Electric propulsion – components

Electric propulsion consists of components:

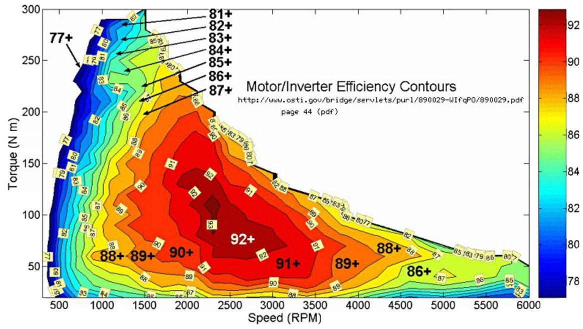
- Electric motor
- Control unit
- Batteries

Each of the component characteristics should be considered, when deciding on purchasing electric vehicle. If we pay attention to those crucial data, we are on good way to purchase an EV (electric vehicle),that will suit our needs.

Electric motor

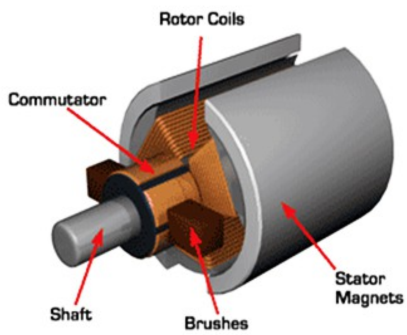
There are some key characteristics, that define electric motors:

- Torque (continuous, peak)
- Rpm (at which voltage)
- Energy efficiency (different operating points)
- Power (continuous, peak)
- Operating voltage
- Compatibility with control unit



DC brushed motor – direct current

DC electric motors and suitable control units are currently being used only with scooters and lighter E-vehicles. There is still quite a number of outdated high power (10-30 kW) brushed DC electric motors located mostly in the United States. New vehicles with brushed motors are not produced in EU. On the used vehicle market there are some PSA vehicles with brushed motors.



This motor types are not installed in new vehicles mostly because of their energy efficiency, which is around 75-80%. Brushes need to be replaced every 50kkm.

Brushed motor Advantages:

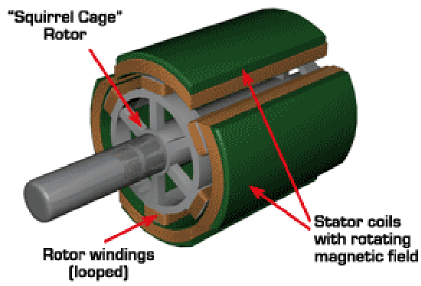
- Simplified wiring: Brushed motors can be wired directly to DC power and control can be as a simple as a switch.
- Low cost

Brushed Motor Disadvantages:

- Less efficient
- Electrically noisy: The switching action of the commutators constantly creating and breaking inductive circuits creates a great deal of electrical and electromagnetic noise.
- Lifespan: As they are in perpetual physical contact with the shaft, brushes and commutators wear out.

Three – phase asynchronous AC motor

Three-phase asynchronous AC motors are currently dominating the electric vehicle market, primarily due to the fact, that they are being used in industry for over 100 years and that fact makes the technology highly developed. Though their efficiency is lower than synchronous PM motors efficiency, their cost is much lower and reliability much better.



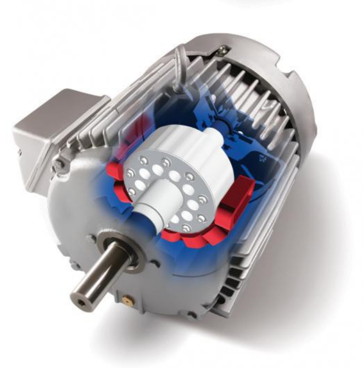
Brushless Motor Advantages:

- Long lifespan: No brushes to wear out
- Low maintenance: No brushes to replace
- High efficiency (85-90%)

Brushless Motor disadvantages:

- High initial cost: Need for commutating device like an encoder and a drive or controller

Motors with permanent magnets



AC permanent-magnet motor cutaway

The synchronous motors with permanent magnets are establishing themselves more and more, due to their superior energy efficiency, but their regulation is considerably more demanding. BMW i3, Opel AMPERA, Nissan Leaf…. are current vehicles using this kind of electric motors.

Advantages:

- High energy efficiency (over 90%)
- Lightweight

Disadvantages:

- Price

Batteries

The battery is the main and the most expensive part of electric vehicle. Its voltage and capacity define all other components of EV propulsion.

Type of batteries used in EV:

- Lead batteries
- Lithium batteries
- Lithium polymer batteries

Battery Technology Comparison

				Li-Ion		
Specifications	Lead-Acid	NiCd	NiMH	Cobalt	Manganese	Phosphate
Specific energy density (Wh/kg)	30 – 50	45 – 80	60 – 120	150 – 190	100 – 135	90 – 120
Internal resistance (mΩ/V)	<8.3	17 – 33	33 – 50	21 – 42	6.6 – 20	7.6 – 15.0
Cycle life (80% discharge)	200 – 300	1,000	300 – 500	500 – 1,000	500 – 1,000	1,000 – 2,000
Fast-charge time (hrs.)	8 – 16	1 typical	2 – 4	2 – 4	1 or less	1 or less
Overcharge tolerance	High	Moderate	Low	Low	Low	Low
Self-discharge/month (room temp.)	5 – 15%	20%	30%	<5%	<5%	<5%
Cell voltage	2.0	1.2	1.2	3.6	3.8	3.3
Charge cutoff voltage (V/cell)	2.40 (2.25 float)	Full charge indicated by voltage signature	Full charge indicated by voltage signature	4.2	4.2	3.6
Discharge cutoff volts (V/cell, 1C*)	1.75	1	1	2.5 – 3.0	2.5 – 3.0	2.8
Peak load current**	5C	20C	5C	> 3C	> 30C	> 30C
Peak load current* (best result)	0.2C	1C	0.5C	<1C	< 10C	< 10C
Charge temperature	-20 – 50°C	0 – 45°C	0 – 45°C	0 – 45°C	0 – 45°C	0 – 45°C
Discharge temperature	-20 – 50°C	-20 – 65°C	-20 – 65°C	-20 – 60°C	-20 – 60°C	-20 – 60°C
Maintenance requirement	3 – 6 months (equalization)	30 – 60 days (discharge)	60 – 90 days (discharge)	None	None	None
Safety requirements	Thermally stable	Thermally stable, fuses common		Protection circuit mandatory		
Time durability				>10 years	>10 years	>10 years
In use since	1881	1950	1990	1991	1996	1999
Toxicity	High	High	Low	Low	Low	Low

Source: batteryuniversity.com. The table values are generic, specific batteries may differ.
*"C" refers to battery capacity, and this unit is used when specifying charge or discharge rates. For example: 0.5C for a 100 Ah battery = 50 A.
**Peak load current = maximum possible momentary discharge current, which could permanently damage a battery.

Picture: Battery comparison

If we look at battery types used for different kind of application, we see, that lead batteries are usable only for light and slow vehicles with top speed of 25km/h, in which case the best choice are traction batteries like **Trojan**, which have deep cycle for discharging.

The market is currently dominated by **Lithium Iron Phosphate** ($LiFePo_4$) and **Lithium Polymer** (LiPo) batteries, which come in various shapes and sizes. **LiPo** batteries have higher specific energy (170-240 Wh/kg) and they are more compact (smaller voltage drop at load) than **$LiFePo_4$** (100-120 Wh/kg). However they are about 40% more expensive, very hard to assemble into battery pack and they are more sensitive to low temperatures (need to heat them when charging below freezing point). For those reasons they are rarely found in serial manufactured vehicles. From current EV on the market, only Renault Twizzy and Nissan Leaf are using this type of energy storage.

BATTERY TYPE (comparison)	LEAD	$LiFePo_4$	LiPo
Capacity(kWh)	25	10	10
Weight(kg)	480	100	60
Range(km)	40-60	50-120	60-140
Km(total)	20000	360000	350000
Price(€)	2600	4000	6000