This paper proposes how to evaluate environmental impacts in a product Life Cycle Assessment at the premanufacture (mining) stage using Toward Sustainable Mining principles. The material supply chain includes a choice between either recycling or mining where mining remains the primary supplier of materials for manufactured products. Integration of TSM with Streamlined life cycle assessment as the bases for an ISO standard on mining environmental impacts.

1. Introduction

The world is 4.5 billion years old, societal structure as we know it started developing about 40,000 years ago, gold mining is around 7,000 years old, human population started increasing dramatically around 200 years ago, and carbon emissions started increasing 200 years ago. So what? What about a sustainable society and Sustainability? The ultimate goal to achieving Sustainability is “Development that meets the needs of the present without compromising the ability of future generations to meet their own needs” [1]. This definition is broad enough to drive the truck of economics through, however, it provides an opportunity for philosophical discussion on meeting the needs of the present. It is not the intent of this paper to go into such a discussion. The intent of this paper is to look at how mining can meet the development needs of the present with the least impact possible upon the environment.

Why mining? Aside from the destructive nature of mining, it is the “canary in the coal mine”. If economies are having difficulty, the demand for mined minerals decreases, and mines decrease their activity. Just look at commodity based economies in 2016 and how less demand for mined minerals has led to decreasing employment, with ripple effects to other areas of employment. From the environmental point of view, decreased mining means less environmental destruction. It can be argued this is a good thing. But mining will grow again due to demand for products. An example is cell phones (mobiles, handies, whatever). We need our mobiles, whether we really need them is another philosophical discussion. But mobiles are a part of our society, everywhere (globally), and the need for the minerals required in a mobile will continue. Unless we achieve 100% recycling, which we have not, then mining will continue to meet the need. And mining is destructive, so we need to minimize that destruction, with the optimum be the least destruction possible.

This paper proposes combining TSM (Toward Sustainable Mining) [2] with Streamlined Life Cycle Assessment (SLCA) [3,4] in evaluating the environmental impacts of mining where products, processes, facilities, services and infrastructure are concerned. If implemented, properly and
globally, “minimized responsible mining” can lead to minimized environmental impacts.

One method used to evaluate impacts of products is Life Cycle Analysis (LCA) [5], of which Streamlined Life Cycle Analysis (SLCA) is a compressed version. In an SLCA, there are 5 stages [3], with stage 1 being premanufacture (mining or recycling) which is part of mineral supply chain. At stage 1, the material supply chain for manufacturing includes a choice between either recycling or mining, with recycling being the ideal for a circular economy, especially from an environmental impact point of view and where resource depletion is concerned.

However, the recycling supply chain has plateaued for many materials as shown in the following, and with expanding economies recycling cannot meet all supply chain requirements, hence mining remains the method whereby industry acquires minerals. Even if recycling is at 100 percent, mined materials will still be needed for manufacturing in a growing economy. Hence the mining industry must be encouraged, with properly designed environmental standards, to have minimal impacts upon the environment. This can be done with TSM (Towards Sustainable Mining), a misnomer which sounds contradictory, but is necessary in optimizing sustainability with minimum impacts upon the environment.

The paper discusses: section 2) the material supply stream with a very brief overview of recycling; section 3) how environmental impacts are evaluated using SLCA; section 4) the concept of Towards Sustainable Mining (TSM) and how it could be integrated into SLCA.

Two definitions are declared here, one for Environment [6] and the other for Sustainability [1]. Without seeming to be too pedantic, Environment and Sustainability must be defined properly, otherwise misunderstandings can occur. For instance, the word “Environment”, can be defined as “surroundings” whether physical or abstract, and can refer to many things: economic environment, educational environment, university environment, industrial environment, design environment, manufacturing environment, cutting environment, or metal forming environment. The possibilities are endless. Hence, the definition of the environment given in reference [6] is used.

Specific details for material supply chain concerns, italicized in the following, are: 1) Minimize environmental toxicity; 2) Energy supply (sustainable); 3) Availability of material resources and recyclability; 4) Maintain natural areas, maximizing biological diversity (i.e. avoid monocultural vegetation); 5) Control wastes: minimize emissions, minimize dumping, minimize degradation of physical geography. These are drawn from references [3, 4].

First the current state with respect to the material supply chain, mining and recycling is discussed.

2. Material Supply

This section discusses recycling versus the mining supply chain for materials, while noting the material supply chain used for manufacturing will depend upon availability and cost.

In a study on being green and competitive, Porter [7] argues that a “tightly monitored material closed-loop system” (circular economy - recycling) reduces variation in production conditions, thus improving product quality, with handling costs (interpreted as transportation costs) decreasing because of specially designed platforms. In addressing the environmental problem, innovation should raise productivity with respect to the use of the many of the resources involved in producing a product. According to Porter [7] the net result is not only dramatically lower environmental impacts but also lower costs, better product quality, and enhanced global competitiveness.

Porter [7] also argued that properly designed environmental standards can trigger innovations that lower the total cost of a product or improve its value. Such innovations allow companies to use a range of inputs more productively, including raw materials, thus offsetting the costs of improving environmental impact. Porter goes on to say that ultimately, this enhanced resource productivity makes companies more competitive, not less.

If a material closed-loop system is used, then mining is unnecessary. However, to reach that state, 100% recycling is necessary without needing any additional materials if total recycling is achieved. Hence, the raw material supply chain for manufacturing is, ideally, all recycled material, giving a closed loop (a circular economy). However, in practice, most material supply chains have not reached 100% recycling as can be seen below in section 3.

Figure 1 is an idealization of the decision path followed with respect to the combination of mined material - recycled material might be. The recycled-mined supply chain is important when conducting an environmentally responsible product assessment.

3. Recycling rates

This section indicates why mining will be a major part of the metal supply chain for some time to come. Mining fills the gap between demand and recycled supply [8]. Mining costs will increase, because ‘easy’ (economically viable) mineral deposits will decrease. An example is Lithium which is one of three metals combined for energy storage (batteries). The three metals include: lithium, cobalt, graphite. The type of mining used is an example of how material costs increase. For lithium, mining can be either brine or hard rock.

Approximate costs are given here:
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