Done by : Ten Wei Ze

EN3006

23-24_S1

Q1(a)(i)

	Oil	Natural gas
Daily consumption in 2015	5.22×10^{14} Btu	3.53×10^{14} Btu
Annual consumption of 2015	1.905×10^{17} Btu	1.288×10^{17} Btu

$$P_t = P_0 e^{at}$$

$$\frac{P_t}{P_0} = e^{at}$$

For oil :

$$\frac{244.9\times10^{15}}{1.905\times10^{17}} = e^{a(35)}$$

a = 0.00718

For natural gas :

$$\frac{218.2\times10^{15}}{1.288\times10^{17}} = e^{a(35)}$$

a = 0.01506

Q1(a)(ii)

	Oil	Natural gas
Proven reserves in 2015	1658×10^9 Barrels	6950×10^{12} ft^3
Proven reserves in 2015 (Btu)	9.62×10^{18}	7.13×10^{18}

$$E = \frac{1}{a} P_0 e^{at_1}\left(e^{a(t_2 - t_1)} - 1\right)$$

<u>For oil</u>

From 2015 to 2050 :

$$E = \frac{1}{0.00718}(1.905 \times 10^{17}) e^0 \left(e^{0.00718(35)} - 1\right) = 7.58 \times 10^{18}\ Btu$$

Remaining reserves : $9.62 \times 10^{18} - 7.58 \times 10^{18} = 2.04 \times 10^{18}\ Btu$

Time taken to consume remaining reserves : $\frac{2.04 \times 10^{18}}{1.905 \times 10^{17}} = 10.7\ years$

Oil will be depleted fully by 2061

<u>For gas</u>

From 2015 to 2050 :

$$E = \frac{1}{0.01506}(1.288 \times 10^{17}\ \text{Btu}) e^0 \left(e^{0.01506(35)} - 1\right) = 5.94 \times 10^{18}\ Btu$$

Remaining reserves : $9.62 \times 10^{18} - 5.94 \times 10^{18} = 3.68 \times 10^{18}\ Btu$

Time taken to consume remaining reserves : $\frac{3.68 \times 10^{18}}{1.288 \times 10^{17}} = 28.6\ years$

Gas will be depleted fully by 2079

Gas will last longer

Q1(b)(i)

Sea transport requires less infrastructure and carries a larger volume of cargo compared to land transport

Q1(b)(ii)

Sulfur emissions lead to environmental problems in the open seas around shipping routes.

NO_x emissions lead to regional issues like acid rain, affects health of people working around the harbours, and lead to eutrophication in costal water around the harbours

Q1(b)(iii)

No. Local governments alone cannot regulate air pollution from shipping in open water. Control of air pollution from open waters would require international collaboration, through the formation of international bodies that would carry-out this regulation.

Q1(b)(iv)

1. Control of combustion process, such as optimisation of pressure or fuel injection timing.
2. Emission control, reducing NO_x emissions through use of selective catalytic reduction.

Q2(a)

Energy Intensity = Energy consumption / GDP

Country	Energy Consumption (10^{15} Btu)	GDP (Billions US$)	Energy intensity (Btu/$)
A	97.595	18983.2	5141
B	3.631	531.3	6834
C	12.245	2064.8	5930

Country	Rank
A	1
B	3
C	2

Country A is the most energy efficient

Q2(b)

CO_2 is a greenhouse gas, it traps heat in the troposphere, raising the temperature of the atmosphere, and subsequently the earth's surface, leading to global warming.

1. Sea level rise leading to flooding of coastal areas
2. Extreme weather patterns leading to droughts and threatening water supply
3. Extreme weather patterns leading to excessively high temperatures, causing heat injuries and weather-related mortalities.

Q2(c)

- Decreasing the amount of CO_2 produced per unit of energy generated would reduce CO_2 emission
- Decreasing the amount of energy used per $ of GDP generated would reduce CO_2 emission
- Increasing GDP per capita would increase CO_2 emission
- Increasing Population would increase CO_2 emission

Q2(d)(i)

- Limited capacity
- Few existing larger power plants within transport distance of these reservoirs

Q2(d)(ii)

- Laying pipes is very costly
- Access to deeper layer of ocean from industrial urbanised areas is limited

Q2(d)(iii)

- High cost of compressing and pumping liquid CO_2 without leaking through permeable overlay formation
- Deep aquifers may not be located near powerplants

Q3(a)(i)

Coal power plant

Energy = 500 × (365 × 24 × 0.8) = 3504000 MWh = 1.26×10^{16} J

Nuclear power

8 Kg of uranium ore gives 3.4×10^{12} J thermal energy

1 Kg of uranium ore gives $3.4 \times 10^{12} \div 8 \times 0.35 = 1.4875 \times 10^{11}$ J of electrical energy

Mass of ores needed = $\frac{1.26 \times 10^{16}}{1.4875 \times 10^{11}} = 84705\ Kg$

Q3(a)(ii)

Nuclear fusion involves the combination of two lighter nuclei to form a larger nucleus while current commercial nuclear power (nuclear fission) involves the splitting of a larger nucleus into two smaller nuclei.

Nuclear fusion practically has unlimited fuel source (deuterium and tritium) while current commercial nuclear power (nuclear fission) has fuel source that can be used up (uranium).

Advantages :

1. Minimal amount of radiation
2. No spent fuel waste

Issues :

1. High temperature needed to overcome the repulsive force of the positively charged nuclei, atoms need to be in plasma state.
2. Plasma contained in small volume at high pressure, requires use of laser and magnetic field.

Q3(b)(i)

500 MW = 500×10^6 W

9 km^2 = 9×10^6 m^2

1 day = 86400 s

Ideal tidal power = $\frac{\rho g \bar{A} H^2}{T} = \frac{1025(9.8)(9\times10^6)H^2}{86400} = 500 \times 10^6 \text{ W}$

H = 21.86 m

Ideal tidal energy = $\boldsymbol{\rho g \bar{A} H^2 = 4.32 \times 10^{13} J = 43200\ GJ}$

Q3(b)(ii)

Ocean tides are the vertical movement of water (up and down) caused by gravitational forces of the moon and sun on the oceans of earth.

Issues :

1. Can change the tidal level in basin
2. Effect on sedimentation and turbidity of water in the basin
3. May interfere with shipping navigation

Q4(a)

$$Power = 0.5\,\rho_{air} A v^3 C_p$$

30 km/h = 8.33 m/s

A = $\pi \frac{d^2}{4}$

$$Power = 0.5(1.2)\left(\pi \frac{40^2}{4}\right)(8.33^3)(0.35) = 152533\,W$$

Number of household = 100,000 / 4 = 25000 households

Power needed = 25000 × 3 = 75000 kW

Number of wind turbines needed = $\frac{75000 \times 10^3}{152533} = 492$

500 wind turbines needed

Q4(b)(i)

Bioethanol is a quasi-form of renewable energy as it is produced from agriculture feedstock, which takes time and resources to grow, and if consumed at an unsustainable rate, it is possible to run out of supply.

Q4(b)(ii)

Advantages :

1. Has High octane number
2. Low evaporative emissions

Disadvantages :

1. Low energy content
2. Less volatile (poor start up in winter months)

Q4(b)(iii)

1. Algae has high surface productivity and cultivable from non-arable land
2. Algae can grow on fresh, brackish, sea or even wastewater
3. Algae can yield around 60% oil per dry basis under stress condition

Q4(b)(iv)

Cost of cultivation, harvesting and oil extraction of algae are still very high, and stress condition needed to produce lipid result in arrest of cell growth and division.

Two possibles area of research :

1. Identifying suitable algae crop
2. Developing cheaper cultivation, harvesting and oil extraction methods