Version JHG/3

EGT2: IIA
ENGINEERING TRIPOS PART IIA

Thursday 3 May 2018 9.30 to 11.10

Module 311

ENVIRONMENTAL SUSTAINABILITY AND BUSINESS

*Answer not more than **two** questions.*

All questions carry the same number of marks.

*The **approximate** percentage of marks allocated to each part of a question is indicated in the right margin.*

*Write your candidate number **not** your name on the cover sheet.*

STATIONERY REQUIREMENTS
Single-sided script paper

10 minutes reading time is allowed for this paper at the start of the exam.

You may not start to read the questions printed on the subsequent pages of this question paper until instructed to do so.

1 Product Lifecycle Assessment and Its Uses

The company that manufactures Guinness and other alcoholic drinks has published on its website several illustrative lifecycle assessments. They capture lifecycle impacts of drink production in terms of two metrics: carbon emissions and water consumption.

The data for 1 pint (568ml) of Guinness, produced and consumed in Ireland, are: 170 grams CO_2 and 65 litres of water. 74% of the CO_2 footprint is attributable to the production and packaging lifecycle phases (the other phases are raw ingredient production, transport, and retail/consumer). 79% of the water footprint is attributable to raw ingredient production (the other phases are production, packaging, transport and retail/consumer).

By comparison, the website indicates typical data for:

- A glass (250ml) of milk as: 325 grams CO_2 and 255 litres of water.
- A can (330ml) of cola as: 170 grams CO_2 and 20 litres of water.
- A plastic bottle (330ml) of mineral water as: 140 grams CO_2 and 7 litres of water.

(a) There are three main stages in doing a lifecycle assessment. What are these and what do they convey? Which of these stages do the data on CO_2 emissions and water consumption represent? [20%]

- *Good answers will convey the three phases as: inventory, impact and interpretation. The data are a result of the inventory phase.*
- *An excellent answer will note that the inventory phase is incomplete as it does not account (yet) for environmental impact, and even impact is subject to subjective interpretation.*

(b) Your vegan friend uses these data to support his choices, by asserting that milk is 'far worse' in terms of its environmental impact, compared to cola, bottled water, or Guinness (which is actively eliminating use of fish membranes as filters, becoming vegan-friendly). Do you agree or disagree with your friend? What additional considerations or data would you need to make a more complete evaluation of the environmental impacts of these beverages? [40%]

- *A good answer will point out that indeed, milk has considerably higher (more than 4X, on a per ml basis) CO2 emissions that does Guinness and even higher water consumption (more than 10X, on a per ml basis). However, this does not tell us the whole story. Students should point out that a comparative footprint (LCA) analysis needs to also account for a reasonable basis for comparing use/consumption (i.e., per capita, or per consumer the milk vs. Guinness comparison would be different because we can assume more people drink milk than Guinness).*
- *A well-argued answer could be crafted to support either that the vegan friend is right, or that he is wrong, but the scope of environmental impacts under consideration must be specified and justified in each case. With reference to 1a, students should recognize the difference between an LCA inventory and the actual impact and interpretation.*
- *A good answer will also point out that other considerations should be taken into account when assessing which is 'worse' in terms of environmental impact; these could include any of (or more):*
    - *What are the sources of the C02 emissions and are they comparable in terms of actual environmental impact? (an excellent answer might elaborate on how much scope there is for reducing or mitigating impact: e.g. for milk production much of CO2 equivalent will come from raising cows; there is no alternative to this; whereas for Guinness production , the majority of the CO2 emissions come from manufacturing/production, for which alternative fuel sources could conceivably be used)*
    - *Similarly, what is the actual environmental impact of the water consumption; impact can vary according to location (water scarce region) and practices (recycling); excellent answers will consider the relative impact of various lifecycle phases.*
    - *There are a number of environmental impacts NOT captured in these data; what about toxic chemical use or discharge, waste production, hazardous waste, etc.*
- *An excellent answer will state that an overall assessment of 'environmental impact' necessarily involves some subjective element, as there must always be a prioritization and weighting of impact areas (e.g. energy, water, toxics) as these are not straightforwardly commensurable; i.e., the interpretation of an LCA is paramount.*

(c) On the website, the CO_2 impact of a pint of Guinness is equated to roughly that needed to watch television for two hours. This is in an effort to make the data understandable in the context of people's lifestyles. Would you recommend to company managers that they publish additional metrics (e.g., loads of laundry, or miles driven) and actively communicate these to consumers to dispel concerns about Guinness' environmental footprint? What might be the benefits and risks of such a move? [40%]

- *A good answer will recognize that companies can get into dangerous territory when they start to use footprint data in communicating with the public. Students can argue either way – if a company wants to provide these data, they should make it easy to consume and meaningful. On the other hand, providing the data inevitably masks considerable complexity in what these data mean and how they will be interpreted by the public.*
- *Benefits include: transparency, conveying that a product regarded as 'wasteful' is comparatively not so, educating the consumer so s/he demands improvement from this/other companies, getting ahead of competitors in terms of developing the capacity to measure, convey, and manage environmental footprint.*
- *Risks include: inviting critique from advocacy groups or critical consumers who will use the data to ask the company to do 'more'; misleading the consumer because a simple CO2 footprint does not capture the multiple, complex aspects of environmental impact.; having the information be regarded as simply a marketing ploy and not taken as a serious signal of the company's intent to reduce its environmental footprint*
- *An excellent answer will draw analogies or comparisons between this example and other cases discussed in class or with which they are aware. E.g., the case of Fiji water, whose effort to publish its carbon footprint coincided with a marketing campaign about going 'carbon negative,' and backfired.*
- *An excellent answer will recognize that the only reason a company should publish carbon footprint data is if it's part of a more comprehensive and sensible strategic approach to address 'material' environmental impacts (not simply marketing).*

2 Water Consumption and Approaches to Mitigate It

The state of California faced a severe water shortage in 2015 due to droughts that affected all of its 39 million residents, as well as industrial and agricultural users of water. At the same time, in the state's agricultural central valley, many farmers were switching from growing 'fallow' crops such as cotton, to the far more lucrative crop of almonds. Almonds are grown in orchards, and the trees need a continuous supply of water in both dry and wet years to survive and thrive. By contrast, a fallow crop like cotton can be left to 'fallow' (die back) in a dry year, and will regrow subsequently and produce a good crop.

(a) Explain why it is favourable for individual farmers to make this crop switch, and what you predict the longer term/larger scale consequences will be, and why. [20%]

- *The key idea here is the 'tragedy of the commons'; given the economic benefit of switching to a more lucrative crop, individual farmers are incented to do this, with little regard to water supply. But if everyone does it, then the resource (water supply) will be overtaxed and rapidly depleted. Excellent answers will explain the origins of the tragedy of the commons in Garrett Hardin's work and illustrate other area where it applies.*
- *According to the tragedy of the commons, as long as individual farmers are incented to switch to almonds as a crop, the water supply will be more and more taxed over time and the almond (and other) crops will suffer. An excellent answer may point out that in the long run, fallow crops (as opposed to almonds) may fare better in the valley because they can survive over drought years. But, the net result is that all farmers will be worse off due to lack of sufficient water for irrigation.*

(b) A long history of complex water rights and provision in the state of California provides the backdrop for current efforts to develop a groundwater sustainability plan for the state. To date, agricultural producers can drill their own wells and draw groundwater, which has contributed to groundwater contamination and shortages. However, a modified regulatory framework to address issues with agricultural groundwater sustainability will take many years to come into effect. Given what you know about the underlying dynamics of the problem, what other possible approaches are there for managing the agricultural water shortages in this area, and what are their pros and cons? [40%]

- *Here students should be able to describe the three main ways that tragedy of the commons problems are addressed: regulation (which can include quotas and/or permits); marketization/privatization (which include buying and selling water consumption credits); and community based management. Excellent answers will provide brief examples of how these approaches have been used elsewhere and some of the ideas behind them.*
- *Pros and cons might include any of the following, and beyond:*

Regulation	**Marketization**	**Community norms**
Pros: can be very effective if limits/quotas set and	Pros: economically more efficient (often) than regulation;	Pros: socially enforced, sometimes leading to better effectiveness than

enforced;		regulation; local ownership of problems/solutions
Cons: relies on strict enforcement; can be economically inefficient as everyone subject (typically) to same limit; relies on good science to comprehend what necessary limits/quotas actually are	Cons: difficult to set 'price' for permits/credits; need to delineate appropriately bounded set of actors; tends to work best when one focused issue (e.g. ozone layer) that has a discrete solution/alternative available; relies on good science to comprehend what necessary limits/quotas actually are	Cons: typically only works in relatively small community/geographic scales;

(c) Many tout that "water will be the next oil," referring to its increasing scarcity, the impact this will have on industrial and agricultural producers (as well as residents), and the rising price of water provision in some parts of the world. Evaluate this statement in light of how water and oil are used in industrial and agricultural production and the trends associated with each. Do you agree with the statement? Explain why or why not. [40%]

- *Here students should evaluate the differences between water and oil consumption in relation to industrial and agricultural uses. They should point out that, while oil (fossil fuels more generally) tend to be used ubiquitously, water consumption does differ by application and by region. Fossil fuels, and climate change, are truly global ('commons') problems, whereas water scarcity and water quality is a more regionally defined problem.*

- *Good arguments could be made either for or against the statement, however. For example, students could assert that we've reached a state where the transition away from oil/fossil fuels is viable through other energy sources, whereas water continues to be a vexing problem (there is no 'replacement'). On the other hand, the qualities of water (its regional/local nature) as a resource mean that it will never be 'like oil' in terms of demanding a major shift across industries and globally.*
- *Excellent answers will consider the question in light of tragedy of the commons concepts, as well as opportunities for each resource to be subject to circular economy or industrial symbiosis approaches. They will also recognize that oil is subject to global commodity pricing, whereas water pricing is controlled locally and often is vastly underpriced/subject to political pressures.*

3 Food Retailing and the Circular Economy

Worldwide, between one-third and one-half of all food produced is wasted, according to estimates. In the UK, this varies from about 45% of all fruits and vegetables being wasted, to 30% of cereals, and 20% of meat and dairy. These figures represent total waste arising from suppliers, retailers and consumers. Given that 87% of the food retail market in the UK is controlled by only seven major retailers (Sainsbury's, Tesco, M&S, Asda, Co-op, Waitrose, and Morrisons), the potential for retailers to take individual or collective action to curb food waste is significant.

(a) Imagine you are advising **one** of the major food retailers in the UK about the topic of food waste, versus another important topic, that of packaging (and packaging waste). Using the logic of a materiality matrix, outline the considerations that the company should take into account for each issue (food waste and packaging). Based on these considerations, which issue would you deem 'more material' to the company's business in the next ten years, and why? State any assumptions you make in reaching this conclusion. [30%]

- *Students should articulate the two major axes of the materiality matrix: impact of issue on the business (strategic consideration) and concern of stakeholders. Hence, answers should contain some details about how each of food waste and packaging influences each dimension.*
- *Either issue could be deemed 'more material' based on exactly what level of concern students argue is associated with stakeholder concern on each issue (food waste is getting considerable airtime right now, but packaging waste has long been a concern of stakeholders). The impact on the business should be articulated in terms of both near term and longer term considerations – if the food waste trend continues, will there be real scarcity? How will longer term trends (climate, water etc) shape the supply of food? Are there viable alternatives to packaging, including increased recycling?*

- *Excellent answers will recognize that for each case the retailers do not control the supply chain (for food or for packaging), however these issues may limit their capacity to do business in the future, so they demand a strategic response.*

(b) The retailer in 3(a) is enamoured by the idea of the Circular Economy and wishes to take part in innovations in this area, focusing specifically on packaging waste. However, the person you are advising at the company is worried about the lessons you have shared about the difficulties Cook Composites and Polymers (CCP) had when considering developing its concrete coating product for sale. Explain whether you consider this person's worries well founded or not, based on comparisons between the retailer's situation and that of CCP. [40%]

- *Students should recall some of the particularities of the CCP case: it dealt with the reuse of a hazardous chemical byproduct, which posed some regulatory and liability concerns; it envisioned the development of a new saleable product, which was not very compatible with its core business. Good answers will point to the differences between these factors (and others) vis a vis food waste. While not fully straightforward legally, there are viable technical solutions to food waste that are not as challenging as those posed by reuse of a hazardous chemical.*
- *Good answers will either: i) argue that the manager's concerns are **not** well founded, as there are more technically and organizationally feasible packaging waste (e.g. collection and recycling schemes, reuse opportunities) given that packaging is not subject to hazardous waste regulations (etc.) as in the CCP case or ii) that her concerns **are** well founded, because regardless of technical characteristics, many circular economy ideas fail to get off the ground because of organizational barriers including awareness, trust, and the sustained work of champions.*
- *Excellent answers should recognize that this is a case of a retailer working out how to influence other players and industries, as it has no direct control over packaging. As well, such answers should address the vexing problem of consumer behaviour, and the difficulty of capturing product packaging at end of life.*
- *Excellent answers will also draw on lessons from other case studies to illustrate the challenges – e.g. with end of life collection.*
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(c) Clearly, to address the food waste problem, action will be needed across the board, as food retailers neither fully control their supply chains, nor consumer behaviour. What is one potentially effective way a single retailer can engage consumers in addressing food waste that might be generated *after* the consumer buys food? Explain why your

idea would be appealing to consumers, and, importantly, why it could also be consistent with the food retailer's strategic goals. [30%]

- *This question seeks a range of creative possibilities, but they must be grounded in a firm understanding of the typical challenge of influencing the consumer to do anything once they have bought a product, and the degree to which it is in the company's strategic interest to do so.*
- *Good answers will reference relevant case examples of retailers trying to influence consumer post-purchase behaviour (e.g. H&M, Patagonia, M&S).*
- *Excellent answers will show originality and flair in their solution; such answers will also leverage concepts such as the materiality matrix to illustrate how the proposal can support or enhance the company's longer term strategy.*

END OF PAPER