

On-Board Charging for Materials-Handling Vehicles: Reducing Costs and Greenhouse Gas Emissions

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1. Introduction

Direct Methanol Fuel Cells (DMFCs) are a new, clean, and cost-effective technology for materials-handling vehicles. Organizations seeking to reduce costs and emissions are using DMFCs to trickle-charge the batteries in their forklifts, tuggers, pallet jacks, and automated guided vehicles. In early 2008, Oorja Protonics released the industry's first methanol-based on-board charging system, called the OorjaPac.™ This new approach to charging lead-acid batteries is already in use at retail, manufacturing, distribution, and aviation facilities where cutting costs and reducing emissions are top priorities. This paper discusses why Fortune 50 companies across this wide range of industries selected Oorja for their operations.

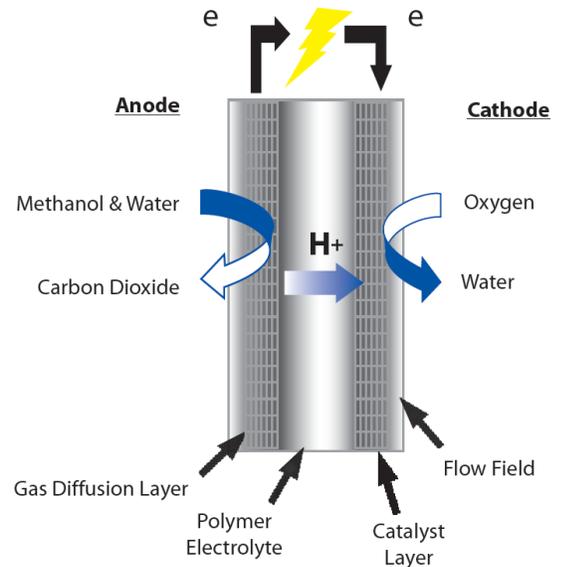
Studies done at facilities using the OorjaPac show that complete payback on investment is often achieved in less than 24 months. For a fleet of approximately 300 vehicles, the net savings over a 5-year period is projected to be between \$16 million and \$20 million.

Oorja fuel cells also improve the carbon footprint of materials-handling facilities. Methanol fuel cells emit no SO_x, NO_x, or CO. During operation, they produce only H₂O and CO₂. On average, they emit 30 percent less CO₂ than charging batteries with electricity supplied from the grid.

2. Direct Methanol Fuel Cells

DMFCs are being used to power small consumer devices such as cell phones and laptops. Oorja is the first company to offer DMFCs powerful enough for materials-handling applications. When used on forklift trucks, operational advantages of methanol fuel cells make them an excellent alternative to charging batteries from the grid.

Unlike internal combustion engines that burn fuel for power, direct methanol fuel cells use a polymer electrolyte membrane to convert chemical energy to electrical energy. Methanol fuel is delivered to the anode side of the membrane, where it is split into protons and electrons. The electrons pass to a circuit and create electrical current, while the protons pass through the membrane to the cathode side of the fuel cell. When the electrons are also delivered to the cathode side of the fuel cell, they reunite with the protons and oxygen to form CO₂ and H₂O.



3. Reducing Costs and Emissions

On-board charging gives managers of materials-handling fleets a way to simultaneously (1) increase productivity, (2) reduce costs, and (3) reduce greenhouse gas emissions. Oorja fuel cells deliver these benefits in the following ways.

3.1 Reducing Labor Costs

Lift truck operators spend a significant part of their day keeping their vehicles charged and running. The amount of time varies by organization, but it is easily quantified and includes: (1) the time required to change vehicle batteries, (2) the time spent driving to and from battery-changing stations, and (3) the downtime other workers experience when the lift truck is

unavailable. Over two 8-hour shifts, estimates of labor lost to swapping and charging range from 30 to 80 minutes. On-board charging reduces this 30- to 80-minute productivity loss to less than 5 minutes over the same two-shift period.

3.2 Increasing Productivity

On-board charging increases productivity in two ways. It eliminates time wasted for battery charging, and it insures full battery power while the vehicle is in operation.

- Oorja fuel cells continuously charge the vehicle battery even as it operates, completely eliminating the time required to stop and charge batteries. Studies show that an extra 15 minutes to 40 minutes per shift become available for productive work when battery changing is eliminated. This results in greater output per worker and ultimately lowered labor costs.
- A second factor plays a role in the productivity improvements available with the Oorja on-board charging system. During a shift, as batteries drain, their output power decreases. This reduces vehicle performance and therefore worker productivity. The productivity loss is even worse as batteries age because they then require more frequent charging. In contrast, Oorja fuel cells maintain a constant state of battery charge and enable the vehicle to operate continuously at peak power.

3.3 Reducing Battery Costs

Using Oorja fuel cells, managers require fewer lead-acid batteries to run their fleets. Traditional operations require two to three batteries to support two-shift operations. Only one battery per vehicle is required with on-board charging. This cuts battery requirements by one-half to two-thirds.

On-board charging improves lead-acid battery life. Charging from the grid causes the batteries to get very hot. Over time, heating shortens battery life. However, batteries never get hot when continuously trickle-charged with Oorja fuel cells. Using on-board charging results in a substantial reduction in battery cost from (1) reduced battery purchases and (2) increased battery life.

3.4 Eliminating Battery Rooms and Storage Space

On-board charging eliminates the need for external battery charging. This eliminates the need to dedicate space for battery charging and battery storage. Valuable cubic footage on prime facility real estate can be returned to productive use.

3.5 Maintaining Current Mode of Operation

On-board charging does not require new facilities, training, or procedures. Operators can continue their current mode of operation with current equipment. Methanol has minimal fueling requirements and presents no increased safety hazards. With Oorja fuel cells, managers can use their current vehicles, facilities, and personnel with few changes to operations. It requires no expensive infrastructure to operate. It requires no special training for operators. It uses existing vehicles and batteries. Therefore, the impact on current personnel and facilities is minimal. This means that Oorja fuel cells can be implemented in a matter of weeks.

3.6 Reducing Pollution

Methanol fuel cells reduce greenhouse gas emissions from materials-handling vehicle fleets. Coal-fired power plants produce 85 percent of the electricity generated in the United States. Methanol fuel cells emit no particulates, NO_x, SO_x, or CO. Oorja fuel cells reduce CO₂ emissions by approximately 30 percent when compared to charging batteries with electricity

supplied from coal-fired power plants on the grid. Reduced battery requirements mean few on-site battery acid spills and also reduce the need to recycle lead. These reductions can be used to meet corporate goals of a cleaner workplace and community.

3.7 Improving Safety

Lead-acid batteries often weigh more than one thousand pounds. Worker safety issues arise with the daily lifting, removing, and replacing of these devices. Onboard charging completely eliminates this worker risk.

4. ROI in On-Board Charging

This paper presents an overview of the areas that contribute to the return on investment available with Oorja fuel cells. The benefits of on-board charging are significant, and Oorja has unique experience in the design and evaluation of on-board charging investments.

Oorja specialists can calculate the payback on-board charging can deliver in your environment. The Oorja analysis includes dozens of variables, which are compared to the characteristics of each materials-handling operation.

Results from data across a number of industries show that per-vehicle savings can range from \$1,855 to \$22,340 annually. Most organizations see a complete payback on their investment within 24 months.

