Flywheel Energy Storage

(Part I)

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An Opportunity for the Automotive Industry and Beyond

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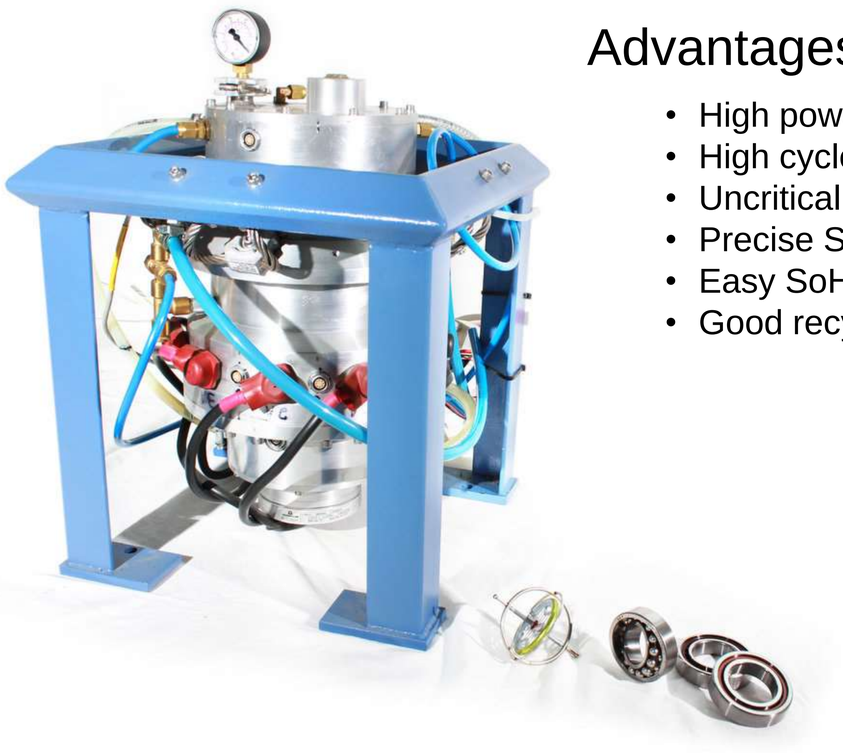
Properties of *Flywheel Energy Storage Systems* (FESS)

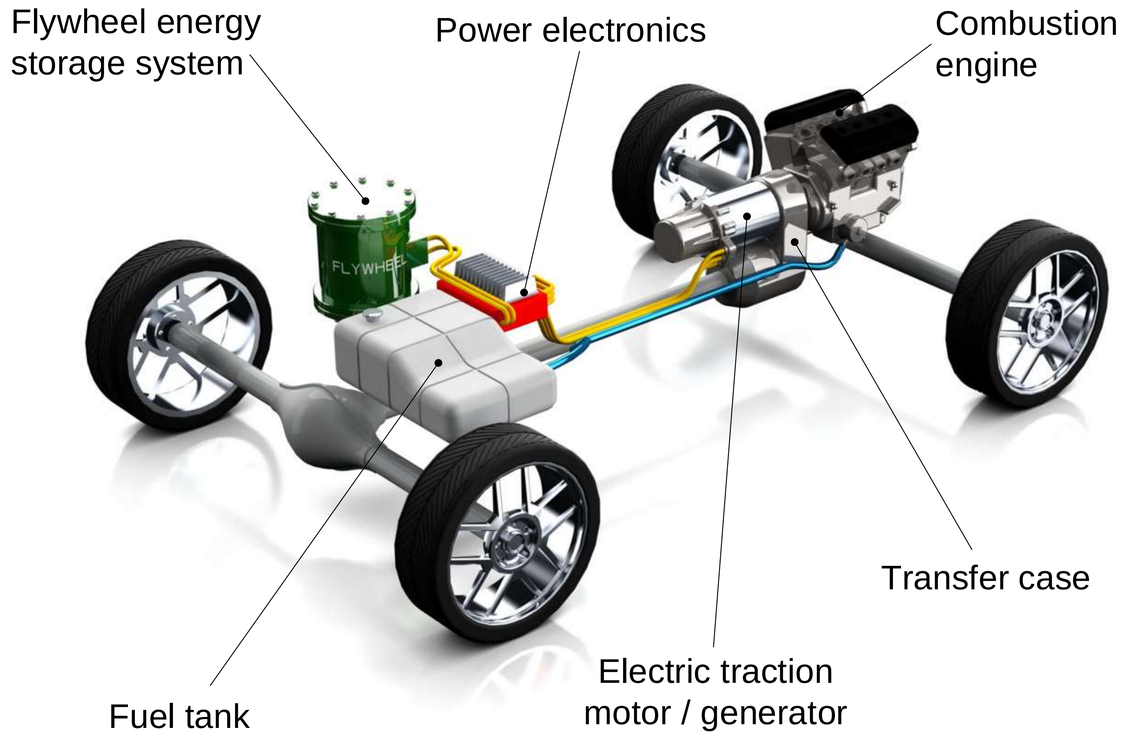


Advantages:

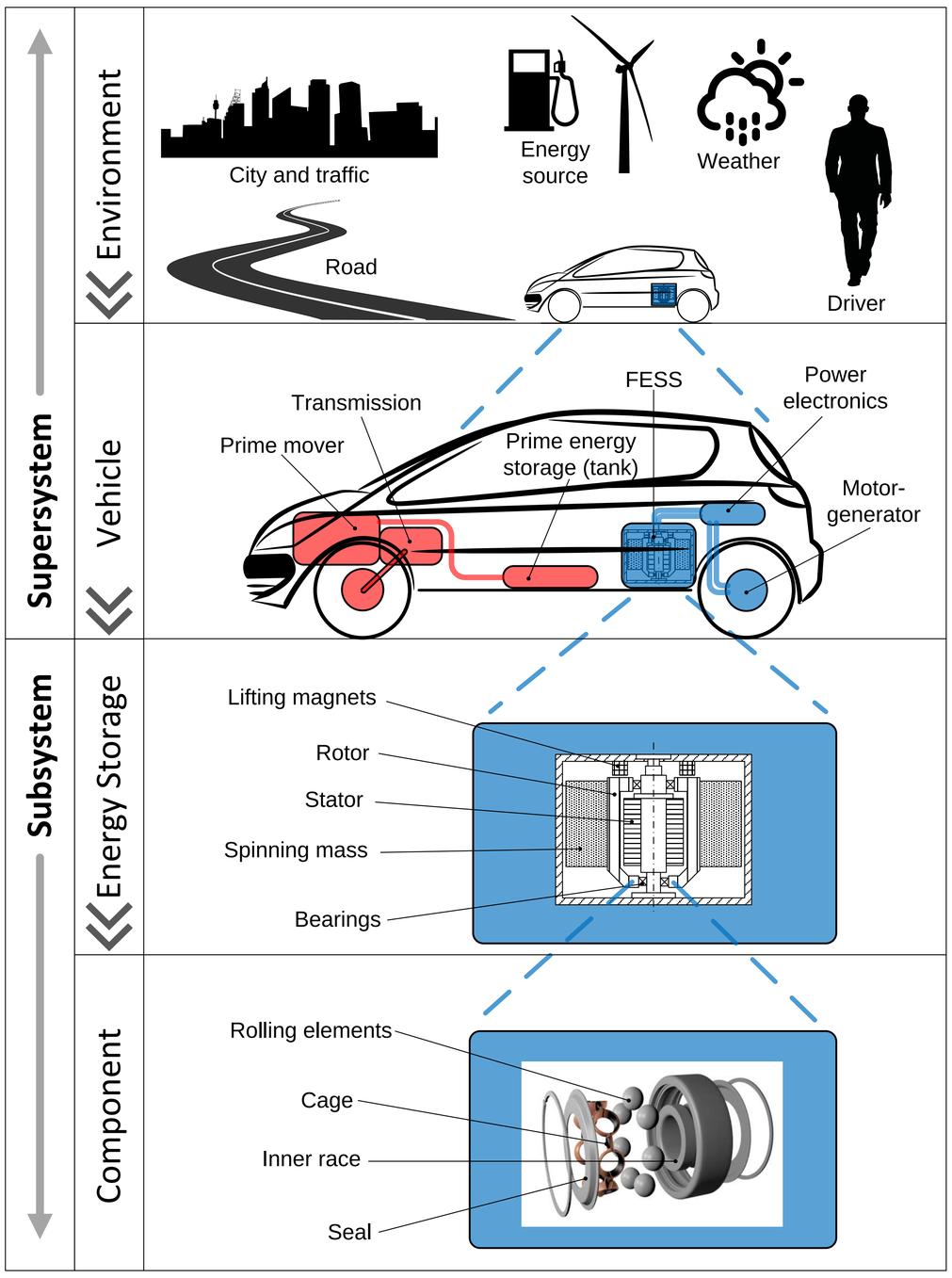
- High power density
- High cycle life
- Uncritical deep discharge
- Precise SoC determination
- Easy SoH determination
- Good recyclability

Disadvantages:

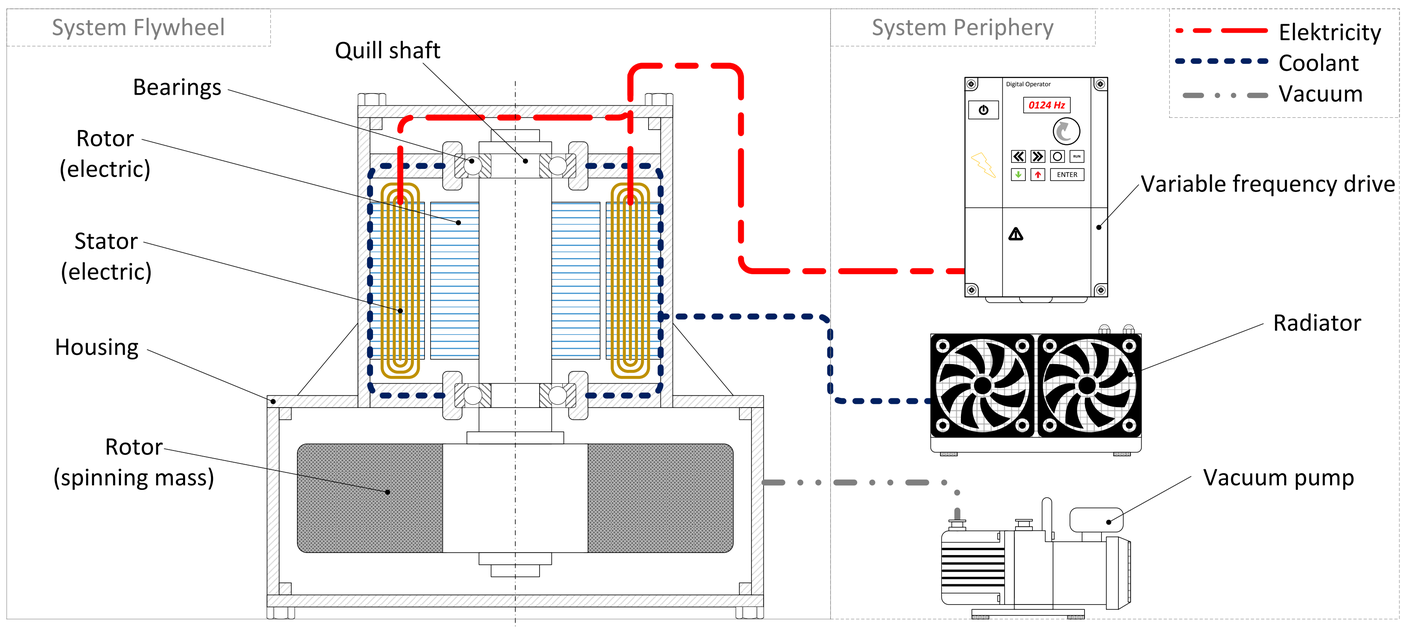
- High self-discharge
- Low energy density
- High costs



System Analysis



Components and Auxiliaries of FESS

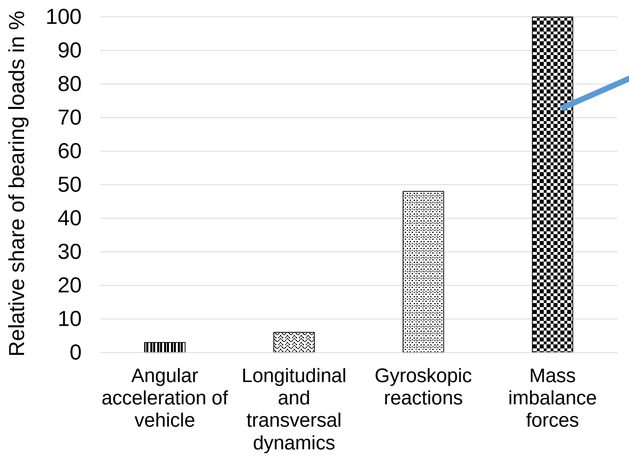


Identification of Critical Components

Component	Current Problems	Development Targets
1. Bearings 	Magnetic bearings result in high costs and control system complexity. Rolling element bearings are an economic alternative, but represent the only part subject to mechanical wear, which also defines self-discharge.	Reduction of torque loss while improving service- and lubrication life time.
2. Rotor 	In order to reach the desired *threshold energy density* higher rotational speeds are required. This results in high costs caused by intricate manufacturing methods and materials (fiber composites). Rotor burst poses a safety risk.	Cost reduction and increased rotor speeds. Optimized inherent safety and improved burst/crash behavior.
3. Housing 	The housing contributes the largest share to the FESS's weight of all components and hence reduces the specific energy of the system. Furthermore, it is a safety-critical component, relevant for approval of the technology in the automotive industry.	Weight reduction while maximizing safety in the case of rotor burst or vehicle crash.

1. FESS Bearing Design

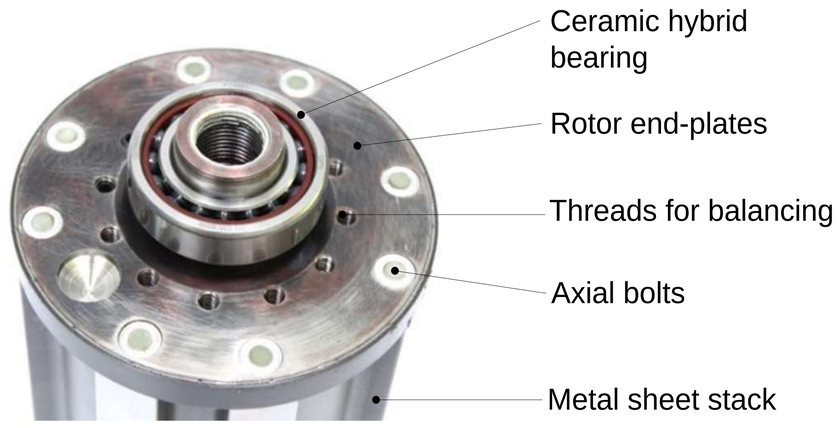
Reasons for bearing loads in FESS



Values determined for a representative case (rotor with 11 kg mass, balancing quality class G=2.5 and max. speed 60,000 rpm).

Mass imbalance forces can be mitigated by a resilient bearing mount and super-critical rotor operation:

Rotor and Bearing



Resilient Bearing Seat