

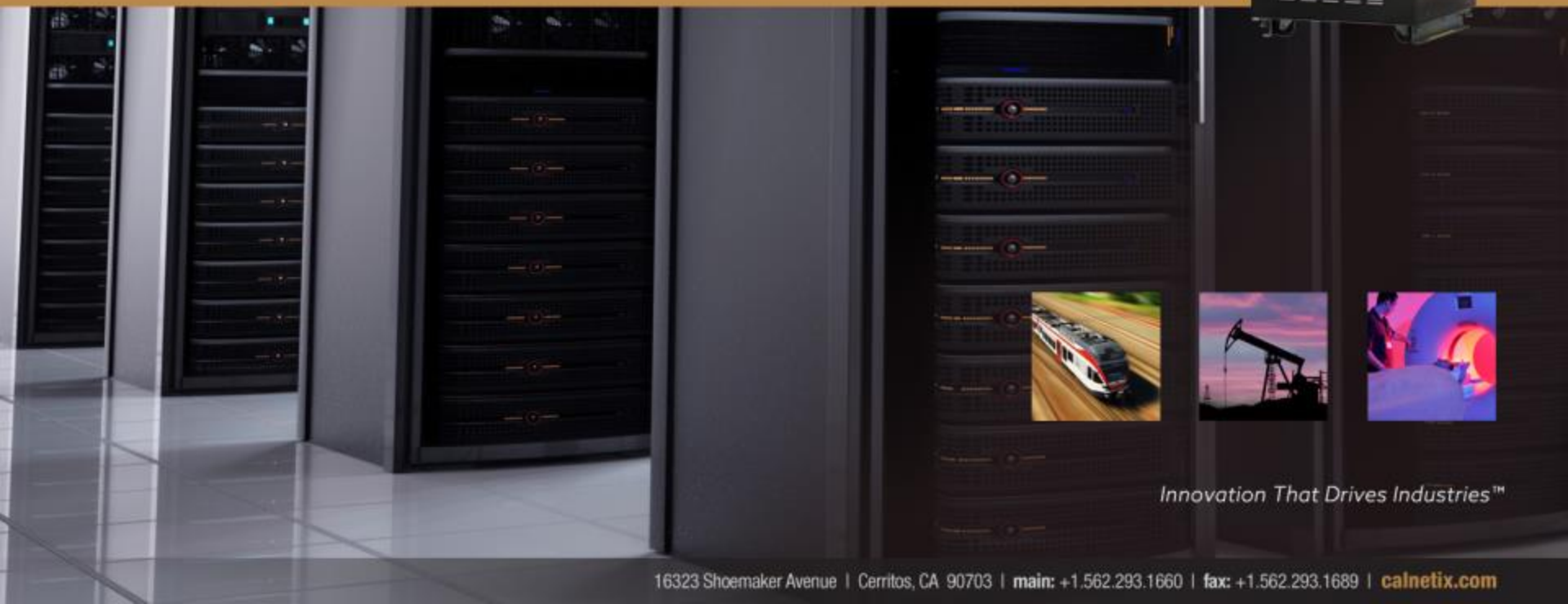


REGEN[®] for Rail Flywheel Energy Storage

Innovation That Drives Industries™

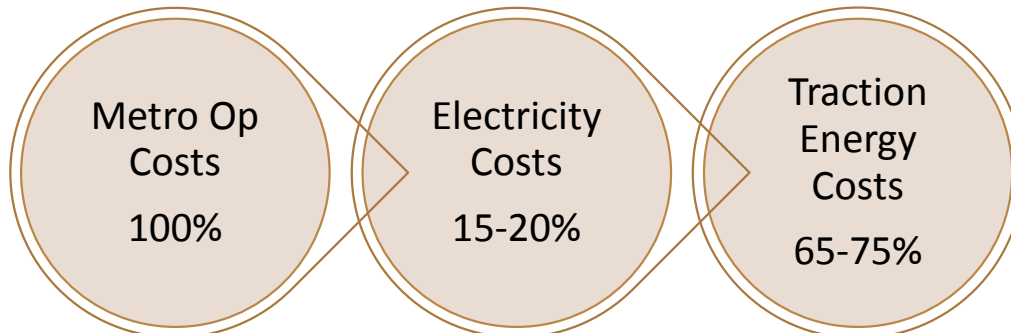
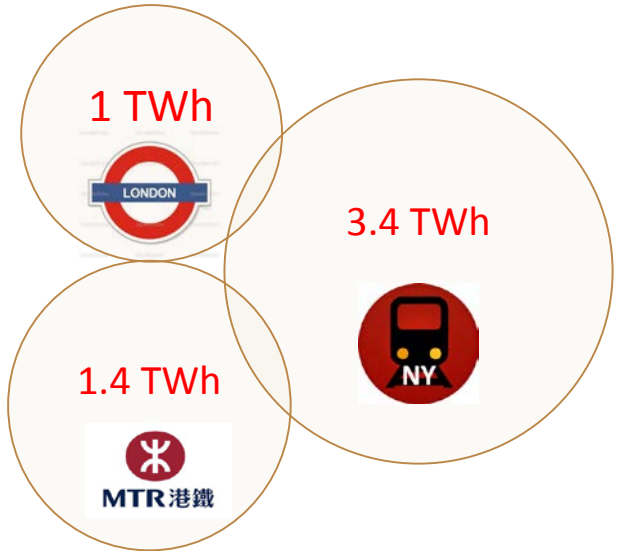
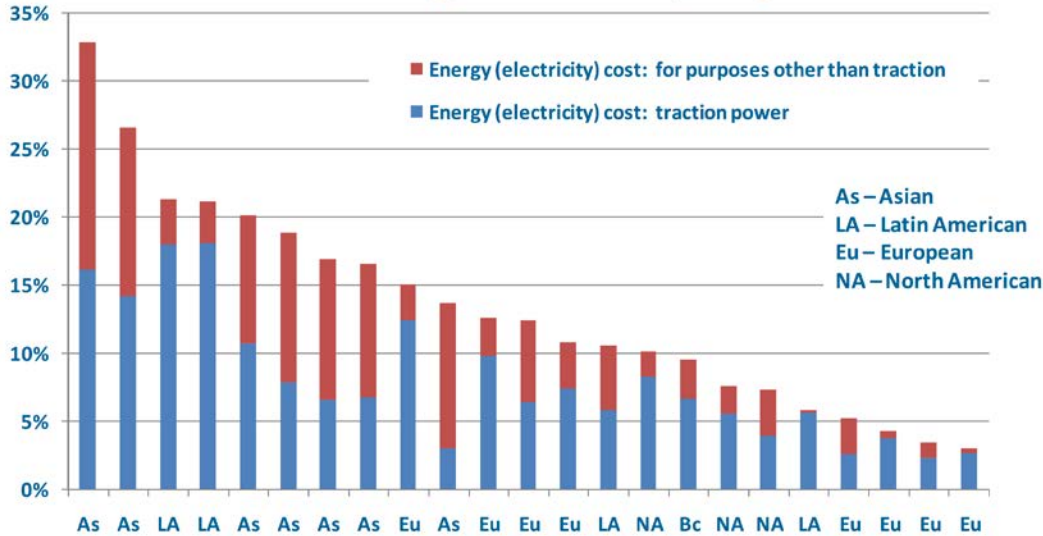


Why Store Energy in Metro Rail?

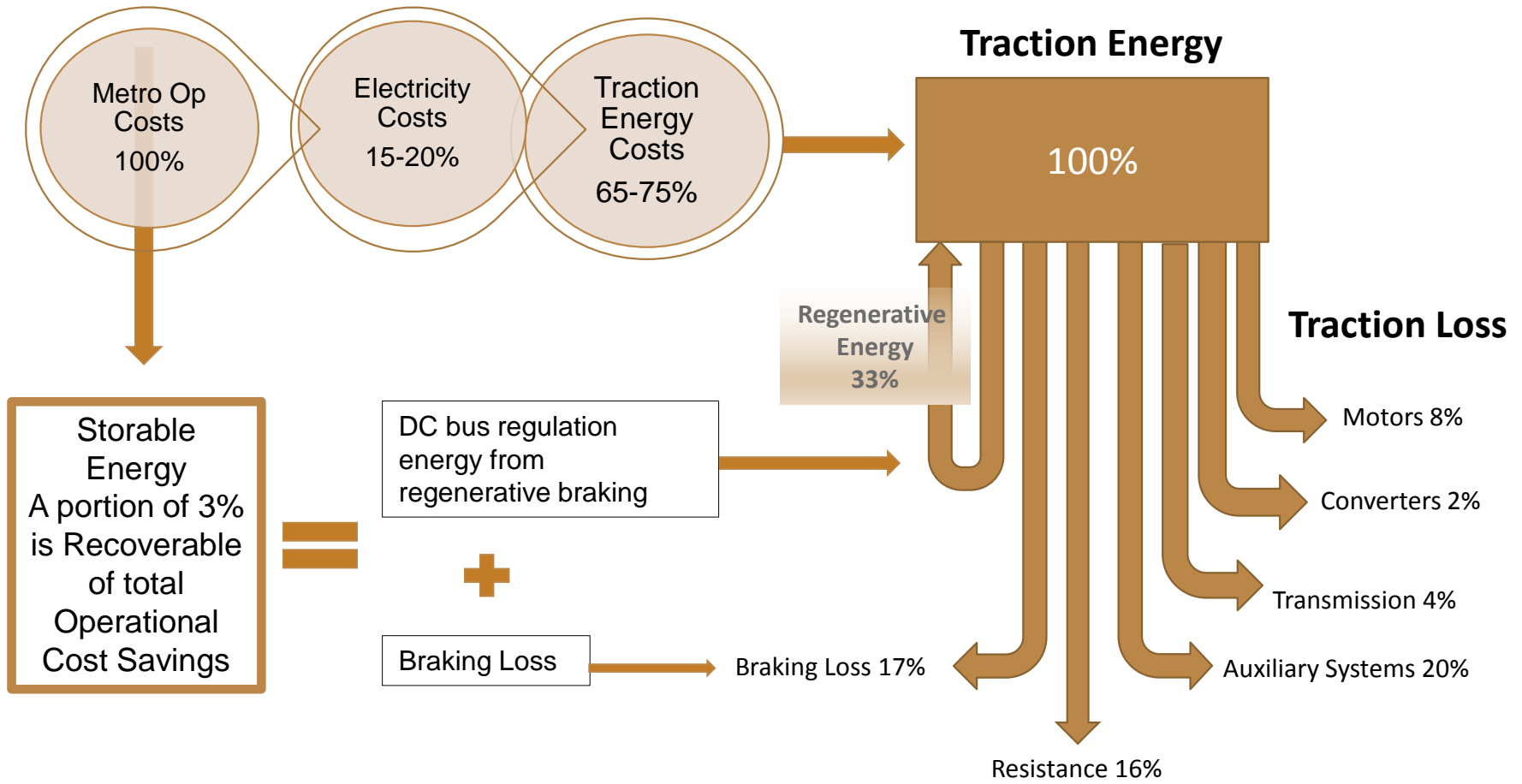


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Metro Energy Costs as % Total Operating Costs

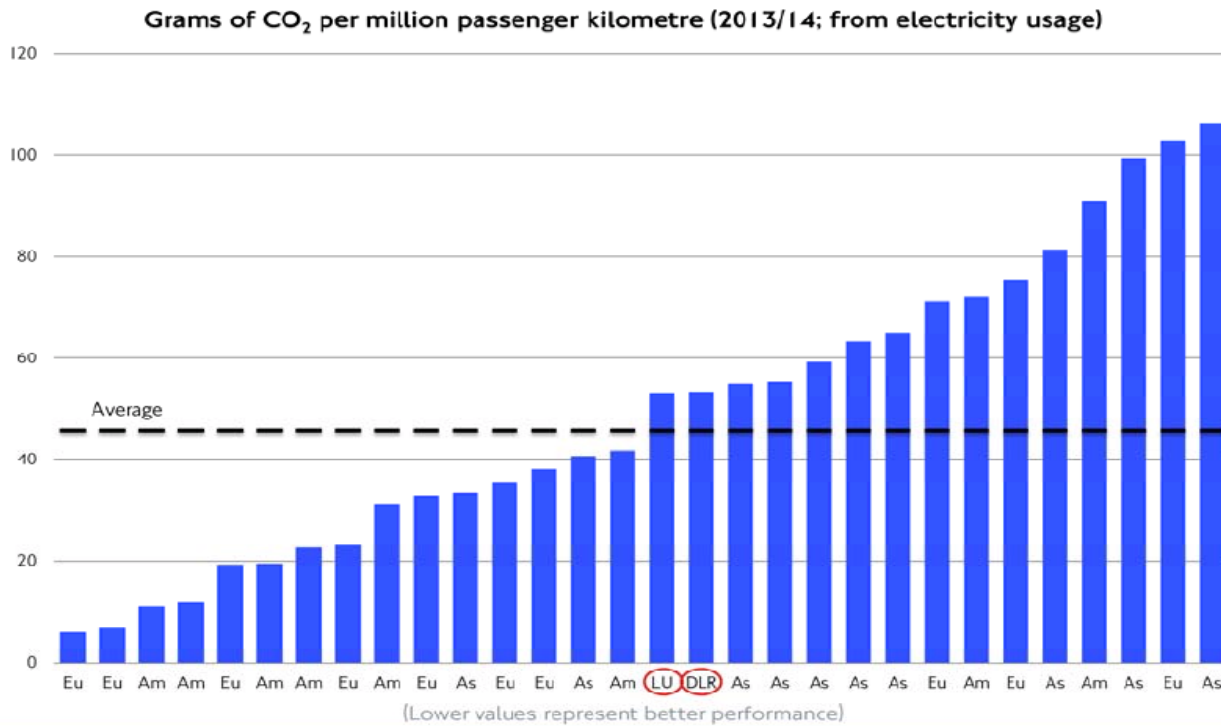


Electricity, Consumption and Losses



CO₂ Emissions of thirty large metros worldwide

Environment: CO₂ emissions 2013/14



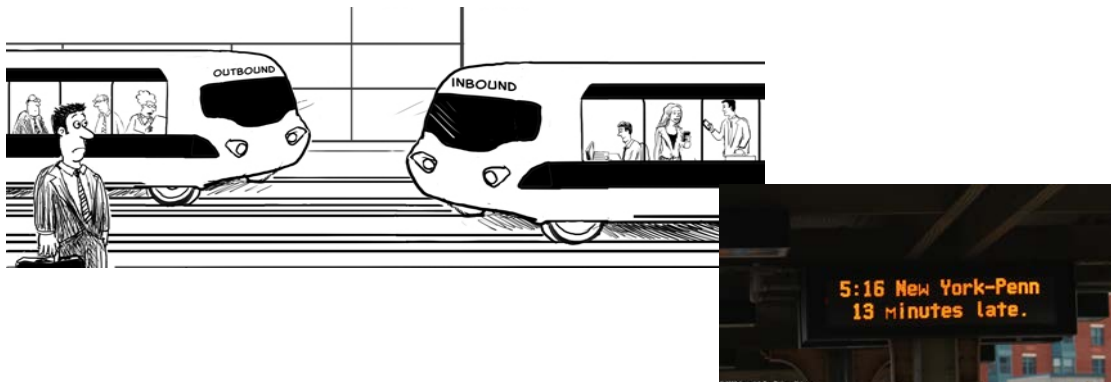
Electricity use contributes nearly 90% of a metro's carbon footprint

- In 2013/14 regenerative braking was introduced on the London Underground.
- As a result, London Underground was able to serve 3% more passenger km whilst producing 4% less grams of CO₂.

Energy Saved = Direct Lowering of CO₂ Footprint

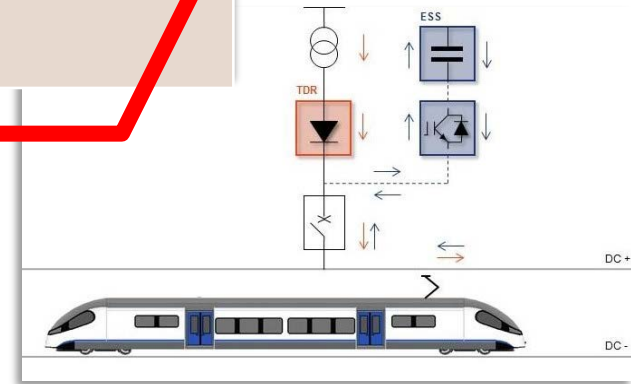
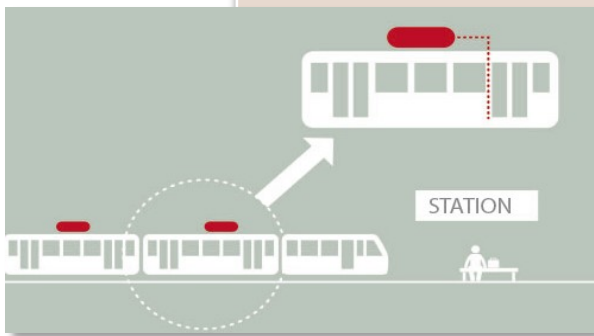
Storage is Central to Supply and Demand Inequalities

- DC to DC regenerated energy is more efficient
- Enables peak shaving and voltage regulations
- Delinks savings from scheduled synchronization
- Minimal interference with the rail network



Where?

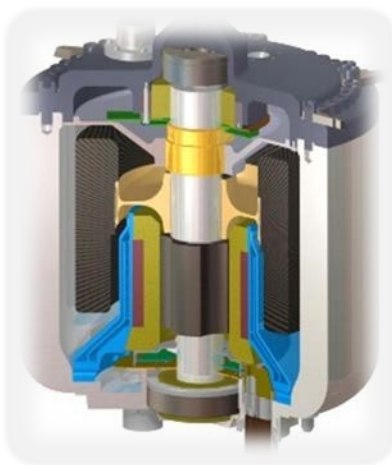
Onboard	Wayside
Lower transmission loss	Can stabilize local substation
Useable only locally in train	Can transfer between trains
Higher energy capacity required for similar savings	Lower energy capacity required for similar savings
Diminishing returns with weight	Less constrained in size and space and weight
Space-constrained	
Higher installation and operational cost	Lower costs overall
Allows catenary-free operation	





Batteries

- Longer cycle time
- High energy density
- Lower life
- Long Term Storage
- Grid Stabilization



Flywheels

- High energy density
- Very long life (virtually unlimited cycle life)
- High Conversion Efficiency
- High Energy Cycling
- Mission Critical Power Bridge



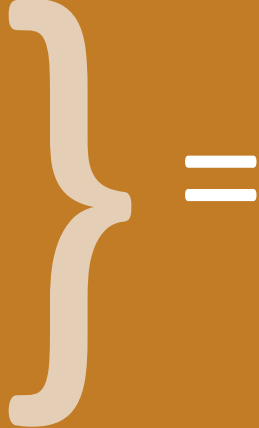
ELDC (Supercapacitors)

- Shorter Cycle times
- Limited life in cycles
- Stringent temperature constraints
- Ultra Fast Discharge
- Portable Application

Optimized Technology in One Package for Metro Rail
> Energy density > Power density > Cycle life

Attributes

- Cycle every 75 – 90 seconds
- Easy installation
- Modular units
- No need for
 - Climate control
 - Cell management
 - Special auxiliary systems
- Minimal or no maintenance

- Efficiency
 - Reliability
 - Life
- 
- Payback
Economics

REGEN[®] for RAIL



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Energy Recycling

REGEN[®] for Rail

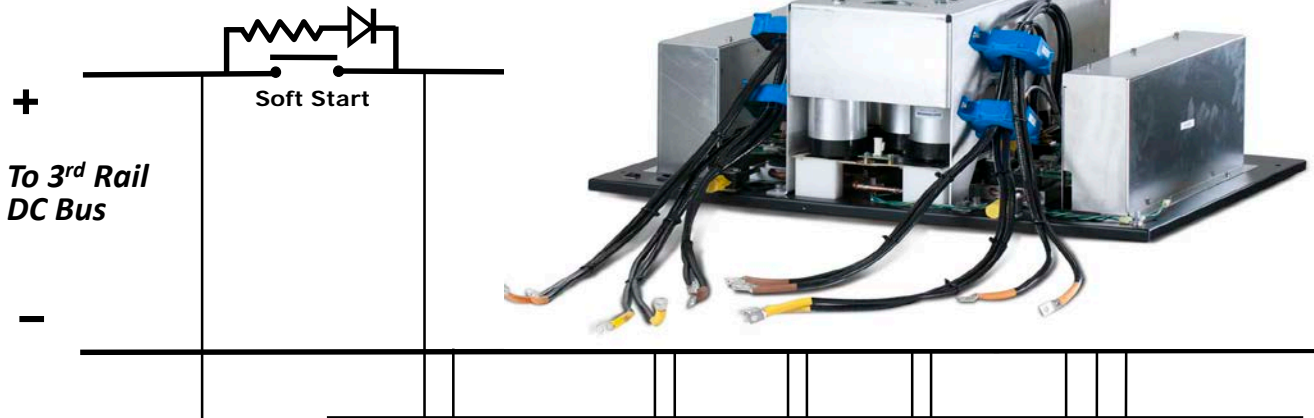
Stores and recycles energy to reduce peak loads or even out demand sags and surges

- 125kW of continuous cycling capability
- 10,000 to 20,000 RPM
- 750VDC and 1500VDC
- 18 secs charge/ discharge of full energy
- Unlimited cycling to full power (charge-discharge) every 75 - 90 seconds
- Payback of 4 to 6 years in Rail applications
- Long +20 year life

REGEN[®] for Rail



REGEN[®]
LA Metro WESS Project



Power Conversion Module & Controller

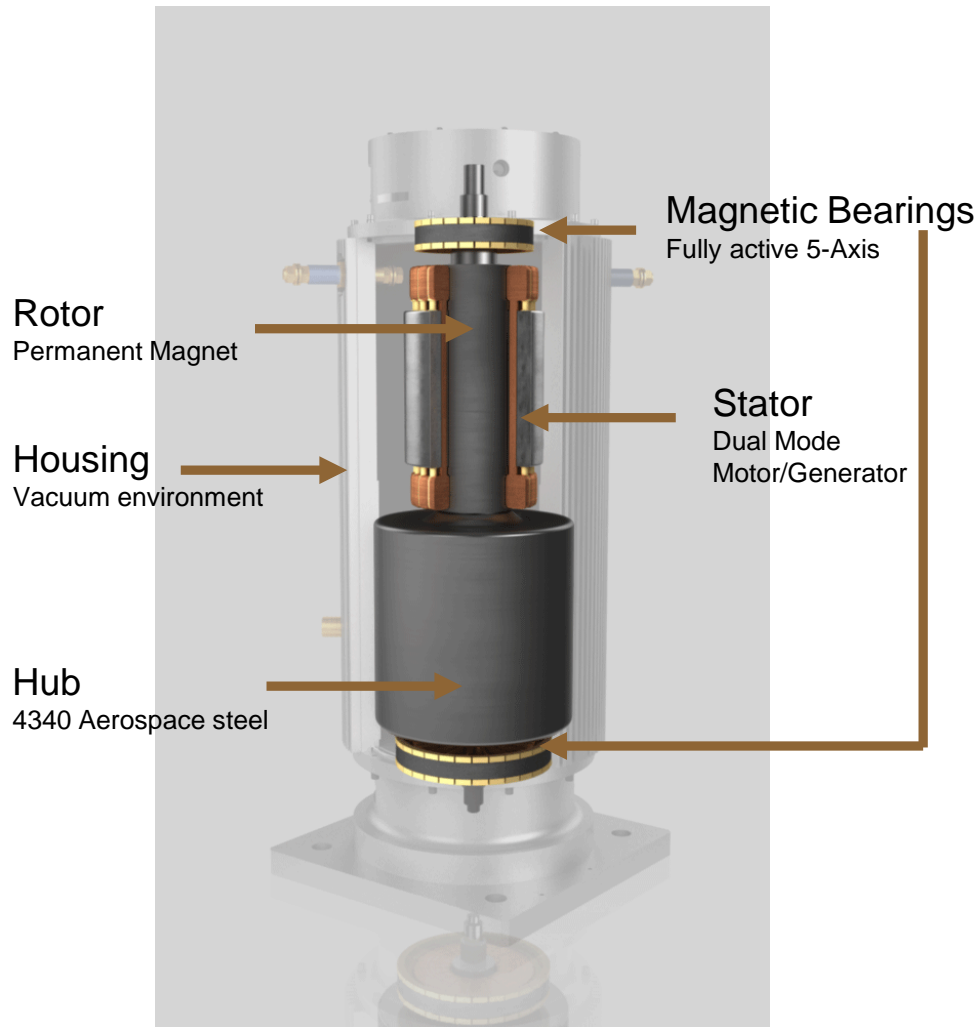


Flywheel with Magnetic Levitation Controller

User GUI

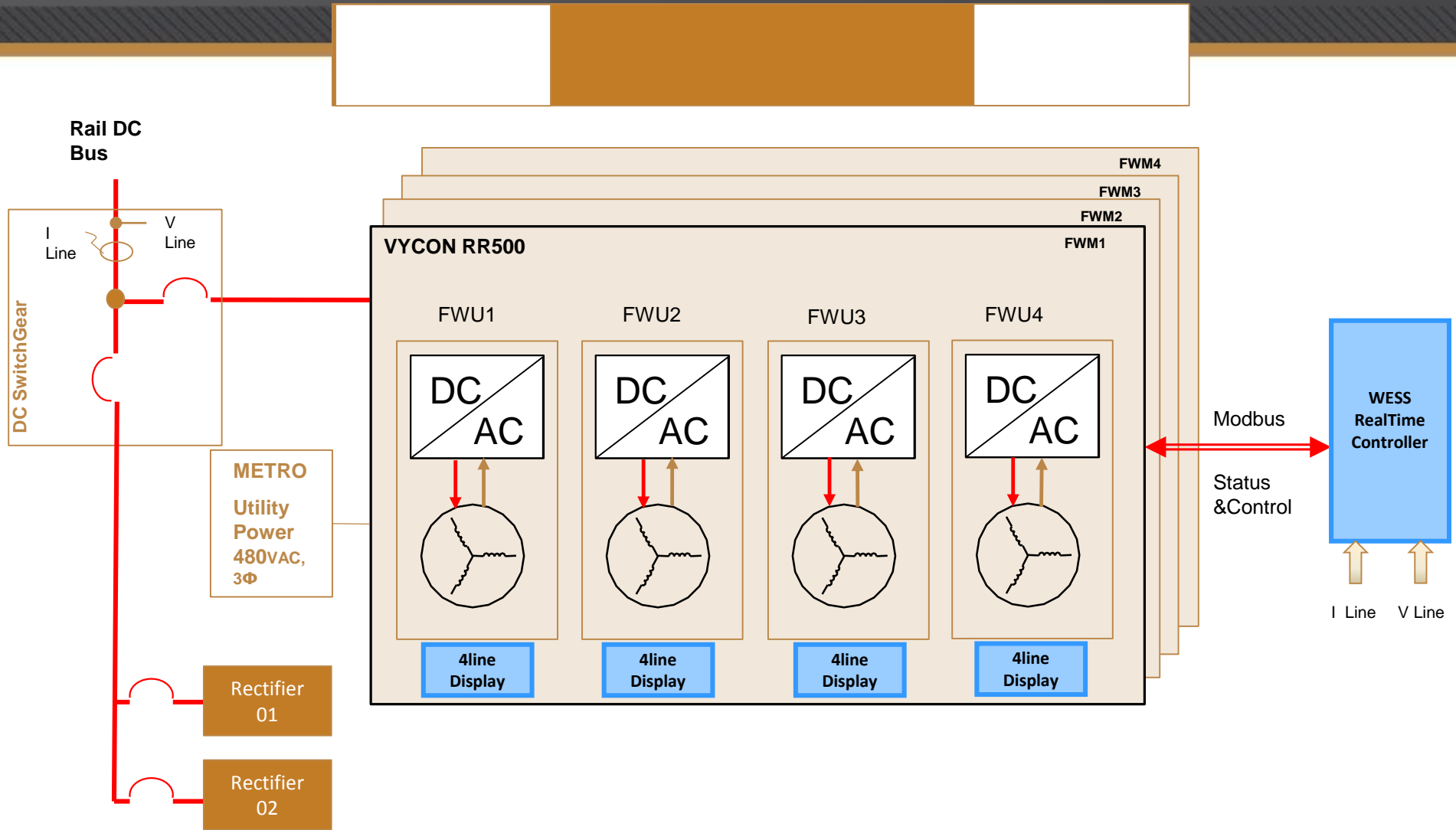


Next Generation Flywheel Design

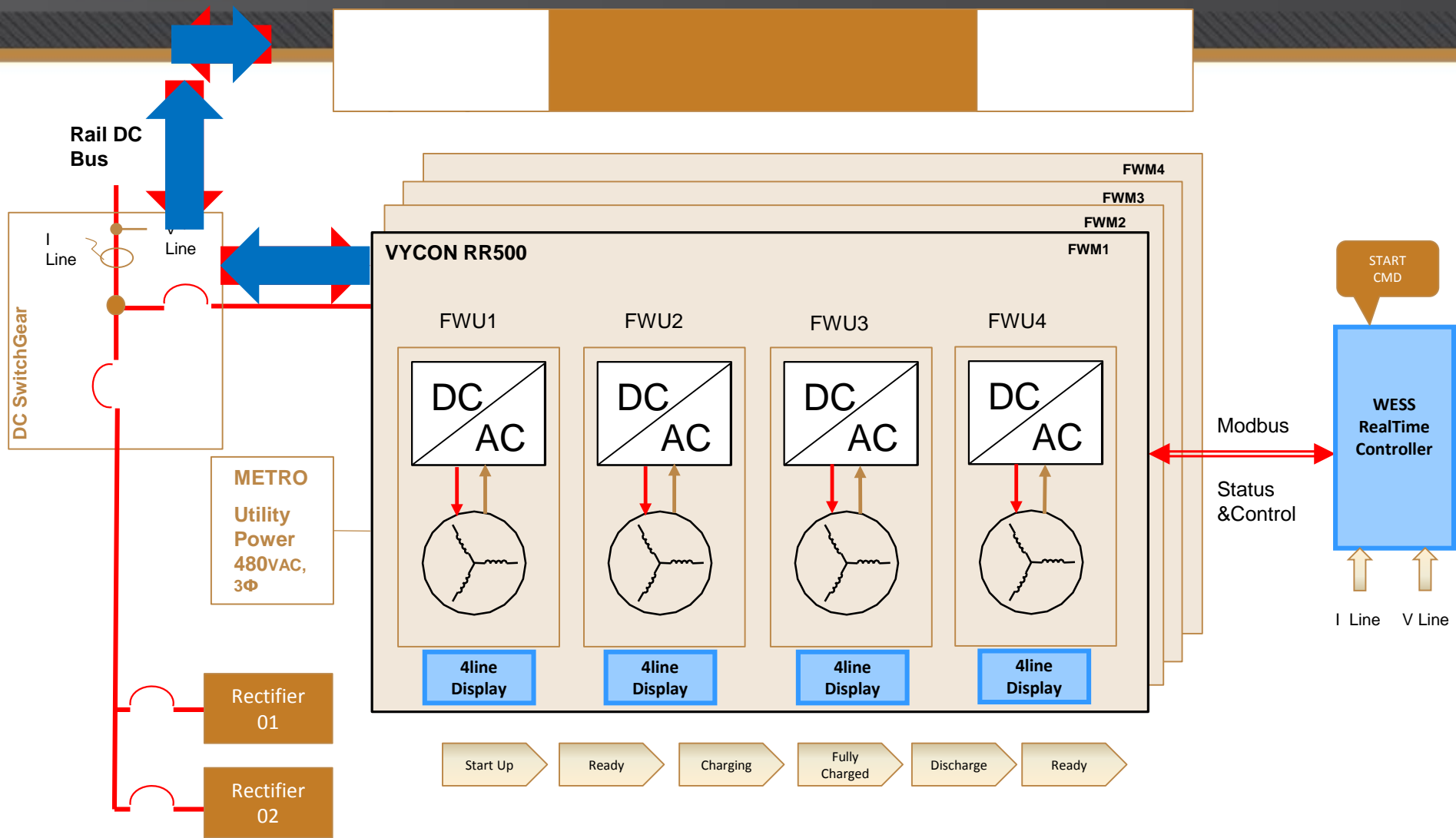


- “Mechanical battery” – stores energy by spinning a mass, produces high power output for short duration (10-30 seconds)
- Dual Mode Motor / Generator – converts kinetic energy into electricity when needed, quickly charges (converts electricity into kinetic energy) to be ready for next event
- Five-axis active magnetic levitation – eliminates any bearing maintenance, no friction losses.
- Efficient – high speed permanent magnet motor/generator in a low friction environment
- Key Benefit – 20 year operating life with no flywheel maintenance

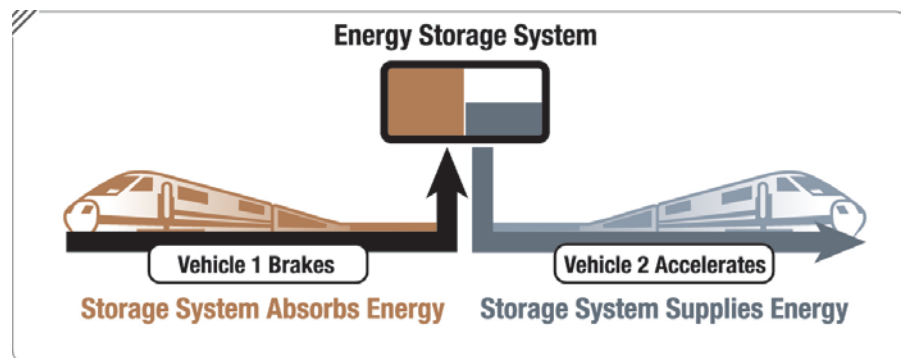
Basic Operational Sequence



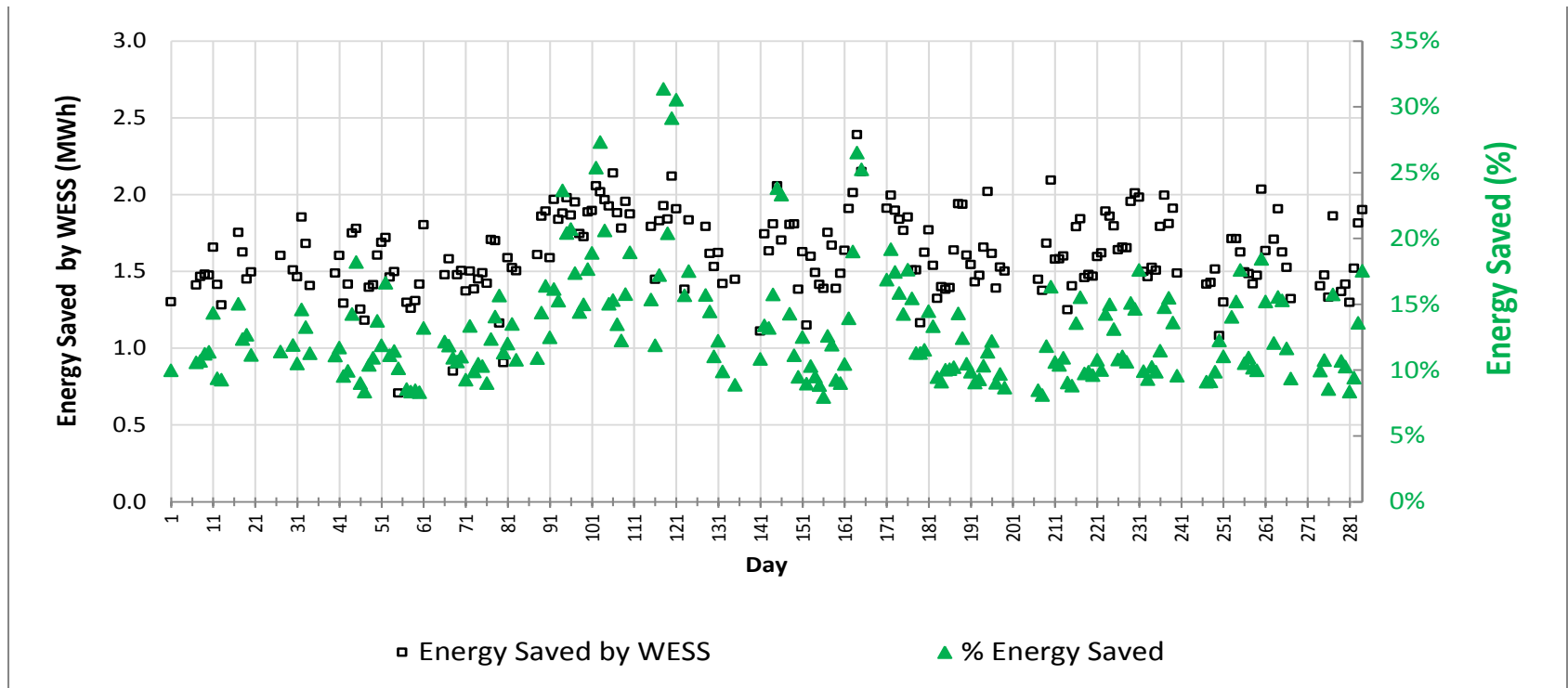
Basic Operational Sequence



- **US DoT, LA Metro, VYCON teamed up to apply a state-of-the-art WESS**
- **Scope:** 2MW / 8.2 kWh REGEN® for Rail System at Traction Power Substation
 - Ready for expansion to 6MW/24.6 kWh capacity
- **Benefits:**
 - Save Energy
 - Reduce peak power demand
 - Provide voltage support
 - Substitute for substations in a new or expanded line
- **Operating continually since 2014**
 - Continuously monitored for data analysis and operational optimization for 3 years
 - Controls capable of switching modes based on maximum benefit to Metro (energy savings vs peak power vs voltage stabilization)



LA Metro Westlake WESS Energy Saved



- Every 24 hours, WESS saves an average of 1.6 MWh or 14.2%
- Maximum Energy Saved: 31%

Everyday the REGEN[®] for Rail system at LA Metro saves an average of 1.6-1.8 MWh energy while providing:

- No maintenance
- No energy degradation
- Minimal size and weight compared to batteries or super caps
- Over 20 years of life
- No need for temperature regulation
- No health risks due to chemical leaks
- Minimal cost /kw compared to other storage devices
- Easy to add or remove modules due to changing schedules
- Real-time monitoring



- Established in field since 2003
- Subsidiary of Calnetix Technologies; largest flywheel manufacturer in the world
- Over 1,200 units operating
- Mission Critical Markets
 - UPS
 - Emergency services (Medical)
 - Defense
- Cyclic Energy Saving
 - Ports
 - Industrial
 - Rail
- Worldwide Certified OEM partners





Thank You

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Visit us at Booth #E09

