

A Mixed Integer Linear Programming Model for Container Collection

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Abstract : In the light of the transition towards a more circular economy, recovery of products, parts or materials will gain in importance. Additionally, the EU proximity principle related to waste management and emissions generated by transporting large amounts of end-of-life products, shift attention to local recovery networks. The Flemish inter-communal cooperation for municipal solid waste management Meetjesland (IVM) is currently investigating the set-up of such a network. More specifically, the network encompasses the recycling of polyvinyl chloride (PVC), which is collected in separate containers. When these containers are full, a truck should transport them to the processor which can recycle the PVC into new products. This paper proposes a model to optimize the container collection. The containers are located at different Civic Amenity sites (CA sites) in a certain region. Since people can drop off their waste at these CA sites, the containers will gradually fill up during a planning horizon. If a certain container is full, it has to be collected and replaced by an empty container. The collected waste is then transported to a single processor. To perform this collection and transportation of containers, the responsible firm has a set of vehicles stationed at a single depot and different personnel crews. A vehicle can load exactly one container. If a trailer is attached to the vehicle, it can load an additional container. Each day of the planning horizon, the different crews and vehicles leave the depot to collect containers at the different sites. After loading one or two containers, the crew has to drive to the processor for unloading the waste and to pick up empty containers. Afterwards, the crew can again visit sites or it can return to the depot to end its collection work for that day. All along the collection process, the crew has to respect the opening hours of the sites. In order to allow for some flexibility, a crew is allowed to wait a certain amount of time at the gate of a site until it opens. The problem described can be modelled as a variant to the PVRP-TW (Periodic Vehicle Routing Problem with Time Windows). However, a vehicle can at maximum load two containers, hence only two subsequent site visits are possible. For that reason, we will refer to the model as a model for building tactical waste collection schemes. The goal is to find a schedule describing which crew should visit which CA site on which day to minimize the number of trucks and the routing costs. The model was coded in IBM CPLEX Optimization studio and applied to a number of test instances. Good results were obtained, and specific suggestions concerning route and truck costs could be made. For a large range of input parameters, collection schemes using two trucks are obtained.

Keywords : container collection, crew scheduling, mixed integer linear programming, waste management

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