

CH2MHILL®

Energy-Storage on rail vehicles



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Energy-Storage onboard rail vehicles

- Two reasons for onboard Energy-Storage on a rail vehicle
- Can On-board Energy Storage pay for itself
- Problems and Benefits of onboard Energy-Storage

Energy-Storage can save \$\$\$ if considered at project concept

The two types of Application for Energy-Storage (ES)

1. Independent operation from a catenary / 3rd rail.
 - DART (2 vehicles for 2014)
2. To reduce consumption by capturing Kinetic Energy
 - TriMet



ES is best (for now) optimized for one or the other application

Application 1 for Energy-Storage Independent operation from a catenary / 3rd rail.

■ Cost reduction / Aesthetics / Safety

– For Electric Vehicles, the reduction of installation, maintenance, and real estate:

- Catenary
- Substations



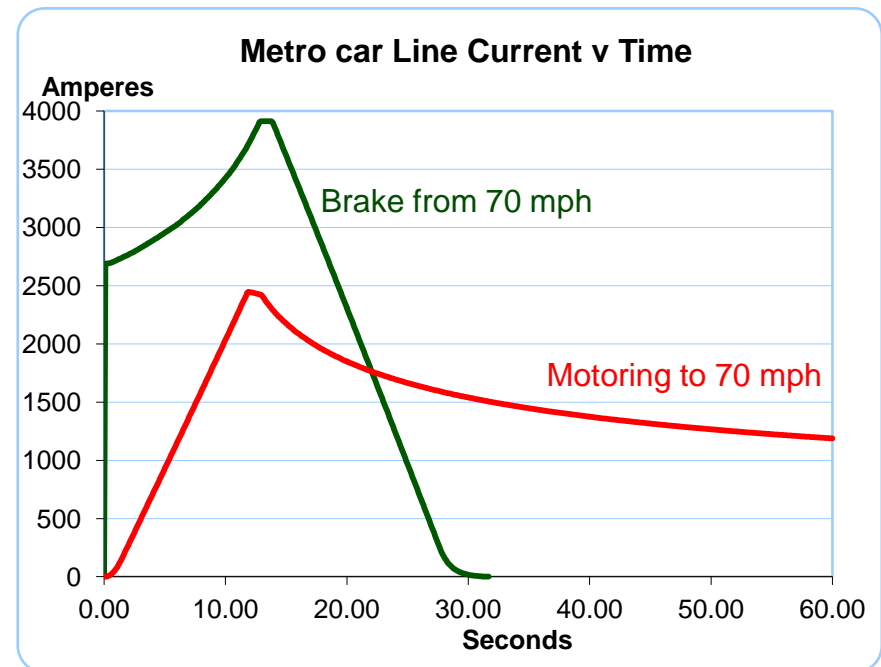
■ This application of Energy Storage has a slower cycle characteristic

– High Energy Density is essential, such as:

- Batteries; (Li-ion or Ni-MH)
- Flywheels are used by Alstom in Rotterdam and by Parry People Movers

Reduce consumption, by capturing Kinetic Energy.

- Cost reduction for all types of frequent stop start applications
 - 20% to 40% of the energy used in motoring can be reclaimed to assist with the next acceleration to either boost performance or reduce energy consumption.
 - Much more energy can be saved than by the classic regenerative brake, back into the supply.
 - Gaps in the supply rails have no effect
 - No coincidence required between vehicles braking and other (receptive) vehicles accelerating.



Technologies for capturing Kinetic Energy (KE)

- For this type of application a fast cycle, High Power Density Energy-Storage (and associated converter) is required

Proven applications are:

- Electric = Super Capacitors + IGBT converter
- Mechanical = Flywheel + continuously variable gearbox



Bus

Carbon Fiber Flywheels were adapted for the rigors of Formula One racing (KERS), but with comparable energy use they are applicable to urban buses

Application 2 for Energy-Storage (ES)

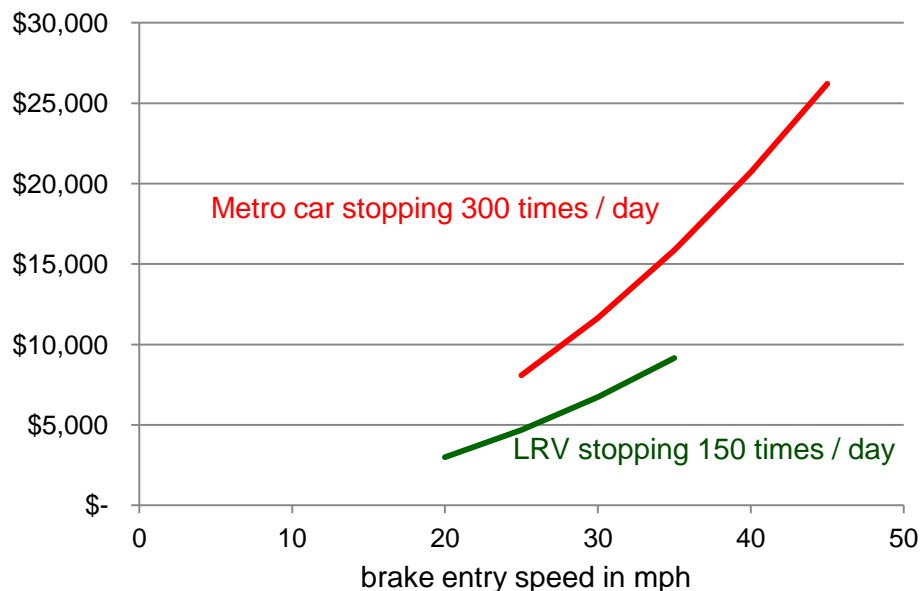
Can recycling Energy pay for the installation of ES?

	Stops /day	Brake entry	Stored Energy	Power	Energy /car /year	Payback period	Price for ES hardware
Metro	300	40mph	6.2MJ	600kW	\$20,000	10 years	<\$200,000
LRV	150	30mph	4.0MJ	400kW	\$7,000	15 years	<\$100,000



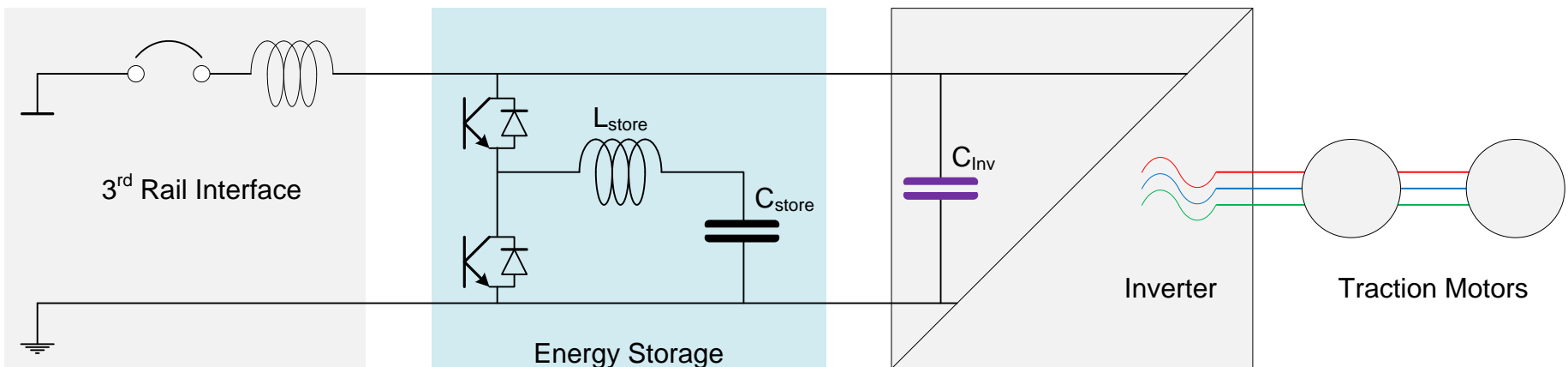
- Savings available from recovering Kinetic Energy (KE)
- Only with the careful and optimized choice of the Energy Storage (ES) hardware can recycling Kinetic Energy directly pay for itself.

Kinetic Energy (KE) value (\$) per vehicle per year
(\$0.11 / kWh)



The minus points ☹️

- Stored Energy must be respected and treated with caution during maintenance or in an emergency situation. Special precautions / procedures are necessary.
- The life for a Super Cap or Battery is a function temperature, and sized accordingly. For a long life (10 to 15 years) the elements run ~50% duty
- Energy Storage system requires space and adds weight (3% - 7% of AW2). They also have a replacement cost when the storage elements degrade.
 - For Kinetic Energy recovery; another “propulsion” case is required.



Energy Storage conclusion ☺

- If considered at project conception Energy Storage can reduce costs:
 - Reduced number of substations (20%) and areas of weak supply
 - Reduced installation of catenary / 3rd rail
 - Reduced energy consumption (20%) and peak electricity charges
 - Reduced city / tunnel heating
- On-board or Wayside Energy Storage?

On-Board	Wayside
Requires no wayside real estate	Economies of scale
Can be integrated into propulsion	Does not add to vehicle weight or space
More suitable for Bus / LRV	More suitable for Metro / Commuter