Abstract

Nuclear Energy for Low-Carbon Fuels

Charles Forsberg

Historically, nuclear power has been used to generate electricity. That may change. The worldwide cost of oil is about four-trillion dollars per year—in addition to the risks associated with dependence on foreign oil and concerns about climate change. In addition to crude oil, liquid transport fuels can be produced from many other feedstocks such as biomass, heavy oil, shale oil, and coal. However, the processes for converting these feedstocks into liquid fuels require massive quantities of energy. Low-carbon nuclear power can provide that energy and thus maximize the liquid fuels production per unit of biomass or fossil fuel while minimizing greenhouse gas releases. Different processes are required to convert corn, corn stover, rice straw, forest residues, and municipal trash to ethanol; sawgrass to ethanol; and heavy oils, oil shale, and oil sands to gasoline or diesel fuel.

Simultaneously, the use of nuclear energy may enable underground refining where heat is used insitu to convert heavy oil, oil sands, shale oil, and soft coal into a high-grade light crude oil and a carbon residue. This would dramatically increase world-wide reserves of "recoverable" oil. The process is similar to the thermal cracking of heavy oils in refineries. However, in refineries the carbon residue is petrocoke that is burnt as fuel. Underground refining results in in-situ carbon sequestration of this residue in the form of carbon and can significantly lower greenhouse impacts from fossil liquid fuels production.

The potential for nuclear-biomass fuels is equally large. This potential can be shown by example. The U.S. could produce ~1.3 billion tons of renewable biomass per year. The energy value of that biomass is equivalent to burning ~10 million barrels of diesel fuel per day. If that biomass is converted into ethanol and biomass is used to provide the energy for the conversion process, the energy value of the fuel ethanol is equal to ~5 million barrels of oil per day. However, if low-carbon nuclear energy is used to provide energy to biomass conversion plants, all the biomass can be converted into hydrocarbon liquid fuels and the equivalent of ~12 million barrels of diesel fuel could be produced per day.

The ultimate potential for biofuels may be much larger. Corn yields have increased by a factor of 10 over 80 years and the same may occur for fuel crops such as sawgrass on lands unsuitable for crops. Simultaneously, biomass forms such as algae have the potential for biomass yields an order of magnitude greater per unit area of land than traditional sources of biomass. However, all biomass forms have high water contents and thus require significant heat for processing—something that nuclear energy can provide.