New Research Effort Aims to Develop Seafloor Power Systems for Deepwater Oil and Gas Operations

In the future, the most productive offshore oilfields in the Gulf of Mexico may be nowhere to be seen. As oil and gas production has moved into deeper and deeper water, increasing numbers of development projects are being carried out via subsea production systems. As these systems are designed to extract oil and gas from locations that are farther and farther away from their surface base facilities, the technical difficulties (and costs) of transmitting electric and hydraulic power to operate the subsea equipment rise. A point will soon be reached where the next logical step will be to locate all of the required production and processing equipment on the seafloor, including the power generation units required to operate the system. A recently launched research project being funded under the EPAct 2005 Section 999 research program and carried out by a team led by the Houston Advanced Research Center (HARC), aims to lay the groundwork for just such a future.

The number of subsea installations is increasing worldwide and the length of subsea tiebacks is also increasing; tiebacks for some subsea gas wells planned through 2012 are expected to reach more than 100 miles and some oil tiebacks nearly 60 miles. These flowlines, together with the umbilicals used for the transmission of hydraulic and electrical power, data monitoring and chemical injection, can represent the largest cost items in the post drilling phase of production system installation. In addition to the cost, as the transmission lines stretch beyond 20 miles, more than 50% of the power supplied from the surface location is lost, requiring increased generation capacity (and emissions) and increased payload requirements at the surface.

Removal of the need for umbilical power transmission through subsea power generation will reduce the power generation requirements at the surface platform, increasing its payload flexibility and lowering costs. Lower costs mean that smaller accumulations of hydrocarbons can be economically developed and produced, increasing the domestic supply of energy. In extreme cases, at ultra-deep locations, subsea power may become an enabling technology that permits development where it would otherwise be impossible.

This project will evaluate alternatives and recommend equipment to develop into hybrid energy conversion and storage systems for deep ocean operations. The result will be a comprehensive analysis of the options available for developing such a system, culminating in a conceptual design for the best option based on both economic and technical criteria. The system will be a "hybrid" system in the sense that it will combine both energy conversion and storage capabilities. The evaluation will result in an unbiased assessment of alternatives; the logical first step in advancing this technology.

The investment in this project, which totals $600,000 and includes a 20% contribution from companies on the research team, is timely. Technologies related to subsea processing are advancing rapidly; subsea multiphase pumping systems, subsea control systems, and flowline heating systems are now proven and available, and subsea compression systems are developing. But a comprehensive look at the options for subsea power generation is needed to focus subsequent research on the best alternatives and accelerate the development of this element of the subsea production system of the future.

Work on what is planned as a four-year project began in November 2008. In addition to HARC, the research team includes experts from Lawrence Livermore National Laboratory, Naval Facilities Engineering Service Center, Yardney Technical Products, Shell Oil Company, Chevron Oil Corporation, Total E&P USA, Curtiss Wright and GE.

HARC operates as a “boundary organization” between producers of scientific knowledge (scientists, inventors, and academics) and users of that knowledge (technology adopters, policy makers, the public). In this role HARC engages with the science community by employing a staff with scientific credibility, while appealing to its sponsors by employing a business-like approach to project management and financial accountability.

Lawrence Livermore National Laboratory (LLNL) has a long and distinguished track record in the development of exotic power systems for demanding applications. Naval Facilities Engineering Services Center (NFESC) provides worldwide technical support to the Navy and other DoD and Federal agencies. Yardney Technical Products (YTP) was among the first companies in the world to successfully produce and commercialize rechargeable silver-zinc, magnesium silver chloride and silver cadmium batteries, and has designed, developed and delivered high energy density batteries for ICBMs, the Mars Explorer Rover missions, and a variety of Air Force and Navy systems (see photos).

Photo of a 2 x 28 volt, 30Ah lithium ion battery designed for the Mars Rover by project team member YTP

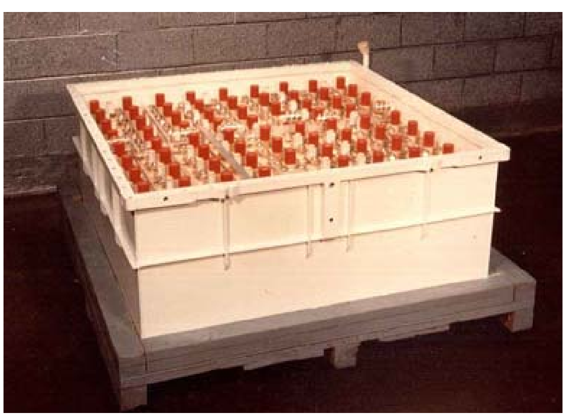

Photo of a 2 x 100 volt, 700Ah silver zinc pressure compensated battery designed by YTP for a Navy Deep Submergence Rescue Vehicle (DSRV)

The project consists of five primary tasks. First, the team will document the performance and functional requirements expected for subsea hybrid power systems. Based on these results, the team will then screen existing high-performance energy conversion and storage systems and develop a data base for the best hybrid power systems. The third task will be to select the two most promising generation-storage combinations, based on performance data, and prepare detailed sub-scale conceptual prototype designs. Initial qualification testing for the purpose of concept demonstration will also be performed. The conceptual designs will have sufficient capacity to power equipment totaling between 20,000-100,000 hp (14 to 70 megawatt), and be capable of long-term reliable operations at pressures up to 5,000 psi and temperatures approaching the freezing point of water.

A formal Risk Assessment of the two conceptual prototype systems will then be carried out and their respective Technology Readiness Levels (TRLs) will be documented. As part of this task, estimates will be developed of the environmental impact (carbon footprint) of these systems when deployed, as compared to conventional gas turbine power generation. The final task will be to document all of the results in a series of publically available technical reports.

Potential systems to be screened may include: ocean-current driven systems; radioisotope thermoelectric generators; thermionic generators; small pressurized-water reactors with low-enrichment fuel (similar to those used on commercial ships); proton-exchange membrane fuel cells powered with hydrogen and oxygen (similar to those used on submarines); and fuel-cells, internal combustion engines or turbines capable of using natural gas from deep-ocean wells.

Battery technologies to be screened may include: compressed-gas storage; liquid redox batteries; secondary batteries in sealed pressure vessels; pressure-tolerant secondary batteries; and other non-conventional battery systems, (for example, oil-compensated polymer-gel lithium-ion batteries); polyurethane potted polymer-gel lithium-ion batteries; lithium-ion batteries; and lead acid batteries.

Following this project, if additional funding is available, work could transition into a second phase that would involve the design and fabrication of prototypes, with both surface and sub-sea testing. A successful technology would then be commercialized through appropriate industrial partnerships. The cost of this second phase of research is estimated to be between $16 MM and $18 MM depending on the type of system chosen for sub-scale prototype construction and testing.