Pearson BTEC Level _ Higher Nationals in Engineering (RQF)

Unit 51: Sustainability

Unit Workbook 3

in a series of 3 for this unit

Learning Outcome 3 & 4

Alternative Energy & Carbon Footprint

Contents

INTRODUCTION

Evaluate the use of alternative energy generation techniques in relationship to their contribution to a low carbon economy.

- *Alternative energy resources:*
  - Nuclear, solar, wind, tidal and wave, biomass and bioenergy.
  - Whole life cycle costing.
  - Precautionary principle.

Analyse a variety of data sources to estimate the carbon footprint of a socio-technical scenario.

- *Types of Carbon Footprint:*
  - Organisational.
  - Value Chain.
  - Product.
  - Carbon Footprint Science.
  - Calculation Methodologies: Direct & Indirect.
  - System Boundaries.
  - Case Study Examples.

GUIDANCE

This document is prepared to break the unit material down into bite size chunks. You will see the learning outcomes above treated in their own sections. Therein you will encounter the following structures;

Purpose

Explains *why* you need to study the current section of material. Quite often learners are put off by material which does not initially seem to be relevant to a topic or profession. Once you understand the importance of new learning or theory you will embrace the concepts more readily.

Theory

Conveys new material to you in a straightforward fashion. To support the treatments in this section you are strongly advised to follow the given hyperlinks, which may be useful documents or applications on the web.

Example

The examples/worked examples are presented in a knowledge-building order. Make sure you follow them all through. If you are feeling confident then you might like to treat an example as a question, in which case cover it up and have a go yourself. Many of the examples given resemble assignment questions which will come your way, so follow them through diligently.

Question

Questions should not be avoided if you are determined to learn. Please do take the time to tackle each of the given questions, in the order in which they are presented. The order is important, as further knowledge and confidence is built upon previous knowledge and confidence. As an Online Learner it is important that the answers to questions are immediately available to you. Contact your Unit Tutor if you need help.

Challenge

You can really cement your new knowledge by undertaking the challenges. A challenge could be to download software and perform an exercise. An alternative challenge might involve a practical activity or other form of research.

Video

Videos on the web can be very useful supplements to your distance learning efforts. Wherever an online video(s) will help you then it will be hyperlinked at the appropriate point.

Hydroelectricity currently accounts for just under 2% of the UK's total electricity production, whilst globally it is the number one source of renewable energy. There are several different forms of hydroelectric power, including pumped storage, run-of-the-river, tidal and offshore. The most common form is the pumped storage hydroelectric dam and this form of electricity production actually dates back to the late 19th century. It acts as a very reliable and cost-effective source, with long-lasting infrastructure and easily stored energy which is quick to react to peaks in demand.

Figure 1.2: *The UK's Largest Hydro Plant in Dinorwig, Wales*

There are downsides to pumped storage electricity generation, the reservoirs and dams used in these processes actually cause a release of methane and carbon dioxide into the atmosphere. Recent studies have found that 1.3% of worldwide greenhouse gases emissions from human activity came from hydroelectric reservoirs. Additionally, a pumped storage hydropower station usually has a very large impact on the surrounding environment and people, whilst the initial construction costs are also very large, similarly to nuclear, the construction methods may also be fossil fuel powered. There is also a limited capacity for this source of energy in the UK due to the lack of available and suitable sites, such sites would have to contain hugely vast bodies of water.
In comparison, tidal hydroelectric power generation has less of an environmental impact and there are far more potential sites across the UK, where it could be implemented.

In comparison to hydroelectricity, the uptake of **wind** power has grown massively in the UK and it is considered as one of the best locations in the world for the technology to be deployed. As of 2018, 18% of the UK's electricity was as a result of wind power and this proportion is rapidly growing, the nation is currently the fourth largest producer of wind power in the world.

A collection of wind turbines at a particular location is known as a wind farm and these farms can either be placed on or off shore. There are currently close to 10,000 wind turbines operating in the UK with approximately 30 offshore locations and 20 onshore. Overall electricity costs are slightly more with wind power, when compared with traditional methods, and the reliability is also less. However, as the uptake of the technology continues across the country, reliability issues are being overcome and the price per unit of electricity is also falling.

Public opinion of wind power is generally positive, many national polls have been conducted which place this energy source at the top of community acceptance levels. Some opposition to wind power still exists indeed, in 2016, the government attempted to halt the spread of onshore wind farms.

Figure 1.3: *Burbo Bank Offshore Windfarm in Liverpool*

Solar energy is simply the use of radiant heat and light from the sun, which is then used for electricity generation. Plants take the solar energy from the sun and convert this to chemically stored energy (photosynthesis). There are artificial methods of photosynthesis which seek to convert the sun's energy into stored electrical energy for use as fuel cells and other engineering applications.
Photovoltaics (PV) is another branch of solar energy application, this is simply the conversion of light into electricity through the use of semi-conductive materials, solar cells are used to directly convert sunlight into a direct electrical current.

The largest solar farm in the world is located in the Californian desert, it is called 'Solar Star' and uses 1.7 million solar panels, covering an area of 13 square kilometres.

Figure 1.4: *Solar Star Power Station in California*

A solar thermal collector is a form of heat collection through absorbing sunlight, as an alternative to creating electricity to power heaters, this method just creates heat directly by warming air or water which is then moved to the locations where it is required for cooking, washing and several other tasks.
Alternatively, some solar power plants generate electricity by heating a fluid which then goes to drive a turbine and generator.

1.1.2 Whole Life Cycle Costing

Any structure, resource or process can be viewed, essentially as an asset that is under ownership, whilst there are inherent costs associated with this ownership over the entirety of the life of the asset, such as actual financial costs of construction and maintenance, as well as other environmental and social costs. The sum of these costs along with its benefits is known as the **whole life cycle costing**. You may notice that the three areas of these costs mirror the three pillars of **sustainable development:** economic, environmental and social. It is important to note a key difference at his point, merely a Life Cycle Costing (LCC) may be included in a Whole Life Cycle Costing (WLCC). An LCC only includes the costs directly associated with construction and operation, whereas a WLCC considers all whole life costs and benefits, as shown below:

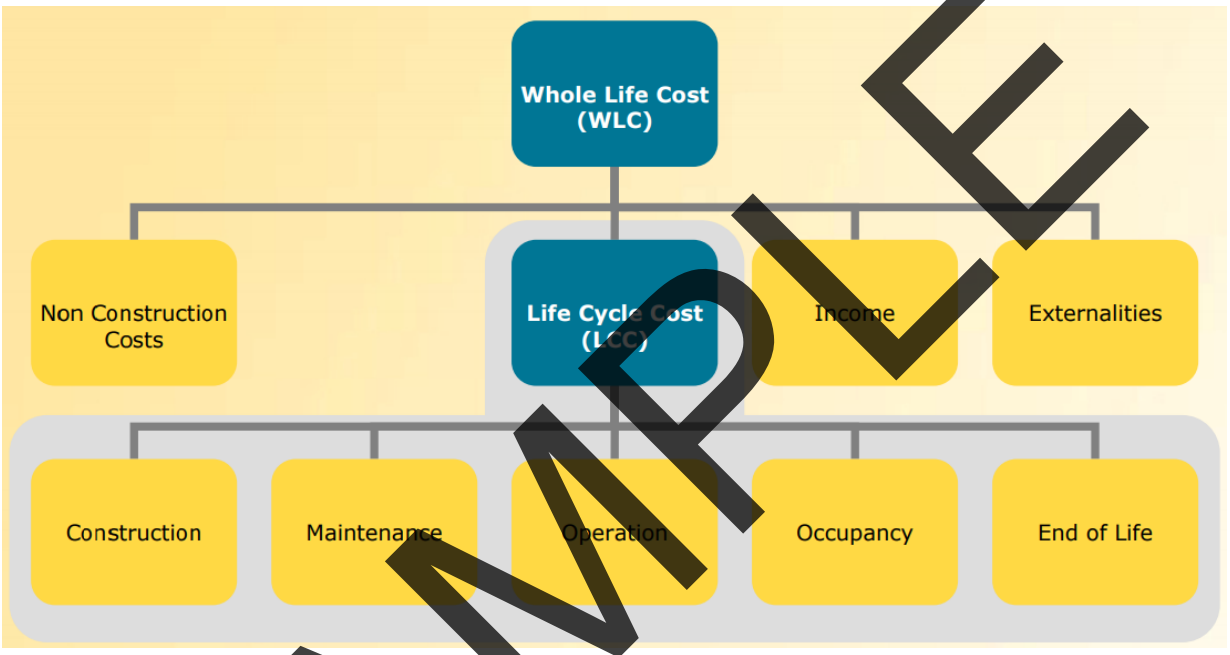

Figure 1.8: *WLCC Encompassing The LCC*

Whole Life Cycle Costing is a very important aspect in the appraisal of any potential asset acquisition or development project because it takes into account the long-term costs of an asset after it has been constructed.

Examples of economic costs include acquisition, planning, design, construction, maintenance, renewal, rehabilitation, operation, disposal and financing charges.

An example of an asset and its environmental costs could be a nuclear power station, whereby there is an environmental cost of producing concrete to build the plant, there is the water required in the copper refinement processes for components within the plant and the emissions from the transport of raw materials and staff to and from the site.

There are usually some social costs to any project, for example a large new discount supermarket may threaten the existing smaller local traders, or a new hydroelectric dam may force the displacement of local people.

1.2 Carbon Footprint

The term 'Carbon Footprint' refers to the amount of greenhouse gas, typically Carbon Dioxide, produced by an entity or asset, be that an individual, a product, company, industry, population or event. The term belongs to a collection of footprints, including land and water as well. The carbon footprint is measured in mass, usually either tonnes or kilograms, depending on the scale and time frame being considered.

For example, a human who is a high meat eater has an average daily carbon footprint of 7.19 Kilograms, whilst a vegan has an average daily carbon footprint of 2.89 Kilograms. Furthermore, the carbon footprint per capita is normally measured in tonnes per year and is represented in the graphic below:

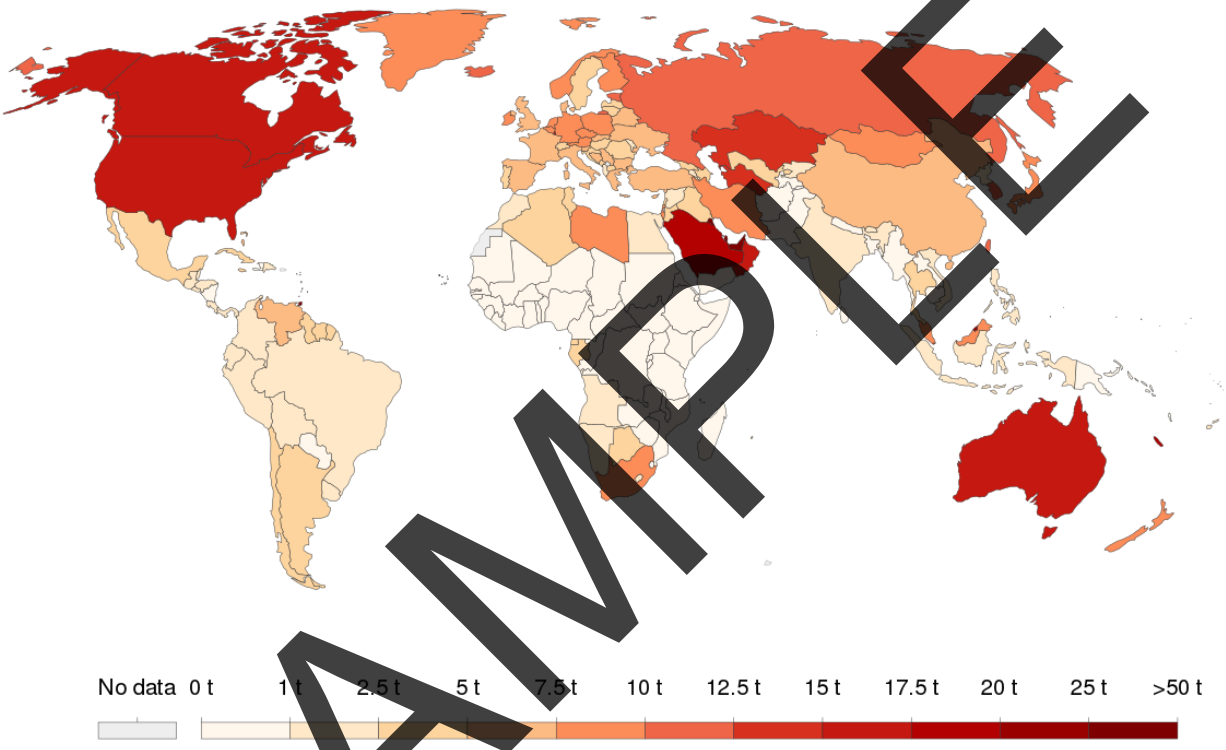

Figure 2.1: *CO_2 Emission per Capita in 2016*

Extensive information and guidance on the subject of Carbon as well as Carbon Footprints can be found at: https://www.carbontrust.com/home/

https://www.carbonfootprint.com/

1.2.1 Carbon Footprint Types, Science & Calculation

Broadly speaking, there are both a **primary** and a **secondary** carbon footprint, the primary is associated with activities that create CO_2 directly and immediately such as driving a car, whilst secondary is all activities that go into creating, moving and manufacturing the asset, such as transporting that car to a sales showroom. The secondary carbon footprint also refers to activities and processes which occur after the asset has served its useful purpose. Carbon footprint also takes into account emissions other than Carbon Dioxide, such as methane and nitrous oxide. In order to simplify the whole calculation process, the impacts of all emisssions are added together and given as a single number in the terms of Carbon Dioxide equivalence (CO_2e).