Recent progress in fusion energy and outlook

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Access to reliable, affordable, and abundant energy - particularly in the form of electricity and heat - is one of the global grand challenges of our time. As energy demand continues to rise worldwide, vast regions still suffer from energy scarcity, impeding economic development, education, healthcare, and overall quality of life. Today, base-load electricity generation remains heavily dependent on fossil fuels, resulting in significant carbon dioxide emissions that drive global warming. Moreover, continued reliance on fossil fuels creates profound geopolitical dependencies for many nations.

Fusion - the process that powers the stars - offers a transformative pathway to clean, virtually limitless energy. It produces no carbon emissions and generates no long lived radioactive waste. For decades, fusion research has centered on plasma physics, particularly magnetic confinement concepts such as tokamak systems. In parallel, inertial confinement fusion has advanced through high energy laser facilities designed to recreate the extreme conditions needed for ignition. In December 2022, the National Ignition Facility at Lawrence Livermore National Laboratory achieved a historic milestone by demonstrating, for the first time, that the fusion energy produced exceeded the laser energy required to initiate the reaction.

This presentation will offer an overview of the current status of fusion energy research and the remaining challenges on the path toward a practical fusion power plant, with an emphasis on inertial confinement fusion. It will highlight key engineering hurdles - including first wall materials, tritium breeding, target fabrication, and advances in laser technology - and discuss how these issues shape the development of future fusion energy systems.