Mixed Integer Non-linear Programming (MINLP) formulation of energy-efficient location routing problem for electric-powered vehicles

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Electric vehicles (EVs) in the robotic context and in the future of logistics networks will play an important role as a sustainable and emission-free tool of transportation. The recent development of EVs such as Nissan LEAF and Chevrolet Volt is a turning point in the modification of transportation networks. Aligned with this green movement, the first EV Charging Station for the State of Kansas has been installed on December, 2010. It happened five months after unveiling the first EV charging station in USA, and within a week of the release of the above mentioned EVs. These actions show the potential promise in the use of EVs in the state. Although there are obvious benefits to the use of EVs, one of their main restrictions is the limited stored energy. Thus, energy-efficient Location-Routing Problem (LRP) becomes an important problem which has not been investigated vastly in literature. This paper provides a novel formulation of LRP which finds the best location-allocation and routing plan of EVs with the objective of minimizing the total energy cost. The vehicle weight and travelled distance are the major contributing factors in the energy consumption. Each vehicle energy limit is enforced in the model so that the vehicle does not get discharged before its travel completion. This research helps to use EVs in the most energy-efficient way. The proposed model can also be applied to situations when there is a mixed-fleet (hybrid, gas, or electric powered). A case study is presented to explain the model.