

Article

# Shortening the Last Mile in Urban Areas: Optimizing a Smart Logistics Concept for E-Grocery Operations

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**Abstract:** Urbanization, the corresponding road traffic, and increasing e-grocery markets require efficient and at the same time eco-friendly transport solutions. In contrast to traditional food procurement at local grocery stores, e-grocery, i.e., online ordered goods, are transported directly to end customers. We develop and discuss an optimization approach to assist the planning of e-grocery deliveries in smart cities introducing a new last mile concept for the urban food supply chain. To supply city dwellers with their ordered products, a network of refrigerated grocery lockers is optimized to temporarily store the corresponding goods within urban areas. Customers either collect their orders by themselves or the products are delivered with electric cargo bicycles (ECBs). We propose a multi-echelon optimization model that minimizes the overall costs while consecutively determining optimal grocery locker locations, van routes from a depot to opened lockers, and ECB routes from lockers to customers. With our approach, we present an advanced concept for grocery deliveries in urban areas to shorten last mile distances, enhancing sustainable transportation by avoiding road traffic and emissions. Therefore, the concept is described as a smart transport system.

**Keywords:** e-grocery; last mile delivery; city logistics; sustainability; location routing problem; vehicle routing problem; multi-echelon optimization; smart city

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## 1. Introduction

The progressing urbanization leads to an increasing demand for all kinds of goods in cities over the entire world. In addition, e-commerce grows steadily, resulting in a rising number of delivery activities and increasing road traffic on the last mile to satisfy customer needs [1]. Politicians aim for a mitigation of global warming by enacting appropriate laws to reduce the emissions of greenhouse gases. As an example, the European Commission defines the objectives of excluding conventionally powered vehicles by 2050 and achieving “essentially CO<sub>2</sub>-free city logistics in major urban centres by 2030” [2] (p. 9). Recent discussions are about national emission ceilings for different pollutants (PM<sub>10</sub>, NO<sub>x</sub>, etc.) to increase the air quality for inhabitants. If such limits are exceeded, city authorities are forced to ban certain vehicles from urban traffic. For example, those driving bans can cover outdated diesel cars (e.g., Hamburg in 2018), vehicles with even/uneven-numbered registration plates (e.g., Paris in 2016), and similar actions. Despite potential vehicle bans, city dwellers need to be supplied with various goods. As one result, the number of electric cars, light-duty vans, and other transport vehicles, such as cargo bi- and tricycles, is rising in urban areas.

As one part of e-commerce, the delivery of online ordered groceries to end-customers (e-grocery) is a steadily increasing market. Sorted by the market size, Figure 1 shows the e-grocery channel share for selected countries in 2018 and 2023 (forecast) illustrating the substantial rise of this industry.