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There is sea uranium for 1000 years to 1.8 billion years

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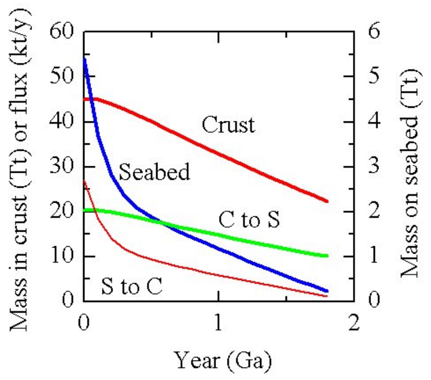
Proven reserves of energy resources will be exhausted in 74 years if primary energy consumption is kept constant. This is a very rough estimation because the exhaustion of reserves does not mean exhaustion of resources and R/P ratio varies with price, discovery of new reservoirs, development of new technology, population increase, economic growth etc. This R/P ratio does not seem to be enough, however, it will increase to 153 years by including probable reserves of oil shale, shale gas and methane hydrate (Ishimoto, 2011 in Japanese). Dependency on gas energy will dominate in several ten years because R/P ratio of petroleum is just 43 years. R/P ratio of uranium is 744 years if only fast breeder reactors are employed instead of light water reactors.

It might be meaningless to worry about human society more than 100 years from now considering the human society 100 years ago and the above energy seems enough. The current author, however, would like to mention that there are a large quantity of thorium and sea uranium.

Thorium is a nuclear fuel and can be smelted from monazite with rare earths. It has been not widely used because it does not produce plutonium which can be used for nuclear weapons. It is found in Turkey, Australia, India (already using), Norway, US, Canada etc. and its proven reserves are 1.58 Mt (MacKay, 2010). The reserves are for 58 years supplying primary energy for the whole world. Thorium has such advantages as most parts fission so that nuclear waste is much less than uranium, fuel has to be changed just once a 30-year period and serious accidents are not expected by its fission mechanisms although the smelting cost is higher than uranium. Thallium in nuclear waste radiates intense Gamma-ray and the half-life is 30 years. It is impossible to significantly increase R/P ratio by the mechanism which is similar to fast breeder reactors because most parts fission.

There is uranium of 4.2 Gt as uranyl carbonate, $UO_2(CO_3)_3{}^{4-}$, at 3.34 ppb in sea water (Davies et al., 1964). Blade type-extracting system using tannin collectors and installed on continental shelves with warm current is under development and the cost is 3 times the uranium from ore (Tamada et al., 2006 in Japanese). The cost for power generation will increase by only 20% if the cost for uranium is 3 times because cost for uranium is just 10% the cost for power generation for light water reactors. Assuming that one quarter of the resources can be collected, probable reserves would be 1 Gt and this is for all primary energy for the whole world of 1000 years. Continental shelves along Indonesia, Philippines, Taiwan, Okinawa-Tosa bay, East coast of Australia, Florida, East coast of Africa would be suitable for collection. However, 110,000 km^2 wide system is necessary and this does not seem practical.

Assuming that only fast breeder reactors are used, all primary energy for the whole world can be supplied by uranium of 10 kt and the necessary area is just 1100 km^2. The cost can be several 100 times the ordinary uranium. Sea uranium is flowed from rivers and dissolute in sea water and precipitate on sea bed. The inflow rate is 27 kt/y (Davies et al., 1964). Apparently, precipitated uranium is subducting to mantle at 27 kt/y. Uranium amount in continental crusts is roughly estimated as 45 Tt based on the volume of continental crust and average concentration (3 ppm). Assuming that a constant portion of uranium in continental crust inflows into sea, a constant portion of uranium in sediments on sea bed subducts to mantle and is supplied to continental crust as magma, plate will stop in 6 Gy at a constant deceleration, sea uranium of 10 kt/y is extracted and considering the half-life time of 238U (4.5 Gy), sea uranium can be extracted for 1.8 Gy. It is supposed that human cannot survive till the time because of the predicted extreme climate change and water shortage at that time if the morph and function of the human is similar to present ones.



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