

## REIES – Lesson 3: Energy Transfer & Conversion

### Exercise Sheet

Complete the exercises below to practise the concepts from Lesson 3. Show all working for calculation questions.

### Section A – Knowledge Questions

#### Exercise 1

##### Knowledge

The lesson organises energy conversion technologies into a matrix with energy forms as both rows (output) and columns (input).

- Complete the table below by filling in the name of the technology that converts or transfers energy between each pair of forms.

| Input → Output                          | Technology | Module |
|-----------------------------------------|------------|--------|
| Radiant → Thermal                       |            | 4a     |
| Chemical → Thermal (combustion)         |            | 4a     |
| Nuclear → Thermal                       |            | 4a     |
| Thermal → Thermal (transfer)            |            | 4a     |
| Electrical → Thermal                    |            | 4a     |
| Chemical → Motion                       |            | 4b     |
| Chemical → Motion (aircraft)            |            | 4b     |
| Thermal → Motion                        |            | 4b     |
| Motion → Motion (wind/water)            |            | 4b     |
| Motion → Electrical                     |            | 4c     |
| Radiant → Electrical                    |            | 4c     |
| Electrical → Electrical (transfer)      |            | 4c     |
| Chemical ↔ Electrical (storage)         |            | 4d     |
| Electrical ↔ Chemical (H <sub>2</sub> ) |            | 4d     |

#### Exercise 2

##### Knowledge

The lesson identifies three main forms in which energy is delivered to homes, factories, and vehicles.

- What are the three main energy delivery forms? Give one real-world example of each.
- The lesson states that converting energy into electricity typically requires more steps than converting it directly to heat or motion. Using the conversion chain diagram from the lesson, trace the full chain from solar energy to electricity, listing every technology involved.
- Now trace the shortest chain from solar energy directly to heat. How many fewer steps does it involve?

### Exercise 3

#### Knowledge

The lesson introduces the concept of reversible energy conversion technologies.

- What does it mean for an energy converter to be reversible? Give two examples from the lesson.
- For the fuel cell / electrolyser: describe what each direction of operation produces, what it consumes, and why this reversibility is particularly valuable for integrating renewable energy.
- For the electric motor / generator: describe both operating directions. Give a real-world example where the same machine operates in both directions (Hint: think about electric vehicles going downhill).

### Exercise 4

#### Knowledge

The lesson distinguishes between energy transfer technologies and energy conversion technologies, and notes that electricity can be either a final energy form or an intermediate step.

- Explain the difference between energy transfer and energy conversion. Give one example of a pure transfer technology from the lesson.
- Give two examples from the lesson of electricity being used as an intermediate step (i.e. converted into something else for storage or use).
- The lesson mentions phase change materials (PCMs). Explain in your own words how a PCM stores and releases energy. What two conversion directions are involved?

## Section B – Calculation Questions

### Exercise 5

#### Calculation

Conversion chain efficiency. A gas-fired power plant converts chemical energy to electricity via two steps: (1) combustion boiler converting chemical to thermal at 90 % efficiency, and (2) a steam turbine + generator converting thermal to electrical at 40 % efficiency.

- What is the overall efficiency of the power plant? Use:  $\eta_{\text{total}} = \eta_1 \times \eta_2$
- If the plant consumes 1000 GJ of natural gas, how many GJ of electricity does it produce?
- How many GJ are wasted as heat to the surroundings? Express this also in MWh. (1 GJ = 0.2778 MWh)

### Exercise 6

#### Calculation

Gravitational (pumped hydro) energy storage. Water with a mass of  $5 \times 10^8$  kg is pumped to a reservoir 200 m above the lower reservoir. Use  $g = 9.81 \text{ m/s}^2$ .

- Calculate the gravitational potential energy stored in Joules. Use:  $E = m \cdot g \cdot H$
- Convert this to kWh and to MWh.
- If the water is released through turbines with an overall efficiency of 80 %, how much electrical energy (in MWh) can be recovered?