Introduction

Flywheel energy systems are simple in concept. An electric motor is used to spin up a wheel or rotor to store energy, then energy is discharged by an electric generator, thus spinning down the flywheel. While the electromagnetic battery concept is decades old, recent advances in high-strength lightweight composite materials, magnetic bearings, and power electronics technology have brought renewed interest in flywheel energy storage technologies. These advances make possible flywheel speeds with resulting energy storage capability that can equal or exceed traditional chemical batteries. Originally developed by NASA for energy storage on spacecraft, this flywheel technology has commercial applications in a variety of industries, including automotive, utilities, and manufacturing.

Glenn G2 flywheel.

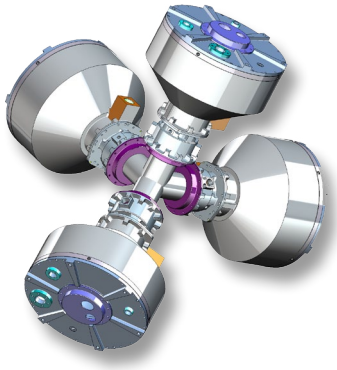
Interest in flywheel systems for terrestrial power and energy management applications is growing. The efficiency of green energy sources like wind and solar power can be improved using flywheel systems. These green sources inherently vary throughout the day, and will not match the demand on the utility grid. By combining these sources with a flywheel-based energy storage mechanism, supply can be matched with demand, reducing or eliminating the need for gas/oil turbine peak power generation. Also, large (250-kVA-plus) industrial uninterruptible power supplies (UPS) systems can benefit from advanced flywheel-based energy storage. Use of flywheels in place of batteries, which are widely used in UPS systems, will eliminate the need for the containment and disposal of hazardous materials such as lead, toxic electrolytes, and hazardous gases, as well as the maintenance and need for access and strict environmental control required in battery-based systems, while reducing size and cycle cost.

Additionally, due to the robustness of this technology, these mechanical energy storage systems can be placed in environments that are remote and more secure, for example, underground, and will allow reduced requirements for environmental conditioning of the storage site, further reducing energy consumption.

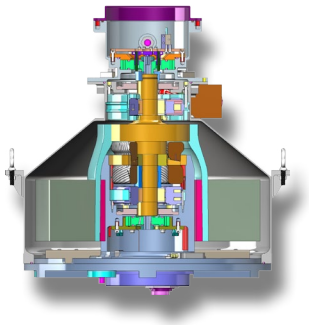
NASA's Investment in Flywheels

NASA Glenn Research Center has three decades of experience in flywheel energy storage systems, and is currently making investments to transition this experience from the realm of space applications to the broader markets of terrestrial use. Specifically we are

1. Developing flywheel designs for ground-based applications.
2. Creating NASA intellectual property in the flywheel area which will lead to system cost reductions and greater energy storage capabilities.


Flywheels in attitude control configuration.

Previously, a demonstration was conducted at Glenn to show simultaneous energy storage and momentum control using two high-speed magnetically levitated flywheels. In addition, flywheel staff designed several generations of flywheel modules leveraging in-house expertise in motors, magnetic bearings, controls, materials, and power electronics.



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NASA Glenn has the staff and facilities capable of performing detailed design, analysis, prototyping, and testing of new flywheel systems and components. In addition, the program has a comprehensive rotor safety certification program.

Technology Benefits

The flywheel technology has inherent aspects that provide for an advantage over other energy storage technologies. These benefits include

- **Environmentally friendly:** Flywheel systems use nontoxic materials that can be recycled.
- **Low maintenance/long life:** Magnetically suspended flywheel systems have a long life minimizing maintenance and replacement.
- **Response time:** Flywheels have a rapid response to peak power demand.
- **Degradation:** Flywheels do not experience performance degradation based on depth of discharge or charge/discharge power.
- **Temperature:** Wide operating temperature ranges, thus requiring less thermal control—flywheels can be located outside climate-controlled buildings, reducing heating, ventilation, and air conditioning (HVAC) costs.
- **Affordable:** Minimize maintenance and overhead to reduce total cost of ownership.

Potential Applications

The advanced flywheel system in development at NASA Glenn has the potential to positively affect a variety of applications including

- **Commercial applications**
  - Grid energy storage for power plants
  - Energy storage for remote bases
  - Uninterruptable Power Supplies (UPS)
  - Load-leveling for aircraft or automotive purposes (e.g., delivery trucks)
  - Power quality improvement
- **Noncommercial applications**
  - Department of Defense forward operating bases
  - Spacecraft energy storage and momentum control

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