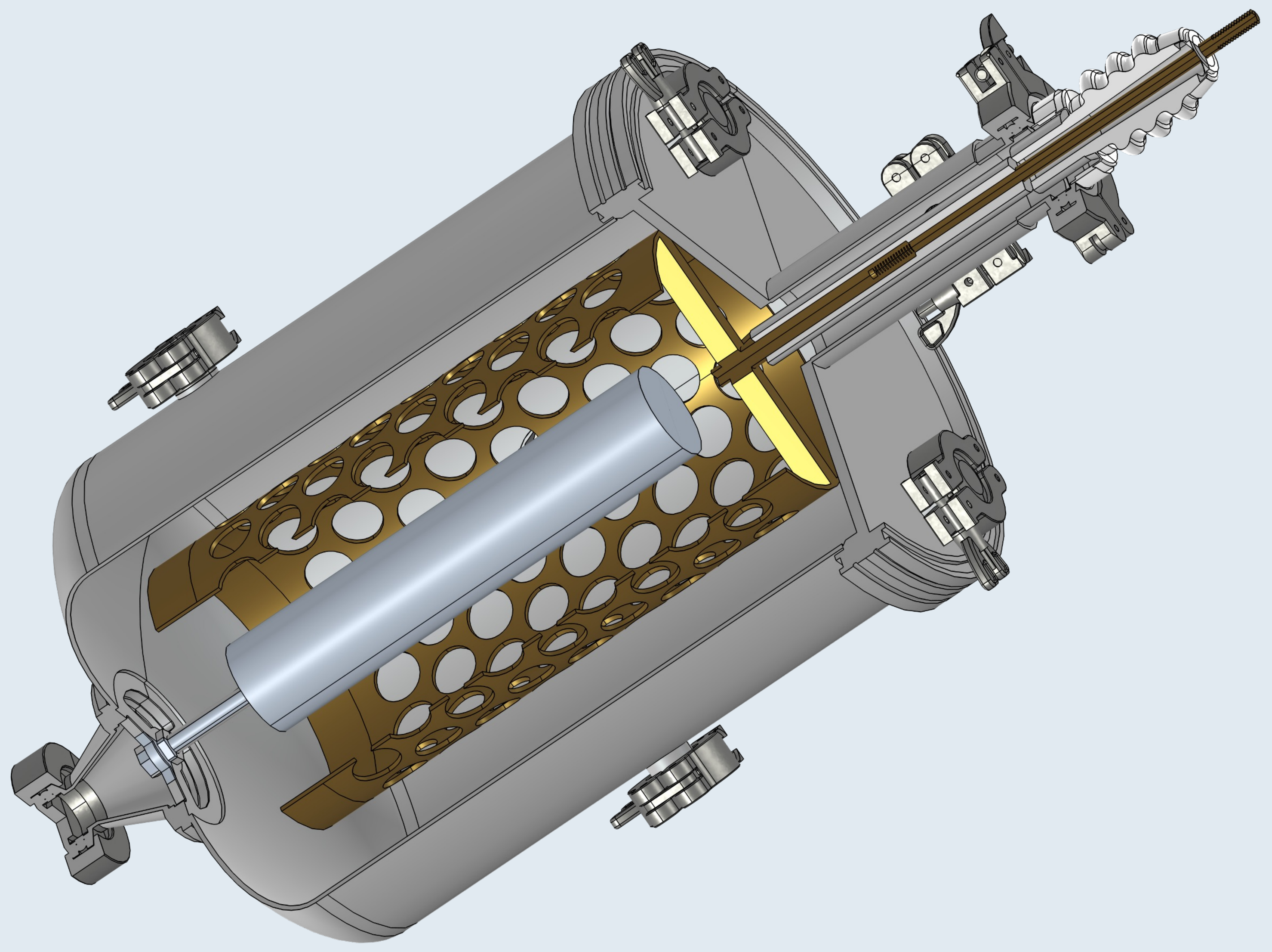

RF Heating Simulations for an Energy Storage System Developed in the Horizon Europe Project Hystore

Optimize high voltage radio frequency electrodes performance by understanding the power density distribution in the load for thermal energy storage systems.

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Abstract

Due to the increase on the academic and industrial interest on thermal energy storage (TES) systems, the EU Horizon project HYSTORE is developing 4 different solutions. In these solutions, the use of thermochemical materials (TCM) and phase-change materials (PCM) are proposed. We proposed an innovating heating methodology for this field: radiofrequency (RF) heating for TCM (specifically Zeolite 13X), instead of the conventional microwave heating. This technology is highly used in industry for its capabilities to provide high intensity and homogeneous electromagnetic fields. In this work, the numerical simulations for the electrodes design is described, in which the Zeolite 13X heating homogeneousness and hence the power density distribution is fundamental. The electromagnetic simulations were developed using the RF Module in frequency domain in order to guarantee the power density distribution efficiency of the process in correspondence with the impedance matching.

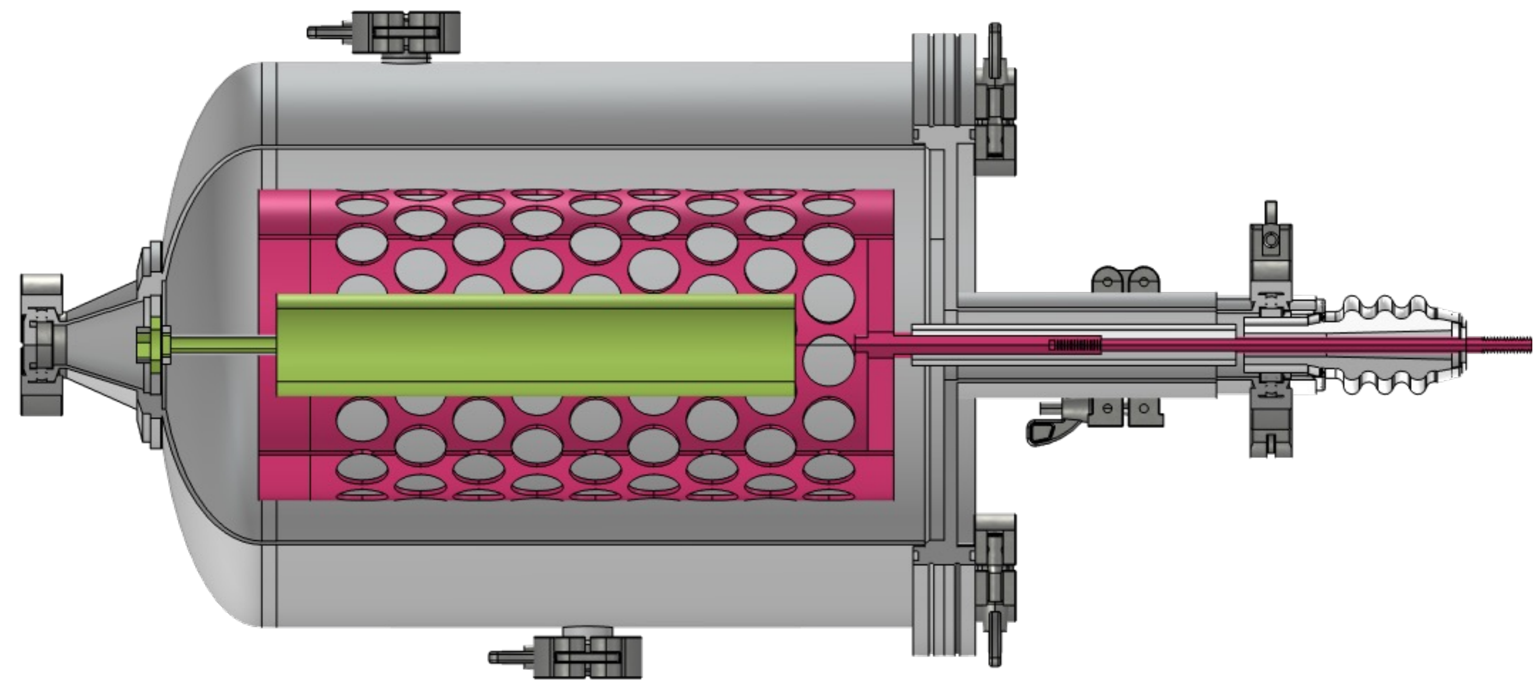

FIGURE 1. Vacuum chamber geometrical configuration with grounded electrode (green) and HV electrode (pink) concentrical cylindrical configuration.

Methodology

The system is designed to optimize the electromagnetic field inside the vacuum chamber (~40 cm height) for a uniform Zeolite 13X heating, and at the same time avoiding zones of extremely high power that may affect the material integrity and properties. The system consists in a 2 concentrical cylindrical electrodes in which the inner electrode is grounded (green) and the external one (pink) provides the high voltage at 27.125 [MHz]. This electrode has been designed as perforated sheet metal to enhance the material circulation and the moisture transport inside the chamber. The 3D geometry has been modeled using the "Electromagnetic Waves, Frequency Domain".

Results and future developments

The simulations conducted aim to find the optimal combination of geometric parameters to achieve uniform field distribution using a parametric sweep in the frequency domain study. A Python statistical algorithm (developed by InovaLab) has been used to analyse the data, focusing on mean, standard deviation, skewness and kurtosis of the power density distribution. Power density distributions are analysed using histograms on a cubic scale to simplify selection.
The thermal energy storage prototype has been realized and it is in testing phase before the installation at the University College Dublin (UCD) Agriculture Building, next year, in the framework of the Hystore Project. In the context of the same project, a second TCM energy storage system will be scaled up for its future operation in Montserrat in 2025.

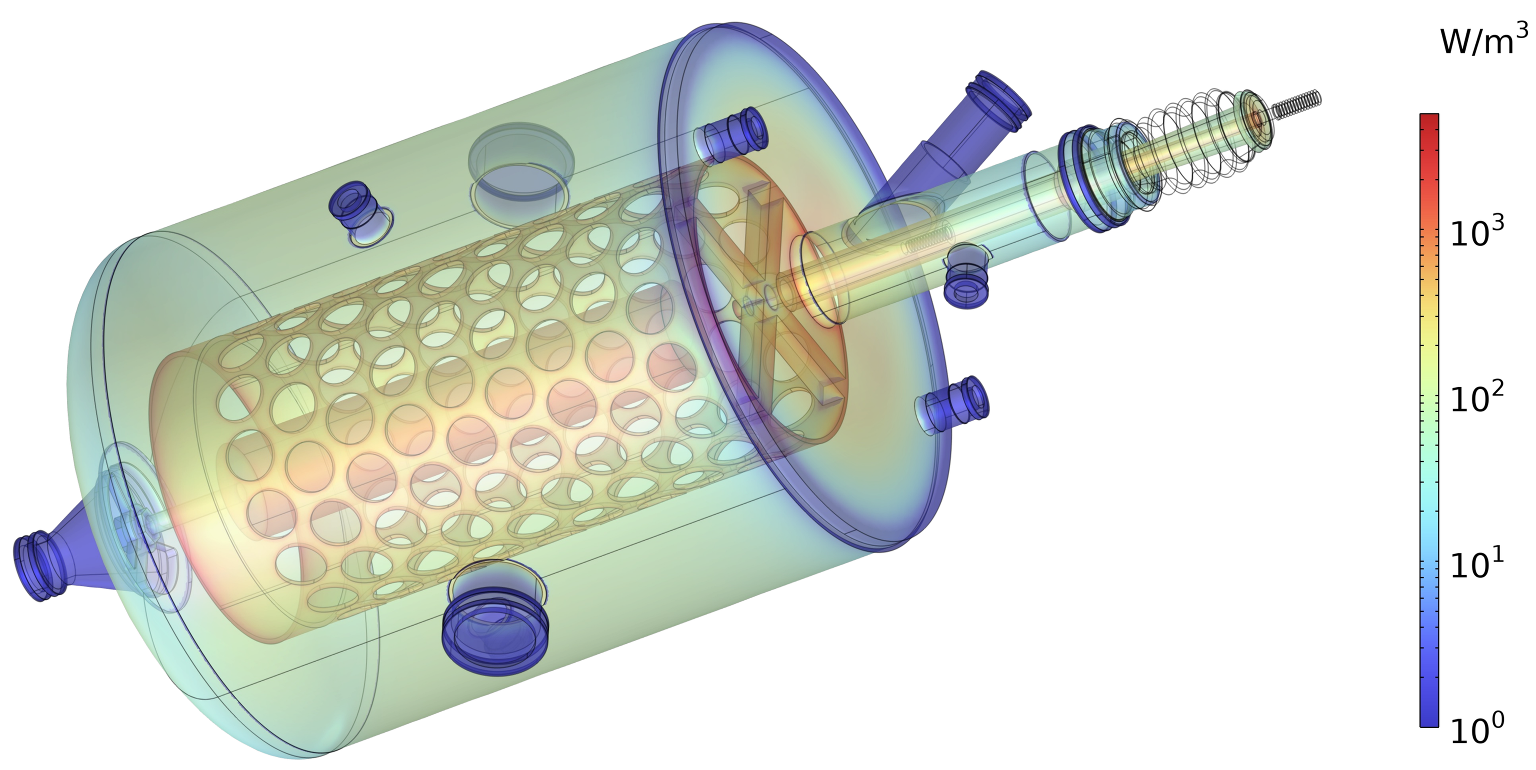

FIGURE 2. Power density distribution (logarithmic scale) in Zeolite 13X material inside vacuum chamber.

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Hybrid Services from Advanced Thermal Energy Storage Systems

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