

Report 9: Task G6-1, 10/15/2025.

Task G6-1 — Extend ACEP/FHS to account for frequency stability (this quarter)

Context (last quarter)

Last quarter we prepared the formulation to:

- represent synchronous inertia by technology,
- add synthetic inertia decision variables for IBRs (wind/solar/storage) tied to headroom/curtailment,
- derive a minimum inertia target from an RLPC (largest contingency) and a RoCoF limit, and
- test with a 3,209 MW RLPC contingency (Eastern Interconnection).

This quarter moves from **formulation** to **implementation & validation**.

What changed this quarter (deeper detail)

1. Inputs finalized and loaded (Excel → GDX), RLPC/RoCoF-based target.

- **Techs:** InertiaConstant_s for synchronous technologies (seconds on machine base).
- **Params:** HeadroomCost, CurtailmentCost (to avoid the model preferring wind/solar curtailment over maintaining storage headroom); .
- **RLPC_RoCoF (new sheet):** Year, Region, RLPC_DeltaP_MW, RoCoF_Limit_Hz/s.
- **In-model computation of target** (broadcast to all blocks in that Year/Region):

$$\text{MinInertia}_{y,region} [\text{MW}\cdot\text{s}] = \frac{\text{RLPC_DeltaP_MW}_{y,region}}{2\pi f_0 \cdot \text{RoCoF_Limit_Hz/s}_{y,region}}$$

We do not index the target by season/block; variation over blocks happens naturally on the LHS via dispatch, headroom, and curtailment.

2. Constraint block enabled (now active in runs).

- **Adequacy screen (high level):**

Synchronous inertia + Synthetic inertia ≥ **MinInertia(Year, Region)** (applied each block).

- **Synchronous component:** sum over committed synchronous units of (*inertia constant*) × (*machine base capacity*); units consistent with the target (MW·s or GW·s as chosen).

- **Synthetic component:** decision variables for IBRs/ESS are capped by available headroom/curtailment and any technology cap (e.g., k_{syn}); prevents double-counting with reserves/energy limits.
- **Costs:** HeadroomCost and CurtailmentCost retained from last quarter to ensure sensible trade-offs.

3. Run execution & first look.

- ACEP executes with the inertia constraint **on**; capacity allocation reflects the RLPC/RoCoF target.
- Systematic validation of results.

Model detail

- **Synchronous inertia (accounting):**

Synchronous inertia: Sum over online synchronous units of (inertia seconds \times MW rating) \rightarrow MW·s.

$$M_{\text{sync}}_{y,\text{region},bk} = \sum_{g \in \text{sync}} H_g [\text{s}] \times S_g [\text{MW}] \times \text{Commit}_{g,y,\text{region},bk}$$

- **Synthetic inertia (availability-linked):**

Synthetic inertia: For each IBR group, available inertia is limited by headroom/curtailment \times a tech seconds factor and by a tech cap; we take the smaller.

For each IBR group r :

$$M_{\text{syn}}_{y,\text{region},bk,r} \leq k_{\text{syn},r} \text{Headroom}_{r,y,\text{region},bk} \text{ and } M_{\text{syn}}_{y,\text{region},bk,r} \leq \text{TechCap}_r$$

- **Adequacy screen:**

$$M_{\text{sync}} + \sum_r M_{\text{syn}}_r \geq \text{MinInertia}_{y,\text{region}} \text{ (applied to every block } bk \text{)}$$

- **No double counting:** synthetic inertia cannot exceed energy/headroom or curtailment limits in dispatch/reserves.

(Representative labels used in code: $M_{\text{sync}}(y,\text{region},bk)$, $M_{\text{syn}}(y,\text{region},bk,r)$, $EQ_MININERTIA(y,\text{region},bk)$, with cap/linkage equations like EQ_SYN_CAP and EQ_SYN_LINK .)

Preliminary observation: in a few periods the model leaned on wind/solar curtailment where storage headroom was tight but low-cost; this may be data-driven, but I'm verifying whether it's (a) correct given inputs or (b) an indexing/reporting artifact.

Plans for next quarter

1. Complete validation and finalize a one-page spec + input template.
2. Summarize binding conditions (where/when the inertia constraint binds) on at least one PIE vision run—starting with Low-Carbon.
3. Provide a short toggle guide for running ACEP with/without the inertia block and propagate across all five visions.

Variance from plan

- **No scope change.**