

## Battery system in electric vehicles

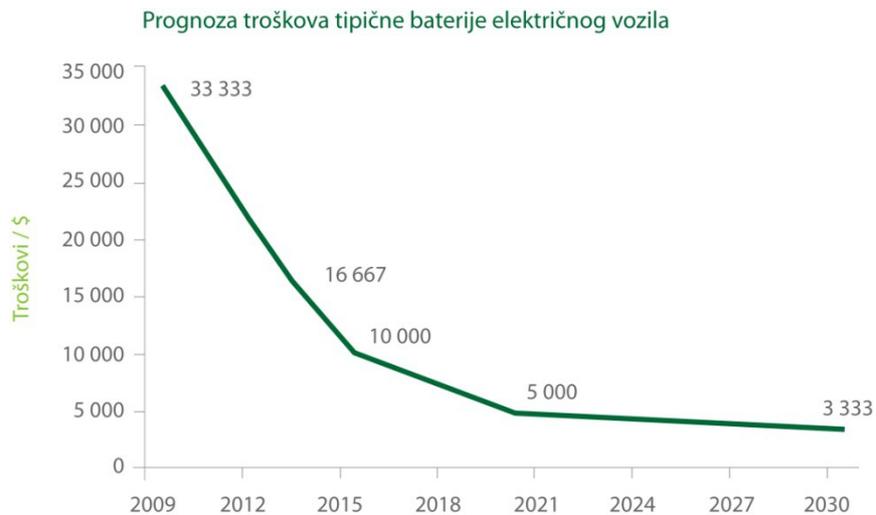
The successful introduction of electric vehicles on the market is highly dependent on the availability of battery technology, which enables reliable storage of electricity in the vehicle and thus directly affects its driving range. Even today, the battery capacities are large enough to cover the daily needs of the use of a car for most consumers. Global battery manufacturers announce an intensive increase in capacity in the near future and the autonomy of driving up to 350 km on a single charge is expected. Battery life is typically warranted for a period of at least 8-10 years.

Batteries should offer a substantial driving autonomy, as well as the proper performance of the vehicle. High security standards must also be ensured, taking into account the large amount of electricity stored in them. The risk of a sudden uncontrolled discharge, in case of a short circuit, overload and overheating, should be minimised. Generally, the original battery capacity decreases over the useful life, regardless of the type of use, and depending on the number and type of discharge cycles.

Safety issues regarding electrical, electrochemical, thermal and mechanical effects are considered to be surmountable, but require the use of a battery management system that regulates the voltage and temperature of cells at all times. High production costs of lithium-ion batteries are responsible for the slower market entry and remain the major area for research and development. Nevertheless, it is assumed that lithium-ion technology has the potential to reduce production costs, as a result of the optimisation of manufacturing processes, due to economy of scale and due to the transition to alternative and cheaper materials. The most significant limiting factor for the production of batteries could be global reserves of lithium.

In electric cars, batteries are the component with the highest added value and they represent the most expensive part of the electric car and thus the impact of battery manufacturers on car manufacturers may be such that in the future battery manufacturers may become manufacturers of the entire car. Noting the major impact of battery manufacturers on further progress of the production process, major car manufacturers have entered into cooperation agreements with battery manufacturers. Not only to ensure the commission on sales but also to be able to impact the development of the batteries.

Picture: The expected batteries price trend in the near future



Source: U.S. Department of Energy

Electric cars contribute to cleaner air in cities as they do not emit harmful substances into the environment, such as particles (soot), volatile organic compounds, hydrocarbons, carbon monoxide, ozone, lead, and various nitrogen oxides. The benefits of clean air are most often of local nature since, depending on the source of the electricity used to charge the battery, emissions of harmful substances into the air are moved to the location where electricity is produced. If all the electricity used for charging electric cars were obtained from renewable energy sources (such a scenario is possible) then the electric cars would be completely without harmful gas emissions.

The average greenhouse gas emissions per kWh of electricity generated in 2006 in the EU amounted to 443 gCO<sub>2</sub>/kWh, while in Croatia in 2008 the same emissions were 550 gCO<sub>2</sub>/kWh of the electricity generated. Taking into account the average consumption of final energy by electric cars in the amount of 12.5 kWh/100km and the average CO<sub>2</sub> emissions per kWh of electricity generated in some EU member states, specific CO<sub>2</sub> emissions per kilometre were obtained.

Table: Comparison of energy consumption and CO<sub>2</sub> emissions for electric cars

Model vozila	Finalna energija	Primarna energija	CO <sub>2</sub> emisije
	(Tank-to-Wheel)	(Well-to-Wheel)	(Well-to-Wheel)
	kWh/100km	kWh/100km	gCO <sub>2</sub> /km
Toyota Prius (hibrid)	44	55	122
REVAi	11	30	50
QUICC!	14	39	63
TESLA Roadster	13	34	56
Nissan LEAF	15	41	67
Mitsubishi i MiEV	10	27	45
Th!nk	16	43	71
Smart Fortwo EV	12	33	53
Citroën C-Zero	13	35	58

Source: <http://www.going-electric.org>

Therefore, electric cars are completely free of local emissions (no exhaust) and the total emissions, if we take into account the production of electricity, are approximately 69 g CO<sub>2</sub>/km on average. Compared to conventional vehicles equipped with internal combustion engines, with an average CO<sub>2</sub> emissions per kilometre of around 165 gCO<sub>2</sub>/km (IEA estimate of actual emissions), the fact that electric cars burden the environment two or more times less than conventional cars is evident.

### **Recycling and disposal of batteries**

Ensuring proper disposal of batteries and their recycling at the end of their life cycle is currently the greatest challenge for electric car manufacturers. For lead-based batteries a system of disposal and recycling has been developed and is commercially available. Recently, the recycling technology for advanced battery systems, such as lithium-ion is also commercially available. Disposal of batteries for hybrid cars is already included in the European Directive 2006/66/EC on batteries.

In the Republic of Croatia, the Ordinance on the management of batteries and accumulators ("Official Gazette", no. 133/2006, 31/2009, 156/2009) is currently in force. This Ordinance prescribes the method of labelling batteries and accumulators, the method of collecting waste batteries and accumulators, obligations and responsibilities of manufacturers of batteries and accumulators and manufacturers of devices whose integral parts are batteries and accumulators, types and amounts of fees payable by persons liable to pay fees, the method and time schedule for calculation and payment of the fees, the amount of fees paid to persons authorised for collecting, processing and recycling of waste batteries and accumulators.

The Sony's report (the study was conducted as part of the Japanese centre for recycling batteries) indicates that 56-61% of the lithium from batteries can be re-used in non-battery products. It is assumed that only the most valuable materials (e.g. cobalt) will be recycled in the beginning. Due to the large size of car batteries compared to small batteries used in mobile devices, the increase in recycling could become an economically attractive activity in the near future.

### **Contribution to noise reduction in urban areas**

Electric cars are the only form of transport that provides almost zero noise during use at maximum speed prescribed for urban areas. The introduction of electric cars will significantly contribute to reducing the environmental burden of noise, and therefore a higher quality of life for citizens. Zero rate noise of

electric vehicles has a negative security feature: when driving electric cars on city roads, there is a relative security problem for blind and visually impaired citizens and cyclists.