

REIES – Lesson 2: Energy Use

Answer Key

You have completed the exercises — well done! Use this document to check your work and deepen your understanding. Read the explanations carefully: they connect the numbers to the bigger picture of the energy transition.

Section A – Knowledge Questions

Answer – Exercise 1

Knowledge

Sector	World 2022 share	NL 2022 share
Industry	30.4 %	23.7 %
Transport	27.8 %	18.0 %
Residential	20.3 %	16.8 %
Services	8.0 %	12.0 %
Agriculture	2.3 %	5.8 %
Other	1.6 %	0.2 %
Non-energy use	9.6 %	23.5 %

The largest consuming sector globally is industry at 30.4 %. Transport is second at 27.8 %. In the Netherlands, non-energy use stands out at 23.5 % versus 9.6 % globally. The reason is that the Netherlands is a major producer and exporter of petrochemicals, plastics, and fertilisers — these use oil and gas as raw material (feedstock), not as fuel. The port of Rotterdam, one of the world's largest, is central to this.

Answer – Exercise 2

Knowledge

Non-energy use means using an energy commodity (such as oil or gas) not to produce heat or power, but as a raw material or feedstock to make products. The energy is not 'burned' — it stays locked in the product.

Examples from the lesson: plastics (made from oil) and fertilisers (made from natural gas via the Haber-Bosch process).

It is important to account for separately because non-energy use does not generate CO₂ in the same way as combustion — burning oil releases CO₂ immediately, but oil locked in a plastic bottle does not (until the plastic is incinerated). Lumping it with energy use would distort efficiency and emissions calculations.

NL non-energy use: 23.5 % of 2713 PJ = $0.235 \times 2713 = 637.6$ PJ.

Answer – Exercise 3

Knowledge

The six recognised renewable energy sources from the lesson: Solar, Wind, Geothermal, Hydropower, Ocean (tidal/wave), Biomass.

Definition: Renewable energy is energy derived from natural sources that are replenished at a higher rate than they are consumed. The key criterion is the replenishment rate — renewables naturally refill (sunlight keeps shining, wind keeps blowing) while fossil fuels took millions of years to form and are consumed far faster than they could ever regenerate.

The three reasons for the shift: (1) Global warming — burning fossil fuels releases CO₂ that was stored for millions of years, raising atmospheric concentrations. (2) Limiting temperature rise to 1.5 °C — the Paris Agreement target requires rapid decarbonisation. (3) Renewables emit no net CO₂ — they release no additional carbon into the atmosphere (biomass is debated, but on balance is considered carbon-neutral over its cycle).

Which is most urgent is a matter of perspective — but the 1.5 °C target creates a hard physical deadline: every year of delay locks in more warming. Most climate scientists would point to the speed of emissions reduction as the most urgent factor.

Section B – Calculation Questions

Answer – Exercise 4

Calculation

Total NL consumption: 2713 PJ (2022)

Residential (16.8 %): $0.168 \times 2713 = 455.8 \text{ PJ}$

Industry (23.7 %): $0.237 \times 2713 = 643.0 \text{ PJ}$

Non-energy use (23.5 %): $0.235 \times 2713 = 637.6 \text{ PJ}$

Residential in kWh:

$455.8 \text{ PJ} \times 277.8 \text{ GWh/PJ} = 126\,600 \text{ GWh} = 126.6 \text{ TWh}$

(= 126 600 000 000 kWh — a very large number, reflecting ~8 million households)

Notice that non-energy use (637.6 PJ) is almost as large as industry in the Netherlands — a reminder of how central petrochemical production is to the Dutch economy.

Answer – Exercise 5

Calculation

Given: 20 million people, 106 kWh per person per day

Total daily demand:

$$20\,000\,000 \times 106 \text{ kWh} = 2\,120\,000\,000 \text{ kWh/day} = 2.12 \times 10^9 \text{ kWh/day}$$

Convert to Joules:

$$2.12 \times 10^9 \text{ kWh} \times 3\,600\,000 \text{ J/kWh} = 7.632 \times 10^{15} \text{ J/day}$$

Convert to Watts (power = energy / time):

$$7.632 \times 10^{15} \text{ J} / 86\,400 \text{ s} = 8.83 \times 10^{10} \text{ W} = 88.3 \text{ GW}$$

This confirms the lesson figure of approximately 88 GW.

Answer – Exercise 6



Calculation

Given: land area = $41\,500 \text{ km}^2 = 41.5 \times 10^9 \text{ m}^2$, 1 W/m^2 , 6 % used

$$\text{Area used: } 0.06 \times 41.5 \times 10^9 \text{ m}^2 = 2.49 \times 10^9 \text{ m}^2$$

$$\text{Power generated: } 2.49 \times 10^9 \text{ W} = 2.49 \text{ GW}$$

Annual energy:

$$2.49 \times 10^9 \text{ W} \times 3.156 \times 10^7 \text{ s} = 7.86 \times 10^{16} \text{ J} = 78.6 \text{ PJ}$$

This matches the lesson figure of 78.5 PJ (small rounding difference).

As % of 2800 PJ target:

$$78.5 / 2800 \times 100 = 2.8 \%$$

Land-based wind alone covers less than 3 % of the national need — which is why the lesson immediately moves on to offshore wind.

Section C – Internet Exploration

Answer – Exercise 7



Internet Exploration

Reference: <https://www.iea.org/reports/key-world-energy-statistics>

The distinction between primary energy and total final consumption (TFC) is important: primary energy includes all energy before conversion losses (e.g. the heat produced in a power station that is not converted to electricity), while TFC is what actually reaches end-users. TFC is typically 60–70 % of primary energy. So 620 EJ primary vs. roughly 400–420 EJ TFC is expected.

Energy per capita: the highest-consuming regions per capita are typically North America (especially the USA and Canada) and the Gulf states. The lowest are Sub-Saharan Africa

and parts of South and South-East Asia. This reflects both climate (heating/cooling needs), industrial structure, and wealth. It also means that as developing regions grow, global energy demand will rise substantially — making the transition to renewables even more urgent.

Energy access: as of the most recent IEA data, around 700–750 million people still lack access to electricity (check the current figure on the site). Without energy access, communities cannot refrigerate medicines, power schools or hospitals, or run small businesses. Addressing this while decarbonising is one of the central tensions of the energy transition.

Go deeper: <https://www.iea.org/reports/world-energy-outlook> | <https://www.iea.org/reports/sdg7-data-and-projections>

Answer – Exercise 8

Internet Exploration

Reference: <https://www.cbs.nl/nl-nl/cijfers/detail/83140NED> | <https://www.energie-nederland.nl>

The exact figures you find will depend on the most recent year available. In general, Dutch total energy consumption has been slowly declining since its peak around 2010 due to energy efficiency improvements and mild winters. The 2022 figure of 2713 PJ may be slightly higher or lower in more recent data.

The Netherlands had a 2020 renewable energy target of 14 % (which it narrowly met) and a 2030 target of 27 % renewable in final energy consumption under the EU Renewable Energy Directive (RED III has since raised EU ambitions to 42.5 %). Check the most recent CBS or PBL (Netherlands Environmental Assessment Agency) data for the current share. As of 2022–2023, the Netherlands was at roughly 14–16 % renewable in final consumption — below the pace needed to meet 2030 targets.

Your reflection paragraph should engage honestly with the gap: offshore wind is expanding rapidly, but heat and transport are lagging. A complete 2050 CO₂-free scenario requires not just more renewables but also electrification of heating (heat pumps), transport (EVs), and industry (green hydrogen). Whether the Netherlands is 'on track' depends heavily on policy decisions in the next 5–10 years.

Go deeper: <https://www.pbl.nl/en> | https://energy.ec.europa.eu/topics/renewable-energy_en