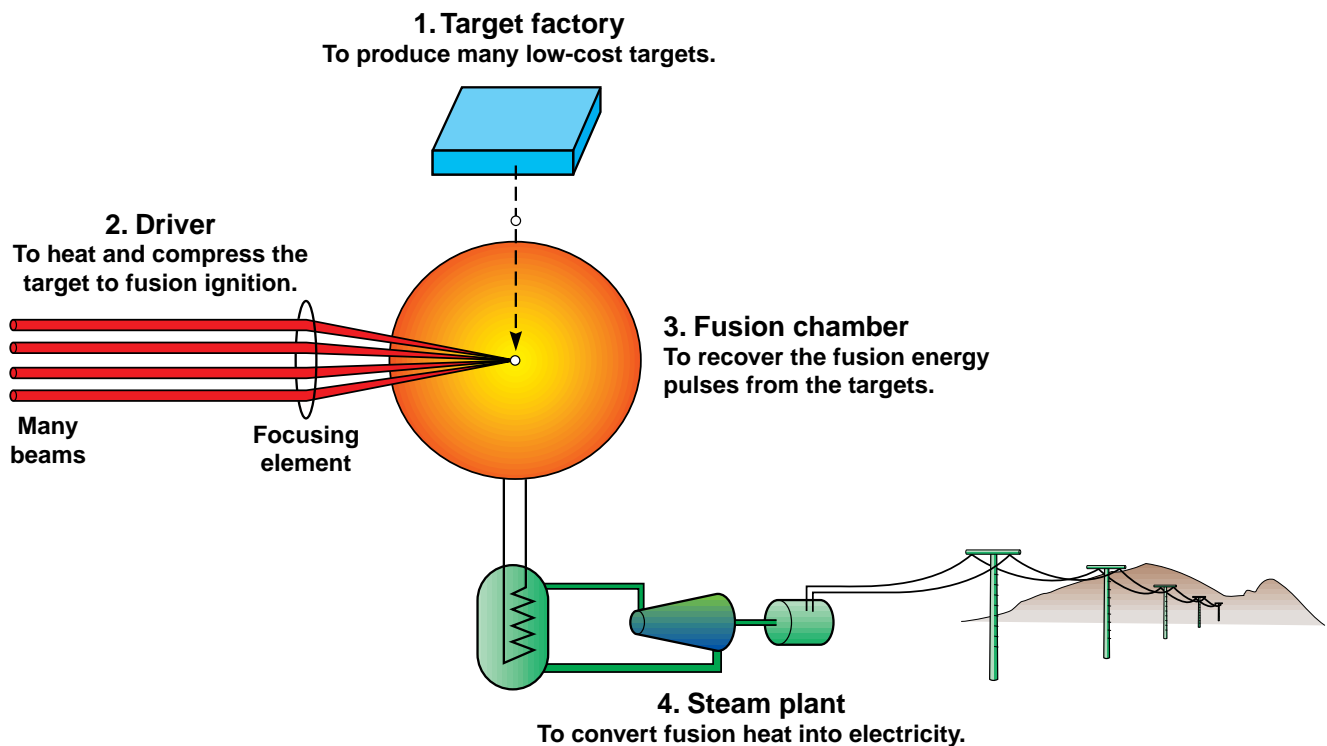


# Inertial Fusion Energy: Opportunity for Fusion Innovation

For more information about Inertial Fusion Energy and other fusion topics, please see LLNL's Laser Fusion Education web page at <http://lasers.llnl.gov/lasers/education/ed.html>

## IFE Power Plant Systems

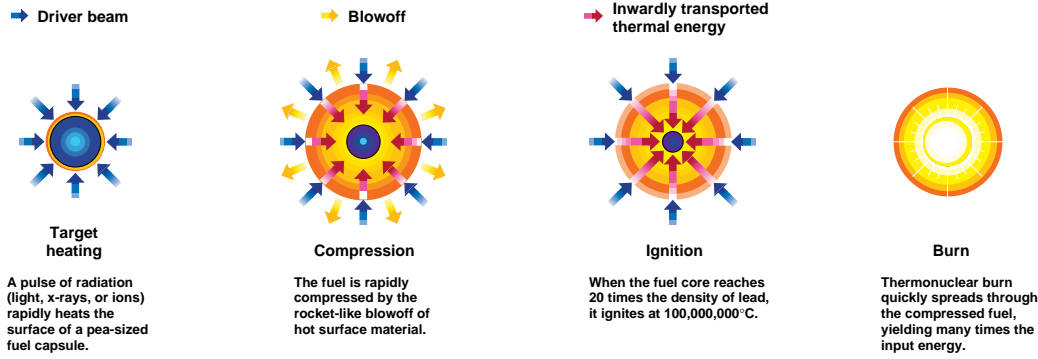


In inertial fusion energy (IFE), a “driver” focuses beams of accelerated ions or intense laser light on a “target” filled with hydrogen fuel. An IFE power plant would have separate areas for the driver, a factory for making the targets, a target chamber where the fusion reactions occur, and a steam turbine to generate electricity. This separability provides design flexibility and allows the driver and target factory to be protected from the fusion radiation environment. The driver must ignite several fusion targets per second to produce the desired power level in the chamber. A single driver could be used to operate multiple chambers by switching the final beam paths between chambers. Various driver concepts are being studied, some for both energy and defense purposes.

Realization of IFE requires the development and demonstration of four things:

- High gain targets (fusion energy output ~50–100 times greater than driver energy input)
- An efficient (~10–30%), high repetition rate (~5–10 Hz) driver
- Low cost target fabrication (about 25¢ each) at high production rate (~100 million per year)
- A long-life (up to 30 years), low-radioactivity fusion chamber

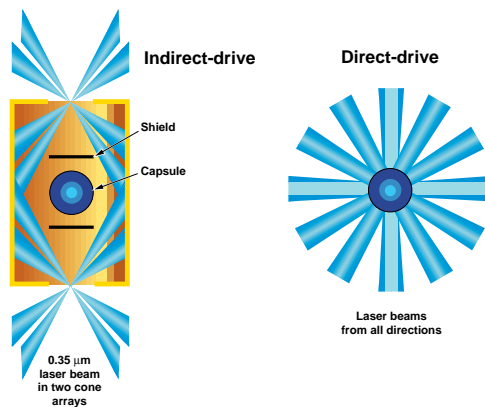
# How Inertial Fusion Works



The total fusion energy released per pulse is about equal to the energy released by burning thirty pounds of coal.

## IFE Targets

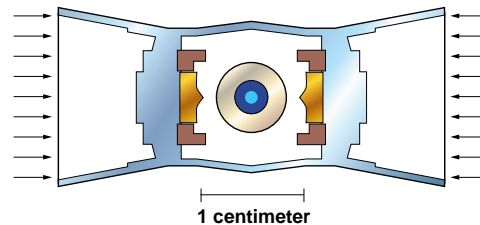
In IFE, the fusion reactions occur within a small capsule containing the deuterium-tritium (DT) fuel, and each driver concept requires specific targets and related mechanisms. In “indirect drive” targets, the laser or ion beams do not strike the target capsule directly but enter a metal cylinder and create thermal x-rays that heat the surface of the fusion capsule. With “direct drive” targets, the beams are focused directly on the target capsule.



### Targets for Solid-State Laser

In the indirect target (far left), the outer metal cylinder of gold or lead contains a plastic fusion capsule (about 3 mm in diameter) that is lined with a solid layer of fuel and that holds a small amount of DT gas. Laser beams enter the cylinder in two conical arrays.

The direct drive target (near left) is uniformly illuminated from all directions.



### Target for Heavy-Ion Driver

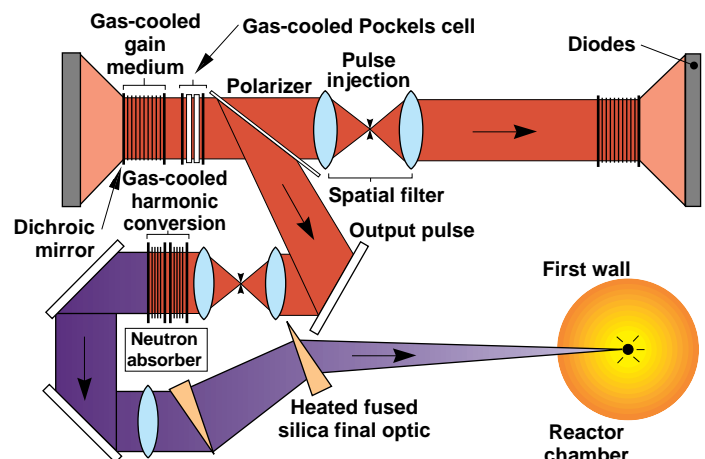
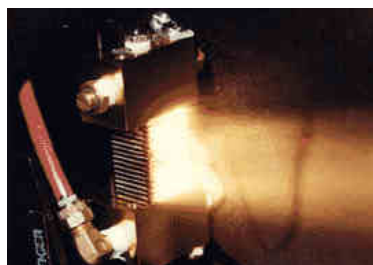
In the heavy-ion target, the plastic fuel capsule is completely surrounded by materials that first convert the ion energy into x rays and then contain the x rays in the volume surrounding the capsule.

## IFE Driver Concepts

### Primarily for direct-drive targets

#### Diode-Pumped Solid-State Laser Driver

Using diodes instead of flashlamps to pump a solid-state laser could permit the rapidly repeated firings and efficiency necessary for power generation. LLNL developed the laser diode array shown here and is beginning the construction of a 10 Hz, 100 J DPSSL.



### Krypton-Fluoride Gas Laser Driver

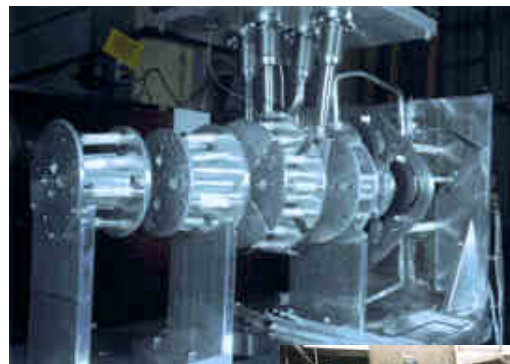
With the KrF laser, the laser medium is a gas that can be circulated for heat removal in high pulse-repetition-rate applications such as IFE. Target physics experiments are being conducted at the Naval Research Laboratory using the Nike KrF laser. Shown here are the large black magnetic field coils used to guide electron beams through the KrF amplifier cell.



### Primarily for Indirect-drive targets

#### Heavy-Ion Driver

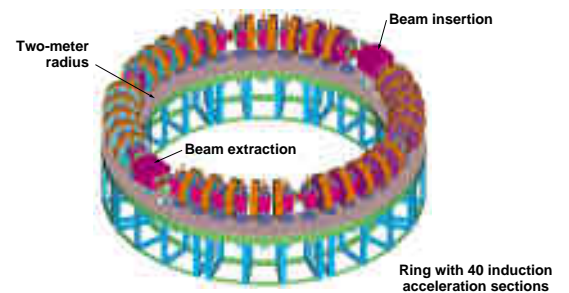
Heavy ion drivers are the leading approach supported by the U.S. DOE Office of Fusion Energy Science. Induction-type acceleration is used to achieve the high currents, high efficiency, and high pulse-rates needed for Inertial Fusion Energy.



Beam-combiner experiment. Diodes and electrostatic quadrupole for the upcoming four-beam combiner experiment at Lawrence Berkeley National Laboratory. (Shown before installation.)

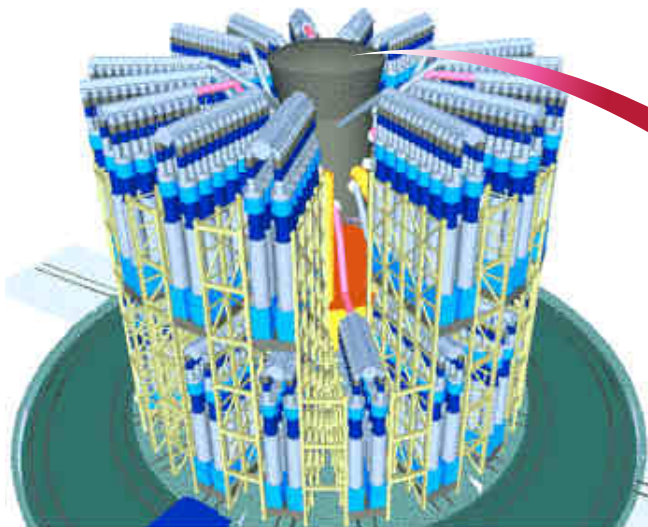


Linear magnetic-transport experiment. Recent scaled experiments at Lawrence Livermore National Laboratory tested the injection, matching, and magnetic transport of a potassium-ion beam.



#### Light-Ion Driver

Light-ion accelerators use pulsed-power generators and magnetically-insulated diodes to produce high currents of light ions such as lithium. Conceptual designs of IFE power plants using light-ion drivers have been completed by the University of Wisconsin and Sandia National Laboratories, New Mexico.

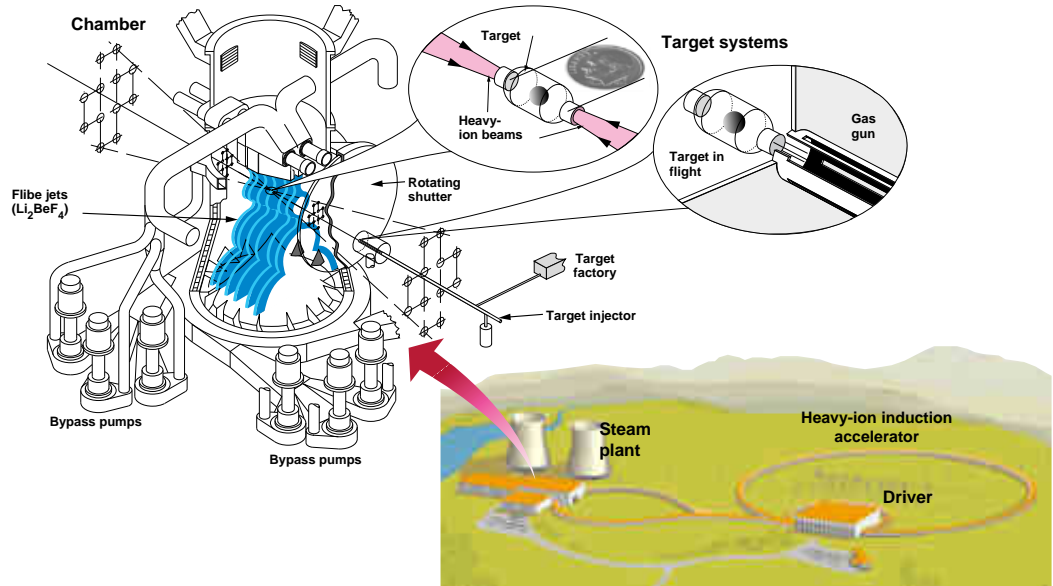


Cross-section of the Libra-Lite chamber

# IFE Power Plant Concepts

## HYLIFE-II

HYLIFE-II is an IFE power plant that uses a heavy-ion driver. The chamber uses liquid jets of Flibe (a fluorine, lithium, beryllium molten salt) to protect the fusion chamber from neutrons. This results in long lifetime components, reduced maintenance costs and low environmental impact.



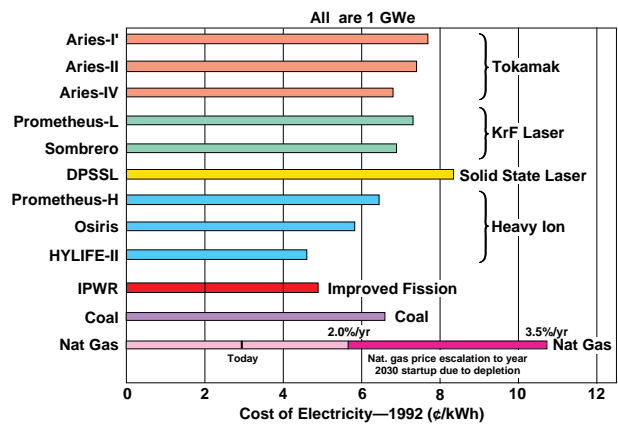
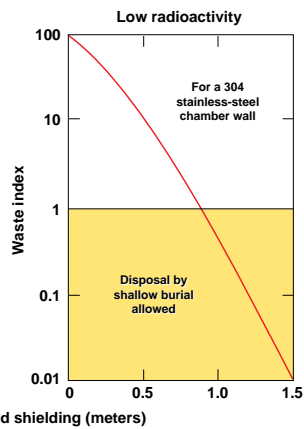
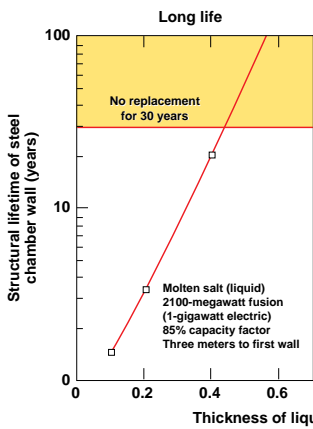
## Sombrero

Sombrero is a fusion chamber concept for direct-drive laser targets. The chamber (far right) is made of low-activation carbon-composites. The flowing ceramic coolant is shown in green. The power plant shown uses a diode-pumped solid-state laser driver. A KrF gas laser could also be used with the Sombrero chamber.



Cross-section of the SOMBRERO Chamber

# Environmental and Economic Considerations



IFE power plants can use renewable liquid-protected walls for long life, low radioactivity, and low maintenance.

The projected cost of electricity from inertial fusion power plants compares favorably with other long-term energy options due to the substantial savings in fusion fuel costs compared to fission and fossil fuels.



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