

Why Modern Warehousing Needs Innovation in Battery Charging Technology

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Presented by:

Jeff Harrison, Director of
Sales and Marketing

Matt Bridge, Director of
Engineering

AMETEK Prestolite Power

Agenda

- Motive battery charger history
- Charging management today
- Effects of improper charging
- Needed charging advancements
- Payoffs for making a technology investment
- Overview



AMETEK Prestolite Power Overview

- AMETEK is a \$4.2B public company
 - American owned and manufactures products in Columbus, Ohio
 - Proven industrial company focused on engineering and leading edge technology
 - Allows access to multiple resources throughout the organization to create products and custom solutions
- In 2016, AMETEK Prestolite Power will enter its 100th year of building chargers
 - Over 120,000 chargers operating in the field
 - Owns all of its IP, design, manufacturing processes and facilities
 - Focused on data collection and driving towards additional data solutions for the industry
 - Multiple disciplines in engineering
 - Software, hardware, controls, mechanical, chemical
 - ISO 9001:2008

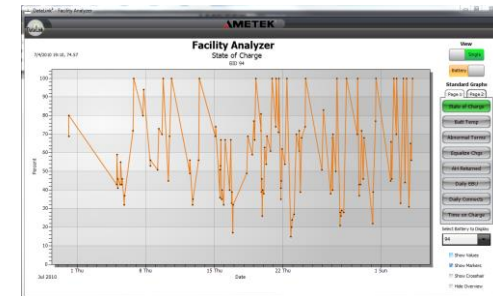
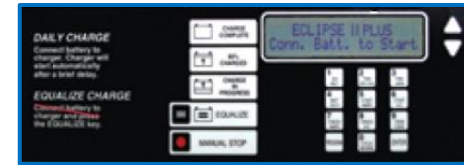
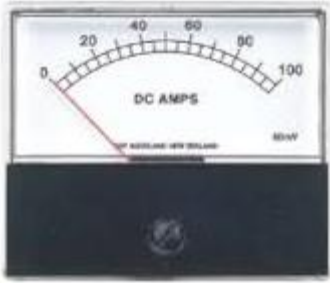


Our Speaker – Matt Bridge

- 15 years of product development – hold 6 patents
- Director of Engineering for AMETEK
 - Technology and Product Management
 - Multi Discipline Engineering team management
 - Product Development
 - High frequency power conversion
 - Instrumentation and data collection
- Previous experience
 - Engine and Transmission controller development
 - Consulting Agency that served many markets: Medical, Military, and Industrial
 - Self employed business owner
- Purdue University Graduate



Motive Charger History



- Huge progress in the last few decades with displays and user interface
 - From simple analog meters and mechanical timers to endless menus for precise control and display
- Strong innovation in data storage to make charger and battery history available to browse as needed to manage a fleet
 - From “Not Available” to endless amounts of data to evaluate

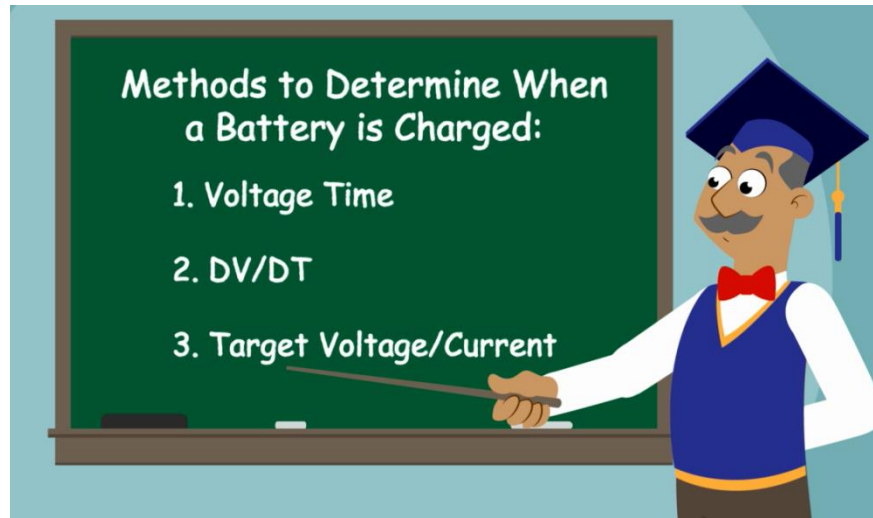
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Motive Battery Charger Purpose

- Charge the battery to keep the material handling equipment moving
- Maintain the battery to maximize the uptime
- Maintain the battery to maximize the lifetime
- Interact with battery devices to store battery information to help manage a fleet of batteries



Charging Termination Types

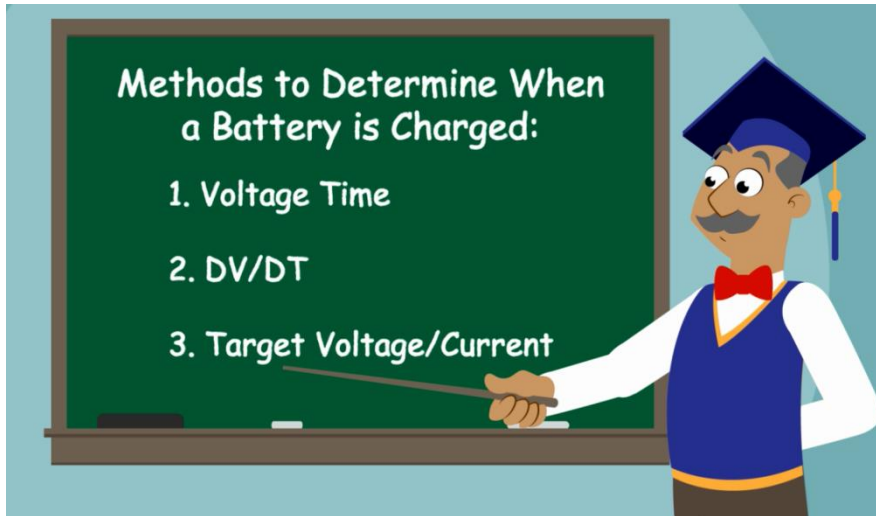


- Voltage Time: Almost always comes with overcharge
- DV/DT: Good until batteries are left at a low state of charge
- Target Voltage: Must be changed with battery temperature and aging



Charging Termination Methods

When is it Done?



- All termination methods are estimates!
- Strong preventative maintenance is required with current technologies to maximize uptime and battery lifetime
- Overcharge both reduces battery life and comes with higher energy costs



Effects of Not Charging Properly

- Under charge
 - Less available AH
 - Sulfation
 - Shorter life
- Over charge
 - Hot battery
 - Electrode damage
 - Shorter life



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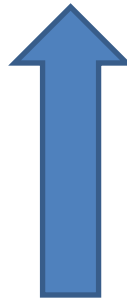
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Typical Facility Maintenance Cycle

- Undercharge – sulfation
 - Less life and capacity

Change to VT and overcharge



Change to DVDT to reduce overcharge

- Overcharge – hot batteries
 - More plate corrosion, less life, less capacity

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What Technology Innovation is Needed?

Goal: Solve problems without human interaction....

1. We need to manage batteries to make them last as long as possible
 2. We need to manage batteries to ensure the most uptime possible
 3. Use the least amount of power possible
- The battery management system should not require a user to adjust settings throughout the batteries life
 - The battery management system should recover a fleet of existing batteries from a mismanaged condition
 - The battery management system should constantly track battery conditions to make sure the charger terminates on target

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What can be Measured During the Charge Curve?

- Common measures
 - Cell balance
 - Volts per cell
 - Electrolyte temperature
 - Electrolyte level
- Proposed new measure
 - **Electrolyte specific gravity**
- Specific Gravity: The ratio of the weight of the battery electrolyte as compared to an equal volume of water. Specific gravity is the most accurate measure of state of charge.



True Management of a Battery

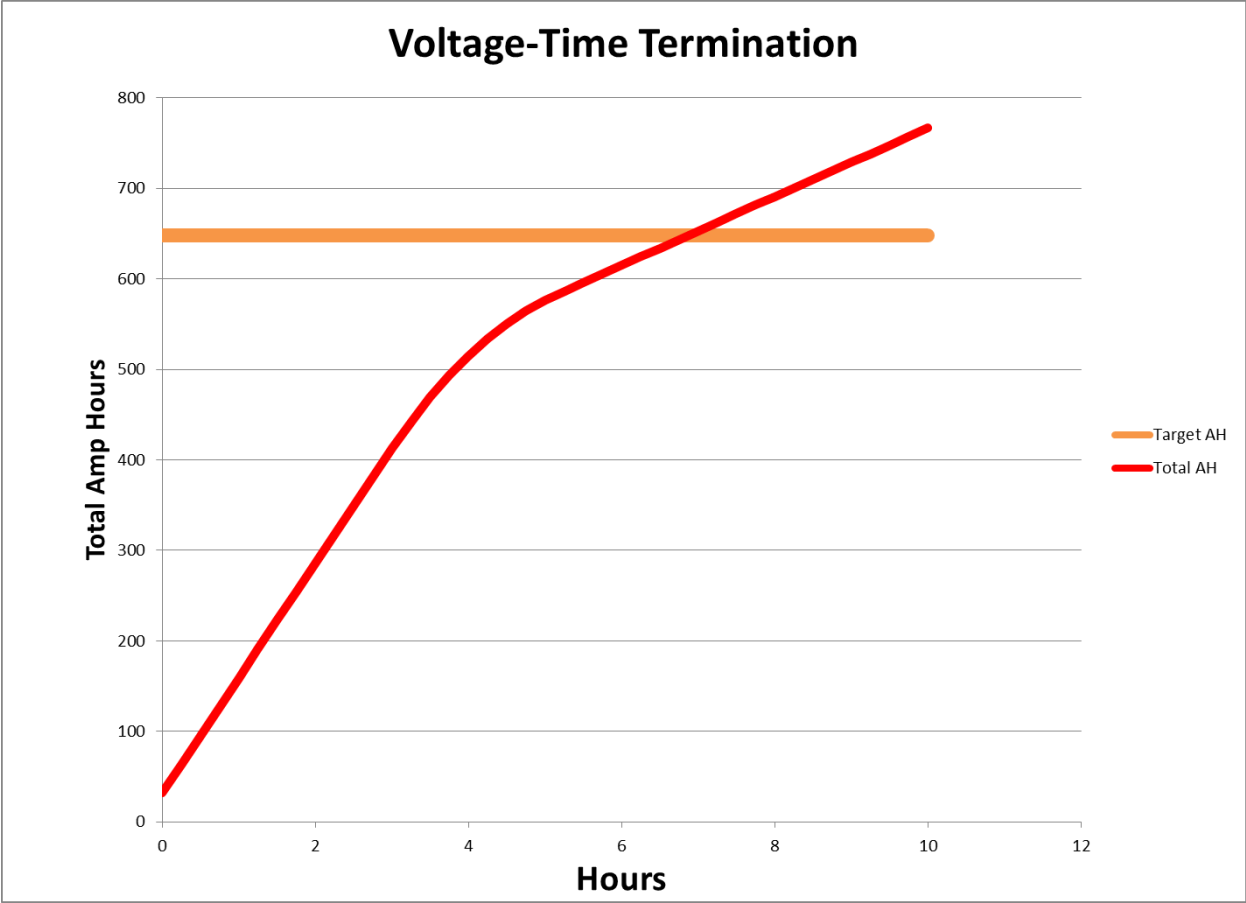
Using the new specific gravity value and all other common measurements the envisioned battery management system could actively manage the battery over its entire lifetime.

- Charge using a specific gravity
- Manage temperatures
- Manage amount of recharge in opportunity charge applications
- Manage equalize schedules

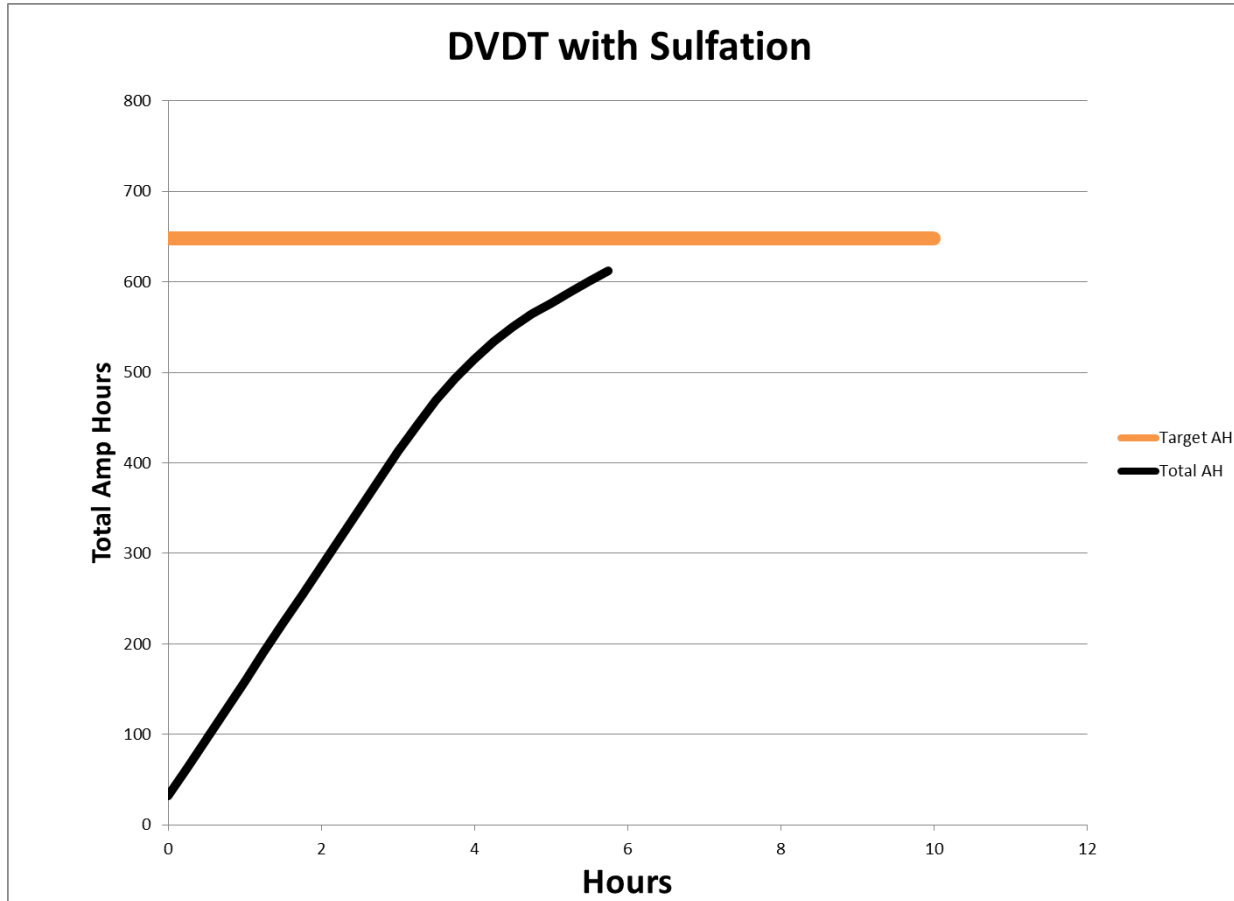
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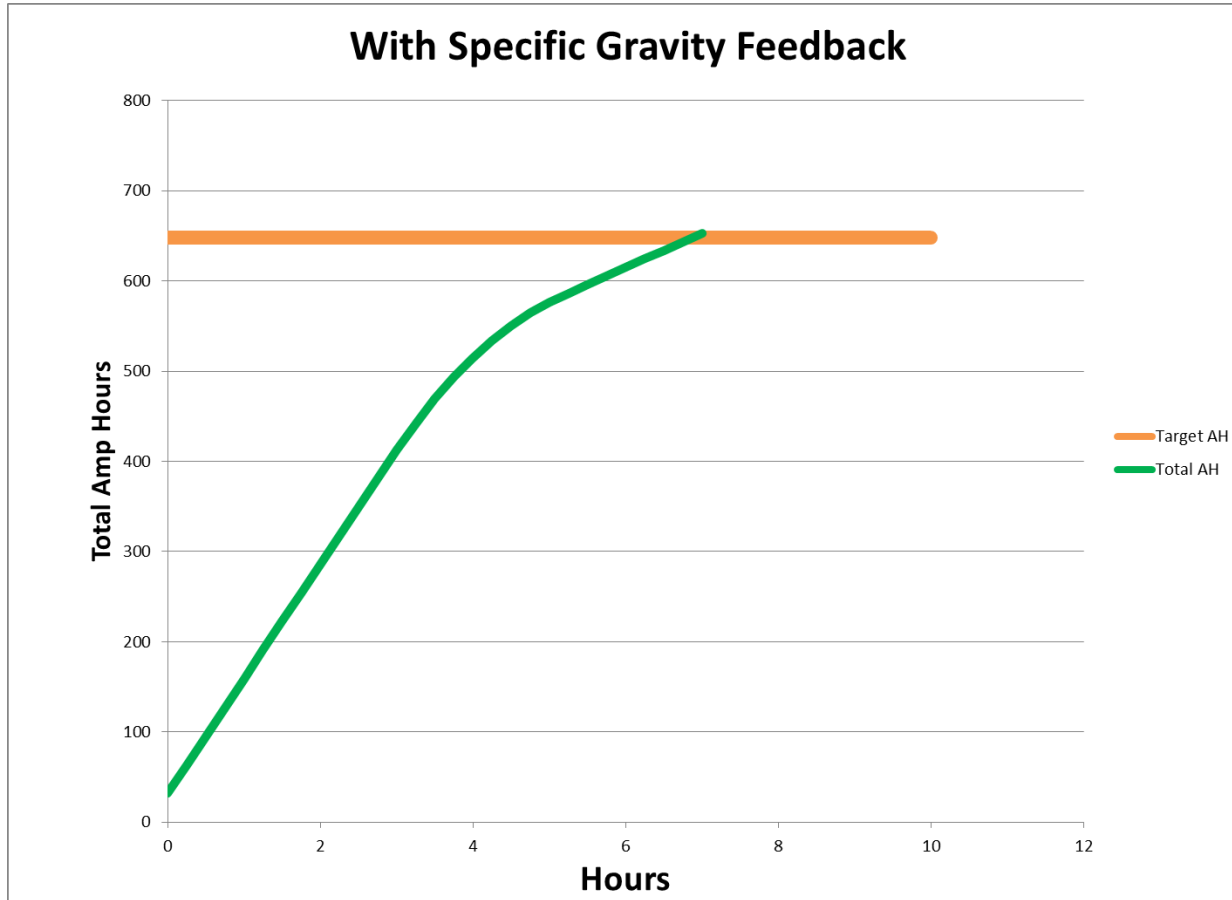
Over Charging



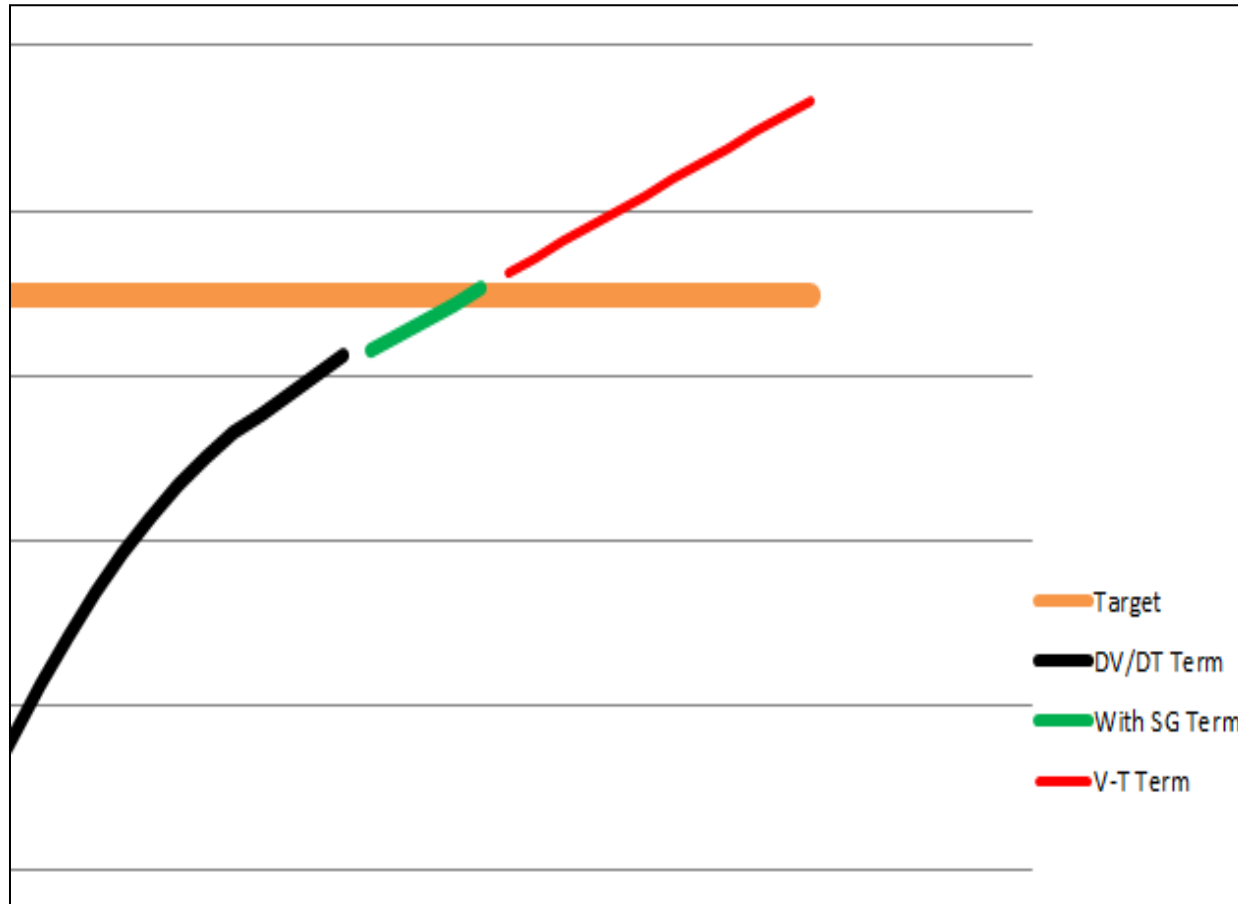
Under Charging



On Target Charging

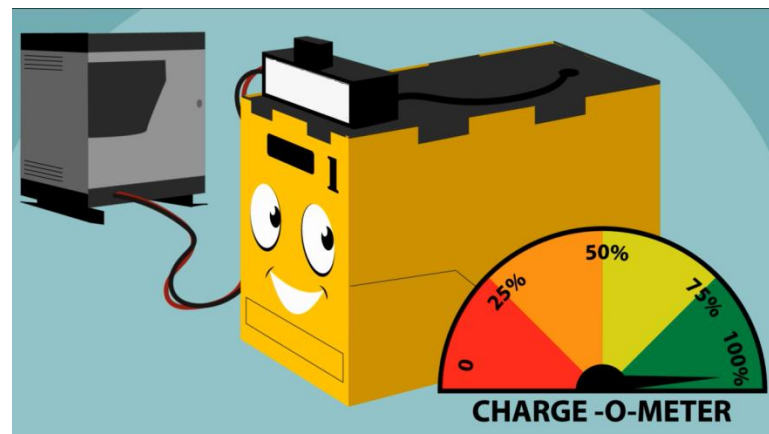


Charge Termination Comparison



Payoff from Technology Investment

- Longer Battery Life
 - Lower overall battery temperatures
- More uptime
 - No sulfation
 - No capacity lost from overcharge
- Less downtime for battery maintenance later in battery life
 - Cell Replacement
 - Offsite sulfation recovery
- Less overcharge
 - Less energy required to maintain the fleet



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Overview – Why We Need Battery Charger Innovation

- New battery management innovations could increase both uptime and battery life dramatically
- Battery management systems with upgraded instrumentation could provide true state of charge for every charge cycle
- Battery management systems should provide customers with lower total cost of ownership
 - Less down time
 - Less required maintenance
 - Longer usage cycle
 - Lower energy costs

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