

BATTERY SWAP STUDY A BEV VEHICLE EVOLUTION



Battery Swap: In short

Battery swapping is a concept that involves replacing a depleted battery pack in an electric vehicle (EV) with a fully charged one, instead of recharging the battery in the vehicle. This process is designed to be quick, typically taking a few minutes, and allows the vehicle to continue operating without extended downtime for recharging. In the context of heavy-duty vehicles, such as trucks, buses, and commercial fleets, battery swapping offers several potential advantages:

1

Reduced downtime

Heavy-duty vehicles often need to operate for long hours or cover extensive distances, making extended recharging times impractical. Battery swapping can significantly reduce downtime by allowing vehicles to quickly swap out depleted batteries for fully charged ones, minimizing disruptions to operations.

2

Increased operational flexibility

Battery swapping enables heavy-duty vehicles to operate on longer routes or for extended periods without being limited by the range of a single battery charge. This flexibility can be particularly beneficial for long-haul trucking or urban delivery operations.

3

Improved utilization

By decoupling the battery from the vehicle, battery swapping allows for more efficient utilization of battery assets. While one set of batteries is being used in a vehicle, another set can be charged at a dedicated charging station, maximizing the productive time of both the vehicles and the batteries.



4

Potential for battery standardization

Battery swapping systems may encourage the development of standardized interfaces between battery packs and vehicles that can be used across different vehicle models and manufacturers. This standardization could improve economies of scale, reduce costs, and facilitate the establishment of a widespread swapping infrastructure.

5

Potential for battery leasing models

Battery swapping could enable new business models where vehicle owners or fleet operators lease batteries instead of purchasing them outright. This approach could reduce upfront costs and shift the battery ownership and management responsibilities to specialized battery service providers

6

Faster adoption of electric heavy-duty vehicles

By addressing range anxiety and reducing downtime concerns, battery swapping could accelerate the adoption of electric heavy-duty vehicles, contributing to the decarbonization of the transportation sector.



1. Market development

-electrification of heavy vehicles



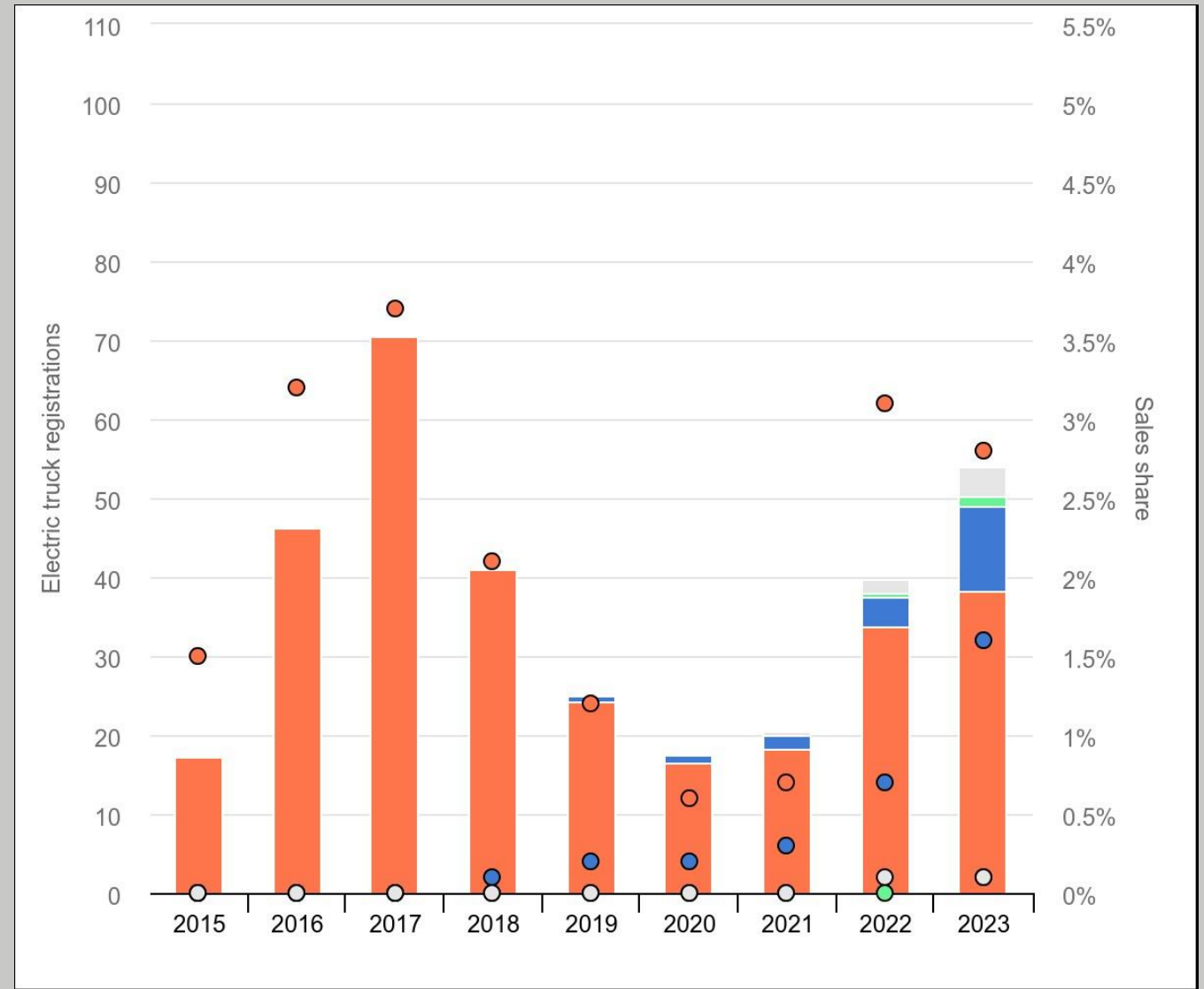
BEV A NEW GROWING MARKET

Sales of electric trucks increased 35% in 2023 compared to 2021, meaning that total sales of electric trucks surpassed electric buses for the first time, at around 54 000.

China is the leading market for electric trucks, accounting for 70% of global sales in 2023, down from 85% in 2022.

In Europe, electric truck sales increased almost threefold in 2023 to reach more than 10 000 (>1.5% sales share).

The United States also saw a threefold increase, though electric truck sales reached just 1 200, less than 0.1% of total truck sales.



Grid stress is a factor of importance for BEV market growth

The electricity grid is a key enabling technology for HDV electrification, and careful planning and investment will be required in order to accommodate new loads.

Although high-powered charging can enable the decarbonisation of freight, it may also present challenges for the electricity grid, like fluctuations in power quality or supply-demand imbalances.

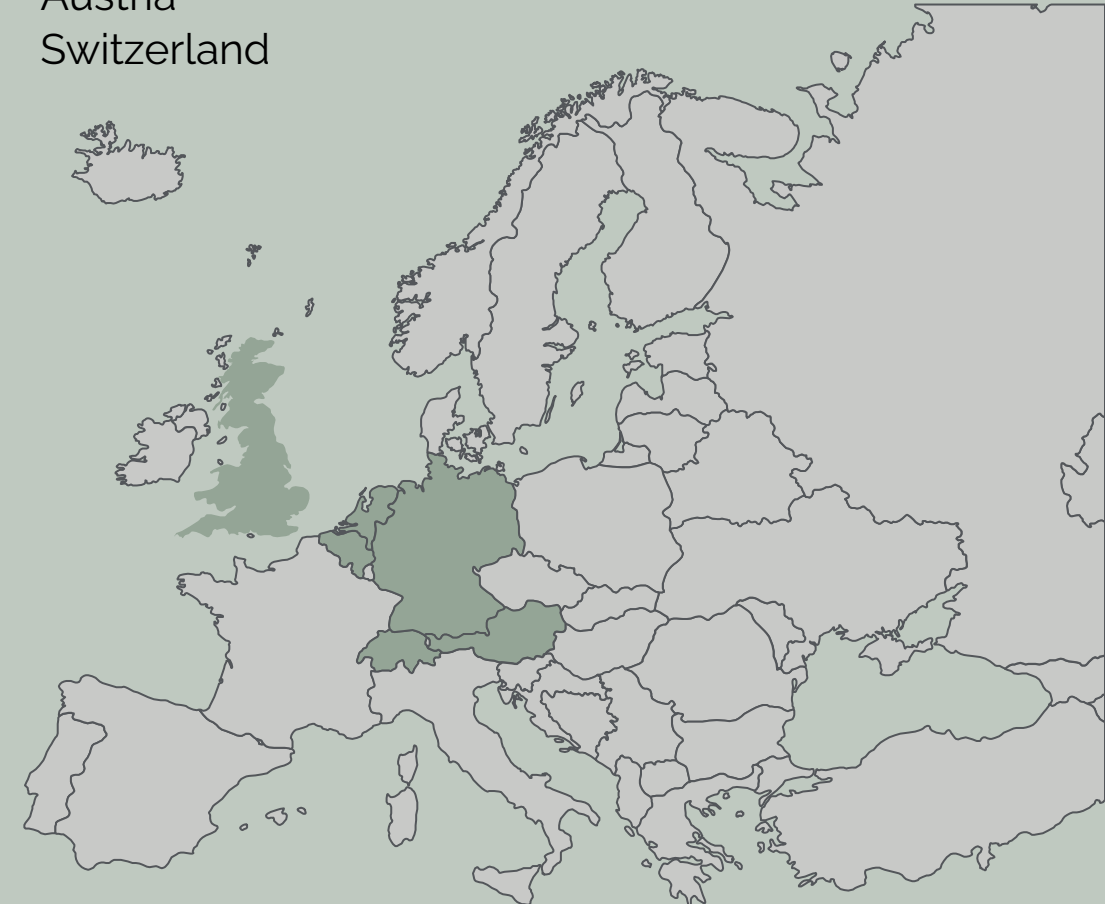
These imbalances can cause grid congestion at the local level and could affect entire regions where there is a large electric HDV fleet. Some countries, such as the [Netherlands](#), are already developing policies to anticipate these issues.

One way to mitigate challenges and avoid peak demand is through stationary storage batteries that are co-located with high-powered chargers. This solution would require significant capital expenditure (CAPEX) for the installation of large, stationary batteries, but it could also offer new revenue streams to charging station owners, such as through electricity price arbitrage or grid services provision. Co-locating renewable sources close to charging hubs can also decrease the stress on the local power grid.

[Electricity Grids and Secure Energy Transitions](#). For more.

Shortage in Europe

- Great Britain
- Benelux
- Germany
- Austria
- Switzerland

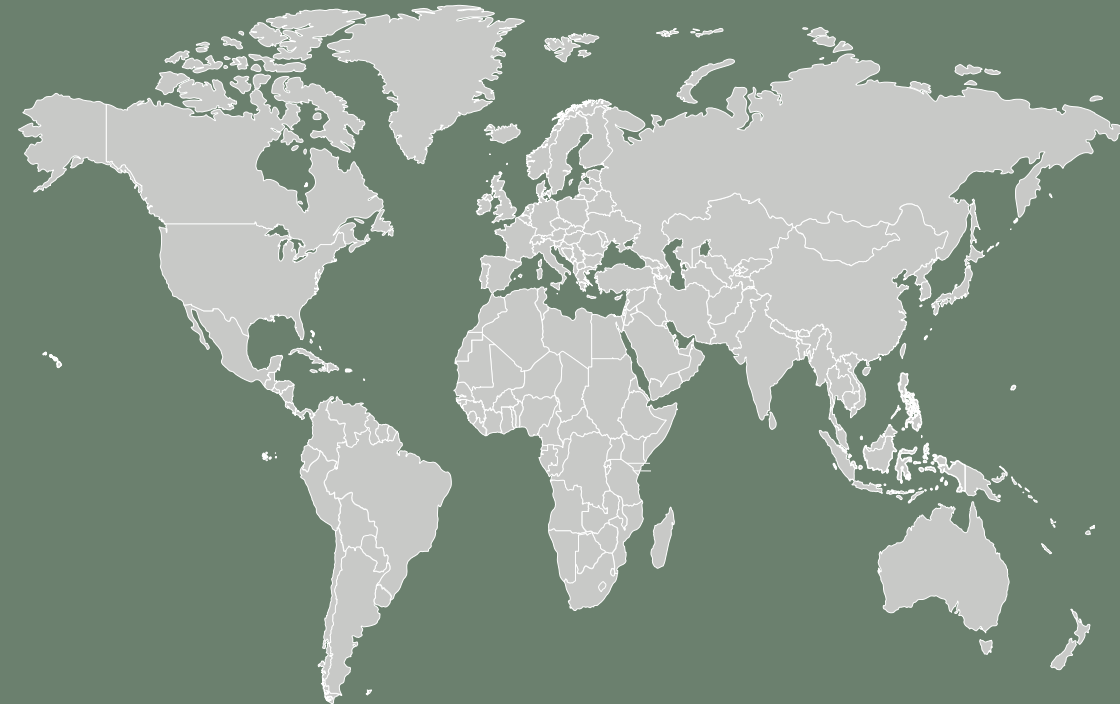




Different market reediness

CHINA THE MOSTE MATURE MARKET FOR BATTERY SWAP

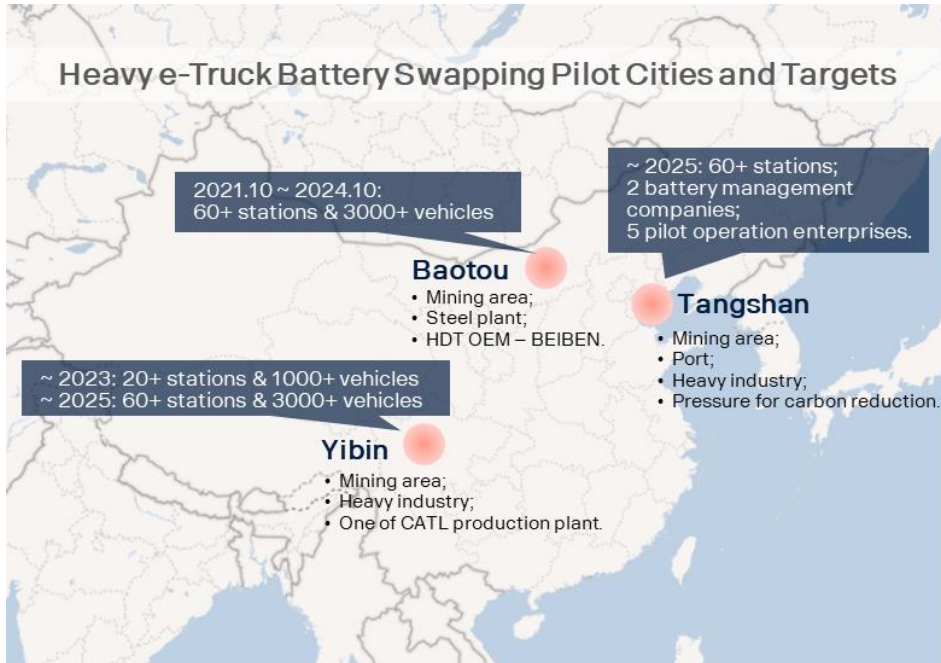
- Technical and economic feasibility of battery-swapping BEVs has been tested and accepted by the Chinese market. This fuelling mode decreases the purchase price of EHTs by 50%. The "Independence of vehicle and battery" business model means operators need only pay for the vehicle, while the battery is owned and handled by the battery bank for operators to rent. It creates economic efficiency by lowering the operating and maintenance costs of BEVs. It increases the efficiency of time and resource utilization because it only takes five minutes to swap the battery. It also requires less energy and land resources compared to charging mode. It offers safer battery management and higher battery value over its lifecycle. Centralized charging improves the safety of battery usage and extends battery service life by 20%. It allows better scheduling of battery charging according to demand on the electrical distribution grid. The market for circularity is also starting up – giving the batteries a second life business.



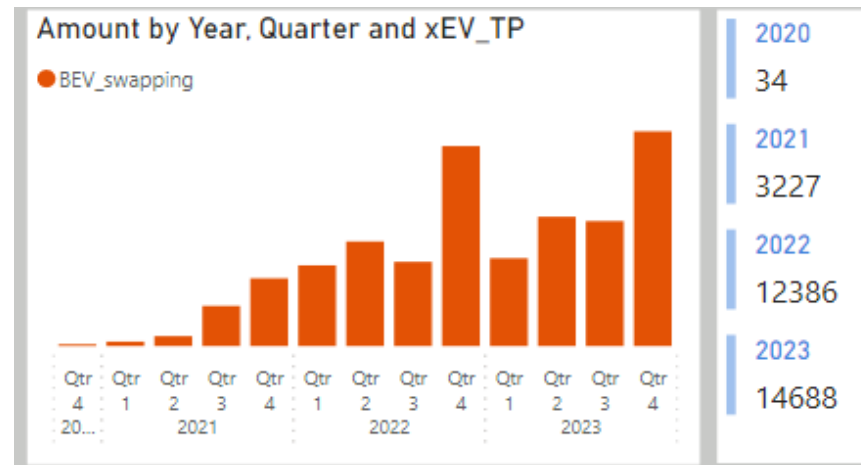
- See teacher notes for source



From decision to 15 000 trucks in three years time



Year 2022: is called “ the first year of HDT battery swapping” and till end of 2023, there are >30,000 battery swappable heavy trucks in total, ≈42% of BEV heavy trucks.



A new document announced in **Feb 2024**, regarding the State Power Investment Corporation (SPIC) will lead and high level plan the investment of the HDT battery swapping station network construction starting from operation demonstration program.

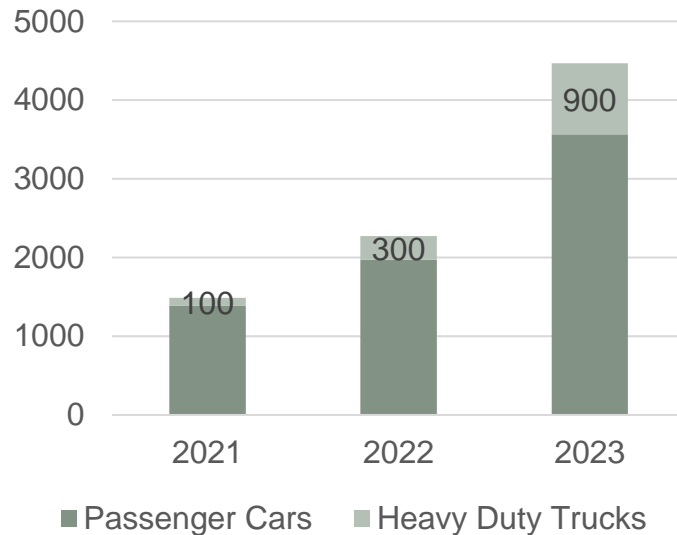
Focusing on short-distance transport, **across scenarios and across cities; swapping tech, operation models, and digital platforms** and so on, short-distance (Tangshan and Shanghai port), across cities (Gansu, inner Mongolia-Shanxi-Hebei) thousand-km corridor of HDT battery swapping network. including the scope of 20000 HDTs.



HDT Battery Swapping Station in China

At present, battery swapping stations are still mainly for passenger cars, and heavy truck battery swapping stations increased rapidly since 2022.

Battery Swapping Station







Data Source:

Passenger Cars – 中国充电联盟

Heavy Duty Trucks – 中国交通通信信息中心

Key Player Future Planning of HDT Battery Swapping Station

Company	Current Status	Future Planning
 国家电投 SPIC	100 stations are set up; 600 stations are under address selection.	4000 stations are planned till 2025
 协鑫能科 GCLET	>20 stations are set up	170 stations are planned till 2025
 CATL 宁德时代	>20 stations are set up	No number published, but will extent to battery bank and digital platform eco
 远程 Geely CV	>40 stations are set up	200 stations are planned till 2025

Swapping Station Investment & Return Model Case:



Currency in CNY (RMB: yuan)	HDT Swapping Station Only need to prepare backup batteries	HDT Swapping Station "Vehicle and Battery Separation" Mode
Assumption	Service 40 trucks/day, and recharge 6,739,200 kWh/year (~460kWh/veh./day)	Service 40 trucks/day, and recharge 6,739,200 kWh/year (~460kWh/veh./day)
Set up Cost	9141k	23141k
Station Construction Cost	4201k	4201k
Line and Other Cost	2590k	2590k
Vehicle in Use Battery Cost	0	14000k (60% of total)
Backup Battery Cost	2590k	2590k
Payback Period	5.21 years (with 11.59% after tax rate of return)	4.92 years (with 10.33% after tax rate of return)

*Based on this model, GCLET plan to build 170 HDT swapping stations in total, and 11 of them are in "Vehicle and Battery Separation" Mode with the battery bank business.

GCLET also run related projects like energy storage, power battery utilization and smart energy management platform and ect.

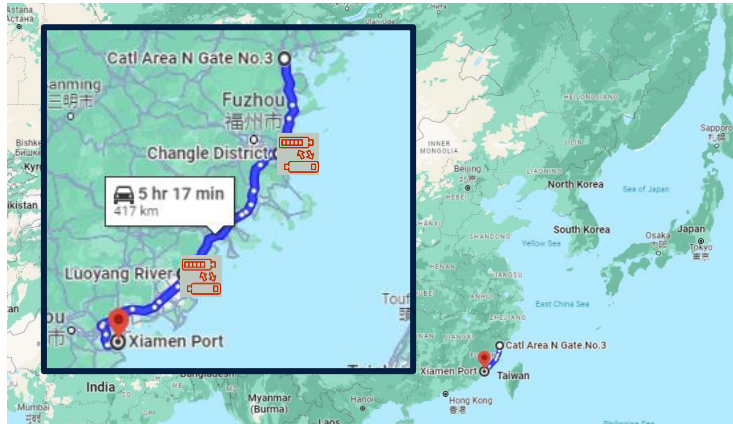
Battery Swapping Heavy Truck Behaviour to map the potential application scenarios



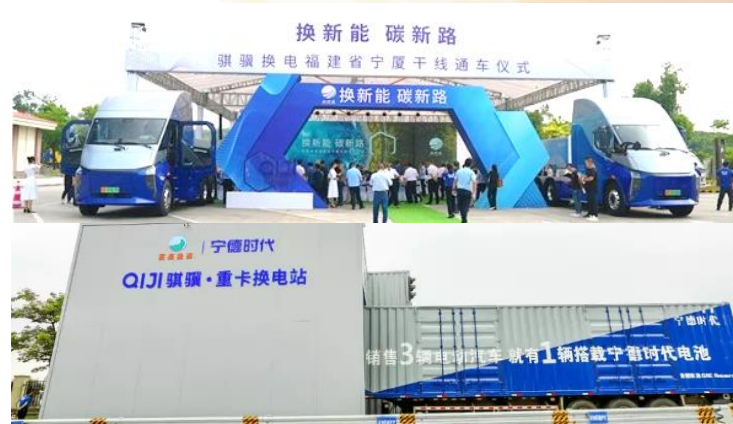
Data Description: Operation behaviour from whole year real time monitoring in 2022

Vehicle Type	Sample Size	Swapping Rate	Daily Mileage	Daily Operation
BEV total	≈ 30,000	/	112 km	5.9 hours
Tractor (swap)	3994	57.6%	209 km 44% with 200km+	10.2 hours
Dumper (swap)	6564	80.7%	184 km 28% with 200km+	8.9 hours

Case Study of Key Player – CATL



- Route: Ningde ↔ Xiamen (Fujian)
- Distance: 420km - oneway
- Station: 4 stations (2 points X 2 directions)
- Partners:
 - Fujian Expressway Group;
 - QIJI (Battery Swap BU of CATL);
- Energy Supply Type:
 - 171kWh per battery block;
 - once 1~3 blocks swappable;
 - one 3-block-swap for 300km driving.



- QIJI Battery Block: based on the 3rd generation of CATL's LFP battery chemistry;
- QIJI Battery Swap Station: adaptive continuous adjustment tech. to realize all-in-one swapping cross models and brands
- QIJI Cloud - all-scenario data aggregation
- Input data from vehicle, battery and station
- Output solutions for real time battery asset manag., station operation, fleet and goods manag., route planning and swap booking.

QIJI Energy

milestones and next steps

- 2023-06-12: QIJI Energy Heavy-duty Truck Battery Swapping Solution Launch
 - 2023-08-24: 1st H2H HDT Battery Swap Expressway line opened in Fujian
 - 1st pilot project for this line is running with 20 Deepway trucks for CATL's logistic needs between Ningde and Xiamen
 - 2023-09-12: CATL signed a strategic cooperation agreement with Shandong Expressway Group aiming to build up the battery swap network for core h2h routes.
-
- Open platform and open ecosystem;
 - Promote the vehicle & battery separation mode to save cost in use and extent the lifecycle usage of power battery.

Case Study of Key Player – SANY



SANY's swapping station is directly under its main brand and product portfolio.

Product manual: <https://cos-www.sanygroup.com/2023/09/07/60q9njrsl35yztmf.jpg>



SY312C

3 charger, 1 backup charger and replacement station

Covered area
35.3m²

Charging time
<1h

Battery replacement time
≤300s

Applicable working conditions

 Product manual



Energy facility
construction

Get a quote

Online consultation



Key Drivers & Advantages

Policy Drivers

- National “dual carbon” target (peak in 2030, neutral in 2060)
- National level application demonstration programs assigned to heavy truck segment
- Local government level subsidies to swapping stations
- Industry level - high emission industry de-carbonization tasks and KPIs

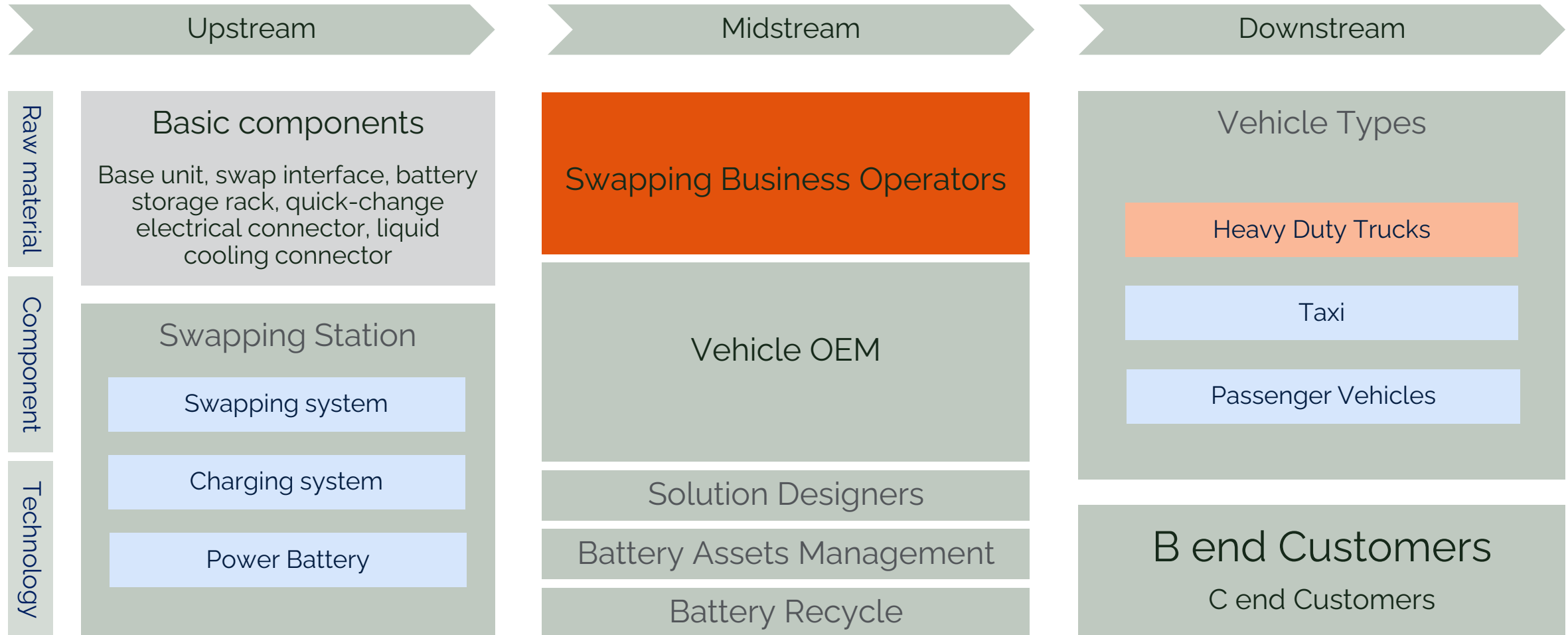
Market Drivers

- Large market size for HDT which is high load and high energy consumption segment
- Short energy replenishment time (3-5mins/swap), which is quite similar to ICE fuel refilling time to release e-range
- New business model of “vehicle and battery Separation” to:
 - ✓ save cost for fleet to upgrade from ICE to BEV and release the concern of battery life
 - ✓ save cost for battery owner when doing group buy
 - ✓ attract early investment from who wanted to occupy the market of new business opportunities in energy sectors

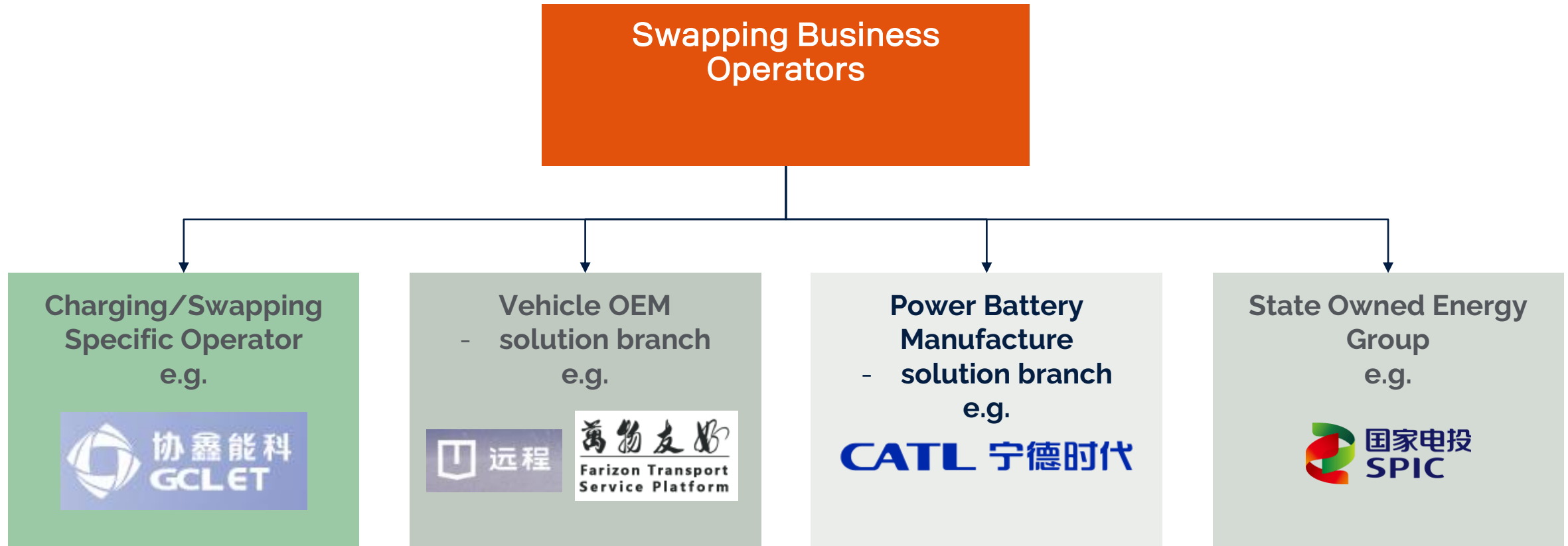
Efficiency Drivers

- Extend the battery life by scientific charging strategy and frequently health management
- New business model will set up a good foundation for power battery recycle and ladder utilization
- Save infrastructure space compared to existing charging solutions
- More friendly to the power grid, and the station can act as distributed energy unit for grid consuming, storage and charging to balance the power usage.

Ecosystem and Key Player



Business Ownership – who owns the interface

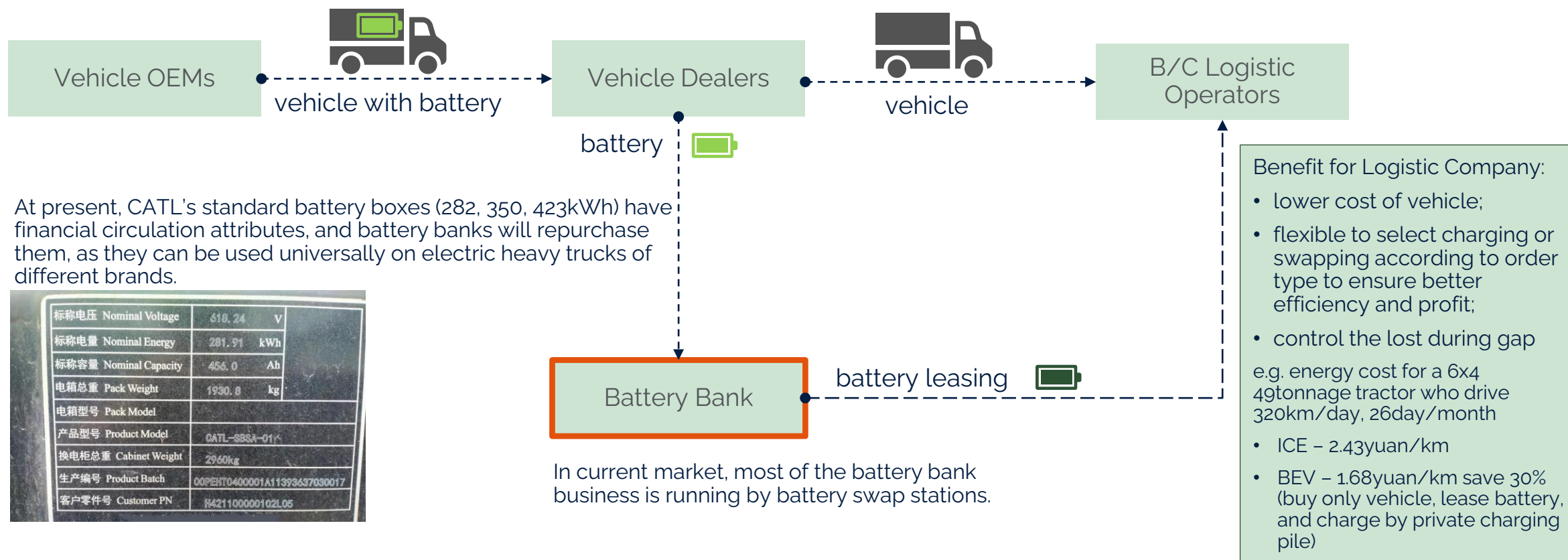


For the end user, the business owner can seek a different cooperation model with logistics companies by using a total solution for purchasing, leasing, long-term contract and retail services and so on.



“Vehicle and Battery Separation” Mode Operation Process

Key Takeaways: the most effective way for electric heavy duty trucks promotion and the main industrialization path for electric heavy duty trucks by solving 2 pain points (recharge time and high cost)



Battery Ownership and Data Access



“Vehicle and Battery Separation” Mode



Ownership: Battery is owned by the operator or battery bank according to the contract

Data Access

Vehicle OEM	access by VIN without battery ID
Vehicle Owner	access when on-site using
Battery Producer	access static data by battery ID
Operator/Platform	access to real time by battery ID
Battery Owner	access to real time by battery ID

“Battery in Vehicle” Mode



Ownership: Battery is owned by the vehicle owner as a lifetime ownership solution, but the physical battery is always changing during swapping

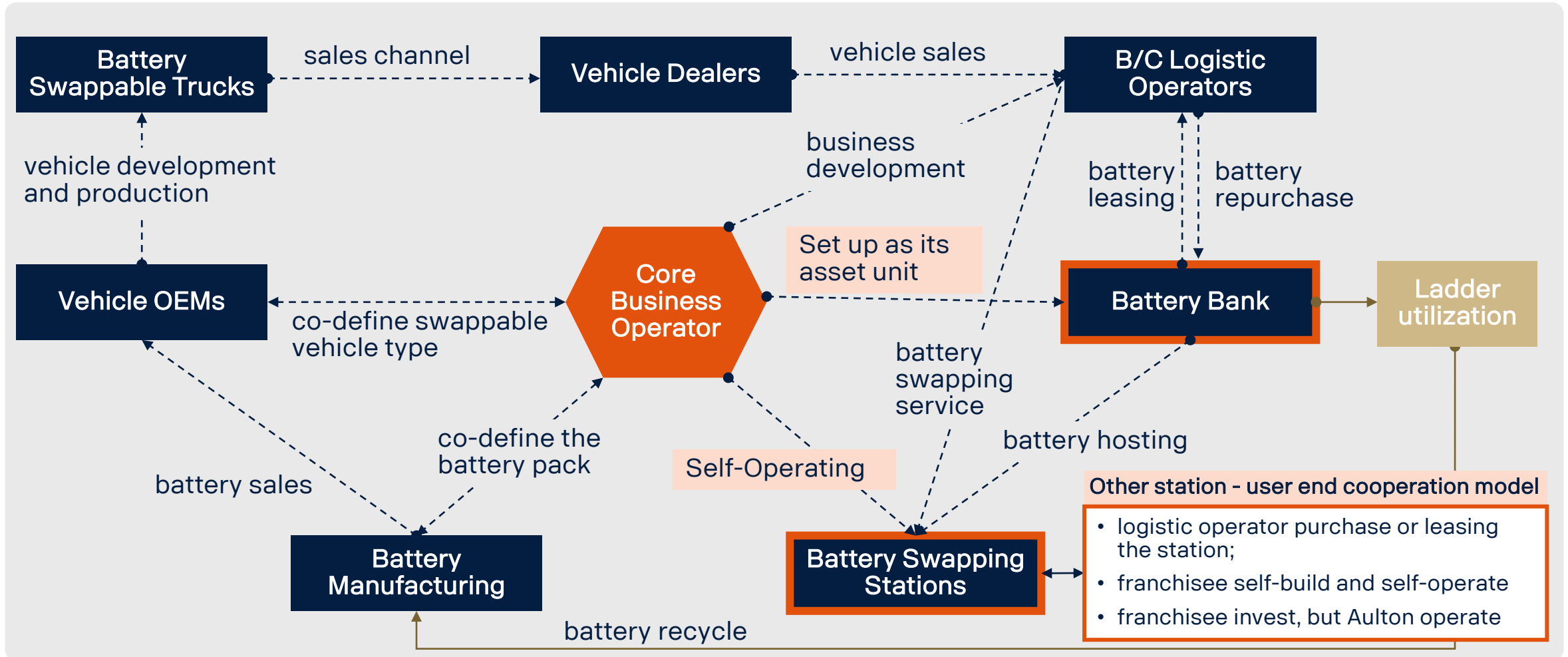
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HDT Battery Swapping Business Model

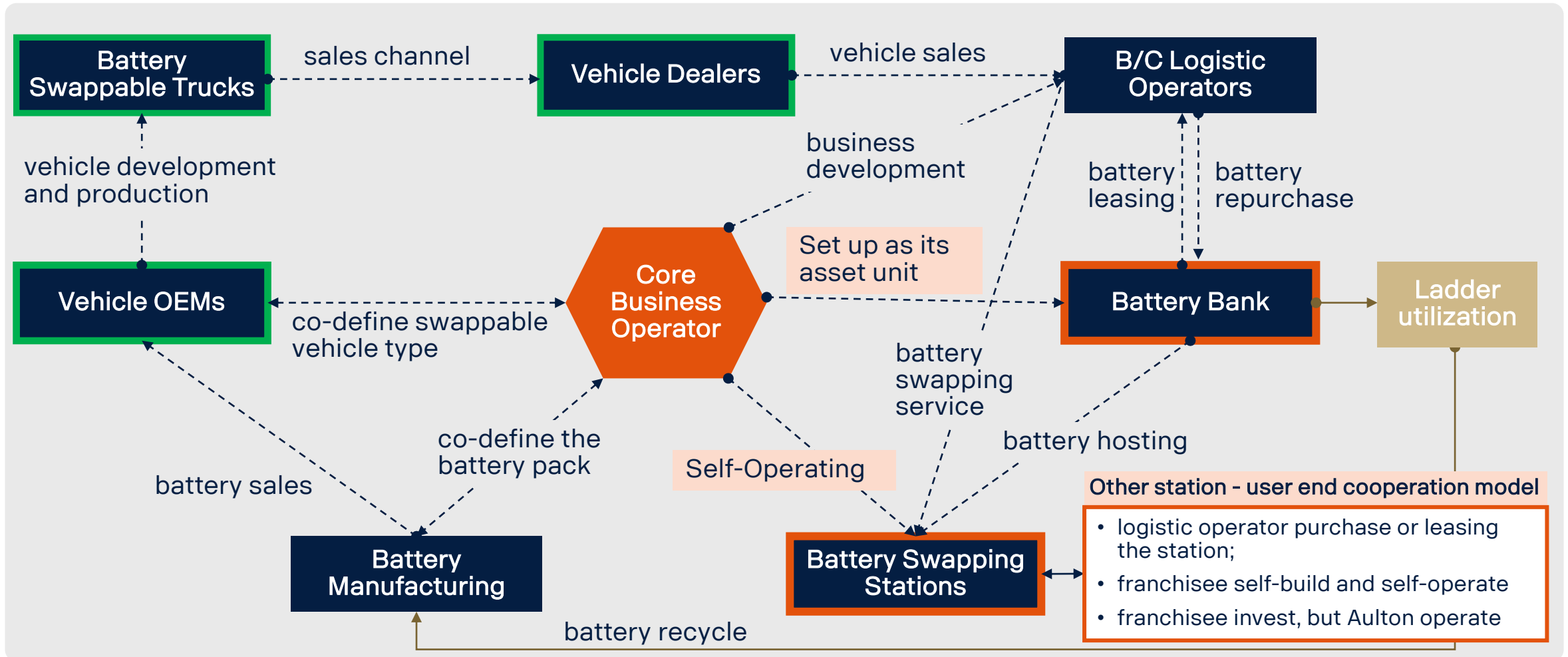


Use Case of Specific Operator





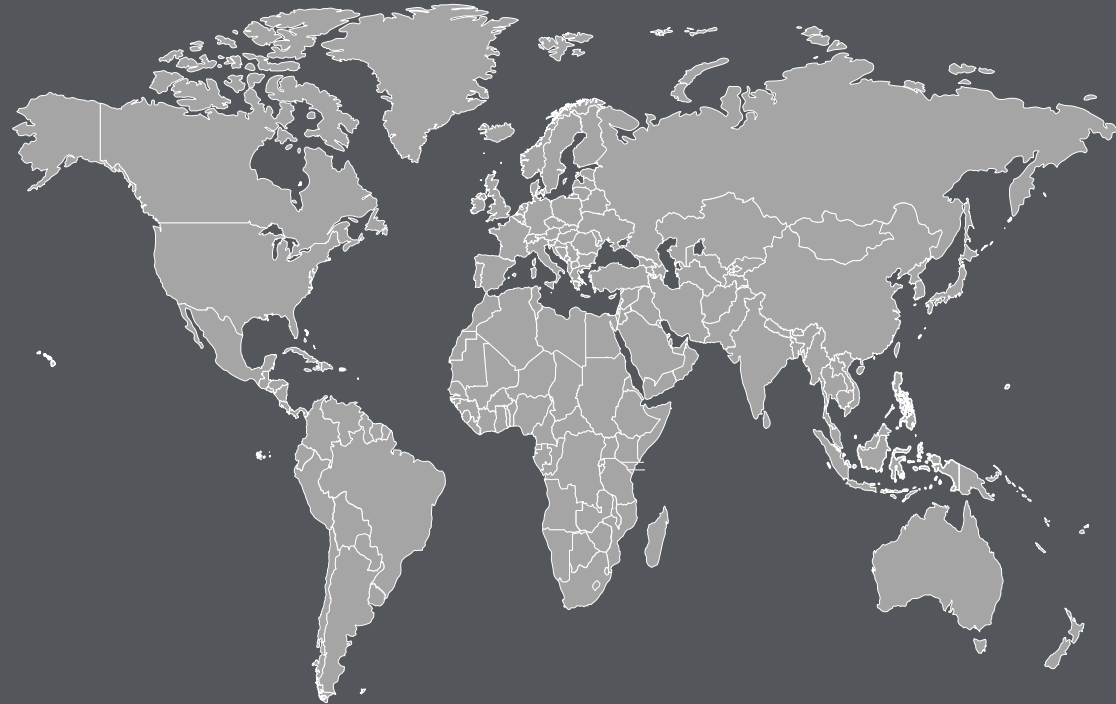
Best business model for China - sales of “Swappable trucks” in partnership CBO



DIFFERENT MARKET REDINESS

GROWING NEW MARKETS

- Battery swap is still just a concept that is tested in most markets. There is a growing interest among operations like harbours and mining that has a need for uptime and the battery pack weight has an impact on productivity.
- In these application battery swap has a great potential. This market will most likely grow in the coming years – where the Chinese players is right now the only ones that has a ready product to offer.
- In Europe here is a growing interest, mostly because it could have a positive effect on the infrastructure investments and that it is a solution that is not dependents of the electrical grid.



CUSTOMER SEGMENTS IN CHINA

Maturing segments

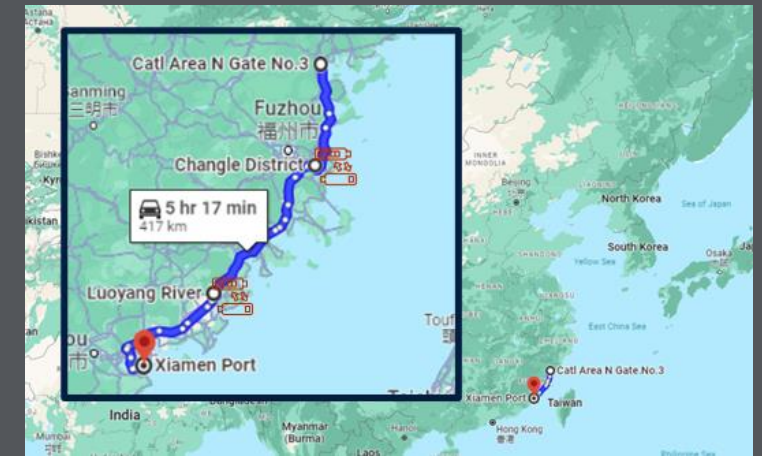


- High-frequency, high-load, un-fixed route but in closed scenarios, such as
 - ✓ Steel/power plants
 - ✓ Mining areas
 - ✓ Ports



- High-frequency, high-load, short-distance and fixed start/end points, such as:
 - ✓ Mine to yard to washing plant
 - ✓ Plants to ports

Scenarios Under Exploration



- “point-like” scenarios to a network system
- High-load and large flow fixed-route hub to hub transportation, such as
 - ✓ Logistic hubs to ports/railway
 - ✓ ...

Case study: EHAUL/UNISWAP

The UniSwapHD project

- Funded by the German Federal Ministry for Economic Affairs and Climate Action (BMWK), builds upon findings from the eHaul project.
- It addresses the challenge of standardizing swappable batteries for heavy-duty commercial vehicles, crucial for the economic implementation of battery swapping.
- The aim is to develop a standardization concept for interchangeable batteries that can be used in various heavy commercial vehicle models for long-distance road freight transport.

Standardization Approach

- The project aims to develop the geometry of a standard battery for semi-trailer tractors and trucks, including contacting and a matching exchange system.
- This will involve aggregating geometric, power electrical, and information technology vehicle data from different manufacturers.
- A generally applicable communication interface for the traction batteries of commercial vehicles will also be designed.

Project Activities and Deliverables

- Identification and analysis of relevant heavy-duty commercial vehicles from various manufacturers, and creation of a requirements catalog for a standardized battery exchange system.
- Conception, development, production, and practical testing of an optimized exchange system for the standard battery concept.
- Conception of a flexible CAN gateway for communication between the battery and vehicle or battery and exchange station.



Mining Electric vehicles

Battery swap technology holds great promise for electric mining trucks, enabling faster and more efficient charging processes and contributing to the ongoing electrification of the mining industry. As technology continues to advance and infrastructure develops, battery swap systems are expected to play a significant role in powering the future of mining operations.

15% of sales is EV in the mining industry and it is growing.



[Battery Swap Scooptram ST14 Battery](#)
[\(youtube.com\)](#)

[A power change that changes everything](#)
[\(youtube.com\)](#)

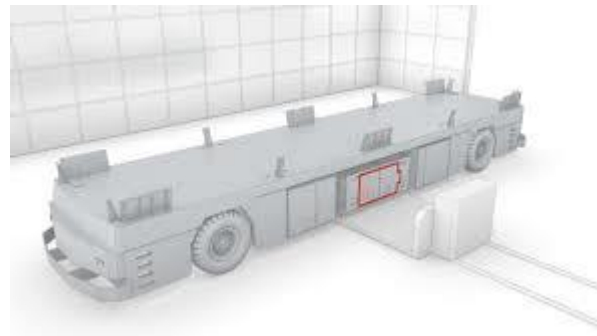
The Automatic Guided Vehicle (AGV)

The Automatic Guided Vehicle (AGV) Battery market is poised for substantial growth between 2024 and 2031, driven by several factors including technological advancements, increasing demand for Automatic Guided Vehicle (AGV) Battery, and supportive government policies. Additionally, the market is expected to benefit from growing consumer awareness and a shift towards sustainable and eco-friendly products. Moreover, the rising focus on health and wellness is likely to contribute to market expansion, as consumers seek products that align with their values and lifestyle choices. In summary, the Automatic Guided Vehicle (AGV) Battery market presents significant growth opportunities for both established players and new entrants, with emerging trends and market dynamics creating a favorable environment for growth.

One of the critical aspects of AGV operation is the battery system, as it directly impacts the vehicle's uptime and productivity. Battery swap solutions have emerged as a promising approach to address the downtime associated with battery charging, thereby enhancing the operational efficiency of AGVs. Here are some developments in the AGV battery swap market:



[Battery AGV \(youtube.com\)](https://www.youtube.com/watch?v=...)



[Fast charging and battery swapping on Automated Guided Vehicles | Stäubli \(youtube.com\)](https://www.youtube.com/watch?v=...)

Fastest growing market with solid-state batteries that can be swapable





6. Conclusions





Same goals, new challenges

Charging is the key...

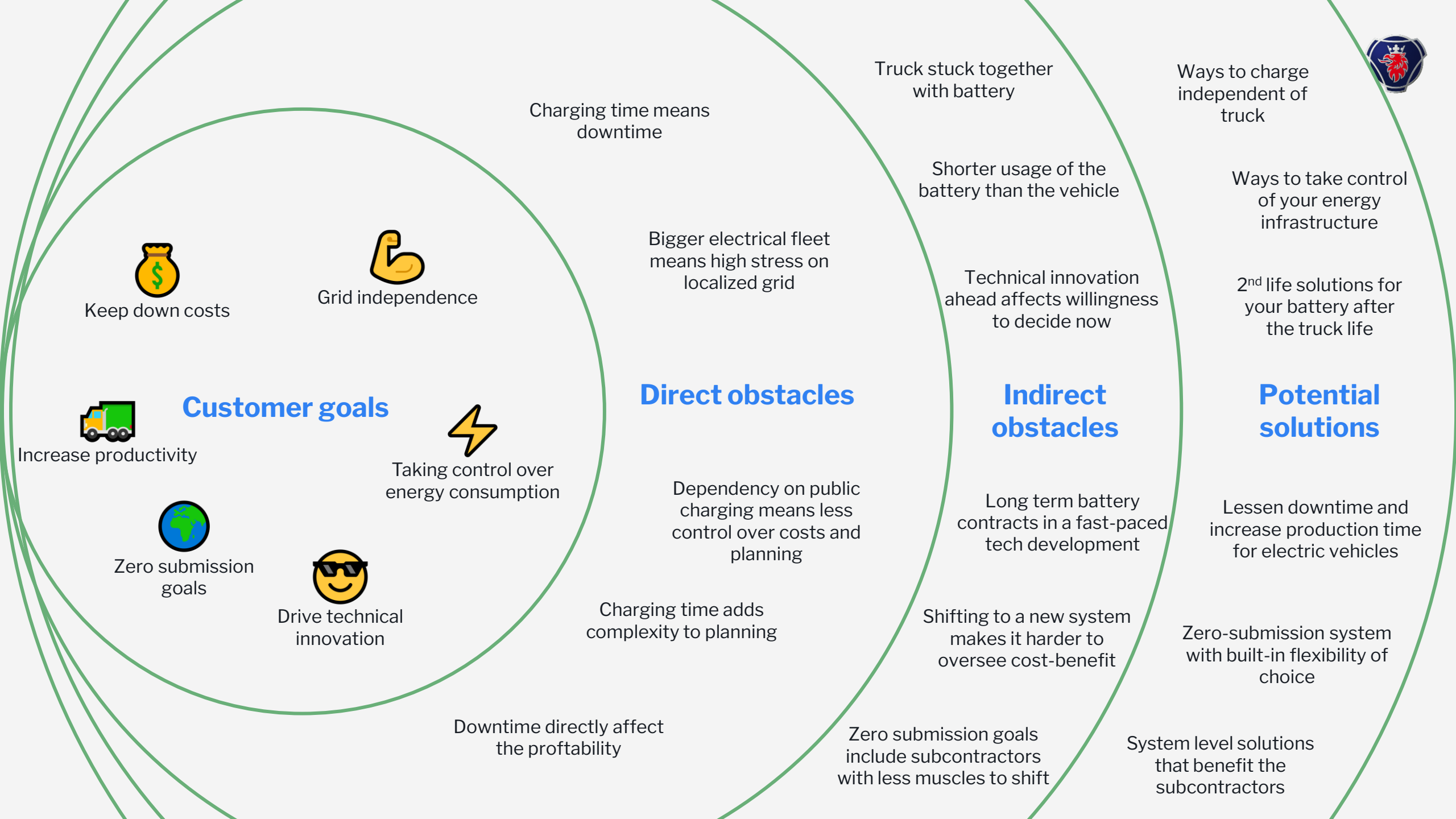
...if the battery could separate from the truck

The goal to shift over to electrification is high on many transport operators.

However, the aim for cost reduction and increased productivity, the very core of their business. The charging method directly and indirectly impacts the business goals. It influences business models and their operations flexibility.

Separating the battery from the truck, as in battery swapping, is the enabler that unlocks new potential for innovative business models and improved productivity, hence profitability.

SCANIA



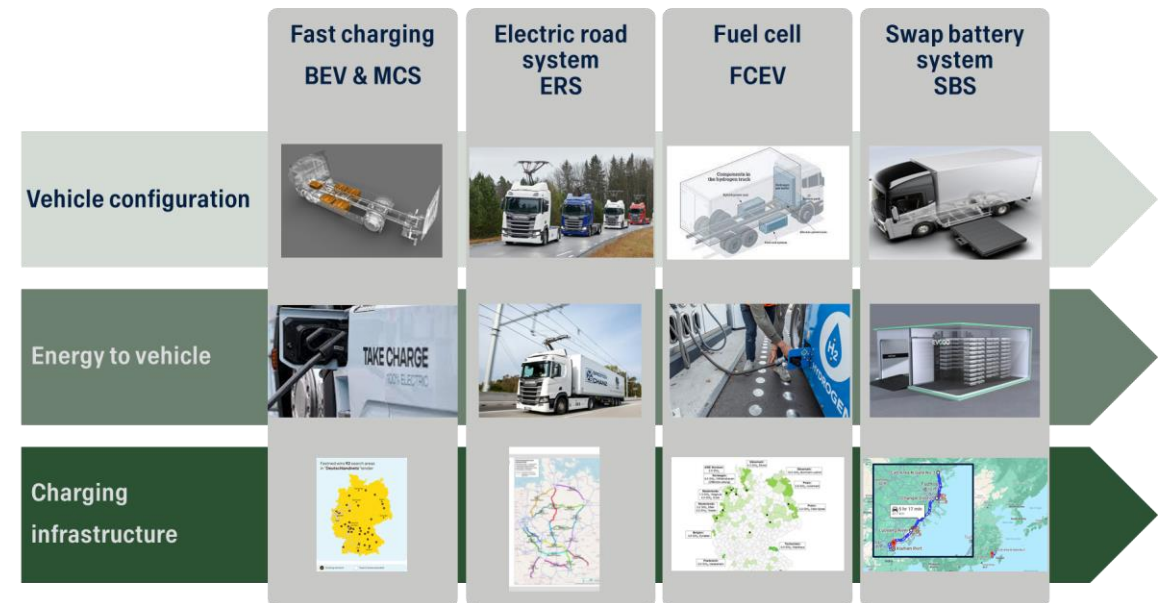


WHY BATTERY SWAP?

The shift from the combustion engine to an electrified drivetrain involves much more than just the vehicle itself. It can be divided into three important areas: vehicle development, charging interface, and charging infrastructure.

The various options for charging infrastructure are now becoming many, and which option will ultimately prevail remains unclear. What is currently happening in our industry follows the same pattern as many technological shifts before this one. So how should we as a company act in this diversity and uncertainty? I believe most of us know the answer – Modularization and clear interfaces. However, we need to get even better at this! Another important aspect is establishing industry standards. The best way to achieve success in this is to have sufficient knowledge of the technical solutions' limitations and possibilities so that the standards are fit for purpose.

Today there is no global standard for battery swap. In the Chinese market there are some system standards that has been agree up on in collaborations between battery producers and heavy vehicles OMEs this has led to various battery swapping systems for heavy trucks have been developed. The pace of development is very fast. New form factors for batteries and trucks or batteries and charging stations seem to be continuously coming to the market. There are several key factors why China is investing in battery swapping as a complement to fast charging. The charging stations utilize less land area, and the turnover of vehicles at the charging station is higher. It also provides an opportunity to balance the power grid. China today accounts for 70% of global electric vehicle sales. No other market has as many vehicles on the road as in China. Therefore, factors like high turnover and land area are important

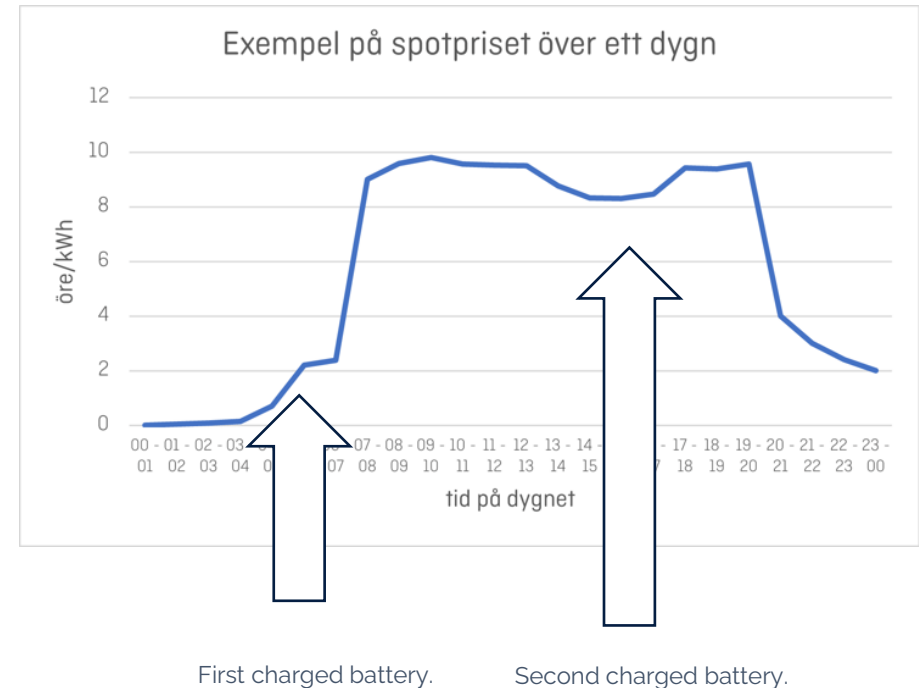


WHY BATTERY SWAP?



The great revolution with electric vehicles is not the vehicles themselves but the charging infrastructure. It can be customized in a much more cost-effective way than gas, diesel, or gasoline. It is also possible to have renewable electricity production in connection with the charging site. This is one of the strong points of battery swaps.

In this pre-study, it is noted that one of the biggest obstacles to the transition is that charging time affects our customers' logistics setups, reducing flexibility. It is not as simple as matching rest time with charging time on a 1:1 basis. The possibility to reduce charging time to even less than fuelling an ICE truck and the possibility to take control over energy prices is two of the strongest arguments for going forward with battery swap.



Possible eco-system for battery swap

