Explaining the BEV – Battery Electric Vehicle

Inmotion Technologies AB

Introduction

The electrification of the vehicle industry is happening now and we at Inmotion Technologies are part of the solution to create a sustainable future.

This paper gives an overview of the architecture and components of an electrical vehicle and explains the function of the components on a high level. Building an electrical vehicle requires special competence and close collaboration with the supplier of components and systems.
At Inmotion Technologies who is part of Zapi Group, we are experts in electrification where we design, develop and manufacture the components supporting the electrification of the vehicle industry.

We offer components, solutions, application engineering support plus required customization of the products to fit different types of vehicles and applications. We are a strong partner, easy to collaborate with and have a global presence with state-of-the-art technology, modern work culture and leadership.

Choosing Inmotion Technologies and Zapi group as your electrification partner will enable a fast, precise and competitive quality solution that allows you to scale up your electrification on a global basis with local support.

Welcome to Inmotion!!

BEV market considerations

Traditional internal combustion engine (ICE) vehicles are projected to go electric more rapidly than ever. As shown in BENF's Electric Vehicle Outlook 2019, the expected market transition to Battery Electric Vehicles (BEVs) is incredible. Today's high share of electrified buses is predominately driven by one market – city buses in China. The forecast market growth for electric buses worldwide is as substantial as other commercial and industrial vehicle market segments.

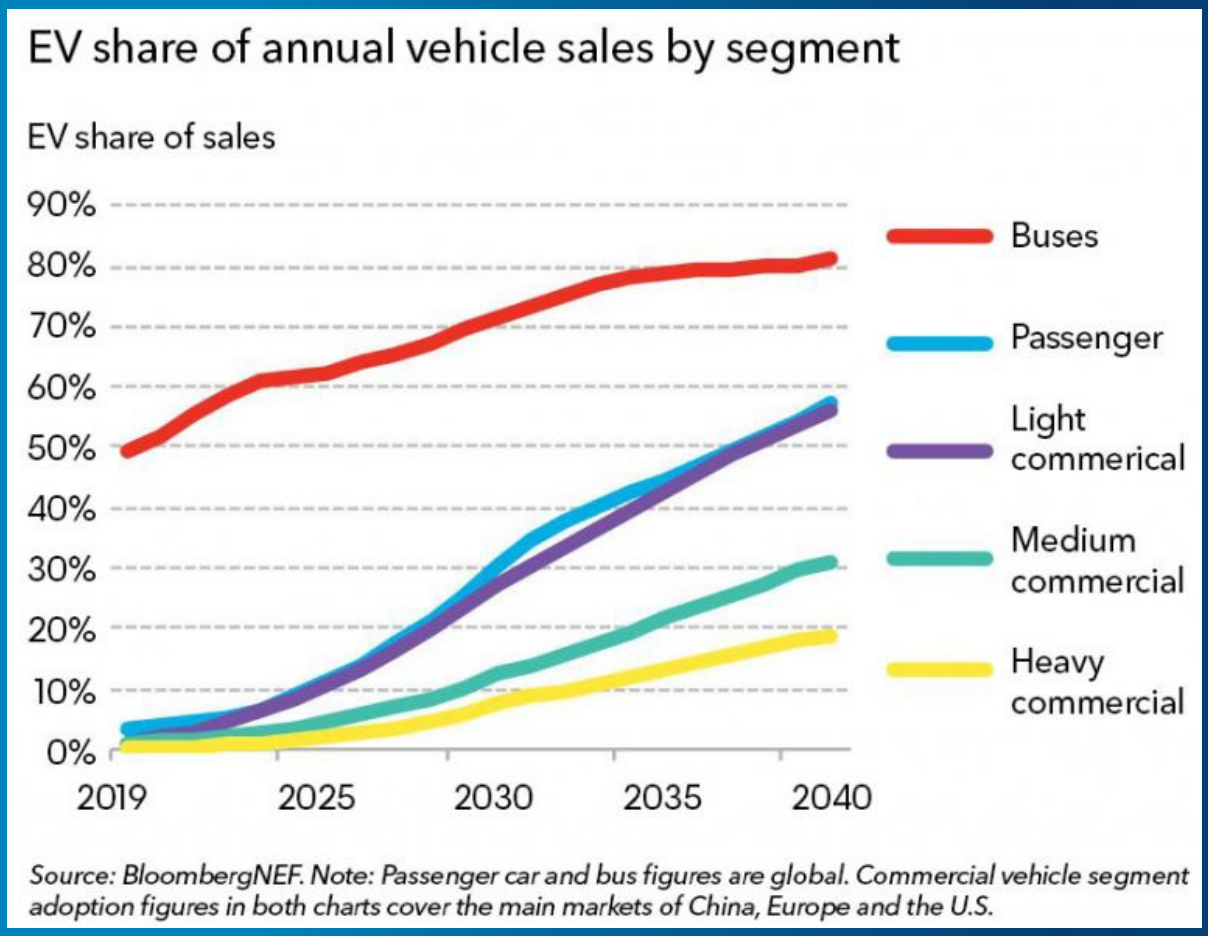


Figure 1 Source; BNEF's Electric Vehicle Outlook 2019. Read more by following link Electric Transport Revolution Set To Spread Rapidly Into Light and Medium Commercial Vehicle Market | BloombergNEF (bnef.com)

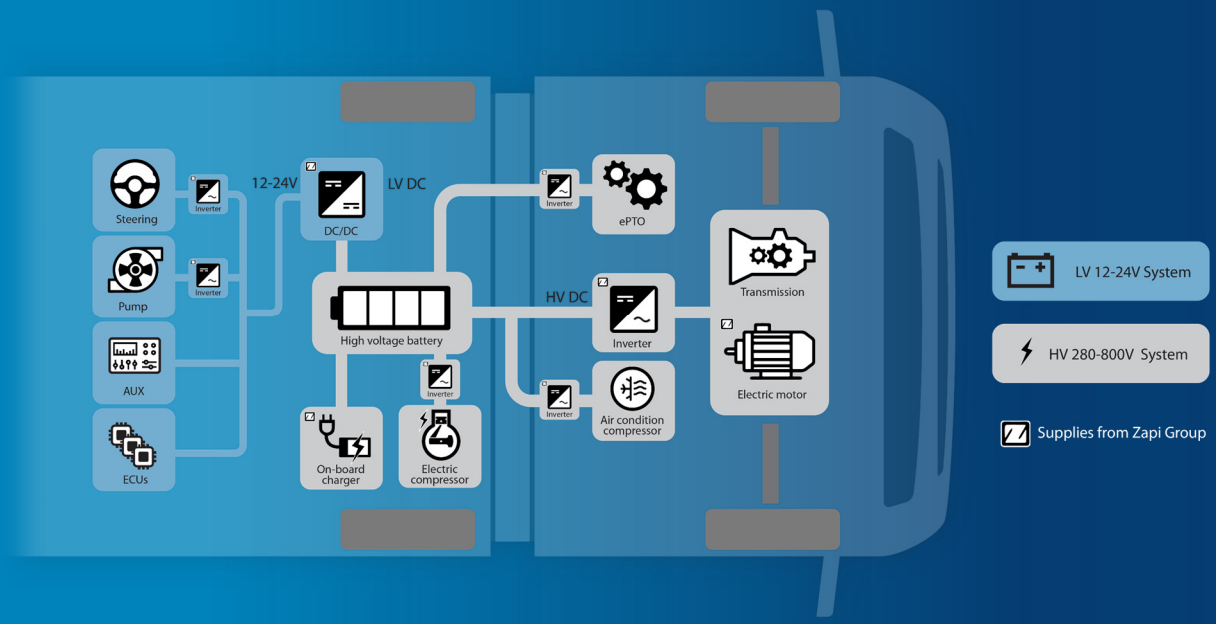
Figure 1 shows the expected growth for electric buses, trucks and cars.

In addition to to figure 1, the transformation is also taking place in smaller segments, such as port and airport equipment, construction equipment, utility vehicles, agriculture and forestry equipment.

Electric vehicle component requirements can vary depending on the market segment and how the equipment is used. However, the overall functions and types of components needed remain the same.

Building an Electric Vehicle

An **electric vehicle (EV)** is a type of vehicle that gets its power from chemical energy stored in rechargeable battery packs. The key components required to build an electric vehicle include a high voltage battery, an electric motor, an inverter, a DC/DC converter, auxiliaries, and an on-board charger.
Below is an example of the architecture of an EV:



Principal architecture of Battery Electrical Vehicle

High Voltage Battery

A high voltage battery is often the most expensive part of an electric vehicle and constitutes approximately 40% of the total vehicle cost depending on type of vehicle and performance. The high voltage battery is where the energy needed to run the vehicle is stored. The technology in the battery sector is being developed a lot at the moment with the aim to reduce cost and improve performance in terms of battery capacity and charging cycles.

The battery voltage ranges between 280 V and 800 V based on the vehicle's desired performance, the selected voltage level is sometimes called the vehicle's "Traction Voltage". A dedicated device, called a Battery Management System (BMS), is integrated with the battery and its function is to manage and monitor voltage, current and temperature at the cell level. This is important as it ensures the battery is within safe operating conditions and keeps the battery healthy.

Inverter / Power Electronics

An inverter is a device that transforms the energy stored in the battery, from direct current (DC) into alternating current (AC) in a structured and controlled way. By "chopping up" the DC-voltage and distributing it into a 3 phase current controlled wave form, the inverter imposes a torque and/or speed out of the electric motor. A modern inverter can reach over 98% efficiency and the higher efficiency the less heat needs to be cooled off in the water cooler.

To control the speed and torque of the motor there are special algorithms implemented in the inverter that are very advanced and must also be adopted to the type of motor and vehicle it is used in. This tuning is made by Inmotion and the customer in close collaboration by special tools that ensures the process is smooth and robust. Inmotion inverters use the PLASMA software platform that is scalable and has built in safety functions to go to market quickly.

The inverter is also connected to the vehicle CAN bus where it provides important information to other units like the MECU, Motor Electronic Control Unit to allow the management of the vehicle performance.

Inverter ACH 6550 from Inmotion

Electric Motor

The electric motor is a device used to convert electric power to mechanical power (i.e. speed and torque) needed to move the vehicle. Compared to a traditional internal combustion engine, an electric motor:

- is made primarily of aluminum, copper and magnets, and the electromagnetic design elements are very complex to ensure its performance and
- has the capability of regenerating energy while braking, and with an inverter, it can recharge the battery
- has higher power density (a 100 kW electric motor can be 10 times smaller than its internal combustion engine counterpart)
- is very efficient—its efficiency can reach over 95%, while an internal combustion engine's is less than 35%
- is sized proportional to its torque capabilities, not its power capabilities
- is available in different technologies with varying benefits such as cost, power density and efficiency. One of the more popular technologies is the permanent magnetic motor because of its high efficiency

DC/DC Converter

A DC/DC converter transforms energy from one voltage to another. Traditional ICE vehicles generate a voltage at 12V/24V to power lights, windshield wipers or on-board entertainment systems with an alternator. A DC/DC converter in an electric vehicle transforms electric energy from the HV battery to the low voltage required by the lights and on-board entertainment system. This 12V/24V system is often called the vehicle's "Low Voltage" system. This is also an area of efficiency improvement—standard alternators work at an efficiency of 55-60% while DC/DC converters can reach greater than 95%.

The power levels that are used in a heavy vehicle can be high, and the DCC2 from Inmotion can deliver 7.5kW output power and this clearly more than you find in a car. Similar to the Inverter, the DCC2 is connected to the vehicle CAN network and communicates information to the MECU to ensure the seamless integration with the vehicle. Due to the high power the system requires water cooling and connectors that are very robust with high performance. If the vehicle needs even more power it is possible to mount more DCC2 units in parallel to allow a higher power take out.

DCC2 Converter from Inmotion

Auxiliaries

Many components perform essential tasks in a vehicle—these are generally described as auxiliaries. In an EV, these auxiliaries are run at either the vehicle's Traction Voltage or Low Voltage. The voltage the auxiliary should run on depends on the power consumption of the auxiliary. Some examples of auxiliaries are:

- Power Steering
- Water Pumps
- Air Condition
- Air Compressors
- ePTO (electric Power Take-Off)

All these functions in an EV need to be implemented with dedicated electric units (each made by an inverter and a motor). Each unit is managed independently: "on demand use" improves vehicle efficiency.

Power Steering

An EV power steering unit is a system where an electric motor and a hydraulic pump are assembled together. Normally it is using the Low Voltage side as the power to drive it is relatively low. The other benefit is if the high voltage side is disrupted for any reason, the vehicle can still be steered and managed.

Water Pumps

An EV often includes multiple water pumps that are controlled by an inverter/motor controller to provide cooling to different components "on demand" – motors, batteries, inverters and DC-DC converters. These cooling systems are a must in the larger vehicles as the power consumption is much higher than in smaller applications. In smaller applications there is either no need for water cooling or the pump can be driven by the Low Voltage circuit with the downside of more power losses.

Air Condition

Air condition is a very power consuming system and therefore connected to the Traction Voltage to reduce the current levels in the AC system. It contains both electric motor, inverter and compressor and the purpose is to cool or warm air for the cab environment. As you can imagine there is a lot of power needed to cool a summer hot cab to an ambient temperature of 20C.

Air Compressors

Air Compressors is common in heavy-duty vehicles where brakes and suspensions are managed by air. An EV air compressor is a system where an electric motor, an inverter and a compressor are assembled together in one unit and connected to the Traction Voltage circuit due to the significant power required.

ePTO

The ability to take-off power for purposes other than traction is essential on large vehicles, such as medium or heavy-duty trucks, construction equipment or agricultural vehicles. And ePTO is used for driving auxiliary equipment such as salt spreader, cranes, lifting devices etc. and is very important to the functions in a commercial vehicle.

While this is done mechanically or hydraulically on traditional ICE vehicles where the engine must be powered on for the duration of the PTO usage. An example is when the crane is used for unloading, the engine is running at medium speed rpm for the duration of the unloading.
The great benefit with the electric drivetrain is that it enables these functions to run "on demand"—leading to significant savings in power consumption and emissions.

On-board Charger

An on-board charger (OBC) is a device used to recharge the battery from a domestic or industrial socket. The power of an OBC is normally limited to <22 kW (mainly to fit grid limitations of a 32A socket). Sometimes, the OBC includes electronics to communicate with the charging station and allow AC and DC fast charging.

Energy Considerations

EVs have a much higher energy efficiency than a traditional ICE vehicle. EV technologies and components deliver high efficiency, and it is possible to recover kinetic energy during the braking phase. You may be asking: "If an EV is so energy-efficient, why is the range of an EV typically shorter than an ICE car?" The answer is in the size of the "tank". Basically, much less energy is stored in a battery compared to the equivalent gas tank of an ICE version.

For example, if we compare VW Golf 1.5 TSI (110 kW) with VW ID.3 (150 kW) as shown in the table below, the equivalent consumption for the Golf (ICE) is 56.2 kWh/100km—that is 4 times the consumption of the ID.3 (EV). As you can see the electric vehicle is much more efficient than a traditional ICE version.

	VW Golf 1.5 TSI (110 kW)	VW ID.3 (150 kW)
WLTP consumption (combined)	5.92 l/100km	14.0 kWh/100km
Tank size	50 l	82 kWh
Mileage (combined)	845 km	550 km*
Usable energy in the tank	475 kWh	77 kWh

**Calculation is done using 94% of the battery capacity (=77 kWh as net capacity) Vehicle data source www.volkswagen.se*

How you contribute to a sustainable future

The EV market is growing at a fast pace and many companies are looking for solutions to move into electrical systems and away from fossil fuels. There is a lot to consider when doing this transformation and Inmotion Technologies and the ZAPI Group are available to help. We have delivered EV components and solutions to a lot of different applications for many years, trust our experience to help you move to electric drive!

Contact us on http://en.evs-inmotion.com/contact/ and we will help you find a suitable solution.

No task is too small when we electrify the vehicle industry - for a sustainable future!