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**Project Title:** Improvement of LiFePO<sub>4</sub> cathodes for Li-ion batteries

<b>Department:</b>	Renewable Energy Department	<b>Employer:</b>	Niroo Research Institute
<b>Project/Program Manager:</b>	Morteza Torabi	<b>Executor:</b>	Shahriar Bozorgmehri
<b>Project Financial Code:</b>	831180	<b>Project Quality Code:</b>	UNEPN19
<b>Type of Project/Program:</b>	Postdoc	<b>Assistant:</b>	Research Affairs

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**Keywords:** Lithium batteries; Phosphate cathodes; Electrochemical performance; Lithium iron phosphate; Modification; Lithium Sulfur

**Project Necessity:** Green transportation is one of the most challenging issue globally. Electrical vehicles not only reduce environmental pollution, but also are energetically more efficient than the internal combustion engines. Two types of the power are used in EVs: Fuel Cells and Batteries. The former is a type of energy generation system with use of fuels such as hydrogen or natural gas and the latter is an electrochemical energy storage system. Both systems have been employed as powertrain in EVs. Both systems have some drawbacks which should consider for domestic and national development. In our country, on the other hand, there is a rich infrastructure in natural gas delivery which could be applied for Fuel Cell Electrical Vehicles (FCEVs). So, it is required to investigate the technological approach of these two energy systems for powering EVs in Iran. Also, the situation of the technological advancement should be investigated in the future in order to make decisions for investment in this industry.

**Project Goals:** Electrical Vehicles (EVs) are very interested in the world because of their advantages over traditional internal combustion automobiles which consumed fossil fuels with low efficiency and high risk for environment. Over the last years, using EVs is going very popular among customers in Iran. It is known that for future, there is a need for investment in EV industry and it is required to develop its technology nationally. So, the main challenge in this industry should be studied for future. There are two types of powertrains for EVs: Fuel Cells and Batteries. On the other hand, the fuels for fuel cells are pure hydrogen and natural gas. For fuel cells, there is a need to develop delivering infrastructure for hydrogen or natural gas. For batteries, this is more complicated. The Battery EVs (BEVs) need charging station and expensive batteries with low mileage. Battery and Fuel Cell industries are in very fast and challenging research and development. So, for concentration in EV industry, it is vital to monitor and analyze the future technologies. With a detailed and precise future study of the technology requirements for EV industry and market for Iran, we can select proper technology and fueling the research and development to advance EV market for future in Iran. In this project, we will consider all aspects for developing of fuel cells and batteries in Iran for EV industry and market.

**Abstract:** In our country, on the other hand, there is a rich infrastructure in natural gas delivery which could be applied for Fuel Cell Electrical Vehicles (FCEVs). So, it is required to investigate the technological approach of these two energy systems for powering EVs in Iran. Also, the situation of the technological advancement should be investigated in the future in order to make decisions for investment in this industry. There are two types of powertrains for EVs: Fuel Cells and Batteries. On the other hand, the fuels for fuel cells are pure hydrogen and natural gas. For fuel cells, there is a need to develop delivering infrastructure for hydrogen or natural gas. For batteries, this is more complicated. The Battery EVs (BEVs) need charging station and expensive batteries with low mileage. Battery and Fuel Cell industries are in very fast and challenging research and development. So, for concentration in EV industry, it is vital to monitor and analyze the future technologies. With a detailed and precise future study of the technology requirements for EV industry and market for Iran, we can select proper technology and fueling the research and development to advance EV market for future in Iran. In this project, we will consider all aspects for developing of fuel cells and batteries in Iran for EV industry and market.

### **Steps and Methodologies:**

The powertrains in EVs with aid of batteries and fuel cells in investigated. Investigating of hybrid systems batteries and/or fuel cells with the other powertrains is done. Evaluation of present and future technology of rechargeable batteries for EVs; National technological needs are evaluated. Evaluation of present and future technology of fuel cells for EVs; National technological needs are done. Investigation of international models in using of batteries and fuel cells for EVs and its future are done. Analyzing of infrastructures, climate issues and strategic approaches for employing the future proper technology for the EVs in Iran are done. The financial analysis of fuel cells and batteries technology for EVs are done. Selection of well-matched technology in the field of fuel cells and batteries for future EVs industry and market in Iran are done.

### **Main Results (technical outputs, patents, papers, books, reports, etc.):**

The main results of the project is investigating of the global advances in the field of modern batteries for electrical vehicles and energy storage systems. The electrochemical performance of the iron phosphate cathodes also are investigated in order to reach to the best performance of this material for lithium ion batteries. The following research article is the output of these investigations:

Neda Tadayon, Ali Ramazani, Morteza Torabi, Seyyed Taher Seyyedin, Using of various metal species for improvement of electrochemical performances of lithium sulfur batteries, Journal of Electroanalytical Chemistry, 878 (2020) 114652.