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Project Title: Roadmap Preparation for Superconductor Electrical Machine Technology Development

Department:	Knowledge and Technology Transfer and Development of Synchronous Reluctance and Superconductor Electric Motors plan	Employer:	Niroo research institute (NRI)
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Type of Project/Program:	Roadmap preparation	Assistant:	Electric distribution department

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Keywords: Superconductor, superconducting electrical motor, superconducting electrical generator, superconducting transformer, high temperature superconductors, superconducting wind electrical generator.

Project Necessity:

Superconductivity means that the resistance of an electrical conductor is zero when an electric current passes through it. Therefore, the use of superconductors in various types of electric motors means the elimination of copper losses for them that result in a significant reduction of those electrical motors volumes.

According to the defined plan for the technological development with the title "Knowledge and Technology Transfer and Development of Synchronous Reluctance and Superconductor Electric Motors", it was necessary to access the state of the art of superconducting electrical machines in the world. Then, a plan for technology development of the superconducting electrical machine technology in the country should be prepared.

Project Goals:

- Review of scientific resources about superconducting electric machines and evaluate their application in various industries Investigation of structures, basic performance relationships, applications and status evaluation of electrostatic and piezoelectric machines.
- Condition assessment of the superconductors used in superconducting electric machines
- Assessment of other countries programs for the technological development of the superconducting electrical machines.
- Identification of important companies that are active in the design and manufacturing of superconducting electrical machines and their future plans for the development of this technology.

- Suggest a roadmap for the development of the superconducting electric machines technology and applications in the country.

Abstract:

Superconducting electrical machines have two important features that make them attractive to use in a variety of applications. These two features are:

- 1- High energy efficiency compared to traditional electrical machines
- 2- High power to volume ratio in comparison with traditional electrical machines

Therefore, if the superconducting electrical motors can be used in the industry, their electricity consumption will be significantly reduced. To analyze this possibility, superconductors that used in electrical machines, the companies that produce these superconductors, and the specifications of their products were investigated. Then, scientific sources about superconducting electric machines were studied. Attempts were made to use resources that were financially supported by research funding organizations, and referred to the practical results of the prototypes. These investigations show that a lot of investments are done in developing the superconducting electrical machines in the following cases:

- 1- Transportation electrification:
 - Ships in sea transportation
 - Electric and hybrid electric airplanes
 - Electric vehicles
- 2- Electric power production, and other industrial application:
 - Large synchronous generators in power plants
 - Wind turbine generators
 - Electrical motors used in industrial application

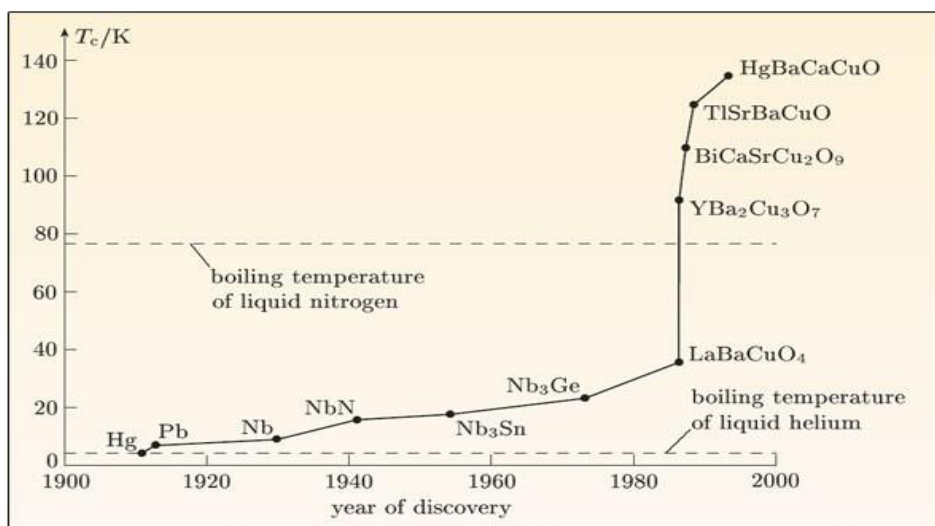


Figure 1: Changes in the superconductors technologies in the last decades

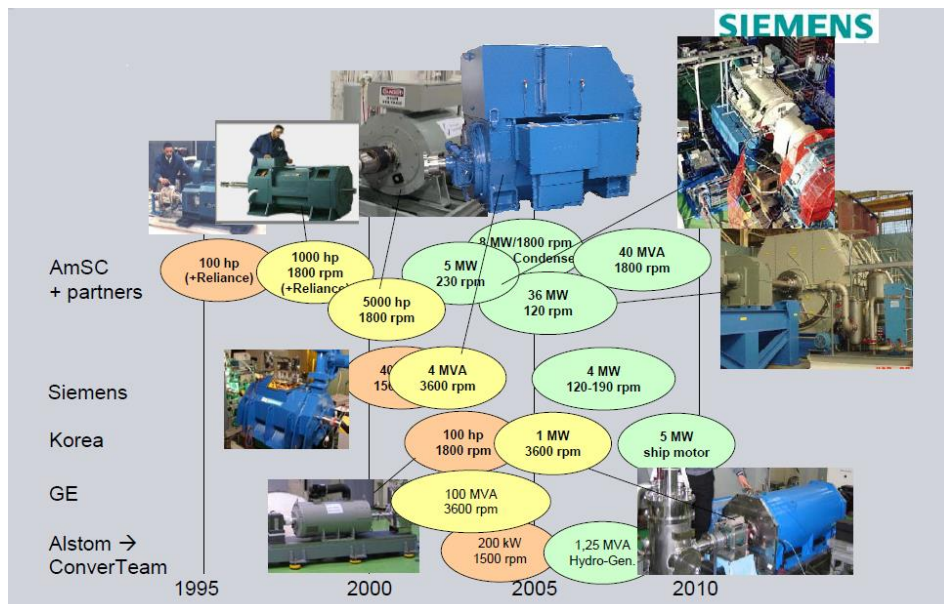


Figure 2: Some superconducting electric machines that were prototyped up to 2010



a



b

Figure 3: a) The picture of wind turbine superconductor generator (2019), b) The picture of superconducting electric motor for use in EVs (2016)

Investigations show that the use of superconducting electric motors in the general applications of industry and EVs will occur in the long run (more than 15 years), therefore, The vision of superconducting electric motor technology development in the country was set for a long time. Also, Studies show that technology assessment of superconducting electric machines challenges in the country are:

- 1- Complexity of superconducting electric motor designs and construction, also, lack of previous practical experience in this field in the country.
- 2- The need to import superconductors and the problems arise from sanctions.
- 3- Costs of superconducting motor design and prototype are so much.
- 4- Lack of enough information about the benefit-costs of the superconducting electric motors between stakeholders.

The required policies that can solve these challenges are suggested. Also, a roadmap for the development of superconducting electric machine technology in the country, according to the studied challenges were developed.

Steps and Methodologies:

The research was conducted using a review on scientific documents. Also, the information provided on the websites of superconducting electric machine manufacturers and research funding organizations in different countries has been reviewed. Technical specifications of the superconducting electric machines and technology development programs of these machines have been extracted using this data. This project has been done in two stages, as follow:

- 1- Superconducting electric machines identification and reviewing research activities in this area.
- 2- Monitoring the technology and its penetration trends in the electric machine industry and the volume of the consumer market

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

- Project steps (1 to 2) reports.