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# A Mass-flow Based MILP Formulation for the Inventory Routing with Explicit Energy Consumption

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## Abstract

Our purpose is to incorporate explicit energy consumption into traditional Inventory Routing Problem (IRP) and present a Mixed Integer Linear Programming (MILP) model for this problem. Under the Vendor Managed Inventory (VMI), the IRP has several flexibilities that make it a promising basis for an energy-efficient routing. First of all, the customer demands can be distributed in different combinations. Secondly, vehicles can be routed to minimize the energy consumption. Last but not least, the time of visits can also be chosen so that rush hours are avoided without lost of customer demands. Our model takes into consideration these three decisions at the same time and use energy minimization as the main objective. The delivered quantity or mass serves as a link between inventory control and energy estimation. Traffic and road conditions are integrated to develop the routing strategy. Based on physical laws of motion, energy consumption is estimated using parameters like vehicle speed, average acceleration rate and number of stops. Experiments are conducted using benchmark instances for inventory routing with parameters for energy estimation. Both exact and heuristic methods are implemented to solve this problem. Finally, the results are compared with the traditional IRP results to analyse the influence of energy consumption to the inventory routing systems and to show the efficiency of the solution methods.

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