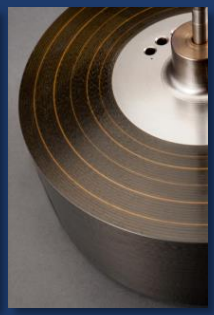
NASA Glenn Research Center
Flywheel Program







Partnering with NASA's Glenn Research Center on Flywheels for Energy Storage

Timothy Dever – Flywheel Project Engineer
Ralph Jansen - Flywheel Project Manger

Topics

- Flywheels: How the Technology Works
- Advantages of Flywheel Energy Storage
- Energy Storage Market Size – U.S. and Global
- Major Market Drivers for Energy Storage
- Commercial Applications for Flywheels
- Alternative Technologies Competing in Energy Storage
- Case Study: Community Energy Storage
- The Energy Conundrum
- Glenn's Near-Term Areas of Interest
- Glenn's Flywheel Team
- Contacts

Flywheels: How the Technology Works

A flywheel is a chemical-free, mechanical battery that uses an electric motor to store energy in a rapidly spinning wheel - with 50 times the storage capacity of a lead-acid battery

As the flywheel is discharged and spun down, the stored rotational energy is transferred back into electrical energy by the motor — now reversed to work as a generator. In this way, the flywheel can store and supply power where it is needed

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To view a short video on flywheels, visit NASA 360:
http://www.nasa.gov/multimedia/podcasting/nasa360/nasa360-flywheel.html

Advantages of Flywheel Energy Storage

- Instantaneous response
- Lower life of system cost
- Life exceeds 10 years and 90,000 cycles
- State of charge is precisely known
- No acids or other hazardous materials
- Unaffected by temperature extremes
- Zero direct greenhouse gas emissions
- Clean, green energy

Energy Storage Market Size – U.S. and Global

U.S. market

- Freedonia projects advanced and renewable micropower demand in the U.S. will ***total $19.3 billion in 2015 based on annual gains of 14.7 percent*** from 2010

Global market

- Pike Research forecasts that advanced energy storage technologies will surpass $3.2 billion global revenue by 2021
- NanoMarkets estimates ***the market for grid storage will grow from $1.5 billion in 2012 to $8.3 billion by 2016***
- A 2010 Frost & Sullivan report predicts ***advanced energy storage technologies (including flywheels) will comprise a niche market from $1 billion-$6 billion***

Large predicted growth in advanced energy storage in U.S. and Global markets

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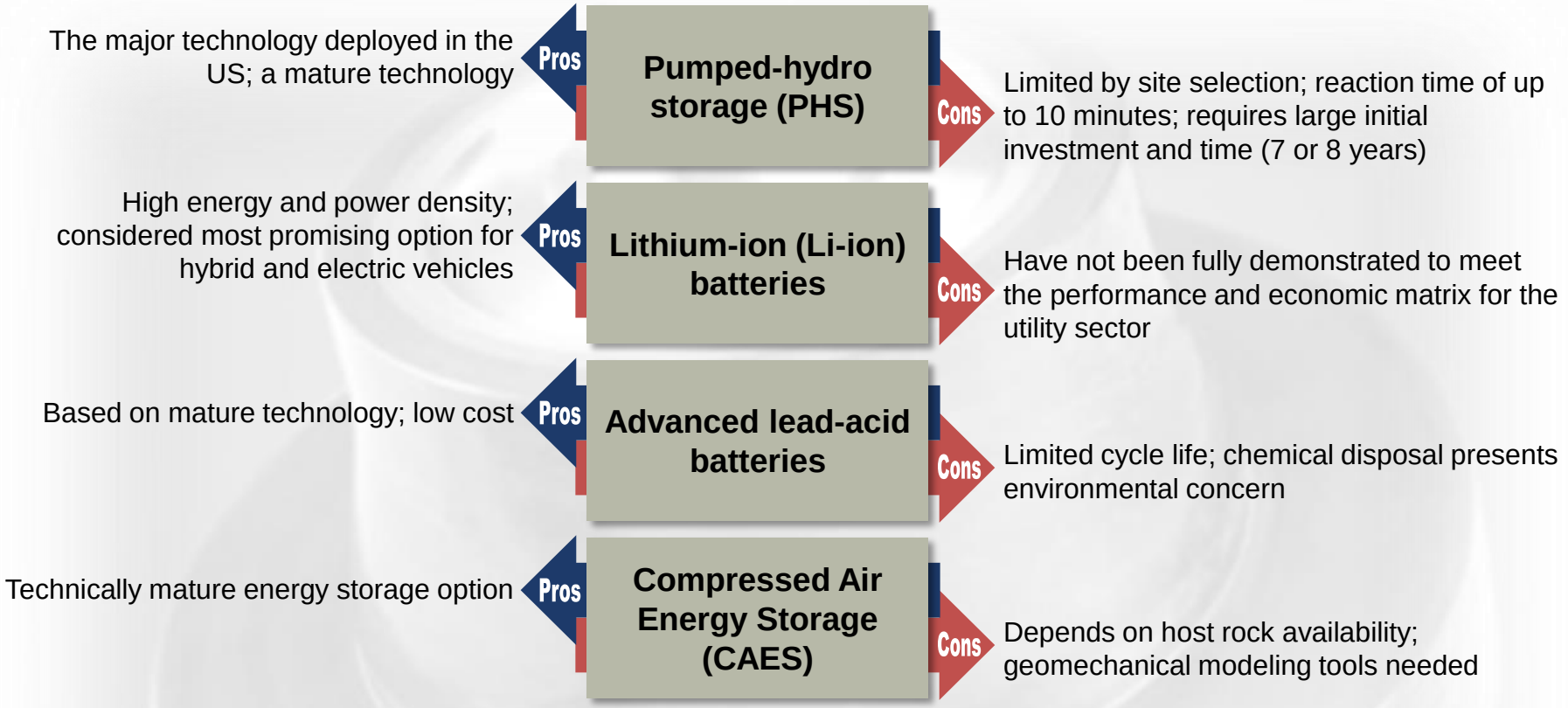
Major Market Drivers for Energy Storage

- Worldwide demand increases
- Aging overloaded grid
- Increasing market penetration for renewable energy
- The onset of smart grid initiatives
- Lack of flexibility of nuclear and coal power generation
- A shift to plug-in hybrid vehicles

Commercial Applications for Flywheels

- Community energy storage (CES)
- Uninterruptible power supply (UPS) systems
- Grid-scale energy storage systems
- Energy storage for remote bases
- Micro-grid energy storage for campuses or military bases
- Frequency regulation
- Hybrid vehicles
- Rail systems
- Power quality improvement
- Solar photovoltaic and wind energy
- DC telecommunications backup power systems
- Back-up power for spacecraft, motor vehicles, hospitals, manufacturing plants, etc.

Alternative Technologies Competing in Energy Storage



Case Study: Community Energy Storage

Local benefits

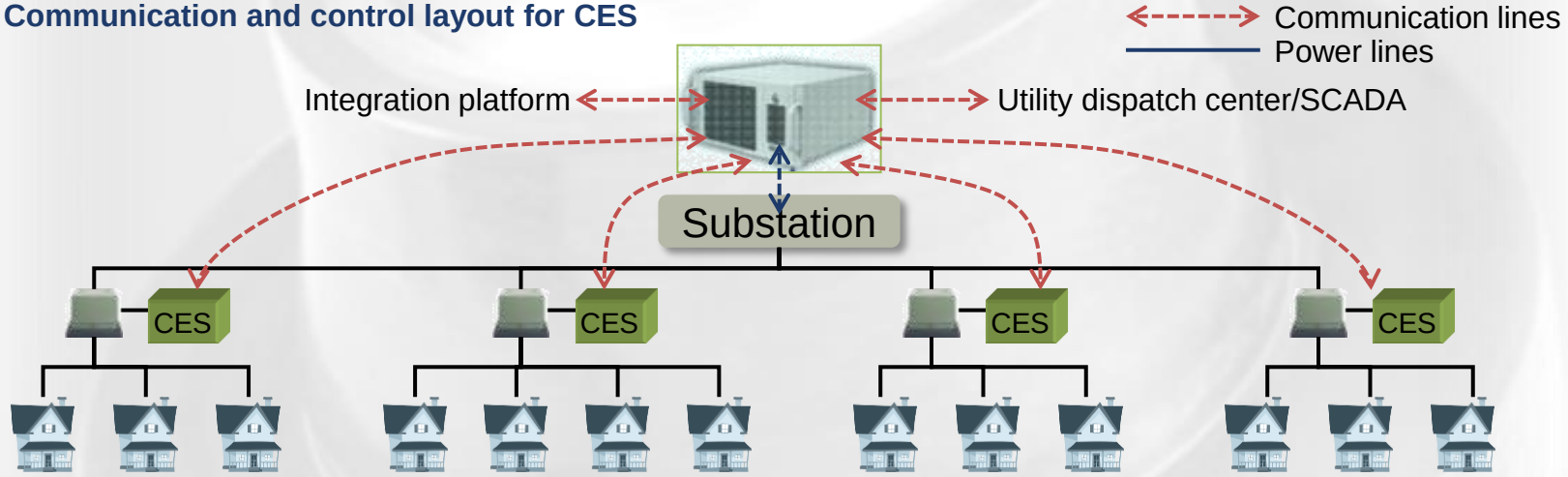
1. Renewable integration
2. Backup power
3. Voltage correction

CES is operated as a fleet offering a multi-MW, multihour storage

Grid benefits

4. Load leveling at substation
5. Power factor correction
6. Ancillary services

Communication and control layout for CES



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The Energy Conundrum

Energy storage has been described as the final piece in the renewable energy jigsaw puzzle. Without reliable energy storage, the U.S. will continue to struggle to gain large-scale penetration for renewables.

Flywheels represent a capital investment in energy storage that will pay dividends for decades

Glenn's Near-Term Areas of Interest

Microgrid energy

- The U.S. military leads the world in deploying and testing new microgrid technologies. DoD anticipates spending $13.5 billion on microgrid technologies just for its U.S.-based installations
- Military microgrid capacity is projected to experience more than 700% growth by 2017

PikeResearch
Cleantech Market Intelligence

Grid-scale energy storage systems

- Pike Research reports advanced energy storage technologies for ancillary services (e.g., flywheels) will surpass $3.2 billion global revenue by 2021

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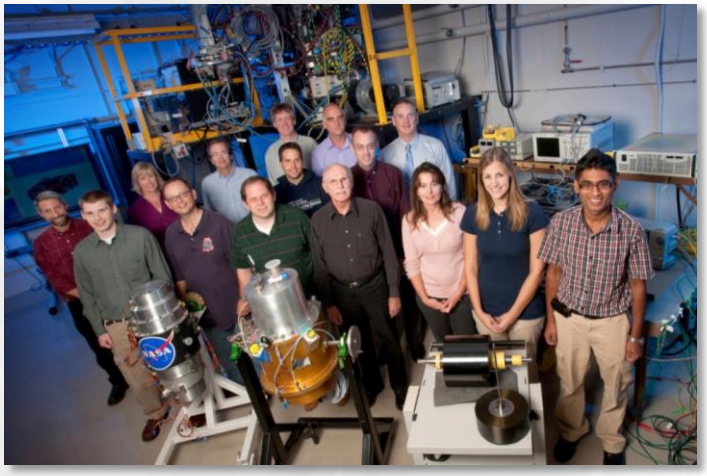
Glenn's Flywheel Team

Principal team leaders

Mr. Ralph Jansen	43 research publications, 24 engineering publications, 1 R&D 100 award, 2 U.S. patents
Dr. Peter Kascak	Author or co-author of 17 publications, 2 U.S. patents
Mr. Tim Dever	Author or co-author of over 20 technical publications, inventor or co-inventor on 10 U.S. patents
Dr. Kirsten Platt Duffy	Author or co-author of numerous publications on rotating machinery and flywheel design, over 20 years experience
Mr. Kevin Konno	Author of 4 flywheel papers, representative to Flywheel Rotor Safe Life (FRSL) working group, over 20 years experience



Glenn has unparalleled depth and breadth of experience -- Glenn will ***leverage cross-cutting technologies*** to ***reduce system cost*** and ***increase energy storage capabilities.***

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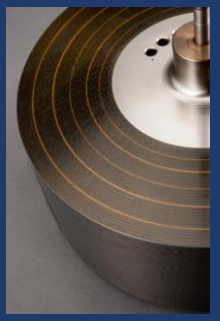

Contact Us

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