

ABSTRACT

Sustainability is claimed too often without a rational verification of the claims. The phenomenon is much like Green Washing. Sustainability analysis is about making decisions on the overall, relative desirability of a system under study. The appropriate approach is to consider environmental, societal, and economic impacts of the system and devise a decision making process that leads to acceptance or rejection of the proposed solution for the system. The approach should also reveal attributes that can be adjusted to further improve the system for sustainability. For evaluating engineering sustainability, approaches have to rely on comparative analyses of different states of a system at different time instants (time is an important variable), or of different candidate solutions to a particular problem (time is an unimportant variable). For successful decision making, a real-world reference system must be chosen, and all competing solutions will be compared against it. Thus a solution can be described as more (or less) sustainable than the reference solution. In the engineering fields, an established technique is to find optimal solutions to achieve some technical goals, such as cost minimization, yield maximization, purity enhancement, or a combination of desired features. In sustainability analyses, engineers need to consider the three domains of sustainability for finding optimum solutions to a system that satisfy the selected sustainability goals. For that purpose, quantifiable indicators (or metrics) need to be judiciously chosen such that the system is completely characterized by them. For m number of candidate options to choose from and n number of indicators used to characterize their behaviors, this dataset will be an $m \times n$ matrix. Systems can appear in various scales, and the indicators will depend on the nature and scale of the system. Choosing an appropriate set of indicators is an art. When such a set is decided upon, various methods have been used, especially for industrial applications, ranging from making a subjective judgment based on visual inspection of the indicator data to comparing an aggregate index for various contenders. In this presentation a methodology will be featured, which demonstrates that an aggregate index is useful for unequivocal decision making on comparative sustainability. In addition, we need to establish which indicators are necessary and sufficient, and the relative importance of these indicators. For that purpose, we apply the statistical technique of Principal Component Analysis (PCA) followed by partial least squares and variable importance in projection (PLS-VIP). PLS-VIP is a supervised model where an overall pattern of the datasets is used to obtain the most important indicators from the given set of indicator dataset. The overall performance pattern is provided by the aggregate indices for the contenders. We will use several case studies to demonstrate successful use of this methodology for parsimonious use of indicators for sustainability analysis of systems.