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The National Ignition Facility: The Path to Ignition, High Energy Density Science and Inertial Fusion Energy

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The National Ignition Facility (NIF) at the Lawrence Livermore National Laboratory (LLNL) in Livermore, CA, is a Nd:Glass laser facility capable of producing 1.8 MJ and 500 TW of ultraviolet light. This world's most energetic laser system is now operational with the goals of achieving thermonuclear burn in the laboratory and exploring the behavior of matter at extreme temperatures and energy densities. By concentrating the energy from its 192 extremely energetic laser beams into a mm^3-sized target, NIF can produce temperatures above 100 million K, densities of 1,000 g/cm^3, and pressures 100 billion times atmospheric pressure—conditions that have never been created in a laboratory and emulate those in the interiors of planetary and stellar environments.

On September 29, 2010, NIF performed the first integrated ignition experiment which demonstrated the successful coordination of the laser, the cryogenic target system, the array of diagnostics and the infrastructure required for ignition. Many more experiments have been completed since. In light of this strong progress, the U.S. and the international communities are examining the implication of achieving ignition on NIF for inertial fusion energy (IFE). A laser-based IFE power plant will require a repetition rate of 10–20 Hz and a 10% electrical-optical efficiency laser, as well as further advances in large-scale target fabrication, target injection and tracking, and other supporting technologies. These capabilities could lead to a prototype IFE demonstration plant in 10- to 15-years. LLNL, in partnership with other institutions, is developing a Laser Inertial Fusion Energy (LIFE) baseline design and examining various technology choices for LIFE power plant

This paper will describe the unprecedented experimental capabilities of the NIF, the results achieved so far on the path toward ignition, the start of fundamental science experiments and plans to transition NIF to an international user facility providing access to researchers around the world. The paper will conclude with a discussion of LIFE, its development path and potential to enable a carbon-free clean energy future.

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