

### 3.2) INSTRUCTOR’S GUIDE TO TRANSPORTATION ENERGY

**Overview:** The following sample calculations were obtained based on data from 2013

**Part A:**

| Fuel used | Total kWh per fuel     | Total fuel consumed   | kWh per unit fuel | Original fuel unit  | Unit conversion | kWh per new fuel unit | New fuel unit       |
|-----------|------------------------|-----------------------|-------------------|---------------------|-----------------|-----------------------|---------------------|
| coal      | $3.016 \times 10^{11}$ | $1.60 \times 10^8$    | 1885              | per ton             | 2000 lbs/ton    | 0.943                 | per lb              |
| oil       | $7.775 \times 10^9$    | $1.34 \times 10^7$    | 580               | per barrel          | 42 gal/bbl      | 13.9                  | per gallon          |
| gas       | $1.65 \times 10^{11}$  | $1.26 \times 10^{12}$ | 0.131             | per ft <sup>3</sup> | N/A             | 0.131                 | per ft <sup>3</sup> |

**Coal:**  $\{(3.016 \times 10^{11} \text{ kWh}) \div (1.60 \times 10^8 \text{ tons})\} \div 2000 \text{ lbs / ton} = \mathbf{0.943 \text{ kWh/lb coal}}$

**Oil:**  $\{(7.775 \times 10^9 \text{ kWh}) \div (1.34 \times 10^7 \text{ barrels})\} \div 42 \text{ gallon / barrel} = \mathbf{13.86 \text{ kWh/gallon oil}}$

**Gas:**  $(1.65 \times 10^{11} \text{ kWh}) \div (1.26 \times 10^{12} \text{ ft}^3) = \mathbf{0.131 \text{ kWh/ft}^3 \text{ gas}}$

| Fuel used | kWh per new fuel unit | Transmission efficiency | Charging efficiency | Miles per kWh | Miles per unit fuel | Fuel unit           |
|-----------|-----------------------|-------------------------|---------------------|---------------|---------------------|---------------------|
| coal      | 0.943                 | 0.94                    | 0.81                | 3.1           | 2.2                 | per lb              |
| oil       | 13.86                 | 0.94                    | 0.81                | 3.1           | 33                  | per gallon          |
| gas       | 0.131                 | 0.94                    | 0.81                | 3.1           | 0.31                | per ft <sup>3</sup> |

**Coal:**  $\{(0.943 \text{ kWh/lb}) \times (0.94) \times (0.81) \times (3.1 \text{ miles/kWh}) \approx \mathbf{2.2 \text{ miles/lb coal}}$

**Oil:**  $(13.8 \text{ kWh/gallon}) \times (0.94) \times (0.81) \times (3.1 \text{ miles/kWh}) \approx \mathbf{33 \text{ miles/gallon oil}}$

**Gas:**  $(0.131 \text{ kWh/ft}^3) \times (0.94) \times (0.81) \times (3.1 \text{ miles/kWh}) \approx \mathbf{0.31 \text{ miles/ft}^3 \text{ gas}}$

**B-1:** The tax per barrel is based on the fact that each 42-gallon barrel of crude oil provides 19 gallons of gasoline.

| Tax per gallon (\$) | Current price per barrel (\$) | Tax per barrel (\$) | % Cost increase | % Economic decrease |
|---------------------|-------------------------------|---------------------|-----------------|---------------------|
| 1                   | 94.52                         | 19                  | 20.10           | 0.15                |
| 2                   | 94.52                         | 38                  | 40.20           | 0.30                |
| 3                   | 94.52                         | 57                  | 60.30           | 0.45                |

**B-2:** Note how a decrease in consumption lowers the world price of oil.

| Mill. bbl. consume by US per day | % reduction in US consumption | Mill. bbl. conserved by US per day | Current price per bbl. | New price per bbl. |
|----------------------------------|-------------------------------|------------------------------------|------------------------|--------------------|
| 18.5                             | 10.00                         | 1.85                               | 94.52                  | 87.12              |
| 18.5                             | 20.00                         | 3.70                               | 94.52                  | 79.12              |
| 18.5                             | 40.00                         | 7.40                               | 94.52                  | 64.92              |

**Answers to Questions:** 1) High cost and mass of batteries 2) 2.2 miles per lb 3) Electric cars will pollute more if coal is used to generate the electricity. 4) 33 mpg 5) You are comparing 33 mpg residual oil versus 33 mpg gasoline. Based on this method of calculation these values are identical. 6) 31 per ft<sup>3</sup> 7) You are comparing 0.31 miles/ ft<sup>3</sup>gas versus 0.25 miles/ ft<sup>3</sup>gas. Based on this method of calculation the electrical pathway is about 20% more efficient. 8) The table will show an inverse relationship between oil price and

economic growth, so high taxes on oil will undermine the economy. 9) Lower demand results in lower prices. 10) Lower oil prices might lead to people consuming more oil. 11). Based on the “rule of thumb” calculations, there may be a point at which substantially reduced oil consumption by the U.S. results in a calculated *negative* international price for oil. Since a negative price for oil is impossible, students should conclude that the “rule of thumb” was designed to deal only with small variations in oil demand. 12) This question forces students to think out of the box. Answers may vary. Some may recommend urban planning that reduces the need for cars.

**Logistics:** This is an individual assignment, but some students may need help navigating the Department of Energy website. You should navigate this website yourself before assigning it to your students to test the links and make revisions if necessary.

**Degree of Difficulty:** 2—Not all students might be 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.