H1 2023 CSQ1: Energy Sources
Suggested answers

(a) With reference to Figure 1, compare the net additions to offshore wind energy capacity in China to those of Germany and the UK over the period 2017 to 2021. [3]

(b) Explain why renewable solar energy produced in Singapore is **not** likely to be a public good. [3]

(c) With reference to Extract 2, explain

(i) **one** positive externality that could arise from the operation of the solar panel energy farm opened in Singapore in July 2021. [2]

(ii) why solar energy produced in the Singapore farm would be under-consumed in a free market. [3]

(d) With reference to Extract 3, explain the likely impact on consumers' energy expenditure as a result of the price increase authorised by Ofgem in August 2021. [5]

(e) With reference to Extract 4 and using a supply and demand diagram, explain and comment on the likely effects of the change in demand for solar energy and the change in government subsidies on the solar energy market in China. [6]

(f) Using the information in Extract 3, discuss the likely effects on energy consumers **and** producers of the UK regulator's decision to increase the maximum price allowed in the energy markets. [8]

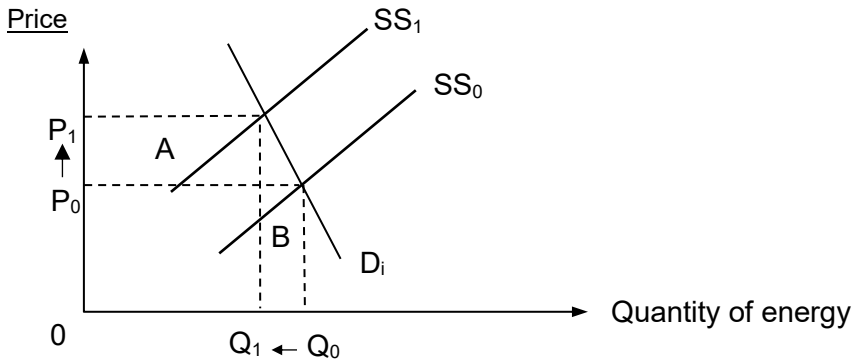
(g) The use of non-renewable energy sources, such as coal, causes market failure. To achieve an efficient allocation of resources, the best government intervention would be an increase in indirect taxation on the sale of energy from non-renewable sources.

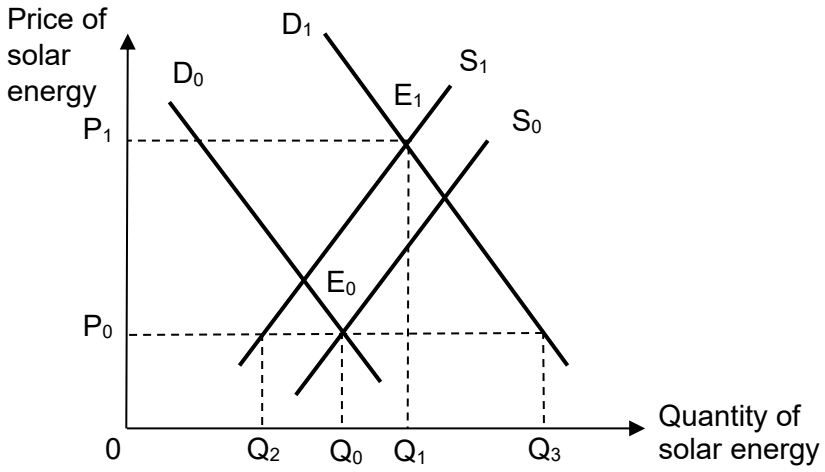
Discuss the view that this would be the best policy. [10]

[Total: 40]

(a)	With reference to Figure 1, compare the net additions to offshore wind energy capacity in China to those of Germany and the UK over the period 2017 to 2021.	(3)
	China net additions to offshore wind energy capacity overall increase whereas Germany and UK have overall decrease. China's net additions consistently increased over the period while for Germany and UK, the net addition only went up from 2018 to 2019. In 2021, China has the largest net additions across the period whereas for UK and Germany, they had the smallest net addition across the years. China has the smallest net additions in 2017 as compared to UK and Germany but by 2021, it has the highest net additions. (any 3 points for 3 marks)	
(b)	Explain why renewable energy produced in Singapore is **not** likely to be a public good.	(3)

	The renewable energy that Singapore developed is solar energy produced by solar panels. Solar energy produced by Singapore is not a public good because it is excludable in consumption which means that users such as households would have access to such energy only if they pay for it otherwise the energy will not be distributed for their use and solar energy supply can be cut off from their houses.	
	It is also rivalrous in consumption which means that the consumption of one more unit of energy would reduce the amount of energy for others. As stated in the extract, 122,000 solar panels are needed to power 5 water treatment plants. This means that at any point in time there is fixed amount of solar energy produced. If there is an additional unit consumed, there will be less available for others. Alternative: Solar energy is also rivalrous in consumption because when one additional user uses it, it diminishes the quantity of energy that is available for the next user. When solar energy is used to power a household, there will be less solar energy available for another household as the amount of solar energy generated at each point in time is limited by the quantity of solar panel and limited space available to set up the solar panels. Alternative: Consumption is also rejectable. Users can choose not to consume electricity generated by solar power but instead choose to use traditional source of energy.	
	Take note: • Good responses provided clear contextual application of these two characteristics of a public good to renewable solar energy production. • Weaker responses wasted vital time with extended explanations of the characteristics fulfilled by a public good in general.	
(c)	With reference to Extract 2, explain	
	(i) one possible positive externality that could arise from the operation of solar panel energy farm opened in Singapore in July 2021.	(2)
	As stated in extract 2, the solar farm helps to reduce carbon emissions equivalent to 7000 cars. This means producing energy using solar panel generates less air pollution. The positive externality of using solar energy is the cleaner air enjoyed by the rest of the Singapore residents who are third parties not involved in the production and consumption of solar energy produced by the solar farm. Alternative: Another example of positive externality is the improved quality of drinking water, that come from better quality water from the reservoir on which the solar farms are located and this positive externality is enjoyed by the rest of Singapore households drinking the water, who are third parties not involved in the production and consumption of solar energy.	
	(ii) why energy produced in the Singapore solar farm would be under-consumed in a free market.	(3)
	In a free market, producers and consumers only consider their private costs and private benefits. They maximized their welfare by consuming and producing at the market equilibrium output at Qo where MPC=MPB. Due to the presence of positive externalities as explained above, marginal social	

	benefit (MPB + MEB) is greater than MPB. From society's point of view, the socially optimal output is Qs where MSC=MSB which is less than Qo. So there is under-consumption of the good by QoQs where the MSB is greater than MSC for the units between Qo and Qs. This leads to a deadweight loss of area ABC as each additional unit generates more benefits than costs. [insert diagram] Note: Drop step 3 in the 5-step market failure explanation. Step 3 is already explained in the earlier part. **Recap 5 step market failure explanation** Step 1: explain MPB, MPC with e.g. Step 2: explain free market equilibrium Step 3: Explain externality Step 4: explain where is socially optimal output Step 5: under/over production/consumption and deadweight loss	
(d)	With reference to Extract 3, explain the likely impact on consumers' energy expenditure as a result of the price increase authorized by Ofgem in August 2021.	(5)
	Consumers' expenditure is price x quantity demanded. The demand for energy is price inelastic of between 0.1 and 0.3 as mentioned in Extract 3. When price increase, quantity demanded will fall by less than proportionately. The increase in expenditure due to the price increment is greater than the fall in expenditure due to the less than proportionate fall in quantity demanded. As a result, the total expenditure of consumers increased.  Figure 2 : Energy Market in UK	

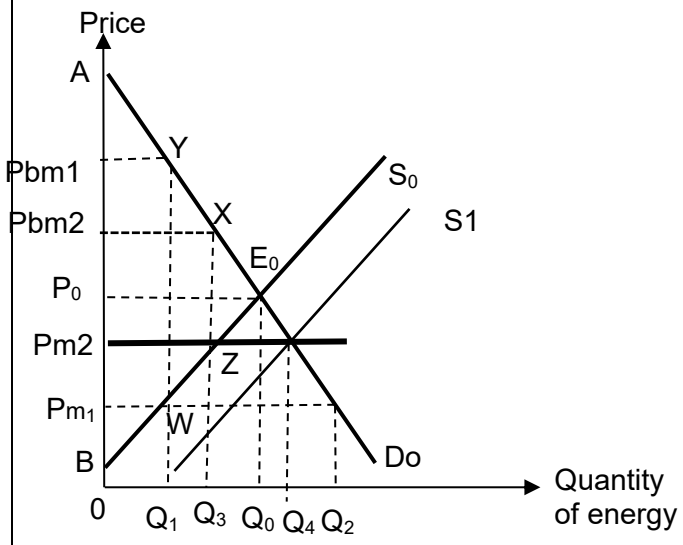
	Take note: • Not recommended to include operation of a price ceiling mechanism	
(e)	With reference to Extract 4 and using a supply and demand diagram, explain and comment on the likely effects of the change in demand for solar energy and the change in government subsidies on the solar energy market in China.	(6)
	 **R1: Overall increase in equilibrium price and increase in equilibrium quantity in the solar energy market** There has been rising solar energy demand in China. Extract 4 mentioned that the growth rate for energy demand was 5.9% and much of this increase was from renewable energy. There could be several factors that may have contributed to this rising demand. Some of these are increase in tastes and preferences due to greater awareness of the non-pollutive nature of such energy compared to fossil fuel energy, increase in income that lead to increase use of energy which includes renewable energy, increase government rules and regulations that discourage the use of fossil fuel energy etc. On the supply side, the Chinese government recently announced that they no longer grant subsidies for new solar power stations. The removal of subsidies for new solar power stations will increase the cost of production of new solar energy producers which reduced their profitability. As a result, they will reduce supply. Overall, the market supply of renewable energy falls the supply curve shifts to the left from So to S1. A rise in demand and a fall in supply will result in a shortage at the market equilibrium price Po. This exerts an upward pressure on prices and price will increase from Po to P1. <u>However, the change in the equilibrium quantity is indeterminate</u>, depending on the extent of the rise in demand and the fall in supply. As the removal of subsidies is only for new solar power stations but not the existing power stations, the fall in supply may not be as great. On the other hand, the rising trend of using renewable energy has been going on for the last 20 years and so it is unlikely to change. As such, it can be assumed that the rise in demand is greater than the fall in supply. As a result, the equilibrium quantity will increase.	

	R2: Overall increase in equilibrium price and fall in equilibrium quantity in the solar energy market Extract 4 states that subsidies given to renewable energy production amassed to a large debt of US$42 billion. This suggests that initial subsidy amount given to each firm is large. The removal of a large subsidy is likely to significantly increase in the overall cost of production for new solar energy producers. This will result in a large fall in supply. Changes in other non-price determinants of demand such as fall in income level during a recession could reduce the extent of increase in demand. Hence, the extent of fall in supply could be greater than the extent of increase in demand. As a result, the equilibrium quantity will fall. **Conclusion** While there is certainty that equilibrium price will increase, the overall effect on equilibrium quantity depends on the relative extent of shift in demand and supply curve.	
(f)	Using the information in Extract 3, discuss the likely effects on energy consumers and producers of the UK regulator's decision to increase the maximum price allowed in the energy market.	(8)
	A maximum price Pm1, is a legally imposed price that is below the market equilibrium price of Pe. **Explain initial state of the market with a maximum price:** At the initial maximum price, Pm1, the quantity supplied is Q1 and the quantity demanded is Q_2 and there is a shortage of Q_2Q_1 created. At Pm1, the actual quantity purchased will be based on the available quantity supplied which is OQ_1. Consumers who are able to purchase the goods (OQ1) pay a lower price Pm1 as compared to Pe. Due to the shortage, consumers may turn to the black market which sells the good at price Pbm1 which is higher than the market equilibrium price. **<u>Thesis: Consumers and producers will be worse off with an increase in the max price</u>** (-ve for consumers) However, when the price ceiling is raised to Pm2, which is still below the equilibrium price of Pe, consumers who consumed OQ1 will be worse off as they now have to pay more (take note: they are still better off than without government intervention where they have to pay Pe). (-ve for consumers) Furthermore, as energy is a basic necessity, any increase in the price ceiling will have adverse equity effects on low income households. Energy expenditure may take up a big proportion of lower income households' total expenditure and this than cause greater inequity. These households would have less income to spend on other necessities like food and rent.	

Anti thesis: Consumers and producers will be better off with an increase in the max price

(+ve for consumers) With the increase in price, there is an increase in quantity supplied from Q1 to Q3 and a fall in quantity demanded from Q2 to Q4. The shortage now is smaller (Q4 – Q3). More consumers are now able to purchase the good as the quantity supplied increased from Q1 to Q3.

(+ve for producers) When the maximum price is raised to Pm2, the producers are better off as now their total revenue increases from OPm1 x OQ1 to OPm2 x OQ3 (Note: It still lower than the total revenue before maximum price is imposed).



Evaluative conclusion

[Depends on the situation] If initial max price of Pm1, is very low, producers may make losses and they will close down and leave the market. In which case both consumers and producers will be worse off. For this reason, it is beneficial to both consumers and producers if the UK regulator raised the maximum price to ensure that energy producers earn enough profits to continue production especially when there is an increase in the costs of production due to higher wholesale prices for energy.

OR

[depends on the situation] Likely effects on producers and consumers also depend on price elasticity of demand and supply. If supply is inelastic and demand is inelastic, the rise in the maximum price will result in less than proportionate increase in quantity supplied and less than proportionate fall in quantity demanded. This will reduce the shortage by a smaller extent. Consumers are better off to a smaller extent.

Or
[depends on the situation] Likely effects of the increase in price ceiling depends on whether the government subsidise the energy producers to remove the shortages created by the price ceiling. If it does, then the supply

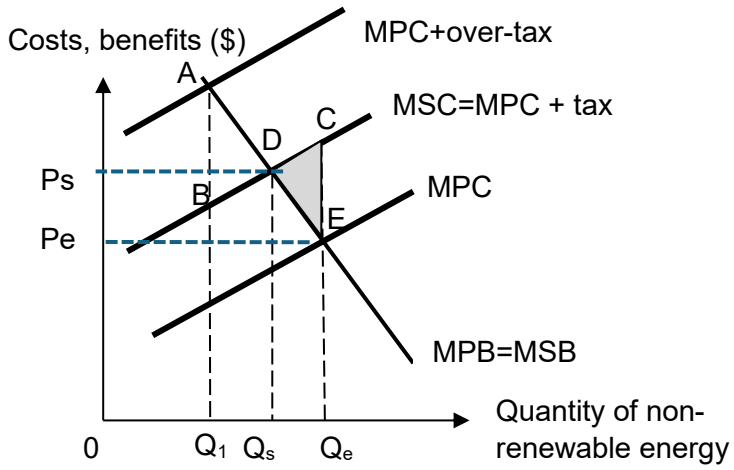
	curve will shift to the right for example to S1. This will bring down the market equilibrium price to Pm2 such that it coincides with the maximum price. In this case, the market clears, there will be no black market and society's welfare is maximized while maintaining a low price of energy for the low income families to enhance equity.	
(g)	The use of non-renewable energy sources such as coal, causes market failure. To achieve an efficient allocation of resources, the best government intervention would be an increase in indirect taxation on the sale of energy from non-renewable sources. Discuss the view that this would be the best policy.	(10)
	[Note that policies are to address a problem (or achieve specific objectives). As there are no questions in the earlier part of the CSQ on the problem caused by non-renewable energy sources, there is a need to give a truncated explanation of the market failure, which is essentially step 3 and 4 only.] **Brief explanation of the market failure** Non-renewable energy such as coal generates negative externalities in the production process, i.e. marginal external cost (MEC) to third parties. This is because carbon emissions are generated from burning of fossil fuels. This leads to global warming which can lead to greater occurrence of floods. The floods will destroy property and cause losses for owners of such property. The MEC results in divergence between MSC and MPC. Socially optimal level of consumption is at Qs where MSB=MSC. However, producers only consider their own marginal private benefit and cost, ignoring the MEC. Hence there is over-usage of non-renewable energy sources and deadweight loss to society from over-allocation of resources to the production of energy from non-renewable sources. **Explanation of <u>H</u>ow the 2 policies work and their <u>L</u>imitations** **P1: Imposition of a tax is a good way to reduce the negative externalities.**  	

Figure 2

How policy works: If the government imposes a tax per unit of output that is equal to the marginal external cost at Qs, it forces producers of non-renewable energy to internalise the negative externality. This raised their cost of production which is reflected by the MPC curve shifting upwards to 'MPC + tax'. The fall in supply will cause the market price to increase from Pe to Ps and the equilibrium quantity is then reduced from Qe to Qs, eliminating the deadweight loss of area CDE. The socially efficient level of oil usage at Qs will thus be attained and the new price Ps, is then the 'true' price of using non-renewable energy.

Evaluation of whether taxation as best policy to achieve allocative efficiency:

Ev of limitations: However, there is difficulty in assessing the monetary value of the external costs as air pollution from the use of coal has wide ranging effects which can spread over large geographical areas and over long periods of time.
[depends on situation] For example, the health problems suffered by the local communities from air pollution may only manifest in the long run and thus, it would be difficult for government to estimate such costs accurately in the short run. Due to insufficient knowledge of MEC, it this can lead to over-taxation at MPC + over-tax, which will reduce production to below Qs at Q1, and can lead to an even greater deadweight loss (Area ABD) as shown in the diagram.

P2: Another way to reduce negative externalities from non-renewable energy is to provide subsidies to renewable energy producers.

How it works: Renewable energy such as wind and solar power generates clean energy that does not cause pollution to the environment. As mentioned in Extract 4, China has been generous in subsidising renewable energy such as wind and solar power. Subsidies reduce costs of production which increase the profitability of producing renewable energy. Producers are incentivised to increase production and when supply increases, there will be surpluses which exerts downward pressure on price of renewable energy. Since renewable energy and non-renewable coal powered energy are closed substitutes as both are sources of electricity, consumers will switch from non-renewable energy which is not subsidised to renewable energy which is relatively cheaper due to the subsidies. From extract 4, it is mentioned that much of China's increase demand for energy comes from renewable energy. This is evidence that consumers are willing to make the switch. This will cause the demand for non-renewable energy to fall. With reference to Figure 2, the MPB curve which is also the demand curve for non-renewable energy will shift leftward and ideally, it intersects MPC at Qs. Thus, the socially optimal output of non-renewable energy is attained and the deadweight loss of area CDE is eliminated.

Evaluation of whether subsidy of renewable energy is the best policy to achieve allocative efficiency:

EV of limitations: However, subsidies would require additional government spending and government would have to borrow which will cause it to incur substantial debt.
[depends on situation] China as already incurred a large debt of US$42 billion. This is not sustainable as there is huge opportunity costs for developing countries as the subsidies could have been used for other projects like housing and education which would significantly benefit the poor. Thus, the Chinese government announced that they would no longer subsidize new renewable energy projects.

Evaluative conclusion
In terms of effectiveness, a pollution tax on non-renewable energy is more effective than subsidies for renewable energy in reducing negative externalities in the short run.
[depends on time period] Given the current state of the environment where there is already high levels of air pollution that cause climate change, an indirect tax is the quickest way of getting results in the SR as profit-maximising non-renewable energy firms would cut back production and consumers will reduce consumption in response to higher costs of production. Subsidy for renewable energy production is more effective in the long run as firms will need to invest and build new capital equipment such as dams, wind vane or solar panels.

OR

In conclusion, taxes should still be the first choice policy followed by subsidies for countries with limited land or unfavourable weather conditions.
[depends on the situation] For example, Singapore can only generate very limited amount of renewable energy due to its small size where there are many competing demands for its land resource. Hence there is a limit to the extend to which subsidy for renewable energy production could increase the supply as there is a lack of resources for renewable energy production.

OR

Subsidy is as it enhances equity in the country.
[depends on the situation] Subsidy of renewable energy can bring down the overall price of energy for households especially for lower income households which may spend a large proportion of their income on energy. Taxing non-renewable energy without providing a cheaper alternative will only increase their cost of living. Subsidy can enhance equity as lower income households can now spend more on other necessities when their expenditure on energy

	falls. This is especially beneficial in countries with large proportion of the population living in poverty.	
	Take note: • You should focus on market for non-renewable energy. • Don't just state many general limitations. Please pick one limitation point for each policy and elaborate with contextualization.	