Meeting U.S. Army Needs for Electricity and Vehicle Fuels with Compact, Lightweight, Transportable Nuclear Reactor Systems as Energy Source

Dr. James R. Powell, Dr. J. Paul Farrell and Mr. Meyer Steinberg
Brookhaven Technology Group, Inc. (BTG), East Setauket, NY

Dr. George Merkel and Dr. Charles Rong
U.S. Army Research Laboratory (ARL), Adelphi, MD

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Compact nuclear reactor power systems that can be transported to and operated at field locations to generate electric power and synthetic fuels for Army vehicles are described. When developed, the Deployable Electric Energy Reactor (DEER) system would generate megawatts of electric power to meet electrical demands, and produce hydrogen by electrolysis of water[1] which can be extracted from the ambient atmosphere. The hydrogen could be combined, using re-designed industrial processes, with carbon dioxide extracted from the ambient atmosphere[2] to produce synthetic fuel[3] for use in existing fleet of Army combat and tactical vehicles. The re-designed industrial processes use both the heat generated by DEER system and the electricity for fuel production processes so that the overall energy efficiency of the entire DEER system will be higher than that to produce electricity only. This technology will enable sustainable fuel generation with feedstock from anywhere in the world, therefore, it will have important impact on the Army in maintaining its un-eroded superiority through reduced dependence on fossil fuel, foreign or domestic.

The general process for liquid fuel production is to utilize electrical power and heat from a nuclear power or other available source to: 1) capture and recover the 385 ppm by volume of CO2 existing in the atmosphere, using physical and chemical means; 2) electrolyze water to produce hydrogen; and 3) combine the H2 and CO2 to produce the synthetic liquid hydrocarbon fuel. The CO2 would be either co-electrolyzed or shifted to CO by the water gas shift reaction and then combined with H2 to produce synthetic fuel using a catalyzed Fischer-Tropsch (F-T) reaction. An alternative to F-T is a catalytic methanol reactor and dehydration to the hydrocarbon synthetic fuel. These methods are being investigated and optimized with respect to development of a mobile system that can be deployed to forward operating bases as part of the DEER system. Advanced electrolysis, F-T reaction, and the thermal energy utilization will be integrated through re-designing processes.

Two reference designs for DEER are described: DEER-10 generates 10 megawatts of electric power. Used to produce vehicle fuels, DEER-10 could supply hydrogen equivalent to 5000 gallons per day of gasoline, or 3000 gallons daily of actual gasoline/diesel fuel, using CO2

extracted from the ambient atmosphere. DEER-50 generates 50 megawatts of electric power, enough to produce hydrogen equivalent to 25,000 gallons daily or 15,000 gallons per day of liquid fuel. At an average cost of $100 per gallon for field use in Iraq, DEER-50 would replace an annual expenditure of over one-half billion dollars for fossil fuel. DEER systems can also produce large quantities of potable water using electrically powered cooling units to condense water vapor from the ambient atmosphere. Used in desert regions such as Iraq, a DEER-10 system could produce 250,000 gallons of fresh water per day.

The DEER system uses existing water cooled and moderated nuclear technology that has operated safely and reliably in many reactors around the world for decades. Three nuclear fuel options for DEER are described, analyzed, and evaluated - TRIGA® uranium/zirconium hydride fuel; UO2 in a ceramic metal matrixl, and TRISO uranium carbide/graphite/silicon carbide particle fuel. All 3 options have operated safely for many years in dozens of reactors worldwide with zero release of radioactivity. TRIGA fuel is selected for the DEER-10 and DEER-50 reference designs because it inherently and instantly shuts down the reactor if fuel temperature exceeds a specified limit. DEER uses a conventional standard steam turbine power system operating at relatively high turbine back pressure (~ 1 atm compared to the ~ 0.1 atm in large turbine systems) minimizes turbine size and weight.

The outer diameter of the DEER-10 reactor pressure vessel is only 600 centimeters. DEER-50 is somewhat larger, i.e. 1200 centimeters in diameter. The DEER reactors have an integral primary shield of tungsten metal so that they can be safely removed and transported away from their field locations within a few days after shutdown. The tungsten shield ensures that any radiation dose from the spent fuel that would be experienced by transport personnel will be below existing operational guidelines. The weight of the DEER reactor and its integral primary shield is low enough that it can be transported using existing Army ground and air systems. When operating in the field, some additional secondary shielding using local materials, e.g. concrete or water, would be used. The whole DEER system could be transported to field locations using existing Army ground and air transportation means. Once in place, the need for logistical supply to the theater with large amounts of liquid fuel presently required to operate vehicles and generate electrical power may be significantly reduced. The DEER system could operate for a year or more without refueling.

Reference:

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