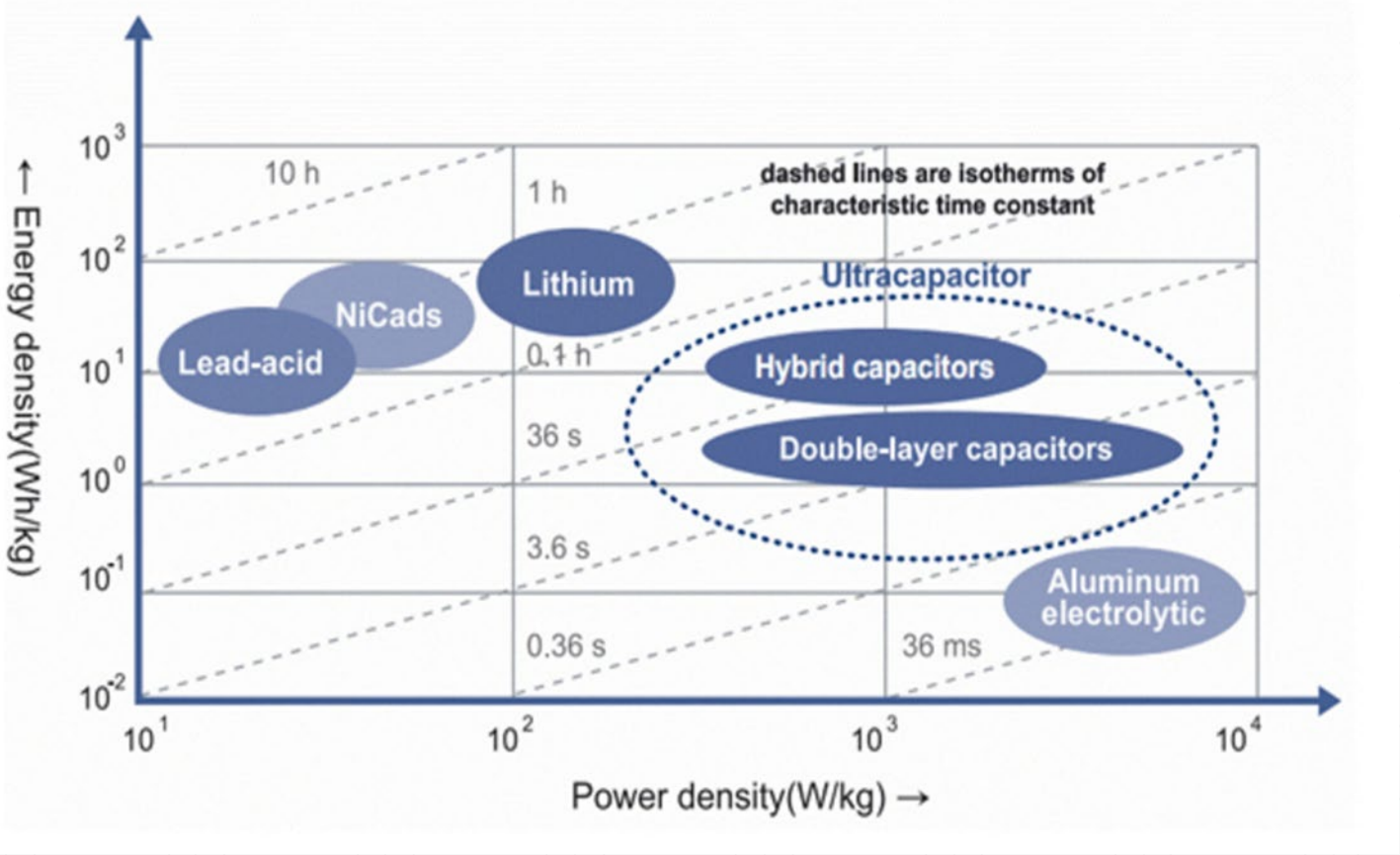
Supercapacitors, Applications and PROS & CONS

Technology Comparison

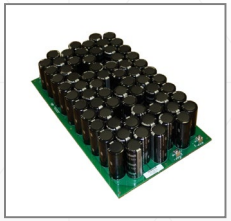


Energy Storage Technology Options

- **Batteries:**
  - \+ very high energy density
  - – bad cycling stability / lifetime
  - – Safety
  - – Shipping restrictions
  - – low peak power

- **Flywheel Storage:**
  - \+ high energy density
  - – bad cycling stability / lifetime
  - – expensive
  - – low peak power

- **Ultracapacitors:**
  - \+ high power density
  - \+ high numbers of cycles / lifetime (>1M cycles, >10yr)
  - \+ simple technical system (reliability)
  - \+ safety – no chemical reaction (store energy electrostatically)
  - \+ no shipping restriction
  - – low energy density



Industry Applications and Trends

- Demand for long life with wide temperature range requirements
- Frequent battery replacement
- Government regulations – reduce rapid depletion of natural resources
- Increased investments and government funding for energy efficient devices
- Demand for small high-frequency devices
- Greater focus on system level collaboration
- Pairing with various battery technologies for load leveling
- Li-Ion safety and logistic concerns

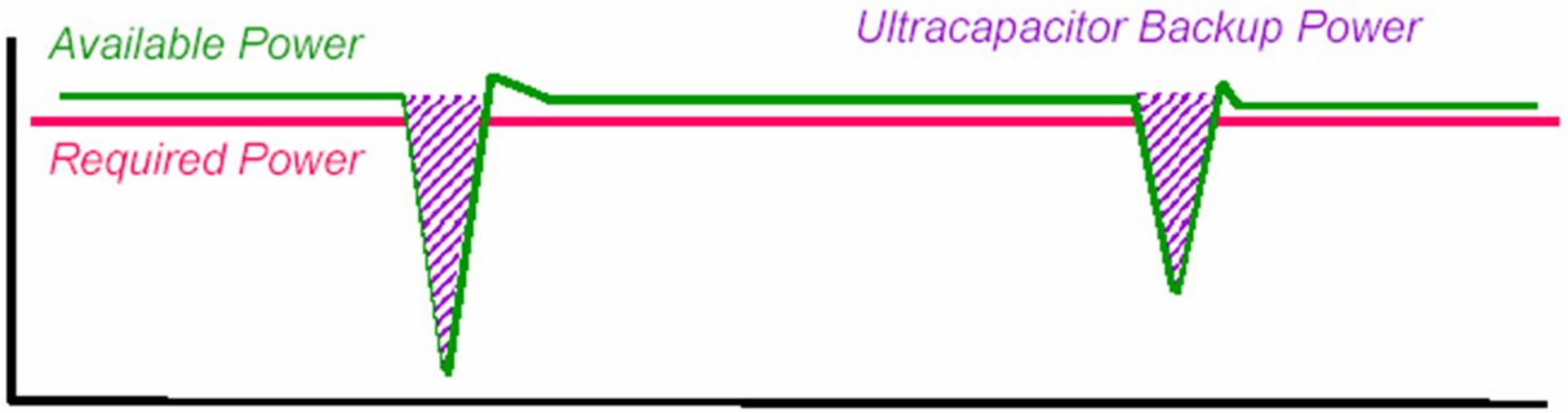
Application Classifications

- **Dynamic**
  - Rapid change of current
  - Rapid change of power in and out of ucap
  - Rapid change of voltage to ucap
  - Wide ambient temperature fluctuations over the application life
  - High current/power loads on ucap
  - High vibration environment
  - Long cycle life requirement

- **Static**
  - Steady operation vs time
  - Majority of time spent in charged state
  - Low charge current, long charge duration
  - DC life critical
  - Self discharge critical

Back up Power Applications

<u>Ultracapacitor Benefits</u>: High reliability, maintenance free, long life



Examples: Graceful Power Down, Bridge Power, Ride Through – seconds to a few minutes

Peak Power Applications

<u>Ultracapacitor Benefits:</u> High Power Charge/Discharge, Up to 1 Million Cycles, High Duty Cycle, Long Life

Examples: Acceleration of a train, bus, car. Lifting for cranes and forklifts, Engine Starting, Recapturing Energy.

Markets and Applications

Industrial	Data Storage	Smart Grid	Consumer	Medical	Telecom	Military
♦ Automation ♦ Scanner/POS ♦ Surveillance ♦ Transportation ♦ UPS ♦ Lighting	♦ Memory Backup ♦ RAID ♦ SSD ♦ HDD	♦ AMR/AMI ♦ Solar ♦ Wind ♦ Energy Harvesting	♦ GPS ♦ Entertainment ♦ Appliance ♦ Smoke/CO Detector	♦ Handheld ♦ Patient Monitoring ♦ Ultrasound/MRI	♦ Infrastructure ♦ Networking ♦ Wireless ♦ XDSL/DSLAM	♦ Emergency Power ♦ Avionics ♦ Radar ♦ Munitions ♦ RF ♦ Vehicles







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Customer-driven power solutions