Done by : Ten Wei Ze

<u>EN3006</u>

22-23_S1

Q1(a)

<u>2015 Nissan Leaf</u>

30 Kwh / 100 mile = 0.1863 Kwh / Km

For 17500 Km : 0.1863 × 17500 = 3260.9 Kwh

Electric cost : 3260.9 × 0.1927 = $ 628.40

<u>Nissan Sylphy 1.6 Lite</u>

For 17500 km : 17500 / 16.1 = 1087 L of fuel

Petrol cost = 1087 × 1.95 = $ 2119.65

Q1(b)

For 2015 Nissan Leaf : 628.40 / 17500 = $ 0.0359 / Km

For Nissan Sylphy 1.6 Lite : 2119.65 / 17500 = $ 0.1211 / Km

Cost difference of car : 108,000 – 95,800 = $ 12,200

Cost difference of travelling 1 Km : 0.1211 – 0.0359 = $ 0.0852

Break-even distance : 12200 / 0.0852 = 143,192 km

Time needed : 143,192 / 17500 = 8.18 years

Q1(c)

Although it costs less for EVs to travel 1 Km compared to petrol cars, their high car price makes petrol cars more cost effective initially, as it will take a long time for fuel cost savings to break-even with the more expensive cost of EVs. It is also harder to find charging points for EVs, as compared to petrol stations which are currently more common.

Q1(d)

While EVs do not consume petrol directly, the electricity it consumes would be equivalent to 31.8 L of petroleum a year. It shows that the EV is way more energy efficient than the petrol car, and consumes energy equivalent to a smaller volume of petrol to travel the same distance compared to a petrol car.

Q2(a)(i)

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

$$\frac{P_t}{P_0} = 2 = e^{a(90)}$$

$$\ln(2) = 90a$$

$$\boldsymbol{a = 0.0077\ /\ year}$$

$$E = \frac{1}{a} P_0 e^{at_1}\left(e^{a(t_2-t_1)} - 1\right) = 114\ billion\ metric\ ton$$

$$P_0 = 3.77\ billion\ metric\ ton$$

$$489.61(e^{0.0077t_2} - 1) = 114$$

$$e^{0.0077t_2} = 1.233$$

$$\boldsymbol{t_2 = 27.2\ years}$$

It will be exhausted **before** the production rate is doubled 90 years later

Q2(a)(ii)

Integrated gasification combined cycle. Coal is first gasified to produce syngas, which is then used in gas-stream combined cycle to generate electricity. Syngas produced is burnt to generate heat, this hot gas is used in a gas turbine for electric generation, the hot gas is then used to heat water to steam, which generates electricity in a steam turbine.

Advantages :

1. Lower SO_x, NO_x, and CO_2 emissions
2. Less solid waste generated
3. >99% sulfur in coal can be recovered for sale

Q2(b)(i)

Gases that trap heat in the troposphere, raising the temperature of the atmosphere and subsequently the earth's surface, leading to global warming.

Burning of fossil fuels in powerplants

Q2(b)(ii)

Rise in sea level. Leads to flooding, destroying homes in costal, low-lying regions.

Extreme weather patterns. Leads to flash floods and droughts, threatening food and water supplies.

Q3(a)(i)

More feasible as CO_2 can be pumped in for enhanced oil recovery from the reservoir. However, might not be economically feasible if price of oil gets too low.

Q3(a)(ii)

Less feasible as CO_2 can only be pumped in after natural gas is depleted as CO_2 will mix with natural gas otherwise. Advantage includes the fact that the gas reservoirs are deep and impenetrable, preventing CO_2 from escaping.

Q3(a)(iii)

Deep aquifers

Q3(b)(i)

The combination of 2 light nuclei, forming 1 larger nucleus and releasing large amounts of energy

Q3(b)(ii)

Advantages :

1. Minimal amount of radiation
2. Practically unlimited raw material

Disadvantages :

1. High temperature needed to overcome strong repulsive forces of positively charged nuclei, atoms need to be in plasma state, making the process expensive
2. Requires containing plasma in small volumes at high pressure, which is a complex process that requires the use of lasers or magnetic fields

Q4(a)

Turbines are used to capture the kinetic energy of falling water, converting it to mechanical energy which is further converted to electrical energy by a generator.

Pelton turbine : For high head water, and is an impulsive turbine.

Francis turbine : For low head water, and is an axial turbine

Q4(b)

$P = 9810 \times H \times Q \times \eta$

$P = 37.5 \times 2 + 250 \times 4 = 1075 \text{ MW} = 1075 \times 10^6 \text{ W}$

$1075 \times 10^6 = 9810 \times 350 \times Q \times 0.96$

$Q = 326.14 \text{ m}^3 / \text{s}$

Q4(c)

Power in a year = 1075 MW × (365×24×0.4) = 3.77 × 10^6 MWh

Disadvantages :

1. Impoundment may increase seismic activity, increase risk of earthquake and landslides
2. Impoundment may compete with other uses of land, permanently flooding fertile farmland, towns, cities, heritage sites. Humans, flora, and fauna lose their habitats.

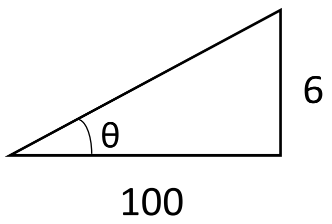
Climate change will lead to droughts, which will lower flowrate Q and thus lower power generation. It will also cause flooding, which will damage hydro powerplants.

Q5(a)

$$P = mV\left[(1+\epsilon)\frac{dV}{dt} + C_R g + g sin(\theta)\right] + (C_D A)\frac{\rho V^3}{2}$$

A = $2m^2$, m = 1200 kg, C_R = 0.12, C_D = 0.25

V = 75 Km/h = 20.83 m/s



tan(θ) = 6 / 100

θ = 3.43 °

P = 1200 × 20.83 [0 + 0.12 × 9.81 + 9.81 Sin(3.43)] + 0.25 × 2 × $\frac{1.2(20.83)^3}{2}$

= 46807 W **= 62.8 hp**

Q5(b)(i)

Hybrid cars have both battery and internal combustion engine. The car runs on petrol using the internal combustion engine. When the car brakes, the electric motor is used as a generator to generate electricity, which is stored in the battery. This electricity can then be used later for driving the electric motor for low-speed cruising or to provide the internal combustion engine more power for acceleration or hill climbing.

Q5(b)(ii)

Hybrid cars are more energy efficient as some of the energy lost during breaking is recovered to power the car later on, thus less fuel has to be burnt, releasing less pollutants into the air.

Benefits :

1. Quieter and lighter engine
2. Better fuel economy

Q5(b)(iii)

Traffic congestions are more likely to occur in cities, cars have to brake, slow-down and stop way more often, wasting a lot of energy. Regenerative braking of hybrid cars allows for some of this energy to be recovered, making hybrid cars more fuel efficient as this recovered energy can be used to power the car. On highways, cars are less likely to brake, slowdown or stop, thus this regenerative braking matters less.

Cars also often drive at lower speeds in cities compared to on highways, allow them to use their electric motors for low-speed cruising instead of burning fuel to power the internal combustion engine.