



# HDV GTR – Energy throughput and verification method proposal

EVE IWG - Session 67

-f2f-

January 09th, 2024

# @ POSITION ON VIRTUAL MILEAGE

Based on real-world data, we request EVE IWG to rethink the virtual mileage proposal and to consider energy throughput as additional lifetime requirement.

$$\text{Virtual distance (km)} = \text{Odometer km} \times \left( \frac{\text{total discharge energy during V2X + PTO + ... [Wh]}{\text{total discharge energy while driving [Wh]}} \right)$$

Or

$$\begin{aligned} \text{Total km} &= \text{odometer km} + \text{virtual distance (km)} = \\ &= \text{Odometer km} \times \left( \frac{\text{total discharge energy [Wh]}{\text{total discharge energy while driving [Wh]}} \right) \end{aligned}$$

Where:

~~"worst case certified energy consumption of Part B family" means the worst case certified energy consumption of a Part B family which needs to be provided according to Annex 2.~~

At the option of the manufacturer, instead of using the worst case certified energy consumption value of the Part B family, the manufacturer may be allowed to use any higher energy consumption value.

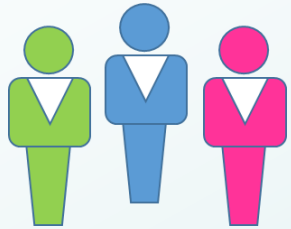
The total distance used for confirming the compliance with the minimum performance requirements will consist of the sum of the distance driven and the virtual distance. The total virtual distance shall be recorded and monitored.

Considering the unique configurations and/or functionalities of HD vehicles:

- 1) Based on expert discussions and real-world data, it is not feasible to differentiate all the separate electric vehicle-internal energy flows
- 2) OICA prefers to apply the whole battery energy/capacity throughput instead of mileage for MPR criteria.

# @CUSTOMER BEHAVIOR AND MARKET FORECAST

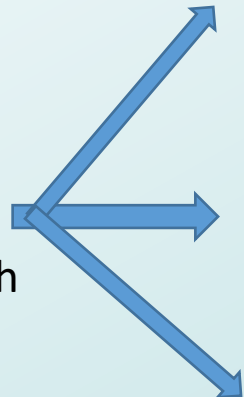
## Customer interests:



- Daily range
- Payload
- Product cost

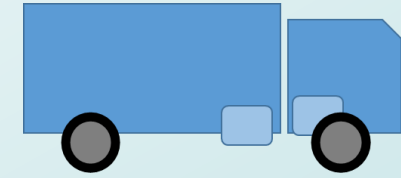
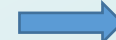


Batterie Pack:  
Nominal Voltage: 670 V  
Nominal Capacity: 130 Ah  
Nominal Energy: 87 kWh

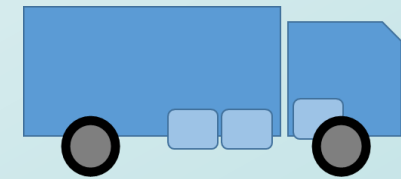
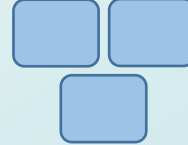


## Modular multi-pack configuration

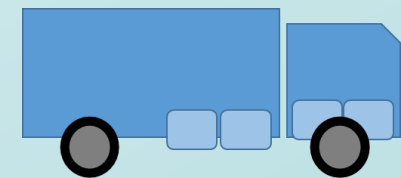
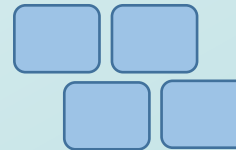
2 Packs



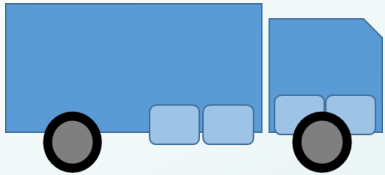
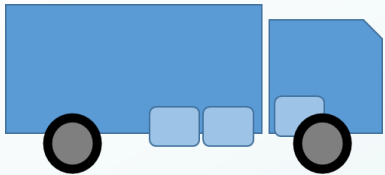
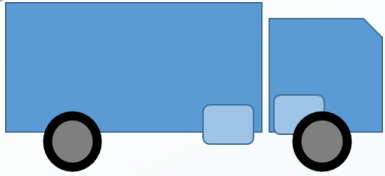
3 Packs



4 Packs



# NOT ONLY ENERGY THROUGHPUT BUT ALSO NUMBER OF PACKS PER TOTAL INSTALLED KWH DECISIVE FOR BATTERY AGING



Battery Pack:  
Nominal Voltage: 670 V  
Nominal Capacity: 130 Ah  
Nominal Energy: 87 kWh

Range criteria: 700.000 km

Assumption: Energy consumption of the vehicle 1 kWh/km (flat test track, no hills!)



Total energy consumption of the vehicle 700.000 kWh

Energy provided **per Pack**:

2 Pack conf.:  
 $700.000\text{kWh}/2 = 350 \text{ MWh}$

3 Pack conf.:  
 $700.000\text{kWh}/3 = 233 \text{ MWh}$

4 Pack conf.:  
 $700.000\text{kWh}/4 = 175 \text{ MWh}$

Given same installed total kWh per vehicle, pack specific energy throughput and thus aging decreases with amount of packs

**Vehicle range** based counter index for in vehicle battery durability **leads to different durability criteria** for **identical battery packs**. This would lead to a decreasing number of customer options and would favor cost intensive vehicle configurations (smaller and more packs).  
**Energy throughput** based on installed Battery energy expressed by **Full cycle equivalent FCE** is an appropriate criteria.

# NUMBER OF FULL CHARGING CYCLES IS A VALID LIFETIME CRITERIA FOR BATTERIES

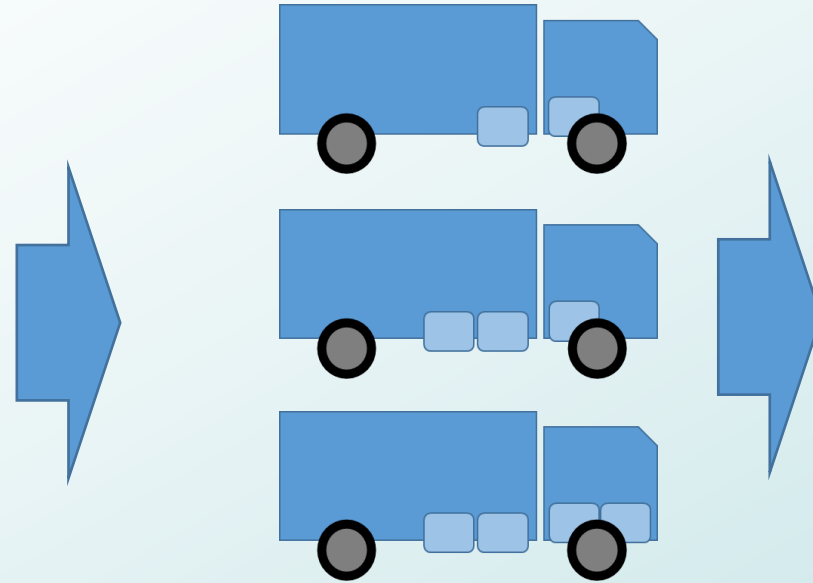
Batterie Pack:  
Nominal Voltage: 670 V  
Nominal Capacity: 130 Ah  
Nominal Energy: 87 kWh

Parameters are clearly visible on the battery label

Lifetime criteria:

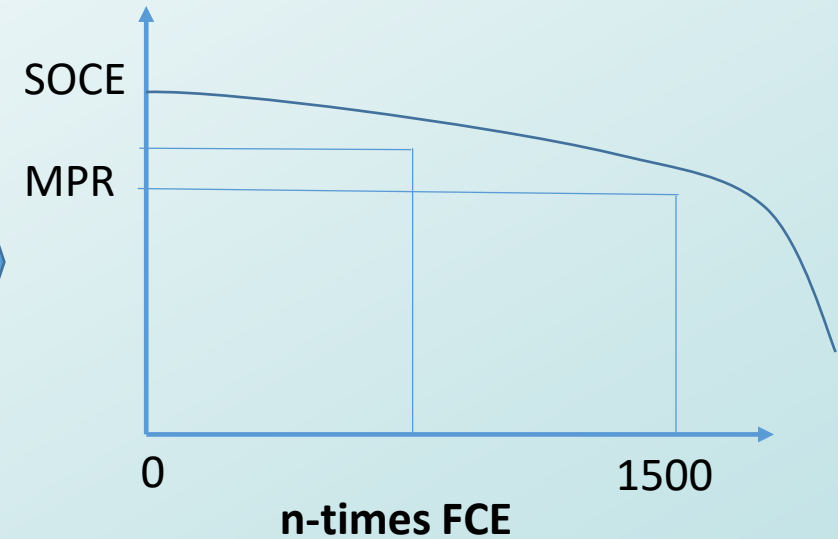
**n-times** Full Charging equivalents

(e.g. 1500 cycles => 130 MWh)



On system or vehicle level:

**n-times** FCE (full cycle equivalent)



**Number of full cycle equivalent n FCE** is representing a lifetime criteria that takes the individual installed battery capacity or energy of the vehicle into account. For multi pack configurations, the lifetime requirement stays the same for each individual pack.



# RESULTING FCE FROM ENERGY THROUGHPUT VS. MILEAGE AND YEARS FOR DIFFERENT CASES

Case	Total installed Vehicle Battery Energy	Efficiency	C-Rate aver.	mileage per day	shift velocity	shift haulage duration	shift vocational/loading duration	mileage per year	years	Mileage	Total Energy Throughput	FCE
	[kWh]	[kWh/km]	[-]	[km]	[km/h]	[h]	[h]	[km/a]	[a]	[km]	[MWh]	[-]
Haulage + PTO	600	1,2	0,2	500	75	7	3	115000	7	805000	966	1610
	400	1,2	0,3	400	65	6	4	92000	7	644000	773	1932
Regional + PTO	200	0,8	0,4	300	55	5	5	69000	7	483000	386	1932
	100	0,4	0,4	200	45	4	6	46000	7	322000	129	1288
PTO only	300	3,0	1,0	60	15	1	9	13800	7	96600	290	966

## Observation

Different use-cases resulting in different energy throughput, whilst years stay same

Mileage and FCE do not correlate linearly

For smaller trucks with small batteries c-rate increases. FCE increases too, which adds more aging to the battery

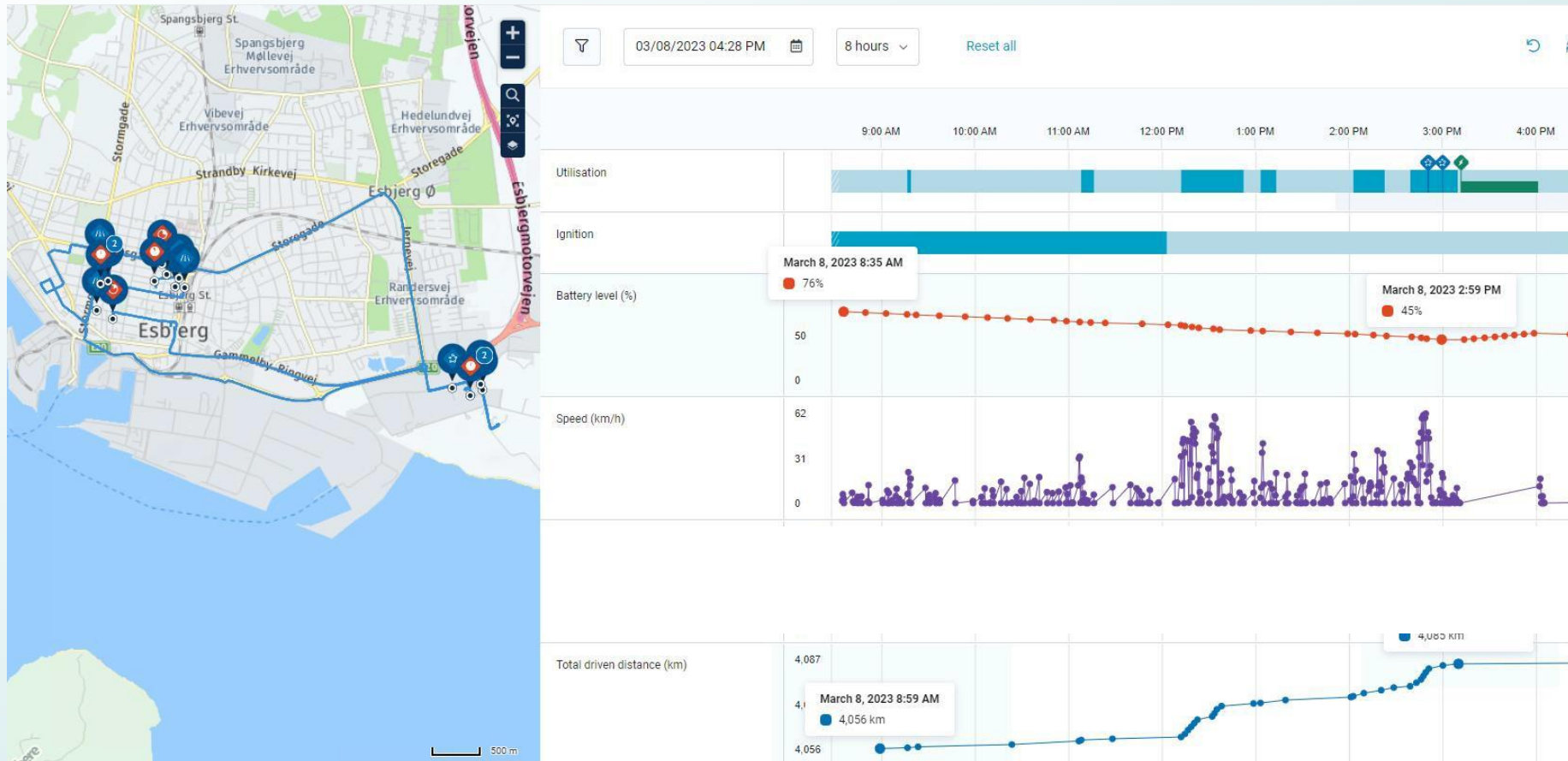
Thus, smaller trucks with lower installed battery energy cycled more often



# EXAMPLE: EV MUNICIPAL UTILITY

## Vehicle:

- Electric HDV
- 4x2 rigid, 32t
- Municipal utility
- Full electric Powertrian (Battery: 300 kWh, Engine: 300 kW Pcont)



## Take aways

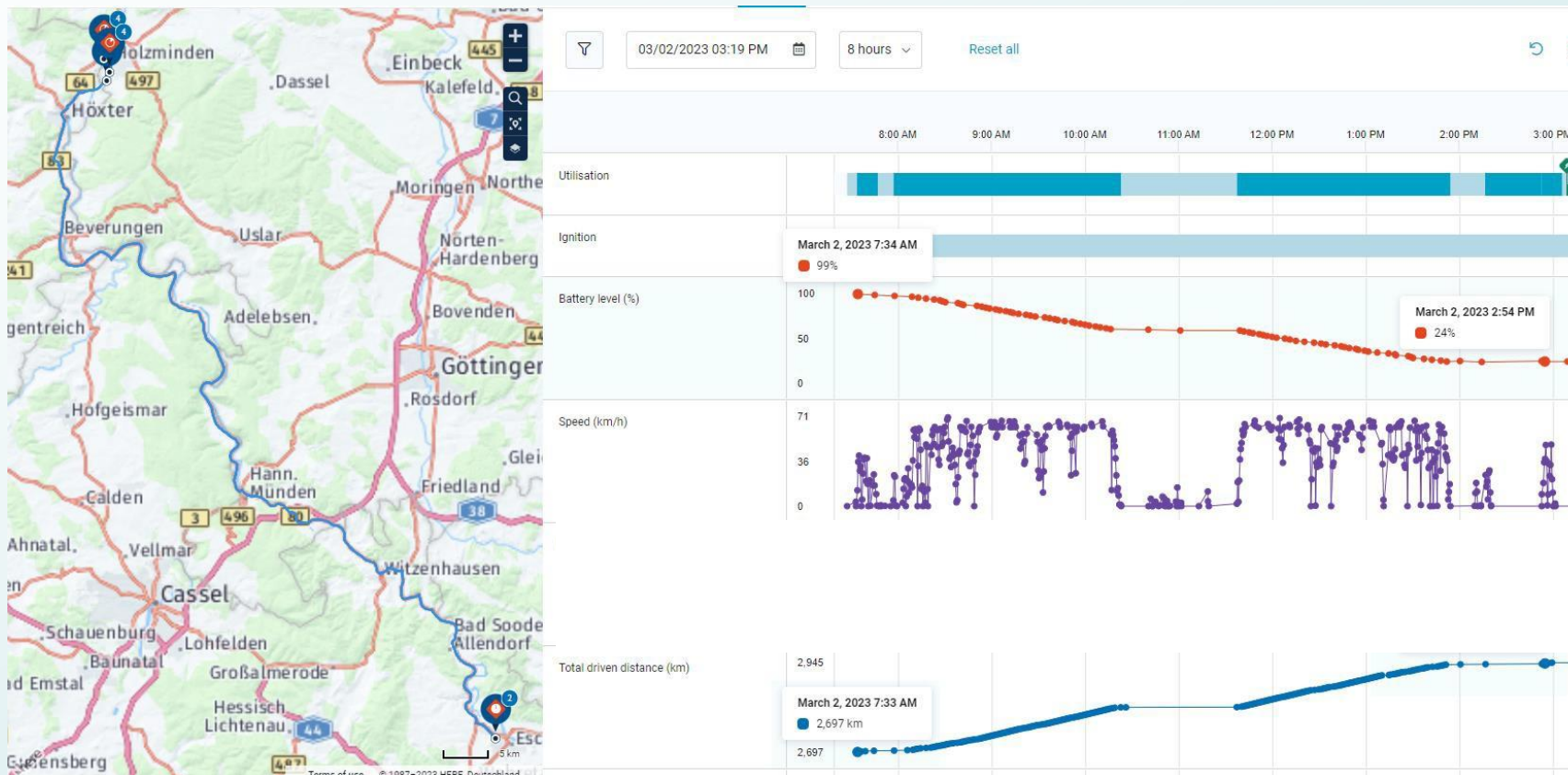
- Mileage: **29km**
- Vaverage: **15 km/h**
- Duration: **4,5h**
- DoD: **31% (76%-45%)**
- Specific DoD: **3kWh/km**



# EXAMPLE: EV LONG-HAUL & REGIONAL DELIVERY

## Vehicle:

- Electric HDV
- 4x2 rigid, 40t
- Long-Haul & Regional Delivery
- Full electric Powertrian (Battery: 300 kWh, Engine: 400 kW Pcont)



## Take aways

- Mileage: **245km**
- Vaverage: **65 km/h**
- Duration: **5,5h**
- DoD: **75% (99%-24%)**
- Specific DoD: **1kWh/km**





# EXAMPLE: DIESEL MUNICIPAL UTILITY & LONG-HAUL

## Vehicle:

- Diesel HDV
- 4x2 rigid, 32t
- Municipal utility
- 78h PTO operation @709km
- 3 PTOs in total installed
- FC: 171 l/100km

## Vehicle:

- Diesel HDV
- 4x2 tractor, 40t
- Long-Haul
- No PTO operation
- No PTOs in total installed
- FC: 24,5 l/100km

▼ Verbrauchswerte	
Gesamtverbrauch 1.218,4 l	Fahrverbrauch 339,9 l
<b>Gesamtverbrauch 171,80 l/100km</b>	σ Fahrverbrauch 47,93 l/100km
▼ Einsatzmerkmale	
<b>Fahrstrecke 709,2 km</b>	σ Gewicht 31 t
Anteil > 85 km/h an Fahrstrecke 0,0 % (0,0 km)	Betriebsbremsweg/Fahrstrecke 4,7 % (33,5 km)
Fahrzeit 22:35:47 (hh:mm:ss)	<b>Standzeit laufender Motor 78:25:48 (hh:mm:ss)</b>
1. Nebenantrieb 74:17:04 (hh:mm:ss)	2. Nebenantrieb 00:00:00 (hh:mm:ss)

▼ Verbrauchswerte	
Gesamtverbrauch 2.675,4 l	Fahrverbrauch 2.650,6 l
<b>Gesamtverbrauch 24,54 l/100km</b>	σ Fahrverbrauch 24,32 l/100km
▼ Einsatzmerkmale	
<b>Fahrstrecke 10.900,7 km</b>	σ Gewicht 21 t
Anteil > 85 km/h an Fahrstrecke 24,9 % (2.718,6 km)	Betriebsbremsweg/Fahrstrecke 1,2 % (133,6 km)
Fahrzeit 155:55:35 (hh:mm:ss)	Standzeit laufender Motor 16:12:27 (hh:mm:ss)
1. Nebenantrieb 00:00:00 (hh:mm:ss)	2. Nebenantrieb 00:00:00 (hh:mm:ss)

## Take aways

- Mileage: **709km vs. 10900 km**
- PTO: **78h vs. 0h**
- FC: **171 l/100km vs. 24.5 l/100km**
- Duration: **96hrs vs. 155hrs**
- Time specific PTO operation: **81% vs. 0%**