

# GE Power Conversion University of Pittsburgh Electric Power Industry Conference

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imagination at work



# DC Architecture for Microgrids

AC vs DC

Protection Strategies

Distribution Practices

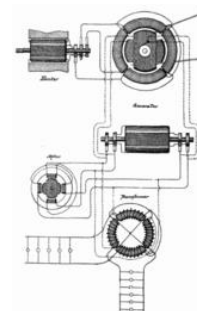
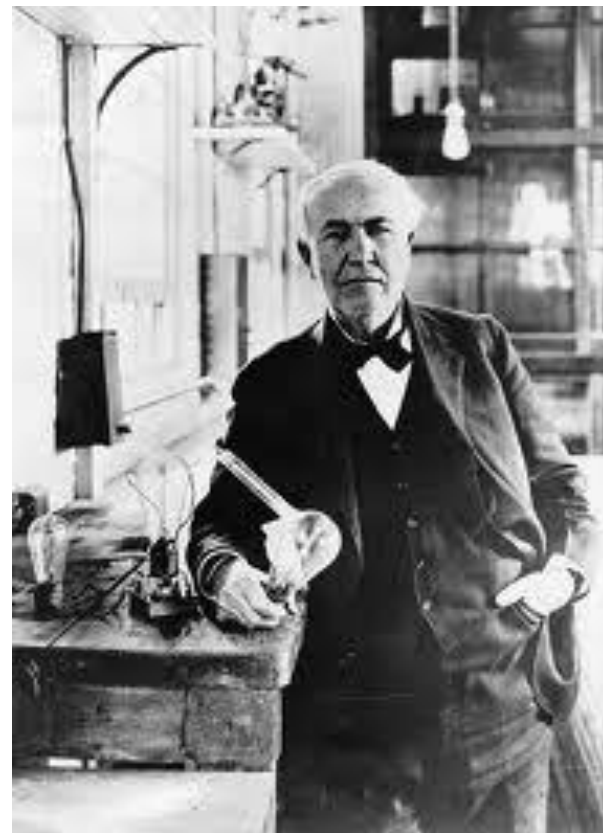
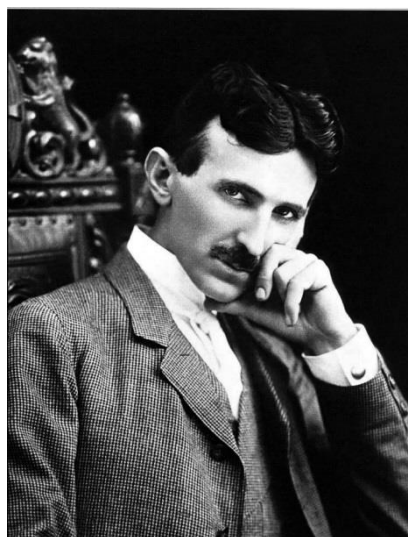
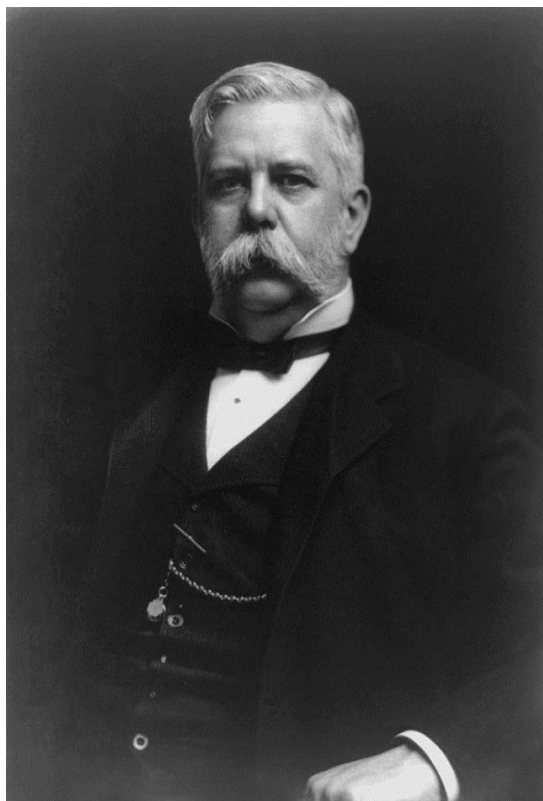
Summary

# Global Research ... GE's Innovation Engine

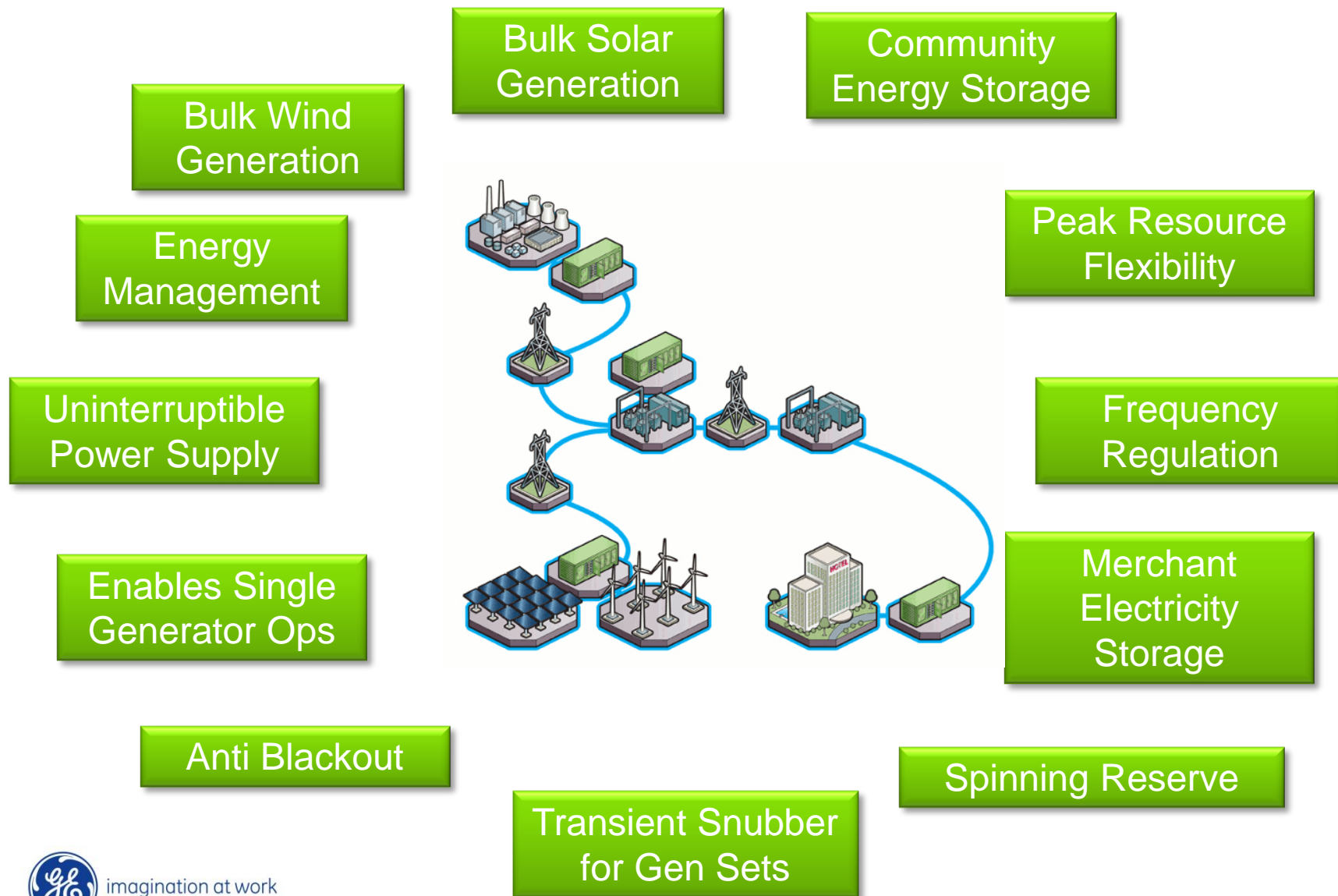
Edison was in support of Direct Current

Westinghouse in support of Alternating Current

Nikola Tesla – Generated several key patents on AC systems



# Power Distribution



# Medium Voltage DC

- Advantages
  - Reduced cabling (can be upto 3X smaller)
  - Power management is more flexible
    - Need to be synchronized is absent
  - Prime mover is decoupled from the DC Bus
    - Prime mover can operate at BEP
- Disadvantages
  - Lack of natural current zero crossing
    - Can't use traditional AC breakers
  - Requires more converters
    - Efficiency penalties
  - System design becomes more complex (but allows increased capabilities – e.g. support multiple frequencies)

# DC Fault Protection



## Two Competing Strategies

- No DC Breakers
  - Power Electronics control current during fault detection
- DC Breakers
  - Deployed at strategic locations
  - Add complexity to the system
  - Not available at higher voltages

# DC Load Centers

# Energy – Storage (Industrial)

## Prudent Energy – Gills Onions USA



Status:	Order awarded Jan 11
Customer:	Prudent Energy
Application:	600kW Energy storage for existing Fuel Cell
Destination:	California USA
Scope:	Design Supply 1 off Power Converter Systems

### PROJECT OBJECTIVES

Improve efficiency of current system

Provide emergency backup power and reduce need to draw electricity from the grid

Save money in operating expenses

Power converter system based on MV3000



# Energy – Tidal Energy

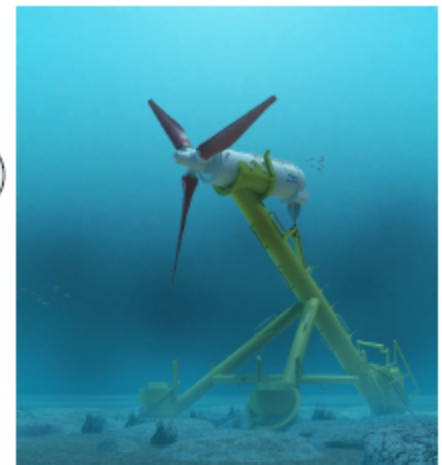
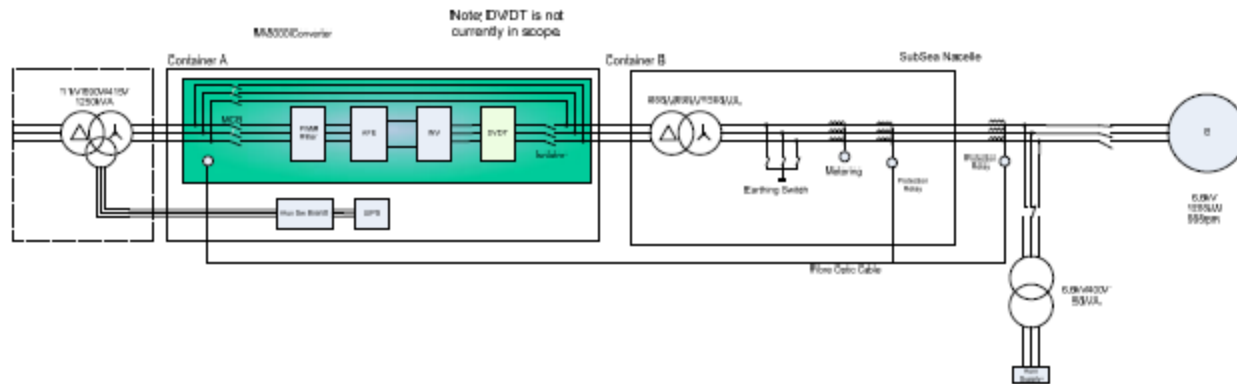
1.2MW Tidal Energy Demonstrator

Containerised MV3000 (4 off LCDs) and transformers

1200kW Subsea generator (6km offshore).

Sub sea energy storage to support nacelle during slack tide

Target 1MW at PCC sited at EMEC in the Orkneys.



# Wind & Solar Energy

## Wind Energy Storage

GE's battery software applications are part of its Brilliant Turbine platform. The battery technology enables short-term energy storage as part of the complete turbine system. Integrating the battery into the wind turbine allows wind farm operators to benefit from wind energy storage without the high costs of farm-level battery storage installation.

This revolutionary wind turbine battery configuration integrates battery technology with three software applications. The resulting system enables power producers and the wind turbines themselves to make data-informed decisions and provide short-term predictable power.



# Large DC Loads

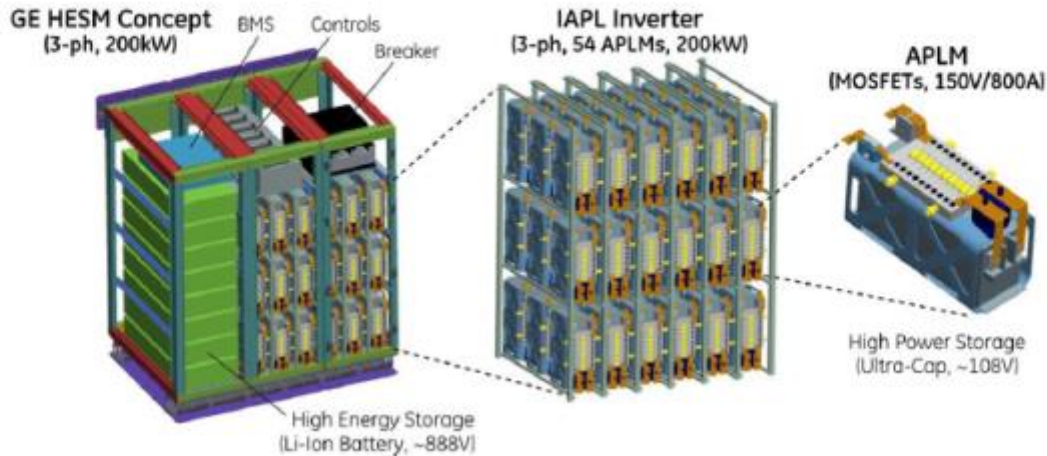
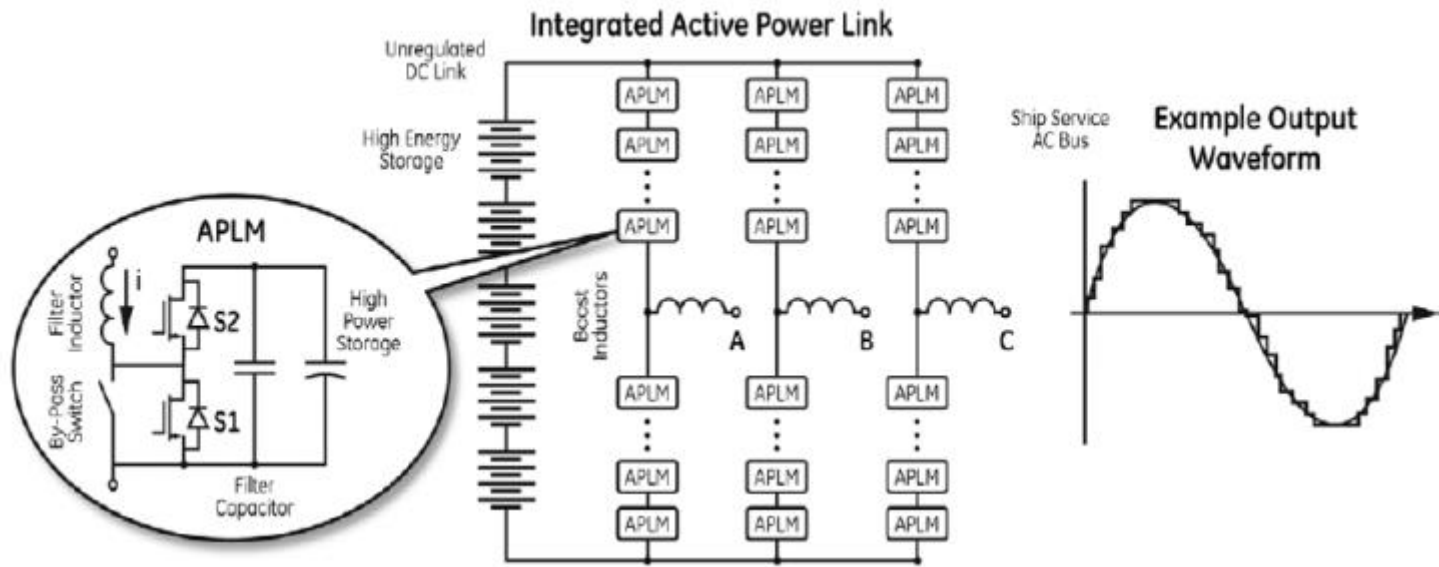


Jet Car Launcher Proposed Replacement with EMCAT



GEPC EMCAT Land Based Test Site  
at Bruntingthorpe Airfield UK

# Hybrid Energy Storage Module (C)



# ESM Grid Utility & Microgrid Market

# Grid Utility Applications



Energy storage can be used at the grid level to provide level demand. DC distribution can be used from Energy Storage to the Load.

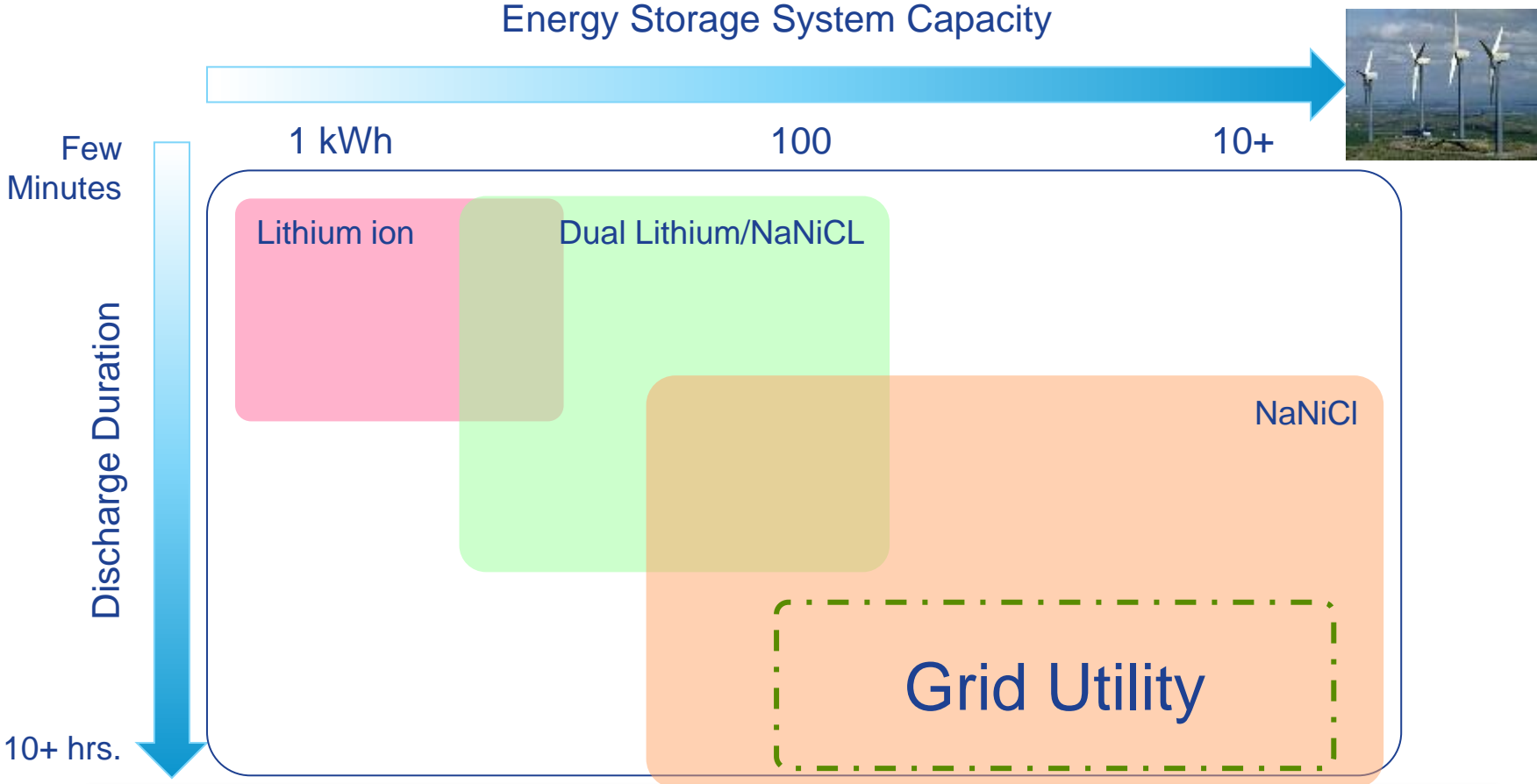
# Off-Grid & Microgrid Applications



Applications range from small cell phone towers to large commercial, industrial (Prudent Energy, Onion Gills), and military customers (29 Palms).

Energy storage is used to enhance microgrid stability by decoupling the generation source from the load.

# Potential Addressable Battery Market



**Target \$1B out of \$12B Grid Utility Mkt**



# Energy Storage in Electromagnetic Launchers



Superman the Escape Ride in Magic Mountain, Los Angeles Cali.  
(GEPC Designed/Equipment)



Jet Car Launcher Proposed Replacement with EMCAT



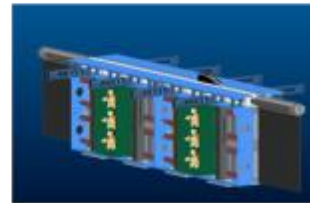
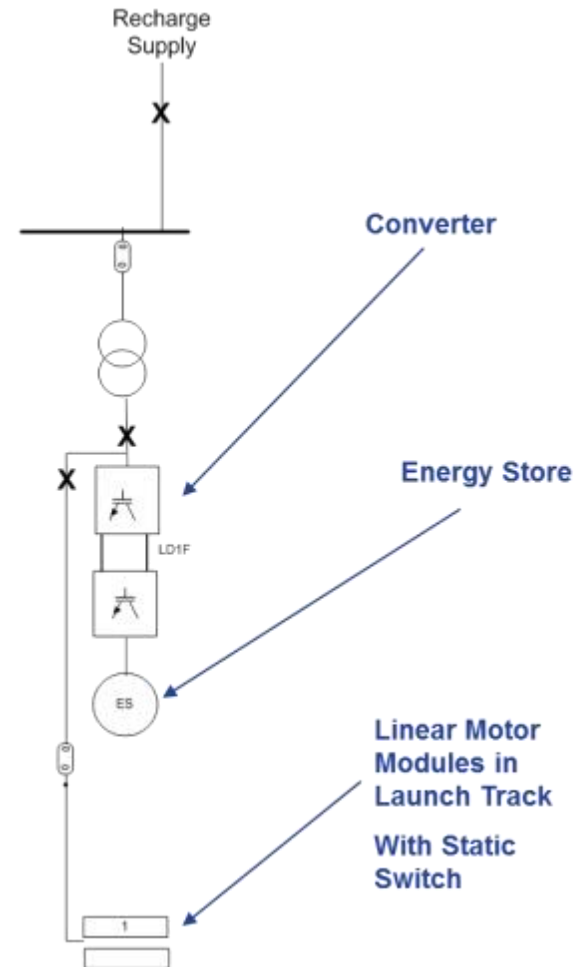
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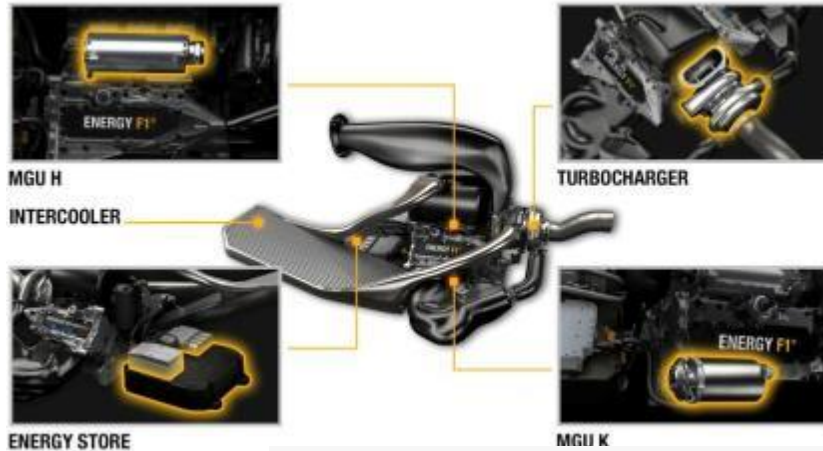
# Energy Storage Media



Energy Storage Media in the EMCAT currently is a Flywheel. However, there has been a shift to batteries and other media types



# Energy Storage for F1



Energy Storage Media is used in the F1 platforms. Flywheels were dominant, however the shift has been to batteries

Energy store is charged during braking and used during quick acceleration to save fuel and provide extra boost



# DC Distribution Summary

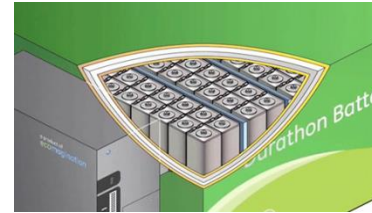
Marine Microgrid



Renewables



Energy Storage



Load Leveling (FOB)



- Not a question of AC or DC....but a question of how much of each.
- Both systems provide benefits. Need to get the best from both.
- Hybrid AC/DC systems may be best approach
- Development of key protection mechanisms still required to push the envelope on large scale DC distribution at HV

Both AC and DC Systems Will be Used to Energize the Future



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