

Batteries for Space Applications

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Space Batteries

- Provides power:
 - Deployment of solar panels, firing pyros and rockets for altitude control
 - During solar eclipse periods
 - Load management and peak shaving for lunar grids

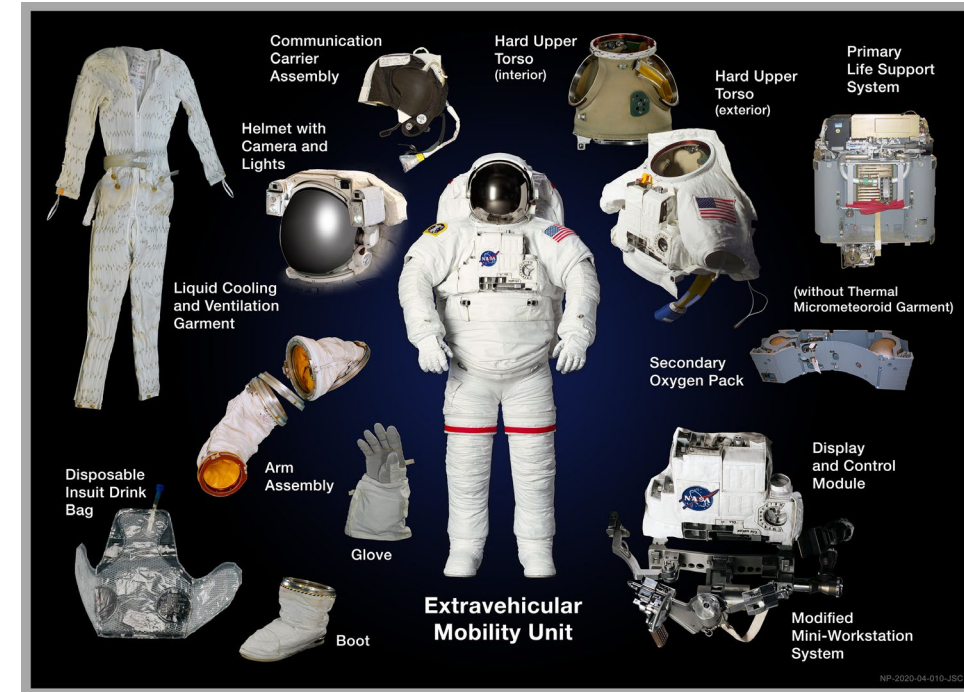


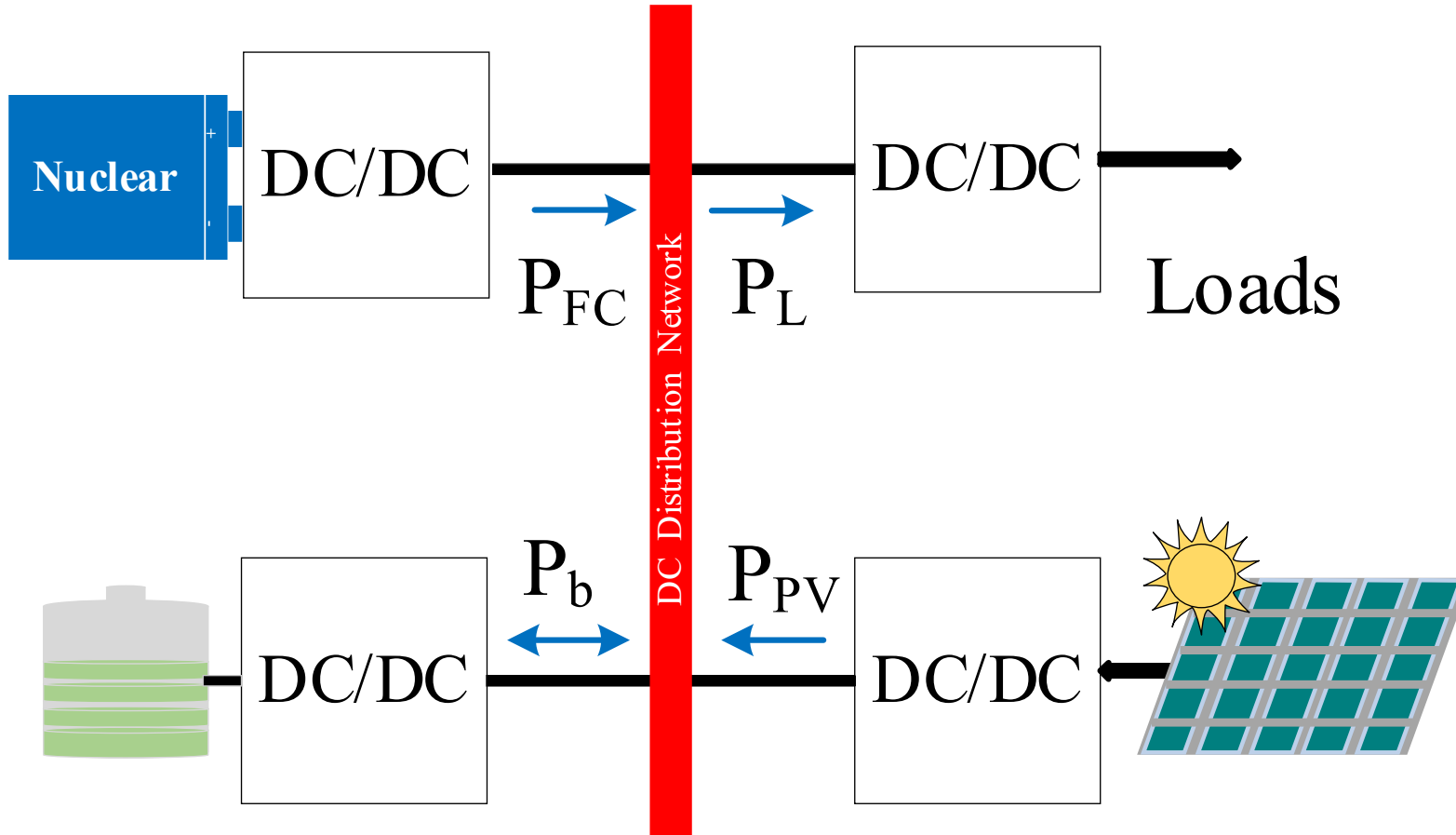
Image taken from: <https://images.nasa.gov/>

Battery Requirements

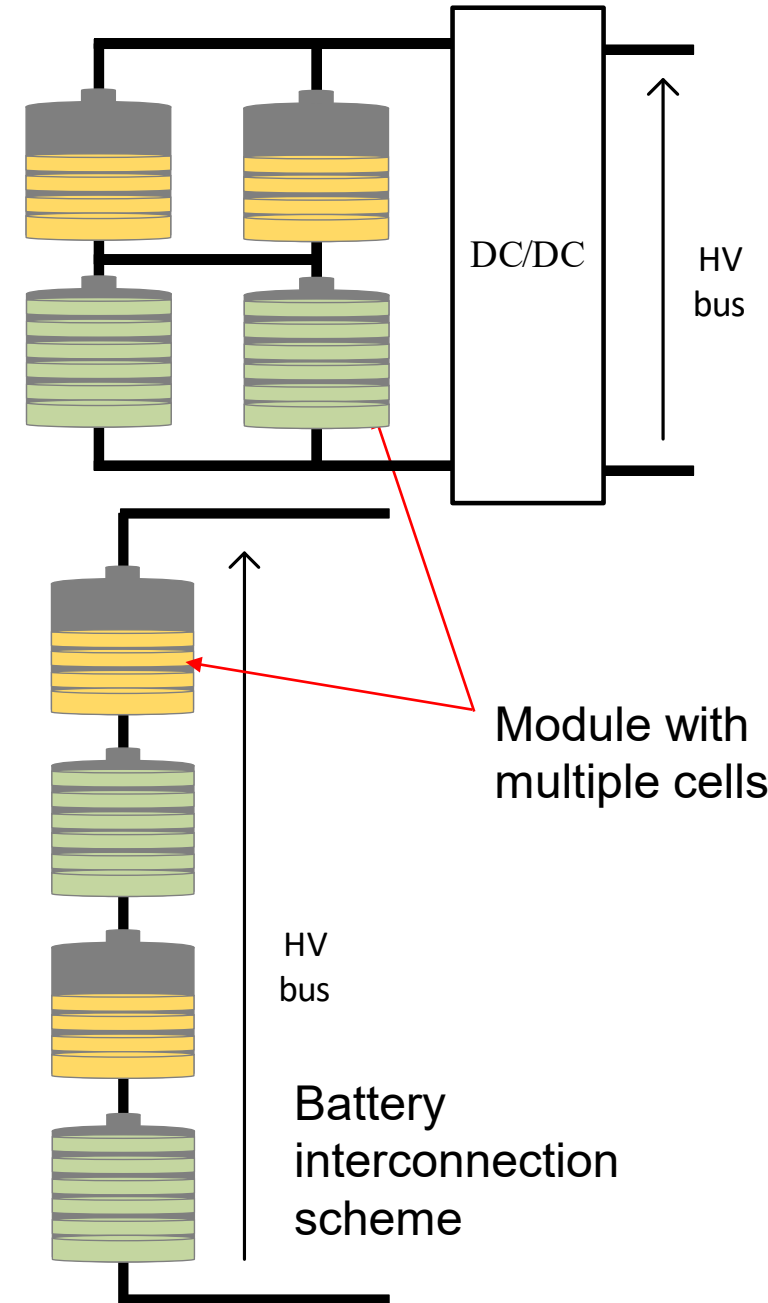
- High safety and reliability especially when tied with human exploration missions
- Mission specific needs:
 - Orbiter mission of Venus has similar temperature as Earth
 - Surface temperature of Venus is 450°C, and lowest on Mars is -125°C near poles
 - High radiation e.g. 4Mrad for Jupiter environments
 - Life of the mission: Orbital, lander, rover has their own needs

Modular Battery Pack

- Modules in series and parallel

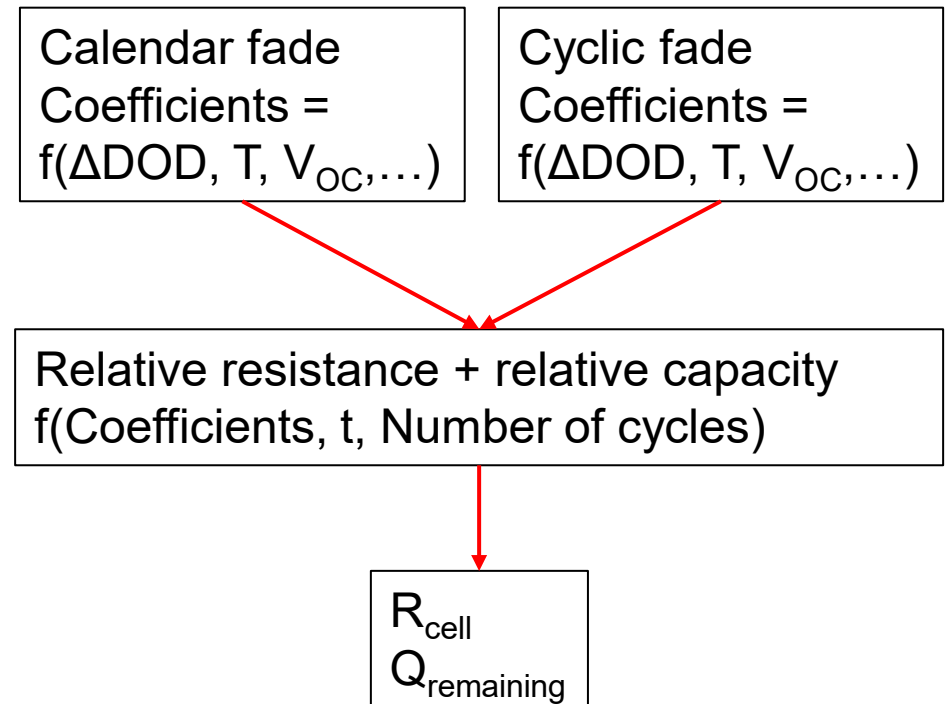
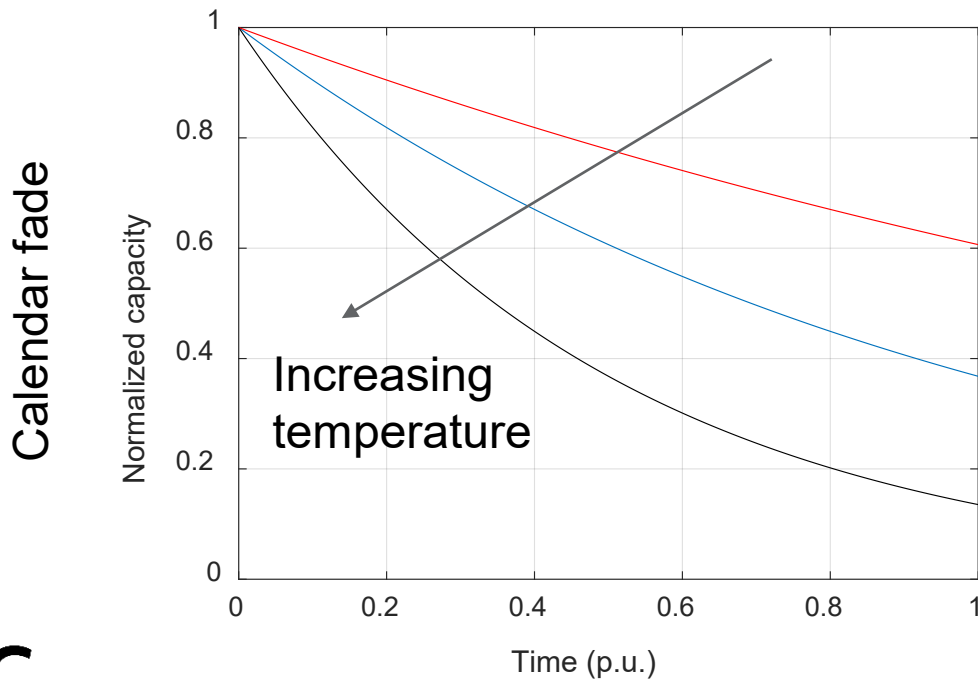


Microgrid architecture



Battery Degradation

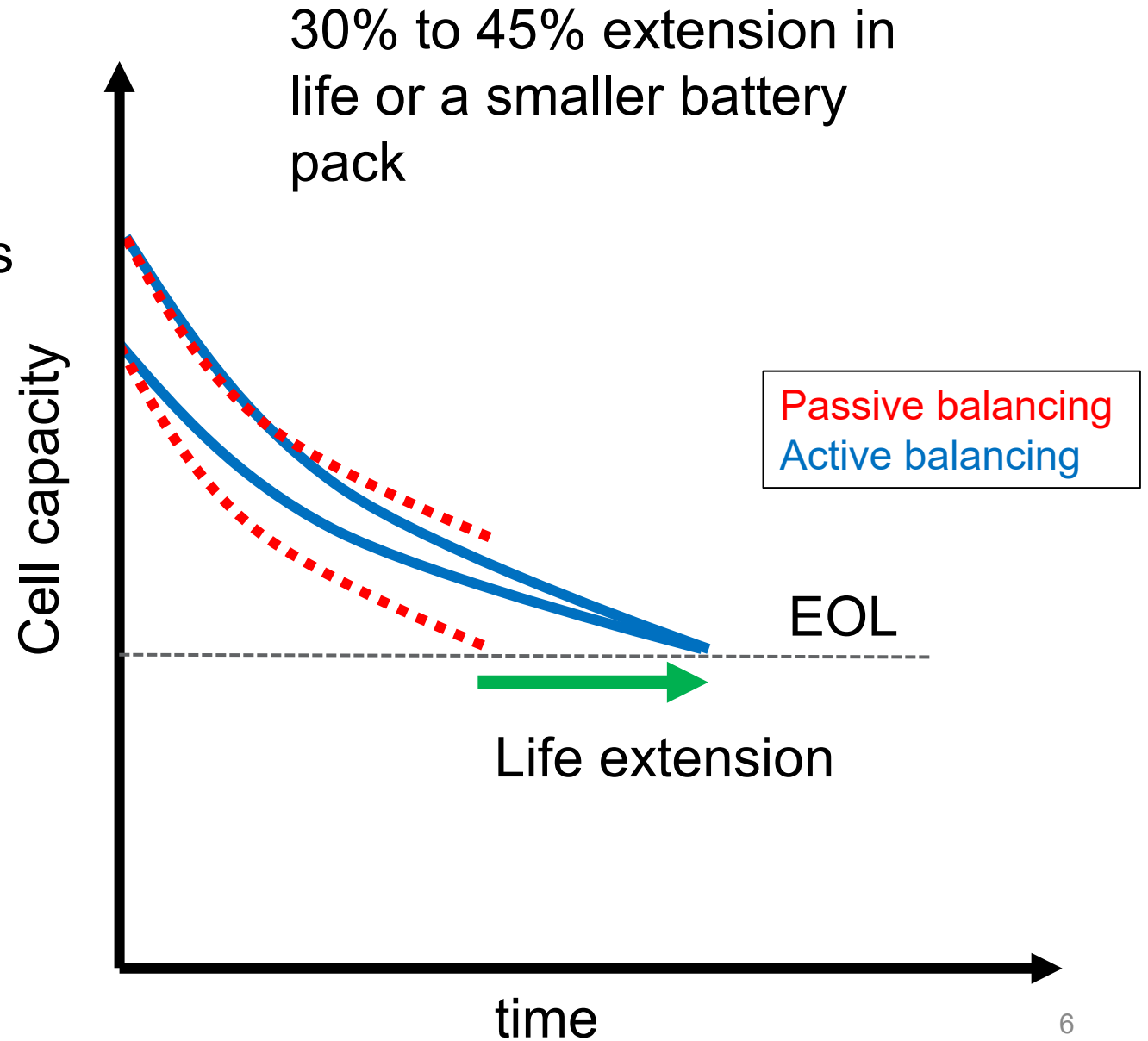
- Dominant mechanism: SEI formation and growth, Lithium plating, current collector corrosion, electrolyte decomposition, electrode fracture, SEI fracture
- Observable effects at terminals:
 - Increase in resistance
 - Decrease in Capacity



Kandler Smith et.al., Optimizing Battery Usage and Management for Long Life, 2016

Life Extension

- Active balancing
 - Power exchange among modules
 - Life extension
 - High efficiency



Capacity Loss Due to Radiation

- Some capacity loss from gamma radiation using a high dose of Cobalt-60
- All the cells tested in the study showed a higher tolerance to radiation
- In comparison to the control cells, the maximum capacity loss of < 2% occurs after 20 Mrad exposure

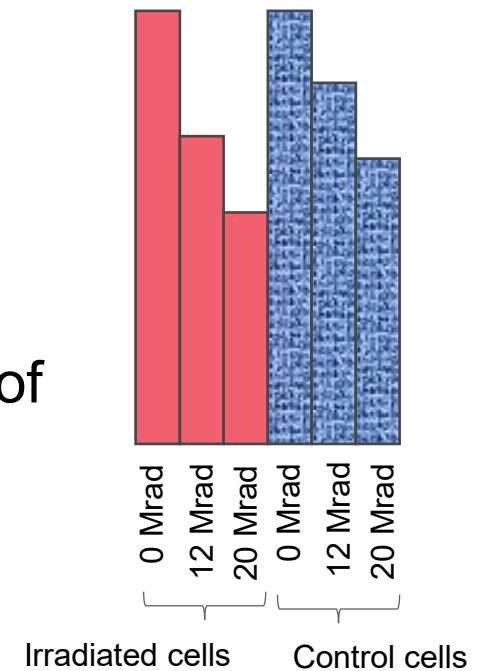


Image adapted from: Performance of Commercial High Energy and High Power Li-Ion Cells in Jovian Missions Encountering High Radiation Environments. NASA Battery Workshop November 19-21, 2019

Battery Design

Inputs

Electrical load profile

Cell database

Input requirements

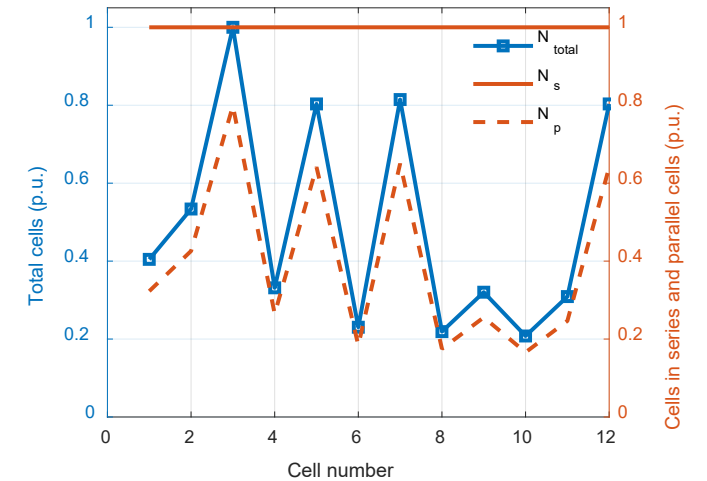
Pre-processing

Optimization

Battery Design Toolbox
(Optimization for weight, volume, cost, life)

Post-processing

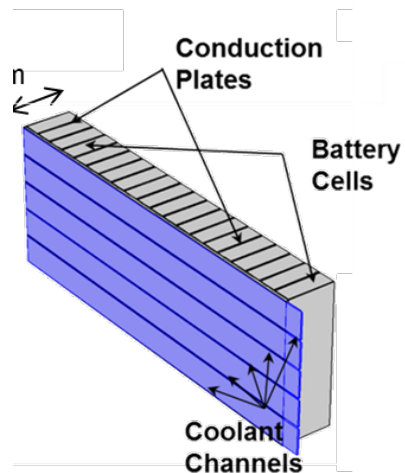
Results



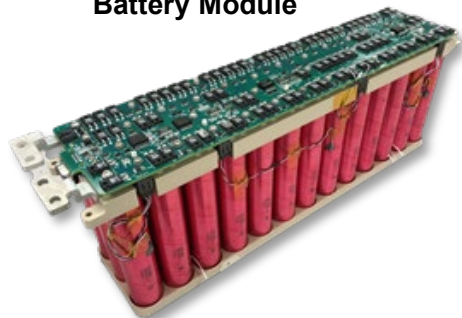
Hybrid Energy Storage Module (HESM)

MODULAR, SCALABLE ENERGY STORAGE

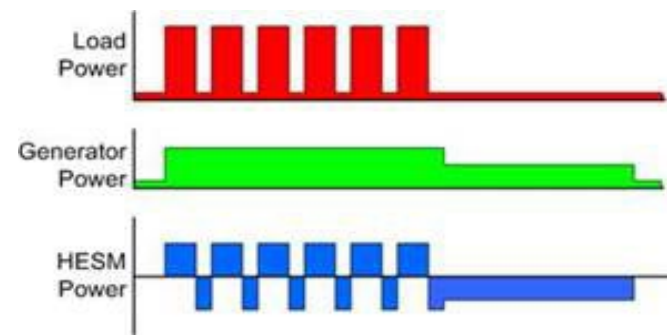
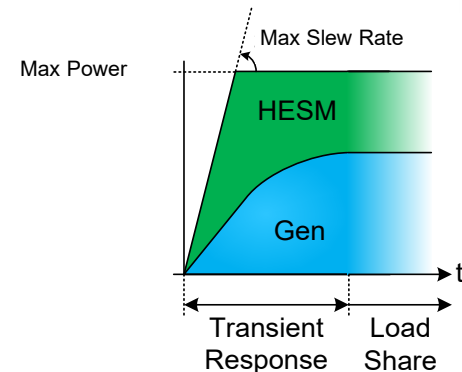
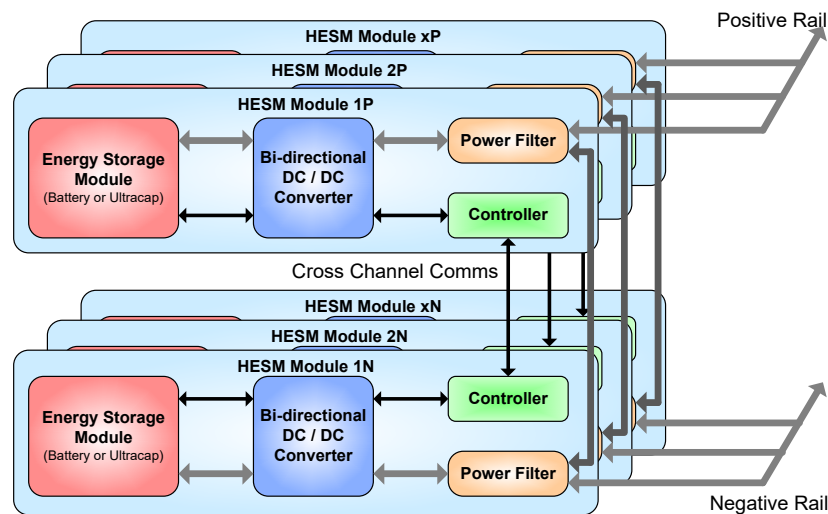
- Bi-directional, high kW converter + energy storage
- Integral charge, discharge, & safety controls
- Active power quality control / filtering of HVDC bus
- HVDC bus stable with pulse and regenerative loads



Battery Module



Capacitor Module



Thank you

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