Transport | Energy Infrastructure | Knowledge & Enterprise

cenex

BETT Deep Dive: Charging Efficiency Analysis

Cenex

Transport Team

Transport | Energy Infrastructure | Knowledge & Enterprise

Document Control

	Name and Job Title	Organisation
Prepared for:	Steven Birch, Continuous Improvement Manager	Leyland Trucks
Prepared by:	Chapa Chandrasekara, Assistant Technical Specialist	Cenex
Approved by:	Tom Allerton and Victor Lejona, Senior Technical Specialists	Cenex

Revision No.	Details	Date Issued
1	Initial draft release	20/12/2022
2	Final release	16/01/2023

Company Details

Cenex
Holywell Building
Holywell Park
Ashby Road
Loughborough
Leicestershire
LE11 3UZ

Registered in England No. 5371158

Tel: 01509 642 500

Terms and Conditions

Transport | Energy Infrastructure | Knowledge & Enterprise

cenex

Charging Efficiency Analysis: Key Points

- Charging data from E-Flux AC chargers and Cenex's data on when vehicles were parked were matched based on date and time. This provided data on the energy delivered by the charger, and the energy delivered into the battery.
- 174 charge sessions with representative data were used in this analysis.
- The average charging efficiency was 89.7%.
- The majority of the journeys the vehicles use less than half of their battery.
- 93% of the charge sessions charge until the battery is full.

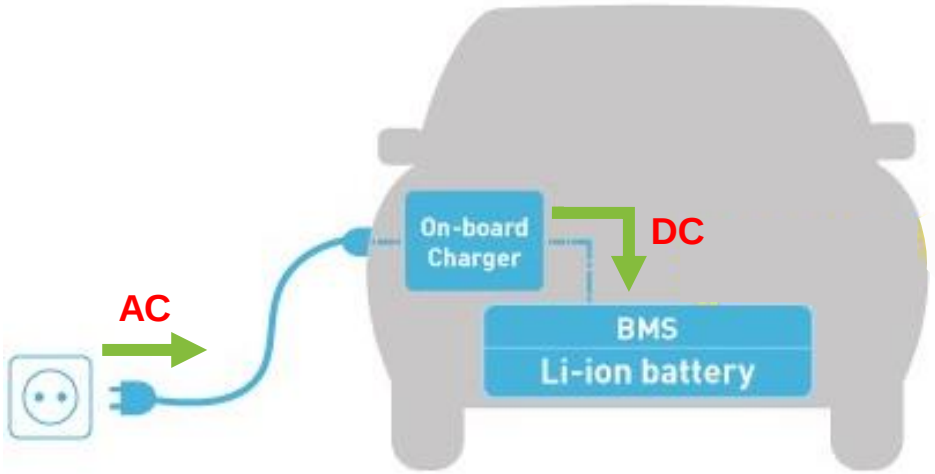
Transport | Energy Infrastructure | Knowledge & Enterprise

cenex

Battery Electric Truck Trial (BETT)

- The UK has set targets to phase out non-zero emission HGVs by 2040. One approach for HGV decarbonisation are battery electric vehicles.
- DAF trucks were awarded funding to commence with the deployment of twenty 19-tonne DAF Electric LF trucks. The trucks have a range of 175 miles on each charge and can be rapid charged up to 150kW.
- Cenex, a not-for-profit research technology organisation and consultancy focussing on low emission transport and infrastructure, are supporting project delivery by providing trial monitoring, analysis and reporting.

Charging Efficiency



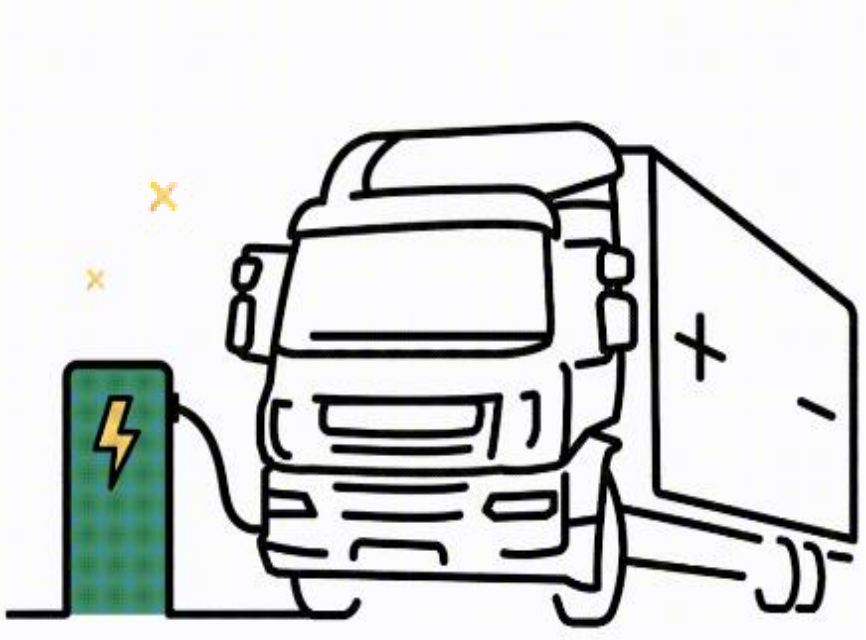
$$\frac{energy\ into\ battery}{energy\ out\ of\ charger} = charging\ efficiency$$

- Electric vehicles (EVs) can be charged via AC (alternating current) charging or DC (direct current) charging.
- When charging an EV with an AC charger, the vehicle has to convert the AC coming from the charger to DC via a converter, known as an “on-board charger.”
- The DC is then used to charge the battery.
- This conversion results in some loss of energy delivered from the charger.
  - The ratio of the energy received by the battery and the energy delivered by the charger provides the charging efficiency.

Transport | Energy Infrastructure | Knowledge & Enterprise

cenex

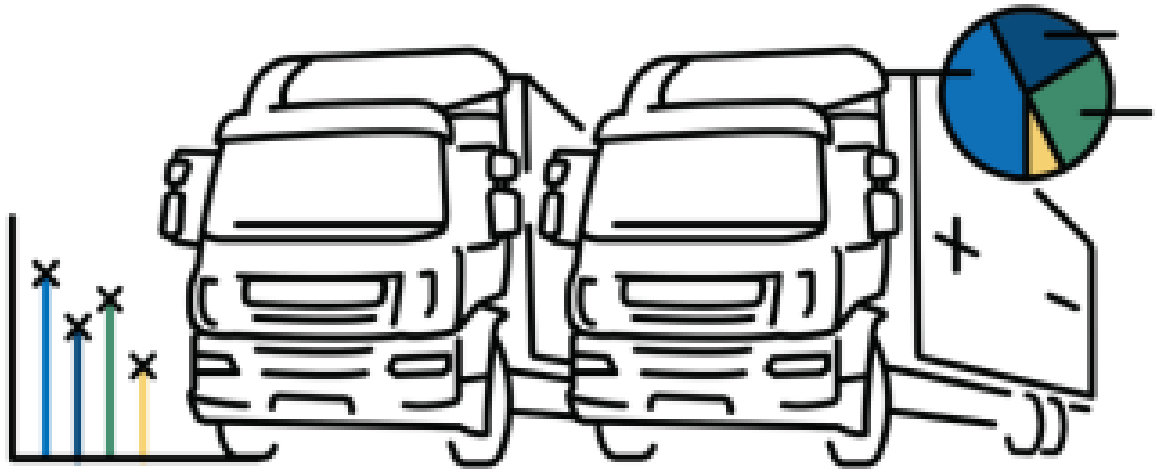
Data Collection



- The chargers for the trucks are managed by a company called E-Flux. They collect energy data from the chargers.
- E-Flux only manage data from AC chargers, which was used for this analysis. Some vehicles exclusively use DC chargers. This analysis does not cover those.
- Cenex has collected telemetry data for the vehicles using CAN Bus loggers, which are managed by Cenex.
- The telemetry data at Cenex is stored as second by second data, whereas the data provided by E-Flux was provided by charge session.

Data Analysis

- E-Flux charge sessions were matched to vehicle parked sessions from Cenex, based on the date and time of parking and charging.
  - Matching was done manually to ensure that the correct parked session was matched to the charge session.
- Using E-Flux data of energy delivered out of the charger, and Cenex data of energy delivered into the vehicle battery, the charging efficiency of each charge session was calculated.

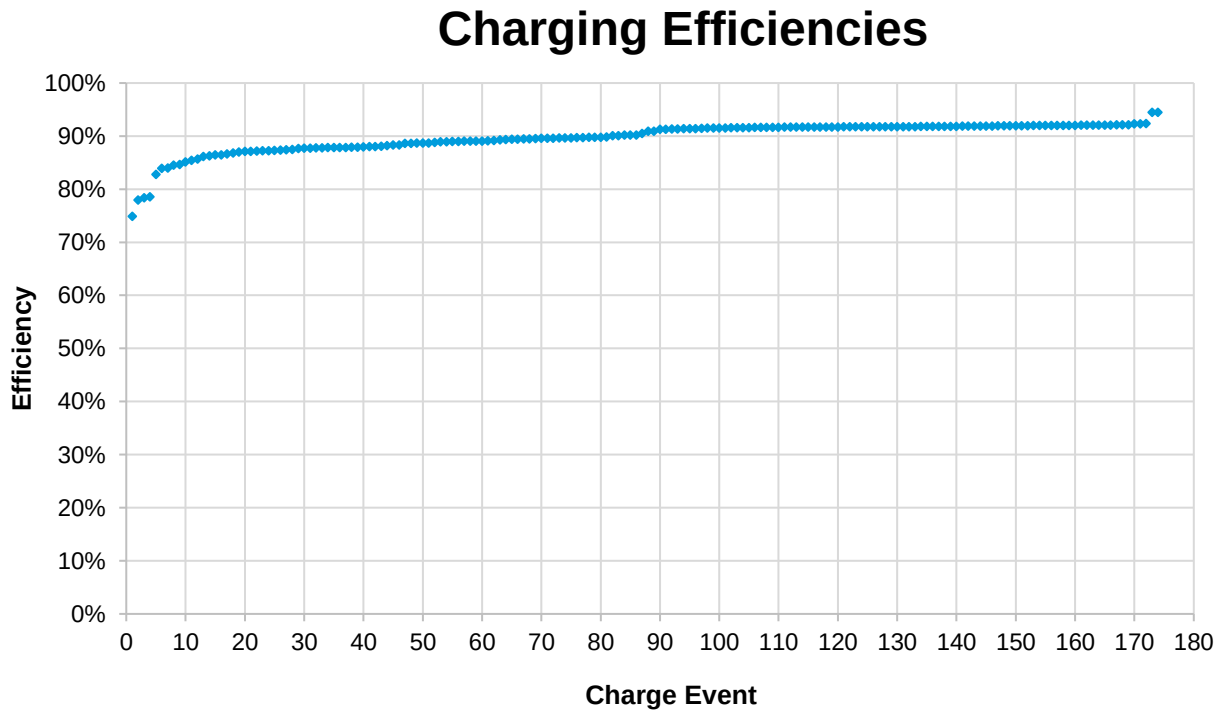


Transport | Energy Infrastructure | Knowledge & Enterprise

cenex

Charging Efficiency

- This graph shows the efficiencies of all charge sessions, ordered by efficiency. It includes 174 charge events in total.
- The majority of the efficiencies lie between 82% and 93%. The average charging efficiency across all sessions was 89.7%.
- This matches well with Cenex's own testing of EV cars and vans, which resulted on an average of 87% charging efficiency.

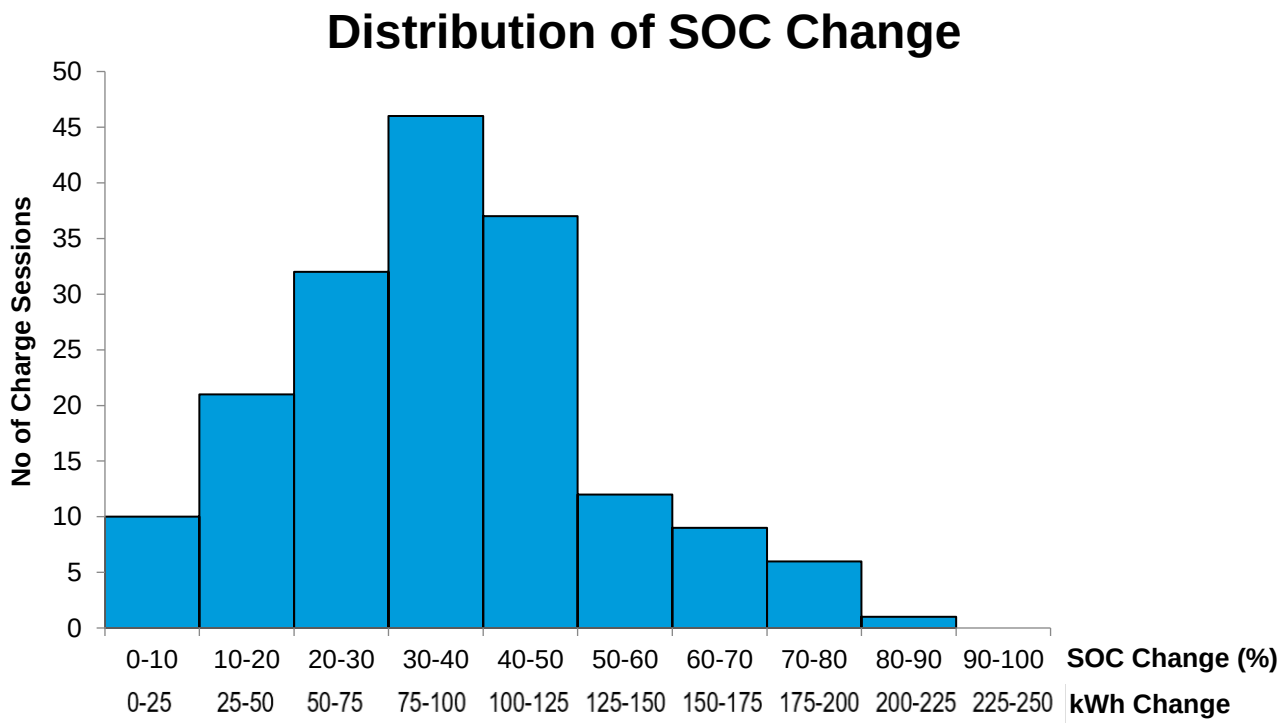


Transport | Energy Infrastructure | Knowledge & Enterprise

cenex

Distribution of SOC Change

- SOC – state of charge. The level of charge in a battery relative to its capacity i.e. battery percentage.
- This graph shows the number of charge sessions that fall into different bands of SOC change, which is how much energy was delivered in each charge session.
- 83.9% of all charge sessions had an SOC change between 0% and 50%.



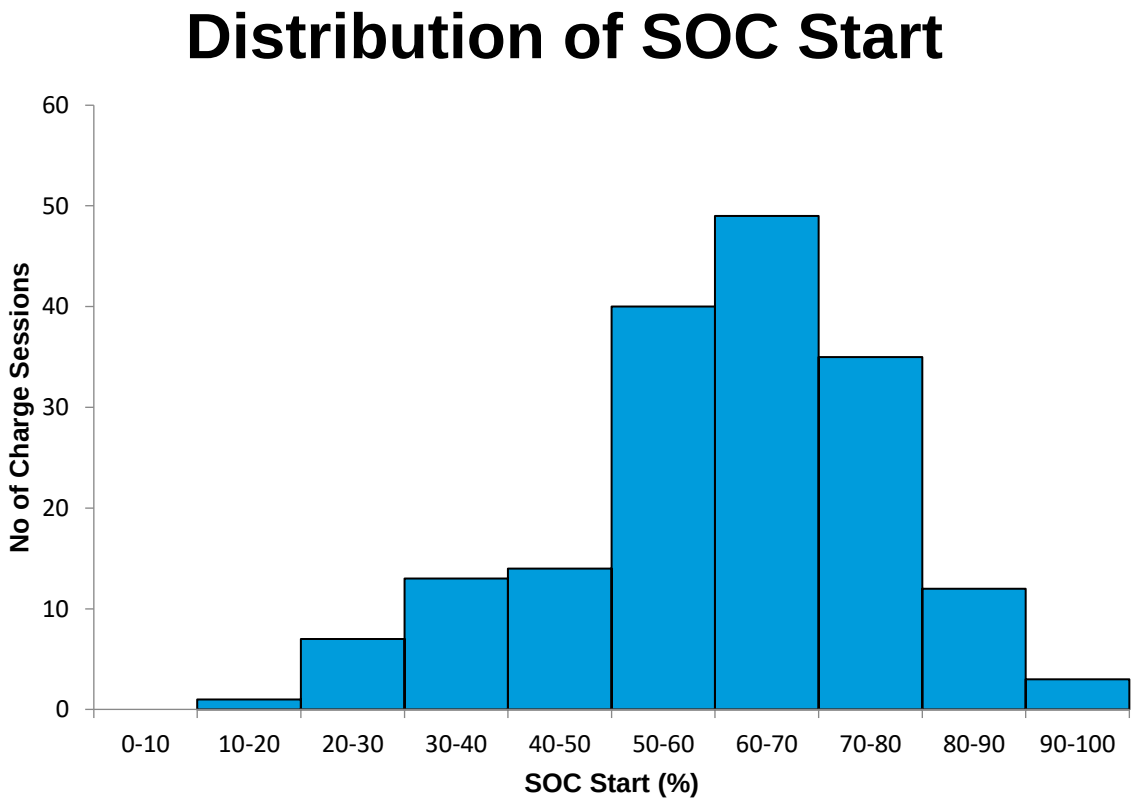
+1% SOC change = 2.5kWh delivered

Transport | Energy Infrastructure | Knowledge & Enterprise

cenex

Distribution of Start SOC

- This graph shows how many of the charge sessions start at various SOCs i.e. how much charge the vehicle had when the vehicle is plugged in.
- 80% of the charge sessions began when the SOC was more than 50%.
- This suggests that these vehicles are more than capable of meeting the requirements of their duty cycles, since they return to their depot with their battery more than half full after a shift.

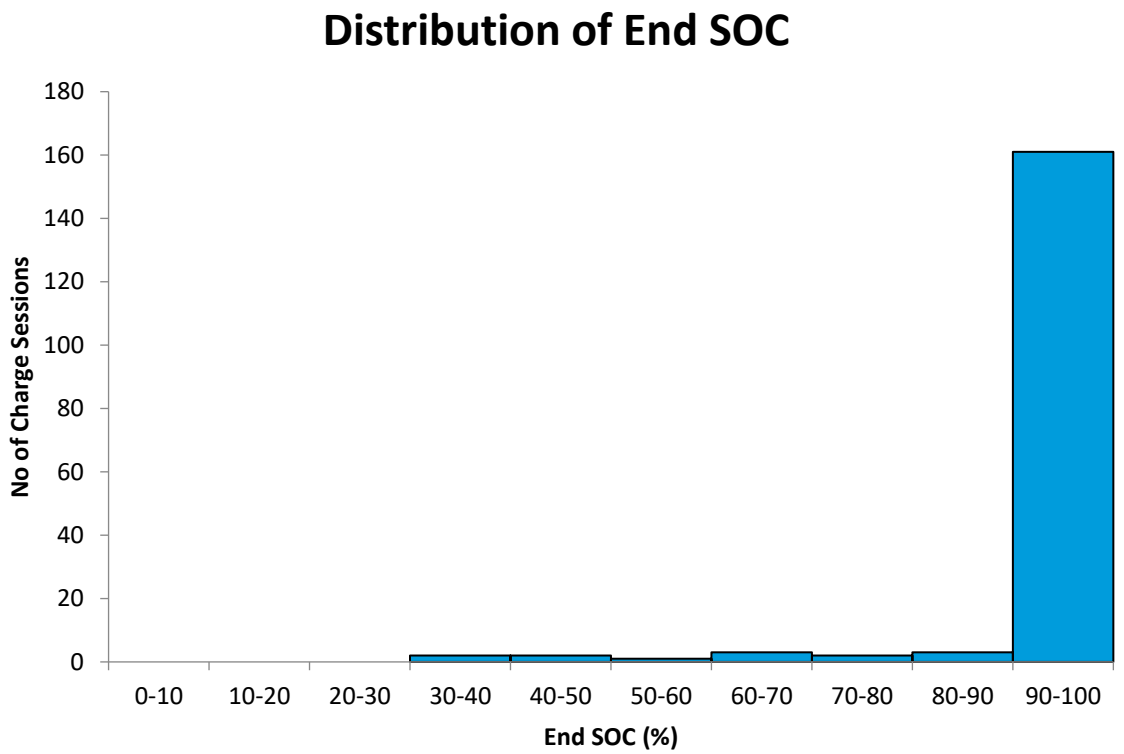


Transport | Energy Infrastructure | Knowledge & Enterprise

cenex

Distribution of End SOC

- This graph shows the SOC of the battery at the end of each charge session i.e. the SOC of the battery when it was unplugged from the charger.
- 91% of the sessions charged till the battery was fully charged.
- A small number of instances where the end SOC was less than 50% were due to the vehicle stopping charging prematurely.
- From these findings, we see that the majority of the charge sessions bring the vehicle to full charge, and that most of the vehicles' SOC are between 50% and 80% when put to charge.



Transport | Energy Infrastructure | Knowledge & Enterprise

cenex

SOC Change Compared to Efficiency

- The graph visualises the relationship between SOC change and the efficiency of each charge session.
- Some charge events with small amounts of energy delivered show lower efficiencies.
- This may be due to measurement inaccuracies or rounding errors in SOC when low amounts of energy are being delivered.
- A small number of sessions with issues in the Cenex data were excluded. It is possible that there are issues in the E-Flux data, which could not be detected, and may have caused the variability seen here.