Uranium conversion and enrichment

Almost all commercial reactors are Light Water Reactors (LWRs). These use ordinary (light) water both as coolant and as moderator, necessary to slow down neutrons in order to keep a chain reaction going. The fuel therefore has to be enriched, which means that the relative content of the fissile U-235 isotope must be raised to 3 to 5% (currently about 4% is normal) to achieve sufficient criticality.

Natural uranium mainly consists of the non-fissile isotope U-238, with only 0.72% U-235 - both isotopes show radioactive decay but U-235 decays faster (has a shorter half-life). There are types of reactors that use heavy water (D_2O) as a moderator, like the CANDU, or graphite, like the Magnox/GGR type. In those cases enrichment is not always necessary. Light water is not such a good moderator, but obviously it is much cheaper.

Prior to enrichment, the uranium oxydes (yellowcake) must be converted to uranium fluoride (hex), which is a gas. Enrichment plants are based upon cascade physics and a method of weight separation. Nowadays, the most common technique is the use of a cascade of many centrifuges. Depending on the desired enrichment at the end of the process and the choice of some operational parameters (such as the tails assay), the natural uranium is separated into a small enriched part and a large depleted part, typically 80 to 90%, most of which is considered merely as waste.

The last step prior to fuel fabrication is the conversion of hex to uranium oxide (UO_2) powder. Some reactors like the Magnox use metallic uranium (obtained by chemical reduction). For commercial purposes, the oxyde fuel form for LWRs is most favorable, because it can reach very high burn-up rates.