1. INTRODUCTION

Most of the world's nuclear reactors use fuel in which uranium is enriched to less than 10 per cent ^{235}U, the only naturally occurring, thermally fissile, isotope. Neutron capture by the fertile material ^{238}U produces plutonium. However, there has long been interest in using thorium as a fertile material to produce ^{233}U, an isotope of uranium with the best neutronic properties, as a thermal reactor fuel. Thorium is far more abundant in nature than uranium.

The use of thorium based fuel cycles has been studied for about 30 years, but on a much smaller scale than uranium or uranium/plutonium cycles. Many incentives have been identified for its use including the fact that public concerns have increasingly focused on the high radiotoxicity and long lived of waste produced during reactor operation. In addition, the end of the Cold War raised concerns about the non-proliferation of nuclear power, that is, on the large stockpiles of Pu produced in civil and military reactors. These changes have further stimulated consideration of thorium based fuel cycles. Some aspects include:

- Increasing the world's fissile resources by breeding ^{233}U from thorium;
- Improving fissile fuel utilization in thermal reactors;
- Significantly reducing ^{235}U enrichment requirements;
- Decreasing production of Pu, and other transuranic elements compared to uranium fuel cycles;
- Achieving higher fuel burnups than uranium based fuel cycles;
- Realizing the potential for Pu burning (civil-grade or weapon-grade) without the need to recycle, i.e. achieving faster reduction of existing Pu stockpiles;
- Decreasing production of toxic fuel waste or long lived radiotoxic waste; and
- Developing the potential to combine the thorium based fuel cycle with accelerator driven systems and hybrid fusion driven systems, to breed ^{233}U and incinerate long lived radiotoxic isotopes.

Thorium based fuel can be used in all proven reactor types, including PWRs, WWERs, BWRs, HWRs, FBRs, HTRs/HTGRs and in possible future reactor concepts, such as the molten salt reactor or aqueous homogenous suspension reactors. Thus it may be possible to realize economic benefits through its use. However, significant financial input will be necessary to reach the same large scale industrial status already attained by the U/Pu cycle.

The consideration of possible advantages, especially for constraining plutonium production and reducing long term fission waste levels, has led to renewed international interest in the thorium based fuel cycle.

2. BACKGROUND

THORIUM FUEL CYCLE DEVELOPMENT AROUND THE WORLD

Research and development

Basic research and development on the thorium fuel cycle has been conducted in Germany, India, Japan, the Russian Federation, the United Kingdom, and the USA. Studies included the determination of material data, fabrication tests on a laboratory scale, irradiation of Th-based fuel in material test reactors with post-irradiation examinations, and