GORE® Fuel Cell Technologies
Optimizing For a Lower TCO

THE ROLE OF PEM ATTRIBUTES IN REDUCING FUEL CELL SYSTEM TOTAL COST OF OWNERSHIP (TCO)

Proton exchange membrane (PEM) fuel cells are considered one of the most efficient, low-emission, low-temperature, and compact energy conversion technologies available today. In the fight against climate change, reducing the cost of PEM fuel cell systems will be the critical factor in their economic viability.

This article explores how PEM technology can help reduce commercial fuel cell vehicle production and maintenance costs, increase power output, and improve fuel efficiency to minimize the total cost of ownership.

Electric powertrains have evolved from a niche product to a common choice for tomorrow's passenger vehicles within a decade. Following this trend, medium and heavy-duty trucks will drive down the same path.

While it is a common goal of fuel cell manufacturers to develop a fuel cell system with a lower initial capital cost, the cost of the stack is only part of the equation.

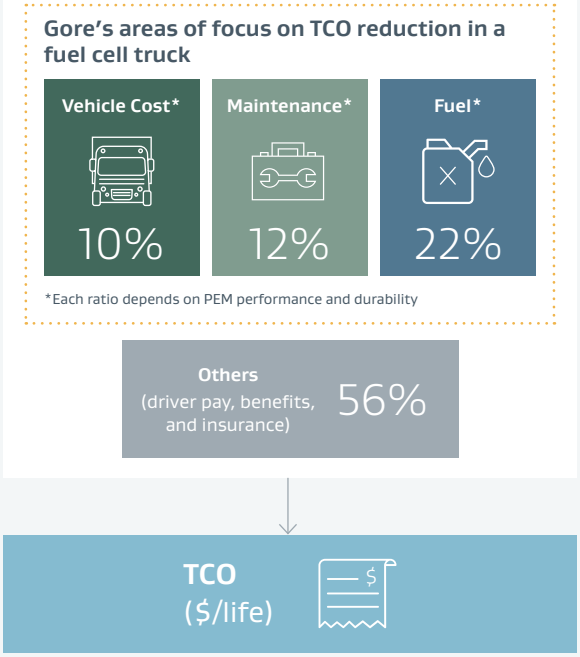
The industry recognizes that the TCO of fuel cell technology needs to achieve cost parity with other options. That's why a more comprehensive look at TCO considers the following categories:

- **Vehicle cost**
  System design considerations
- **Maintenance costs**
  Repair frequency and complexity considerations
- **Fuel cost**
  Cost per distance considerations
- **Operating costs**
  Variable workforce cost considerations

Figure 1.

TCO Influencers for a Commercial Diesel Truck

TCO cost break-downs –
Vehicle Cost : Maintenance : Fuel : Others ≈ 1 : 1 : 2 : 6



Want to Optimize Your Fleet? Know Your Average Trucking Cost per Mile, Paragon, https://www.paragonrouting.com/en-us/blog/post/want-optimize-your-fleet-know-your-average-trucking-cost-mile/
What is Total Cost Per Mile for truckload carriers?, FreightWaves, 2020, https://freightwaves.com/news/understanding-total-operating-cost-per-mile
The Real Cost of Trucking – Per Mile Operating Cost of a Commercial Truck, TruckersReport, https://www.thetruckersreport.com/infographics/cost-of-trucking/

Aside from operating costs, vehicle, fuel, and maintenance costs account for 44% of the TCO considerations of a conventional diesel truck (Figure 1). But beyond this, Gore continually asks how

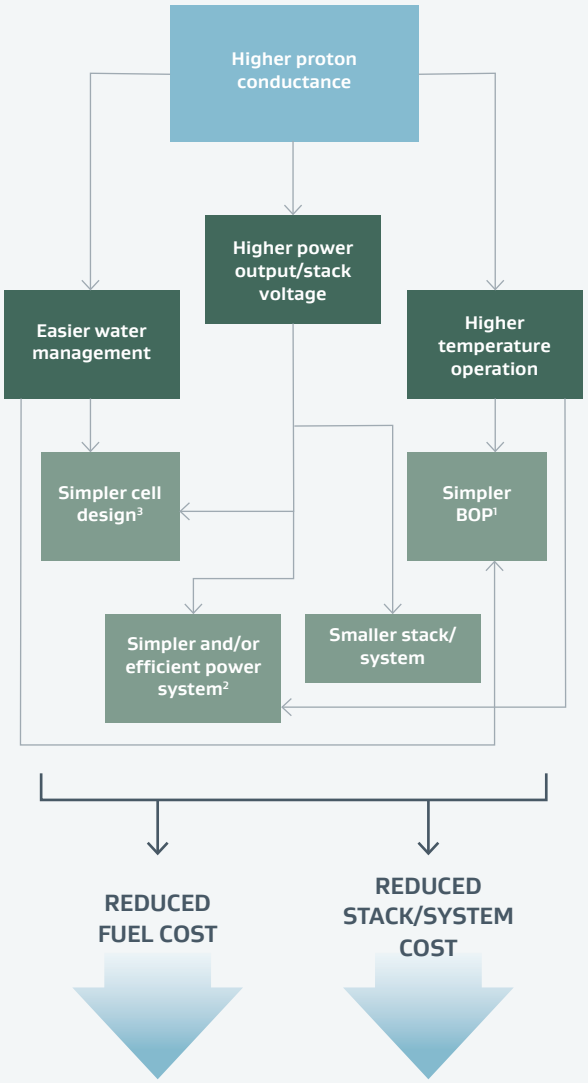
the overall value chain of a fuel cell ecosystem could achieve a lower TCO to make fuel cell systems a viable alternative compared to fossil fuel or battery-powered applications.

Understand how PEM contributes to a lower TCO

PEM attributes can be leveraged to achieve better fuel efficiency and optimized system design to achieve TCO parity. One example of the contribution of Gore reinforced membranes to TCO is shown here for high proton conductivity.

Figure 2.

Membrane Attributes that Impacts TCO



[1] BOP (Balance of Plant): radiator, water pump, pipe, coolant, humidifier, air intercooler, etc.

[2] Power system: battery, boost converter, electric cable, etc.

[3] Cell design: MEA, bi-polar plate, gas diffusion layer, gasket, frame, etc.

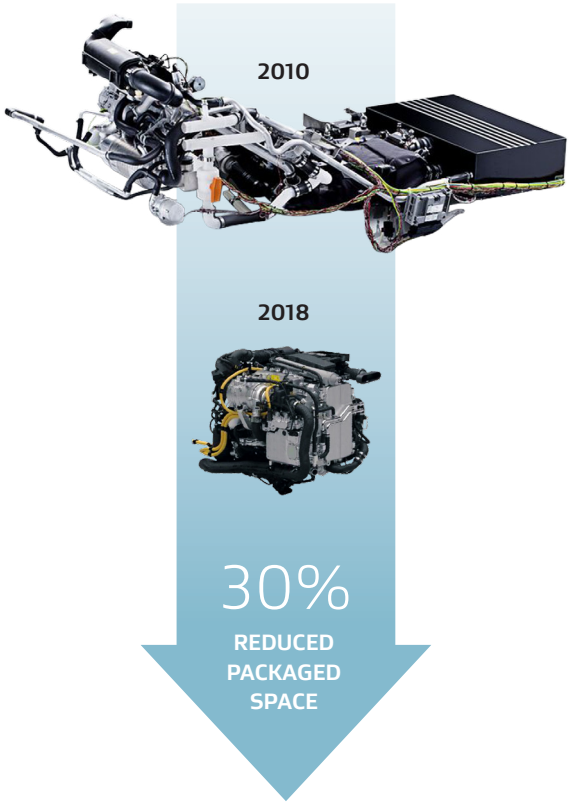
Highly proton-conducting electrolyte membranes allow for operation at higher temperatures, as well as higher power and higher stack voltages. In addition, along with the thin membrane effect of GORE-SELECT® Membranes, it also facilitates the management of water in the cell.

This allows for smaller stack and system sizes, enabling simpler BOPs and more straightforward cell designs to be applied, resulting in more efficient FC systems. As a result, the cost of the stack system can be lowered and fuel costs can be reduced due to a more efficient system, contributing to lower TCO (Figure 2).

Lower TCO with GORE-SELECT® Membranes

Gore reinforced PEMs are made from expanded polytetrafluoroethylene (ePTFE) with custom perfluorosulfonic acid ionomers and special additives.

> **Thinner membrane makes fuel cell systems smaller, resulting in greater design flexibility.**



The Intelligent Fuel Cell Plug-in Hybrid Drive System of the Mercedes-Benz GLC F-Cell, MTZ Worldwide, 2019, https://doi.org/10.1007/s38313-018-0121-6

With a higher proton conductance and low gas crossover, these PEMs enable commercial fuel cell vehicles to operate at higher temperatures,

contributing to greater fuel efficiency. They also allow manufacturers to use existing parts to make radiators, or even create smaller radiators with fewer materials, lowering vehicle manufacturing costs.

In addition, the GORE-SELECT® Membrane enables good water management, which may eliminate the need for an external humidifier or reduce the size of a bulky one, even at low relative humidity (RH) and high operating temperatures. This reduces the system cost and the need for frequent and complex maintenance (which lowers maintenance costs).

Over the coming years, there will be a significant increase in the number of hydrogen-powered vehicles and hydrogen applications beyond transportation. A systematic approach in selecting PEM attributes will enable manufacturers to progress faster toward a future of low TCO.

Gore can analyze fuel cell system requirements and adjust materials to reduce the total cost of ownership. This way, the most suitable PEM membrane is selected

for commercialization based on a holistic consideration of a fuel cell vehicle, fuel, and maintenance cost.

Get in touch if you'd like to learn more about how Gore can lower the total cost of ownership of a fuel cell system for your organization.

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Shinichi Nishimura is a global product specialist for fuel cell technologies at W. L. Gore & Associates and has more than 20 years of experience in polymer electrolyte membranes for fuel cells and other applications.

If you wish to learn more about Gore and its GORE-SELECT® Membrane technology, please visit https://www.gore.com/alt-energy.

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