

# Improving locomotive starting performance

A comprehensive review on the application of supercapacitor starting assist technology on locomotive starting performance.

June 21, 2023



# Challenges Faced by the Rail Industry

The rail industry plays a crucial role in transportation, emphasizing efficiency, cost reduction, and environmental sustainability. With a focus on improving operational performance and reducing environmental impact, the rail industry is continually looking for technology solutions to:

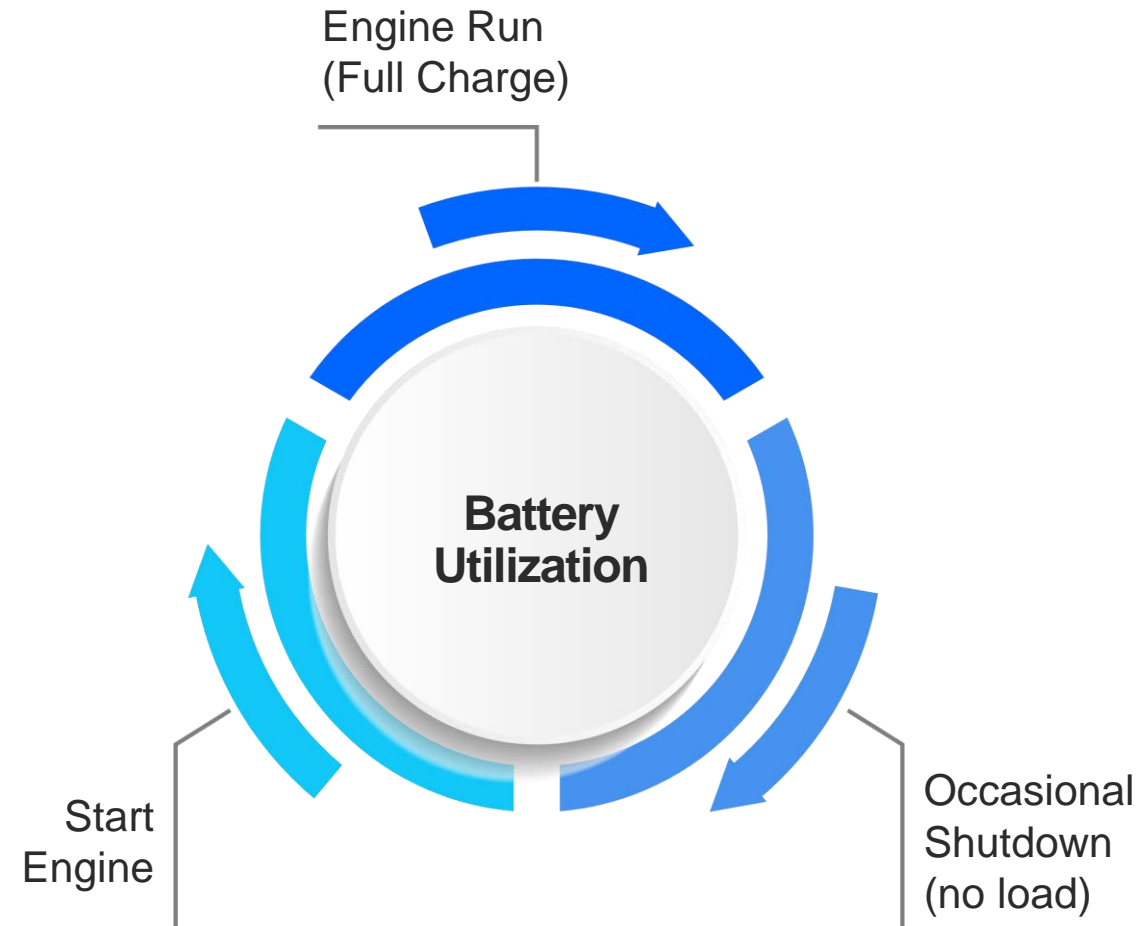
- Improve locomotive efficiency
- Reduce Operating Costs
- Increase environmental sustainability

This has led to the **proliferation of technologies** to achieve the above goals, but have had an undesired impact on availability, fuel consumption and emissions. **It all starts with the batteries.**

# Battery Health Wasn't a Problem Decades Ago

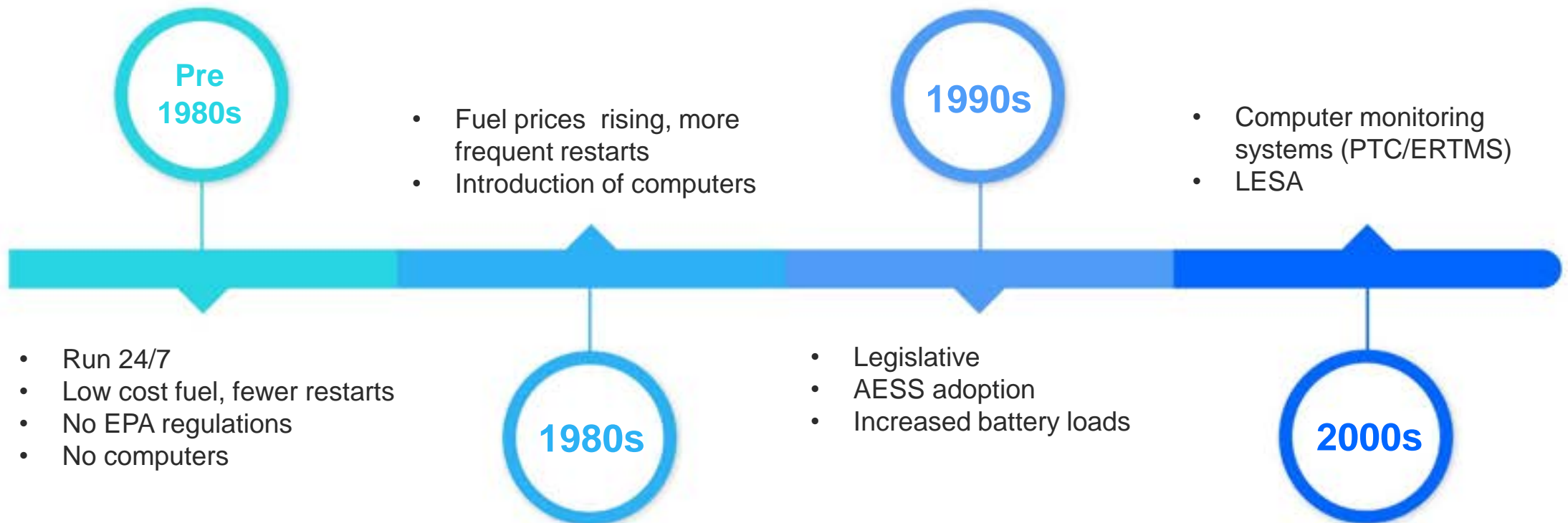
Starting lead acid batteries were used solely for starting purposes (as intended):

- **Decades ago:** Lead Acid Batteries lived a happy life and utilized as intended for use
- **Charging:** Healthy – engines ran a long time
- **Start/Stop:** Infrequent – long engine idle times
- **Hotel Loads:** No electronics to power



# Battery Utilization Changed

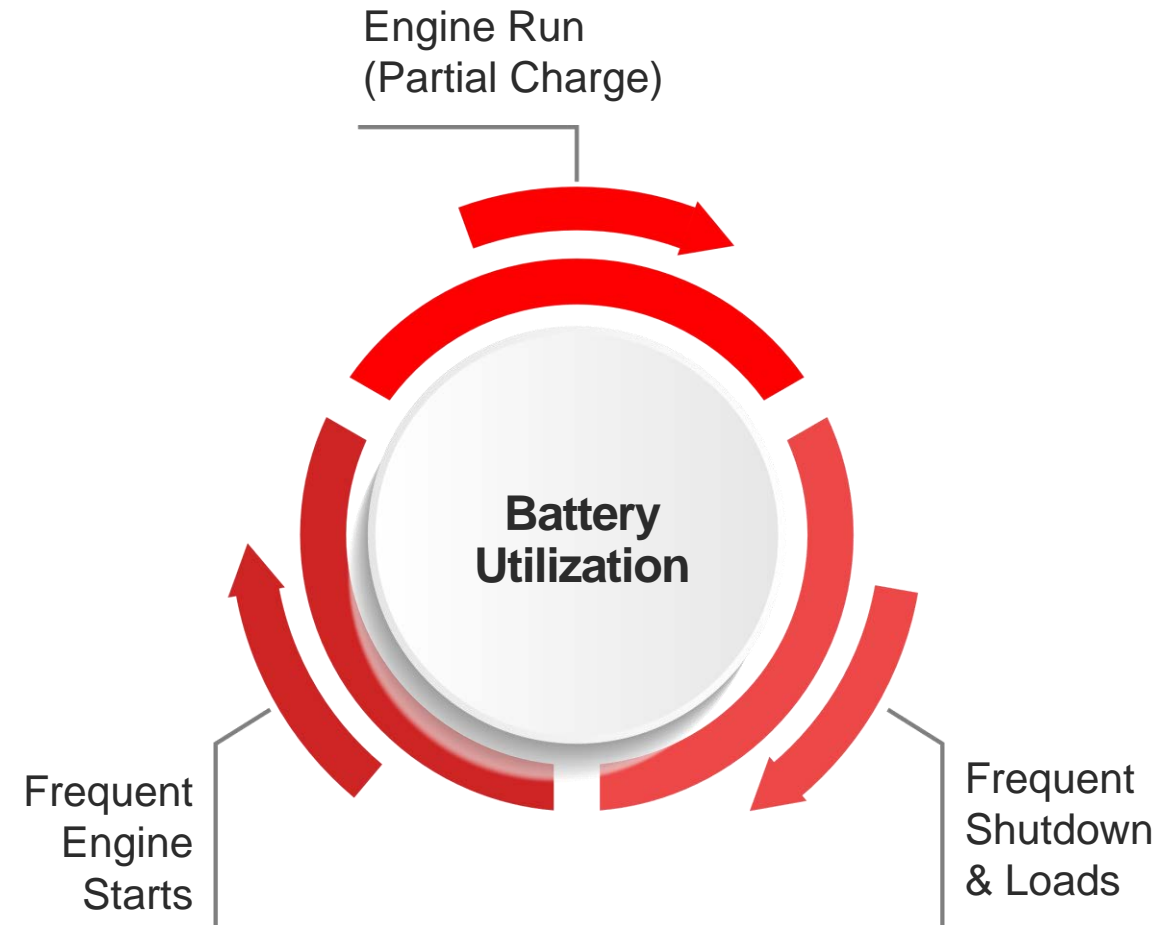
Rising fuel cost, legislation, proliferation of cab electronics resulted in lead acid batteries being used for unintended purposes.



# Batteries Now Under Perform

Today batteries are no longer meeting the required needs of a locomotive:

- **Charging:** Inadequate – less engine idle time
- **Start/Stop:** High – more taxing on batteries
- **Hotel Loads:** High – not strength of lead acid batteries







# Cascading Effect of Impacted Batteries



Poor battery health has a cascading affect:

- Failed engine starts (dead won't start) which results in operational disruptions and locomotive availability
- Reduced effectiveness of AESS - these systems must idle until the batteries are charged and restart the locomotive when battery voltage drops to a certain point. Batteries in poor state will extend AESS idle time, and reduce shutdown time negatively impacting fuel savings
- Reduced fuel savings directly impact decarbonization initiatives

# A Solution to These Challenges

Supercapacitor starting assist technology is an excellent means by which to address these issues and at a sensible cost.

We will now provide a thorough technical and financial assessment of applying supercapacitor starting assist technologies to avoid dead-won't start events while also reducing unscheduled locomotive battery and starting system maintenance

The analysis uses data collected from the ZTR KickStart supercapacitor solution – a technology that has already been installed on thousands of locomotives globally – and demonstrates how this type of technology can:



Improve locomotive availability



Reduce fuel consumption



Lower emissions



Provide a good return on investment



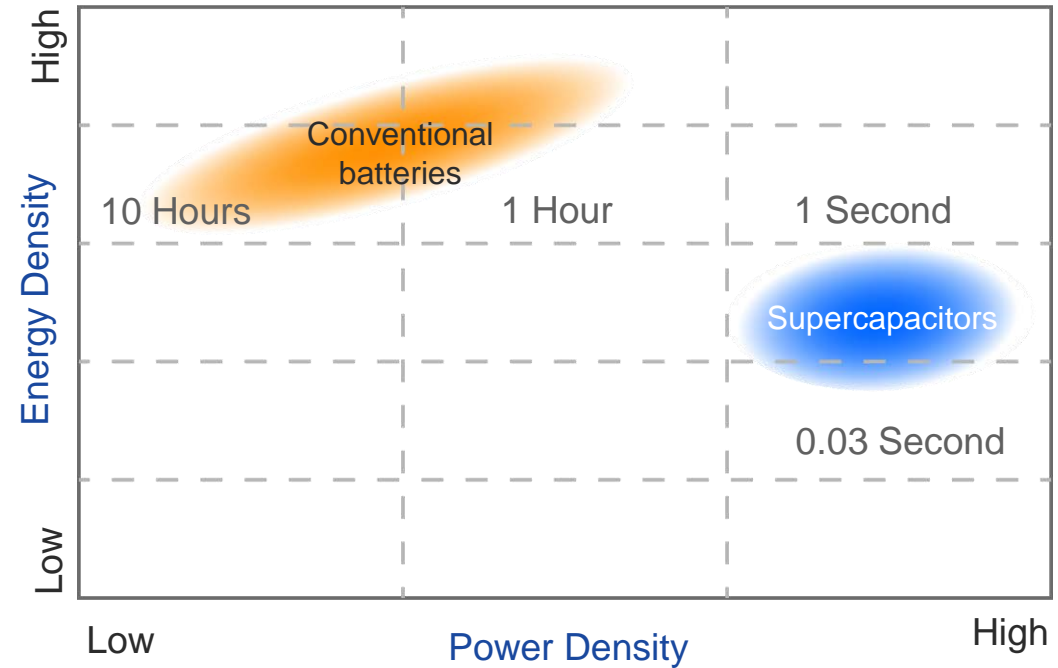
# Supercapacitor Starting Assist Technology

Supercapacitor starting assist technology is a modern and effective solution designed to improve locomotive starting performance. It utilizes supercapacitors, high power energy storage devices, to provide instantaneous power during engine cranking. The technology ensures reliable engine starts, reduces battery stress, and enhances overall performance.



# Supercapacitors vs Lead Acid Batteries

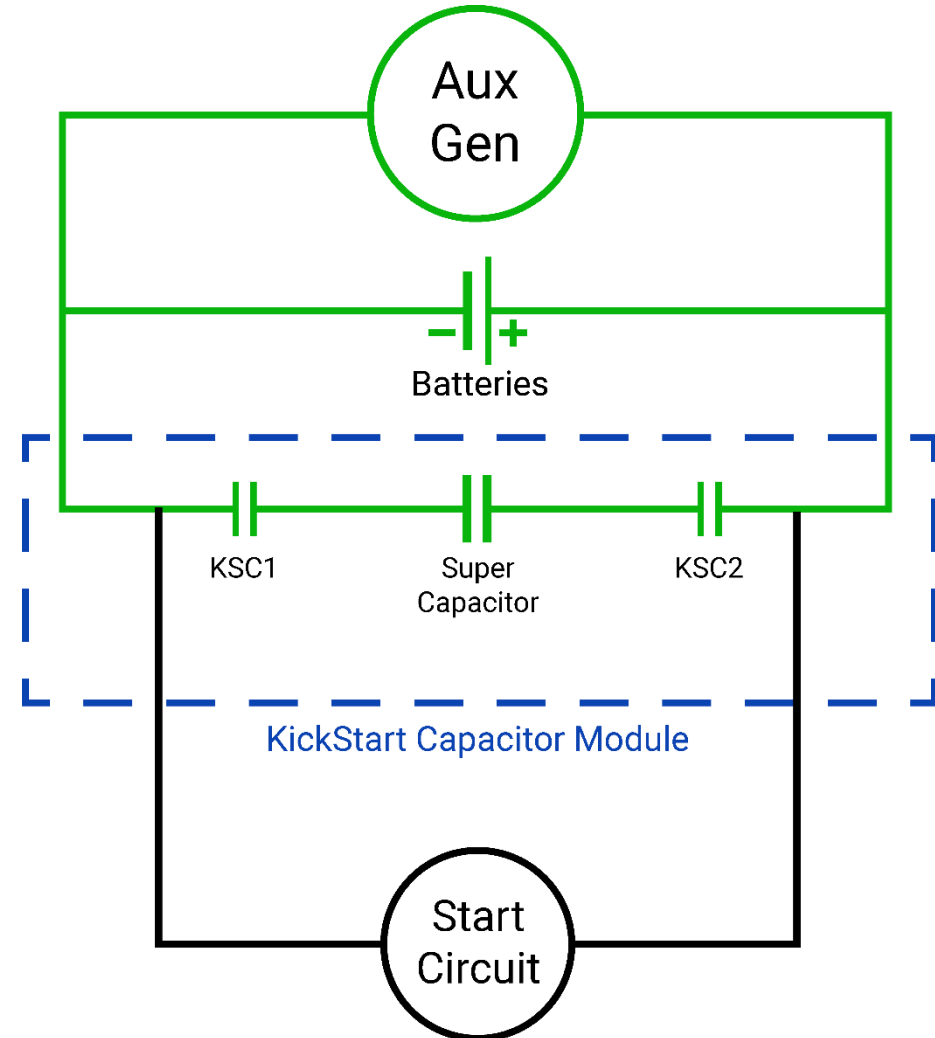
- **Supercapacitors** have higher power density than batteries
- They are able to recharge quickly and discharge energy at a rate much faster than batteries, resulting in reliable engine starting performance
- Supercapacitors also have consistent performance across a wide temperature and, unlike lead acid batteries, they are not impacted at colder temperatures



# How Supercapacitor Starting Assist Works

Supercapacitor starting assist technology works by utilizing the stored energy in supercapacitors to provide a burst of power during engine cranking. Here's a simplified overview of the process:

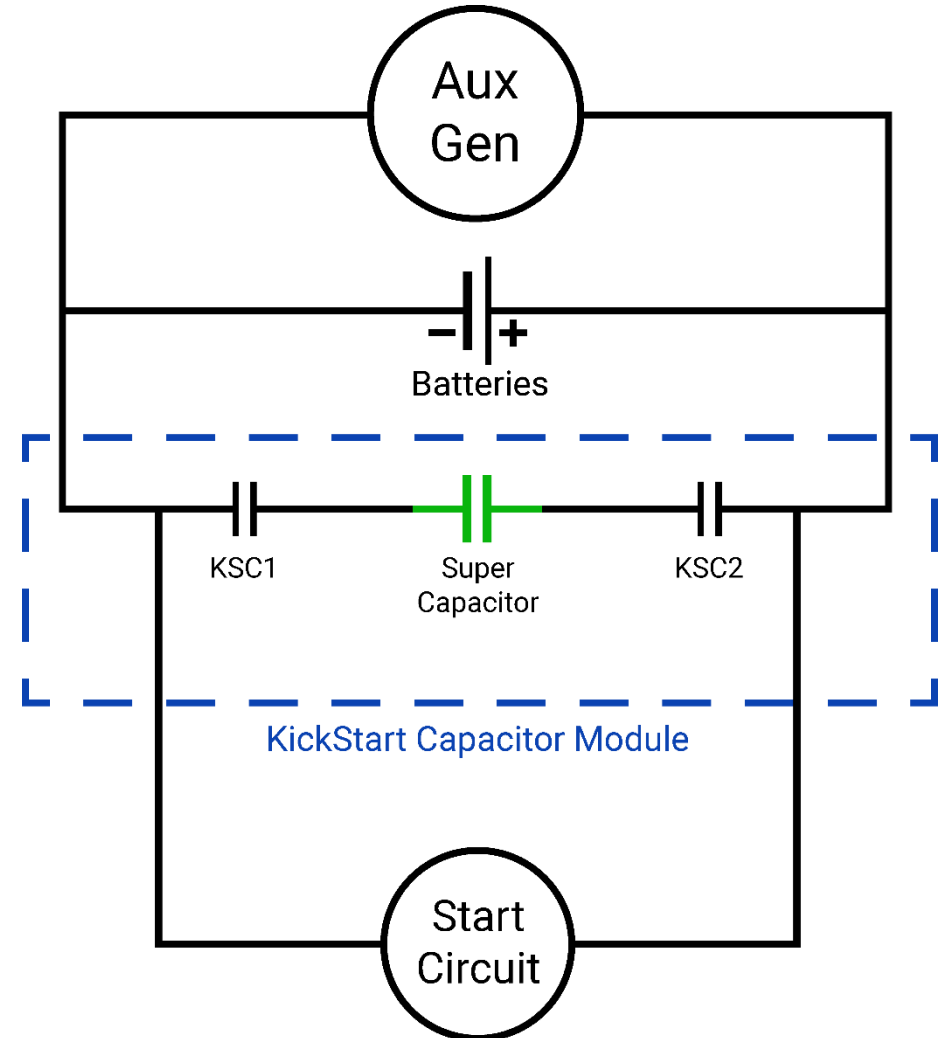
1. When the locomotive engine is running the supercapacitor charges from the auxiliary generator



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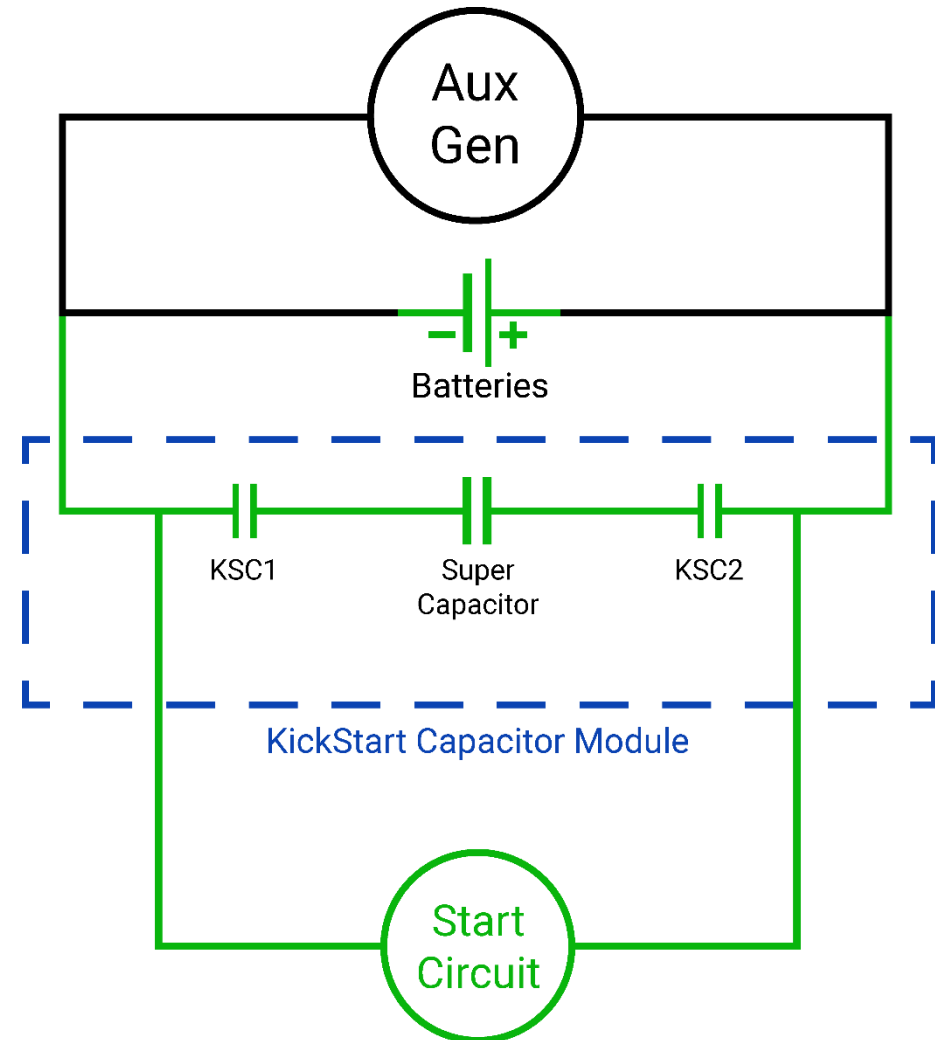
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# How Supercapacitor Starting Assist Works

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1. When the locomotive engine is running the supercapacitor charges from the auxiliary generator
2. When the engine is off, the supercapacitor is isolated from the battery system and maintains its charge
3. During the engine crank cycle, the supercapacitor connects with the battery to the starting circuit, providing the peak current (torque) to successfully start the engine



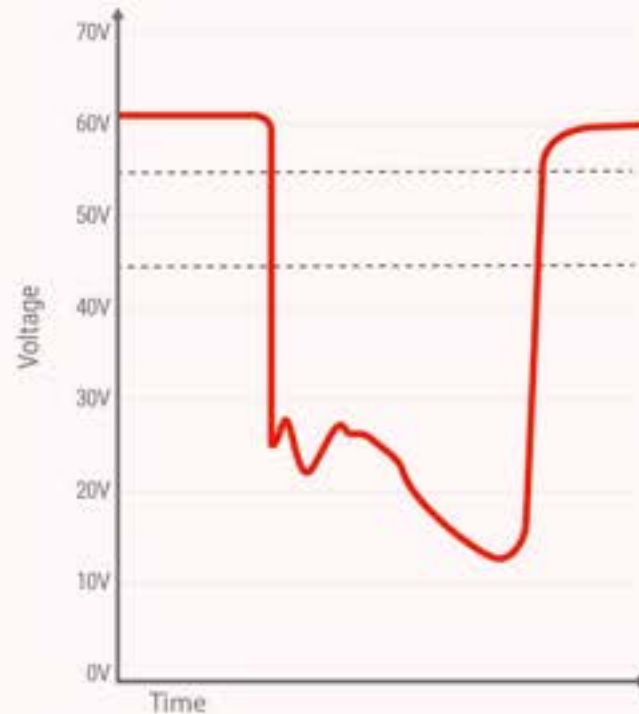


# Improving Locomotive Availability

Batteries are one of the leading causes for engine starting problems. Once the voltage drops below the dropout voltage, the onboard electronics will cycle and the cranking will cease causing a dead-won't start.

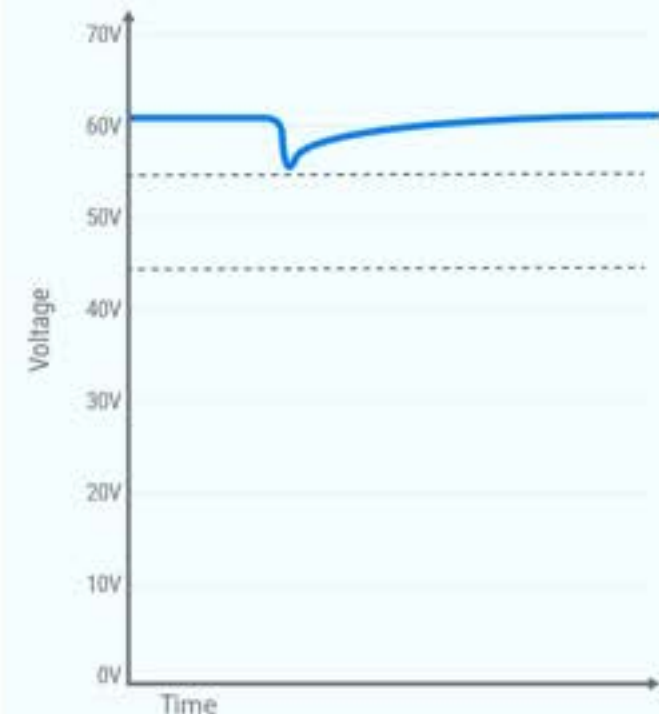
With a supercapacitor starting assist solution, the initial kick provided results in a higher engine rotating velocity, which means less voltage sag.

**Engine Restart Without Supercapacitor Starting Assist**



Showing a failed start due to the engine crank causing voltage to drop below 55 volt threshold.

**Engine Restart With Supercapacitor Starting Assist**



Showing a successful engine start using a supercapacitor starting assist.

# Improving Locomotive Availability

On average, a locomotive will have a dead-won't-start once every 3 years that is caused by weakened batteries. This is avoidable with the implementation of supercapacitor starting assist technologies.

## Dead-Won't-Start Cost

The cost of a DWS ranges from about **\$4,000** to more costly mainline failures that can have financial implications up to **\$45,000** per instance.

Avoiding one DWS every 3 years per locomotive across a fleet of 1,000 locomotives, at an average cost of \$21,000 per DWS, would save a railway over \$7,000,000 each year.



# Extending Battery Life

The typical battery life of a lead acid battery in a locomotive application with an AESS is expected to be about 2 years. This life can be doubled to an expected 4-5 years by installing a supercapacitor starting assist system.

At a typical battery replacement costs of \$6,000 per locomotive, the supercapacitor system can save about \$6,000 to \$12,000 in battery replacements over 5 years.



Save

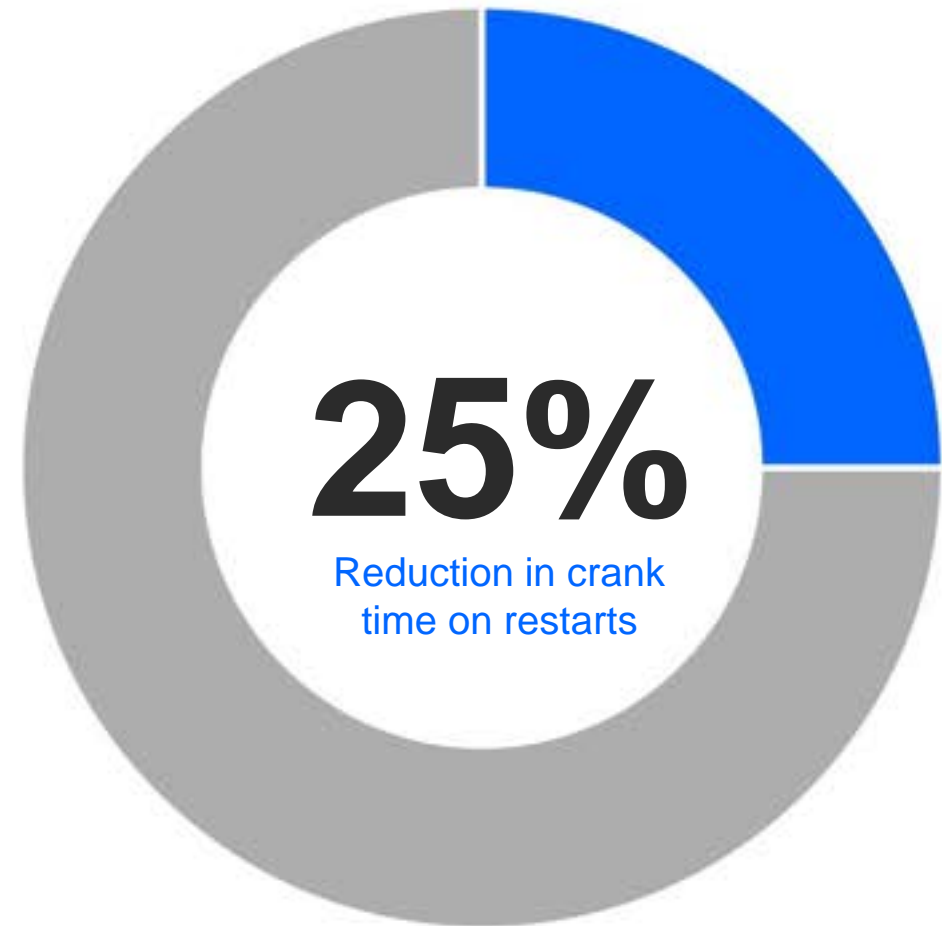
**\$12,000**

in battery replacements  
over 5 years

# Improved Start Performance

## Case Study: Reduced Crank Time

The KickStart supercapacitor starting assist technology has demonstrated the ability to reduce crank time on restarts by 25% thus cutting the current drawn from a battery while also minimizing wear on starting systems.

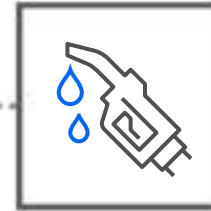




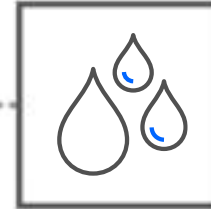
# Reducing Locomotive Fuel Consumption



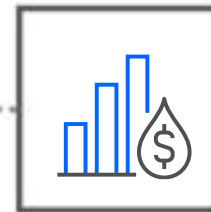
Fuel consumption is a critical driver of locomotive operating expense.



It's the second largest expense for a railway



4-5 gallons per hour while idling up to nearly 200 gallons per hour for larger locomotive engine sizes in use



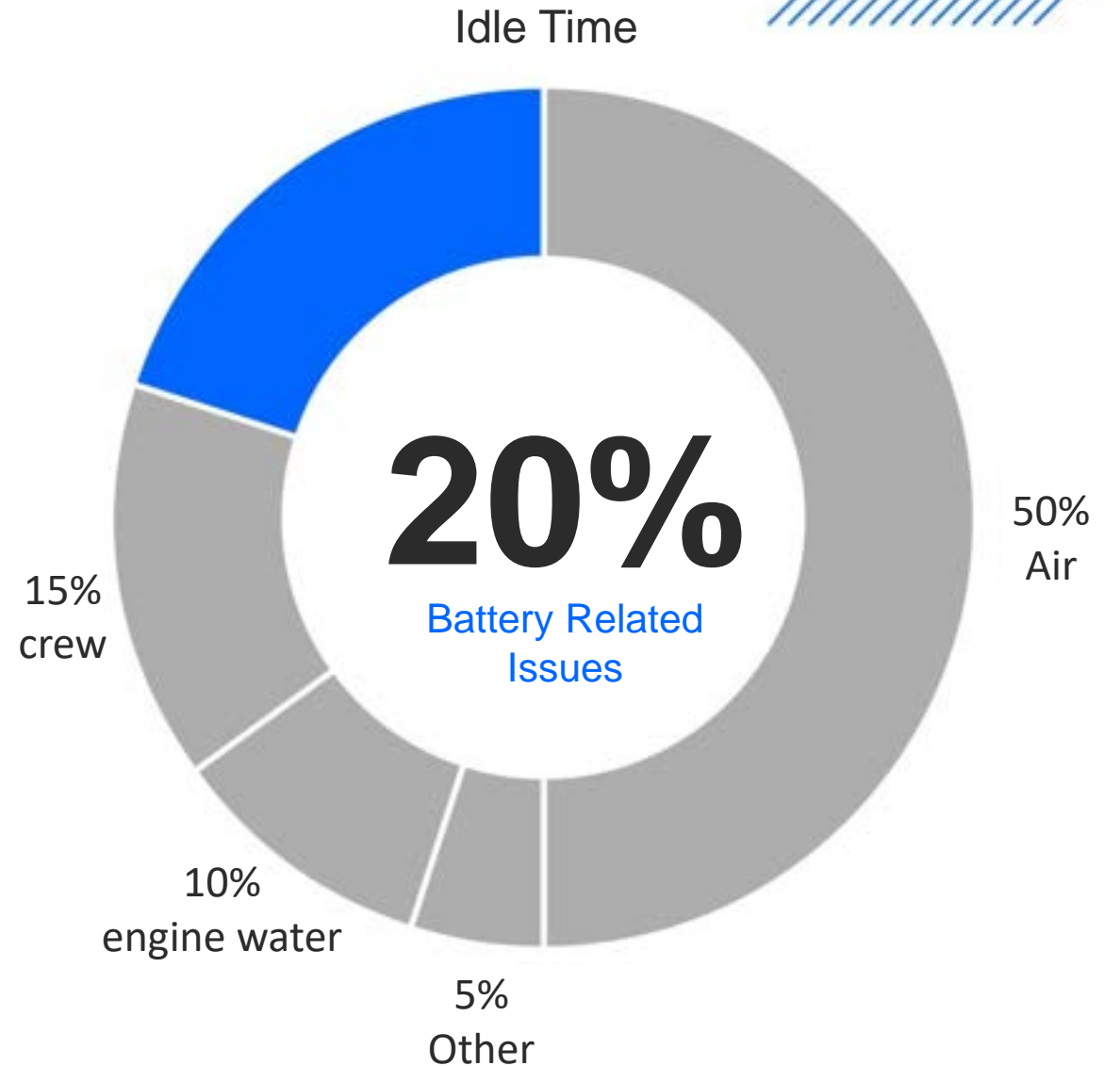
Cost over \$800 in fuel per hour of operation.

# Reducing Locomotive Fuel Consumption

## Case Study:

Reduction in AESS Idle Time

- 20% of locomotive engine idling is caused by battery related issues.



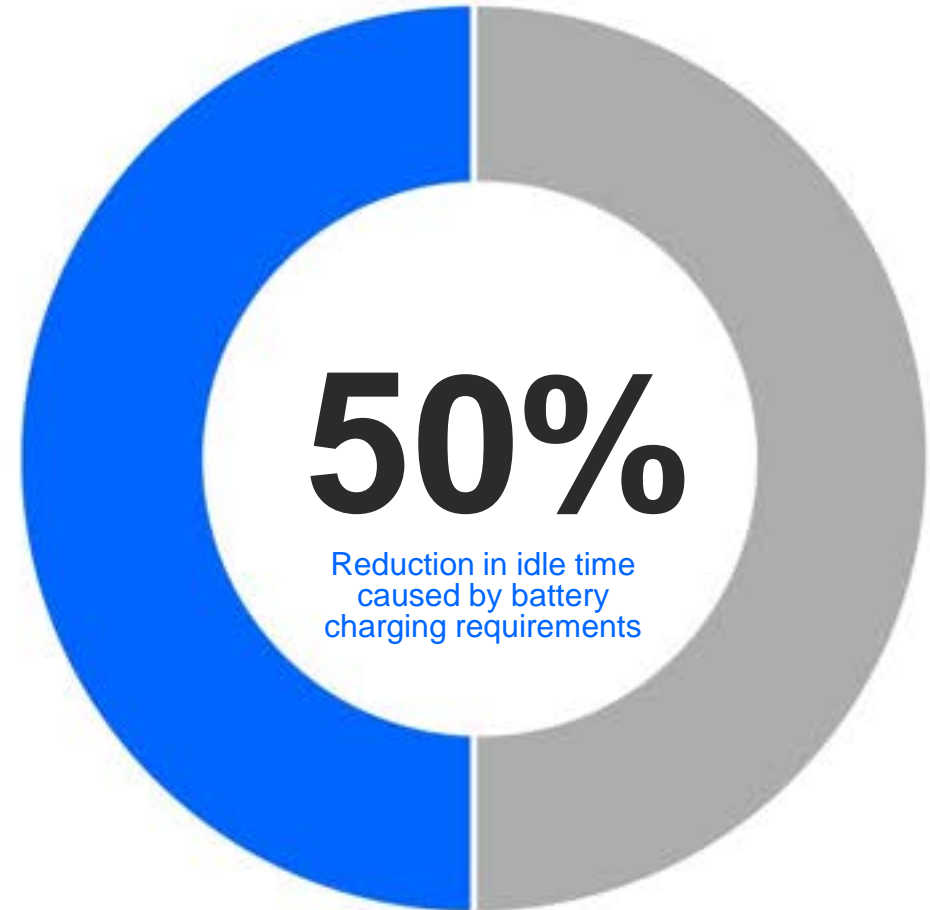
# Reducing Locomotive Fuel Consumption

## Case Study:

Reduction in AESS Idle Time

Installations of KickStart supercapacitor systems on SD40-2 locomotives

- 50% reduction in time waiting for batteries to charge
- This is a 50% reduction in the amount of idle time caused by battery charging requirements; going from 36 to 18 hours per locomotive per month.
- Provided an additional 18 hours of shutdown time per month per unit

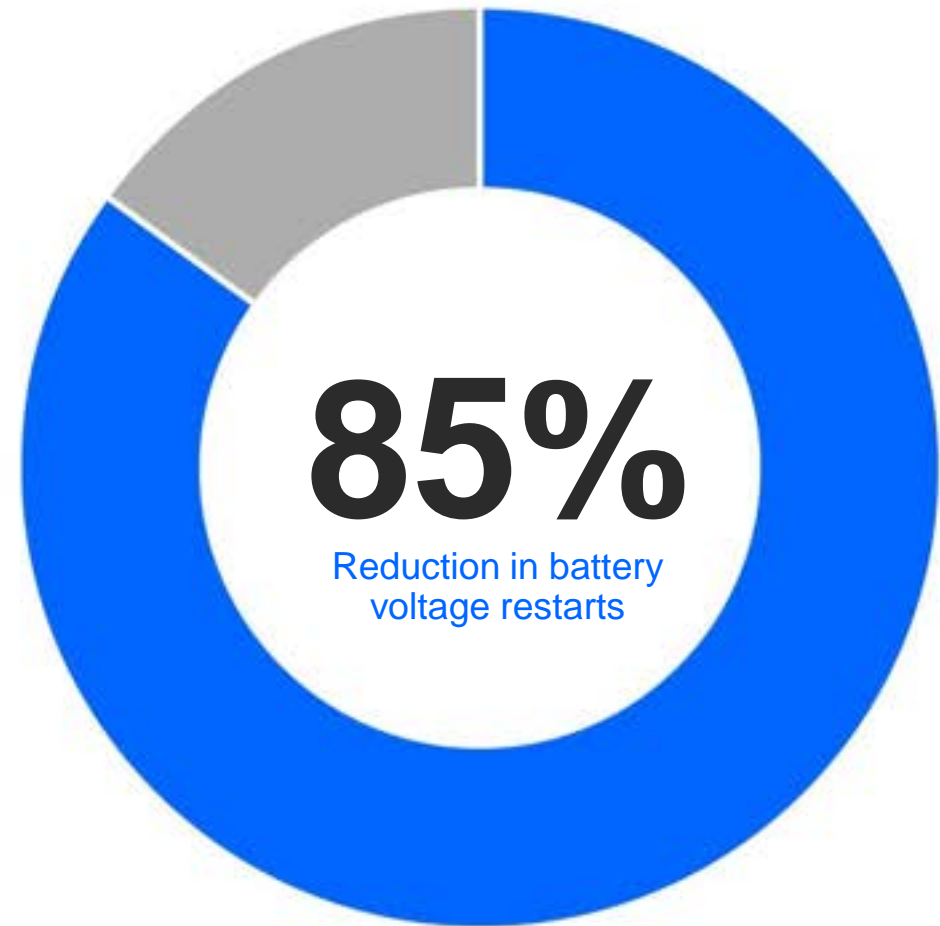


# Reducing Locomotive Fuel Consumption

## Case Study:

Reduction in AESS Idle Time

- The KickStart supercapacitor starting assist technology has demonstrated the ability to reduce battery voltage restarts by 85% thus extending engine shutdown time and saving fuel





# Reducing Locomotive Fuel Consumption

## Case Study:

Reduction in AESS Idle Time

- This reduced fuel consumption by over 1,080 gallons per year per locomotive.
- This equates to roughly \$4,320 per locomotive per year.

**\$4,320**  
Yearly fuel savings

# Reducing Locomotive Emissions

Supercapacitor starting technologies can prevent 10.99 tons of CO2 per year per locomotive that they are installed on.

A fleet of 1,000 locomotives equipped with supercapacitor starting assist technology could cut 10,990 Tons of CO2 each year which is equivalent to:



2,219  
cars



11,889  
Acres of  
forest

# Reduction in air quality contaminants

**7,181**

grams of Particulate Matter (PM)

**28,754**

grams of Carbon Monoxide (CO)

**150,509**

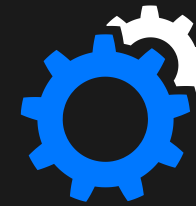
grams of Nitrogen Oxide byproducts (NOx)

# Implementation Costs

The costs of purchasing and installing a supercapacitor starting assist technology like KickStart is quite low in comparison to the overall value generated from the systems but is expected to be below \$15,000 for purchase price and installation costs per system.

Supercapacitors systems like KickStart are maintenance free and can withstand hundreds of thousands of charge and discharge cycles, making them much more durable than traditional batteries and without any ongoing maintenance costs.

**\$15,000** or less for most installs



Maintenance free



Extremely durable



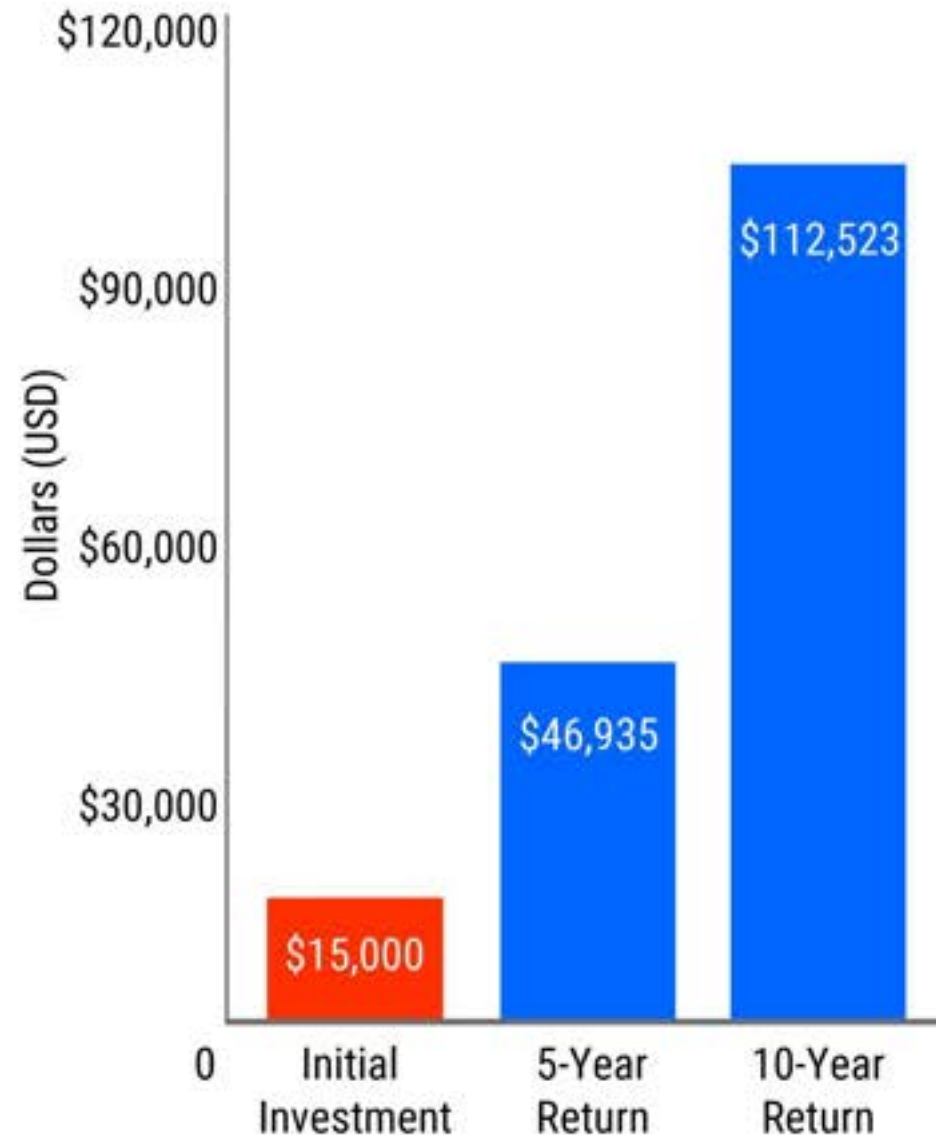


# Return on Investment (ROI – 10 years)

The durability and longevity of supercapacitor systems ensure long-term savings over a 10-year period, resulting in a favorable payback period.

The implementation of supercapacitor starting assist technology for solutions like KickStart is expected to generate more than **\$112,000 in savings** over 10 years when the supercapacitor asset life is 20 years. Consider the **low \$15,000 investment**, the payback period is just about one year.

Assuming reductions in battery replacements from once every two years to once every 4 years, and an inflation rate of 3%.





Studies show that the technology can lead to significant fuel savings, resulting in cost reductions and improved profitability.

### Fuel consumption reduction



### Improved locomotive availability

The technology minimizes dead-won't-start (DWS) events, leading to increased availability and reduced maintenance costs.



### Emissions reduction

By optimizing engine starts, locomotive emissions can be reduced, contributing to environmental sustainability efforts

Q&A