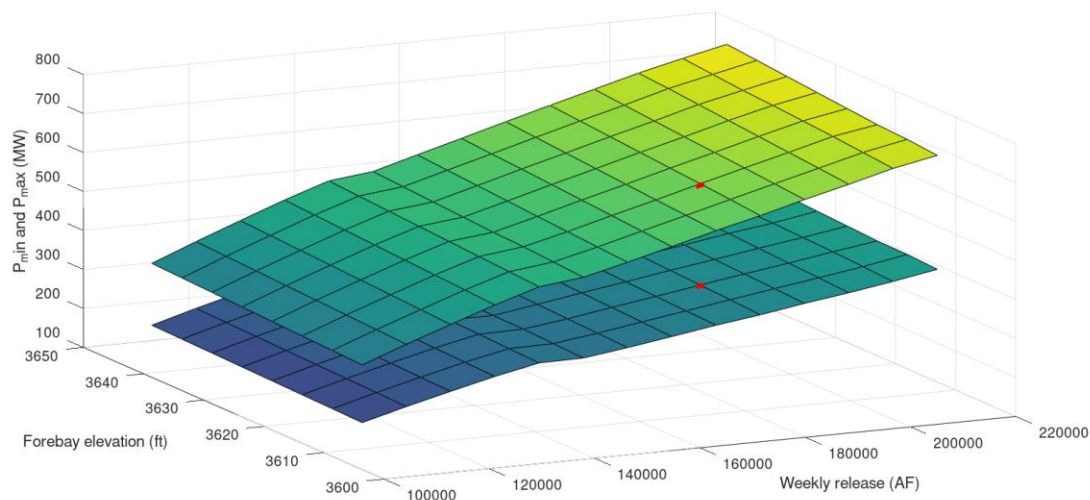# PROPOSED ANALYSIS

Hydro-economics surfaces

- The two surfaces represent the values for minimum and maximum power output (P_min and P_max) depending on the weekly water release and forebay elevation

- The two red dots represent the extracted P_min and P_max values for specific hydrology conditions

P_min and P_max surfaces at Glen Canyon Dam during a given week

THANK YOU

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