

# Using Ontology to Enhance Decision-Making for Product Sustainability in Smart Manufacturing

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**Abstract**— Smart manufacturing is widely focused on sustainable development at the industrial level. The lack of knowledge about using smart manufacturing limits the ability to assess, share, and reuse knowledge by decision makers. The goal is to enable decision-makers to use sustainable information relevant to life cycle sustainability assessment techniques based on ontology at the design stage by facilitating the assessment, sharing, and reusing of knowledge. In this paper, we present the materials and process selection tools by illustrating their application to promoting reusability in manufacturing. It is expected that this study will contribute to solving the problem of the lack of information sharing and providing high quality and comprehensive recommendations for supporting the processes of smart manufacturing.

**Keywords**—Ontology, decision-making, sustainability, inference, manufacturing

## I. INTRODUCTION

Sustainable development is achieving a balance between the exploitation of natural resources and the preservation of ecosystem services [1]. Smart industries still lack appropriate design tools for sustainable development [2]. Smart manufacturing has become a hot topic recently and has focused on sustainable development [3]. Smart manufacturing is applied to serve society efficiently in several fields, such as smart cities, health care, and intelligent transportation systems. Due to the rapid use of ontology in many fields, such as smart cities, health care, vehicles, transportation, and intelligent manufacturing, it is becoming more and more popular in facilitating decision making for selecting materials and processes, while the main advantages of using ontology are knowledge design, process simplification, and knowledge sharing. Ontology provides an assistant tool for decision-making by integrating different information systems and facilitating environmental performance through the use of Life Cycle Assessment (LCA), Life Cycle Cost (LCC), and Social Life Cycle Assessment (SLCA) for decision support systems and an automated decision-making method for product evaluation. Ontology has been used to enhance decision-making in other fields with great success, but working with industry ontology has been obstructed by a lack of forward-looking, strategic, collaborative, and principled thinking regarding its development. To our knowledge, there is no research dealing with the use of expert knowledge about sustainable manufacturing to identify opportunities for change and to suggest sustainable solutions in all three of its aspects: environmental, economic, and social. The main contribution of this review paper is that it briefs the current industrial design tools and their main challenges. This paper is organised as follows. Section II presents product sustainability; Section III introduces ontology engineering;

Section IV describes decision-making; and Section V summarises the conclusion.

## II. PRODUCT SUSTAINABILITY

Sustainability systems are required for sharing and extracting knowledge and making decisions from huge data collected at high rates and real time. Product sustainable design is a design process based on the consideration of all dimensions of sustainability through the product life cycle and should be applied at the earliest phase of design [4]. Sustainability has three dimensions: environmental sustainability, social sustainability, and economic sustainability [5]. Life Cycle Sustainability Assessment is a methodology for integrating Life Cycle Assessment (LCA), Life Cycle Costing (LCC), and Social Life Cycle Assessment (SLCA) [6], aimed at improvement to provide a comprehensive view of product sustainability [7]. Environmental sustainability refers to the effective use of natural resources and minimal impact on the environment, whereas economic sustainability refers to the lowest life-cycle cost that allows a structure to meet the requirements of users in a functional manner [4], while social sustainability refers to nurturing social cohesion by providing a safe and healthy built environment. The design stage plays a significant role in product sustainability [8]. Thus, understanding customer needs and preferences is crucial, and should be incorporated into the early stages of the product design stage [9]. Life Cycle Sustainable Assessment (LCSA) is a method to support the decision-making procedure for widely sustainable life cycle products during the designing phase [10].

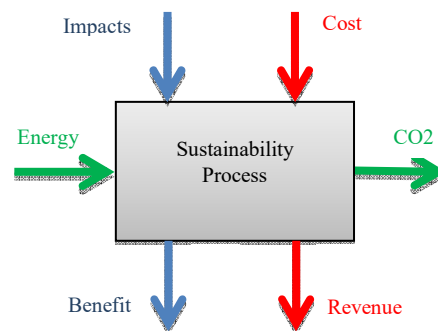


Fig. 1. Product sustainability process

Figure 1 explains the information gathering of LCSA related to every sustainability process, which integrates environmental (in green), social (in blue), and economic (in red) data.