Cost analysis of seawater uranium recovered by a polymeric adsorbent system

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In tandem with its adsorbent development and marine testing efforts, the United States Department of Energy, Office of Nuclear Energy, routinely updates and expands its cost analysis of technologies for extracting uranium from seawater. If informed by repeatable data from field tests, a rigorous cost analysis can convincingly establish seawater uranium as a “backstop” to conventional uranium resources. A backstop provides an essentially unlimited supply of an otherwise exhaustible resource. Its role is to remove the uncertainty around the long-term sustainability of the resource. The cost analysis ultimately aims to demonstrate a uranium production cost that is sustainable for the nuclear power industry, with no insurmountable technical or environmental roadblocks. It is also a tool for guiding further R&D, identifying inputs and performance factors where further development would offer the greatest reduction in costs and/or uncertainties.

A life cycle discounted cash flow methodology is used to calculate the uranium production cost and its uncertainty from the costs of fundamental inputs including chemicals and materials, labor, equipment, energy carriers and facilities. The inputs themselves are defined by process flow models of the adsorbent fabrication and grafting, mooring at sea, recovery, and elution and purification steps in the seawater uranium recovery process.

Pacific Northwest National Laboratory (PNNL) has carried out marine tests of the Oak Ridge National Laboratory amidoxime grafted polymer adsorbent in natural seawater. Multiple test campaigns demonstrated that after 60 days of immersion the uranium uptake averaged 3090 ± 310 µg U/g of adsorbent. Past ocean experiments on similar material by the Japan Atomic Energy Agency (JAEA) demonstrated that the adsorbent may be used in the sea six times before being replaced, with 5% uptake degradation per reuse. The mooring and recovery system envisioned for the adsorbent is similar to one proposed by JAEA for its braided polymers, but with costs reduced by eluting the uranium offshore and adopting a lighter weight mooring system. Both measures reduce the number, cargo capacity and energy use of the ships required to service an offshore field.

Given these parameters, the cost of producing uranium from an offshore adsorbent field with a capacity of 1200 tonnes U per year is $640/kg U. When uncertainties in input costs and adsorbent performance are considered, the 95% confidence interval is $470 to $860/kg U. Costs associated with adsorbent production, primarily for purchasing or fabricating chemicals, account for 56% of the $640/kg U total. Mooring and deployment costs contribute 37% and are dominated by anchoring system and work boat purchase and operations. Uranium uptake is the key cost driver: if 60-day uptake reached 4890 µg U/g of adsorbent, the ORNL adsorbent saturation capacity found in the PNNL experiments, the uranium production cost would drop by 30% to $445/kg U. If the durability of the adsorbent could be improved, so that capacity loss was limited to 3% per reuse over 12 uses, the cost would drop by a further 18% to $360/kg U. This corresponds to the peak uranium spot price reached during the 2007 boom.