6. FLEXIBILITY

Facts about climate-friendly road freight transportation

What's the best strategy for realizing climate-friendly road freight transportation? Let's take a look at the facts.

Flexibility is important for both trucking operators and policy makers.
The operators are keen to ensure that alternative technologies can perform at least the same missions as existing technology. That way the operators can sustain their businesses. This requirement also influences the re-sale price of alternative trucks, which feeds back to the total cost of ownership (TCO) calculations discussed in the previous article. Policy makers also prize flexibility. Even though infrastructure for zero-emission heavy-duty trucks needs to be deployed at scale within this decade, requiring fast and substantial action, policy makers still value having the flexibility to tailor the roll-out of infrastructure over time, so that the right capacity and set-up for each roll-out phase can be ensured. Another motivation is that flexibility allows infrastructure to accommodate future technology developments, e.g., highly automated trucking on corridors.

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Overhead contact line (OCL) infrastructure can be understood as an upgrade of existing motorways and can be installed with practically no impact on regular traffic operations. The vehicles using the system have on-board energy storage which allows for some gaps in the OCL infrastructure while still enabling fully electrical operation. This makes it possible to build the infrastructure in a cost- and time-efficient way, as potentially complex sections of the route, like motorway junctions, can be skipped. OCL infrastructure can also be phased in, so as to meet growing energy demand step by step, i.e., by gradually adding more substations, more km of OCL infrastructure, or both.

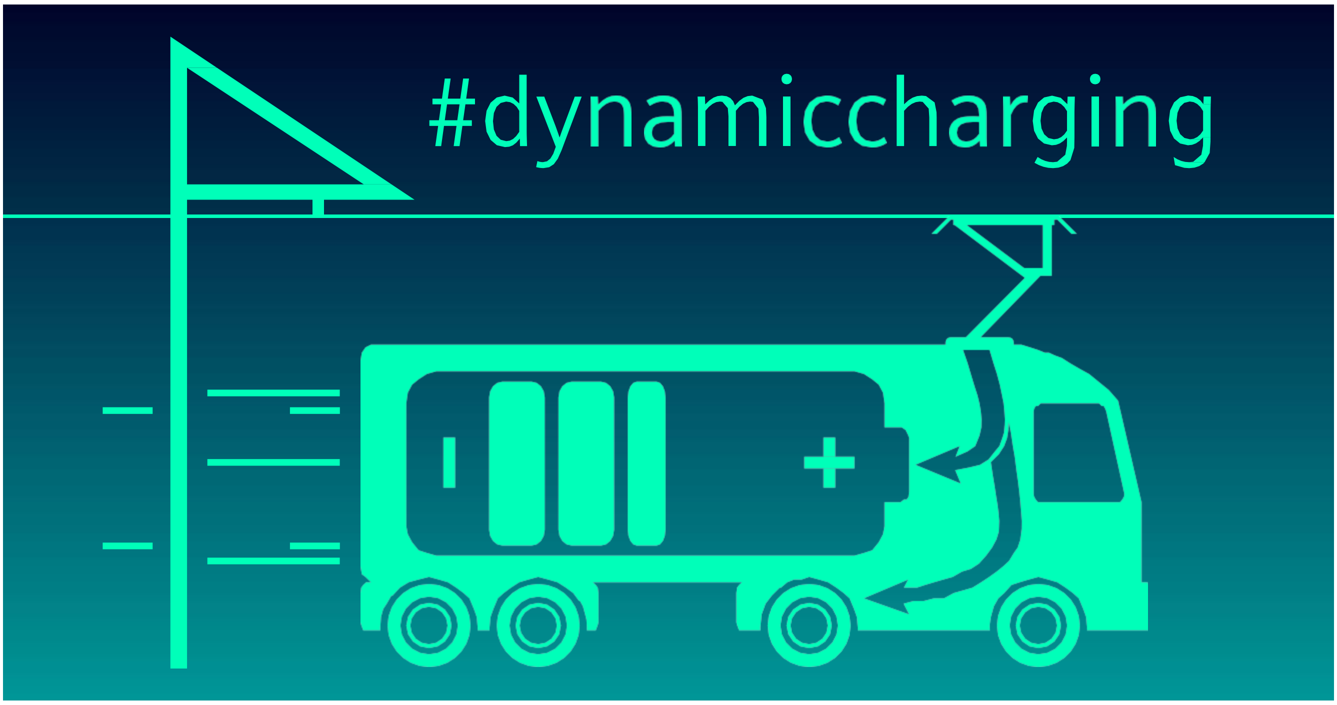
No down-time due to dynamic charging

Trucks can use the OCL flexibly because it requires no charging downtime. Instead, the technology is built for dynamic charging, i.e., charging while driving. This is possible due to the trucks' ability to connect to and disconnect from the OCL even at highway speeds. The ability of the trucks to drive electrically outside of the OCL, combined with the robust overhead contact line and its segmented installation, means truckers can rely on the fact that the OCL is making power available for the truck's mission. Furthermore, because such trucks do not need large batteries, the OCL gives trucking operators the same flexibility with payloads as conventional trucks.

OCL technology is compatible with and complements other fuels and drive trains. This includes hybrid vehicles, which may have a role to play in the transition phase, when the only consistent refueling infrastructure available across Europe is the network of current service stations. The OCL also complements and combines with other possibly significant trucking technologies in the coming decade. To give just two examples: High-capacity vehicles (HCV), or even just efforts to maximize the loading of the trucks, increase energy consumption per truck and thus give an advantage to highly energy-efficient technologies. Second, automated highway trucking (e.g., "Hub-2-Hub"), which Germany aims to deploy nationwide as early as 2022, increases the value of time. OCL's **dynamic charging** capacities give it the best flexibility to make use of this parallel technology development. For these reasons implementing OCL is a no-regret decision.

OCL technology is compatible with and complements other fuels and drive trains

When considering the flexibility of battery electric vehicles (BEVs), balancing the desired range, payload, battery size, and cost requires choosing a specific vehicle configuration that in one way or another limits flexibility. For instance, small batteries make vehicle cheaper, but will rely more heavily on megawatt charging in the operational stage, with correspondingly higher costs in delivered electricity, to overcome the range limit imposed by small batteries. If an operator instead wants to rely on overnight charging to reduce electricity costs, this requires larger batteries, which lead to a higher vehicle cost (and possibly a reduction in payload). The megawatt infrastructure is flexible in that it can be thinly deployed over a geographically spread-out area[1]. If the targeted locations are equipped with enough space and strong grid connections, it is also possible to gradually add individual charging points to meet rising demand. Although long-haul operations in Europe today need to respect the requirement of 45 minutes of rest time for every 4 hours' driving time, there are already operations where drivers are swapped, thus making it important to have short refueling times. As mentioned above, with the prospect of highly automated trucking, this aspect can become increasingly important to ensure the operational flexibility desired by trucking operators. One important advantage for BEVs is that there is a more wide-spread deployment of less powerful chargers, providing a safety net for Europe-wide operations, albeit with longer charging times.



A commonly touted advantage of fuel cell electric vehicles (FCEV) is that their high refueling speeds and energy density (energy per kg) are superior to BEV technology for providing the range that flexible long-haul operations require. However, FCEVs' energy density per m^3 is much less favorable, because H_2 itself is very voluminous and because the tanks add to the size of the whole system. Space is just as much of a concern as weight when trying to pack as much cargo as possible in a shipment. Moreover, the two benefits stated above — refueling speed and energy density per kg — depend on how H_2 is stored on board, with the highest benefits achieved only when using liquid H_2 [2]. Compared with BEVs, there are also more concerns about the use of FECV trucks in confined spaces like tunnels or garages, due to the increased fire risk.[3] This too could pose a challenge for flexibility of operations.

Although some hydrogen stations are already deployed (e.g. almost a hundred in Germany[4], for 507 registered cars, in 2020[5]), these currently cannot supply trucks with liquid hydrogen without substantial modifications. The available refueling infrastructure is thus likely to be a hard constraint on the flexible operations of FCEV — especially until consistent standards for such refueling have been set (see previous article on time to market). Regarding the fuel itself, FCEVs require very pure hydrogen to avoid shortening the lifetime of the fuel cells. Although the climate goals demand that all hydrogen be made by electrolysis using renewable electricity ("green hydrogen"), FCEVs are flexible in the sense that they can use hydrogen regardless of its origin, which today in 99,3 % of cases means relying indirectly on fossil fuels. These are used to make the ca. 120 m tons of H_2 annually that the world currently consumes (of which less than 0.01 % is used in transport). Hydrogen production thus emits ca. 830 m tons CO_2 per year[6].

For renewable fuels (RF), as noted in a previous article, the infrastructure would remain the same and the operation and service of the trucks would stay the same. However, this theoretical promise of maintaining today's flexibility can only be realized if enough renewable fuels can be affordably supplied. As another article noted, that too is an unlikely prospect any time soon.

This article and the previous one dealt with the primary concerns of trucking operators (TCO and flexibility). The next and final article will look at the CO_2-abatement costs, since policy makers are primarily concerned with reaching climate goals as cost-effectively as possible. That article will also provide a conclusion, synthesizing the different perspectives offered in this series.

[1] https://www.isi.fraunhofer.de/content/dam/isi/dokumente/cce/2021/BOLD_Truck_charging_discussion%20paper.pdf

[2] https://www.ft.com/content/5803025a-6328-4959-8ebe-8b42b50399b9

[3] TF https://www.itf-oecd.org/regulations-and-standards-clean-trucks-and-buses

[4] https://www.adac.de/verkehr/tanken-kraftstoff-antrieb/alternative-antriebe/wasserstoffauto-so-funktioniert-es/

[5] https://www.spiegel.de/auto/wasserstoff-autos-diese-modelle-gibt-es-in-deutschland-zu-kaufen-a-088cffed-f8c5-4fdc-a773-cfbf5e18749d

[6] https://www.iea.org/reports/the-future-of-hydrogen

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