Fusion is the process that powers the sun and stars. If harnessed on earth, it promises a clean, virtually inexhaustible source of energy for future generations.

The Australian Plasma Fusion Research Facility is the centrepiece of Australia’s contribution to the international fusion effort. The $35M facility comprises two high-temperature magnetized plasma confinement devices: the H-1 ‘heliac’ and the MAGPIE plasma pinch. Plasma - the 4th state of matter - is produced by heating gases like hydrogen to extreme temperatures, typically more than a million degrees!

The Facility program advances the prospects for the controlled release of fusion power through:

**Basic and Applied Research** into the confinement of plasma using magnetic fields (H-1) and the properties of materials when exposed to extreme plasma environments (MAGPIE),

**Joint research programs and access to billion-dollar international facilities** around the world. A key goal is to contribute to, and ultimately secure an Australian involvement in the **ITER International Fusion Experiment**, a multi-national, multi-billion dollar project aimed at demonstrating 500 Million Watts of power from plasma fusion.

**Research Training** of the next generation of undergraduates, post graduates and postdoctoral researchers.

In comparison with international facilities, the APFRF represents excellent value for money:

- It is a focal point for researchers at Universities and national institutions such as ANSTO who study plasma and its many applications.
- It inspires the next generation of engineers and physicists.
- It enhances Australia’s international scientific reputation through its outstanding graduates, its scientific achievements and through the deployment of world-first instruments and techniques on frontline devices around the world.
- The Facility ensures Australia remains intellectually and technologically equipped to benefit from the future fusion power economy.

The **H-1 Heliac** holds hot plasma using a magnetic field 10,000x stronger than the earth’s. The magnetic field is highly shaped under computer control to improve confinement and plasma stability.

The Magnetised Plasma Interaction Experiment (MAGPIE), creates conditions approaching those at the edge of a fusion reactor, to study the effect of plasma and intense heat on candidate materials for the vessel walls. The picture shows the plasma being focussed onto a region of high intensity by the magnetic field.
Recent Highlights from the Australian Plasma Fusion Research Facility

An instrument developed at the APFRF has provided the first images the magnetic field inside a tokamak plasma. The red stripe indicates localised current at the plasma edge that can drive potentially harmful plasma instabilities. Understanding and control of these instabilities is crucial to the success of fusion power. Installed on the flagship Korean experiment ‘KSTAR’, this world-first experiment will be continued later this month.

In a joint program with the Australian Nuclear Science and Technology Organisation (ANSTO) micro bubbles (shown highly magnified) were observed to form on the surface of a tungsten alloy after exposure to high energy helium plasma in “MAGPIE”. Understanding and ultimately preventing this and resulting damage is essential to the success of fusion energy. This project addresses important gaps in our understanding of the interaction of materials with plasma.

Plasma Fusion – Clean Energy for the Third Millennium

The world is facing an energy crisis; oil prices continue to rise, and there are increasing concerns over greenhouse gas emissions and dwindling fossil fuel reserves. It seems unlikely that renewables will be able to meet all of the world’s ever-increasing demands. Plasma fusion is an alternative ‘clean’ nuclear technology by which hydrogen isotopes are heated to many millions of degrees, causing them to fuse together, releasing vast amounts of energy.

Fusion, the process that powers the sun, has several significant advantages over fission. The raw materials can be extracted from seawater, the end product is helium, not a long-lived radioactive isotope, and the reaction cannot get out of control. Current experimental reactors are beginning to reach “breakeven point”. Within a decade or two, next step reactors will be producing high fusion power output.

Australia actively participates in this necessarily international effort through the H-1 Heliac and the MAGPIE materials facility (left) of the Australian Plasma Fusion Facility. MAGPIE is used to study the interaction of plasma with materials, including materials suitable for fusion reactor walls.

The H-1 heliac holds super-hot plasma in a twisted magnetic bottle. Though of much smaller scale than prototype reactors such as ITER (below), H-1 offers unparalleled flexibility in its configuration and is particularly suited to the development of advanced remote sensing instrumentation, such as that developed for imaging plasma waves (right). Some of our instruments are employed on large scale reactors overseas or have been adapted to service other industries at home.

‘Powering Ahead’ (http://fusion.ainse.edu.au) outlines a five year strategy building on Australia’s experimental, theoretical and engineering capabilities in plasma fusion with the aim of securing an Australian involvement in the international ITER fusion experiment, and contributing world-leading Australian instrumentation.

The Australian Plasma Fusion Research Facility was established by an $8.7M grant under the MNRF scheme, and supported by $7M EIF upgrade funding and NCRIS operating funds (~$0.5M pa). It is operated by the Australian National University and is available through the Australian Institute of Nuclear Science and Engineering (AINSE) to researchers from around the country and internationally through collaborations.