

Hydrogen Car Cheat Sheet

Fuel cell vehicle basics, costs and trade-offs vs. EVs

ENGINEERING
CHEAT SHEET

Key equations

Quantity	Equation	Notes
Overall reaction	$2 \text{H}_2 + \text{O}_2 \rightarrow 2 \text{H}_2\text{O} + \text{electricity} + \text{heat}$	Only water leaves the tailpipe
Anode	$\text{H}_2 \rightarrow 2 \text{H}^+ + 2 \text{e}^-$	Platinum catalyst; the membrane passes protons, electrons go around
Cathode	$\frac{1}{2} \text{O}_2 + 2 \text{H}^+ + 2 \text{e}^- \rightarrow \text{H}_2\text{O}$	Electrons do work in the motor circuit
Ideal cell voltage	$E^\circ \approx 1.23 \text{ V}$	Real cells run lower under load. Stack many cells in series
Stack power	$P = V \cdot I$	Stack power scales with cell count and active area
Catalyst cost	$1.0 \text{ mg/cm}^2 \text{ Pt at } 0.5 \text{ W/cm}^2 \approx \$100 \text{ per kW}$	100 hp $\approx 75 \text{ kW} \rightarrow$ about \$7,500 of catalyst
Membrane cost	$\$400/\text{m}^2 \text{ PFSA}$	About \$6,000 for a 100 hp stack; projected below \$50/m ² at volume

Key takeaways

- An FCEV drives an electric motor like an EV, but makes electricity on board from hydrogen. A small battery handles regen and power bursts.
- A fuel cell is an **open system** (fuel supplied, no recharge). A battery is a **closed system** that must be recharged.
- Energy stored depends on the **hydrogen tank size**, not battery size. Range is about 400–600 miles vs. 100–350 for BEVs, and refueling takes minutes.
- Weakness: infrastructure. About 52 public hydrogen stations in the U.S. (nearly all in California), usually one nozzle each.
- Hydrogen fuel costs about four times as much to refuel as gasoline, and FCEVs lack the power surge of a big battery, so they suit cruising over hard acceleration.
- Safety: high-pressure tanks are built to survive severe crashes, with no hydrogen-related injuries reported in cars sold to date.
- Sold in the U.S. since 2015: Toyota Mirai, Hyundai Nexo, Honda Clarity (discontinued). Buses are the most mature use today.

Prototype benchmarks from the guide

Vehicle	Fuel cell	Notes
Ford Focus FCV (2002)	85 kW PEM	4 kg H ₂ at 5,000 psi, ~50 mpg-equivalent
NECAR 5 (2000)	85 kW PEM	Methanol reformed on board, 150 km/h
Mitsubishi Grandis FCV	68 kW PEM	Compressed hydrogen, 140 km/h
GMC S-10 (2001)	25 kW PEM	Low-sulfur gasoline, 112 km/h