3.3) INSTRUCTOR'S GUIDE TO BATTERIES AND BIOFUELS

Overview: For **Part 2** and **Part 6**, there are many websites that provide this information on the mass of gasoline and total barrels consumed in US per day. You can make sure students get this right by either giving them the links or checking their answers. For **Part 7**, you calculate the kilowatt hours per ton of switchgrass by dividing 19,607,000 kWh by 15,647 tons of switchgrass (See reference 3). The following values were collected in 2020-2023:

Sample Results for Table 1

A	B	C	D	E	F	G
Battery type	Volts	Ah	Wh (B X C)	**Battery Mass (lbs)**	kWh (D ÷ 1000)	Lbs / kWh (E ÷ F)
Lithium	12	40	480	13.5	0.48	28
Lead	12	40	480	28.38	0.48	59
Lithium*	9	0.50	4.5	0.062	0.0045	14
Nickel*	9	0.17	1.5	0.097	0.0015	65
Lead*	12	1.3	16	1.25	0.016	78

*Batteries weighed during class.

Sample Results for Table 2

A	B	C	D
Fuel type	**Lbs / gallon**	**kWh /gallon**	Lbs / kWh (B ÷ C)
gasoline	6.2	36.6	0.17

Sample Results for Table 3

A	B	C
EV model	**kWh / mile**	kWh / 100 miles (B X 100)
Volkswagon e-Up	0.19	19

Sample Results for Table 4

A	B	C	D
Energy type	kWh/100 miles (Table 3)	Lbs/kWh (Tables 1 & 2)	Lbs/100 miles (B X C)
lithium	19	28	532
lead	19	59	1123
gasoline	19	0.17	3.23

Sample Results for Table 5

A	B	C	D	E	F
Battery materials	**Cost**	kWh (from Table 1)	Cost / kWh (B ÷ C)	kWh / 100 mi. (from Table 3)	Cost / 100 mi. (D X E)
lithium	$499.99	0.48	1042	19	$19,800
lead	$239.70	0.48	499	19	$9,488

Sample Results for Table 6

A	B	C	D	E	F	G
Gas use/day in US bbls	Gas to ethanol ratio[1] ÷ 0.67	Total Gal. need X 42 gal./bbl	Gal./ year need X 365 day/yr	Switchgr. need/yr [2] ÷ 80 gal./ton	Total Acres/yr [2] ÷5.2 ton/acre	Total Land need/yr ÷640 acre/squ.mi.

8.8×10^6	13×10^6	55×10^7	2.0×10^{11}	2.5×10^9	4.8×10^8	760,000

Sample Results for Table 7

A	B	C	D	E
Switchgr. [3] kWh/ton	Switchgr. kWh/lb ÷2000 lb/ton	Transmission efficiency[4] X 0.85	Charging efficiency[5] X 0.75	Switchgr. mi./lb for electr. Ford Focus[6] X 3.23 mi./kWh
1253	0.627	0.533	0.399	1.29

Sample Results for Table 8

A	B	C
Gas-powered Ford Focus mpg	Gas to ethanol ratio[1] ÷ 0.67	Switchgr. mi./lb for ethanol-Ford Focus[2] X 0.040 gal./lb
31	21	0.83

Answers to questions: 1) Lithium batteries are lighter   2) Lead batteries are cheaper. 3) Gasoline powered vehicles are lighter and cheaper.   4) 760,000 square miles   5)   This   is slightly bigger than Alaska.   6) Biofuels need way too much land.   7) The electric car gets more miles per lb of switchgrass.   8) Answers may vary.

Logistics: This is an individual assignment, but some students will need guidance doing the equations. You should navigate the websites yourself before assigning it to your students to test the links and make revisions if necessary.

Degree of Difficulty: 1-2—If student enter values into a spreadsheet template with equations, the assignment is very easy. If you choose to have students do the equations by hand, some will need help. Not all students are proficient with spreadsheets, so you may want to teach a few key students how to insert data and functions into the spreadsheet. These students can in turn teach everyone else. Inserting the data into the prepared spreadsheet template is relatively easy, but some students will struggle to understand the results and answer the questions.