Holistic Approach to Energy—Part 1

A) **Battery storage**. Use as the example Tesla model S

Parameters

- Powertrain
- Model S is a rear wheel drive electric vehicle. The liquid-cooled powertrain includes the battery, motor, drive inverter, and gear box.
- 60 kWh microprocessor controlled, lithium-ion battery
- Three phase, four pole AC induction motor with copper rotor
- Drive inverter with variable frequency drive and regenerative braking system
- Single speed fixed gear with 9.73:1 reduction ratio

- Warranty
- 4 year, 50,000 mile (whichever comes first) new vehicle limited warranty
- 8 year, 125,000 mile (whichever comes first) battery and drive unit warranty for 60 kWh battery equipped Model S
- 8 year, unlimited mile battery and drive unit warranty for 85 kWh battery equipped Model S
- Both battery warranties cover damage from improper charging procedures and battery fire, even if the fire results from driver error

Electric motor	310 kW (416 bhp), 600 N·m (443 ft·lb), Three-phase AC induction motor
Transmission	1-speed fixed gear (9.73:1)
Battery	60 or 85 kWh lithium ion[4]
Electric range	**85 kWh** 265 mi (426 km) (EPA) 310 mi (500 km) (NEDC) **60 kWh**

	208 mi (335 km) ([EPA](#))
[Plug-in charging](#)	233 mi (375 km) ([NEDC](#))
	• 11 kW 85-265 V onboard charger for 1? 40 A or 3? 16 A [5] on IEC Type 2 inlet[6]
	• Optional "Twin Charger" for 22 kW for 1? 80 A or 3? 32 A[5]
	• Optional Supercharger for 120 kW DC offboard charging, adapters for domestic AC sockets (110-240V)

60 kWh will go 208 miles = 3.5 miles/kWh

cost of travelling 1 mile = cost of 1kWh/3.5

from the warrantee, the batteries are warranteed for 120,000 miles/208 miles = 570 cycles

If the cost of the battery is $500/kWh, the cost per cycle= $0.87per kWh amortisation.

We have to add the cost of electricity assume $0.15/kWh, total cost per mile = ${0.87+0.15}/3.5 = **$0.29/mile**

B) Toyota mirai FCV, high pressure hydrogen fuel

Powertrain

[Electric motor](#)	[fuel cell](#)-powered 113 kW (152 hp) 335 N·m (247 lbf·ft)[1]
[Battery](#)	1.6 [kWh](#) [Nickel-metal hydride](#)[2][3]
Range	480 km (300 mi) (Toyota)[4]

Fuel cell system with an output power density of 3.0 kW/L

The FCV range is expected to be approximately 700 km (430 mi) under Japan's [JC08 test cycle.](#)[15]

The exhaust H_2O or water volume is 240 mL per 4 km running.[35]

the stack's world-leading power output density of 3.1 kW/L

The tanks store hydrogen 70 MPa (10,000 psi). The tanks have a combined weight 87.5 kg (193 lb).[1][34]

The electric traction motor delivers 113 kilowatts (152 hp) and 335 N·m (247 lbf·ft) of torque. The Mirai has a 245V (1.6 kWh) sealed nickel-metal hydride (NiMH) traction rechargeable battery pack

The front tank holds 60.0 liters, the rear tank, 62.4 liters. Total hydrogen storage mass is about 5 kg.

http://www.thegreencarwebsite.co.uk/blog/index.php/2014/08/14/toyota-admits-fuel-cell-cars-will-cost-more-to-fill-up-than-petrol-models/

They estimate $50 for a full tank of H2 and 300 miles range. Compare this with a Prius, which is cheaper, can refuel at any gas station, has a range of 595 miles, and the gasoline would cost $18 to go 300 miles. With competition like that, the FCV could be a difficult sell, even in Japan.

Using the data above.

Mirai has 300 miles range for the 5kg of H. to compare to Tesla, we use 120,000 miles warrantee

The 5kg H fuel costs estimated by toyota, $50 or $10/kg. to go one mile has a fuel cost of $50/300 = $0.17/mile

We have to amortize the cost of high pressure cylinder + the cost of FC stack over 120,000 miles.

We do not have numbers from Toyota, but from NREL the estimate is $2400, or $2400/120,000 miles, = $0.02/mile

total cost of travel $0.17 +$0.02 = $0.19/mile