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ASTRABAT Deliverable D2.5

Analysis of battery requirement for vehicle applications WP2, T2.4

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[1] PU = Public, PP = Restricted to other programme participants (including the Commission Services) , RE = Restricted to a group specified by the consortium (including the Commission Services), CO = Confidential, only for members of the consortium (including the Commission Services)

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Deliverable Review*

Glossary

Term	Definition
AEVs	all-electric vehicles
PHEVs	plug-in hybrid electric vehicles
BEVs	AEVs include Battery Electric Vehicles
FCEVs	Fuel Cell Electric Vehicles

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Abstract

This deliverable report the vehicles' requirements for power system. The document describes the simulation of performance preferences and requirements (continuous C-rate, power, voltage level, peak C-rate, specific energy, etc.) for battery electric vehicle (BEV).

We also analyze the battery requirement for the vehicle.

The EUCAR test protocols namely Hazard Level Testing including abuse tests are detailed.

An analysis of the performance preferences and requirements for different vehicle types are also described.

The commercial aspect of advanced battery uses in BEV is also discussed, hence providing a guide for the project ASTRABAT, partners innovation design and research activities.

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1 Basics definitions of Electric Vehicles

1.1 Definitions and general view

Plug-in electric vehicles or EVs have different capabilities that can accommodate different drivers' needs who can plug them in to charge from an off-board electric power source. This distinguishes them from hybrid electric vehicles, which supplement an internal combustion engine with battery power but cannot be plugged in.

The EVs are classified into two main categories. The first one, the **all-electric vehicles (AEVs)** that run only on electricity. Most of them have all-electric ranges of **80 to 100 miles**, and **up to 250 miles** for a **few luxury models**. The second one, the **plug-in hybrid electric vehicles (PHEVs)** running on electricity for shorter ranges **(6 to 40 miles)**, then can switch over to an internal combustion engine running on gasoline when the battery is depleted. Because of the flexibility of PHEVs, the drivers can use electricity from the grid reduces fuel costs as often as possible while also being able to fuel up with gasoline if needed. This cuts petroleum consumption, and reduces tailpipe emissions compared with conventional vehicles. When driving distances are longer than the all-electric range, PHEVs act like hybrid electric vehicles, consuming less fuel and producing fewer emissions than similar conventional vehicles. Depending on the model, the internal combustion engine may also power the vehicle at other times, such as during rapid acceleration or when using heating or air conditioning [1].

In addition to charging from the electrical grid, both types are charged in part by regenerative braking, which generates electricity from some of the energy normally lost when braking. Right now, the fastest available EV chargers are generally on public networks and can juice an EV to about 80 percent full in about 30 minutes. Currently, there are three main kinds of EV chargers, known as Levels 1, 2 and 3 summarized in the Table 1.

	Level 1	Level 2	Level 3
Power	120-volt charging & **1.4 kW**	208 to 240 volts 6.2 to **7.6 kW**	480V volts; 20 and **50 kW**
Charging time	Slow: **17 & 25 hours** to fully charge	Fast: **four or five** hours. Compatible with all EV and PHEV	Fast charge: <**20 min**, but not compatible with all vehicles
Types/ ranges of EVs	**100 miles**	**100 miles**	Mitsubishi "i", Nissan LEAF, Audi E-Tron SB
Availability	Can be **easily carried out wherever you want** in the trunk of your car	**Home installation, wall-box** (wide range of manufacturers and models); can't be transported	Level 3 stations are designed for **public** use

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Networked Stations	Not connected	Connected	Connected
Safety switch/ Weatherproof	yes	yes	yes

Table 1: Characteristics of the different EV chargers (Levels 1, 2 and 3)

Tesla's Supercharger network, designed specifically for Tesla vehicles, is marketed as the standard to which all other EV infrastructure should aspire. It operates at 150 kW, which is enough to charge some cars in as little as an hour. The Supercharger, which operates up to 120 kW, can charge a Tesla about 80 percent in about 30 minutes [2].

Additionally, the efficiency and driving range of EVs varies substantially based on driving conditions, the extreme outside temperatures and the driving speeds. An increase of the temperature or the rapid acceleration lead to reduce the range because of the energy required to overcome increased drag. Moreover, hauling heavy loads or driving up significant inclines also reduces range [1].

1.2 The key organs of electric vehicles

Battery electric vehicles (BEVs) use a large traction battery pack to store the electrical energy that powers the electric instead combustion engine. The battery pack must be plugged in to an electric power source for example a charging station or wall outlet to charge. Because BEVs produce no direct exhaust or emissions, they are categorized as zero-emission vehicles.

The EVs is composed of different main internal organs, among others [3, 4]:

- Battery (all-electric auxiliary) that provides electricity to power vehicle accessories in an electric drive vehicle.
- Charge port that allows the vehicle to connect to an external power supply in order to charge the traction battery pack.
- DC/DC converter that converts higher-voltage DC power from the traction battery pack to the lower-voltage DC power needed to run vehicle accessories and recharge the auxiliary battery.
- Electric traction motor to drives the vehicle's wheels. Some vehicles use motor generators that perform both the drive and regeneration functions.
- Onboard charger takes the incoming AC electricity supplied via the charge port and converts it to DC power for charging the traction battery. It monitors battery characteristics such as voltage, current, temperature, and state of charge while charging the pack.
- Power electronics controller that manages the flow of electrical energy delivered by the traction battery, controlling the speed of the electric traction motor and the torque it produces.
- Thermal cooling system that maintains a proper operating temperature range of the engine, electric motor, power electronics, and other components.
- Traction battery pack stores electricity for use by the electric traction motor.

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- Electric transmission that transfers mechanical power from the electric traction motor to drive the wheels.

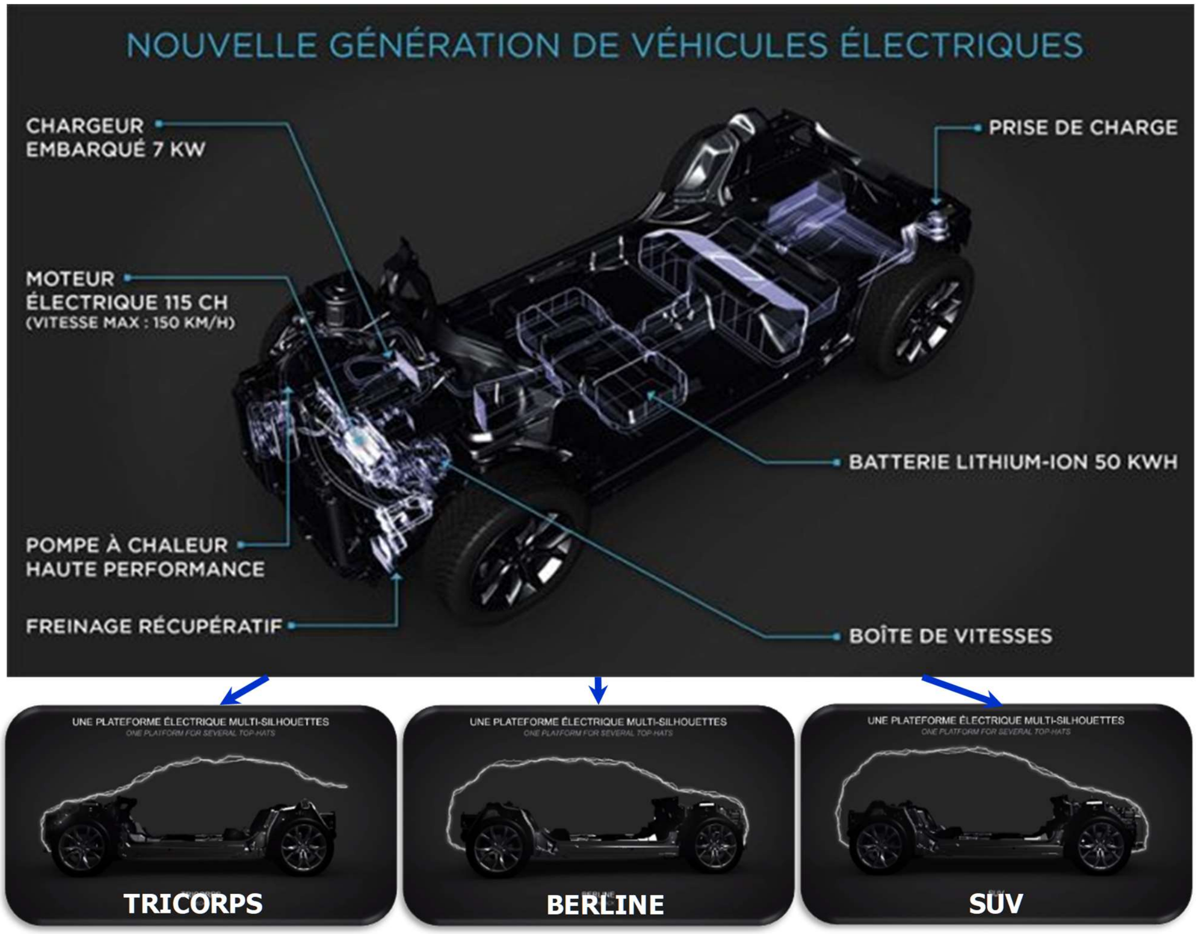

Figure 1: key components of a battery electric vehicle (for PSA Common Modular Platform) [3, 4]

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2 Electric Vehicles Requirements

2.1 Methodology

For this work, we have considered and aligned the battery pack requirements with those of PSA BEV project as the e-208 or DS3 Crossback with embedded energy of **95 KWh** i.e two times higher than the recent technology. Based on PSA internal battery pack architecture we could define the appropriated volume of the modules and battery pack. It should be noted that the details of the ASTRABAT cell information on the dimensions, the volume and the weight are available in the deliverable D2.3. For the Leclanché cell design, characterized by a flat geometry and the use of a soft packaging, the energy density of the **50 Ah cell** is expected to be approximately **290 Wh kg^{-1}** and **1050 Wh L^{-1}**. In the case of the **10 Ah cell**, the energy density of the cell is expected to be close to **242 Wh kg^{-1}** and **958 Wh L^{-1}**. Thus, two cells with the target capacity of 10 Ah and 50 Ah have been considered. By taking similar hypothesis with the PSA BEV (e-208 or DS3 Crossback) architecture pack battery, the useful volume of the module for ASTRABAT project has been estimated.

2.2 Requirements for ASTRABAT battery electric vehicle

We considered an 800V battery pack and the power of 350 KW in charge, which lead to increase the current in the battery pack. The voltage of the pack being low, the level current is high to obtain a power of 350 kW. We consider this level of energy with 800 V and 350KW. However, the use of 200 or 250 KW to make it realistic. The limits values of the voltage (minimum and maximum voltage) of the battery pack and the associated volume have been used similarly to standard our module database that has been assembled with the cells with same chemistry.

The keys values and characteristics for the EV given by the electric motor manufacturer (here ELAPHE) and the design of vehicle architecture to be able to make a low vehicle (defined by PSA) will be used to build a vehicle for ASTRABAT project. In fact, the volume of the battery pack is the limited element in the vehicle. The height is already limited and defined size. The battery is putted down in the base. Therefore, the notion of the height (z) is important and not negligible in designing of the battery pack architecture. The weight is also a key element.

We give a global vehicle requirement namely the energy levels, the power levels that will be visited during the use of the vehicle. These vehicle data are very important to be defined for different reasons, for example, the motors and the inverters are linked to the voltage values. The volume/weight ratio and the power/mass ratio directly affect the dynamics performances of the vehicle, and is linked to the power. With respect to the power demand, it is linked to the motor and the inverter.

Table 2 shows the vehicles requirements for ASTRABAT project using the solid state battery cells.

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	vehicles requirements for ASTRABAT
Vehicle application	BEV
Embedded energy (kWh)	95
Useful energy (kWh)	85
Maximum power 30s under charging (kW)	250
Maximum power 30s in discharge (kW)	250
Maximum continuous discharge power (kW)	200
Maximum continuous charge power (kW)	350
Hypothesis	
Minimum voltage(V)	600
Maximum voltage (V)	840
Pack volume (L)	160
Pack weight (kg)	340
Specific mass useful energy (Wh/kg)	250
Volumetric useful energy (Wh/L)	531
Battery charging time (mn)	< 30 (5 to 80% SOC)
Autonomy (Km)	>450

Table 2: vehicles requirements for ASTRABAT project

Note that, the hypothesis in voltage is very high and challenging and can be problematic for the charging current.
Figure 2 shows pouch type cell which geometry shape will be developed in this project.

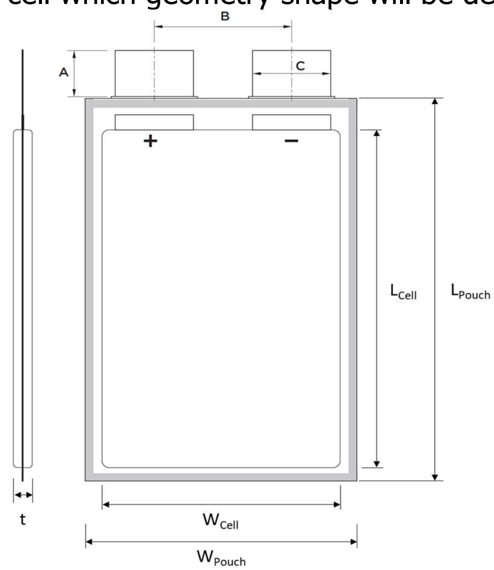

Figure 2: shows a sketch of the cell inside the pouch and the dimensions are given in Table 3

Table 3 shows the summary battery pack characteristics and the vehicle data for ASTRABAT electric vehicle project calculated from the cell information.

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Prototype cell capacity (Ah)	**10 Ah**	**50 Ah**
Length module (mm)	590	590
A [mm]	30	33
B [mm]	70	90
C [mm]	20	50
L_{Pouch} [mm]	80	290
L_{Cell} [mm]	60	250
W_{Pouch} [mm]	140	180
W_{Cell} [mm]	125	150
t [mm]	5	12
Cumulative cell vol. in the battery pack [L]; conside ring all the protection and inactive part of the cells (V_{Tot})	177.4	206.2
Vol $_{Tot\ cells}$/Vol $_{pack}$ [%]	+ 9.8 %	+28.9%
Cumulative cell vol. in the battery pack [L]; conside- ring only the volume of the active part of the cells (V_{useful})	86.4	192.6
Vol $_{useful\ cells}$/Vol $_{pack}$ [%]	54 %	+20.4%
Linear capacity (Ah/mm)	2.0	4.2
Number of cell in serie / module	192	214
Number of cell in parallel / module	12	2
Cumulative thickness of the cell / module (mm)	11520	5136
Number of module	1	1
Minimal cell voltage (V) (for electric engine)	4.2	4.2
Maximum cell voltage (V)	4.2	4.2
Minimum voltage single branch (V)	806.4	898.8
Maximum voltage single branch (V)	806.4	898.8
Minimum voltage double branch (V)	403.2	449.4
Minimum voltage double branch (V)	403.2	449.4
Single branch machine compatibility	0	0
Double branch machine compatibility	1	1
Compatibility recharge 800V	1	1
Useful energy (kWh) (90% of Embedded)	87.1	80.9
Embedded energy (kWh)	96.8	89.9
Current 5C (A)	600.0	500.0
Minimal power single branch (W)	**403.2**	**449.4**
Maximum power single branch (W)	**403.2**	**449.4**
Minimal power double branch (W)	201.6	224.7
Maximum power double branch (W)	201.6	224.7

Table 3: Dimensions of the 10 Ah prototype cell and the A4-sized pouch cell (50 Ah). The battery pack characteristics and vehicle data for ASTRABAT electric vehicle project.

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For the ASTRABAT project, to obtain a useful energy of 85 kWh and 800 V of the battery pack using a 10Ah and 50 Ah pouch cells at least 192 cells (800 V / 4.2 V = 192 biggest cells) are needed to be connected in serie/module. Then, we can easily determine the number of cells mounted in parallel. Therefore, this correspond to 192 “10 Ah pouch cells” in serie / module and 214 “50 Ah pouch cells” in serie / module. The number of cell in parallel / module are 12 and 2 for 10 Ah and 50 Ah, respectively.

The total number of pouch cells necessary to constitute a battery pack 12P 192S for 10 Ah cell and 2P 214S, if 50 Ah prototypes cells are considered.

Interestingly, the cell information provided by the battery maker Léclanché (Table 3) allow us to calculate the total volume of the pouch cells in the battery pack architecture for both cells with the capacity of 10 Ah and 50 Ah.

The total volumes occupied by the pouch cells including the tabs and surplus of protecting aluminum for 10 Ah and 50 Ah are 177.4 L and 206.2 L. These values are higher (+**9.8 %** and +**28.9%** when the pack is composed of 10 Ah and 50 Ah, respectively) than the available volume for the battery pack which 160 L. On the other hand, by optimizing the volume utility by using the bipolar cell design or by considering only the active part of the cell, the useful volumes occupied by the pouch cells for 10 Ah and 50 Ah are 86.4 L and 192.6 L. This corresponds to **54 %** and **120.4%** of the available volume for the battery pack when the pack is composed of 10 Ah and 50 Ah, respectively.

These results show that different optimization strategies in the battery pack assembly are required to free up some space to host the electronic components as the BMS, the battery cooling system, the CMC, the Bus-bars the junction box etc.

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3 EUCAR TESTS

Batteries for electric vehicles require following Electrical batteries safety criteria. This information is mainly link to the subtask of hazard level testing including abuse tests. The results of these tests must comply with the EUCAR protocol for level 4 (or <) value defined as minimum for possible integration in EVs

The European Council for Automotive R&D (EUCAR) have established a set of safety standards where **level 4 or lower** is expecting as a minimum for possible integration in EVs. The levels are described below in Table 4 [5].

In this framework. CEA will conduct abuse testing on cells to assess their tolerance to nail penetration. overcharge and short circuit events. In all cases. the temperature of the cell's surface as well as the tab temperature will be monitored together with the current and the voltage profile.

Also. thermal stability and gas released (destructive test. 2 cells) will be performed: the Accelerated Rate Calorimeter (ARC) will be used for the thermal abuse tests. in order to determine the temperature at which the cell becomes unsafe as well as the quantity of thermal energy released by that cell. The generated gas will be collected and analysed.

Level	Description	Classification criteria and effect
0	No effect	No loss of functionality
1	Passive protection activated	Cell reversibly damaged. Repair needed
2	Defect	No leakage. Cell irreversibly damaged
3	Minor leakage or venting	No fire or flame. Weight loss ≥50% electrolyte
4	Major leakage or venting	No explosion, but fire/combustion
5	Fire or flame	No explosion, but internal parts expelled
6	Rupture	No explosion, but internal parts expelled
7	Explosion	Explosion (disintegration)

Table 4 - EUCAR Hazard Level descriptions [5]

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4 Performance preferences and requirements for ASSB cells

This deliverable reports the vehicles' requirements for power system. This chapter describes the simulation of performance preferences and requirements (continuous c-rate. power. peak c-rate. etc.) for ASSB battery cells. Below we provide an analysis of the performance preferences and requirements for different vehicle types.

4.1 Evaluation/simulation method

In order to measure vehicle efficiency and determine if a vehicle is in line with emissions standards a new Worldwide Harmonized Light-Duty Vehicle Test Procedure -WLTP (Figure) has replaced NEDC on September 1st 2017. Three different WLTC test cycles are applied. depending on vehicle class defined by rated engine power / kerb weight ratio PWr in W/kg: Class 1 – low power vehicles with PWr <= 22; Class 2 – vehicles with 22 < PWr <= 34; Class 3 – high-power vehicles with PWr > 34. Most common cars have nowadays power-weight ratios of 40–100 W/kg. so belong to class 3. Vans and buses can also belong to class 1 or 2.

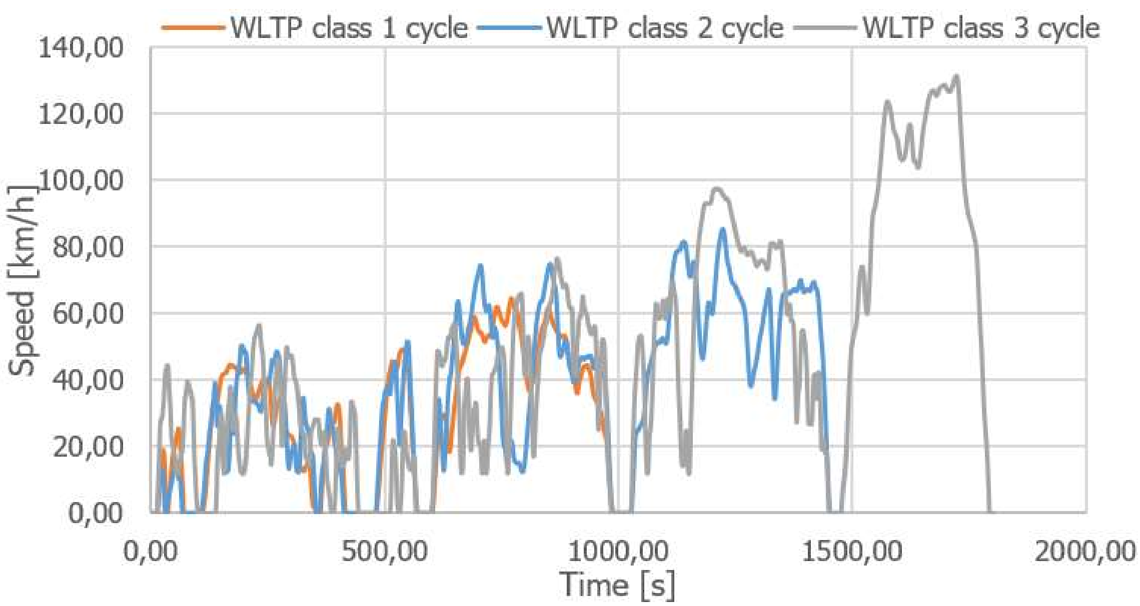

Figure 3: Worldwide Harmonized Light-Duty Vehicle Test Procedure cycles. Three WLTP cycle classes that correspond to different vehicle segments. For the analysis in this chapter we will mostly use class 3 cycle that is divided into 4 different sub-parts. each one with a different maximum speed: Low. up to 56.5 km/h. Medium. up to 76.6 km/h. High. up to 97.4 km/h and Extra-high. up to 131.3 km/h. These driving phases simulate urban. suburban. rural and highway scenarios respectively.

The WLTP cycle will be used to evaluate the needed continuous battery discharge rate (cycle accelerations. air drag and rolling resistance will be included) while 0 to 100 km/h

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acceleration simulation will be used to evaluate the maximum battery discharge rate. In Table existing production EVs and their properties are listed for different vehicle segments. Similarly, in Table 6 vehicle performances are listed for two wheelers. L-type vehicles. light commercial vehicles. busses and trucks.

		Vehicle segments						
		A	B	C	D	E	F	S
		Smart EQ forfour. Peugeot iOn. Volkswagen e-Up!	**BMW i3.** Renault Zoe. Peugeot e-208.	**Volkswagen e-Golf.** Nissan Leaf. Hyundai IONIQ Electric	**Tesla Model 3 Long Range.** Mercedes EQC 400 4MATIC	**Audi e-tron 55 quattro.** Jaguar I-Pace	**Porsche Taycan Turbo S.** Tesla Model S Performance	**Tesla Roadster (concept)**
Empty weight	kg	1125	1345	1540	1847	2490	2295	2000
0 to 100 km/h	s	12.7	7.3	9.6	4.6	5.7	2.8	2.1
Range*(WLTP range)	km	95 (130)	235 (310)	190 (230)	460 (560)	370 (436)	380 (412)	970
Energy consumption	W.h/km	179	161	145	158	243	220	206
Battery full capacity	kWh	17.6	42.2	32	75	95	93.4	200
Max speed	km/h	130	150	150	233	200	260	410
Total power	kW	60	125	100	330	300	560	1000
Max Fast charge power	kW	22	49	40	250	155	270	250
Power/weight ratio	W/kg	53.3	92.9	64.9	178.6	120.4	244	500
WLTP driving cycle class		3	3	3	3	3	3	3

*Cold weather (-10°C) city driving

Table 5: Battery Electric Vehicle (BEV) data for existing production vehicles. Basic vehicle data is gathered for one vehicle per segment to serve as input data for battery performance simulations.

		Vehicle segments					
		Two Wheelers **Zero SR**	L – category vehicles **Renault Twizy**	LCVs **Peugeot Partner electric**	Small city busses **BYD electric bus**	Small trucks **Freightliner eCascadia (2019)**	Large trucks **eActros (2016)**
Empty weight	kg	140	450	1580	13800	12500	18000
0 to 100 km/h	s	6.5	15 (0-80)	19.5	20 (0-50)	<45 (0-80)	N/A
Range	km	158	90 (NEDC)	170	249	400	200
Energy consumption	W.h/km	45	58	205	1300	1380	1200
Battery full capacity	kWh	7.2	6.1	22.5	325	550	250
Max speed	km/h	200	80	110	96	N/A	N/A
Total power	kW	34	13	49	180	545	250
Standard charge power	kW	1.3	2.3	50	60	260	150
Power/weight ratio	W/kg	242.8	28.8	31.0	13.0	43.6	13.8
WLTP driving cycle class		3	2	2	1	3	1

Table 6: Vehicle performances and properties for two wheelers. L-type vehicles. light commercial vehicles. busses and trucks.

Air drag and rolling resistance in WLTP cycle are calculated in the following way:

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Air drag depends on the density of air and on the size. shape. and speed of the vehicle. One way to express this is by means of the drag equation:

$$F_D = \frac{1}{2}\rho v^2 c_D A.$$

where ρ is the density of air (1.225 kg/m^3 at 15°C). v is the speed of the vehicle relative to air. A is the frontal cross sectional area of the vehicle and c_D is dimensionless drag coefficient.

Rolling resistance or the rolling friction is the force that resists the motion of a vehicle tires and was calculated using

$$F_r = c_r m g.$$

where c_r is a rolling resistance coefficient. m is vehicle mass and g is gravitational acceleration.

Rolling resistance coefficient for automotive tires on dry road can be estimated as

$$c_r = 0.005 + \frac{1}{p}\left(0.1 + 0.0095\left(\frac{v}{27.7}\right)^2\right).$$

where p is tire pressure (bar) and v is vehicle velocity (m/s).

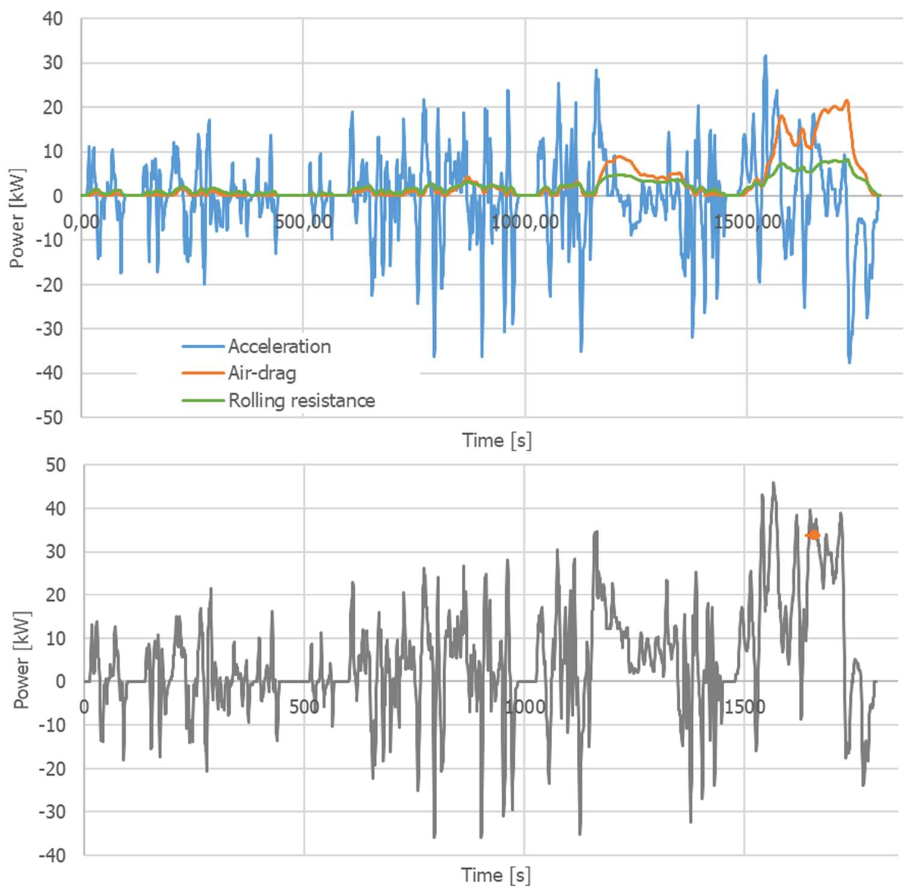

Figure 4: **Top:** Power consumption contributions needed for acceleration. air drag and rolling resistance in WLTP cycle (class 3). **Bottom:** Combined mechanical power needed during WLTP cycle. The highest 30 s rolling average power consumption is marked with orange dot.

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Vehicle acceleration (0 – 100km/h) is very demanding load case in terms the battery power. In most cases battery max. power output and/or the tire-to-road grip are the limiting factors for the total max. mechanical power output of the EV drivetrain. In Figure one such acceleration simulation is shown. Speed. motor torque. battery current and battery voltage are shown for a typical C segment vehicle. Max battery output in this simulation is 100 kW.

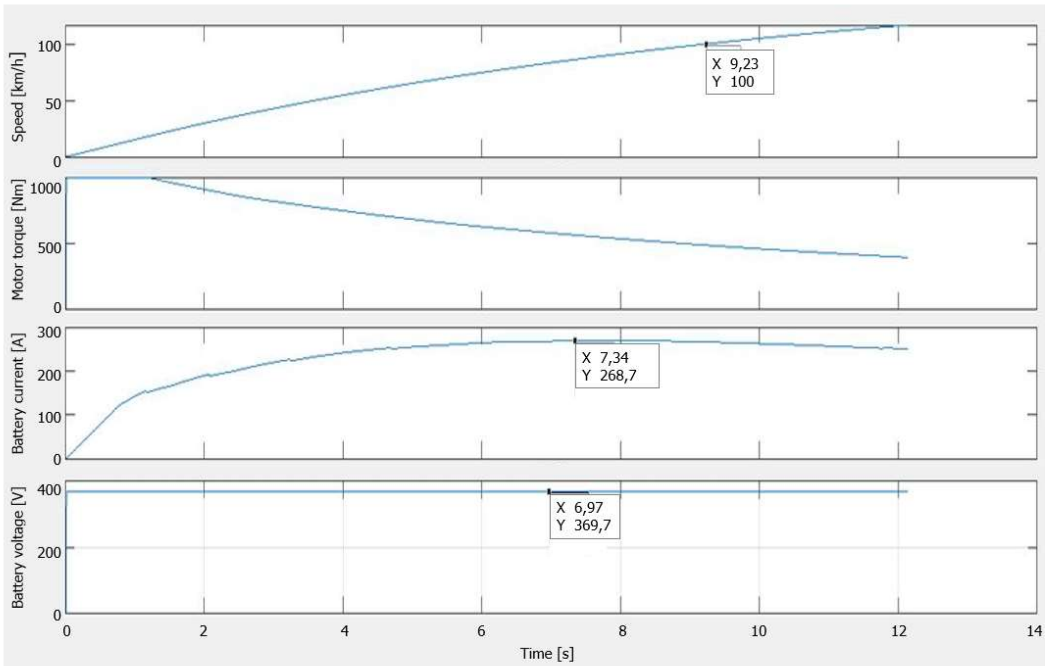

Figure 5: Typical C segment vehicle acceleration simulation. 0 to 100 km/h time is 9.2 s and max. power output is just below 100 kW. At low speed max motor torque and tire grip are the limiting factors and at higher speeds the battery power output is the limiting factor. Generic permanent magnet sinchronous motor efficiancy map is assumed.

In Figure 6 mechanical power and direct current battery power output for one vehicle corner during such acceleration simulation is presented. A generic direct drive e-motor efficiancy map is assumed for simplicity.

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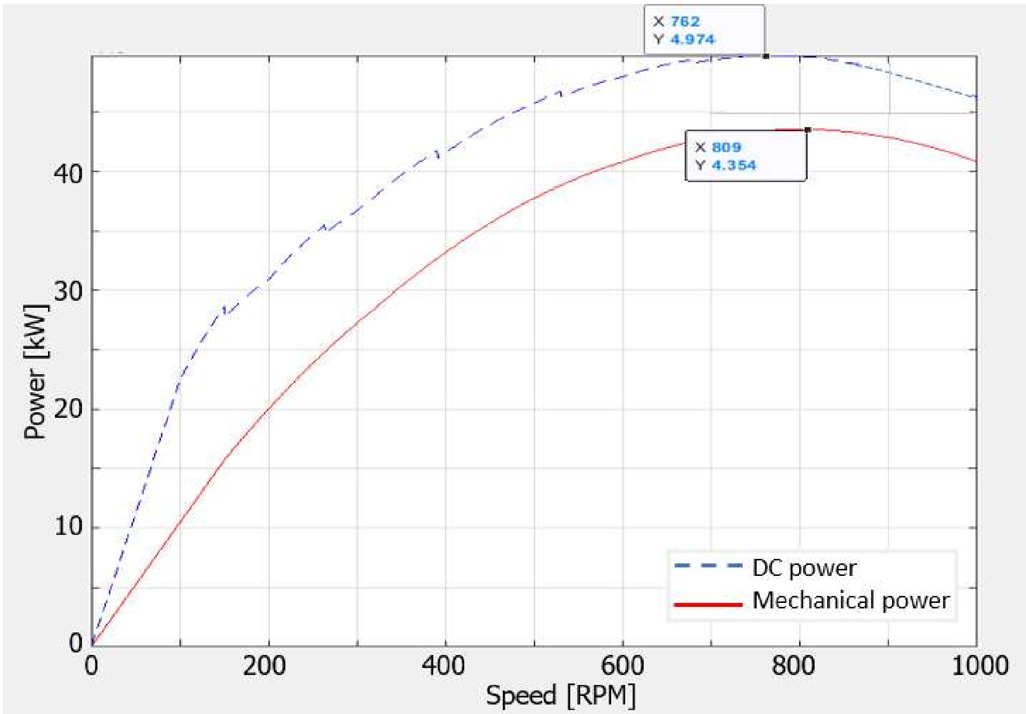

Figure 6: Battery DC power output and e-motor mechanical power output for a single EV vehicle corner during the acceleration simulation presented in **Figure** .

4.2 Results

Simulation and calculation results for existing production vehicles is gathered in **Table** .

Vehicle segments		**Air drag coefficient (frontal area)**	**Max 30s WLTP drivetrain power**	**Max 30s WLTP Battery discharge**	**Peak battery discharge**	**Battery charge rating 7.2 kW**	**Battery fast charge rating**
	EV vehicle examples	(m^2)	kW	c-rating	c-rating	c-rating	c-rating
A	**Smart EQ forfour**. Peugeot iOn. Volkswagen e-Up!	0.35 (1.95)	28.1	1.59	3.41	0.41	1.25
B	**BMW i3**. Renault Zoe. Peugeot e-208**.**	0.29 (2.38)	30.8	0.73	2.96	0.17	1.16
C	**Volkswagen e-Golf**. Nissan Leaf. Hyundai IONIQ Electric	0.27 (2.59)	33.2	1.03	3.12	0.22	1.25
D	**Tesla Model 3 Long Range Dual Motor**. Mercedes EQC 400 4MATIC	0.23 (1.78)	32.9	0.44	4.4	0.10	3.33
E	**Audi e-tron 55 quattro.** Jaguar I-Pace	0.25 (2.65)	45.7	0.48	3.15	0.07	1.63
F	**Porsche Taycan Turbo S**. Tesla Model S Performance	0.22 (2.33)	41.0	0.44	6	0.07	2.90
S	**Tesla Roadster (concept)**	0.22* (2.33)*	36.5	0.18	5	0.04	1.25

*Estimated

Table 7: Simulation and calculation results for existing production vehicles.

Air drag and frontal area of the vehicle is taken from the available vehicle on-line databases – this data is used for air drag calculations. Maximum 30 s WLTP power is calculated as graphically presented in Figure 4 bottom. Maximum 30s WLTP battery discharge C rating is

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calculated by dividing maximum 30 s WLTP power with battery full capacity as listed in Table 5. Peak battery discharge is estimated via 0 to 100 km/k acceleration simulation so that it matches battery full capacity and total drivetrain power listed in Table 5. Battery 7.2 kW and battery fast charge C ratings are evaluated using data from Table 5 directly. The above described calculations and simulations are used to 'calibrate' the evaluation method described in subchapter 4.1 as battery data for these vehicles can be straightforwardly estimated from available data.

The calibrated method was used to simulate performance preferences and requirements for vehicle segments listed in **Table** . The results are gathered in **Table** .

	Air drag coefficient (frontal area)	**Max 30s WLTP drivetrain power**	**Max 30s WLTP Battery discharge**	**Peak battery discharge**	**Battery charge rating 7.2 kW**	**Battery fast charge rating**
EV vehicle types	(m^2)	kW	c-rating	c-rating	c-rating	c-rating
Two Wheelers Zero SR	0.41 (0.9)	11.07	1.53	4.72	1	0.18
L – category vehicles Renault Twizy	0.64 (1.1)	6.83	1.12	2.13	1.18	0.377
LCVs Peugeot Partner electric	0.37 (3.2)	17.13	0.76	2.17	0.32	2.22
Small city busses BYD electric bus	0.68 (8.16)	68.01	0.21	0.55	0.02	0.18
Small trucks Freightliner eCascadia	0.6* (9.7)*	273	0.49	1	00013	0.47
Large trucks eActros	0.6* (9.7)*	86	0.34	1	0.028	0.6

*Estimated

Table 8: Simulation and calculation results for vehicles listed in **Table** .

Conclusions: The above data shows peak battery discharge ratings for personal vehicles and commercial vehicles which are lower than or around 3C. except for luxury and sports/performance vehicles where the peak discharge ratings are between 4C and 6C. This is realized with existing technology and satisfies the performance requirements.

On the other hand. increase in battery energy density would bring the range of the vehicles closer to 50 km while keeping the weight of the battery pack low. Already huge battery packs on commercial vehicles mean that discharge C-ratings there are not the limiting factors. Also. with high energy consumption of commercial vehicles the battery energy density is even more important.

If possible ASSB should provide improved battery capacity at low temperatures in order to overcome the low temperature operating limitations of existing Li-ion battery technology.

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5 Conclusions

We have given some vehicle requirement to make an electrified vehicle with a useful energy density of 85KWh using 10 and 50 Ah pouch cell.

The safety concern as Hazard Level Testing including abuse tests have been presented and defined to be less than 4.

The simulation of performance preferences and requirements for battery electric vehicle (BEV) have been done. The data shows peak battery discharge ratings for personal vehicles and commercial vehicles which are lower than or around 3C. except for luxury and sports/performance vehicles where the peak discharge ratings are between 4C and 6C. This is realized with existing technology and satisfies the performance requirements.

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