CHAPTER I
INTRODUCTION

Process design using process simulators is a creative activity that leads from the identification of a need to a process that satisfies that need, subject to economic, operational conditions, environment, safety and other constraints. The relative importance of the constraints has varied over the years. Traditionally process design, the environment impact of a process is focused primarily upon minimizing cost. This design procedure may often lead to the production of large quantities of waste materials and pollutions. However, pollution prevention and waste reduction are increasingly significant nowadays. Several environmental constraints began to be added in a part of the design process which is giving birth to green engineering. Moreover, concepts of pollution prevention or waste minimization (El Halwagi, 1997) aim at not generating the pollutants in the first place.

Process simulations are currently and widely used by industries for process analysis, design, and modification. The appropriate design methodologies to combine financial, and environmental impact needs to be developed to effectively make use of process simulators, and the optimal design gives good results in selecting the environmental friendliness of a process design and at the same time being profitable. The investment-planning problem is one of the first efforts in combination of financial considerations in enterprise within process systems engineering that started using deterministic models. However, a mechanism to address risk is not considered. Generally, financial risk is also absent in the area of process synthesis, especially in the literature that is related to design under uncertainty. Typically, risk is associated to the uncertainty of demands and prices, influencing the design variables accordingly. However, there are other risks that are associated with the uncertainty of parameters and the distribution of the process operation objectives. For example, it is customary to design flexible processes that can adapt and work efficiently for all the range of uncertain parameters, or the uncertain supply as well as product specification. However, one might consider not fulfilling maximum efficiency for all the cases, but in a reduced range an efficient operation may change and allow performance deterioration in others. This has been

considered by Barbaro and Bagajewicz, (2003). Thus, risk is associated with the probability of meeting an economical performance aspiration level, that is, to limiting the lost revenue. Likewise, environmental risk has been poorly defined and only taken into account in the form of evaluation of environmental impact indices based on deterministic conditions.

Green engineered plants satisfy both profitability and reduced environmental impact. However, very hardly these two objectives are not conflicting. Usually, the reduction of the environmental impact is accompanied by a reduction in profitability. This prompted the use of multi-objective approaches (Mallick *et al.*, 1996; Dantus and High, 1999; Lim *et al.*, 1999; Alexander *et al.*, 2000; Chen *et al.*, 2002; Chakraborty and Linninger, 2002, 2003), and popularized the use of pareto optimal solutions. Although uncertainty was analyzed, environmental risks related to uncertain conditions in the future, especially operational, was not considered.

Although the use of stochastic models in design is somewhat widespread, the treatment of financial risk in process design is less studied. Because risk is probabilistic in nature, stochastic models are needed. One can easily assess risk a posteriori of the design, that is, after one structure has been determined. This project proposes to extend existing approaches to manage risks (financial and environmental) together with the design.

This project will extend the above definition of financial risk to environmental risk associated to green engineering designs and incorporate it as part of the design process. The risk is of course associated to the fact that most of the parameters used to design/plan green processes are uncertain, most of the environmental impact indices are based on uncertain information, and in the case of planning, conditions (both market and environmental) in the future are also uncertain. The project will produce a methodology that a decision maker can use to request levels of risk in a design.