



# Thermag VIII – International Conference on Caloric Cooling

## Invited Talk

### **Rare-Earth-Free Magnetic Field Source**

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The magnetic field source represents one of the most important parts of a magnetocaloric device. It serves for the generation of a high magnetic field, necessary to perform the magnetocaloric effect. Its performance is not crucial only for the energy efficient operation. Namely, this important part represents far the largest cost contribution. Most of the “room temperature” magnetocaloric prototype devices apply magnetic field sources, which consist of permanent magnet assemblies. A number of research activities in this particular domain regard different magnet design concepts and optimization methods. The use of permanent magnets, compared to other types of magnetic field sources, represents on one hand energetically more efficient way for the generation of the magnetic field. However, the permanent magnet assemblies are constrained by rare-earth magnet materials. In magnetic refrigeration, their use requires moving parts and need for a motor drive, both of which cause additional costs and reduced energy efficiency. Further restrictions are given by the speed of magnetization/demagnetization process, which is crucial for the compactness of device, since it defines the frequency of the operation. With permanent magnets, one also cannot achieve an instant, step- change of the magnetic flux density in the magnetocaloric material, regardless the principle of movement.

The investigation of static electro-magnetic field sources was up to date not a serious issue of research in the magnetocaloric scientific community. Joule heating, active cooling of magnets and large energy consumption were the reasons, why these kinds of magnets were largely avoided.

Until recently, when the group from the Faculty of Mechanical Engineering - University of Ljubljana has discovered and developed a way for substantially improved and energy efficient electromagnetic field source. This can provide a millisecond step-increase in the magnetic field being thus capable of running at very high frequencies of the operation, which also follow the research trends toward the use of thermal switches or thermal diodes. Moreover with the regeneration of the magnetic energy, the Joule heating is being substantially decreased, enabling the electromagnetic field source to bridge the existing obstacles of very low energy efficiency.

This contribution represents an overview of activities and characteristics of the developed electromagnetic system, for which we believe, will open new frontiers not only in magnetocalorics, but also some other domains of magnetism.