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Charge Planning for Grocery Distribution

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Executive Summary

E-mobility and transitioning to electric vehicles come with new challenges for grocery distribution fleets. A new breed of advanced scheduling solutions is required to maintain efficient business operations and fully take advantage of e-trucks. This scheduling solution needs to work hand-in-hand with the transportation plan, the charging infrastructure and the e-trucks while on the road or at the warehouse or supermarket.

Keywords: electric vehicle (EV), charging, commercial, fleet, smart-charging

1. State of Charge – or why it's important to look at the details

While emissions from almost all other industries have declined to vary degrees, the transportation sector remains high, at 37% globally [Fig. 1]. From that, 5% of GHG emissions are attributed to commercial transport. Electric vehicles are seen as an important contributor in the transition to a world of net zero transportation. Of course, commercial fleets have a significant contribution to make toward this goal. While commercial vehicles account for ~20% of all vehicles, they account for nearly 40% of the transportation sector's GHG emissions.

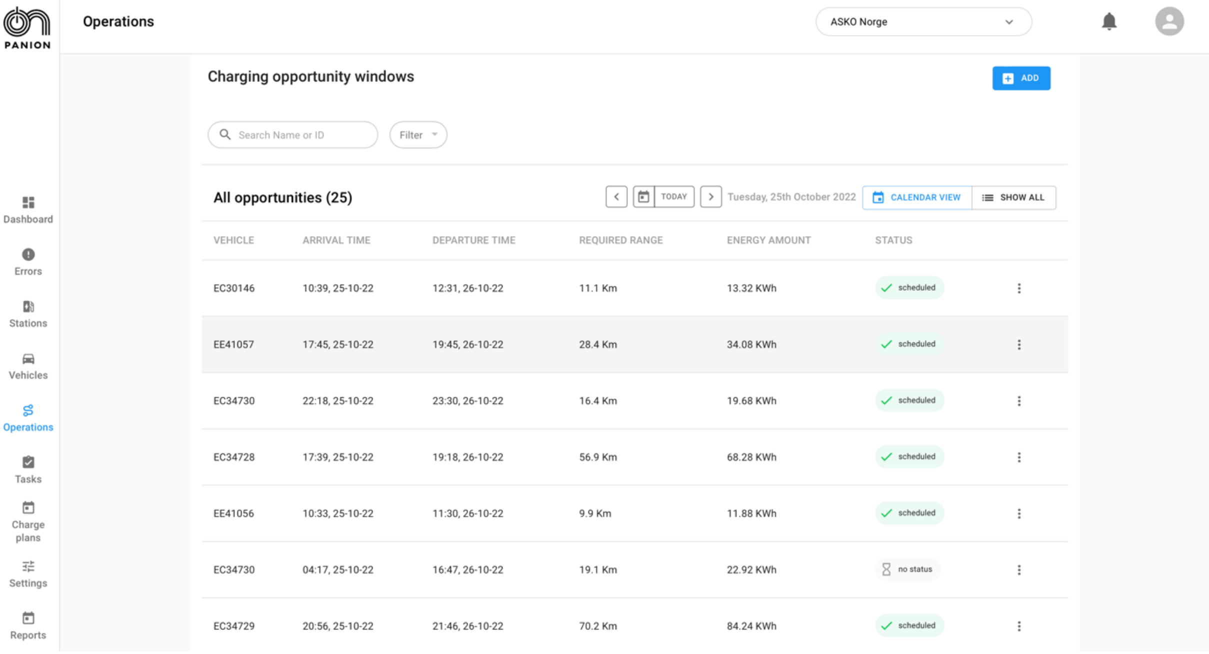


Fig. 1: **Charging opportunities advise the fleet manager when charging is possible and whether the plan uses them**.

Commercial fleets have primarily built their operating model around the use of combustion engines. For instance, the time drivers are permitted to drive is seen as the only major constraint for distance. With EVs, this is changing drastically as range is typically limited to maybe 200 or 250 miles [Fig. 2]. Similarly, the fuelling of vehicles is not a consideration with combustion engine vehicles, and typically, drivers organize the refueling as part of their trips. With electric vehicles, the "fuelling" removes several hours per day from the vehicle as a critical asset of business operation.

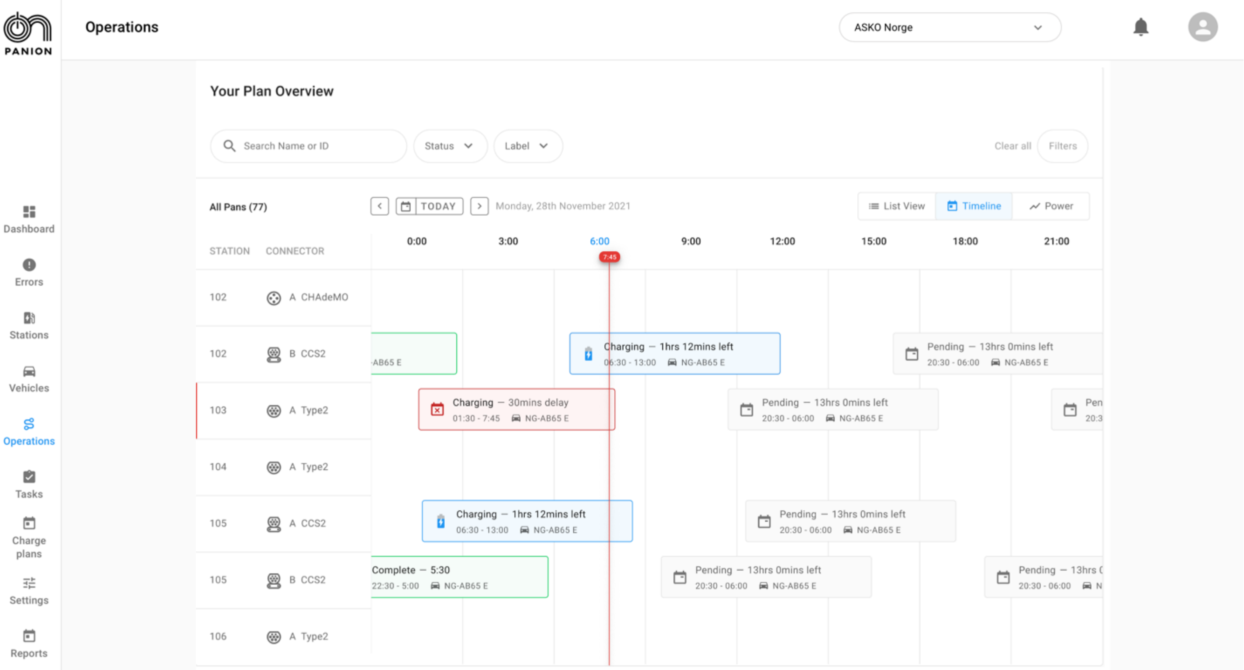


Fig. 2: **The charge plan time schedule provides a clear line of sight to the fleet manager for which vehicles are planned on which charger at what time and what the target state of charge should be**.

That means as commercial fleets adopt the use of electric vehicles, they need to review their operating models. They need to find ways to align the charging of the vehicle batteries with the schedule of the business operations they are conducting. And they need to make sure business operations aren't at risk due to the increasing use of electric vehicles in support of these operations. And in all this, we must not forget that most commercial fleets are operating on an extremely slim profit margin [Fig. 3].

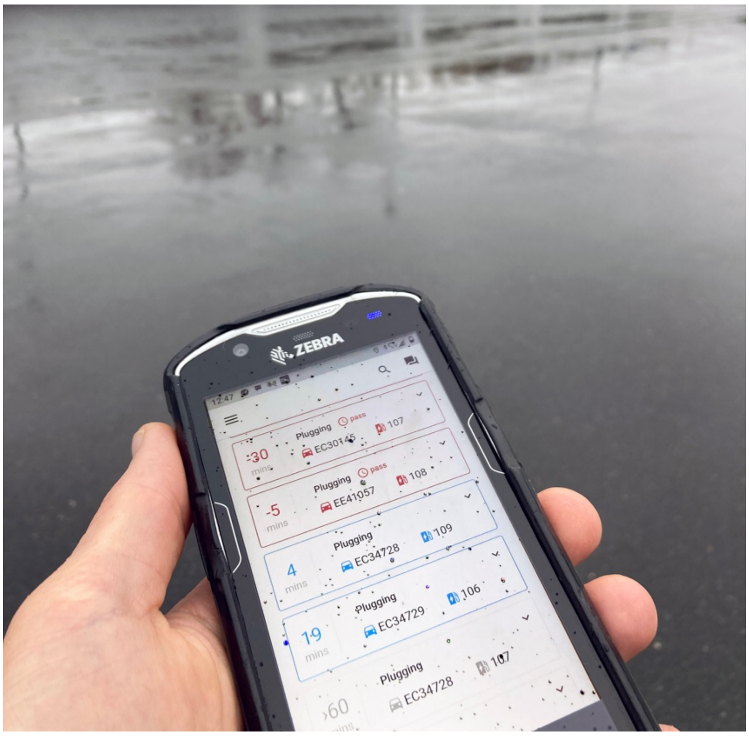


Fig. 3: **Drivers are informed about the charge schedule via mobile app communication including visual alerts for overdue charging sessions.**

Thus, commercial fleets are increasingly considering complementing their transportation plans with vehicle charging plans.

2. Intro into grocery logistics (in Europe)

Grocery logistics looks straightforward from the outside but, indeed, is relatively complex beneath the surface. Often, supermarket chains own a considerable part of their distribution network. That means they own and operate distribution warehouses along transportation arteries from where a fleet of — typically mid-duty — trucks distribute groceries to oftentimes several supermarkets. Fulfillment in a grocery context is none other than the process of receiving supermarket orders, picking up goods, packing them onto pallets and rollable containers, and loading them onto trucks and trailers, which are used to dispatch the products to the designated supermarkets. The additional complexity of grocery logistics is implied from goods' perishability and limited shelf-life time, though not of immediate relevance to the distribution process. The distribution process is impacted by the presence of cooled and dry goods as well as the wide variety of products. Both increase the number of times an individual supermarket receives shipments from the same distribution warehouse in a week or even on the same day. That makes for interesting new challenges as the supermarkets typically have space and equipment for only one or two trucks to unload at any given time. Thus, trucks must comply with prearranged arrival time windows at the supermarket.

3. Challenges of grocery logistics in an EV world

Introducing EVs into this already complex setup certainly does not make things simpler. First and foremost, EV trucks (eHDVs) must be charged for the job ahead. This should be done during the depot standing time at night — typically between 10 pm and 5 am. The charge must, at a minimum, suffice for the eHDV to complete the next job. This is a multi-stop tour from depot to the depot with several in-between supermarket stops. During that time, the truck needs energy for the drive, the cooling unit, the forklift or lifting ramp, and many other auxiliary components required for safe and healthy grocery distribution. Most trucks in these grocery distribution centers operate with two or three tours per day, bringing goods to either the same or different supermarkets in the region.

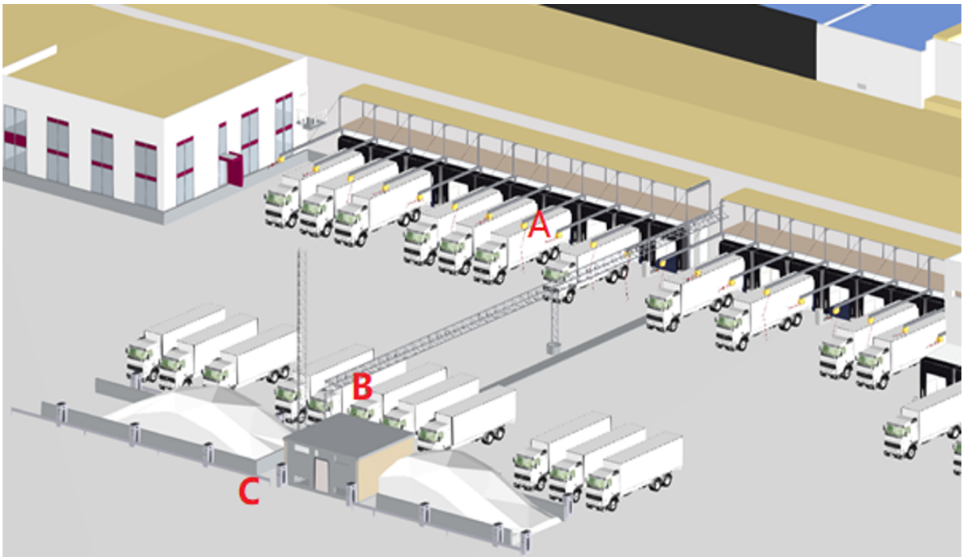
The fleet manager has an interest in minimizing the time the truck is in the depot between such tours. With the use of e-trucks for distribution, this time is critical as it is the only opportunity for a top-up charge. Ideally, it would be combined with the mandatory break time for the driver (which in the absence of an EV charging requirement, could be taken any place). Potentially it can be provided while the truck is loading new cargo at one of the warehouse bays. Fleet managers must decide whether the truck needs a top-up charge to make sure it can cover the next tour, or perhaps even two tours, with an intermittent depot break too short for a top-up charge.

When using eHDVs, fleet managers must have accurate information about the energy demand for the next tour(s), the state of charge of the vehicle battery (SoC), the charger availability, and the energy grid capacity constraints available. This determines whether a charge is possible, how much energy is needed on the truck, and where and when this energy could be provided.

And all this must fit into the fleet manager's transportation plan and is constantly updated throughout the day based on changes in traffic or potential vehicle problems.

4. Optimization potential through data-driven charge planning

Much like commercial fleets in other segments, grocery distribution companies have started setting up charging infrastructure along their warehouse networks to provide charging capacity to their gradually expanding e-truck fleets. Of course, these aren't your usual AC wall boxes but high-performance, often top-of-the-line DC chargers [Fig. 4]. These can provide the power rates required for charging large 300 kW+ batteries in e-trucks. Even with high-performance chargers, a full charge of the truck battery may take two hours to complete.



typical site set up

Charging Power:

A = 5 x 360 kW

B = 7 x 184 kW

C = 12 x 175 kW

Battery capacityin e-trucks:

300 kW/h

Fig. 4: **Example site layout**

Often a single charge may not be sufficient to cover the distribution distance assigned to the e-truck for a single day. So, the million-dollar question for fleet managers is: where and when to find the time for an e-truck to receive its charge?

Enter the charge scheduling solution! Determining how to meet a number of customer demands with constraint capacity has been the domain of planning and scheduling in production facilities for years. Why couldn't we apply the same principles to the topic of charging? It seems we can. It does take a bit of a different mindset, though. Firstly, we need to understand the transportation plan, which represents the energy demand of the vehicle. Secondly, we need to understand the charging infrastructure and its capabilities. Thirdly, we need to understand the grid's power constraints and the cost of energy, as this varies over the course of the day. Additionally, we need to understand how the e-trucks are consuming their battery energy, when they will be returning to the warehouse location, and what the SoC is going to be upon their return.

All of this looks like a nice IoT and integration problem. Bringing all this information together allows one to decide which vehicle to charge, on which charger, at what time, and for how long [Fig. 2]. Thus, receiving enough charge for the next tour (or a couple of tours) to be covered with the energy available on the battery upon completion of the charging activity. All this can be done while minimizing the cost of energy drawn from the grid. We can also do this by favoring the consumption of locally produced renewable energy. It is, of course, also smart to consider the charging curves of the vehicles — which for instance, would allow assigning the most powerful chargers to those vehicles with the best charging performance (and presumably the biggest batteries).

A tiny little bit of additional complexity is related to the fact that all this must be done lightning-fast. All the pieces are in constant flux. The trucks, by design. The transportation plan is because things like demand, availability of goods, trucks, and drivers are constantly changing. Also, the availability of energy due to the use of renewable energy and the increased variability in grid capacity that comes along with it. So, the charge schedule must be super responsive and still provide stability needed to run complex business operations and secure grocery delivery on time to the designated supermarkets.

Is anything missing here? Yeah, of course, the driver — an integral part of the delivery process. Connecting to their mobile devices, drivers are in the know to which charging station to park their e-trucks at and when to return to the truck from their break [Fig. 3]. The connection allows them to request charging session preponement if they've had a lucky day and completed their tour ahead of schedule or an out-of-schedule charge if they are on a special mission not covered in the fleet's transportation planning system.

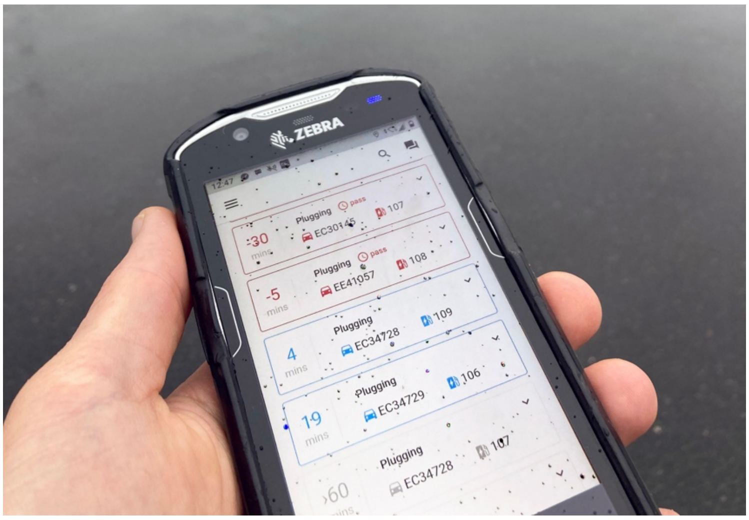


Fig. 3: **Drivers are informed about the charge schedule via mobile app communication including visual alerts for overdue charging sessions.**

This paper presents research that has been conducted using a combination of industry experience, close collaboration with some of the biggest grocery chains in Germany and delivery companies in Scandinavia. The research has been undertaken in order to explore and understand the challenges facing electrification of the grocery delivery industry, and to identify potential solutions. Through our collaborative approach, we have been able to gain valuable insights into the operations and logistics of these companies, as well as the consumer demand for grocery delivery services. Our findings will hopefully provide important insights for policymakers, business leaders, and industry stakeholders who are seeking to improve the efficiency and effectiveness of electrification for grocery delivery services and beyond.

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Presenter Biography

Dr. Ulrich Kalex is CPO at ABB eMobility Digital Ventures GmbH, where he is responsible for the product roadmap, go-to-market, and product scope of the PANION product portfolio geared at enabling e-mobility for commercial fleets.

Before joining PANION in May 2022, he held several positions at Alfabet between 2005 and 2022, and at i2 Technologies between 1998 and 2005.

Before serving as a consultant and developer for companies such as Numetrix and Monsanto from 1994 to 1998, Dr. Kalex lectured in information technology and mathematics at the Bauhaus University in Weimar, Germany. Having studied in Jena, London, and Turin, he completed his doctorate in mathematics at the Dresden Technical University.