Chapter 5


M. Pilar de la Cruz
University of La Coruña, Spain

Alberto Castro
University of La Coruña, Spain

Alfredo del Caño
University of La Coruña, Spain

Diego Gómez
Intacta Gestión Ambiental, Spain

Manuel Lara
University of La Coruña, Spain

Guillermo Gradaille
NaCoM Energy, Norway

ABSTRACT

In the previous chapter, the MIVES and MIVES – Monte Carlo methods were presented. MIVES is based on requirement trees, value functions, and the analytic hierarchy process. It helps integrate environmental, social, and economic sustainability indicators in a global sustainability index. Deterministic models can cause significant problems in terms of adequately managing the sustainability objective of a project. A method not only has to estimate the potential sustainability index at the end of the project. It also has to evaluate the degree of uncertainty that may make it difficult to achieve the sustainability objective. The MIVES – Monte Carlo method employs simulation to solve this problem. This chapter presents an alternative method, based on MIVES and fuzzy arithmetic. Different defuzzification parameters are proposed. An example of potential application related to heating and air conditioning systems in residential buildings is put forward. The advantages and drawbacks of using both methods are summarized.

INTRODUCTION

The MIVES method (Integrated Value Model for Sustainability Evaluation) was presented in the previous chapter. It is a deterministic method based on requirement trees, value functions, and the Analytic Hierarchy Process (AHP). It helps to integrate environmental, social, and economic sustainability indicators.
in a single, global sustainability index. It takes into account the relative weight or importance of the different aspects included in that evaluation, making it possible to consider non-linearity in the assessment.

MIVES does not allow one to consider the uncertainty that could affect the variables included in sustainability assessment models. For this purpose, the MIVES – Monte Carlo method was also presented in the previous chapter. It takes into account the uncertainty affecting the indicators, the weights of those indicators, and the shape of the value functions. It is based on MIVES and the Monte Carlo simulation technique.

As an alternative to the MIVES – Monte Carlo method, this chapter presents the Fuzzy-MIVES one, based on MIVES and fuzzy arithmetic. The first objective in this chapter is to explain the fuzzy arithmetic theory needed for the method presented here. The second is to summarize the Fuzzy-MIVES method.

The final part of the chapter will look at how to apply the Fuzzy-MIVES method to assess sustainability, in general, and with particular reference to heating and air conditioning systems in residential buildings. The third objective is to summarize ways of approaching this kind of application, while the fourth and final aim is to compare the MIVES – Monte Carlo and the Fuzzy-MIVES methods. The advantages and disadvantages of using both methods are summarized.

The reader should bear in mind that this and the previous chapter make up an inseparable whole. To have a clear understanding of the present chapter, it is necessary to read and understand the previous one.

**FUZZY ARITHMETIC**

Fuzzy sets were conceived as an extension of the crisp, conventional sets for constructing models that could embrace the imprecision or vagueness of many human concepts. The fuzzy sets theory can be applied to solve a broad range of problems. It was proposed by Lotfi Zadeh (1965) in the 1960s as a possible approach for dealing with uncertainty. Fuzzy sets led to the development of fuzzy logic, as well as possibility theory, for dealing with forms of uncertainty which are inherently non-statistical in nature.

Probability theory is based on principles of randomness, and there are specific characteristics of uncertainty not related to randomness (Dubois & Prade, 1988). On the other hand, some of the aspects covered by many uncertainty problems have a part related to randomness. Hybrid methods could be developed for treating each part of uncertainty with the most suitable techniques, but both techniques can really be applied to solve the vast majority of uncertainty problems. Each has specific advantages and disadvantages.

There are abundant publications dealing with fuzzy sets and their application to the analysis or control of processes and physical systems, in addition to decision making (Almeida Ribeiro, 1999; Cox, 1994; Dubois & Prade, 1980, 2000; Gil-Aluja, 2010; Juang, 1988; Kaufmann & Gupta, 1985, 1991; Lowen, 2010; Ross, 2010, Wadia-Fascetti & Smith, 1996; Zadeh et al., 1975; Zimmermann, 1991; for example).

As for project uncertainty, fuzzy sets have played a role in project selection; project financial analysis; time and cost estimation and control; contractor selection; and risk analysis (Abbasianjahromi & Rajaie, 2012; Carr & Tah, 2001; del Caño, 1992; Gil-Aluja, 2010; Kangari & Boyer, 1987; Kangari & Leland, 1989; Kaufmann & Gupta, 1985, 1991; Li et al., 2007; Nguyen, 1985; Pham & Valliappan, 1993; Singh & Tiong, 2005; Zadeh et al., 1975; among others).

Along the lines of its simulation-based counterpart, already described in the previous chapter, the fuzzy method to be presented here is based on using fuzzy sets for modeling the opportune parameters affected by a relevant uncertainty. Fuzzy arithmetic comes into play to calculate a fuzzy set representing the global sustainability index of an engineering system.