The handling, holding and transportation of temperature-sensitive products along a supply chain is known as the cold supply chain (or cold chain). The cold chain is important from both a financial and environmental perspective. In this dissertation, we formulate a new inventory model for cold items, called: Cold Items Cost and Emission Model (CICEM). The CICEM model considers both cost and emission functions for environments where temperature-controlled items need to be stored at a certain, non-ambient temperature and to do so modular temperature-control units are used. Transportation unit capacity and storage unit capacity are considered, which results in non-linear, non-continuous cost and emissions functions. A set of exact algorithms are developed to find the optimal order quantity based on cost and emission function minimization, and the mathematical proof of the optimality of the solutions are presented.

Furthermore, we expand the CICEM model to include multiple product types and consider the cost as the only objective function. A product type may or may not share transportation or holding capacity with other types. We consider a group of products that share capacities as a family of products. The products within a family must share transportation and holding capacity, but products from different families may not share any capacity. Therefore, the problem has two sets of decision variables: (1) on deciding if a product is a member of a family or not, and (2) how much to order and how frequently to order for products within each family. We propose a solution procedure according to the decision variable sets: (1) we propose a procedure for grouping (partitioning) the products into different families and (2) we propose a procedure to solve the inventory problem for each family.