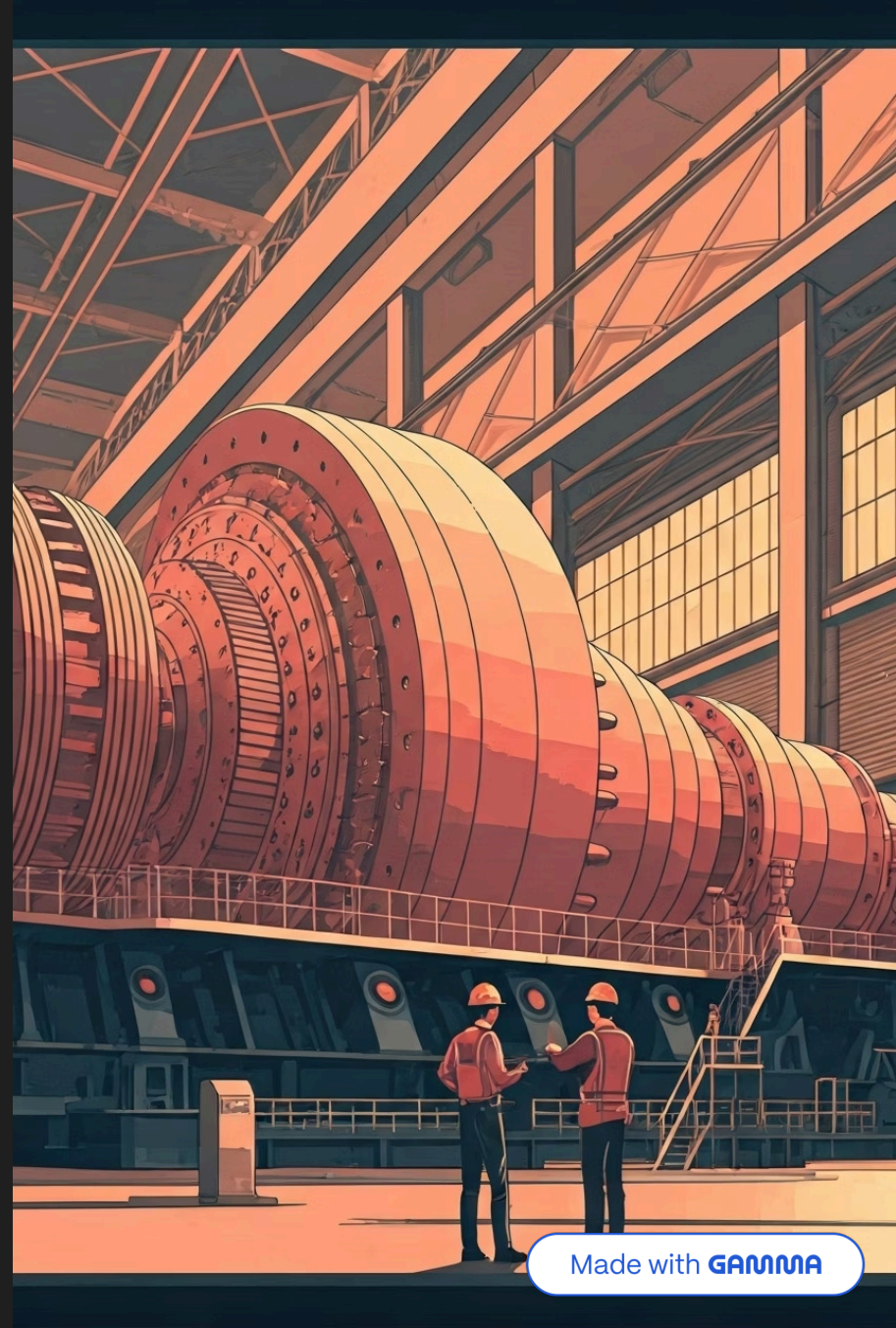
TwinScroll Grid Balancer (TSGB)

A Safe-by-Design Mechanical Inertia Anchor for Post-Inverter Grids

The TSGB is a revolutionary solution to the critical challenge of grid instability in renewable-dominated power systems. By providing true mechanical inertia without software mediation, it offers instantaneous grid support that inverter-based systems cannot match.



The Grid Inertia Crisis

Vanishing Inertia

As traditional generation (coal, gas, nuclear) is decommissioned, the grid has lost its natural ability to resist frequency fluctuations and voltage collapses.

Digital Limitations

Inverters require 20-100ms to detect and respond to disturbances - by then, the damage may already be done.

Increasing Instability

Modern grids experience faster RoCoF events (>1.0 Hz/s), wider voltage swings, and fragile recovery from faults.

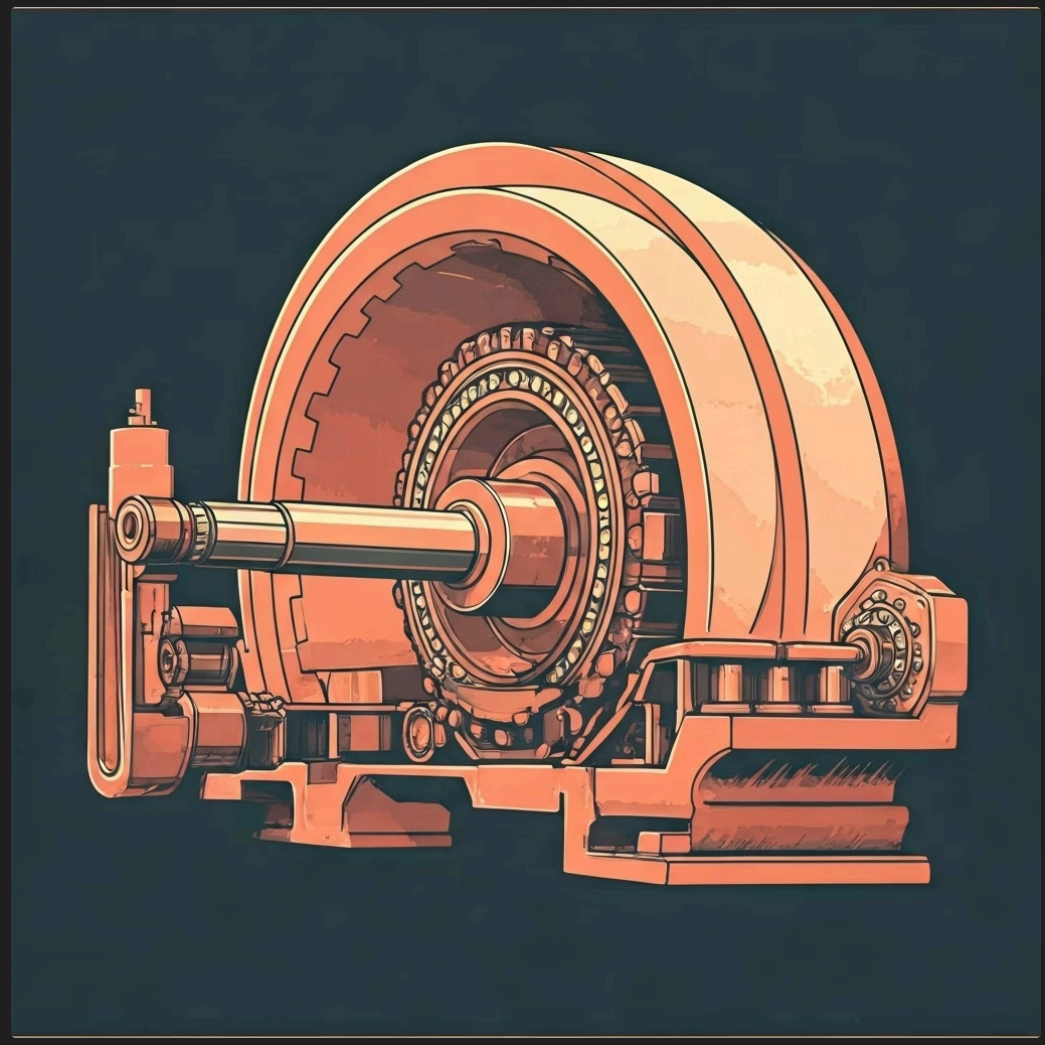
In some regions, inertia has dropped from ~6 seconds per GW to below 1.5 seconds—a catastrophic vulnerability that software alone cannot address.

TSGB: The Mechanical Solution

The TwinScroll Grid Balancer is a hybrid system combining:

- A DC-powered, fixed-speed drive
- A massive rotating mechanical mass (5,000-10,000 kg)
- A synchronous generator locked to grid frequency

Unlike batteries, inverters, or software solutions, the TSGB physically resists grid disturbances through inertia alone.



Physics Over Firmware

Inverter Response

Detect disturbance (10-50ms) → Process signal (5-10ms) → Execute command (5-20ms)

Total delay: 20-80ms minimum

TSGB Response

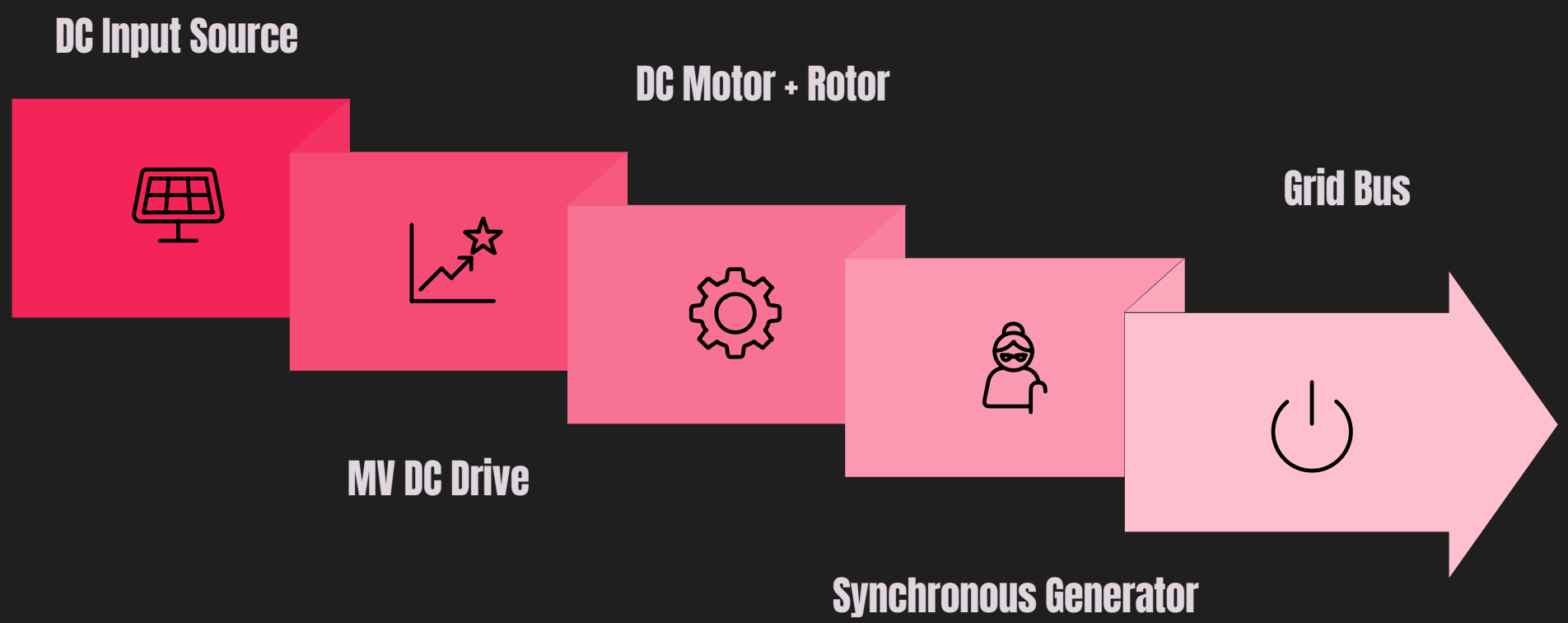
Grid slows → torque is released

Grid speeds → torque is absorbed

Response time: ZERO milliseconds

The TSGB doesn't think; it acts. Its response is not programmed—it's built into its physical structure.

Core Architecture



The TSGB integrates three primary subsystems that work together to provide instantaneous grid support without software control:

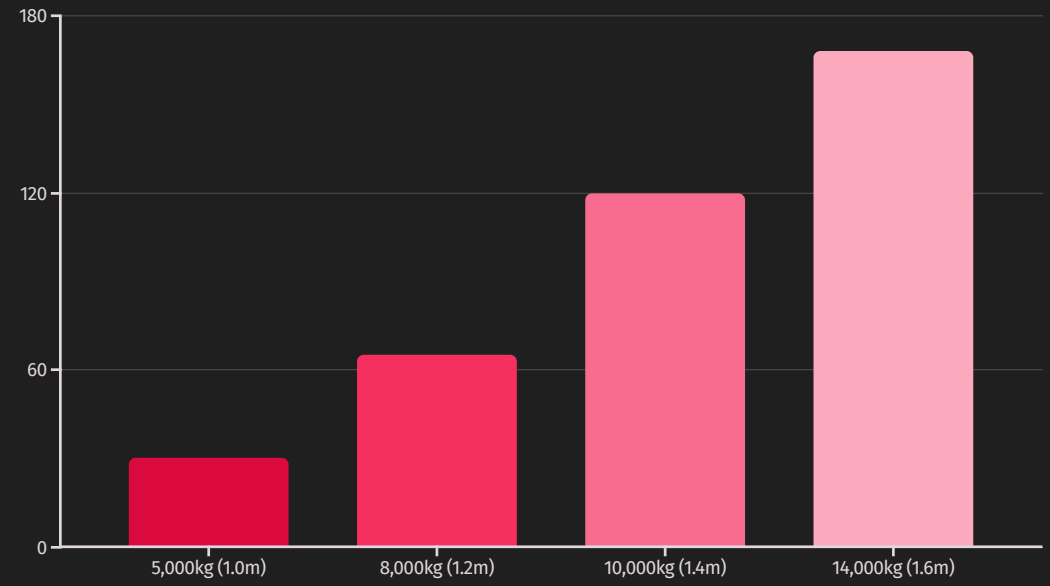
- DC Input Powertrain: Converts renewable DC power into mechanical rotation
- Rotating Inertial Core: A tuned high-mass rotor operating at 3000 RPM
- Synchronous Generator Output: Converts mechanical energy into grid-synchronous AC power

Mechanical Design Excellence

Rotor Specifications

A 10,000 kg rotor at 1.4m diameter stores approximately 120.8 MJ of kinetic energy - equivalent to 12 seconds at full rated output.

This energy is delivered smoothly, proportionally, and immediately as torque shifts between generator and grid.



All components use commercial off-the-shelf (COTS) parts from established industrial supply chains, ensuring reliability and ease of maintenance.

Software-Optional Operation

Zero Boot Time

Always online, always spinning, always ready to respond to grid events.

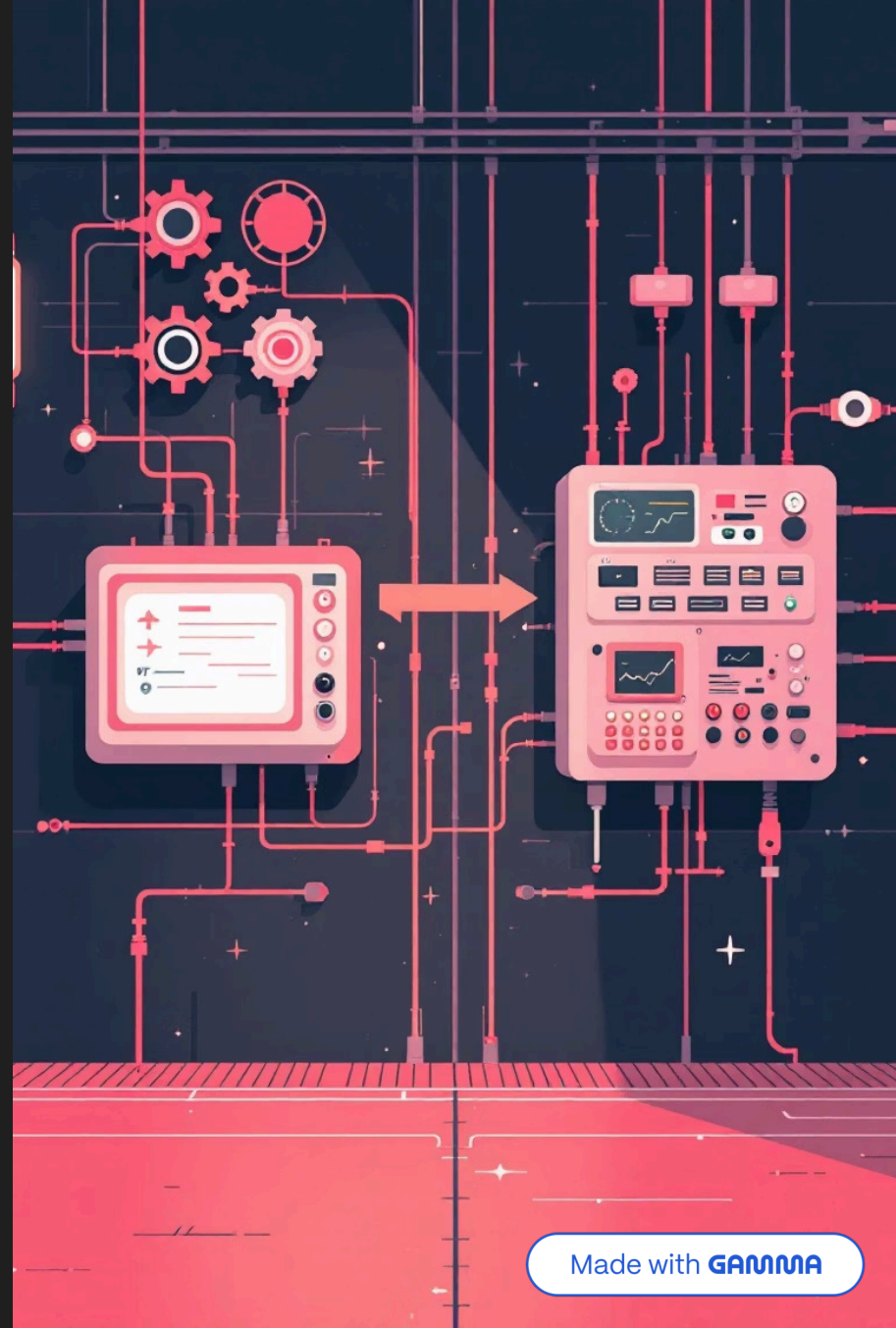
Zero Code Surface

No firmware, no operating system, no patches required for core functionality.

Zero Cyber Risk

Cannot be hacked, spoofed, or intercepted - air-gapped by design.

While digital SCADA overlays can be applied for monitoring, the core function of the TSGB remains purely physical. It transforms SCADA from a control dependency into a diagnostic lens—critical for operators but non-critical for real-time operation.



"Deadlift Mode": Revolutionary Blackstart

Autonomous Rotor Spin-Up

TSGB is fed DC from solar, HVDC, or battery source; MV Drive brings rotor to 3000 RPM with no AC source required.

Self-Excitation & Waveform Formation

Generator excitation circuit activates; rotor magnetic field induces stator voltage; terminal waveform stabilizes into clean 50 Hz sine.

Islanded Grid Formation

TSGB becomes the waveform source for local grid; inverters synchronize to TSGB signal.

Grid Reconstruction

Priority loads reconnect; multiple TSGBs synchronize; larger islands form; regional grid is reestablished.

Unlike inverters, the TSGB can restart a section of grid from zero without external power or reference signals.

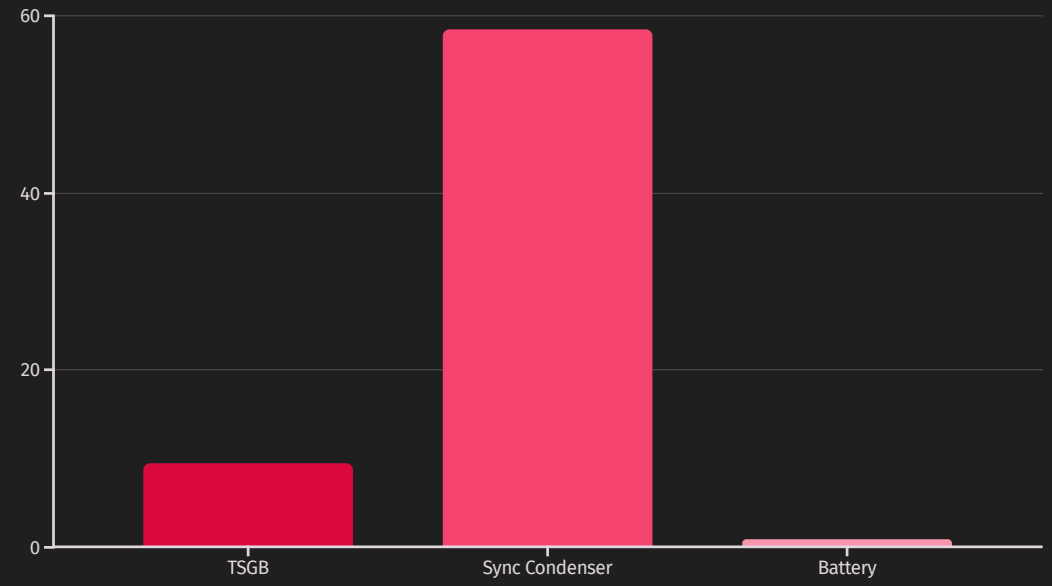
Economic Advantage

Capital Expenditure (10 MW TSGB)

- Rotor & Shaft Assembly: $420,000
- Generator & Excitation: $280,000
- MV Drive (DC-fed): $195,000
- Housing, Bearings, Frame: $90,000
- Installation + Interconnect: $115,000
- SCADA Integration: $25,000

Total: ~$1.13 million ($113,000 per MW)

Inertial Energy Comparison



Batteries provide no inertia, only delayed response.

The Future of Grid Stability

Backbone Nodes

10-50 MW units at major transmission substations and HVDC interties provide grid stiffening and frequency damping.

Anchor Nodes

1-10 MW units at renewable collector stations stabilize inverter-based resources and provide VAR support.

Emergency Response

Mobile units provide rapid deployment for disaster recovery and critical infrastructure support.

Edge Nodes

500 kW - 2 MW units in rural and weak-grid areas enable islanding and microgrid formation.

The TSGB is not just a product—it's a paradigm shift in how we approach grid stability in a renewable-dominated future. Physics beats firmware when it comes to real-time grid stability.