MITHRA · ENGINEERING NOTE

AI compute on an islanded gas site: what has to happen in the first second

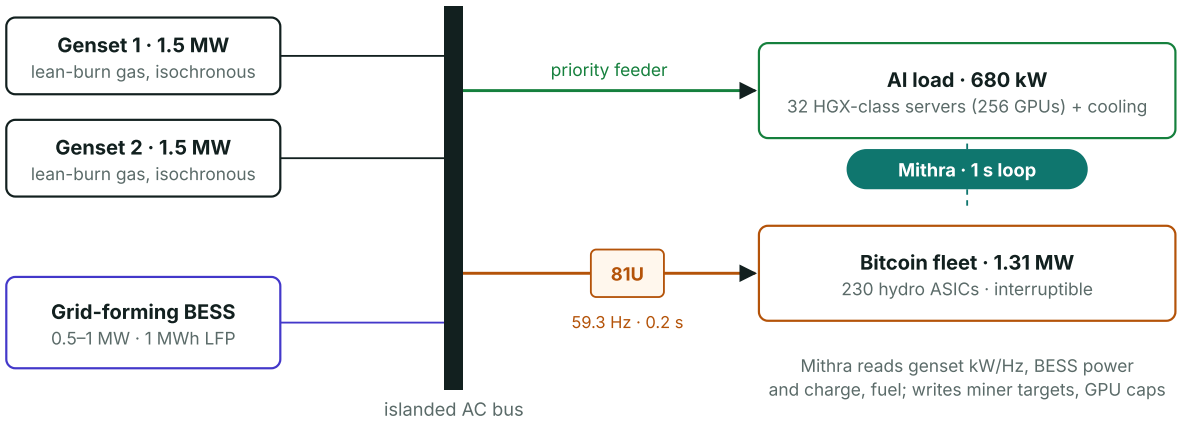
Reference site: two 1.5 MW lean-burn gas gensets with no grid. They carry 680 kW of priority AI load (256 GPUs plus cooling) and a 1.31 MW Bitcoin fleet as the interruptible load. On an island, a shortfall shows up first as bus frequency, within milliseconds, not as missing kWh. The question is which part of the control system can act inside that window.

1 **A genset trip is decided in about 0.32 s. Software curtailment cannot save the AI load.** At any API latency from 0.25 to 10 s, the bus holds above 57 Hz only with at least ~700 kW of grid-forming battery. A hard-wired under-frequency (81U) relay on the miner feeder cuts that to ~400 kW.

2 **AI training swings move the bus between 59.13 and 60.59 Hz every two seconds.** Bitcoin shedding is far too slow to help, and a tight 59.3 Hz relay nuisance-trips the whole fleet. A 500 kW battery holds 59.76–60.19 Hz.

3 **A fuel-gas sag over a minute is the supervisory layer's job, and loop design decides it.** Mithra's current open-source loop (10 s, one miner per pass) loses the bus 58.19 s into the sag. A 1 s shed-to-target loop holds 59.90–60.10 Hz with no battery at all.

Proposed architecture: two speeds, clear authority



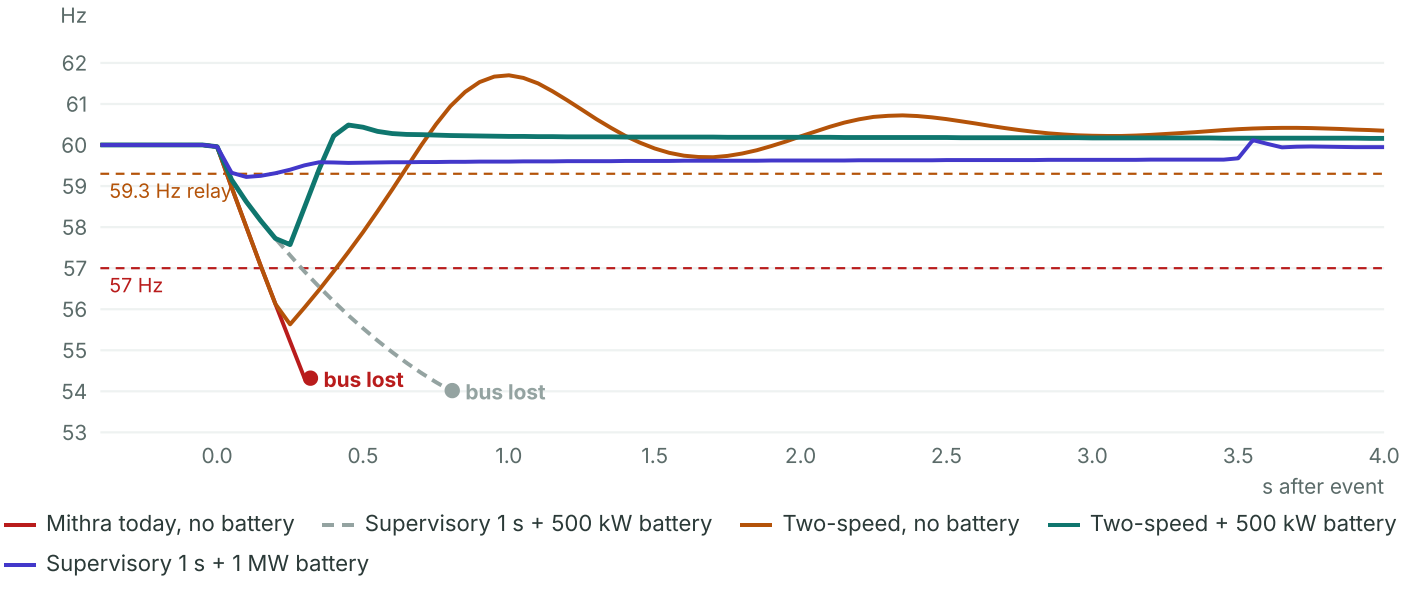
LAYER	ACTS WITHIN	OWNS	NEVER DOES
Protection + BESS hardware	20–250 ms	Grid-forming battery absorbs steps and trips. 81U relay drops the miner feeder in two stages (to limit load rejection on the surviving engine). Genset protection stays with the OEM controller.	Depend on software, network or cloud.
Mithra supervisory	1 s to minutes	Tracks fuel and engine headroom, sheds and restores miners to target, recloses the miner feeder with miners asleep, restores battery charge, caps GPU power ahead of known swings.	Act as the only safety function. It degrades to "hold, then shed" on stale data.

Ali Emadi · CEO.Gatekeeper@outlook.com · 1/3

EVENT 1 · GENSET TRIP

Losing one of two engines

At t = 0 genset 2 trips. Genset 1 was at 993 kW and now faces 1,985 kW against a 1,500 kW rating. Frequency falls at 19.9 Hz/s, faster than any network command can complete.



ARCHITECTURE (MINER API LATENCY 3 S)	NO BATTERY	500 KW BATTERY	1,000 KW BATTERY
Mithra today (10 s loop, one miner per loop)	**Lost at 0.32 s**	**Lost at 0.81 s**	**59.22 Hz, then battery-only***
Supervisory only (1 s loop, shed to target)	**Lost at 0.32 s**	**Lost at 0.81 s**	**Rides through, nadir 59.22 Hz**
Two-speed (81U relay on miner feeder + 1 s Mithra)	**Rides through, nadir 55.50 Hz**	**Rides through, nadir 57.39 Hz**	**Rides through, nadir 59.22 Hz**

* Battery-only: see the finding below. "Lost" means genset under-frequency protection operates (below 54 Hz, or below 57 Hz for more than 2 s).

Battery needed vs miner release latency

MINER API LATENCY	0.25 S	1 S	3 S	10 S
Supervisory only	700 kW	700 kW	700 kW	700 kW
With 81U relay	400 kW	400 kW	400 kW	400 kW

Minimum grid-forming battery power for a nadir at or above 57 Hz, in 25 kW steps. Latency barely matters: the first 300 ms decide survival, and no software path acts inside them.

Finding: frequency-only shedding goes blind behind a battery

With a 1 MW battery, Mithra's current rule (shed below 59 Hz) never fires. The battery holds the bus at 59.76 Hz while discharging 485 kW, the miners keep running, and the battery is empty in about 61 minutes. Then the bus goes. The supervisory loop must read engine headroom and battery power or charge, not just frequency.

EVENTS 2 AND 3 · AI LOAD SWINGS AND FUEL-GAS SAG

Battery for the swings, Mithra for the sags

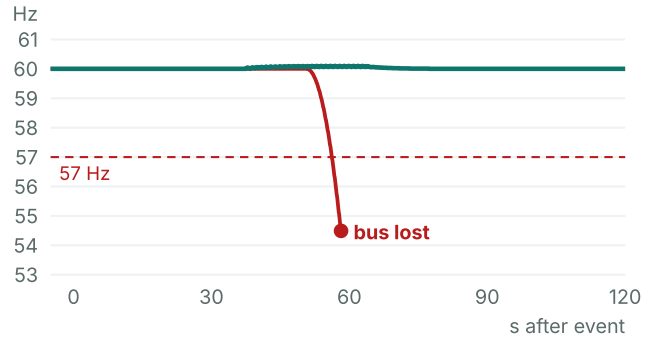
AI training swings: 30 % ↔ 100 % of 480 kW



No battery — 500 kW battery

Synchronous training steps make the GPU block switch about 340 kW in milliseconds. Lean-burn engines answer in seconds, so the bus swings 59.13–60.59 Hz on every step. With a 59.3 Hz relay fitted, the dips nuisance-trip the miner feeder (peak 62.39 Hz after the dump). The battery, or GPU power smoothing, has to come first.

Fuel-gas sag: 3.0 → 1.8 MW available over 60 s



Mithra today (10 s loop) — Mithra 1 s shed-to-target

A separator slug or a compressor upset cuts fuel pressure, so available engine output falls by 20 kW/s. One miner (5.7 kW) per 10 s pass cannot keep up. The engines hit their limit and the bus is lost 58.19 s into the sag. A 1 s loop that sheds straight to a headroom target rides it out at 59.90–60.10 Hz with no battery. This is the layer Mithra is built for.

Design requirements this replay implies

- **Battery:** a grid-forming inverter sized to the largest credible step: about half of one genset's rating with a staged 81U relay, or about the full deficit without one. A grid-following battery does not help here.
- **Miner feeder:** a two-stage 81U relay, set below the worst AI-swing dip with the battery in service, and blocked from auto-reclose until Mithra confirms the miners are asleep.
- **Mithra loop:** 1 s or faster. Shed to a target based on engine headroom, fuel pressure and battery power/charge, not one miner per pass on frequency alone. Restore at the engine's load-acceptance rate.
- **GPU side:** power capping or smoothing on the training cluster, coordinated with Mithra before job starts and checkpoints.

Limits of this model, and what a real site replay needs

Aggregate swing equation with isochronous PI governors (0.6 s engine lag, 25 %/s ramp on new load, turbo memory, anti-windup). It is tuned so a 25 % load step dips about 6.6 % and recovers in about 5 s, and a 45 % rejection overshoots about 6.3 %. Inertia H = 1.0 s per set, which is generous: real recips are often lower, and that makes every result worse. Constant-power loads; voltage, reactive power, load-sharing error and power-supply ride-through are not modelled. This is not a calibrated plant model.

MEASUREMENT	WHY IT MATTERS
Bus Hz and per-genset kW, 20–100 ms	Calibrates inertia, governor lag and load acceptance
Curtail commands vs miner feeder meter	The real command-to-release latency of the fleet
Genset protection and any 81U settings	Defines what "bus lost" means at that site
Fuel pressure; GPU cluster power at ≥10 Hz	Rate and depth of real gas sags and AI swings