ROMBLON STATE UNIVERSITY
College of Engineering and Technology
Main Campus, Odiongan, Province of Romblon

HANDOUT #4

CE4113 ENVIRONMENTAL ENGINEERING **Friday: 1-4:00PM**
Engr. Reynaldo P Ramos, PhD **CET 07**

A. SUSTAINABILITY AND CRADLE-TO-CRADLE DESIGN

Sustainable Materials Management (SMM) – an approach to promote sustainable materials use, integrating actions targeted at reducing negative environmental impacts and preserving natural capital throughout the life-cycle of materials, taking into account economic efficiency and social equity.

Framework for Sustainability
It is also called as "The Natural Step" – a framework that provides a set of four system conditions that define a sustainable society based on the laws of thermodynamics and natural cycle. This also considers that the Earth as a closed system for materials and as an open system for energy that sustains life through a complex interactive network of material cycles that uses solar energy to counteract the tendency of materials to dissipate and otherwise increase in entropy.

1. *Extracting concentration of substances from the Earth's crust* – condition that refers to the extraction of minerals and fossil fuels which these substances are scarce and should be substituted with those that are more abundant. It should be used efficiently and recycled, and dependence on fossil fuels should be systematically reduced.
2. *Building up concentrations of human-made compounds in nature* – condition that refers to the manufacture of persistent and unnatural compound which should be replaced with those that are abundant and or that break down completely and easily in nature. All substances produced should be used efficiently.
3. *Utilizing renewable resources at rates faster than they are regenerated and reducing the productive capacity of nature* – condition refers to the use of natural resources which should be drawn only from well managed ecosystems for productive and sustainable uses.
4. *People are able to meet their needs worldwide* – condition means using all the resources efficiently, effectively, fairly, and responsibly for the use of future generation.

Cradle-to-cradle Design
It is the same concept to the design of human industry. The key principle is just as in natural systems where one organism's waste becomes food for another. It is also defines two metabolisms within which materials are conceived as nutrients circulating benignly and productively through metabolisms: biological nutrients within biological metabolism, and technical nutrients cycle within technical metabolisms.

Three design principles are:
1. Use of current solar income – harnessing solar energy directly and indirectly for human purposes
2. Celebrate diversity – development of diverse products fitting for different preferences, cultures, ecosystems, and geographies.
3. Waste equals food – no waste in nature; human system can be designed to circulate materials productively to eliminate generation of waste.

B. ENGINEERING DECISIONS

"Environmental engineers have the immense responsibility of protecting both humans and the environment. Our decisions directly and indirectly affect lives and ecosystems, so we must take into consideration a multitude of factors when making decisions."

The implementation of any engineering project – large or small entails series of decisions made by engineers. The potential to harm thousands at a time through incorrectly designed systems by engineers is inevitable.

1. Decisions based on technical analyses – design, specifications, technical data/information. Technical decisions are clearly quantifiable and can be evaluated and checked by other competent professional engineers.

2. Decisions based on cost-effectiveness analyses – annual cost, present worth, capital cost, interest, capital recovery factor.
   Annual cost = is the total amount required to operate or spend in a year;
   Present worth = present value = the value in the present time of a sum of money; it describes how much a future sum of money is worth today.
   Capital cost = a cost incurred on the purchase of land, buildings, construction and equipment to be used.
   Interest = A fee paid for the use of another party's money. To the borrower it is the cost of renting money, to the lender the income from lending it.
   Capital recovery factor = it converts a present value into a stream of equal annual payments over a specified time, at a specified discount rate (interest).

3. Decisions based on benefit/cost analyses – It is an estimate of the benefits derived from is compared in ration form to the cost incurred. Ratio between benefit and cost is more than 1.0, monetary values.

4. Decisions based on risk analyses – life and health, hazards, mortality (deaths)
   Risk assessment = a study and analysis of the potential effect of certain hazards on human health. It is intended to be a tool for making informed decision.
   Risk management = is the process of reducing risks that are deemed unacceptable.

   Risk = is defined as the ratio of the number of deaths in a given population exposed to a pollutant divided by the number of deaths in a population not exposed to the pollutant (per unit time). It can also be determined by calculating the number of deaths due to various causes per population and compare these ratios.

   There are procedures to analyze environmental risk. 1. Defining the source and type of pollutant, 2. Identifying the pathway; 3. Defining the receptor; 4. Defining the effect; 5. Deciding what is acceptable; 6. Calculating the acceptable levels of pollution; 7. Design treatment strategies

5. Decisions based on alternatives assessment – green chemistry and green engineering; benchmarking. It is an emerging as an approach to guide decision making toward improved human and environmental health, safety, and sustainability. It complements with risk assessment by identifying options that have lower hazard. It is also answer the question – "which option is safer?" which supports continual improvement. The goal of alternatives assessment is to identify possible alternatives existing chemicals, products, or processes and to choose among with the intent to choose more health and environmentally protective options. Alternative assessment is thus a comparative process intended to generate safer or less toxic products and practices. Achieving relatively greater safety depends on judgments about a variety of factors, which may include relative exposures, relative human health and environmental hazards, as well as life cycle, social, and economic considerations

To focus on green chemistry and green engineering, an alternatives assessment typically includes one or more of the components of a traditional risk assessment, but the focus is on comparing alternative/options that (a) are available, and (b) could be developed. Therefore, what is assessed are the "relative" utility/functionality (benefits), costs, hazards, exposures, and/or risks of the alternatives to discover or identify situations that provide win-win or win-win-win opportunities.

6. Decisions based on environmental impact analyses – identify potential impacts to the environment (importance, magnitude, and nature (either positive or negative effect). This is the conduct of inventory (baselining) – gathering of data, and assessment (quantitative checklist in terms of the importance of the impact, the magnitude of the impact, and the nature of the impact – negative or positive).

7. Decisions based on ethical analyses – environmental ethics, values and spirituality. Ethics provide a systematized framework for making decisions where values conflict. The selection of the nature and function of that decision making machinery depends on one's own moral values.

SUMMARY: Both cost-effectiveness analysis and the benefit/cost analysis are methods for making decisions based (mostly) on money. Risk analysis calculates the potential damage on health, and environmental impact analysis provides a means for decision making based on long-term effects on resources. Ethics is similarly a framework for decision making. But the parameters of interest are not dollars (cost) or environmental data but values or some ethical system.

CASE STUDY:

The local government units of Sibuyan and Tablas Islands have received financial assistance from the World Bank to improve the waste collection and disposal system of these two islands in Romblon. It was proposed to purchase new units of dump trucks to meet the current demand of the islands. However, the purchase or acquisition of the new trucks will be done per island. Due to accessibility and road network problem, the truck can only collect the solid waste from the 40% of the population. Determine or compute the following:

1. Total solid waste generation per municipality (kg per day)
2. Number of trucks (25 cubic meters capacity per truck) needed per island.

<table>
<tr><th>Municipality</th><th>Population (2016)</th><th>Assumption</th></tr>
<tr><td>Sibuyan Island</td><td></td><td rowspan="8">(a) Solid waste generation rate of 1.5kg/capita/day.
(b) Refuse compaction rate of the dump truck is 400 kg/cubic meters
(c) One dump truck 25 cubic meters capacity. Can collect twice a day.</td></tr>
<tr><td>San Fernando</td><td>23,271</td></tr>
<tr><td>Cajidiocan</td><td>21,861</td></tr>
<tr><td>Magdiwang</td><td>14,142</td></tr>
<tr><td>Tablas Island</td><td></td></tr>
<tr><td>San Andres</td><td>15,589</td></tr>
<tr><td>Odiongan</td><td>45,367</td></tr>
<tr><td>Ferrol</td><td>6,964</td></tr>
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Reference:

Vesilind P.A, Morgan, S.M., and Heine, L.G. (2013*). Introduction to Environmental Engineering*, 1st Philippine reprint, Singapore: Cengage Learning Asia Pte Ltd.