Alternative Fuel Vehicles

Introduction: Environmental concerns and political instability in the Middle East has intensified research into vehicles that run on alternatives to fossil fuels. The most common alternatives in the U.S. are flex-fuel vehicles that run on 85% ethanol and electric vehicles. Another alternative being considered are fuel cell cars.

Cars with internal combustion engines use only 20% of the fuel energy for movement. Fuel cells are more efficient because they convert fuel energy directly to electricity, thereby boosting efficiency to a whopping 60%. This is why fuel cell cars usually get about three times more miles per unit fuel than their internal combustion engine counterparts.

Batteries are heavy because they contain all the reactants needed to generate electricity. Fuel cells are lighter because (like internal combustion engines) they run on fuels that react with oxygen from the air. The main disadvantage of fuel cell cars is that they run on hydrogen, a fuel that is expensive to generate and difficult to transport and contain. This is why fuel cell cars are still not on the market. The technological breakthroughs most needed are affordable fuel cells that run directly fossil fuels because this would cut fossil fuel consumption by as much as 60%.

Part 1: Mass Energy Ratios of EV Batteries

Table 1: Mass energy ratios of different batteries

A	B	C	D	E	F	G
Battery materials	Volts	Ah	Wh *(B X C)*	Battery Mass (lbs)	kWh *(D ÷ 1000)*	Lbs / kWh *(E ÷ F)*
lithium	*12*	*40*				
lead	*12*	*40*				

Table 2: Mass energy ratios of liquid fuels

A	B	C	D
Fuel type	Lbs / gallon	kWh / gallon	Lbs / kWh *(B ÷ C)*
gasoline			

Table 3: Efficiency of a selected electric vehicle

A	B	C
EV model	kWh / mile	kWh / 100 miles *(B X 100)*
Volkswagon e-Up		

Table 4: Mass needed to drive 100 miles

A	B	C	D
Energy type	kWh / 100 miles *(from Table 3)*	Lbs / kWh *(from Tables 1 & 2)*	Lbs / 100 miles *(B X C)*
lithium			
lead			
gasoline			

Table 5: Battery cost per 100 mile range

A	B	C	D	E	F
Battery materials	Cost	kWh *(from Table 1)*	Cost / kWh *(B ÷ C)*	kWh / 100 miles *(from Table 3)*	Cost / 100 miles *(D X E)*
lithium					
lead					

1. What is the main advantage of lead batteries over lithium batteries?

2. What is the main advantage of lithium batteries over lead batteries?

3. What are two advantages of gasoline-powered vehicles over electric vehicles?

4. A gasoline-powered "Volkswagon Up" gets about 60 miles per gallon. This comes to about 10 lbs of gasoline per 100 miles. This is more than three times the value calculated in Table 4 because the calculation converts this energy directly into electricity without accounting for the 20% efficiency of electric generators (which always use internal combustion engines). What kind of electric generator provides three times more electricity than an internal combustion engine? (Hint 1: The answer is in the second paragraph of the introduction) (Hint 2: It has not yet been invented)

5. What technological breakthrough needs to take place before a gasoline-powered "Volkswagen Up" acquires gas mileage comparable to the value calculated in Table 4? (Hint: The answer is in the second paragraph of the introduction).

Websites needed for Part 1:

Lithium batteries
https://www.lithiumion-batteries.com/products/lithium-ion-solar-batteries/12v-200ah-lithium-ion-battery.php

Lead acid batteries
https://www.grainger.com/category/electronics-appliances-and-batteries/batteries-battery-chargers/sealed-lead-acid-batteries-chargers/sealed-lead-acid-batteries

Converting gasoline energy to kWh
https://www.convertunits.com/from/kWh/to/gallon+%5BU.S.%5D+of+automotive+gasoline

Electric vehicles
https://pushevs.com/2017/05/23/electric-car-range-efficiency-table-nedc/

Part 2: The environmental cost of growing fuel on land

6. How many square miles of switchgrass are needed to satisfy the current gasoline demand in the US? (use the spreadsheet to answer this)

7. Which state is closest in size to your answer to question 1? (use provided link below)

8. Which vehicle gets more miles per 100 lbs of switchgrass? The electric or the ethanol powered Ford Explorer? (use the spreadsheet to answer this)

9. Weighing your answer to question 3 against the convenience of flex fuel vehicles, is it better to convert switchgrass to ethanol or just burn it to generate electricity?

10. Based on your answer to question 1, what is the main problem with relying on biofuels grown on land?

Websites needed for Part 2:

State sizes
https://state.1keydata.com/states-by-size.php